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A CASE STUDY OF ENVIRONMENTAL CONTAMINATION: GELMAN SCIENCES, INC.

by

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ABSTRACT

This project is a case study of an incident of groundwater contamination, the suspected source of which is Gelman Sciences, Inc. ("Gelman"). Gelman is an international corporation based in Ann Arbor, Michigan. At the Ann Arbor facility production occurs of microporous membranes and filters, for medical use.

Toxic chemicals (most significantly 1,4-dioxane) used in Gelman's production process have been dumped, sprayed, and seeped into the environment. These contaminants have affected the quality of the groundwater (and possibly the air), and have rendered over 50 wells in the area unusable. 1,4-dioxane ("dioxane") was first shown to be an animal carcinogen in1965 and is a suspected human carcinogen.

Research by the Gelman Master's Project group was undertaken with the intent of providing useful information to those most personally affected by the situation--the citizens living in the vicinity of Gelman Sciences. Our process of information-gathering has included conducting literature reviews of relevant topics, researching the DNR files on the case, and conducting interviews with those involved in the case.

In this case study we have examined the chain of events surrounding the Gelman contamination issue and have attempted to understand them in the context of larger societal constructs. We have also broken the case study down into its components for further analysis. Areas of inquiry in regard to environmental contamination include: land use concerns, sciences and technologies, the response of government and industry, the response of the University of Michigan, and citizen efficacy in protecting their environment and health.

We have examined the roles of science and technology in our society, based on the understanding that sciences are not studied, nor are technologies created, in a social, economic, or political vacuum. Through an analysis of risk assessment and deep well injection, two practices undertaken by Gelman Sciences, we have discussed how science

and technology can contribute to the environmental problems which they are expected to solve.

This case study illustrates many of the inadequacies of our political, social, and economic systems in addressing environmental contamination. Remedial responses to contamination, like those used in the Gelman case, demonstrate a lack of willingness to confront the root causes of pollution. Unless proactive measures are taken, society will be perpetually committed to costly response activities.

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INTRODUCTION

Groundwater flows unseen beneath the surface of the earth, occurring in saturated sand and gravel and in fractured or porous rock. It helps to sustain both human populations and ecological communities. The amount of groundwater present within the continental United States is immense. That which can be retrieved with current technology is at least six times greater than all the water stored in our surface lakes and reservoirs. It provides almost one-fourth of all water used in the country. Withdrawals of groundwater in the U.S. nearly tripled between 1950 and 1980, growing to 88 billion gallons per day in 1980. Groundwater serves these important purposes (Conservation Foundation, 1987):

- Groundwater is the source of drinking water for more than 50 percent of the total U.S. population and for 97 percent of rural residents.
- Of all water withdrawn for municipal water supplies, 35 percent comes from the ground.
- Groundwater accounts for some 40 percent of all agricultural irrigation water and 26 percent of industrial withdrawals, excluding electric power plants.
- Groundwater sustains many ecosystems. These ecosystems provide areas for fish production, wildlife habitat, recreation opportunities, and other attributes. In periods of droughts groundwater serves important ecological functions, such as providing fresh water for many lakes, rivers, inland wetlands, bays, and estuaries.

Nationally the threat to groundwater is not definitively known. As of October 1987, the United States Environmental Protection Agency (EPA) had placed 951 landfills, impoundments, and other waste sites on its National Priority List, which covers sites requiring urgent remedial action (EPA, 1987). The agency estimates that the list will grow to not more than 2,500 sites and that cleanup costs may total some $23 billion. The Congressional Office of Technology Assessment (OTA) estimates that the number of

priority sites could climb to 10,000 resulting expenditures of $100 billion; roughly $400 for every U.S. resident (OTA, 1985). The majority of these sites contain hazardous wastes. According to the Resource Conservation and Recovery Act, toxic or hazardous wastes are those which may "cause or significantly contribute to an increase in mortality or....serious irreversible or incapacitating illness; or pose a substantial present or potential threat to human health and environment." Thousands of well closures have occurred throughout the U.S. More than 200 organic and inorganic chemicals have been identified in various groundwater supplies (OTA, 1984). Groundwater's slow movement and complicated pattern (making it difficult to trace), often delay the detection of pollution.

In recent years our understanding of contaminants and the threats they pose to groundwater, has become greater. Today, specific organic chemicals in water can be measured to the parts-per-billion or parts-per-trillion level. New toxicological studies have supplied information regarding the toxicity of various substances to humans. Hydrogeologists are gaining a better understanding of water movement below the earth's surface and from the surface to the subsurface. Public outcry has brought attention to various contamination sites. As a result, many response efforts have focused on clean-up.

There are two major threats to groundwater: 1) withdrawals are in excess of natural recharge, leading to groundwater depletion; and 2) there is a decline in quality caused by a growing number of groundwater contaminants (Conservation Foundation, 1987).

Historically, the dumping of various hazardous substances onto the land and into surface water has been an acceptable practice. The earth's natural filtering system was relied upon to cleanse groundwater. As a result of the accelerated rate of dumping both historically and currently, contaminants are now present in the groundwater that threaten human health and the integrity of the environment.

Today, contaminants in the groundwater include biological, inorganic, organic, and radioactive contaminants. Biological contaminants include bacteria, viruses, parasites, and other biological agents that can cause illness. There is very little information about which

specific pathogens are actually present in groundwater. An Office of Technology Assessment report indicated that several different types of bacteria and viruses, including those that cause typhoid, tuberculosis, cholera, and hepatitis, exist in groundwater throughout the U.S. (OTA, 1984).

Inorganic substances include metals, nitrates, salts, and other compounds that do not contain carbon. The Office of Technology Assessment has identified 37 inorganic substances (including 27 metals) in the groundwater (OTA, 1984). The Environmental Protection Agency has established primary drinking water standards for ten inorganic compounds; between 1975 and 1985, these standards were exceeded in an estimated 1,500 to 3,000 groundwater supplies. The most commonly exceeded standards were for fluoride (in 1,000 to 2,000 supplies) and for nitrate (in 500 to 600 supplies) (Rice, 1985).

Organic compounds are those which contain carbon. There are many naturally occurring organic substance, petroleum being the most notable. There are also tens of thousands of synthetic organic compounds, which have been developed in laboratories. These are used in common products such as dyes, food additives, detergents, plastics, and pesticides. For years there was little groundwater monitoring for contamination from organic chemicals. Today, organic chemicals are being detected in groundwater supplies throughout the country.

Almost all groundwater contains a small amount of naturally occurring radioactive substances. Activities associated with nuclear power generation, atmospheric testing of nuclear weapons, and the use of radionuclides in medical or scientific research, releases additional (both natural and human-produced) radiation into the environment. The presence of increasing quantities of radionuclides in groundwater is alarming because of the threats these substances pose to human and environmental health.

The sources of groundwater contamination are diverse. They include waste disposal, handling and storage of hazardous materials, mining and drilling, agricultural practices, etc. The disposal of society's waste is probably the greatest threat to

groundwater quality. Substantial amounts of solid, liquid, and gaseous waste are generated in the U.S. There are approximately 29 metric tons of waste generated per person per year (Conservation Foundation, 1984). The technologies posing the greatest threat to groundwater include on-site sewage disposal, underground injection wells, surface impoundments, land application such as (spray irrigation), and landfills. Hazardous and radioactive wastes, which are two types of waste requiring special handling and disposal, are of increasing concern to human and environmental health.

Political and economic context of contamination

The way in which contamination is viewed in our society, changes with the political, economic, and scientific constructs off the time. Traditionally, pollution has not been accounted for as a factor in the cost of production. Instead, it became an externality incurred by the American people. Until the late 1960's and 1970's there was no comprehensive system of laws and regulations to govern the production, use, and disposal of hazardous materials. The production and use of these materials often precede our understanding of the threats they pose to human health and the environment. The initial large scale production of synthetic organic chemicals occurred in the 1940's. However, it is was not until the mid 1960s that there was a widespread recognition within the scientific community of the potential threats to human health and the environment posed by many of these chemicals. This changing political, economic, and scientific context of pollution provides insights into why incidents, such as the Gelman case, are so prevalent in the U.S.

The development of the synthetic organic chemical industry is a good example of the economic and political context that allows and promotes the development of technologies that threaten human health and the environment. During World War II many materials were in short supply. The science of organic chemistry made it possible to create substitutes for the materials needed. The U.S. annual production of synthetic organic

chemicals rose fifteen times between 1945 and 1985, from 6.7 million metric tons to 102 million metric tons (U.S. International Trade Commission, 1986). Worldwide, some 70,000 chemicals are presently in daily use, with between 500 and 1,000 added to the list each year (Shodell, 1985).

Synthetic substitutes help to provide a better material life. Synthetic organic chemicals are used in the production of items ranging from antibiotics and birth control pills, to detergents and plastics. However, these synthetics are manufactured in a high-temperature, pressurized, and energy intensive process of distillation and evaporation which often results in contaminants in solid, liquid, and gaseous states. Some of these synthetic organic chemicals (e.g. 1,4-dioxane) do not readily biodegrade and are persistent as carcinogens in the environment.

Events reveal that "better living through chemistry" comes with serious costs. In the absence of either imposed government regulations or self-imposed responsibility for the environment, the synthetic organic chemical industry has created an ecological nightmare. For example, pesticides thought to degrade in soils are turning up in rural drinking wells; chemicals from abandoned waste sites and other unsound disposal methods, have contaminated soils and created plumes of groundwater contamination; and a gas leak from a chemical production plant in Bhopal, India resulted in the death of more than 2,000 people. As of 1980, chemical production accounted for an estimated 60 percent of hazardous waste produced in the U.S. (Brown, 1980). As of 1983, more than 77 billion pounds of hazardous waste were generated in the U.S. per year, which comes to about 20 pounds for each person on earth. There are 48,500 different chemical compounds on the market (EPA, 1983). The U.S. National Research Council (NRC) estimates that for 79 percent of the more than 48,500 chemicals listed in the inventory prepared by the Environmental Protection Agency, no information on the toxic effects is available (NRC, 1986).

The extent of groundwater contamination by synthetic organic chemicals is alarming in terms of the potential threats to human health and to the future use of this resource. The

Office of Technology Assessment has found 175 different organic chemicals present in groundwater supplies (OTA, 1984). Synthetic organic chemicals have been found in groundwater often in concentrations several orders of magnitude higher than found in the most contaminated surface water (Council on Environmental Quality, 1981). A nationwide groundwater supply survey was conducted during 1980-1981 and found 29 volatile organic compounds in 945 groundwater systems (EPA, 1983).

The clean up of contaminated soils and groundwater is extremely expensive and billions of dollars have already been spent in this pursuit. Even the cleanup of a single site can be very costly and there are more than 2,500 included on the National Priority Lists. The EPA spent $33 million to buy Times Beach, Missouri after the streets had been sprayed with oil contaminated with 2,3,7,8-TCDD, one of a class of chemicals called "dioxins" (Boraiko, 1985).

At the same time, very high profits are generated by the production of synthetic organic chemicals. The annual value of synthetic organic chemicals to the chemical industry in 1980 was approximately $70 billion (Crone 1986, Fig. 2.4). Pesticide sales alone totaled nearly $6.6 billion in 1985 (Brown, et. al 1988).

The political climate of the past 40 years has produced a laissez-faire attitude toward the regulation of industry. This allowed the production of synthetic organic chemicals to grow almost unchecked. Until the late 1960s, there were no federal laws specifically designed to protect the public from toxins. The hands-off policy of the Federal government allowed production of synthetic organic chemicals without accountability and responsibility for the harmful effects of these chemicals. The only public recourse for damage caused by toxins previous to the late 1960s were private lawsuits, known as damage suits, to stop one person (or company) from doing harm to another. As the scope of the hazardous waste problem became more clear, it became obvious that litigation was an inadequate vehicle for protecting human health.

Citizens, interest groups, scientists, and politicians during the 1960s and early 1970s, focused attention on and increased awareness of the extent of the threats presented by synthetic organic chemicals. In 1962, Rachel Carson's Silent Spring called public attention to the dangers that organic chemical insecticides pose to health and ecosystems. The publication of Silent Spring coincided with the development of laboratory techniques and equipment capable of measuring minute amounts of DDT, mercury, and other pollutants. Later, scientists and citizens at Love Canal linked birth defects with toxins found in the canal. They also called attention to the dangers of synthetic organic chemicals.

As a result of public outcry, a system of laws was developed in the late 1960s and the 1970s, designed to restrain these environmentally unsound activities. These laws include the National Environmental Health Policy Act, the Toxic Substances Control Act, the Clean Air Act, the Federal Water Pollution Control Act, and the Resource and Conservation Recovery Act. These statutes contain broad imminent-hazard provisions that enable the EPA to take immediate action to restrain activities posing a threat to human health and any feature of the environment, including groundwater.

Few of these laws have been vigorously enforced by Federal government officials since their passage. However, some enforcement of these statutes has occurred due to pressure applied to citizen action by citizens. For example, the Clean Water Act requires the EPA to control the discharge of toxic chemicals into waterways, but litigation by environmental interest groups was necessary to cause these regulations to be enforced. Citizens and various interest groups are becoming more effective at creating political change. These groups have been able to mobilize and effectively use various resources (such as information) to appeal to fundamental moral values, and to consequently mobilize large numbers of people around environmental issues. These groups have also gained many skills needed to create change (for example, leadership, organization, legal knowledge and communication). Laws, although they may look strong on paper, are meaningless if not enforced.

The synthetic organic chemical industry is beginning to respond to the high costs the various regulations have imposed upon them for creating, storing, and disposing of hazardous wastes. Incineration of organic chemicals costs between $500 and $1,200 per ton. Waste management costs for Du Pont, the nation's largest chemical producer, now exceed $100 million annually. Paul Chubb, Vice Chairman of Du Pont's Manufacturing Committee, says that "an economical and environmentally acceptable" waste management plan now "holds the key to success or failure of many of our businesses" (Brown, L. et al., 1988). The various laws and regulations governing hazardous waste, like many of those governing synthetic organic chemicals, force industry to become more responsible in the production, storage, and disposal of these wastes. As the costs to industry increase, they may look to less destructive waste management alternatives, e.g. waste reduction, reuse, and recycling.

To locate and clean up every leaking landfill, waste lagoon and contaminated groundwater source throughout the country would be extremely costly. Remedying the legacies of irresponsibility and mismanagement only begins to address the dilemma of environmental contamination. Unless the wastes currently produced are better managed, society will perpetually be committed to costly response activities. Moreover, new "out of sight out of mind" technologies of waste disposal promoted by the Federal government, such as deep well injection, do not address the hazardous waste problem. These technologies relocate the hazard further below the earth's surface, where the waste can slowly migrate back up into the aquifers containing drinking water. Without concerted efforts to reduce and recycle hazardous waste and to develop biodegradable alternatives, the quantities and varieties produced will overwhelm even the best treatment and disposal systems, and the goal of safe and sustainable waste management will remain unattainable. To achieve this goal requires that federal and state governments force industry to adopt safe and sustainable waste management strategies and that citizens demand accountability.

The Gelman case

The Gelman case is a local incident of groundwater contamination which illustrates many of the issues pertinent to layer issue of environmental contamination. Specifically, this case provides an opportunity to explore the social, political, and economic context of groundwater contamination. Specific areas of inquiry in regard to environmental contamination include: land use concerns, sciences and technologies, the response of government and industry, and citizen efficacy in protecting their environment and health.

Gelman Sciences, Inc. ("Gelman") is located on 600 Wagner Road in Scio Township, Washtenaw County. The site covers approximately 55 acres. The Gelman facility contains offices for its world headquarters and a manufacturing plant where it produces microporous membranes and filters used in hospitals and laboratories. Gelman currently employs approximately 600 people at the Wagner Road facility. The Gelman facility is located in an area of interspersed agricultural, rural residential, commercial, high-tech research and development, and light industrial land uses.

Gelman's past wastewater handling and disposal practices are widely believed to have caused widespread groundwater and surface water contamination with synthetic organic chemicals. Since 1963 Gelman has used the following methods of waste disposal at the 600 Wagner Road site: direct surface discharge, seepage from unlined lagoons where aerobic and anaerobic microbial treatment occurred, disposal and burning of chemical wastes in an unlined pit, spray irrigation after aerobic and anaerobic microbial treatment, and deep well injection.

The chemical of most concern is 1,4-dioxane (which will subsequently be referred to as "dioxane"). Dioxane was first shown to be an animal carcinogen in 1965 (Argus et al, 1965) and has been on Michigan's Critical Material Register every year since 1980. (The Critical Material Register is a list of toxic chemicals which, if used or discharged by a business or industry, must be reported annually to the State, (Kelley et. al v. Gelman,

2/26/88). Dioxane is a highly volatile, flammable colorless, water soluble liquid compound used in solvents. Long-term animal studies have shown dioxane to induce nasal and liver tumors. Dioxane is a suspected human carcinogen (Kelley et al v. Gelman, 2/26/88, and Michigan Department of Public Health (MDPH) Dioxane Risk Assessment - DNR files, 6/87).

Gelman used dioxane in the process of making filters from 1966 through 1986. In June 1980 Gelman reported using or storing 60,000 pounds of dioxane annually (Kelley et al. v. Gelman, 2/26/88). A recent hydrogeology study commissioned by Gelman indicates that the most likely source of dioxane in the groundwater was Gelman's early seepage lagoon (EPA, 9/24/86).

The presence of dioxane in the ground and surface waters was confirmed in 1985. Gelman was subsequently ranked 84th on the annual Priority List of cases of environmental contamination under the Michigan Environmental Response Act. Early in 1986 some of the residents in the area for whom groundwater was their water supply, were notified not to drink or bathe in their water. Bottled water was supplied to these homes by the State.

In April 1987 the Gelman site was ranked second on the annual Priority List. At present over fifty residential and commercial wells are known to be contaminated. The plume of contamination has spread as far as one mile from the Gelman facility. To date, no successful action has been taken to stop the spread of contaminated water.

As a result of this environmental contamination, Gelman, citizens, and state and local governmental agencies have responded in various ways. We will be exploring in detail the response activities, the interests and motivations, the resources available, and the efficacy of the different actors involved.

Specifically, this document first, introduces the case and our reasons for studying it. Second it provides the background to the case and includes the history of Gelman's waste disposal practices, and the resource activities of Gelman, the Department of Natural

Resources, the Department of Public Health, and the citizens; and third it analyzes various response activities and other specific aspects of the case. Finally, it explores the root causes of environmental contamination within the context of our society's political, social, and economic constructs.

Goals and objectives

The following is a list of the reasons we chose to study the Gelman case of groundwater contamination: 1) It provided an opportunity to explore a real case study of environmental contamination as opposed to theoretical research; 2) It is a local issue; 3) It provided an opportunity to help the surrounding community by providing them with information that is helpful in understanding the case; 4) The case affects the members of the Gelman Masters Project group directly because of the contamination of Third Sister Lake, a University property; 5) Many of the members of the group are environmental educators and advocates who will be dealing with concerns similar to those presented in this case after leaving the University; 6) The case study allows us to analyze the existing and proposed land use pattern of Ann Arbor in relation to industry and to develop recommendations to prevent similar land use conflicts in the future; and 7) this case study has provided opportunities to gain valuable experiences and skills in the areas of group process, information gathering, problem solving, etc.

Our specific goals and objectives are as follows:

Goals

1) Use the contamination of groundwater with 1,4-dioxane on and surrounding the Gelman Science, Inc. property as a case study. The expected outcome of this study is to develop a story of what occurred and future directions for the case, including the interactions and efficacy of the various actors involved, the use of various sciences and technologies for

resolving the contamination problem, and the relationship between industrial and rural land uses.

2) Explore the political and economic context of environmental contamination in the Gelman case in order to gain insight into the causes of pollution.

3) Make this document available to those most personally affected by the contamination, the community residents, with the intent of providing them with useful information about the case.

4) Present our findings, analysis, and recommendations to interested parties (i.e., the Michigan Department of Natural Resources, Gelman, the Michigan Department of Public Health, etc.), with the intention of providing helpful information for resolving this and other incidents of environmental contamination.

Objectives

1) Reconstruct the history of Gelman Science, Inc. as it relates to the groundwater contamination issue and analyze their response.

2) Document the response of the Michigan Department of Natural Resources to the contamination, and evaluate the effectiveness of that response.

3) Explore the roles of public participation and citizen actions in the Gelman case.

4) Explore the roles of the School of Natural Resources and the University of Michigan in the Gelman case.

5) Examine how the sciences of hydrogeology and risk assessment, and the technology of deep well injection, shape the response to contamination.

6) Visually demonstrate the contamination plume in order to gain a better understanding of the study area.

7) Evaluate the relationship between industrial and rural residential land uses and the potential for contamination when developing recommendations for future land use planning.

8) Research the various laws and regulations governing groundwater contamination and the Gelman case.

9) Explore the root causes of environmental contamination in our country and the implications for future contamination.

Methodology

Research by the Gelman Master's Project group was conducted with the intention of providing information which is useful to those most personally affected by the situation--the citizens. In addition, it is hoped that the document will serve as a case study relevant to any of a growing number of instances of groundwater contamination and communities which are faced with similar problems.

The Gelman Masters Project group adopted an approach where research has led group members, not vice-versa. The end result of the document was not decided upon prior to conducting research. Rather, each step of gathering information has led to a next step, which in turn determines the next direction, and so on. After each step of information-gathering, reflection occurred to evaluate the relevance of the material and to provide insights for future directions of research. This has been a process of developing a story and an understanding of the events that led to the contamination of the groundwater, along with the various responses by state and federal agencies and citizen groups. Our process of gathering information included conducting literature reviews of relevant topics, researching the DNR files on the case, and conducting interviews with the various actors within the case.

The development of "The Story" was a lengthy process of gathering information. For an overview of the various events that led to the contamination and the response activities that followed we found newspaper articles very helpful. (The Ann Arbor Public Library has updated files.) We also used the Michigan Freedom of Information Act (Act 442, P.A. 1976) to gain access to Department of Natural Resources and Environmental Protection Agency files. (For helpful information see East Michigan Environmental Action Council, "Groundwater Contamination Sites: A Citizen's Guide to Fact Finding and Follow-up," 1984, or contact your local Representative.) Finally, we found it necessary to conduct interviews with various individuals to obtain their personal perspectives and to

further develop the story. This information along with current literature provided the basis for our analysis.

THE STORY (EVENTS FROM 1959-PRESENT)

Events from 1959-1980

An introduction to Gelman, Science, Inc.

In 1959, the Gelman Instrument Company was founded by Charles Gelman, an enterprising graduate of the University of Michigan School of Public Health. Gelman had served in the U.S. Public Health Service from 1956-57, where he had developed an air pollution monitoring device for the government (the Automatic Sequential Air Sampler). After leaving the service in 1957, he was commissioned by the government to produce the device, and within two years his fledgling business had outgrown its basement location. From 1959-63, Gelman Instrument Company operated out of a storefront in Chelsea, Michigan, and in 1963 the company moved to a larger facility in Scio Township at 600 South Wagner Road, where it has been headquartered ever since (Gelman Science, Inc, 1987 a,b).

Gelman specializes in perfecting filtration membranes used in a variety of purification and separation processes. Today the company produces over 3,000 different microfiltration products and is divided along two lines: 1) the Filtration Division and 2) the Membrane and Device Division. The Filtration Products Division produces supplies used in clinical and research laboratories and industrial processes. These include products used in electrophoresis, cell and tissue culture, as well as specialized products used by industry. Pharmaceutical and beverage companies are just two of the industries which use Gelman products. Gelman also produces environmental testing products, including products used in sewage treatment plants, air pollution monitoring devices, acid rain filters, and asbestos monitoring materials. The Membrane and Device Divison produces supplies for hospital wards and operating rooms (Gelman Science, Inc., 1987 a).

In 1978, Gelman Instrument Company became Gelman Science, Inc. ("Gelman") to reflect the diversification of its product line. The company has thrived in Scio Township, and in 1986 was listed in "The 101 Best Performing Companies in America" (Gelman Science, Inc., 1987 a).

Problems with Gelman's waste treatment methods

It is ironic that Gelman, a company founded to produce environmental monitoring devices, now ranks second on the Priority List of Michigan Sites of Environmental Contamination. Gelman's problems with its waste stream began in the 1960's. During those years local residents began complaining about the foul odor emitted by the plant's waste storage lagoons. Two lagoons had been built (one in 1964 and the other in 1967) on Gelman's property to receive its waste stream from production processes (Reynolds , 11/7/69). The waste stream, containing water and organic solvents, was pumped into one lagoon for "minor degradation and then into a second one for aerobic treatment" (DNR files, 5/21/87). The aerobic lagoon contained bacteria which were supposed to "feed" upon the solvents. Unfortunately, the production of a new type of filter in late 1967 increased Gelman's wastewater output to approximately 20,000 gallons per day. Gelman's degradative bacteria were unable to keep up with this increased discharge (Reynolds, 11/7/69).

These odor complaints prompted investigation by the Water Resources Commission (WRC), a state agency responsible for water quality monitoring. Samples taken from the waste discharge in March and April 1968 revealed a high biological oxygen demand (BOD) of 420 mg/l (Reynolds, *Ann Arbor News* , 11/7/69). High BOD is an indication that waste contains a high amount of oxidizable organic chemicals. WRC officials also discovered at this time that waste water was overflowing from the lagoons into a swamp, and possibly into Honey Creek via a drainage ditch. (Honey Creek is a tributary adjacent to the Gelman property which flows into the Huron River.) Gelman was notified that the company was in

violation of the Order of Determination issued in 1965 which prohibited surface water discharge, and limited the company's wastewater output to 9,000 gallons per day. Gelman's high BOD was also in violation of the Order (DNR files, 3/3/68).

Although an inspection by the WRC in October 1968 found no overflow from the lagoons, problems with the treatment lagoons began anew in early 1969. In February, the WRC inspected Gelman again and found that the newest of two lagoons was discharging into a swampy area adjacent to Honey Creek. A memo in the DNR files notes, "The 20 gal. per minute flow was brackish (dark gray) in color and possessed a septic odor" (DNR files, 2/21/69). The DNR memo noted that Gelman must be aware of the discharge, since "it traverses through a corrugated metal pipe from the secondary lagoon placed there no doubt by the company" (DNR files, 2/19/69). The BOD was measured at 820 mg/l. Soon after this the WRC circulated an internal memo which suggested that the high organic load of Gelman's waste stream might be harmful to the "receiving stream," Honey Creek. The memo, written by J.M. Bohunsky, Regional Engineer for the WRC, urged WRC District Engineer W. Denniston, who had visited the site, to make a follow-up visit as soon as possible (DNR files, 3/12//69).

Denniston subsequently informed Vice President of Manufacturing G.J. MacMahon of the company's violations, and told him the company would have to apply for an amended Order of Determination (DNR files, 3/17/69). MacMahon replied in April that the company was actively working to reduce its waste output (DNR files, 4/3/69).

Effluent from the lagoons sampled in July showed the BOD had increased to an extremely high level--1200 mg/l. A letter from the WRC informed Gelman that its "second treatment lagoon was inadequate" as shown by the high BOD. The letter noted that such effluent could prove detrimental to Honey Creek, and that any effluent discharged into the creek should have a BOD no higher than 15 mg/l (DNR files, 8/22/69). David Dennis, then a regional water quality director for the State, described the BOD levels as"being four times the amount of organic solvent in normal, untreated sewage" (Reynolds, 11/7/69).

After the March and August notifications from the WRC concerning their violations, Gelman applied for an increase in their permitted discharge limit to 50,000 gallons per day. Their "Statement of New or Increased Use" filed under Act 245 noted that continued discharge of their waste stream into Honey Creek was an option being studied. Gelman had commissioned J.A. Borchardt, a civil engineering professor at the University of Michigan, to study the feasibility of this discharge route and to determine how Gelman's wastewater could best be treated. The application describes the proposed method of treatment: waste water would be treated by activated sludges in the lagoons, along with aeration and the addition of additives. 30-40 percent of the waste water would be lost through seepage and evaporation. The remaining waste water would either go (depending on the outcome of feasibility studies) into a "tile" field or into surface water flowing into Honey Creek (DNR files, 8/14/69).

In the same month that Gelman filed this permit, the WRC filed a statement of potential environmental impact cautioning against discharge into Honey Creek. The statement warned that increased BOD in the creek would harm existing fish populations. The report described the Honey Creek watershed as a high quality "warm-water feeder stream" and concluded, "do not permit any waste waters to leave the factory via surface drainage" (DNR files, 8/27/69).

Possible impacts on Saginaw Forest

At this time, concern was expressed for Saginaw Forest, a research property of the University of Michigan contiguous with Gelman's property. Odors had been detected within the forest and the WRC warned that Gelman's waste might damage the property. The WRC noted in a September 1969 memo that, "the University of Michigan uses the Third Sister Lake for experimental studies and for special educational purposes. It is a very high quality lake, there is serious concern over possible contamination of any ground water which might gain entrance to the lake " (DNR files, 9/12/69).

Two University of Michigan Forestry faculty, John R. Bassett and Beverly L. Driver, expressed concern over Gelman's activities and its possible impacts on the forest. They thought the ecology of the forest might be adversely affected and its research potential diminished. They called for seepage studies to determine where Gelman's waste water was flowing, and an elimination of the odors (Reynolds, 11/7/69). Walter E. Lewis, Consulting Engineer to Gelman, denied that overflow from the lagoons could enter the lake, saying, "It would have to run uphill" (Reybolds, 11/7/69).

Gelman attempts to solve the odor problem

Professor Borchardt, in addition to studying the feasibility of discharging waste into Honey Creek, had installed new aeration devices in the lagoons. He was testing their ability to inject a level of oxygen into the ponds sufficient to maintain a population of bacteria capable of degrading solvents in the waste. Borchardt's device was designed to overcome problems unique to Gelman's waste stream--the stability of the solvent and the high oxygen requirements of the degradative bacteria. His device consisted of rotating plastic disks on which colonies of bacteria could anchor themselves. These disks operated partially submerged and allowed the bacterial colonies to "work on " the solvent. Ultimately, the disk-bound colonies were exposed to the air and dried out (Reynolds, 3/10/70).

Gelman requested that the WRC not take any actions against the company while Borchardt was completing his study, nor draw up a new Order of Determination until its completion. Robert C. Medl, Manager of Chemical Engineering, commented to *The Ann Arbor News*, "We've told the Water Resources Commission any order issued could be out of date almost as soon as they issue it. We've urged them to wait for Prof. Borchardt's results. We're asking, 'Why do it twice?' Our target date is February (1970)" (Reynolds, *The Ann Arbor News, 11/7/69).* Borchardt completed the first phase of his study in October 1969, but did not complete the entire study until October 1970, well after the

proposed deadline. The WRC received no progress reports on Borchardt's study until late 1970. In August the WRC had asked Gelman to submit a progress report within 30 days. Gelman then notified the WRC that it would submit a report soon, and that the problem had turned out to be more intractable then expected; thus, the reason for the delay. They also reported no waste had been discharged since November 1969.

The Borchardt report was finally submitted on October 2, 1970. It stated that the first lagoon had been converted to an anaerobic lagoon during the summer. A supplement to the report, issued a week later, noted that for the past nine to twelve months, waste discharge had averaged 7,500 gallons per day. At this time, Gelman noted its waste stream had been reduced and withdrew its request for a waste discharge increase.

The Ann Arbor News reported soon after this in an article entitled, "Pollution Paradox is Solved" that Gelman had taken a number of measures to rectify its waste problems, and had received an "A" rating for 1970. Gelman had received an "E" rating from the WRC for two consecutive years (1968-69), the worst rating a company could get for its waste disposal practices. The article noted that the lagoons had been deepened and the overflow stopped and that changes in the production process had significantly reduced Gelman's waste output. The odor problem proved more difficult to solve and the article commented that Borchardt's rotating disk aerators had just been installed to cope with the problem (Reynolds, *The Ann Arbor News,* 4/28/71).

The News' optimism proved premature, as new problems surfaced in 1973. At that time residents filed complaints with the Air Quality Division (AQD) concerning mist and foam blowing off the lagoons (DNR files, 8/2/73). Furthermore, the complaints received by the AQD characterized the odor as extremely gaseous and septic-like. Although Gelman agreed to shut off its aerators during high wind conditions to reduce foaming on August 2, a report was filed with the WRC a week later by Transidyne General, a company on Wagner Road. Employees there had complained of an odor which had lasted for one week, and which caused "slight nausea" (DNR files, 8/9/73).

Gelman attempted to attack the continuing odor problem by installing a new cover on the anaerobic lagoon. The AQD was satisfied with this measure and believed it had resolved the odor problem (DNR files, 9/10/73).

In 1973 Gelman began a new waste treatment process--spray irrigation. The company had installed a three million gallon holding lagoon on its property which was used to contain its waste stream while it was aerated, and "stabilized" through aerobic digestion. The "digested" waste was then spray irrigated onto Gelman property (DNR files, 5/21/87).

Odor problems surfaced again in June and July 1975. In that month complaints of a severe odor problem at the Gelman plant initiated another investigation of Gelman's waste treatment processes. Air Pollution Control came to the plant in July and found holes in the plastic covers on the lagoons. Gelman installed a new cover on the anaerobic lagoon on July 11 and equipped the second lagoon with new aerators. Gelman pronounced the situation firmly under control and notified Air Pollution Control in 1975 that there had been a "noticeable reduction in odor" (DNR files, 7/15/75).

Within a month after this pronouncement, the AQD received several more odor complaints (as documented in DNR files). The AQD returned to the site for another investigation, but could not determine the source of the problem. Residents continued to complain of the odor emanating from Gelman, and the AQD responded to complaints by returning to the site to inspect it. The DNR followed up some of the first complaints and attributed the odor to a tear in one of the lagoon covers (DNR files, 8/23/76). However, the odor had existed before the cover was torn, and the AQD suspected that the damaged cover was not the only culprit (DNR files, 9/26/76). The AQD requested that Gelman keep spare covers on hand (DNR files, 9/27/76).

Gelman's spray irrigation comes under fire

Continuing odor complaints resulted in the WRC sending a letter to Gelman on September 20, 1976 informing the company that it was in violation of its Order of

Determination. "We have a number of complaints regarding odors coming from your process waste water treatment ponds and from your use of spray irrigation..." The WRC told Gelman to, "...cease and desist the spray irrigation...immediately" (DNR files, 9/20/76). The WRC claimed that Gelman's waste water from the spray irrigation process was entering surface waters, and thus was in violation of the permit.

Barbara Carr, a local resident, filed a complaint with the AQD stating, "The noxious odors which have been bothering us for the past month appear to be caused by Gelman's new spray irrigation procedures as well as the absence of a plastic cover on the lagoon." She requested a written report on the status of Gelman's activities and the AQD's actions (DNR files, 9/27/76). The AQD replied that the cover had been "faulty" since June or July and that its replacement would reduce the odor greatly. The AQD also noted that Gelman had ceased spray irrigating its wastes, while trying to determine if this process violated its permit (DNR files, 9/28/76).

Gelman complied with the WRC's order to stop spray irrigating on its property, but soon requested temporary permission to resume it. Gelman estimated their water discharge to be 25,000 gallons per day process waste and 3,000 gallons per day sanitary waste. (The original permit allowed 9,000 gallons per day of all discharge.) Because the lagoons had limited storage capacity, and Gelman's discharge had reached such a high rate, temporary permission to spray irrigate became a necessity. Since at that rate of discharge output, the lagoon would overflow. The WRC granted the temporary permit and informed Gelman that it had to apply for a state discharge permit.

Gelman filed the state discharge permit application in November. The permit process continued through 1977, with several revisions in the terms of the permit made by both parties. A draft was issued to Gelman on April 6, but soon after this Gelman requested an increase in the amount of waste water it could discharge. The company requested that the permit read, "112, 700 gallons/day rather than 44,000 gallons/day," because it could only spray irrigate during the growing season months of March to

November. In order for the lagoon to store discharge generated in the winter months, spray irrigation would have to occur at a rate twice that currently permitted.

The WRC sent Gelman a revised permit which contained the desired provisions in July 1978 and the State approved the permit in September. The new permit, in addition to increasing Gelman's allowed output, specified that "There shall be no runoff from spray irrigation to any surface watercourse" (DNR files, 9/5/78)

Odor complaints occurred less frequently in 1977. In July a Wagner Road resident informed the State that Gelman's waste disposal practices created "obnoxious fumes" which aggravated respiratory problems from which both she and her husband suffered. She also attributed headaches and nausea to the odor (DNR files, 7/8/77).

Despite the number of complaints filed in the preceding years, the State's inspections, and Gelman's purported efforts to deal with the problem, things did not improve in 1979. In July, another local resident wrote that there were "excessive, terrible odors from Gelman instruments. Smells like dog waste. Can't stand to be out in the yard. Son can't breathe. Severe nuisance." He noted that the problem had been occurring for four years (DNR files, 7/16/79).

This letter brought prompt action from the AQD, which investigated the site within one day of receiving it. The AQD found that Gelman's lagoons had been malfunctioning. The anaerobic lagoon had been shut down in 1977, but the aerated lagoons continued to serve as reservoirs for Gelman's waste. The aeration system had broken down for several weeks in the spring, which initiated a severe odor problem as the lagoon became partially anaerobic. The AQD noted that Gelman was attempting to rectify the situation by installing four new aerators. The AQD believed the odor problem would temporarily persist until the aerators had operated long enough to make the lagoon aerobic again (DNR files, 8/1/79). In response to the AQD's inquiry about Gelman's waste water treatment system, the WQD replied that Gelman had no "real" problems with its system.

In November 1979, the WRC was summoned to investigate a new complaint filed by a Gelman employee. The employee saw a fellow employee dump an "unknown substance" into a hole in the ground near the water tower. The WRC found that the site contained waste plastics (DNR files, 11/14/79). Gelman was notified that it had violated its NPDES Industrial Wastewater permit, and was ordered to clean up the site. Gelman wrote to the WRC explaining that the it no longer used the pit to dispose of "cellulose acetate and miscellaneous research mixtures" and did not intend to use the pit for the disposal of any materials in the future. In 1980, Gelman received an "I" (inadequate) rating for using the waste pit on its property during 1979 (DNR files, 1/28/80).

History from 1980-present

Introduction to dioxane

It was in the year 1980 that 1,4-dioxane ("dioxane") issue first surfaced. Although Gelman's waste disposal practices have been frequently questioned by citizens and the Department of Natural Resources (DNR) over its years of operation, the contamination of the groundwater by dioxane has become area residents' and state regulatory agencies' primary concern.

Dioxane was first shown to be an animal carcinogen in 1965 (Argus et al, 1965) and has been on Michigan's Critical Material Register every year since 1980. (The Critical Material Register is a list of toxic chemicals which, if used or discharged by a business or industry, must be reported annually to the State. MCL 323.6b; MSA 3.526 (2)) (Kelley et. al v. Gelman, 2/26/88 (DNR lawsuit against Gelman)).

On March 18, 1980, a former Gelman employee notified the DNR that one of Gelman's wastewater holding ponds leaked and had been draining waste into Third Sister Lake in the University of Michigan (hereafter U-M)-owned Saginaw Forest. He also

accused Gelman of having operated a chemical pit, which they had buried the previous month.

This pressed the DNR into sampling Gelman's wastewater. Dioxane was detected in each of Gelman's three holding lagoons. One sample showed dioxane at a concentration of 25,000 parts per billion (ppb) (DNR Files, 2/20/81). Gelman had been reporting their dioxane usage in their yearly reports to the DNR for several years. However, it seems that these reports were not being read carefully, as this was the first time that DNR officials became aware that Gelman was using dioxane. Tetrahydrofuran, another organic solvent (although not carcinogenic), was also detected in the lagoons (Kelley et al v. Gelman, 2/26/88). Tetrahydrofuran, in large doses, is known to cause liver and kidney damage in laboratory animals (Cohen, 2/2/86).

In June 1980, Gelman reported using or storing 60,000 pounds of dioxane annually. Half of this volume was disposed of by spray irrigation, of which 25 percent was expected to evaporate. In 1981-82, Gelman used approximately 4,400 pounds of dioxane per month. Gelman was spray irrigating in violation of a permit issued by the Michigan Water Resources Commission in December 1965, which prohibited the discharge of "any substance that was or might become injurious to public health, or to commercial, industrial, or domestic uses of State water resources" (see Federal and State Statutes section). Any discharge of dioxane to groundwater or surface waters was therefore unauthorized. Gelman, however, has consistently claimed that they were not in violation because the DNR had known that Gelman was discharging dioxane, and had allowed this to continue.

On October 27, 1980 the Environmental Enforcement Division (EED) received a complaint that Gelman was illegally discharging wastes being held in a storage lagoon. The next day the EED investigated and found the following:

> The pond at the northwest corner of the Gelman property had a pump which was running, sitting on the southwest bank, with one hose running into the

> almost entirely drained pond water, and the other end running up onto the west bank and toward the northwest property line. The line terminating approximately 15 feet from the fenceline at the northwest corner of the pond. The natural ditch in that bank was leading the water towards the fence line and off of the Gelman property. A wooden structure at the fenceline appeared to be made specifically to let water through the fence" (DNR files, 10/28/80).

In this way, Gelman was illegally discharging wastewater into the adjacent swamp area.

On February 20, 1981, the EED of the DNR sent a memo to the Water Quality Division (WQD) concerning the contamination detected in Gelman's lagoons.

> The presence of dioxane is of concern because it is an animal positive carcinogen and was added to the Critical Materials Register this year. If dioxane is present in the lagoons, dioxane could potentially enter the groundwater through spray irrigation of the wastes and seepage from the lagoons. You agreed to re-sample the lagoons to determine whether dioxane is still present... Please send me a copy of the results when they are available (DNR files, 4/9/81).

Results from samples collected on April 9, 1981 showed no detectable contamination; however, those taken on May 26 showed dioxane in pond No. 3 at 90 parts per million (ppm).

Unlike the DNR (which is concerned with the quality of groundwater in general), the Michigan Department of Public Health (MDPH) is concerned only with groundwater quality as it affects drinking water supply wells. In a memo sent to the DNR on June 10, 1981, the MDPH stated:

> Gelman information indicates that the site is located on a narrow outwash channel. Groundwater flow is to the north and southwest and is intercepted by intermittent streams. There appears to be no water supply wells between the source and its point of surface discharge from the area. Based on this, no sampling is recommended with respect to this site (DNR files, 6/10/81).

Permit violations and air quality complaints

Gelman committed another violation in September 1981. On September 1 contacted the DNR regarding complaints received by the "Action Please" column that burning was

taking place at Gelman. An official from the DNR's Air Quality Division (AQD) contacted Gelman and Gelman indicated that the burning was conducted as part of a fire extinguisher burning demonstration, by a local fire equipment company. However, later in the day, James Marshall, Vice President of Operations for Gelman, called back the AQD to change his statement to include that "small stacks of confidential papers were infrequently burned." The AQD informed him that this practice was prohibited and Marshall agreed to discontinue it (DNR files, 9/1/81).

From July 1980 to October 1982, according to the monthly discharge reports submitted to the DNR by Gelman, the maximum daily discharge permitted limit of 112,700 gallons was often exceeded, sometimes by more than 100,000 gallons. Nutrient (i.e. organic components of the waste stream which are broken down by bacteria in holding ponds) levels also often exceeded permitted levels (Cohen, 4/27/86).

Throughout 1980, 1981, and 1982, Gelman was the cause of excessive odor problems, for which the DNR received numerous complaints. In August 1980 alone, the AQD received twelve telephone complaints. The odors were verified by AQD staff on several occasions. On August 12, 1980, the AQD conducted a community survey of residences in the vicinity of Gelman. Of the fifteen residents interviewed, eleven indicated they felt there was an air pollution problem in their neighborhood. The most frequently mentioned problems were odors and/or fumes. Ten of the eleven residences identified Gelman as the suspected source of the problem.

The odors have been described in complaints to the DNR as follows: "...a sickening smell, worse than rotting garbage" (8/20/80). "...smells like decomposing animals. People are getting sick and nauseous from breathing this and would like some action on the matter" (8/10/81). "Gelmans [sic] has been a serious problem for our neighborhood for several years. We have complained to Gelmans [sic] every summer about the terrible smell their plant emits, only to be given excuse after excuse and never any relief from the odor" (8/18/81). "Last summer our neighborhood was polluted by the

Gelman smell. It made breathing uncomfortable. On some days my nasal passage was so irritated a bloody nose resulted and my throat had a burning sensation. At other times it made me nauseous..." (8/18/81) (All complaints taken from DNR files). In addition, several citizens appeared before the Michigan Air Pollution Control Commission monthly meeting in August 1981 to complain about problems they had been experiencing since 1966 with the terrible odors in the neighborhood, caused by Gelman (DNR files, 8/18/81).

The AQD did investigate the odors on numerous occasions (DNR files: 7/7/75, 8/6/75, 8/7/75, 7/15/80, etc.). Gelman responded to requests by the AQD to address the odor problems by installing plastic covers on the company's anaerobic wastewater treatment lagoon in order to reduce odors (DNR files, 9/10/73), and by keeping a spare cover on hand (DNR files, 10/27/76). However, responses by Gelman were inadequate in addressing the odor problems. The covers installed by Gelman were reported to have holes in them and to be emitting odors on several occasions (DNR files: 7/7/75, 8/76, 7/79). The Washtenaw County Health Inspector found the cover to be off the lagoon on September 3, 1976. The aerators within the lagoons were reported to be malfunctioning by both Gelman and the DNR on numerous occasions (DNR files: 9/76, 7/17/79, 8/1/79, 7/15/80, 8/19/80).

According to Gelman, the odors were caused by a die-off of microorganisms which are present in the lagoons to break down waste. The die-off occurs when the aerators in the lagoons fail and dissolved oxygen levels fall to a level too low to support aerobic bacteria. When the bacteria become anaerobic, the foul odor results. It's also possible that some of the problems being experienced by residents were due to the evaporated dioxane. According to Brenda Irish of the DNR's Site Assessment Unit (SAU), in a February 1987 report, "Dioxane vapor is known to be harmful and a known lung and mucous membrane irritant" (DNR files, 2/87).

Gelman's production lines

As of October 1981, Gelman was operating two production lines: a fabric coating line and a membrane casting belt. The existing fabric coating line was covered by permit 757-80. This line was in operation since late 1979 and did not use dioxane. The two membrane casting belts (at the time, one existed and one was proposed) were covered by two then un-approved permits (544-81 for the existing line and 126-81 for an identical line not yet completed).

A wide variety of solvents were used in those lines, including approximately 4,400 pounds of dioxane per month. The fact that dioxane was being used on the existing membrane casting line was only discovered during an AQD investigation of Gelman on June 25, 1981 (DNR files, 6/25/81). The AQD's main concern was with the two existing lines (757-80 and 544-81) which were running uncontrolled. The AQD instructed Gelman to install a scrubber to control air pollution on the existing line in a letter dated June 30, 1981. The AQD felt that the emissions from the membrane casting line, including dioxane, constituted a likely violation of the existing permit. The permit application for installing a new scrubber on the existing membrane casting line (544-81) was approved on March 12, 1982. The permit for the new solution casting belt (126-81) was approved on March 22, 1982 (Laura Lodisio's AQD summary, DNR files, 10/16/81).

Gelman's deep well

Early in 1981, the need to explore alternative disposal technologies was apparent to Gelman. Building more holding lagoons and maintaining the spray irrigation system was becoming very costly and was allegedly environmentally unsound (and consequently was coming under fire from DNR officials). Gelman also claimed they had grown impatient, having waited fifteen years to be hooked into a sewage line (as had been promised by Scio

Township authorities). Thus, Gelman began construction of a 6,500-foot underground injection well.

The well was available in December 1981 for use. In this system, wastes are pumped into rock formations a mile underground. The spray irrigation system was to be used as a backup in case of malfunction of the deep well system (see Deep well section).

The Geological Survey Division (GSD) of the DNR was responsible for issuing deep well permits until 1984 under Act 315 of 1969, the Mineral Wells Act (see Federal and State Statutes section). Whereas the AQD only discovered that Gelman was drilling the deep well during an on-site investigation on June 25, 1981, the GSD, in an internal DNR memo dated June 30, indicated that they had granted Gelman all the necessary permits and that they did "not foresee any adverse environmental impacts." The GSD had issued the permit for well construction on May 12, 1981 (DNR files, 5/12/81).

The deep well issue, however, generated much concern among some DNR officials. Some concerns of these officials were whether an environmental impact assessment had been performed, the nature of the waste to be disposed of in the deep well, the opportunity for the public to have input on the granting of a deep well permit, and which unit of state government would be responsible for monitoring the well (DNR files: 7/7/81, 7/8/81, 7/29/81).

The response by the Mineral Well Unit of the GSD was to describe briefly the evaluation which the GSD had conducted prior to approval of the well and to include the description of waste submitted by Gelman. The GSD also claimed that the Michigan Environmental Review Board (MERB) had reviewed the disposal well permitting program in 1978 and "found it to be both effective and safe." It was also noted that the Environmental Protection Bureau had conducted a review of the process (DNR files, 8/12/81).

The Office of Toxic Materials Control, however, indicated that the Environmental Protection Bureau's review of injection well disposal processes was inadequate and largely

unregulated. It stated that the GSD is mainly concerned with well construction and maintenance and does not take into consideration the control of the disposal of toxic organic compounds. It was also stated that the entire process merits a detailed review by the DNR, MERB, and Toxic Substance Control Commission (TSCC), which was not the current practice (DNR files: 7/7/81, 7/8/81) (see Deep well section).

To test public reaction to the well, Gelman had an open house in early July and invited all parties with drinking water wells within a one-half mile radius, to hear a review of their proposed plan. According to GSD officials, however, "There didn't seem to be much interest as only two families were present out of some 50 or 60 that were invited" (DNR files, 11/12/81).

Several citizens, however, did express concern over the deep well in the coming months. Citizens who wrote to the DNR were responded to by a GSD form letter claiming:

> We understand the concern of the people over groundwater pollution with all of the misuses in the past, but I can assure you that this type of liquid waste disposal can cause no such problem. This type of waste disposal (deep well) has been in use in Michigan for over 20 years and not a single groundwater pollution problem has been attributable to the use of one of these wells... Michigan geology is ideal for their use; I am sure there have been problems in other states where unconsolidated rock has been used (DNR files: 8/17/81, 9/9/81).

Several citizens appearing before a Michigan Air Pollution Control Commission monthly public meeting also expressed concern that there may be problems from the deep well injection system and submitted letters from neighbors, as well. These people were referred to the GSD.

On December 15, 1981, the Mineral Well Unit of DNR's Geological Survey Division approved the use of Gelman's deep well for disposal of waste (DNR files, 12/15/81). Gelman began using the well the first week in January (see Deep well section).

Possible RCRA violations and Act 307 listing

In April 1982, Gelman applied for a reissuance of their expired groundwater discharge (spray irrigation) permit. Questions arose in the DNR as to whether Gelman should be classified as a Hazardous Waste Management Facility due to their handling of dioxane. Their permit reapplication was subsequently reviewed for two and a half years, during which time Gelman was allowed to legally operate. Only in September 1984, after Gelman had been disposing of dioxane under their original permit for seven and a half years, did the DNR inform them that the permit did not allow them to dispose of dioxane and other organic chemicals. The Groundwater Quality Division (GQD) advised Gelman to cease all spray-irrigation practices and to dispose of all process waste water in the deep well. At this time, plans were initiated to connect Gelman to the Scio Township sewer line. Soon after, Gelman ceased spray irrigating.

On May 21, 1982, an inspector from the DNR's Resource Recovery Division (RRD) inspected Gelman for hazardous waste problems. In the investigation,

> the key question was whether or not this process water was considered hazardous because it had not been determined if the waste still exhibited the hazardous characteristics managed by Resource Conservation and Recovery Act (RCRA). It is quite possible that because the wastes are so diluted in the process water that they no longer exhibit such characteristics and are not managed (DNR files, 5/21/81).

