REVIEW OF THE ADEQUACY OF THE BFI/CECOS ABER ROAD HAZARDOUS WASTE LANDFILL FACILITY CLOSURE AND POST-CLOSURE PLANS TO PROTECT PUBLIC HEALTH AND THE ENVIRONMENT

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EXECUTIVE SUMMARY

A review has been conducted of the adequacy of the BFI/CECOS Aber Road hazardous waste landfill facility Closure and Post-Closure Plans that have been approved by the Ohio EPA. It has been found that the BFI/CECOS hazardous waste landfill facility contains large amounts of hazardous and deleterious chemicals that are a threat to public health, ground and surface water quality, domestic water supplies, and the environment. This threat will exist effectively forever.

Clermont County's domestic water supply for approximately 30,000 people, which depends on the East Fork of the Little Miami River and Harsha Lake, as well as the environmental resources along Pleasant Run Creek and the East Fork of the Little Miami River, including Harsha Lake, are significantly threatened by the inadequacies in the Ohio EPA-approved BFI/CECOS Aber Road hazardous waste landfill facility Closure and Post-Closure Plans.

A significant error was made in the development of the landfilling approach used by BFI/CECOS where large amounts of caustic/alkali chemicals were added to some of the waste subcells for the purpose of immobilizing some metals. This caustic material has caused the pH of the leachate in certain subcells to be sufficiently high to destroy the clay liner underlying the subcells.

BFI/CECOS accepted low molecular weight solvents (VOCs) as hazardous waste at the BFI/CECOS hazardous waste landfill facility. Many of these VOCs can rapidly penetrate through the plastic sheeting layer used in the landfill cell liners through permeation (pass through) of the liner. The leachate contains sufficient concentrations of these VOCs to be a significant threat to groundwater quality by permeation of the intact (without holes) liner. Many of the VOCs present in the leachate are regulated as human carcinogens because of their threat to public health.

Examination of the leachate chemical characteristic data shows that there is a possibility that DNAPLs (dense non-aqueous phase liquids) are present in the leachate. Such presence can lead to rapid passage of hazardous chemicals through the liner system into the underlying groundwaters which would move in the groundwater system underlying the hazardous waste cells in a direction different from that of the groundwaters underlying the cells.

A critical review of the properties of the plastic sheeting and clay liners used at the BFI/CECOS Aber Road hazardous waste landfill facility shows that the inherent design permeabilities of these liner components will, within a few years, allow sufficient hazardous waste to penetrate through the liners into the underlying groundwater system to pollute these groundwaters with hazardous chemicals.

The Ohio EPA-approved Closure and Post-Closure Plans are significantly deficient in preparing for the inevitable large-scale groundwater and surface water pollution that will occur from the plastic sheeting and clay lined hazardous waste landfill cells. There is substantial evidence for leakage of hazardous chemicals from the landfill cells through the liner systems into the underlying groundwaters.

The groundwater and surface water monitoring requirements, as established in the Post-Closure Plan, do not comply with federal RCRA and state of Ohio regulatory requirements for protection of public health, groundwater and surface water quality, and the environment from BFI/CECOS landfilled hazardous waste.

The BFI/CECOS Aber Road facility is located at a geologically unsuitable site for a hazardous waste or municipal solid waste landfill. The complexity of the geology and hydrogeology of this site makes the reliable monitoring of groundwaters for pollution by landfilled wastes extremely difficult to achieve.

There are substantial quantities of unregulated hazardous and deleterious wastes at the BFI/CECOS hazardous waste facility which are not now being considered in the post-closure monitoring requirements.

The inherent permeability of the landfill liner containment systems used at the BFI/ CECOS hazardous waste landfill facility, coupled with the permeation of certain low molecular weight organics through the plastic sheeting liner component and the degradation of the clay liner that will occur for those cells with a high pH, provide ample justification for the Ohio EPA to substantially modify the Closure and Post-Closure Plans for the BFI/CECOS Aber Road facility.

