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NONSECURITY OF THE SECURE CHEMICAL LANDFILL

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ABSTRACT

Hazardous waste disposal is a problem of major proportion, not yet completely addressed. Engineering evaluations show the flawed reasoning of landfill use. Geological aspects are developed, linking theories of soil formation and anticipated leachate dispersion. Ideas about clay impermeability and the use of clay and synthetic liners are examined. Examples of the state-of-the-art sites are reviewed to determine the basis for failure potential, and some areas of needed research are suggested. Also, legal and economic considerations, tied inextricably to engineering decisions, are highlighted. Because the evidence points toward inevitable danger, another direction is presented. Taking into account the legal, economic and engineering experience, as well as the protection for the public, recommendations are given for a transitional approach. Without causing a disruptive break in present operating procedures, a change is suggested in objectives, in financial systems and in safeguards leading eventually to an improved environment.

1. INTRODUCTION

Hazardous waste disposal in the United States is not satisfactory. Since 1976, a series of state-of-the-art landfills had been proposed or built. In the judgment of many of our peers, these sites are failed or questionable. Federal targets of resource conservation and recovery have not been met- and will not be met - under the present system.

To determine why such difficulties exist, examples of landfill projects are examined for failure potential. As a foil for this comparison, a critical review of the Chemical Manufacturers Association advertisement is made.

The major elements of hazardous waste disposal decisions should include engineering, economics and law with attendant regulations. But in the past, engineering has not been the dominant concern. Instead, decisions tend to be political in nature. The inability to fully apply science and not politics, may be at the heart of the problem.

But there was understanding among some federal and state employees, as exemplified by two publications. In 1977, the Environmental Protection Agency (EPA) published a guide for state legislatures [1]. By 1980, the National Conference of State Legislatures responded in kind with a parallel guide [2]. For reasons not yet clear, the bulk of the states did not accept the guidance.

2. LAW AND LOGIC IN HAZARDOUS WASTE DISPOSAL

Legal roots for dangerous item liability may be traced to a 1916 Supreme Court decision, MacPherson vs. Buick [3]. It was decreed that a manufactured item or device that inherently could injure or destroy or place life and limb in peril, could be held the manufacturer's responsibility, if negligence is involved. Hazards of nature or acts of God are thus separate from artificial hazards, and when so distinguished, allow companies to be held liable in case of injury.

But to-day, this 1916 decision is again challenged. In order to counter rising fears of ground and water contamination, statements by prominent chemists argue that natural dangers, such as the lethality of the oleander, for example, are so great that, in comparison, the leaching of a little dioxin does not matter [4-6]. This not only thwarts the meaning of the 1916 decision, but also removes the freedom of choice. An individual need not eat the oleander, but has no choice at all in dioxin or other toxic exposure perpetrated by others.

Present law and ensuing regulations on hazardous waste may be questioned for logic, and in some cases, for engineering definitions. For example, waste burial is not disposal at all [7], but only temporary storage, at best. The specific time of failed burial is unknown, and experience indicates relatively short periods. Yet some of our respected scientists advocate landfill as a disposal procedure, acceptable within regulations.

The positive response of legal effort may be illustrated by two cases,only six weeks apart. In June 1980, an underground plume containing polychlorinated biphenyls (PCBs) approached Youngsville, Pennsylvania wells. But Congress had not provided the financial and political mechanism to correct the problem [8]. Then by July, the Justice Department set out, for the first time, to hold the producers of the waste just as liable as the dump operator [9]. This is a turning point, as is Reference 3, since it puts the responsibility at the source, and not wholly upon some often less than knowledgeable operator.

During the past 10 or 15 years, controls for contaminants were developed through a series of acts and regulations. A legal cornerstone is the Resource Conservation and Recovery Act, RCRA, of 1976 [10]. But after eight years, there is a nation-wide perception that the system is not working. The intent and spirit of the law has not been honored, and the law itself may have been violated. Criticisms range from charges of ineptitude to gangsterism.

Because of the improper or failed sites, a cleanup program was initiated, known as Superfund [11]. The activity under Superfund has been minimal, at about one percent of targeted sites, but the projected costs are astronomical, and are estimated to-day at $40 billion and in excess of $100 billion by the turn of the century.