The EPA (Environmental Protection Agency) later used the same RCRA criteria in making a non-hazardous determination of Gelman's waste stream and the contaminated groundwater when granting Gelman's deep well permit (see Deep well section).

The RRD, in its investigation, also noted that Gelman had approximately fifty 55-gallon drums of waste which had been stored on Gelman property for over 90 days without having a storage permit for the waste (DNR files, 5/21/82). On June 1, 1982 the RRD sent

Gelman official notice of these violations and the next day, according to AQD records, Gelman disposed of the waste through a licensed hauler.

On June 4, the RRD determined that the Gelman waste stream would not be classified as "hazardous/toxic" under RCRA management. This determination was made because "none of the solvents listed in the November 17, 1981 Federal Register with restrictions of 1 parts per million (ppm) and 25 ppm are in their waste water" (DNR files). Gelman, on June 9, submitted an action plan for correcting their RCRA deficiencies. They also claimed that their waste "... does not exhibit any of the characteristics of hazardous waste" (DNR files, 6/9/81).

However, on March 30, 1984, the non-hazardous determination was reversed. DNR officials acting as representatives of the EPA, conducted an investigation to evaluate compliance with the requirements of Subtitle C of RCRA (see Federal and State Statutes section). "The inspection revealed that your (Gelman) facility was a generator of hazardous waste and was not in compliance with personnel training requirements as specified in 40 CFR 265.16(d)." On April 11, Gelman responded to the RCRA violations notice of March 30 and outlined a formal training program that was to begin within six weeks (DNR files, 4/11/84).

The Hazardous Waste Division, on March 19, 1985, again notified Gelman of violations of Subtitle C of RCRA based on an inspection which occurred on March 6. The violations included no weekly inspection program for containers and no contingency fire and evacuation plan (DNR files, 3/19/85).

DNR officials learned of further possible RCRA violations by Gelman when they talked with Janet Cohen of *The Ann Arbor News* on January 29, 1985.

> Ms. Cohen stated that in conversations with the company she learned that the sludge from filtering the hazardous waste before deep well disposal is put in a lined surface impoundment. I did not see Gelman listed on the recent list of regulated land disposal facilities, so the question arises as to whether, in fact, they do have hazardous waste in the lagoon and, if so,

> what is the status of compliance with RCRA and Act 64 (Clean Water Act) activities" (DNR files, 1/29/85) (see Federal and State Statutes section).

On April 15, 1986 DNR conducted an investigation of Gelman for the EPA to evaluate compliance with RCRA. Gelman had several violations one of which was discharging acetone in their waste stream. DNR gave Gelman an April deadline to correct deficiencies (DNR files, 4/15/86).

On June 12, the DNR sent Gelman a memo acknowledging their receipt of materials submitted by Gelman, addressing DNR's (acting as representatives of EPA) concerns about RCRA violations.

> Your submittal has addressed the concerns that were raised as a result of the inspection, and is adequate demonstration of compliance with the provisions of RCRA evaluated at the time of the inspection. Compliance with these requirements does not limit the applicability of other provisions of the RCRA regulations. Staff will return to your facility to verify compliance (DNR files, 6/12/86).

When dioxane was first detected in Gelman's discharge and lagoon, Gelman had been placed on DNR's list of suspected sites of groundwater contamination of the 1982 environmental assessment. In late 1982, James Marshall (Vice President of Gelman) contacted the DNR about this status. Marshall felt that Gelman should be removed from the suspect list, since at the time Gelman was injecting wastes into the deep well. The WQD responded that "Gelman was on the suspect list because they met the criteria, and the way to get off was to clearly show that groundwater is not contaminated" (DNR files, 12/1/82).

In 1983, Gelman was placed on the Priority List of Michigan Sites of Environmental Contamination. The Priority List was established by Act 307, and defines locations "where there has been a release, or where potential for a release of a discarded hazardous substance exists" (DNR files, 5/21/87) (see State and Federal Regulations section).

In February 1984, Gelman requested to be removed from the Act 307 list. In response to this, the DNR began a review of the decision to list Gelman. The results of the review did not convince the DNR to change their decision. In December 1985, Gelman again requested a review of their site, this time to prevent being placed on the Act 307 list for 1985. Gelman stated they were originally listed due to "... concerns related to the disposal of dilute solutions of various solvents by impoundment in an aeration lagoon followed by spray-irrigation of treated wastes of Gelman property" and that since November 1984, all wastes had been disposed of down the deep well (DNR files, 12/11/85) (see Deep well section). In 1985, however, Gelman was placed 89th on the Priority List of contaminated sites. As the contamination situation grew ever more complex, Gelman's Priority List ranking for 1986 jumped to "2".

Dan Bicknell and the discovery of dioxane in Third Sister Lake

The discoveries of contamination which led to Gelman's high ranking on the Act 307 list, began on April 4, 1984. On that date, Dan Bicknell, then a School of Public Health graduate student at the University of Michigan (U-M), took water samples from Third Sister Lake. (Third Sister Lake is in Saginaw Forest, a U-M-owned property which borders Gelman's property on the west side.) As part of a classroom demonstration, the samples were run (using gas chromatography) by Clifford Rice, then a research scientist at the U-M Institute of Science and Technology. Very low concentrations were found of dioxane and other compounds, as follows: chloroform, methylene chloride, tetrahydrofuran, hexane, benzene, and an unknown alkaline. In June of that year, Dan Bicknell released his report entitled, "Hazardous Waste Introductions into Third Sister Lake, Washtenaw County, Michigan." In this report, Bicknell concluded that more research on this question needed to be done.

In August 1984, Bicknell did more sampling. This time, in addition to Third Sister Lake, he tested the small tributary (now known as "Bicknell Creek") which runs from

Gelman's property, into the lake. In this study he showed the same elements were present, but in different concentrations. Most importantly, Bicknell found that levels of dioxane were several times higher in the creek than in the lake. Therefore, he was able to identify the creek, coming from Gelman, as the source of the pollution (Interview with Dan Bicknell, 2/23/88).

Bicknell's study was swiftly criticized from all sides. "Gelman officials questioned Bicknell's results, saying he did not explain how the test was conducted or provide an error rate, and that a misspelling of the compound dimethylformamide in the study raised questions about Bicknell's scientific knowledge" (Jones, Detroit Free Press , 9/13/84). Gelman's response to Bicknell's findings in Gelman's "Summary of Waste Water Treatment" was, "U/M Student running for drain commissioner alleged that GSI was polluting. The allegations were based on non-empirical evidence. A public issue was created, which in turn became a political issue."

Bicknell's report was also criticized for reporting results in parts per trillion (ppt), whereas parts per billion (ppb) is the standard measure. "The concentration levels he's talking about are so small there's nothing in the Federal Register that regulates amounts that small," said Tim Gibelyou, Gelman's operations manager (Jones, 9/13/84). Soon after, Gelman decided to attempt to begin monitoring wastes in ppt, thus lending credibility to the notion that wastes can be monitored in such small quantities.

In order to more actively address this potential environmental hazard and other contamination problems in the county, Bicknell filed as Republican candidate for Washtenaw County Drain Commissioner that June. In a Detroit Free Press article of 9/13/84, it was reported that:

> Bicknell...stated he is especially concerned about the presence of dioxane. Although the lake is used solely for research, Bicknell contends that if Gelman is the source of dioxane, surface or groundwater near the Gelman lab may be contaminated as well and could end up in drinking water supplies, water used by farmers and in swimming water (Jones, *The Detroit Free Press* 9/13/84).

Bicknell responded to the criticism being leveled against him and his report by stating, "What I know is I found dioxane and the solvents in the lake. (Gelman) is trying to discredit me and my numbers, but by discrediting me, (Gelman) isn't dealing with the issue. It's whether dioxane is out there" (Jones, 9/13/84).

Although Gelman doubted the validity of Bicknell's results, they were very concerned about what Bicknell was saying in public and how that affected Gelman's image. Gelman officials tracked down a list of Bicknell's scheduled campaign appearances. Paul Chalmers, Gelman's chemist, told the Detroit Free Press reporter, "We want to know anything (Bicknell) might be saying about us. We might not necessarily do anything about it. We just wanted to know" (Jones, 9/13/84).

Bicknell's report also initiated other types of action. It succeeded in bringing about further testing of Third Sister Lake by Gelman and the DNR. Gelman commissioned studies by a U-M research lab and a private firm, Canton Analytical Labs (CAL). CAL's results, which Gelman released in a meeting with the DNR on October 9, were negative for dioxane. DNR's tests were also reported to be negative. Accordingly, a DNR memo regarding the October 9 meeting between Gelman and the DNR stated, "Gelman - The CAL test data confirm DNR tests - did not confirm Bicknell's reported results. Gelman now prefers to let that matter drop." In a follow up letter to the DNR which included CAL's complete test results, Gelman's attorney, Philip Grashoff, Jr., stated, "Since the report substantiates the MDNR results, it is the company's (Gelman's) understanding that it need not undertake any additional activity relating to the Bicknell charges" (DNR files, 10/9/84).

CAL's samples were held for fourteen days before they were tested. Some believe that holding times for sample testing were violated by Canton and this may be the reason dioxane was not detected (Ewart, 10/87; and Interview with Dan Bicknell, 2/23/88). However, others, including Mary Vanderlaan of the DNR, claim that the holding time has no bearing when testing for dioxane (Interview with Mary Vanderlaan, 2/24/88).

A controversy arose when Gelman refused to publicize the results from Clifford Rice, the U-M researcher who conducted the study for Gelman (and who also originally tested Bicknell's samples). Both the DNR and Bicknell requested Clifford Rice's results from Gelman. Gelman refused to release them, stating they were "inconclusive" and "would serve no useful purpose" (Ewart, 10/87). Dr. Rice, despite his commitment of confidentiality to Gelman, chose to go to the press with his findings. "I do believe that the dioxane was present (in Bicknell's samples), and my tests definitely show that it's present in the lake...and it was definitely present in the samples that Gelman gave me," Rice said (Jones, 9/13/84).

The DNR, in the meantime, was consistently reporting negative results for dioxane in their tests. Gene Hall, the DNR water quality specialist who investigated charges of Gelman's 1,4-dioxane contamination, stated in a recent interview that the reason the DNR's dioxane test results always came back "No Detect" was because the DNR lab could not test for dioxane (our emphasis). Hall maintains that the reason agency officials informed Gelman, Bicknell, and the public that the DNR's test results for dioxane, tetrahydrofuran and hexane were negative was because the lab had never run the tests for the chemicals and DNR staff members had simply not understood their test results. Dan Bicknell, whose tests first identified the contamination problem, says the DNR fully understood the limits of its tests for dioxane in 1984, but made a decision to rely on tests obtained by Gelman Sciences, Inc. (Ewart, 10/87).

The DNR chose not to push for the release of those tests. "As it stands now, Gelman's attorney has stated that Gelman will not release those results to us due to the fact that they feel the results are inconclusive," Gene Hall wrote to Bicknell on January 23, 1985 in response to Bicknell's inquiry (Ewart, 10/87).

The second week in August Bicknell was invited to the Gelman site, along with Gene Hall and Ron Kooistra of DNR. They toured the site and examined the surface water being discharged into Bicknell Creek (which leads to Third Sister Lake). Gelman claimed

that all that was discharged there was groundwater that they had used in production, with iron removed. Nonetheless, Gelman and DNR officials present agreed that this was an illegal discharge (according to Bicknell) and that an NPDES (National Pollutant Discharge Elimination Systems) permit was required. However, it took three years and much pressure placed upon the DNR by Bicknell and a local environmental group, Tocsin, before the DNR even made Gelman apply for the permit. During this time, Gelman continued to illegally discharge into Bicknell Creek.

On March 8, 1985 the DNR Site Assessment Unit concluded the matter by writing to Grashoff that the DNR was satisfied with having received the results which Gelman chose to reveal. "Thank you for providing me with the CAL and MDNR sample data for the Gelman Sciences, Inc. facility," the letter stated. "Based on this information, the site listing for Gelman has been changed to include nothing in the 'Resources Affected' column, and groundwater, soil, and surface water in the 'Resources Potentially Affected' column." The DNR did not pursue the matter further (Ewart, 10/87).

Well-testing and contamination plume identification begins

In late April 1985, Bicknell drew up a petition which was circulated by a local resident, requesting testing of residents' wells. Bicknell presented the petition to Dr. Atwater, Medical Director of the Washtenaw County Health Department. Two weeks later, on May 15, Bicknell presented the petition at the Washtenaw County Board of Commissioners meeting. The following day, the Board instructed the Department of Public Health to begin testing residents' wells.

The well testing finally began in September 1985, nearly one year and five months after Bicknell first detected dioxane in Third Sister Lake. Dr. Barry Johnson, Washtenaw County Director of Environmental Health, admitted during a recent interview that the well testing would not have happened if not for the citizens' petition. Johnson claimed that a lack of resources, lack of public concern, and a lack of established testing procedures

prevented the Public Health Department from beginning a well testing program when the contamination was first discovered in Third Sister Lake (Ewart, 10/87).

Testing of Third Sister Lake and nearby Honey Creek, have yielded results of up to 510 ppb and 2,000 ppb dioxane, respectively. 20,000 ppb dioxane has been detected in the wetland adjacent to Gelman's property (Ewart, 10/87). To date, water samples analyzed by the Michigan Department of Public Health (MDPH) have tested positive for dioxane and/or tetrahydrofuran for over 50 private water supply wells (residential and commercial) to the north, northeast, and northwest of Gelman (Kelley, et al. v. Gelman, 2/26/88). The State limitation for dioxane in drinking water is 2 ppb and the limitation for body contact is 100 ppb. The discovery of dioxane contamination has led to the 1987 ranking of Gelman as the second worst environmental site in the state.

Testing began with the wells of industries in the immediate vicinity of Gelman. One of those tested earliest was the drinking water well of nearby Redskin Industries. On December 3, 1985 dioxane was found in this well at 180,000 ppb and tetrahydrofuran was found at 300 ppb (Kelley, et al. v. Gelman, 2/26/88). In January further testing was conducted and yielded positive for dioxane in the wells of five area industries as follows: Redskin Industries (up to 200,000 ppb), H&H, Inc. in Jackson Plaza (up to 800 ppb), Automated Data Processing (up to 90,000 ppb), Frito Lay (up to 90,000 ppb), and Guldberg Agency on Wagner Road (up to 500 ppb). The Frito Lay well also tested positive for tetrahydrofuran in concentrations up to 909 ppb and benzene up to 4 ppb. In February, a water sample taken from the caretaker's well in Saginaw Forest showed 24 ppb dioxane (Kelley, et al. v. Gelman, 2/26/88).

In January 1986, while the DNR requested an initial remedial action plan from Gelman (to be submitted by February 28), the MDPH began sending health advisories to area residents and businesses warning them that it is unsafe to drink water contaminated with more than 2 ppb dioxane. MDPH claimed that the risk assessment implied that if one were to drink water with 2 ppb dioxane for 70 years, one would have a one in one million

chance (greater than if not exposed to dioxane) of getting cancer. Arrangements were also made to provide bottled water to those affected under Act 307, the Michigan Environmental Response Act (MERA). Residents were notified of these arrangements by the following letter from the Washtenaw County Health Department (WCHD):

> Dear Property Owner:
>
> It has come to our attention that your drinking water has been found to contain chemicals in concentrations that may be harmful to your health.
>
> The Michigan Environmental Response Act, Act 307, P.A. 1982, was enacted to provide a mechanism for identifying and assessing sites of environmental contamination. Act 307 also provides funding for connection to community water supply or well replacement, and bottled water delivery. Bottled water will be offered free of charge to you until connection to a community water supply or well replacement can be completed. It has been determined that the average person consumes a half gallon of water per day, including use for cooking purposes. Bottled water will be delivered once every two weeks in boxes containing six one-gallon plastic jugs. You may receive additional amounts of water if you need it...

Many questions which arose at that time are still unanswered today. For instance, which of Gelman's waste disposal methods is the source of the contamination? Possibilities include Gelman's original unlined waste storage/seepage lagoon, the wastewater which was spray irrigated, direct discharge into nearby surface waters, an underground storage tank, a waste water spill from a cut hose, or the deep well injection system. While it is not known for sure, the most recent hydrogeological study contends that Gelman's early seepage lagoon is the most likely source of the contamination (EPA, 9/24/86).

Another unanswered question is the extent of the plume of contamination. New tests continue to yield new results. Furthermore, sites up to three miles away from Gelman have tested positive for dioxane contamination, with uncontaminated stretches between these sites and Gelman. Thus, it is presently impossible to determine definitively for which sites Gelman is the source of the contamination.

As of February 23, 1986, seven wells on Wagner Road and in Jackson Plaza (in the immediate vicinity of Gelman) had been confirmed as contaminated with dioxane. Gelman agreed to pay for an extension of Ann Arbor water lines to these areas within a month, according to an article of February 23, 1986 in *The Ann Arbor News* . At the same time, construction would begin to connect Gelman and neighboring businesses to Ann Arbor's wastewater treatment system.

Original tests, conducted by the Washtenaw County Health Department (WCHD), indicated that the plume of contamination was limited to a small area north of Gelman. However, Barry Johnson, Environmental Health Director of the WCHD, stated in *The Ann Arbor News* on February 23 that the testing was not near completion. It seemed that the more contamination was found, the more complex the problem was discovered to be. Johnson expressed disappointment that Gelman had not yet provided the groundwater study which the WCHD had requested. "We have no information on the direction of (groundwater) flow. We've been having to test a lot of wells to determine if there is contamination," Johnson claimed (Cohen, 2/23/86).

By mid-April, eleven wells (eight businesses and three residences) had tested positive for dioxane. One of these residential wells was beyond the small plume which had already been determined -- in a Westover subdivision (east of Wagner Road) well, dioxane was found at 10 ppb. This caused the WCHD to expand its testing area. Gelman responded by again agreeing to pay for water line hook-ups (which was to be completed by the end of May) for all businesses and homes with contaminated wells. Gelman also claimed to have cut back on its use of dioxane, with plans to eliminate it completely by the end of May (Cohen, 4/27/86).

On May 5, a public meeting was called by state and county officials and representatives of Gelman. The meeting was to update residents of Scio Township on progress made in studying the dioxane contamination. Approximately 100 residents attended to ask about the effect the contaminated water may have on the health of

themselves and their children. They also had questions about falling property values. Some of the residents voiced that they felt their concerns were not being taken seriously. Gelman representatives claimed that they were working hard toward a solution. "Gelman's Marshall called efforts by Gelman and state and local officials 'heroic' and said, 'No one, by any stretch of the imagination, has been sitting around doing nothing'" (Hooper, 5/6/86).

The contamination: whose fault?

The issue soon heated up and accusations began to fly. This began when reporter Janet Cohen wrote a piece entitled "Gelman resisted DNR warnings of water contamination" for the *The Ann Arbor News* on April 27, 1986. In this article, Cohen made the following assertions: 1) that Gelman had been warned by the DNR of a problem as early as 1980; 2) "that Gelman resisted performing studies and installing monitoring equipment that could have detected groundwater contamination before toxic chemical wastes migrated off company property;" and 3) that Gelman did not monitor itself as it is required to do under its permits, which is "particularly disappointing because the company makes precise filters used in medical and pollution control equipment and had the scientific expertise to do so" (Cohen, 4/27/86).

In addition, Cohen reported that former Gelman employees had informed the DNR of Gelman's illegal waste disposal practices. One such allegation was that Gelman had instructed employees to dispose of barrels of hundreds of different chemicals in a "pit." An informer had also notified the DNR of someone known as "the Professor" in Lansing, who was on Gelman's payroll. Cohen quoted a DNR memo describing "the Professor" as: "He advises (Gelman) of pending inspections before the fact, allowing (Gelman) to disguise or dismantle illegal operations until after the inspection." Although the allegation of "the Professor" was never confirmed, Warren Hutchinson, the supervisor of the DNR's criminal investigation unit, claimed that the informant had proven very reliable in previous

allegations, but that there was just not enough information to pursue the case of "the Professor" (Cohen, 4/27/86).

James Marshall, Vice President of Gelman, responded to Cohen's article by issuing a letter to the community on May 5. Excerpts from that letter are as follows:

> As an employee of Gelman Sciences with more information about the groundwater contamination issue than was displayed in *The Ann Arbor News*, April 27th, may I comment on some of the inaccuracies and the false impression that Gelman resisted contamination warnings and acted irresponsibly in the disposal of wastes...
>
> The reporter injects dramatic color with the account of a nameless Lansing "Professor" who magically pulled government strings to benefit Gelman. Colorful, yes; true, no. Our only "Professor" was an eminent consultant at the University of Michigan who served for several years and helped us design a waste treatment system. Perhaps reporters should resist reporting everything they read in DNR's gossipy informant files...
>
> The irony of all this is how hard we have worked to cooperate with DNR and the voluntary steps taken to improve its waste disposal systems. My conclusions from the inaccuracies in the April 27th article is that there are dangers in using non-scientists to report on complex scientific issues because they are unqualified to evaluate and interpret what they are told...Why is it the good stories in companies never seem to get printed? Gelman's well known and widespread community services, for instance, were shoved aside unmentioned because we used something called dioxane before it was suspected of being a problem. The article should have made clear, but did not, that the scare phrase "tainted with the carcinogenic solvent 1,4 dioxane" does not and never has applied to the situation here. No known toxic effects have occurred involving employees, residents or the environment in the vicinity at the levels found of 1 part per billion to 200 parts per million. (DNR files, 5/5/86)

Cohen, in her April 27 article, also discussed problems with the DNR's environmental enforcement capabilities in relation to the Gelman contamination issue. Cohen mentioned inadequate numbers of DNR employees as a reason for DNR's failure to follow through with investigations into illegal waste disposal practices. She claimed that the DNR "can barely manage to check complaints. Routine inspection and monitoring of industrial sites throughout the state are virtually nonexistent." Another problem attributed to the DNR was lack of communication between divisions. Regarding the Gelman case, Cohen stated, "No one can say with certainty that prompt action by the DNR on warnings

and complaints would have prevented the current problem. But environmental leaders familiar with the case say the Gelman situation is too typical for comfort, almost a textbook example of what's wrong with Michigan's pollution control system" (Cohen, 4/2786).

Water supply and annexation issues

On May 16, the WCHD issued a Drinking Water Advisory to all residents (approximately 35 homes) in the Westover area. On May 14, eleven more wells in the Westover area had been found contaminated with dioxane at levels ranging from 1 ppb to 650 ppb, bringing the total number of contaminated wells to 24. The WCHD recommended that all residents of the Westover area not use their well water for drinking and that bottled water would be provided to all residents with wells contaminated with dioxane levels greater than 2 ppb. (On May 28 it was announced by the MDPH that all Westover residents would be supplied with bottled water.) It also warned residents against using water with greater that 100 ppb for bathing. It stated that Gelman would be working with residents to arrange for bathing facilities (DNR files, 5/16/86 and 5/28/86). Gelman's response to the situation is stated in their "Groundwater Project Progress Outline" in the May 14th entry: "Learned of Westover area being contaminated. Residents panicked by Health Department. (Gelman) confirmed results, talked to neighborhood, and set up rooms at Holiday Inn."

Two more businesses' wells were also found to be contaminated in the May 14 results. The sampling yielded the first confirmation of contamination north of Jackson Road, at Busy Bee Collision. The new findings alarmed some DNR officials. "'Things are getting a lot more serious,' said (DNR) groundwater geologist Matt Frisch, after learning of the new findings Thursday" (Cohen, 5/16/86). He explained that the new findings indicated that the plume of contamination was wider than originally thought.

Gelman rented rooms for bathing at the nearby Holiday Inn for the six families with well contamination of over 100 ppb dioxane. However, many of the community's

problems due to the contamination, went unaddressed. Residents were not only inconvenienced by the lack of running water, but were worried about the potential health effects. "You forget how many times you use it (water)," said Debbie Lau, a resident of Ferry Street. Mary Jo Campbell, who had settled in Westover in 1967, stated, "What worries us is, was it (the water) more contaminated years ago than it is now? We'll never know" (Cohen, 5/18/86).

Residents also voiced frustration with Gelman. They claimed that their earlier complaints to Gelman received no response. "We called, we complained. They ignore you. We didn't get anyplace...They (Gelman) pay big taxes, we pay little taxes, the township doesn't care... We do not like anything Gelman has done or said," stated Campbell. Her neighbor, Bonnie Knapp, added, "Everyone's really upset with Gelman" (Cohen, 5/18/86).

The installment of a replacement water supply was a major concern of Westover residents. In early June, discussions began with the city of Ann Arbor to hook Westover into the city water main. The issue became very complicated, involving questions of how the water main construction would be funded, costs of a new sewer system, and annexation of Westover to Ann Arbor.

Originally, Gelman made the offer to front the $315,000 that was the estimated cost of the water hook-up. Under the proposal, if it were determined in the future that Gelman was not responsible for the groundwater contamination, the city would have to pay Gelman back in full.

This proposal met with much negative response. Ann Arbor City Council member Jeff Epton questioned Gelman's motives at a City Council meeting in early June. "I'm wary of supporting this... What is Gelman's public position on why they're willing to pay for the consequences of an event for which they're not accepting liability?" (DeSimone, 6/3/86). Epton was concerned over how Gelman's "innocence" would be judged (by a

court, the DNR, or by Gelman's own studies). Epton suggested that Gelman should just agree to pay for the water main at the outset.

Westover residents, wary of having costs passed on to themselves, echoed Epton's response. One resident, Genevieve Wright, stated, "It seems like there's a shady deal going on, and we're trying to find out where it is... Why should we be responsible? All we want is water" (DeSimone, 6/3/86).

Gelman's attorney (and former Ann Arbor Mayor), Robert Harris, offered a different viewpoint at the June 9 Ann Arbor City Council meeting. "Harris said Gelman made the offer for three reasons: 'good citizenship,' 'public relations' and protection from coercive action by the state Department of Natural Resources, which could sue if the firm does not make every effort to cooperate with the push to get water to the residents" (DeSimone, 6/10/86). Harris stated, "It's not a gift of hundreds of thousands of dollars... Nobody's found Gelman guilty and Gelman doesn't think it's guilty. We thought we'd made everyone happy, and now we're being told to pay for a whole new water system" (DeSimone, 6/10/86).

Soon after, however, a new proposal was discussed in which Gelman would pay, outright, the costs for water main hook-ups to occupied properties (but not vacant lots) in the Westover area. The estimated cost for this was $215,000; substantially less than the initial figure of $315,000. Gelman therefore agreed to this. Gelman's Harris, accordingly, changed his tune. "It's a gift this time... Gelman is trying to be a good citizen" (DeSimone, 6/24/86).

Westover residents were still not completely satisfied with this proposal. On June 23 they requested that Ann Arbor City Council delay approval of the agreement for one month. Westover residents were concerned about annexation to Ann Arbor (and the resulting higher taxes), which is the usual procedure followed when a city provides water service. It was clear that Scio Township would not oppose the annexation of Westover to Ann Arbor, as they had signed an agreement with Ann Arbor several years prior

designating Westover for future annexation. Even not becoming part of Ann Arbor would be costly. If annexation would not be an immediate result, those receiving city water or sewer service would pay the non-resident rate, which is double the resident rate, plus a special fee.

The residents also had questions about the costs associated with the new $439,000 sewer system which would be another result of annexation to Ann Arbor. Westover residents would be required to hook into the Ann Arbor sewer system once a failure occurred in their septic systems. The DNR had rejected Westover's request for emergency funding for the new sewer system. Residents then turned to Gelman and were having closed meetings to discuss the projected costs. It appears that an agreement was never reached in those talks.

On July 21, a plan to provide city water to Westover residents was approved. The agreement stipulated the following: 1) Gelman would foot the bill for water main hook-ups to residences in Westover subdivision and would retain the right to sue any other party that was found to be responsible for the pollution; 2) residents would be annexed to Ann Arbor as soon as they were connected to the water main; and 3) vacant land would only be annexed to the city once it was sold (Rzepka, 7/22/86). The first of the water hook-ups were completed in November 1986.

The plan, however, did not address the residents' concerns about future costs of the sewer system. Residents were left with the possibility of paying approximately $10-15,000 per household in the future, when their septic systems would fail.

Preliminary cleanup plans

Meanwhile, the DNR began pushing Gelman to clean up the contamination plume. In a May 29, 1986 article from *The Ann Arbor News* , both Gelman representatives and DNR officials voiced optimism that the cleanup could start as early as that summer. The DNR claimed that Gelman would be made to pay for the cleanup of any contamination for

which they were responsible. John Shauver, of the DNR's Environmental Enforcement Division, stated, "If they clean up, to our satisfaction, we'll close the file on them and say that's the end. If not, we'll go see the Attorney General" (Schimdt, 5/29/86).

On June 12, the DNR sent Gelman a memo requesting results of the initial hydrogeological investigation of dioxane contamination, for which Gelman had commissioned Keck Consulting Co. The memo also requested that the following issues be addressed by Gelman: groundwater cleanup methods to be used, alternative storage methods of wastewater, and plans to lower concentrations of "contamination in soils on and adjacent to Gelman's property" (DNR files, 6/12/86).

Gelman offered a preliminary cleanup plan on July 14. They proposed to purge the contaminated aquifers and to inject the contaminated water down the deep well. The Redskin well, which was the well of highest dioxane concentration, would be purged first. The main obstacle was the hook-up of Gelman to the Ann Arbor sewer line. Once hooked up, Gelman could dispose of process wastes in the sewer, thus saving the deep well for disposal of contaminated groundwater (Cohen, 7/15/86).

After examining Gelman's preliminary cleanup plan, the DNR responded on September 4 by requesting that a "draft remedial action plan be developed and submitted by Oct. 15, 1986 for DNR approval. The initial phase of the remedial action should be ready for implementation by Nov. 15, 1986" (DNR files, 10/15/86). The DNR also requested that a vertical and horizontal inventory of the plume of contamination be completed by December 1, 1986. Gelman's attorney responded that he felt those dates were unrealistic.

Several concerns, however, were raised over the prospect of Gelman using the sewer to dispose of dioxane. It was feared that the sewer system could be damaged by a heavy chemical load. The Ann Arbor system was designed to handle municipal, as opposed to industrial waste. (Gelman is now the largest industrial user of the sewer system.) Ann Arbor and Scio Township officials agreed that companies using the sewer would be responsible for recording their waste stream components and pre-treating

potentially harmful effluents. Nonetheless, the fear remained that bacteria used to break down organic sewage would be killed by the chemicals, or that the chemicals would escape through the process into the Huron River.

The condition of Third Sister Lake and Saginaw Forest

In late July, another site was added to the list of those contaminated. A U-M study determined that dioxane was present in the caretaker's well in Saginaw Forest (37 ppb) and in the water (53-98 ppb) and sediment (40 ppb, average) of Third Sister Lake. Tests had been showing significant levels of dioxane since late May. This was in contrast to the results of sampling done by the DNR and Gelman in late 1984, after the Bicknell report came out. At that time the DNR and Gelman had asserted that dioxane was not present in Third Sister Lake. The new detection of dioxane in the lake expanded the geographical area known to be contaminated to the southwest, and indicated that the area's surface water system was also polluted.

Bottled water was provided for the Saginaw Forest caretaker under the Michigan Environmental Response Act, but no apparent action was taken by the University. It was decided by the director of U-M's Occupational Safety and Environmental Health Department, Ken Schatzle, and (then) U-M Business Operations Director, Jack Weidenbach, that only additional testing should be pursued by the University at that time. "It appears that we may have a problem, but I don't want to put a lot of faith in one set of samples... We don't want to make any decisions based on one set of data," Schatzle said (Cohen, 7/27/86).

A second set of samples taken in mid-August showed no dioxane in the caretaker's well, but still showed dioxane in the water and sediments of the lake. There had also been samples taken in February and March, in which dioxane had not been detected in the caretaker's well. This pattern of contamination proved puzzling to county and state health officials (Cohen, 9/9/86). A third set of samples was taken in September, showing

dioxane in concentrations of 33 ppb - 200 ppb in lake water and 110 ppb - 880 ppb in the lake's sediments.

A wastewater spill occurs on Gelman property

On July 14, another incident occurred which brought Gelman into the headlines. A hose leading from the lined lagoon to the deep well on Gelman's property had been cut, according to Gelman, when it was run over by the tractor-lawn mower of a contracted lawn mowing company. The wastewater, which was being pumped into the deep well from the lagoon, contained a solution of 99.7 percent water and .3 percent various solvents, including dioxane. The exact concentration of dioxane in the lagoon water was not known, but according to Gelman it was below 20 ppm.

Gelman notified the DNR of the spill in a letter dated July 22, which was received on July 24. In the letter it was stated:

> Around 8:30 a.m. on Monday, July 14, during a routine maintenance check, the line was found to have been lacerated along the top of a three foot section, and to be leaking water onto the ground. The pump was immediately shut off and the standing water to the north of the pipe covering about a 10-20 foot wide area extending toward the north. The pipe had apparently been cut during lawn mowing operations carried out over the weekend... (DNR files, 7/22/86)

On July 30, an article entitled "Gelman failed to give timely notice of spill" appeared in the *The Ann Arbor News*. In this article, *News* reporter Janet Cohen wrote, "Gelman Sciences, Inc. has violated a state law by failing to give the Department of Natural Resources timely notice of a wastewater spill earlier this month." The article pointed out that the spill had occurred the same day (July 14) that DNR officials had been at Gelman, discussing a groundwater study of the dioxane contamination with Gelman officials and touring the Gelman site. The spill was not mentioned during the meeting and the area of the spill was avoided during the tour, according to DNR officials present at Gelman that day.

It was further stated that the DNR didn't learn of the incident until Friday, July 25, which constituted a violation of Gelman's discharge permit. The permit required the company "to alert the DNR immediately following any unexpected discharge and to follow the verbal notice in writing within 10 days" (Cohen, 7/30/86).

DNR geologist, Matt Frisch, was quoted as saying, "They missed on both counts... You've got to wonder sometimes about these guys... In some ways they appear to be coming clean, but at the same time they are remaining really sneaky" (Cohen, 7/30/86).

The day after that article appeared, James Marshall responded to Matt Frisch with a letter. The letter criticized both Janet Cohen and Matt Frisch for what Marshall felt was unfair treatment of Gelman. Following are excerpts from Marshall's letter to Frisch:

> The enclosed article is the most devastating yet to Gelman Sciences and personally, to Paul Chalmer and myself. The essence of this article was also aired on local radio...
>
> Janet Cohen and *The Ann Arbor News* are taking the position "absence of malice" as a facade and there is nothing Gelman Sciences, Paul or myself can do to correct this posture. We certainly deserve more credit and respect than given us by Cohen and the News...
>
> I respectfully urge the DNR to work with us rather than the news media. You can clearly see the effect of how opinions and side comments can be used...
>
> Matt, I certainly don't believe you intended to paint this type of picture of Gelman Sciences, Paul or myself...
>
> We urge you to respond in strong language to *The Ann Arbor News* responding to the incredible disservice done to us... (DNR files, 7/31/86).

On August 1, Matt Frisch responded in a letter to Paul Chalmers of Gelman, claiming he regretted having told *The Ann Arbor News*. what he did. Frisch wrote,

> It is not my intention to cast (Gelman) as "really sneaky" or as purposefully misleading the DNR. I realize such statements undermine (Gelman's) and your credibility. My comments were voiced out of frustration regarding the wastewater spillage incident. They were made prior to gaining full

> knowledge of the circumstances surrounding its discovery and (Gelman's) actions thereafter... (DNR files, 8/1/86)

Soon after, *The Ann Arbor News* ran a story entitled "DNR unfair about spill, Gelman says." In this article, the News printed Gelman's assertions that 1) it took Gelman officials 36 hours to discover what had happened and that they attempted to call the DNR within 24 hours after that, 2) Gelman officials were not aware of the spill at the time of their meeting with the DNR on Gelman's property on July 14, and 3) the DNR was notified in writing of the spill within eight working days.

Nonetheless, Gelman received a letter from the DNR dated August 8, informing them of permit violations due to the spill and its untimely reporting. The letter claimed that a violation had occurred of the section of Gelman's Groundwater Discharge Permit which reads, "A person shall not discharge into the groundwaters any substance that is, or may become, injurious to the public health, safety or welfare or to the domestic, commercial, industrial, agricultural, recreational, or other uses which are being or may be made of the groundwaters" (DNR files, 8/8/86). Furthermore, the letter claimed that Gelman was required to notify the DNR immediately after the spill and to file a report within ten days of the spill. "Notification of this incident took place nearly sixty hours after Gelman had information that a spill had occurred. This type of response is not immediate nor acceptable to MDNR" (DNR files, 8/8/86).

The deep well issue heats up

In August 1986, Gelman's deep well disposal system again came into question. On August 15, Gelman's application for a permit to continue injecting approximately 70,000 gallons/day of process waste water was complete, and soon thereafter was made available for public review. Gelman had been required to file this application in 1984, when deep well permitting responsibilities were transferred from the Michigan DNR to the U.S. EPA. The original application had several deficiencies which required Gelman to supply

additional information. During the permit application process, Gelman had been allowed to continue operating the deep well under interim rules.

A public hearing over the deep well permit was held by the EPA on September 17, 1986. At that hearing, sixteen area residents spoke--all in opposition to the deep well. Although residents' concerns at the hearing were supposed to be limited to the EPA's technical review of the deep well, the issue of the groundwater contamination was also raised. The contamination had by that time affected the wells of approximately 40 businesses and residences.

By the time of the hearing, Gelman had been disposing of most of its wastes through the Ann Arbor sewer system, to which it had been connected in May. Gelman claimed to want the deep well for the following purposes: as a back-up system to the sewer, to dispose of certain chemicals that were not acceptable to the Ann Arbor Wastewater Treatment Plant, and for disposal of contaminated groundwater being purged from the nearby Redskin well.

Despite several citizen concerns (none of which the EPA considered valid), the EPA granted the deep well permit on September 30, 1986. Soon after, members of Tocsin, a citizen group which had been formed around the issue, filed appeals. During the appeal period, Gelman was allowed to continue to operate the deep well under interim rules. In December 1987, the appeal was overturned.

Beginning in the summer of 1987 Gelman had been using the deep well to dispose of contaminated water being purged from the Redskin well. This was allowed under interim rules. However, since the appeal was overturned Gelman's use of the deep well has been regulated by the permit which was granted to them in September 1986. This permit was only for "process waste." Consequently, Gelman has had to cease the purge operation and file for a minor modification of the permit. Gelman is still awaiting the EPA's granting of this modification.

The contamination spreads - Gelman's response is questioned

By November 1986, six more wells had tested positive for dioxane in "relatively high levels" (Cohen, 11/23/86). The contamination had spread through the groundwater as far as one mile from Gelman. This raised the concern that the contamination may be entering previously pristine aquifers. The belief that the dioxane would continue to spread prompted the DNR to pressure Gelman to purge the contaminated aquifers.

Washtenaw County Drain Commissioner Jim Murray and DNR staff expressed frustration with Gelman's cleanup progress. Jim Murray stated:

> I'm concerned that there doesn't seem to be any action out there... We need a program to stop the migration (of chemicals) from the site. It's been well over a year since they discovered very high levels and to just let it go is unconscionable. It's taking too long, in my opinion (Cohen, 11/23/86).

"There's no particular indication that the company (Gelman) is not moving forward, but we don't know exactly what they are doing," added Dave Dennis, DNR Chief of Compliance (Cohen, 11/23/86). Mary Vanderlaan (EED), also expressed skepticism. "There was the concern that they potentially aren't sharing all their material," she stated (Cohen, 11/23/86).

Gelman Vice President James Marshall, however, denied the allegations and claimed that the company was making substantial progress. According to Marshall, Gelman had been working with a hydrogeologist to define the plume of contamination, had continued testing wells and surface water (with their new system which could detect dioxane down to 1 ppb), had hired a U-M toxicologist (Rolf Hartung) to review the literature on dioxane and to propose cleanup standards, had begun working on ways to break down dioxane, and had hired an engineer to work with the Ann Arbor Wastewater Treatment Plant to assess the quality of Gelman's waste (Cohen, 11/23/86).

A leak is reported in Gelman's underground storage tank

In early February 1987 Gelman reported to the DNR that they had discovered a leak in their 3,200 gallon underground storage tank. The leak was due to a crack in the lower right corner of the concrete tank. It was not known when the crack had first developed. The leak was discovered by Gelman staff the first week in February, "when they ran into wet soil during maintenance operations on a pipeline from the main building to the wastewater disposal well" (Cohen, 2/7/87). DNR staff, in field notes taken during a February 9 site visit, noted, "Significantly, there had been a well alongside the vault for leak detection, but GSI either hadn't sampled it or had ignored it until recently. The well wasn't what tipped off GSI to the leak" (DNR files, 2/9/87).

According to notes taken by DNR representatives on February 9, prior to Gelman's construction of the deep well, this tank had been used to hold Gelman's "most contaminated" process wastewater (DNR files, 2/9/87). Gelman scientist Paul Chalmers claimed that the wastewater was considered nonhazardous by RCRA standards. DNR officials disagreed. In a February 10 memo regarding the incident, DNR geologist Charles San Juan wrote, "(I) suspect that Gelman's wastewater may be hazardous in nature. Most of the chemicals are organic solvents of some sort or another" (DNR files, 2/10/87). Contamination of surrounding soils resulted from the leak. The DNR and Gelman each had different ideas of what to do with the contaminated soils. During the February 9 site visit, DNR officials had recommended excavation of all contaminated soils. Chalmers, however, proposed that contaminated soils not be excavated, but be treated on the site. The DNR expressed concerns that if soils were to be kept, they would have to be kept in a "diked containment area with an impermeable membrane," in order to prevent groundwater contamination (DNR files, 2/9/87). In a follow up memo of February 10, Charles San Juan elaborated on the matter:

> I recommended to Chalmers that all contaminated soil be transported as hazardous waste to a Type 1 facility. Chalmers stated that he would like to

> develop some sort of in-situ treatment for the soil, however, it was my contention that if the volume of soil to be removed was a fairly small quantity (less than 1,000 cubic yards) it would behoove Gelman to get rid of it instead of fooling with some mumbo-jumbo in-situ treatment system (he mentioned something about spreading the soil out on visquene and then letting the "leachate," i.e. wastewater, drain to a central point and then be discharged via their deep well system) (DNR files, 2/10/87).

According to allegation #30 of the DNR lawsuit against Gelman,"...Gelman removed some, but not all, of these contaminated soils" (Kelley et al v. Gelman, 2/26/88).

Groundwater contamination was another possible consequence of the leak. According to Charles San Juan's memo,

> (I) also suspect that up to 1,000 gallons may have leaked out from the lift tank to local groundwater (based on the assumption that the crack in the tank leaked at least 1 gal/day for a theoretical period of three years). Soils were predominantly fine sands/silt, some clay observed. Groundwater is at least 20 ft + deep. Depending on porosity, hydraulic conductivity, and the volume of wastewater lost from the tank, local groundwater may have been severely impacted by leakage from the tank. Recommend monitor wells in the area of the tank and wastewater line (DNR files, 2/10/87).

Gelman ranked as second worst environmental hazard in Michigan

In 1987, Gelman's ranking on the Michigan Priority List of Environmental Contamination jumped to "2" (up from the previous year's ranking of "89"), making Gelman, according to DNR scoring methods, the second worst environmental hazard in Michigan. The ranking of sites is required by Act 307, the Michigan Environmental Response Act (see State and Federal Statutes section).

Sites' rankings on the Priority List are determined by a numerical scoring system. Points are assessed for factors regarding the nature of the pollution, such as its toxicity and the resources it is affecting. Also taken into consideration is the potential for human exposure and environmental damage. Gelman's score for 1987 was 986 out of a possible 2,000 points. A Michigan site has never scored higher than 1,200 (Cohen, 4/5/87).

"The dramatic jump in rank reflects new information indicating that contamination is spreading and that growing numbers of people are faced with contaminated wells," said

Brenda Irish, a DNR environmental quality analyst who helped prepare the list (Cohen, 4/5/87).

Some felt that Gelman's ranking was still too low. Barry Johnson of the Washtenaw County Health Department stated, "It should be at the top of the list. Even at the top ranking site, no one's wells are affected. I don't think the contamination has even gone off the site" (Cohen, 4/5/87).

At the time the list was published, over forty business and residential wells, up to one and a half miles from Gelman, had tested positive for dioxane. Sixteen families and businesses with polluted wells were still receiving bottled water. The known extent of the contamination was:

> Groundwater is polluted in a commercial area to the north, the residential Westover subdivision to the northeast, and a mixed-use area as much as 11/2 miles to the northwest. In addition, dioxane has been detected in surface water and sediment samples from Third Sister Lake...; an un-named lake due west of Third Sister Lake; Little Lake to the northwest; and along a tributary of Honey Creek, which flows to the northwest from Gelman (Cohen, 4/5/87). Contamination had also been detected in a second unnamed lake west of Gelman and a wetland adjacent to Gelman (DNR files, 4/10/87).

Another function of Act 307 is that it "requires the DNR to recover public monies spent on sites where a responsible party can be identified" (Cohen, 4/5/87). It was reported at the time the Priority List was published that the state had spent $21,000 on bottled water through March 1, 1987. In addition, the DNR's Jackson District office requested "just over $1 million for investigation and clean-up activities in the Gelman area" (Cohen, 4/5/87). The Michigan Department of Public Health requested an additional $409,000 from the DNR to extend water lines to areas for which Gelman had not agreed to fund the extension (Cohen, 4/5/87).

Gelman officials had expressed disagreement and disappointment with their 1986 ranking of 89th, and had been working to convince the DNR that Gelman was not such a significant contamination problem. In November 1986 the DNR came out with an Act 307

Proposed Priority List. On this list, Gelman was ranked 86th. Two attorneys from one of the three law firms representing Gelman, wrote to the DNR on January 5 1987, regarding the proposed list.

> Dear Sirs [sic]:
> ...(We have a) strenuous objection...to the proceeding in light of the failure of the Department of Natural Resources ("DNR") to prepare a revised proposed Site Assessment System Score for Gelman. Due to the DNR's inaction, Gelman has not been and will not be afforded an opportunity to comment at a public hearing as required by Act 307...We hereby reiterate our objection to this denial of Gelman's rights and accordingly request a public hearing and an opportunity to comment once the reevaluation of Gelman's Site Assessment System Score has been completed. Gelman and its attorneys also renew their request for an opportunity to meet with officials within the Site Assessment Unit to further discuss issues relating to Gelman's Site Assessment System Score sheet (DNR files, 1/5/87).

Gelman's lawyers also provided a point-by-point critique of DNR's scoring of the Gelman site.

When the actual 1987 Priority List came out, Gelman's score ("2") was much higher than the proposed list had indicated. James Marshall responded to the ranking, stating, "If Gelman is rated No. 2 in the state, then the state is in pretty good shape... The toxicity level is not that high. It's (dioxane's) not that critical a material" (Cohen, 4/10/87). Gelman had similar objections to the DNR's 1988 ranking of Gelman as No. 11 on the Priority List.

<u>More contamination discovered</u>

Through 1987 the contamination continued to spread and the question of the extent of the plume grew more puzzling. In July, up to 106 ppb dioxane was found in wells approximately three miles from Gelman, near Zeeb Road, Enterprise Drive, Metty Drive, and Staebler Road (Cohen, 7/13/87). At that time, DNR officials did not suspect that Gelman was the source of this newly discovered dioxane because the pattern of groundwater movement appears to be from the aforementioned area toward Gelman, and

not vice-versa. The groundwater patterns of the area are, however, exceedingly complicated. Both Gelman and the DNR have sought other possible sources of the dioxane contamination in the area, but have yet to find one. At present, the source of the contamination in the Staebler Road-Zeeb Road area is still not known.

A hydrogeological study done for Gelman by Keck in March 1987 reported that at least four of the aquifers beneath and near the Gelman site were contaminated with dioxane, among other organic solvents. Three of those four aquifers supplied drinking water (Kelley et al v. Gelman, 2/26/88). In addition, it is stated in the DNR lawsuit against Gelman that the "plumes (or zones) of groundwater contamination have spread and are continuing to spread outward from the Gelman site" (Kelley et al v. Gelman, 2/26/88).

According to Dan Bicknell (who is presently employed with the EPA Region V), it is very possible that the wells in the Staebler Road-Zeeb Road area were contaminated by Gelman's dioxane. Bicknell contends that of all known solvents, dioxane is one of the fastest-moving in groundwater. Bicknell claims that it should be expected that the dioxane will move out of certain areas and into others (Interview with Dan Bicknell, 4/8/88).

Recognizing the scope of contamination attributable to Gelman, as well as that potentially attributable to Gelman, the DNR filed a request with the Region V EPA to include Gelman on the National Priorities List, which would make the Gelman site eligible for Superfund funding. The letter, sent by Gary Guenther, Chief of the Environmental Response Division, stated:

> The (Gelman) site is of great concern to the State of Michigan. Groundwater contamination is currently documented two miles from the site, with nearly 60 drinking wells being affected, to date... Given the impact and extent of this groundwater problem, the State believes that the (Gelman) site must be included on the October 1987 proposed listing of sites for inclusion on the National Priorities List... (DNR files, 9/1/87).

Gelman's recent cleanup proposals

On January 16, 1987 Gelman offered Phase I of their Groundwater Cleanup Project. According to Gelman's proposal, "The primary objective of the first phase is to reduce the dioxane concentration in the core area (the area of highest dioxane contamination, to the north of the unlined lagoon), to preclude this area from serving as a source for further spread" (DNR files, 1/16/87).

Gelman's plan included purging the wells in the area of highest contamination, for which they were considering two methods. One possible method was to dispose of purged, contaminated groundwater into the deep well (which would be allowed under EPA's interim rules while Gelman's deep well permit was under appeal) (see Deep well section). This was contingent on Gelman being hooked into the Ann Arbor sewer system. (Since the deep well had limited capacity, it would be necessary for Gelman to dispose of their waste stream in the sewer.) The other possibility was to chemically treat the purged water and then to discharge it either to surface water (which would require an NPDES permit), to an unlined lagoon, or to the municipal sewer (DNR files, 1/16/87). Gelman's proposal further stated:

> The choice among these possibilities is contingent on regulatory acceptance, and issuance of appropriate permits.
>
> The injection option can be implemented more quickly than any of the other mentioned options, subject to the approvals noted above. We propose to begin this method as rapidly as possible, while the development of the chemical treatment method is completed...
>
> At 35 GPM (gallons per minute), one well will be capable of producing up to 18 million gallons of water per year...
>
> With 2-3 wells in service, using a rough estimate of 40 million gallons as the capacity of the affected aquifer, one aquifer volume could be treated in about a year (DNR files, 1/16/87).

Gelman submitted a "Comprehensive Cleanup Program Preliminary Outline" to the DNR on May 21, 1987. This document discussed methods of cleanup and locations in

which cleanup efforts would be concentrated. The cleanup outline included a tentative timeline, with plans extending into 1992.

In this document Gelman proposed to begin pumping groundwater from the most contaminated areas and to initially dispose of this water in the deep well. This plan was contingent on the fact that Gelman's waste stream would be connected to the sewer system sometime in June. Given the capacity limitations of the deep well, Gelman would be able to pump approximately 50,000 gallons per day of groundwater into the deep well. It was stated in the report, "Injection can provide a good start to the core area cleanup, but additional treatment methods would accelerate the process considerably" (DNR files, 5/21/87). Gelman also discussed the possibilities of disposing of the groundwater (once a treatment system had been developed) via surface water discharge (into Honey Creek tributary), groundwater recharge (into the core area aquifer), spray irrigation, or the sewer system (DNR files, 5/21/87).

It was stated in mid-June that Gelman was considering patenting the technology it had been developing to degrade dioxane. Gelman representatives indicated that the system utilized ultraviolet light, but would give no details. "'We are developing a proprietary system and are protecting it. No one has ever treated dioxane before,' (Gelman attorney, Philip) Grashoff said" (Cohen, 6/15/87).

