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Comments on Waste Management's "A Compilation Of Expert Reports Provided To The Pottstown Landfill Closure Committee," Dated June 1, 2005

Via email

Ruth Damsker, Chair
Pottstown Landfill Closure Committee

Dear Chairperson Damsker and Members of the Committee:

At the June 1, 2005, meeting of the Pottstown Landfill Closure Committee (Committee), Waste Management (WM) provided the Committee with "A Compilation Of Expert Reports Provided To The Pottstown Landfill Closure Committee" (Compilation), dated June 1, 2005. This report was developed by Waste Management to attempt to discredit Dr. Cole and my peer review reports to the Committee on the current environmental and public health problems with the Pottstown Landfill as well as the issues that the Committee may wish to consider in developing a final closure plan for this landfill. I wish to provide the Committee with information on the unreliable, inadequate and distorted information that Waste Management and its consultants have provided on Dr. Jones-Lee and my March 13, 2005, report (Lee and Jones-Lee, 2005a). Dr. Cole will be providing separate comments on Waste Management's comments on his reports.

In general, for many topic areas, Waste Management and its consultants have provided essentially non-technical superficial comments. For those apparently technically supported comments on our draft report, "Expected Performance of the Pottstown Landfill Containment and Monitoring Systems" (Lee and Jones-Lee, 2005a), many of the comments are not applicable to the conditions that will exist in the closed Pottstown Landfill. A critical review of the so-called technically supported comments shows that they largely ignore the physical, chemical and biological processes that will occur in the Pottstown Landfill when a properly installed and maintained low-permeability cover is placed on the landfill in accordance with Pennsylvania Department of Environmental Protection (DEP) regulations.

Waste Management and its consultants, in the June 1, 2005, comments on our March 13, 2005, report, have failed to address the site-specific information that we provided to the Committee in our comments on the deficiencies in the GAI draft report (Lee and Jones-Lee, 2005b). They also have not addressed the site-specific comments that we provided to the Committee in our report on the current and potential future problems that will exist at the Pottstown Landfill that Dr. Cole and I presented at the June 1, 2005, Committee meeting (Lee and Jones-Lee, 2005c). Additional information on site-specific issues of concern is provided in the following comments.

WM in the Executive Summary of its Compilation stated, *"We believe that these reports demonstrate that the Pottstown Landfill operations, as permitted under current regulations, are protective of human health and environment."* This is another of Waste Management's self-serving statements that are not in accord with the facts. Waste Management and its consultants have ignored the large number of Notice of Violations (NOVs) that DEP has had to issue to Waste Management on the recent past operations of the Pottstown Landfill. Dr. Cole, in his June 1, 2005, presentation to the Committee and in his supporting report (Cole, 2005a,b), provided a summary of many of the failures of Waste Management to comply with regulatory requirements for this landfill. As was pointed out by the Committee members, it was inappropriate for GAI, in its draft report, to claim that Waste Management is in compliance with regulatory requirements. Waste Management has a long, documented history of inadequate control of gas releases, including odors, as well as excessive generation of leachate and landfill gas. If Waste Management is unwilling to operate this landfill in accordance with regulatory requirements while there is a funding source from its current acceptance of wastes, is there reason to believe that, during the very long postclosure period while the landfill will only represent a financial liability to Waste Management, WM will be diligent in providing the required maintenance and monitoring to fully protect public health and the environment for as long as the wastes in the landfill will be a threat to release waste-derived constituents through landfill gas and leachate?

Waste Management's Executive Summary of Their Consultants' Comments

WM, in the Executive Summary of its Compilation, summarized "key points" from its various consultants' comments.

WM's Summary of Key Points from Koerner's Comments

Koerner has indicated that,

> *"The geosynthetic materials incorporated into the Pottstown Landfill liner systems and final cover systems have been determined to be those that are most resistant and durable and provide the highest level of environmental protection, as required by USEPA [United States Environmental Protection Agency] and PADEP [Pennsylvania Department of Environmental Protection] regulations."*

The issue is not whether the Pottstown Landfill design conforms to regulatory requirements. It is whether meeting these requirements as implemented by WM for the Pottstown Landfill liner system will be expected to collect leachate that can be generated in the landfill and thereby prevent groundwater pollution for as long as the wastes in the Pottstown dry tomb type landfill will be a threat to generate leachate. As discussed in our March 13, 2005, draft report and in the backup document (Lee and Jones-Lee, 2005d, "Flawed Technology" review), as well as in numerous references cited in those documents, the wastes in a dry tomb type landfill will be a threat to generate leachate, effectively, forever. The thin plastic sheeting and compacted clay layers in the liner, and the thin plastic sheeting in the landfill cover have a finite period of time when they can be expected to function as designed. This was acknowledged by the US EPA (1988a) when it developed the draft Subtitle D landfilling regulations. The US EPA (1988a) 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 (1988b) Criteria for Municipal Solid Waste Landfills 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."*

Further, Koerner, since the late 1980s and including his statements in the Waste Management June 1, 2005, submission to the Committee, has been predicting that the plastic sheeting HDPE liner will deteriorate and become non-functional at some time in the future. Koerner (1990) predicted, through Arrhenius modeling, the effective life of an HDPE liner to be "784 years." Koerner, in a US EPA report (Bonaparte et al., 2002), claimed that the halflife of engineering properties for an HDPE liner is 750 years. In the 2002 report he discussed the fact that there are many factors that can significantly reduce the service life of the plastic sheeting liner in a landfill.

One of the approaches used by Koerner and his associates in an attempt to predict long-term durability of HDPE plastic sheeting liners is the application of the Arrhenius equation. This equation is used in physical chemistry to relate the effect of temperature on the rates of reactions. A critical review of the technical base for this estimate shows that it is based on an Arrhenius equation extrapolation of a few studies on liner stability that were conducted for short periods of time at elevated temperatures compared to landfill temperatures. This approach for extrapolation is highly speculative and likely to be unreliable.

As discussed by Lee and Jones-Lee (2005d), Needham et al. (2003) reported on a study commissioned by the Environment Agency of the UK on the long-term service life of HDPE geomembrane liners. They concluded that,

> "*Degradation of the HDPE liner is controlled by the liner exposure conditions, the activation energy of the antioxidant depletion process and the oxidative resistance of the material. Where the liner is subjected to long-term stresses, stress cracking will lead to the development to holes, and the rate of cracking will increase once oxidation of the liner commences.*"

As I discussed with the Committee on June 1, 2005, there is no reasonable doubt that ultimately the Pottstown Landfill plastic sheeting liner system will deteriorate during the time that the wastes in the landfill will be a threat to generate leachate, leading to failure of the liner system in preventing leachate from passing through it. The Committee, as part of protecting public health and the environment from the threat of the Pottstown Landfill landfilled wastes, needs to consider this situation and work with the DEP to prepare for the potential inevitable failure of the liner system.

One of Koerner's "key points" in his review of our report was,

"Important aspects of the system design at the Pottstown Landfill are as follows:

- *The liner geomembranes are 20% thicker than the recommendation of State and Federal regulations;"*

However, a 20% thicker geomembrane (plastic sheeting liner) will likely slow down the rate of failure, but it will not prevent it.

- *"The composite layer (geomembrane placed above a geosynthetic clay liner "GCL") was incorporated ...prior to the regulatory requirement...;"*

As discussed in my comments and in the backup "Flawed Technology" review, there are significant questions about the reliability of a thin layer of bentonite clay in a GCL to function as intended without accelerated failure to slow down the rate of passage of leachate through it, due to cation exchange cracking of the clay layer. As referenced by Lee and Jones-Lee (2005d), some authorities who have investigated the situation recommend against allowing a GCL to be substituted for two feet of compacted clay. Auboiroux et al. (1999) has investigated the impact of calcium exchange for sodium in bentonite geosynthetic clay liners for landfills. They stated, "*Results suggest that while GCL's may be considered as useful materials for reinforcing compacted clay layers at the base of landfills, they should not be considered as "equivalent" to compacted clay layers, at least in terms of pollutant breakthrough times."*

Koerner stated,

- *"Coarse gravel was used in the collection system in lieu of the sand...to ensure long-term collection capacity without clogging."*

It is highly speculative to claim that the use of coarse gravel rather than sand will eliminate the clogging of the leachate collection system. The chemical and biological clogging of leachate collection systems is such a serious problem that even gravel may not be effective in preventing it.

Koerner further states,

> *"The report prepared by Drs. Lee appears to be nothing more than a compilation of past papers that they have authored or co-authored to express their personal opinions that are completely biased against the current state of the federal and state regulatory framework for solid waste containment."*

Koerner has provided a highly distorted statement of the technical basis of our report. If he had accurately reported on it, he would have noted that in Dr. Jones-Lee and my reviews, several of which have been peer-reviewed, we have provided substantial references to the literature on the issues that we have discussed about the long-term problems with the ability of thin layers of plastic sheeting and compacted clay to serve as an effective barrier to leachate pollution of groundwater for as long as the wastes in a dry tomb type landfill will be a threat. A credible review of our report by Koerner would have included comments by him on the unreliability of

the work that we cited in our publications, such as Auboiroux, et al. (1999). Without pointing out that the references that we used to the literature are based on technically invalid assessments, our references to the literature stand unchallenged. Instead, Koerner attempts to discredit our credible review of these issues by making blanket statements about the reliability of thin plastic sheeting and clay layers to protect groundwaters from pollution by landfill leachate for as long as the wastes in the landfill will be a threat.

Koerner stated,

> *"Drs. Lee conjecture about the "failure" of the liners. None of the claims are substantiated."*

With respect to Koerner's claim that we have not "substantiated" that in decades to hundreds of years the Pottstown Landfill liner system can be expected to fail to collect and transport to a sump where it can be removed, all leachate generated within the landfill when the landfill cover no longer prevents moisture from entering the landfill during the postclosure period, this is another of his superficial statements critiquing our reports and the backup documents to them. Koerner's work on long-term liner failure is one of the primary references used in our reports for inevitable failure of the liner system.

