5 Cleaning Up the Wastes of an Industrial Economy

Take your refuse elsewhere or you will be fined.
—A Roman signpost

Waste: Any unlawful act or omission of duty on the part of the tenant which results in permanent injury to the inheritance.
—Black's Law Dictionary

Cleanup: Actions taken to deal with a release or threatened release of hazardous substances that could affect health and/or the environment.
—U.S. Environmental Protection Agency

Toxic Wastes Invade Every City and County

After returning from Love Canal to the Las Vegas laboratory in 1981, I was both relieved and depressed. The EPA had determined that at least for the short term the wastes in the Canal posed no threat to the residents still living in the area. The wastes that were present could be contained within the Canal without difficulty for the next few years.

However, the containment solution of the EPA relied on an underground drainage system around the two-mile perimeter of the Canal. The drains channeled any leaking liquids into catchment basins. The chemicals were then removed and sent to a nearby disposal facility. In the long run such an approach would surely be exorbitantly expensive. Millions of dollars were required each year to operate the system and to monitor the condition of the Canal with little assurance that the system

would not break down or that such a Band-Aid solution could hold political support in the future.

At that time, estimates by engineering companies of the cost of trucking out the wastes were in the range of 400 to 800 million dollars (estimates which seemed then and now to be much too low). These estimates assumed the wastes could be removed without excessive risks of explosions or releases of dangerous chemicals during the extraction operations. The EPA quickly rejected this solution for removing the wastes on financial grounds alone even though in the long run a one-time high cost would probably be lower than the cost of superintending the leaking wastes over the next one or two centuries.

Thus, the soundness of the approach of containment and controlled drainage seemed questionable at best. But in view of near-term realities as to cleanup funds which were available, I had no better alternative solution. In any event, specialists from the Las Vegas laboratory had completed their assessment of the problem, and future responsibility for Love Canal within the Agency resided with the EPA regional office in New York City. Thus, our laboratory specialists turned their attention to other waste sites.

While I had been concentrating on Love Canal, the laboratory's photographic interpreters had already been hard at work scanning aerial photographs of a number of metropolitan areas. They had discovered over 100 locations on Staten Island alone, for example, which looked like abandoned waste sites. They had found hundreds of suspicious indicators of refuse on photographs of Pennsylvania, and the photographs of Virginia had been so heavily annotated by the interpreters that we could hardly recognize the Commonwealth. Clearly, prior to these photographs the EPA had been unaware of hundreds of these potential problem sites around the country. A modest effort using existing aerial photographs netted an unexpectedly large number of questionable sites.

In a related effort, the laboratory had provided support to a small environmental office in a county in upstate New York which had undertaken an inventory of abandoned wastes within its jurisdiction. In addition to using aerial photographs, the county environmental specialists had enlisted the local population in a hunt-the-dump campaign. Based on telephone tips from concerned residents, the county officials had

located dozens of sites where dumpers had abandoned barrels, boxes, and loose sludges laden with chemicals.

Armed with aerial photographs and reports from the county in New York, I flew to the EPA headquarters in Washington confident that the Agency could mount a low-cost nationwide campaign which would provide an authoritative assessment of the extent of the abandoned waste problems. The Congress had recently enacted the Superfund law, and an obvious first step seemed to be to size up the problem.

The reaction at the EPA headquarters to my overtures for a coast-to-coast hunt-the-dump program was discouraging. "The Reagan Administration doesn't want to hear about problems. It wants to hear solutions." "There are enough well-known Superfund sites to keep the EPA busy for a decade. Let's not identify more and simply complicate the task." "The Las Vegas laboratory should direct its efforts to supporting cleanup actions that are under way and should forget about trying to change the Agency's priorities." "Deep-six those photographs, and forget about the project in New York." We complied with these instructions, except we saved the photographs.

Three years later, in a total about-face under pressure from the Congress, the EPA headquarters instructed the Agency's regional offices, with support to be provided by the Las Vegas laboratory, to identify all abandoned waste sites that required remedial action across the nation, and our specialists dusted off their photographs. In 1990, EPA had 32,000 sites in its inventory of potentially hazardous sites, with preliminary assessments indicating that further action was not necessary on 14,000 sites.[1]

Meanwhile, as the laboratory complied with the original instructions of 1982 to concentrate on well-known sites, I undertook a three-week tour of a few of these toxic dumping grounds to gain a better appreciation of the on-site problems. The laboratory was particularly interested in providing field-monitoring crews with portable equipment that could be used to determine the presence of dangerous chemicals that were escaping into nearby residential areas or that could pose a threat to the field crews themselves. For example, laboratory scientists were evaluating hand-held instruments which NASA had developed for sensing the presence of toxic metals on other planets. Also, they were testing the accuracy and reliability of monitoring devices which were

small enough to be carried in shirt pockets. Occupational safety specialists had developed these devices for monitoring air quality in chemical plants. Finally, our scientists had purchased an array of portable geophysical instruments for probing the conditions under the surface of the Earth in their search for buried barrels and for plumes of chemical contaminants in shallow groundwater.

My first stop was at a group of abandoned sludge ponds on the edge of Tacoma, Washington, where I witnessed negotiations between EPA lawyers and lawyers for the company responsible for the chemical gunk. The company accepted its responsibility for the cleanup, and the lawyers debated the location of a well for monitoring the condition of the groundwater. Meanwhile, a rig mounted on a large truck stood by ready to move 30 feet to the left or right to drill the well once the negotiations were concluded. However, an agreement could not be reached. The lawyers instructed the drilling crew to wait for several days at a cost to the company of $2000 per day until the experts could meet in Seattle and come to a conclusion.

At the Springfellow site near Riverside, California, the enormous amount of industrial waste which had been dumped into a very large canyon for many years was an overpowering sight. We stood atop a clay barrier that went down 90 feet to the floor at a narrow point in the canyon. The waste was packed in from the barrier back up the canyon for 200 to 300 yards. The only problem was that the barrier looked good at the surface but was full of leaks under the ground. Heavy metals and organic solvents had migrated through the barrier into water wells several miles below the barrier. Inaccurate press accounts fueled rumors that the drinking water was contaminated even though the wells in the area were used primarily for agriculture and had not provided drinking water. At that time, after years of investigations of the problems at the site which had already cost tens of millions of dollars, the EPA would again provide $1.5 million for still another study to determine what needed to be done.

Near Galveston, Texas, I visited a Superfund site along a very busy freeway. The contractor hired by the EPA to assess the condition of the site and to begin cleanup was proceeding very slowly due to safety concerns. Each field worker entering the site spent 40% of his or her time donning or removing protective clothing and passing through

hygienic checkpoints. The safety personnel at these checkpoints outnumbered the field workers. This procedure, which had become standard in the region, seemed a little excessive since the preliminary assessment did not reflect such a high degree of hazard as to warrant these extreme precautions. Meanwhile, passersby walked within several feet of the fence erected but 10 yards from the contaminated areas, and monitoring measurements did not indicate any problems.

At Woburn, Massachusetts, our jeep drove over hundreds of acres of buried wastes. Several chemical companies had accepted partial responsibility for the wastes, and they had engaged engineering firms which were busily assessing the extent of groundwater contamination. Many rigs for drilling monitoring wells were on-site. The EPA project officer was convinced that contaminants would follow the drills down the shafts of the wells but was reluctant to intervene lest he be accused of delaying progress. Also, several engineers noted the inadequacy, due to financial limitations, of the underground venting system. It had been installed a few years earlier to allow gases to escape through the soil and thereby reduce the possibility of buildups of pockets of dangerous gases which might explode. Residents of the area appeared numbed by the whole experience. They had given up on the likelihood that the EPA would come to their rescue. They didn't trust the assessments being directed by the responsible parties under what they considered the less-than-watchful eye of the EPA.