Even today, Gelman is quite secretive about their ultraviolet treatment method of dioxane. The DNR has become skeptical (Interview with Mary Vanderlaan, 2/24/88) about Gelman's secrecy on this matter and doubts have been expressed by others as to the prospects of such a system working. Westover resident and U-M research chemist, Alfin Vaz, when asked, "What do you think about Gelman's proposed cleanup plan?" answered as follows:

> I would rather see Gelman put the money into finding a way to biologically degrade the waste.

> Dioxane is like water in its physical properties. It is completely immiscible in water, boils at the same temperature as water, and does not evaporate easily. It cannot be easily separated from water in a lab. There are millions and millions of gallons of water in the aquifers. If that water can dissipate, then the dioxane can eventually dissipate. But this is very unlikely.
>
> The money could be best spent by giving it to someone at the University studying bacteriology. The UV (ultraviolet) process that Gelman has been talking about has been known to chemists since the 1940's. If you take dioxane, expose it to UV in the presence of oxygen, the oxygen gets excited, goes to a peroxy intermediate, reacts with the dioxane and forms an acetic acid derivative with ethylene glycol. This derivative breaks down faster than dioxane. The problem is that it is a very inefficient reaction.
>
> I can't believe that all of a sudden Gelman would do this. It's a stalling technique. They have nothing to show. Once they take it to the patent office, it's no longer a secret. It will be available for public scrutiny. Gelman is trying to make the neighborhood feel like they are taking care of the problem.
>
> I am a strong proponent of not cleaning up the aquifers irrationally. The money spent by Gelman on PR (public relations) and lawyers should be spent productively to develop some way of breaking down the contamination (Interview with Alfin Vaz, 3/12/88).

On June 15 it was stated in *The Ann Arbor News* that the initiation of Gelman's cleanup was only awaiting approval of Gelman's permit to hook in to the Ann Arbor sewer system. This permit was granted on July 17 and the purge of the Redskin well (Gelman's neighboring industry, with dioxane at the highest concentration levels discovered thus far--approximately 200 ppm) began on July 20 (Cohen, 6/15/87, and Gelman, March 1988).

On July 28, Gelman's lawyer Grashoff discussed the initial stages of the groundwater purge operation. "It's going fine. There have been no problems," Grashoff said (Cohen, 7/28/87). DNR officials, however, could not be quite as confident about the success of the operation.

> Matt Frisch, the DNR geologist assigned to the Gelman case until earlier this month, said the company had not told him that the cleanup had started. The company last week denied DNR's request to access company property to inspect the purge setup, he added.
>
> The DNR's new project manager, Roger Jones, also said he had not heard from Gelman that the purging had begun (Cohen, 7/28/87).

Throughout January 1988, Gelman was working to supplement its 1987 "Comprehensive Cleanup Program Preliminary Outline." On January 12, a technical meeting was held with representatives from Gelman, Keck, DNR, and MDPH. At this meeting Gelman presented a first draft of their cleanup program supplement. According to DNR representative Mary Vanderlaan, "James Marshall said he was not ready to distribute the document and thus requested that no notes be taken during the presentation and we would be unable to keep the document presented" (DNR files, 1/12/88).

On February 3, Gelman released their 1988 "Comprehensive Remedial Program." It was sent to the DNR along with a cover letter dated February 4, stating, "The provision of the enclosed program outline further demonstrates Gelman's continued cooperation. Gelman does not acknowledge responsibility for any or all of the presence of 1,4-dioxane in the aquifers and surface waters" (DNR files, 2/4/88). This remediation document, as did the previous year's, discussed the following: areas of potential contamination concern, proposed remedial activities, and treatment methods (which in our copy of the remediation document were omitted and in its place was stated, "This section contains proprietary information which is deemed to be confidential and is being supplied under separate cover, in accordance with Michigan's Freedom of Information Act."). Also included was a task list for 1988 and various appendices (DNR files, 2/4/88).

At the outset of the report it is stated:

> In the following pages, a plan is presented with the objective of reducing the concentrations of 1,4-dioxane to levels which will ensure a negligible risk to human health and to the environment, and to do so in a manner which will not cause damage to the affected area. In accordance with statements in the May 21, 1987 submittal, Gelman is proposing target levels... Parenthetically, these levels are consistent with the purpose of Act 307.
>
> GSI (Gelman) proposed a target level of 3 mg/l (3 ppm) in groundwater, which is consistent with (U-M School of Public Health professor) Dr. Rolf Hartung's draft assessment. With respect to surface water, since the University of Michigan studies indicate 16 mg/l (16 ppm) in surface water, which is 1/10 of the level at which adverse effects were observed in the most sensitive organisms, GSI proposes 16 mg/l as a target level (DNR files, 2/4/88).

Thus Gelman, through the results of a privately contracted risk assessment of dioxane, was attempting to reestablish "acceptable" levels of dioxane in groundwater, to redefine dioxane as a "threshold" carcinogen (meaning that there are certain levels below which dioxane is not carcinogenic), and to determine the area requiring cleanup, based on these findings.

The legal arena

In recent months attempts at cooperation between various parties in the dispute involved have failed, and a number of lawsuits have resulted. To date, the State of Michigan has sued Gelman and Gelman has sued the DNR. Gelman has also filed suit against its insurance company (which has refused to pay Gelman's cleanup costs), and against Dow Chemical and seven other dioxane manufacturers.

The lawsuit which the DNR requested the Attorney General's office bring against Gelman, represents one of the first cases ever to be brought to trial under Act 307. The DNR's policy, as summarized by reporter Janet Cohen, is

> ... to start by assuming polluted resources must be cleaned to background levels. Companies which contend that such levels are economically or technically impossible to achieve may be given the opportunity to demonstrate that a less stringent cleanup would not harm human health or the environment (Cohen, 11/29/87).

In the same article of November 29, Donald Inman, Chief of the DNR's Environmental Enforcement Division (EED), explained that the state would outline cleanup requirements which it would press Gelman to meet "whether it takes Gelman to court or sets up a voluntary, court-supervised consent agreement with the company" (Cohen, 11/29/87).

As of June 15, 1987, the State Attorney General's office assumed responsibility from the DNR for the Gelman case. The reason for this was described by Mary

Vanderlaan of the DNR: "Every time we met, their lawyers were speaking for them so we thought it would be better if our lawyers spoke for us" (Cohen, 6/15/87).

The involvement of the Attorney General in the case was also sought by Washtenaw County Drain Commissioner, Jim Murray. Murray felt that the DNR was not pressing Gelman forcefully enough to move along in their cleanup plans. Murray claimed, "It's been more than a year, and nothing has been cleaned up yet" (Cohen, 6/15/87).

On April 1, 1987 a draft of a letter had been prepared, from the DNR's EED to the Attorney General's office. It stated:

> Environmental Enforcement Division requests your assistance in exploring possible legal action against (Gelman) for contaminating groundwater and drinking water supply wells in the vicinity of their facility...
>
> Presently, Gelman is conducting bench tests for treatment of 1,4-dioxane. However, they have not started any clean-up of the ground or surface waters, nor provided a complete remedial clean-up plan or schedule. In DNR's opinion Gelman is not pursuing the completion of the hydrogeologic investigation in a very timely manner nor have they provided a schedule for completing this work.
>
> Thus your assistance is requested to provide guidance on how to proceed with this company to affect a clean-up and obtain reimbursement for State monies spent. Presently, this site ranks number 2 on the MERA Sites of Environmental Contamination List. EED feels Gelman should fund the groundwater clean-up, not the State (DNR files, 4/1/87).

Soon after, a memo was sent from Mary Vanderlaan of the DNR's Environmental Response Division to several DNR divisions in the Lansing and Jackson offices, and to Lois Elliot-Wilson of the MDPH. It stated,

> (Gelman) has contaminated the groundwater in the vicinity of their plant... This groundwater contamination problem has been referred to the Attorney General's office for further action. (Gelman) has been instructed to direct all communication with the DNR through the assistant attorney general assigned to the case... (DNR files, 4/29/87).

Even as the DNR was initiating legal action against Gelman, Gelman had not accepted responsibility for the contamination. In a May 14 letter to Robert Reichel (Assistant Attorney General), Grashoff wrote, "(Gelman's) commitment continues notwithstanding the fact that no discrete source of (dioxane) has been found on or under the (Gelman) site. (Gelman) does not, therefore, believe that (dioxane) is presently being 'released from the Gelman facility' or is 'emanating from the Gelman facility'" (DNR files, 5/14/87). This opinion stated by Gelman's lawyer was contradictory even to Keck Consulting Company, the company hired by Gelman to study the hydrogeology of the area, which had concluded that the most likely source of the dioxane was Gelman's original unlined seepage lagoon.

The State's intention to sue Gelman was made public on November 29, 1987. According to Donald Inman, Chief of the DNR's EED, the Attorney General's office would likely seek a court-ordered cleanup program, in addition to damages, fines, and penalties (Cohen, 11/29/87). Despite Gelman's claim of having pumped 2.7 million gallons of groundwater from the Redskin well by the end of September, DNR officials were frustrated by the pace and scope of Gelman's cleanup efforts. According to Mary Vanderlaan of the EED, Gelman had not presented a plan for halting the spread of dioxane in the groundwater and had not submitted a comprehensive remedial action plan. Vanderlaan also voiced that "Gelman has... been slow to deliver technical data requested by the DNR, has declined to pay for the $500,000 water line along Park Road, and has refused to enter a voluntary, court-ordered consent agreement defining cleanup standards" (Cohen, 11/29/87).

Donald Inman added:

> What we saw was significant groundwater contamination with (chemicals) that are hazardous and toxic, and a company to the point of wanting to replace the water system but write off the resource, and a company that is technically and economically able to take care of (the problem) but is not (taking care of it) (Cohen, 11/29/87).

Stuart Freeman, Chief of the Attorney General's Environmental Division, added that he felt it was important to pursue the Gelman case in court because "a concensus of health professionals, elected representatives and attorney colleagues have said it is serious." *News* reporter Janet Cohen added that Freeman felt that "'tactics' of Gelman attorneys and a 'circle the wagons mentality' on the part of the company convinced him that litigation was the only way to proceed toward a cleanup" (Cohen, 11/29/87).

Soon after this, Gelman initiated a lawsuit against the DNR (DNR Director Gordon E. Guyer was named as defendant) over their No. 2 ranking on the Act 307 list.

> The suit contends that the DNR's rating of the firm, issued in April 1987, was assigned without evaluating all related data or holding a public hearing, and without following all provisions of state administrative law. By doing this, the DNR violated Gelman's right to due process and equal protection of law... (Reynolds, 1/26/88).

The suit, which challenged the DNR to provide evidence in court supporting Gelman's rating of "2" on the Priority List, also asked $10,000 in damages and sought an injunction against publication of the 1988 Act 307 list. The lawsuit claimed that without reevaluation, Gelman "will suffer irreparable harm through loss of or damage to reputation or goodwill with customers, with the public and with its employees, jeopardizing of its position with local, state and federal government entities and exposure to liability through public and private claims" (Reynolds, 1/26/88).

On February 2 the DNR responded to Gelman's charges by calling them "conclusory and unsupported" (Cohen, 2/2/88). The DNR claimed that it was "undisputed" that Gelman was responsible for the contamination of groundwater by dioxane in the area. The DNR response further stated:

> Between April 1987 and January 1988, as groundwater contamination continued to spread essentially unremedied, Gelman's officers, lawyers, and public relations specialists have attempted to convince DNR staff that the Gelman site assessment score was erroneous and/or the process by which it was derived improper (Cohen, 2/2/88).

The next in the chain of lawsuits emerged on January 7, when Gelman filed suit against Dow Chemical Company, Union Carbide, and six smaller chemical companies: Ashland Chemical Company, Chemcentral Detroit Corporation, McKesson Corporation, Van Waters & Rogers Inc., PVS-Nolwood Chemicals, and Ecclestone Industrial Chemical Company (all of which allegedly sold dioxane to Gelman).

According to Stephen Cain and Roy Reynolds, reporters for *The Ann Arbor News*, "The key to the Gelman suit is the accusation that the defendants were negligent in not testing dioxane for persistence in the environment or giving the company adequate instruction on how to handle the substance" (Cain and Reynolds, 2/24/88). In the suit, Gelman asked for all costs of cleanup and costs to cover any claims filed against Gelman. It also asked for compensation for loss of reputation, goodwill, present and future revenues, and property value (Cohen, 2/24/88).

Attorneys for two of the defendants, PVS-Nolwood and Ecclestone, denied that their clients had ever sold dioxane to Gelman. Dow's lawyers also denied any liability in the case (Cohen, 2/24/88).

On February 26, the Attorney General's office, on behalf of the DNR, the Natural Resources Commission, and the Water Resources Commission, filed suit against Gelman. A press release prepared by the Attorney General's office stated:

> Gelman has engaged not one, but three high-priced law firms to fight us on this case. These firms have tried to turn the focus in every direction except where it belongs, with Gelman. Instead of spending millions of dollars on fighting their responsibility, Gelman should be working to clean up the mess they have caused (Cohen, 2/26/88).

The Attorney General's lawsuit contained many allegations of misconduct by Gelman over the years. Some of the main points addressed are as follows:

> Gelman's releases of toxic chemicals, including, but not limited to, 1,4-dioxane, have polluted, impaired, or destroyed the State's resources, including groundwaters, surface waters, and soils. The continued presence

> of toxic chemicals in soils, groundwaters, and surface waters at and near the Gelman site will, until abated, cause further leaching and migration of contaminants, threatening public health, welfare, and natural resources.
>
> Based on hydrogeologic and groundwater quality data on the Gelman site available to MDNR, including hydrogeological investigation reports and data prepared by Gelman's consultant, releases of toxic chemicals from the Gelman site are principally, if not exclusively, responsible for the groundwater, surface water, and soil contamination at and around the Gelman site (Kelley et al. v. Gelman, 2/26/88, p. 19).

The suit also addressed monetary compensation the State was seeking for bottled water and water main extensions, for which the State had spent $28,000 and $446,000, respectively. In addition, the State was seeking the establishment of a fund for alternate water supply for residences which may become contaminated in the future (Kelley et al v. Gelman, 2/26/88, p. 18).

The allegations of the lawsuit conclude with, "Despite repeated requests by Plaintiffs, Gelman has refused to enter into an enforceable commitment to comprehensively investigate, abate, and remedy the environmental contamination at and emanating from its site" (Kelley et al. v. Gelman, 2/26/88, p. 19).

On April 11, Gelman's lawyers filed their response to the State's lawsuit against Gelman, which denied allegations made by the Attorney General. The response stated,

> Gelman admits that reports of analyses of samples taken from water supply wells...indicated the presence of...dioxane, but denies that these wells are or were contaminated...The defendant has not caused and is not responsible for any pollution, impairment, destruction or contamination of the waters or other resources of the state (Cohen, 4/13/88).

Gelman's response challenged many of the State's specific allegations. For example, Gelman claimed not to have refused to enter into a voluntary cleanup agreement with the DNR. Gelman also claimed to have been in full compliance with all state licenses and permits which had been granted them. (Cohen, 4/13/88).

At present, these lawsuits are awaiting further action in the courts. It is not unlikely that the litigation will continue into the 1990's. Gelman's cleanup is presently on hold, awaiting a modification for their deep well permit. Although Gelman claims to have spent approximately one million dollars thus far in cleanup activities (Cohen, 4/17/88), it is very possible that the contamination is continuing to spread. Gelman's manufacturing process continues and wastewater is currently injected in to the deep well or disposed of in the Ann Arbor municipal sewer system. There are many who believe that both of these disposal methods are potential sources of future contamination.

INTRODUCTION TO ANALYSIS SECTION

This case study raises many questions: how dangerous is dioxane? how safe is Gelman's deep well? how effective have government regulatory agencies been? and how are rural residential areas of Ann Arbor affected by groundwater contamination? We have investigated these issues and others in an effort to form a comprehensive picture of the Gelman case.

While investigating incidents specific to the Gelman case, it became obvious to us that we could not isolate this case from its larger social, political, and economic context. This section, in addition to analyzing this specific case, addresses many of these general issues and themes surrounding environmental contamination:

- The use of technological solutions, rather than the examination of the root causes of pollution, in response to environmental problems.
- The tendency of government agencies to act "reactively" as opposed to "proactively" to find solutions to our waste management problems.
- The exclusion of citizens from the various decision making processes which affect the general health and welfare of society.
- The University of Michigan's role as "expertise-provider" for industry.
- Grassroots citizens' movements as an effective force in creating change.

The analysis section is divided into seven parts. The first two explore risk assessment and deep well technology--scientific and technological issues relevant to Gelman. The remaining five explore social, political and economic issues. These include land use planning, citizen participation, the University of Michigan's role, the DNR's role, and Gelman's response to the contamination.

SCIENCE AND TECHNOLOGY ISSUES IN THE CASE STUDY

RISK ASSESSMENT AND THE HARTUNG REPORT

In September 1987, Dr. Rolf Hartung, professor of Environmental Toxicology in the School of Public Health at the University of Michigan ("U-M"), issued a report entitled "Draft Health and Environmental Effects Assessment for 1,4-Dioxane" ("the Hartung Report"). The report, commissioned by Gelman Sciences, Inc. ("Gelman"), is a literature review of all toxicological and epidemiological studies on 1,4-dioxane ("dioxane"). It concludes with an estimation of risk for dioxane using a variety of statistical models.

Dr. Hartung, a member of the Science Advisory Board for the United States Environmental Protection Agency, is a respected member of the Public Health community. Thus, his report may figure prominently in the outcome of the lawsuits which the Michigan Department of Natural Resources and Gelman have filed against one another. The DNR is suing Gelman because Gelman has neither submitted a remedial action plan in a timely manner for the contaminated area, nor submitted a plan to stop the spread of the contamination. Gelman is suing the DNR because Gelman feels it has been ranked too highly and unfairly on Michigan's priority list of contaminated sites (see The Story, p. 69)

Based on this report, an exposure level corresponding to a predetermined "acceptable level of risk," and therefore an acceptable level of contamination, may be set. This will determine what (if any) level of cleanup will be undertaken. Gelman has used the Hartung report to support its position that the safe level for groundwater be set at 3 parts per million (ppm), with 16 ppm established as the safe concentration for surface water (Gelman Remediation Plan, DNR Files, 2/4/88). These target levels would entail less

extensive cleanup than that required by the DNR. The DNR maintains that groundwater must be cleaned up to background levels.

We do not pretend to be toxicologists and will not attempt to analyze Hartung's report. However, we feel it is important to present the major issues surrounding the Hartung report and the field of risk assessment in general. There is considerable debate about the scientific models and techniques employed in risk assessment. A thorough discussion of this debate will place the Hartung report in a larger context and demonstrate the uncertainty, as well as the political nature of risk assessment. This section concludes with a summary of carcinogenic theory, an overview of the Hartung report, and the DNR's critique of that report.

Risk assessment: what is it?

Every day we engage in risk assessment at some level or another--consciously estimating the probability that we will suffer harm or loss from an activity, while simultaneously estimating the probability that we will benefit from that activity. We also consider the magnitude of harm or benefit in our calculations before choosing between our alternatives. For example, we may choose not to run a red light because the expected benefits (getting home one minute earlier) do not exceed the possible costs (a traffic accident or ticket). If we run the light at the height of rush hour traffic, our chances of being in an accident are very high. Similarly, we are exposed to many hazards in our environment (e.g. pollutants in the air and drinking water). In these situations we are dependent upon government regulatory agencies to assess risks for us .

Risk assessment is defined as the "process of determining the adverse consequences that result from the use of technology or some other action" (Conservation Foundation 1985, p.6). This process consists of three parts:

1) an estimate of the probability of a hazard occurring;

2) the determination of the types of hazard posed; and

3) an estimate of the number of people, wildlife, and environmental elements likely to be exposed to the hazard and the number likely to suffer adverse consequences.

Although the Conservation Foundation speaks in general terms, this definition can be applied to the risk assessment of chemical compounds--the use of scientific studies (toxicological, epidemiological, etc.) to determine if a compound poses any threat to humans or other organisms and the degree to which this threat exists. More specifically, it entails determining if a chemical causes a particular effect (usually through experiments on animals), and the probability that a particular effect will occur at different dosage levels in test animals. The last steps consist of extrapolating dose-response data to human populations and then estimating how many individuals are exposed to the particular hazard and to what extent they are exposed. Finally, the magnitude of human risk is calculated ("risk characterization"), taking into account the exposure assessment and dose-response extrapolation.

Risk characterization includes presenting estimates of numerical risk. For example, numerical risk for a hypothetical carcinogen "x" might be expressed as the concentration of "x" in drinking water which will produce one excess case of cancer in a population of 1,000,000 persons exposed to "x" for a lifetime (70 years). The numerical risk assessment usually assumes the average person weighs 70 kg (170 lbs) and consumes 2 liters (approximately one half gallon) of water a day. Concentration is often expressed as parts per million (ppm) or parts per billion (ppb) and refers to the milligrams of "x" in one liter of water (Nesmith, 9/7/83(b), Federal Register, 9/24/86, pp.33993-99; and Cohen, 4/3/86).

In a typical toxicological study, a researcher might test a chemical on a group of several hundred rats. Some of the rats become "controls" and are not exposed to the

chemical, but are treated like the exposed rats in every other way. The non-control rats are exposed to the chemical by one of several routes: intravenously, orally, through the air they breathe, or dermally (skin contact). Dosages of the chemical are administered at different concentrations ranging from zero to the maximum dose which can be tolerated by the animal. High doses are used to increase the incidence of cancer, thus reducing the number of rats that would typically be needed in a low-dosage study. This would also shorten the time frame of the experiment, which is important since the lifespan of a rat is only two years. After a predetermined period the tissues of the animals are examined for effects of the chemical. If they die before the preordained period, their tissues are also examined. If rats exposed to the chemical show a higher incidence of tumors (that is statistically significant) than control rats, then the chemical would be a suspected carcinogen, and the dosage at which carcinogenesis occurs will be determined from the dosages administered. Such evidence suggests, but does not conclude, that a substance is carcinogenic in humans (Cohen, 4/3/86; and Nesmith, 9/7/83(b)).

From the high dosages administered, statistical models are used to extrapolate to the low dose region. A low-dose response curve is constructed so that the carcinogenicity of small concentrations (which are more likely to be encountered under non-experimental conditions) can be determined This low-dose response curve is extrapolated from rats to humans using conversion or safety factors. There are a number of uncertainties inherent in extrapolating as outlined above. Depending on the statistical models and safety factors used, the results can vary tremendously.

There are many types of studies used to assess the various aspects of a compound. In addition to carcinogenicity, other effects assayed include teratogenicity and mutagenicity. A teratogen is "an agent or factor that produces physical defects in the developing embryo or that otherwise produces an adverse birth outcome" (Legator, et al., 1985, p.25). Mutagens, which may or may not be carcinogens, are agents which damage the genetic

material of the cell. They may cause point mutations* or genetic changes which affect entire chromosomes (e.g. through breakage or duplication).

It is important to note that the impetus behind risk assessment is not to predict how many individuals exposed to a chemical will contract cancer, but to determine the exposure level which corresponds to "acceptable risk" levels. For instance, one in one million excess deaths may be considered the acceptable level of risk. Given this, risk assessment attempts to define the concentration of a contaminant a person can be exposed without incurring a higher risk than that.

The politics of risk assessment

"Environmental Risk Assessment," defined in a broad sense is a process in which scientific, political, economic, and social data are considered in making an ultimate decision regarding the "prohibition, control, or management of chemicals in the environment" (Conway, 1982). This definition recognizes that scientific studies are insufficient to make a judgment on a compound and also recognizes that decisions regarding the use of a chemical are not made in a political or economic vacuum. It describes the larger process of regulating a chemical.

The EPA, in "Guidelines for Carcinogen Risk Assessment," describes "risk assessment" and "risk management" as two separate processes. Risk assessment deals only with the assessment of the "adverse health consequences of exposure to toxic agents..." (Federal Register, 1986, p. 33993). The EPA describes "risk management" as the merging of these scientific data with socio-economic, political and other factors in

* Point mutations affect single nitrogen bases in the DNA. Nitrogen bases are the "letters" of the genetic code; there are only four bases or four letters in the DNA "alphabet." (A,T, C, and G for adenine, thymine, cytosine and guanine respectively). Changes in these "letters" affect the message encoded, and may be detrimental to the organism.

deciding how to control exposure to a toxic chemical. Thus, according to either definition above, scientific studies contribute to, but do not dictate, decisions regarding regulation of chemicals.

Priorities for determining which chemicals undergo risk assessment

There are an estimated 60,000 chemicals in use in the United States. Since it would be nearly impossible to assess each of these chemicals, not every chemical is tested. How do agencies decide which chemicals to assess? Some direction is provided by the scientific community, but other parties and factors also influence the agenda (Conservation Foundation, 1985).

Chemicals which cause birth defects are also dangerous, and one might argue worse than carcinogens, because they affect an individual's entire life. Nonetheless, assessment priority is usually given to suspected carcinogens, perhaps due to the public's fear of contracting cancer. Also important in determining which chemicals will receive assessment priority is the number of deaths the chemical causes. This raises questions of whether chemicals that increase the death rate in older individuals are as dangerous as ones that increase childhood mortality (Conservation Foundation, 1985).

Furthermore, if a chemical does not cause cancer, but is correlated with an increase in some chronic disease, should it be more heavily weighted? How do we compare the loss of work time to society due to chronic illness, with cancer deaths of retired individuals? How do we weigh the risks to non-human populations?
These are some of the many questions underlying the risk assessment process which cannot be answered through an objective ranking system. Priorities are set and risks are often evaluated in terms of non-scientific criteria.

We will return to this point repeatedly; risk assessment is not an exact science. There is much uncertainty involved and much disagreement about methods of risk

assessment. In Hartung's report alone, there are 50 different risk estimates for dioxane. He used five statistical models and ten studies to arrive at these estimates.

Scientists are limited in their ability to arrive at risk assessments for many chemicals because of the lack of adequate models and data available for most compounds. Furthermore, the assessment and regulation of a compound does not occur in a political vacuum. Those parties interested in the prohibition of a chemical may influence the assessment process, as can those parties who would benefit from its continued use. The National Research Council has concluded that "the choices encountered in risk assessment rest to various degrees on a mixture of scientific fact and consensus, on informed scientific judgement and on policy determinations" (Conservation Foundation, 1985, p. 31).

The economic debate

There is ongoing debate between the regulatory agencies and industry as to what constitutes fair risk assessment. Garrett (1979), in her article "Understanding Cancer," describes the debate over carcinogen regulation as "the most heated scientific-governmental-industrial debate our country has ever witnessed." On one side of the debate are industry supporters who say that because our technological ability to detect chemical contamination has outstripped our ability to assess the risks posed by each chemical, government is being overly cautious in restricting chemical use (Nesmith, 9/4/83(b)). They claim that it takes much higher concentrations of a chemical than previously suspected to cause cancer. (Gelman maintains that this is true of dioxane.)

Joining the debate are environmentalists--scientists and citizens who argue that, because the interpretation of scientific data is so uncertain, "...the whole business of regulating carcinogens is too uncertain to take any chances with public health." They support the hypothesis that it only takes minute quantities of a substance to initiate

carcinogenesis, and that regulatory policy must reflect this (Nesmith, 9/4/83(b)). (The DNR has taken this position with respect to dioxane.)

Industry maintains that overzealous regulation is harming the nation economically. According to Gio Batta Gori, former deputy director of the Division of Cancer Cause and Prevention at the National Cancer Institute, "undeniably human life has transcendent value. But excessive regulation hampers technological development and denies its fruits to the poor in our own society and elsewhere in the world" (Gori, 1982, p.176.).

Gori's concerns about the unreliability of scientific methods used in risk assessment are shared by individuals on both sides of the debate. However, his assertion that over-regulation will hurt the poor appears to be a conviction shared only by those on the "industry side." He assumes that technological development helps the poor, while ignoring the fact that often the economically and politically disenfranchised are those most affected by environmental contamination. The United Church of Christ Commission for Racial Justice found a significant correlation between race and the location of uncontrolled toxic waste sites. "Three out of every five Black and Hispanic Americans lived in communities with uncontrolled toxic waste sites." It was also found that the likelihood of the siting of a hazardous waste facility in one's community increases as socio-economic status decreases (The Commission for Racial Justice, United Church of Christ, 1987, pp. xii-iv).

Gori suggests that the process of risk assessment be removed from the political domain : "Safety might be achieved with greater fairness, by an approach that explicitly recognized the socio-political nature of regulation and resisted the temptation to force arguments under scientific disguise" (Gori, 1982, p.177). He implies that the risk assessment agenda is under the influence of special interests pushing a hardline or "zero-risk" stance. Although he argues for objectivity and political neutrality, it appears he is "pushing" the interests of a large special interest--industry. He is essentially arguing that one political agenda be replaced by another. His article concludes, "All human lives cannot be preserved at all costs" (Gori, 1982, p.177)

This statement echoes those of James Tozzi of the Office of Management and Budget (OMB)--"the number two person in the White House regulatory reform office in the early '80s"(Nesmith, 12/25/83).* Tozzi stated, "What we are saying is the government will protect you to the degree of economic prudence, but some Americans are going to die" (Nesmith, 12/25/83). Tozzi had been a driving force behind the Reagan administration's efforts to enact regulatory reform, and had strongly pushed for more lenient regulation of carcinogens. Tozzi pressured the Food and Drug Administration (FDA) to go easy on Red Dye No. 19, a suspected carcinogen, after meeting with industry representatives. The FDA subsequently delayed action on Red Dye No. 19. These events caused a commotion in Congress; former EPA chief of staff John Daniel testified in a House hearing that the OMB was allowing itself to be used as a "conduit" between industry and regulatory agencies for influencing regulatory policy (Nesmith, 12/25/83).**

In another case, the Reagan administration implemented a policy of evaluation of EPA employees based on how quickly they resolved pesticide/herbicide issues (Nesmith, 9/4/83(a)). Since the rejection of an application usually leads to a protracted battle between the company which proposed the pesticide/herbicide and the government, this policy change increased the odds that a pesticide/herbicide would not be reviewed thoroughly before it was approved.

An example of this occurred in 1982 when Uniroyal applied for approval of its herbicide Harvade. Although the raw data submitted with the application indicate the chemical causes brain tumors in rats, this evidence was disregarded in Uniroyal's interpretive report. An EPA employee then copied the Uniroyal report verbatim, and also ignored the data's true implications. Although in this case this blatant oversight was later

* James Tozzi later resigned from OMB and started a consulting agency to assist companies having trouble with government regulations (Nesmith, 12/25/83).

detected by another EPA employee who reviewed the data, the pesticide had been well on its way to approval.

Ethylene dibromide (EDB), a fumigant and suspected potent carcinogen, was being phased out under the Carter administration. In toxicological assays it had been shown to cause at least seven types of cancer, including those of the liver, lung, spleen, kidney, mammary gland , adrenal gland and stomach. It also caused mutations in several plant and animal species. Dr. Victor Alexander, medical officer at the Occupational Safety and Health Administration (OSHA), commented that the case against EDB was "so strong," there was no question that it should be banned.

In sharp contrast, John Todhunter, then assistant administrator of the EPA, recommended not only that the phasing out order be rescinded, but that the office that had recommended this action be disbanded. At that time, 450 million pounds of EDB were produced annually for use in agriculture and the petroleum industry; manufacturers of EDB and farmers had lobbied to keep it on the market. It is likely that Todhunter's actions resulted from this lobbying effort (Nesmith, 9/25/83).*

When profits are at stake, industry's argument that strict regulation is harmful to everyone, appears particularly specious. In this regard, Dr. Samuel Epstein, professor of environmental medicine at the University of Illinois commented, "Attempts by industry and its consultants to dismiss or explain away the carcinogenicity data, lack scientific validity and are patently self-serving" (Nesmith, 9/4/83).

Science is often portrayed as an unbiased and objective field. It is not, however, conducted in a vacuum. These examples are cited to illustrate the highly political nature of scientific regulatory policy.

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* John Todhunter was one of the EPA officials (along with Anne Burford) who resigned during the House's investigation of EPA handling of Superfund. (Nesmith, 9/25/83(a)).

This case study involves two parties with unequal distributions of money and influence. Gelman has the money to hire experts, the resources to do their own studies, and access to high-powered legal counsel. The residents neighboring Gelman do not. This disparity in resources has given Gelman greater influence and leverage throughout the case history.

The uncertainties of science

A discussion of scientific studies will elucidate some of the problems associated with making definitive statements about the risks associated with toxic chemicals. In determining whether a chemical is teratogenic, carcinogenic, or otherwise toxic to humans, the scientist must rely (in most cases) upon data from animal experiments. Because humans differ metabolically from animals, the researcher can never be sure results will apply to humans. Test data are also complicated by the fact that there is not only interspecific (between species) variation, but also intraspecific (within a single species) variation. A chemical may be categorized as having low carcinogenicity, but this categorization does not account for variability among individuals in their genetic susceptibility to particular carcinogens (Federal Register, 1986).

Researchers extrapolate from high to low dose regions using statistical models. However, there is no consensus on which model to use. The EPA notes, "...different extrapolation models may fit the observed data reasonably well but may lead to large differences in projected risk at low doses" (Federal Register, 1986, p. 33997). It is also likely that different models will be appropriate for different chemicals. When there are limited data and much uncertainty regarding the "mechanisms of carcinogenic action," the EPA recommends the use of a linear model for extrapolations into low dose regions (Federal Register, 1986, p. 33997).

Another complication arises when the low dose response curve is extrapolated to humans. This involves the use of some conversion or safety factor to account for the differences between humans and animals. Two commonly used factors are based on surface area and body weight; each yields different results. In the absence of adequate data, the EPA recommends surface area conversion (a conservative approach), because "certain pharmacological effects commonly scale according to surface area" (Federal Register, 1986, p. 33998).

An example of how use of different statistical models, species, and scaling factors can lead to widely disparate risk estimates is illustrated in the case of the cleaning solvent perchloroethylene (PCE). Two studies which used mice and rats, and employed different models and safety factors, yielded risk assessments which differed by a factor of 35,000 (Conservation Foundation, 1986).

It is often assumed (sometimes incorrectly) that compounds which are carcinogenic in animals will also be cancer-causing in humans. The reverse may also be true. Compounds which are carcinogenic in humans, but not in animals, will go undetected in animal assays (Rall, 1980).

There are other problems with experimental results. Due to time and cost constraints, few chemicals have been tested over a wide range of species. Also, even though a study may adequately demonstrate carcinogenicity, little has been learned of its reproductive, developmental, neurobehavioral, and mutagenic effects (Rall, 1980). Unfortunately, assays to demonstrate these other effects (except for mutagenicity) have not been well developed (Interviews with Foran 3/31/88, and Head, 3/30/88).

Quite often very few studies have been done on a particular chemical, and those conducted may have used an experimental protocol which makes it difficult to adjust the results to human standards. For example, those making an assessment may find themselves trying to extrapolate from studies in which rats received a compound by

intravenous injection, when the human exposure route is more likely to be by ingestion or by inhalation.

Most chemicals are assayed alone, rather than in conjunction with other chemicals. A problem results, then, if two chemicals are synergistic--exhibiting greater carcinogenicity or toxicity when administered together (in a multiplicative fashion) than when administered alone. Exposure to a myriad of compounds occurs in the course of one's lifetime. Synergistic, as well as additive effects may thus be particularly important (Conservation Foundation, 1985). Some (e.g. Hartung), however, claim that synergistic and antagonistic factors may cancel each other out.

Epidemiological evidence (evidence from studies done on human populations) is preferred for use in risk assessment. However such data, if existent, are often sparse. A population's exposure to a particular chemical is difficult to determine since individual lifestyles and activities vary greatly. Furthermore, human populations are exposed to many compounds, making it difficult to distinguish the effects of one specific chemical. An exception to this is occupational studies, in which the exposure to a chemical is well known and the population may be fairly homogenous. Human control populations (i.e. unexposed populations for comparison purposes) may be difficult (if not impossible) to find (Conservation Foundation, 1985).

Carcinogenesis: current theories and controversies

An overview

Much of the confusion over methods of risk assessment, stems from a lack of knowledge of the mechanisms of carcinogenesis. Cancer research is proceeding rapidly, but many unknowns remain. Currently, researchers believe that chemical carcinogens are of two general categories: 1) initiators, and 2) promoters. It is believed that the two act at

different stages in carcinogenesis. Initiators lead to permanent genetic damage. The role of the promoter ("cocarcinogen") is less well understood. Due to these different actions, many have proposed that promoters be less stringently regulated than initiators. Because mechanisms are uncertain, and few assays exist for differentiating between carcinogen types, others have resisted this trend. EPA guidelines treat promoters and initiators equally, except in cases when "there is evidence to the contrary because it is, at present, difficult to determine whether an agent is only a promoting or cocarcinogenic agent" (Federal Register, 1986, p. 33995).

This issue is crucial to understanding the Hartung report, which posits that dioxane is a threshold* carcinogen. Hartung states, "It is most probable that 1, 4- dioxane acts as a promoter or epigenetic** carcinogen at those high dose levels. This approach to risk assessment of 1, 4-dioxane implies a threshold below which no carcinogenic responses would occur" (Hartung, 1987, p. 80). The DNR maintains that there is not enough evidence to support this hypothesis, and that dioxane should therefore be handled as a non-threshold carcinogen. In the following section, we develop these distinctions more clearly, in order that their impact on the Gelman case becomes evident.

Carcinogenesis: Cancer cells are cells characterized by unrestrained growth. They do not die off as normal cells do, but continue dividing, resulting in a mass of tissue called a tumor. If not removed or controlled in some way, death of the organism will result.

Scientists understand generally the way chemical carcinogenesis works. They believe it to be a multi-step process in most cases. The initiator begins the process by inducing a permanent change in a cell's genetic material (e.g. a point mutation or chromosomal rearrangement). This change leads to cancer when the promoter, a second

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* Threshold carcinogens act only at a threshold dosage level; below this dosage the chemical is rapidly metabolized and excreted without causing harm to the organism.

** An epigenetic carcinogen is capable of causing the activation or expression of genes leading to transformation, but does not alter genetic material.

chemical, is present. The promoter causes the cell to divide, thus expressing the change made by the initiator. The initiator and promoter do not necessarily act on the cell simultaneously. In most cases the promoter is believed to act on the cell much later than the initiator. It is known that the initiator must always precede the promoter. This delayed activation of the carcinogenic change may explain the tendency for humans to be more likely to develop cancer as they become older. They have lived longer and thus a have a greater likelihood of having encountered initiators and promoters (Prescott and Flexer, 1982).

Some initiators are termed **complete** or **ultimate** carcinogens, because they are capable of producing both the necessary genetic change and promoting this change.

There is presently enough data to support the existence of promoters, although their actions are not well understood (Interview with Head, 3/30/88). The fact that some cancer cells will revert to normal cells under certain conditions provides evidence for promoter existence. The genetic makeup of such cells has not changed. Thus, promoters are said to be **epigenetic**--they may cause the activation or expression of genes leading to transformation, but they do not alter genetic material as initiators do (Oppenheimer, 1982). It is unclear how this actually occurs; researchers propose that the promoter could lead to the expression of genes coding for a certain protein. This protein may precipitate a series of events leading to the cell's transformation into a cancerous cell (Interview with Head, 3/30/88). This change may last only as long as the promoter is in contact with the cell. Thus, if the promoter is only present for a short while, the cell may revert to normal.

The initiator-promoter process can be compared to damage done to a wooden board. If a nail is driven into the board, a change results. This is analogous to the genetic change created by the initiator. The board remains essentially the same despite the nail, and can still "function" normally as a bookshelf (or other intended purpose). Similarly, if the board is soaked in water, it will dry, returning to its initial state. However, if this treatment is continued, the board will become permanently warped. If a nail had been driven into a

weak spot, the warped board might split into two pieces, thus becoming permanently damaged. Both the nail and soakings would be necessary to bring about this "split" state (Interview with Head, 3/30/88).

This analogy illustrates the difference between promoters and initiators and the reasons some researchers believe the two should be regulated differently. The initiator affects permanent genetic change, requiring an event to occur only once. The amount of carcinogen involved may be small--one "nail." The promoter, on the other hand, must work repeatedly to alter the cellular control mechanisms. Thus, prolonged contact with it may be necessary. (The cell can "dry out" if only "soaked " once, or for a few short periods.) Thus, the hypothesis has been established that promoters act at some "threshold" dose, below which they are not harmful to the cell.

Although evidence supports this mechanism, much remains unknown about the promoter-initiator process. Presently, initiators and promoters cannot be readily differentiated in laboratory assays (Interview with Foran, 3/31/88). Scientists are thus reluctant to revise regulations to classify promoters as threshold carcinogens. This fundamental disagreement about the initiator-promoter process has created a divergence of opinion between industry and environmentalists concerning carcinogen regulation.

The state of Michigan has not been immune to this controversy. In June 1987, the Critical Materials Register (CMR) Scientific Advisory Board* in Michigan proposed that chemicals currently on the CMR be reevaluated in terms of their mechanisms of carcinogenesis (promoter vs. initiator). The proposal would have removed some chemicals from the CMR and would have directly affected the ranking of all chemicals. The National Wildlife Federation noted in a letter to the director of the DNR that many different state and federal agencies use the CMR to identify "potential pollutants of concern," and that this proposal would affect "the MDNR's toxic pollution control programs," and would

* Dr. Rolf Hartung and Dr. Jeffery Foran are both members of the CMR Advisory Board.

"undermine the state's enforcement position in several pending matters." Gelman's case was among the pending matters. If this proposal had been adopted, dioxane would have been one of the first chemicals reevaluated for exclusion from the CMR (Foran, and Van Putten, 6/27/87).

The National Wildlife Federation opposed these changes on the grounds that good science (i.e. differentiating between different types of carcinogens) does not necessarily imply good policy. "Our conclusion is that the CMR should continue to weight all suspected human carcinogens, regardless of theories of action" (Foran, and Van Putten, 6/27/87). At present there have been no changes in the CMR; the matter remains under discussion. (Interview with Foran, 4/19/88)

The Hartung report

The Hartung Report is an extensive review of scientific studies done on 1,4-dioxane. It concludes by using a series of statistical models to estimate risk using the gathered data. The risk estimates determined from these models exhibit great variation, depending on the model and data used. Both threshold and non-threshold models were used in this risk assessment; however, Hartung recommends a threshold model as more suited for estimating the risk level of dioxane. He concludes that the data collected support the hypothesis that dioxane acts as an epigenetic or threshold carcinogen (Hartung, 1987, p. 80). Based upon a threshold mechanism, the reference dose of dioxane for humans becomes 3 ppm in water (0.096 mg/kg/day or 3.36 mg/l for a 70 kg human). The Michigan Department of Natural Resources has critiqued this report, maintaining that studies to date do not provide sufficient evidence to characterize dioxane as an epigenetic carcinogen.

Major points discussed in the Hartung report

1,4-dioxane is a solvent with many industrial applications. It dissolves in water and some organic solvents, and readily moves through groundwater. It is subject to photo-oxidation and will break down in sunlight and air in 3.9 days. Dioxane is described as relatively resistant to biodegradation in water and soils. It does not appear to bioaccumulate or bioconcentrate (Hartung, 1987, p. 3).

The report surveys experimental tests of dioxane's toxicity (chronic and acute) in rats, mice, guinea pigs, bacteria, and aquatic organisms, and observational studies in humans. In studies done on aquatic organisms to date, it has shown low toxicity (Hartung, 1987, pp. 25-27). Pharmacokinetic studies (referring to the absorption, metabolism, distribution, and excretion of a chemical) in rats indicate that dioxane is metabolized to HEAA (ß-hydroxyethoxcyacetic acid) in the body. At high dosages in rats the metabolic pathways become saturated, and the ability of the body to metabolize dioxane declines. This evidence supports the contention that dioxane causes toxic effects at some threshold level, below which it is rapidly metabolized and excreted without causing harm to the organism (Hartung, 1987, pp. 28-42).

The liver and kidneys are target organs of 1,4-dioxane. High levels of dioxane have been associated with kidney and nasal tumors in rats, and liver tumors in mice (in drinking water studies). Two small epidemiological studies of workers exposed to 1,4-dioxane were discussed; neither study showed an increase in cancers over the general population. Hartung cites two human studies to conclude that the pharmacokinetic properties of dioxane are similar in both rats and humans (Hartung, 1987, pp. 67-68).

1,4-dioxane shows no signs of teratogenicity in the studies Hartung cites, though it does exhibit mild fetotoxicity (harmful to the fetus). It tested negative for mutagenicity in the Ames test.* This lack of mutagenicity is evidence that dioxane does not act as an initiator (Hartung, 1987, p. 78). It did, however, increase DNA breakage and repair

frequency** in studies on rat hepatocytes (liver cells) at high doses (Hartung, 1987, pp. 43-68).

The DNR critique

Dr. Hartung and the DNR disagree over the fundamental mechanisms by which dioxane operates. Maria Martinez, Waste Management Division Toxicologist, authored the DNR's critique of the report. Martinez objects to the classification of dioxane as a threshold carcinogen, stating, "It is my opinion that evidence supporting the epigenetic mechanism of carcinogenesis for dioxane is limited with numerous significant issues remaining unaddressed" (Martinez, 1987, p. 9). The distinction between a threshold (epigenetic) and non-threshold carcinogen is crucial, since it may affect the manner in which the dioxane contamination is handled. Although Hartung uses both threshold and non-threshold models to assess the data, he prefers the threshold model because he believes the pharmacokinetic, genotoxic, and dose-response data can be linked to support a threshold mechanism (Hartung, 1987, p. 78).

Incompatibility of pharmacokinetic and toxicological studies

Hartung cites pharmacokinetic studies done by Young et al. (1978) on rats as evidence that dioxane exerts toxic effects only at high dosages. As mentioned previously, the major metabolic product of dioxane is believed to be HEAA. Rats were given

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* The Ames test is an assay in which mutant bacteria, lacking the ability to synthesize the nutrient histidine, are grown in cultures lacking that nutrient. Only bacteria which reverse this mutation and aquire the ability to synthesize histidine, are able to survive and give rise to colonies. Thus, by counting the number of reverse mutant bacterial colonies capable of growing in histidine deficient media, experimenters can assess the mutagenic ability of a chemical added to the media.

** High DNA repair rates indicate that a chemical induced genetic damage which has been subsequently repaired.

intravenous doses of 3, 10, 30, 100, 300, and 1000 mg/kg, and showed that at high dosages (above 30 mg/kg) the metabolic pathways responsible for converting dioxane to HEAA became saturated. This is evidenced by the decreased rate at which HEAA is excreted in the urine.

In another study by Young (1978), seventeen single consecutive oral doses of dioxane were given to rats, and again showed that, "the proportion of unmetabolized 1,4-dioxane increased as the dose was increased". Hartung also cites a study by Young, in which humans were exposed to low levels of dioxane, as evidence that rats and humans metabolize HEAA similarly (Hartung, 1987, p. 35).

Hartung links the pharmacokinetic studies on rats and humans to acute and chronic toxicity studies done by Kociba (1974) and the National Cancer Institute (NCI) (1978). Since these studies show only tissue damage and tumor formation at high doses, Hartung concludes, "At the high doses at which cancers have been produced, the metabolic pathways for 1,4-dioxane have been saturated, and liver or kidney damage, including liver tumors, have not been detected at exposure levels where metabolic pathways were not overwhelmed" (Hartung, 1987, p. 78).

Martinez criticizes Hartung's conclusion that those dosages at which the metabolic pathway are saturated are the dosages at which toxic effects occur (dosages in excess of 100 mg/kg/d). She disputes this conclusion on the grounds that the routes of administration of dioxane in the pharmacokinetic studies differed from those of the toxicity studies. In the pharmacokinetic studies, dioxane was administered by a single intravenous injection of 100 mg/kg/day. In the toxicity studies dioxane was administered orally, in single or multiple doses. Since we do not know how efficiently dioxane is absorbed into the bloodstream via these routes, Martinez claims we cannot assume that saturation will be reached at the same doses for each route of administration (oral vs. intravenous). We therefore cannot be certain of the equivalent oral dose at which saturation occurs (Martinez, 1987, p.2).

Martinez comments that it is also important to consider the temporal distribution of dioxane. She criticizes Hartung's conclusion that toxic effects observed in rats in which oral doses were increased to 100 mg/kg/day are due to the saturation of metabolic pathways. In the study cited by Hartung, dioxane was administered in the drinking water; the dose was actually administered in small increments (rats do not drink continuously) over the course of 24 hours. Those increments totaled approximately 100 mg/kg/day. Martinez comments, "...it is safe to say that it is very unlikely that plasma level (level in blood) of dioxane would be equal to the level observed when 100 mg/kg was administered in a single bolus i.v. dose" (Martinez, 1987, p. 3).

Martinez notes that there is sufficient pharmacokinetic data from repeated oral doses administered to rats at 1000 mg/kg to conclude that the metabolic pathway is saturated at this level. However, one cannot maintain that tumor formation only occurs at saturation doses simply by linking this conclusion to studies in which 1000 mg/kg doses produced tumors. The pharmacokinetic studies were done at doses of 10 mg/kg and 1000 mg/kg. Thus, even though tumors were formed at 1000 mg/kg, and we are confident the pathway was saturated, we do not know the lowest point of saturation. Tumors and liver damage have been observed at doses of 100 mg/kg and 350 mg/kg, but we have no evidence as to whether saturation occurs at these dosage levels (Martinez, 1987, p. 3). Martinez further notes that the routes of administration between the two oral studies differed.

Martinez's major complaint throughout the Hartung report seems to be that incompatible studies are compared to predict the actions of the compound. We cannot adequately integrate the results of carcinogenic studies and pharmacokinetic studies unless we know more about the pharmacokinetics of dioxane (and its metabolites) when it is inhaled or ingested. We also know nothing of dioxane's carcinogenic moiety, i.e. we do not know whether it is dioxane itself or one of its metabolic products that is the actual carcinogen.

Hartung has concluded from mutagenicity assays that dioxane is not likely genotoxic (toxic at the genetic level). Martinez contends that dioxane's genotoxic potential has not been adequately explored. It tested negative for mutation in the Ames test under varied conditions, and did not increase DNA alkylation* on in vivo studies in rats. These results are taken as indications that dioxane is non-mutagenic. It did, however, stimulate DNA repair at high chronic doses. Martinez further notes that dioxane's actions on chromosomes have not been explored. This may be significant, since many cancers are believed to result from chromosomal damage. Martinez also questions the dosage levels, and length of experiments in the DNA assays which tested negative. "The maximum dose levels used in a lifetime bioassay are determined such that there are sufficient animals surviving at the end of the study. Thus, for less than chronic studies (i.e. short term), higher doses should be used to compensate for the shorter exposure periods" (Martinez, 1987, p. 4).

Finally, Martinez discusses Hartung's inclination to dispense with the surface area conversion (or "safety") factor. Normally, in extrapolating data from rats or other animals, a conversion factor is employed to correct for differences between species. These differences (according to Martinez) include metabolism, size, and pharmacokinetics. Hartung believes the surface area conversion is unnecessary because it appears that the metabolism of dioxane is the same in both rats and humans. Martinez disputes this, arguing that there is not enough evidence to support this claim. Even if there were, the conversion factors do not account simply for metabolic differences, but also for a number of other "pharmacodynamic" properties. These properties include the ability of the organism to scavenge free radicals (important if we assume carcinogens are generally electrophilic compounds looking to "steal" electrons away from DNA or proteins), and to alter DNA repair rate and cell turnover. Furthermore evidence that the pharmacokinetics of

* Alkylating agents are highly reactive chemicals that attack molecules like DNA and RNA and can alter genetic information (Creasey, 1981).

rats and humans are the same is insufficient. Plasma and urinary clearance rates (i.e. the distribution of dioxane and its metabolic products in the blood plasma and urine over time at different dosage levels) have been studied in humans, but the distribution of dioxane and its metabolites in tissues has not been studied (Martinez, 1987, pp.5-6).