Koerner states,

> *"It should be noted that everything in our world has a finite period of time during which the materials can be expected to function as intended. Correspondingly, the waste mass will not be a threat since the half-life of the geomembrane is forecast to be in excess of 500 years."*

This is more of the unreliable information by Koerner, where he claims in his section of the Bonaparte et al. (2002) report that, since he projects that the waste in a dry tomb type landfill will no longer be a threat at some time less than the projected service life of the landfill liner system, this liner system will be protective of public health and the environment. Koerner, in Bonaparte et al. (2002), states,

> *"The required service lifetime of such GMs [Geomembranes] varies according to the type of waste, the sensitivity of the local environment, the stipulated regulations (if any), and other factors. Service timeframes that have been considered for landfills have typically fallen into the following ranges:*
>
> - *regulatory minimum (post closure) = 30 years*
> - *typical nonhazardous waste = 50 – 200 years*
> - *hazardous/low level radioactive waste = 200 – 1000 years"*

As discussed in our report to the Committee and in the "Flawed Technology" review which serves as a key component of our report, Koerner has made a significant error in claiming that typical nonhazardous waste will be a threat to produce leachate that can pollute groundwaters for only 50 to 200 years. Koerner does not provide a reference to this value. It is certainly not a defendable assessment, and it is clearly outside his areas of expertise. If he had performed even

a cursory examination of the literature as provided in our "Flawed Technology" review of the duration of leachate generation by the classical non-dry-tomb type landfills, he would know that such landfills can generate leachate well beyond 200 years (see Freeze and Cherry, 1979, for Roman Empire landfills; and Belevi and Baccini, 1989, for Swiss landfills).

There is substantial literature authored by various investigators (see Lee and Jones-Lee papers and reports on www.gfredlee.com) on the slow rate of decay of many MSW components in classical sanitary landfills in wet climates. There is also no doubt that the rate of decay of MSW waste components in dry tomb landfills with effective covers will be much slower. This is the basis for the dry tomb approach of landfilling. As we discussed in our comments on the GAI report (Lee and Jones-Lee, 2005b), in our March 13, 2005, report (Lee and Jones-Lee, 2005a), and in my presentation to the Committee on June 1, 2005 (Lee and Jones-Lee, 2005c), the key to waste decomposition is moisture. As we discussed, Christiansen and Kjeldsen (1989) have reviewed information on the effects of moisture on landfill gas production, which shows that, in the absence of moisture, landfill gas production and leachate production stops. However, at near water-saturated conditions, the rate is greatly accelerated (see Figure 8 "Impact of Moisture on Landfill Gas Formation" in our March 13, 2005, report to the Committee, which is from Christensen and Kjeldsen, 1989). If Koerner questioned the reliability of the Christensen and Kjeldsen assessment of the effects of moisture on rates of decay of wastes, he should have commented and provided literature that showed that Christensen and Kjeldsen are in error. Instead, he did not comment on this, but persisted with an inappropriate assessment that the MSW waste components in a dry tomb landfill will only be a threat for 50 to 200 years.

Koerner is apparently not familiar with or is ignoring the widespread interest in converting dry tomb landfills to bioreactors, where leachate/moisture is added to the landfill in order to eliminate the long-term problems of dry tomb landfills that lead to groundwater pollution. If Koerner's assessment that the US EPA Subtitle D landfill liner service life compared to the duration that the wastes in a dry tomb landfill will be a threat had technical validity there would not be the widespread interest in bioreactor landfill development. Contrary to Koerner's claims, there is widespread understanding that dry tomb landfills lined with thin plastic sheeting and a clay liner are not reliable for protecting groundwater quality from the landfilled wastes for as long as the wastes will be a threat.

There is no doubt that if the dry tomb conditions are achieved and maintained in the Pottstown Landfill, the moisture supply to the landfilled wastes will be stopped and the wastes will enter a dormant period, which will persist until the landfill cover no longer maintains its integrity. It should be noted that, in accordance with Pennsylvania regulations, the landfill cover design requires that it be no more permeable than the bottom liner. This means that WM, in accordance with current regulations, is required to install and maintain a low-permeability cover over all sections of the landfill that have been closed since the early 1990s. To the extent that WM achieves this requirement, leachate and gas generation will be curtailed, and the Pottstown Landfill will become a dormant "tomb" for waste storage. This situation, however, will change when WM no longer adequately maintains the cover for the landfill once it has achieved a true low-permeability cover over the landfill in accordance with current regulatory requirements.

Koerner, at several locations in his presentation, mentions a US EPA report as support for his position on the ability of thin plastic sheeting HDPE and compacted clay liners to prevent leachate that can be generated in a landfill from passing through it for as long as the wastes in a dry tomb landfill will be a threat to generate leachate. While not referenced, the report he is referring to is the Bonaparte et al. (2002) report, in which he is the author of a section of this report. Several regulatory agencies have considered this report and concluded that a single composite liner consisting of HDPE plastic sheeting and compacted clay (including a GCL layer) is not a reliable basis for constructing dry tomb type landfills.

For example, in July 2002, GeoSyntec (Giroud) made a presentation, "Landfill Liner Performance Discussion" (Giroud, 2002), to the California Regional Water Quality Control Board, Central Valley Region (CVRWQCB), in an attempt to convince this Board that a single composite liner would be protective of groundwater resources from pollution by landfill leachate. "Excerpts from EPA Report on Landfill Liner Performance: 'Assessment and Recommendations for Optimal Performance of Waste Containment Systems,' US EPA, National Risk Management Research Laboratory, Cincinnati, OH," which became the Bonaparte et al. (2002) report, was provided to the CVRWQCB in support of the reliability of a single composite liner in protecting groundwaters from pollution by landfill leachate. Shortly thereafter the Board considered the University of California, Davis, proposed expansion of its campus landfill, where the Board concluded that the expansion should be based on a double composite liner – i.e., a single composite liner is not a reliable liner for protecting groundwaters from pollution by landfill leachate for as long as the wastes in a dry tomb landfill will be a threat. Lee (2003a) has reviewed this situation.

In addition, the California Regional Water Quality Control Board, Los Angeles Region (LARWQCB) has concluded that the proposed expansion of the Sunshine Canyon Landfill should be based on a double composite liner, rather than a single composite liner. Lee (2005) has recently commented on this situation.

Overall, the Bonaparte et al. (2002) US EPA report, including the chapter on plastic sheeting liner durability issues by Koerner, is not being found to be a reliable source of information in support of the position that the thin plastic sheeting and compacted clay in a composite liner will prevent leachate from passing through it for as long as the wastes in a dry tomb type landfill will be a threat to generate leachate upon contact with moisture.

In summary, all of Koerner's (and, for that matter, Waste Management's) assessments that the landfill liner system for the Pottstown Landfill, involving thin layers of plastic sheeting and compacted clay, will be protective of groundwater resources, are based on a fundamentally flawed analysis of the characteristics of the Pottstown dry tomb type landfill.

WM's Summary of Key Points from Earl's Comments

According to Waste Management's Executive Summary, "key points" from their hydrogeologic consultant include the statement that,

> *"In 1991 a row of six (6) ground-water extraction wells was installed at the southwestern corner of the original landfill to intercept impacted groundwater originating from the*

older, unlined landfill. This system of recovery wells remains in operation today and is effective in providing capture of impacted groundwater originating from beneath the old portion of the landfill."

Earl further states,

"It is therefore evident, based on the bedrock characterization completed at the Pottstown Landfill, that a "continuum approach", similar to that in a coarse-grained, porous material can effectively monitor groundwater quality conditions downgradient of the facility. This approach has been implemented at Pottstown Landfill."

It appears that Earl did not carefully read and has not reliably reported on the problems that have been encountered with the groundwater remediation system that Waste Management has had to install to try to prevent further offsite migration of leachate-polluted groundwater from the old unlined section of the Pottstown Landfill. Waste Management's consultants have repeatedly pointed out that the initial design of the groundwater pumping system was found to be inadequate, since subsequently it was found that leachate-polluted groundwater was not being captured by the initially designed system. If the groundwater aquifer behaved as a continuum, as Earl claims, there would not have been the problems with the initial groundwater extraction system. The facts are that the hydrogeology underlying the Pottstown Landfill consists of fractured rock, where the fractures can provide conduits for offsite pollution of groundwaters by leachate derived from the landfill.

Earl further states,

"In summary, I have concluded that the geologic and hydrogeologic conditions at the site have been adequately characterized. Further, I have concluded that based on this characterization, an early detection ground-water monitoring system has been developed that is protective of human health and the environment."

This is more of the superficial approach that is frequently used in developing groundwater monitoring systems for plastic sheeting lined landfills. Even if there were not fractures that provide preferential pathways that can cause an inability to detect leachate-polluted groundwater from unlined landfills, the plastic sheeting liner underlying most of the western and eastern landfills creates a situation where the initial leakage of leachate will produce narrow plumes that can readily pass undetected between the monitoring wells, which are spaced hundreds of feet apart. As discussed in my March 13, 2005, report (Lee and Jones-Lee, 2005a), and in the backup document (Lee and Jones-Lee, 2005d), as well as my presentation to the Committee on June 1, 2005 (Lee and Jones-Lee, 2005c), John Cherry (Cherry, 1990), who is an internationally recognized authority on groundwater hydrology, has pointed out that the initial leakage through plastic sheeting lined landfills will produce narrow plumes of leachate near the edge of the landfill. A proper analysis of the situation at the Pottstown Landfill will show, as I discussed on June 1, 2005, that, with monitoring wells spaced 400 to 500 feet apart, even without the fractures, the monitoring well array has a low probability of detecting the initial pollution of groundwater when it first reaches the row of monitoring wells along the down groundwater gradient edge of a section of the landfill. It is important to note that the regulatory requirements

are that the monitoring wells detect the polluted groundwater when any of it first reaches the monitoring well array – i.e., when the leading edge of the leachate-polluted plumes reach this point. This situation is designed to prevent the initial plume(s) from polluting an offsite production well with leachate and thereby provide for the opportunity to clean up the polluted groundwater before it migrates offsite.

At best, Earl's superficial review of this issue represents an unreliable assessment of the reliability of the groundwater monitoring system that Waste Management has developed for the Pottstown Landfill to detect leachate-polluted groundwater when it first reaches the compliance point represented by the monitoring well array that exists at the Pottstown Landfill.

WM's Summary of Key Points from Sullivan's Comments
Sullivan states,

> *"The Pottstown site is very diligent about complying with the requirements to minimize water infiltration into the waste mass; however, a dry landfill concept is never really achieved, particularly in wet climates like Pennsylvania, with the amount of annual rainfall prior to the site being capped. It is for this reason that leachate collection and removal systems (LCRSs) exist and are operated at the Pottstown site. As such, LFG generation still proceeds at rates that are expected for wet climate landfills like the Pottstown site, which is sufficient to degrade the majority of waste mass during the active and early post-closure life of the landfill."*

According to the DEP's findings, Waste Management has been far from diligent in controlling moisture entering the closed sections of the landfill. It is clear that Sullivan does not understand, or at least is not reliably reporting on, the history of violations of DEP requirements with respect to excessive leachate and landfill gas generation. These issues were summarized in Dr. Cole's presentation to the Committee on June 1, 2005, as well as in his report (Cole, 2005a,b).

