Permitting of New Hazardous Waste Landfills and Landfill Expansions: A Summary of Public Health, Groundwater Resource and Environmental Issues

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Executive Summary

The authors have been involved in a review of the permitting of several proposed and existing hazardous waste (US EPA Subtitle C) landfills. Presented herein is a discussion of their experience in reviewing existing and proposed new hazardous waste landfills that are supposed to be constructed in accord with US EPA RCRA Subtitle C requirements as well as state regulatory agency requirements which are as at least as protective as RCRA Subtitle C.

Based on the review of several landfill applications and regulatory agency draft permits, the following conclusions and recommendations have been developed. While this discussion focuses on hazardous waste landfills, with few exceptions, the same problems exist to the same, if not greater degree, for municipal solid wastes (US EPA Subtitle D) landfills.

Suitability of a Landfill Site

- The geological and geographic/demographic setting of many landfill sites is unsuitable for the development of a safe and acceptable landfilling of hazardous and municipal solid wastes. These sites typically are hydraulically connected to groundwaters that in time can be polluted by landfill leachate.

Adequacy of Regulatory Agency Permit Conditions

- The draft permit conditions set forth by regulatory agencies typically do not conform to the agencies' regulatory requirements for operation of a hazardous waste landfill at an existing or proposed site.

Deficiencies in Regulatory Agency Review of Siting a New Landfill or the Continued Operation of an Existing Landfill

- Typically regulatory agency reviews of a landfill containment system and groundwater monitoring systems do not adequately consider US EPA RCRA and state regulatory requirements for protection of groundwaters from pollution by landfill leachate for as long as the wastes in the landfill will be a threat. Normally, regulatory agencies consider the potential for groundwater pollution by a landfill to exist for only a short period of time compared to the period of time that the wastes in the landfill will be a threat to groundwater quality.

- Regulatory agencies frequently fail to adequately consider the information available on the properties of a landfill's waste containment system components (landfill cover, leachate collection and removal system, liner systems and leak detection system) to function as an effective, reliable barrier to moisture entry into the landfill that will produce leachate and to the transport of leachate out of the landfill that can pollute groundwaters for as long as the wastes in the landfill will be a threat.
- Regulatory agencies frequently fail to adequately evaluate the reliability of the landfill liner containment system, leachate leak detection system, and groundwater monitoring systems to detect leachate leakage from the landfill at the point of compliance for groundwater monitoring before widespread groundwater pollution occurs by waste-derived constituents.
- Many components of the waste that are placed in landfill cells in a new landfill or proposed continued operation of an existing landfill represent a significant threat to groundwater quality and could be expected to impair the uses of groundwaters for domestic and many other purposes effectively forever.
- The treatment of hazardous wastes prior to deposition in landfills is not adequate to prevent groundwater pollution by hazardous and otherwise deleterious components of the wastes that can cause groundwaters to be unusable for domestic and many other purposes. Further, regulatory agencies fail to adequately consider the potential for the large amount of unregulated waste chemical constituents that will be deposited in the landfill to be adverse to groundwater quality.
- The period of time during which the landfill cover and base liners (composed of plastic sheeting and compacted clay layers) can potentially be effective in preventing moisture from entering the landfill which generates leachate, and in collecting the leachate that is generated in the landfill, is extremely limited compared to the period of time that the wastes in a landfill will be a threat to groundwater quality.
- The key component of the leachate collection and detection systems is the plastic sheeting layer (flexible membrane liner) in the two composite liners of a hazardous waste landfill. It has been well-known since the late 1980s that such a plastic sheeting layer will deteriorate over time and eventually fail to function as an effective barrier for leachate transport through it. The contaminating lifespan of the landfilled wastes with respect to causing groundwater pollution by hazardous and otherwise deleterious chemicals far exceeds the expected service life of the landfill liner system. Therefore, ultimately, a hazardous waste landfill can be expected to lead to groundwater pollution, rendering the groundwaters unusable for domestic and many other purposes. Such pollution would be in violation of current US EPA and state regulatory requirements.
- The current regulatory agency accepted groundwater monitoring systems for hazardous waste landfills have a low probability of detecting leachate migration past the point of compliance for groundwater monitoring. The spacing of groundwater monitoring wells, typically about 400 feet apart along the downgradient edge of the landfill, coupled with each monitoring well's zone of capture with a radius of about one foot, means that there are about 398 feet between monitoring wells where leachate-polluted groundwater could pass en route to off-site groundwater pollution without be detected by the monitoring wells.
- Frequently, unsaturated zone monitoring systems consisting of suction lysimeters are installed under landfill cells for the purpose of providing an early warning detection

of the passage of leachate through the liner system into the unsaturated (vadose) zone. Typically suction lysimeters have limited ability to detect leachate migration because of the small zone of capture compared to the total area through which leachate can pass through the liner system into the vadose zone.

At some landfill permitting hearings, regulatory agency staff attempt to justify continued operation of an existing hazardous waste landfill based on the "fact" that thus far the groundwater monitoring wells and the unsaturated zone monitoring systems have failed to detect groundwater pollution by the existing landfilling operations. A critical review of this situation will often show, however, that such claims about the safety of an existing landfill based on failure to detect groundwater pollution are fundamentally flawed and more appropriately reflect the inability of the groundwater monitoring system and vadose zone monitoring system to reliably sample the leachate leakage through the liner system that is occurring. The failure to detect pollution of the groundwaters at existing landfill cells normally reflects the short period of time that landfill cells have been in existence and the unreliable nature of groundwater monitoring and leachate migration detection programs that have been allowed to be installed associated at existing landfill cells.

- At some locations a surficial groundwater table surrounds a landfill. Landfill applicants, with the support of regulatory agencies, install clay cutoff walls around the landfill for the purpose of keeping the surficial groundwaters from entering the waste management unit. Frequently, however, regulatory agencies provide inadequate attention to the *ad infinitum* monitoring and maintenance of the waste cell isolation barrier system (dikes) to ensure that they will function reliably and effectively forever to prevent surficial groundwaters from migrating laterally into the waste cells when the liner systems are no longer effective in preventing migration of groundwater through them. Further, the high groundwaters in surficial groundwater tables surrounding landfill cells also represent a leachate pathway to surface waters of the region should at any time in the future the landfill applicant fail to remove leachate from the landfill during the time that the wastes in the landfill will be a threat.
- Landfill applicants and some regulatory agencies state that post-closure care for a landfill will be provided for a period of 30 years after closure. Such an approach is not in accord with regulatory requirements of the US EPA RCRA or many states. The 30-year period specified in federal and state regulations is the minimum period for post-closure care. These regulations do not limit the period of post-closure care but, rather, require that public health, groundwater resources, the environment, and the interests of those potentially impacted by the landfill be protected. Obviously, if protection is, in fact, to be achieved, the post-closure care period planned for in the permitting of a landfill must be for the period of time during which any of the waste components, either hazardous or deleterious, represents a threat to groundwater quality for the use of the groundwaters for domestic and other purposes.
- Typically regulatory agencies at the federal and state level allow landfill applicants to develop closure and post-closure funding levels of a few million dollars for closure of the landfill and a few million dollars for minimal 30-year post-closure care. These amounts of funds are significantly deficient compared to the true costs of properly closing a landfill and for the 30-year post-closure care period, much less the infinite

period of time that post-closure care will have to be provided if a landfill is to be maintained in accord with current regulatory requirements.

- Some state regulations allow the regulatory agency director to revoke the operating license of an existing landfill if it is found that new information or standards indicate that a threat to human health or to he environment exists which was unknown at the time of the original permitting of the landfill. From the time that the landfill was originally permitted until now, considerable new information has been developed on the significant deficiencies in plastic sheeting and compacted clay-lined landfill liners of the type that conform to minimum landfill containment system component design set forth in RCRA Subtitle C requirements and which have been incorporated into many state agency regulatory requirements in protecting public health, groundwater resources and the interests of those within the sphere of influence of the landfill.

Also, since the original license was issued for many existing landfills, new information has become available on the significant deficiencies in the ability of the minimum groundwater monitoring systems such as those typically allowed today by federal and state regulatory agencies to detect leachate-polluted groundwaters at the point of compliance in accord with regulatory requirements. These requirements mandate that the environmental monitoring system be capable of detecting a release of hazardous waste or hazardous waste components from the facility with a high degree of reliability. Further, the groundwater monitoring systems must reliably monitor the groundwaters to provide an early warning of failure of the hazardous waste management unit containment system. Frequently, operating permits for existing or proposed continued operation of a landfill groundwater monitoring system fail to recognize the unreliable monitoring of groundwater pollution that will occur with the monitoring approach allowed.

While current regulatory requirements mandate the operating license for a hazardous waste landfill be renewed every five years, it is important that this renewal not be a perfunctory, automatic process but includes a comprehensive, in-depth review of the adequacy of the landfill's containment system and groundwater monitoring system to protect the groundwater resources, public health, environment and interests of those within the sphere of influence of the landfill from waste-associated constituents for as long as the wastes in the landfill will be a threat.

Some state regulatory requirements permit the director of the regulatory agency to revoke the construction or operating permit of a existing landfill based on the failure of the landfill owner (applicant) to fully disclose all relevant facts or to misrepresent any relevant facts pertinent to the safety of the landfill. With few exceptions, landfill applicants fail to adequately and reliably discuss the long-term threats that the wastes in the landfill represent to the groundwater resources, public health and the environment as a result of migration through the landfill liner system and the inability of the groundwater monitoring systems to detect leakage through the liner system before widespread pollution occurs.

A critical review of all hazardous waste landfill applications for renewal of an operating permit must be conducted to ensure that the current information available on the

adequacy of the landfill's liner and monitoring system is properly evaluated in light of what is known today about the long-term threat that treated hazardous waste residues represent to public health and to the environment.

- The geographic and demographic setting of many hazardous waste landfills and their proximity to adjacent properties and populated areas are such that insufficient bufferlands owned by the landfill owner are provided to allow dissipation of airborne releases from the landfill that represent significant threats to the health and welfare of people of the region. In those situations where the landfill owner has operated the landfill in such a manner as to cause off-site releases of gaseous products to the atmosphere to preclude the issuance of a permit for continued operation of the landfill. Such off-site odors are also significant public health threats through the presence of the odor as well as non-odorous compounds in the airborne emissions. Any landfill owner that has a proven record of being a poor neighbor through failure to operate a landfill in a manner to retain all emissions from the landfill on the landfill owner's property should not be allowed to continue operate and existing or proposed landfill.

Implementation of Effective Programs for Control of Potential Groundwater Pollution from an Existing Landfill

- An existing hazardous waste landfill should be closed immediately if it does not comply to regulatory requirements of protecting groundwaters from pollution by landfill leachate for as long as the wastes in the landfill will represent a threat. Further, regulatory agencies should take the necessary steps to require that the landfill owner establish a reliable landfill leachate leakage detection program under the existing landfill cells that will reliably and with a high probability detect when leachate containing hazardous and deleterious constituents derived from the wastes already deposited in the landfill begin to pollute the aquifer system underlying the landfill. This will likely require drilling of many horizontal wells under the landfill at sufficiently close-spaced intervals to reliably detect, using vadose zone monitoring systems, leakage through the liner system into the vadose zone.
- The landfill owner should also be required to install a leak detectable cover on the closed waste management unit that will detect any holes, rips, tears or points of deterioration in the cover that could allow moisture to enter the cover and generate leachate. This system should be operated and maintained for as long as the wastes in the landfill represent a threat.

The regulatory agencies should also require that a landfill owner of a landfill sited where inevitable groundwater pollution will occur establish a dedicated trust fund of sufficient magnitude to install, operate and maintain a reliable leachate leakage detection system under the existing landfill cells for as long as the wastes in these cells represent a threat. For planning purposes, the wastes in existing landfill cells should be considered to be a threat effectively forever. The magnitude of these funds should be sufficient so that if the landfill applicant fails to take appropriate action when leachate migration is detected under the landfill that is a potential threat to the quality of the groundwater resources underlying the landfill, the landfill applicant must use the funds available to exhume the

wastes and properly manage them at an appropriate location for the waste management approaches adopted.

A discussion of the technical base for the issues discussed above is presented in this report.

Introduction

The authors, Drs. G. Fred Lee and Anne Jones-Lee, have been invited by water utilities, municipalities, adjacent/nearby property owners and concerned public to critically review the siting of a new hazardous waste landfill and/or the continued operation of a hazardous waste landfill. The discussion presented in this report encompasses an assessment of the potential for waste-derived constituents to be a threat to public health, groundwater resources and the environment from hazardous or otherwise deleterious chemicals that are present in the hazardous wastes deposited in a landfill for as long as the wastes will represent a threat. Normally, the authors' involvement in the review of a proposed or existing landfill encompasses a detailed review of the landfill applicant's supporting documents covering the characteristics of the site and the landfill. Further, the authors conduct a review of the expected performance of the proposed landfill design, operation, closure and post-closure care to conform to federal and state regulatory requirements. It has been the authors' experience that a review of these documents and other pertinent issues, shows that the landfill applicant and in some cases regulatory agencies provide inaccurate and unreliable information on the ability of a proposed or existing landfill containment system, leak detection systems, and groundwater monitoring systems to perform in accord with regulatory requirements of protecting public health, groundwater quality and the environment from pollution by landfill leachate for as long as the wastes in the landfill will be a threat.

This report has evolved from the authors' many years of work in conducting landfill reviews on behalf of governmental agencies, industry, water utilities, and the public. It represents a synthesis of the authors' experience in conducting such reviews in many locations in the US and in other countries. It provides guidance on the issues that should be considered and appropriately addressed in the development of new hazardous waste (Subtitle C) landfills as well as the continued operation of existing hazardous landfills. While the focus of this discussion is hazardous waste landfills, with few exceptions, the same issues and problems occur with US EPA Subtitle D municipal solid waste landfills. It is, therefore, applicable, with minor changes, to the development of a new or expanded municipal solid waste landfill.

Overall Conclusions and Recommendations from Site-Specific Hazardous Waste Landfill Reviews

It has been typically found that existing, as well as proposed, hazardous waste landfills are sited at unsuitable locations for the proposed landfill design compared to that needed to protect groundwaters from pollution by landfill leachate-derived constituents for as long as the wastes in the landfill will be a threat to groundwater quality. The natural

geological strata, the characteristics of landfill containment systems, and the properties of groundwater monitoring systems are frequently such that the construction and operation of a new landfill as well as the continued operation of an existing landfill will not conform to current regulatory requirements of protecting public health, groundwater resources, the environment and the welfare of those potentially impacted by a landfill.

Regulatory agency reviews of landfills are often based on inadequate, badly out of date, and unreliable evaluations of the ability of a proposed or existing landfill to protect public health, groundwater resources, and the environment from waste-derived constituents for as long as the wastes in the landfill will be a threat. The authors have found that frequently the agencies staff understand the deficiencies in their proposed permitting of a new or continued operation of an existing landfill. However, they recommend what is obviously a technically invalid and highly inappropriate approach for permitting of existing or proposed landfills, based on a variety of factors which include not changing the way in which landfill permitting has been done in the past and continues to be followed today, political pressure from their supervisors, elected officials, and others to keep the cost of landfilling low compared to its true cost, a lack of appreciation of the water quality significance of the pollution of groundwaters/aquifer systems by landfill leachate, and a lack of being aware of the current literature and expected performance of the ability of today's landfill containment systems and groundwater monitoring systems to protect groundwaters from pollution by landfill leachate for as long as the wastes in the landfill will represent a threat.

It is typically found that the regulatory agencies's review of an existing or proposed landfill has not adequately and reliably investigated the potential for the landfill to pollute groundwaters by landfill waste-derived constituents for as long as the wastes in the landfill will be a threat. The regulatory agencies also typically fail to properly evaluate the conformance of a proposed landfill or the continued operation to conform to current regulatory requirements. Current regulations require that public health, groundwater quality, and the environment be protected from waste-derived constituents for as long as the wastes in the landfill will be a threat. With few exceptions, the authors have found that the continued operations of existing landfills, the closure of an existing landfill, or the development of a new landfill will, at best, only postpone for a relatively short period of time, compared to the time that the wastes in the landfill will be a threat, when groundwater pollution occurs. It has been found that on a number of occasions, the permitting of new hazardous waste landfills and the permitting of the continued operation of existing landfills are based on a variety of factors other than the technical merit of the landfill site and the ability of the landfill containment system and groundwater monitoring systems to conform to meet regulatory requirements of protecting public health, groundwater resources and the environment from pollution by landfill leachate for as long as the wastes in the landfill represent a threat. This situation leads to regulatory agency staff at public hearings providing unreliable and inadequate information on the potential for a landfill to protect public health, groundwater resources, the environment, and the public's interests.

Another problem that is frequently encountered in the way in which regulatory staff implement current regulations is that the regulations specify a minimum design standard for landfill liners, leachate collection removal systems, groundwater monitoring systems, landfill cover, and post-closure care period. These regulations also specify a performance standard for their implementation which requires that the development of a landfill protect groundwaters from pollution/impaired use by landfill leachate for as long as the wastes in the landfill will be a threat. Regulatory agency staff often assume the minimum design standard set forth in the regulations will be protective. A critical, reliable review, however, shows that such an assumption is obviously invalid. With few exceptions, the minimum design standards for the landfill containment and monitoring system are not specified in the regulations as necessarily adequate for the development of the landfill. Typically, the regulations explicitly state that the minimum design standards may not be adequate to achieve the purpose of the regulations, namely the disposal of solid wastes, in a manner that will protect public health, the environment, and groundwater resources from waste derived constituents for as long as the wastes in the landfill will be a threat.

This situation leads to the current facade of the regulatory agencies claiming that a landfill meets regulatory requirements and will be protective when, in fact, it is obvious that this statement is not true. The situation also leads to perpetuation of the landfilling of solid waste, both hazardous and non-hazardous, at initially less than the real cost for managing hazardous and solid waste by landfilling. This ultimately has lead to the national Superfund program where billions of dollars will be spent paying for the true cost of landfilling that was practiced in the past. Today's landfills will lead to tomorrow's Superfund sites. Further, the cost that today's society is avoiding by not properly landfilling its solid wastes will have to be paid by future generations in Superfund site-like cleanup and remediation and a loss of groundwater resources.

Today's landfills are based on a technology that evolved in the early 1980s. At that time the full range of the deficiencies of compacted clay and plastic sheeting liners was not known. Further, while it should have been obvious, it was not until the late 1980s that the highly significant deficiencies in the current groundwater monitoring programs associated with Subtitle C and D landfills were recognized. While it used to be believed that groundwater monitoring could be used to detect when liner failure occurs before widespread pollution occurs, today it is recognized that current groundwater monitoring systems for plastic sheeting lined landfills are largely cosmetic and are essentially a waste of funds. With the more generally recognized realization that plastic sheeting lined landfills operated in a "dry tomb" type approach, where the wastes are "isolated" from moisture and any leachate that is generated is supposed to be collected, significant improvements in landfilling technology and approaches have been developed in the last few years.

It is time the new technology developed in the past few years begin to be implemented into the landfilling of hazardous waste residues and municipal solid wastes. Some of the areas of greatest concern are the monitoring of liner leakage and the funding of activities to address inevitable failure of the landfill containment system that essentially every landfill will face when the liner systems no longer function effectively. The regulatory

agencies should immediately require the landfill owner develop a much more effective and reliable approach for monitoring leachate migration from existing waste management cells. The closure of landfills should include the installation of a leak detectable cover and its operation and maintenance for as long as the wastes in the landfill will be a threat. Further, the landfill owner should be required to develop a dedicated trust fund of sufficient magnitude to address plausible worst-case failure scenarios that could lead to pollution of the aquifer underlying the landfill hydraulically connected to the waste management units for as long as the wastes will be a threat. This dedicated trust fund should be of sufficient magnitude to provide adequate funds *ad infinitum*(for as the long as the wastes in the existing landfill are a threat) monitoring and maintenance as well as waste exhumation and proper management if the landfill applicant cannot prevent migration of waste-derived constituents out of the landfill containment system. These and other issues associated with problems with today's landfilling approaches and suggested approaches to addressing these problems are discussed in this report.

Review of the Potential for an Existing or Proposed Landfill to Protect Groundwaters from Pollution by Landfill Leachate for as Long as the Wastes in the Landfill Will Be a Threat

The first step in evaluating the ability of a proposed landfill or landfill expansion to comply with groundwater quality protection regulations is to determine whether the landfill site is hydraulically connected to groundwaters that are or could at any time in the future be used for domestic or other water supply purposes. If there are potable and palatable groundwaters hydraulically connected to the landfill, then it is necessary to evaluate whether natural barriers, such as thick, low permeability layers that do not have fractures, cracks, sandy lenses, etc., that could provide avenues for leachate transport exist between the landfill base and the groundwaters that could potentially be polluted by landfill leachate at any time in the future while the wastes in the landfill represent a threat.