The DNR's critique has been presented not because we are certain that all the criticisms contained within it are correct, but to portray the divergence of opinion existing between Hartung and the DNR, as well as to underscore the uncertainties of risk assessment.

Conclusion

In an age when scientists are elevated to a lofty status, the language of science becomes mystical and laden with jargon which bars the uninitiated from participating in the discourse. Marvin Legator, an ex-branch chief of the FDA, calls the belief that only individuals who are well-versed in scientific method have the right to participate in scientific debate, the "myth of exclusivity." He believes that not only can laypeople comprehend scientific procedures and principles, but that they can use them to their benefit. For instance, Legator feels that residents near toxic sites have the ability to conduct their own health surveys and collect reliable epidemiological data to document problems at those sites (Legator, 1985). We do not deny the importance of science, nor deny that some individuals have earned a level of expertise in the sciences. However, we do question the exclusion of citizens from discussion concerning issues that affect their lives.

Dr. Hartung favors a threshold model, while the DNR favors a non-threshold model for the carcinogenicity of dioxane. The residents are essentially removed from the debate, but they will be most affected by its outcome.

It is significant to note that all concern thus far has focused on dioxane as a carcinogen, but what of its other effects? How well has the incidence of chronic illnesses (e.g. rashes, respiratory problems, and reproductive problems) been documented?

Residents in the contaminated region have undergone months of stress and inconvenience. Perceived health threats, family disruption, and emotional distress are important factors which directly affect the quality of life. These should not be overlooked.

Scientific methods for conducting risk assessment are uncertain, as carcinogenesis is not fully understood. Thus, risk assessment is, as of yet, only a tool which can be used to help society decide how to best protect its members. The issue of "How clean is clean" is decided outside the realm of science (Interview with Head, 3/30/88). How is this decision made? One would hope it is made in the interests of multiple parties. Unfortunately, from some of the examples cited, it is apparent that those who have access to power and the money to hire experts, also have the ability to influence decisions. Notably, the residents surrounding Gelman lack this ability.

AN ANALYSIS OF DEEP WELL INJECTION AND ITS APPLICATION TO THE GELMAN CASE

Introduction

In 1981, for a variety of reasons, Gelman began considering the use of deep well injection for disposal of their waste stream. Deep well injection is in many ways symptomatic of our society's attempts to deal with its growing waste treatment problem. The role of science and technology and its relation to our growing waste disposal crisis is a relationship which is seldom considered. Deep well disposal is generally considered a technical solution to a technical problem. The technical problem is characterized as one in which an engineering oversight has created environmental contamination or a waste product which neither economically, scientifically, nor politically can be dealt with adequately by society. Clearly, deep well injection can be more accurately characterized as a way to avoid dealing with this growing problem.

Rather than exploring ways to reduce production of toxic chemicals which our society is not equipped to handle, we simply push this generation's problems onto future generations. The issue of deep well injection must be viewed in terms of the modern economic system's struggle to deal with what is generally considered an "externality." Obviously there is a problem with "externalities" in a closed system. They do not go away. They are either exported to developing countries (e.g. banned pesticides and herbicides), belched out of taller smokestacks onto unsuspecting neighbors (e.g. acid rain-Canada), burned in incinerators which spew toxic fumes, or pumped into deeper and deeper wells. As far as our economic system is concerned, these so-called "externalities" impede economic growth and progress. As a result the system imposes these "externalities" on those who have been externalized by the system itself. Minorities in the U.S. and people

of color in developing countries receive the bulk of the poison produced in the economic centers of industrialized nations.

The following is a detailed analysis of the history of deep wells in general, and a review of the specific issues surrounding Gelman's deep well. This detailed analysis includes a point-by-point discussion of the inadequacies of regulations regarding deep wells. On a broader scale, this analysis is used to provide a picture of how the national push to develop deep wells has blatantly ignored both public safety and environmental protection. We will argue that the direction of resources away from recycling, source reduction, and other alternative treatment and production technologies, is symptomatic of the national problem of the disposal of human generated poisons. Our society's blind reliance on unecological technologies to solve environmental problems must be questioned.

Deep Well Injection

Underground injection has become an increasingly popular form of disposal for hazardous waste in the last twenty years. For the purposes of this case study we will discuss only "deep wells"--wells which transport hazardous waste below "usable" drinking water supplies to depths which are typically one-quarter to one mile below the surface of the earth. These wells are called Class I wells by the Environmental Protection Agency (EPA). Other classes of injection wells include those in which wastes are injected directly into or above usable drinking water.

Most deep well injection occurs either in the Gulf Coast or in the Great Lakes regions. EPA Region V (headquarters in Chicago), which includes Michigan, contains approximately twenty percent of these types of wells (EPA, 5/85, p. 6). The largest user of deep wells is overwhelmingly the chemical industry. Use is divided among manufacturers of organic chemicals (64 percent), petrochemical refining and industry (25 percent), metals and minerals industry (6 percent), aerospace (2 percent), and general

commercial facilities (4 percent) (EPA, 5/85, p. 2). Today, approximately ten billion gallons, or 60 percent of the disposed hazardous waste, is injected (not all in deep wells) (Gordon and Bloom, 1985, p. 1). Most deep wells (89 percent) are operated directly by manufacturers, while only 11 percent of wells are off-site commercial wells. Commercial wells pose a number of problems due to the wide variety of waste they receive, the difficulties in predicting movement of the wastes underground, and the reactivity of mixed wastes. Among the most frequently injected wastes are corrosive wastes, organic compounds, reactive wastes and metals, and spent solvents. Acetone (an element of Gelman's waste stream) is a commonly injected waste (Gordon and Bloom, 1985, p. 6).

The main reason that deep well disposal technologies have been so widely adopted is because in the short term it is economically preferable. One study has shown that even the best alternatives to deep well injection at Class I facilities would be between sixteen and forty times costlier than the current injection system (Guthrie et al 1986). Many have also argued that the reduction of environmental risk is an important factor in the increasing use of deep well injection. For example, the May 1986 Michigan Department of Natural Resources (DNR) study, "Deep Well Injection of Hazardous Waste in Michigan," states this position, yet bases it on several unsubstantiated assumptions about deep wells. While acknowledging that risk can only be assessed on a case-by-case basis, the report goes on to state,"...the risks would generally be higher for the alternative (surface disposal above 'usable aquifers'), since the contaminants would be placed above the aquifers being protected rather than below them" (DNR, 5/86). This statement ignores the fact that the same pathway by which downward migration of contaminants occurs, upward migration may also occur. Yet, as we feel this case study shows, this argument is typical of those used by deep well proponents to convince the public of the safety of deep well disposal.

Rather than investing our future in another unproven disposal technology we should be exploring how to contain the wastes which are being generated so that we know

where they are and where they are going. Deep well technology advocates ignore this issue by assuming that containment (by an unidentified mechanism) of the wastes will occur.

The increase in use of deep well disposal technology has occurred due to several factors. First, increasing concern over illegal, unregulated surface disposal has forced companies to seek alternative disposal techniques. Second, a lack of sufficient state or federal regulation of this activity, especially in Michigan, has led to a lack of commitment to seriously address the issue of industrial wastes in this country.

History of Deep Well Injection

Deep well injection was originally used in the 1930's as an alternative to surface disposal for brines produced from oil fields. The injection of brines into oil fields is a technique for increasing oil yields and is still extensively used today. According to "Deeper Problems: Limits to Underground Injection as a Hazardous Waste Disposal Method" by Wendy Gordon and Jane Bloom of the Natural Resource Defense Council, Inc., almost 100,000 of these enhanced recovery wells are known to be in operation. These wells use injected water or brines to maintain pressure within and thus prolong the life of the oil bearing structure. Brines are injected into both enhanced recovery wells and at least 20,000 wells used strictly for the purpose of brine disposal (Gordon and Bloom, 1985, p. 8). The injection of brines in Michigan began in 1943 when the Dow Chemical Company in Ludington began using a deep well.

Deep well injection of industrial waste began in the 1950's (Clark, 1983, p.2). The first deep well of this type was the Parke-Davis facility in Holland, Michigan, which began operation in 1951. According to the May 1986 DNR report, "deep well injection was considered a method to isolate wastes that could not be easily treated by placing them in deep formations. It was believed that this would separate the waste from the accessible

environment for geological time." However, others familiar with the track record of deep well disposal were not nearly as optimistic.

Problems With Deep Wells and Deep Well Construction

According to Gordon and Bloom (1985), there are at three basic reasons for questioning the safety of this disposal method.

> First, as the experience of the oil and gas industry indicates, underground injection is not an appropriate method for disposal of industrial wastes. Over half (17) of the 32 oil and gas producing states reported cases of groundwater contamination from the disposal of brines (Feliciano, 1983). Contamination of groundwater by injected hazardous waste is now also being reported.
>
> Second, in contrast to oil production brines which are typically returned to the formations from which the oil-gas-brine mixture was originally pumped, chemical wastes are entirely foreign to the rock strata into which they are being injected and may not be compatible with the strata of their native fluids. The injection of incompatible waste streams has proven to be a problem at a number of injection operations, and has resulted in environmental damage, including groundwater contamination.
>
> Third, although the most popular locations for hazardous waste injection operations have been the oil and gas producing regions where abundant macro-scale subsurface geological data are available, very little may be known about the micro-scale geochemical parameters that affect the suitability of a formation to accept and contain hazardous waste. The absence of this information significantly increases the uncertainty associated with injection of hazardous waste (Gordon and Bloom, 1985, pp. 8-9).

The most critical concern for deep well injection is the possible escape of hazardous materials from the injection zone. The United States Office of Technology Assessment (OTA) developed a set of potential contamination pathways out of the injection zone (OTA, 1983, p. 196):

(1) Leak through inadequate confining beds.

(2) Leak through confining beds due to unplanned hydraulic fracturing.

(3) Displacement of saline water into potable aquifer.

(4) Migration of injection liquid into a potable water zone within the same aquifer.

(5) Injection into a saline aquifer that is eventually classified as a potable water source.

(6) Upward migration of waste liquid from the receiving zone along the outside of the well casing.

(7) Escape into potable aquifer due to wellbore failure.

(8) Vertical migration and leakage through abandoned or closed wells in the vicinity.

There many examples where deep wells are suspected of causing contamination of underground water supplies. Two cases indicate some of the potentially extreme effects of deep well disposal.

In Denver, Colorado the Rocky Mountain Arsenal injected wastewater into a deep well from 1962 to 1966. After seven weeks of injection, the well (which was over 12,000 feet deep) began to trigger earthquakes. The earthquakes ranged in magnitude from 0.5 to 5.3 on the Richter scale, with epicenters up to five kilometers from the well. 1,514 earthquakes were recorded between 1962 and 1967. Studies have shown a strong correlation between the amounts of waste injected and the frequency of the earthquakes. The well was finally shut down in 1966, although earthquakes continued into 1967 (Gordon and Bloom, 1985, p. 16, and DNR, 5/86, p. 72).

The second case (this one not involving earthquakes) occurred in 1979 at Presque Island State Park in Erie, Pennsylvania when noxious liquids began seeping out of an abandoned gas well. After initial investigation of companies which produced the seeping liquids, it was discovered that Hermill Paper Company had operated three injection wells from 1964 to 1972 in Erie, Pennsylvania, approximately four miles away. The deep wells are now considered the source of the contamination at the island and government officials are concerned that the contaminants may show up in other abandoned wells in the area. The distance which these wastes migrated has challenged previous assumptions about the

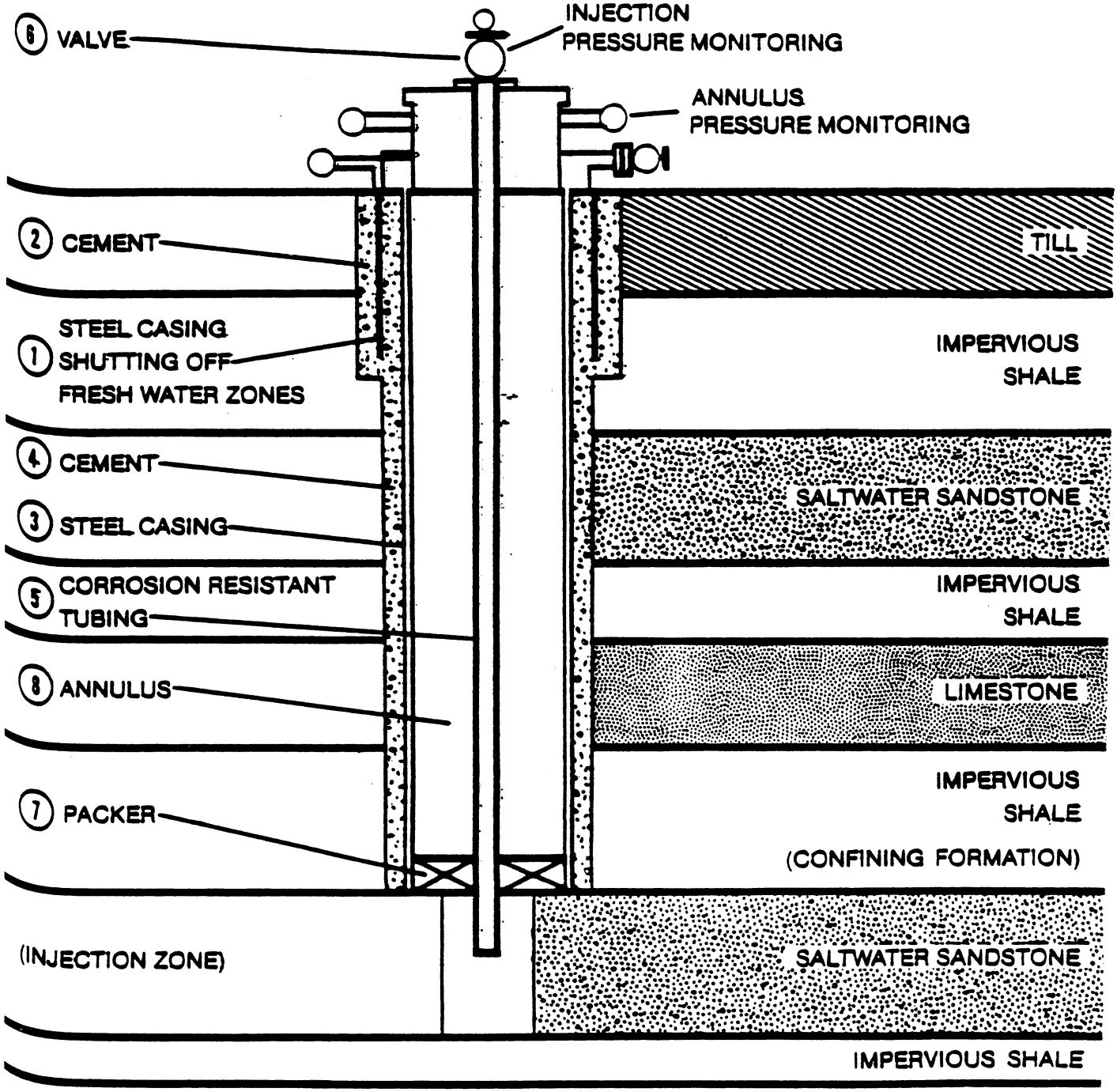
ability of wastes to migrate once they are injected into the ground (Gordon and Bloom, 1985, p. 10, and DNR, 5/86, p. 68).

The existence of multiple potential paths of migration of waste, combined with the fact that we know very little about the actual fate of injected wastes, makes it even more important that we monitor and control injection well facilities closely. Theoretically, a properly designed, built, and monitored injection well should safely deliver waste to the injection zone. Figure 1 shows the usual structure of an injection well to be used for hazardous waste disposal.

These wells are constructed from the outside to the inside. First, a hole is drilled below the level of all drinking water. A steel pipe (1) is placed along the full length of the hole and cement (2) is used on the outside of the pipe to seal the casing to the hole. This steel and concrete barrier provides the first and innermost protection of drinking water sources. Next, the hole is drilled deeper (into the injection zone) and another steel pipe (3) is installed, this time from the surface to the injection zone. This pipe is again sealed with cement (4) on the outside and provides the second barrier between the drinking water and the well. The injection tube (5) is usually a small pipe about 2 1/2 inches in diameter, which is secured and sealed both at the top (6) and at the bottom (8). Once this is done, the space ("annulus" (7)), between the injection tube (5) and outside casing (3), is filled with a non-corrosive fluid that is kept under pressure. Both the annulus and injection pressures are continually monitored to assure that injection waste is not leaking out of the injection tubing at any any point. However, without other systems, such as monitoring wells, annulus and injection pressure monitoring provide little assurance against waste migration (see Monitoring and Well Integrity later in this section).

FIGURE 1.

ENGINEERING AND ENVIRONMENTAL CHARACTERISTICS FOR A TYPICAL DISPOSAL WELL REGULATED BY THE UNDERGROUND INJECTION CONTROL PROGRAM



Source: Adapted from Patrick Sullivan, An Assessment of Class I Hazardous Waste Injection Wells. Ball State University, Muncie, Indiana; 1983.

History of Gelman's Deep Well

In 1978 Gelman was given a National Pollutant Discharge Elimination Systems (NPDES) permit by the DNR to dispose of their liquid plant wastes. The wastes were first placed in a treatment pit and then spray irrigated on company land. According to Gelman officials, alternatives to this process were sought after expansion plans showed that not enough land was available to continue the spray irrigation (Interview with James Marshall, 3/3/88). However, documents obtained from Gelman show that there were other reasons as well. According to a time line prepared by Gelman in 1981, "Deep well injection became the preferred method of disposal--non-controversial." It appears it was a combination of both of these factors, plus increasing public attention on Gelman's existing disposal methods, which led Gelman to consider deep well technology.

The Geological Survey Division of the DNR was contacted regarding the feasibility of deep well injection at the site. According to DNR files, "They (Gelman) were informed (in 1981) that the geology of the area was not well defined but it might be feasible" (DNR Files, 11/3/86). DNR files show that Gelman then contacted the Mineral Well Permit Unit (DNR) regarding a feasibility study. This study was completed and the DNR issued a construction and drilling permit on May 12, 1981. The well was inspected by a DNR engineer during construction and later was pressure tested as required by law. The well, which cost approximately $2 million (Cohen, 11/3/87), began operating in late 1981.

Under the Safe Drinking Water Act (FPL 93-523) which was implemented in 1984, the well had to be retested for mechanical integrity as part of the transfer of permit responsibility from the state level to the federal level. Throughout this permitting process the well was operated under interim rules as mandated by the EPA, which allowed Gelman to continue to use the deep well. Gelman's application for the EPA Underground Injection Control permit ("EPA-UIC" or "UIC") was received on December 20, 1984. After several notices of deficiencies and the resultant filing of new information by Gelman, the application was deemed complete on August 15, 1986. The EPA held a public meeting in

Ann Arbor on September 17, 1986 to answer questions about the well. Residents and others expressed a variety of concerns (EPA, 9/24/86), to which the EPA provided written responses. The permit was granted on September 30, 1986, after the EPA Region V office found none of the citizens' concerns "valid" (EPA, 9/24/86).

After reviewing these comments from the EPA one member of a group of fifteen appellants filed an appeal with 556 signatures, requesting an administrative (national EPA) review of EPA Region V's permitting process The appeals, filed between November 25, 1986 and January 16, 1987, were based on a wide variety of issues and exposed many of the problems with the EPA-UIC regulations. Gelman continued to operate the deep well under interim rules during the appeal process. According to EPA officials in Washington, the appeal was receiving high priority during the summer of 1987 (Interview with Moretta, 7/87). However, the decision did not come until December 1987. The request for administrative review was turned down and Gelman received the permit which was originally granted in September 1986.

Throughout the EPA-UIC permitting process, Gelman continued to use the deep well, despite what was then identified as an expanding contamination plume. The well was first used for disposal of process waste. Beginning in the summer of 1987, in compliance with interim rules of the appeal period, it was used for the disposal of contaminated water which was purged from aquifers. When the request for administrative review was turned down, the original permit once again became effective. Gelman's original permit (granted 9/86) was only for "process waste." Therefore Gelman had to cease disposal of purged contaminated groundwater in the deep well. As a result, Gelman's clean-up operations also came to a halt while Gelman filed for the necessary permit modification. The EPA has recently stated that the Gelman request is only a "minor modification," therefore the entire permit is not up for review (Interview with Moretta, 2/88). Because the contamination has already been classified as non-hazardous by the EPA, Arthur Moretta felt there would be no major problems in granting the permit modification. Gelman, however, is required to hold

a public hearing over this modification because of an agreement with citizens from the first public meeting.

Many of the following concerns arose specifically out of citizen opposition to the EPA-UIC permitting process and the subsequent appeal. In particular, one citizens' group, Tocsin, a main appellant, contributed a very thorough analysis of the issue. Much of the following is a summary of the work done by Tocsin. Other issues appeared in our own investigation of the issues surrounding Gelman's deep well and other deep wells around the country. We feel the following are the most important issues involving the deep well; other concerns will be briefly summarized.

Geology

There is considerable uncertainty inherent in any description of the geology of an area thousands of feet beneath the earth's surface. Modeling and other forms of predictive theory are used in an attempt to assure, with a certain probability, that an expected event will or will not occur. However, interpretations vary of the degree of certainty achieved and the degree of certainty needed. Assessment of a particular activity's risk to human health or the environment is a difficult and highly controversial task (see Risk assessment section). The controversy over differing descriptions of the geology of Washtenaw County and of the Gelman site serves as an excellent case for examining the problems associated with evaluating risk. It also illustrates one of the main concerns with deep well disposal--the uncertainty that the waste will stay where it is placed.

The DNR permitting system, through which Gelman's original deep well permit was granted in 1981, required very little information regarding the geology of the area. At the time, one DNR official stated that "...injection well disposal of wastes is largely unregulated from a water quality standpoint" (DNR Files, 9/9/81). The unregulated nature of deep well disposal (especially in regard to geology) in the 1970's and early 1980's, has

left Michigan and other states with a number of potentially unsafe wells. In 1984 the EPA assumed responsibility for the permitting process and for uniformly regulating deep wells throughout the country. Many problems, however, still exist with the EPA regulations.

In 1984 the EPA began to collect the information needed to develop an UIC permit for Gelman's deep well. Based on information from EPA files and statements regarding the permitting process, the EPA consulted the following sources: the permit application (prepared for Gelman by Golden Strata Services); Gelman's deep well log (prepared by Tooke Engineering); the plat book for the area; "The Hydrogeological Atlas of Michigan" (published by Western Michigan University); Jeanne Ann Fisher's Master's thesis, "Fault Patterns In Southeastern Michigan;" and additional information requested by the EPA and provided by Golden Strata Services for Gelman.

On May 15, 1985 the EPA sent a letter to Gelman stating, "Agency reports indicate the presence of the Washtenaw Anticlinorium: a system of basement faults in Southeastern Michigan, which include the proposed area of review. The information regarding structural geology in your application is so generalized that no reference to this feature was made." On receiving more information and completing their review, the EPA decided to grant the permit. "EPA geologists did not find evidence indicating structural geological problems that could allow upward migration of waste fluids" (EPA, 1/87, p. 9). It is notable that whereas the EPA "did not find evidence indicating structural geological problems," the EPA was not able to find evidence that structural problems did not exist.

Tocsin felt, as did many others, that the EPA had not adequately supported its decision to grant Gelman's deep well permit. The thoroughness of the information available about the region's geology was also called into question. Based on review of EPA documents, Tocsin concluded that the Fisher study (one of the few general studies of southeastern Michigan geology) and the site-specific information provided by Gelman's well log were the primary sources used by the EPA for evaluating the safety of the geology for deep well disposal.

The EPA originally singled out the Fisher study as the one which resolved the "issue of structural geology" (EPA, 9/24/86, p. 10). The Fisher report addresses several theoretical questions about southeastern Michigan geology and cites the existence of fault structures in Washtenaw County (which are both complex and not well documented). The presence of these structures raises serious questions about the safety of southeastern Michigan for deep well injection.

The EPA attempted to support their decision to grant Gelman's deep well permit by citing the Fisher study as proof of a "lack of evidence" of fault structures in the immediate vicinity of GSI. However, nowhere in the report is the specific question of the suitability of southeastern Michigan geology for deep well injection addressed (Fisher, 1981, and Tocsin, 11/26/86). It thus appears to us that the EPA, in the absence of more relevant information, misinterpreted the information provided in the Fisher study. The EPA then used this information to support their position of granting Gelman's deep well permit.

Only after the request for administrative review was filed and the appellants asserted that the Fisher study, contrary to the EPA's contentions, raised more concerns about the region's geology than it resolved, did the EPA acknowledge its error. The EPA stated that the Fisher study "does not provide a detailed analysis of the GSI site nor its suitability for deep well injection" (EPA, 1/87, pp. 9-10).

Issues raised by the EPA's permitting process

The EPA's decision to grant Gelman the deep well permit raises two important questions: 1) the relevance of the Fisher study, and 2) the ability to generalize about the geology of an area from the information generated at one well (the Gelman well). The discussion of the relevance of the Fisher study has focused on two points: first, the relevance of the geological information printed in the study for evaluating the safety of deep well injection; and second, whether or not the Fisher study reflects a general consensus among professionals about the geology of the area.

Geological Information in the Fisher Study

In her report Fisher discussed faults, although their relevance to the safety of Gelman's deep well is unknown. The features addressed in the Fisher report which were most applicable to the Gelman site, include the Howell Fault and the Lucas-Monroe Fault. According to the request for administrative review filed by Tocsin (Tocsin, 11/26/86, p. 3), "The former lies more than ten miles to the North of Gelman," and "the latter cuts directly through Washtenaw County in such a way that the Lucas-Monroe Fault is likely to either directly or indirectly influence the Gelman site." Fisher mapped the fault as passing directly through Washtenaw County. She also claimed that "the Lucas-Monroe is probably a series of faults rather than one single continuous fault" (Tocsin, 11/26/86, p. 64). Therefore, even if one fault was identified, it was implied that there may exist other faults in the area. Because of the complex nature of the faults and a lack of information about them, it is purely conjecture to attempt to deduce the exact location of the fault or faults, and their possible impact on the deep well's integrity.

Yet the EPA contends that "actual data on the location and extent of any such faults is not provided (by Fisher)" (Tocsin, 11/26/86, p. 4). The main reason this is not possible is not because of inadequacies in the Fisher study, but because of a lack of adequate data to document the existence, location, and extent of the faults. It appears that the EPA interprets this "lack of evidence" as proof that the area is fault free, rather than as a lack of information (i.e. a lack of the necessary studies), on the exact location of the fault. Despite what apparent professional consensus that a fault exists in the area, the EPA was unwilling to require that the necessary studies be performed to actually document the faulting pattern. In fact, the EPA demands for "specific evidence" directly pushed the burden of proof onto the citizens who were involved in the appeal. If there is no specific evidence, EPA regulations state, it is up to the operator of the well to provide the necessary information. It should not be the responsibility of citizens to prove the disposal is unsafe.

The need for more complex studies was also reflected in Fisher's study. According to the Requests for Judicial Review (Tocsin 11/26/86, p. 4), " (the) Fisher thesis clearly indicates that while a macro analysis may be suitable for other regions, in this particular case area only a detailed micro analysis of the site's suitability for injection will prevent the agency from taking an unnecessary risk with the public's health and safety." While it is clear that the Fisher study does not provide a definitive statement about the region's geology, the study does recognize the need for more information to accurately assess the geological structures.

Consensus on the area's geology

Information used to evaluate geology in the permit, the appeal, and EPA's assessment of the appeal included Briggs (1969), Fisher (1969), Ells (1969), Dorr and Eschman (1970), Simpson (1975), Syrjamaki (1977), and Cohee and Landes (1984), in addition to previously mentioned resources. The consensus reached in all of this work is stated by Syrjamaki, 1977. "Structures within the Michigan Basin (Howel Anticline, Lucas-Monroe Monocline, Albion Scipio Trend, etc.) are generally thought to be fault controlled [i.e. the geology of the area is heavily influenced by faults]...(our emphasis)" (Syrjamaki, 1977).

Briggs (1968) states, "There are two known faults in southeastern Michigan. One associated with the Howel Anticline... another, associated with the Lucas-Monroe structure... Faults of this type are difficult to find in the subsurface unless they have large displacement, because most of the area is mantled by glacial drift which hides the bedrock structure." Fisher states, "The structural trends in the southeastern Michigan Basin are most likely controlled by many fault blocks which lie in a rectilinear pattern... This idea has been suggested by several researchers" (Fisher, 1981, p. 48).

Fisher also cites work done by Ells (1969) which "summarized all previous work done in the Michigan Basin." Fisher states that "In the area he (Ells) designates as the

Washtenaw Anticlinorium, he postulates the existence of three major fault blocks which have moved relative to one another in a vertical manner" (Fisher, 1981, pp. 31-32). Fisher also notes that "The placement of faults on a structural map is a subjective process, and may differ between workers" (Fisher, 1981, p. 53). The difficulties in locating faults at this depth are also stated by Syrjamaki (1977). "As well control is poor at the depth involved the problems of trying to exactly deduce displacements, as well as the approximate position of the fault itself, are extremely difficult." This means that despite all assurances, we may never be fully certain as to the exact location of the faulting pattern. This raises many questions about the safety of placing waste at these depths.

The sources discussed above indicate a general consensus around the theory that a series of complex faulting patterns exists in Washtenaw County. However, the exact nature of these faulting structures remains undetermined and as a result, it is difficult to generalize about the location of such faults. It thus appears that Fisher's proposed faulting structures do represent the most widely agreed upon interpretation of the existing information.

The use of site specific geological information

Despite the general consensus cited above, the EPA relied heavily on the site-specific information prepared by Golden Strata Services for Gelman. A brief section of the Golden Strata study provides an example of the generality with which the complex faulting structures of the region are addressed.

"Within the area of review there is a lack of complex geological structures such as faults and folds (our emphasis). The Mt. Simon Sandstone, Eau Claire, Dresbach, and Franconia Members of the Munising Formation are nearly flat lying with a shallow dip as seen in the structure contour maps... They are areally extensive and not bound by faulting or folding which might pose a constraint to waste disposal operations" (Tocsin, 11/26/86, p. 7).

Again, this is site specific information which the EPA cited. The Golden Strata geological analysis represents a minority opinion. It reaches a largely unsubstantiated conclusion about the region's geology based on information from one well, and ignores most of the prior work which has been done on the region's geology.

The EPA contends that, "The lack of adequate geological data was resolved with information generated by drilling the well" (EPA. 9/24/86, pp. 9-10). The EPA and Gelman claim that the site specific data generated from the drilling of the deep well does not indicate the presence of any "fractures, faults or solution channels which could compromise (the well)" (Tocsin, 5/10/87, p. 5). Yet, given the complex geology of the area, the possible existence of multiple faults, and the widespread groundwater contamination, it would seem to be unwise to generalize about the region's geology from the information generated from one well.

For example, during the drilling of the deep well there was a six degree deviation in the hole. There are several possible interpretations of this event. One interpretation is that the drill encountered a change in hardness or porosity in the rock. Another is that the drill encountered a fault or fracture, by which it was deflected. Because of the absence of a geologist during the drilling, there was no analysis of the deviation done at the time. The EPA's contention that the deviation was due to a change in hardness seems questionable given the presence of faults and extensive groundwater contamination in the area.

Existing Contamination and Violations

To date there has been no determination of the source of the groundwater contamination at the Gelman site. The EPA (EPA, 1/87, p. 12,) contends that, "no evidence was found to indicate the deep well as a source of groundwater contamination." However, the simple fact that there has been "no evidence" does not prove that any of Gelman's past or present practices are not the source of the contamination. Regulators,

especially the EPA, have frequently confused (purposefully or not) this "lack of evidence" with positive proof showing the safety of the well and ruling out other potential sources of contamination. In doing so the EPA appears to be willing to side with industry in a "pollute until proven guilty" position, and has placed the burden on citizens to develop information which "proves" the well is unsafe. Again, this is clearly not the true intent of the federal regulations.

The EPA contradicts itself for a second time in its response to the appellants (EPA, 9/24/86, p. 1) when it states that "...the existing groundwater contamination was not determined to be due to the injection practices." Again, the EPA apparently feels that "no evidence" to indicate the wells as a source of the contamination means that the well is not the source of the contamination. No evidence means no evidence. It means that more monitoring, and more detailed studies need to be conducted. The absence of information, especially in regard to specific concerns does not mean that we should settle for broad and unsubstantiated generalizations.

The reality of this situation was emphasized by James Bernard, formerly of the Michigan Environmental Council. "There's a large credibility gap in the ability of the EPA to determine where the contamination is coming from. Is it from spray irrigation? Is it coming from the deep well injection? Is it from a leaking lagoon? (The) EPA has systematically failed to make a determination" (Cohen, 9/25/86). The EPA failed to require Gelman to generate the information needed to make an accurate determination about the safety of the deep well and, as a result, was forced to make a decision based only on existing information. While this is not in itself illegitimate, the EPA made an interpretation which we feel is clearly not substantiated by the literature.

This attitude also contradicts both the letter and spirit of the EPA regulations. EPA regulation 40 CFR @144.12 (a) states that "No owner or operator shall construct, operate,...or conduct any other injection activity in a manner that allows the movement of fluid containing any contaminant into Underground Sources of Drinking Water,...if the

presence of that contaminant may cause a violation of any primary regulation under 40 CFR Part 142 or may otherwise adversely affect the health of persons. The applicant for a permit shall have the burden of showing that the requirements of this paragraph are met" (our emphasis).

Studies conducted by Keck Consulting, Inc. ("Keck") for Gelman in July 1986 (Phase I), and March 1987 (Phase II), which provide the most specific information on groundwater movement on the site, do not determine the source of the contamination (Keck, 7/14/86, and Keck, 3/30/87). The EPA summarized the findings of the Phase I report by stating "The study concluded that the most likely cause of the breaching of the layers was due to GSI's (Gelman's) past practices of deepening the unlined lagoon which caused penetration of the (clay) layers that led to contamination of the drinking water aquifer" (EPA, 9/24/86, p. 3). Rather than resolving questions, the hydrogeological studies have revealed the complexity of groundwater flow in the area and the need for further study to document what is actually occurring thousands of feet under the earth's surface. It is anticipated that the Phase III report (of which completion is projected to be at the time of this writing) will shed more light on this question. However, it is significant that the EPA made their decision to grant the deep well permit before completion of hydrogeological work (the Keck studies). According to the EPA (EPA, 1/87, p. 12), "The GSI record of compliance with other environmental regulations has no bearing on the present permit." Significantly, the EPA did not, at least in this case, consider Gelman's extensive history of permit violations to be an indication of likely problems with a new permit. According to comments filed with the request for administrative review (Tocsin, 11/26/86, p. 9-10), "GSI never reported, as requested in the UIC permit application, that there was a known groundwater contamination problem at the site. Moreover, in the permit questionnaire section, GSI did not indicate they have failed to comply with or even apply for a required NPDES permit (a surface discharge permit which was only applied for and received after considerable pressure from citizens in the Fall of 1987). These infractions in

the application process are a violation of the UIC permit." The EPA, in its effort to present deep well injection as a safe disposal option, appears to have ignored its own regulations and refused to acknowledge a lack of the information necessary to protect public safety,

Hazardous Determination

A central issue in the granting of the deep well permit by the EPA was the hazardous vs. non-hazardous determination of Gelman's waste stream. Hazardous determination of Gelman's waste stream would have meant that Gelman's permit application would have subjected to the much more stringent EPA and Resource Conservation and Recovery Act (RCRA) regulations (joint regulation by both RCRA and the Safe Drinking Water Act (SDWA)). A non-hazardous ruling (which Gelman's waste stream received) allowed Gelman to avoid the above regulations. Gelman's waste stream was defined as non-hazardous even though it contained 1,4-dioxane, a suspected human carcinogen.

The hazardous waste stream determination would also have forced Gelman to seriously explore alternative disposal techniques under RCRA, HWSD (1984) (EPA, 1/88, p. 22). Since Gelman received a non-hazardous permit, the EPA was under no obligation to force Gelman to pursue alternative disposal techniques.

The listing of Gelman's waste stream as non-hazardous, followed by a subsequent evaluation of the dioxane-contaminated groundwater also as non-hazardous, is questionable indeed. Over 52 residential and commercial wells have been condemned by the Michigan Department of Public Health due to contamination by dioxane(Toxic Substance Control Committee Meeting, 3/10/88), yet the material is considered non-hazardous. Gelman's waste <u>is</u> hazardous to public health, however EPA regulations do not consider this fact. An excerpt from an EPA response to the aforementioned concern highlights the obvious contradictions.

> EPA's classification of the GSI waste stream as non-hazardous was made in accordance with 40 CFR @261.3 (a)(2)(iii) which states: 'When a characteristic hazardous waste is mixed with a solid waste and the waste no longer exhibits the characteristic for which it was listed, it is not a hazardous waste.' In this case, acetone, the only constituent of the waste stream which is listed under 40 CFR @261.31 (hazardous waste from non-specific sources) as hazardous is only listed because it exhibits the characteristic of ignitability. When the acetone is mixed with other constituents of the GSI waste stream, it is no longer ignitable; therefore rendering the waste stream's classification as non-hazardous.
>
> Two other constituents of the GSI waste, 1,4-dioxane and tetrahydrofuran, as well as acetone, are listed under 40 CFR @261.33 (f) as hazardous waste from discarded commercial chemical products, off-speciation species, container residues, and spill residues thereof. This hazardous waste listing does not refer to manufacturing process waste such as the GSI injection fluid. (EPA, 1/88, p. 16)

Thus, according to the EPA, the fact that dioxane was part of the waste stream, as opposed to being a single discarded product or residue, classified it as less toxic to the environment and people. This is a clear example of the type of logic which allows the EPA to make what appear to be arbitrary decisions regarding the "hazard" of a substace. Regarding the EPA's contentions, Maroline Hense, a local resident, stated, "If it is non-hazardous, why are people telling us not to drink our water or to wash with it?" (Cohen, 9/25/86).

Monitoring and Well Integrity

The problems of confirming well integrity are directly related to a lack of strong EPA-UIC regulations to assure the integrity of a wells. Mechanical integrity refers in general to the ability of the monitoring system to assure that wastes are not migrating upward, in, or around the well. During well construction a variety of tests are performed to assess the initial sealing of the well and formation of the annulus test zone. Once a well

is in operation, the operators of the deep well are required to continually monitor annulus pressure and injection pressure (see deep well diagram).

In this manner a determination is made on the long term integrity of deep wells. According to the EPA (EPA, 1/87, p.14), "... it is the director's discretion, pursuant to 40 CFR @144.28 (g) (i) (iii) to require ground water monitoring." In the same memo (p.14) the EPA explains its basis for such a decision. The concerns are: "(a) that detection of leaks in the injection well can be more readily detected by monitoring and mechanical integrity testing than by groundwater monitoring, (b) that placement of monitoring wells in a deep aquifer may be unsound because the monitoring well may itself create a route for fluid movement through confining formations, and (c) that in the unlikely prospect that a confining formation has been breached, fluids would only reach a monitor well after an extremely long time due to naturally slow rates of fluid movement in the subsurface."

Concern (a) should be expressed as "may" rather then "can." Indeed, past experience shows that this is a largely unsupported statement. Both Sullivan (1983), and Gordon and Bloom (1985) describe traditional problems of injection well monitoring systems. An injection well at Vickey, Ohio was assumed to be operating properly with an EPA approved monitoring system. Yet, over twenty million gallons of hazardous waste leaked from the well into an aquifer above the injection zone when a "minor loss" of fluid pressure was treated as insignificant. Based on this example and many others (Gordon and Bloom, 1985, pp. 10-19), the authors conclude that, "The success of monitoring well head injection rates and annulus pressure to detect and prevent waste injection (migration) has not been demonstrated. Indeed, evidence from actual injection operations indicates that injection rate and annulus pressure monitoring are quite limited in their ability to detect leaks and cannot support the claim that an injection operation is not or will not contaminate a drinking water supply or otherwise adversely affect the environment".

Concern (b) does not address the fact that monitoring wells are increasingly becoming the preferred method for assuring that wastes are contained. At least six states

currently require monitoring wells for all hazardous waste injection (Gordon and Bloom, 1985, p. 27). Furthermore, wells which monitor aquifers above the injection zone cannot provide avenues for waste migration because they do not penetrate the zone which seals the waste. Even wells which do not penetrate the injection zone can and have been designed so as to not allow migration of wastes (Gordon and Bloom, 1985, p. 27). The EPA's position is particularly contradictory on this point because it maintains that a deep well can be constructed and guaranteed safe, while the same is not presumed true for a monitoring well. In addition, the monitoring wells do not need to be pumped (monitored) constantly, and therefore would not affect either the natural migration of groundwater or an aquifer (Gordon and Bloom, 1985, p. 26).

Even if the migration of waste to the monitoring wells would take "an extremely long time," as stated in concern (c), it would still be advantageous to discover this migration (which apparently would be undetected by mechanical monitoring at the well). The only other way to detect the contamination would be in sources of drinking water. This is especially relevant to the Gelman site where contamination exists and monitoring wells could provide important information regarding the source of the contamination.

Significantly, there is no direct monitoring of groundwater (i.e. there are no monitoring wells at the appropriate depth) for Gelman's deep well. Monitoring wells which Keck Consulting Company, Gelman, the DNR, and the EPA have used, were explicitly constructed to monitor movement and concentration of the contamination--not to monitor the deep well. The function of these monitoring wells has been a source of much confusion both in the press and among regulators.

A number of concerns were raised in the deep well permit appeal, in reference to the mechanical integrity of Gelman's well. Again, many of these concerns typify the issues surrounding the integrity of deep wells in general.

First, the EPA's interpretations of the data seem to ignore what little is known about the region's geology. The potential presence of faults, combined with the presence of

groundwater contamination and the potential for this contamination to affect significant residential populations, would seem to argue for greater caution in the EPA's decision.

The second issue is that Gelman has experienced repeated problems with the maintenance of its deep well. On two occasions Gelman has had to replace the well's injection tubing due to deterioration and leakage (Rogers, 1/25/87). Not only does this call into question the general issue of the durability of deep wells, but also Gelman's ability (in particular) to prevent leakage. According to the EPA (EPA, 1/87, p. 8), "Pursuant to 40 CFR @146.8, an injection well has mechanical integrity if there is no significant leak in the casing, tubing, or packing." However, on at least two occasions there have been leaks in the injection tubing of the Gelman deep well. Gelman has been unable to prevent "significant" leaks since the well began operating in 1981, and there is no evidence that the company will be able to prevent such leaks in the future.

A number of other specific concerns have been raised by the appellants regarding the integrity of the well construction (Tocsin, 11/26/86, and Tocsin, 5/10/87). However, for many of the issues raised, there exists two equally viable interpretations of the data. We feel that in these situations the EPA should be making the most conservative decision possible, i.e. the decision which provides the greatest possible protection for human health and natural resources. Yet, based on a review of the well integrity and monitoring well information in the DNR and EPA files, it appears that decisions with reference to the deep well were consistently made in a very non-conservative manner. There seems to be a lack of initiative on the part of regulatory agencies to demand from companies the generation of the new information necessary to adequately consider the issues before making decisions.

Environmental Impact Statement and Disposal Alternatives

Gelman was not required to prepare an Environmental Impact Statement (EIS) or to fully explore possible alternatives to deep well disposal before being granted the permit by

EPA. The National Environmental Policy Act (NEPA), which requires EIS's of all federal agencies, states that the agencies must consider "any adverse environmental effects" and "alternatives" to the proposed actions. However, court decisions from 1973-1979 have repeatedly stated that since the EPA's statutory mandate insured the consideration of environmental impacts, the agency was exempt from this requirement. The court did conclude that the EPA must show "functional equivalent" to the requirements of NEPA. In the Gelman instance, the EPA cites the case State of Maryland v. Train, as the best summary of what is required for the functional equivalency test. The court stated, "Where federal regulatory action in circumscribed by extensive procedures, including public participation, for evaluating environmental issues and is taken by an agency with recognizable environmental expertise, formal adherence to the NEPA requirements is not required unless Congress has specifically directed" (EPA, 1/87, p. 24)

While no court has specifically exempted the EPA from NEPA requirements, the Congress has exempted the EPA from the EIS requirement of NEPA under the Clean Water Act (44 FR 64174, 1979 or 40 CFR Part 6) as long as the "functional equivalent" is met. The EPA contends that public hearings, such as the one held on September 24, 1986 in Ann Arbor, meet the functional equivalent. However, based on EPA files, it appears that the functional equivalent of the information normally required under NEPA Section 102 (2)(c) was not met at the public hearing. Alternatives to deep well disposal do exist; apparently, none of these were explored in the permitting process.

Further, it appears that the EPA was not aware of any alternatives to deep well injection that Gelman was exploring, or had already developed, at the time of the permitting. In fact, Gelman had for several years been requesting to beconnected to the Ann Arbor Sewage Treatment System, and less then a year after they received the deep well permit; they were connected to the system.

Furthermore, Gelman had publicly announced its intention to use the deep well for injection of contaminated groundwater, in addition to process waste, throughout the

permitting process. The permit they were applying for, however, clearly did not allow disposal of purged, contaminated groundwater. The EPA's decision to grant the permit when Gelman clearly had other disposal options available, (and when Gelman was considering alternative uses of the deep well) must be questioned. It appears that the EPA either failed to meet the functional equivalence test, or was ignoring both the disposal alternatives available to Gelman, and Gelman's real plans for the use of the injection well. It seems logical that the "functional equivalence" of exploring all possible alternatives should not be met by selectively ignoring facts and concerns which are raised.

In our group's discussions with Gelman Vice President Jim Marshall, we also learned that Gelman has conducted reviews of several alternative treatment systems. However, according to DNR officials (Interview with Mary Vanderlaan, 2/24/88) the company has not provided this information to the DNR when requested. The DNR contends that Gelman's unwillingness to provide written documentation of these studies has limited the DNR's ability to assess Gelman's cleanup plans.

Suggestions for Federal Regulatory Change

The following summary of suggestions for regulatory change is taken from Gordon and Bloom (1985), which contains a more detailed analysis of each of the points raised below.

Lax regulations are only an agent which allows potentially harmful disposal technologies to be used. As such it is important to look at the regulations, but it is even more important to understand how the inadequacies of the regulations are characteristic of the limitations of the general regulatory approach. The efficacy of regulations depends on the social, political, and economic climate in which they are being developed and implemented. An examination of the role of regulations and regulatory agencies, i.e. the DNR and the EPA, (see DNR analysis section) must be accompanied by the following analysis.

Regulatory Analysis:
(1) The UIC regulations fail to prohibit the injection of wastes that are incompatible with the well materials, the injection zone and confining layers.

Currently the EPA administrator is required to consider the compatibility of the waste intended for injection with the well materials and the fluids and minerals of the injection zone (47 FR 32274-32388, 6/82). However the regulations fail to provide specific parameters needed to evaluate the compatibility of the wastes. As a result, the EPA has been able to make a relatively small number of compatibility determinations. The development of new regulatory parameters, testing procedures, and analyses are needed to fully examine the long term fate and effect of injected wastes on the injection zone (Gordon and Bloom, 1985, p. 45).

(2) The UIC regulations fail to require the monitoring of (a) underground sources of drinking water through which or near where the well bore passes; (b) the injection zone; and (c) the confining layers to determine whether contaminants have migrated.

This aspect is perhaps of greatest significance to the Gelman case. UIC regulations only require continuous monitoring of annulus pressure and injection pressure, flow rate, and volume. Other methods, such as groundwater monitoring, are not required except on a case-by-case basis as determined by the EPA administrator. In general, the EPA has assumed that "as long as an owner or operator is in compliance with 'good engineering' practices such as mechanical integrity of the tubular goods and the absence of man-made (sic) communication between the injection zone and higher strata, endangerment of nearby underground sources of drinking water will have been avoided" (45 FR 42487, 6/24/80).

However, the EPA itself acknowledges that "... a great deal is still unknown about the movement of fluids below the surface," and that "...monitoring of interactions (below the surface) is both difficult and uncertain" (45 FR 42477, June 24 1980). These contradictory statements again point to the fact that the "...monitoring (of) well head injection rates and annulus pressure to determine 'significant leaks' has not been demonstrated" (Gordon and Bloom, 1985, p. 46). Leaks have not been detected in several instances because the leak is too slow to be detected by pressure monitoring devices.

As explained by Gordon and Bloom (1985), the monitoring of other forms of disposal, such as landfills, is much more stringent. Monitoring wells are generally required at both the walls of a landfill and at aquifers downgrade from the fill, to monitor the major potential migration pathways. The EPA's failure to provide assurances (in the form of monitoring wells) for deep well technology, "...demonstrates the agency's failure to show sufficient caution when confronted with both significant uncertainty and risk to invaluable groundwater" (Gordon and Bloom, 1985, p. 47).

(3) The regulations rely on highly speculative and in some cases inaccurate assumptions about the migration of waste in the subsurface.

Current UIC regulations require the operator of an injection well to determine an area of review around the well, within which they must identify fractures, faults, abandoned wells, or other potential conduits for wastes. This area is based on a mathematical model which establishes a zone of endangering influence of fixed radius. The zone of endangering influence is defined as an area, "the radius of which is the lateral distance from an injection well, field or project in which the pressures in the injection zone may cause the migration of the injection and/or formation fluid into an underground source of drinking water" (40 CFR Part 264.03 (a)). The regulations provide a formula which is used to develop the exact distance which must be included in the area of review. Applicants for Class I well permits (i.e. Gelman's) must also identify all known wells within the area of review and assure that they are either plugged or cannot serve as a conduit for the movement of fluids (40 CFR 146.30 (b)(c) and 40 CFR 122.44). Gelman was required to identify all wells within two miles of the site.

Most concerns center around assumptions which are made about the ability of the waste to move once it has been injected. First, the formula used relies on numerous assumptions about the homogeneity of underground geological structures. For example, the formula does not account for the fact that underground formation pressures may differ from point to point. Therefore, the pressure measured at the injection point (the usual

practice) may differ from another point in the zone of endangerment. Second, calculations of radial movement assume that the waste moves outward in a cylindrical shape versus moving directly horizontally. The use of the cylindrical model can greatly underestimate the distance which the waste will move (Texas Department of Water Resources, 1983). In the case of the Gibraltar Chemical Resources facility in Owentown, Texas, only five feet of a 150 foot injection zone were found to be receiving wastes (Moldenhauer, 1984). The assumption of cylindrical movement needs to be closely examined. Third, several instances of long-distance migration of waste (up to three miles from the injection site) brings into question the applicability of the one-quarter mile rule.

Clearly, new methods for documenting the ultimate fate of wastes are needed. Only by understanding what happens to these wastes over the course of many years will accurate parameters be established to predict waste behavior. However, even with this capability the variability of local geological conditions may make it nearly impossible to accurately track wastes.

(4) The UIC regulations provide insufficient safeguards against potential pressure effects.

UIC regulations currently limit injection pressure to insure that increases in pressure do not initiate new fractures or faults, or cause waste migration through an existing fault (40 CFR 146.13). However, the adequacy of this aspect of the regulations is often undermined by the one-quarter mile area of review provision (Gordon and Bloom, 1985, p. 51). Based on the regulations (40 CFR 146.06), faults and fractures outside of the one-quarter mile radius of the well are not required to be identified; therefore, any potential pressure effects on these faults or fractures are not considered.

According to Gordon and Bloom (1985, p. 51), "Technically, it is quite possible to predict pressure changes over considerable distances as a result of pressure increases at a point. Consequently, the 1/4 mile limit is not only inadequately protective, but patently arbitrary." Pressure effects have been documented up to 40 miles from injection wells and earthquakes caused by injection of wastes have occurred up to three miles from an injection

site (Gordon and Bloom, 1985, p. 51). Despite this evidence, the EPA has been reluctant to expand the area-of-review around deep wells to better reflect the potential area of impact from injection.

