Creating a Toxic Landscape: Chemical Waste Disposal Policy and Practice, 1900-1960

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Since the public discovered the infamous Love Canal waste dump in the late 1970s, it has regarded the chemical industry as one of the chief contributors to a toxic landscape. Certainly, chemical manufacturers have been a leading source of hazardous by-products for many years, and especially since the 1940s. The organic chemical industry grew some tenfold after World War II, and by the mid-1980s represented the largest single source of hazardous wastes in the country.[1] During this period of rapid expansion, the leading producers reported depositing some 762 million tons of chemical wastes in more than 3,300 locations around the country.[2] This massive load of industrial by-products has become the center of legislative efforts and also federal and state environmental investigations that currently have identified more than 1,200 priority clean-up sites, with some estimates suggesting there may be a total of 10,000 nationwide.[3]

The toxic landscape of the 1990s is not just a post-World War II product. Rather, it is an outcome of continually evolving government regulation, internal corporate policy, and technological capabilities over the course of this century. Each element interacted with and had an impact on the other. Waste disposal practices responded to external legal pressures, whether common or later statutory law, as public agencies revised the legal context for industrial waste disposal. Internal policy reflected constantly changing technical capabilities and also dynamic economic priorities and an expanding knowledge base of the problems posed by wastes.

The relict dump sites that are the object of current clean-up efforts are deeply imbedded in a complex history of decision-making, and within the chemical industry many independent decisions created a wide range of policies and practices. An analysis of contemporary technical literature will illustrate the range of options open to decision makers and reveal contrasts between the stated policies of chemical makers and their practices during the first two-thirds of this century. It will show that frequently there was a wide disparity between stated waste control objectives and the actions of particular companies. Neither government nor industry failed to see potentially hazardous outcomes because of inadequate control of harmful waste products. Both promoted and sought solutions to waste disposal problems from an early date. Manufacturers moved slowly to adopt existing technology to minimize recognized liabilities, while outwardly proclaiming the problem was under control. Before 1930 a deliberate course of action was understandable given existing volumes of hazardous wastes and manufacturers' ability to find isolated sites and thereby avoid creating a public nuisance. Between 1930 and 1948, industry took a clearly articulated position, but failed to provide waste treatment in accord with its pronouncements and its ability. After 1948, the public waste-management discussion became more contentious, and practice continued to lag behind stated industry objectives and treatment capabilities.

Common Law, Dilution, and Isolation, 1900 - 1929

The chemical industry was not a leading creator of public nuisances at the turn of the century, but by 1920 it had distinguished itself as capable of producing a number of waste products, both gaseous and liquid, that were both unpleasant and noxious. The chemical manufacturing industry grew in a legal environment that provided neighbors with a means to redress undesirable situations. Either private citizens or a public agency could file a nuisance suit to halt water and air pollution. By 1905, statutory law defined certain offensive industrial activities as nuisance-causing.[4] Dilution provided a common method to avoid nuisance complaints. This practice offered an inexpensive waste disposal technique, although it did not reflect contemporary technological capabilities. At the turn of the century dilution found support among public health officials who believed streams had natural purification powers and considered certain toxic discharges beneficial owing to their germicidal effects.[5] Industry looked upon streams as natural sewers.[6] This widespread reliance on dilution, along with the increasing quantities of urban and industrial sewage, ultimately spawned discord.

Private nuisance suits reflected a growing dissatisfaction with dilution as the principal waste treatment technique. Nuisance case histories indicate that private complainants against surface-water polluters won their actions as often as they lost them before 1900.[7] In fact, nineteen states provided statutory support to common law by protecting "all" waters as early as 1901, thereby refining the basis for legal action.[8] In terms of groundwater, correlative rights—which allowed reasonable use of underground water resources to the extent that it does not injure the supplies of a neighbor—guided the majority of groundwater pollution cases.[9] Common law also provided a clear distinction between municipal wastes, which were considered unavoidable additions to public waters, and industrial wastes, which could be excluded, and at the time, withheld any special privileges for locally important manufacturing concerns. The judicial tradition held that one could not acquire the right to create a public nuisance simply by prescription.[10] Thus, there was ample legal foundation to discourage undesirable discharges of pollutants, and statutory law passed during this period added legal means to control chemical waste discharges.

As the chemical industry grew, and with it the volume of industrial wastes, local and state agencies, seeking to protect public water supplies, joined private litigants in opposing uninhibited use of riverine environments for the trade waste dilution.[11] Among the more aggressive early state programs was the Illinois Rivers and Lakes Commission. During its short-lived existence (1911-1916), it held hearings on stream pollution complaints from all sections of the state. In several cases involving "trade wastes" from gas works, the commissioners issued cease pollution edicts.[12] These orders forced the gas producers to install treatment equipment for their phenolic and tar wastes. Although the available treatment technologies—which included ammonia distillation, benzol recovery, settling tanks, and biological oxidation—offered limited pollution control benefits, their effluent was less damaging to waterways than untreated discharges. Not only were there various forms of treatment for gas-works waste, a leading sanitary engineer argued in 1917 that "the impression that the [industrial] wastes cannot be successfully treated is in many cases not true."[13] Waste treatment manufacturers even argued that treating chemical plant wastes was less expensive than treating polluted municipal water supplies and that industries should logically bear that expense.[14]

Pollution's environmental impact became ever more apparent during the 1920s, and treatment specialists sought remedies to the most obvious and troublesome wastes. Legislative and technological responses focused narrowly on single sources of nuisance, such as oils and phenols. Congress, after much debate, passed legislation prohibiting the dumping of oil wastes into maritime waters in 1924.[15] An American Water Works Association committee reported on the taste problem caused by the interaction of phenols and chlorine and offered evidence that there were several available, albeit unperfected, options for treating waste waters containing phenols, which originated at gas works, coke works, chemical plants, and oil refineries. These included retention tanks or ponds, chemical treatment, sedimentation, and activated sludge treatment. Cost considerations, led by-product coke manufacturers to opt for a treatment procedure that vaporized phenolic wastes. While less technologically sophisticated than other forms of treatment, quenching coke with phenolic liquors alleviated stream pollution.[16] The intensive scrutiny of oil and phenols captured most of the professional attention directed to stream pollution during the 1920s, thereby diverting interest from other hazardous substances discharged by chemical works and other sources.