3. HAZARDOUS WASTE SITE EVALUATIONS

Three examples of hazardous waste sites are chosen for state-of-the-art illustrations from 1978 to 1984. Studies for each of these are cited to demonstrate the failure potential in liners, in some encapsulation efforts and in engineering design.

The reasons for failure are shown to be those of basic engineering and related science concepts. It is less a matter of proper management than it is a problem of defying natural consequences, which inexorably doom the secure chemical landfill.

3.1. Wilkinson County, Georgia, Secure Chemical Landfill

This hazardous waste site operated through state arrangement, seven months in secret and two months with public awareness. It was closed September 13, 1978. There were a number of legal and ethical problems, but this discussion involves engineering aspects only.

A worse location could hardly have been chosen. Yet the site was attractive for one major reason. It contained lenses of clay called Twiggs clay, primarily a montmorillonite known as fuller's earth. Fuller's earth is a generic term referring to the ability of such fine-grained earths to adsorb color and oils in the cleaning or fulling of wool. The evaluation of montmorillonite and its close relation, bentonite, is a crucial item in the so-called secure chemical landfill.

Although every location has individual differences, it is useful to group areas for a general understanding of the geological conditions. Differences in soil structure affect the time rate of failure, but not the final effects. It is no coincidence that the major site considerations for dumps are where ancient seas once existed. These tend to be cheap, except for mainly outside interests of mining and timber. See Figure 1 for southeast locations.

Except for site B, which is in the lower Piedmont and is discussed below, all other sites are in the sand hills over ancient seas. Site B is in a zone of transition with a similar unreasonable placement. The rest are in areas of deposits of a vast sedimentary disposition, extending from Arkansas, through Mississippi and on up to Virginia. Where like conditions exist in other states, they are targets for similar dumps.

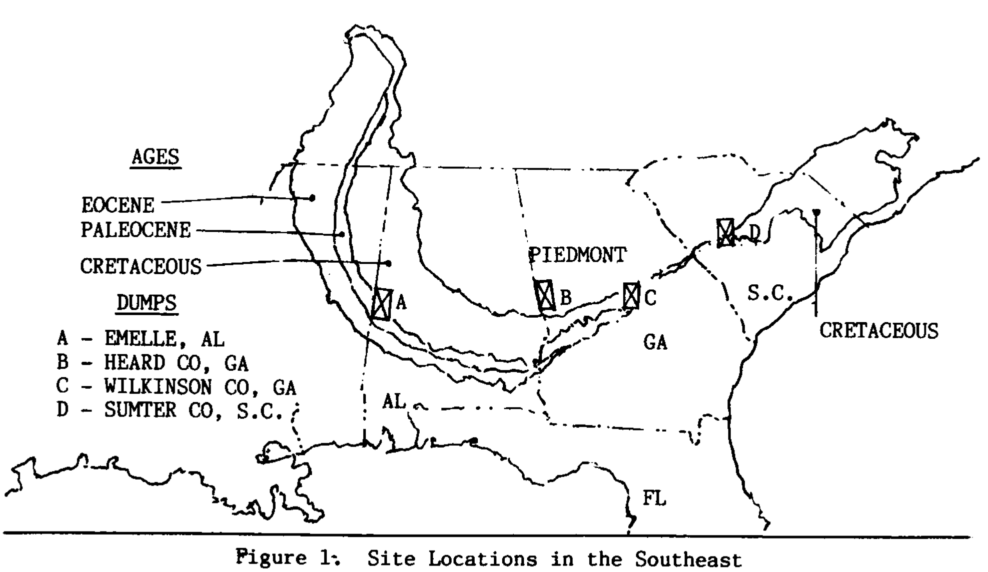

Figure 1. Site Locations in the Southeast

The Wilkinson site C is in the commercial kaolin mining belt. These are whitish clays that formed during various ages through combinative actions of sedimentation, laterization (soil chemical change formations following rock breakdown) and erosive actions in vast ancient seas and freshwater lagoons. A generalized section of the toxic dump area is seen in Figure 2.

Unfortunately, this is the recharge zone of a major aquifer. This aquifer, called the Tuscaloosa, is of the cretaceous age deposit of massive white kaolinite. The younger Twiggs clay, the basis for site location, was assumed to be essentially impermeable, as mentioned previously.