(5) The UIC regulations require insufficient mechanical integrity testing to detect damage to the well bore before significant leaking occurs.

Current EPA-UIC regulations (40 CFR 146.08) state that an injection well possesses mechanical integrity if there is no significant leak in the casing, tubing, or packer, and if there is no significant fluid movement into underground sources of drinking water through vertical channels adjacent to the well. Leaks in the casing, tubing, and packer are monitored using annulus pressure. Vertical movement along the well bore is tested with a temperature or noise log. These tests must be run at least every five years or at the time of every new permit application or renewal.

The central problem with these limited monitoring requirements is that several documented cases of leakage have occurred less than three years after the wells have begun operating (Leenheer and Malcolm, 1973). The testing is useful in detecting leaks after they have already occurred. More frequent testing is needed to catch leaks before they can become major problems.

(6) The UIC regulations fail to require post-closure monitoring and maintenance and the showing of financial responsibility for post-closure care, third-party liability, and cleanup of contaminated groundwater.

All other hazardous waste disposal in the U.S. requires the development of a waste containment system for at least 30 years after closure (RCRA Regulations). Injection wells are exempt from this requirement.

According to the EPA (1980),

> "financial responsibility for UIC facilities differs from that of RCRA permitted facilities...the circumstances are fundamentally different... (a) [the] properly sited, designed and operated Class I disposal well offers little risk of leakage and contamination during the period of injection... Thus, the primary purpose of financial responsibility is to insure proper plugging and abandonment.... After the well is plugged, the plugging operation leaves an impermeable barrier between the injection zone and any USDW... Thus,

post-closure monitoring wells and other post-closure maintenance required under RCRA are unnecessary" (45 Fed. Reg. 33335, 5/19/80).

In May 1984 the EPA reaffirmed this statement. "...Requirements for post-closure care, while a necessary part of the RCRA requirements, have no referent in the UIC program since the technology of underground injection is designed to place fluids into confined formations and isolate them from the accessible environment for geological time" (Gordon and Bloom, 1985, p. 55).

The EPA's statements make many assumptions about the safety of injection well disposal. Most of these assumptions (such as the one that a properly operated, state-of-the-art well will not cause contamination either during or after the period of operation) simply ignore the fact that accidents, leaking, and underground movement of wastes have occurred due to injection wells across the United States. Recent well-plugging techniques have not withstood the test of time and there is little evidence on which to evaluate the long term integrity of well plugs (Gordon and Bloom, 1985, p. 56). The EPA's assertion that wastes cannot migrate up through a sealed well is simply not true. Wastes can and do migrate upward, along the outside of the well bore (Gordon and Bloom, 1985, p. 56).

Unfortunately, by not requiring post-closure care or third party liability insurance, the regulations under Superfund impose the risk of injection activities on surrounding landowners and residents, or on the public. Instead, the cost of risks should be imposed on those parties in the best position to minimize risks, and who are directly benefited by the risk-creating activity--the injection well owner. Requiring financial assurance will not impose undue burdens on injection well owners and operators if the technology is as safe as it has been represented to be.

Three states; Louisiana, Mississippi, and Ohio, already require financial insurance for injection wells (Gordon and Bloom, 1985, p. 57). Well owners and operators should be required to perform post-closure monitoring for groundwater contamination, and also to demonstrate financial ability to take responsibility for third party liability and cleanup.

(7) The UIC regulations authorize the use of underground sources of drinking water as depositories for hazardous wastes in direct contradiction to the spirit of the Safe Drinking Water Act.

The Safe Drinking Water Act states, "Underground injection endangers drinking water sources if such injection may result in the presence in the underground water which supplies or can reasonably be expected to supply any public water system of any contaminant, and if the presence of such contaminant may result in such system's not complying with any national primary drinking water regulation or may otherwise adversely affect the health of persons "(42 U.S.C. @300 (h)(d)(2)).

While there are clearly alternative interpretations of the Safe Drinking Water Act's intent, the above quote highlights the Congressional intention to protect present and future sources of drinking water from degradation. However, the EPA has declined to specify criteria by which the determination of whether a potential source of drinking water is "not reasonably expected to supply a public water system" (Gordon and Bloom, 1985, p. 60). Perhaps more troubling is the fact that the EPA has not established criteria for determining which sources of drinking water are "economically and technologically impractical" to be made fit to drink. Given our rapidly changing technological capabilities, it is very likely that water which is unusable today may become usable in the future. Instead of making these determinations, the EPA has left the decisions largely up to individual states.

Thus, states are left to make seemingly arbitrary decisions about what constitutes an unusable aquifer. As usual, the burden of enforcing the SWDA falls not on the federal or state levels of government, but on the citizens.

(8) The UIC regulations do not prohibit underground injection of hazardous wastes when more environmentally sound alternatives are commercially available.

Underground injection is economical because the "true costs" of this disposal practice are simply passed on to future generations. The current UIC regulations fail to establish the "true costs" of operating a deep well. Deep well disposal would be much more expensive if monitoring was required and full financial responsibility was

established. The EPA regulations should require the use of the most environmentally sound treatment alternative which is available and industries should be held responsible for assuming the total costs of their waste management methods.

The Politics of Deep Wells

> Trillions of gallons of wastes have been pumped down these wells for years. It's an out-of-sight, out-of-mind disposal method that worries us.
>
> --Diane Hebert, Environmental Congress of Mid-Michigan (ECOMM)

> Instead of dealing with pollution, we're simply building our smokestacks higher and our injection wells lower. But it always comes back to haunt us.
>
> --Jim Butler, Aide, Texas Department of Agriculture

> It's a giant problem, but it's a stepchild within both the environmental movement and the regulatory systems. I've been distraught over how little attention it has received. We can't show dead bodies right now. It's a classic out-of-sight, out-of-mind technology. I feel that underground injection is posing the greatest threat to our groundwater because of inadequate regulations. They're just postponing our day of reckoning with the hazardous waste problem.
>
> --Suzi Ruhl, Legal Environmental Assistance Fund(LEAF)

Deep well disposal is indeed a classic out-of-sight, out-of-mind disposal practice. As Michael Brown has stated (Brown, 1986, p. 17), "While the more familiar surface dumps remain one of the hottest issues on Capitol Hill (and last Autumn dominated the gubernatorial race in New Jersey), the federal government has not even tabulated all of the problems associated with deep well disposal." Indeed the lack of public awareness about deep well disposal, and the resulting lack of political opposition to it, has created an environment of lax governmental regulations for the "low visibility" practice of deep well disposal. This pro-deep well mentality has permeated regulatory agencies, which attempt to silence voices of dissent both within their own ranks and in the public at large. From

information we have surveyed, it appears that there is a rapidly increasing pro-deep well mentality in national and state regulatory agencies.

Nearly every DNR official we spoke with regarding this issue with had reservations, some very strong, about the use of deep wells. However, it appears that these concerns are systematically ignored by high level bureaucrats in the DNR and EPA. During the initial permitting and construction processes in 1981, a variety of concerns over the use of deep well injection were raised by DNR staff close to the project. In a July 16, 1981 letter from Jack Larsen, District Engineer, Ann Arbor Office (now Jackson Office) to Bob Miller of DNR's Air Quality Division (AQD) raised several specific concerns.

> To reiterate my comment from the July 1, 1981 meeting. Gelman Science of Ann Arbor will soon be converting from aerated lagoon for treatment of wastewaters, to a deep well injection system. Based on A.Q.D. (Air Quality Division) Permit No. 126-81, we expect the wastewater stream to periodically receive slugs of 1,4-dioxane (demonstrated animal carcinogen) to the extent of 4,360 pounds per month. I request you continue to treat as confidential much of this proprietary information. In light of available alternative disposal possibilities, I question the appropriateness of this new well. (our emphasis) In general, it seems that the EPB and Public Health would desire some routine input into the State well-permitting process (DNR files, 7/17/81).

Judging by the absence of correspondence on alternatives to deep well disposal in the DNR files it appears that alternatives were never given serious consideration by the DNR. On June 28, 1981 the *The Ann Arbor News* published an article on the Gelman deep well and its proposed future uses (Fulton, 6/28/81). In response to this article Larsen sent a memo to the Michigan Environmental Review Board (MERB) on June 29, 1981 asking, "(1) did MERB review this project?; (2) was the proposal publicly aired, complete with published notices in the local newspaper?; (3) was it declared a major state action?; (4) what are the names of the organic chemicals which will be going down the well?; (5) what unit of state government is responsible for monitoring what is going down the well?" (DNR files, 6/29/81). On August 4, 1981 the MERB responded (DNR files, 8/4/81) that

they "...had no knowledge of the disposal well..." and referred Larsen's letter to the Geological Survey Division which responded on August 12, 1981. The Geological Survey Division stated (DNR files, 8/12/81) that the original permit was only for drilling, and "... did not cover its ultimate use." The letter also noted that Gelman had an open house (apparently DNR regulations didn't require this) in which all parties with wells within one-half mile were invited to review the proposed plan. According to the memo, "There didn't seem to be much interest as only two families were present out of some 50 or 60 that were invited." The letter again emphasizes the lack of public concern by noting to Larsen that "Yours has been the only inquiry about the well..." (DNR files, 8/12/81). However, it appears the source of this lack of public concern was the fact that both Gelman and the DNR failed to adequately inform the local residents about the new well.

The Geological Survey Division's responses to Larsen's specific questions were as follows:

> To answer your questions: (1) MERB made a detailed review of the disposal well permitting program in early 1978 and found it to be both effective and safe. (2) There will be public notices made prior to issuing an operating permit or letter of confirmation of the well. (3) This is not a major State action. There are over 100 of these wells permitted in the State and there has not been one case of groundwater pollution that was attributed to their use. (4) I am attaching a list supplied by Gelman of the organic chemicals that will be expected to be in their waste. This will probably vary from time to time due to the batch process they utilize but it is and has been in the past 99+ percent water. No other chemicals may be included without this office's approval. (5) As indicated in number 4, the Geological Survey Division is responsible for the monthly monitoring of the operation of these wells. In that effort a monthly operating report is reviewed by this office for each well operating in the State." (DNR files, 8/12/81)

However, the MERB review of the State of Michigan's deep well permitting process in 1978 was conducted before substantial changes in regulations, such as RCRA, significantly altered the regulatory climate and efforts to control wastes. Also, the assurance that "... there has not been one case of groundwater pollution that was attributable to their (deep wells') use" has not been proven and is another example of DNR's efforts to promote deep well disposal as a cheap, simple solution to a complex

problem at the expense of public safety. In fact, the copy of the memo contains an unidentified handwritten note next to this response inquiring, "How about Hemlock, Mich.?" referring to a then suspected site of deep well contamination. The response to question #4 indicates the State's willingness to allow the injection of a suspected carcinogen into the deep well. In an interview with James Marshall, Gelman's Senior Vice President for Operations, (Interview with James Marshall, 3/3/88), he highlighted the fact that Gelman could inject anything they desired with the original permit. This was the message which the DNR, intentionally or not, was communicating to industry.

The DNR's letters to concerned citizens also provide a revealing look at the State's efforts to assuage citizens' concerns over deep wells. In an August 17, 1981 letter to a concerned citizen, the Geological Survey Division stated (DNR files, 8/17/81),

> I understand the concern of the people over groundwater pollution with all of the surface misuses in the past, but I can assure you that this type of liquid waste disposal can cause no such problem. This type of waste disposal well has been in use in Michigan for over 20 years and not a single groundwater pollution problem has been attributed to the use of one of these wells. Michigan geology is ideal for their use...

Despite DNR's assurances that deep wells are perfectly safe, the track record of these wells shows differently. The Hemlock, Michigan case cited earlier is a case in point. In addition, in the late 1960's and throughout the 1970's Dow Chemical of Midland, Michigan disposed of up to 300,000 gallons of waste per day by pumping it into deep wells. Dow's Midland factory produces over 500 different chemicals, some of which produce a deadly by-product, dioxin. Many of the residents in Hemlock, which is fourteen miles from Midland, have shown signs of dioxin poisoning. The deep well disposal is the most likely source of the contamination (Culver, 1984, p. 4). Over half a billion gallons of fluids, including phenolic compounds, chlorinated benzene compounds, tardon (Agent White), and 2,4,5-T were injected into three wells at the site prior to 1973 (Culver, 1984, p. 4). Additional fluids were injected until the mid-1980's when Dow decided to quit using most of its injection wells. According to Diane Hebert of the Legal Environmental

Assistance Fund (Culver, 1984, p. 4) "the same strata that have been used for extracting brine, oil, and gas have also been used to inject chemical waste. The possibility for intermingling of these materials seems to be a real possibility [sic] that has never been seriously evaluated, even though all of the clues have been there." According to Culver, "Dow has limited the number and scope of the tests on the brine" which would be needed to "prove" the source of the contamination. Thus, even in Michigan's "favorable geology," there is no solid basis on which to "assure" citizens that "...this type of disposal can cause no such problems."

As stated earlier, the DNR's public position on deep wells is also reflected internally. On August 31, 1981 Jack Larsen, District Supervisor at the Jackson DNR Office, sent a letter to the Office of Toxic Materials Control (DNR) asking, "Do you basically agree with this letter (8/12/81 response to Larsen's inquiry) from Geology Division?" In the letter he also asked,

> (1) Do you think it's time for a MERB (or other) review of the disposal well permitting process?; (2) Does Geology notify Public Health and Environmental Protection whenever they receive an application? Are you offered routine input?; (3) Have disposal wells ever contaminated groundwater? In Michigan?; (4) Is WQD (Water Quality Division) ever consulted as to whether the well is essential, or (if) alternative disposal methods are available? Or whether the waste quantity and species on the well application agree with WQD's (Water Quality Division) reports?" (DNR files, 8/31/81)

On September 9, 1981 Thomas Roehrer, Office of Toxic Materials Control, issued the following response (DNR Files):

> I share many of your concerns about the entire deep well disposal process. Unfortunately past attempts at getting anyone in our Bureau to thoroughly review this process have been unsuccessful. <u>As a result, injection well disposal of wastes is largely unregulated from a water quality standpoint</u> (our emphasis). Geological Survey concerns itself only with the physical aspects of well construction and maintenance and assumes that the Water Quality Division determines what is acceptable for disposal by this method. To my knowledge water quality has never attempted to control the disposal of toxic organic compounds via injection wells. I will refer your particular questions to the Office of Hazardous Waste Management for additional review. In my opinion the entire process merits a detailed review by this agency, MERB, and the Toxic Substance Control Commission. However,

> I have not been able to generate any interest in instigating such a review. I hope that you meet with more success. (DNR files, 9/9/81)

It is revealing that even DNR officials admitted in 1981 that deep wells at the time were "...largely unregulated from a water quality standpoint," when water quality is the main concern related to deep wells. Yet, despite the fact that Roehrer and Larsen had serious concerns about "...the entire deep well process" it is readily apparent that neither was able to generate any action within the regulatory agencies and that their complaints fell on deaf ears. Several officials within the DNR who were/are involved in the case have anonymously stated that they have been very "frustrated" with the lack of concern higher-ups have shown on the deep well and other issues.

Even more notable is the discrepancy between the DNR's public and private statements. In a June 28, 1981 article in the *The Ann Arbor News* (Fulton, 6/28/81), Ray Ellison of the DNR's Geological Survey Division explained the DNR's public position on deep well safety. "We not only have the requirement for periodic inspection as the well is being drilled, but we also require monthly reports of operation, and make periodic inspections on the site. Michigan has very strong laws to control deep disposal wells. In fact, our laws serve as models for the federal regulations which will be enforced by the EPA..." Ellison also assures the public that "Michigan has some of the best geology in the country for this type of disposal" and that "this (geological) formation has been extensively studied for a long period and over a wide range." Clearly these statements regarding the area's geology are contradictory and oversimplified.

Of even more concern is the EPA's reliance on unproven technologies. There is no consensus within the DNR or EPA on the safety of deep wells. However, deep well disposal is portrayed to the public as a highly regulated, very safe disposal technology. At the same time that one DNR official is saying the "injection well disposal is largely unregulated from a water quality standpoint," a second official is telling the public that the laws are "very strong" and "serve as models for the federal regulations."

The DNR and EPA are not alone in their smoke and mirror show. Charles Gelman, referring to the drilling of the deep well, stated "I guess we should have told some of our neighbors, and explained the process to them, so they wouldn't be worried...but this kind of disposal well is unusual, and we didn't want to attract a nuisance suit from those who might not understand it , and get all tied up in court" (Fulton, 6/28/81). Clearly, both the DNR and Gelman realize that the only obstacle to the use of deep wells is public opposition (see Citizen Response section).

One must wonder why, if deep well disposal is such a safe solution, the DNR, EPA, and Gelman appear to have gone to great extents to misinform the public, and to silence their critiques. If deep well disposal was truly "not only environmentally acceptable, but also the best way to solve Gelman's problem" (Fulton, 6/29/81) the company, DNR, and EPA should have great interest in publicizing this fact.

Other officials within the DNR have also voiced their concerns about deep wells. Dr. James Truchan of the DNR claims "It's (deep in the earth) the worst place you want to put toxic wastes" (Gearhart and Weinstein, 6/87). Environmentalists, especially of the Natural Resource Defense Council (NRDC) and the Legal Environmental Assistance Foundation (LEAF), have consistently raised concerns and proposed alternatives to deep wells. However, all of the concerns raised by, environmentalists, citizens those within the DNR, and others appear to have done little to curb the "out of sight, out of mind" mentality of industry and top-level environmental bureaucrats. This attitude is reinforced by the powerful economic, political, and social forces which have become institutionalized in our regulatory agencies. Excessive reliance on unproven and potentially unsound technological solutions to deal with synthetic chemicals, is a major problem with how regulatory agencies and industries regard waste.

Summary

As stated earlier in this section, lax regulations, public misinformation, and other issues raised in this section are only the agents which allow irresponsible disposal practices employed by industries to destroy the environment. The details are presented here only to illustrate the intricate workings of this system. The more important goal of this section is to provide insights into the systematic causes of environmental destruction.

Gelman's use of deep well injection is part of a national trend in waste disposal. Industries are increasingly seeking out inexpensive and, less visible ways to dispose of wastes. Incineration and deep well disposal are two forms of disposal which have become increasingly popular. One method removes the waste from sight, while the other change the waste's form. These methods create a distance, both physically and metaphorically, between the waste and the industry which generated it. Deep well disposal merely prolongs the day of reckoning with the hazardous wastes which have been created in tremendous amounts in recent years.

However, an opposing trend also exists in this country. Many industries are modifying their production processes in response to the ecological problems that have occurred due to past waste disposal practices. Increasing attention is being focused on alternative means of reducing the amount of waste produced. Source reduction, recycling and reuse of chemicals, and the replacement of highly toxic chemicals with less toxic ones, are for the first time being seriously examined by some industries. However the pace of this development, and it's ability to curb the systematic forces at work, remains to be determined.

SOCIAL, ECONOMIC, AND POLITICAL ISSUES OF THE CASE STUDY

LAND USE PLANNING ISSUES

What is planning? Why should we be concerned with planning? How does planning work in Michigan? And how does planning relate to the case study?

Planning, more specifically land use planning, in its most basic sense is concerned with the allocation of resources (natural, human, and financial) toward some end. Consequently, the resources and their various interrelationships become limiting factors in the development of any site. Land use planning is a critical tool used to shape the present and future built environment in which we live, and that our children will inherit. "Planning provides a means to iron out issues before they develop into conflicts, prevent over-extensions of public services, protect natural resources, and provide an opportunity for coordination among all (significant actors)" (Washtenaw County Metropolitan Planning Commission ("WCMPC"), 1986, p.i).

An important role of planners is to determine the types of land uses that are compatible with one another, and those that are not. For example, residential areas are very compatible with public parks and are often "planned" to be together. Parks are often sited with particular emphasis given to the proximity of large residential areas. Commercial land uses are often grouped together near major circulation corridors, and away from residential areas.

Planners make decisions about land use compatibility and many other concerns as part of their responsibility in government agencies or as private consultants. The field, by its very nature, requires a general knowledge about many areas such as economics,

architecture, engineering, and politics. Consequently, planners must be able to communicate with many different kinds of people to be effective in their jobs.

In a general sense, the planning responsibilities lie in the hands of local governments. The townships, towns, and cities of Michigan have jurisdiction over their specific areas in terms of writing planning documents and enforcing their various planning regulations. The counties of Michigan have county planning agencies which have been charged with the task of providing consultation to all parties within their boundaries. Thus, the counties are a natural governing body to which communities, especially those which cannot afford to hire outside consultants, look for assistance. This assistance often takes the form of developing zoning ordinances, development guidelines, and master planning documents.

County Planning Agencies also develop master plans at the county level, beyond assisting the smaller legal entities within their boundaries. These master plans look at a multitude of factors that can affect the physical growth of a county. These factors include major institutions, natural features like rivers and mountains, transportation systems, existing infrastructure such as sewer and water systems, and macro-economic trends that influence the national economy. From a basic understanding of these factors and many others, planners make projections about the future. They attempt to project the needs of the people within their county and to decide how these demands will become expressed physically in terms of new development or redevelopment of existing facilities.

In a sense, planners create a framework from which development interests operate. In turn, developers try to respond to the demands of the "marketplace" by financing construction projects that will fulfill those demands.

Zoning ordinances are a common and powerful tool used to regulate the growth of an area. Government bodies typically use zoning ordinances to regulate the allowed uses of land within their domain. These ordinances, however, are subject to change. Development interests can alter zoning designations for a parcel of land if they can provide

a reasonable argument for their requests. This situation is not uncommon. At times, however, zoning is based on outdated assumptions or development trends, and serves to hinder positive future growth (i.e. growth benefiting the best interests of our society). The task of projecting the "right" land uses for particular pieces of land is very difficult. However, it is important that growth and development proceed in some established order or pattern.

Planners, with the aid of zoning ordinances and master plans, serve a very important function for the growth and development of an area. They create a vision of the pattern of future growth in that area based on their knowledge of the present and their perception of the future. Underlying this vision of the future are overriding concepts. These concepts are expressed in terms of written regulations in zoning ordinances and in terms of graphics as master plans. Together, these documents paint a conceptual picture of what a local government body wishes to see in the development of their area of responsibility.

There are a number of environmental issues raised by the case study that directly relate to land use planning. For instance, what are the risks, in terms of human health and welfare in allowing residential and industrial land uses to be adjacent to one another? How compatible are all other land uses with industry? These questions focus on the potential danger that industry poses if its activities pollute the environment, as this case study demonstrates has happened.

Washtenaw County

Gelman Sciences, Inc. ("Gelman") is located in Washtenaw County in southeastern Michigan. The facility is approximately 45 minutes from downtown Detroit. Ann Arbor is the largest city within the County, with Ypsilanti being the second largest city. This urban core holds the majority of the County's population, with many smaller communities and

rural residential areas dotting the landscape. Surrounding this urban core is a major transportation network that connects the County to other nearby cities.

Gelman's site is located just west of Ann Arbor within the Jackson Road Corridor. This corridor is one of strip development comprised of varied land uses. There are at least six major types of land uses located along this strip, including light industrial, commercial, office space, agricultural, and residential land uses. This is not an ideal situation aesthetically, but that, in and of itself, is not disastrous. A more serious consequence of this type of development is environmental degradation. This has occurred as major aquifers spreading from the vicinity of the Gelman site have been contaminated due to waste management practices. The Jackson Road Corridor is typical of much of the development of approximately the past thirty years in America.

Linear mixed use development addresses the extensive use of automobiles as well as lower land costs away from urban areas. Outlying areas around cities often consider any development as a positive sign of growth, allowing it to grow (however disorderly) into the countryside. Seldom is there any attempt made to predetermine land uses along development corridors other than in the most general terms. Consequently, incompatible land uses wind up neighboring one another, as is demonstrated by Gelman and the Westover Hills Neighborhood.

Washtenaw County Metropolitan Planning Commission ("WCMPC"): land use policies

With a basic understanding of what planning is, who is responsible for it, and why it is important, we can examine the current master plan for Washtenaw County. In particular, we will review the relationship between rural residential and industrial land uses. Some issues that arise in this context are the viability of agricultural lands in the face of nonagricultural uses in rural areas, the cost of providing urban services such as sewer and water to rural residential areas, the effect on local traffic of rural industrial sites, and the

potential contamination of rural wells by industry. There are many more concerns surrounding the compatibility of these two land uses, but these are the major ones that will be addressed.

The County master plan addresses what it sees as the current trends in development. Recent trends in development signal a more thorough, compact type of development, some combining different types of land uses. Several examples of this can be cited throughout the County, especially in urban fringe areas that surround the Ann Arbor/Ypsilanti urban area, and some of the smaller urban centers in the County. This development calls for larger blocks of land and is aimed at specific markets, mostly technological and research oriented groups. There are areas of growth which are still oriented towards strip development. Strip development is responsible for the convergence of the Ann Arbor/Ypsilanti communities into one urban form and for major extentions of urban growth along major transit corridors. In the urban fringe, strip development and development in general is due to independent thinking on the part of each of the townships surrounding the Ann Arbor/Ypsilanti area and how each township views their future. The fact that each of the surrounding communities have been willing to extend public services for development indicates that this independence and competition will continue. Some strip development of compact self-contained activity centers is adequately served by public utilities and urban services. Newly planned activity centers, and those currently under construction have produced and are expected to produce significant spin-off uses...Other proposals, especially the high-tech/research parks are expected to have major impact on the County's economy and future development. Additionally both the Ann Arbor and Ypsilanti areas have recently completed new sewer treatment plants that will more than adequately serve growth in the Ann Arbor/Ypsilanti urban areas (WCMPC, 1986, p.12).

In more specific terms the County sees a 48 percent population increase from 264,740 persons in 1980 to 391,669 persons in 2005 (WCMPC, 1986). Juxtaposing the

projected population increase with a 22 percent decrease in manufacturing jobs over the last ten years shows a distinct county-wide shift away from manufacturing. The workforce in the county increased from 1970 to 1985 by 42,000 persons. "Almost one-half of these wage and salary earners are employed by the University of Michigan, Eastern Michigan University, Ford Motor Company and General Motors" (WCMPC, 1986, p.14).

Further, Washtenaw County is considered by many to be a desirable place to live. The expanding metropolitan Detroit area is exerting development pressures on the county from the east. Likewise, there is a general trend toward the dispersion of certain wholesale, finance, and retail trade functions. These commercial activities prefer dispersed locations so they can attract a larger regional market, and take advantage of lower rural land prices and a highly efficient circulation system. The cities of Ann Arbor and Ypsilanti, as well, are attractive to new businesses and residents. These cities offer a high quality of life. "The abundant natural resources, (and) the attractiveness of much of (the) existing urban development (and) the varied labor force..." will continue to draw businesses and new residents (WCMPC, 1986, p.33).

In both its cities and the outlying areas, Washtenaw County is an attractive area to development interests. Much of the new industrial growth is projected to involve high-tech research and development businesses. There are three prime areas for this type of development as determined by the County. They are the new University of Michigan Technology Park northeast of Ann Arbor, the State Street Corridor which runs south of Ann Arbor to Michigan State Route 12, and the Jackson Road Corridor which moves westward from Ann Arbor. All these sites are located on the fringe of the city, taking advantage of the surrounding freeway system. These areas are projected to expand from the city into the rural landscape beyond Ann Arbor. The way this expansion occurs and which land uses are determined to be compatible to these areas are of critical importance. The scale of the projected high-tech industrial growth is quite large in comparison with the existing size of Ann Arbor. These development areas will contain much of the future

growth of Ann Arbor.

The continued growth of Ann Arbor and the areas around the growth corridors is the focus of the Washtenaw County Map provided in appendix E. This map shows a simplified version of the land use pattern that exists in the county. The employment zone (including commercial, office, and industrial uses) shown is based on the County's Master Plan, which depicts the WCMPC's projection for the development of the County. Purposefully, all other land uses are represented as they exist. This has been done to examine the treatment of the "edges" of the employment zone.

Much of the current thought in planning for high-tech industrial sites is that they are very compatible with single family housing. High-tech industry is perceived by the planning community to be very "clean." They don't pollute, they don't make noise, and they don't emit foul odors. However, if the assumption about the "cleanliness" of these sites is false, a major conflict arises with the theory of compatibility of residential and high-tech land uses. This is where the Gelman case leaves us--in a major conflict, with the well-being of human lives at stake. A specialized high-tech manufacturing operation has polluted a large area of groundwater, contaminating the wells of many neighboring businesses and homes. Unfortunately, this settlement pattern is fixed. However, there is time to redirect the development patterns of the bordering high-tech land uses that are to come.

From analysis of the County's Master Plan, it is clear that they do not share the same apprehensions of allowing rural residential uses to border high-tech industrial sites. Their plan shows extensive rural residential tracts bordering all three of the aforementioned high-tech industrial areas. By definition, rural residential areas lack urban services. Often this means that rural homes use well water for consumption and septic systems to treat their sewage. Until recently, this was the case along the Jackson Road Corridor. However, in 1986 and 1987, sewer services (and some water lines) were extended along Jackson Road with some minor extension of water lines.

The residents of Scio Township, in which Gelman is located, want to preserve the existing atmosphere of a rural landscape. They would like to see any new housing in the area built on large lots of from one to ten acres. This density is very low for single family housing and would indeed insure a strong rural condition. The residents argue that they have chosen to locate in the township for its rural ambiance. Yet, the Westover Hills Neighborhood has been annexed into the City of Ann Arbor in order to receive water services as a result of the groundwater contamination. Most of these homes use well water and septic systems, and this makes them vulnerable to the quality of the water of the aquifer below them.

This type of development, a very low density residential fabric, is in conflict with adjacent industrial land uses that the County proposes as an employment zone in their land use plan for the area. In particular, the close proximity of high-tech industry to rural housing that uses well water is a very unstable settlement pattern. The lower the density of a rural residential area, the greater the expense of extending water and sewer lines will be in the future. More water line connections will need to be made if more groundwater is contaminated or is found to be unfit for human consumption. This is likely to occur with the advent of more sophisticated testing technology and new epidemiological studies.

This situation applies to other townships as well. Rural residential sites neighbor both present and proposed industrial sites in Lima, Ann Arbor, Superior, Pittsfield, and Lodi Townships. This settlement pattern seems to be establishing itself. It is unlikely that this will change given the present County planning which supports it. However, contamination of residential groundwater by Gelman is a case in point that such a pattern may be unwise. Given the considerable uncertainty in terms of compatibility between high-tech industrial and rural residential land uses, it seems quite short-sighted of the County to ignore these potential problems.

Analysis

While planning policies may look very good on paper, there is often a discrepancy between those policies and the built environment. Planning policies for a community are only as good as their implementation. There are multi-faceted weak links in the chain between planning and construction. This disparity can be considered from many perspectives. Ours is based on trying to understand the role of planners, planning commissions, and developers in the shaping of the built environment.

Planning agencies are staffed by people employed by a municipality or some other government body. As such, planners are civil servants and in this respect their role differs from that of members of a planning commission (or board). Members of a planning commission are typically appointed by a mayor and approved by a city council, in the case of a city, and serve as public servants. While a seat on a planning commission carries a public responsibility, the position tends to be political in nature.

A commissioner's responsibilities are very different from those of a person in a planning agency. A commissioner attends weekly or bi-weekly zoning meetings and may have other minor responsibilities beyond this. Commissioners do not establish planning policy nor do they receive much financial compensation. On the contrary, planners develop or revise an area's planning policies, and are full time employees of a given municipality. While a member of a planning staff may be much more qualified to make specific land use decisions, planning commissioners are shouldered with this responsibility. Planning commissions bridge the gap between proposal and policy by deciding whether or not to approve developments.

An important aspect of planning commissions is their political nature, as appointees tend to reflect the opinions and biases of those who appointed them. Commissioners tend to outstay those who appointed them, thus creating a legacy for future elected public officials to handle. Therefore, a mayor (or other appointer), while still in office, can significantly impact an area's development for years to come through appointments to the

planning commission.

Although it is important to understand the relationship between the staff members of planning agencies and planning commissions it is possibly more important to understand the role of developers and the development of our lands. Developers take an active role in bringing a building project from an idea into reality. They typically employ architects, engineers, and landscape architects in the early stages of a project to develop an idea, to appropriate the necessary permits, and to complete drawings for the construction of a project. General contractors then build the project. Not only do developers guide architects and contractors, but they arrange the financing, marketing, and sale of a project through to its completion.

Developing land is a risky business. When the economy is "strong" the pay-off on successful developments can be among the highest of all conventional investments. However, if the economy is "weak" or if the project is difficult to market, developers can take a loss. It is not unreasonable to expect a 10 to 15 percent return on invested capital from land development projects. Quite substantial gains can be made by one who has several million dollars invested in a project. Developers desire a quick turnover of their capital, in order that they may continue to reinvest it. This mind-set, one of making a fast buck at whomevers' expense, can cause a great deal of resentment toward developers from their employees and the public in general A general lack of trust pervades public sentiment toward developers.

From a development standpoint, major concerns include raising the capital to begin a project, and engaging in a project that will yield a high rate of return, with a consequential short term committment. Accordingly, most of the projects of the recent past (commissioned by corporations and wealthy individuals) have been undertaken with these concerns in mind. While much construction of the past five years has been focused on expensive single family homes, and commercial and office space, there have, of course, been many other types of development. The focus of development, however, is always on

those groups that can afford the services, be it the private or public sector.

Developers seek markets that will have a high rate of return. Very seldom will the private sector originate projects for lower income people. Rather, developers will do marketing research and determine the building needs of those who can pay.

The arena

Given this description of the main actors, the focus will shift to the arena in which these actors meet and make decisions about development, planning commission meetings. All meetings of the planning commission which concern the granting of zoning variances are open to the public. Variances may be granted to parties interested in changing the zoning designation on a parcel of land so that they can construct a structure, or use the parcel for some other function not allowed under the existing zoning ordinance. Variances are commonly granted and this is a point at which the planning commission becomes extremely influential in the development process. An example of a case where variances are routinely requested is Ann Arbor, which is a desirable city to many developers, as well as others. The general factors that influence desirability are: the quality of an area's schools and recreation opportunities, employment potential, the educational level of an area's residents, entertainment opportunities, etc. Conversely, an area that is not perceived as desirable is not likely to attract development interests. Its planning infrastructure, therefore, will have few development options to consider.

Developers are knowledable when it comes to working with the "system." When a variance is needed for a project, it is the architect or the landscape architect who goes before the planning commission to convince them of the merit of the project. The developer keeps a low profile to avoid aggravating those opposed to the development. The practice of planning has inherent weaknesses in that it is impossible to always predict accurately what is best for a community. Variances, an integral part of the planning process, may be

manipulated in both positive and negative ways, depending on the interests and values of the developers and the commissioners who make variance decisions.

Scio Township

Scio Township is an example of a planning commission trying to respond to intense external and internal pressures. The township residents are very adamant about keeping the area as it is (farmland with scattered low-density housing mixed within it). The Jackson Road Corridor slices the township in two and continues to attract mixed land uses (i.e. light industrial and commercial).

While the township residents are very vocal about keeping Scio Township as it is, there is financial pressure on the township adminstrators to pay off the debt they have incurred recently in extending sewer services from Ann Arbor. According to Jim Schafer of the Washtenaw County Metropolitan Planning Commission, the township is facing a $1,000,000 annual payment on these capital improvements. This is a substantial burden on the township. The response of the township administrators is to encourage new development to broaden their tax base and to ease the township's financial burden. Further, industrial sites pay substantially higher taxes than residential areas, and have a certain appeal to Scio Township administrators at this time.

Consequently, the planning commission is aware of the township's financial pressure and have been influenced by it to some degree. There are two large housing developments that have been approved in the township within the last year. The Jackson Road Corridor is also growing rapidly, with the extension of the sewer line. Meanwhile, the citizens have become increasingly vocal in their opposition to this. Several members of our group attended a February public meeting of the planning commission that was held to help revise the township's land use plan. The residents were very upset by the recent planning decisions, supposedly made in their best interests. They felt the planning process

had not been adequately addressing many of their interests , and they were mad enough to go out and provide input to the process.

Certainly the groundwater contamination from Gelman has made local residents very conscious and concerned about their property and the future of the township. When one works a lifetime to buy their own home and becomes part of a community, any threat to the well being of that will motivate people to respond. We believe that is the situation for many Scio Township residents. They are being threatened by mushrooming land development, and directly or indirectly by groundwater contamination. This is the time for the planning process to effectively respond to their needs. We believe that the citizens of the township must be vocal in expressing their needs and should attend the meetings of the planning commission on a regular basis to ensure that their needs are being addressed. The planning process is convoluted with multiple interests and divergent needs at times, and if left to itself often does not respond to the needs of local citizens. The process, however, is designed to incorporate the input of citizens and should be utilized by the residents of Scio Township.

Since a planning commission is designed to serve the people of a municipality, planning commission members are obligated to listen to the needs of local residents. Often public participation is lacking from planning decisions because people are uninterested, uninformed, or simply lack knowledge of how to enter the arena. While this cycle of public interest is difficult to remedy the planning commission can make efforts to see that the public remains informed of their actions, and to actively seek public input on decisions.

Future growth in relation to rural residential areas and high-tech sites

Planning can be seen as both a proactive and reactive public service. It is proactive when it seeks to prevent problems from occurring (i.e. planning and zoning ordinances) and is reactive when it seeks to accomodate the interests of developers. The following

discussion addresses both aspects of planning and attempt to challenge the "system" to make it serve the general public better than it does currently.

In terms of the development of high-tech industry, there are several measures that could help minimize the potential for groundwater contamination. A primary means of addressing this issue would be to mandate that all new industrial sites recycle waste materials on site and seek ways to reduce the volume and toxicity of substances routinely used. These regulations could be written into the land use policies that currently exist, and an enforcement arm of the local public health department could be given jurisdiction over their implementation. While planning agencies typically do not make recommendations of this scope, it is a positive means of expressing the public's concern for a clean environment. This type of regulation makes it clear to the producer that the status quo is not acceptable and a progressive means of waste management must be sought within the given area.

Another primary means of denying industry the opportunity to contaminate groundwater would be to require all new industrial sites to have sanitary sewer service and to dispose of their wastes through a centralized wastewater treatment plant. There would be no individual on-site waste disposal permitted in the area. The wastewater treatment plant could monitor its inflow and treat it accordingly.

Requiring new high-tech industrial sites to use sanitary sewers would provide incentive for the physical infrastructure (i.e. sewer and water services) to develop compact technology centers or "parks." A compact development pattern is useful in two spheres. First, it uses urban services more efficiently because the distance between hook-ups is shorter than in an urban sprawl situation. Second, if the environment is accidentally contaminated, a compact industrial park will more likely be able to respond financially and technologically to it than sprawling industrial development. Likewise industrial parks would be concerned with their public image and would likely seek a unified response to contamination regardless of an individual site's responsibility. In contrast, individual

industrial sites have much less of a resource base from which to clean up their own mistakes and protect neighboring land uses. Also, if several industrial sites have contaminated their own "backyard," it would be easier to accomplish environmental clean-up efforts in a concentrated area.

Further, a system of monitoring wells on high-tech industrial sites using toxic substances should become part of local land use policies. In our opinion the cost of the installation and maintenance of the wells should be borne by the industry and routinely checked by the Michigan Department of Natural Resources. This type of environmental monitoring would serve as a safeguard against the contamination of groundwater for local residents and employees of these industrial facilities.

Land use buffers should be established between rural residential areas and the proposed employment zone. Presently, these areas contain a mix of commercial, wholesale, office and industrial uses. As the County currently depicts this relationship, there is no buffer between the different land uses. Without prior knowledge of the land use that will occur in these employment zones, there is a potential for high-tech industry to locate anywhere within them. Not knowing where the industrial uses will locate, it becomes impossible to adequately isolate rural residential areas from them. Buffer zones of agricultural or park land would serve, to a degree, as physical barriers to prevent contaminated groundwater from spreading too rapidly to residential wells. Periodic well monitoring may be the only way to ensure the knowledge of the quality of well water of residents in close proximity to industrial sites. Further, by providing some physical distance between these land uses, it may at least buy individuals and the government regulatory agencies time to react to groundwater contamination problems should they arise.

It is important to regulate industrial practices--waste disposal in particular--for the well being of people and the environment. Also, the siting of high-tech manufacturing plants should be done with sensitivity to rural residential areas. The compatibility of industrial sites with existing hydrogeologic conditions of an area needs to be determined to

prevent industry from locating on very sensitive groundwater recharge areas.

Likewise, development of new residential areas may need to be more carefully regulated in the future. Particular attention needs to be paid to the location of high-tech industrial sites when developing new rural residential areas. A healthy respect for the potential threat of industrial sites must be conveyed to builders and other development interests.

The current pattern of rural residential areas is one of linear dispersion along various rural roads. This pattern is easy to accomplish and relatively inexpensive in the short run when compared to "planned" rural centers. Often, the requirements for septic tanks' leaching fields are such that dispersed housing is the only way possible to properly dispose of domestic sewage.

Another option to the sprawled rural residential fabric which pocks our country's landscape would be to cluster rural areas. By clustering homes, urban services (water and sewer) would be less expensive to provide. This clustering of homes onto small areas in the countryside would not only preserve agricultural land, it would be visually less obtrusive to the landscape as a whole. The potential for rural residential areas to receive municipal water and sewer services would greatly reduce the threat of ingesting contaminated groundwater (although it would not prevent groundwater contamination). This land use pattern would also be a more "responsible" form of land stewardship.

Conclusion

While "planning" has it weaknesses as a means of guiding the future of land use patterns, it serves a very important function. Planning forces us to look at where we are and where we want to go. This process of evaluation and reflection on the quality of our built environment and its effectiveness helps us to direct a response to the development issues of the day. Presently, we are improving our understanding of the physical

environment, both in terms of its effect on us, and on our effect on it. Our heightened understanding is forcing us to recognize our abuse of the environment. From some industries' mistakes, the public is experiencing a serious health threat in terms of exposure to carcinogens. This case study offers a glimpse at the complexity of one industry's contamination of the environment, and the ensuing situation's impact on various people, institutions, and organizations.

Planning cannot stop development or force all land uses into rigid, predetermined locations, but it can acknowledge real and potential hazards to people. When potentially hazardous land use relationships exist, planning can regulate these problems by changing zoning ordinances and drawing attention to particularily sensitive areas. Also, those most affected by conflicting land use relationships, the local residents, can use the planning process to voice their opinions and demand that the "system" work in their best interests.

To reiterate, our recommendations are broad and seek to address the role planning can play, both in terms of proactive and reactive ways to minimize the present threat of groundwater contamination to our society. Industrial sites should be required to recycle their wastes on site, and to seek ways to reduce the volume and toxicity of their waste. New industrial sites can be required to have sanitary sewer hook-ups and to locate in compact industrial parks. Also, monitoring wells and land use buffers can be required of all new industrial sites.

Lastly, it must be recognized that in our industrial society groundwater contamination has been a problem, still is one, and will continue to be one for at least the near future. We believe that with a concerted effort, the threat of groundwater contamination can be minimized and eventually eliminated. At present, however, the resources have not been made available to clean all existing sites of contamination. Thus, we must adapt our development of the land so that we can live healthy productive lives with this threat. This type of reactive response, however, is not good enough. We must push planning agencies to be the visionaries they are paid to be, and encourage them to take a

proactive stance toward environmental pollution. The more difficult government policy becomes for industry to ignore, the sooner a new status quo can be molded into a more environmentally sensitive aspect of our culture. We must also push for tougher regulations which work to prevent industry from engaging in environmentally unsound practices.

AN ANALYSIS OF THE RESPONSE OF CITIZENS TO THE CONTAMINATION ISSUE

> To not be able to drink, cook in, bathe in, wash clothes or dishes in, or touch your main water supply is a deprivation of a basic right to which we have always believed we were entitled. To have to scream at a small child for taking a drink of water is an outrage. To be ignored by the Health Department, gambled with by the DNR, and manipulated by the Ann Arbor City Council and Scio Township has been a totally humiliating experience. When this happened to us, we found that we were left alone to beg for what we assumed was a basic human right.
>
> -Timothy and Elizabeth Polk, residents of the Westover neighborhood with a contaminated well (Polk, *The Ann Arbor News*, 9/11/1986).

Citizens who one day find that their well is contaminated by a synthetic, organic chemical such as 1,4-dioxane ("dioxane"), also find themselves with little or no experience and few skills for coping with the situation. They are faced with a problem they neither created nor even realized would be created. Residents and businesses surrounding the Gelman Sciences, Inc. ("Gelman") site have had to put up with odor problems for over fourteen years, and with contaminated groundwater and associated health risks for an unknown number of years. They recently had to be annexed into the city of Ann Arbor, the result of which is that residents are faced with increased taxes and future costs for sewer hook-ups. The objectives of public participation have changed with the immediate concerns posed by Gelman, the City of Ann Arbor, and Scio Township. The following is a list of citizen objections and how they have evolved over time.

- Citizens alerted the Department of Natural Resources (DNR) Air Quality Division (AQD) about odors emitted by Gelman's treatment lagoons for over fourteen years.

- Citizens brought to DNR's attention incidents of illegal waste discharge and burning of wastes by Gelman.

- Citizens sought to get their drinking water tested by the Department of Public Health after learning of the groundwater contamination problem.

- Citizens requested a safe alternative water supply system for their homes.
- Citizens fought the increased taxes and the costs of future sewer hook-ups that would result from annexation to Ann Arbor.
- Citizens demanded timely remedial action to address health and environmental concerns.
- Citizens tried to understand the health and environmental risks associated with dioxane, the extent of contamination, and with whom the responsibility lies.
- Citizens challenged the injection well permit granted by the Environmental Protection Agency (EPA) as a means of waste disposal at the Gelman site.
- Citizens could potentially seek compensation for economic costs and personal injury resulting from the contamination.

We have defined five phases of public participation in the Gelman incident of environmental contamination. These phases include odor complaints and complaints about illegal waste disposal, Bicknell's discovery of dioxane, activity surrounding annexation issues, Tocsin, and the functions of the Citizen Information Committee. It is our intent to explore the importance of public participation and efficacy of public involvement in the Gelman case.

Citizen complaints over odor problems and illegal waste disposal

The first phase of citizen involvement focused on odors emitted by Gelman's treatment lagoons and illegal waste disposal by Gelman. Citizens first complained about the odors in October 1967. According to Gelman Vice President for Operations James Marshall, the odors were a result of both the treatment lagoons becoming anaerobic and the covers on the ponds ripping (Interview with James Marshall, 2/5/88). These complaints continued for over fourteen years; the last odor complaint was received by the AQD of the DNR in March 1982 (see The Story section, pp. 16-28).

According to complaints filed with the DNR, citizens expressed feeling disempowered next to a large and powerful company like Gelman. According to Westover

resident Mary Jo Campbell, "Mr. Gelman and his fellow employees would never permit anything such as this happening in his neighborhood but we who are not as financially well off as he have to put up with this health hazard" (DNR files, 8/17/81). Mary Jo Campbell in a later interview with Janet Cohen, a reporter from *The Ann Arbor News* , said, "We called, we complained. They ignore you. We didn't get anyplace. They (Gelman) pay big taxes, we pay little taxes, the township doesn't care" (Cohen, 5/18/86).

Some individuals complained directly to Gelman. Carl A. Brauer, a local realtor who developed the Jackson Plaza Business Park, informed Charles Gelman on October 31, 1967 that run-off from Gelman's treatment lagoons was flowing onto portions of lots 21 and 22 that he owned in Jackson Plaza. He claimed that the runoff had a "strong sewage odor." Charles Gelman wrote a letter responding to Brauer's concerns on November 2, 1967. In his letter Mr. Gelman stated,

> We hope to turn our pond into an asset in short order. Designed as a holding pond for runoff water, it has worked well. Unfortunately, at present there is no circulation or aeration within the pond. The water pumped into the pond is pure enough to drink... We are in the process of installing a pump to aerate the pond water and also plan to stock the pond with fish. Once there has been enough growth, we hope to be able to invite you to share in our harvest (DNR files, 11/2/67).

Mr. Gelman, in his letter, claimed that the pond containing runoff water from the parking lots was overflowing onto Brauer's property. However, the pond containing runoff water from the parking lots was several hundred yards to the south of Jackson Plaza at the time, and would not have contained sewage sludge or smelled like sewage. The lagoons that were adjacent to Jackson Plaza and Brauer's property, according to DNR records, and our interview with James Marshall were unlined treatment lagoons. In these lagoons, anaerobic and aerobic treatment occurred on Gelman's waste stream (which contained dioxane as of 1966). Marshall also informed us that sewage from the Ann Arbor Sewage Treatment Plant was added to these ponds to encourage microbial action. These lagoons, according to Marshall, would periodically overflow into the bog north of Gelman's lagoon, which is in the direction of Brauer's property (Interview with James

Marshall, 2/5/88). Therefore, it seems that the letter Mr. Gelman wrote was inaccurate and very misleading.

During a telephone conservation on March 28, 1987, Carl Brauer informed us that he had traced the water to Gelman's treatment lagoons. He found Mr. Gelman to be "self serving and vague" in his letter. Brauer felt that Mr. Gelman used this letter as a "smoke screen to diffuse the issue."

During the period from 1967 to 1982, many citizens felt as though the DNR had failed to adequately address their concerns about the odors emanating from Gelman's treatment lagoons. Mrs. Mary Mickelson, a community member, stated in an interview with us that she was "very disappointed with the DNR" and had written a letter to them several years ago complaining about the odor problem. "We've put up with a lot over the years" (Interview with Mary Mickelson, 2/17/88). The AQD did investigate the odors on numerous occasions (DNR files: 7/7/75, 8/6/75, 8/7/75, 7/15/80, etc.), yet the odor problem lasted for over fourteen years.

Gelman responded to the AQD's requests to reduce odors by installing plastic covers on the company's anaerobic wastewater treatment lagoon (DNR files, 9/10/73), and by keeping a spare cover on hand (DNR files, 10/27/76). However, responses by Gelman were inadequate in addressing the odor problems. The covers installed by Gelman were reported to have holes in them and emitted odors on several occasions (DNR files: 7/7/75, 8/76, 7/79). The Washtenaw County Health Inspector found the cover off the lagoon on September 3, 1976 (DNR files, 9/3/76). The aerators within the lagoons were reported to be malfunctioning by both Gelman and the DNR on numerous occasions (DNR files: 9/76, 7/17/79, 8/1/79, 7/15/80, 8/19/80). When the aerators malfunctioned, the dissolved oxygen within the lagoons would fall to a level too low to support aerobic bacteria. The lagoons would then become anaerobic, and the foul odor would result (see The Story section, p. 28). The AQD did follow up on many of the citizen complaints regarding both

odor problems, yet the odor problem was not remedied until Gelman began disposing of wastes in its deep injection well.

Complaints, such as those from Brauer, help to record a pattern of irresponsible behavior by Gelman and to alert government officials to illegal waste discharges and practices. Other examples of illegal waste disposal by Gelman were brought to light by citizens. On October 27, 1980, the DNR Environmental Enforcement Division ("EED") received an anonymous complaint. According to the DNR files, the complainant informed them that Gelman was "emptying the second pond, at the rear of the property, by draining it off of the property." The EED investigated and verified the report (see The Story pp. 26-27).

Citizens and the deep well

In 1981 Gelman began construction of a deep injection well. To many of Gelman's neighbors, the well came as a surprise. In an article entitled, "Gelman drills a well to solve waste problem," Charles Gelman states, "I guess we should have told some of our neighbors, and explained the process to them, so they wouldn't be worried, but this kind of disposal well is unusual, and we didn't want to attract a nuisance suit from those who might not understand it, and get it all tied up in court" (Fulton, 6/28/81). Consequently, in order to test public reaction to the well, Gelman had an open house in early July and invited all parties with drinking water wells within a one-half mile radius to hear a review of their proposed plan. According to GSD officials, however, "There didn't seem to be much interest as only two families were present out of some 50 or 60 that were invited" (DNR files, 11/12/81). Accordingly, in Gelman's "Summary of Waste Water Treatment," they state that in 1981, "there was no public opposition to use of deep well."