The visits to 15 sites left me with several impressions which paralleled the conclusions of hundreds of other case studies of waste areas which I had read in the popular press and in the scientific literature. First, each site is unique, and approaches to assessing and cleaning up the site must be customized to its specific characteristics and to the local political as well as environmental conditions. Also, the scientific and engineering aspects are often highly complicated. Unfortunately, too often these very complexities are used as an excuse for inaction. Finally, though cleanups are expensive, shortcuts to save money usually end up increasing costs in the long run. Our nation simply cannot afford return visits to sites to correct the shortcomings in initial assessments or cleanup actions.

Turning to the field operations, I was repeatedly struck by the dedication but the lack of experience of the EPA employees who were assigned as project officers for the sites. The specialists from the state

environmental agencies working at the sites were somewhat more seasoned, but they were primarily classical geologists who were entering unfamiliar territory of chemical pollution. The de facto management of the site activities was in the hands of contractors, and they relied heavily on young specialists who were in their first professional positions following recent graduation from college. Somewhat belatedly, in 1990 the EPA began assigning senior scientists to assist government project officers at sites throughout the country, and this influx of technical expertise should help the Agency gain greater control over cleanup details.

More important, however, was the lack of decisiveness in the cleanup approaches at the sites. Nowhere did I encounter a passionate determination among the contractor specialists, in particular, to clean up the wastes as rapidly as possible and either restore the area to a usable condition or, at a minimum, ensure that the surrounding areas would be free of a dangerous eyesore. The contractors were methodically following instructions of the EPA or the state agencies, and only infrequently did they demonstrate the type of initiative and aggressiveness needed to overcome the long list of obstacles for an effective cleanup. In several cases, the approach was simply to "stabilize" the wastes (an undefined concept at best) and then to pave over the site or plant sod on contaminated areas so they would look good even though many specialists on the scene scoffed at this solution.

When asked about "permanent solutions," field personnel usually dodged the question and complained about the "system"—a system controlled by officials in Washington, the state capitals, and the EPA regional offices. These officials, they believed, were seeking as many quick fixes as possible. Many would soon go on to other pursuits, and most of them were so tied to their desks that they were out of touch with the realities of cleaning up the environment anyway, according to the workers in the field. Such comments were not entirely fair since senior environmental officials were wrestling with a new, politically charged program which was being constantly changed by shifts in congressional attitudes and new budget priorities.

Cleaning up the trash of our predecessors is a dirty job. It is time-consuming and expensive. It is anything but glamorous, but it must be done. Corrective actions have "stabilized" many waste sites, at least for the present, but many others are still leaking. Determined and re-

lentless cleanups can greatly reduce those leakages which threaten our natural resources.

Most importantly, attitudes among a number of leaders of the industries largely responsible for the waste problems have changed significantly during the eight years since these visits from recalcitrant, insensitive, and calloused to an apparent determination to work with the government to solve the problems as rapidly as possible. One highly visible indication of the commitment of some large companies to cleanups has been the establishment of Clean Sites, Inc., a corporation formed by industry and environmentalists to help clean up sites and to mediate site negotiations. Hopefully, this attitude of increased industrial responsibility and cooperation together with a greater readiness to share cleanup costs will permeate all industrial organization in the years ahead.

Expectations and Disappointments of Superfund

President Bush's commitment to the Superfund program seems clear enough: "I'm for an aggressive, no-nonsense approach to cleaning up toxic waste dumps. I'm for strengthening enforcement against dumpers, quickening the pace of our cleanups, and streamlining the bureaucracy that sometimes slows them down."[2]

Recent critiques of the program by congressional organizations, private groups, and the EPA itself suggest that the political, financial, and technical problems surrounding the program will not be easily solved. President Bush will have left office long before we have achieved sufficient progress to warrant optimism that we as a nation can eventually stop the flow of chemicals into groundwater and the atmosphere.

Still, the president's leadership in the immediate future is essential if the program is to move forward at a rate that will allow the nation to conquer the problems of hazardous wastes by the end of the century. He needs to strongly support budget requests for environmental protection. He should take the lead in stimulating greater contributions to cleanups by state and local governments. He must become the point man in forging a better partnership between the Congress and the executive branch—a partnership that helps the EPA withstand local political pressures for funds for favorite projects and that convinces the Con-

gress to remove some of the legislative barnacles currently shackling administration of the program.

In its fourth stinging critique of Superfund in 1989, the Congressional Office of Technology Assessment called for scrapping some of the program's basic approaches. The report was particularly critical of the way that the EPA pushed more of the cleanup responsibility onto the industrial polluters who are culpable for many of the waste sites around the country. According to the report, in exchange for greater willingness on the part of the responsible parties to move forward with cleanups, the Agency often settles for less stringent cleanup remedies than would be applied if federal funds were used. The implications of this criticism become clear when considering that industry is expected to shoulder the bulk of the expenditures for cleanups, expenditures which Congress estimates will reach $500 billion over the next 50 years to clean up 9000 bad sites.[3] The EPA denies the allegation that cleanups by industry, under EPA scrutiny, are less thorough than government cleanups, pointing to recent internal studies that document the adequacy of industrial responses.[4]

Meanwhile, the Rand Corporation notes that by 1989 only 18 sites had been declared "clean" despite expenditures of more than $2 billion of federal funds. Rand traces much of the delay in cleanups to the original congressional decision to establish a system that relies in the first instance on forcing industry to pay for cleanups rather than simply having the government pay the bill and, in effect, run a public works program. Rand points out that the current approach results in a series of procedural obstacles related to negotiations with the responsible parties which inhibit prompt action.[5]

While many experts disagree with the implied suggestion of Rand to shift more of the financial burden to the government, the small number of cleaned up sites has been a particularly contentious issue for a number of years and has been a principal reason why the Congress repeatedly places unrealistic deadlines before the EPA in carrying out the Superfund program. The EPA argues that the number of completely cleaned up sites is a misleading indicator of progress since hundreds are in various stages of cleanup, all known near-term health risks have been abated, and complete remediation of a site takes many years of monitoring to demonstrate that there is no residual leakage. However,

the EPA's reasoning is politically flawed since the public simply cannot understand why after a decade of effort only a handful of sites can be listed as completely safe. Therefore, the Agency needs to give greater attention to carrying cleanups to conclusion even if cleanup actions are limited to fewer sites.

The amount, character, and sources of hazardous wastes are of considerable importance. In brief, "hazardous" wastes are produced at the rate of 250 million tons per year—enough to fill the New Orleans Superdome 1500 times over. However, this is only 6% of the six billion tons of the total wastes generated each year in the United States. The other 94% consists mainly of agricultural and mining wastes, with much smaller amounts of municipal and public utility wastes.[6]

The chemical and petroleum industries created much of the hazardous wastes found in Superfund sites. Some sites were once municipal landfills that accumulated excessively large quantities of pesticides, cleaning solvents, and other hazardous products which were mixed in with household trash. A few sites are the chemical debris from transportation accidents. Others are the resting places of persistent toxic pollutants contained in industrial wastewater discharges. An increasing number are governmental facilities which in earlier years had been allowed to operate beyond the scrutiny of environmental officials for national security reasons.

What should be done about these wastes? Surely the EPA's long-standing first priority to eliminate any immediate hazards to people or the environment is correct. This priority may require physical removal of the most threatening wastes which could lead to fires, explosions, or other disastrous situations at the sites. Frequently, cleaning up or containing leaking barrels, loose solids, or uncontained liquids which can be washed by rain or melting snow into surrounding areas demands prompt attention. It may also be necessary to capture powdered waste which can be blown about or to interdict underground chemical plumes which are approaching drinking water or food supplies.