It is this fuller's earth fallacy that requires a detailed review, since it is the type of clay chosen for much of the toxic waste containment or encapsulation. Fuller's earth of this variety and bentonite have the same characteristics, other than volcanic glass shards in bentonite [12]. Until about 1970, geologists insisted they were the same.

This fuller's earth, montmorillonite, is a clay mineral, sandwich-like, consisting of two sides of silica tetrahedral sheets and a central octahedral sheet (Gibbsite). There is a deficiency of charge which allows an extensive cation exchange between particles [13,14]. This feature permits the montmorillinite to act as an adsorption system up to 40 times its own plate thickness. See Figure 3 for an idealized view.

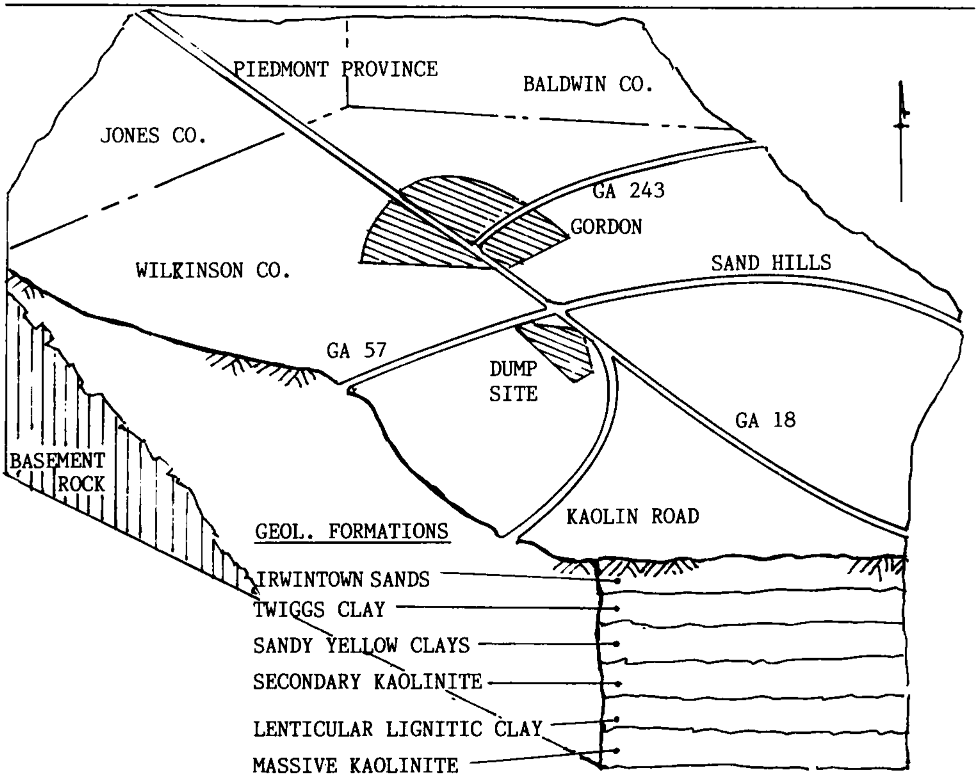

Figure 2. Wilkinson Dump Site Area

The cation adsorption capacity of montmorillonite is some 15 times that of kaolinite, a more stable clay. The closed Wilsonville, Illinois site of 1977, was a kaolin clay. Thus it seemed logical to go to the clay with greater adsorptive capacity as the next step, following the Wilsonville closing.

However, a literature search should have alerted the dump designers in Wilkinson County, Georgia. There had been a previous case of the inability of fuller's earth to contain wastes. A report on the Allegheny River-Lake Erie Basin had noted groundwater contamination [15].

There, encapsulated chrome waste in fuller's earth leached into the Olean aquifer. Remedial removal of the fuller's earth with its encapsulated waste, decreased chrome concentrations in adjacent well waters.

With respect to the failure in the Wilkinson County, Georgia dump, it is not known whether the montmorillonite clays were permeable originally, or became so due to the chemical action of the wastes. There was no planned test and research project, in addition to a lack of adequate base data for the site.

The geologist, LeGrand, clarified the relationship between geology, groundwater and the recharge system for the area [16]. Although the underground water is a temporary or transient storage, with flow moving slowly around clay lenses, some waters move through seemingly impermeable clays. Within clay, flow also moves vertically, up or down, depending on geological and hydraulic circumstances. In Wilkinson County, we would suggest there is an unusual circumstance, namely, reverse flow in the aquifer.