Suitability of the Landfill Site for an Existing or Proposed Landfill's Continued Operations

With few exceptions, hazardous waste landfills are hydraulically connected to potable groundwaters that are now and will certainly be used in the future as domestic water supply sources. Further, examination of the geological characteristics of the groundwater system underlying the existing landfill and proposed location for the landfill's continued operation and the groundwater resources of the region that could be polluted by landfill leachate, shows that there is an inadequate natural barrier between the landfill and the groundwaters of concern. While there may be "low" permeability clay between the base of the landfill and the uppermost aquifer, this clay will only slow down the transport of waste-derived constituents that penetrate the liner system into the underlying aquifer system.

Typically there is insufficient investigation of the characteristics of the geological formations underlying the landfill cells to justify that there are no higher permeability

pathways through the clay layer that would more rapidly transport leachate-associated constituents from the base of the landfill to the underlying aquifer system. It has been the authors' experience that while landfill applicants and their consultants often claim, based on a somewhat cursory examination of the characteristics of a low-permeability clay layer that underlies an existing or proposed landfill cell, that the layer is a barrier to leachate transport, frequently a more comprehensive study of the potential for transport of leachate through the layer shows that it could be much more rapid than originally predicted.

While at some locations, an underlying aquifer is somewhat confined with the result that there is a reported upward groundwater gradient (piezometric surface) which would retard the movement of leachate-containing waste constituents through the clay layer, such a situation, if it is a real barrier to leachate migration, cannot be relied on to prevent the downward migration of leachate into the waterbearing strata. The location of the piezometric surface for the confined uppermost aquifer cannot be assured to remain in its current position for as long as the wastes in the landfill represent a threat. That position is determined by a variety of factors, such as climate-precipitation, groundwater use, etc. To assert that a situation that exists today governing the position of the uppermost aquifer's piezometric surface will always be the situation during the infinite period of time that the wastes in the existing landfill or proposed landfill continued operation will be a threat is inappropriate. Climate change and/or altered groundwater pumping situations could readily significantly change the hydraulic gradient between the base of the landfill and the waterbearing strata underlying the landfill that is considered to be the uppermost aquifer.

Another factor to consider in evaluating the so-called isolation of the uppermost aquifer from the base of the landfill is that in low-permeability clay systems the major transport mechanism may be diffusion control rather than advective control. Diffusion, while slow, will transport leachate-derived constituents through the clay layer, eventually polluting the underlying aquifer system. Often, landfill applicants and their consultants and the regulatory agency personnel ignore the fact that for low permeability clay, diffusion is a more important mechanism for pollutant transport than advection. Diffusion becomes dominant as a transport mechanism for clay layers with advective transport of less than about 10^{-8} cm/sec.

There is potential for the sandy lenses that occur in geological strata in clay layers to serve as a conduit for more rapid transport of leachate than is now predicted. In addition, there could readily be cracks, fissures or other high permeability pathways through the low permeability layer underlying landfill which would enable leachate to reach the underlying aquifer system more rapidly than currently predicted by the landfill applicant. Further, because of the frequent limited permeability testing and the way the permeability tests are often conducted, it is likely that the permeability of the underlying strata is at some locations somewhat higher than those reported by the applicant.

There is also a potentially significant problem with a high groundwater table present in the surficial sands/soils located around some landfills. This groundwater will likely be a

source of moisture entering the waste management cells at sometime in the future which could lead to increased leachate generation. Further, the surficial sand/soil aquifer system that occurs near some landfills provides a possible pathway for leachate to leave the waste management cell and inter surface waters of the region.

With few exceptions, it is the authors' experiences that existing or proposed landfills are located at hydrogeologically unsuitable sites for the proposed type of landfill since leachate that escapes from this landfill will lead to groundwater pollution, impairing its use and thereby violating US EPA's and state landfilling regulations.

Deficiencies in Proposed Landfill Design

RCRA Subtitle C requires the use of a double composite liner as a primary component in the waste containment system. Typically, the proposed approach for design of a landfill conforms to minimum design requirements set forth in the US EPA's and a state's hazardous waste landfill liner design requirements. However, as discussed in the literature cited below, double composite liners of the type that a landfill applicant has proposed and a state and the US EPA have accepted, based on the permitting of similar landfills at other locations, are well-known to leak leachate at the time of construction, and ultimately the liner will deteriorate to the point where it will be an ineffective barrier for transport of leachate through it on its way toward the groundwater resources hydraulically connected to the landfill that could be used for domestic water supply purposes at any time in the future.

The US EPA (1988a) as part of promulgating RCRA Subtitle D regulations in which the Agency proposed to adopt a single composite liner of the type that is typically used today, stated,

"First, even the best liner and leachate collection system will ultimately fail due to natural deterioration, and recent improvements in MSWLF (municipal solid waste landfill) containment technologies suggest that releases may be delayed by many decades at some landfills."

The US EPA's "Criteria for Municipal Solid Waste Landfills" (US EPA, 1988b) stated,

"Once the unit is closed, the bottom layer of the landfill will deteriorate over time and, consequently, will not prevent leachate transport out of the unit."

The Subtitle D single composite liner is essentially the same with respect to materials of construction as the liner systems that are used in Subtitle C double composite liner systems. The US EPA 1988 assessment of the ability of a minimum Subtitle D single composite liner to prevent groundwater pollution by landfill leachate is still applicable today. If anything, today there is more widespread general recognition that a single or double composite lined "dry tomb" landfilling will not protect groundwaters from pollution by landfill leachate for as long as the wastes in the landfill will be a threat. It is important to understand the situation that occurred in the 1980s when Subtitle D was

proposed. US EPA found itself in a difficult situation of environmental groups filing suit against the Agency for not promulgating the Subtitle D regulations in accord with legislative requirements. Further, some members of Congress were bringing considerable pressure on the Agency to develop some kind of Subtitle D requirements. Yet the Agency staff understood the single composite liner system would at best only postpone when groundwater pollution occurs. This was not a new realization of the deficiencies in a single composite liner system. Several years prior to that time several states, such as New York and New Jersey, had, on their own initiative, adopted double composite-lined landfills for municipal solid wastes. Therefore, it may be concluded that by 1990, there was widespread general realization that ultimately a single and/or double composite-lined landfill of the type that was being developed then and today would ultimately fail to collect leachate generated within the landfill, and, thereby, lead to groundwater pollution.

It is important to understand that the inherent problems with today's landfills evolved out of the approach that was adopted in the early 1980s by environmental groups who, through work with Federal Congress, got Congress to dictate to the US EPA how to design a hazardous waste landfill. Environmental groups were concerned the Agency was not going to develop adequately protective hazardous waste landfills. Based on what was known at that time, the "dry tomb" type of landfilling evolved where the wastes were to be enclosed in plastic sheeting and compacted clay liner system. The Congress' re-authorization of RCRA in the 1980s was highly unusual in that normally federal regulations dictate a performance standard for protection of the environment and require that the US EPA develop national standards for landfilling of wastes that would achieve the performance standard. This is not the approach that was adopted in the early 1980s and is not the approach that exists today. While many within the US EPA recognize the significant problems with Subtitle C and D landfill liner systems and groundwater monitoring systems of protecting groundwaters from impaired use for as long as the wastes in the landfill will be a threat, the Agency is trapped into basically flawed regulations, where today it is recognized that the dictated minimum landfill liner design will not be protective.

While the Agency and states could adopt more appropriate landfill containment system designs than the minimum Subtitle C or D, there is tremendous legislative and other political pressure by those who want to keep the initial cost of landfilling artificially low by opposing any improvement in landfill design which would be more costly. A prime example of this situation occurs in California. It has been recognized for many years in this state that the minimum landfill liner system the State Water Resources Control Board adopted in its landfill liner design in 1984, as well as the current minimum design of a Subtitle D single composite liner, will not meet the performance standards set forth in Chapter 15 of protecting groundwaters from impaired use by waste-derived constituents for as long as the wastes in the landfill represent a threat. Yet, the State Water Resources Control Board has been and apparently continues to be unwilling to adopt, as a minimum, a double composite landfill liner system for MSW. There are at least half a dozen states in the US today that officially recognize the deficiencies in a single composite liner in preventing groundwater pollution.

The political pressure to not change current landfilling approaches for hazardous waste and municipal solid waste comes from industry, commercial establishments, chambers of commerce, public works directors, and others whose interests are primarily focused on short-term economic issues at the expense of the true cost of landfilling by today's "dry tomb" landfills, which must include the long-term cost associated with perpetual ad infinitum care, and unless significant changes are made in the closure of Subtitle C and D landfills of the type being developed today, the inevitable groundwater cleanup and waste site remediation (Superfund).

Lee and Jones (1992) have conducted a review of the literature on what is known about the properties of flexible membrane liners and clay liners to prevent landfill leachate from passing through them for as long as the waste in the landfill will be a threat. Lee and Jones-Lee (1996a) have recently brought the 1992 review up to date discussing some of the more recent work on this topic in the context of predicting whether an existing or proposed landfill will pollute groundwater by landfill leachate for as long as the waste in the landfill represent a threat. They conclude that these types of liner systems, while possibly providing short-term protection of groundwater quality, are not reliable for long-term protection and will ultimately fail to prevent leachate from passing through them.

Hsuan and Koerner (1995) have reported on the initial phase of long-term (10-year) studies that are underway on examining the rates of deterioration of flexible membrane liners. The focus of Hsuan and Koerner's work is on the breakdown of the polymers in the plastic sheeting liners. They predict that this breakdown will occur due to free radical polymer chain scission in 40 to 120 years. These estimates are indicated by Koerner to consider only some of the mechanisms that could cause breakdown. It is possible that breakdown could begin much earlier. Even if the breakdown of the plastic sheeting polymers took 100 years or so, there is still no question that ultimately the plastic sheeting in the flexible membrane liners will break down, leading to an inability to prevent leachate from passing through it, causing groundwater pollution in the area. It is also evident from current estimates of the rates of breakdown of the plastic sheeting liners that these liners will, if properly constructed, likely function effectively through the 30 year post-closure period. When this period is added to the normal active life of a landfill of 20 to 30 years, it is likely that the plastic sheeting liners will just get the landfill owner past the mandatory minimum post-closure period. If, at that time, the regulatory agencies sign off on no further need for post-closure care, the public in general will be in the same position as they are today of there being no funds available to address the water pollution that will inevitably occur at many of today's Subtitle C and D landfills.

An area of growing concern with respect to plastic sheeting-lined landfills is that dilute aqueous solvents can permeate through an intact, without holes, HDPE liner. This is a chemical transport process in which the low molecular weight organics dissolve into the liner and exit on the downgradient side. Sakti, et al., (1991) and Park, et al. (1996a,b) have reviewed the available information on this topic and have conducted excessive research on it. They found that an HDPE liner would have to be over an inch thick to prevent permeation of certain organics through it within a period of 25 years. Buss, et al. (1995) has recently reviewed the information on the mechanisms of leakage through

synthetic landfill liner materials. They discuss the importance of permeation of organics through plastic sheeting liners as a landfill liner leakage mechanism that does not require deterioration of the liner properties. This is an issue that is typically not addressed by landfill applicants and/or regulatory agencies that can be important for rapid penetration of organic solvents through plastic sheeting liners. Such permeation could lead to rapid significant groundwater pollution since the organic solvents of concern are highly mobile and persistent in aquifer systems, and many of them are known are suspected human carcinogens that can cause cancer in man at low concentrations.

Reliable Reporting on FML Properties. One of the problems with addressing the ultimate breakdown of the liner system is the failure of landfill applicants and their consultants to reliably report on the long-term stability problems with flexible membrane liners. There are several examples in the literature such as Fluet et al. (1992), Tisinger and Giroud (1993) and Flood (1994) where individuals who work for landfill applicants inadequately and/or unreliably report on the ultimate breakdown of flexible membrane liners. As discussed by Lee and Jones-Lee (1993a), a common approach used by landfill consultants is to claim that the liner system will be "protective." However, they fail to discuss their definition of the duration of time in which they will be protective and fail to mention the fact that, ultimately, this protective definition they use will result in groundwater pollution beyond the time they are considering to be of significance. Often this time is considered to be only 30 years beyond the closure of the landfill.

Freeze and Cherry (1979) of the University of British Columbia and the University of Waterloo, respectively, in their book, Groundwater, discuss that landfills developed in the Roman Empire about 2,000 years ago are still producing leachate. Belevi and Baccini (1989), two Swiss scientists who have examined the expected contaminating lifespan of Swiss landfills, have estimated that Swiss landfills will leach lead from municipal solid wastes at concentrations above drinking water standards for over 2,000 years. Additional discussion of the long-term liabilities associated with municipal solid waste and hazardous solid waste landfills is provided by Lee and Jones-Lee, 1994a "Landfilling of Solid & Hazardous Waste: Facing Long-Term Liability" and Jones-Lee and Lee, 1993 "Groundwater Pollution by Municipal Landfills: Leachate Composition, Detection and Water Quality Significance."

While the latter paper focuses on municipal solid waste landfills, similar issues arise and situations occur for hazardous waste landfills. Whether lead or some other hazardous/deleterious chemical is in a "dry tomb" type municipal solid waste landfill or "dry tomb" type hazardous waste landfill does not, for many constituents, affect the overall period of time that the constituent will be hazardous in that type of landfill.

Deficiencies in Landfill Groundwater Monitoring Systems

While typically landfill applicants and their consultants assert that the groundwater monitoring system for a landfill will detect groundwater pollution by landfill leachate before widespread pollution occurs, in fact, when critically examined, it can be readily ascertained that the proposed groundwater monitoring system will not be effective in

detecting pollution of groundwater by landfill leachate before widespread pollution occurs. Dr. Cherry (1990) of the University of Waterloo was the first to point out that typical groundwater monitoring systems involving vertical monitoring wells spaced at hundreds of feet apart around a landfill have a low probability of detecting leachate leakage from the landfill that can pollute groundwater before widespread pollution occurs.

Dr. Jones-Lee and the author published a review article on this topic in which they have utilized Cherry's findings to point out that minimum Subtitle C (hazardous waste) and D (municipal solid waste) landfills that utilize typical vertical monitoring wells will not be reliable for monitoring landfill pollution of groundwaters by the landfill before widespread pollution occurs (Lee and Jones-Lee, "A Groundwater Protection Strategy for Lined Landfills," 1994b). This situation is easily understood by the fact that the initial leakage through the flexible membrane liner of the composite liner for a minimum design Subtitle C landfill or the equivalent, can initially leak through holes, rips, tears or points of deterioration within the flexible membrane liner. Such leaks will produce finger plumes of limited dimensions compared to the spacing of groundwater monitoring wells. Groundwater monitoring wells of the type typically used will have zones of capture of about one foot on each side of the well.

The senior author has found that many landfill applicants space the primary groundwater monitoring wells at about 400 feet apart at the down groundwater gradient edge of the waste management unit. This means that the finger-like leachate plumes produced from the initial leakage through the flexible membrane liner of a landfill could readily fail to be detected by the monitoring wells. There is a space of about 398 feet between the monitoring wells through which the finger plumes of leachate, which could be on the order of a few feet wide at the location of the monitoring wells, could pass and never be detected.

The deficiencies in groundwater monitoring in lined landfills are not new. In addition to the reports by Cherry (1990), Parsons in Davis (1992) discussed these issues in an ASTM symposium proceedings, Current Practices in Ground Water and Vadose Zone Investigations. They point out that for reliable monitoring of groundwaters, the zones of capture of the monitoring wells must intersect the leachate plumes at the point of compliance for groundwater monitoring. Since the zones of capture of a typical Subtitle C or D monitoring well is about one foot on each side of the well, and since the width of the leachate plumes at the point of compliance for groundwater monitoring may only be a few feet wide, it is obvious that today's groundwater monitoring of lined landfills is fundamentally flawed and provides little possibility of detecting leachate leakage through the liner system before widespread pollution occurs.

As discussed in the authors' review of this issue, (Lee and Jones-Lee, 1994b) the groundwater monitoring approach of the type that is typically used is a fundamentally flawed technological approach for protecting groundwaters from pollution by landfill leachate. This means that the normal groundwater monitoring approach associated with Subtitle C and D landfills for monitoring groundwater pollution by leachate that passed

through the liner system could readily fail to be detected by the monitoring wells. This leachate would eventually likely be detected in off-site production wells. By then there would be widespread pollution of groundwaters by the leachate.

Burden of Proof for Groundwater Quality Protection Should Be on the Landfill Applicant

A review of a typical landfill application shows that the applicant and the regulatory agencies for approving these applications adopt the approach of placing the burden for critical review of the deficiencies in the landfill location, design, operation, closure and post-closure care on the public, who would be potentially adversely impacted by the landfill. The landfill applicant should have provided a critical, in-depth review of the reliability of the landfill containment system and groundwater monitoring systems to protect public health, groundwater resources and the environment from pollution by landfill leachate for as long as the waste in the landfill will be a threat.

It is important that as part of developing a landfill or the relicensing of a landfill for continued operations, the landfill applicant should be required to convincingly demonstrate that the landfill will be sited, designed, constructed, operated, closed and provided with post-closure care such that it will protect the groundwater resources, public health, environment and the interests of those within the sphere of influence of the landfill for as long as the wastes in the landfill represent a threat. As discussed herein, for planning purposes, the wastes that are proposed for deposition in today's hazardous waste landfills and municipal solid waste landfills should be considered a threat to public health, the environment and groundwater resources forever.

If there are questions about any particular landfill being appropriately sited, designed, constructed, operated and closed and whether there will be adequate post-closure care funding and implementation for as long as the wastes represent a threat, i.e., forever, then the landfill should not be developed, allowed to continue to operate or be expanded. Those who own or use properties near landfills should be protected from adverse impacts of the landfill. This will require that those who generate wastes that are placed in a landfill pay the true cost associated with landfilling the wastes and not pass these costs, health and environmental threats and groundwater resource losses on to the public within the sphere of influence of the landfill.

In those situations where there is inadequate information to evaluate whether a landfill will be protective, it is appropriate to err on the side of protection of public health, the environment and the interests of those who live or utilize properties near landfills rather than on the side of cheaper-than-real-cost waste disposal. As discussed in the Lee and Jones-Lee (1996a) report, "Evaluation of the Potential for a Proposed or Existing Landfill to Pollute Groundwaters," a properly conducted risk/hazard assessment should be developed for each landfill to determine the potential for the landfill to pollute groundwaters with waste-derived constituents for as long as the waste in the landfill will be a threat.

Further, there is need to recognize the technical invalidity of the approach of claiming that meeting the minimum containment system component design requirements and groundwater monitoring requirements is adequate to enable the landfill owner to continue to operate the landfill. Rather than the superficial review involving a mechanical comparison between the minimum regulatory requirement for a particular component of the landfill containment and monitoring system, such as the installation of a minimum of three monitoring wells along the downgradient edge of the waste management unit, as is typically followed and approved by state regulatory agencies and the US EPA, the applicant, as well as the regulatory agencies, should critically examine the reliability of only utilizing three monitoring wells along the downgradient edge of the landfill as a basis for detecting leachate pollution of the groundwaters in accord with current regulatory requirements covering public health, groundwater resource and environmental protection. In most cases the critical in-depth review of the reliability of a landfill groundwater monitoring system would show that the system has a poor reliability and obviously cannot conform to regulatory requirements. The same situation applies to the liner systems, leachate collection and removal system, leak detection system, etc.

Extrapolating Current Experience of Leachate Leakage/Groundwater Pollution from and Existing Landfill Cell

Sometimes landfill applicants and regulatory agencies attempt to justify the continued operation of a landfill based on the observation that the groundwater monitoring and leachate leakage detection systems that have been used for the existing landfill cells have thus far not detected leachate leakage or groundwater pollution from these cells. The basic reasoning (no pollution of groundwaters by landfill leachate has yet been detected) that is being used to support continued operation of a landfill is fundamentally flawed for several reasons. These issues are discussed below.

Travel Time of Leachate. In low-permeability strata underlying a landfill have a finite period of time that is needed for leachate to move from the edge of the landfill containment system, if there is any, to the point of detection. It is appropriate to inquire whether there has been sufficient time for leachate migration from the waste deposition areas to the leak detection areas to enable a reliable conclusion to be developed that there is no migration of leachate from the landfill cells. For some landfills, it is likely that there has not been sufficient time at the existing landfill cells for leachate to have moved the required distance so that it has been detected by the detection systems used.

The burden of proof for investigating this situation should be on the applicant and the regulatory agencies, not on the public. Such an investigation should be conducted before it is claimed, as has been done by the regulatory agencies' staff, that the landfill's continued operation application should be approved, since no pollution has been found from the existing waste management cells.