Beyond the consensus on taking care of these emergency situations, opinions differ on how to address the longer-term problems of cleaning up sites that blight the countryside and that will eventually become more threatening problems in the future. Constraining the debate are the complexities of the scientific and technical issues. Also, as

the EPA has pointed out, the trust fund is finite (currently $8.5 billion) and at present the pipeline is full.[6]

The EPA readily acknowledges that it has neither the financial nor management capability to adequately cope with all of the currently designated Superfund sites, let alone take on additional sites. The present estimate of the average lead time of 13 years that will be necessary between identification of a Superfund site and initiation of cleanup activities may become longer rather than shorter given these limitations.

Critics of the program offer all types of suggestions for its improvement. These suggestions fall largely into four categories: improving the administration and management of the program; deciding when and how to seek cleanup funds from the polluters and when to use the trust fund; establishing priorities for cleanup actions; and determining when a site is clean enough. Given the large sums of money involved, political and economic groups throughout the country will continue to exert pressures to direct larger shares of federal funds in their directions. Their views of administrative efficiency, use of the trust fund, priorities, and cleanliness will seldom be based on objective criteria.

First, with regard to management efficiency and administrative timetables, the Congress should move away from trying to define the details of how the program should be managed by the EPA. Within the constraints already imposed by the Congress, and particularly the ground rules concerning the role of the private sector in the programs, the EPA has been quite responsible in setting in place a reasonably effective program. Congress initially believed that the program would be short term and, therefore, called for heavy reliance on contractors. Indeed, governmentwide policy in almost all areas has a long history of requiring a contract with private industry for a job whenever possible. When Federal Procurement Regulations require the use of the least expensive qualified contractor, the EPA must frequently select less than the best. Also, as noted, when the law requires the Agency to resort to the trust fund only if responsible parties cannot be forced to shoulder the financial burden, the EPA must spend considerable time and effort trying to extract commitments from industry while delaying its own activities.

Auditors unleashed by the Congress are constantly reviewing Superfund activities, and the EPA is required to divert the time of senior

personnel to ensure that the auditors receive complete and authoritative information. Meanwhile, the current level of direct congressional involvement in details is already excessive and simply adds unnecessary distractions and complications to the EPA's task. Periodic reviews by the Congress of the EPA's administrative efficiency are important to keep the Agency on its toes, but placing unrealistic administrative timetables and other detailed management criteria in the law is counterproductive.

However, before the Congress will relax the administrative requirements imposed on the EPA, the Agency will have to restore confidence on Capitol Hill that even in the absence of congressionally mandated requirements, the EPA will effectively carry out the intent of the law. In particular, the EPA must demonstrate visible results from its own initiatives. Such confidence building will be difficult given the many stereotypes of failures of the program in the past, but the stakes are too high for the EPA not to make Herculean efforts to gain greater congressional trust. Shortly after the beginning of the Bush Administration, the Agency began a very serious effort in this regard, and such sensitivity to congressional concerns should continue.

With regard to the financial liability of those companies which originally generated the abandoned wastes years and even decades ago, the Congress has decreed that the companies shall now pay the bill for cleanups. Is this really fair? Should a company which violated no law when it disposed of wastes in the 1950s now be required to go back and make amends? Perhaps after enactment of the National Environmental Policy Act of 1969, all companies should have known better than simply to dump their chemicals on the doorsteps of others. But prior to that environmental awakening, should they have foreseen the urban sprawl that would soon surround those previously desolate fields which no one used to care about? Should they have been able to predict that science would uncover new insights about the toxicity of small traces of chemicals and about the slow but steady movements of chemicals below the Earth's surface? The Congress has answered "yes" to these questions, and it is unlikely that it will change its views. Thus, the EPA and the Department of Justice have the practical problem of retracing history to find the responsible parties and then forcing them to assume their financial liabilities.

As to emergency situations, the only approach that makes sense is

"shovels now, and lawyers later." For other situations, the EPA, the Congress, and the public need to be patient, and the "enforcement first" approach of the EPA is sound. If years are needed for documenting the cases in order to force responsible parties to pay, then the EPA should take the time.

Superfund is a long-term program, and delays of even several years at some of the sites in sorting out responsible parties will not make a great difference. Companies have an incentive to pay at the time of cleanup, and the EPA should capitalize on this incentive. Specifically, recalcitrant responsible companies can be fined three times the cost of cleanups if the Agency uses the trust fund and then demonstrates the liability of the companies. The current congressional three-year statute of limitations on collecting payments and fines after the cleanup, however, is too short and should be amended to five years since the EPA has only limited personnel to develop the cases to support such collections.

The EPA should rethink how it distributes its efforts among sites that have already been designated as Superfund sites and do not pose an immediate health hazard. If the responsible parties for a site can be easily identified and are prepared to pay cleanup costs, the Agency should not hesitate to move forward without delay in cleaning up that site at minimal cost to the government even though the site may seem to be of relatively low priority. Low-priority sites have to be addressed sooner or later, and there are both political and environmental advantages in reducing the long list of dirty sites as soon as possible. Of course as already mentioned, special attention needs to be given to leaking sites since a few million dollars spent toward the prevention of groundwater contamination can save tens of millions of dollars in cleaning up polluted aquifers.

During the past several years, priorities among sites have been established by the EPA using risk assessments by experts who rank sites around the country based on the likelihood that hazardous discharges could have an impact on people and ecological resources. However, for sites which are not emergency locations, these impacts will not occur for some years, and the traditional approaches to assessing chemical risks are of limited reliability. In addition to the difficulty in predicting the behavior of chemicals in the land, experts simply do not know how to value the ecological resources surrounding the sites. Wastes are blights on the landscape as well as possible long-term

threats to human health, and such contaminated areas have many effects on the surrounding physical and human ecology. The experts need to broaden their conception of the meaning of risks to society, risks which extend far beyond near-term, identifiable health and ecological impacts of chemicals.

Twenty years or 100 years from now the demographic patterns of a region surrounding a site will differ significantly depending on whether the site is retained in its current condition, whether the area is modified in some manner to meld the waste with the countryside, or whether the waste is taken away and the land is reclaimed. In most cases there is no way to predict these patterns. Still, one indicator of the negative impact on society of a waste site is the value which owners, residents, and potential purchasers of nearby property place on their property given the presence or absence of the wastes in their current condition.

Thus, a new dimension in prioritizing Superfund sites is suggested. This consideration should complement, and not substitute for, the EPA criterion of "worst" sites first which is based on risk assessments that emphasize the likelihood that toxic pollutants will reach people in the relatively near term. Specifically, at the outset, the federal government should place more of the burden of prioritizing sites within states on the states themselves. Allocation of funds from the trust fund to geographic regions should take into account the severity of the problems in each state, the track record of the state in responding to waste problems, and the economic conditions of the state. In very general terms, the more sites in a state, the higher the federal contribution to cleanups in the state; the greater responsiveness of the state itself in cleaning up sites, the higher the contribution; and the poorer the state, the higher the contribution.

The states in turn should use a widely publicized test as one important criterion in setting their priorities—namely, the importance which the counties and local communities surrounding the sites on the Superfund list themselves attach to cleanups of the sites. The sites located in communities which contribute financial resources to cleanup operations, contributions scaled to the resources available to the community, would receive a higher priority than similar sites located in communities which are not prepared to make financial commitments. The contribution need not be great, but it should be significant. This

approach will provide at least some indication of the long-term risks to society, as perceived by the affected people, associated with the sites. This does not mean that health and ecological risks as determined by experts aren't important, for usually they will be the most important criterion for prioritizing sites. However, local residents are often just as expert as the national experts in determining how dirty sites will adversely affect their life-styles and the life-styles of their successors, and this perspective should not be ignored.