Additional justification for modifying the Closure and Post-Closure Plans stems from the inadequate groundwater and surface water monitoring programs that the Ohio EPA has allowed at the BFI/CECOS hazardous waste landfill facility.

The following recommendations should be adopted in order to conform to current regulatory requirements of providing for public health, groundwater and surface water quality, domestic water supply and environmental protection for as long as the wastes at the BFI/CECOS hazardous waste landfill facility will be a threat.

- The Ohio EPA, BFI/CECOS and the US EPA must acknowledge and plan for the fact that the wastes in the BFI/CECOS hazardous waste landfill cells will be a threat to public health and the environment, effectively forever. The current 30-year minimum post-closure care period that BFI/CECOS has adopted as their period of responsibility for the Aber Road facility represents an infinitesimally small part of the time that post-closure maintenance, monitoring and remediation will have to be funded at the Aber Road facility.
- A dedicated trust fund based on transfer of cash to the fund should be immediately established to provide for proper closure, *ad infinitum* post-closure monitoring, maintenance and remediation for as long as the wastes at the Aber Road facility represent a threat.
- A worst-case scenario failure evaluation should be used in developing closure and post-closure plans that will be protective of public health, domestic water supply and the environment for as long as the wastes at the Aber Road facility will be a threat.
- A comprehensive monitoring of individual cell/subcell leachate characteristics, liner leak detection systems where they exist, cell underdrains and groundwater should be immediately implemented in order to assess the magnitude of the leakage that is now occurring through the landfill liner systems and to detect when further failure of the landfill cell containment systems occurs.
- Leak detectable covers should be installed on each of the landfill cells. These covers should be operated and maintained in perpetuity, i.e. for as long as the wastes in the cells are a threat

- The groundwater table around each of the hazardous waste landfill cells should be lowered to at least five feet below the bottom of the cell underdrain.
- A highly reliable groundwater monitoring program should be developed that can detect, in accord with current regulations, when leakage of hazardous waste components occurs through the landfill cell liner systems.
- A neighbors' well sampling program should be initiated to monitor the quality of groundwater wells near the BFI/CECOS hazardous waste landfill facility.
- A highly reliable, comprehensive surface water monitoring program should be initiated to determine when the pollution of surface waters by stormwater runoff or groundwater discharge to surface water occurs. This program should include frequent measurement of a large number of chemical parameters and biological responses in Pleasant Run Creek, the East Fork of the Little Miami River and Harsha Lake. This monitoring program should include measurements of the suite of chemicals present in waste landfilled at the BFI/CECOS Aber Road facility and their transformation products, as well as the potential biological impacts of these chemicals that are a threat to public health and the environment.
- Because of the potential for radioactive wastes disposal at the BFI/CECOS hazardous waste landfill facility and the inadequate screening for radioactive wastes, gross alpha, gross beta and gamma radiation should be measured at quarterly intervals in the cell leachate standpipes, cell underdrains, groundwater monitoring wells, and surface water samples.

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INTRODUCTION

The Clermont County, Ohio Board of Commissioners requested that the author, Dr. G. Fred Lee, conduct a review of the adequacy of the Closure and Post-Closure Plans for the BFI/CECOS hazardous waste landfill Aber Road facility (BFI/CECOS hwl). This 208-acre facility is located in Jackson Township, Clermont County near Williamsburg, Ohio. This hazardous waste landfill facility consists of 12 land disposal units: a sanitary landfill; an intermediate bulk disposal unit (intermediate cell); two disposal units containing pre-RCRA industrial waste; and seven RCRA hazardous waste landfill cells. The site also has several surface impoundments and other waste management areas that have been closed as landfills. The BFI/CECOS hazardous waste landfill operated from the early 1970s through fall 1989, when it was closed by the Ohio EPA.