In Illinois, as elsewhere, chemical manufacturers continued to rely on waterways for dilution or "natural purification" of their discharges. Excluding the Chicago metropolitan region, there were dozens of chemical or chemical by-product manufacturers that released untreated wastes into Illinois streams. Most of these chemical works were small in scale and widely dispersed, leading the State Water Survey to report in 1924 that there was no indication their wastes exceeded the carrying capacity of the streams: the survey scientists, warned that steps should be taken to prevent overloading of streams in the future.[17] In the Chicago area, chemical wastes severely damaged the Calumet River and periodically threatened Chicago's drinking water supply, provoking a public outcry. The solution was to divert the wastes from coke works, oil refiners, chemical manufacturers, and steel works into the Illinois River drainage basin via a system of canals and thereby rely on dilution in another larger waterway—and one not affecting Chicago's water supply.[18]

The most obvious and pervasive response to nuisance law was not a legislative or technological solution. Rather it involved adopting an isolation policy into the plant siting process. Selecting remote locations enabled chemical producers to guard against a variety of nuisance liabilities, such as off-site property damage due to explosions in addition to water and air pollution. Traditional economic criteria such as relative proximity to market or raw materials, transportation services, and labor and power costs remained the leading influences at a regional scale, while waste disposal issues contributed to decisions at the local level. The recognition of potential hazards posed by the manufacturing process and the risk of legal action in the event of current or future pollution problems was implicit in the selection and use of suburban factory sites.

The chemical waste management literature of the period contained numerous discussions of geographic solutions for pollution problems. Harrison Eddy, a founder of the prominent engineering firm of Metcalf & Eddy, asserted in 1917 that selecting a suitable site for a waste-producing manufacturer was extremely important. He advised chemical manufacturers to keep in mind that "in no case can one acquire a right, by proscription [sic] or otherwise, to create a nuisance." He counseled plant builders "to anticipate complaint of objectionable conditions."[19] While Eddy admittedly was promoting the waste treatment services his company offered, his remarks underscore the realization that wastes were offensive. Not only was it difficult to guard against encroachment in remote sites, manufacturers had to anticipate it.

Eddy encouraged manufacturers to plan for pollution problems, although more commonly, writers cited isolation, or removal from densely settled regions, as a means to escape nuisance liability altogether. Victor Kelsey, an assistant manager at Corning Glass Works, advised manufacturers to be aware that some communities, after going to great lengths to attract a new factory, found that they had acquired obnoxious fumes, dust, odors, or hazards from fires and explosions. He claimed that a manufacturer that preceded residential development had the right to continue polluting. If the factory followed residential land uses, then the burden to remove the nuisance lay with the industry. He concluded a community-relations discussion by stating that "with proper care and foresight so-called undesirable chemical industries can select locations relative to towns or cities that will result beneficially to all concerned."[20]

In recognition of legal liabilities associated with chemical manufacturing hazards, the explosives industry followed a strict isolation policy. When selecting a northern Alabama site, the Hazard Powder Company identified seclusion as one of its primary criteria. A contemporary newspaper account (1892) reported:

> In selecting the location Mr. Emanuel was particular to see that the site should be one remote from the city and other industries.... There is not a house within a mile of the site, nor a furnace or other industry within three miles. The land is broken, being bounded by mountains, hills and forests. This just suits for a site, as such things break the force of explosions.[21]

Other powder manufacturers also selected sites outside city limits and nestled in narrow valleys.[22]

Discussing siting factors, A. D. Smith listed several typical economic issues in selecting a petroleum refinery site. The first of his other "important" influences was local water quality and quantity, which impinged directly on waste disposal. He warned builders to consider whether the drainage of effluent may later form the basis for a pollution suit and advised refiners to consider local nuisance laws prior to building. He discouraged the purchase of a plant site in congested territory unless "exhaustive engineering study, legal advice and general business counsel" suggested there were no liabilities.[23]

Writing for the National Association of Real Estate Boards in 1926, the geographer Richard Hartshorne pointed to waste disposal as an important local consideration in selecting factory sites. He singled out chemical manufacturers as one of a few industries that produced large quantities of unmarketable by-products and noted that these substances needed disposal at a minimum expense. Not being a technical specialist, he listed liberation of gases to the atmosphere and discharge of liquids to rivers and streams as acceptable techniques. Hartshorne warned that regulations applied to such practices, especially when they involved objectional or poisonous material. He pointed out that fewer restrictions impinged on waste disposal practices in unsettled parts of the country.[24]

Perhaps the most repeated advice on chemical plant siting first appeared in 1927. R. L. Kraft recognized the offensive nature of chemical plants, commenting that "chemical plants are not usually looked upon as desirable neighbors." He advised plant site selection teams to choose locations that were sufficiently removed from houses and public institutions or develop a plan to compensate neighbors for damages to their property. He also made a particularly prescient observation about the potential for groundwater contamination. Acknowledging that nuisances resulted not just from atmospheric and surface-water discharges, Kraft specifically pointed out that release of liquid wastes to the ground surface could lead to contamination of groundwater supplies down gradient, and a process that caused the closing of several factories during World War I.[25] This particular passage was printed, without attribution, in one of the most widely used text books on chemical engineering.[26]

There were obvious limits to a policy of geographic isolation in a country with increasing population density and economic factors that favored sites near the consuming markets. During the 1920s, suburban and rural chemical plants became more common across the country, but isolation was difficult to maintain. The greatest expansion of industrial activity was in the so-called manufacturing belt, which included the northeastern and midwestern states. As the Department of Commerce reported in 1933, "Despite the general tendency toward manufacturing decentralization...the dispersion which has occurred consists principally of expansion into areas adjoining the dominant population and industry centers."[27] This thrust industry into suburban agricultural areas. In 1926 several downstream farmers sued the Monsanto Chemical Company plant in Illinois for damaging their crops with harmful effluent dumped into a sluggish floodplain slough.[28] Isolation was often short-lived. Many businesses took an active role in building or encouraging the construction of worker housing near their plants. Across the Mississippi River from St. Louis, chemical and oil refineries built new facilities, partly to avoid nuisance statutes in Missouri, and constructed residences for workers in their company towns.[29] As the population density surrounding the plants increased, the risk of nuisance suits rose. Personal injury and property damage suits, as well as nuisance complaints, posed a risk to operations.[30] There were also courtroom successes for manufacturers. One nuisance-causing industry won a case in Cleveland, where it initially located on an isolated tract and argued that later residential arrivals could not complain about a pre-existing condition. The court agreed.[31]

The isolation policy allowed chemical manufacturers to ignore developments in waste treatment technology and to build plants without pollution abatement equipment. The absence of treatment, even in sparsely populated regions, eventually earned chemical manufacturers a tarnished reputation. Neighbors did not appreciate dead vegetation and unusable water, and when the chemical manufacturers found themselves proximate to populations, they devised strategies to minimize their culpability in pollution cases. The du Pont de Nemours and Company, for example, purchased both property and the right to pollute neighboring properties when it acquired land in Virginia for a munitions plant during World War I. It drew up contracts with adjacent land owners that included a disclaimer for harm to property caused by the processes used at the plant. When several landowners sought redress for alleged damages caused by acid pollution, du Pont lawyers immediately put these contracts to use in their defense.[32] During litigation of the pollution complaints, and perhaps anticipating an unfavorable ruling, staff at the Hopewell, Virginia, plant drew up waste treatment plans and also estimated the cost to dredge sediments from the river. The company chose not to implement either the treatment or remediation measures because the costs were greater than both litigation and fines.[33]

Early twentieth century chemical waste management practices reflected a series of decisions that clearly acknowledged hazardous conditions associated with chemical manufacturing, yet choices seldom included technological fixes. Dilution, which continued throughout the period, relied on nineteenth-century concepts of natural purification. Nuisance law provided a means to restrict pollution with only limited success, at least in the most densely settled areas. Statutory law and regulatory agencies also made inroads against industrial pollution. Yet the adoption of an isolation policy enabled chemical producers to avoid many legal problems. Neither dilution nor isolation reflected the technological capabilities of the day, although both proved remarkably persistent as waste management strategies in the future. The fact that the experts in treatment technologies remained with private consulting firms that sought business with the chemical companies indicated there was little interest in securing internal expertise.