Finally, with regard to the level of cleanup, the Congress should mandate a general standard that should apply to all cleanups whether paid for by industry or the trust fund. The EPA should not be given the flexibility to make exceptions. This standard could be based on the best prediction of the status of the site in 100 years, or thereabouts. One hundred years is too short a time horizon, but predicting conditions even that far in advance is fraught with uncertainty. Also, there is the latent hope that technologies might evolve within the next century which could revolutionize the approaches to management of hazardous wastes.

As an example of a standard, the Congress might call for a non-degradation standard—namely, that the background environmental conditions at the fence line of the site will not be degraded due to residual contaminants at the site for at least 100 years. If such a demanding standard requires hauling away the wastes, then they should be hauled away for appropriate disposal by the responsible parties or by the government.

Partial cleanups should not be undertaken, with the exception of erecting barriers to prevent the spread of groundwater contaminants which could complicate delayed cleanups. Once initiated, cleanups should be carried out quickly with sufficient funds set aside in advance so that funding issues will not be a reason for delay. Such an approach may require reducing the number of sites which are in the cleanup phase at any one time because of the personnel constraints on the EPA and the states for supervising cleanups.

I hope that the following dilemma posed by an EPA site manager will be more easily resolved as the Agency begins to give greater attention to the longer-term implications of site cleanups:

> For this site, I have three remedies that should work—that is, should protect human health. One is a conventional containment approach

> and the other two use treatment. One of the treatment methods involves chemical fixation and encapsulation; the other would yield nearly complete destruction of the toxics at the site. Although that remedy provides the most complete treatment and is the most reliable long-term remedy, it is significantly more costly—nearly two times the cost of the other treatment remedy and six times the cost of the containment remedy . . . . I know the lower cost remedy may not be as reliable in the long term, but I don't know how much more to spend on treatment.[6]

The earlier discussion suggests that the most expensive near-term remedy may be the best long-term remedy, even if it means a considerable delay until cleanup begins.

Safe Disposal of Hazardous Wastes

While the Congress designed the Superfund program to clean up wastes which have been discarded in the past without adequate attention to the environmental consequences, the Resource Conservation and Recovery Act establishes a framework for ensuring that wastes will be handled properly in the future.[7]

Hazardous wastes should be controlled from the time they are generated until their final disposal—from cradle to grave. This is how the current procedure works: For wastes which are shipped off the site of a manufacturing plant for disposal, the manufacturer prepares a manifest which is signed by the transporter of the waste. It is again signed when the waste reaches the disposal facility, and then it is returned to the manufacturer. If the company which generated the waste does not receive the manifest back within a specified time, it can take steps to track down the waste and avoid liability for any possible mishandling of the waste.

This law provides the basis for regulating about 320 high-temperature incinerators and an equal number of special landfills which receive hazardous wastes throughout the country, including spoils from Superfund sites. Many incinerators and landfills are managed by the waste generators themselves. They prefer to take care of their own wastes due to a combination of short-term economic calculations and

long-term liability concerns. Consequently, only about 20% of the incinerators and 5% of the landfills are commercial operations open to everyone who does not have access to private disposal facilities.

All landfills receiving hazardous wastes must have systems for monitoring nearby groundwater, and the operations must be covered with liability insurance. The newer landfills are encapsulated within two liners, usually involving layers of clay, concrete, and plastics which are designed to withstand chemical leakages. Engineering systems collect liquids which, despite precautions, nevertheless penetrate the liners. In addition, warning systems for detecting leaks during their early stages are required.

Of course, as we will discuss in a later chapter, the best solution to hazardous waste disposal problems is not to generate the wastes in the first place—a "low-waste" manufacturing strategy. Also, recycling and reuse are obvious ways to cut down on wastes for disposal. These alternatives should be pursued whenever practicable.

If wastes must be taken from a chemical plant, a steel mill, a print shop, or any other facility for disposal, treatment technologies can often reduce the waste volume or render the wastes harmless. For example, precipitation is a technique that removes dissolved chemicals from liquids. Neutralization reduces the acidity or alkalinity of wastes to produce more neutral conditions. Ion exchange is used to remove organic ions from a solution. Oxidation/reduction breaks chemical bonds to detoxify chemicals such as cyanide wastes. Physical treatment can segregate harmful elements from less worrisome chemicals. Incineration destroys wastes at high temperatures. Solidification reduces the migratory potential of waste constituents.

Recent regulations now prohibit the burial of many chemicals in the ground. They are considered too toxic and too persistent for this type of permanent disposal. Many other wastes must be pretreated as described above to reduce their toxicity before the refuse can be placed in a hazardous waste landfill. Frequently, incineration which effectively destroys toxic organic components is selected as the pretreatment method although the other methods are also regularly used. There is now a total ban on placing bulk liquids in waste sites unless they are packed in containers with absorbents to reduce their migratory potential. Another technique to respond to concerns over the escape of liquid wastes is to

mix the liquids with fly ash which acts as an absorbent and then to handle the resulting mixture as a solid material.

Despite efforts of the government and industry to reduce the amounts of hazardous wastes and to impose increasing strictures on land disposal of wastes, for the foreseeable future land burial will be the only economically feasible option for substantial amounts of toxic wastes. In this regard, many liquid wastes are placed in surface impoundments where the waste volumes shrink as the water content evaporates. This technique is frequently an important intermediate step toward permanent disposal.

Much of the liquid waste generated nationally is associated with oil extraction and processing in Texas and the South. It is injected into wells one mile or more deep into the earth as a means of permanent disposal. To date there is no evidence that these liquids migrate and pose subsurface problems. However, many environmentalists are concerned over eventual migration of the wastes into both deep and shallow aquifers in, say, 100 years. They fervently believe that this method of deep disposal should cease although they have no economically feasible alternative to offer at present.

The law also establishes general ground rules for the operation of the tens of thousands of municipal landfills that dot every community throughout the country. Unfortunately, over the years many communities have deposited mixes of household trash and toxic waste in dumps that are little more than large holes in the ground. Even today segregation among the individual components in waste streams collected by municipalities—employing a pseudoscience called garbology—is too often the exception rather than the rule.

Municipal waste is diverse. It contains some materials that can be recycled and others that cannot, some that burn and some that do not, and some that should be buried and some that should not. On a national basis, more than 40% of municipal solid waste is paper and paperboard; 18% yard wastes; 8% glass; 8% metals; 6% plastics; 8% rubber, leather, textiles, and wood; 8% food wastes; and 2% miscellaneous wastes.[8]

Leaking municipal landfills are widespread, and many have been declared Superfund sites. However, the problems have not been capped. Every day wastes containing toxic chemicals, sometimes in

liquid form, continue to pile up in many landfills which were never designed to contain such wastes. This co-disposal of municipal and hazardous waste is generally prohibited, but the practices of refuse collection and disposal still lag regulatory requirements.

More than one-third of the nation's municipal landfills will be full within the next decade. While the EPA believes that less municipal waste will be placed in landfills as recycling regains its popularity of many years ago, the Agency still predicts that very large quantities of chemical wastes will be deposited in municipal landfills even after the turn of the century. The need to upgrade the requirements for containment capabilities of future local landfills seems clear, and every community will have to shoulder much of the financial burden for new disposal sites. However, this burden for future landfills seems small compared to the more worrisome problem of uncontrolled leaking of toxic chemicals in the decades ahead from many of the poorly designed dump sites of the past.