This report presents the author's initial review of the adequacy of closure and post-closure monitoring and maintenance of the BFI/CECOS Aber Road hazardous waste landfill facility to protect public health and the environment from landfilled wastes for as long as the wastes in the landfill cells will be a threat. Presented in this report are references to the literature which provide additional information on the topics covered. Several of the references cited are to the author's and his colleagues' papers and reports which present comprehensive reviews of the literature. These review papers contain numerous references to the work of others on the topics covered. Additional work is being done to further refine the conclusions and recommendations set forth in this report on the deficiencies in the current Closure and Post-Closure Plans for the BFI/CECOS Aber Road facility. This report also presents recommended approaches that the state of Ohio should adopt in modifying the BFI/CECOS hwl Closure and Post-Closure Plans to protect the quality of the East Fork of the Little Miami River, and especially the Village of Williamsburg upground surface water impoundment and Harsha Lake.

The BFI/CECOS hazardous waste landfill facility borders on Pleasant Run Creek. Pleasant Run Creek enters the East Fork of the Little Miami River about two miles south of the BFI/CECOS facility. The Village of Williamsburg obtains its domestic water supply from the East Fork of the Little Miami River about seven miles south from where Pleasant Run Creek enters this river. About two miles further downstream of the Village of Williamsburg, the East Fork of the Little Miami River enters Lake Harsha, which is a major domestic water supply for Clermont County. The quality of the East Fork of the Little Miami River and Lake Harsha are important to maintaining a high-quality domestic water supply for the County. Of particular concern is the release of hazardous and/or solid waste components from the BFI/CECOS hazardous and solid waste landfill cells located at the Aber Road facility as they may impact the quality of the surface water supplies downstream from the BFI/CECOS hwl, as well as the groundwater resources near the facility. In addition to concerns about domestic water supply water quality, there is also concern about the potential impacts of BFI/CECOS hwl-derived hazardous and solid wastes on the environmental resources within the sphere of influence of this landfill facility and along Pleasant Run Creek and the East Fork of the Little Miami River including Harsha Lake.

This review focuses on evaluating the adequacy of the Closure and Post-Closure Plans for the BFI/CECOS hwl to protect the public from adverse impacts of landfilled wastes for as long as the waste residues present in the BFI/CECOS Aber Road facility landfill cells represent a threat to public health and the environment. Considered in this review is the ability of the landfill cells containment systems to prevent the release of hazardous and/or deleterious waste-derived components that could be transported off-site from the Aber Road facility via surface water and/or groundwater. Also considered is the adequacy of the Ohio EPA-approved groundwater and surface water monitoring programs developed as part of the Closure and Post-Closure Plans for the BFI/CECOS Aber Road facility landfill cells. Of particular concern is the reliability of detecting releases of hazardous and/or deleterious waste-derived components at the point of groundwater monitoring compliance that could be transported off-site for as long as the wastes at the BFI/CECOS Aber Road facility represent a threat.

Recommendations are presented that the state should adopt to significantly improve the public health and environmental protection from landfilled waste-derived constituents associated with closure and post-closure monitoring and maintenance of the BFI/CECOS Aber Road hazardous waste landfill facility.

CONCLUSIONS

- The BFI/CECOS 35+ acres of hazardous waste landfill cells and the solid waste landfill, industrial waste landfills and other waste management units located at the Aber Road facility represent significant long-term threats to the downstream surface water resources along Pleasant Run Creek and the East Fork of the Little Miami River.
- In addition to being a threat to public, private, and environmental resources along Pleasant Run Creek and the East Fork of the Little Miami River, the BFI/CECOS Aber Road facility landfilled wastes represent significant threats to the quality of the domestic water supplies for the Village of Williamsburg, and the Clermont County residents who use Harsha Lake as a domestic water supply.
- The post-closure monitoring and maintenance requirements for the BFI/CECOS hwl developed by the Ohio EPA are significantly deficient in protecting the public from landfilled wastes for as long as the wastes in the BFI/CECOS Aber Road facility represent a threat to public health and the environment. Some of the issues and deficiencies in the current closure and post-closure requirements are listed below.
    - **Threat to Public Health and Environment Forever.** The Ohio EPA-allowed Post-Closure a monitoring and maintenance Plan for the BFI/CECOS hwl that does not reliably consider the period of time that the wastes at the Aber Road facility will be a threat to public health and the environment. Many of the waste components and their transformation products present in the BFI/CECOS hazardous waste landfill cells and the solid waste landfill, as well as other waste management units at the Aber Road facility, will be a threat to public health and the environment, effectively forever.
    - **Threat of "Non-Hazardous" Wastes.** In addition to so-called landfilled hazardous wastes at the BFI/CECOS Aber Road facility, the landfilled wastes in the solid waste landfill, industrial waste landfill cells 1 and 2 and the hazardous waste landfill cells 3 through 10, as well as the ponds closed as landfills contain waste components that, while not classified as "hazardous," are significant threats to domestic water supply water quality.
    - **Threat of Unregulated Chemicals.** In addition to the large amount of landfilled hazardous wastes that are known to be present at the BFI/CECOS Aber Road facility, there are a large number of unregulated (without water quality standards)