Several citizens, however, did raise concerns over the deep well in the coming months. Citizens appearing before a Michigan Air Pollution Control Commission monthly

public meeting expressed concern that there may be problems from the deep well injection system and submitted letters from neighbors. Citizens who wrote to the DNR were responded to by a GSD form letter claiming that "this type of waste disposal (deep well) has been in use in Michigan for over twenty years and not a single groundwater pollution problem has been attributable to the use of one of these wells" (DNR files: 8/17/81, and 9/9/81). However, several problems with deep wells in the United States have been documented and there is no guarantee that these types of problems won't occur in Michigan (see Deep well section).

The Bicknell discovery

In June 1984, Dan Bicknell released his report entitled, "Hazardous Waste Introductions into Third Sister Lake, Washtenaw County, Michigan." In the report, Bicknell traced the source of the dioxane and other chemicals to Gelman by sampling the creek which runs from Gelman's property into the lake. Bicknell's study was criticized by Gelman and others because of his "lack of credibility," his misuse of titles, and his political motivations. However, his discovery of dioxane (among other chemicals) alerted the public to the potential health and environmental hazards (see The Story section, pp. 35).

In late April 1985, Bicknell drew up a petition, which was circulated by a local resident, requesting that residents' wells be tested by the Washtenaw County Health Department (WCHD). Bicknell first gave the petition to WCHD Medical Director Dr. Atwater. Two weeks later Bicknell presented the petition at a meeting of the Washtenaw County Board of Commissioners. The following day the WCHD was instructed by the Board of Commissioners to begin testing residents' wells. Subsequently, the WCHD found dioxane in six commercial wells, a drainage ditch and a swampy area north of the Gelman property. To date, over 50 wells have been found to be contaminated. It was the work of citizens like Dan Bicknell and those who signed the petition that helped to force the

State and Gelman to recognize that there was a contamination problem and to start addressing it.

The annexation issue

The first organized citizen involvement in the Gelman case began when a group of approximately 40 homeowners organized around the issue of annexation to the City of Ann Arbor. In order to provide a safe source of drinking water to residents with contaminated wells, the decision had been made to extend the Ann Arbor water supply system to them. This action mandated the annexation of the Westover Hills subdivision to the City of Ann Arbor. Gelman agreed to pay for the original water hook-ups, but residents still faced higher taxes and future costs for sewer hook-ups that would result from annexation. According to our interview with Alfin Vaz, a Westover resident and a University of Michigan chemistry professor, these costs would amount to close to $1,000 per year in increased taxes (Interview with Alfin Vaz, 3/12/88). It would also cost $10,000 to $15,000 per household over approximately a five year period for capital improvements (i.e. sewer construction). The City of Ann Arbor wanted Scio Township residents, if they were not annexed, to pay twice the price for water that Ann Arbor residents pay. According to Alfin Vaz, these were lower to middle income residents, many of them with fixed incomes who had lived there for 40 years or more, and they were not able to pay the increase in taxes and costs for sewer hook-ups.

Residents postponed the vote over the city water hook-up and annexation four times. In an interview with the *The Ann Arbor News*, Priscilla Cheever, an attorney and resident of the Westover area, said, "We have some concerns other than just getting the water. We're nervous about the possibility of a sewer, which would be very expensive for all of us." Cheever continued, "As a 'price' for getting the water, residents would be required to agree to annexation to the City of Ann Arbor, which could also entail

connecting to the sewer at a cost of $439,000" (Cohen, 7/16/86). Approximately 40 homeowners organized a meeting with the Ann Arbor City Council Democratic Caucus in order to arrange for a five year grace period before the taxes would increase during early July 1986. This would allow those who could not afford the tax increase time to move or to make arrangements for payment.

According to Alfin Vaz, during the meeting with the Democratic Caucus all of the Democrats except for Larry Hunter agreed to provide the homeowners with a five year grace period before taxes would be increased. However, two weeks later, on July 22 when it came to a vote, all members of the Democratic Caucus (except for Hunter) reversed their position on this issue. The approved agreement said that Gelman would pay the cost of the water main constructed for the homes in the Westover Hills subdivision just east of Wagner Road. The agreement also stated that lots with homes on them would be annexed to the City as soon as the water hook-ups were connected. No sanitary sewers were planned at the time for the 32 houses in the subdivision. However, once sewer lines were installed, residents would have to hook into the system when their septic systems failed.

The Westover Hills subdivision was officially annexed to Ann Arbor in January 1987. Some of the Westover residents' septic systems are already beginning to show signs of failing. This may be a result of adding Ann Arbor water to the septic fields. According to Alfin Vaz, Ann Arbor water has a pH of 10 and is heavily chlorinated. It is not known definitively, but it is likely that the bacteria within the septic field would not survive in Ann Arbor city water (Interview with Alfin Vaz, 3/12/88).

In addition to the added costs of annexation, some of the residents in the area contend that property values have fallen as a result of the contamination problem. Carol Dudley, Executive Assistant of Saginaw Hills Development Company, stated, "We can't sell property--I wouldn't consider buying it." However, Scio Township manager Don McDevitt, when asked how this situation impacted the communities adjacent to Gelman,

replied that there is no adverse effect on growth and that property values in the Township have risen by 20 percent over the last two years.

Tocsin

In 1986 a citizen group formed, claiming to represent residents of the Scio Township subdivisions of Westover, Lakeview, and Lakeside, as well as a growing number of concerned citizens of southeastern Michigan. This citizen environmental action group named themselves "Tocsin," which means an alarm bell or warning signal. The reasons Tocsin formed are,

> ...because of the many problems that are believed to be associated with Gelman Sciences' poor history of waste management. We are concerned about what the companies' [sic] chemical waste may mean to our health, our safety, our property and our interests in a decent environment. We share concerns about the contamination of our groundwater, the effects this has had or might have on our families, the reduction of our property values, the short term and long term danger posed by the deep injection well, and the threat Gelman's waste might pose to Ann Arbor's Sewage treatment system" (Introductory Tocsin newsletter, undated).

Tocsin members felt that Gelman, government authorities, and other organizations had not adequately responded to their needs. Specifically, these parties had at times failed to alert them about the dangers posed by Gelman's waste management practices, to provide timely notification of the contamination problem, and to provide adequate remedial action. Tocsin was successful in organizing community members around several issues.

Tocsin members, and residents of Westover not associated with Tocsin, organized around the issue of Gelman's deep injection well for industrial waste disposal. They attended a public hearing sponsored by EPA regarding the injection well on September 25, 1986. Citizens at the public hearing demanded proof that the deep well was safe. "Until someone can make a statement 'your kids aren't going to be poisoned again,' I see no reason...to issue the permit," said Elizabeth Polk, who was not a member of Tocsin.

According to Brian Ewart, the founder and primary organizer of Tocsin, the serious questions that community members were posing to the EPA were met with superficial answers (Interview with Brian Ewart, 3/28/88).

In October 1986, Tocsin had pressured the County Board of Commissioners to write a strong letter to the EPA in support of their stand against granting Gelman a deep injection well permit (Interview with Brian Ewart, 3/28/88). The main objections to the deep well were that there was: 1) no adequate monitoring system, and 2) no knowledge of the source and extent of the current groundwater problem (see Deep well section). In November 1986, more than 400 area residents signed a petition (drafted by Tocsin) asking federal and state legislators to intervene in the EPA's decision to grant a permit to Gelman for the injection well. The petition was presented to Governor James Blanchard, U.S. Representative Carl Pursell, and U.S. Senators Carl Levin and Donald Riegle.

In December 1986 Tocsin organized another petition. They collected over 1,000 signatures and attached a 29 page document addressing the problems with the injection well. They again called for a denial of the injection well permit. Copies of the petition and letter were sent to both state and local government representatives. Tocsin claimed that the EPA had evaluated the well using "test data that bears evidence of possible tampering, analyses that are often superficial and incomplete, and interpretations of fact that are grossly inaccurate" (Rogers, 12/23/86) Tocsin based its analysis on two reviews done on the primary source used by the EPA. Both individuals who reviewed the report (a graduate student in geology and a person who does deep well testing) agreed that there was evidence that the geology of the area was not safe for deep injection wells (Interview with Brian Ewart, 3/28/88). Based on the opinions of these individuals, Ewart and Tocsin challenged the integrity of the geology surrounding Gelman's injection well.

In January 1986, Tocsin asked the EPA to monitor Gelman's waste well, citing a loss of pressure in the well's injection tubing and the well's possible contribution to the nearby groundwater contamination. The loss of pressure indicates a possible leak from the

injection well into the surrounding strata. Ewart claims he uncovered evidence of this upon examination of U.S. EPA documents, and felt the EPA had been trying to hide this. Ewart brought this to the attention of Gelman and the governmental agencies in order to let them know that they were being held accountable. Tocsin and other community residents also wrote letters to Ronald McCallum, Chief Judicial Officer, U.S. EPA, requesting a review of the permit decision (Interview with Brian Ewart, 3/28/88).

On June 12, 1987 Tocsin called for regulatory action regarding illegal wastewater discharge by Gelman. Tocsin informed both the press and Governor James Blanchard that for over two years Gelman had been illegally discharging wastewater via a drainage ditch (known as Bicknell Creek) which originated at a Gelman building. Tocsin also informed the press that in July 1986, DNR officials had notified Gelman that this discharge was illegal and had requested that the corporation obtain the required National Pollutant Discharge Elimination Systems ("NPDES") permit. With this action, Tocsin attempted to focus attention on Gelman's "unsatisfactory record of waste disposal" and the DNR's "casual attitude" toward these violations (Tocsin Press Release, 6/12/87). Following Tocsin's press release, the DNR wrote to Gelman and mandated the registration of Gelman's "currently unauthorized discharge" into Bicknell Creek (DNR files, 7/1/86).

When the EPA Region V decision to issue Gelman a deep well permit met with considerable opposition from citizens, the national EPA office decided to review the Region V decision. The draft permit approved by EPA Region V had called for a monitoring well system proposal to be submitted for approval within 45 days after granting the permit. However, a review would prolong the decision for several months and Gelman, during the process, would be allowed to continue to operate the injection well without monitoring wells. Therefore, on January 23, 1987 Tocsin members requested that U.S. EPA Region V Water Division Director Charles H. Sutfin order Gelman to immediately install both deep and shallow wells for the monitoring of the company's underground injection of liquid waste. Tocsin's appeal of Gelman's injection well was denied in December 1987.

Tocsin was quite successful at focusing attention on critical information and pushing for remedial action. They alerted the public about the questions associated with the technology and sciences surrounding the deep injection well, and alerted government officials and agencies to illegal surface discharge by Gelman. They also found evidence of a leak in the injection well, organized the community around the issue, and attempted to make both the government and Gelman accountable.

Citizen information committee

In addition to the usual methods of keeping citizens informed about local issues (e.g. public meetings, progress reports, making available file information), the DNR has formed a Citizen Information Committee (CIC) due to the long term nature of the Gelman case. The purpose of the committee is as follows:

> 1) To ensure that community representatives are informed about the details and status of the groundwater investigation and proposed clean-up.
>
> 2) To ensure that local citizens have a consistent and easily accessible means of receiving up-to-date information regarding project progress and of expressing concerns to DNR staff and local government officials;
>
> 3) To advise the DNR project staff and local and state officials regarding local concerns and alternatives for communicating information about the projects to citizens
> (Letter from DNR to CIC representatives, DNR files, 6/17/87).

The CIC in the Gelman case is comprised of local residents, Scio Township officials, a representative from affected businesses, state and local government representatives, and a Gelman representative.

We interviewed seven of the nineteen CIC members listed on DNR Progress Report #1 of September 22, 1987 (DNR files, 9/22/87). Of these one wasn't aware he was a CIC member and was never formally told that he was a member (James Crowfoot, Dean of the

University of Michigan School of Natural Resources), and another needed to be reminded (Ken Schatzle, University of Michigan Office of Safety and Environmental Health).

DNR direction of the CIC also appears to be lacking. When asked who was in charge of the CIC, Karen Clark of the Jackson office of the DNR was not certain. Clark, who has been employed by the DNR since late 1987, responded that she "guessed" she was in charge (Interview with Clark, Larsen, and Kooistra, Jackson DNR, 2/25/88).

CIC members were asked, "How does the CIC disseminate information to and collect information from the community? Describe how the CIC actually functions." Responses ranged from, "There exist no formal channels for disseminating information" and it is "haphazard," to "information is disseminated by word of mouth. Each neighborhood has a representative (for approximately 100-150 residents) on the committee. DNR sends out mailings to all residents announcing public meetings. Residents are supposed to call representatives with questions" (Interview with Douglas Mark, 1/6/88). One CIC representative, Westover resident and attorney Priscilla Cheever, distributed periodical newsletters to the community on her own initiative (Interview with Priscilla Cheever, 1/4/88). Another CIC member felt that the CIC was set up "to make it look like something was going on. Its purpose was to get together a bunch of opinion leaders and sway their opinions" (Interview with Kathy Edgren, 2/25/88).

Information we were able to gather indicates that the CIC has met on only two occasions, July 30, 1987 and September 2, 1987. We were told that the first meeting was not announced to the public. The CIC has not met since early Fall, and no formal channels exist through which CIC members can disseminate information to citizens. It seems to be a haphazard attempt by the DNR to involve citizens in the remediation process.

Citizens have been actively involved in this case in several ways. They have worked to protect their own interests--both financially and in terms of health. They have also attempted to hold Gelman accountable for the contamination of the environment, and to hold the DNR accountable for enforcing environmental regulations. The citizens have

interjected themselves into the process through self-initiated efforts, in the absence of effective channels for participation.

THE RESPONSE OF THE UNIVERSITY OF MICHIGAN TO THE CONTAMINATION ISSUE

The University of Michigan administration response

The official University of Michigan ("U-M" or "University") position regarding the contamination of Third Sister Lake, a U-M property located in Saginaw Forest, is one of not addressing the problem. The School of Natural Resources (SNR) has stewardship over the land, but the U-M Board of Regents, in whose name the land is titled, have the ultimate authority and responsibility for the land. Actions to address the problem must come from the U-M Administration. According to Jack Weidenbach, then-U-M Business Operations Director, the University's position on the contamination is one of "wait and see" (Interview with Weidenbach 2/18/88). Weidenbach explained that in order to sue Gelman, the University must be able to prove damages either to the value of the land, or to ongoing academic research on the site. According to Weidenbach, the University is waiting for: 1) evidence from the School of Natural Resources which shows decreasing land value due to contamination; 2) more information regarding the risks associated with 1,4-dioxane ("dioxane") to human health and the environment; and 3) a court decision establishing responsibility for the contamination.

Ken Schatzle, Director of Occupational Safety and Environmental Health (OSEH) at U-M, claims that the University's only concern is Third Sister Lake and that it's not known if the contamination therein is caused by Gelman (Interview with Schatzle, 1/4/88). Schatzle found Gelman's response to the contamination to be "very favorable." Schatzle was thus condoning Gelman's response. Gelman's response has been characterized by: taking responsibility for the contamination, and inadequate response to the surrounding community.,

It appears that there are grounds on which the University could pursue a lawsuit against Gelman. The University is currently liable for the well that supplies water to the caretaker's cabin in Saginaw Forest, thus, the University will need to continue monitoring the well for dioxane. Carl Brauer, owner of land adjacent to Gelman, states that he is liable to his tenants in the Jackson Plaza and is continually monitoring these wells, although dioxane has not been detected thus far. He is holding a suit in abeyance against Gelman for these reasons.

According to Carol Dudley, Executive Assistant of Saginaw Hills Development Company, property values in the area have fallen and sales in the area have slowed significantly (Interview with Dudley, 2/23/88). If the same land value assessment applies to Saginaw Forest, then the University would have another basis on which to pursue legal action.

The University has made little or no attempt to determine the extent of environmental damage at the site. Saginaw Forest, including Third Sister Lake, is currently used for research. A study of the environmental effects of dioxane could be initiated to answer the above question.

It is possible that the University has adopted a "wait and see" policy because of financial ties to Gelman or due to other political pressures. Since July 1975 Gelman has given gifts to the University totalling $63,532. As of February of this fiscal year, Gelman has contributed $6,000. These contributions are significant, relative to other donations received by the University, and could influence the University's response to the contamination. Another possibly influential factor is that U-M economics professor Saul Hymans, is a member of Gelman's five-person Board of Directors.

In addition, if the University were to pursue legal action in this case, it may discourage the high-tech industrial development which the University is committed to attracting to the Ann Arbor area. The University's support for high-tech research and

development coincides with the State of Michigan's interests in diversification and stimulation of the economy.

> In 1987 the State captured three major national centers for manufacturing science space robotics and super computer communications. It became a finalist for the $5.6 billion Superconducting Supercollider...
>
> Researchers at more than twenty Ann Arbor campus locations have agreements with 336 industrial affiliates in Michigan and the County (Blanchard, Frank, 1980).

Accordingly, this commitment to high-tech growth by the State and U-M, has resulted in the reduction or elimination of numerous environmental programs. For example, the University recently cut the budget of the School of Natural Resources by 28% as of a 1981 review, and the elimination of the School was considered in 1983. This reflects a national tendency which is to favor development over protection of the environment. It also transmits a message to industry that consequences for pollution are minimal, while quelling the voices of those who might oppose this policy.

According to Weidenbach, U-M does not act on local issues, but always waits for a local governing body to take the initiative (Interview with Weidenbach, 2/18/88). Yet, the University has boldly proclaimed its support for high-tech development such as the Supercollider, and has outlined the importance of the Supercollider to the State of Michigan. However, the University does not address the problems of environmental contamination in the State--even if it affects their own property! Is it ethical for U-M to support research and development without also encouraging responsible behavior toward human health and the environment?

School of Public Health and the School of Natural Resources response

When Dan Bicknell released his report in June 1984, Gelman chemist Paul Chalmers quickly contacted the SNR office because Bicknell's report resembled an

"official" University report (SNR files, 6/84). The School of Natural Resources then contacted the School of Public Health (SPH) and conveyed Gelman's concerns. On September 18, 1984, SPH Dean June E. Osborn wrote a memo to Dan Bicknell. She explained that the title "Principle Investigator" (which Bicknell had used on his report) has a very specific meaning in University governance, being generally restricted to individuals on professorial or scientist appointment tracks. Dan Bicknell also claimed (in his campaign fliers while running for Drain Commissioner) to have his M.S. in Public Health, although at the time he had not yet received a degree. The University thus responded quickly to Gelman's concerns, but apparently made no effort to congratulate a U-M student who discovered the contamination and alerted the public to the potential threat to health and the environment.

The School of Natural Resources has responded by collecting data on the levels of contamination in the caretaker's well in Saginaw Forest, and in the sediments and water of Third Sister Lake. SNR administrators have met a number of times with representatives from Gelman, the Washtenaw County Public Health Department, and the DNR to address the issues surrounding the contamination. Bottled water was supplied to the caretaker at Saginaw Forest beginning in February 1986. Samples taken from the caretaker's well in February, and again in May, showed the presence of dioxane, as did the water and sediment of Third Sister Lake. Hexane, benzene, and methlyene chloride were detected in the lake's sediments as well. The results of tests performed since July have detected contamination in the lake water and sediments but have shown no dioxane in the well water. A number of SNR faculty members have expressed concern over the contamination situation and have recommended "that the School of Natural Resources urge the University legal counsel to vigorously pursue all appropriate action to halt further damage to University assets at Saginaw Forest, including Third Sister Lake, and to obtain appropriate compensation for loss of research opportunities at this property" (Memo from nine SNR

faculty members to SNR Dean Jim Crowfoot, 4/28/86). Never have these concerns been discussed in an open forum with SNR faculty and students.

Significantly, the School of Natural Resources is still struggling to preserve itself as an independent academic unit within the University. The School has been subject to an ongoing review process as required by the University Administration, despite its continued top ratings among natural resource schools nationwide. The School occupies a weak position politically within the University hierarchy. The administrators of SNR are presently concerned with the long-term viability of the School and are not willing to pursue actions contrary to the official University position regarding the contamination of Saginaw Forest. It has been brought to our attention that members of the University community have questioned the continued existence of our Masters Project group. We are grateful to the School of Natural Resources for its continued support of our project and its support of academic freedom.

SNR's mission includes a commitment to the pursuit of sustainable development. Sustainable development, in our opinion, does not include development without responsibility for the environment. SNR should not silently observe while industry pollutes the immediate environment, particularly when University property is being contaminated.

Contracting of professors by Gelman

Under contract, U-M professors, over the years, have performed various studies for Gelman. For example, Gelman hired Professor Borchardt from the U-M Department of Engineering to develop a microbiological digestive process which Gelman then used for approximately ten years. Another example is that Rolf Hartung, professor of Environmental Toxicology in the School of Public Health, was commissioned by Gelman to perform a risk assessment of dioxane. Gelman commissioned this study with the

intention of developing regulatory standards for dioxane. Hartung's report has provided Gelman with the information they are using to attempt to redefine what is a "safe" level of dioxane in drinking water. Gelman now considers this level to be three parts per million, as opposed to the State's established level of two parts per billion.

Gelman was able to hire this U-M expert to help redefine toxicity levels of dioxane, at considerable expense. Citizens' groups, in contrast, cannot afford to hire such experts. For example, when the citizens' group Tocsin was attempting to assess the integrity of Gelman's deep well, they were unable to find a U-M faculty member to assist them without a large consultation fee. This raises the question of who is able to hire U-M experts and also illustrates the influence of University professors on the decision-making process.

The University of Michigan, by choosing to ignore the problem and not pursuing meaningful action to resolve an environmental threat on their own land, infers a lack of concern for environmental health and integrity. Despite costs incurred for testing, potential loss of property value, and future liabilities, the University has adopted a "wait and see" approach. The Gelman contamination issue exemplifies the University's commitment to industry, as opposed to the community of which it is a part.

AN ANALYSIS OF THE RESPONSE OF THE DEPARTMENT OF NATURAL RESOURCES TO THE CONTAMINATION ISSUE

The years following World War II have been a time of tremendous industrial expansion in the United States. During this period the manufacture of chemical products, e.g. pesticides, herbicides, solvents, and other synthetic organic chemicals was initiated. Along with industrial development and the evolution of the field of organic chemistry, has come an increased hazardous waste problem. This problem was created, in part, by the very lax environmental regulations existent at the time. Presently "...as many as 10,000 sites may be contaminated in Michigan alone" (Bradford, 12/87, p.10). In this regard, the need for a more comprehensive regulatory framework had become apparent.

In the early 1960's, state and federal statutes protecting water and air quality were at their early stages of development. As this regulatory framework was defined, the Michigan Department of Natural Resources (MDNR) was charged with the task of implementation of the regulations. This was a particularly difficult task given that industrial practices had been proceeding virtually unchecked and that pollution had been considered an externality, rather than a cost of production.

The State has placed great importance on the development of high-tech industries as a means by which to diversify and stimulate a faltering and unpredictable economy. It was stated in a 1988 University of Michigan Special Report:

> The state snared three major national centers for manufacturing science, space robotics and supercomputer communications. It became a finalist for the $5.6 billion Superconducting Supercollider with its promise of thousands of jobs and billions in economic enterprise...The British journal *The Economist* hailed southeast Michigan as "the fastest growing high-tech corridor in the United States today (Blanchard, F., 1988).

The late 1960's and 1970's were also a period of a growing societal awareness of problems due to environmental contamination. Citizens and newly formed environmental groups began to demand that this country's resources be preserved. They pushed for more stringent environmental regulations governing industry, and pressured government regulatory agencies to fulfill their stated mission of enforcing these regulations.

Environmental regulations vary from state to state. Accordingly, since these regulations have the effect of increasing the cost of production, industry is more likely to locate in a state with less stringent regulations. The MDNR has been charged with the nearly impossible task of trying to implement environmental regulations, while at the same time being expected to support the economic priorities of the State.

The case study

In the immediate vicinity of Gelman Sciences, Inc. ("Gelman") there are now over 50 residential and commercial wells known to be contaminated with 1,4-dioxane ("dioxane"). Dioxane is an organic solvent and a potential human carcinogen used in Gelman's production process. It is believed that the dioxane entered groundwater and surface waters through one of Gelman's several unsound past disposal methods.

The DNR has been involved in this case in the following roles: issuing permits for waste disposal practices, monitoring the site, enforcing regulations, providing information to the public, and pushing Gelman to clean up the contamination. The DNR places blame for the contamination on Gelman.

The DNR as a reform-oriented agency

The mission of the DNR is clearly mandated and narrowly defined by state and federal governments. A framework has been constructed within which the DNR must

work to implement and enforce regulations. Inherent in this framework is the notion that the DNR must not regulate or monitor industry in such a way that it interferes with the expansion of industry within the state. The DNR's efforts have not been entirely successful at forcing industries to internalize costs. Pollution is still considered, to a degree, an externality, which is passed on to taxpayers.

Thus, in the case of Gelman, the DNR is limited in the role they can play. For instance, the DNR does not instruct Gelman not to produce waste, but rather aids Gelman in finding the best available methods for disposal of their waste. The DNR does not tell Gelman not to discharge into the ground or the surface water, but rather sets limits on the amounts Gelman may discharge. When one disposal practice proves problematic, the response is to work with industry to identify a more suitable disposal practice. When that practice proves unsound, another is suggested, and so on. This type of process has led to Gelman's current disposal practices: deep well injection and discharge to the Ann Arbor sanitary sewer. Both methods are potential environmental hazards--the safety of these practices has been widely questioned.

Reactive vs. proactive efforts

Many of the DNR's reform activities can also be characterized as being reactive in nature. For example, since the contamination problem was discovered, the DNR has responded by monitoring the site, attempting to define the plume of contamination, acting to protect the health of the community (by providing alternative water supplies), and pushing Gelman to clean-up the contamination. While this type of regulatory action is needed, it does little to address the cause of the contamination.

In contrast, proactive efforts are directed at the root of the problem. Proactive measures not only work to stop contamination from occurring, but they also have greater long-term economic viability for the regulator and for society. Prevention is less costly

than the development of a remedy after soil, water, or air is already contaminated. Proactive measures would force companies to internalize externalities by not allowing them to treat factors such as waste products, as though they exist outside of the economic equation. The use of source reduction and recycling are examples of ways in which it is possible to require companies to take full responsibility for all materials used in the production process.

Institutional factors

> The system is one of putting a finger in a dike. When you have 30,000 to 40,000 industries & 50,000 known or potential sites of groundwater contamination, and 300 to 400 people (in the DNR) to keep on top of it all, it's damned impossible to be in a preventive mode--John Sauver, DNR Environmental Enforcement Division (Cohen, 4/27/86b).

The DNR has been charged with the very impressive task of monitoring and enforcing regulations at industries all throughout the state. The agency, however, lacks the funding and staff needed to satisfactorily fulfill this mission. DNR staff at the Jackson Office have acknowledged that these factors impair their ability to respond to complaints and take the proper steps to prevent or abate contamination (Interview with Clark, Kooistra, and Larsen; Jackson DNR, 2/25/88).

Another limitation placed upon the DNR is the structure they must work within to enforce regulations--this structure places the DNR in a weak bargaining position. First, although industries are expected to monitor themselves and turn in reports to the DNR in the case of a suspected wrongdoing, the burden of proof falls on the DNR (rather than industries being required to prove they were in compliance with regulations). In a case of alleged contamination, the process then relies on the good faith of industries, as negotiations between the industry and the DNR ensue. Finally, if the negotiations do not succeed in achieving a mutually consented clean-up agreement, the DNR may initiate a

lawsuit against the company. As a result, the effectiveness of the DNR in compelling industries to comply with regulations, which in many cases entails convincing polluters to clean up, is questionable.

The Gelman case is a prime example of this. The DNR, after collecting the evidence, was able to identify Gelman as the "potentially responsible party" for contamination. The DNR and Gelman then engaged in clean-up negotiations, which continued for nearly two years (during which time Gelman refused to accept responsibility for the contamination). The DNR's threat of legal action was not sufficient to convince Gelman to enter into a voluntary (and legally binding) consent agreement. Thus, the DNR has finally turned the case over to the Attorney General's office for legal action. As seen in the case of Gelman, the consequence of the process described is that it may be a very lengthy one, during which time contamination goes unabated and may continue to spread.

Other restraints due to institutional factors

Other ways in which the institutional factors outlined above work to impede the DNR's effectiveness, include placing limitations on the DNR's ability to generate information (i.e. perform studies), to monitor reports and sites, and to run tests for the presence of contaminants.

The generation of information

The DNR, due to lack of staff and funds, faces quite severe limitations in its ability to generate information. In most instances the DNR relies on industry to provide the necessary information regarding a site. In this case, the DNR has been reliant on Gelman to provide information on the integrity of the deep well, and the extent of the contamination and the way in which it may be treated. Citizens have also supplied the DNR with the necessary information in many cases. Citizens originally exposed the existence of the

dioxane contamination, incidents of illegal waste discharge, and the potential problems with Gelman's deep well.

Two problems inherent in this system of information gathering are: 1) the DNR cannot be assured that the information it receives and upon which it bases its actions is always accurate or complete, and 2) the DNR is not capable of providing citizens with complete information regarding the site around which they live. The second aspect is particularly important, because an informed citizenry is a basic tenet of our notion of a participatory democracy. There is no guarantee that the company will provide the public with all the pertinent information they need to make informed decisions and to participate in the remediation process (see Citizen response section).

Monitoring industry

The DNR is largely dependent on industry to monitor itself and to submit periodic reports. There exists the obvious problem with this system that a company may not accurately monitor or report its activities. This problem is often compounded by the DNR's inability to monitor industries' reports due to a lack of the necessary staff-hours.

Both problems have been evident in the Gelman case. For example on July 14, 1986 approximately 18,000 gallons of contaminated water spilled on the Gelman property when a hose running from a storage lagoon to the deep well was cut. DNR officials were meeting with Gelman officials at the Gelman plant the day the spill was detected; however, they were not informed of the problem. The DNR finally learned of the spill on July 25, over ten days later (Cohen, 7/30/86). Thus, the DNR's dependence on industries to monitor themselves may result in untimely reporting or lack of reporting of incidences of contamination.

In addition, many of Gelman's monitoring reports were never examined by the DNR. Between July 1980 and October 1982 Gelman submitted routine daily discharge reports. During this period the reports showed that the discharge of waste water often

exceeded the maximum allowable discharge of 112,700 gallons per day, "...sometimes by more than 100,000 gallons" (Cohen, 4/27/86a). The DNR has acknowledged that they do not generally review these reports unless there is a complaint filed. Thus, it is not uncommon that such violations go unnoticed by the DNR.

Gelman was also required to submit yearly summaries which listed the chemicals used in their production process. While the DNR contends that until 1981 they were unaware that Gelman was using dioxane, Gelman had included dioxane as a component of their waste stream in yearly summaries prior to this date. However, in this case again, the DNR claims that these forms are seldom read by DNR officials (Interview with Vanderlaan, 2/24/88). It appears that the DNR has no systematic way of dealing with this information in order to help catch problems before they become very severe. In addition, there appears to be a lack of communication, and consequently a degree of discrepancy, in the way in which regulations are interpreted by the various divisions with the DNR.Had the DNR been examined reports submitted by Gelman, the contamination problem that exists today may have been averted.

Testing for contamination

The DNR, in the initial stages of discovery and confirmation of the problem (in 1984-85), relied on Gelman to finance tests. Although the DNR split samples with Gelman on several occasions, it was later revealed that the DNR's lab could not test for dioxane. (During the time that the DNR was running tests for a compound they were unable to detect, they were mistakenly reporting the results as "no detect" (Ewart, 10/87)). Thus, the DNR was dependent on the results of tests financed by Gelman.

The basic problem which resulted was that Gelman then had control over the test results. On at least one occasion Gelman refused to release results which showed dioxane contamination (Ewart, 10/87). The results were later made public by the University of

Michigan researcher (Clifford Rice) who ran the test. The DNR, however, did not to push Gelman to release those results.

Conclusion

The DNR, in the case of Gelman, has been left in the frustrating position of attempting to force the company to clean up, without possessing adequate enforcement capabilities. Thus, over two years after the discovery of the contamination, the case has finally been relinquished to the courts. The DNR, however, has not always adequately addressed violations committed by Gelman. If they had done this at an early date, the contamination problem may not have reached its present-day scope.

The DNR has been structurally reorganized several times over the last twenty years. These changes have coincided with efforts by state and federal governments to enlarge the scope of environmental concerns addressed in the existent regulatory framework.

The way in which the DNR operates is mandated by the guidelines set forth in these regulations, and is still, for the most part, reactive. There are, however, forward-thinking individuals in the DNR, who are questioning the traditional methods by which the DNR operates. These people are challenging the "out of sight, out of mind" mentality which still exists in the agency's approaches to waste management (most notably, deep well injection).

AN ANALYSIS OF THE RESPONSE OF GELMAN SCIENCES, INC. TO THE CONTAMINATION ISSUE

An overview

There exists a very serious case of groundwater contamination in Scio Township, which the State of Michigan has attributed to Gelman Sciences, Inc. (Kelley, et al. v. Gelman Sciences, Inc., 2/26/88). (Gelman Sciences Inc. will hereafter be referred to as "Gelman" and any references to Charles Gelman, founder of Gelman Sciences, Inc., will be made explicit.) Toxic chemicals (most significantly, 1,4-dioxane ("dioxane")) have been dumped, spilled, leaked, sprayed, seeped, burned, and drained by Gelman Sciences into the environment. These contaminants have affected the quality of the groundwater (and possibly the air), and have rendered over 50 wells in the area unusable (Kelley, et al. v. Gelman Sciences, Inc., 2/26/88). Gelman claims they had no knowledge that dioxane was hazardous until recently (Interview with James Marshall, 2/5/88); however, dioxane has been a known animal (and potential human) carcinogen since 1965 and has been on Michigan's Critical Materials Register every year since 1980 (see The Story, p. 26). Charles Gelman, who has a Master's degree from the University of Michigan (U-M) School of Public Health, should have been aware that his unsound disposal practices could have negative environmental effects.

Earlier this year, two members of our project group were walking in Saginaw Forest and encountered an elderly man. We began chatting about how the contamination might be affecting Saginaw Forest. This man then told us an interesting account of an incident which had recently taken place at the Rotary Club in Manchester. He said that Charles Gelman was there to "reassure" people that the contamination wasn't much of a problem at all. To demonstrate his sincerity, Mr. Gelman took two glasses of clear liquid

(one which he claimed contained water and the other, dioxane), combined them, and drank the solution. He then stated, "And this is what they're condemning me for."

It's one thing if Charles Gelman, who in 1986 claimed a yearly salary of $250,000 (and had tucked away a "golden parachute" of $1.95 million in case he would choose to leave the company (Haglund, 4/27/86)), chooses to drink the poisons of his treasure. It's an entirely different story to subject hundreds of local residents, who had no say in the matter, to drinking contaminated water on a daily basis, for an unknown number of years.

Gelman's interactions with various concerned parties

This section takes a look at how Gelman conducts itself in its interactions with the various groups of individuals who are in some way affected by Gelman's operations or the resulting contamination problem. By examining these relationships, we will address the question of Gelman's accuracy in its claim to be a responsible corporate citizen.

Our experiences with Gelman Sciences, Inc.

On February 5, 1988, two members of our group conducted an interview with James Marshall, Gelman's Vice President of Operations. In the ground rules created for the interview, we had stated, "We will provide a written summary of the questions and the responses given so that you can modify them and then return them to us as your official responses" (Letter to James Marshall, 1/24/88). (We had included this provision due to the fact that Gelman is currently involved in four lawsuits and therefore may have concerns about statements they release to the public.) We would then be able to use the interview in our report. We also tape recorded the interview but were not permitted to leave the premises with the tapes.

Shortly after the interview, we submitted our notes to Marshall. The next several weeks were spent attempting to contact Marshall regarding the notes. When we finally

contacted him, he asked that we set up a second meeting at which we could discuss the modifications he had made.

Thus, in early March we returned to speak with Marshall. It turned out that the modifications he had referred to were relatively few in number and insignificant. He requested that we re-type the interview with his modifications. We could then bring it back out to the site and he would sign it. A few days later we brought the interview to Marshall and since he was not there, we left it for him.

Shortly thereafter, Marshall informed us that he had turned the interview over to his lawyers who were studying it. He said he would get back to us when his lawyers had approved it.

In the following weeks we placed several calls to Marshall's office, but were unable to contact him. When we did finally reach him on April 8, Marshall explained that his lawyers had recommended he not release the interview to us. He further stated that he could not return our tapes but would pay for them. We told him that we would send him a bill to cover the cost of the tapes.

On April 21 we called Marshall to invite him to our project presentation. Marshall took this opportunity to express his wishes that we not include his interview in our report. He felt that if it were included, it would indicate that we had breached the ground rules agreement. We responded that we felt that he had already breached the agreement and that we were intending to use the interview.

Approximately one hour later, Marshall called back to request changes in the interview. We asked him, "Does this mean you're giving us permission to use the interview?" "No," he replied. We said we would consider the changes he wanted to make. Marshall was then abruptly called away from the phone.

The following day, April 22, Marshall called us back to discuss the changes he wanted to make. The changes, again, were relatively insignificant and we agreed to incorporate them into the final interview. Marshall then requested that we give his lawyers

until Tuesday April 26, to add their comments to his responses. We agreed to consider his lawyer's comments, but did not commit to incorporating them, particularly due to the late date in our project timeline.

We feel that we met the requirements of the ground rules because we provided a written summary of the questions and Marshall's responses, which Marshall then returned to us with modifications. To return them a second time for review by their attorneys was above and beyond the stated ground rules. We have, therefore, decided to go ahead and use the interview in our report. It is our belief that Marshall never intended to return the interview, but intended to stall until our project deadline had passed. His unwillingness to permit us to use the interview notes or tapes, we feel, is typical of Gelman's unwillingness to share information with other parties, which will be discussed in more detail later (see Interview with James Marshall in Appendix IV.D).

Gelman's interactions with the public

Area citizens claim they have been "ignored," "stonewalled," "deceived," and otherwise mistreated by Gelman. "We called, we complained. They ignore you. We didn't get anyplace... They (Gelman) pay big taxes, we pay little taxes... We do not like anything Gelman has done or said," stated Mary Jo Campbell, a Scio Township resident (Cohen, 5/18/86). These comments embody the frustration and disempowerment that many citizens have felt when attempting to deal with Gelman.

More examples of this type of response are as follows:

- "They (Gelman) schmooze over trying to pacify us. They think we're a bunch of dummies" - Carol Dudley, Executive Assistant of Saginaw Hills Development Company (Interview, 2/23/88).

- "They (Gelman) have admitted nothing and have stonewalled for three years. They are not responsive to the public. They supply limited information which is favorable to them. They have put on a facade of openness" - Priscilla Cheever, Attorney and Westover resident (Interview, 1/4/88).

> • "At the first meeting after dioxane was detected in residential wells, Gelman's scientist (Paul Chalmers) tried to make people feel that dioxane isn't any more dangerous than water... Soon after, I met with Marshall and Chalmers. Again, they claimed there was no problem... Chalmers tried to defend the company's stance on dioxane, then backed down when he found that I was a chemist" - Alfin Vaz, Research Chemist at U-M and Westover resident (Interview, 3/12/88).

Gelman's interactions with citizens have also been characterized by a lack of honesty and a tone of arrogance. This is well illustrated in the account of Carl Brauer, a local realtor and Jackson Plaza Business Park developer. Brauer first approached Charles Gelman in 1967 over a concern about runoff with a "strong sewage odor" which was coming from Gelman's treatment lagoons and flowing onto his property. Mr. Gelman asserted, "... The water pumped into the pond is pure enough to drink..." Gelman also stated that he planned to stock the lagoon with fish and invited Brauer to "share in (the) harvest" (see Citizen response section).

Another instance in which Gelman did not properly inform its neighbors was in 1981, when it was first drilling a deep well. Charles Gelman admitted in *The Ann Arbor News* (Fulton, 6/29/81) that local residents had not been told of this activity. Mr. Gelman then claimed that there was no public opposition to this type of technology, which he described as "non-controversial" (see Citizen response section).

It thus appears, by the way Gelman interacts with area citizens, that Gelman is purposely concealing information from citizens and that it attempts to discourage individuals from asking questions and becoming involved. It is clear to us that the area citizens represent nothing more than another element in Gelman's cost equation -- an equation that Gelman attempts to minimize. For this reason, Gelman will take steps toward remedying the problem, i.e. paying for the water hookup to affected residences. This is the minimum with which Gelman feels they can get away. The citizens, by being forced to pay for a sewer, are internalizing Gelman's externality (pollution), thereby inflating Gelman's profits.

Gelman is attempting to make citizens feel that it is a "responsible corporate citizen" by absorbing some of the costs. However, responsibility for the problem rests squarely on the shoulders of Gelman. The citizens did not cause the pollution, therefore there is no reason why the citizens should have to pay. In order to be a "responsible corporate citizen," Gelman should pay all costs out of its own profits.

Gelman's interactions with the DNR

DNR officials have also expressed anger and frustration over their attempts to work with Gelman. Gelman has been described as "variably cooperative" and "minimally cooperative" by DNR officials at the Jackson office and the Lansing office, respectively (Interview with Clark, Kooistra, and Larsen, 2/25/88; and Interview with Vanderlaan, 2/24/88). One DNR official said he was glad our group was doing this study. "There are a lot of skeletons to be found here and those skeletons have to pay," he remarked.

One point that has been mentioned to us several times by the DNR is their sense of Gelman's unwillingness to share information. In an interview at the Jackson office, DNR staff stated, "Things have been progressing, but very slowly. Gelman hasn't given the DNR all required information. It's been frustrating working with them" (Interview Clark, Kooistra, and Larsen, 2/25/88). In our interview with Mary Vanderlaan, she stated also stated that it had been difficult to get written information from Gelman. She claimed that in many of the meetings at Gelman's headquarters, Gelman officials had refused to let DNR staff leave the meeting with certain information and had restricted what they could copy. "The only way we will get to see their files is to sue them,"she commented (Interview with Vaderlaan, 2/24/88).

The sentiments voiced by DNR officials strike a common chord with those voiced by area citizens and are reinforced by the experiences of our group. Gelman consistently conducts its business in a way that infers that they have something to hide. Whether regarding the deep well, technical data, or simply their responses in an interview conducted

by a group of students, the company chooses to withhold the information that if released, may cause interested parties to question their practices. One could presume that if a company is acting in a legal and ethical manner, they wouldn't feel the need to be so tight-lipped about their activities.

Gelman's interactions with their employees

The way a company relates to their employees may be another indication of how they run their affairs in general. A former Gelman employee, in an interview conducted February 29, provided us with insight into this matter.

Ruth Kraut is presently employed by the Ecology Center as editor of their newsletter. Prior to this, she worked for eight months as editor of Gelman's internal newsletter. Ruth's opinion is that Gelman is a "poorly run company" in terms of labor relations. She claimed that working at Gelman presents several occupational hazards and that "employees are...treated a lot worse than the earth is being treated."

Ruth told us that in production areas fumes "get really fierce." She has experienced headaches after going into these areas for just ten minutes to interview people. The production work is done mostly by young women. The women protect each other (in the absence of formal mechanisms) by not letting pregnant women work in the worst areas.

Ruth gave an example of the type of problems experienced by Gelman employees. She told of a graphics artist with whom she had shared an office, who had eight miscarriages. This woman, who had previously worked in production, also had throat problems which her doctor said were work-related. When she went to see a lawyer because she wanted to sue Gelman, however, she was told that it would be difficult to prove the cause of her miscarriages.

Ruth also described how attempts at unionization were "squashed" by Gelman officials. If workers had been unionized, events such as the following may have been prevented: In 1986 about thirty workers were laid off. Ruth felt that they weren't laid off

on the basis of the utility of the position they were filling, rather on the basis of whether or not Charles Gelman liked them personally.

This account by a former Gelman employee strengthens the pattern that has been established through analysis of Gelman's community and professional relations. That pattern seems to be one of Gelman officials working to disempower those who may challenge Gelman's practices, while showing little or no regard for those who may be harmed by those practices.

Gelman and the press

Gelman, quite concerned with its public image, attempts to influence what does and does not appear in the press. It does this in several ways, one of which is by placing pressure on agencies and individuals to keep the contamination issue out of the press. An example of this occurred after DNR geologist Matt Frisch criticized Gelman in the press for taking over ten days to report a leak of hazardous substances to the DNR. James Marshall immediately wrote to Frisch and said, "...We certainly deserve more credit and respect than given us by (Janet) Cohen and the News... I respectfully urge the DNR to work with us rather than the news media... We urge you to respond in strong language to the Ann Arbor News responding to the incredible disservice done to us..." (DNR files, 7/31/86). Approximately one week later another article appeared in *The Ann Arbor News,* this one much more favorable toward Gelman.

Gelman also tries to influence what is published about them by attempting to discredit reporters who disclose information that is unfavorable to Gelman. This has been the case with Janet Cohen, a reporter for *The Ann Arbor News*. On April 27, 1986, Cohen wrote an article entitled, "Gelman resisted DNR warnings of water contamination." After this was published, Gelman circulated a letter in the community refuting what had been said

in the article and claiming that "there are dangers in using non-scientists to report on complex scientific issues."

This second tactic is one commonly used by Gelman in its interactions with the community. Gelman may feel it is in control of the situation as long as the issues are framed in such a technical way that people cannot understand them. It is quite disempowering to community members to think they must be experts to understand anything because the issues are "complex" and "scientific." However, once the issues are demystified and made accessible to the general public, it becomes risky to Gelman. It is at this point that people can stop depending on the "experts" to shape their opinions and can assess and challenge situations on their own.

Are Gelman's attempts to censor the media effective? To a degree, yes. It is also possible that the press, to a certain extent, engages in self-censorship. Although the Gelman issue has received much attention in the press, there have been certain issues that *The Ann Arbor News* (the news medium which has covered the Gelman case more than any other) has refused to cover. One issue not covered by *The News* was the unpermitted discharge by Gelman into Bicknell Creek --a practice which went unchallenged by the DNR for almost three years from the time the DNR discovered it. *The Ann Arbor News* also did not pick up on the fact that the DNR had for several months reported "no detect" in their tests for dioxane, when in fact the DNR lab could not test for dioxane. In both of these cases *The Ann Arbor News* was provided with information by the citizens' environmental group, Tocsin, and both stories were later covered in Ann Arbor's alternative news monthly, *Agenda.*

We also noticed that Gelman's statements to the press often go unchallenged. An example of this is that Gelman will repeatedly refuse to claim responsibility for the contamination. However, a hydrogeological study commissioned by Gelman points to Gelman's original unlined seepage lagoon as the most likely source of the contamination

(EPA, 9/24/86). These obvious contradictions have not been exposed by *The Ann Arbor News*.

Another significant fact is that in late February 1988, *The Ann Arbor News* ran an editorial discussing sites of environmental contamination around the state and the need for tougher regulations by the DNR and greater compliance by industry. However, this article failed to mention anything about the contamination site nearest to *The News*, which at the time had been ranked Number 2 in the state -- Gelman Sciences! Whether this was an omission or an oversight, it is significant that Gelman was not mentioned. Information is crucial and people must be able to depend on the press for careful reporting and critical analyses of issues which affect an entire community.

How Gelman has responded to the contamination issue

When an industry discovers that its manufacturing processes have polluted the environment, the following are some steps which that industry should take:

1. accept responsibility for the damage done,

2. work cooperatively with state regulatory agencies to undertake a prompt and thorough cleanup operation,

3. pay any costs that state agencies or surrounding residents may have incurred as a result of the contamination, and

4. explore and implement sustainable practices (i.e. waste reduction and recycling) which would prevent such an incident from occurring in the future.

Gelman, however, has done none of these. In this section we will examine how Gelman has responded to the contamination situation.

First, Gelman has denied responsibility for the contamination. As has been determined thus far, Gelman was (until 1986) the only industrial user of large quantities of dioxane in the immediate area, used dioxane for over twenty years (some years in quantities of 60,000 pounds or more per year) and has engaged in unsound disposal practices (i.e. an

unlined seepage lagoon, spray irrigation, and direct discharge of wastes into surrounding surface waters and wetlands) for over twenty years. The groundwater of residential, agricultural, industrial, and recreational areas surrounding Gelman has shown contamination with dioxane in levels up to 200,000 ppb. The DNR, the Washtenaw County Drain Commissioner, and the Michigan Attorney General's office, among other state and county agencies, point confidently to Gelman as the source of the contamination. At this time, Gelman stands virtually alone in its position of questioning its responsibility for the creation of the problem.

Gelman has undertaken several different strategies in its attempt to absolve itself of responsibility in this situation. One tactic used is that of trying to shift the blame. In an interview conducted on February 5, 1988, we asked James Marshall if Gelman was responsible for the contamination. He responded, "A lot of people are responsible." Among those he listed as responsible were Dow Chemical Company, the DNR, other state agencies, and "possibly" Gelman. Gelman has also carried its attempts to shift the blame into the courts. At this time Gelman is suing its insurance agency for not funding the cleanup; Dow, Union Carbide, and six smaller chemical companies which allegedly sold dioxane to Gelman for not giving proper instructions for how to handle dioxane; and the DNR for its allegedly unfair ranking of Gelman on the Priority List of Sites of Environmental Contamination. Thus, the contamination remains and possibly continues to spread while the issue is tied up (possibly for years) in court.

Another tactic used by Gelman is that of downplaying the harmful nature of dioxane, thus attempting to diffuse the seriousness of the contamination problem. For instance, at a public meeting held in 1986, Gelman told area citizens that dioxane "isn't any more dangerous than water" (Interview with Alfin Vaz, 3/12/88). Marshall reinforced this stance when, upon discovering that Gelman had been ranked Number 2 on the 1987 Priority List, he stated, "If Gelman is rated Number 2 in the state, then the state is in pretty good shape... The toxicity level is not that high. It's (dioxane's) not that critical a material"

(Interview with Marshall, 4/10/87). Finally, Gelman has attempted to redefine the levels at which dioxane is harmful to humans through a risk assessment study Gelman commissioned from Dr. Rolf Hartung of the U-M School of Public Health. According to Hartung's conclusions (which have been widely criticized by state and County toxicologists, who claim there is no threshhold level for a carcinogen) dioxane is toxic to humans only at levels much greater than those levels defined by the State. In the February 5 interview, James Marshall also stated: "... There are acceptable risks. We take risks every day -- when we drive in our cars, when we breathe the air..." The point that Marshall is missing is that these are risks we choose to take. It is another matter when risks we are faced with are mandated by the actions of another party.

Gelman has consequently applied Hartung's standards of dioxane toxicity to redefine the plume of "significant" contamination. Dioxane has been a known carcinogen since 1965 and has been defined as a Critical Material by the State since 1980. Its exact toxicity levels are not known, but that is not the central issue. The issue is that the groundwater has been polluted such that the potential exists for damage to human health, as well as to the environment. The task before Gelman should be to return the groundwater its condition before the dioxane contamination occurred.

Another way in which Gelman has responded to the contamination issue is through an intensive public relations campaign. To convince the public of the sincerity of their efforts, Gelman has held public meetings, has sent out several glossy mailings, has bought space in various local publications, and has sent out numerous press releases. Through this PR, Gelman has tried to win public sympathies by casting themselves in the role of "innocent victim" and "hero." For example, at a public meeting on May 5, 1986 when area residents voiced that they felt their concerns were not being taken seriously, "Gelman's Marshall called efforts by Gelman and state and local officials 'heroic' and said, 'No one, by any stretch of the imagination, has been sitting around doing nothing'" (Hooper, 5/6/86). This was further illustrated in our interview with Marshall. He first

claimed disappointedly, "We will never be a hero..." He later stated, "The only way to develop sympathy for what we have been through is to go through it yourself" (Hooper, 2/5/88).