Even more pertinent to the subject, are the studies of later geologists, who indicated that dissolved chemicals of natural origin penetrate the Twiggs clay in a complicated physico-chemical metamorphosis [17,18]. As humic and other natural acids pass through the clays and alternately through sands, calcareous deposits and other sediments, the clays are altered, montmorillonite to kaolinite, kaolinite to bauxite, etc. In the discussion on liners, below, it is noted that the action of some hazardous wastes carry the changes to the extreme, the clays changing irreversibly and are no longer clays at all.

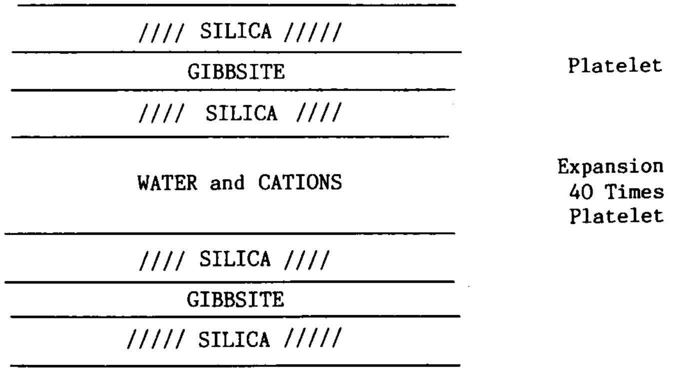

Figure 3. Montmorillonite - An Idealized View

Table 1. Area Well pH Disparity

No. Tested	Location	pH Range	pH Average
20	Rural wells, 1 mile radius	4.5 to 7.2	5.9
3	Gordon	4.1 to 5.0	4.6
12	Kaolin Mine, Gordon	N/A	5.2
7	Old Monitoring Wells, Dump	7.7 to 8.1	7.9
8	New Monitoring Wells, Dump	7.9 to 8.3	8.0

This provides the first analytical tool. If a disparity is noted between the normal pH of the surrounding area and the monitoring wells, one should be aware that a problem may exist. Awide pH variation is a precursor of eventual breakthrough of contaminants. See Table 1 for such a disparity.

Table 1 shows that the normal pH of this humid Fall Line area tends to be well on the acid side, while the dump site wells are consistently abnormal with respect to pH readings. In time, with the acid soils of the area, the pH at the dump will change. It is not known yet whether this may result in a massive unloading and migration into the aquifer, but this is a possibility.

As far as is known, there is nothing unique about the site geology that might account for the difference in pH. These disparities exist both for deep and shallow wells at the site, or, from water table to deep aquifer. Since the variation is picked up at the monitoring wells, it follows that some migration from the encapsulating montmorillonite has occurred.

Eleven months after the closing of the site, a joint statement by the state Environmental Protection Division (EPD) and the EPA Region IV office indicated that the original 7 monitoring wells had not been properly developed. Tests showed elevated levels of chromium, lead and cadmium in the unfiltered samples, but not in the filtered samples. A well developed well, they said, would have filtered out the contaminant particles.

But it may be that this recommendation indicated that a thorough research had not been conducted. For not only had the contaminants appeared in the dump vicinity, but had also been noted in a deep well, 1600 feet (488 m) from the site. This was in a well originally intended as a potable source for the office and laboratory by the EPD design team, and it was located in a direction opposite to accepted aquifer flow direction.

A water chemistry study should have given pause to the EPA/EPD statement on filtered versus nonfiltered samples. First, the term "dissolved" is difficult to define due to the different forms in which nonaqueous materials appear in water [19]. Second, subcolloidal particles, which collect on the membrane filter are found even in natural aquifer waters, and should not be separated out just because they are contaminants.

The explanation of ill-developed wells was made long after the fact. No tests on the filter entrapped materials were reported. The possibility that a change in solution pH, to determine whether the filtrate may dissolve, was never explored.