potentially hazardous chemicals in the hazardous waste cells, industrial waste landfill cells, solid waste landfill and other waste management units closed as landfills that are significant threats to public health, domestic water supply water quality and the environment. These chemicals are being largely ignored in the Ohio EPA Closure and Post Closure Plan requirements for the BFI/CECOS Aber Road facility.

- **Limited Reliability of Landfill Liners and Caps.** The closed hazardous waste landfill cells' containment systems (liners and cover) have a limited, finite period of time, compared to the time the waste in the cells will be a threat, during which they can be expected to function as an effective barrier to waste transport out of the landfill cells to the underlying groundwater system.

  The BFI/CECOS hwl cells, including cells 9 and 10 which utilized a double composite liner, will eventually fail to prevent large scale hazardous and deleterious waste components present in these cells from polluting groundwaters underlying the cells.

  BFI/CECOS and Ohio EPA call the hazardous waste landfill cells at the Aber Road facility "Secure Chemical Management Facilities" (SCMFs). The "security" provided by these originally clay-lined, now plastic sheeting- and clay-lined landfill cells to protect public health and the environment from leachate generated within the cells for as long as the wastes represent a threat is complete fiction. Security provided by such cells is only transitory and is really a façade in terms of protecting public health and the environment from the long-term threats that the wastes in the plastic sheeting and compacted soil-lined cells represent.

  A fundamental error was made in the landfilling of certain hazardous wastes at the BFI/CECOS hazardous waste landfill facility where large amounts of caustic was added to the waste for the purpose of immobilizing certain heavy metals. This causes the pH of the leachate in some subcells to be sufficiently high to destroy the integrity of the clay liner used for the subcells.

  While not well understood at the time that the landfilling of hazardous waste took place at the Aber Road facility, it has been known since the late 1980s that the landfilling of low molecular weight solvents, such as that which took place in the BFI/CECOS landfill cells, leads to rapid penetration of the plastic sheeting layer through permeation (passage through) of the low molecular weight organic solvents. This results in hazardous chemicals to fail to be retained within the landfill cell where they can be removed in the leachate. These hazardous chemicals, many of which are carcinogens, rapidly pass through the plastic sheeting layer of the liner to ultimately enter the underlying groundwater system. There is substantial evidence that permeation of the plastic sheeting layer by low molecular weight solvents, which are at times, present in the leachate at high concentrations has occurred leading to pollution of the underdrain and underlying groundwaters by these hazardous constituents.

  Examination of the chemical characteristics of the hazardous waste cell "underdrains" waters provided by BFI/CECOS to Ohio EPA shows that hazardous constituents which were most likely derived from the hazardous waste present in the hazardous waste landfill cells have leaked through the hazardous waste landfill cell liner system into the cell underdrain.

The density of the leachate due to salts and the possibility of DNAPL formation in the leachate, at times, leads to additional potential for transport of hazardous chemical through the liner and in the groundwaters underlying the landfill cells.

Even if there were no significant short-term and long-term problems with the ability of the plastic sheeting and clay liners used in the BFI/CECOS hazardous waste landfill cells, the inherent permeability of the plastic sheeting layer and compacted clay layer will allow transport of significant quantities of hazardous waste components through the liner system into the underlying groundwaters within a few years after waste placement. This penetration of the liner is due to diffusion of the hazardous constituents in the leachate through the intact liner system. This diffusion will occur at a sufficient rate even if the liner components function as designed.