Unreliable Groundwater Monitoring. One of the primary reasons why the pollution of groundwaters by an existing landfill has not been detected is that the method of detection of groundwater pollution involves vertical monitoring wells spaced hundreds of feet apart

near the downgradient edge of the landfill. These monitoring wells have zones of capture into the aquifer of about one foot based on a three borehole volume purge of the well before sampling. This same situation applies to the suction cup lysimeters that are sometimes used at landfills. These devices have limited zones of capture compared to the area through which leakage could occur. Basically, unless there is widespread general leakage throughout the bottom of the landfill liner system, the plumes that are generated from initial leakage would not likely be detected by the groundwater monitoring wells or the suction cup lysimeters.

As discussed above, Parsons and Davis (1992) have discussed the approach that should be used to develop reliable groundwater monitoring systems for lined landfills. Basically, the zone of capture of the monitoring wells at the point of compliance for groundwater monitoring must be of such dimensions (lateral extent) so as to intersect the leachate plumes that arise from leaks through the liner system. This would require that monitoring wells that could detect leaks through the liner system that arise near the down groundwater gradient edge of the landfill waste management unit be no more than a few feet apart.

There may be an attempt to argue that leaks through the upper composite liner would be detected by the leak detection system between the two composite liners, and, therefore, the unreliability of the groundwater monitoring system to detect leaks through the liners is of no consequence in protecting groundwater quality. However, such an argument is not technically valid for the period of time that the waste in the landfill will be a threat. The key component of the leak detection system between the two composite liners is the plastic sheeting flexible membrane liner which serves as the upper component of the lower composite liner. It is this component that conveys leachate that passes through the upper composite liner to a sump where the presence of leachate in the leak detection system can be assessed.

Ultimately, however, the flexible membrane liner base of the leak detection system will deteriorate to the point where it is no longer an effective barrier to leachate passing through it. Under these conditions, the leaks that occur through the upper composite liner will enter the leak detection system and pass through it into the lower composite liner without being detected in the leak detection system.

From an overall perspective, the leachate leakage detection system and the groundwater pollution monitoring system that are used at Subtitle C landfills for existing waste management cells are unreliable in detecting leachate leakage from these cells at this time. Leakage of leachate has almost certainly been occurring from the existing cells that has not yet been detected.

Regulatory Requirements

The first step in reviewing an existing or proposed landfill is to examine the regulatory requirements for the landfill. This section summarizes typical state and federal regulatory requirements covering the development and operation, continued operation, and

expansion of a hazardous waste landfill. The state of Michigan regulations are used in this discussion. They are typical of the regulatory requirements adopted by states. In general, these requirements must be at least as protective as minimum US EPA RCRA Subtitle C.

The state of Michigan's Administrative Rules Promulgated Pursuant to Michigan's Hazardous Waste Management Act 1979 PA 64, as Amended (Act 64) which became effective June 18, 1994 provide the regulatory basis governing the continued operation of existing landfill in the state. Excerpts from these regulations that are pertinent to examining the appropriateness of the continued operation of a landfill are presented below.

"R 299.9504 Construction permit application; content.

Rule 504. (1) In addition to the information that may be required by subrule (16) of this rule, all applications for a construction permit shall include all of the following items:"

"(e) An environmental assessment, including a failure mode assessment that provides an analysis of the potential major methods by which safe handling of hazardous wastes may fail at a treatment, storage, or disposal facility. The owner or operator of a facility that stores, treats, or disposes of hazardous waste in a surface impoundment or a landfill shall include, in the environmental assessment, information that is reasonably ascertainable by the owner or operator on the potential for the public to be exposed to hazardous wastes or hazardous constituents through releases related to the unit. At a minimum, the information shall address all of the following subjects:

(i) Reasonably foreseeable potential releases from both normal operations and accidents at the unit, including releases associated with transportation to or from the unit.

(ii) The potential pathways of human exposure to hazardous waste or constituents resulting from the releases described in paragraph (i) of this subdivision.

(iii) The potential magnitude and nature of the human exposure resulting from the releases described in paragraph (i) of this subdivision."

It is the authors' experience that environmental assessments for existing landfills are typically superficial, self-serving documents generated by the landfill applicant and/or its consultant. After reviewing over a dozen of these, the author has failed to find a single environmental assessment for a proposed or existing landfill that would comply with the state of Michigan requirements set forth above.

"R 299.9518 Operating license denial

Rule 518. (1) The director shall deny an application for an operating license if the operation of the treatment, storage, or disposal facility for which the license is sought will violate the act of these rules.

(2) The applicant is on notice that, in addition to any other of these rules, the director shall deny an operating license application if any of the following occur:"

"(b) The existing construction or operation of an existing facility or facility newly subjected to the licensing requirements of the act and these rules presents a hazard to the public health or the environment.

(c) The applicant has not submitted sufficiently detailed or accurate information to enable the director to make reasonable judgments as to whether the license should be granted."

The regulatory agency director can, and in many cases should, deny the application for continued operation of a landfill based on the fact that waste placed in this landfill will be a significant hazard to public health and the environment. Further, regulatory agency directors can usually readily justify denying a landfill application for renewed operation of a landfill site based on the landfill failing to provide sufficiently detailed and accurate information to enable the director to make a reasonable judgment on the potential threat that this landfill represents to public health and to the environment.

"R 299.9519 Modification, revocation, and suspension of construction permits and operating licenses during their terms.

Rule 519"

"(4) Suitability of the facility location shall not be considered at the time of construction permit or operating license modification, suspension, or revocation unless new information or standards indicate that a threat to human health or the environment exists which was unknown at the time of license issuance. In addition, the director shall not modify a construction permit beyond what is authorized in the construction permit by the site review board."

"(11) A construction permit or operating license may be revoked for any of the following reasons:"

"(b) A determination that the licensed activity endangers human health or the environment.

(c) The owner or operator fails in the application or during the construction permit or operating license issuance process to disclose fully all relevant facts or at any time misrepresents any relevant facts."

This section provides the authority for a regulatory agency director to revoke an operating license based on new information on the ultimate failure of liners to prevent groundwater pollution and the inadequacies of the groundwater monitoring system that exists now that was not well understood at the time of the original licensing.

"R 299.9602 Environmental and human health standards generally.

Rule 602. (1) All treatment, storage, and disposal facilities shall be located, designed, constructed, and operated in a manner that will prevent all of the following:"

"(d) Exposure of humans or the environment to harmful quantities of hazardous waste or hazardous waste constituents.

(e) Pollution, impairment, or destruction of the natural resources of the state."

This section establishes the overall standard for continued operation of a landfill. In some situations, the proposed landfill continued operation cannot conform to the requirements of protecting people and the environment from harmful quantities of hazardous waste and waste constituents. Further, for some sites the continued operation of the landfill will likely cause pollution, impairment and destruction of state's natural resources.

"R 299.9603 Location standards.

Rule 603. (1) Active portions of new treatment, storage, or disposal facilities or expansions, enlargements, or alterations of existing facilities shall not be located in any of the following areas:"

"(5) Landfills, surface impoundments, and waste piles shall only be located in areas where there is not less than 6 meters of soil with a maximum permeability of 1.0 x 10^{-6} cm/sec at all points below and lateral to the liner or bottom of the landfill, surface impoundment, or waste pile, unless the owner or operator substitutes an engineered backup liner of equivalent design and demonstrates to the director that it provides equivalent environmental protection."

Failing to conform to this section's requirements represents one of the significant deficiencies in the current landfilling regulations in that it allows individuals who want to site a landfill at an inappropriate location to do so by claiming that they meet the minimum location requirements of Act 64. It is important to note, however, that the location standards set forth above do not state that these minimum requirements are necessarily protective. As discussed, the purpose of the regulations is to protect public health, groundwater resources and the environment from pollution from landfill leachate for as long as the waste in the landfill represent a threat. Since the waste in a landfill will be a threat effectively forever, providing for a few tens of years of transport time through a geological strata that has a maximum permeability of 1.0 x 10^{-6} cm/sec is obviously not protective. The 40 year value is derived from the fact that under one foot of head, 10^{-6} cm/sec represents about one foot per year of leachate transport through 18 meters strata.

A regulatory agency staff member that reviews a particular landfill should (must) evaluate whether the location provides for true protection of public health, groundwater resources, the environment or simply postpones when pollution occurs. In many situations, the landfill site does not provide for true protection but at best, postpones for a

few tens of years when pollution occurs. Because of this situation, many sites do not conform to the overall groundwater protection standards set forth within Act 64 of preventing pollution by waste derived constituents.

"R 299.9604 Facility design and operating standards.

Rule 604. (1) The owner or operator of a treatment, storage, or disposal facility shall design, construct, operate, and maintain all of the following:"

"(c) Systems to prevent hazardous waste or hazardous waste constituents from escaping into the soil, directly or indirectly into surface water or groundwaters, or uncontrolled into drains or sewers."

This section explicitly indicates that a landfill shall be designed and operated to prevent the escape of hazardous waste constituents from the landfill unit. There is no time limitation on this requirement. Many landfills cannot conform to this requirement. At best, they only postpone for a period of time when escape of constituents in the waste from the landfill will occur.

"R 299.9611 Environmental monitoring.

Rule 611. (1) An owner or operator of a hazardous waste treatment, storage, or disposal facility shall develop an environmental monitoring program that is capable of detecting a release of hazardous waste or hazardous waste constituents from the facility."

This section provides the regulatory basis for concluding that a landfill's proposed groundwater monitoring system and the regulatory agency approval of this system is inappropriate. A groundwater monitoring system that has a low probability of detecting when releases of waste occur at the point of compliance cannot conform to the requirements set forth in this section.

"R 299.9613 Closure and post-closure.

Rule 613. (1) The owner or operator of a hazardous waste treatment, storage, or disposal facility shall comply with the closure and post-closure provisions of 40 C.F.R. part 264, subpart G, except 40 C.F.R. 264.112 (d) (1), 264.115, and 264.120."

This section establishes the regulatory basis for requiring that a landfill be properly closed and that proper post-closure care be required for as long as the waste in the landfill will be a threat.

"R 299.9619 Landfills.

Rule 619. (1) Owners or operators of facilities that use landfills to dispose of hazardous waste shall comply with the design and operating requirements of 40 C.F.R. part 264, subpart N.

(2) In addition to the liner system requirements of 40 C.F.R. 264.301, the owner or operator of a landfill shall design the liner system to meet the requirements of R 299.9620.

(3) All landfills shall contain a leak detection, collection, and removal system beneath the liner system that is designed, constructed, operated, and maintained in accordance with the provisions of R 299.9622, unless the landfill is exempted pursuant to the provisions of R 299.9622."

"(5) In addition to the closure and post-closure care requirements of 40 C.F.R. 264.310, the owner or operator of a landfill shall do all of the following with respect to closure and post-closure care:

(a) Close the facility so that the final cover includes both of the following:

(i) Compacted clay which is in compliance with the requirements of R 299.9620 (3) and which is not less than 90 centimeters thick.

(ii) Not less than 60 centimeters of additional material, such as topsoil, subsurface drainage media, or cobbles to prevent animal burrowing. The additional material shall be applied in a manner that protects the clay and any synthetic component from the effects of temperature, erosion, and rooted vegetation. For temperature protection, the additional material thickness shall equal not less than 60 centimeters or the maximum depth of frost penetration, whichever is greater."

This section establishes several minimum design requirements for the landfill containment system. At no place does it indicate that these minimum design requirements will be protective. Any landfill applicant who develops a landfill must develop a landfill that is protective of public health, groundwater resources, the environment and those within the sphere of influence of the landfill for as long as the wastes in the landfill will be a threat. A landfill, while meeting minimum design requirements, will not necessarily be protective as long as the waste in the landfill will be a threat. Therefore, the design of landfills often does not conform to the groundwater protection standard set forth in Act 64 and should not be relicensed.

"R 299.9622 Leak detection systems.

Rule 622. (1) Each new unit and lateral expansion or replacement of an existing unit at a landfill, surface impoundment, waste pile, or land treatment facility shall include a leak detection system capable of detecting leaks of hazardous constituents at the earliest practicable time.

(2) If contamination is detected in the leak detection system required by this rule, the owner or operator shall do all of the following:"

"(c) If failures have occurred, do either of the following on a schedule which insures the protection of human health and the environment:

(i) Repair the failures in the liner system and obtain the certification of a registered professional engineer that, to the best of his or her knowledge and opinion, the failure has been corrected.

(ii) Cease placing waste in the failed unit and take action to prevent the migration of hazardous waste and hazardous waste constituents from the facility."

This section requires the operation and maintenance of the leak detection system for as long as the wastes in the landfill are a threat. Typical landfill applicants only proposes to provide post-closure care for 30 years. State regulatory agencies and the US EPA do not necessarily establish in the permit an assured funding mechanism that provides a high degree of reliability that the leak detection system requirements set forth above will be carried out for as long as the waste in the landfill will be a threat.

The requirements set forth in this section will likely require waste exhumation in order to replace the flexible membrane liner when it deteriorates to the point where it is no longer an effective base of the leak detection system. This could occur during the post-closure period, year 31 after closure, year 50, 100, 200, etc. The waste in this landfill will still be a threat at that time. It is, therefore, essential that sufficient funds be made available in the dedicated trust fund to carry out the requirements set forth in this section for the leak detection system. A landfill should not be licensed/permitted unless there is a high degree of reliability that the leak detection system can, in fact, be maintained in accord with the requirements set forth above for as long as the waste in the landfill will be a threat.

"R 299.9629 Corrective action.

Rule 629. (1) Owners or operators of facilities that treat, store, or dispose of hazardous waste shall conduct corrective action as necessary to protect the public health, safety, welfare, and the environment in accordance with a corrective action program approved by the director. The corrective action program shall be conducted as follows:

(a) Owners or operators of facilities that apply for, or have been issued, an operating license pursuant to the provisions of the act shall institute corrective action for all releases of a contaminant from any waste management units at the facility, regardless of when the contaminant may have been placed in or released from the waste management unit."

The corrective action requirements cited above are clear in requiring that a landfill be able to effectively implement corrective action for all releases of waste-derived constituents at any time in the future. There is no 30-year limit on corrective action.

In order to implement the requirements of this corrective action regulation with a high degree of reliability, a landfill owner should be required to develop a dedicated trust fund

of sufficient magnitude that could address all plausible worst-case scenario failures of the landfill containment system for as long as the waste in the landfill will be a threat.

"R 299.9703 Financial assurance for closure and post-closure care.

Rule 703. (1) The owner or operator of each facility shall establish financial assurance for closure of the facility by utilizing the options specified in R 299.9704 to R 299.9709. The owner or operator of each disposal facility shall establish financial assurance for post-closure care of the facility utilizing the options specified in R 299.9704 to R 299.9709."

The US Congress General Accounting Office (GAO 1990) in a report to Congress entitled, "Hazardous Waste Funding of Postclosure Liabilities Remains Uncertain," discussed the fact that current US EPA RCRA regulations do not mandate that the landfill owner/operator will, in fact, provide the necessary funding for post-closure care activities to ensure that the wastes in the landfill do not result in groundwater pollution for as long as the waste components will be a threat.

The GAO has issued a number of other reports on the inadequacies of current hazardous waste management landfilling practices. For example, GAO (1995a) has discussed that 74% of the hazardous waste facilities in the US have had releases to groundwater. The majority of these facilities were constructed prior to the development of the current landfill liner containment systems, and in time the plastic sheeting and compacted clay-lined landfills will also have releases to groundwater. Further, the GAO concluded that many of the hazardous waste facilities did not have adequate groundwater monitoring systems.

The GAO (1995b), in a report to Congress, "Superfund Operations and Maintenance Activities Will Require Billions of Dollars," discusses the fact that on-site management of waste at superfund sites using RCRA landfills and other remediation approaches is not now being adequately and reliably implemented by state and federal regulatory agencies. There are significant questions about who is going to provide the ad infinitum funding that will be required to operate and maintain the on-site hazardous chemical management facilities. There is no assured funding available for this activity. There can be little doubt that today's RCRA landfills will become future Superfund sites and will require funding as part of the billions of dollars that will be needed at these sites.

The GAO discusses in their 1995b report that many state regulatory agencies do not have the funds necessary to carry out the mandated regulatory functions of inspection and periodic reevaluation of the adequacy of the remediation of a site needed to ensure that the site is not a significant threat to public health, groundwater resources, and the environment. The situation today of inadequate regulatory attention by the US EPA and state regulatory agencies will not likely improve in the future. In fact, if anything, the regulatory agencies will be provided with less funds to ensure that hazardous waste and/or PCB landfills will be adequately and reliably monitored and maintained to meet current regulatory requirements for as long as the waste in the landfill will be a threat.

The GAO review points to a significant problem with current US EPA RCRA Subtitle C regulations, namely that the health, welfare and long-term interests of the public who reside on or use properties within the sphere of influence of a hazardous waste landfill are not necessarily protected under a permit. State landfilling regulations also do not ensure that adequate funds will be available for as long as the wastes will be a threat to protect public health, groundwater resources and the environment from pollution by hazardous waste landfill leachate.

It is important that the interpretation of this regulation require that a landfill owner establish financial assurance that has a high probability of being implemented at any time in the future while the wastes in the landfill are a threat in order to be able to address all plausible worst-case scenario failures of the landfill containment system for as long as the waste in the landfill will be a threat. Hickman (1992, 1995) has discussed the importance of using a dedicated trust fund as the financial assurance instrument for landfills. As he points out, all other financial instruments have uncertainties as to whether or not they will be available when needed during the post-closure care period.

The typical 30-year post-closure fund associated with both hazardous and non-hazardous waste landfills is deficient compared to the funds that will likely be required during the 30-year period, much less the infinite period of time that funds will be needed to address contingencies that will ultimately have to be addressed at the landfill. An important aspect of this situation is whether private landfilling companies will, in fact, be economically viable in the future when the funds will be needed--20, 50, 100 or so years from now. As discussed by Lee and Jones-Lee (1993b, 1994a), private landfilling companies are accruing massive liabilities that ultimately will cause these firms' stockholders to sell their stock, making the firms financially unstable, ultimately leading to their bankruptcy. This past year, at the annual meeting of the Waste Management of North America Stockholders, the WMX CEO, D. Buntrock, noted that WMX was losing money on its hazardous waste management business. D. Buntrock is quoted in the Chicago Tribune as stating at this meeting, "Most of us in the company wish today we never heard of the business."

Situations such as this give little confidence that landfill companies will, in fact, meet their long-term obligations associated with post-closure care of landfills. Some states, such as South Carolina, are beginning to address this issue by requiring that waste management companies post cash bonds to address long-term landfill contingencies. It is important that the financial instrument used to provide post-closure care not be dependent on the solvency of the company. It is for this reason that dedicated trust, established at the time of landfill operation, be available to address routine maintenance and monitoring, as well as all plausible worst-case scenario failures associated with the landfill's operation, closure and post-closure care.

While generally today, regulatory agencies are not adequately addressing the long-term issues associated with municipal and hazardous waste landfills ultimately failing to protect public health, groundwater resources and the environment from waste derived constituents, there is growing recognition of the deficiencies of current regulatory

approaches where the minimum landfill design for Subtitle C and D landfills is recognized as being badly out of date and not protective of public health and the environment for as long as the wastes in the landfill will be a threat. An encouraging situation recently developed in the state of Indiana where the Hazardous Waste Facility Siting Authority reviewed a Chemical Waste Management of Indiana proposal to expand a hazardous waste landfill where it became clear that ultimately that landfill would pollute groundwaters of interest to the city of New Haven, which is located immediately adjacent to this landfill. The Siting Authority concluded in an eight-to-one vote that the landfill should not be expanded, even though it met minimum design requirements, because of its potential to ultimately pollute groundwaters of interest to New Haven, Indiana.

"R 299.9712 Cost estimate for corrective action.

Rule 712. (1) The owner or operator of a facility who is required to perform corrective action pursuant to the provisions of the act or these rules shall have a detailed written estimate, in current dollars, of the cost of performing corrective action at the facility in accordance with the provisions of R 299.9629.

(2) The cost estimate shall be based on the cost of hiring a third-party to complete the corrective action measures required pursuant to the provisions of R 299.9629."

It is typically found that landfill applicants do not adequately comply with this requirement since they do not reliably estimate the cost of performing possible corrective action at any time in the future while the waste in the landfill will be a threat. Further, typically permits issued by state regulatory agencies and the US EPA do not adequately and reliably address this issue. Since this issue is an extremely important part of providing public health, groundwater resource and environmental protection for those in the sphere of influence of the landfill, the permit should not be approved without fully complying with this requirement.