On February 5, 1988, James Marshall stated, "I don't believe that you will find a company that deliberately contaminates the environment." Given that "...about 90 percent it (toxic waste) is disposed of in open dumps, unlined land fills, midnight dumpings, or in equally unsafe ways," (Vandermeer, 1986) we do not concur with his position. Even of companies that don't "deliberately contaminate the environment," many do not go out of their way to prevent contamination from occurring. Environmental quality often doesn't receive a high priority in a company's economic equation. Thus, perhaps a more relevant question would be: did that company prevent the contamination of the environment? In the case of Gelman, the answer is "no."

Gelman is not going to correct the contamination problem by denying responsibility for it, by diffusing the issue, by redefining pollution, by attempting to foster public sympathy, or by denying that a problem exists ("There is no evidence of any damage done whatsoever" -- Interview with Marshall, 2/5/88). It is true that Gelman has paid for water hookups to affected residences and has begun on a purge operation of contaminated groundwater from one industrial well. This, however, is only a start. Gelman's foot-dragging activities have forced the DNR to turn the process over to the courts. The only way Gelman will be regarded as a "hero" is if they accept responsibility and begin serious efforts in cleaning up their mess.

While this analysis is very specific to the case of Gelman Sciences, the larger questions must be examined. How do political and economic constructs in our society allow for industries to regard contamination as an "externality?" What must be done to make industry more accountable to the public and the environment? What must done to prevent contamination cases such as this from occurring in the future?

DISCUSSION

The Problem

This case study illustrates many of the inadequacies of our political, social, and economic systems in addressing environmental contamination. Remedial responses to contamination, like those used in the Gelman case, demonstrate a lack of willingness to confront the root causes of pollution. Unless proactive measures are taken, society will be perpetually committed to costly response activities. Cleanup costs are soaring at Superfund sites with contaminated groundwater. For example, groundwater contamination at the U.S. Army's Rocky Mountain Arsenal in Colorado is projected to cost 1.8 billion dollars to cleanup (Boraiko, 1985). Efforts are needed to develop biodegradable alternatives, to encourage reduction, reuse, and recycling. Without these efforts the quantities and varieties of hazardous waste produced will overwhelm even the "best" treatment and disposal systems.

The U.S. needs a strong commitment to promoting "cleaner technologies". EPA's 1988 budget request waste minimization activities totals $398,000. This is just 0.03 percent of its $1.5 billion operating program budget, and less than was spent in 1986. The nation is facing costs between $20 billion and $100 billion to clean up existing toxic waste sites (Brown, et al. 1988).

The role of science and technology in our society often goes unquestioned. They are often viewed as value-free, neutral and objective tools that can cure all societal ailments. However, as our case study has shown, the role of science and technology in our society is not so simple. The synthetic organic chemical industry and the production of products like 1,4-dioxane (dioxane) exemplify many of the complex problems associated with science and technology.

In the Gelman case risk assessment and deep injection wells have been used to respond to the contamination problem. The science of risk assessment provides a valuable tool for defining risks associated with contamination. However, this science can also help to perpetuate the problem.

Risk assessment is a process used to determine the adverse consequences resulting from the use of technology and helps us to measure associated risks. Risk assessment incorporates scientific, political, economic, and social information in determining risks associated with, and the management of chemicals (Conway 1982, p.264).

James Tozzi, the number two person in the White House Regulatory Reform Office in the early '80s stated, "What we are saying is the government will protect you to the degree of economic precedence, but some Americans are going to die" (Nesmith, 12/25/83). People, driven by a paradigm of economic progress that does not include social and ecological responsibility, are deciding how many people are going to die and how much of our environment is going to be destroyed. Risk assessment in this context becomes a tool to balance the "need" for progress and with the deaths that result from progress.

It is often argued that science and technology will aid the poor in our country and in developing nations. According to Gio Batta Gori, a former deputy director of the Division of Cancer Cause and Prevention at the National Cancer Institute, "undeniably human life has transcendent value. But excessive regulation hamper technological development and denies its fruits to the poor in our own society and elsewhere in the world" (Gori, G. 1982, p.176). It is often the wealthy few receive the "fruits" of technology while the poor in our country and in developing countries receive the poisoned fruit.

Racial and ethnic communities in the U.S. have been, and continue to be beset by poverty, unemployment, and problems related to poor housing, poor education and inadequate health care. The members of these communities cannot afford the luxury of being primarily concerned about the quality of their environment. Findings from a recent

study entitled "Toxic Wastes and Race in the United States" show that the "fruits" of technology received by Black and Hispanic communities include an inordinate presence of hazardous waste facilities and a disproportionate concentration of uncontrolled toxic waste sites (Lee, 1987). Some of the specific findings of this study include:

> •Race proved to be the most significant among variables tested in association with the location of commercial hazardous waste facilities. This presented a consistent national pattern.
>
> •In communities with one commercial hazardous waste facility, the average minority percentage of the population was twice the average minority percentage of the population communities without such facilities.
>
> •Three out of every five Black and Hispanic Americans lived in communities with uncontrolled toxic waste sites.
>
> •More than 8 million Hispanics lived in communities with one or more uncontrolled toxic waste sites (Lee, 1987).

Technology exported to developing countries often results in negative consequences. After a U.S. ban on cyclamites in food, U.S. corporations deliberately dumped products containing cyclamates on overseas markets. Cancer-causing Tris was found in baby clothes in developing countries after Tris was banned by the U.S. Congress. Currently, at least 25 percent of U.S. pesticide exports are products that are banned, heavily restricted, or have never been registered for use here (Weir et al, 1981). Some of these pesticides are widely known to cause cancer, birth defects and genetic mutations. Yet, the Federal Insecticide, Fungicide, and Rodenticide Act explicitly states that banned or unregistered pesticides are legal for export (Weir et al, 1981).

Conclusions derived from scientific data can be uncertain, such as the carcinogenic effects associated with dioxane, and the hydrogeological information used to justify the use of deep injection wells. Citizens who one day find their well contaminated do not typically have the skills and resources to interpret the integrity of these technologies.

Information surrounding the various sciences and technologies are often laden with jargon and technical terms that make it difficult to understand. It is a language of experts that often excludes citizens from the decision making process. The arguments presented by scientists, politicians, lawyers, economists, etc., are often perceived as legitimate, while those presented by citizens affected by contamination are often perceived as irrational, emotional, and uneducated. Thus, the language of experts often becomes the language of exclusivity and power. This is particularly frightening in a society driven by economic progress with little concern for human health and the environment.

The problems created by various technologies often keep scientists busy trying to develop technologies to fix these mistakes, or "technological fixes." Deep well technology is a good example of a "technological fix." The technology of deep injection well, in the Gelman case, is responding to problems created by a previous technologies that used dioxane. Deep well injection perpetuates the problem by relocating the hazard further below the earth's surface, from where the waste can potentially migrate back up into the aquifers containing drinking water. This technological fix does not address the the root causes of pollution and it does not promote source reduction, reuse, and recycling. Instead, deep well technology justifies the continued production of these harmful chemicals by providing the opportunity to claim that we have safe and proper methods for disposal of these materials.

George Bradford, in a pamphlet against the Detroit Incinerator (another technological fix), stated that "society's response to our growing waste problem has simply been more business-as-usual." The business-as-usual paradigm is to not address the problem but to let it continue. By the year 2,000 one quarter of the world's drinking water will be contaminated by industrial waste. Ninety percent of the 90 million pounds of toxic waste produced annually in the U.S. is disposed of improperly. Even if waste is disposed of "properly" can we trust that it will not again, one day, become a problem. As many as 10,000 sites in Michigan alone may be contaminated (Bradford, 12/87). Our response has

been to let those who know best, the politicians, scientists, and technical experts, take care of the problem. Those who know best often turn to technological fixes and do not address the root causes of pollution. They do not address the real task of reduction, recycling, reuse, and the eventual elimination of hazardous products and their waste by-products.

Directions for the Future

> In our progress-minded society, anyone who presumes to explain a serious problem is expected to offer to solve it as well. But none of us - singly or sitting in a committee - can possibly blueprint a specific "plan" for resolving the environmental crisis. To pretend otherwise is only to evade the real meaning of the environmental crisis: that the world is being carried to the brink of ecological disaster not by a singular fault, which some clever scheme can correct, but by the phalanx of powerful economic, political, and social forces that constitute the march of history. Anyone who proposes to cure the environmental crisis undertakes thereby to change the course of history.
>
> -Barry Commoner, 1971

The collection of values, beliefs, and attitudes that form society's reference or worldview is dominated by progress. Progress in our country is often defined by economic growth or the accumulation of capital. Pollution is not considered as a factor in the cost of production but instead it becomes an externality incurred by society. The environmental crisis that we face today, the problems of acid rain, ozone depletion, the clearing of the earth's tropical rain forests, and the contamination of our water, soil and air, are all symptoms of powerful political, social, and economic forces that shape our relationship with the natural environment. Efforts must be made to develop a new paradigm of progress that includes social and ecological responsibility.

An ecologically responsible relationship between people and the natural environment is one that is sustainable. A sustainable relationship removes people from the role of conqueror and steward of the ecosystem to an integral member of the ecosystem. A

sustainable relationship with the ecosystem requires that we protect the system from depletion, waste, and damage, so that it can continue to exist through perpetuity.

Social responsibility requires that pollution not be considered a cost to be incurred by society. It requires that those who are poor, those who are black and Hispanic, and those who live in developing nations not receive a disproportional amount of pollution.

A new paradigm or worldview is needed that incorporates social and ecological responsibility. This worldview needs to be included in education reform, grass roots organizing, community empowerment, Institutional change, and legislative reform. Change is required before people will explore the social and ecological consequences of science and technology and the powerful economic, political, and social forces that drive them. A change is needed before we can effectively work toward solutions that address the root causes of pollution. While we do not pretend to have the answers to the environmental crisis we must explore potential directions for the future.

The various statues protecting our environment have been used primarily to respond to problems as they arise. New statues and approaches at the state and federal level are needed that prevent the occurrence of contamination and that encourage hazardous waste reduction, reuse, and recycling. Statues are needed that change the role of pollution in our economic system from that of an externality to a factor in the cost of production.

Legislation introduced in the U.S. Congress in June 1987 contains some of the elements needed to address the need for waste reduction. This legislation would create an Office of Waste Reduction within EPA. It authorizes up to $18 million for waste reduction activities: $8 million to operate the new office and $10 million for grants to the states (Brown, et al. 1988).

A Lawsuit, such as the current lawsuit against Gelman by the DNR, is one measure that can potentially force industry to cleanup after incidents of contamination. However, lawsuits often become protracted disputes while the contamination goes unabated. A state Superfund law, similar to the federal Superfund law, would provide the

leverage needed to force industry to respond to incidents of contamination. This law could impose heavy fines on industry for every day the pollution goes unabated along with imposing triple charges for any state cleanup activities.

Measures need to be taken to prevent the export of our destructive technologies to developing nations. Proactive measures like including a ban within the Federal Insecticide, Fungicide, and Rodenticide Act to make it illegal to export pesticides, drugs, and other chemicals that are banned and unregistered within this country.

Changes in the education system of this country are needed that promote social justice and a sustainable relationship between people and their environment. Our current educational system teaches the rudiments of communication, mathematics, biological and physical sciences, social sciences, etc. However, students are rarely taught how to address the problems that we face in society and how to work toward solutions. Students are not taught the connections between an economic system without environmental and social responsibility, a political system that has historically adopted a hands off policy toward this economic system, and a society driven by progress.

Environmental education is one approach that contains many of the elements necessary to develop a citizenry that understands the root causes of the ecological and social problems that we face. Environmental education helps people to develop the skills necessary to work toward solutions of these complex problems. Environmental educators seek to develop a world population that is,

> ....aware of, and concerned about the total environment and its associated problems, and which has the knowledge, attitudes, motivations, commitments, and skills to work individually and collectively toward solutions of current problems and the prevention of new ones (Stapp, 1981).

Citizens who one day find themselves with contaminated wells have few skills and resources for addressing their concerns. They find themselves with very few if any formal channels or power to express these concerns. However, citizens are becoming more

effective in utilizing information, emotional appeal, the courts, the press, etc. in helping them achieve their objectives. Tocsin is a good example of grass roots organizing by citizens in the Gelman case. Tocsin successfully alerted the public about the problems surrounding Gelman's deep injection well, they notified government officials about illegal waste discharges, they held both Gelman and the government accountable for their actions, and they organized the community around the issue. This form of community organizing can help to prevent the contamination of local ecosystems and can publicize incidents that do occur.

Formal channels such as the Citizen Information Committee, provide citizens with no formal power and often become a haphazard attempt to include them in the remediation process. These channels for citizen involvement could serve a valuable function if they were implemented more effectively. The CIC has the potential of creating channels of communication between citizens and the DNR. Currently, there is no assurance that citizen concerns will be addressed. It is important that the DNR and other agencies recognize the importance of citizen participation and that they provide effective channels for participation. Citizens have provided the DNR with valuable information regarding illegal waste disposal practices and discharges. Therefore, we feel that the DNR should work closely with the citizens and provide formal channels for citizen participation.

The only formal channel for citizens to address their concerns is the legal system. The legal process is very expensive and often requires expert testimony that can exclude citizens. Private suits are often lengthy and require a great deal of time and energy. Currently, they are the only means for citizens to receive compensation for economic costs incurred or for personal injury resulting from incidents of contamination.

A new worldview is needed that includes social and ecological responsibility. This worldview should be included in education reform, grass roots organizing, institutional change, community empowerment, and legislative reform. These are directions for the future that will begin to address the root causes of pollution. Powerful economic, social,

and political forces shape our relationship with the land. It is these forces that must be addressed before we well experience a more socially responsible and ecologically sustainable future.

RECOMMENDATIONS

Based on the findings made in this case study, we present the following recommendations:

1. Sustainable land use practices should be adopted in which priority is given to the protection of the environment.

2. Incompatible land uses (e.g. industrial and rural residential) should not be planned in the same general vicinity.

3. The social, political, and economic implications should be considered in all scientific research, and in the development and use of technologies.

4. The citizens living in the vicinity of Gelman Sciences should continue to place pressure on the company in an attempt hold it accountable for all past, present, or future contamination of the environment.

5. The citizens living in the vicinty of Gelman Sciences should attempt to negotiate with the company for complete reimbursement of costs incurred by citizens as a direct or indirect result of the contamination of their water supply. In the case that negotiations do not succeed, citizens should pursue legal action against Gelman Sciences.

6. The University of Michigan should not encourage industrial development without accompanying, environmentally sustainable practices.

7. The University of Michigan should assume responsibility to the citizenry in the community of which the University is a part (i.e. providing access to information and experts).

8. The University of Michigan should assess any loss of property value or other damages incurred in Saginaw Forest due to contamination by chemicals that are or have been used in Gelman's production process.

9. The University should attempt to negotiate with Gelman Sciences for payment equal to the assessed damages. In the case that negotiations do not succeed, the University of Michigan should pursue legal action against Gelman Sciences.

10. The Michigan Department of Natural Resources should attempt to work within the financial and other limitations imposed on it by the State, to improve its monitoring of industrial sites.

11. The Michigan Department of Natural Resources should encourage industries to adopt sustainable waste management practices. Examples of these practices include waste reduction, recycling, and the replacement of highly toxic substances used in production with less toxic substances.

12. The Michigan Department of Natural Resources should encourage Gelman Sciences to undertake cleanup activities during the time that the lawsuits regarding this matter are pending.

13. Gelman Sciences should accept responsibility for the environmental contamination that has resulted from their past (and possibly present) unsound waste disposal practices.

14. Gelman Sciences should work cooperatively with state regulatory agencies to undertake a prompt and thorough cleanup operation.

15. Gelman Sciences should pay any costs that state agencies or surrounding residents may have incurred as a result of the contamination.

16. Gelman Sciences should explore and implement sustainable practices (i.e. waste reduction and recycling) which would lessen the chances that contamination would occur in the future.

REFERENCES

Introduction

Argus, et al. 1965. in "International Agency on Research of Cancer 1984 Composium." Washington, D.C.

Backman, J. 1970. "The Economics of the Chemical Industry." Manufacturing Chemists' Association: Washington, D.C.

Boraiko, Alan A. March, 1985. "Storing Up Trouble--Hazardous Waste." National Geographic vol. 167, no.3, Washington, D.C.

Brown, Larry & Deborah Allen. 1983. "Toxic Waste and Citizen Action." Science for the People. vol. 15, no. 4. July/August.

Brown, Lester R., et al. 1988. State of the World 1988. W.W. Norton and Company: New York.

Brown, Michael. 1980. EAF News. Environmental Action Foundation: Washington, D.C.

Chemical and Engineering News. June 14, 1982. "Production by the U.S. Chemical Industry." pp.32-38.

Commoner, Barry. 1974. The Closing Circle: Nature, Man and Technology. Alfred A. Knopf, Inc.: New York, N.Y.

Conservation Foundation, The. 1987. Ground Water Protection. Washington, D.C.

Conservation Foundation, The. 1984. "State of the Environment: An Assessment at Mid-Decade." Washington, D.C.

Council on Environmental Quality. 1981. "Contamination of Ground Water By Toxic Organic Chemicals." U.S. Government Printing Office: Washington, D.C.

Crone, Hugh D. 1986. Chemicals and Society: A Guide to the New Chemical Age. Cambridge University Press: New York.

Eastern Michigan Environmental Action Council (EMEAC). 1984. Groundwater Contamination Sites: a citizens's guide to fact-finding and follow-up. Birmingham, Michigan.

Huisingh, Donald et al. 1986. "Proven profits from pollution prevention: case studies in resource conservation and waste reduction." Institute for Local Self-Reliance: Washington, D.C.

Kelley Frank J., Attorney General, et al. v. Gelman.Sciences Inc., File No. 88-34734-CE. February 26, 1988.

National Research Council. 1984. Toxicity Testing: Strategies to Determine Needs and Priorities. National Academy Press: Washington, D.C.

National Research Council. 1986. Ground Water Quality Protection: State and Local Strategies. Committee on Ground Water Quality Protection. National Academy Press: Washington, D.C.

Office of Technology Assessment, U.S. Congress. 1984. "Protecting the Nations Groundwater From Contamination." U.S. Government Printing Office: Washington, D.C.

Office of Technology Assessment, U.S. Congress. 1985. "Superfund Strategy." U.S. Government Printing Office: Washington, D.C.

Patrick, Ruth et al. 1987. Groundwater Contamination in the United States. 2nd ed. University of Pennsylvania Press: Philadelphia.

Rice, Rip G. ed. 1985. Safe Drinking Water: The Impact of Chemicals on a Limited Resource. Drinking Water Research Foundation: Virginia.

Shodell, Michael. October 1985. "Risky Business." Science.

U.S. Congress, Committee on Government Operations. 1984. "Groundwater Protection: The Quest for a National Policy." 98th Congress, 2d Session--House Report 98-1136. U.S. Government Printing Office: Washington, D.C.

U.S. Environmental Protection Agency. 1983. "The Groundwater Supply Survey: Summary of Volatile Organic Contaminant Occurrence Data." By Westrick, et al. U.S. EPA, Office of Drinking Water, Technical Support Division: Cincinnati.

U.S. Environmental Protection Agency. 1984. "National Statistical Assessment of Rural Water Conditions." Office of Drinking Water: Washington, D.C. EPA 570/9-84-004.

U.S. Environmental Protection Agency. 1985. RCRA/CERCA Hotline: Washington, D.C.

U.S. Environmental Protection Agency. July 31, 1987. "Overview of State Ground-Water Program Summaries Vol. I." Office of Ground-Water Protection: Washington, D.C.

U.S. International Trade Commission. 1986. "Synthetic Organic Chemicals: United States Production and Sales 1985." U.S. Government Printing Office: Washington, D.C.

The Story (events from 1959-present)

Argus, et al. 1965. In International Agency on Research of Cancer Composium. 1984. Composium: Washington, D.C.

Bicknell, Daniel J. June 26, 1984. "Hazardous Waste Introductions into Third Sister Lake, Washtenaw County, Michigan."

Cain, Stephen & Roy Reynolds. February 24, 1988. "Gelman blames dioxane makers for tainted wells." The Ann Arbor News.

Child, Charles. October 22, 1984. "State may clear Gelman Sciences of pollution charges." The Ann Arbor News.

Cohen, Janet. April 5, 1987. "Gelman second in state for toxins." The Ann Arbor News.

Cohen, Janet. April 13, 1988. "Gelman denies charges." The Ann Arbor News.

Cohen, Janet. April 27, 1986. "Dioxane tests near site worry health experts." The Ann Arbor News.

Cohen, Janet. April 27, 1986. "Gelman resisted DNR warnings of water contamination." The Ann Arbor News.

Cohen, Janet. August 10, 1986. "DNR unfair about spill, Gelman says." The Ann Arbor News.

Cohen, Janet. August 29, 1986. "Gelman deep well draft permit available for public to review." The Ann Arbor News.

Cohen, Janet. February 2, 1986. "Filter maker waits, and waits, on sewer." The Ann Arbor News.

Cohen, Janet. February 2, 1986. "Tests verify pollutants in wells west of city." The Ann Arbor News.

Cohen, Janet. February 2, 1988. "Gelman strategy dangerous, DNR says." The Ann Arbor News.

Cohen, Janet. February 7, 1987. "Crack found in Gelman's waste tank." The Ann Arbor News.

Cohen, Janet. February 23, 1986. "Gelman to pay for water line extension so neighbors can avoid tainted wells." The Ann Arbor News.

Cohen, Janet. February 26, 1988. "Pollution suit names Gelman." The Ann Arbor News.

Cohen, Janet. July 13, 1987. "Dioxane find sparks new round of tests." The Arbor News.

Cohen, Janet. July 13, 1987. "Gelman plans groundwater cleanup." The Ann Arbor News.

Cohen, Janet. July 15, 1986. "Gelman offers disposal plan for polluted groundwater." The Ann Arbor News.

Cohen, Janet. July 16, 1986. "Annexation fears delay water deal." The Ann Arbor News.

Cohen, Janet. July 27, 1986. "Study shows dioxanes on U-M tract." The Ann Arbor News.

Cohen, Janet. July 28, 1987. "Gelman begins groundwater purge operation." The Ann Arbor News.

Cohen, Janet. July 30, 1986. "Gelman failed to give timely notice of spill." The Ann Arbor News.

Cohen, Janet. June 15, 1987. "Gelman develops method to treat polluted water." The Ann Arbor News.

Cohen, Janet. March 1, 1988. "Gelman denies violating laws." The Ann Arbor News.

Cohen, Janet. May 18, 1986. "Toxins disrupt tranquil Scio area." The Ann Arbor News.

Cohen, Janet. May 21, 1986. "Westover area may not have water for several weeks." The Ann Arbor News.

Cohen, Janet. May 28, 1986. "Residents of contaminated Scio area to get bottled water." The Ann Arbor News.

Cohen, Janet. May 29, 1986. "Gelman cleanup may begin soon." The Ann Arbor News.

Cohen, Janet. May 30, 1986. "Toxic wastes may be threat to city sewer." The Ann Arbor News.

Cohen, Janet. May16, 1986. "More toxins found in Scio well water." The Ann Arbor News.

Cohen, Janet. November 3, 1986. "Residents fighting deep well." The Ann Arbor News.

Cohen, Janet. November 23, 1986. "Gelman cleanup pressure mounts." The Ann Arbor News.

Cohen, Janet. November 29, 1987. "State may sue Gelman Sciences over pollution." The Ann Arbor News.

Cohen, Janet. November 29, 1987. "Water and soil tests bear out predictions dioxane fanning out in different layers." The Ann Arbor News.

Cohen, Janet. September 9, 1986. "EPA's probe of Gelman leaves officials frowning." The Ann Arbor News.

Cohen, Janet. September 9, 1986. "Puzzling pattern of contamination revealed." The Ann Arbor News.

Cohen, Janet. September 25, 1986. "Residents want proof disposal well is safe." The Ann Arbor News.

DeSimone, Bonnie. June 3, 1986. "City puts Gelman proposal on hold." The Ann Arbor News.

DeSimone, Bonnie. June 10, 1986. "Gelman water main offer 'not a gift'." The Ann Arbor News.

DeSimone, Bonnie. June 24, 1986. "Gelman agrees to foot bill for water main construction." The Ann Arbor News.

"DNR files on Gelman Sciences Inc. Reveal Gaps, inconsistencies." April 27, 1986. The Ann Arbor News.

*DNR files on Gelman Sciences, Incorporated. 1965-1988. Lansing, Michigan.

Ewart, Brian. October, 1987. "Lack of proper testing keeps Gelman disaster a secret for 17 months." Agenda. p. 1.

Fulton, Doug. June 29, 1981. "Gelman drills a well to solve waste problem." The Ann Arbor News.

Gearhart, Jeff and Mark Weinstein. June, 1987. "Gelman Second Worst Environmental Disaster in Michigan." Agenda. p. 3.

Gearhart, Jeff. July, 1987. "EPA ruling on Gelman permit due." Agenda. p.1.

Gearhart, Jeff. July, 1987. "When watchdogs only bark." Agenda. p. 1.

"Gelman official downplays DNR's pollution ranking." April 10, 1987. The Ann Arbor News.

Gelman Sciences, Inc. 1987a. "Innovations in Microfiltration for Science and Industry."

Gelman Sciences, Inc. 1987b. "Management Sketchbook." Gelman Sciences Management Personnel: A Collection of Biographical references.

Gelman Sciences, Inc. March 1988. "Groundwater project progress outline, 1986-1988."

Gelman Sciences, Inc. March 1988. "Summary of waste water treatment, 1963-1986."

"Gelman site still ranks No. 2 worst." November 24, 1987. The Ann Arbor News.

Haglund, Rick. April 27, 1986. "Charles Gelman banking on 'Sunbeam' to rescue his troubled kingdom." The Ann Arbor News.

Hooper, Celia. May 6, 1986. "Scio Township residents get update on study of Gelman dioxanes." The Ann Arbor News.

Interview with Alfin Vaz. March 12, 1988.

Interview with Dan Bicknell. April 8, 1988

Interview with Dan Bicknell. February 23, 1988.

Interview with Mary Vanderlaan. February 24, 1988.

Jones, Jackie. September 13, 1984. "What's in the lake? Scientists studying chemical samples." Detroit Free Press.

Kelley Frank J., Attorney General, et al. v. Gelman.Sciences Inc., File No. 88-34734-CE. February 26, 1988.

"One million spent on cleanup, so far, firm says." April 17, 1988. The Ann Arbor News.

Reynolds, Roy. April 28, 1971. "Pollution Paradox is Solved." The Ann Arbor News.

Reynolds, Roy. January 26, 1988. "Gelman sues DNR chief over pollution ranking." The Ann Arbor News.

Reynolds, Roy. March 10, 1970. "Ironic Industrial Pollution Problem May be Solved Soon." The Ann Arbor News.

Reynolds, Roy. November 7, 1969. "Gelman Firm's Case Illustrates State Industry Conflict." The Ann Arbor News.

Rogers, Tom. Dec. 23, 1986. "Citizens group opposing Gelman's deep well permit." The Ann Arbor News.

Rogers, Tom. January 25, 1987. "Group, citing leak, asks EPA to monitor Gelman's waste well." The Ann Arbor News.

Rzepka, Marianne. July 22, 1986. "Gelman to pay city water bill for Westover." The Ann Arbor News.

Schmidt, Wayne. May 29, 1986. "More monitoring of drinking water urged." The Ann Arbor News.

U.S. Environmental Protection Agency. March 31, 1987. "p-Dioxane: Health Advisory." Office of Drinking Water. U.S. Government Printing Office, Washington, D.C.

*DNR files on Gelman Sciences, Inc. is unbound and unpublished. It consists of thousands of uncatalogued documents which are organized chronologically. They are stored at the Michigan Department of Natural Resources, Lansing Michigan, and can be obtained through the Freedom of Information Act.

Risk assessment

Cohen, Janet. April 3, 1986. "The uncertain science of risk assessment." The Ann Arbor News.

Conservation Foundation, The. 1985. Risk Assessment and Risk Control. Washington, D.C.

Conway, R. A. 1982. "Introduction to environmental risk analysis." in R.A. Conway, ed.. Environmental Risk Analysis for Chemicals. Van Nostrand Reinhold Company: New York, New York.

Creasey, William A. 1981. Cancer: An Introduction. Oxford University Press: New York, New York.

*DNR files on Gelman Sciences Incorporated. 1965-1988. Lansing, Michigan.

Federal Register, The. September 24, 1986. Part II U.S. EPA "Guidelines for risk assessment." Vol. 51, No. 185 Washington, D.C.

Foran, Jeffery & Mark Van Putten. June 27, 1987. Letter to Gordon Guyer, Director Michigan Department of Natural Resources. Re: Critical Materials Registry. National Wildlife Federation: Ann Arbor, Michigan.

Garrett, Laurie. 1979. "The biology of cancer." In Mark Renneker, and Steven Leib, eds. Understanding Cancer. Bull Publishing Company: Pao Alto, California.

Gori, Gio Batta 1982. "The regulation of carcinogenic hazards." In Christoph Hohenemser and Jeanne X. Kasperson, eds. Risk in the Technological Society. Westview Press, Inc.: Boulder, Colorado.

Hartung, Rolf 1987. "Draft health and environmental effects assessment for 1,4-doxane." Prepared for Gelman Sciences, Inc. The School of Public Health, The University of Michigan: Ann Arbor, Michigan.

Interview with Jeffrey Foran. March 31, 1988.

Interview with Jeffrey Foran. April 19, 1988.

Interview with Rebecca Head. March 30, 1988.

Kociba, R.J., et al. 1974. "1,4-dioxane toxicity as determined by a two-year dose-response study in rats." Meeting abstract. Toxicol. and Appl. Pharmacology 2: 263-282.

Legator, Marvin S., et al. 1985. The Health Detective Handbook: A Guide to the Investigation of Environmental Health Hazards by Non-Professionals. The Johns Hopkins University Press: Baltimore, Maryland.

Martinez, Maria Carmen F. 1987. "Critique of the draft health and environmental effects assessment for 1, 4-dioxane." Michigan Department of Natural Resources: Lansing, Michigan.

Nesmith, Jeff. December 25, 1983a. "Chemical deaths expected; Reagan policy claims protection has limits." The Washington Post.

Nesmith, Jeff. December 25, 1983. "White House tied to halt FDA ban on dye." The Atlanta Journal and Constitution.

Nesmith, Jeff. September 4, 1983a. "Billions spent studying how carcinogens cause cancer in cells." The Atlanta Journal and Constitution.

Nesmith, Jeff. September 4, 1983b. "Critics claim policy on carcinogens is lax." The Atlanta Journal and Constitution.

Nesmith, Jeff. September 4, 1983c. "The great debate on carcinogens." The Atlanta Journal and Constitution.

Nesmith, Jeff. September 7, 1983a. "Dispute on health rules is inevitable, report says." The Atlanta Journal Constitution.

Nesmith, Jeff. September 7, 1983b. "White House fears cost of cancer programs." The Atlanta Journal and Constitution.

Nesmith, Jeff. September 25, 1983a. "U.S. ignored warnings on carcinogens." The Atlanta Journal and Constitution.

Nesmith, Jeff. September 25, 1983b. "EPA Position Flip Flop on Threat." The Atlanta Journal and Constitution.

Oppenheimer, Steven B. 1982. Cancer: a Biological approach and clinical introduction. Allyn and Bacon, Inc.: Boston, Massachusetts.

Prescott, David M. and Abraham S. Flexer. 1982. Cancer: The Misguided Cell. Charles Scribner and Sons: New York, New York.

Rall, David P. 1980. "Three decades of environmental concern." In H. Burchenal and Herbert F. Oettgen, eds. Cancer: achievements, challenges and propects for the 1980's. Grune and Stratton: New York, New York.

Theiss, Jeffrey C. 1980. "Detection of carcinogens." In H. Burchenal and Herbert F. Oettgen, eds. Cancer: achievements, challenges and prospects for the 1980's. Grune and Stratton: New York, New York.

Young, J.D., W.H. Braun, & P.J. Gehring. 1978. "The dose-dependent fate of 1,4-dioxane in rats." J. Environ. Pathol. and Toxicology. 2: 263-282.

*DNR files on Gelman Sciences, Inc. is unbound and unpublished. It consists of thousands of uncatalogued documents which are organized chronologically. They are stored at the Michigan Department of Natural Resources, Lansing Michigan, and can be obtained through the Freedom of Information Act.

Briggs, Louis I. 1968. "Geology of Subsurface Waste Disposal in the Michigan Basin." in John E. Galley, ed. Subsurface Disposal in Geological Basins: A Study of Reservoir Strata. American Association of Petroleum Geologists. Tulsa, Oklahoma.

Clark, Lyman H. December 1983. "Briefing & Policy Review: Underground Injection of Hazardous Waste, Draft." U.S. EPA: Washington, D.C. p. 2.

Cohee, G.V. & Kenneth H. Landes. 1958. "Oil in the Michigan Basin." Habitat of Oil. American Association of Petroleum Geology: Tulsa, Oklahoma.

Cohen, Janet. September 25, 1986. "Residents want proof disposal well is safe." The Ann Arbor New

Cohen, Janet. November 3, 1986. "Residents fight deep well." The Ann Arbor New

Cohen, Janet. November 23, 1986. "Gelman Clean-up Pressure Mounts." The Ann Arbor New

Dorr, John A. & Eschman, Donald F. 1970. Geology of Michigan. University of Michigan Press: Ann Arbor, Michigan.

*DNR Files on Gelman Sciences, Inc. 1965-1988. Lansing, Michigan.

DNR (May 1986). "Deep Well Injection of Hazardous Waste in Michigan." Michigan Department of Natural Resources: Lansing Michigan.

Ells, Garland D. 1969. "Architecture of the Michigan Basin." Michigan Basin Geological Society, Annual Guidebook. Lansing, Michigan.

Fisher, J.H. 1969. "Early Paleozoic History of the Michigan Basin." Michigan Basin Geological Society Annual Field Conference. Lansing, Michigan. pp. 89-93.

Fisher, Jeanne Ann. 1981. "Fault Patterns in Southeastern Michigan." Master's Thesis. Michigan State University: East Lansing, Michigan.

Fulton, Doug. June 13, 1981. "Gelman drills a well to solve waste problem." The Ann Arbor News.

Gelman Sciences, Inc. "Groundwater Project Progress Outline 1996-1988."

Gelman Sciences, Inc. "Summary of Waste Water Treatment 1963-1988."

Gearhart, Jeff and Mark Weinstein. June, 1987. "Gelman Second Worst Environmental Disaster in Michigan." Agenda. p. 3.

Gordon, Wendy & Bloom, Jane. 1985. "Deeper Problems: The Limits to Underground Injection as a Hazardous Waste Disposal Option." Natural Resources Defense Council, Inc.: Washington, D.C.

Guthrie, M., et al. March 1986. "The Impacts of Alternative Technologies for Treatment and Disposal of Liquid Hazardous Wastes." Presented at the International

Symposium on Subsurface Injection of Hazardous Wastes. Unpublished manuscript.

Interview with Mary Vanderlaan. February 24, 1988.

Interview with Arthur Moretta. July 7, 1987. Region V EPA, Chicago, IL.

Interview with Arthur Moretta. February, 1988. Region V EPA, Chicago, IL.

Interview with James Marshall, March 3, 1988.

Keck Consulting Services, Inc. July 14, 1986. "Interim Report, Hydrogeologic Investigation, Gelman Sciences, Inc. Section 25, Scio Township, Washtenaw County Michigan." Prepared by James W. Brode and Robert C. Minning: Williamston, Michigan.

Keck Consulting Services, Inc. Mach 30, 1987. "Report of Phase II Hydrogeologic Investigation, Gelman Sciences, Inc. Section 25, Scio Township, Washtenaw County Michigan." Prepared by James W. Brode and Robert C. Minning: Williamston, Michigan.

Leenheer, J.A. & R.L. Malcolm. 1973. "Case History of Subsurface Waste Injection of and Industrial Organic Waste." Underground Waste Management & Artificial Recharge. vol. 1. pp. 565-569.

Moldenhauer, David. 1984. "Draft Report on Deep Well Injection of Hazardous Waste in Texas." Texas Department of Agriculture: Austin, Texas.

Office of Technological Assessment, U.S. Congress. 1983. "Technologies & Management Strategies for Hazardous Waste Control." U.S. Government Printing Office: Washington, D.C.

Rogers, Tom. January 25, 1987. "Group, citing leak, asks EPA to monitor Gelman's waste well." The Ann Arbor News.

Simpson, Frank. 1975. "Deep Well Injection of Fluid, Industrial Wastes in Canada." Unpublished paper. University of Windsor.

Sullivan, Patrick. 1983. "An Assessment of Class I Hazardous Waste Injection Wells." Ball State University: Muncie, Indiana. pp. 1-2.

Syrjamaki, Robert M. 1977. "The Prairie Du Chien Group of the Michigan Basin." Master's Thesis. Michigan State University: East Lansing, Michigan.

Texas Department of Water Resources. 1983. "Report 274: Underground Injection Control Technical Assistance Manual," Austin, Texas. pp. 22-33.

Toxic Substance Control Committee Meeting, March 10, 1988. Presentation by Dave Rymph and Mary Vanderlaan. Ann Arbor, Michigan

Tocsin, November 26, 1986. "Request for Administrative Review," 2349 Arrowwood Trail, Ann Arbor, Michigan.

Tocsin, 1987. "Update of Request for Administrative Review," 2349 Arrowwood Trail, Ann Arbor MI.

U.S. Environmental Protection Agency. September 1985. "Report to Congress on Injection of Hazardous Waste." U.S. Government Printing Office: Washington, D.C. 570-9/85-003.

U.S. Environmental Protection Agency. September 24, 1986. "Response to Comments and Permit Revisions to Underground Injection Control Permit, #MI-161-1I-0001, Gelman Sciences, Inc.," EPA Region V: Chicago IL.

U.S. Environmental Protection Agency. September 24, 1986. " Regional Response to Request for Review of Underground Injection Control Permit, #MI-161-1I-0001, Gelman Sciences, Inc.," EPA Region V: Chicago IL.

U.S. Environmental Protection Agency. January 1987. "Regional Response to Request for Review of Underground Injection Control Permit , #MI-161-1I-0001, Gelman Sciences, Inc.," EPA Region V: Chicago IL.

*DNR files on Gelman Sciences, Inc. is unbound and unpublished. It consists of thousands of uncatalogued documents which are organized chronologically. They are stored at the Michigan Department of Natural Resources, Lansing Michigan, and can be obtained through the Freedom of Information Act.

Land use planing issues

Beal, Frank, et al. 1980. The Practice of Local Government Planning. International City Management Association: New York. pp 202-13, 262-272.

Bennett, Charles F. 1983. Conservation and Management of Natural Resources in the United States. John Wiley and Sons: New York.

Interview with Jim Schafer. January 22, 1988.

Michigan Department of Natural Resources, Groundwater Quality Division (undated). "Michigan's Hidden Resource." Lansing, Michigan.

Ritter, Dale F. 1978. Process Geomorphology. W.M.C. Brown: Dubuque, Iowa.

U.S. Water Resources Council. 1978. "The Nation's Water Resources 1975-2000." Vol. 2. Water Quantity, Quality, and Related Land Considerations. U.S. Government Printing Office: Washington, D.C.

Washtenaw County Metropolitan Planning Commission, 1986. "Washtenaw County Land Use Policies." Ann Arbor, Michigan.

Cohen, Janet. July 16, 1986. "Annexation fears delay water deal." The Ann Arbor News.

Cohen, Janet. May 18, 1986. "Toxins disrupt tranquil Scio area." The Ann Arbor News.

*DNR files on Gelman Sciences Incorporated. 1965-1988. Lansing, Michigan.

Eastern Michigan Environmental Action Council--EMEAC 1984. Groundwater Contamination Sites: a citizens's guide to fact-finding and follow-up. Eastern Michigan Environmental Action Council: Birmingham, Michigan.

Fulton, Doug. June 28, 1981. "Gelman drills a well to solve waste problem." The Ann Arbor News.

Huisingh, Donald et al. 1986. "Proven Profits from Pollution Prevention." Case Institute for Local Self-Reliance: Washington, D.C..

Interview with Alfin Vaz. March 12, 1988.

Interview with Brian Ewart. March. 28, 1988.

Interview with Carl Brauer. March 28, 1988.

Interview with Priscilla Cheever. January 4, 1988.

Interview with Karen Clark, Ron Kooistra, & Jack Larsen (Jackson DNR). February 25, 1988.

Interview with Jim Crowfoot. February 7, 1988.

Interview with Carol Dudley. February 23, 1988.

Interview with Kathy Edgren, February 25, 1988.

Interview with Douglas Mark, January 6, 1988.

Interview with James Marshall. February 5, 1988.

Interview with Ken Schatzle. December 5, 1987.

Interview with Mary Mickelson. February 17, 1988.

Introductory Tocsin Newsletter. Undated. Ann Arbor, Michigan.

Polk, Timothy and Elizabeth Polk. September 11, 1986. "Public should voice concern over deep-well injecting." The Ann Arbor News. Letter to the editor.

Rogers, Tom. December 23, 1986. "Citizens group opposing Gelman's deep well permit." The Ann Arbor News.

*DNR files on Gelman Sciences, Inc. is unbound and unpublished. It consists of thousands of uncatalogued documents which are organized chronologically. They

are stored at the Michigan Department of Natural Resources, Lansing Michigan, and can be obtained through the Freedom of Information Act.

An analysis of the response of University of Michigan to the contamination issue.

Blanchard, Frank. 1988. "U-M Profs Pitch In." The University of Michigan Special Report: The U-M in Partnership with Buisness. Office of News and Information Services: `Ann Arbor, Michigan.

*DNR files on Gelman Sciences Incorperated. 1965-1988. Lansing, Michigan.

Interview with Carl Brauer. March 28, 1988.

Interview with Carol Dudley. February 23, 1988.

Interview with Jack Weidenbach. February 18, 1988.

Interview with Jim Crowfoot. Febuary 7, 1988.

Interview with Ken Schatzle. January 4, 1988.

Interview with Ken Schatzle. December 5, 1987.

SNR files on Gelman Sciences Incorporated. 1984-1988. University of Michigan: Ann Arbor.

SNR files on Third Sister Lake, 1984-Present. Ann Arbor, Michigan.

*DNR files on Gelman Sciences, Inc. is unbound and unpublished. It consists of thousands of uncatalogued documents which are organized chronologically. They are stored at the Michigan Department of Natural Resources, Lansing Michigan, and can be obtained through the Freedom of Information Act.

Ann Arbor News, The. April 27, 1986a. "DNR files on Gelman Sciences, Inc. shows gaps, inconsistencies."

Blanchard, Frank. 1988. "U-M Profs Pitch In." The University of Michigan Special Report: The U-M in Partnership with Buisness. Office of News and Information Services: `Ann Arbor, Michigan.

Bradford, George. December 1987. Evergreen Alliance Newsletter. Detroit, Michigan.

Cohen, Janet. April 27, 1986b. "Gelman resusted DNR warnings of water contamination." The Ann Arbor News.

Cohen, Janet. July 30, 1986. "Gelman failed to give timely notice of spill." The Ann Arbor News.

Ewart, Brian. October, 1987. "Lack of proper testing keeps Gelman disaster a secret for 17 months." Agenda. p. 1.

Interview with Karen Clark, Ron Kooistra, & Jack Larsen (Jackson DNR). February 25, 1988.

Interview with Mary Vanderlaan. Febuary 24, 1988.

Ann Arbor News, The. April 10, 1987. "Gelman official downplays DNR's pollution ranking."

Cohen, Janet. May 18, 1986. "Toxins disrupt tranquil Scio area." The Ann Arbor News.

Gelman, Charles. April, 1988. Washtenaw Jewish News.

Fulton, Doug. June 29, 1981. "Gelman drills a well to solve waste problem." The Ann Arbor News.

Haglund, Rick. April 27, 1986. "Charles Gelman banking on 'Sunbeam' to rescue his troubled kingdom." The Ann Arbor News.

Hooper, Celia. May 6, 1986. "Scio Township residents get update on study on Gelman dioxanes." The Ann Arbor News.

Interview with Alfin Vaz. March 12, 1988.

Interview with Bob Reichel. March 15, 1988.

Interview with Dan Bicknell. April 8, 1988.

Interview with Dan Bicknell. Febuary 23, 1988.

Interview with Karen Clark, Ron Kooistra, & Jack Larsen (Jackson DNR). February 25, 1988.

Interview with James Marshall, February 5, 1988.

Interview with Mary Vanderlaan. Febuary 24, 1988.

Interview with Priscilla Cheever. January 4, 1988.

Vandermeer, John. 1986. "Toxic Wastes." Unpublished Manuscript. The University of Michigan. Ann Arbor, Michigan.

Discussion

Boraiko, Alan A. March, 1985. "Storing Up Trouble--Hazardous Waste." National Geographic Vol. 167, No.3, Washington, D.C.

Bradford, George. December 1987. Evergreen Alliance Newsletter. Detroit, Michigan.

Brown, Lester R. et al. 1988. State of the World 1988. W.W. Norton and Company: New York, N.Y.

Commoner, Barry 1974. The Closing Circle: Nature, Man and Technology. Alfred A. Knopf, Inc.: New York, N.Y.

Conway, R. A. 1982. "Introduction to environmental risk analysis." in Conway, ed. Environmental Risk Analysis for Chemicals. Van Nostrand Reinhold Company: NewYork, New York.

Devall, Bill & George Sessions. 1985. Deep Ecology: Living as if Nature Mattered. Peregrine Smith Books: Salt Lake City, Utah.

Gori, Gio Batta 1982. "The regulation of carcinogenic hazards." In Christoph Hohenemser and Jeanne X. Kasperson, eds. Risk in the Technological Society. Westview Press, Inc.: Boulder, Colorado.

Nesmith, Jeff. December 25, 1983. "White House tied to halt FDA ban on dye." The Atlanta Journal and Constitution.

Stapp, William B. and Dorothy A. Cox 1981. Environmental Education Activities Manual. E.P. Dalton: New York.

Weir, David and Mark Schapiro. 1981. Circle of Poison: Pesticides and People in a Hungry World. Institute for Food and Development Policy: San Francisco, CA.

Federal and state statutes and their application to the Gelman Case

Conservation Foundation The. 1987. Ground Water Protection. The Conservation Foundation: Washington, D.C.

Eastern Michigan Environmental Action Council--EMEAC 1984. Groundwater Contamination Sites: a citizens's guide to fact-finding and follow-up. Birmingham, Michigan.

Gordon, Wendy & Jane Bloom. 1985. "Deeper Problems: The Limits to Underground Injection as a Hazardous Waste Disposal Option." Natural Resources Defense Council, Inc.: Washington, D.C.

Patrick, Ruth et al. 1987. Groundwater Contamination in the United States. 2nd ed. University of Pennsylvania Press: Philadelphia.

U.S. Congress, Committee on Government Operations. 1984. "Groundwater Protection: The Quest for a National Policy." 98th Congress, 2d Session--House Report 98-1136. U.S. Government Printing Office: Washington, D.C.

APPENDIX A: FEDERAL AND STATE STATUTES AND THEIR APPLICATION TO THE GELMAN CASE.

The following is a summary of the state and federal statutes pertinent to the Gelman incident of groundwater contamination. These statutes provide for the protection of human health and the environment, the regulation and monitoring of waste disposal by state and federal agencies, and response and enforcement activities by state and federal agencies.

Human health and the environment

Since 1963 Gelman has used the following methods for the disposal of its processed waste at the 600 Wagner Road site: direct surface discharge, seepage from unlined lagoons where aerobic and anaerobic microbial treatment occurred, disposal and burning of chemical wastes in an unlined pit, spray irrigation after aerobic and anerobic microbial treatment, and deep well injection. Regardless of the method used for waste disposal by Gelman, the waste, according to law, must not be injurious to either public health or the environment. The State Water Resources Commission Act (WRCA) prohibits any discharge, either directly or indirectly into the waters of the state, that is or might become injurious to public health, the environment, or to commercial, industrial, or domestic uses of State water resources. According to the WRCA waters of the State include groundwater, lakes, rivers and streams. The Michigan Environmental Protection Act (MEPA) also prohibits any conduct that has or is likely to pollute, impair, or destroy water or other resources.

WRCA authorizes the Attorney General to bring a civil action for injunctive relief, penalties, and natural resource damages as well as the authority to bring actions to abate

violations. MEPA empowers the Court to grant equitable relief to protect the water and other natural resources, and public health.

Registration and permitting

WRCA requires that all toxic chemicals be registered with the Critical Materials Register (established in 1971). This register is a list of toxic chemicals which, if used or discharged by a business or industry, must be reported annually to the State. Businesses are required to indicate the quantities of the material used and the nature of the enterprise in these reports. 1,4-dioxane was placed on Michigan's Critical Material Register effective October 1, 1980 and has been included on the Register every year since. Gelman first reported discharging 30,000 pounds annually of 1,4-dioxane, via spray irrigation in 1981, as required by WRCA.

All waste disposal into the waters of the State by Gelman requires a permit from the Water Resources Commission. The Clean Water Act and the 1972 ammendments to it established a system for imposing effluent limitations on, or otherwise preventing discharges of "pollutants" into any "waters of the United States" from any "point source." A permit program, known as the National Pollutant Discharge Elimination System -- NPDES, is one element of this system. Under the NPDES program, any person responsible for the discharge of a pollutant or polutants into any waters of the United States from any point source must apply for and obtain a NPDES permit. The state of Michigan elected to take over the program from the Environmental Protection Agency and made it a part of WRCA on April 15, 1973. According to section 7 of WRCA any waste discharged after April 15, 1973 into the waters of the State requires an NPDES permit.

Previous to the NPDES permitting program, any business discharging waste into the waters of the state required an "Order of Determination" permit from the Water Resources Commission pursuant to WRCA. Orders of Determination permits include

provisions for waste discharge. Gelman's initial 1965 discharge permit provided that the wastewater "be disposed of into the ground in such a manner by means of such facilities and at such location that they shall not injuriously affect public health or commercial, industrial and domestic water supply use." Any new method of waste discharge required that Gelman apply for a new permit.

Injection wells

The ways in which permits for injection wells are granted have undergone many revisions since Gelman received their initial permit in 1981. The first injection wells in Michigan were permitted under an "Order of Determination" by the Water Resources Commission pursuant to WRCA. There were no specific regulations regarding waste injection wells at that time. The MDNR paid close attention to well design, but did not examine the geologic formations or abandoned oil exploratory wells of the area.

The Mineral Wells Act, 1969 P.A. 315, and the Administrative Rules of the act provided additional State regulatory control. This act provides control over the drilling, operation, and abandoning of mineral wells to prevent surface and underground contamination. After the passage of this act the MDNR conducted a review of all wells used for waste injection, with special attention focused on relatively shallow wells. Under orders of the DNR, those shallow wells were phased out by 1977 and have since been replaced with deeper wells. New regulations under the Mineral Wells Act included (1) the requirement for a feasibility study which includes an area review of dry holes, (2) proof of an acceptable receiver reservoir, (3) a monthly reporting system, and (4) full time professional staff trained in the technical aspects of injection wells.

Gelman contacted the Mineral Well Permit Unit (DNR) regarding a feasibility study in 1980. Once this study was completed the DNR issued a construction and drilling permit on May 12, 1981. The well was inspected by a DNR engineer and pressure-tested as required by law. The well began operating in late 1981.