Chemical Pollution and Federal Legislation, 1930-1947

The chemical industry took stock of its waste management practices and its related legal and social obligations twice during the 1930s. These self-assessments corresponded with rising public interest in water quality and efforts to pass federal pollution abatement legislation. The contrast between the chemical trade organization's public statements and critics' comments present a sharp contrast. In effect, industry reported all was well and lobbied vigorously against federal legislation, while environmental conditions and the implementation of existing technologies lagged far behind the proclamations of industry spokesmen.

The first of the assessments appeared in a 1931 special edition of *Chemical and Metallurgical Engineering*. Its editors offered an optimistic view of the place of waste treatment in the industry:

> It is only natural, therefore, that the disposal or utilization of wastes has come to be recognized as a definite part of the manufacturing process. In planning a new enterprise, it is now given the same consideration as water, labor, transportation, and the several other factors that logically determine plant location.[34]

Their statement clearly indicated a recognition of the pollution problem and the potential liabilities and costs it presented to manufacturers, while accentuating the lingering importance of isolation as a waste management practice. The special issue reviewed technological options such as waste recovery and raw material conservation, underscoring the economic and natural resource concerns of the times, although most contributors emphasized the need to reduce waste generation within chemical plant design and development rather than as an add-on technology.

Some experts of the time declared that there was ample technology available to deal with existing industrial wastes. E.B. Besselievre, a noted sanitary engineer with the Dorr Company—a leading manufacturer of waste treatment equipment—pointed out that in 1931, "based upon the handling of many industrial waste problems over a period of years, that *there is no waste discharged for which there is not a treatment* [emphasis mine]." He conceded that the start-up costs of a treatment system might discourage small plants from adopting them, but he argued that "what may at first seem to be an exorbitant expense in order to stop polluting a stream may prove to be a boon to a plant by the proof to the owner that he is throwing away a product that may be of value." He summarized several basic treatment options, recommending screening fibrous solids, sedimentation to remove suspended solids, and chemical precipitation for solutions containing dyes and metals. Each of these treatment options produced a sludge or semi-solid residual and Besselievre argued that by-product recovery from such intermediate wastes might minimize treatment program operational costs.[35] Recovery would help underwrite handling and equipment, and fit the concerns of managers during hard economic times. Even after recovery, there would remain some solid residues. For these Besselievre mentioned several options, including filling low ground. While land reclamation or filling was based on traditional "out of sight, out of mind" principles, Besselievre warned of possible dangers resulting from "indiscriminate piling of wastes."[36]

Despite process modification's promise to provide comprehensive waste management and by-product recovery systems, in practice, technologies that simply removed a single offending waste item from an effluent stream became the principal pollution control methods. As had been the case with vaporization of phenolic wastes and separation of floating oils during the 1920s,[37] treatments tended to be selective and limited.[38] This, in part, reflected the oftentimes complex nature of chemical industry waste streams and the frequent need to treat each component separately.[39] One of the least expensive treatments available was controlled effluent release. Relying on dilution, this procedure involved constructing holding tanks or ponds that restrained offensive liquors on the manufacturer's property until conditions were favorable for the receiving stream to accommodate a large volume of waste.[40] This method required extensive land holdings, but retention ponds or lagoons served a dual function by allowing partial evaporation of troublesome wastes, although they also permitted harmful fluids to percolate into groundwater supplies.

Other treatments included neutralization and incineration. Acidic and caustic wastes, common chemical manufacturing outputs, could be mixed to neutralize one another. Where the volume or strength of alkaline wastes was insufficient to offset the effects of acids, manufacturers sometimes added lime.[41] Residue incineration was another viable technology that waste management experts promoted. Besselievre spoke of combustion as a means of handling general industrial wastes, but he also noted it as a method used for oil and tar waste destruction at an organic chemical plant.[42]

The economic crisis of the early 1930s inspired a re-evaluation of materials discarded by industry. Manufacturing engineers sought means to recover marketable by-products and thereby recoup a return on waste treatment expenditures. Although exceptional, recovery of silver from photographic film production sludges was touted as one of the more successful examples.[43] The oil refining industry accounted for several recovery achievements. Propane reclamation, propylene conversion to isopropanol, and ethylene conversion to a series of solvents were notable accomplishments.[44] But, by-product recovery did not eliminate wastes. A lack of markets for recovered products and the expense of developing recovery techniques limited its applicability.[45] As a consequence, manufacturers undertook relatively little research on waste composition or recovery. In 1934, M. M. Ellis of the U.S. Bureau of Fisheries reported to a congressional stream pollution investigation that industrialists welcomed information about the chemical composition of their pollutants. Although he cited their eagerness to gain information about their waste streams to portray the cooperative spirit of industry, the example illustrated the lack of corporate knowledge about what they were throwing away and a lack of interest in deriving revenue from wastes until government bore the expense of research.[46]

During the 1930s, the perception that toxic wastes were beneficial additives to waterways with large populations of pathogenic bacteria largely gave way to a recognition that they posed real dangers to aquatic life. Finding means to dispose of toxic wastes without causing environmental damage had become particularly vexing, especially as industry introduced new, more complex, and environmentally persistent chemicals. By the 1930s, toxicologists pointed to the increasing menace of synthetic chemicals and public health experts began to consider deadly chemicals as serious components of industrial pollution—in addition to biological wastes which carried waterborne diseases.[47] Biologists singled out chemical plant effluent as harmful to human and aquatic life, and they argued for a reduction in dilution treatment.[48]

As water disposal became increasingly unacceptable, particularly as a solution for the new, more complex waste streams, segregation and land burial of toxics became more common procedures. Monsanto Chemical Company's plant near East St. Louis separated its toxic wastes as early as 1932 to prevent them from entering the Mississippi River. They buried toxic wastes in pits on their property during the 1940s,[49] while at Love Canal, New York, Hooker Chemical Company began burial of toxic chemical residues on company property in the same decade.[50]