One of the most difficult environmental issues is the siting of landfills, whether they are earmarked for hazardous waste or for municipal waste. Nearby residents want to close operating landfills and unanimously oppose new waste sites. Still, the nation must have large, well-designed sites for receiving huge quantities of segregated hazardous wastes. Almost every community will need new or larger disposal areas which will inevitably receive some toxic materials mixed with the municipal waste.

With regard to commercial hazardous waste facilities, some states with existing facilities are increasingly resistant to importing out-of-state wastes for disposal at these sites. Also, the capacity of some existing commercial landfills is being approached. In the long run, every state will probably need its own sites. Regardless of the proposed locations for new sites, residents of nearby communities will undoubtedly raise objections.

Greater emphasis on the use of public lands owned by the federal or state governments as locations for landfills may help reduce, but not eliminate, opposition to new sites. In every state there are military stations, for example, that have been dormant for many years or are scheduled for closing in the near future. As part of the "peace dividend" from the relaxation in East–West military tensions, some of these facilities which are geologically appropriate should be made

available for hazardous waste sites and for municipal landfills. Such locations could be leased to private contractors who would manage the facilities as commercial operations under tight government controls.

Two Hundred Thousand Leaking Tanks

During the past decade Americans have finally realized that the more than one million underground tanks for storing gasoline, heating oil, and other chemicals which punctuate the nation's landscape have finite lifetimes. In describing the problems associated with leaking tanks, an EPA official reported at a conference in 1989: "A gas station explodes in Council Bluffs, Iowa; a shopping center is shut down for more than one week in Durham, North Carolina; more than a thousand people are evacuated in the predawn hours from their homes in Claymont, Delaware; and throughout the country hundreds of drinking water wells are contaminated."

Bringing the problem closer to home, the storage tanks at the gasoline station two blocks from where we lived in Las Vegas began leaking so badly in 1984 that they had to be replaced immediately, disrupting normal shopping patterns in the area. Then, as I landed at the airport in Miami, Florida, a few days later, I encountered a row of trucks pumping aviation gasoline from the ground near the storage tanks for Eastern Airlines. According to the press headlines, gasoline had spilled and leaked around the tanks for many years and finally entered the shallow aquifer near the airport that fed into Miami's drinking water supply.

Sometimes, cleaning up leaks makes economic as well as environmental sense. Several companies in Texas and Oklahoma, for example, have made substantial profits in recovering large quantities of spilled and leaked chemicals around petroleum storage tanks in the region.

The unfortunate incidents cited by the EPA and others are not the results of careless disposal of chemicals. Rather, they exemplify the concentration of businesses and farmers on the near-term future and not on problems that are not easily foreseen. Most of us have believed that steel tanks are surely adequate to store gasoline or heating oil; and if there were an underground leak, the liquid wouldn't go very far. How

wrong we have been. The potential costs to the nation of cleaning up are very high.

In 1984, the Congress responded to the many reports of leaking storage tanks. New legislation established a program to improve standards for owning and operating tanks, to help detect leaks as soon as possible, and to provide the legal and financial tools for prompt cleanup of escaped liquids. When corrective actions seem necessary, the EPA can require owners and operators to test their tanks for leaks, to excavate sites and assess the extent of contamination, and to clean up the contaminated soil and groundwater.

However, many leaking tanks are discovered at abandoned sites, and the responsible parties have disappeared long ago. In other cases, the owners or operators may not be able to afford the cleanups, or they may refuse to take action. Thus, another fund was created to enable the EPA or the states to take immediate action when necessary to clean up the problems. The fund relies on a small federal tax on certain petroleum products, primarily motor fuels. However, the fund is not a bailout, and owners and operators remain liable for the costs which will probably become higher if the government rather than the responsible parties undertakes the remedial actions.

Owners and operators of underground storage tanks are now required to maintain the financial capability to clean up leaks through liability insurance or other means. For petroleum production, refining, and marketing facilities, for example, the Congress has established minimum coverage levels at $1 million for each occurrence of a leak.

How can the EPA, the states, and the nation cope with the huge number of tanks which have already been discovered and will be discovered? The early estimate of 200,000 leaking tanks may only be the beginning. Many of the tanks are owned by individuals who have neither the technical wherewithal nor the financial resources, and in some cases not even the personal commitment, to adequately monitor the state of their tanks for the indefinite future.

In order to increase the incentives for greater diligence toward maintaining the integrity of underground tanks, some states only permit transfers of a title for commercial property if the state environmental agency has certified that the property is free of leaking tanks. Other states should be encouraged to adopt similar programs which place significant economic value on protected groundwater resources. This

type of requirement might be extended to include agricultural and residential property as well.

The Fears and the Reality of Nuclear Waste

Some citizens are frightened of anything nuclear. Not surprisingly, nuclear waste disposal is one of the most politically volatile environmental issues facing the nation.

Since the accident at Three Mile Island, nuclear power and nuclear weapons have become inextricably linked in the minds of rabid antinuclear activists. They have forged alliances with many other calmer but still concerned Americans who believe that both of these products of World War II pose serious threats to our survival. Few federal, state, or local politicians can afford to ignore vocal constituencies who vehemently oppose bringing the waste by-products of weapons or reactors into their jurisdictions. They perceive no economic value from such waste disposal industries, only lots of headaches.

However, if nuclear power is to become a more significant component in the energy mix of this country, or indeed retain its current place as an important contributor to our electrical energy, the issues surrounding the disposal of nuclear fuel rods which have been used up in power reactors and are impregnated with radioactive contaminants—usually called high-level waste—must be resolved. Even if nuclear power is abandoned, the nation will have to cope with the current inventory of used fuel rods for centuries to come. The temporary solution since the late 1950s has been to simply retain the high-level waste at each of the 110 reactors around the country. This shortsighted approach, which has been the only politically feasible solution to date, is expensive and will require construction of additional storage capacity at some locations as sites reach their storage limits. Meanwhile, as nuclear wastes accumulate, local political anxieties heighten at many of the reactor locations.

Other types of nuclear waste generated from different sources are also important, and problems encountered with these wastes often confuse the debate about nuclear power. In particular, many hospitals and commercial facilities use radioactive isotopes for diagnosing the conditions of both people and materials. Scientific laboratories use radioac-

tive tracers and nuclear irradiation techniques for understanding the laws of physics and chemistry. Luminescent dials and signs rely on the radioactive properties of some materials. Occasionally, wastes from such industrial, medical, or research activities are not handled properly, and low but detectable levels of radioactive wastes turn up in junkyards or dumps not designed to handle such materials. Over the years radioactive contaminants have crept into many Superfund sites, thus complicating cleanup procedures. These concerns must be addressed but should be kept separate from the debate over nuclear power.

Three key issues with both economic and environmental dimensions will largely determine the future viability of nuclear power. They are demonstrated safe performance of reactors as evidenced by prevention of accidents which might contaminate workers or nearby residents, the safe decommissioning of nuclear stations after their useful lifetimes of 40 or 50 years, and as noted, environmentally sound disposal of fuel rods which have accumulated high levels of radioactive contaminants.

Prevention of reactor meltdowns and other types of accidents is discussed in a later chapter. Particular emphasis is placed both on the importance of designing and testing reactors which will shut down automatically in the event of human or mechanical failures and on the necessity to improve the capabilities of operating personnel to respond to unexpected events, even with reactors believed to be completely safe.

As far as the decommissioning of old power reactors is concerned, the initial American experience is encouraging. An early power reactor which operated at Shippingsport near Pittsburgh, Pennsylvania, has been successfully dismantled. Building on this initial experience, the industry will undoubtedly begin decommissioning other reactors during the next decade, confident that the technical problems will be easily resolved. Of course some elements of the public will always object to the selection of any location as the final resting place for old reactor vessels, pipes, and other large contaminated components that are removed from nuclear reactor sites. Still, outmoded reactor complexes can be dismantled, decontaminated, and then used for other industrial purposes provided they have not been the scenes of major accidents such as Chernobyl which has become a permanent nuclear graveyard—a testimonial to a unique Soviet reactor design that paid little heed to safety requirements.