The practice of underground injection came under Federal control in 1974, when the Safe Drinking Water Act (SDWA) was passed. Subtitle C of the SDWA, designed to prevent "endangerment" of underground drinking water sources by injection wells, contains the Underground Injection Control (UIC) program. The Safe Drinking Water Act required the U.S. EPA to write a set of regulations that would be used for nationwide regulation of waste disposal wells. These regulations, known as the UIC regulations, took effect in 1980. The UIC program directs the EPA to establish minimum requirements for underground injection of wastes. Under the regulations, all injection wells must have a permit in order to operate and must meet all the applicable technical criteria and standards set forth. Once the EPA established these technical requirements, each state was required to develop and submit for approval a state UIC program meeting the EPA's criteria. Recognizing that several years might pass before the EPA could approve state UIC programs under the SDWA, the EPA decided that the disposal of hazardous waste by underground njection in each state would be regulated under Resource Conservation and Recovery Act's (RCRA) "interim status" regulations until an approved UIC program had been established in that state. Thereafter, injection operations permitted under the UIC program would automaticallly be granted a permit under RCRA. Today, both the State Mineral Wells Act and the Federal (UIC) permits are required before an injection well can be constructed. Gelman applied for a UIC permit from the EPA on December 20, 1984 and the permit was granted on August 15, 1986. This permit only allowed for the injection of processed waste. Therefore, Gelman was not permitted to use the well to dispose of purged, contaminated groundwater.

The Solid Waste Amendments to RCRA of 1984 mandated the ban of land disposal of hazardous waste unless the EPA Administrator were to find that the practice is protective of public health and the environment. Under the amendments, deep well injection is permitted. Wells are tested by the EPA to determine whether or not injection is safe and should continue.

The 1984 amendments further prohibit injection of hazardous waste into or above a formation which contains an underground source of drinking water within one-quarter mile of the well bore, unless the aquifer has been exempted or the injection is a response action or part of a corrective action taken under the Comprehensive Environmental Response, Compensation and Liability Act of 1980. Gelman's waste stream was identified as non-hazardous. If the waste stream had been deemed hazardous, more intense monitoring requirements would have been necessary and Gelman may have had to adopt an alternative disposal technique.

Response to environmental contamination

Environmental response and enforcement for contamination sites within Michigan are governed by the Michigan Environmental Response Act (MERA). The MERA provides an objective process for evaluating sites of environmental contamination. MERA provides for the indentification, risk assessment, and priority evaluation of environmental contamination sites in the State. Known and suspected sites of contamination in Michigan are listed on an annual priority list. Sites are ranked according to the relative risk of harm they pose to human health and the environment. The sites are scored according to the Site Assessment System, a numerical scoring system which takes into account present and potential hazards to health and the environment, along with the types and amounts of waste on the site. The Site Assessment System is used as a guide for allocating limited state funds to individual sites. The DNR has included the Gelman site on the annual priority lists every year since 1983. In 1987 the DNR nominated the Gelman site to be included on the federal National Priority List pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERLA). This would provide federal monies for responding to the contamination at the Gelman site.

An annual appropriation of State funds for response activities is authorized by MERA. Funds may be used if there is an immediate health threat, or to address long-term health and environmental protection. Money has already been spent by the DNR at the Gelman site to provide temporary and permanent replacement of private water supplies contaminated by hazardous substances, and for water sampling and investigation. MERA provides the Attorney General with the authority to seek compensation and reimbursement from a party whose action has required the expenditure of state funds under MERA.

The Michigan Public Health Code (MPHC) gives the Department of Public Health and county health departments the power to use several different methods to reduce and eliminate public health threats. Health agencies must respond if a determination is made that there is imminent danger to public health. In the Gelman incident of groundwater contamination, private drinking water wells were initially sampled by the Washtenaw County Health Department from September through December, 1985. In response to the widespread contamination by 1,4-dioxane in the vicinity of the Gelman site, the Michigan Department of Public Health, in January 1986, issued a health advisory warning affected residents and businesses not to drink waters contaminated with 1,4-dioxane in concentrations greater than 2 ppb.

At sites where a potentially responsible party has been identified, environmental enforcement is pursued by the DNR. Environmental enforcement involves notification, follow-up, and possible legal action. The goal of environmental enforcment is to obtain a voluntary agreement with the responsible party for clean-up and necessary response activities such as supplying bottled water. This agreement is known as a Consent Agreement and is legally binding. When a voluntary agreement is not forthcoming, the Attorney General's Office may pursue legal action. According to the Attorney General's Office, despite repeated requests, "Gelman has refused to enter into an enforceable commitment to comprehensively investigate, abate, and remedy the environmental contamination at and emanating from its site" (Kelley, et al., v. Gelman Sciences, Inc.).

The identification of responsible parties, the preparation of court documents, and the negotiation of cleanup agreements with responsible parties may increase the time required to complete actions at some sites. The State Attorney General, Frank Kelley, filed a civil action suit for "injunctive and monetary relief to abate and remedy illegal releases of toxic chemicals into the environment from an industrial facility owned and operated by Gelman Sciences, Inc. " This civil action suit was filed on February 26, 1988 (Frank J. Kelly, Attorney General for the State of Michigan v. Gelman Sciences, Inc.).

Federal Statutes and Strategies pertaining to groundwater protection and regulation.

Although there is no statute specifically aimed at protecting groundwater, there are many programs that provide some measure of protection. The following are the federal statutes and strategies concerning groundwater.

Environmental Protection Agency Groundwater Protection Strategy

In 1984 the EPA set forth a groundwater protection strategy which addressed four main objectives needed for effective groundwater protection: 1) the need to strengthen state groundwater programs; 2) the need to address groundwater contamination problems of national concern; 3) the need to create a policy framework for guiding EPA programs; and 4) the need to strengthen regulations pertaining to groundwater.

In order to strengthen state groundwater programs, the EPA has provided states with funds to establish state strategies, to support necessary program development and planning, to create data systems, to assess legal and institutional impediments to comprehensive state management, and to develop state regulatory programs such as permitting and classification.

In order to address groundwater contamination problems of national concern, the EPA has undertaken reviews of a number of groundwater contamination sources that appear to have caused widespread problems (e.g., leaking underground storage tanks and other faulty disposal facilities). Guidelines were greatly needed for the assurance of consistency within EPA's groundwater protection programs. The strategy's framework is based on the rationale that not all groundwater is of equal value. Therefore, protection should be based on its vulnerability to contamination and its respective value. Lastly, in order to strengthen groundwater regulations, the EPA has established the office of Groundwater Protection to oversee the implementation of this strategy.

Resource Conservation and Recovery Act (1976) -- RCRA

RCRA outlines a "cradle to grave" management program for all hazardous wastes. The Hazardous Waste program establishes standards for treatment, storage, and disposal of hazardous waste; it seeks to protect groundwater as a principal point of vulnerability to contamination from hazardous wastes.

Under Subtitle C. Section 3004, the EPA must promulgate regulations establishing standards applicable to owners or operators of hazardous waste treatment, storage and disposal facilities. A "hazardous waste," under Section 1004, (5), because of its quantity, concentration, or physical, chemical, or infectious characteristics, may either (a) lead to illness or mortality or (b) "pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of, or otherwise managed." This section, by referring to protection of "human health or the environment," covers all natural resources, including groundwater.

Subtitle D (Solid Waste regulations) contains provisions ensuring that land disposal facilities present "no reasonable probability of adverse effects on health or the environment from disposal of solid waste at such a facility." These standards also address groundwater. The Act also authorizes enforcement actions to abate imminent hazards caused by solid waste or hazardous waste.

In 1980, the Environmental Protection Agency decided that the disposal of hazardous waste by underground injection in each state would be regulated under RCRA's "interim status" regulations until an approved Underground Injection Control (UIC) program had been established in that state. Thereafter, injection operations permitted under the UIC program would automatically receive a permit under RCRA.

Comprehensive Environmental Response, Compensation, and Liability Act (1980) -- CERCLA

CERCLA authorizes the EPA to respond to substantial threats posed by releases into the environment (including groundwater) of any hazardous substance, pollutant, or contaminant which may present an imminent and substantial danger to the public health and welfare. CERCLA is often called the "Superfund" law, since it created a special fund for responding to severe contamination sites.

Section 101(3) defines environment as including "navigable waters, the waters of the contiguous zone, and the ocean waters of which the natural resources are under the exclusive management authority of the United States under the Fishery Conservation and Management Act of 1976" and any other surface water, groundwater, drinking water, water supply, land surface or subsurface strata, or ambient air within the United States..."

As required by CERCLA, the EPA has published the National Oil and Hazardous Substances Contingency Plan, also called the National Contingency Plan (NCP). Officially published in July 1982, regulations in the NCP specify the procedures to be used in identifying, removing, or responding to releases of hazardous substances. The NCP provides for priority listing for response to hazardous waste sites, and for the preparation of separate response programs for each contamination site.

The National Priority List (NPL) ranks contamination sites according to degree of hazard to a human population or the environment. Sites are scored according to the Hazard Ranking System (HRS). For each site, the potential for exposure to humans via groundwater, surface water, air, direct contact, and fire and explosions is estimated. The scoring and ranking is the first step in considering a site for CERCLA funding. The NPL is revised and updated on an annual basis, although information about sites may be submitted by citizens, agencies or businesses at any time. Periodically the Michigan DNR nominates sites to the EPA for inclusion on the NPL.

Safe Drinking Water Act (1974) -- SDWA

This statute authorizes the EPA to set maximum contaminant levels and monitoring requirements for public water systems.

The Underground Injection Control (UIC) program regulates the uses of underground injection wells to protect drinking water aquifers. The SDWA states that the program regulations must contain "minimum requirements for effective programs to prevent underground injection which endangers drinking water sources." Section 1421(d)(2) specifies that the source of concern is "undergroundwater which supplies or can reasonably be expected to supply any public water system." This is further defined as a system providing piped water for human consumption, for at least 15 connections or 25 individuals.

The Sole Source Aquifer provisions allow the EPA to designate an aquifer as the sole source of drinking water for an area, guaranteeing its protection from contamination by projects receiving Federal financial assistance. Section 1424(e) of the SDWA provides local, regional, or state agencies a legal mechanism (petitioning the EPA Administrator) to protect the recharge zones of special aquifers. The EPA Administrator may designate an aquifer which is a sole or principal drinking water source if contamination "would create a significant hazard to public health." If the designation is made, no federal financial commitment may be made for any project which the Administrator determines may contaminate such an aquifer through a recharge zone so as to create a significant public health hazard.

Clean Water Act --CWA

The CWA's objective (Section 101) is to "restore and maintain the chemical, physical and biological integrity of the Nation's waters." This statute makes general reference to groundwater protection in municipal wastewater treatment, planning, and research programs. Its principal regulatory programs, however, focus on surface water.

The first part of the Act to address groundwater (Section 104) requires the EPA to "establish, equip and maintain a water quality surveillance system for the purpose of monitoring the quality of the navigable waters and groundwaters..." This section has been most often applied to surface waters, with only limited surveillance of groundwater.

The principal mechanism for achievement of the goals and objectives proposed originally by the 1972 Act is a system for imposing effluent limitations on or otherwise preventing discharges of "pollutants" into any waters of the United States from any "point source." A permit program (the National Pollutant Discharge Elimination System -- NPDES) is one element of this system (Section 402). Under the NPDES program, any person responsible for the discharge of a pollutant or pollutants into any waters of the United States from any point source must apply for and obtain a permit. The EPA has jurisdiction over all NPDES permits in a state until such time as the state elects to take over program administration and obtains EPA approval of its program. Approximately two-thirds of the states have approved NPDES programs and function as the issuing authorities for permits in their jurisdictions, including Michigan.

Toxic Substances Control Act (1976) -- TSCA

The TSCA authorizes the EPA to restrict or prohibit the manufacture, distribution, and use of products presenting an unreasonable risk of injury to public health or the environment. Section 3(5) defines "environment" to include "water, air and land and the inter-relationship which exists among and between water, air, and land and all living things". Groundwater is included in this definition.

Uranium Mill Tailings Radiation Control Act (1984)

This statute establishes health and environmental standards applicable to management of uranium mill tailings.

Atomic Energy Act (1954)

This act gives the EPA authority to establish standards applicable to materials, including radioactive materials, governed by the Act. These standards are implemented by the Nuclear Regulatory Commission.

Federal Insecticide, Fungicide, and Rodenticide Act (1971) -- FIFRA

This statute gives EPA the responsibility to control the use of pesticides. Environmental impacts, including those affecting groundwater, must be taken into consideration.

Michigan Acts pertaining to groundwater protection and regulation

Two state agencies, the Department of Public Health and the Department of Natural Resources, regulate and manage Michigan's groundwater resources. The Department of Public Health issues permits for domestic and public supply wells and requires well drillers to submit copies of their drilling records to the county health departments. This department also monitors the quality of public water supplies and tests wells for contaminants.

The Department of Natural Resources assists those who use groundwater by maintaining files of drilling records and by performing hydrogeological groundwater quality studies. The department also maps and describes geological formations and monitors mineral wells and subsurface injection of brine (USGS, 1985). The Water Resources Commission of DNR established rules for the non-degradation of groundwater quality, a permitting system for a discharge into groundwater, and monitoring requirements for existing and new discharges. The non-degradation policy of the State of Michigan calls for the protection of groundwater at its existing quality. The following are the State of Michigan statutes pertaining to groundwater, and those pertinent to the Gelman incident of contamination.

The Michigan Environmental Response Act (1982) -- MERA

MERA was established in 1982 by the State legislature to provide an objective process for evaluating sites of environmental contamination. The Groundwater Quality Division of the Michigan Department of Natural Resources has been designated by the Governor to administer the program. An annual appropriation of State funds for response activities is authorized by the MERA. Funds may be used in the case of an immediate health threat or for addressing long-term health and environmental protection. Unlike the CERCLA program, funds may be used at sites with contamination caused by gasoline and fuel products.

Known and suspected sites of contamination in Michigan are listed on the Act 307 Priority List. Sites are ranked according to the relative risk of harm the sites pose to human health and the environment. The Michigan Department of Public Health (MDPH) shares responsibility with MDNR to determine whether a hazard is being posed to human health through direct contact with waste or contaminated soils, or through a contaminated water supply system. Local health departments also play an important role in identifying sites, providing information on site conditions, and sampling private water supply wells. The sites are scored according to the Site Assessment System (SAS), a numerical scoring system which considers present and potential hazards to health and the environment, and the nature and amount of waste on the site. The SAS is used as a guide for allocating limited state funds to individual sites. Funded actions at a site can include replacing a contaminated well, supplying bottled drinking water, fencing off a site, investigating a site to better define problems, and/or providing for comprehensive cleanup.

Environmental enforcement involves notification, follow-up, and possible legal action at sites where a potentially responsible party has been identified. Such identification is always the first goal pursued by the Environmental Enforcement Division of the DNR. When a voluntary response from the identified party is not forthcoming, the Attorney General's Office may pursue legal action. MERA requires the State Attorney General to seek compensation and reimbursment of State funds from those whose actions resulted in a contamination site that required MERA funds for cleanup. The identification of responsible parties, preparation of court documents, and negotiation of cleanup agreements with responsible parties may increase the time required to complete actions at some sites. Environmental enforcement, when possible, is always the first step before the expenditure of public monies is considered. In the case of a long-term project a Citizen Information Committee (CIC) may be established as a liaison between the community and the DNR. The EPA carries out enforcement activities when federal laws have been violated. When

both federal and state statutes are involved, state and federal staff coordinate their efforts to avoid duplication.

The Michigan Water Resources Commission Act (1929) -- WRCA

The Water Resources Commission ("Commission") was established in 1929 under the WRCA. The Commission's mandate is to "protect and conserve the water resources of the state, to have control over the pollution of any waters of the state and the Great Lakes, (and) to have control over the alteration of the watercourses and the flood plains of all rivers and streams..." The Commission has the authority to regulate pollutant discharges and to prevent and abate pollution, to establish restrictions and water quality standards, to control alterations of watercourses and floodplains, to provide surveillance and monitoring programs, to prohibit pollution of any waters of the state and Great Lakes, to assure compliance with federal law and regulation, and to create and prescribe the power and duties of a commission. Finally, the Commission has the authority to provide penalties for the violation of this act.

Section 323.6(a). "It shall be unlawful for any persons directly or indirectly to discharge into the waters of the state any substance which is or may become injurious to the public health, safety or welfare; or which is or may become injurious to domestic commercial, industrial, agricultural, recreational, or other uses which are being or may be made of such waters; or which is or may become injurious to the value or utility of riparian lands; or which is or may become injurious to livestock, wild animal, birds, fish, aquatic life, or plants or the growth or propagation thereof be prevented or injuriously affected; or whereby the value of fish and game is or may be destroyed or impaired."

"Every industrial or commercial entity which discharges liquid wastes into any surface or groundwaters or underground or on the ground other than through a public sanitary sewer shall have waste treatment or control facilities under the specific supervision

and control of persons who have been certified by the commission as properly qualified to operate the facilities."

Section 323.11. "Waters of the state" include groundwater, lakes, rivers, and streams.

Section 323.6(c). "A violation of a provision of this is evidence of the existence of a public nuisance and, in addition to the remedies provided for in this act, may be abated according to law in an action brought by the attorney general."

Section 323.6(b). "Every person doing business within this state, discharging wastewater to the water of the state or to any sewer system, which contains wastes in addition to sanitary sewage shall file annually reports on forms provided by the commission setting forth the nature of the enterprise, indicating the quantities of material used in and incidential to its manufacturing processes and including by-products and waste products, which appear on a register of critical materials as compiled by the commission with the advice of an advisory committee of environmental specialists designated by the commission and the estimated annual total number of gallons of wastewater including but not limited to process and cooling water to be dicharged to the waters of the state or to any sewer system."

Section 323.7(a). "After April 15, 1973, a person shall not discharge any waste or waste effluent into the waters of this state unless he is in possession of a valid permit therefore from the commission."

Section 323.10. This section authorizes the Attorney General to bring a civil action for injunctive relief, penalties, and natural resource damages for violations of WRCA or rules promulgated thereunder.

Rule 323.1057. This rule was added to the WRCA in 1986 and governs toxic substances. "Toxic substances shall not be present in the waters of the state at levels which are or may become injurious to the public health, safety, or welfare; plant and animal

life; or the designated uses of those waters. Allowable levels of toxic substances shall be determined by the commission using appropriate scientific data."

Rule 323.1233. This rule establihed the critical material register in October, 1971.

Rule 323.1234. "A list of those critical materials listed on the register, including the annual amounts thereof, which are to be disposed of as waste products or by-products to the waters of the state or any sewer."

Rule 323.2101 (1973). "These rules are promulgated to implement the 1972 amendment to the commission act which authorized the initation of a waste or waste effluent discharge permit system compatible with the National Pollutant Discharge Elimination System (NPDES). The NPDES has been initiated by the Federal Congress through the enactment of "The Federal Water Pollution Control Act Amendments of 1972....." Rule 2106. "A person discharging wastes into the surface or groundwaters of the state or on the ground as a point source discharge, whether or not in compliance with an outstanding order of determination, final order of determination or stipulation with the commission, shall promptly make application for and obtain from the commission a valid national or state permit pursuant to section 7 or 8 of the commission act and according to procedures and deadlines set forth in these rules."

Rule 323.2201. This rule establishes groundwater quality standards and was added to WRCA in 1980. 1) "The purpose of the groundwater quality rules is to protect the public health and welfare and to maintain the quality of groundwaters in all usable aquifers for individual, public, industrial, and agricultural water supplies." 2) "These rules provide for the nondegradation of groundwater quality in usable aquifers, define the requirements for hydrogeological study before permitting a discharge into groundwaters, establish groundwater monitoring requirements for new and existing groundwater discharges, and establish a procedure for obtaining variances from these rules."

Michigan Environmental Protection Act (1970) -- MEPA

The Michigan Environmental Protection Act was enacted to promote resolution of environmental disputes and allow judicial review by the Attorney General of all activities likely to cause "pollution, impairment, or destruction of natural resources and the public trust therein."

Section 51. "The public health and general welfare of the people of the state are hereby declared to be matters of primary public concern. The legislature shall pass suitable laws for the protection and promotion of the public health."

Section 52. "The conservation and development of the natural resources of the state are hereby declared to be of paramount public concern in the interest of the health, safety and general welfare of the people. The legislature shall provide for the protection of the air, water and other natural resources of the state from pollution, impairment, and destruction."

MEPA imposes a duty on individuals and organizations to prevent or minimize environmental degradation. It specifically prohibits conduct that has or is likely to pollute, impair, or destroy water or other resources or the public trust.

Mineral Wells Act (1970)

"The Mineral Wells Act provides control of the drilling operation and abandoning of mineral wells to prevent surface and underground waste. This act requires a feasibility study for any underground injection well which includes an area review of dry holes, proof of an acceptable receiver reservoir, a monthly reporting system, and a full time professional staff trained in the technical aspects of injection wells."

The Hazardous Waste Management Act (1979) -- HWMA

"The HWMA is an act to protect public health and the environment, to regulate removal and disposal of hazardous waste, to provide hazardous waste facilities, to create a site approval board, to provide inspection, monitoring and manifesting of hazardous

wastes, to develop hazardous waste management plans, to regulate the siting, design, construction and operation of hazardous waste facilities, to establish trust and service trust funds, to promulgate rules, and to prescribe the powers and duties of certain state agencies."

Michigan Public Health Code (1978)--MPHC

"MPHC is a comprehensive statement of the broad legal authority of the Michigan Department of Public Health and county health departments. The code gives health agencies the power to use many different remedies to reduce and eliminate public health threats. Health agencies must respond if a determination is made that there is imminent danger to public health."

APPENDIX B: GELMAN PERMIT INFORMATION

NPDES (National Pollutant Discharge Elimination Systems):

1978 - "Gelman Sciences, Inc. was given an [NPDES] Permit by the [DNR] in 1978 to dispose of their liquid plant waste by placing it in an approved pit where the various organics would be biodegraded, at which time the fluid could then be spray irrigated onto lands owned by Gelman adjacent to the plant." [DNR memo - letter from Gordon Guyer to David Dempsey, Dec. 3, 1986].

April 2, 1982 - WQD receives Gelman's application for reissuance of their NPDES permit ("to discharge to the waters of the state"), Act 245.

757-80 Existing Fabric Coating Line:

Aug. 25, 1980 - Permit application for reissuance of Gelman's existing fabric coating line received is by AQD.

Oct. 1, 1980 - Permit application is incomplete and placed on inactive status pending receipt of additional information requested by AQD.

Nov. 10, 1980 - Gelman submits additional information for permit application.

March 3, 1981 - AQD contacts Gelman and requests additional information to complete the review of their permit application.

June 10, 1981 - Gelman and AQD Permit Unit agree on volatile organic compound limits of 18 tons per year on permit.

June 23, 1981 - Permit approved.

June 29, 1981 - Gelman submits request to operate equipment under permit.

July 6, 1981 - AQD informs Gelman of modifications and supplement to Permit to Install.

126-81 New Solution Casting Line:

Feb. 16, 1981 - Gelman submits application for a permit to install a new solution casting belt with wet scrubber control proposed to be completed by Oct. 1, 1982.

March 23, 1981 - AQD Permit Unit sends a letter to Gelman indicating that their permit application for the new solution casting line is incomplete and has been placed on inactive status pending receipt of additional information including toxicity data, final specifications for proposed control equipment, demonstration of BACT and a test procedure for 1,4-dioxane (hereafter "dioxane"), a suspected carcinogen, using the most sensitive available analytical procedures and a detection limit for the compound. In the letter an explanation is given for AQD's policy on carcinogens: i.e. that the control equipment must be capable of removing dioxane from the exhaust stream such that concentrations at the stack exit point are at a not detectable concentration using the most sensitive test procedures.

June 25, 1981 - AQD contacts EED. AQD expresses concern that the process covered by the permit for solution casting lines uses approximately 4,400 pounds of dioxane per month. EED had informed AQD that during a routine monitoring of Gelman's ponds, conducted by DNR, samples tested positive for dioxane.

Aug. 13, 1981 - AQD internal memo is generated by Jack Larsen regarding this permit. It states that dissolved oxygen (D.O.) in the treatment lagoon should not be less than 1.0 ppm.
March 12, 1982 - Permit to install for Permit 126-81 approved.

March 22, 1982 - AQD, in response to odor complaints received from Gelman's neighbors, informs Gelman that 126-81 requires that D.O. in the lagoon be not less than 2 ppm.

544-81 Installation of scrubber existing on membrane casting line:

June 25, 1981 - AQD investigates Gelman. It was determined that the existing solution casting line (pre-1967 installation) presently being run at the plant is identical to the process covered in 126-81 and is not a duplicate of process equipment covered in 757-80 for a film coating operation. The existing line uses identical process material (including dioxane) as that covered in the new permit. Up until this time DNR had been under the impression that the existing line was using the same chemicals as the coating lines (757-80) and that dioxane was not being used.

June 30, 1981 - Letter to Gelman indicates that due to the nature of air emissions from the existing casting line (i.e. dioxane), it is AQD's opinion that there have been likely permit violations and that AQD was requiring installation of appropriate air pollution equipment as approved. It is also stated that Gelman would be required to apply for appropriate air use permit (544-81) for the installation of such control equipment.

Aug. 13, 1981 - AQD receives the permit application to install a new scrubber on the existing membrane coating line at Gelman. This is the old line which is very similar to equipment covered in 126-81.

Aug. 17, 1981 - AQD internal memo regarding Gelman's "Permit to Install Scrubber on existing counting line (old line)" addresses special conditions for use. These include: "1. Maintain 2 ppm oxygen in ponds. 2. Company shall not use dioxane formulations on the 'old line' after 6-15-82 unless equipped with approved scrubber control device."

Oct. 13, 1981 - A letter to Gelman from AQD Permit Unit indicates that despite several attempts to obtain requested information, application numbers 126-81 and 544-81 remain incomplete. AQD requests that one of the following alternatives be taken to dispose of pending application: 1) submit the requested information, 2) request application to be voided, or 3) do not submit requested information such that AQD will recommend denial of all the application at November commission meeting. Gelman is informed that if no response is delivered by Oct. 23, 1981, permits will be denied.

Oct. 23, 1981 - Gelman provides AQD with the information requested on Oct. 13. Gelman notes that during a meeting with DNR officials on Sept. 15, it was agreed that, because of the time needed to hook-up dioxane removal equipment on the old line (544-81), if Gelman would hook up all dioxane production onto the new line (to become

operational May/June 1982) they would not have to install any other pollution control equipment on the old line (even though dioxane was still being used in old line).

March 12, 1982 - Permit to install for Permit 544-81 approved.

June 24, 1982 - AQD inspection yields the response: "... scrubber is installed and operating satisfactorily."

Dec. 15, 1982 - AQD contacts Gelman and Gelman states they have still not developed adequate test procedures for wastewater discharge from scrubber (which are required in their permit).

March 8, 1983 - AQD activity report states, "The 1,4-dioxane is run 1 to 2 days/month, with three days being the maximum. Currently he [Tim Gibelyou of Gelman] is getting readings of up to 300 ppm out of the scrubber exhaust. The permit limit equals about 21 ppm. He isn't sure what exactly is the problem but thinks it might be a combination of several items. Initial estimates of amounts vaporizing may be inaccurate, the scrubber may be considerably less efficient than the 95% guaranteed. He indicated that he hasn't notified the AQD of permit exceedances before because he wasn't real certain due to scanty data. But now that more GC (Gas Chromatography) data has been accumulated he can now identify distinct problems."

March 26, 1985 - AQD notifies Gelman that their Permits to Install (126-81 and 544-81) require them to develop an acceptable standard for monitoring stack emissions. AQD states that permits to operate will not be granted and lines should not be operated unless compliance with the monitoring standard can be proved. AQD promises to send information on acceptable testing procedures and asks Gelman to submit plan by May 15.

October 16, 1985 - Gelman submits proposed stack testing procedures, but cannot submit complete information because AQD failed to provide the information promised on March 26. However, it appears Gelman also missed the May 15 deadline for submitting the plan.

M 00337 Groundwater discharge permit (i.e. spray irrigation):

Jan. 11, 1982 - GSD indicates to AQD that Gelman should be granted a variance of the requirement for a hydrogeological study for their discharge permit (for spray irrigation), stating that "... I [B.F. Shirey, GSD] do not feel that 1,4-dioxane in any great concentrations is to be expected in groundwater offsite, and that private water supplies downgradient will not be effected by the spray irrigation at the Gelman site." GSD adds that no dioxane had been detected in surrounding waters, after over five years of spray irrigation.

April 1, 1982 - Office of Toxic Materials Control sends a memo to AQD regarding Critical Materials Discharge by Gelman. The memo indicates that Gelman requested a permit modification on Sept. 16, 1980 to their groundwater discharge (spray irrigation) permit and on the permit stated that no Critical Materials were used in the manufacturing process. However, dioxane was placed on the Critical Materials Register which became effective Oct. 1, 1980. Information from WQD files shows that samples collected in March, 1980 and June, 1981 each showed the presence of dioxane in Gelman's treatment lagoons.

Aug. 27, 1984 - Ron Kooistra, DNR district groundwater quality supervisor in Jackson, writes to the Chief of Compliance for GQD in Lansing. He recommends that a review of the Gelman permit renewal application receive "high priority," since the company was legally entitled to follow past practices until the DNR officially acted on the permit renewal application. "Bicknell's study raises questions regarding the potential impact of Gelman wastes on surface and groundwater."

Sept. 20, 1984 - A letter is sent from DNR Permits Section of the GQD, to Gelman regarding Gelman's permit application. It states that after a site visit, Ron Kooistra (GQD) found dioxane in spray irrigation discharge, which is unauthorized under the existing permit. "Therefore, the discharge is in violation of the permit and must be terminated." GQD refuses to process Gelman's application for reissuance until Gelman is in compliance with the existing permit. The matter is referred to Compliance Section for "appropriate action."

Sept. 25, 1984 - Interoffice memo from AQD to GQD states: "Jack Larsen of the AQD's Jackson district office has asked the Technical Services Section and Permit Section to comment on the potential emission of dioxane by Gelman, through the spray irrigation of process waste containing this chemical. Greg Edwards of the Permit Section has evaluated the potential for dioxane to be emitted into the air through this process. Based on his evaluation, Edwards stated the following: essentially no volatilization of this compound is expected to occur under these conditions. Therefore, from an air quality standpoint, spray irrigation of dioxane-contaminated process waste is not expected to be a problem. There is a concern from a total environmental standpoint, however, since dioxane has been shown to be carcinogenic in laboratory animals, and therefore has the potential to cause cancer in humans. Since dioxane is not expected to volatilize during spray irrigation, contamination of the groundwater with this carcinogenic chemical may occur from treatment in this manner."

Oct. 12, 1984 - A letter from Gelman's law firm (Honigman, Miller, Schwartz and Cohn) to Kooistra states that Gelman understands that "Permit M 00337 continues in full force and effect during the period of time that its reissuance application is pending with MDNR." Reference is made to a letter from Weston (DNR) - it is claimed that the letter does not indicate that Gelman must cease any of its present discharge practices (including spray irrigation). Gelman intends to continue to spray irrigate.

Oct. 15, 1984 - Ron Kooistra sends a letter to Jim Marshall (Vice President of Gelman) with the discharge permit application. Gelman must submit the completed application including a complete waste characterization report, an updated hydrogeological study, and irrigation site soil tests and monitoring well data to determine impacts from past irrigation. There is a reminder that the permit does not authorize discharge of dioxane - this must be terminated. Gelman may or may not receive the discharge permit pending results of their application. Seven suggestions were made: 1) The revisions and specifications for the proposed liner replacement for pond No. 2 were not included and need to be sent. An analysis is requested as to why the existing liner failed after only approximately10 years and how new liner will be more durable. What seepage and impacts on the ground and groundwater have occurred due to failed liner? Would a leak detection system be feasible such as between the old and new liner? 2) A storage permit may be needed for the buried, 12,000 gallon steel storage tank located between ponds 2 and 3. Gelman's discharge permit renewal application should include this tank. What is the function of the tank? 3) Provisions must be made for proper removal, handling and disposal of accumulated sludge (potentially hazardous) from Pond 3 prior to placement of new liner. 4) Overflow pipes from garage piping chamber would allow raw or partially treated process wastewater to flow to ponds 1 and/or 2 (unlined earthen pits). Why are these overflows necessary? 5)

The irrigation area must be fenced off and an isolation zone should be shown which prevents aerosol drift from irrigation equipment from reaching areas occupied or frequented by people.

Nov. 5, 1984 - Gelman responds to DNR's Oct. 15 correspondence: 1) The proposed replacement liner is of same material as original liner. The only difference is that the new one will not only line sides of lagoon (as original did), but bottom also. 2) "Buried 12,000 gallon steel tank" to which DNR referred has never existed. 3) Sludge from Pond 3 has been analyzed and is non-hazardous. 4) Overflow pipes are no longer necessary since deep well is fully operational. 5) "We are currently determining if a problem of unauthorized access to the spray irrigation area exists, and what our options may be. Our course of action depends on many factors, including the status of the spray irrigation permit renewal."

March 4, 1985 - Gelman submits results from a test for base, neutral, and acid extraction analyses in conjunction with their permit application.

Sept. 4, 1986 - A letter is sent from GQD to Gelman. "It is our understanding from our Jackson District Staff that your facility will not require a discharge permit because all discharges from the site will either be to the Ann Arbor Sewer System or to deep well injection." Gelman should request a withdrawal of their groundwater discharge permit application and a termination of their current groundwater discharge permit.

Storage permit for lagoon and chemical storage:

Sept. 4, 1986 - A memo is sent from GQD to Gelman stating, "Due to the lagoon and the on-site chemical storage our district staff indicates you will need a storage permit under Act 245, P.A. 1929, as amended."

Additional notes on permits:

Sept. 15, 1981 - At a meeting with several Gelman representatives and representatives from AQD District Office and Permit Unit, the following is discussed: AQD's requirement of the additional information on permits 126-81 and 544-81 in the immediate future in order to evaluate for approval/denial; the need for a firm commitment from Gelman on air pollution control equipment and their ability to meet BACT limits; stack testing and risk assessment considerations; and the fact that Gelman is presently running dioxane on their old line uncontrolled and that AQD would make some decision on whether Gelman would be allowed to continue this until air pollution control equipment was installed. The proposed date for completion of the new line with applicable air pollution control equipment is indicated to be approximately 12 months. Gelman requests permission to build only one scrubber instead of two and to continue running dioxane on their old line until the new line is installed with adequate control equipment. At that time, Gelman would run all dioxane-containing products on the new line. AQD recommends that they control the existing line immediately and run dioxane products only on that line.

Oct. 15, 1981 - Laura Lodisio (AQD) provides a 0historical summary of AQD concerns relating to Gelman. As of Oct. '81, Gelman operated two production lines, a fabric coating line and a membrane casting belt. The existing fabric coating line is covered by approved Permit 757-80. This line has been in operation for approximately two years and does not use dioxane. The membrane casting belt units (one existing, one proposed) are covered by two un-approved permits: 544-81 for the existing line, and 126-81 for an identical line to

be completed by the fall of 1982. A wide variety of solvents are used in these lines, including approximately 4,400 pounds per month of dioxane. Gelman has an approved groundwater discharge permit (spray irrigation - not NPDES permit) from the MWRC. "Our correspondence with the WQD, however, has indicated that they feel the system is in compliance with their regulations and special conditions of their permit. WQD does not appear willing to take action against the company regarding excessive odors. The discharge permit has minimal monitoring requirements but no discharge limits." The report goes on to state that AQD's main concern is with "the two existing lines (757-80 and 544-81) [which] are presently running uncontrolled. The company has proposed air pollution control equipment on the new line (126-81). Though the company has made no firm commitment on what exactly this control will be, it is required that it be BACT and capable of meeting either nondetectable or specified emission limits set by risk assessment evaluation, due to dioxane emissions."

APPENDIX C: GLOSSARY OF ABBREVIATIONS

Abbreviation	Complete name
AQD	Air Quality Division (of the MDNR)
BACT	Best Available Control Technology
CAL	Canton Analytical Labs
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIC	Citizen Information Committee
CMR	Critical Materials Register
CWA	Clean Water Act
DNA	Deoxyribonucleic Acid
DNR	Department of Natural Resources
EED	Environmental Enforcement Divison (of the MDNR)
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
GC	Gas Chromatography
GQD	Groundwater Quality Division (of the MDNR)
GSD	Geological Survey Division (of the MDNR)
HEAA	beta-hydroxyethoxcyacetic acid
HWMA	Hazardous Waste Management Act
KG	Kilogram
MAPCC	Michigan Air Pollution Control Commission
(M)DNR	(Michigan) Department of Natural Resources
MDPH	Michigan Department of Public Health
MEPA	Michigan Environmental Protection Act
MERA	Michigan Environmental Response Act
MERB	Michigan Environmental Review Board
MG	Milligram
MPHC	Michigan Public Health Code
MWRC	Michigan Water Resources Commission
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List

OSEH	Occupation Safety and Environmental Health
OTA	Office of Technology Assessment
PEAS	Pollution Emergency Alerting System
ppb	parts-per-billion
ppm	parts-per-million
ppt	parts-per-trillion
RCRA	Resource Conservation and Recovery Act
Rfd	Reference Dose
RRD	Resource Recovery Division (of the MDNR)
SAS	Site Assessment System
SAU	Site Assessment Unit (of the MDNR)
SDWA	Safe Drinking Water Act
SNR	School of Natural Resources
SPH	School of Public Health
TSCA	Toxic Substances Control Act
TSCC	Toxic Substance Control Commission
U-M	University of Michigan
UIC	Underground Injection Control Program
(U.S.)EPA	(United States) Environmental Protection Agency
WCDH	Washtenaw County Department of Health
WCMPC	Washtenaw County Metropolitan Planning Commission
WQD	Water Quality Divison (of the MDNR)
WRCA	Water Resources Commission Act

APPENDIX D: Interview with James C. Marshall Senior Vice President of Operations, Gelman Sciences, Inc. 2/5/1988 Dates amended, 3/4/1988, 4/22/1988, and 4/26/1988.

Is Gelman Sciences, Inc. responsible for the contamination of the groundwater?

"A lot of people are responsible." There is a the need to define the term responsible. Those responsible include Dow, DNR, state agencies, and possibly Gelman Sciences, Inc (Gelman).

History

In 1963 Gelman Sciences, Inc. established a membrane casting plant. Gelman Sciences used solvents in the process of casting membranes. The waste flow at the time consisted of approximately 2,000 gallons per day. This water contained fragments of membranes and was released into a ditch on Gelman's property (a tributary of Honey Creek). Gelman realized that this was an unacceptable practice because the stream banks were becoming lined with the white membrane fragments.

Gelman hired Professor Borchardt from the Engineering Department within the University of Michigan to develop a new method for disposing of Gelman's waste. Dr. Borchardt developed a microbiological digestive process which the company then used for approx. 10 years. Two lagoons were built to contain the waste. Sewage sludge from the Ann Arbor Waste Water Treatment Plant was added to the ponds to encourage microbial action and the breakdown of "biodegradable" organic compounds. The waste would seep into the ground after microbial action had begun. The DNR was working with Gelman throughout this process and approved of seepage as an acceptable practice. Seepage was suggested by governmental agencies as the preferred method. These ponds would periodically overflow into the bog north of Gelman's lagoon. We had been working with the DNR on BOD and COD so the DNR was inspecting the site regularly and never said anything." It was very difficult for them to manage the microbial balance necessary to make the ponds efficient. Occasionally the lagoons would become anaerobic and microbes within the ponds would die off. More sludge would then be required to reactivate the ponds. Occasionally the covers on the ponds would rip. At these times odors from the ponds would create problems. in the surrounding neighborhoods. DNR, during this

period, complained about Gelman not getting the BOD and COD levels to those suggested by the state. Gelman first started using 1,4-dioxane in the production of filters in 1966.

When seepage became an unacceptable practice in 1972, a new lined lagoon was added. The intent of the third lagoon was to develop a recycling system. This system did not work so in 1976 Gelman obtained permits to spray irrigate. The permits allowed Gelman to apply waste at a rate of .23 gallons per square foot per day and only between the dates of May 15 and October 1. The waste water was pre-treated in lagoons and then spray irrigated. The waste stream at this time consisted of around 30,000 gal per day. The waste stream has remained at approximately 20,000-40,000 gallons a day for the past fifteen years. This practice required Gelman to buy more land in order to treat the waste stream because Gelman's original land was needed for building expansion and parking lots. (The result was an increase in the properties at the Ann Arbor site to an area of approximately 55 acres.) It became very expensive to cut the grass twice a week (the grass grew quickly as a result of spray irrigation) and to purchase the land needed to spray the pre-treated water on.

In 1981, deep well injection became the preferred method of disposal and Gelman obtained a permit for the well. The well was completed in 1981 and injection began. Spray irrigation was slowly phased out, in part because the lagoons needed to be drained. In 1984 spray irrigation ceased. In 1986, Gelman stopped the use of 1,4-dioxane because they learned that it is was not biodegradable and it was responsible for the high BOD and COD. Gelman phased out the line of filters that required the use of 1,4-dioxane in production and replaced this line with a new and improved filter. Dow had never informed Gelman that 1,4-dioxane was not biodegradable and that it was considered a carcinogen at extremely high doses. Gelman does not manufacture chemicals and presently uses only "common" chemicals that are biodegradable.

In the summer of 1987, Gelman hooked up its waste stream to the city of Ann Arbor's waste water treatment plant. Because of the high levels of both BOD and COD, Gelman is forced to pay a surcharge to the city of Ann Arbor. The connection with the city treatment plant was set up in conjunction with an engineering group. The waste flow was built so that it ran parallel to the city waste stream. This arrangement allowed comparisons to be performed between Gelman's waste stream and Ann Arbor's. It was found that waste from Gelman did break down completely within a matter of hours. In the future, Gelman may be required by the city to do pre-treatment in order to bring COD and BOD levels to acceptable levels. This would be at considerable expense to Gelman.

How do you explain Gelman's rating on the 307 list?

"The original E rating previous to the 307 list was a result of odor problems caused by the lagoons." The DNR became aware of the odor problem from citizen complaints.

Gelman hired outside consultants to drill monitoring wells to confirm allegations by Dan Bicknell that Gelman was polluting the groundwater and Third Sister Lake (January of 1984). Tests did not indicate the presence of 1,4-dioxane and were submitted to the DNR. A memo that Gelman received from Elmore E. Eltzroth of the DNR stated that no detectable levels of 1,4-dioxane were found in tests conducted at a 25 ppb detection level (Feb. 6, 1984). Gene Hall, from the DNR, continually informed Gelman that no contamination could be found (Oct.- Nov). The County Health Department also monitored testing wells and citizen wells for contamination throughout 1984-1986 period and found no detectable levels of 1,4-dioxane.

In January of 1986 the Redskin well was found to have 1,4-dioxane at levels of 150ppm (See outline provided for further summary of events).

How did GELMAN respond to the Bicknell report?

Dan Bicknell, who was a U/M SPH student, reported in January of 1984 that he detected levels of 1,4-dioxane, among other chemicals, in Third Sister Lake. He wrote a report accusing Gelman of contaminating the lake. Gelman found the report to contain questionable language. The report contained no validation of the techniques used for testing and also indicated the presence of a number of chemicals not used by Gelman. Gelman believes that the report was politically motivated because Bicknell was, at the time, running for the position of Drain Commissioner.

What new technology has Gelman developed to treat the contaminated groundwater?

The DNR is concerned that the new technology developed by Gelman to treat dioxane will not work. According to Gelman, extensive studies have been submitted to the DNR. However, they insist that they still do not have enough information. Gelman, on the other hand, insists that they have provided more than enough information. Gelman investigated a number of other technologies to break down dioxane, including ozone treatment, steam stripping, ultraviolet treatment, freezing, carbon treatment and burning. ""We have not written a thesis on each of these technologies, we are not in the writing

business." The DNR has not received our experimental design and we are not going to write it up for them. The DNR has received all of our results from these various tests.

Gelman developed a group to work cooperatively and share information with DNR and the Health Department. Gelman has provided assistance to another company in North Carolina with a similar problem. "We are the experts on 1,4-dioxane treatment technology, and we have been developing the technology to break it down." It is important to note that the technology for treating dioxane did not exist previous to this case and there is presently no established method for removing the contamination from the environment.

Costs to Gelman

- High costs in terms of dollars, time, and research.
- Created a poor public image.
- Costs and time required for litigation
- Employee distractions
- Customer anxieties (Gelman is often the sole source of a product for a customer.)

How do you view the role of the media in this case?

"We have found the media to be irresponsible in their approach to reporting." The articles written about the incident have been "full of partial truths." Information and quotes have been used out of context. A partial truth is that 1,4-dioxane is a carcinogen. The truth is that 1,4-dioxane is a carcinogen at very high levels in laboratory animals, at the 1% level. Another partial truth occurred in the Detroit Free Press article of September 6, 1984, where they showed a picture of Third Sister Lake with a sign that read, please no swimming or fishing. However, the sign had been there long before the contamination in the groundwater was discovered. The various newspapers and television stations have not been reporting the efforts that Gelman has made to work toward a solution. The media has often used third-hand information, such as the article that claimed that Gelman had an informant in Lansing who informed them of plant inspections ahead of time. Channel 7 News arrived one day and interviewed people in the surrounding community but never talked to Gelman representatives -- we were ready to talk with them but never got the opportunity. Instead, Channel 7 filmed Fran Coy's beauty shop business and showed film clips of her customers. She had requested that her customers' faces not be shown. It is important to note that her well was not one of those that was contaminated. It is important to note that Gelman has been making considerable progress toward the resolution of this problem, which is never included in the press' reports.

Why did you contract Dr. Hartung to compile a risk assessment for 1,4-dioxane?

According to the State Health Department and Dr. Sidu, 2 ppb of 1,4-dioxane is the health advisory set by the state for safe drinking water. This advisory is based on a model for one additional case of cancer in one million people, if each person drinks three liters a day for 70 years. The state guideline for body contact is 100 ppb. Gelman feels that there are no problems associated with 1,4-dioxane at the levels present in the environment . "We (Gelman) would normally choose the low range of a risk assessment if it is based on the correct model, and the state model is not an acceptable model. There are acceptable risks. We take risks every day--when we drive in our cars, when we breath the air..." We feel that the levels should be based upon a correct model. The advisories could be 3 ppm for drinking water, according to the Hartung risk assessment.

How would your describe your relationship with the DNR and are they partially responsible?

"Everyone is involved when it comes to responsibility. We were working cooperatively to develop answers to the questions. We were working scientifically to determine the extent of the problem, and to develop technologies for solving the problem. However, when the process departed from the realm of science, it became a game of politics and bureaucracy...it became uncontrollable and unpredictable." We blame the State for the way they have been handling themselves as professionals, and for their scientific information.

We submitted the third remedial action program this week. The DNR is claiming that it is incomplete. "We have removed effectively 4,000 lbs of 1,4-dioxane. The level of 1,4-dioxane in the Redskin well has been reduced from 200 ppm to 60 ppm . We have taken over 1200 samples. We have talked face to face with over 300 people. We have developed the technology to clean up 1,4-dioxane at our initiative and expense." The DNR should "take credit for this progress in a proper manner" and should present a mood of cooperation "rather then playing an adversarial role. I don't believe that you will find a company that deliberately contaminates the environment. Things happen that you don't know about and you have to accept that." Accidents are bound to happen, but in general, no industry wishes to pollute or degrade the environment.

"We will never be a hero," yet we would like to be treated in a responsible manner by the DNR and the media. The news media has scared people in the surrounding area.

Many residents do feel that we have done a good job and sympathize with us. "There is no evidence of any damage done whatsoever."

A Gelman employee notified Washtenaw County Health Department of a dump located on Gelman property and the practice of burning wastes in the dump (November 1979). How do you explain this incident?

"Gelman uses mixing vessels for mixing various compounds. On occasion, a batch of compounds has been incorrectly mixed. The standard practice for this situation was to dump the vessels' contents into a pit dug into a clay base. The residue would then be burned. We did not feel that this practice was improper. We did not have a permit and did not think we needed one. The DNR site inspectors had walked by it 100 times and had never said anything. Therefore, Gelman thought that the practice was acceptable."

DNR Environmental Enforcement Division observed the Gelman Property and noted that "the pond at the Northwest corner of the Gelman property had a pump which was running, sitting on the Southwest bank, with one hose running into the almost entirely drained pond water, and the other end running up onto the west bank and toward the Northwest property line, the line terminating approximately 15 feet from the fenceline at the NW corner of the pond. The natural ditch in that bank was leading the water towards the fenceline and appeared to be made specifically to let water through the fence." How do you explain this incident?

"The pond was built by Gelman to hold runoff water from our parking lots." The pond consisted of runoff water from the parking lot and back-flush water from our water softeners. "There was no processing water in the pond." It was our "nature pond with turtles in it." We put a pipe in the dam and drained the overflow water into Bicknell Creek.

What are your reasons for suing the DNR?

"There are two issues here: the first is the refusal by the DNR to give a proper evaluation." There is a great deal that the DNR doesn't know. They need to work more closely with industry. Gelman gave the DNR suggestions on the rating system but the DNR did not listen to these suggestions. They refused to talk with Gelman about the

system. "Gelman feels that industry should be able to sit down with DNR and see that the process is done fairly. They refuse to consider progress being made at this site." In justifying Gelman's ranking on the 307 list they claim that "Gelman is a chemical and rubber manufacturing company," that gives Gelman 40 points. "Gelman is not a chemical and rubber manufacturing company." The DNR did not follow its own rules for the list. There is a mathematical mistake in the ranking and there are areas where it is subjective. Evaporation of 1,4-dioxane from water is not a linear relationship but the DNR claims that it is. "People are not at risk." The second major issue Gelman has with the ranking system is that "the DNR has never promulgated rules and regulations for the system." You cannot have a system without rules and regulations. The system is not approved as a part of the legislature.

How would you evaluate the process for dealing with the contamination and your response to the contamination?

Gelman paid for bottled water. We paid for the hookup of City water lines to the houses of affected residents. There have been many hidden agendas and the process of working toward a solution has become political. We cannot reach solutions being reactive, instead the process must be pro-active. "I don't believe that any company would intentionally endanger people or the environment." Chloroform which is used to help purify drinking water is ten times more toxic than 1,4-dioxane. The national average for chloroform in drinking water is 83 ppb which is 40 times that which was suggested for 1,4-dioxane. State and federal agencies need to work with companies and permit their activities. They need to demonstrate alternatives, the technology is there. We do everything possible to protect our workers. We looked up information that was known about the chemicals that we were using. "1,4-dioxane is not a toxic substance. We believe that Dow knew that 1,4-dioxane would not break down." Dow also claims to have stewards who visit companies that use their chemicals. Stewards check to see if the chemicals are being handled properly. "We have never seen a Dow Chemical Steward. We probably would not have used dioxane if we had known."

The total thrust of DNR needs changing. "The technical expertise is often zero as a result of constantly changing staff." We have, on occasions, had to train and educate DNR people here. We need an agency that works with industry. "We have been forced to rely on our own experts." Hartung developed the risk assessment for us. He sent it to six world scientists for review. It was then sent to the EPA and to the State. It has been four months now and we have received no feedback. These cases must be dealt with on an

individual case level. "The only way to develop sympathy for what we have been through is to go through it yourself."

Deep Well Injection

The first permit for the deep well from the DNR allowed Gelman to inject "processing and non-processing water." Almost any material could have been injected except for materials like radioactive substances, PCB's, etc.

On our new permit we made the mistake of stating that the well would be used for "the injection of our processing water." This was a mistake because now we can no longer inject purged water from the Redskin well.

"The deep well is not a long-term solution but for the short-term it is perfectly acceptable." What we need for the future is "total destruction of compounds or recycling." Businesses should be forced to use recyclable materials or materials that are totally destructible. "What we need is a program to work with companies toward that end." The government needs to assume a proactive role and "stop it before it gets out there." Remedial action and a"strong arm approach is not doing anybody any good." "The State should require permits for every single activity and work with the people." State resources should be transferred from a reactive approach (remedial action) to a proactive approach.

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