Sullivan further states,

> *"It is well known and recognized that LFG generation rates will decrease over time to eventually insignificant levels and that the maximum LFG generation rate occurs at or within two years of closure."*

This is what I indicated in my report (Lee and Jones-Lee, 2005a) and in my June 1, 2005, presentation to the Committee (Lee and Jones-Lee, 2005c). However, if Sullivan had examined the operating records for the plastic sheeting covered portions of the western landfill, many of which have been closed for a number of years, he would have found that the cover system that Waste Management has installed over parts of this landfill is allowing substantial amounts of moisture to enter the landfill to generate what the DEP considers to be excessive leachate and landfill gas. Further, Sullivan evidently does not understand about a dry tomb type landfill entering a dormant phase, where, with a properly installed and adequately maintained low-permeability cover, the decreased moisture supply results in the landfill no longer producing landfill gas and leachate. This, however, is the condition that will exist only as long as the low-permeability cover on the landfill remains effective in preventing moisture from entering the

wastes. When the plastic sheeting layer in the cover deteriorates, and moisture begins to enter the wastes again, landfill gas and leachate generation will resume. This assessment is not just my view. As I discussed in my comments on the deficiencies in the GAI report (Lee and Jones-Lee, 2005b), in December 2004 the California Integrated Waste Management Board staff independently presented a report that projected the same pattern of a dormant phase followed by increased leachate and gas production at some time during the postclosure period.

Sullivan states,

> *"In one part of the Lee report, it is suggested that since much of today's trash is disposed in plastic bags, that the organic contents of these bags can "hide" from decomposition, and will begin to decompose and contribute to a surge of gas production long after the site is closed, and perhaps to a "hundred or more years" in the future. That premise is ridiculous and not supported by the scientific literature or even common sense."*

Once again, Sullivan has demonstrated little or no understanding of landfill processes. This is an issue that has been of concern for some time. I have reviewed the literature on what is known about the decomposition of polyethylene plastic bags that are used for disposal of household and some commercial solid wastes. These bags, when placed in a landfill, do not decompose rapidly. They, however, will, over some period of time, decompose, thereby exposing the solid wastes that are contained within them, which have only been crushed as part of landfilling. Contrary to Sullivan's non-technical review of this issue, it is common sense that the very thin polyethylene bags that contain household garbage will over time decompose in the landfill. As this occurs the wastes will be available for interaction with any moisture that is present in the landfill at that time. Sullivan should be required to present the so-called scientific literature that purports to support his non-technical assessment of this issue.

The problems that thin polyethylene bags used for household garbage disposal cause in landfills go beyond just hiding wastes from exposure to moisture. Snider (pers. comm.), formerly with Weston Solutions, has found that plastic garbage bags have created a perched layer of leachate within a landfill, which caused the leachate to surface as a seep on the aboveground side slope of the landfill. As we have discussed in our previous writings, there is need to restrict the use of polyethylene garbage bags for solid waste disposal, in favor of the decomposable plastic bags that are available.

WM's Summary of Key Points from Caldwell's Comments

According to WM, one of Caldwell's "key points" is that,

> *"Both USEPA and PADEP acknowledge that prior to termination of the PCC period a site-specific determination of whether the landfill poses a threat to HH&E [human health and environment] must be completed and approved by the state agency. Any conclusion on threat to HH&E from a MSW [municipal solid waste] landfill without such a site-specific determination, (as Lee & Associates have provided) is technically unsupportable and alarmist in nature."*

As discussed by Lee and Jones-Lee (2004), Caldwell, as part of an effort to mislead regulatory agencies such as the California Integrated Waste Management Board, claimed in his presentation to the Board in December 2004 that it is possible, based on measurements that can be made of leachate and gas production, to predict how long the postclosure period will last for a dry tomb type landfill. However, a review of Caldwell's presentation and the references he cited, shows that he ignored the dormant period that will occur in dry tomb type landfills, which makes such predictions unreliable. The duration of the dormant period depends entirely on the rate of deterioration of the plastic sheeting layer in the cover of the landfill. Caldwell has not provided reliable information on these issues.

Caldwell further states,

> *"Assertions by Lee & Associates that monitoring of leachate (as part of the leachate management program) must continue "as long as the wastes in the landfill have potential to generate leachate" is not technically justified from peer-reviewed literature, and not supported in Federal or State regulation or guidance on the subject since they provide no consideration to evaluating threat at the point(s) of exposure. More simply stated, the mere presence of leachate in a landfill does not render its existence a threat to HH&E."*

It appears that Caldwell does not understand the basic principles of groundwater resource and public health protection. The presence of a waste that can generate leachate upon contact with water, as well as leachate itself in a landfill, is a threat to public health and the environment, especially when the only containment barrier for the leachate is a thin plastic sheeting and compacted clay layer. Caldwell's approach requires that someone's production well be exposed to leachate-polluted groundwater before action is taken to control the threat to the person's health and water resources.

Caldwell's statement, *"Therefore, a similar indefensible conclusion is made by Lee & Associates that monitoring of subsurface gas migration (as part of the landfill gas management program) is necessary, 'as long as the wastes in the landfill have the potential to generate gas,'"* is more of his technically invalid approach to protecting public health and the environment from the adverse impacts of landfill gas. Why would anyone (except for a landfill owner) claim that it is not necessary to monitor for landfill gas migration so long as the wastes in the landfill, when in contact with water, can produce landfill gas? Obviously, landfill gas monitoring should continue for as long as the wastes in the landfill have the potential to generate landfill gas.

Caldwell should be required to provide the technical literature that he claims supports his statement about the predictability of the processes that occur during the dormant phase in a dry tomb type landfill. In his December 2004 presentation to the California Integrated Waste Management Board, the basis for his purported ability to predict the postclosure period was work on non-dry-tomb landfills. He evidently does not understand and has not adequately reviewed the conditions of the dormant period of dry tomb landfills that cause any attempts to predict the duration of the postclosure period to be highly unreliable.

Caldwell's statement that, *"The mere state of potential moisture content of the waste mass as indicated by Lee & Associates is a completely inadequate and inappropriate criterion in drawing*

any conclusions regarding the relative threat of the Pottstown landfill, especially in the absence of any other site-related information," is not coherent or relevant to my reports.

Caldwell makes the statement that,

> *"Review of the analytical database of the Pottstown Landfill indicates that historical detected leachate constituents are consistent with typical MSW leachates and the detected concentrations of constituents of concern (i.e., volatile organic compounds) are relatively low compared to other MSW landfills. Conclusions provided by Lee & Associates that the leachate at the Pottstown Landfill pose a long-term threat to HH&E is not founded in peer-reviewed literature on typical MSW leachates and does not consider site-specific data to support their conclusions."*

As part of my peer review of the current operations of the Pottstown Landfill for the Pottstown Landfill Closure Committee, I examined a number of Waste Management's reports to the DEP on the characteristics of Pottstown Landfill leachate. This leachate, like other municipal landfill leachate, contains a variety of known hazardous chemicals that, when present in groundwater polluted by leachate, can cause those who use this groundwater as a water supply, to become ill.

Further, as discussed in my March 13, 2005, report to the Committee and in the backup document, the recent work by Daughton of the US EPA has indicated that municipal landfills represent a significant threat to public health and the environment through the disposal of unregulated chemicals in municipal solid wastes. Daughton (2004a,b) has indicated that there are over 22 million organic and inorganic substances, with nearly 6 million commercially available. The current water quality regulatory approach addresses less than 200 of these chemicals, where in general pharmaceuticals and personal care products (PPCPs) and many other chemicals are not regulated as potential water pollutants. According to Daughton, *"Regulated pollutants compose but a very small piece of the universe of chemical stressors to which organisms can be exposed on a continual basis."* Daughton has indicated that one of the routes of environmental exposure is through trash placed in municipal solid waste landfills. He specifically singles out "leaching from municipal landfills" as an origin of PPCPs in the environment. He characterizes municipal landfills as "pollution postponement."

As I indicated in my presentation to the Pottstown Landfill Closure Committee on June 1, 2005, municipal solid waste leachate contains a wide variety of so-called nonhazardous unregulated chemicals that cause groundwaters that are polluted by landfill leachate to be unusable for domestic water supply purposes. The US EPA (1988a), as part of promulgating Subtitle D regulations, indicated that the pollution of a water supply well by leachate causes tastes and odors and other adverse characteristics of sufficient magnitude to cause the well to have to be abandoned and a new well developed outside of the area of leachate-polluted groundwater.

With respect to Caldwell's statement quoted above that the peer-reviewed literature does not support the conclusion that leachate of the type generated by the Pottstown Landfill does not pose a long-term threat to human health and the environment, this is more of Waste Management's (Caldwell's affiliation) self-serving propaganda to try to mislead the public and regulatory agencies into believing that this landfill does not represent a long-term threat to public

health and the environment. Caldwell should be required to produce the so-called "peer-reviewed literature" which he claims exists in support of his (Waste Management's) position on this issue.

WM's Summary of Key Points from Houlihan's Comments
Houlihan stated,

> *"I agree with the elements of the WM response document [Caldwell, May 20, 2005] and believe that they are entirely consistent with the requirements of the PADEP and Federal Subtitle D requirements for performing and terminating PCC. Therefore, based on my review of the WM response document and GeoSyntec's experience in evaluating PCC at MSW landfills, I concur with the information contained in the response document."*

It is not surprising that Houlihan of GeoSyntec, a consulting firm that derives considerable funding from working with landfill developers, would support Waste Management's position on this issue. I have had repeated occasions to examine the technical validity of GeoSyntec staff's presentations on behalf of landfill developers on the environmental protection provided by a landfill. These situations include unreliable information on the expected performance of plastic sheeting liners. An example of unreliable information provided by GeoSyntec occurred in a contract that this firm had with the California Integrated Waste Management Board to evaluate the performance of California's municipal landfills. As I discuss (Lee 2003b, 2004a,b), the approach used by GeoSyntec in making this evaluation was technically invalid.

GeoSyntec, on behalf of its private landfill clients, made a presentation at the Salt Lake City ASTSWMO meeting in July 2003, which was similar to that made by Caldwell in December 2004 to the California Integrated Waste Management Board discussed in another section of these comments, claiming that it was possible to predict the long-term performance of dry tomb type landfill releases of landfill gas and leachate to the environment. As discussed by Lee (2004c), the GeoSyntec approach is not technically valid.

Overall, GeoSyntec staff have repeatedly made unreliable statements regarding the expected performance of plastic sheeting and compacted clay liners in protecting public health and the environment for as long as the wastes in a dry tomb type landfill will be a threat. The statement by Houlihan is more of this type of unreliable information.