US EPA RCRA Subtitle C Regulations
Code of Federal Regulations
Part 40, July 1, 1995

Subpart C - Characteristics of Hazardous Waste

"261.24 Toxicity characteristic.

(a) A solid waste exhibits the characteristic of toxicity if, using the Toxicity Characteristic Leaching Procedure..."

Table 1, "Maximum Concentration of Contaminants for the Toxicity Characteristic" in this section lists 30 chemicals that are regulated under this provision out of the many tens

of thousands of chemicals that could be hazardous to public health groundwater quality that will be present in the waste that will be deposited in a hazardous waste landfill. Further, these wastes which leach the listed constituents many times drinking water standards, are considered non-hazardous wastes.

This approach was based on an administrative decision by the US EPA in the implementation of RCRA to limit the size of the hazardous waste stream that had to be managed by the agency. It does not reflect a finding that the unregulated chemicals, as well as the regulated chemicals, that are classified as non-hazardous wastes do not represent a significant hazard to public health or to groundwater quality. It is, therefore, important to understand that just because a waste passes the current toxicity characteristic leaching procedure-TCLP test that it is not a significant hazard to public health, groundwater quality and the interests of those within the sphere of influence of the landfill.

The public, potentially impacted by a hazardous waste landfill, is entitled to know the adequacy of the treatment requirements that are being imposed on the landfill operator by the regulatory agencies to protect their health, groundwater resources, the environment, interests and welfare. Those familiar with how environmental quality standards are developed know that they are often based on significant compromises between public health protection and cost. This means that those within the sphere of influence of a source of hazardous chemicals, like a waste treatment facility and/or landfill, can be exposed to hazardous or deleterious chemicals even though the emissions from this facility meet current standards.

As part of the work that the author has done on superfund site and hazardous waste clean-up as well as on drinking water standards development, he has become aware of the deficiencies in developing regulations. In addition to regulatory requirements being compromises, sometimes they are also badly out-of-date and often lag behind knowledge of when the standards need to be updated by many years to tens of years. Lee and Jones-Lee (1994c) published a review, "Does Meeting Clean-Up Standards Mean Protection of Public Health and the Environment," on this issue.

Subpart F - Releases From Solid Waste Management Units

"264.93 Hazardous constituents.

(a) The Regional Administrator will specify in the facility permit the hazardous constituents to which the ground-water protection standard of 264.92 applies. Hazardous constituents are constituents identified in appendix VII of part 261 of this chapter that have been detected in ground water in the uppermost aquifer underlying a regulated unit and that are reasonably expected to be in or derived from waste contained in a regulated unit, unless the Regional Administrator has excluded them under paragraph (b) of this section."

A review of Appendix VII of Part 261 shows that there is a wide variety of constituents that will be present in the waste that will be accepted most hazardous waste landfills that represent threats to groundwater quality that are not classified by the US EPA as hazardous constituents. It is, therefore, important to understand that even if a leachate developed in the landfill does not contain any so-called hazardous constituents based on the US EPA's classification approach, this leachate can be hazardous to public health and significantly detrimental to groundwater quality. The contamination of a well by hazardous waste landfill leachate would likely cause it to have to be abandoned as a domestic water supply source.

"264.97 General ground-water monitoring requirements.

The owner or operator must comply with the following requirements for any ground-water monitoring program developed to satisfy 264.98, 264.99, or 264.100:

(a) The ground-water monitoring system must consist of a sufficient number of wells, installed at appropriate locations and depths to yield ground-water samples from the uppermost aquifer that:"

"(B) Sampling at other wells will provide an indication of background ground-water quality that is representative or more representative than that provided by the upgradient wells; and"

"(3) Allow for the detection of contamination when hazardous waste or hazardous constituents have migrated from the waste management area to the uppermost aquifer."

"(d) The ground-water monitoring program must include consistent sampling and analysis procedures that are designed to ensure monitoring results that provide a reliable indication of ground-water quality below the waste management area. At a minimum the program must include procedures and techniques for:"

The minimum requirements set forth for the groundwater monitoring program are not met by typical hazardous waste landfill groundwater monitoring programs. Further, permits issued by state and federal agencies do not require that the landfill owner develop a credible groundwater monitoring program that would satisfy the above requirements. As discussed herein, the groundwater monitoring programs typically used at hazardous waste landfills are largely cosmetic. They have a low probability of detecting releases from the landfill before widespread pollution occurs. Further, there is typically an insufficient number of wells to comply with the above-listed requirement.

"264.117 Post-closure care and use of property.

(a)(1) Post-closure care for each hazardous waste management unit subject to the requirements of 264.117 through 264.120 must begin after completion of closure of the unit and continue for 30 years after that date and must consist of at least the following:"

This section does not limit the post-closure period to 30 years; it only specifies that 30 years is the minimum period for which post-closure care must be provided. Post-closure care must be provided for as long as the wastes in the landfill will be a threat, not just for 30 years as typical landfill owners and regulatory agencies allow. Lee and Jones-Lee (1992) have discussed the error that was made by Congress in the 1970s in establishing the RCRA 30-year minimum post-closure care period. Those responsible for this value did not understand the difference between landfill gas generation in a classical sanitary landfill and leachate generation in such landfills as well as in "dry-tomb" landfills of the type being developed today. Thirty years is an infinitesimally small part of the total time that highly active post-closure care will be needed if a RCRA Subtitle C landfill is to prevent groundwater pollution by waste-derived constituents.

Subpart N - Landfills

"264.301 Design and operating requirements.

(1) A liner that is designed, constructed, and installed to prevent any migration of wastes out of the landfill to the adjacent subsurface soil or ground water or surface water at anytime during the active life (including the closure period) of the landfill."

(2) A leachate collection and removal system immediately above the liner that is designed, constructed, maintained, and operated to collect and remove leachate from the landfill. The Regional Administrator will specify design and operating conditions in the permit to ensure that the leachate depth over the liner does not exceed 30 cm (one foot). The leachate collection and removal system must be:"

"(1)(i) The liner system must include:

(A) A top liner designed and constructed of materials (e.g., a geomembrane) to prevent the migration of hazardous constituents into such liner during the active life and post-closure care period; and

(B) A composite bottom liner, consisting of at least two components. The upper component must be designed and constructed of materials (e.g., a geomembrane) to prevent the migration of hazardous constituents into this component during the active life and post-closure care period. The lower component must be designed and constructed of materials to minimize the migration of hazardous constituents if a breach in the upper component were to occur. The lower component must be constructed of at least 3 feet (91 cm) of compacted soil material with a hydraulic conductivity of no more than 1 x 10^{-7} cm/sec."

Specifications for the design and operations of the liner system require containment of waste-derived constituents for as long as the wastes in the landfill represent a threat. The typical landfill applicant proposed landfill liner design and proposed approach for closure and providing post-closure care which are approved by state and federal regulatory agencies will not comply with the requirements set forth in this section during the time

that the wastes in the landfill will be a threat. The liner system will eventually deteriorate to the point where it will no longer be effective in preventing waste-derived constituents from leaving the landfill en route to high-quality groundwaters underlying the landfill.

"264.310 Closure and post-closure care

(a) At final closure of the landfill or upon closure of any cell, the owner or operator must cover the landfill or cell with a final cover designed and constructed to:"

"(1) Maintain the integrity and effectiveness of the final cover, including making repairs to the cap as necessary to correct the effects of settling, subsidence, erosion, or other events;

(2) Continue to operate the leachate collection and removal system until leachate is no longer detected;

(3) Maintain and monitor the leak detection system in accordance with 264.301(c)(3)(iv) and (4) and 264.303(c), and comply with all other applicable leak detection system requirements of this part;

(4) Maintain and monitor the groundwater monitoring system and comply with all other applicable requirements of subpart F of this part;"

As discussed herein in connection with review of other requirements, a typical proposed landfill closure and post-closure care approach as well as the approach approved by the US EPA and state regulatory agencies as set forth in the facilities permit do not comply with the requirements for closure and post-closure care set forth in this section. Most hazardous waste landfills should not be permitted without significantly changing the post-closure care requirements and assurance of funding for as long as the wastes in the landfill will be a threat.

Lee and Jones-Lee (1995a) have discussed how properly sited hazardous waste landfills can be closed with appropriate post-closure care to protect public health, groundwater quality and the environment for as long as the waste in the landfill will be a threat. Information on their recommendations is presented in various sections of this report.

Subpart F - Ground-Water Monitoring

"265.91 Ground-water monitoring system.

(a) A ground-water monitoring system must be capable of yielding ground-water samples for analysis and must consist of:

(1) Monitoring wells (at least one) installed hydraulically upgradient (i.e., in the direction of increasing static head) from the limit of the waste management area. Their number, locations, and depths must be sufficient to yield ground-water samples that are:"

"(2) Monitoring wells (at least three) installed hydraulically downgradient (i.e., in the direction of decreasing static head) at the limit of the waste management area. Their number, locations, and depths must ensure that they immediately detect any statistically significant amounts of hazardous waste or hazardous waste constituents that migrate from the waste management area to the uppermost aquifer."

This section explicitly sets forth in (2) above the requirements for development of a credible, highly reliable groundwater monitoring program at the edge of the waste management unit. It is important to note that this section does not state that the minimum of three downgradient wells is sufficient to detect any statistically significant amounts of hazardous waste or hazardous waste constituents at the point of compliance. Typically, the hazardous waste landfill groundwater monitoring program of only installing the minimum number of required wells obviously does not comply with the requirements set forth in this section.

Subpart G - Closure and Post-Closure

"265.111 Closure performance standard

The owner or operator must close the facility in a manner that:

(a) Minimizes the need for further maintenance, and

(b) Controls, minimizes or eliminates, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere,"

This section sets forth the overall requirements for closure and post-closure care.

US EPA Code of Federal Regulations 40, 761 Polychlorinated Biphenyls, Subpart D, "Storage and Disposal."

The regulations governing the landfilling of PCB waste are set forth in part 761.75. Part 761.3 provides a definition of a chemical waste landfill that can be used to dispose of PCBs. Such a landfill is defined as:

"a landfill at which protection against risk of injury to health or the environment from migration of PCBs to land, water, or the atmosphere is provided from PCBs and PCB Items deposited therein by locating, engineering, and operation of the landfill as specified in 761.75"

In general, it is widely recognized that the specific landfilling requirements for PCBs set forth in these regulations are badly out of date and are not necessarily protective. These regulations were originally developed in the late 1970s and have not been significantly updated in some key areas of groundwater quality protection since that time. Even with

this situation, the above landfill definition makes it clear that the performance standard for the landfill is protection against risk of injury to health and the environment from PCB wastes.

Regulatory Authority

One of the issues that frequently arises in the review of hazardous waste, and for that matter municipal solid waste landfills, is that the regulatory agencies staff claim that they do not have the authority to require the landfill owner to go beyond the minimum design requirements. Such statements are inappropriate in that with few exceptions most regulations contain a statement of the overall objectives of the regulations as being protection of public health, groundwater resources and the environment. These regulations do not necessarily state that these requirements are only for a limited period of time. The purpose of landfilling regulations such as those discussed above is to protect public health and groundwater resources from pollution by landfill leachate for as long as the waste remains a threat. While the minimum landfill containment component design requirements set forth in the regulations may be applicable to some sites, they are not universally applicable to all sites or even most sites.

It is important that under conditions where the minimum design requirements are not adequate to protect public health, groundwater resources, the environment, and interest and welfare of those within the sphere of influence of the landfill, that the landfill be sited, designed, operated, closed and receive post-closure care to provide true protection for as long as the wastes in the landfill represent a threat. It is the obligation of the regulatory agency personnel to make known to the public any deficiencies in current minimum regulatory requirements so that the public can work through their elected representatives and the courts to change the regulations so that protection is, in fact, achieved.

Examples of Unreliable Discussions of Issues Pertinent to Hazardous and Solid Waste Landfill Development, Operation, Closure and Post-Closure Care

The authors have participated in many landfill administrative hearings and court proceedings, and they have reviewed many documents developed by landfill applicants and regulatory agencies that are designed to permit the operation of a landfill. This section presents examples of the presentation of unreliable information in the permitting of a hazardous waste landfill.

Landfill Permit Application

The comments presented in this section focus on discussing the deficiencies in a landfill application for the TSCA permit covering the disposal of PCB's in a hazardous waste landfill. These comments have, with few exceptions, direct applicability to a landfill application for continued operation of a hazardous waste landfill.

The application states, *the applicant operates a hazardous waste landfill and is requesting approval from the United States Environmental Protection Agency (USEPA) to allow the disposal of waste containing polychlorinated biphenyls (PCBs) in concentrations equal to or in excess of 50 ppm that are approved for landfill disposal as specified in 40 CFR 761.60 pursuant to the Toxic Substances Control Act (TSCA).*

The applicant states, *TSCA regulations require a liner system to prevent the migration of leachate from the landfill.* The applicant also states, *given the hydrogeologic setting of the landfill and the quality of the material used in the construction of the recompacted clay liner, the liner system at the site complies with, and exceeds, applicable regulations.* The applicant lists as a factor governing the suitability of the site *...natural clay deposits having permeabilities ranging from 4.6 x 10^{-9} to 7.9 x 10^{-8} cm/s*. The applicant states that another reason for permitting the proposed landfill is that it complies with TSCA regulations requiring a clay liner permeability of 1 x 10^{-7} cm/sec or less.

The applicant has difficulty understanding/reliably reporting on the regulatory requirements and the properties of the natural strata and compacted clay liner to *...prevent the migration of leachate from the landfill* and, thereby, conform to the regulations for as long as the PCB's and other hazardous wastes in the landfill will be a threat. Those familiar with the properties of wastes and waste residues of the type that are typically disposed of in hazardous waste landfills and the characteristics of landfill containment systems know that these wastes will be a threat to groundwater quality effectively forever.

The landfill applicant seems to be operating under the misconception that it only has to be concerned about the minimum 30-year post-closure care period specified in RCRA. The facts are that the TSCA regulations require that the landfill have a "*...liner system to prevent the migration of leachate from the landfill.*" There is no time limitation on conformance to this requirement. The only issue that should be considered in performance of the containment system relative to the regulations is, therefore, the ability of the liner system to prevent leachate from passing through it for as long as the wastes represent a threat. The PCB wastes and other wastes placed in this landfill will be a threat to groundwater pollution far longer than the liner system will have sufficient integrity to prevent leachate from migrating through it. As a result, this landfill cannot be permitted for continued operation where it would accept PCB waste. The same problems occur with respect to continuing operation of landfills as RCRA hazardous waste landfills.

With respect to the attempts by the landfill applicant to use the natural strata which is part of the underlying aquifer system as a supplemental barrier to the migration of PCB and other wastes, such an approach is not in accord with regulatory requirements. Even if this were allowed by the regulations, the landfill applicant has provided unreliable information on the properties of the natural strata in preventing leachate migration through the strata. The permeabilities cited are based on laboratory measurements, which often underestimate the permeability of the strata.

Even if the laboratory-measured permeabilities were, in fact, reliable estimates of the actual permeability, the liners and the natural strata will not prevent leachate-containing PCB and hazardous/deleterious waste components from passing through it for as long as the wastes will be a threat.

The landfill applicant presents a discussion of synthetic membrane liners where it is stated that, a*ccording to TSCA regulations, synthetic membrane liners (geomembranes) or composite liners are not mandatory for facilities accepting PCB waste and are required only if necessary because of hydrologic or geologic conditions, to achieve the permeability requirements discussed above in regard to clay soil. Since the clay soil used in the construction of the landfill is less permeable than required under 40 CFR 761.75(b)(1), a geomembrane component would not typically be required as part of the liner design for a TSCA landfill at this site.*

Such an analysis of the regulations represents a superficial approach toward their review. Typically, landfilling regulations establish an overall performance standard such as preventing waste migration through the liner and some minimum containment system design requirements such as the permeability and thickness of clay layers, the need for plastic sheeting liners, etc. The applicant is attempting to convince the regulatory agencies and the public that meeting the minimum design requirements for containment system components meets the overall public health and groundwater protection standards set forth in the regulations. The regulations do not state that meeting the minimum design requirements will be protective. It is up to the applicant and the regulatory agencies to ensure that public health, groundwater quality and the environment are protected from the waste-derived constituents for as long as the wastes are a threat.

It is the responsibility of the applicant and the regulatory agencies to reliably evaluate whether the minimum design requirements or some other design for the containment system components will provide protection. In light of what is known today about the properties of compacted clay and plastic sheeting liners and the ability of natural strata of the type underlying the landfill, the liner system and the natural strata will not protect groundwater quality and public health from waste-derived constituents for as long as the wastes represent a threat. Therefore, the applicant's statements about the need for a synthetic liner membrane, etc. are inappropriate since neither the compacted clay, natural strata or synthetic liners will be protective.

The applicant states, *according to US EPA guidance documents, the clay and the geomembrane in the primary liner work to provide a barrier to any potential migration of leachate that is more effective than a liner system constructed solely of clay or a geomembrane acting alone.*

Again, the applicant has provided unreliable information on key issues pertinent to whether this landfill, as proposed, conforms to TSCA regulations. The issue is not whether a composite liner is a more effective barrier than a liner system constructed solely of clay or a geomembrane. The issue is whether the liner system the applicant proposes to use to manage PCB wastes conforms to the regulatory requirements of

preventing releases of waste components from the landfill for as long as the wastes represent a threat. The US EPA (1988a, b) acknowledged that composite liners only delay when groundwater pollution occurs; they do not prevent it. Therefore, a single or double composite liner cannot prevent leachate from passing through it for as long as the wastes represent a threat.

The applicant provides a discussion of the hydrologic setting for the landfill where it is stated,*the first useable aquifer is a medium to coarse sand and gravel layer, which overlies shale bedrock beneath the site. The thick silty clay glacial till in which the landfill is constructed provides natural protection of this aquifer. The hydrogeologic setting and the engineered liner features will provide protection equivalent to or greater than that required for TSCA landfills in 40 CFR 761.75 (b)(1).*

In this statement the applicant admits that there is a useable aquifer underlying the site. The applicant's statement, however, about how the glacial till provides natural protection for this aquifer is inaccurate. The glacial till, at best, postpones when the aquifer will become polluted by waste-derived constituents. It will not prevent it. Further, the engineered liner also only postpones when waste-derived constituents enter the aquifer system. Again, the applicant has provided unreliable information to the regulatory agencies and the to public on the ability of the proposed landfill to manage PCB wastes in accord with regulatory requirements.

The applicant mentioned that the water table is encountered in the "*deltaic surface sand*." The high water table alone should make the site unsuitable for a landfill of any type. In an effort to try to circumvent this situation, the applicant has constructed a cutoff dike and a subsurface drain around each cell which *"...intercepts the groundwater entering the site from the north and transfers it off-site such that the flow eventually passes to a local lake."* No discussion, however, is presented about the need to ensure that this system functions effectively for as long as the wastes in the landfill will be a threat, i.e., forever. Who in post-closure year 31, 100, 200, etc., will inspect the cutoff dike and drain system and make the necessary repairs to ensure that the surficial groundwaters do not penetrate the wastes and thereby serve as an additional source of moisture that generates leachate that will pollute the groundwaters underlying the landfill?

The landfill liner system cannot be relied on in perpetuity to prevent the surficial groundwaters from entering the waste cells. Eventually the liner system will be ineffective in preventing the surficial groundwaters from entering the waste and generating leachate.

The applicant states *TSCA regulations (40 CFR 761.75[b][3]) require that a 50-foot separation distance of unspecified geologic composition be maintained between the historically high water table and the bottom of the landfill liner system. While the landfill site cannot strictly meet this requirement, its natural hydrogeologic setting and engineered liner system exhibit important features that make the landfill equivalent to or more protective of a site designed to minimum TSCA requirements. These features are the*

basis for the justification of a request that the 50-foot separation distance be waived under the provision in 40 CFR 761.75(c)(4).

The applicant admits the site is an unsuitable site for PCB wastes since it does not conform to the basic minimum TSCA landfill siting criteria. Contrary to the statements made, the natural hydrogeologic setting and the engineered liner system do not make this landfill site more protective. They only slow down when groundwater pollution occurs.

The applicant discusses the approach that is being followed to conform to TSCA groundwater monitoring requirements. This approach involves the placement of three monitoring wells at the downgradient (southern) edge of the landfill cell. These wells are located about 400 feet apart. With each of these wells having a zone of capture with a radius of about one foot, there is on the order of 398 feet between the wells through which leachate-polluted groundwaters can pass without being detected by them. The applicant must be required to conduct an in-depth comprehensive assessment of the ability of the proposed groundwater monitoring system to detect leachate-polluted groundwater at the point of compliance for as long as the wastes in the landfill will be a threat.