Basically, the liner systems used for the BFI/CECOS hazardous waste landfill cells represent a fundamentally flawed approach for preventing groundwater pollution by hazardous waste components. After a few years over time due to deterioration of the liner components, the advective transport (flow) of hazardous waste components through the liner will be sufficient so that there will be massive groundwater pollution associated with each of the landfill cells at the BFI/CECOS Aber Road facility.

The characteristics of the leachate being produced in the hazardous waste landfill cells are such that the leachate represents a significant threat to cause groundwater pollution by a variety of hazardous chemicals that are known carcinogens. Further, the leachate contains components that can pass through the intact (no holes) plastic sheeting layer (flexible membrane liner) in a short time after contact with the liner. In addition, for certain subcells to which large amounts of alkali was added, the leachate has a pH which will cause dissolution of the basic structure of the clay liner.

- **Geological Unsuitable Site.** The BFI/CECOS Aber Road facility is located at a geologically unsuitable site for a hazardous waste and/or solid waste landfill. The site provides no natural protection of off-site groundwaters and surface waters from pollution by landfilled waste. Further, the complexity of the geology and hydrogeology of this site makes monitoring of the pollution of groundwaters by hazardous and deleterious wastes difficult to reliably achieve.
- **Groundwater Pathways for Hazardous Waste Transport Off-site.** The geology/hydrogeology of the BFI/CECOS Aber Road facility provides pathways for transport of hazardous and deleterious waste components that enter the groundwaters under the hazardous waste landfill cells to off-site groundwaters and to surface waters through groundwater discharge to Pleasant Run Creek, which will transport the waste-derived constituents to the East Fork of the Little Miami River and Harsha Lake.

- **Unreliable Groundwater Monitoring.** The groundwater monitoring system allowed by the Ohio EPA in the Post-Closure Plan for the Aber Road facility for detection of landfill liner failure is unreliable in detecting groundwater pollution by Aber Road facilities landfilled wastes before widespread off-site groundwater pollution occurs.

- **Unreliable Slurry Wall.** The slurry wall system required by the US EPA around certain of the BFI/CECOS Aber Road facility's waste management units is significantly deficient in preventing off-site transport of waste-derived constituents from inside the slurry wall to off-site groundwaters and through groundwater discharge to surface waters to surface water.

- **Inadequate Surface Water Monitoring.** As part of the Aber Road facility's Post-Closure Plan, Ohio EPA is allowing BFI/CECOS to conduct an inadequate surface water quality monitoring program to detect when surface water pollution of Pleasant Run Creek and the East Fork of the Little Miami River occurs by BFI/CECOS Aber Road facility-derived wastes. In addition to stormwater runoff-carried wastes components spilled on the surface soils, waste leaking through the above-ground sides of the landfill units, there will be transport of wastes from the facility via groundwater transport to Pleasant Run Creek. The pollution of surface waters by BFI/CECOS Aber Road facility wastes is a significant threat to domestic water supplies, recreational use of the East Fork of the Little Miami River, Harsha Lake and the environmental resources along Pleasant Run Creek and the Little Miami River.

- **Inadequate Closure and Post-Closure.** The Ohio EPA-allowed closure and post-closure monitoring and maintenance of the BFI/CECOS hazardous waste and solid waste landfill cells will not, as currently being implemented, protect Clermont County residents' public health, domestic water supply water resources and the environment for as long as the BFI/CECOS landfilled wastes represent a threat. There is a high probability that the BFI/CECOS hazardous waste and solid waste landfilled wastes will, unless significant improvements in closure and post-closure requirements are implemented, cause significant water resource, environmental and public health damage.