Table 2. Heavy Metal Concentrations (samples taken and run by the Ecology Institute, U. of Ga. Sampling date 3/04/80. Values in parts per billion, ppb)

LOCATION	Chrome	Cadmium	Lead	Copper	Cobalt	Nickel	Zinc
New Monitoring Well #3	80	6	104	42	200	50	60
Impoundment Below Site	53	0	53	13	91	39	99
Spring on Adjoining Property	23	0	36	4	44	23	10
Stream Draining Site	45	3	46	10	41	40	2

Special test for Mercury in the soil, sampled average taken from the site 84 ppb, and from samples taken below the site on adjoining property, average 19 ppb.

In addition to the subcolloidal matter which may be entrapped, a gelatinous suspension, in the manner of agglomerations of a shmutzdecke could develop on the filter. Crystalline and noncrystalline particles could be caught, yet, might pass easily in aquifer flow.

There are a number of experiments that should have been run in a designed test plan to help close the gap in our knowledge about contaminants carried in the aquifer. Instead, the decision of the EPD/EPA to replace the monitoring wells appears arbitrary and lacking in the expected research approach.

At any rate, the seven original monitoring wells were replaced by eight new monitoring wells, presumably developed in an improved manner. The methodology was duly reported in the appropriate scientific publication [20]. Both old and new wells were prepared under the jurisdiction and guidance of the EPD.

Fortunately, a public service laboratory and research organization, the Ecology Institute of the University of Georgia, came in to test as one of the new wells was being developed. The test team also sampled off-site locations at our request. This procedure demonstrates the advantage of having an Ombudsman-like service available for the affected population.

The relevant Ecology Laboratory results are seen in Table 2. Subsequently, it was found that the new properly developed wells still had to have their samples filtered in order to reduce the reported contaminant levels. Table 2 shows why this would be the case, since the evidences of site failure are apparent in the sampling by an impartial laboratory. The point should be made, additionally, that the site is in a remote, formerly heavily forested land with no modern contamination.

The old monitoring well to the north of the site served an important function of an additional analytical tool. The well showed measurable contamination and indicated the possibility of reverse flow in the aquifer.

Ordinarily, flow in this area is southeasterly, toward the Atlantic Ocean. But there is a massive withdrawal of about 5 million gallons (2.273×10^7 l) per day by the Gordon mine. There may be some 35 million gallons (1.59×10^8 l) by the other mines in the immediate kaolin belt. It is evident that aquifer flow patterns and possible changes in groundwater need further study and definition.

3.2. Heard County, Second Georgia Secure Landfill Site

By 1980, the EPD realized that sites would have to be more sophisticated to be accepted by the local population. The technical aspects of the newer dumps may be seen by examining the advertisement put out by the manufacturers' trade group for the chemical industry. The problem is that the deliberate scale distortion leaves an impression not consistent with the actual situation.

The simplified representation seen in Figure 4 is a common method of exaggerating the scale in the draftsman's favor. Ordinarily it is a perfectly harmless way of emphasizing a point. But in this case, the vertical scale is expanded, and the horizontal scale is compressed to make the process appear fully controlled and safe.

The clay seal, which is actually 2 to 5 feet is made to look very deep, perhaps as much as forty feet. The solid waste layers are made to look like parts of a small sand castle, but in actuality are massive, spread over acres and sometimes as high as a six story building. While the solid waste appears small, relatively, the intervening natural soil also appears massive. In the Heard County application, in some instances, the intervening soil was found to be less than 5 feet to groundwater.