While the applicant claims it is going to provide "ongoing" monitoring, in fact, it only proposes to utilize a 30- year post-closure period. Who is going to monitor the wells in year 31, 50, 100, 500? The waste will still be there and still be a threat. These are issues that must be addressed in any credible landfill permit application.

The applicant presents information on the leachate collection and removal system. The key issue that must be addressed in considering the reliability of this leachate collection system is how effective will it be when the flexible membrane liner, which serves as the base of the system, has deteriorated to the point that significant amounts of leachate pass through the liner en route to the groundwaters underlying the landfill. This is an issue that the applicant must address as part of not only applying for acceptance of PCB waste, but also for continuing to operate the landfill for RCRA hazardous wastes.

The applicant states, with reference to the high groundwater table that surrounds the landfill cell area, *cutoff dikes, composed of silty clay that is keyed into the native clay deposit, have been constructed around each cell within the landfill.* These cutoff dikes are supposed to be designed to try to limit the lateral movement of groundwater into the cells and leachate out of the cells for as long as the wastes in the landfill would be a threat. Cutoff dikes of this type can function to limit water from moving into the cells for a period of time, provided they are constructed properly. Ultimately the high groundwater table in the surficial sand layer in the vicinity of the landfill could enter the cells through the cutoff dikes and the deteriorated liner system adding additional moisture to the waste management cells which generates leachate. Therefore, even if an impermeable cover was installed and maintained in perpetuity on this landfill through the use of a leak detection system in the cover, there is still the potential for leachate generation due to the high groundwaters surrounding the landfill cells. It appears that this issue has been ignored by the applicant, its consultants and the regulatory agencies in developing this

landfill. The landfill application should have discussed these issues. Failure to do so is yet another example of the inadequacy of the application.

The application states that underlying the surficial sands is a glacial till layer which has a mean vertical permeability of about 3×10^{-8} cm/sec. The glacial till contains varying amounts of sand and gravel. Some samples of the silt and sandy silt underlying the landfill area have been found to have permeabilities of 10^{-5} cm/sec. Basically, the geology of the area in which the landfill cells are constructed is such that it does not provide for natural protection of the aquifer system underlying the landfill.

There are several aspects in this discussion of the hydrogeology of the region that need to be considered. First, the permeability measurements which serve as a basis for the "mean" vertical permeability of 1×10^{-8} cm/sec were generated using laboratory-based permeability measurements. Such permeability measurements are not necessarily reliable. They tend to underestimate the actual permeability that would govern the transport of waste-derived constituents through the geological strata underlying the landfill.

It is inappropriate to use the mean permeability in an assessment of this type. The public whose well could be polluted by landfill leachate is not interested in the mean value of how long it takes leachate to move from the base of the landfill to their well. They want to know and should know what is the fastest rate, i.e., the highest permeability, that waste-derived constituents could move from the base of the landfill to their well.

The applications states that groundwater recharge of an underlying aquifer occurs through the transition silts. This statement indicates that the geological strata of the region have sufficient permeability to recharge the aquifer at a sufficient rate to maintain the aquifer. It has been the authors' experience that at geological settings of this type the dating of the waters in the aquifer using radioisotopes often show that atmospheric moisture (precipitation) has moved from the surface of the soil through the low permeability layers to the underlying aquifer at a rate much higher than that predicted based on the mean permeability rates measured by laboratory-based measurement techniques. The applicant must conduct a much more comprehensive, up-to-date assessment of the hydrogeology in the vicinity of and underlying the landfill site as part of permitting the continued operation of the this site and the acceptance of PCB wastes at this site.

The applicant discusses the groundwater monitoring system, which consists of groundwater monitoring wells spaced approximately 400 feet apart. As discussed above, such an approach is highly unreliable in detecting leachate pollution of groundwaters before widespread pollution occurs.

The applicant indicates that five pairs of vacuum pressure lysimeters are installed in the silty clay beneath the existing landfill cells. While not discussed, lysimeters of this type have a small zone of capture and are largely ineffective in detecting leakage from landfill cells under the conditions being used by the applicant for their location.

Overall, the groundwater quality monitoring conducted at this landfill site will be deficient compared to that needed to detect leachate-polluted groundwater before it passes the point of compliance for groundwater monitoring. The area of sampling by the monitoring wells and the lysimeters represents a small part of the area through which leachate containing waste constituents derived from the landfill could pass the point of compliance for groundwater monitoring and not be detected by the monitoring system.

The landfill cover that will be used will consist of a clay layer with a maximum permeability at the time of construction of 10^{-7} cm/sec. A geomembrane will be placed over the clay layer. On top of the geomembrane will be placed a protective layer of soil and a layer of topsoil. The area is to be fertilized, seeded and mulched. The detailed expected performance characteristics of the cover are not discussed. This is yet another significant deficiency in this application that should cause it to be rejected as a credible application for acceptance of PCB wastes as well as the continued acceptance of RCRA hazardous wastes.

While in the early 1980s, when this landfill was originally permitted, the level of hydrogeologic investigation that the applicant has submitted in its 1995 application could possibly have been considered adequate in light of what was known then about the long-term threat that hazardous wastes represent to public health and groundwater quality, today this level of hydrogeologic investigation is not acceptable. There could readily be pathways through the low permeability layer underlying the landfill that would allow much more rapid transport of hazardous waste constituents and PCB waste constituents to the groundwaters than has been estimated by the applicant and by its consultants.

Further and most importantly, the approach that was used in the 1980s for assessing the permeability of the low-permeability layer underlying the landfill involved laboratory measurements of permeability. It has been well-known for many years that laboratory measurements of permeability typically significantly under-estimate the real permeability of the geological strata being investigated. There are many places where laboratory measurements of permeability are not allowed because of this problem.

Environmental Assessment

Many states require that an environment assessment, environmental report, impact assessment, or a similar document be developed as part of permitting a new landfill. If the landfill involves federal lands, then a CEQA environmental impact statement must be prepared. In general, the federal and state assessments require full disclosure of potential environmental issues associated with the development and/or continued operation of a new or existing landfill. An example of this type of requirement at the state level is the Michigan Act 64. According to R 299.9504 Construction permit application; content, Rule 504 of this Act, (1) In addition to the information that may be required by subrule (16) of this rule, all applications for a construction permit shall include all of the following items:

"(e) An environmental assessment, including a failure mode assessment that provides an analysis of the potential major methods by which safe handling of hazardous wastes may fail at a treatment, storage, or disposal facility. The owner or operator of a facility that stores, treats, or disposes of hazardous waste in a surface impoundment or a landfill shall include, in the environmental assessment, information that is reasonably ascertainable by the owner or operator on the potential for the public to be exposed to hazardous wastes or hazardous constituents through releases related to the unit. At a minimum, the information shall address all of the following subjects:

(i) Reasonably foreseeable potential releases from both normal operations and accidents at the unit, including releases associated with transportation to or from the unit.

(ii) The potential pathways of human exposure to hazardous waste or constituents resulting from the releases described in paragraph (i) of this subdivision.

(iii) The potential magnitude and nature of the human exposure resulting from the releases described in paragraph (i) of this subdivision."

The regulations in Michigan as well as in many other states have explicit requirements on the topics that need to be covered in the "environmental assessment" of an existing or a proposed landfill. It has been found, however, that landfill applicants are able to produce, through their consultants, highly superficial discussions of these issues. The regulatory agencies at the state and federal levels rarely perform critical reviews of the adequacy of the environmental assessment of the existing or proposed landfill. This situation places the burden for critical review of the potential environmental impacts on the public who could be affected by the landfill. However, often those within the sphere of influence of a landfill have limited resources that can be used to acquire technical, as well as legal, advice in addressing the technical deficiencies of an environmental assessment. In most situations, the environmental assessment approach is a facade by which landfills can be permitted without having been critically reviewed by independent, knowledgeable experts on the potential impacts of a proposed landfill on public health, groundwater resources and other interests of those located within the sphere of influence of an existing or proposed landfill.

The authors have observed a number of situations where landfills have been forced on a local community since the community was not in a position to oppose the power of the governmental entity and/or garbage company that was supporting the development of a landfill. Frequently where a political jurisdiction such as the city, water utility, or other entity with financial resources opposes the development of a landfill, the landfill is not developed since those potentially impacted are able to demonstrate that the proposed landfill will not be protective of the health, welfare, and interests of those within the sphere of influence of the landfill. The authors have recommended (Lee and Jones-Lee 1993, 1994, 1995c) that a funding approach similar to the one in Ontario, Canada of landfill applicants being required to provide "intervener funding," where as part of developing the landfill, the applicant must provide sufficient funds (typically in the order of several hundred thousand dollars) to assist those potentially impacted by the landfill in

acquiring technical expertise and legal assistance in investigating the proposed approach for landfill development, design, operation, closure, and post-closure care to insure the landfill will, in fact, be protective of public health, groundwater resources, the environment, and the interest of those within the sphere of influence of the landfill for as long as the wastes in the landfill represent a threat. Adoption of this approach would result in the development of more appropriate landfills than is being accomplished today.

Those concerned about the short-term and long-term impacts of an existing or proposed landfill often find that the regulatory agency review is perfunctory where the applicant and regulatory agency will produce consultants or have staff who will claim the landfill is protective when it is obviously not protective, but only postpones for a period of time when adverse impacts will occur. These views will be opposite those of the concerned citizens, water utilities, municipalities and others who find that the approach proposed for the development of the landfill will not be protective. The net result is that the regulatory agency boards either face or are able to utilize the conflicting opinions of "experts" as a basis for permitting the landfill based on political or other factors and thereby enable the permitting of a landfill that obviously will not comply with the regulatory requirements of protecting public health, groundwater resources and the environment from adverse impacts for as long as the wastes in the landfill will be a threat.

The authors have faced this situation sufficiently frequently so that they have developed a professional paper, "Practical Environmental Ethics: Is There an Obligation to Tell the Whole Truth?," (Lee and Jones-Lee, 1995c) which provides a suggested peer review approach where the landfill applicant and/or his/her consultants as well as the regulatory agency staff and those who are potentially inversely impacted by the landfill must present their information in a full, public peer review arena where experts in the topic area who have no interest in the particular situation or future income that would be derived from future similar situations could critically review the position of all parties on technical issues about which there is a dispute and render advice to the regulatory body/board on the correct interpretation of the information available. Adoption of this approach would represent a significant step toward developing a more credible review of landfills than is occurring today.

Associated with the review of the continued operation of an existing landfill as well as the proposed expansion of the waste types accepted by the landfill to include PCBs, the authors have found that the landfill applicant and the regulatory agency personnel at the state and federal levels in a draft permit for this landfill have made the following statements in support of the landfill. These comments provide examples of inappropriate approaches being used in the permitting of landfills.

Threat to Ground Water Supply. In the environmental assessment for the proposed landfill, mention is made that there are about 120 to 125 registered drinking water wells within 3 miles of the site. It is further stated, *"It is estimated that approximately 235 to 240 additional wells exist for which records were unavailable."* Further it is noted that a municipal well field is located near the landfill. It is clear the groundwaters in this region

are extensively used for water supply purposes and that pollution of these groundwaters could be a significant public health, groundwater resource and environmental threat.

The basic issue that must be resolved in the siting of any landfill is whether there are groundwater resources hydraulically connected to the landfill that could, at any time in the future, transport leachate that leaks through the liner system to offsite groundwaters that are now or that could, at any time in the future, be used for domestic water supply purposes. It is important in making this evaluation to not assume that the hydraulic gradient between the base of the landfill and offsite groundwaters that exists now will exist in perpetuity and, thereby, provide a natural barrier to groundwater pollution by the release of leachate from the landfill. A properly developed environmental assessment would provide a detailed discussion of these issues.

Environmental assessments for a landfill often discuss the possible failure of the landfill liner systems where it is stated, *thus FML's installed at the landfill may fail at some future time, but the chances of such failure are virtually unknown.* Such statements are designed to convey the impression that the liner system could be protective of groundwater resources in the vicinity of the landfill. The facts are the liner systems for today's Subtitle C and D landfills will ultimately fail to prevent leachate generated within the landfill from passing into the geological strata adjacent to the landfill. With few exceptions, this will eventually lead to groundwater pollution by the leachate.

For landfills where there is an existing waste management unit that has not yet found to be polluting groundwaters, the environmental assessment will state, *to date the landfill owner has not detected any hazardous constituents in the leak detection systems installed beneath any of the disposal cells.* The fact that the landfill owner has not detected leakage which has been found in the groundwater monitoring well system does not mean significant leachate leakage is not occurring; it reflects the fact that the number of monitoring wells used is inadequate to provide an early warning of leachate leakage. The work of Dr. John Cherry (1990) as well as others has shown monitoring wells of the type being used today to monitor leakage from landfill cells has a low probability of detecting leakage before widespread pollution occurs.

The environmental assessment for existing landfills that are being reviewed for continued operation was often compared ten or more years ago. Since then substantial information and literature has been developed that confirms what was beginning to be suspected by the late 1980's, that the plastic sheeting and compacted clay liners being used in today's "dry tomb" landfills will not prevent leachate from migrating out of the landfill leading to groundwater pollution during the time that the wastes in the landfill will be a threat. If an environmental assessment that was prepared several years ago is brought up-to-date, as it should be, there could be unequivocal statements made that major failure of the landfill containment system (liners) is inevitable. It is only a matter of time until the liner systems fail and allow leachate to penetrate into the aquifer system underlying the landfill. There is no question about the fact that the landfill liner system will fail to prevent leachate from passing through it and the groundwater monitoring system used will have a high

probability of failing to detect these leachate-polluted groundwaters before widespread pollution occurs.

Some landfill applicants state, *however, some cells were constructed with a double synthetic liner. For these units, the liner systems greatly reduce the probability of a release and subsequent downward/horizontal migration.* This analysis is fundamentally flawed. The liner systems will prevent movement of leachate downward through the geological strata for a period of time dependent on the quality of construction and a number of other factors; they will not prevent the movement of the hazardous and deleterious components of the waste down through the aquifer system for as long as the wastes in the landfill will be a threat. This is the issue that should have been addressed in the environmental assessment.

The environmental assessment mentions the problems that the applicant has had in maintaining odor control at the facility. A review of the public's comments on the odor problem associated with the applicant's waste treatment and disposal operations shows that the applicant has been a poor neighbor and has significantly impaired the health, interests and welfare of those within the sphere of influence of its waste management activities. As discussed in another section of this report, odors of the type that the public has experienced are now recognized as a significant threat to their health.

Typically, environmental assessments contain a section in which the project proponent is supposed to discuss the mitigation measures that will be used to address all significant adverse impacts on public health, the environment, and the interest of those within the sphere of influence of the project. This landfill environmental assessment, however, does not mention any mitigation measures for the inevitable groundwater pollution that will occur associated with the past and proposed future landfilling. This environmental assessment is deficient from the perspective of failing to address the groundwater pollution issues and how these would be mitigated. It has to be rejected as an inappropriate assessment of issues for the continued operation of this landfill as an RCRA hazardous waste landfill as well as a proposed PCB landfill.

Landfill Fact Sheets

Regulatory agencies, in connection with the development of a proposed permit/licence for a landfill, often prepare a summary "fact sheet." A review of some of these fact sheets, however, shows that they contain unreliable or inadequate information on the potential threat a landfill represents to public health, groundwater resources, and the environment. In connection with the review of the continued operation of a hazardous waste landfill, the state regulatory agency fact sheet stated that the regulatory agency is required *...to issue a license to a hazardous waste treatment, storage or disposal facility unless: the facility has not been constructed in accordance with approved plans, applicable rules or the conditions of the approved construction permit; the construction or operation of the facility presents a hazard to public health or the environment; or the applicant has not submitted sufficiently detailed or accurate information to enable the*

regulatory agency to make a reasonable judgement as to whether the license should be issued.

It is the authors' experience that contrary to the statements made by the regulatory agency, the landfill applicant has not provided sufficiently detailed and accurate information to enable a reliable estimate to be made by the regulatory agency on the public health and environmental threat that the continued of the landfill presents. The facts are that often the landfill has in the past and if relicensed will continue to represent a significant hazard to public health and the environment.

The fact sheet for a landfill may state *the facility does not at this time present a hazard to human health or the environment.* The authors find the regulatory agencies often haven taken significant liberties with its required mandate of public health, natural resource, and environmental protection in making this evaluation. The issue is not whether it represents a threat "at this time;" the issue, according to the regulations, is whether the facility represents a threat to public health or to the environment. At many locations, there is no question that the landfills are a significant threat to public health through contamination of groundwaters by landfill leachate. To take a narrow view of only considering whether pollution has already occurred that has been detected by the inadequate monitoring program that exists is not in accord with the regulations governing the landfilling of hazardous waste.

The fact sheets prepared by regulatory agencies that plan to approve the permit application for a particular landfill sometimes state *the application submitted by landfill applicant is sufficiently detailed to demonstrate that the facility's design and operation complies with the applicable technical standards.* In most cases the technical standards which must be achieved require, with a high degree of certainty, the groundwaters hydraulically connected to the landfill will be protected from pollution by landfill leachate for as long as the wastes in the landfill will be a threat. A critical review of the information submitted to the regulatory agency by the landfill applicant shows that the finding of adequacy of submissions is not reliable. Frequently, there are many issues that need to be addressed in more detail in order to fully evaluate the reliability of the landfill containment and monitoring systems to be able to reliably determine the magnitude of the threat that this facility represents to public health and groundwater resources.

With respect to discussing groundwater monitoring, the fact sheets state, *the landfill applicant conducts a groundwater monitoring program to evaluate whether hazardous constituents from the landfill cells have entered the groundwater under the waste management areas. The results of the monitoring to date, have shown that the operation of the landfill has not impacted the groundwater.* It further states, *the draft operating license includes a groundwater monitoring program to detect contamination and to effectively evaluate and remediate the groundwater, if necessary.*

A critical review of the technical base of these statements shows that they are unreliable. The groundwater monitoring program that has been proposed to be allowed at a landfill is often unreliable in detecting groundwater pollution by landfill leachate. It would be

unusual that this groundwater monitoring system would detect leachate-polluted groundwaters at the point of compliance for groundwater monitoring when leachate-polluted groundwaters first reach that point. The number and spacing of the groundwater monitoring wells and their zones of capture of groundwaters associated with their sampling are such that the groundwater monitoring system proposed by the landfill applicant and proposed for licensing by the regulatory agency is unreliable.

The reliability of the groundwater monitoring system is one of the areas in which landfill applicants and regulatory agency frequently fail to provide adequate and reliable information. An appropriately developed groundwater monitoring program would have included a critical analysis of the probability of detecting leaks through the landfill liner system into the underlying groundwaters with the groundwater monitoring program proposed/used. An elementary evaluation of this topic area shows the monitoring wells proposed have a zone of capture of about one foot. They are often spaced about 400 feet apart at the point of compliance. Therefore, there are 398 feet between each well where leachate-polluted groundwaters could pass and not be detected by the groundwater monitoring system. This issue should have been discussed by the regulatory agency in their so-called fact sheet supporting the relicensing of the landfill.

Another reason that would justify termination of an existing landfill's operations at the time of repermitting is the failure of the landfill applicant to provide adequate information on the long-term properties of the landfill liner system and cover to prevent moisture from entering the landfill and generating leachate and to prevent leachate from passing through the liner for as long as the wastes in the landfill will be a threat. These are two areas (ultimate failure of the liner system and inadequate groundwater monitoring system) that are typically not adequately and/or reliably described in the original application and in the reapplication. For landfills that were originally permitted prior to 1990, these issues were not well understood at the time of filing the original application for the landfill. Today, they are well understood. There is no question that the containment system used is deficient in being able to prevent leachate generation and leachate migration to groundwater underlying the landfill for as long as the wastes in the landfill will be a threat. This situation provides ample justification for not approving the regulatory agency's proposed draft license for the continued operation of a landfill.

Overall, the fact sheets developed by regulatory agencies in support of a particular landfill often do not present credible discussions of the potential environmental impacts of an existing or proposed landfill. These fact sheets are self-serving documents designed to support political or other decisions developed by regulatory agencies governing the permitting of an existing or proposed landfill. If there are questions about the credibility of a particular fact sheet's statements on an issue, the statements in question should be peer reviewed in a public arena by individuals knowledgeable in the topic area who will reliably report on the "facts" pertinent to a particular situation.

Comments on Draft Operating Permits/Licenses for Hazardous Waste Facilities

Presented in this section is a discussion of some of the significant deficiencies in a regulatory agency's Draft Hazardous Waste Management Facility Operating License.