Burial followed the precepts of isolation. By excluding the toxic waste streams from waterways, chemical manufacturers evaded scrutiny by state pollution control agencies. Confining sludges and residues to burial grounds on their own property limited public exposure and kept dangerous substances in areas where workers, usually trained to handle dangerous substances and covered by company insurance policies, supposedly would avoid injury or ill-effects.[51] Waste management specialists realized that toxic chemical burial was inadequate to prevent human exposure. In 1942, E. F. Eldridge, the author of an early industrial waste treatment textbook, advocated fencing around toxic waste ponds and warned that leachate could seep into neighboring wells.[52]

Despite a wide range of chemical waste treatment options, chemical manufacturers remained reluctant to install treatment facilities. The Manufacturing Chemists' Association (MCA) surveyed its eighty-seven member companies in 1936 and found that among the 230 individual plants only forty-seven had "installed equipment for trade waste treatment." Although the MCA touted this as an impressive figure, it represented a mere twenty percent of its membership's facilities, to say nothing of the plants owned and operated by non-members.[53] Several years later forty-nine percent of urban sewage received treatment before being released to a waterway.[54] Although these two waste streams were quite distinct, the chemical industry had made less progress treating its wastes than municipalities.

In certain areas of the country, the chemical industry accounted for a large share of the total stream pollution load. In New Jersey, for example, the chemical manufacturers discharged more than 6.8 million gallons of waste waters into the state's rivers each day.[55] If twenty percent received treatment, over 5.4 million gallons per day flowed untreated into the state's waterways. Following this method to estimate national volumes, approximately 509 million gallons of chemical industry wastes entered streams without treatment each day.[56] Urban areas nationwide released approximately 2.5 billion gallons of untreated sewage per day into waterbodies. The concentration of chemical works, coke ovens, and oil refineries in the northeast and Great Lakes states exaggerated the impact of industrial pollution in those regions.[57]

By the early 1930s, several federal legislators felt stream despoilment had reached a crisis. They organized a conference in 1934 and presented several bills for Congress to consider in 1936.[58] The centerpiece of this legislative agenda was a bill to prevent the pollution of navigable waters of the country (S. 3958, 74th Cong., 2nd session). It called for the subdivision of the country into sanitary water districts that would fix standards of purity for the waters within their respective territories, declared any solid, gaseous, or liquid waste discharges into a navigable stream a public and common nuisance, and empowered the U.S. Attorney General to take action against anyone causing pollution that was deleterious to wildlife, navigation, or public health.[59] A compromise bill (S. 4627) would have created a division of Stream Pollution Control in the Department of Public Health and provided loans for the construction of sewage treatment facilities. As had earlier efforts to regulate water pollution, these bills caught the attention of the chemical manufacturers and other industries that relied on waterways for dilution treatment.

In early 1936, responding to an inquiry by the association's secretary, Lamott du Pont wrote that he felt the Manufacturing Chemists' Association, the industry's main trade organization, should have a witness testify before Congress. He agreed with the objective of the legislation to limit "unreasonable pollution of navigable waters," but commented that "bills with this intent may very well be entirely unreasonable." Du Pont encouraged the MCA to support passage of "reasonable legislation of this type."[60] Sheppard T. Powell, a noted consulting engineer, spoke on behalf of the MCA on March 24, 1936, denouncing the proposed water pollution control legislation. He claimed that the they would "vitally and detrimentally, affect the normal functioning of these industries, many of which must discharge certain byproducts into surface waters." Powell cited numerous examples of chemical plants installing expensive treatment equipment as evidence of the cooperative spirit of industry and argued that greater progress was possible through such collaborative efforts rather than through regulation.[61]

The central points of the MCA's argument were that "contamination of waterways is more frequently occasioned by municipal sewage discharge than by industrial wastes" and that there was no "satisfactory method of treatment for a number of industrial wastes."[62] In a subsequent brief, the MCA claimed that a stream's proper functions was to provide for "safe and proper disposal for measurable quantities of varieties of trade wastes," even though the trade group supported federal investigations of waste treatment technologies.[63] As part of its lobbying effort, the trade organization submitted a compromise resolution asking for prohibitions only against waste discharges by new, not existing, plants.[64]

Congress eventually passed the compromise bill (S. 4627) in 1936. This legislation, the more moderate of the two bills, would have merely provided federal support and encouragement for stream pollution abatement efforts at the state level. It was never enacted. Senator Augustine Lonergan of Connecticut, sponsor of the more powerful bill (S. 3958), entered a motion to reconsider Senate bill 4627.[65] His tactical move eventually doomed both acts that session. Congress again passed a moderate federal pollution control act in 1938. Like the 1936 legislation, it would have created a Division of Stream Pollution Control that would coordinate abatement programs through state offices. President Franklin D. Roosevelt, vetoed the bill, charging that its funding mechanism for loans and grants-in-aid bypassed executive review and represented an unacceptable congressional attempt to usurp fiscal authority.[66]

The actions of the MCA and its allies reflected a strong desire to avoid federal involvement. In an attempt to retain control over waste treatment expertise within its industry, and to show good will, the MCA formed a stream pollution committee in 1937. It was to stay abreast of developments in pollution control and to provide for the dissemination of pertinent information to members.[67] Statistics compiled by the trade organization itself indicated only a few member companies were willing to make expenditures to reduce offensive discharges or analyze their own waste streams. The MCA even brought in an outside consultant to testify before Congress, reflecting the lack of internal specialists. The National Resources Committee criticized the trade group's posturing and lack of activity in developing treatment technologies:

> Industries which contribute heavy pollution loads to surface waters are more inclined to spend money in fighting regulatory legislation and State and local enforcement activities than in finding practicable means of waste treatment. Most manufacturers and their associations have not chosen to study techniques of abatement, and State governments have been handicapped by lack of funds.[68]

Those who argued against the MCA position before Congress in 1936 pointed out the numerous cost-effective means of waste recovery available, the small number of wastes that defied practical methods of treatment, and the relative costs of pollution as compared to pollution control.[69] One proponent of pollution abatement even pointed out that delays in installing simple treatment equipment increased the ultimate cost of pollution control. He estimated that the costs in 1936 had doubled since the 1920s and reported that manufacturers could expect the price to rise 10 percent annually.[70]

A second industry self-examination appeared in 1939. It called for cooperation between industry and government in developing water pollution legislation,[71] but pointed out that regulation was a matter for the states and that nuisance law provided a means to settle conflict.[72] Although the contributors to this special volume considered all streams as potential carriers of industrial wastes, important technological achievements weakened the claim that effective waste treatments were unavailable or were too costly. I. F. Harlow of Dow Chemical Company reported that five "waste control" processes had been installed at their Midland, Michigan, plant to protect the Tittabawassee River and thereby avoid legal action.[73] This example suggested that where obvious problems existed, companies were capable of employing extant technologies to abate pollution.