At the present time, disposal of depleted nuclear fuel rods is a

principal nexus for joining the public debate over the future of nuclear power. Las Vegas is in the center of the debate. I, like most Nevadans, have been exposed to hundreds of newspaper accounts and many hours of television broadcasts about high-level nuclear waste disposal.

Tempers run high and engineering concepts are constantly challenged in southern Nevada when the conversation turns to the disposal of high-level wastes. Since the early 1980s when the federal government began to settle on Yucca Mountain to the north of Las Vegas as the permanent cemetery for spent fuel rods, my days on the tennis courts of several casinos and my evenings at social gatherings have been frequently punctuated with expert citizen advice to all who will listen on how to change the policies of the Department of Energy on radioactive waste disposal. This advice is usually very simple: Take the waste somewhere else. I disagree with this advice.

To provide a perspective, the technical problems associated with disposal of nuclear fuel rods are minor in comparison with the problems of chemical wastes. The volume of these nuclear wastes is relatively small, and even if the nation increases its dependence on nuclear power the growth will remain small in comparison with the huge volumes of chemical wastes already in the ground and being generated each year. In contrast to its uncertain assessments of chemical pollution, our government knows exactly where the fuel rods are located. They are concentrated at a relatively small number of locations, and there are no undiscovered burial sites. Our specialists know how to monitor for the presence of radioactivity. They do not need to launch a major research program to develop new lines of devices for detecting and measuring radiation.

Having studied for 40 years the health impacts of radiation on the Japanese population following the nuclear detonations in Hiroshima and Nagasaki, American and Japanese doctors know the degree of danger associated with human exposure to radiation. They need not rely on highly uncertain extrapolations to humans from the reactions of laboratory rats and mice as the basis for their medical judgments.

Yucca Mountain is a barren patch of desert 100 miles northwest of Las Vegas where even the jackrabbits have difficulty finding companions. For many years it has been off-limits to wandering prospectors, to lost campers, and now to antinuclear demonstrators since it is at the edge of the Nevada test site, a high-security area where nuclear weap-

ons are tested. Rainfall is a rarity, and many hundreds of feet below seemingly impenetrable volcanic rock groundwater flows with a speed so slow that it is difficult to measure. The mountain rises perhaps 1000 feet above the desert floor with a special appeal for desert artists who are taken with picturesque sunsets.

Sometimes the discussion at Las Vegas cocktail parties turns from showgirls competing in bicycle races, from heavyweight title fights, and from Wayne Newton to the dangers of transporting nuclear fuel rods along the highways of Nevada. In reality, the risks in transporting a limited number of fuel rods in specially designed and repeatedly tested containers are minimal. The lead canisters simply will not split open regardless of impact.

Meanwhile, every day the residents of Las Vegas live with the risks of transportation accidents involving chemicals being carried through the city in trucks of all descriptions. However, to appease Nevadans, the federal government has proposed to build a special rail line across federal lands for transporting nuclear wastes from the border of the state to Yucca Mountain.

The weak link in the case of the Department of Energy for placing high-level wastes in Yucca Mountain is the burial method. The idea is to permanently emplant the fuel rods in deep shafts where the radioactivity can decay over many centuries in a manner that will not affect the environment. They are to be sealed forever and eventually become an integral part of the earth's mass. This concept of permanent geological burial was developed 30 years ago. Geoscientists have spent hundreds of millions of dollars trying to persuade political leaders that nuclear wastes, buried in appropriate locations, will not bother anyone for 10,000 years.[9]

At Yucca Mountain, the proposed burial site is sufficiently high above the groundwater that even if leakage begins, the time for migration of the radioactive liquid through the volcanic rocks to the aquifer will be thousands of years, argue the government experts. Also, they contend that the likelihood of an earthquake disrupting the repository is so remote as to be negligible.

Interminable arguments are now under way between these experts of the federal government and other experts mobilized by the state who challenge the underlying concepts that led to the choice of Yucca Mountain. The state argues: Can you really be sure that there will not

be an earthquake? Even if the earthquake doesn't impact on the repository directly, couldn't it change groundwater patterns and increase the vulnerability of the water to leaks? Couldn't population growth in areas near the site and attendant withdrawals of groundwater for drinking and agriculture change groundwater flow patterns? Couldn't miscalculations result in burial practices that generate excessive amounts of heat which would lead to dangers of combustion in the repository?

Trying to predict conditions hundreds of years into the future, and in this case thousands of years, is plagued with uncertainties. There is always a chance, albeit very small, that an earthquake could occur in this region which has been historically quite free of earthquakes. Furthermore, the costs of preparing the repository, emplacing wastes in the repository, and maintaining surveillance of the conditions hundreds of feet under the ground would take billions of dollars within the first few years.

An approach that would seem more acceptable technically and politically and that would be cheaper in both the short term and the long term is simply to store the high-level waste in lead containers on the surface of the desert. They could be appropriately spaced and cooled by the air with no chance of mechanical failures and no danger of building up excessive heat. An earthquake could of course disrupt the site and perhaps scatter the canisters over the countryside. However, the site would be relatively easy to restore. The canisters would probably remain intact, or at worst the contamination from those that cracked under the great pressure would be localized. But compare these consequences to the disruption of underground caverns with highly uncertain subsurface consequences which could not be put back in order. Further, sufficient distances between the wastes and the fence line could ensure that the radiation levels off the site would not even be measurable. There certainly is no shortage of space near Yucca Mountain, and security will be extensive for the indefinite future given the military secrets buried in the adjacent weapons testing area. Of course, some nuclear-phobic members of the public might find burial more comfortable than having easily photographed exposed waste—regardless of the technical considerations. But nothing short of impossible transformation of nuclear waste into harmless dust will ever satisfy rabid antinuclear forces.

In the past, the Department of Energy has considered such an

approach, although not in Nevada. The department has referred to collecting high-level waste from around the country and then placing it in surface storage at a single location, preferably near Oak Ridge, Tennessee, as an "interim" retrievable disposal method for perhaps 20 years pending permanent geological burial. Unfortunately, the department's two-step process of interim and permanent disposal in different locations doubles the number of politicians who oppose the scheme.[10]

After spending the past several decades trying to develop an acceptable approach to permanent geological burial, the department should abandon such a concept, at least for the time being. Interim "retrievable" storage aboveground should be considered the goal for the next century. If technologies of the future offer new opportunities either for alternative disposal approaches or for unanticipated future use of the materials embedded in the fuel rods, the wastes would be readily accessible. The Nevada desert has everything required for such storage.

Two common arguments against surface storage have been (1) vandals or terrorists could disturb the wastes and (2) nuclear devices on incoming missiles could hit the site and scatter radioactive debris. However, vandalism in the Yucca Mountain region is not easy, given the remoteness of the area and the security procedures nearby at the Nevada test site. Meanwhile, a crowded Caesar's Palace on the Las Vegas strip offers a far easier and more lucrative target for terrorists than a high-security area in the desert. As to a surface-storage site being a sitting duck for a nuclear attack, I would rather have the incoming nuclear weapon hit a site 100 miles north of the city and take my chances that the lead caskets will contain most of the stored waste than having ground zero be downtown Las Vegas. The suggested threat scenarios depict extraordinarily inefficient ways to cause harm through the spreading of nuclear debris.