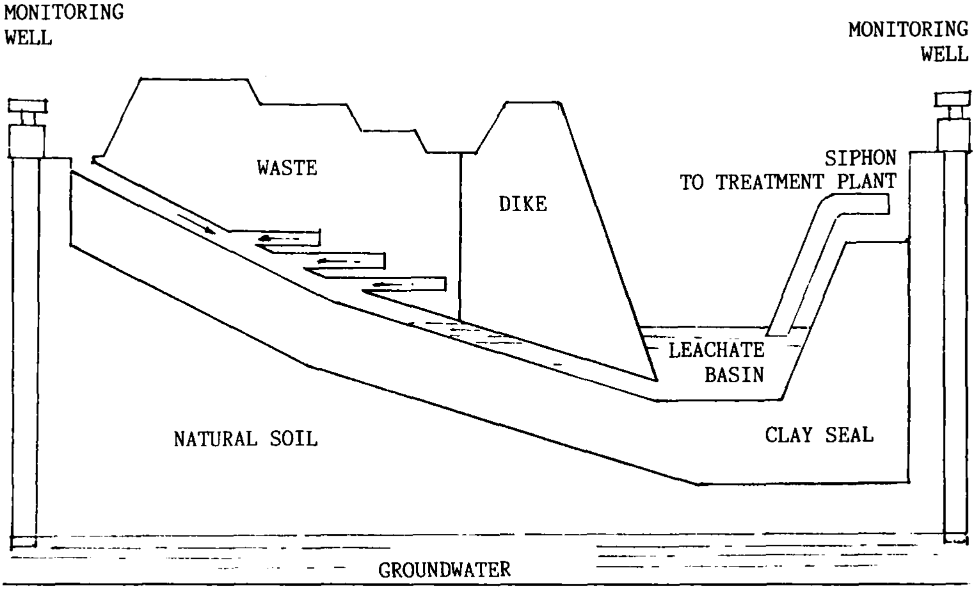

Figure 4. The Secure Chemical Landfill

Horizontally, the scale is compressed by a factor approximately 100. On the other hand, the diameter of the monitoring well is relatively expanded about 10 times, giving an exaggerated idea of safety in monitoring, at about a psychological factor of 1000. The monitor extends into a mythical representation of groundwater, which is not an underground river at all, but a series of interstices. Thus the monitoring well may not always be successful in intercepting a contaminant plume.

In the case of the Heard County site, the engineering firm that designed the project took the cue for such scale exaggeration in their application. In part this was for acceptance by the state officials, but more particularly, for acceptance by the local population. Resistance was strong, however; the legal fight went as high as the State Supreme Court, and the facility is yet to be built.

With regard to the technical aspects, the application was found to be lacking. Factors of risk included liner design, longevity of the facility, transportation to the site, long term costs to the state and local community, and the laboratory control was questioned [7].

The choice of site was not in accord with the guidance of Reference 1. Specifically, high risk areas are designated as those with high humidity and high well withdrawal for water sources. Both risks are involved. This is a region of the so-called high precipitation-evapotranspiration potential contour of Reference 1, comparable to the Tennessee Valley Authority region. The Heard County location is within "tornado alley."

It is precisely this humid condition that poses further problems. The environment is that of extreme weathering. The top soil is thin or nonexistent. Subsoils are minimal, and the decomposing rock-in-place is called saprolite, a pre-soil stage in evolution.

Saprolite is a permeable, noncompacting material and not suitable for the fill compaction called for in the application. Bentonite-like additives were never demonstrated as successful improvements, and the permit application did not specify test results or what type of clay would be used.

The site was located 4 miles (6.44 km) from an ancient, vast land fault called the Brevard. Although seismic activity is extremely low, shear zones (potential failure planes) lie immediately to the north and south of the site. This is an area of transition in the lower Piedmont and should be regarded as fragile with its changing character in geological time.

Design elements include the main feature of filling a polyethylene bag, whose dimensions in plan are 150,000 to 160,000 square feet (13935 to 14864 m^2) and some 20 to 50 feet (6.07 to 15.17 m) deep, depending on base slope. The filling will include about 60 to70 percent of waste in drums, some dry wastes, and the remainder in loose granular fill, all arranged so as to form a cell. Cells are designed to be small and individual, that is, to be surrounded by compacted earth on all sides. Each cell is filled separately and capped with impermeable fill, and cells will number some 16 to 25 per polyethylene bag. Filling and compaction with heavy equipment, the application states, will require great care not to tear the vulnerable seamed and sealed plastic liners. The native population dubbed these huge burial shrouds, big-baggies.

The permit application and design were inolved and well detailed, but one point is worthy of mention. The chemically contaminated waters, leached or otherwise drained, will be managed by a small water treatment plant. Effluents will be lagooned, then utilized either to fight fires which may occur on the site, or the remainder to be disposed by land spray irrigation.

The assumptions of design predict,

- Important failures will occur only in an individual cell.
- Because of cell grouping, with earth wall separation, failures will not be cumulative, but will be completely isolated.
- The system for impounding contaminated waters is failsafe.
- The fill, drums and synthetic liner are not vulnerable to major damage.
- Caps and other clay liners are impermeable.
- The entire system is static, i.e., liner, bedrock, fill, and surrounding soil will not move or deteriorate.
- The wastes are stabilized, forever, primarily with such additions as lime.