The entry of the United States into World War II interrupted legislative attention to stream pollution issues, but certainly did not suspend the use of streams as waste carriers. The unrestrained use of waterways for waste disposal created an obvious impact, and industry's contribution to the problem was undeniable. Thomas Parran, the Surgeon General of the U. S. Public Health Service, claimed that "we have the task of trying to catch up with years of neglect."[74] The pressing demands of wartime production had forced even the most responsible manufacturers to omit treatment equipment from production expansion projects. Many of the sanitary engineers across the country were plucked from public service jobs and pressed into the military. In addition, local courts often allowed industry greater latitude to pollute as a result of the exigencies of war-time production.[75] These factors contributed to wholesale neglect of waste treatment of all types and permitted unsurpassed volumes of industrial effluent to flow into American waterways.

After the war, industry spokesmen still argued that one of the natural functions of streams was to purify wastes, but an advisor to the Pulp, Paper, and Paperboard Industries called for a coordinated effort to develop treatment techniques that would avoid overtaxing watercourses.[76] Other consulting engineers reiterated advice from the 1930s that treatment should be considered a fundamental part of any manufacturing process, and one went so far as to claim that manufacturers should not consider a process "workable until a satisfactory method for dealing with wastes has been developed."[77] By 1947, the total pollution load of industrial activity exceeded that of general urban sewage, despite claims in a chemical engineering text that the days of uninhibited release of noxious wastes into rivers had past.[78]

During the period between 1930 and 1947, the chemical industry twice considered its waste management practices. By its own account, the situation was well in hand. Outside observers reported on conditions that stood in sharp contrast, although there was agreement that technologies existed to treat most chemical wastes. The MCA reported that member companies were expending vast sums on treatment equipment and that they shared a concern for equipping plants with proper control devices, even though only a fifth of its members reported having such facilities. In contrast to industry positions, waste treatment specialists and others argued that implementation costs were manageable and that environmental damage was extensive. The Dow Chemical Company example from Midland, Michigan, supports the claim that treating wastes would not bankrupt a company. Chemical producers continued to favor low technology solutions despite the promise of viable options. By the end of the 1930s, the argument that municipalities were the primary culprits in stream pollution lost its validity and eroded further by the late 1940s. Nonetheless, chemical producers continued to use outdated arguments to lobby against legislation that presaged federal action.

Deferred Responsibility, 1948-1965

In the face of industrial opposition, Congress finally passed federal legislation to reduce water pollution in 1948. Although the Water Pollution Control Act preserved the states' authority to legislate and enforce specific abatement measures, it provided a substantial boost to treatment technology research. The act was to provide up to $1,000,000 annually to underwrite basic investigations on industrial waste treatment systems. This portion of the legislation won industry's approval.[79] Chemical manufacturers, however, responded in inconsistent ways to the new legislative environment. In some respects they sought greater control of technical expertise in waste management, while at the same time declaring their right to continue using waterways without treatment. The industry also sought to shift responsibility for pollution to other parties.

While not a universal practice, du Pont de Nemours and Company finally adopted a policy first recommended in the 1930s that proclaimed that all new plant construction would be accompanied by plans for adequate waste disposal.[80] Industry representatives spoke as though the du Pont practices were widely accepted. Lyman Cox, a du Pont employee and spokesman for the MCA Stream Pollution Abatement Committee, summarized the chemical industry's accomplishments before a national task force organized in 1950 to coordinate pollution control strategies. The committee's basic objectives were to stimulate interest of member companies in controlling their own wastes, emphasize the importance of clean water to chemical producers, underscore public relations benefits of proper waste disposal, foster uniform state pollution control legislation, and encourage the exchange of technical and regulatory information. According to Cox, the committee had been "rather successful in arousing the interest of the chemical industry in this problem."[81] Its achievements included two manuals on water pollution control published before 1950. Subsequent manuals appeared during the early 1950s.[82] Their program and publications followed the lead of the American Petroleum Institute (API) by thirteen years and offered no information about the number of plants that adopted the recommended technologies.[83]

Critics found the MCA's efforts inadequate. Sheppard Powell, who had lobbied on behalf of chemical manufacturers in 1936 and knew the inner workings of the profession well, pointed out inadequate research into waste management:

> Industry tends to concentrate its ablest minds on production problems relating to cost and quality of plant output. Too often industrial waste problems are delegated to less experienced personnel who do not receive the support, guidance, and financial aid necessary for carrying out a successful corrective program.[84]

Thomas Parran, Surgeon General of the U. S. Public Health Service, castigated the chemical industry, albeit somewhat naively: "it is inconceivable that the technicians who have developed American industry to its predominant position should confess defeat on such a relatively minor technical problem [as adequate waste treatment]." He also claimed that "industry has not accepted its responsibility to prevent development of a condition which today reacts not only to its own detriment, but to that of many other groups."[85] The noted chemical waste treatment expert E. B. Besselievre charged industry in general with evading the costs of waste treatment plants as long as possible and with being one of the causes of the pollution problem of the time.[86] These views contrasted with those of industry spokesmen and reflected both the *ad hoc* corporate policy of delaying treatment whenever possible and underscored the frustration of treatment specialists with their industrial clients.

In response to the broad-based attack, the head of Allied Chemical Company's pollution research staff fell back to a defense of technological inadequacy. He asserted that chemical industry waste diversity eliminated the possibility for one general treatment method and "no wholly satisfactory methods of treatment for all individual or selected groups of wastes are known or visualized." He discounted waste recovery's significance, claiming that "no value is visualized at present for most of the remaining by-products," and pointed to the diversion of wastes to municipal treatment works or controlled dilution as partial solutions to the problem. Although his review offered a pessimistic perspective, sophisticated waste treatment technologies existed, such as oxidation with biochemical filters, neutralization of acids and alkalies, recovery of organic solvents, and destruction of cyanide. The MCA also had a number of ongoing investigations to develop corrective measures and each was reviewed by its pollution abatement committee—thereby disseminating information throughout the industry. Under the eye of the MCA, each new chemical development project was to give attention to minimizing pollution in the research and development stage of process formulation. The committee reportedly reviewed proposals for updating manufacturing processes to make certain that modernization efforts included established pollution control equipment.[87]

The MCA committee process offered promise and contradicted the argument of technological inadequacy, but actual practices fell short of its objectives. The absence of a comprehensive national inventory of chemical waste management practices before 1957 and the disparity between new developments noted in the technical literature and their acceptance make it difficult to portray the general practices in the early post-war years. Many chemical manufacturers employed a mix of treatment technologies, ranging from the most rudimentary to sophisticated destructive systems. In general, use of more advanced treatment technology indicated that a severe pollution problem existed in previous years, suggesting some response to the threat of litigation or regulatory enforcement. Relative costs also played a part in selecting a treatment system. In one example, Dow Chemical Company grappled with a series of pollution problems at its Midland, Michigan, plant for several years and ultimately modified its treatment system.[88] The facility used biological oxidation to treat phenolic wastes and incinerated burnable tars. It also provided a three-phase treatment for 50 million gallons a day of general organic wastes. The wastes passed through a primary treatment of a screen and grit chamber to remove solids. A clarifier then removed additional suspended solids material and the wastes passed through an aeration system to reduce the odor and oxygen demand of the effluent. Sludges served as fill on areas not designated as future building sites.[89] While this was one of the most widely touted treatment systems in the industry, its design reflected primary concern with traditional measures of water quality (BOD) and the long-standing belief that waterways should be part of a company's waste disposal system. In fact, Dow still used dilution for brine wastes in the late 1940s.[90]