Overall, it is found that a regulatory agency's review of a landfill can be superficial, and the draft facility operating license may not conform to regulatory requirements. Draft operating licenses often fail to consider the information that has been developed in the last 10 years on the properties of the landfill waste containment (liner) system to protect the groundwater resources associated with the landfill from pollution by landfill leachate for as long as the wastes in the landfill will be a threat. A landfill is sometimes located at an unsuitable site for continued operation of a landfill or for the development of a new or expanded landfill in that area. The landfill containment system design recommended for approval in a draft operating license and the natural geological strata may not prevent the pollution of the groundwaters hydraulically connected to a landfill. Also, draft and, for that matter, final operating licenses/permits often fail to properly evaluate the reliability of the groundwater monitoring system and liner leak detection system to detect waste constituent migration from the landfill to the groundwaters underlying the landfill before widespread pollution occurs.

The state of Michigan and the US EPA regulations governing the development or continued operation of a landfill require, *the licensee shall maintain and operate the facility to prevent the possibility of a fire, explosion, or any sudden or non-sudden release of hazardous waste or hazardous waste constituents to the environment, including air, soil, or waters of the State which could threaten human health or welfare or the environment. {R 299.9602, R 299.9606, R 299.9607, and 40 CFR 264.31 and 264.51, which are ABR in R 299.11003.}* Therefore, these regulations explicitly require the containment of waste components within the landfill for as long as the wastes represent a threat. Any landfill liner system that is attempted to be used to control waste-derived constituents within the landfill must be able to conform to this requirement. Failure to do so will be a violation of explicitly stated regulatory requirements of the US EPA RCRA and state regulations.

As discussed herein, in time, the hazardous waste landfill will pollute the waters of a state and, thereby, threaten human health, welfare, and the environment. The basis for this conclusion is that:

- the wastes in the landfill will be a threat effectively forever;
- the landfill cover will not prevent moisture from entering the landfill for as long as the wastes represent a threat;
- moisture that enters the landfill will generate leachate, which is a threat to groundwater quality;
- the leachate generated in the landfill ultimately will not be collected by the leachate collection and removal system and, therefore, will pass through the liner system into the underlying strata, eventually reaching the groundwaters of the state;
- the groundwater monitoring program that has been developed by the landfill applicant and recommended for approval by a regulatory agency in the draft license is

deficient compared to that needed to detect pollution of groundwaters by landfill leachate for as long as the wastes are a threat;

One of the key issues in evaluating the adequacy of the draft operating license to conform to regulations is the requirements established for closure and especially post-closure care of the landfill. The applicant states, *this plan addresses those activities necessary for the proper management of the facility during the 30-year post-closure period.* The applicant further states that during this period, *the primary areas of responsibility include monitoring, inspection, and maintenance activities and their frequencies. During post-closure, damaged or malfunctioning equipment or structures will be repaired or replaced as necessary to maintain the facility in proper condition.*

The applicant and the regulatory agencies have only planned for a 30-year post-closure care period. US EPA RCRA and many states do not limit the post-closure period to 30 years, as the draft permit proposes to do. The purpose of post-closure monitoring, maintenance, etc. is to protect health, welfare, groundwater resources and interests of the people that are within the sphere of influence of the landfill. Since the wastes in this landfill will be a threat to public health, groundwater resources and the interests of those within the sphere of influence of the landfill effectively forever, the post-closure period has to be effectively forever.

A draft license is deficient in establishing the conditions of post-closure care that are being imposed on the landfill applicant if it does not explicitly require that the applicant is responsible in perpetuity for post-closure care for the landfill. The public is entitled to high degrees of protection over the period of time that the wastes are a threat. There should be no question about this requirement, and it must be explicitly stated in the operating license conditions and requirements. Further, there must be a well-defined, valid dedicated trust fund of sufficient magnitude to address all plausible worst-case failure scenarios for an existing landfill as well as any proposed continued operations of it. Any landfill application and/or permit that does not provide this information and assurances should not be permitted.

There can be little doubt that under the current draft license, at some time in the future, the landfill applicant will not carry out the requirements set forth by the regulatory agency and the RCRA proposed post-closure care activities. The landfill applicant must be required to provide a detailed discussion of how the post-closure activities would be implemented for as long as the wastes would be a threat and how such activities will be funded during this time. Also, the landfill applicant should discuss the magnitude of the funding that will be needed and the source of funds to address these post-closure care activities when needed at any time in the future. The information provided by the landfill applicant should contain sufficient detail to enable the regulatory agencies and the public to critically review its reliability.

Often draft licenses/permits do not require any maintenance of the low permeability layers in the cover. These are the key layers in preventing moisture from entering the landfill, which generates leachate. The low permeability layers of plastic sheeting and

compacted clay will deteriorate over time. There will be need for reliable inspection and maintenance of these layers. Regulatory agencies allow landfill applicants to close landfills without maintaining the purpose of the cover, namely to prevent moisture from entering the landfill and producing leachate that will pollute groundwaters for as long as the wastes in the landfill will be a threat. While cover maintenance is required for a 30-year post-closure care period, based on the amount of funds typically allocated for this maintenance, adequate maintenance of the cover is not provided for during this period, much less the infinite period during which the waste in the landfill will be a threat. Any draft license that does not provide this information must be judged to be significantly deficient, and the landfill should not be allowed to be constructed and/or be allowed to continue to operate.

The draft permit states, *the primary anticipated maintenance concerns will be pump operations. Should damage or failure occur to this system, repair or replacement of the defective equipment will be performed promptly. Damaged surface pipes will also be repaired.* This statement is a superficial assessment of potential problems associated with the leachate detection, collection and removal system. The primary area of concern with respect to this system is the integrity of the flexible membrane liner. When the flexible membrane liner develops holes, cracks or areas of deterioration, it will no longer be effective in transporting leachate to the sump so that the leachate can be pumped out. This will lead to groundwater pollution.

Since the integrity of the liner is less than that of the contaminating lifespan of the wastes, and since the liner system cannot be repaired without removing the wastes from the landfill, it is clear that the approach outlined by the applicant in maintaining key components of the landfill containment system is fundamentally flawed in protecting groundwaters from pollution by landfill leachate. Under these conditions a landfill of the type the applicant proposes to continue to operate cannot be permitted at such a site since obviously continued operation of this landfill will lead to groundwater pollution in violation of regulatory requirements.

The draft permit states, *in accordance with 40 CFR part 264.310(b)(2), during the post-closure care period, the leachate collection and removal system will continue to operate until leachate is no longer detected.* This approach is not technically valid and represents one of the potential problems in interpretation of RCRA. There could be a period of time after closure of the landfill when the cover for the landfill will have sufficient integrity to prevent moisture from entering the wastes. However, especially under the proposed license where the applicant is not required to maintain the integrity of the low permeability layers of the cover during the post-closure care period, the cover will, in time, fail to prevent moisture from entering it. This situation could readily lead to one in which leachate is no longer detected for a period of time, but in time, leachate would be generated again within the landfill due to the deterioration of the low-permeability layers of the cover.

The fundamental approach that is used to address post-closure activities by the applicant in its application for continued operation and in the regulatory agency's draft operating

license is flawed. It is not designed to comply with the regulations of protecting public health, groundwater resources and the interests and welfare of those potentially impacted by the landfill. It is basically designed to dispose of wastes at cheaper-than-real-cost, which then results in a significant threat to those in the vicinity of the landfill who wish to use these lands for their appropriate purposes.

The draft permit states, *in accordance with 40 CFR Part 264.310(b)(3), the groundwater monitoring system will be maintained and monitored throughout the post-closure period. The leak detection systems will also be maintained and monitored throughout the post-closure period.* This is another of the superficial statements that occur in the application and in the draft license and which present unreliable information on the post-closure activities that will, in fact, be carried out. There are no provisions to maintain the plastic sheeting layers (flexible membrane liner) in the leak detection systems for as long as the wastes represent a threat. Since there are no provisions to maintain the low permeability layers of the cover so that moisture does not enter the landfill during the time when any moisture that enters the landfill could generate leachate that threatens groundwater quality, the applicant and regulatory agencies should be required to explicitly discuss how this requirement will, in fact, be implemented for as long as the wastes in the landfill represent a threat. The requirements that the leak detection system shall be maintained and monitored throughout a properly defined post-closure period cannot be carried out in a meaningful way, with the result that this landfill cannot be licensed for continued operation.

The applicant has provided a post-closure inspection report form for the waste disposal. This form was included in the draft regulatory agency permit. It states, *the entire landfill surface (final cover) must be examined during the 30-year post closure period for evidence of erosion damage, subsidence that could potentially lead to surface water ponding, animal damage, and the presence of inadequate and inappropriate vegetative cover.* Again, the applicant has only indicated a 30-year period of post-closure care. This is highly inappropriate; it should be specified that this post-closure care period is for as long as the wastes are a threat, which is understood to be effectively forever. This license cannot be approved with its current wording and comply with regulatory requirements.

The applicant should be required to explain how it is going to implement the control of*, conditions that lead to increased surface water infiltration.* The primary condition that leads to surface water infiltration is the rips, tears, holes or points of deterioration in the plastic sheeting layer that is buried several feet below the surface of the top soil. These holes, rips, tears, etc. are not visible from the surface. This is a superficial statement that has no real meaning since it cannot be carried out by visual inspection of the surface, and there is no requirement for a leak-detectable cover to be installed on this landfill.

Under "Leachate Collection System," there is no requirement to detect failure of the flexible membrane liner to collect leachate for as long as the wastes represent a threat.

Under "Leak Detection, Collection, and Removal System," there is no requirement for inspection of the flexible membrane liner, which is the key functional component of the

system. The reason that this liner cannot be inspected is that it is buried under the solid wastes. The applicant and regulatory agencies are ignoring this issue in relicensing this landfill.

The draft permit states, *the licensee's current closure cost estimate is $3,791,382, and the post-closure cost estimate is $5,466,670.* The post-closure costs are far lower than what will be necessary, even within the 30-year period, much less the infinite period that the wastes will be a threat.

The draft permit discusses financial assurance issues. An independent third party should critically review the reliability of the financial instruments proposed by the applicant and accepted by the regulatory agencies to provide the funds needed to address all plausible worst-case scenario failure needs as well as routine monitoring and maintenance of the cover, including periodic replacement of the low permeability layers of the cover for as long as the wastes in the landfill will be a threat. Further, these funds should be of sufficient magnitude to remove (exhume) the wastes from the landfill, properly treat them and relocate the treated residues at an appropriate site that provides for protection.

The draft permit states as one of the requirements for continued operation of this landfill, *in accordance with Section 304(u) of RCRA and the regulations promulgated pursuant thereto, the Permittees must institute Corrective Action as necessary to protect human health and the environment for all releases of hazardous waste(s) or hazardous constituent(s) from any solid waste management units (SWMUs) at the facility, regardless of the time at which waste was placed in such units.* This requirement establishes the regulatory requirements for high levels of perpetual care of this and other landfills. The waste in this landfill will be a threat to human health and to the environment from releases from the landfill for effectively an infinite period of time. Many of the waste components will not decompose. So long as the dry-tomb character of the landfill is maintained, i.e., the wastes are effectively isolated from moisture, the wastes will remain a threat to public health and to the environment, and, therefore, corrective action could be needed.

The landfill application for continued operation of the landfill as a hazardous waste landfill, has indicated that it only plans to provide post-closure care for 30 years. Further, the post-closure care funding that the applicant proposes to make available, $5,466,670, is inadequate to meet proper post-closure care activities during the minimum 30-year period required under RCRA. The applicant has not provided the assured funding that will be needed to implement corrective action for as long as the wastes in the landfill will be a threat. This funding should be of sufficient magnitude to address all plausible worst-case failure scenarios that could occur in the landfill during the period of time that the wastes will be a threat. Because of the deficiencies in the application in addressing the post-closure care corrective action requirements set forth in the draft permit, this draft permit cannot be approved and comply with RCRA requirements.

The US EPA has developed a "Draft for Public Comment" permit which would allow the applicant to dispose of PCB wastes in the landfill. Comments on selected aspects of this draft are presented below.

Under draft permit findings, it is stated, *the local clay pan impedes hydraulic communication between the Cell and underlying water bearing units.* It is also stated, *the clay pan is continuous and relatively water tight because it has been demonstrated to have prevented significant downward natural seepage of water since 1953 even though there is approximately five feet of head groundwater standing on it in the shallow sandy overburden directly overlying the clay pan.* Also it states, *the bottom of the Cell liner system is underlain by at least 10 feet of recompacted clay with the permeability tested and certified as less than 1 x 10^{-7} cm/sec.* These series of "findings" indicate that, while there is a so-called clay pan (layer of low-permeability clay) underlying the landfill, this clay layer is not impermeable (it only "impedes" hydraulic connection). In time, PCB wastes and other wastes released through the landfill liner system will penetrate the low-permeability clay layer and begin to pollute the underlying groundwaters, rendering them a significant threat to public health and to the environment and unusable for domestic and many other purposes.

The draft permit further states, *the Upper Aquifer's artesian water pressure head reaches to the base of the Cell's liner, and in some places it is slightly higher than the Cell floor. Therefore, there is a natural no flow zone below the Cell and a laterally extensive slow flow zone in the clay around the Cell.* The reliability of this finding is questioned at this time, much less over the infinite period that this landfill will be a threat. Changes in pumping of groundwater and/or climate could change the characteristics of the so-called no natural flow zone underlying the waste cells. Further, even with no natural flow, there will be diffusion of PCB and other waste components through the clay layer. At this time, there is insufficient characterization of the hydrogeology underlying the landfill to support the findings set forth in this draft permit.

The draft permit states, *the Upper Sand Unit, which is an unprotected, highly permeable, water-bearing, gravelly sand classified as unusable by the regulatory agencies. The sand around the Cell did not meet the minimum 25-foot depth to water criterion and was removed from the Cell during the construction and was replaced with a ten-foot thick compacted clay isolation barrier. S* uch a barrier (dike) can reduce the amount of flow into the waste cell; however, this system will have to be maintained forever. No provisions have been made for such maintenance.

Failure to inspect and maintain the isolation barrier for as long as the wastes in the landfill will be a threat to public health and/or groundwater quality (likely an infinite period of time) will result in moisture entering the landfill that can generate leachate due to the high water table surrounding the landfill. This leachate can leave the landfill through the bottom or through the sides of the landfill if leachate is not adequately removed from the landfill for as long as the wastes in the landfill will be a threat.

The lateral transport of leachate through the sides of the landfill into the surficial groundwater system represents a potentially significant source of waste constituents that can pollute the surface waters of the region by PCB wastes and many other types of wastes. Such pollution is an even greater threat to public health and to the environment than the pollution of groundwaters, as a result of the fact that many of these waste components bioaccumulate in aquatic life, causing fish and other aquatic life to be unsuitable for use as food by humans and wildlife. As a result of bioaccumulation, surface water quality standards for PCBs and some other waste constituents are far lower than drinking water MCLs (standards).

The issue of adequate protection of the surficial groundwaters hydraulically connected to the waste cell from pollution by waste-derived constituents for as long as the wastes in the landfill will be a threat has not been adequately or reliably addressed by the regulatory agencies in issuing draft permits for the continued operation of the landfill, as well as the acceptance of PCB waste in the landfill.

The draft permit discusses the permeability characteristics of the underlying geological strata. While it indicates that these are laboratory values, there is no indication that laboratory values are necessarily reliable. It is possible that, if properly evaluated, the permeability of the natural strata underlying the waste cell is greater than 10^{-7} cm/sec at some locations. There has been insufficient testing of permeability using reliable methods to properly characterize the geological strata underlying the waste cells.

The draft permit states, *two 80 mil high density polyethylene synthetic membrane liners each of which are more than double the minimum thickness specified for a TSCA commercial landfill in 40 CFR 761.75* . While these liners may be more protective than the minimum specified in TSCA, they obviously will not provide the level of protection needed to conform to TSCA requirements of preventing the release of PCB waste components from the landfill unit for as long as the wastes in the landfill will be a threat.

The requirements for groundwater monitoring are discussed in the draft permit. These include vertical monitoring wells spaced 400 feet apart at the point of compliance. There is no discussion, however, of the reliability of this monitoring approach in support of the requirements that the landfill is suitable to accept PCB wastes. This is a significant deficiency in the draft permit and should cause it to be voided.

The draft permit states, *prior to closure, the Parties must complete a closure/post-closure plan approved by the US EPA. This plan must include a perpetual maintenance plan that establishes a monitoring program for post closure and provide for the decontamination and disposal of PCB-contaminated areas above applicable cleanup levels and random testing of areas, equipment or stabilization materials before they are removed from service to assure that no PCBs are present. Construction testing for the final cover must follow the most current version of the EPA document, "Quality Assurance and Quality Control for Waste containment* [sic]*Facilities" (EPA/600/R-93182 September 1993).* No specific details are provided as to what might be developed in the future in the way of post-closure plans that would include perpetual maintenance. Detailed information on

what would be required if the landfill closed today should be available for the public to review. Without this information, the public cannot judge the adequacy of the proposed approach to be reasonably certain that the US EPA will, in fact, require the funding be available for as long as the PCB wastes in the landfill will be a threat to public health, groundwater resources, and the environment to maintain, monitor and to address all plausible worst-case failure scenarios that could develop at this site. Because of the inevitable failure of the landfill containment system and the unreliability of the leak detection and groundwater monitoring systems, the post-closure care funding must be of sufficient magnitude to, at any time in the future, exhume and properly manage the PCB and other hazardous and deleterious wastes managed at this site if it should be found that the applicant does not provide the perpetual care needed to ensure public health and environmental protection.

The post-closure funding plan has to be developed now to ensure that adequate funds will be set aside during the operating life of the landfill to address the need for funding during the infinite post-closure care period that will be needed at this site.

No information is provided on the requirement that, *cell closure requires installation of a final cap subject to Agency Approval.* This information has to be provided now so the public can judge the adequacy of the Agency's proposed approach for capping this landfill. If the Agency does not propose to provide and maintain a landfill cover (final cap) that will prevent moisture from entering the landfill for as long as the wastes represent a potential threat, then the landfill should not be permitted. Specifying the characteristics of the cap and the amount of funds needed and funding sources for perpetual leak detection and maintenance including periodic cap replacement now would not preclude the Agency, after appropriate public review, from altering the required characteristics of the cap, at some time in the future, as a result of new information that may be developed on how to better cap landfill cells of this type than is being done today.

Also, the Agency needs to require that the applicant specify how it will maintain the cut-off dikes (compacted clay isolation barriers) and surficial groundwater drainage system so that at no time in the future while the wastes are a threat will the surficial groundwaters enter the waste cells and generate leachate that could leave the waste cells either through the bottom of the landfill or, if leachate is not adequately removed from the landfill, though the sides of the landfill into the surficial groundwaters that surround the landfill cells. The applicant should specify the amount of funds that will be needed for the inspection and maintenance and the source of the funds that will be needed at any time in the future to address the problems associated with siting this landfill at a location where there is a high groundwater table around the landfill.

The draft permit states, *in accordance with 40 CFR 761.75 and the aforementioned findings, U.S. EPA, has determined that the Application is consistent with TSCA and that the Cell, when operated in compliance with the conditions of this Approval, does not present an unreasonable risk of injury to health or the environment from PCBs.* Many of the findings set forth in this draft permit are based on the inadequate, unreliable review of the application. This landfill, as it is proposed, should not be permitted for the reasons set

forth in this report since it cannot conform to the regulatory requirements of protecting public health, groundwater resources and the environment from PCB waste constituents for as long as the wastes in the landfill will be a threat.

Comments Made at a Public Hearing on the Proposed Continued Operation of the Landfill and the Expansion of the Landfill to Accept PCB Wastes

The US EPA and the state regulatory agency conducted a public hearing on the proposed draft licenses and permits covering the continued operation of the landfill as a hazardous waste landfill and the expansion of this landfill's permit to accept PCB wastes. Presented below is a review of selected aspects of the transcript of this hearing. Emphasis in this discussion is placed on a review of the adequacy and reliability of the information provided to the public by the regulatory agency personnel. The regulatory agencies did not provide the public with the information that should have been provided to enable the public to evaluate the adequacy and appropriateness of the review that the agencies conducted of the landfill application.

A regulatory agency staff member indicated that the composite primary liner consists of an 80 mil plastic liner and five feet of recompacted clay. Above this liner is a leachate collection and removal system. Underlying this liner is a secondary liner that consists of a 60 mil plastic liner and at least 10 feet of native clay. Between the primary and secondary liner is a leak detection system for the primary (upper) composite liner.

An agency staff member described the proposed cover for the landfill as six inches of intermediate cover over the wastes overlain by three feet of clay. On top of the clay will be a 30 mil plastic liner. Overlying the plastic liner will be a one-foot thick drainage sand layer. Overlying the sand layer will be two feet of "general" soil and six inches of topsoil.