Comments on Waste Management's Consultants' Reports
Presented below are additional comments on the reports prepared by Waste Management's consultants that are presented in Waste Management's June 1, 2005, Compilation. Topics that have been covered in the above comments on Waste Management's Executive Summary are not repeated below.

Koerner
Many of Koerner's specific comments have been included in Waste Management's Executive Summary. My comments on the unreliability of his statements on those issues in the Executive Summary are applicable to the same issues in his report.

According to Koerner,

> *"The Lees' report is not specific to Pottstown Landfill to support their forecast that there are or will be any liner performance issues. Drs. Lee apparently do not understand the design principles of the Pottstown system. They provide nothing specific to Pottstown Landfill that supports their accusations that there are or will be any leachate collection system performance issues. Drs. Lee also apparently do not understand the Pottstown Landfill leachate collection and removal system design principles."*

Koerner's statement that we apparently do not understand the design principles of the Pottstown Landfill fails to reflect the fact that we provided in our March 13, 2005, report a detailed discussion of the design of the Pottstown Landfill and the expected performance of each of the containment and monitoring systems that have been used in this landfill. Our discussions were based on the information provided by Waste Management to the Pottstown Landfill Closure Committee during the tour of the landfill that Waste Management provided to the Committee in October 2004. As indicated in our report, the briefing document that WM provided to the Committee members during this tour contained significant unreliable information on the expected performance of the landfill containment and monitoring systems. It was because of this situation that we developed a general discussion of the characteristics of these systems, so that the Committee could better understand the long-term threat that the landfilled waste components represent to public health and the environment.

Koerner's statement that there is nothing specific in our report about the Pottstown Landfill containment and monitoring systems is obviously inaccurate to anyone who reads our report. The report specifically discusses each of the containment and monitoring system components, where many of these components have been used in Subtitle D landfills since the regulations were adopted in the early 1990s. Considerable discussion is provided in our report on the unusual aspects of the Pottstown Landfill design, such as the leak detection (witness) zone. In discussing this zone system our report specifically points to the problems with its design, where the plastic sheeting layer in the zone is not backed by and in intimate contact with compacted clay, thereby failing to achieve composite liner performance. As discussed by Daniel (1990), such a design can result in leaks through holes in the plastic sheeting at a high rate compared to the commonly used design of placing the plastic sheeting in intimate contact with compacted clay.

Further, our report specifically discusses significant potential problems with the Pottstown Landfill composite liner design, where a thin GCL bentonite clay layer is used in the composite liner. In the 1960s, while a professor in the department of Civil and Environmental Engineering at the University of Wisconsin, Madison, and Director of the graduate degree program in Water Chemistry, I had a graduate student (Fruh) conduct his PhD dissertation on the interactions between various cations and expandable and non-expandable lattice clays. This work was published as Fruh and Lee (1967). It was through this work that we became familiar with the shrink-swell properties of clays as a function of the cation located on the clay surface.

In the 1970s, at the request of the US EPA National Groundwater Research Center, we conducted research on various factors that could influence the performance of compacted clay

layers similar in properties to compacted clay liners used in landfills and waste disposal lagoons. It was through this work that we demonstrated that organic solvents can cause compacted clay layers to shrink, crack and allow rapid penetration of the solvent through the clay layer. A summary of this work is provided by Green et al. (1983).

In the late 1980s, at US EPA workshops on landfill liner design, I commented that the use of bentonite clays in a landfill's composite liner could lead to problems with shrinkage and cracking of the liner. Dr. David Daniel, one of the presenters at that conference, agreed that this is an issue that needed to be considered. Daniel, in his section of the Bonaparte et al. (2002) report, has discussed this problem, pointing to the potential for failure of the bentonite clay layer in a composite liner associated with cation exchange reactions. This issue was mentioned in our March 13, 2005, report to the Committee, and discussed in more detail in our "Flawed Technology" backup document (Lee and Jones-Lee, 2005d).

Koerner states,

> *"Drs. Lee provide nothing specific to Pottstown Landfill that supports their accusations that there are or will be performance issues with the geomembrane final cover system. They forecast "failure" without any support data specific to the Pottstown Landfill systems."*

With reference to Koerner's comments about failing to provide a detailed dissertation on the inevitable failure of the Pottstown Landfill cover system during the time that the wastes in the landfill will be a threat to generate leachate and landfill gas upon contact with moisture, he has again made blanket statements that do not consider what is well known about the problems with the plastic sheeting layer in the cover of landfills. As discussed in our March 13, 2005, report and in the "Flawed Technology" backup, as well as in several references to the literature that has been published on this topic, it is well known that landfill covers are subject to considerable stress due to differential settling. Such stress can lead to accelerated failure of the plastic sheeting. Further, as discussed in our report, the free radical degradation of the HDPE plastic sheeting is likely to be much greater in a landfill cover where the waters in contact with the plastic will have higher oxygen concentrations (free radicals) than those in contact with the liner under the landfill.

Koerner further states,

> *"The baseless conjecture about the potential failure of systems does not draw from the 30+ years of research and performance monitoring as well as evaluation on the geosynthetics utilized in the design and selection of the Pottstown Landfill liner and final cap systems."*

On the contrary, as discussed herein in comments on Waste Management's Executive Summary of Koerner's statements, our discussions about the inevitable failure of the HDPE plastic sheeting liners in the Pottstown Landfill do draw on the information in the literature, including from Koerner's publications, which leads to the unequivocal conclusion that the Pottstown Landfill liner system will at some time in the future fail to prevent leachate that can be generated

in the landfill from passing through it. While Koerner has greatly stretched the experience with HDPE liners to "30+ years," a critical review of the use of HDPE in various types of applications (such as coating of electrical wires) has shown that HDPE has failed to perform its design function as originally predicted. A similar situation occurred with HDPE liners in landfills when they first started to be used in the 1980s, where stress cracking of the liners became a very significant problem. Even today, while the problems of stress cracking of HDPE liners have been significantly reduced, they have not been eliminated. There is substantial reason to question the reliability of any extrapolation of a few years of laboratory-based testing and field experience to many decades and hundreds of years, as Koerner does in his attempts to predict the service life of landfill liner systems, including the cover. These issues have been discussed in detail, with references to the literature, in our publications, which are on our website, www.gfredlee.com.

Koerner states, *"They attack the regulatory protocol and guidelines yet they offer no alternative solutions for effective environmental management of waste disposal systems."* This is another of Koerner's highly inappropriate statements about our work. If he had reviewed the references provided in our report and the "Flawed Technology" report, which are readily available on our website, he would have found that we have provided specific guidance on how the non-recyclable components of the municipal solid waste stream can be managed in landfills with a high degree of public health and environmental protection. Specific papers/reports include a series of publications on fermentation and leaching of wastes to accelerate waste decomposition,

> Lee, G. F. and Jones-Lee, A., "Landfills and Groundwater Pollution Issues: 'Dry Tomb' vs F/L Wet-Cell Landfills," Proc. Sardinia '93 IV International Landfill Symposium, Sardinia, Italy, pp. 1787- 1796, October (1993). Available upon request from gfredlee@aol.com.
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> Lee, G. F. and Jones-Lee, A., "Wet Cell Versus Dry Tomb: Pay a Little Now or More Later," *MSW Management* 5:70,72 (1995). Available upon request from gfredlee@aol.com.
>
> Jones-Lee, A. and Lee, G. F., "Appropriate Use of MSW Leachate Recycling in Municipal Solid Waste Landfilling," Proc. Air & Waste Management Assoc. 93rd annual national meeting Salt Lake City UT paper 00-455 CD ROM Pittsburgh, PA June (2000). http://www.gfredlee.com/leachatepapsli.pdf

and include specific recommendations on the design, closure and postclosure monitoring, maintenance and funding:

> Lee, G. F. and Jones-Lee, A., "Recommended Design, Operation, Closure and Post-Closure Approaches for Municipal Solid Waste and Hazardous Waste Landfills," Report of G. Fred Lee & Associates, El Macero, CA, 14pp, August (1995). http://www.gfredlee.com/msw-hwl1.htm.
>
> Lee, G. F. and Jones-Lee, A., "Overview of Landfill Post Closure Issues," Presented at American Society of Civil Engineers session "Landfill Closures - Environmental

Protection and Land Recovery," New York, NY, October (1995). Available upon request from gfredlee@aol.com.

Lee, G. F., "Solid Waste Management: USA Lined Landfilling Reliability," An invited submission for publication in *Natural Resources Forum*, a United Nations Journal, New York, NY, December (2002). http://www.gfredlee.com/UNpaper-landfills.pdf

These papers, as well as several other papers and reports on our website, provide guidance on how to manage municipal and industrial "nonhazardous" solid waste by landfilling. Koerner's statement that we have offered *"… no alternative solutions for effective environmental management of waste disposal systems,"* is another of his blanket attempts on behalf of WM to discredit our report. The facts are that we have discussed in detail how the problems with the current landfilling approaches can be greatly reduced or eliminated.

Koerner has provided a series of specific page reference comments. One of these is,

> *"Page 17: The incorporation of a double liner system allows for leakage monitoring and detection should any waste compounds penetrate through the composite primary liner components. It has been shown in a recent USEPA report that the geomembrane/GCL primary liner in 287 landfills provides essential zero leakage after final cover is placed."*

Koerner has failed to provide the Committee with a full disclosure of the serious limitations of this assessment being a reliable indication of what will happen to the integrity of the landfill liner system and cover during the time that the wastes in the dry tomb parts of the Pottstown Landfill will be a threat. A review of the literature (as discussed by Lee and Jones-Lee in papers on our website and references contained therein) will show that, initially, with the development of dry tomb type landfills in the 1980s, there were significant problems with the quality of construction and the stress cracking of HDPE plastic sheeting liners. This situation caused several states, such as New York, New Jersey and Michigan, to adopt double composite lined municipal solid waste landfills as the standard landfilling practice. At about the same time, Pennsylvania adopted as standard practice the leak detection zone to detect when the composite landfill liner system failed.

Eventually, it became possible, through good QA/QC in liner construction and careful placement of the wastes in the landfill, to avoid immediate failure of the liner system. The 287 landfills referred to by Koerner are landfills that evidently had high-quality liner construction and appropriate waste placement. However, what Koerner has not discussed, which has been reviewed by Lee and Jones-Lee (1996), is that, with high-quality liner construction and appropriate waste placement, a single composite liner would not be expected to show leaks through the liner's compacted clay layer in the short period of time that such liners have been used. As Lee and Jones-Lee (1996) discuss, under one foot of head (leachate depth), two feet of compacted clay with a permeability of 10^{-7} cm/sec would not be expected to have allowed leachate to pass through it in less than about 20 to 25 years. Therefore, it is inappropriate for Koerner to attempt to support his unreliable assessment of the ability of a thin layer of plastic sheeting and compacted clay, such as used in the Pottstown Landfill, to prevent leachate from passing through the composite liner into the leak detection zone during the very long period of

time that the wastes in the dry tomb part of the Pottstown Landfill will be a threat, based on the relatively short-term performance of landfill liner systems.