Of growing significance during the 1950s was concern with the toxic effects of industrial wastes on aquatic and human life. The U.S. Fish and Wildlife Service expressed serious concern about the discharge of toxic wastes into waterways in 1940, and the 1948 Water

Pollution Control Act supported research on toxicity by the U.S. Public Health Service.[91] In addition, extensive environmental testing by the chemical industry got underway in the late 1940s—in response to legal action on the part of state fisheries agencies.[92] Under the apparent threat of state prosecution, du Pont de Nemours and Company hired a biologist to conduct a "biodynamic survey" of a stream below a new Texas plant. This study intended to establish a biological bench mark so company specialists could gauge change after the plant began discharging wastes to the river. Due to the receiving stream's small average volume, du Pont engineers developed treatment and disposal techniques to exclude most harmful wastes from the river. They employed solar evaporation on dilute aqueous solutions. Prior to constructing evaporation ponds, they conducted geologic testing to insure there would be no "seepage of wastes into fresh [potable] ground waters." Their plan called for incineration of organic chemical wastes, and they hoped to use deep well injection to divert high-salt content wastes from the stream. The intent was to release only sanitary sewage and cooling water to the waterway.[93]

Along similar lines, Monsanto Chemical Company reported a series of toxicity tests in conjunction with a Texas facility expansion in the early 1950s. Its scientists sought to determine the toxicity level of cyanide and chlorinated solvents that would be in their wastes released to a tidal estuary. Working in cooperation with the state game and fish commission, they established standards for specific wastes and then repeated the process when the plant developed new waste streams.[94] Such steps reflected growing concern and increased internal research about hazardous wastes, but trailed experiments with the toxic effects of oil refineries by a full decade.[95] Although industrial researchers sought to establish upper limits for toxic concentrations, major chemical producers intended to continue using waterways as waste receptacles. Their desire to maintain a favorable public image among local sportsmen and public health authorities perhaps provided greater motivation for this line of research than concern with wildlife.[96] Also, both the Texas examples follow local pressure from public agencies and the prospect of fines for polluters.

Although the initial alert came from outside the industry itself, the potential human-health risks posed by toxic waste disposal finally emerged as a major public health issue during the early 1950s. Chemical companies, which had employed toxicologists for years,[97] remained on the sidelines as corporate-sponsored laboratories sought minimum lethal doses and searched for the linkages between workplace and environmental hazards.[98] One researcher wrote, "considering the careful study given to potential toxicity of constituents in food and drug preparations, it seems inconsistent to have ignored substances in water, which is a universal food."[99] This extremely important comment represented an undeniable recognition that toxic releases posed a threat to public water supplies.

Despite concern over toxics and other hazardous wastes, the MCA manual on alkaline and acidic wastes carried the message that discharges to waterways would continue, although in modified form. Acidic wastes in particular presented a problem to chemical works beyond the potential harm they posed to aquatic life. They could not be diverted to municipal treatment facilities as a result of their corrosive action on plumbing, and in rivers and lakes they were capable of damaging bridges and ships. The MCA recommended several techniques for neutralizing acidic and alkaline wastes, but warned that they could be quite costly. It advised blending or equalization for waste streams that were not continuously acid, batch neutralization, use of limestone beds for small volumes, and multiple-stage neutralization for more complex and irregular acid wastes. When alkaline wastes were present, it recommended using them to offset the pH of the acidic effluent.[100] Although techniques for monitoring and controlling the eventual output of neutralization facilities had improved, the basic process was one of the oldest chemical waste treatment techniques.

With growing pressure from state and local authorities to restrict the release of harmful effluents into waterways during the early 1950s and the adoption of primary waste separation techniques, sludges and semi-solid residues that required land disposal increased in volume. Lagoons, evaporation ponds, and infiltration basins offered inexpensive and low technology remedies to stream pollution for companies with adequate space for such facilities. A California sanitary engineer even argued that land disposal offered many advantages, particularly in arid regions. There were widespread concerns about these methods. In fact, his claim that the "soil has the ability to oxidize many toxic and noxious organic and inorganic wastes"[101] flew in the face of general principles of the time. Certainly aquifer recharge using domestic sewage was an accepted practice, but by the late 1940s, hydrologists, geochemists, public health officials, and industrial waste management experts all were familiar with harmful consequences of toxic effluents. Groundwater contamination caused by industrial waste releases to unlined lagoons or basins prompted public health officials to take action in California, New York, and Michigan prior to 1950.[102] Sheppard Powell warned manufacturers to avoid surface impoundments in a major engineering forum, cautioning that lagoons might increase the risk of nuisance suits.[103] This advice reflected both water consumers' and waste disposers' recognition that chemical wastes could travel substantial distances with the general groundwater flow without significant dilution or degradation.[104] The MCA acknowledged the potential of groundwater contamination and warned members to take precautions against the escape of wastes from ponds which could affect water-bearing formations.[105] But low costs and technological simplicity made lagoons a common, although when used in improper geologic settings, highly inadequate chemical waste treatment.[106]

In spite of the MCA's highly touted Water Pollution Abatement Committee, chemical manufacturers continued to use rudimentary treatment technologies. As a consequence, in 1954 the MCA became the object of criticism . Testifying before Congress, a representative of the U.S. Public Health Service criticized industry in general and chemical manufacturers in particular for their lack of research into pollution problems. Undaunted, the MCA fired back a sharp response. It proclaimed that chemical producers devoted between 2.5 and 4 percent of all construction costs to pollution control equipment and that the industry spent $40 million annually to abate pollution.[107] The following year, the USPHS took a less antagonistic tone and hailed industry as doing a "remarkable job" in removing pollution by treating approximately 40 percent of its effluent.[108] A spokesmen for the MCA argued that the existing legislation (Public Law 845) adequately served the country's interest. He claimed that the pollution problem was already on the wane as a result of efforts to reduce pollution by groups such as the MCA and the federal funding allocated to developing treatment technologies. The chemical industry had adopted the general position of providing pollution equipment at new plants, and this process was in accord with most state regulations.[109] The debate produced no short-term changes in federal policy.