While an agency staff member discussed the general characteristics of the components of the liner system and cover that the applicant has been, for the liner, and will be, for the cover, allowed to construct under the proposed license/permit, he failed to discuss the properties of these components of the cover and liner with respect to being able to carry out their required function, i.e., preventing moisture from entering the landfill for the cover and collecting/preventing leachate from leaving the landfill and entering the groundwaters underneath the landfill for as long as the wastes in the landfill will be a threat. As discussed herein and by Lee (1994), Lee and Jones (1992) and Lee and Jones-Lee (1995a, b) and in references cited therein, it is well-known today that plastic sheeting and compacted clay liners of the type described by an agency staff member can, at best, only postpone groundwater pollution. They will not prevent it for as long as the wastes in the landfill will be a threat.

In time, the cover described by an agency staff member for this landfill will allow moisture to enter the landfill and generate leachate. The plastic sheeting in the primary and secondary composite liners will eventually deteriorate to the point where it will no longer be effective in collecting leachate. The compacted clay layers, including the so-called natural layer, will eventually allow the transport of leachate through them that will

pollute the groundwaters underlying the landfill with hazardous and deleterious chemicals. The landfill cover and liner system described by an agency staff member cannot prevent leachate generation and leachate from passing through the liner for as long as the wastes in the landfill will be a threat. No one can predict how long the liner system will prevent leachate from passing through it, but this system will fail long before the wastes in the landfill are no longer a threat.

The public who are potentially impacted by this landfill have the right to know this situation. An agency staff member, in describing the characteristics of the landfill containment system (cover and liners), should have discussed these issues.

An agency staff member stated that the proposed license would allow the applicant to accept *"...a wide variety of waste that are subject to land disposal restrictions..."* . These wastes will have to be treated to *"...meet specific standards before they can be placed in the landfill."* He did not discuss the fact that these treatment standards do not produce a treated waste residue that is not a significant threat to cause groundwater pollution by hazardous and otherwise deleterious chemicals long after the liner system for the landfill has failed to prevent leachate from passing through it. This is an issue that should have discussed by the regulatory agency staff. The public is entitled to know this situation.

Further, the regulatory agency staff member did not discuss the fact that there will be a wide variety of unregulated hazardous chemicals present in the waste residues deposited in this landfill. In addition, he did not discuss the fact that even if there were no hazardous chemicals in the so-called non-hazardous waste components placed in the landfill, which will certainly not be the case, the leachate generated from these wastes will still be a significant threat to groundwater quality, rendering the groundwaters unusable and/or impaired for use for domestic and many other water supply purposes. The public, who is concerned about this landfill, is certainly entitled to know that the wastes that the regulatory agencies propose to allow to be deposited in this landfill under its continued operations license will be a significant threat to public health, groundwater quality and to the environment, effectively forever.

A regulatory agency staff member discussed some of the components of the license application. He did not, however, provide any information on the characteristics of these components or their required performance, except to state, *"...closure and post closure plans for the closure and long term care and maintenance of the facility for a minimum of 30 years after the closure has been completed, financial assurance to be maintained for closure, post closure and environmental liability."* As discussed herein the closure and post-closure plans for the landfill are inadequate to provide the level of public health and environmental protection that the public should have associated with the development and continued operation of a hazardous waste landfill and a PCB waste landfill in their region.

A regulatory agency staff member also stated, *"the monitoring that has been done to date has show* [sic] *that there have* [been] *no releases of hazardous constituents from the facility."*

A regulatory agency staff member stated that the existing landfill cells that have been closed have shown that there have been no releases of hazardous constituents from the facility. This discussion should have included a discussion of the adequacy of the monitoring that has been done to detect such releases. The authors' report, "Detection of the Failure of Landfill Liner Systems," (Lee and Jones-Lee, 1996b) discusses why failure to detect liner failure in a hazardous waste landfill in the short period of time that a landfill has been operating (10 to 20 years) should not lead to the conclusion that there will not be liner failure and releases of hazardous and deleterious constituents from the landfill during the time--effectively forever--that the wastes in the landfill will be a threat.

This is the issue that the regulatory agency staff member should have discussed. The public is entitled to know the significant qualifications that must be understood in order to properly assess the importance of the staff member's statement about no releases of hazardous wastes having been detected thus far from the existing landfill cells. It is probable that releases of waste components have already occurred but have not been detected and that, in time, there will be large-scale releases of hazardous and deleterious waste components from the existing closed landfill cells as well as the currently active cell. The regulatory agency staff member should have examined and discussed the reliability of the above-quoted statement in order to not mislead the public as has done into believing that since no leakage from the existing waste cells has been found thus far, in the short period of time that they have been in existence, that this is a reliable indication of what will happen in the infinite period of time that the waste in the landfill will be a threat.

Overall, the regulatory agency staff member's discussion of issues of importance to the public concerning the proposed continuation of operation of this hazardous waste landfill and the expansion of the permit/license for the acceptance of PCB wastes is superficial and inadequate to properly discuss the potential problems of the proposed landfill design, operation, closure, monitoring and post-closure care to protect the groundwater resources hydraulically connected to the base of the landfill from pollution by landfill leachate for as long as the wastes in the landfill will be a threat. While the regulatory agency staff member stated that a minimum of 30 years of post-closure care funding for maintenance, monitoring and other activities designed to protect the public from adverse impacts of the wastes, was to be provided, he did not discuss the fact that there is no assurance that post-closure care funding for monitoring, maintenance and remediation will, in fact, be available in sufficient amounts to meet plausible worst-case scenario failures for as long as the wastes in the landfill will be a threat. This is an issue that is of great interest to the public. As discussed above, the US Congress General Accounting Office has found highly significant problems with the approach being followed by the US EPA in implementing RCRA with respect to providing for long term protection of public health and the environment. As the GAO (1990, 1995a,b) has indicated, there are significant questions about post closure care funding associated with today's hazardous waste landfills.

The public, justifiably, has great concern about the siting of a landfill and/or the continued operation of a landfill, where there is inadequate bufferlands between the waste

management units and adjacent property owners' lands. They become even more concerned when they find that the regulatory agencies' personnel at a public hearing do not adequately and reliably discuss issues of concern to them. Governmental agency representatives have an obligation to fully and accurately describe the characteristics of a proposed landfill containment system as well as any potential problems associated with the components of this system that could lead to the wastes in the landfill polluting groundwaters by hazardous and deleterious chemicals at some time in the future.

Overall, the regulatory agency staff member discussion of issues was basically pro-applicant, in support of the landfill's relicensing. The staff member took the approach of placing the burden of proof on the public of showing the significant deficiencies in the proposed landfill design, operation, closure and post-closure care that he superficially described in his testimony at the hearing. The burden of such review should first be placed on the public agency representatives who are supposed to be working on behalf of the public in protecting their interests from hazardous and deleterious chemicals present in the wastes.

A geologist for the regulatory agency reviewed the geology and the monitoring of the landfill. He stated, *the results of this investigation were also used to develop the facility environmental monitoring programs.* The staff member mentions the suction lysimeters that have been installed under the existing cells where he states that *"They are built detection monitoring system."* He did not, however, discuss the reliability of these systems in detecting leaks through the liner system before widespread pollution occurs. As discussed herein, suction lysimeters sample a small area compared to the area through which landfill leachate can pass through the liner on its way toward causing groundwater pollution.

It is inappropriate fora regulatory agency staff member to mention some component of the landfill monitoring system, such as suction lysimeters, implying that they are an important component of protecting groundwater quality without also discussing the reliability of the component in performing as required to achieve regulatory requirements in protecting public health, groundwater resources, and the interests and welfare of those within the sphere of influence of the landfill.

The agency staff member discusses the geology of the landfill site where he states...*from the surface, from zero to approximately 20 feet at the side, there is a surficial sand and fill unit.* He states in the next paragraph that this sand and fill area was removed during the construction of the landfill and that the landfill is physically and hydraulically separated from it through *"diking and a drain tile system."* This agency staff member did not, however, discuss the long-term issues associated with the prevention of the surficial groundwaters surrounding the waste cells from entering the wastes for as long as the wastes are a threat. He also does not discuss the potential problems associated with failure to remove leachate from this landfill for as long as the waste in the landfill will be a threat, which could lead to surficial groundwater pollution by waste constituents causing surface water pollution. These are important issues that should have been evaluated and discussed with the public so that they understand the adequacy and

reliability of the various approaches that the landfill applicant has proposed to follow in trying to "engineer" a suitable site for a landfill, when the basic characteristics of the site are such that the original landfill should never have been sited at this location.

On page 26 beginning on line 9, the regulatory agency staff member discusses what he calls the next unit below the sand layer. He states, *it's this silty clay fill, and what this is is a clay rich material which contains some sand and gravel. It's a very good mixture of it and gives us very good permeability characteristics. It's a very impermeable material.* He states that *the landfill applicant is required to have a minimum of 10 feet of something called one times 10 to the minus seven centimeters per second clay, silty clay beneath the facility.* He further states, *this material forms the sub-base of the hazardous waste cells.* Below this layer, according to the staff member, are geologic materials which *...coarsens as you move downward and gradually turns into a silt material called the transition silts.* He states, *this material does have some fairly good permeability characteristics in terms of it's got a fairly low permeability, but it's not acceptable for a landfill containment, although it would probably meet the permeability criteria.*

The regulatory agency personnel continues his discussion of the geology of the site by stating,*...this silt material overlies a sand here which is considered to be the uppermost aquifer at the facility.* Therefore the uppermost aquifer below this landfill is a sand aquifer system in which there is at least 10 feet of low permeability (1×10^{-7} cm/sec) clay-like material and a higher permeability silt.

While the regulatory agency staff member goes to considerable lengths to describe the geological strata underlying the site of the landfill cell, stressing their low permeability and conformance to minimum regulatory requirements, he does not provide the public with a discussion of what this means in the way of protecting the groundwaters underlying the site from pollution by leachate for as long as the wastes in the landfill will be a threat. The public is entitled to know this information.

The facts are that while there is a low-permeability layer of clay underlying the site, the testing of the permeability of this layer has not been adequately or reliably done, since it is based on laboratory testing. Further, the number of tests and their locations are not adequate to describe whether the geological strata underlying the site conform to minimum regulatory requirements. More reliable testing could show that the geological strata underlying the site are not adequate to conform to minimum regulatory requirements.

The regulatory agency staff member should have also discussed the fact that there is a significant long-term problem associated with this site because of the relatively thin layer of low-permeability clay between the base of the landfill and the aquifer system underlying the site. This low-permeability layer will obviously not prevent leachate derived from this landfill from eventually penetrating through the layer and polluting the groundwaters under the site. The public is entitled to know that this is a significant issue that must be considered in the relicensing/permitting of this site. Basically the regulatory agency geologist's presentation at the public hearing did not provide the public with the

information that he should have on the characteristics of the geological strata underlying the landfill site.

The regulatory agency staff member states, *this resource is monitored by 17 monitoring wells at the facility, and this is a key item that we focus on in terms of environmental protection.* This staff member should have presented a discussion of the results of a detailed analysis conducted, if not by the landfill applicant, by the regulatory agency staff, of the reliability of the monitoring well system used in detecting groundwater pollution by leachate before pollution occurs beyond the point of compliance for the monitoring. The three downgradient monitoring wells are located about 400 feet apart. Each well has a zone of capture associated with a sampling event of about one foot on each side. Therefore, there are 398 feet between the wells where leachate-polluted groundwater could pass and not be detected by the wells. As discussed above, Cherry (1990) showed that the leachate plumes generated from leakage through a plastic sheeting-lined system, such as those used at hazardous waste and municipal solid waste landfills today will produce finger plumes of leachate-polluted groundwater a few feet in width. Lee and Jones-Lee (1994b) published a review of this issue. They point out the difficulties of trying to reliably monitor lined landfills with vertical monitoring wells spaced hundreds of feet apart. Basically, the monitoring system proposed for this landfill is flawed and will not protect the groundwater resources downgradient from the landfill. This information should have been provided by the regulatory agency staff member to the public on the reliability of the groundwater monitoring system that the regulatory agency is proposing to allow the landfill applicant to operate associated with the licensing of the continued operations of the landfill. If he had properly analyzed the situation and provided this information to the public, it would have been obvious that this landfill should not be relicensed with this groundwater monitoring system.

The regulatory agency staff member states that the surficial sand layer contains groundwaters *...flowing at the site from north to the south-southwest toward a nearby lake.* He does not, however, discuss that the surficial groundwaters in the sand layer are a potential route for transport of leachate from the landfill to the surface waters of the region at some time in the future if the landfill owner does not remove the leachate from the landfill for as long as the wastes in the landfill will be a threat.

The regulatory agency staff member states, a landfill *is required to operate redundant environmental monitoring systems at the facility.* He further states, *the facilities are--or the monitoring programs are designed to detect a release at the earliest possible time, and so if there is a problem, it can be reacted to and corrected before it becomes an environmental problem.*

Someone not familiar with the details of how effective the various monitoring programs are in detecting releases from the landfill before groundwater pollution occurs might be led to believe from the regulatory agency staff member's statements that these systems are effective in detecting leachate released from the landfill that could cause groundwater pollution. However, as discussed herein, the staff member failed to properly analyze the reliability of the groundwater monitoring systems. He should have discussed each of

these so-called redundant monitoring systems with respect to their likelihood of detecting leachate released from the landfill before widespread groundwater pollution occurs. This is an issue that the public wants to know.

As discussed herein, the groundwater monitoring wells at this and many landfills are unreliable in detecting leachate-polluted groundwaters before widespread pollution occurs. The same situation also applies to the suction lysimeters mentioned above. Each of these systems measures a very small area. There are three monitoring wells that are critical to detecting leachate leakage from the landfill. These wells are spaced several hundred feet apart. Each well has a radius zone of capture of approximately 1 foot. Since the leakage from the liner system will be through plumes that can be a few feet in width near the downgradient edge of the waste management unit, which is also the point of compliance for groundwater monitoring, the regulatory agency staff member's statement *...the monitoring programs are designed to detect a release at the earliest possible time...* is inaccurate and over-exaggerates the ability of the monitoring system to effectively detect failure of the liner system that will lead to groundwater pollution.

The regulatory agency staff member states, w*e have over five years of data on the leak detection systems for the existing landfill cell and none of that data has indicated an environmental problem.* He also states, *we have not detected any volatile organic compounds or anything that would suggest that we have leachate going through the primary liner of the landfill.* He should have informed the public when leaks through this system would be expected to be observed. It would be longer than the five years unless there was a large-scale failure of the liner system. He should have also indicated that the situation experienced over the past five years compared to what would be expected over the infinite time that the waste in the landfill would be a threat is not a reliable prediction of what will occur in the future. Obviously, the period that the landfill has been operating represents such a small part of the total time the wastes will be a threat as to be inconsequential and certainly not an appropriate basis to judge what will happen in the future.

The regulatory staff member states that, *cells were constructed prior to the leak detection requirements and a leak detection system was retrofitted under the landfill by the suction lysimeters.* He describes the suction lysimeters as *... horizontal wells that were drilled underneath the landfill parallel to the bottom of the landfill...* that are located in the clay where he states *... they would yield an indication of leakage from the landfill prior to that being able to get into the ground water.* He should have conducted an evaluation of the amount of area actually sampled by these suction lysimeter horizontal wells compared to the area through which leakage could occur.

Keller (1994) in a presentation at the California Groundwater Resources Association annual meeting entitled "What Constitutes a Reliable Vadose Monitoring System?" discussed how to evaluate the reliability of vadose monitoring systems. The approaches he has described should be used at a landfill to determine whether the suction lysimeters that are being used have any significant probability of detecting leakage from the landfill unit before widespread pollution occurs. Conducting such a review will show that it is

inappropriate for him to imply that the suction lysimeters that have been installed under these landfill cells are reliable monitoring devices to detect leachate penetration of the liner systems for these cells at all of the places where leachate leakage from the cell could have occurred. Further, he should have discussed whether they will be reliable devices to detect future leachate leakage that will occur from these cells for as long as the wastes in the cell will be a threat.

A critical examination of the potential for the leachate leakage through the liners to be detected by the suction lysimeters would show that they have a low probability of detecting leachate before pollution of groundwaters occurs. These issues are subject to quantification. There is no need to follow the superficial approach that is being used by a regulatory agency in review of a landfill groundwater monitoring system. The continued operation and expansion of a landfill, in terms of the waste accepted, should not be permitted/licensed until a proper evaluation of the reliability of the monitoring system that exists has been conducted.

The regulatory agency staff member states, *if it would get out, we would first detect it in a leak detection system, and also if for some reason that they got past the leak detection system without being detected, it would detect it in a ground water monitoring program.* The facts are that ultimately the leak detection system will fail to function effectively to collect leachate since its ability to function depends upon the integrity of the flexible membrane liners in the lower double composite liner. Further, the groundwater monitoring system that has been installed is unreliable in detecting leachate before widespread pollution occurs.

The regulatory agency staff member states, *again, these systems are redundant for the purpose of identifying any problem at the earliest possible time and then being able to correct it.* This statement is superficial and does not properly describe the reliability of these systems. From the long range perspective, i.e., during a significant part of the time that the wastes in the landfill will be a threat, the liner leakage detection systems are essentially ineffective in detecting leaks. The way leaks would be detected is by off-site production wells. He should have discussed these issues rather than providing the public with unreliable information on the ability of this system to serve as a reliable leak detection system for the leakage of leachate through the liner system en route to the groundwaters.

The regulatory agency staff member states that, *to summarize, the geology of this site meets state hazardous waste siting requirements and is suitable for hazardous waste disposal activities.* This is a pro-applicant statement that does not properly reflect the length of time that the wastes in the landfill will be a threat. He should have discussed this issue from the public's perspective rather than from a short-term landfill applicant's perspective. There will be people living in the vicinity of this landfill who will want to use groundwaters in this area who should be entitled to groundwaters free of landfill leachate forever. To follow the approach that the staff member has followed of only examining the system for a short period is superficial and disregards the interests of the public.

The regulatory agency staff member states, *the integrity of the site has been demonstrated by over 15 years of ground water monitoring data. We've had ground water monitoring data for over 15 years from monitoring wells surrounding the site and those - that data does not indicate leakage from the landfill.* Again, if he had conducted a proper analysis of the situation he would have indicated that the 15 year period for this site is an inadequate period to make a reliable assessment of whether the wastes in the landfill unit will ultimately pollute groundwater. He should have pointed this out. Failing to do so shows a bias towards the applicant in licensing of the landfill.

The regulatory agency staff member states, *it is necessary to do continued detection monitoring of the site in order to verify the performance of the system.* He should have discussed the fact that for year 31, one year after a landfill's post-closure period ends, there is no assurance that funds will be available to continue the detection monitoring even if in that year, 31, there is a problem. What about year 50, 100, 200? The wastes in the landfill will still be a threat then. The people in the region will still want groundwater without PCB wastes and other hazardous and deleterious chemicals in it. Why does a landfill applicant, with regulatory agency support, only examine the potential for this landfill to pollute during a short period of time and does not consider or at least report on the issues of concern to the public? Namely, will this landfill at anytime in the future pollute groundwaters rendering them unusable for domestic or other purposes?

Overall, the regulatory agency staff member has not provided the public with adequate and reliable information on the potential for the proposed continued operation of the landfill to pollute groundwaters with landfill leachate rendering these waters unusable for domestic and many other purposes.

A regulatory agency staff member who is responsible for inspection of the hazardous waste treatment and disposal facility states with regard to problems with past operations of the hazardous waste treatment and disposal facility a*nd there were penalties. There was a half a million dollar penalty and cost reimbursement.* It is clear that the landfill applicant has not conducted its waste management activities in such a way as to be a responsible corporate entity that should be allowed to continue to operate a hazardous waste landfill at this site.

This staff member's discussion of issues does not address many of the issues of concern to the public, such as would his inspections detect the incipient pollution of groundwaters by landfill leachate that has passed through the liner system and is not detected in the ineffective leachate pollution monitoring system. He should have discussed these issues in order to inform the public of not only what he does in his inspections but also the deficiencies of what he does compared to what is needed to protect public health, groundwater resources, the environment and the interests of those within the sphere of influence of this hazardous waste management facility.

Another regulatory agency staff member mentions the odor problems associated with past operations of the hazardous waste management facility. A review of the public's comments concerning the experiences they have had in living or utilizing properties near

the landfill and waste treatment facility shows that these facilities have been a poor neighbor where repeated significant adverse impacts on the public have occurred in the vicinity of the landfill. Where a landfill company fails to conduct its operations in an appropriate manner so that they are not adverse to the adjacent and nearby property owners and users, it is inappropriate to allow the firm to continue to operate.