Thirty years after the site is closed, it becomes the property of the state, to be maintained forever.

3.3. New York State Secure Chemical Landfill

Three miles from Love Canal, a chemical dump was developed to represent the newest breed of secure chemical landfill [21]. In size comparison, Wilkinson's dump was 87 acres (35.2 ha), Heard's dump was to be about 280 acres (113.3 ha) and the New York State dump is 365 acres (147.71 ha). The polyethylene liner increased from 3 acres (1.2 ha) to 10 acres (4.05 ha) in New York. Publicity and organization are well developed in New York. Reference 21 quotes the public affairs director as saying, "We call ourselves the NASA of the industry." And the health safety and environmental control manager said, "We're part of the solution, not the problem."

In a manner similar to the Heard proposal, chemical wastes are segregated by programmed dumping into subcells separated by 4 foot (1.2 m) thick walls of clay. After a pit, containing a number of subcells, is filled and covered, pumps will continue to extract water until all contained pollutants, cut off by the thick clay and polyethelene liner, are bone dry.

Unlike the proposed Heard dump water use for firefighting and land spraying, the New York dump will send its drainage and leachate to the sewage treatment plant after being found acceptable at the site; final release will be into the Niagara River. The release of these effluents, both Heard and New York, seems a risky procedure, far too dependent on human decision and inevitable error.

There were some critical comments on the design of the landfill. One was that the solutions were not more than "semi-solutions", as quoted in an article on liners [22]. Also the general design of the polyethylene bag system, complicated and sophisticated though it may be, was likened to a clay barge floating on high groundwater.

About a year later, it was found that the most efficient way to handle the problems was to relax the rules for leachate, but at the same time, to make the installation more complicated and expensive [23]. For example, if two synthetic liners are used with leak detection devices between them, in place of the single liner, then no groundwater monitoring, as in the Wilkinson dump, would be required.

3.4. Problems of Liners

The issue is now joined. The integrity of the liner is the crux of the burial system. Dr. Peter Montague, head of the Princeton research program on toxic waste stated in Congressional hearing testimony, " The conclusion is inescapable that all landfill liners will ultimately fail." Further, in a newspaper interview, Montague said, " I think the whole idea of secure landfills is really a figment of optimistic imagination" [24].

Specific research projects support these views. It was found that organic fluids such as solvents substantially increase the permeability of compacted clay soils including the most impermeable expansive montmorillonite [25]. This was supported by Dr. G. Fred Lee in his independent experiments [22]. Reference 22 indicates that caustics and acids would be included as well. In New Jersey, analysis showed that four landfills had failed in one to four years [26[.

Reference 26 emphasizes the major considerations of failure. First, these sites were established by important chemical companies at the highest level of the state-of-the-art. Second, the failure mode puts the public in danger at some unknown future time because of the new EPA risk assessment policy. Damage will be pervasive, and, when recognized, remedial action will be too late.

In some of the cases, the leak detection established that there were significant increases in leachate volume. However, when consultants, knowledgeable in hydrology and waste dump technology, were brought in, they were unable to locate the actual leak source. Therefore, Dr. Montague suggested that the radioactive tracer, tritium, be added to the waste to travel with the leachate after liner failure. The tritium is easily detected and would provide an indisputable parameter for leak tracking.

4. COSTS: THE ECONOMICS OF HAZARDOUS WASTE ERRORS

All waste sites will leak. Some sites are short-lived, others longer. Failures may incur large costs in a variety of ways [27 to 30].

A few examples may be cited to illustrate the range of costs. In the most publicized , Love Canal, 21,800 tons (19,800 Tonnes) of wastes were buried in a clay trench with a deep clay cover. Expenditures included $26 million for tests, about $10 million for new home relocation, and the cleanup costs are estimated at $50 million. The lawsuits total about $2.7 billion.

In the Valley of the Drums, Shepardsville, Kentucky, there were about 100,000 drums, with estimated cleanup cost of $100 per drum or $10 million. In Charles City, Iowa, where arsenic wastes leached into the Cedar River, through the aquifer, estimates ranged from $10 to $50 million for cleanup.

But the Comptroller General of the United States questioned whether control and decontamination technology had been sufficiently developed. A design office may recommend remedial measures with barriers, liners and treatment systems, but the damage may be pervasive and essentially uncontrollable.