A 1957 U. S. Department of Health, Education and Welfare (USHEW) survey of waste treatment facilities revealed serious shortcomings of chemical waste treatment capabilities. The post-1945 policies to install treatment equipment at new plants left most existing operations entirely without treatment. Data supplied by state officials in New England, the Middle Atlantic States, and the Midwest to the USHEW indicated that 36.1 percent of the reporting chemical plants provided some form of "industrial" treatment while another 34 percent utilized either methods normally reserved for domestic sewage or practiced land burial. The "industrial" treatments included physical removal of solids, filtration, neutralization, oxidation, or regulated discharge. While this represented an improvement from the 1936 MCA survey, 23.8 percent of the plants tallied provided no treatment whatsoever. Regionally, the older chemical districts in New Jersey and Delaware reported forty-five percent without any treatment, indicative of the absence of equipment at older plants. What the survey failed to reveal was the percentage of all plants using treatment equipment. There were approximately 5,967 chemical plants in the three regions that made up the manufacturing belt, but only 252 reported using any kind of treatment equipment—an abysmal 2.9 percent.[110]

A congressional survey of active chemical plants compiled in 1979 in the wake of the discovery of Love Canal did a slightly better job of identifying common pre-1960 waste disposal practices. It identified forty-nine chemical waste disposal sites in use in Illinois before 1960. Among the more common disposal techniques were pits, ponds, and lagoons, along with land burial of chemical residues.[111] Many of these sites now present the most severe environmental problems in the state due to unrestricted hazardous substance accumulations in improper geologic settings.[112] For the chemical industry as a whole, less than seventeen percent of liquid wastes received treatment before release to waterways in 1959 as compared to more than seventy-seven percent of general urban sewage.[113]

Choices of treatment techniques during the 1940s and 1950s were not confined to lagoons and dumps; sophisticated technology was available. Process modification represented an effective technique for eliminating wastes altogether, but was vastly underutilized. Various waste concentration methods, incineration, chemical treatment, and biological degradation existed, along with catalytic and ion exchange treatments. These techniques were not untested, experimental procedures, nor were they privately guarded secrets.[114] Although many were costly, they were readily available. Sufficient hydrologic and chemical toxicity information, much of it compiled by industry, was available to permit waste disposers to foresee the potential harmful outcome of land disposal practices.

Another option open to chemical manufacturers was to divert their effluent to municipal treatment plants. This allowed them to present themselves as responsible community members and transferred final legal responsibility for discharges to the sewage treatment authority. There were numerous problems posed by relying on the typical biological decomposition treatment processes commonly used by municipal facilities. Many toxic or acidic wastes could either destroy the bacterial flora or severely corrode the facilities. Sludges from municipal treatment works that handled chemical wastes often contained concentrations of toxic metals or other hazardous substances not destroyed by the biological treatment techniques. Pre-treatment of industrial effluent could minimize the impact of harmful constituents, but frequently manufacturers and municipal officials simply relied on the general urban waste stream's diluting capacity and regulated the flow of trade wastes to negate the impact of shock loads.[115] The total volume of chemical wastes handled by municipal treatment works was only 3.5 percent of the industry's output in 1959.[116] Even the limited use of municipal facilities reflects the inadequate research effort directed to chemical waste problems.

As in previous decades, the focus of waste treatment research was extremely narrow. Two major text books provided broad overviews of the existing technology, but neither explored the chemical industry in particular.[117] Willem Rudolfs, a leading industrial waste expert, reviewed the status of treatment technologies in the manufacture of synthetic fibers, acids and explosives, and oil refining, illustrating the existence of numerous working technologies. Public attention and research dollars during much of the 1950s and early 1960s became fixed on solving the largely aesthetic problem caused by high suds detergents.[118] Federal funding for treatment research was erratic at best. In the first two years of the Water Pollution Control Act, Congress authorized only one quarter of the research money called for by the legislation. Again in 1956, Congress approved only $300,000 of the $1.37 million research budget.[119] At the local level, public health agencies tended to seek single-source remedies.[120] While experts worked to resolve one problem, many others remained unattended.

Public policy regarding industrial pollution underwent no significant changes between 1948 and 1955. Although Congress passed the Water Pollution Control Act (1948), it placed primary responsibility for pollution control on local government. Water quality protection fell under public health agencies, most of which had authority to halt public water supply defilement. All too often, their principal concern remained with disease-causing bacteria rather than toxic industrial wastes in water supplies. Domestic sewage treatment fell within their purview, but dealing with treatment of biological wastes was poor preparation for complex and often confidential chemical brews. Both the mandate and experience of public health agencies forced them to give little attention to toxic wastes. In fact, it was the expressed policy of the Illinois Sanitary Water Board that industry was responsible for developing treatment technologies and managing their own wastes.[121] Infrequent enforcement reflected public trust that industry would fulfill its obligation to protect public waters, a recognition that industry responded better to cooperative initiatives than confrontation, and a respect for industry's wish to safeguard its proprietary chemical formulae. The absence of public interference did not authorize industry's behavior, but merely underscored the reliance of public officials on the makers of dangerous substances to minimize public exposure.

Yet waste management policy during the 1950s suggested a tendency to transfer the recognized legal liabilities to third parties, as in the Love Canal situation. Insurers offered coverage for off-site damages for fire or explosions, and also coverage for individuals injured when trespassing. Hooker Chemical Company held such coverage for its Love Canal site as early as 1942.[122] As residential land uses encroached on the disposal grounds, it considered retaining control over the site, but ultimately opted to sell it to the local school board, in part to avoid future liabilities.[123]

While concerns over waste management gained corporate level attention before 1950, the implementation of pollution control measures prior to 1960 remained largely a plant-level matter. Not until the mid-1960s did numerous chemical companies appoint corporate-level executives to oversee pollution abatement programs. Even after making a corporate commitment to self-regulation, individual companies found plant managers resisted pollution control policies as a result of cost considerations.[124] Such responses were predictable given the industry's public posture toward government efforts to abate pollution. Both in trade magazines and testimony before Congress, chemical producers sharply contested government statements and presented evidence that the problem was well in hand.[125] Public relations experts tutored their colleagues to place the issue before the general public in terms that highlighted the costs incurred by manufacturers.[126]

In effect, corporate policies during the 1950s relied on the outdated technologies of dilution and isolation of most industrial wastes. For those that were too hazardous for dilution, simple land burial became the chief disposal means. Disposers sought protection against liabilities through insurance coverage or transferring the risk to unprepared custodians. Although there was internal expertise on toxicology, it was seldom applied to chemical wastes except when public agencies pressured individual companies. According to national surveys, the application of technological solutions to chemical waste problems was severely retarded during the 1950s. Industry spokesmen claimed they were handicapped by costs, but there was no evidence at the time to support this argument.[127]

Conclusions

The interplay of government regulation, corporate policy, and technological capabilities is obvious in chemical waste management practices before 1970. At the outset of the twentieth century, the legal system equated chemical pollutants with other nuisances such as smoke and explosions. The most expeditious means to prevent nuisance suits was either to dilute chemical wastes in sufficiently large waterbodies or to create a geographic buffer around the site of production, as was common with other nuisance-causing activities. This worked to a limited degree at least through the 1930s, but urban expansion and increased production worked against such responses to a static legal system. Lobbying efforts by the chemical industry helped deter major legislative initiatives that might have brought federal agencies into local pollution regulation during the 1930s. As long as the common law remained the dominant control mechanism, non-technological solutions of dilution and isolation provided a means to satisfy the law.