  The gross deficiencies in the groundwater monitoring to detect the failure of the cell liner system to prevent hazardous chemicals from entering the underlying groundwater is compelling justification to modify the Post-Closure Plan monitoring requirements for the BFI/CECOS hazardous waste landfill facility. The revised post-closure monitoring requirements must include a reliable monitoring system which can detect the groundwater pollution when it first occurs. Reliable detection of initial groundwater pollution is essential to initiation of the groundwater remediation program that will be needed for each of the hazardous waste cells at the BFI/CECOS site. Without a reliable groundwater monitoring program and the ability to initiate a comprehensive groundwater remediation program, initial large-scale off-site groundwater and surface water pollution will occur that is a threat to public health, domestic water supply and the environment.

RECOMMENDATIONS

The 35+ acres of hazardous waste landfills which contains an estimated over 1 million 55-gallon drum-equivalents of hazardous waste including large amounts (81,000 tons between July 1, 1987 and June 30, 1988) of PCB wastes, coupled with the inability of the hazardous waste landfill cells to prevent waste component release now, much less over the infinite period of time that the wastes at the Aber Road facility will be a threat, mandates that the Closure and Post-Closure Plans for the BFI/CECOS hazardous waste landfill facility be substantially modified. New Closure and Post-Closure Plans should be developed to conform to regulatory requirements of protecting public health, surface and groundwater quality, and the environment from the landfilled wastes.

Because of the fundamentally flawed landfilling approach that was followed by BFI/CECOS at the Aber Road facility for prevention of groundwater pollution where:

- even if the liner systems function perfectly as designed, there would be groundwater pollution within a few years by carcinogens and other hazardous chemicals;
- coupled with the significant errors that were made in the landfilling of wastes where large amounts of hydroxide (caustic-alkali) were added to certain waste cells which leads to a high pH leachate that can destroy the integrity of the clay liner within a short period of time;
- as well as the permeation of hazardous low molecular weight organics through the plastic sheeting layers used as the primary component of the liner to prevent groundwater pollution,

mandates that a drastically different approach be immediately developed for closure and post-closure approach and monitoring and maintenance of the BFI/CECOS hazardous waste landfill cells. It is only a short time until what are now the initial stages of release of hazardous constituents through the liner system into the underlying groundwater system will become increasingly more significant.

There must be initiated a much more comprehensive, reliable monitoring system to detect the inherent failure of the liner system as well as the ultimate large-scale deterioration of this liner system. Further, it is mandatory that BFI/CECOS immediately establish sufficient, assured funding to establish a large-scale pump and treat operation as well as reliably collect and treat all hazardous waste components that will penetrate through the liner for as long as the wastes in the landfill cells are a threat. It is recommended that revised Closure and Post-Closure Plans be developed for the BFI/CECOS Aber Road hazardous waste landfill facility that incorporate the following issues and approaches.

- **Wastes Threat Forever.** The Ohio EPA and BFI/CECOS must acknowledge that many of the waste components in the BFI/CECOS hazardous waste landfill cells, solid waste landfill, industrial waste landfill cells and the ponds closed as landfill will be a threat to public health, domestic water supply water quality and the environment, effectively forever. There should be no further discussion of only a 30-year post-closure period for the BFI/CECOS Aber Road facility.

  For planning purposes for appropriate post closure monitoring and maintenance of this facility, the wastes at this site in the existing cells should be acknowledged to be a threat **forever** and the Closure and Post-Closure Plans should be modified accordingly to control this threat with a high degree of reliability.

- **Dedicated Trust.** BFI/CECOS should immediately develop a non-refundable dedicated trust fund based on funds actually transferred to a trust account of sufficient magnitude to provide for proper closure and *ad infinitum* post-closure monitoring and maintenance of the hazardous waste cells, industrial waste cells, solid waste landfill and other waste management units located at the BFI/CECOS Aber Road facility.

  This dedicated trust fund should be of sufficient magnitude to not only implement appropriate closure of the existing hazardous waste management cells, post-closure monitoring and maintenance, but also to exhume all wastes present at the BFI/CECOS Aber Road facility for off-site management if at any time in the future it appears that the modified closure and post-closure monitoring/ maintenance is not adequate to provide a high degree of public health, domestic water supply and environmental protection for as long as the wastes present at the BFI/CECOS Aber Road landfill facility represent a threat.