Perhaps the most popular argument offered by local politicians against depositing waste in the state is that Nevada has done more than its share for the nuclear effort. Indeed, more than 700 underground caverns filled with radioactive debris from underground tests punctuate the Nevada test site. Each one of these hot sites more than qualifies as a Superfund site, and the tests are continuing. Not surprisingly, with at least 5000 jobs directly dependent on continued testing—let alone associated service jobs in Las Vegas—the same politicians who oppose a nuclear repository in Nevada support increasing the

state's nuclear burden through continued testing which creates the most undesirable type of debris. Similar economic incentives will be needed together with Washington political muscle, to begin to mollify the Nevada opponents of a waste repository in their state.

The political realities were crisply summarized by a columnist in the Las Vegas *Review Journal* in March 1990 as follows:

> . . . the state's top officials are so adamantly anti-dump that they fight it in court and use guerilla bureaucracy to delay study of the site. . . . The federal government and the nuclear lobby had it made in 1974, but they screwed up their chance and now think they can force the dump on Nevada. It's a big miscalculation. Nevadans can stand nuclear testing and, at least at one time, could tolerate the idea of nuclear waste storage. But not now, not ever, will Nevadans take kindly to being bullied by the federal government. That's something that makes Nevadans downright unreasonable.[11]

Another viewpoint by a Las Vegas resident was published several days later:

> The Nevada Test Site is already a repository of nuclear waste, and the addition of new material from around the country seems of small consequence. After at least 700 acknowledged explosions above and below ground, it would appear to any reasonable thinking individual that contamination of the site exists. The trained personnel already in place plus the equipment, housing, facilities, guards, transportation, and knowledgeable companies that have done this testing for years seem an excellent investment to continue to monitor and oversee this storage of nuclear material. As pressure continues to mount for the cessation of all nuclear testing, it seems a waste to allow this enormous expenditure of taxpayer dollars, manpower, and expert knowledge not to be put to use.[12]

From the Washington vantage point, southern Nevada is the obvious choice for the repository. No other location can combine physical isolation, a large workforce highly experienced in handling nuclear materials, and readily available security services. Historically, Nevadans have accepted environmental contamination of a remote desert area through nuclear testing, and the added burden of placing nuclear wastes in a nearby location is small.

In the end, the political forces in Nevada will probably be overwhelmed. The problems of nuclear waste are simply too important and

will not go away. However, the Nevada politicians will undoubtedly extract from Washington substantial financial benefit for the state in exchange for allowing this expansion of nuclear activities in the desert.

Environmental Neglect at Nuclear Weapons Plants

For 40 years officials of the U.S. government responsible for the nuclear weapons program were protected by the shield of national security in presenting their case to the nation that nuclear weapons could be produced quickly and *safely* and at a reasonable cost. While every president since Harry Truman has taken an intense interest in the capabilities of nuclear weapons to destroy the Soviet Union's environment, prior to the ascendancy of George Bush not a single one bothered to investigate what nuclear weapon production was doing to our environment. Had one of our presidents looked inward as well as outward, he would have seen hundreds of examples of environmental abuse—large areas of soil laced with plutonium which can be resuspended in the air, radioactive liquids leaking from storage tanks into underground aquifers, and contaminated vehicles and other equipment which were simply abandoned and covered with loose dirt. Such abuses were too often reflected in an attitude of, "Dump the wastes out back, and we'll worry about them later."

Largely as the result of citizen pressure, "glasnost" has come to the nuclear weapons complex. In a rapid turnaround, many congressional leaders as well as senior officials of the executive branch who ignored the problems for many years have now become the nation's most vocal environmentalists. "Environmental protection first, weapons production second," proclaims the Secretary of Energy while relying on advice from many experts who have been quiet on the issue for decades. Meanwhile, the Department of Defense is having an increasingly difficult time making the case that "The Russians are coming, and we need to expand our nuclear stockpile of 22,000 weapons."

During my time as director of the EPA's environmental advisory services on nuclear testing at the Nevada test site from 1980 to 1985, I was often disturbed by the views of some of the managers of our nation's weapons production, and particularly Washington-based offi-

cials who visited the desert. Their overriding objective was to develop more efficient weapons, and they did not appreciate having impediments put in their way, including environmental assessments which might complicate their task. Some thrived on their image as nuclear cowboys, symbolized in the readily available government pickup trucks, subsidized steak dinners, and large budgets to support projects with questionable justifications.

As noted earlier, the Nevada test site was designed to be an environmental wasteland. The possibility of preserving the area for any purpose other than nuclear waste activities disappeared with the first nuclear tests in the 1950s. The EPA's major preoccupation, therefore, has been to help ensure that radioactivity does not leave the site. While not enthusiastic about the EPA's intrusion into their affairs, the weapons managers have recognized the public relations value of having the EPA on their side; and they try very hard to ensure that the EPA can endorse their approaches to off-site safety. As history is now revealing, the record of environmental consciousness at the Nevada test site, aside from the deliberate contamination of the subsurface environment every time a weapon is detonated, has been very high in comparison to the records at the other dozen or so sites of the nuclear weapons complex. Still, the mind-set of "better weapons whatever the price" has permeated the Las Vegas area as well as the other sites for many years.

In the early 1980s I traveled to Idaho to review environmental programs at another large test facility of the Department of Energy. My suspicions about the incompatibility of weapons activities as they were then conducted and environmental protection were confirmed. A problem of particular concern was the leakage of radioactive tritium into a large underlying aquifer which feeds into the Snake River. The tritium had already migrated several miles off the federal property, and the nearby communities had become upset that the pollutant would contaminate their drinking water supplies.

Our host at the manufacturing facility responsible for the tritium leakage told us not to worry about the stories of off-site environmental problems. The environmental groups in the region had carefully reviewed the situation and had concluded that the tritium leakage was insignificant. When I expressed interest in the involvement of environmental groups, he smiled. He then proudly stated that he was an active

member of the local Audubon Society and had played an important role in the "independent" environmental critique of the manufacturing facility where he was employed.

In 1989 the task of cleaning up the refuse from weapons activities at Rocky Flats in Colorado, Hanford in Washington, Fernald in Ohio, and the other nuclear weapons facilities (occupying a territory larger than the states of Delaware and Rhode Island combined) began in earnest. Projections are that the price tag over the next 20 years will be about $250 billion of federal funds. This cost boggles the minds of environmentalists who often are satisfied with grants of $10,000, $100,000, and occasionally $10 million to restore a polluted area. However, the members of the military–industrial complex, accustomed to annual defense budgets which significantly exceed $250 billion, took the cleanup costs in stride.[13]

John Glenn, chairman of the Senate Subcommittee on Governmental Affairs and a leading activist in promoting environmental awareness throughout the military weapons complex, offers the following guidelines: First, the Department of Energy in developing and producing weapons should operate on a pay-as-you-go basis, including the costs of health, safety, and environmental protection. More realistic assessments of the need for additional nuclear materials and alternatives to increases in our weapons arsenal should be explored. Greater oversight by competent scientists and representatives of the public of nuclear weapons activities is needed both in the management of facilities and in the design of radiation research programs. Finally, steps must be taken to ensure that once production activities at a facility end, there will not be residual environmental problems.[14]

The following admonition of Senator Glenn is right on target: ". . . the notion of harming the health and safety of large numbers of Americans in order to produce weapons makes a mockery of the phrase 'national security.' We must face up to this reality by bringing America's nuclear weapons industry into the modern era and making it accountable to the citizens it is designed to protect."[14]

Since the advent of nuclear weapons, the Department of Defense has failed to consider adequately the environmental costs of its military activities. Now the nation's defense budget, and not its environmental budget, should be charged the costs of cleaning up the debris from the nuclear weapons complex.