During the 1940s, the volume of industrial wastes surpassed domestic wastes in the nation's waterways. This fundamentally changed the problem. It obviated the long-standing argument that domestic wastes were the primary pollution problem and brought renewed attention to manufacturers. Although industry continued to argue that they had acquired a right to use waterways to remove noxious wastes, society increasingly sought to reclaim clean streams. There was an array of technological solutions to accomplish this goal even though industry spokesmen frequently denied it. Consequently, the adoption and installation of such equipment was exceptional rather than common. In states where water pollution control agencies took aggressive legal action, industry showed an ability to respond efficiently and install equipment to restrict pollution.

In the face of a changing legal environment, industry lobbyists frequently argued that the purchase of pollution control equipment would cripple companies. Chemical producers claimed that they had spent substantial sums on treatment equipment, although they awaited investigations on toxicity by public laboratories, applauded public funding of research, and turned to outside experts for guidance and even lobbying expertise. Their disregard for internal expertise resulted in serious delays in adopting available treatment equipment and led to the low percentage of chemical plants with pollution control facilities. Finally, chemical manufacturers sought to displace the responsibility for the hazards posed by their wastes. Through the agency of insurance policies, by transferring title to burial grounds, or by diverting liquid wastes to municipal treatment works, the toxic waste producers explored various means to minimize culpability.

Common law worked quite well as long as there remained territory in which nuisance-causing activities could be secluded. When the buffer zones disappeared and environmental damage accelerated, new remedies became necessary. Experts suggested technological solutions, but industry claimed they were infeasible. Society called for federal legislation, but chemical producers argued it was unnecessary. Public officials maintained that continuing chemical pollution posed serious human health and environmental risks, while industry spokesmen responded that the problem was well in hand. Chemical producers lobbied effectively and ultimately produced the serious lag between recognition of a serious environmental problem and the implementation of technological and legal solutions.

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[3] Milton Russell, W. W. Colglazier, and B. E. Tonn, "The U.S. Hazardous Waste Legacy," *Environment* 34 (July/August 1992): 14.

[4] Edwin B. Goodell, *A Review of the Laws Forbidding Pollution of Inland Waters in the United States* (Washington, DC: U.S. Geological Survey, Water-Supply and Irrigation Paper No. 152, 1905).

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[7] Martin V. Melosi, "Hazardous Waste and Environmental Liability: An Historical Perspective," *Houston Law Review* 25(1988): 767. This work cites a study by C. Rosen, "Differing Perceptions of the Value of Pollution Abatement across Time and Place," *Law and History Review* 11 (1993): 303-380.

[8] J. L. Leal, "The Legal Aspects of Water Pollution," *Public Health: Papers and Reports* 27(1901):103-112. Of the nineteen, only Massachusetts, New Jersey, Ohio, West Virginia, and Illinois were industrial states.x

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[23] A .D. Smith, "Refining," in *A Handbook of the Petroleum Industry*, V. II, David T. Day, ed. (New York: Wiley and Sons, 1922), 1-3.

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25 R. L. Kraft, "Locating the Chemical Plant," *Chemical and Metallurgical Engineering* 34(1927):678-679.

26 Frank C. Vilbrandt, *Chemical Engineering Plant Design* 1st ed., (New York: McGraw-Hill, 1934), 30-31. The text went through numerous revisions through the mid-1950s and all but one carried the warning. A caution about ordinances relating to waste-related nuisances also appeared in the first edition of John H. Perry, *Chemical Engineers' Handbook* (New York: McGraw-Hill, 1934), 2408.

27 U. S. Department of Commerce, Bureau of Census, *Location of Manufacturers, 1899-1929* (Washington, DC: 1933), 47.

28 W. K. Hasfurther and C. W. Klassen, "Industrial Waste Discharges from Industries at Monsanto [Illinois]," unpublished Illinois Sanitary Water Board Report, March 6, 1942, Illinois Environmental Protection Agency, Land Pollution Control Division microfilm files, Reel 0958, Springfield, IL.

29 C. E. Colten, "Environmental Development in the East St. Louis Region, 1890-1970," *Environmental History Review* 14(1990):93-116.

30 O'Connor v. Aluminum Ore Company, 224 Ill. App. 613 (1922). As was common, the circuit court found in favor of the plaintiff. The appeals court concluded "that if appellant operated its plant in such a manner that dangerous acids, gases, smoke, dust, etc., were thrown into the air and were carried by the wind into, over and upon plaintiff's residence, and that she was deprived of the comfortable use and enjoyment of her property by reason thereof, appellant would be liable for maintaining a nuisance." The plaintiff, however, failed to prove the nuisance arose from the defendants property, and the appeals court reversed the earlier decision.

31 W. C. Platt, "Business Protected from Encroachment of Residences," *National Petroleum News* 20(March 21, 1928):30.

32 The contract between J. C. Charvat and E. I. du Pont Nemours and Company, September 14, 1915, released du Pont from "any and all claims, demands, suits, actions, at law or in equity, now existing or claimed, or that may hereafter be claimed" on Charvat's land. It also relieved du Pont from responsibility "for any injury by drainage or sewerage into the James River or Bailey's Creek." Legal Department Records, Accession 1305, Box 626, folder 21, Hagley Museum and Library Archives, Wilmington, DE.

33 Du Pont chief engineer to H.F. Brown (Director of Legal Department), February 15, 1917, provided an estimate for dredging Bailey's Creek of $5,000 and recommended that action await the court's decision. He also outlined steps to reduce pollution of the creek by constructing two settling basins on the plant site thereby intercepting cotton and other sediments escaping into the creek. Legal Department Papers, Series II, Part 2, Accession 1305, Box 626-630, folder 4, Hagley Museum and Library Archives, Wilmington, DE.

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46 Testimony of M.M Ellis (U.S. Bureau of Fisheries), in Senate Doc. 10, *Stream Pollution and Stream Purification*, 74th Cong., 1st sess., January 30, 1935, 47-48.
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48 R. D. Hoak, "Industrial Stream Pollution Problems and their Solution," *Chemical Industries* 49(August 1941):173; and M. M. Ellis, "A Study of the Mississippi River from Chain of Rocks, St. Louis, Missouri, to Cairo, Illinois, with Special Reference to the Proposed Introduction of Ground Garbage into the River by the City of St. Louis," U. S. Fish and Wildlife Service, Special Scientific Report Number 8, Mimeographed, (Washington, DC: 1940), esp. 17.
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