Another issue that Koerner has failed to address, which was discussed in our report to the Committee, is the permeation of organic solvents that are present in Pottstown Landfill leachate through the HDPE liner in a few days to a few weeks. It would still take some time to pass through the GCL layer underlying the plastic sheeting. As I pointed out in my presentation to the Committee on June 1, 2005, the current required monitoring of the fluid in the leak detection zone does not require analysis of the organic solvents present in the leachate. This is a significant deficiency in the current landfill monitoring program.

None of Koerner's specific page reference comments provide a reliable basis for critiquing our overall conclusions and recommendations to the Pottstown Landfill Closure Committee that those parts of the Pottstown Landfill that have been developed as a dry tomb landfill will be a threat to generate leachate and landfill gas for a very long period of time. As we have discussed, for planning purposes, this period should be considered to be infinite. It is our recommendation to the Committee, as discussed in our reports, that the Committee work with the DEP to establish a closure plan and postclosure monitoring and maintenance implementation that will be effective for as long as wastes in the landfill, when contacted by water, have the potential to generate leachate and landfill gas. Koerner's position, on the other hand, in his superficial attempt to support Waste Management's position that there is only a limited postclosure period that should be of concern to the Committee, is obviously technically invalid and strongly contrary to basic public health and environmental protection principles.

Earl

A review of Earl's report shows that there is nothing in his statements that has not been addressed in our comments on Waste Management's Executive Summary of his "key points." While Earl provides a list of references that he claims to have reviewed, he fails to include the information provided in several of these references about the fact that the groundwater extraction system originally designed for the Pottstown Landfill failed to capture all of the leachate-polluted groundwater arising from the old landfill. If the hydrogeology underlying the Pottstown Landfill were as well-characterized as Earl claims, the unreliability of the initial groundwater extraction system should not have occurred. With monitoring wells spaced hundreds of feet apart, the initial leakage of leachate through the composite liner and the plastic sheeting layer of the leak detection zone could readily pass into fractures that would transport it, undetected, past the monitoring well array that now exists at the Pottstown Landfill.

Sullivan

Dr. Cole, in his comments on the June 1, 2005, Waste Management Compilation, will address many of the landfill gas issues raised by Sullivan. I only wish to comment that Sullivan has inappropriately made a number of claims in his report that our report ("the Lee report") stated that there was a potential for explosions and fires within the landfill. At no place does our report mention fires in any context, much less in the landfill, nor do we discuss the potential for explosions within the landfill. It is clear that Sullivan did not carefully read our report, since we did not make such statements. Dr. Cole, however, has discussed these issues in detail in his presentation to the Committee on June 1, 2005, and in his report (Cole, 2005a,b).

As I discussed with the Committee on June 1, 2005, the key issue with respect to detecting the inevitable failure of the Pottstown Landfill composite liner system is proper functioning of the leak detection zone for as long as the wastes in the landfill will be a threat to generate leachate upon contact with water. We have included specific recommendations in our reports to the Committee on the kind of expanded monitoring that should be done of the fluid that collects in the leak detection zone, to detect incipient leakage of leachate through the composite liner system.

Sullivan states,

> *"However, Figure 9 in the Lee report suggests that 30 years after closure, LFG generation could increase again if liquids are allowed to infiltrate into the refuse mass, resulting LFG generation rates that are greater than the peak rate, which typically occurs the year after closure. This is an outrageous statement, far divorced from fact, and simply not supported by the available data on this or any other site. It is well known and recognized that LFG generation rates will decrease over time to eventually insignificant levels and that the maximum LFG generation rate occurs at or within two years of closure."*

Sullivan's comments on Figure 9 in our report represent a distortion of the figure. Had he critically reviewed it, he would have seen that our projections of landfill gas production when a landfill owner fails "to keep wastes dry" are represented by a dashed line with a question mark, indicating that the rate of landfill gas production under those conditions is dependent on a wide variety of site-specific conditions, including the rate of moisture entering the landfill, the degree to which the plastic bags have decomposed at the time this occurs (thereby exposing the hidden waste to the moisture entering the landfill), the hydraulic characteristics of the landfill, etc. What is known is that at the end of the dormant period, when the landfill owner fails to maintain the landfill cover to meet regulatory requirements of no greater permeability than the landfill liner system, there is the potential for renewed landfill gas and leachate generation. The Pottstown Landfill Closure Committee, DEP, and others concerned about protection of public health and the environment need to recognize this situation and prepare for it.

Overall, as discussed in Dr. Cole's response to Sullivan's statements on landfill gas issues and my comments on selected sections of Sullivan's comments pertinent to what he calls "the Lee report," Sullivan has not provided a reliable assessment of the potential for landfill gas generated at the Pottstown Landfill to be a threat to health, safety and other interests of those near the landfill. Again, as with other issues, the Pottstown Landfill Closure Committee and the DEP need to require that Waste Management conduct a comprehensive landfill gas monitoring program for as long as the wastes in the landfill represent a threat, when contacted with water, to produce landfill gas.

Caldwell

Caldwell of Waste Management states,

"In summary, both USEPA and PADEP acknowledge that prior to termination of the PCC period a site-specific determination of whether the landfill poses a threat to HH&E must be completed and approved by the state agency. Any conclusion on threat to HH&E from a MSW landfill without such a site-specific determination, (as Lee & Associates have provided) is technically unsupportable and alarmist in nature."

Caldwell in this statement continues his distortion of information when he asserts that we have advocated that there is no need for a site-specific evaluation of the threat of the Pottstown Landfill to public health and the environment associated with the landfilled wastes. Even a cursory examination of our reports and presentation to the Committee shows just the opposite. We have examined the leachate amounts and characteristics of the leachate being generated within the Pottstown Landfill now. At this time, the landfilled wastes represent a threat to public health and the environment that must be recognized and controlled. We have examined the characteristics of the Pottstown Landfill containment system and monitoring systems that are proposed to be in place during the postclosure period. As we have discussed, the wastes in the landfill will be a threat to public health and the environment beyond the time that the landfill liner systems can be expected to function effectively.

We are concerned that Waste Management continues to try to mislead the Committee in its publications into believing that there is only a 30-year postclosure care period. As we have discussed, the postclosure care period – i.e., the period during which there should be concern about releases from this landfill being adverse to public health and the environment – will be very long, effectively, forever, so long as the dry tomb characteristics of this landfill are maintained. Should the dry tomb characteristics of the landfill be no longer maintained, then there will be a very long period (likely many decades to hundreds of years) when this landfill can produce leachate that can pollute groundwater, rendering it unsafe for use for domestic purposes. This is especially of concern with respect to nearby domestic water supply wells that can be polluted through the transport of leachate through the fractured rock aquifer system that exists at this location. Throughout our report and presentations to the Committee, we have repeatedly emphasized the need for site-specific evaluations prior to issuance of any Certificate of Final Closure, where representative samples of wastes from various parts of the landfill are obtained and are subjected to water to determine if they still have the potential to generate leachate and/or landfill gas.

Caldwell states,

> *"In a December 2004 presentation to the California Integrated Waste Management Board (CIWMB) (Caldwell, 2004), a summary from the draft GeoSyntec report was provided stating:*
>
> - *The quality of leachate and landfill gas (LFG) in a landfill can be correlated to the "phase" of life of the landfill;*
> - *The factors that affect a landfill as it progresses through each phase of its life are understood and can be identified for a particular landfill; and*
> - *The future trends of leachate and LFG can be predicted based on known, current quality and knowledge of the phase of its life.*

Lee & Associates responded to these statements in a letter dated December 18, 2004 stating "These statements apply to some extent to the classical sanitary landfill where there is no attempt to keep moisture from entering the wastes through the cover; they do not apply to a "dry tomb" landfill that is dormant due to limited moisture input." Therefore, Lee & Associates supports the conclusions for many, if not most, MSW landfills and do not provide any evidence to conclude that these published findings are not appropriate as a basis of a performance-based evaluation at the Pottstown Landfill."

It is still apparent that Caldwell simply does not understand and is not reliably reporting on the processes that will occur to cause the landfilled wastes in the Pottstown Landfill, once the landfill enters the dormant phase where little or no leachate and landfill gas is being generated because the landfill cover is effective in keeping moisture from the landfilled wastes, to stop generating leachate and landfill gas until moisture again enters the landfilled wastes. The references that Caldwell has cited, which he claims support his position that the generation of landfill gas and leachate is a predictable situation, are based on classical sanitary landfills, not dry tomb type landfills. Most of the western and all of the eastern parts of the Pottstown Landfill are dry tomb type landfills.

With regard to leachate quality, Caldwell states,

"According to Pohland (1980), Christensen (1994) Barlaz et al. (2002) and O'Brien (2005), heavy metals do not constitute a frequent groundwater contaminant problem at MSW landfills, partly because MSW landfill leachate usually contain only modest concentrations of heavy metals and partly because heavy metals are subject to strong attenuation by sorption and precipitation."

Caldwell's citing of the O'Brien article, where he states that heavy metals in landfill leachate are not a threat to groundwater quality, is an example of the unreliable information that is being developed by landfill owners and the organizations that support them. The O'Brien article cited by Caldwell is based on a report developed by the Solid Waste Association of North America (SWANA) Research Foundation, where O'Brien, as Executive Director of this Foundation, is the primary author of that report. Lee (2004d) commented on the unreliable approach that SWANA/O'Brien used in assessing the water quality significance of heavy metals in today's landfill leachate. More recently, Lee and Jones-Lee (2005e) have commented on the unreliable information that O'Brien provided in his *MSW Management* article summarizing the results of the SWANA Research Foundation heavy metals report. Our comments on the unreliable information provided by O'Brien have been accepted for publication in a national journal. As we discuss, the O'Brien/SWANA approach of comparing heavy metal concentrations in today's MSW leachate to the RCRA regulatory limits for classification of hazardous waste is not a technically valid approach for assessing whether heavy metals in today's MSW leachate are a threat to cause groundwater pollution that would exceed US EPA drinking water MCLs.

As noted above, Caldwell continues to make reference to the "peer-reviewed literature." He should be required to provide the Committee with copies of the literature that he claims supports his position that it is possible to reliably predict the course of leachate and landfill gas production

in a dry tomb type landfill, including the Pottstown Landfill, while the landfill is in the dormant phase.