Protecting Our Groundwater Resources

Accompanying the dramatic increase since the early 1980s in public anxiety over radioactive and hazardous waste disposal practices has been a growing awareness within and outside government agencies that the quality of America's groundwater is slowly but steadily deteriorating. A key concern at almost every waste disposal site is protection of the groundwater under and near the site. Unfortunately, the documented cases of leaking wastes which have contaminated underground drinking water supplies are on the increase in many regions.

People depend on groundwater in every state. It may be only a few feet below the surface or it may be hundreds of feet into the Earth's crust. It currently provides one-fourth of the water used in the country. One-half of the American population including 97% of the residents of rural areas obtain their drinking water from underground aquifers. Groundwater provides 40% percent of agricultural irrigation water and a considerable portion of water used by industry. Also, it nourishes aquatic ecosystems which are valued for their fish, wildlife, and recreation opportunities. In periods of drought, groundwater is particularly important in ensuring a continuing supply of fresh water for many lakes, rivers, wetlands, and estuaries.

Most groundwater in the United States is clean and available in adequate quantities to meet our needs. The nation as a whole is clearly not facing a groundwater crisis. However, in a few regions, the withdrawals of groundwater exceed replenishments. Of our immediate interest, a wide array of contaminants have been detected in many areas. Agricultural fertilizers, pesticides, heavy metals, and solvents have received the most publicity as groundwater contaminants. Meanwhile, government surveys have found many more chemicals, totaling over 200, in the nation's groundwater.

In most contaminated subsurface areas, the experts have discovered only minute levels of these substances. Further, most cases of serious groundwater pollution are highly localized with contamination plumes seldom being more than one or two miles in length. The plumes usually can be traced to chemicals escaping from wastes sites, spills of chemicals, leaking underground chemical tanks, old septic tanks, or excessive use of agricultural chemicals.

Unfortunately, many of the patches of groundwater which are

contaminated with man-made chemicals are located in densely populated areas where groundwater is an important source of drinking water. In some localities, officials have closed contaminated wells. Such closures already have affected millions of consumers. For the foreseeable future, this pattern of localized pollution of groundwater will probably continue to intensify, and health inspectors will continue to close wells. Even if additional chemicals were not deposited on the land in an uncontrolled manner, some areas of soils are already saturated with chemicals which will eventually reach the water table. The costs of halting the movement of contaminants toward underground resources, pumping out contaminated groundwater, cleansing it at the surface of the ground, and reinjecting it back into an aquifer are very high and often prohibitive; and we must accept the inevitability of additional groundwater contamination.

As to underground contamination that can cover large areas, the problems of groundwater pollution from farming practices are finally being recognized throughout the country. Nitrate fertilizers and soil additives such as gypsum and sulfur are found in groundwater in some agricultural areas. High levels of salinity are induced through reuse of irrigation waters that collect and concentrate chlorides. These chlorides may occur naturally or may be constituents of agricultural chemicals. Animal wastes often contribute bacteria and salts to groundwater. Of course, excessive use of pesticides remains at the top of the list of concerns, and this problem is discussed in the next chapter.

Other sources of groundwater contamination that can affect large areas include acid drainage from mining areas, runoff from highways of deicing salts, and seepage of wastes from leaking septic tanks. Also, in some areas groundwater is so close to the Earth's surface that it intermingles freely with surface waters receiving all of the common runoff pollutants that plague streams and rivers.

At the national level, several types of actions are designed to protect groundwater resources. First, we have already discussed efforts to contain chemical wastes and chemical storage facilities and to clean up those sites where chemicals leak into groundwater. Second, federal and state agencies restrict the use of pesticides and other toxic chemicals which are placed on the land and do not degrade for many years, with the restrictions designed to ensure that they will not reach ground-

water. An additional program calls for a few large aquifers, often spreading across large portions of several states, to be designated as particularly valuable resources of drinking water. Federally financed projects which might impact on the aquifers, such as construction and water development schemes, can only be undertaken after studies confirm that these activities will not adversely affect the quality of the aquifers. Cutting across all of these activities are federal standards for drinking water—namely, the levels of chemical contaminants which pose no threat to health. These levels are generally used as a guide as to when groundwater is clean enough.[15]

Of comparable importance are the actions taken by the states to protect groundwater. Many agricultural states, such as Nebraska, are adopting strong stands to limit the excessive use of agricultural chemicals and to discourage farming practices which permit runoff water to drain into groundwater. In a few areas such as Long Island, geographical zones are designated according to the present condition of the groundwater—such as pristine, partially contaminated but usable, and contaminated. Activities permitted in each of the zones are constrained by regulations to prevent further degradation. For example, waste sites may be located only in zones where the groundwater is already contaminated, and even there they must be carefully monitored. In the pristine zones, activities are sharply limited to those with little possibility of spilling chemicals into the subsurface environment.

The protection of groundwater is first and foremost a land-use issue. Historically, all levels of government have been hesitant to tell citizens how they can use their land. In recent decades, the responsibility for local zoning restrictions has been aggressively pursued in communities throughout the country. While activities funded by federal and state agencies do influence these local deliberations, the agencies have usually stood aside during the detailed planning of areas which are primarily private property.

Groundwater resources typically extend far beyond the boundaries of individual communities. Few communities have the technical wherewithal to assess the likelihood of threats to groundwater in their immediate vicinity and the feasibility of abating these dangers, let alone the problems of movement of underground water into other areas. Furthermore, communities usually have short time horizons of, say, 50 years

whereas groundwater pollution induced today will be with us for centuries into the future. The states, with a broader perspective, can make important contributions to local decisions.

About 20 years ago, the federal government awakened to the accelerating pace of real estate development which threatened the ecology of the nation's coastal areas. This was also a land-use issue involving private property, and the decisions of one coastal community affected others as well. Thus, the special role that the states could play was recognized. The federal government has provided grants to states for planning coastal development in accordance with very loosely articulated nationwide objectives. Also, tied to these planning activities are a variety of federally funded programs which impact on coastal development. Thus, many states have adopted a protective stance to the regulation of private property. Lessons from this experience seem relevant to the approach for groundwater protection.

Indeed, every state has a designated groundwater office. The financial support and the technical advice of the federal government are very helpful to these offices. Also, a firm commitment of the many interested federal agencies to try to shape the local programs which they fund within the overall regulatory frameworks developed by these offices can provide greater rationality in both the national and local approaches to groundwater protection.

However, even with unprecedented success of federal and state efforts to reverse trends in groundwater contamination during the next few years, the United States will enter the next century with patches of the nation's groundwater polluted beyond hope of recovery. In some localized areas, groundwater supplies must be written off as not recoverable for some uses, and the local populations must become accustomed to this reality.

At the same time, a reasonable goal to establish now is the prevention of further significant degradation after the turn of the century of *any* underground aquifer with a potential for use. Policies and programs during the 1990s should be directed toward minimizing the extent of the contamination that could eventually migrate into aquifers. Strong efforts are needed to keep the number of American citizens who believe they have no choice but to resort to bottled water as low as possible. Currently, more than 20 million of our citizens drink bottled water. Some have rejected tap water in favor of a chic habit. Others prefer the

taste of sparkling mountain springs. Still others are convinced that tap water is unhealthy. And some live in areas where they simply have no other choice.

All of the approaches for reducing and controlling wastes discussed in this chapter will impact on the status of the nation's groundwater. Policies for cleaning up improperly discarded wastes, for handling municipal wastes, for improving the integrity of underground storage tanks, and for locating and operating permanent disposal facilities for chemical and nuclear wastes are critical for the preservation of much of the nation's freshwater resources. While other types of environmental threats such as air pollution from factories and cars may be of more immediate concern for human health, in the longer run waste problems must be at the top of the list of environmental protection priorities.

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