There may be another approach to the economic view. The generators of waste correctly state that for them, landfill is cheaper, generally by a large factor. The usual method for comparing alternative choices is to examine whether the the profit is sufficient for the rate of return to exceed the minimum, when comparing the alternative to the burial rate. External circumstances, such as penalties, transport difficulties or regulatory harassment may tilt the decision toward alternative choices.

Since civil and criminal penalties are rarely invoked, the generator often finds it good business to do the least. An improved environment might result from the enlightenment that accompanies greater penalty and public pressures.

But for the longer term, as commodities become more scarce, the perception of future needs dominate. Some examples of hazardous materials in short supply, say by the year 2000, in descending demand, are chromium, mercury and asbestos. An estimate of the expected sources might be:

- Chromium - 40 percent from Zimbabwe, 24 percent from the Soviet Union and 17 percent from the Philipinnes.
- Mercury - 31 percent from Spain, 21 percent from Italy and 14 percent from Canada.
- Asbestos - 92 percent from Canada.

Is there any guarantee for good trade relations with these countries in the year 2000?

Considering these selected examples, if we were to recycle and reclaim, our dependency index would decrease in accordance with our ability to stockpile for the target year. Even as depletion allowances are made for mineral resources, so too, accretion allowances may be appropriate for hazardous waste reduction.

5. DISCUSSION

The message of the inadequacies of land burial practices has not yet registered in engineering circles. The use of bentonite in slurries or combined with other liners for waste filled deep trenches is advocated at this time [31]. The newer systems are more sophisticated although lined trenches were used in the past. The present advocacy comes from new methods and lower costs. The guarantee by liner seal manufacturers is for 20 to 40 years. Since much of the wastes will last forever, the guarantee may seem minimal.

In a sense, the waste industry has gone full circle. Although much less sophisticated, the Wilkinson dump was a montmorillonite trench system. Communication does not appear satisfactory in waste dump technology.

The pattern of events in secure landfill shortcomings seems to call for some new direction. Aside from research, a need exists to remove industry from the burial habit, through a transition stage and finally toward full conservation and recovery practices. An immediate problem is the fear, almost panic, of the public on mention of toxic dump [32]. Experience suggests that this may be due to arbitrary land allocation by less than knowledgeable state authorities.

The degree of inadequacy of state authorities has been noted by the Congress of the United States [33]. But exceptions are to be found, and particular mention is given to California's alternative concepts [34].

It appears that first, a better geological study is required before site decisions are made. The choice of a site should include a very wide buffer zone to provide for engineering error forgiveness. Transport routes should be well planned and improvements made where required to reduce the risk of accidents. And the public should be informed that the state recognizes that this is a limited temporary solution with all safeguards, bonding and compensation.

The example of the crucial tests by the University of Georgia Ecology Institute illustrates the concept of the people's contractor or Ombudsman Laboratory and Engineering Service as a mechanism to protect and help bolster public confidence. Such a service, having only public interest, could help fulfill many of the research requirements, in addition. Although there are exceptions, in general, state and federal organizations have been found wanting in their regard for the public.

And to attack the problem at its root, total costs should be borne by the generator, since there is no more basic responsible party. If the state or local community has a waste producing industry, which they fear would be in need of assistance as a result, that governmental body should arrange for financial support. The burden should not fall upon some innocent and unsuspecting community as in the Wilkinson case.

On the other hand, if the participating generator contributes to the success of the project through alternatives and reclaiming or recycling, rewards should be high. Such public benefit should receive tax relief at state and federal levels.

6. RECOMMENDATIONS

- Public confidence should be regained by using only isolated, geologically acceptable public lands for sites, with wide buffer zones.
- As a major safeguard, sites should be developed with an Environmental Impact Statement [35].
- Burial should be recognized as temporary storage only. Plans for safe removal and treatment should be in place.
- Adequate insurance and bonding should cover all operations, including transportation.
- For evenhandedness, regional Ombudsman Laboratory and Engineering Services should be established as the people's contractors.
- For use of alternative waste disposal and stockpiling of reclaimed material, companies should benefit from tax credits.
- For burial, violations, accidents, program overhead, laboratory services, the costs should be proportionately assessed at the source, i.e., the generators who do not use alternative systems of waste disposal.

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