In his summary, Caldwell states,

> *"The anecdotal conclusions provided by Lee & Associates for the Pottstown Landfill on the long-term threat of a "dry tomb" landfill with the expected degradation of in-place engineering controls and the period of post-closure care required to determine such impact is not based upon any site-specific defensible evaluation of threat. Their paper is intended to draw upon the unknown condition in the future and hypothesize that the worst-case condition will occur and when it does it will risk the lives of near-by residents. These conclusions are not based upon a site-specific evaluation of threat using peer-reviewed technical information or USEPA guidance but rather use predominantly self-referenced reports that promote eventual doomsday for neighbors of a "dry tomb" landfill. Specifically, Lee & Associates advocate (with no scientific basis) that any "dry tomb" landfill poses a threat if such a landfill contains waste that has the potential to generate leachate and gas because any leachate and/or gas that is generated will travel along ever-present exposure pathways to impact HH&E.*
>
> *The timing of when to conduct such a technical evaluation remains as an important issue. At a minimum, the technical evaluation cannot be reasonably performed until landfill post-closure end uses are defined, and data objectives and elements are ascertained based on these end uses. Then, the data required to complete such an evaluation must be obtained. Accordingly, the current state-of-the -practice guidance on completion of a performance-based evaluation of threat during the post-closure care period is that an evaluation can be completed no later than ten (10) years following closure of the landfill. This evaluation will provide assurance that if a threat is identified, sufficient funds are available to manage and/or monitor the source prior to termination of the post-closure monitoring plan for the facility."*

Caldwell's guidance of conducting the site-specific evaluation of the threat represented by Pottstown Landfill wastes *"… no later than ten (10) years following closure of the landfill"* represents more of his lack of understanding of the processes that will occur in closed dry tomb landfills, and specifically, the Pottstown Landfill. In evaluating the reliability of Caldwell's statement, it is appropriate to examine the current leachate and landfill gas generation in those parts of the western landfill that have been closed as a dry tomb type landfill with low-permeability covers. As documented by Dr. Cole in his presentation to the Committee on June 1, 2005, and in his report (Cole, 2005a,b), as well as in the summary by Cole and Lee (2005), parts of the western landfill have been closed for over ten years. Waste Management has not yet complied with regulatory requirements of installing and maintaining a landfill cover with a permeability no greater than the composite liner underlying the landfill over those parts of the dry tomb type landfill that have been closed. The DEP is requiring that Waste Management achieve control of landfill gas and leachate production at this landfill.

If this is ever achieved, those parts of the Pottstown Landfill that have been or will be closed as a dry tomb type landfill will enter a dormant phase of leachate and landfill gas generation. This

landfill will remain in that dormant phase so long as Waste Management maintains an effective low-permeability cap over the landfill. However, the dormant phase does not mean that the wastes will not be in a position to generate leachate and landfill gas when water is added to them. Contrary to Caldwell's assertions, there is no reliable way to predict the duration of the postclosure period based on performance evaluation. The period will extend so long as the wastes in the landfill, including those that are hidden within crushed plastic bags, can generate leachate and landfill gas when contacted with water.

Houlihan

As discussed in the comments on Waste Management's Executive Summary statements by Houlihan of GeoSyntec, GeoSyntec, on behalf of their landfill clients, has been attempting to mislead regulatory agencies and others into believing that, by some ill-defined process, considering what has happened in non-dry-tomb type landfills, the duration of the postclosure period of monitoring and maintenance, and remediation of polluted groundwaters, can be predicted in a dry tomb type landfill. This is more of the technically invalid approaches that GeoSyntec has been foisting on regulatory agencies in an attempt to limit the duration of postclosure liability of landfill owners.

As referenced in our above comments on the Executive Summary of Houlihan's statements, the approach that GeoSyntec is advocating is without technical merit. The basic problem is that the ultimate failure of the landfill cover low-permeability layer is not predictable based on any site-specific evaluation. It is possible that Waste Management could comply with regulatory requirements of installing and maintaining a low-permeability cover over the dry tomb parts of the Pottstown Landfill that has a permeability no greater than the composite liner underlying the landfill. Achieving this situation will cause the landfill to enter a dormant phase where the wastes will still be a threat to generate leachate and landfill gas upon contact with moisture. As we have emphasized, the Pottstown Landfill Closure Committee and the DEP need to understand and establish postclosure activities that will address this situation with a high degree of reliability. This means that Waste Management will be required to continue to fund comprehensive postclosure monitoring and maintenance, and pay substantial fines for failing to conform to regulatory requirements, until such time as the wastes in the landfill can no longer generate leachate and landfill gas upon contact with water.

Qualifications

The Waste Management consultants provided statements of their qualifications as part of WM's June 1, 2005, submission to the Committee. I have enclosed, in Appendix A, a summary of my landfill evaluation expertise and experience. Many of the papers and reports listed therein are available as downloadable files from our website, www.gfredlee.com. One of the areas of particular significance to this discussion is the university research that I have done on behalf of the US EPA and Gundle Lining Systems, Inc., in investigating compacted clay and HDPE liners' ability to maintain their integrity for as long as the wastes in a landfill represent a threat to generate leachate. Additional information on our qualifications to provide our reports and these comments is available upon request.

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Appendix A
Dr. G. Fred Lee, PE(TX), DEE
AAEE Board Certified Environmental Engineer

Expertise and Experience in Hazardous Chemical Site and Municipal/Industrial Landfill Impact Assessment/Management

Dr. G. Fred Lee's work on hazardous chemical site and municipal/industrial landfill impact assessment began in the mid-1950s while he was an undergraduate student in environmental health sciences at San Jose State College in San Jose, California. His course and field work involved review of municipal and industrial solid waste landfill impacts on public health and the environment.

He obtained a Master of Science in Public Health degree from the University of North Carolina, Chapel Hill, in 1957. The focus of his masters degree work was on water quality evaluation and management with respect to public health and environmental protection from chemical constituents and pathogenic organisms.

Dr. Lee obtained a PhD degree specializing in environmental engineering from Harvard University in 1960. As part of this degree work he obtained further formal education in the fate, effects and significance and the development of control programs for chemical constituents in surface and ground water systems. An area of specialization during his PhD work was aquatic chemistry, which focused on the transport, fate and transformations of chemical constituents in aquatic (surface and ground water) and terrestrial systems as well as in waste management facilities.

For a 30-year period, he held university graduate-level teaching and research positions in departments of civil and environmental engineering at several major United States universities, including the University of Wisconsin-Madison, University of Texas at Dallas, and Colorado State University. During this period he taught graduate-level environmental engineering courses in water and wastewater analysis, water and wastewater treatment plant design, surface and ground water quality evaluation and management, and solid and hazardous waste management. He has published over 850 professional papers and reports on his research results and professional experience. His research included, beginning in the 1970s, the first work done on the impacts of organics on clay liners for landfills and waste piles/lagoons.

His work on the impacts of hazardous chemical site and municipal/industrial solid waste landfills began in the 1960s when, while directing the Water Chemistry Program in the Department of Civil and Environmental Engineering at the University of Wisconsin-Madison, he became involved in the review of the impacts of municipal solid waste landfills on groundwater quality.

In the 1970s, while he was Director of the Center for Environmental Studies at the University of Texas at Dallas, he was involved in the review of a number of municipal solid and

industrial (hazardous) waste landfill situations, focusing on the impacts of releases from the landfill on public health and the environment.

In the early 1980s while holding a professorship in Civil and Environmental Engineering at Colorado State University, he served as an advisor to the town of Brush, Colorado, on the potential impacts of a proposed hazardous waste landfill on the groundwater resources of interest to the community. Based on this work, he published a paper in the Journal of the American Water Works Association discussing the ultimate failure of the liner systems proposed for that landfill in preventing groundwater pollution by landfill leachate. In 1984 this paper was judged by the Water Resources Division of the American Water Works Association as the best paper published in the journal for that year.

In the 1980s, he conducted a comprehensive review of the properties of HDPE liners of the type being used today for lining municipal solid waste and hazardous waste landfills with respect to their compatibility with landfill leachate and their expected performance in containing waste-derived constituents for as long as the waste will be a threat.

In the 1980s while he held the positions of Director of the Site Assessment and Remediation Division of a multi-university consortium hazardous waste research center and Distinguished Professor of Civil and Environmental Engineering at the New Jersey Institute of Technology, he was involved in numerous situations concerning the impact of landfilling of municipal solid waste on public health and the environment. He has served as an advisor to the states of California, Michigan, New Jersey and Texas on solid waste regulations and management. He was involved in evaluating the potential threat of uranium waste solids from radium watch dial painting on groundwater quality when disposed of by burial in a gravel pit. The public in the area of this state of New Jersey proposed disposal site objected to the State's proposed approach. Dr. Lee provided testimony in litigation, which caused the judge reviewing this matter to prohibit the State from proceeding with the disposal of uranium/radium waste at the proposed location.

Beginning in the 1960s, while a full-time university professor, Dr. Lee was a part-time private consultant to governmental agencies, industry and environmental groups on water quality and solid and hazardous waste and mining management issues. His work included evaluating the impacts of a number of municipal and industrial solid waste landfills. Much of this work was done on behalf of water utilities, governmental agencies and public interest groups who were concerned about the impacts of a proposed landfill on their groundwater resources, public health and the environment.

In 1989, he retired after 30 years of graduate-level university teaching and research and expanded the part-time consulting that he had been doing with governmental agencies, industry and community and environmental groups into a full-time activity. A principal area of his work since then has been assisting water utilities, municipalities, industry, community and environmental groups, agricultural interests and others in evaluating the potential public health and environmental impacts of proposed or existing hazardous, as well as municipal solid waste landfills. He has been involved in the review of approximately 75 different landfills and waste piles (tailings) in various parts of the United States and in other countries.

Dr. Anne Jones-Lee (his wife) and he have published extensively on the issues that should be considered in developing new or expanded municipal solid waste and hazardous waste landfills in order to protect the health, groundwater resources, environment and interests of those within the sphere of influence of the landfill. Their over 50 professional papers and reports on landfilling issues provide guidance not only on the problems of today's minimum US EPA Subtitle D landfills, but also on how landfilling of non-recyclable wastes can and should take place to protect public health, groundwater resources, the environment, and the interests of those within the sphere of influence of a landfill/waste management unit. They make many of their publications available as downloadable files from their web site, www.gfredlee.com.

Their work on landfill issues has particular relevance to Superfund site remediation, since regulatory agencies often propose to perform site remediation by developing an onsite landfill or capping waste materials that are present at the Superfund site. The proposed approach frequently falls short of providing true long-term health and environmental protection from the landfilled/ capped waste.