The operating records shows that this company has a history of releasing odorous materials from the waste treatment facility. While there may be some that may ignorantly assert that these are only malodorous conditions and not harmful to health, it is well known that malodorous conditions of this type may be significantly adverse to public health. Shusterman (1992), of the California Department of Health, has conducted extensive studies on the adverse public health impacts of malodorous situations. He reports that such situations are significantly detrimental to the health of many individuals experiencing the malodorous conditions.

Lee and Jones-Lee (1994d) in a report to the State of California Environmental Protection Agency Comparative Risk Project entitled, "Impact of Municipal and Industrial Non-Hazardous Waste Landfills on Public Health and the Environment: An Overview," discuss how releases from landfills can be adverse to the health, air and groundwater quality and the interest/welfare of those within the sphere of influence of a landfill. This sphere of influence can extend several miles or more from the landfill. They recommend that the siting or continued operation of a landfill include, as part of the cost of landfilling, acquisition of sufficient bufferlands owned by the landfill applicant to dissipate all releases of hazardous or otherwise deleterious chemicals including odors from the landfill that are not controlled by the landfill's owner/operator at their point of generation.

The landfill has been allowed to develop and is proposed to be allowed to continue to operate without sufficient control of releases of hazardous and/or deleterious chemicals from the landfill to protect the health, groundwater resources, the environment and the interests of those who own or use properties within the sphere of influence of the landfill. This approach enables the landfill company and the waste generators to experience cheaper than real cost waste management at the expense and health of those within the sphere of influence of the landfill. Such an approach should not be allowed to continue.

A review of the operating records of the landfill company and affiliated companies leads to the conclusion that these companies should not be allowed to continue to operate this landfill. If the landfill company is issued a license for continued operations, one of the conditions of this license should be that if one more incident of off-site adverse impacts of any type, including odor, occurs, all facilities at this location would be permanently shut down with no possibility of continued operation. This company(s) should not be allowed to continue to conduct its operations in such a way as to be periodically adverse to those who own or use properties in the vicinity of the landfill.

A geologist with another regulatory agency states with respect to the disposal of PCBs in this landfill, a*pproval is based on satisfying all of the technical requirements specified in*

the regulations and any others that the regional administrator might find is necessary in order to demonstrate that the landfill meets the standards with no unreasonable risk. He further states, technically it's no unreasonable risk to human health and the environment, but we think it's important to realize that we're out there to protect your health. It is important to understand that the basic regulations governing the management of PCBs in landfills were developed in the late 1970s based on the technology that was available during the mid-1970s. The author has yet to find anyone who understands the adequacy of these regulations and who will reliably report on them who will not admit that the TSCA regulations governing PCB landfilling are badly out-of-date. Therefore, meeting these regulations does not mean protection.

The regulatory agency staff member states with reference to the underlying geologic material for the landfill cell, *the material that failed was removed and it was replaced by satisfactory material. That way we know that the clay pan under which this landfill is constructed is more than just natural material. It's engineered and is specially placed. It makes it's* [sic]*considerably better than uncontrolled material.* The issue that should have been addressed is not whether the material is better than uncontrolled material. The public wants to know whether this material will prevent leachate from passing through it and polluting groundwaters of interest to them and future generations for as long as the wastes in the landfill represent a threat. The regulatory agency personnel should have addressed this issue.

The regulatory agency staff member stated, *you'll notice up this side I have -- some of these items are marked as meeting the TSCA requirements and some of them exceed the TSCA requirements.* As discussed above, meeting or exceeding TSCA minimum requirements for landfilling of PCB waste does not mean protection of public health and groundwater resources will be achieved.

The regulatory agency staff member stated, *the TSCA requirements say that if it's in a clay pan, you don't even have to have a liner.* He also states, t*his facility has three liners two synthetic ones and re-compacted clay pan.* Again, this is a misleading presentation of issues that are of concern to the public. The public is interested in whether this system will protect for as long as the wastes are a threat. The regulatory agency staff have failed to address this issue. Simply meeting badly-out-of-date regulations does not protect public health, groundwater resources, the environment and the interests of those who own or use properties within the sphere of influence of the landfill and the waste treatment facility.

The regulatory agency staff member stated with reference to these three liners, *these were put in there to compensate for the fact the facility is within 50 feet of the ground water table.* While the agency staff member did not discuss this, he has admitted by this statement that this site fundamentally does not meet minimum TSCA requirements of a 50-foot separation between the groundwater table and the landfill. While he attempted to minimize this deficiency by indicating that there are a number of liners installed, it is well-known that these liners will not prevent leachate from passage through them for as long as PCB and other wastes in the landfill will be a threat. To assert as the staff

member did, that these three liner systems are more effective than 50 feet of natural clay in protecting groundwaters for as long as the wastes in the landfill represent a threat is inappropriate. The staff member's comment that a liner which is known to fail is better than 50 feet of natural strata, represents a superficial review of issues and only considers short-term behavior.

The regulatory agency staff member stated, *the synthetic landfill liner is much thicker than the minimum requirements.* Again, while this is true, it is misleading. Since both the thinner and the thicker liners will ultimately fail, it is only a matter of time until groundwater pollution occurs. This is the issue that should have been discussed.

The regulatory agency staff member's statement that, *the composite construction is more than three times more protective than a single liner,* represents an inappropriate approach in presenting information of interest to the public. While a composite liner can be protective for a short period of time compared to the length of time that the wastes are a threat, ultimately it will fail to prevent leachate from passing through the liner. The public should have been made aware of this situation.

The regulatory agency staff member states that, *the TSCA cells have double liners -- under a leak detector. The leak detector is to make sure that no landfill material ever gets out, no liquids get out.* Either he does not understand the properties of liners with respect to their long-term stability or is deliberately failing to reliably report on them by such a statement. There is no question that that statement is unreliable, is non-factual and does not represent a proper description of the situation. Waste materials placed in this landfill, including PCB waste materials, will "get out" of this landfill containment system during the time that the wastes in this landfill will be a threat. It is important to point out that TSCA does not limit the time that the public health is supposed to be protected by the landfill containment system.

A regulatory agency staff member states, *the cover system for the cell is a continuous cover that would cover all the sub-cells within that area and it's designed and constructed in accordance with the hazardous waste regulations to promote drainage and prevent precipitation from entering the landfill and generating leachate during the closure and post-closure care.* It is not clear from this statement whether he considers that the post-closure care period is only 30 years after closure or for as long as the wastes in the landfill will be a threat. He should have fully defined what he meant in order to eliminate the ambiguity that exists now on whether he is considering only protecting the public's interests for a short period of time that the waste will be a threat or throughout this period.

Anyone who is familiar with the properties of landfill covers of the type which he describes knows that his statement that these covers will unequivocally prevent moisture from entering the landfill are inaccurate and a significant misrepresentation of what will actually occur. As discussed in a number of papers presented at the American Society of Civil Engineers Landfill Closure conference proceedings that was held in October 1995, "Landfill Closures, Environmental Protection and Land Recovery," there are great

problems in developing landfill covers that only minimize moisture entering a landfill. At this conference the author presented and invited overview paper entitled, "Overview of Landfill Post Closure Issues," (Lee and Jones-Lee 1995b). A review of this paper and the references cited therein and the other papers presented at the ASCE conference as presented in the proceedings shows that landfill covers of the type that the regulatory agency staff member described as being able to prevent moisture from entering the landfill will not, in fact, prevent moisture from entering the landfill for as long as the wastes in the landfill represent a threat. The clay layer in the cover will, in a short time after installation, experience desiccation cracks. The plastic sheeting layer in the cover will develop holes and cracks and eventually deteriorate. A number of companies such as those discussed in the authors' review of landfill post-closure issues are developing leak detection systems for plastic sheeting liners.

An important aspect of this situation that the regulatory agency staff members need to explain to the public is how the regulatory agencies are going to ensure that the landfill owner maintains the cover for this landfill so that it will prevent moisture from entering the landfill for as long as the wastes in the landfill will be a threat. The key layer in the cover preventing moisture from entering the landfill is the plastic sheeting layer. This layer is buried below about 2.5 feet of covering material. Without installing a leak detectable cover system and maintaining and operating it forever, there is no way to determine when holes, cracks, rips, tears or points of deterioration develop in the plastic sheeting layer by visual inspection of the ground, i.e., the topsoil layer. It is impossible for the landfill owner, with the proposed landfill cover system, to "prevent" moisture from entering the landfill for as long as the wastes represent a threat.

It is also important to understand that the operation of a leak detectable cover on a landfill will require that considerable funds be devoted to the operation and maintenance of the cover, including periodic replacement of the cover. Since the wastes in the landfill will be a threat forever, the cover must prevent moisture from entering the landfill forever. Ultimately, the liner system underlying the landfill will deteriorate and since it cannot be repaired without removing the wastes, the ability of this landfill containment system to prevent groundwater pollution will be dependent upon the integrity of the cover. The regulatory agency staff have not thought out/discussed the realities of installing and maintaining a reliable cover on this landfill cell for as long as the wastes represent a threat.

A regulatory agency staff member stated, *in terms of the hydrogeology of the site, it is a proven site today.* He does not define what he means by a "proven site." Does he mean that the hydrogeological characteristics of the site are well understood? If so, why did he not discuss how long it would take for waste derived constituents to move from the base of the landfill through the so-called low permeability layers into the groundwater system underlying the landfill? Also, why did he not discuss the significant deficiencies in the hydrogeologic information that exists for the site? This information should have been provided. It would show that under plausible worst-case scenario failure situations, it is only a matter of time until groundwater pollution occurs.

A regulatory agency staff member stated, *in summary, the geology of the site meets state hazardous waste siting requirements and is suitable for hazardous waste disposal activities. The integrity of the site has been demonstrated by over 15 years of ground water monitoring data.* This staff member has unreliably represented the ability to detect leachate leakage from the waste management units based on the 15 years of operation and extrapolated this period to the period of time that the waste in the landfill will be a threat, i.e., forever. This staff member has presented inadequate and unreliable information to the public on these issues.

A regulatory agency staff member stated, *under the TSCA program, we have a situation we call perpetual care. As long as the PCB is in place, they're required to maintain it. That exceeds the minimum requirements.* In order for such a statement to have any meaning, the staff member must inform the public how using the financial instruments available, the landfill owner can provide perpetual care for as long as the PCB waste in the landfill will be a threat (forever). It is important to note that the landfill owner only proposes to maintain the landfill for 30 years after closure. The public is entitled to know how the perpetual care will be accomplished, with particular reference to who will fund this perpetual care, the amount of funds needed, and the source of funds that will be available at any time in the future to meet routine monitoring and maintenance and plausible worst-case scenario failure situations.

Overall, I find that the staff member's discussion of information pertinent to permitting of the landfill represents a distorted presentation of issues that are of great importance to the public. The public is entitled to a more appropriate discussion of the issues of concern than they were provided at the public hearing.

The hearing officer discussed the concept of significant testimony which includes *...significant and environmental hazards to human health and the environment.* The waste management unit that is proposed for relicensing represents a significant hazard to human health, groundwater resources and the environment.

It is stated that the license must be approved unless it is found that the landfill *...presents an unacceptable hazard to the public health or the environment or the application was not sufficiently detailed or adequate and, therefore, misleading.* As the author has documented in the discussions presented herein, the draft license/permit issued by the regulatory agencies is based on an inadequate, unreliable review of the ability of this landfill to protect public health, groundwater resources and the environment for as long as the wastes in the landfill will be a threat. Further, the landfill applicant has not provided adequate or reliable information in its application for relicensing/permitting to justify continued operations. This situation should cause the application for continued operation of this landfill to be disapproved.

The hearing officer states that we will respond in writing to all comments that are significant in the public record. *That is done so that we can provide a thorough and accurate response to all comments and concerns, and that a written response will be sent to persons indicating they wish to be notified.* Since having been involved in a number of

landfill permitting situations of this type over the years where regulatory agencies do not adequately review the landfill applications prior to issuing a draft permit, such as in this case, it is imperative that an adequate mechanism be established whereby full, public peer review be conducted of any responses that the regulatory agency staff or the landfill applicant make where they attempt to justify the previously adopted position that this landfill should be allowed to continue to operate and be allowed to accept PCB waste.

In order to resolve conflicts on technical issues, the author (Lee and Jones-Lee 1995c) recommends that if the regulatory agency personnel, the landfill applicant or its consultants, or others, claim that their position on technical issues is appropriate, which is contrary to the positions set forth in these comments as well as in the backup documents provided, then these issues should be peer reviewed by independent knowledgeable individuals. This peer review should be conducted in a full public peer review arena to provide decision makers an assessment of the technical validity of the relative positions on particular issues. The author is confident that a proper peer review of any technical issue in question will show that the regulatory staff or others' positions which are contrary to those set forth in these comments, are technically invalid and inappropriate and that they are based on a superficial review of the basic science and engineering that is pertinent to the topic under question.

References

Belevi, H., and Baccini, P., "Water and Element Fluxes from Sanitary Landfills, "IN: Sanitary Landfilling: Process, Technology and Environmental Impact, Academic Press, San Diego, pp. 391-397 (1989).

Buss, S.E., Butler, A.P., Johnston, P.M., Sollars, C.J., and Perry, R., "Mechanisms of Leakage through Synthetic Landfill Liner Materials," J. CIWEM 9:353-359 (1995).

Cherry, J.A., "Groundwater Monitoring: Some Deficiencies and Opportunities," In: Proc. of the 10th ORNL Life Sciences Symposium, Gaitlinburg, TN, Hazardous Waste Site Investigations; Towards Better Decisions, Berven & R.B., Gammage, (editors), Lewis Publishers, B.A. (1990).

Flood, D.R., "Synthetic Linings for Hazardous Wastes," National Environmental Journal, May/June (1994).

Fluet, J.E., Badu-Tweneboah, K., Khatami, A., "A Review of Geosynthetic Liner System Technology," Waste Management & Research, 10:47-65 (1992).

Freeze, R.A., and Cherry, J.A., Groundwater, Prentice-Hall, Englewood Cliffs, NJ (1979).

GAO, "Hazardous Waste Funding of Postclosure Liabilities Remains Uncertain," General Accounting Office, Report to Congress, RCED-90-64, Washington D.C., June (1990).

GAO, "Compliance With Groundwater Monitoring Requirements at Land Disposal Facilities," General Accounting Office, Briefing Report to the Ranking Minority Member, Committee on Governmental Affairs, US Senate, GAO/RCED-95-75BR, February (1995a).

GAO, "Superfund Operations and Maintenance Activities Will Require Billions of Dollars," General Accounting Office, Report to Congress, RCED-95-259, Washington D.C., September (1995b).

Hickman, L., "Financial Assurance-Will the Check Bounce?," Municipal Solid Waste News, March (1992).

Hickman, L., "Ticking Time Bombs?," Municipal Solid Waste News, Solid Waste Association of North America, March (1995).

Hsuan, Y.G. and Koerner, R.M., "Long Term Durability of HDPE Geomembranes Part I - Depletion of Antioxidants," Geosynthetic Research Institute Report #16, Drexel University, Philadelphia, PA, (1995).

Jones-Lee, A. and Lee, G.F., "Groundwater Pollution by Municipal Landfills: Leachate Composition, Detection and Water Quality Significance," Proceedings of Sardinia '93 IV International Landfill Symposium, Sardinia, Italy, pp. 1093-1103, October (1993).

Keller, C., "What Constitutes a Reliable Vadose Monitoring System?", A presentation at the Groundwater Resources annual meeting in Napa, CA, Sept. 29-30 (1994) (Available from Eastman Cherrington, 1640 Old Pecos Tr., Suite H, Santa Fe, NM 87505).

Lee, G.F., "Comments on Tisinger and Giroud `The Durability of HDPE Geomembranes'," Submitted as Letter to the Editor, Geotechnical Fabrics Report, Minneapolis, MN, 4pp (1994).

Lee, G.F. and Jones, R.A., "Municipal Solid Waste Management in Lined, `Dry Tomb' Landfills: A Technologically Flawed Approach for Protection of Groundwater Quality," Report of G. Fred Lee & Associates, El Macero, CA, 68pp, March (1992).

Lee, G.F. and Jones-Lee, A., "Municipal Landfill Post-Closure Care Funding: The 30-Year Post-Closure Care Myth," Report of G. Fred Lee & Associates, El Macero, CA, 19pp (1992).

Lee, G.F. and Jones-Lee, A., "Geosynthetic Liner Systems for Municipal Solid Waste Landfills: An Inadequate Technology for Protection of Groundwater Quality?" Waste Management & Research, 11(4):354-360 (1993a).

Lee, G.F. and Jones-Lee, A., "Landfill Post-Closure Care: Can Owners Guarantee the Money Will Be There?" Solid Waste and Power, 7(4):35-39 (1993b).

Lee, G.F. and Jones-Lee, A., "Landfilling of Solid & Hazardous Waste: Facing Long-Term Liability," IN: Proceedings of the 1994 Federal Environmental Restoration III & Waste Minimization II Conference, Hazardous Materials Control Resources Institute, Rockville, MD, pp. 1610-1618, April (1994a).

Lee, G.F., and Jones-Lee, A., "A Groundwater Protection Strategy for Lined Landfills," Environmental Science & Technology, 28:584-5 (1994b).

Lee, G.F. and Jones-Lee, A., "Does Meeting Cleanup Standards Mean Protection of Public Health and the Environment?," IN: Superfund XV Conference Proceedings, Hazardous Materials Control Resources Institute, Rockville, MD, pp. 531-540 (1994c).

Lee, G.F. and Jones-Lee, A., "Impact of Municipal and Industrial Non-Hazardous Waste Landfills on Public Health and the Environment: An Overview," Report to State of California Environmental Protection Agency Comparative Risk Project, Berkeley, CA, 45pp, May (1994d)

Lee, G.F. and Jones-Lee, A., "Recommended Design, Operation, Closure and Post-Closure Approaches for Municipal Solid Waste and Hazardous Waste Landfills," Report to Greenpeace, Mexico, G. Fred Lee and Associates, El Macero, CA (1995a).

Lee, G.F. and Jones-Lee, A., "Overview of Landfill Post Closure Issues," Presented at American Society of Civil Engineers Convention session devoted to "Landfill Closures - Environmental Protection and Land Recovery," San Diego, CA, October (1995b).

Lee, G.F. and Jones-Lee, A., "Practical Environmental Ethics: Is There an Obligation to Tell the Whole Truth?," Published in condensed form "Environmental Ethics: The Whole Truth" Civil Engineering, Forum, 65:6 (1995c).

Lee, G.F. and Jones-Lee, A., "Evaluation of the Potential for a Proposed or Existing Landfill to Pollute Groundwaters," Report of G. Fred Lee & Associates, El Macero, California, July (1996a).

Lee, G.F. and Jones-Lee, A., "Detection of the Failure of Landfill Liner Systems," Report of G. Fred Lee & Associates, El Macero, CA, April (1996b).

Park, J.K., Sakti, J.P. and Hoopes, J.A., "Transport of Organic Compounds in Thermoplastic Geomembranes. I: Mathematical Model," Journal of Environ. Engr., 122(9):800-806 (1996a).

Park, J.K., Sakti, J.P. and Hoopes, J.A., "Transport of Organic Compounds in Thermoplastic Geomembranes. II: Mass Flux Estimates and Practical Implications," Journal of Environ. Engr., 122(9):807-813 (1996b).

Parsons, A.M. and Davis, P.A., "A Proposed Strategy for Assessing Compliance with the RCRA Ground Water Monitoring Regulations," Current Practices in Ground Water and

Vadose Zone Investigations, ASTM STP 1118, David M. Nielsen and Martin N. Sara, (editors), American Society for Testing and Materials, Philadelphia, PA (1992).

Sakti, J.P., Park, J.K., and Hoopes, J.A., "Permeation of Organic Chemicals through HDPE Geomembranes," In: Proceedings of ASCE National Environmental Engineering Conference, ASCE, New York, July (1991).

Shusterman, D., "Critical Review: The Health Significance of Environmental Odor Pollution," Archives of Environmental Health 47(1):76-87 (1992).

Tisinger, L.G., and Giroud, J.P., "The Durability of HDPE Geomembranes," Geotechnical Fabrics Report, p. 4-8, September (1993).

US EPA, "Solid Waste Disposal Facility Criteria; Proposed Rule," Federal Register 53(168):33314-33422, 40 CFR Parts 257 and 258, US EPA, Washington, D.C., August 30, (1988a).

US EPA, "Criteria for Municipal Solid Waste Landfills," US EPA Washington D.C., July (1988b).

Reference as: "Lee, G.F., and Jones-Lee, A., 'Permitting of New Hazardous Waste Landfills and Landfill Expansions: A Summary of Public Health, Groundwater Resource and Environmental Issues,' Report of G. Fred Lee & Associates, El Macero, CA (1996)."

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