In the early 1990s, Dr. Lee was appointed to a California Environmental Protection Agency's Comparative Risk Project Human Health Subcommittee that reviewed the public health hazards of chemicals in California's air and water. In connection with this activity, Dr. Jones-Lee and he developed a report, "Impact of Municipal and Industrial Non-Hazardous Waste Landfills on Public Health and the Environment: An Overview," that served as a basis for the human health advisory committee to assess public health impacts of municipal landfills.

In 2004 Dr Lee was selected as one of two independent peer reviewers by the Pottstown. PA Pottstown Landfill Closure Committee to review the adequacy of the proposed closure of the Pottstown Landfill to protect public health, groundwater resources and the environment for as long as the wastes in the closed landfill will be a threat.

In addition to teaching and serving as a consultant in environmental engineering for over 40 years, Dr. Lee is a registered professional engineer in the state of Texas and a Diplomate in the American Academy of Environmental Engineers (AAEE). The latter recognizes his leadership roles in the environmental engineering field. He has served as the chief examiner for the AAEE in north-central California and New Jersey, where he has been responsible for administering examinations for professional engineers with extensive experience and expertise in various aspects of environmental engineering, including solid and hazardous waste management.

His work on landfill impacts has included developing and presenting several two-day short-courses devoted to landfills and groundwater quality protection issues. These courses have been presented through the American Society of Civil Engineers, the American Water Resources Association, and the National Ground Water Association in several United States cities, including New York, Atlanta, Seattle and Chicago, and the University of California Extension Programs at several of the UC campuses, as well as through other groups. He has also participated in a mine waste management short-course organized by the University of Wisconsin-Madison and the University of Nevada. He has been an American Chemical Society

tour speaker, where he is invited to lecture on landfills and groundwater quality protection issues, as well as domestic water supply water quality issues throughout the United States.

SUMMARY BIOGRAPHICAL INFORMATION

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July 27, 1933	530/753-9630	530/753/9956
Delano, California, USA	(home/office)	(home/office)

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EDUCATION

Ph.D.	Environmental Engineering & Environmental Science, Harvard University, Cambridge, Mass. 1960
M.S.P.H.	Environmental Science-Environmental Chemistry, School of Public Health, University of North Carolina, Chapel Hill, NC 1957
B.A.	Environmental Health Science, San Jose State College, San Jose, CA 1955

ACADEMIC AND PROFESSIONAL EXPERIENCE

Current Position:

Consultant, President, G. Fred Lee and Associates

Previous Positions:

Distinguished Professor, Civil and Environmental Engineering, New Jersey Institute of Technology, Newark, NJ, 1984-89

Senior Consulting Engineer, EBASCO-Envirosphere, Lyndhurst, NJ (part-time), 1988-89

Coordinator, Estuarine and Marine Water Quality Management Program, NJ Marine Sciences Consortium Sea Grant Program, 1986

Director, Site Assessment and Remedial Action Division, Industry, Cooperative Center for Research in Hazardous and Toxic Substances, New Jersey Institute of Technology et al., Newark, NJ, 1984-1987

Professor, Department of Civil and Environmental Engineering, Texas Tech University, 1982-1984

Professor, Environmental Engineering, Colorado State University, 1978-1982

Professor, Environmental Engineering & Sciences; Director, Center of Environmental Studies, University of Texas at Dallas, 1973-1978

Professor of Water Chemistry, Department of Civil & Environmental Engineering, University of Wisconsin-Madison, 1961-1973

Registered Professional Engineer, State of Texas, Registration No. 39906

Diplomate, American Academy of Environmental Engineers, Certificate No. 0701

PUBLICATIONS AND AREAS OF ACTIVITY

Published over 1,025 professional papers, chapters in books, professional reports, and similar materials. The topics covered include:

- Studies on sources, significance, fate and the development of control programs for chemicals in aquatic and terrestrial systems.
- Analytical methods for chemical contaminants in fresh and marine waters.
- Landfills and groundwater quality protection issues.
- Impact of landfills on public health and environment.
- Environmental impact and management of various types of wastewater discharges including municipal, mining, electric generating stations, domestic and industrial wastes, paper and steel mill, refinery wastewaters, etc.
  Stormwater runoff water quality evaluation and BMP development for urban areas and highways.
- Eutrophication causes and control, groundwater quality impact of land disposal of municipal and industrial wastes, environmental impact of dredging and dredged material disposal, water quality modeling, hazard assessment for new and existing chemicals, water quality and sediment criteria and standards, water supply water quality, assessment of actual environmental impact of chemical contaminants on water quality.

LECTURES

Presented over 760 lectures at professional society meetings, universities, and to professional and public groups.

GRANTS AND AWARDS

Principal investigator for over six million dollars of contract and grant research in the water quality and solid and hazardous waste management field.

GRADUATE WORK CONDUCTED UNDER SUPERVISION OF G. FRED LEE

Over 90 M.S. theses and Ph.D. dissertations have been completed under the supervision of Dr. Lee.

ADVISORY ACTIVITIES

Consultant to numerous international, national and regional governmental agencies, community and environmental groups and industries.

Municipal Solid Waste Landfills and Groundwater Quality Protection Issues Publications

Drs. G. Fred Lee and Anne Jones-Lee have prepared several papers and reports on various aspects of municipal solid waste (MSW) management and hazardous waste management by landfilling, groundwater quality protection issues, as well as other issues of concern to those within a sphere of influence of a landfill. These materials provide an overview of the key problems associated with landfilling of MSW and hazardous waste utilizing lined "dry tomb" landfills and suggest alternative approaches for MSW management that will not lead to groundwater pollution by landfill leachate and protect the health and interests of those within the sphere of influence of a landfill. Copies of many of these papers and reports are available as downloadable files from Drs. G. Fred Lee's and Anne Jones-Lee's web page (http://www.gfredlee.com). Recent papers and reports on landfilling issues are listed below. Copies of the papers and reports listed below as well as a complete list of publications on this and related topics are available upon request.

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Lee, G. F. and Jones-Lee, A., "Overview of Subtitle D Landfill Design, Operation, Closure and Postclosure Care Relative to Providing Public Health and Environmental Protection for as Long as the Wastes in the Landfill will be a Threat," Report of G. Fred Lee & Associates, El Macero, CA (2004). http://www.gfredlee.com/LFoverviewMSW.pdf

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Landfills Evaluated by
G. Fred Lee and Anne Jones-Lee

Arizona *(State Landfilling Regulations)*	Verde Valley - Copper Tailings Pile Closure Southpoint Landfill, Mobile
California *(State Landfilling Regulations)*	Colusa County - CERRS Landfill San Gabriel Valley - Azusa Landfill City of Industry - Puente Hills Landfill North San Diego County, 3 landfills San Diego County - Gregory Canyon Landfill El Dorado County Landfill Yolo County Landfill Half Moon Bay - Apanolio Landfill Pittsburg - Keller Canyon Landfill Chuckwalla Valley - Eagle Mountain Landfill Barstow - Hidden Valley Broadwell Hazardous Waste Landfills Cadiz - Bolo Station-Rail Cycle Landfill University of California-Davis Landfills (4) San Marcos - San Marcos Landfill Placer County - Western Regional Sanitary Landfill Placer County – Turkey Carcass Disposal Pits Imperial County - Mesquite Landfill Los Angeles County - Calabasas Landfill Los Angeles County – Palos Verdes Landfill Contra Costa County – Concord Naval Weapons Station Tidal Area Landfill Nevada County, CA Lava Cap Mine Area Landfill Sylmar, CA Sunshine Canyon Landfill
Colorado (*State Landfilling Regulations)*	Last Chance/Brush - Hazardous Waste Landfill Denver - Lowry Hazardous Waste Landfill Telluride/Idarado Mine Tailings
Florida (*State Landfilling Regulations*)	Alachua County Landfill
Illinois (*State Landfilling Regulations*)	Crystal Lake - McHenry County Landfill Wayne County Landfill
Indiana (*State Landfilling Regulations*)	Posey County Landfill New Haven-Adams Center Landfill (Hazardous Waste)
Michigan (*State Landfilling Regulations*)	Menominee Township - Landfill Ypsilanti- Waste Disposal Inc. (Hazardous Waste - PCB's)
Minnesota	Reserve Mining Co., Silver Bay - taconite tailings Wright County - Superior FCR Landfill
Missouri	Jefferson County - Bob's Home Service Hazardous Waste Landfill
New Jersey (*State Landfilling Regulations*)	Meadowlands – Landfill Fort Dix Landfill Scotch Plains Leaf Dump
New York	Staten Island - Fresh Kills Landfill, Niagara Falls - Hazardous Waste Landfill, New York City – Ferry Point Landfill

Ohio	Clermont County - BFI/CECOS Hazardous Waste Landfill, Huber Heights - Taylorville Road Hardfill Landfill
Pennsylvania (*State Landfilling Regulations*)	Pottstown, PA - Pottstown Landfill Closure Committee
Rhode Island	Richmond Landfill
South Carolina	Spartanburg - Palmetto Landfill
Texas (*State Landfilling Regulations*)	Dallas/Sachse – Landfill Fort Worth - Acme Brick Hazardous Waste Landfill City of Dallas - Jim Miller Road Landfill
Vermont	Coventry, Vermont – Coventry Landfill
Washington (*State Landfilling Regulations*)	Tacoma - 304th and Meridian Landfill
Wisconsin	Madison and Wausau Landfills
INTERNATIONAL LANDFILLS	
Belize	Mile 27 Landfill
Ontario, Canada (*Prov. Landfilling Regulations*)	Greater Toronto Area - Landfill Siting Issues Kirkland Lake - Adams Mine Site Landfill Pembroke - Cott Solid Waste Disposal Areas
Manitoba, Canada (*Prov. Landfilling Regulations*)	Winnipeg Area - Rosser Landfill
New Brunswick, Canada (*Prov. Landfilling Regulations*)	St. John's - Crane Mountain Landfill
England	Mercyside Waste Disposal Bootle Landfill
Hong Kong	Three New MSW Landfills
Ireland	Bottlehill Landfill, County Cork Central Waste Management Facility, Ballyduff, County Clare
Korea	Yukong Gas Co. - Hazardous Waste Landfill
Mexico (*Haz. Waste Landfilling Regulations*	San Luis Pontosi - Hazardous Waste Landfill
New Zealand	North Waikato Regional Landfill
Puerto Rico	Salinas - Campo Sur Landfill

Surface and Groundwater Quality Evaluation and Management
and
Municipal Solid & Industrial Hazardous Waste Landfills

http://www.gfredlee.com

Dr. G. Fred Lee and Dr. Anne Jones-Lee have prepared professional papers and reports on the various areas in which they are active in research and consulting including domestic water supply water quality, water and wastewater treatment, water pollution control, and the evaluation and management of the impacts of solid and hazardous wastes. Publications are available in the following areas:

Landfills and Groundwater Quality Protection
Water Quality Evaluation and Management for Wastewater Discharges
    Stormwater Runoff, Ambient Waters and Pesticide Water Quality Management Issues, TMDL Development, Water Quality Criteria/Standards Development and Implementation
Impact of Hazardous Chemicals -- Superfund
    LEHR Superfund Site Reports to DSCSOC
    Lava Cap Mine Superfund Site reports to SYRCL
    Smith Canal
Contaminated Sediment -- Aquafund, BPTCP, Sediment Quality Criteria
Domestic Water Supply Water Quality
Excessive Fertilization/Eutrophication, Nutrient Criteria
Reuse of Reclaimed Wastewaters
Watershed Based Water Quality Management Programs:
    Sacramento River Watershed Program
    Delta -- CALFED Program
    Upper Newport Bay Watershed Program
    San Joaquin River Watershed DO and OP Pesticide TMDL Programs

Stormwater Runoff Water Quality Science/Engineering Newsletter

G. Fred Lee & Associates was organized in the late 1960s to cover the part-time consulting activities that Dr. Lee undertook while a full-time university professor. In 1989, when Dr. Lee retired from 30 years of graduate-level teaching and research, he and Dr. Anne Jones-Lee, who was also a university professor, expanded G. Fred Lee & Associates into a full-time business activity. Examples of governmental agencies, consulting firms, citizens groups, industries and others for whom G. Fred Lee has served as an advisor include the following:

U.S. Environmental Protection Agency - Various Locations
Vison, Elkins, Searls, Connally & Smith, Attorneys - Houston, TX
International Joint Commission for the Great Lakes
U.S. Public Health Service - Washington, DC
Attorney General, State of Texas - Austin, TX
Madison Metropolitan Sewerage District - Madison, WI
Great Lakes Basin Commission - Windsor, Ontario
U.S. Army Environmental Hygiene Agency - Edgewood Arsenal, MD
City of Madison - Madison, WI
Council on Environmental Quality - Washington, DC
National Academies of Sciences and Engineering - Washington, DC
Water Quality Board State of Texas - Austin, TX
U.S. General Accounting Office - Washington, DC
U.S. Army Corps of Engineers - Vicksburg, MS
Tennessee Valley Authority - Various locations in Tennessee Valley
National Oceanic & Atmospheric Administration - Various locations
Organization for Economic Cooperation & Development - Paris
Attorney General, State of Illinois - Chicago, IL
State of Texas Hazardous Waste Legislative Committee - Austin
State of New Mexico Environmental Improvement Agency - Santa Fe
New York District Corps of Engineers - New York, NY
San Francisco District Corps of Engineers - San Francisco, CA
Wisconsin Electric Power Company - Milwaukee, WI
WAPORA - Washington, DC
Reserve Mining Company - Silver Bay, MN
United Engineers - Philadelphia, PA
Automated Environmental Systems - Long Island, NY
Procter & Gamble Company - Cincinnati, OH
Inland Steel Development Company - Chicago, IL
Kennecott Copper Corporation - Salt Lake City, UT
U.S. Steel Corporation - Pittsburgh, PA
Nekoosa Edwards, Inc. - WI
Zimpro, Inc. - Rothschild, WI
FMC Corporation - Philadelphia, PA
Acme Brick Company - Forth Worth, TX
Monsanto Chemical Company - St. Louis, MO
Gould, Inc. - Cleveland, OH
Illinois Petroleum Council - Chicago, IL
Inland Steel Corporation - Chicago, IL
Industrial Biotest Laboratories - Northbrook, IL
Wisconsin Pulp & Paper Industries - Upper Fox Valley, WI

Thilmany Pulp & Paper Company - Green Bay, WI
Chicago Park District - Chicago, IL
Nalco Chemical Company - Chicago, IL
Boise Cascade Development Company - Chicago, IL
Foley & Lardner, Attorneys - Milwaukee, WI
Timken & Lonsdorf, Attorneys - Wausau, WI
Strasburger, Price, Kelton, Martin & Unis, Attorneys - Dallas, TX
Rooks, Pitts, Fullagar & Poust, Attorneys - Chicago, IL
Jones, Day, Cockley & Reaves, Attorneys - Cleveland, OH
Sullivan, Hanft, Hastings, Fride & O'Brien, Attorneys - Duluth, MN
Hinshaw, Culbertson, Molemann, Hoban & Fuller, Attnys - Chicago, IL
Colorado Springs - Colorado Springs, CO
Mayer, Brown & Platt, Attorneys - Chicago, IL
Pueblo Area Council of Governments - Pueblo, CO
Platte River Power Authority - Fort Collins, CO
Linquist & Vennum, Attorneys - Minneapolis, MN
Norfolk District Corps of Engineers - Norfolk, VA
Spanish Ministry of Public Works - Madrid, Spain
The Netherlands - Rijkswaterstaat - Amsterdam, The Netherlands
U.S. Department of Energy - Various locations in US
King Industries - Norwalk, CT
Attorney General, State of Florida - Tallahassee, FL
State of Colorado Governor's Office - Denver, CO
Cities of Fort Collins, Longmont, and Loveland - CO
E.I. DuPont - Wilmington, DE
Allied Chemical Company - Morristown, NJ
Outboard Marine - Waukegan, IL
Amoco Oil Company - Denver, CO
Appalachian Timber Services - Charleston, WV
Mission Viejo Development - Denver, CO
Fisher, Brown, Huddleston & Gun, Attorneys - Fort Collins, CO
Tom Florczak, Attorney - Colorado Springs, CO
Wastewater Authority - Burlington, VT
Tad Foster, Attorney - Pueblo, CO
Holmes, Roberts & Owen, Attorneys - Denver, CO
Center for Energy and Environment Research - Puerto Rico
City of Brush - Brush, CO
Rock Island District Corps of Engineers - Rock Island, IL
Santo Domingo Water Authority - Dominican Republic
Ministry of Public Works and Environment - Buenos Aires, Argentina
Neville Chemical - Pittsburgh, PA
Fike Chemical Company - Huntington, WV
Stauffer Chemical Company - Richmond, CA
Adolph Coors Company - Golden, CO
Water Research Commission - South Africa
Grinnell Fire Protection Systems - Lubbock, TX

City of Lubbock Parks Department - Lubbock, TX
National Planning Council - Amman, Jordan
City of Olathe - Olathe, KS
City of Lubbock - Lubbock, TX
US AID - Amman, Jordan
Buffalo Springs Lake Improvement Association - Buffalo Springs, TX
Union Carbide Company - Charleston, WV
Canadian River Municipal Water Authority - Lake Meredith, TX
Mobil Chemical Company - Pasadena, TX
Unilever Ltd. - Rotterdam, The Netherlands
Brazos River Authority - Waco, TX
U.S. Army Construction Engineering Research Laboratory - Champaign, IL
James Yoho, Attorney - Danville, IL
Zukowsky, Rogers & Flood, Attorneys - Crystal Lake, IL
State of California Water Resources Control Board - Sacramento
Public Service Electric & Gas - Newark, NJ
Health Officer - Boonton Township, NJ
Scotland & Robeson Counties - Lumberton, NC
International Business Machines Corporation - White Plains, NY
Newark Watershed Conservation & Development Authority - NJ
State of Vermont Planning Agency - Montpelier, VT
CDM, Inc. - Edison, NJ
Attorney General, State of North Carolina - Raleigh, NC
City of Vernon - Vernon, NJ
Ebasco Services - Lyndhurst, NJ
Kraft, Inc. - Northbrook IL, with work in Canada, FL and MN
USSR Academy of Sciences - Moscow, USSR
Tillinghast, Collins & Graham, Attorneys - Providence, RI
City of Richmond, RI
Idarado Mining Company - Telluride, CO
Levy, Angstreich, Attorneys - Cherry Hill, NJ
Newport City Development - Jersey City, NJ
Orbe, Nugent & Collins, Attorneys - Ridgewood, NJ
Schmeltzer, Aptaker & Shepard, Attorneys - Washington, DC
CP Chemical - Sewaren, NJ
Dan Walsh, Attorney - Carson City, NJ
William Cody Kelly - Lake Tahoe, NV
NJ Department of Environmental Protection - Trenton, NJ
Hufstedler, Miller, Kaus & Beardsley, Attorneys - Los Angeles, CA
Main San Gabriel Basin Watermaster - CA
Metropolitan Water District of Southern California - Los Angeles, CA
San Diego Unified Port District - San Diego, CA
Delta Wetlands - CA
Simpson Paper Company - Humboldt County, CA
City of Sacramento - CA
Northern California Legal Services - Sacramento, CA

Rocketdyne - Canoga Park, CA
RR&C Development Co. - City of Industry, CA
American Dental Association - Chicago, IL
Emerald Environmental - Phoenix, AZ
Clayton Chemical Company - Sauget, IL
Stanford Ranch - Rocklin, CA
Public Liaison Committee - Kirkland Lake, Ontario
Miller Brewing Company, Los Angeles, CA
ASARCO Inc., Tacoma, WA
CALAMCO, Stockton, CA
Yunkong Gas Company, South Korea
Sutherlands, Pembroke, Ontario
Silverado Constructors, Irvine, CA
Agricultural Interests in Puerto Rico
City of Winnipeg, Manitoba
Strain Orchards, Colusa, CA
Davis South Campus Superfund Oversight Committee, Davis, CA
Monterrey County, California Housing Authority, Salinas, CA
CROWD, Tacoma, WA
Newport Beach, CA
SOLVE, Phoenix, AZ
Sports Fishing Alliance, San Francisco, CA
Caltrans (California Department of Transportation)
Citizens Group near St. John's, New Brunswick
Colonna Shipyards, Norfolk, VA
Clermont County, OH
Wright County, MN
Waikato River Protection Society, New Zealand
Drobac & Drobac, Attorneys, Santa Cruz, CA
Phelps Dunbar, L.L.P., Houston, TX
Walters Williams & Co, New Zealand
Environmental Protection Department, Hong Kong
NYPRIG New York City, NY
DeltaKeeper, Stockton
City of Stockton, CA
Central Valley Regional Water Quality Board, Sacramento, CA
Carson Harbor Village, Carson, CA
Sanitary District of Hammond, IN
South Bay CARES, Los Angeles, CA
Memphremagog Regional Council, Quebec, CANADA
Mobile, AZ
Pottstown Landfill Closure Committee, Pottstown, PA
Grand Forks County Citizens Coalition, Grand Forks, ND
Sunshine Canyon Landfill, Sylmar, CA