- **More Appropriate Evaluation of the Threat of BFI/CECOS Hazardous Waste Landfill Facility.** Currently the Ohio EPA has allowed BFI/CECOS to close the hazardous waste landfill cells using approaches that are overly optimistic on the ability of the landfill cells' containment systems and monitoring systems to protect public health, domestic water supply and the environment for as long as the wastes in the landfill cells will be a threat. The landfill containment systems (liners and caps) will fail to prevent leachate from being generated within the hazardous waste landfill cells and will fail to collect all of the leachate generated in these cells for as long as the wastes in the cells will be a threat. Sufficient leachate leakage through the cell liners and underdrains will occur to pollute the groundwaters underlying the cells. The pollution of this type that is already occurring is a forerunner of the massive pollution that will occur as the integrity of the landfill liners further deteriorate over time.

  The Ohio EPA-allowed post-closure groundwater monitoring for landfill liner leakage and groundwater pollution that will occur at the BFI/CECOS Aber Road facility hazardous waste landfill cells is unreliable for detection of groundwater pollution by landfill leachate before off-site pollution occurs.

  The Ohio EPA should develop revised closure requirements for each of the hazardous waste landfill cells, industrial waste landfill cells and the solid waste landfill and other Aber Road facility waste landfill cells that are based on a plausible worst-case-scenario failure for the landfill cells' containment systems to prevent landfilled waste release to the groundwaters underlying each landfill cell or other waste management unit.

  Revised post-closure groundwater monitoring requirements should be developed which conform to regulatory requirements of detecting initial leakage of leachate through the hazardous waste landfill liners and underdrains before off-site groundwater pollution occurs.

- **Worst Case Scenario Failure Evaluation.** For each of the waste management units, the Ohio EPA should conduct a critical, in-depth, plausible, worst-case-scenario evaluation of each of the hazardous waste landfill cells' containment systems' ability to prevent waste-derived constituents from leaving the landfill cell or other waste management unit and entering groundwaters underlying the unit, for as long as the wastes in the cell are a threat. Based on this evaluation, appropriate modifications of the Closure and Post-Closure Plans should be made to protect the public health, groundwater resources and the environment of Clermont County from pollution by BFI/CECOS Aber Road facility-associated wastes.

- **Reliable Landfill Cell Leak Monitoring.** Based on the plausible worst-case scenario failure evaluation, the Ohio EPA should develop a reliable landfill cell containment system leakage monitoring approach that has a high probability of detecting incipient leakage of landfilled wastes when it first occurs.

  The statistical reliability of this monitoring system to detect initial leakage of waste-derived constituents from any part of a landfill cell should be evaluated. The overall monitoring system should have a high probability of detecting initial leakage from any part of an individual subcell at the point of compliance for groundwater monitoring, which is the down groundwater gradient edge of the waste deposition area.

  Each of the geological strata that could possibly serve as a means of transport of leachate-polluted groundwater developed under a landfill cell must be reliably monitored.

- **Reliable Groundwater and Landfill Cell Monitoring.** The current approach in which the Ohio EPA is allowing BFI/CECOS to significantly reduce the monitoring associated with the hazardous waste landfill cells as part of post-closure monitoring must be immediately reversed. A far more comprehensive monitoring program to determine the characteristics of the leachate generated in each of the cells' subcells, as well as in the leak detection systems (where such systems exist in cells 9 and 10) and the underdrains, should be implemented on a quarterly basis.

  The full suite of potential pollutants, based on the characteristics of the wastes placed in each cell/subcell and/or found in the leachate, should be monitored quarterly for a period of five years. If after five years, the composition of the leachate in each of the subcells and the chemical characteristics of the leak detection system water, where such systems exist, can be predicted with a high degree of reliability, then BFI/CECOS may petition the Ohio EPA for approval for a reduced monitoring program to monitoring semi-annually for subcell leachate and the characteristics of the leak detection system and underdrain waters.

  BFI/CECOS should contribute funds to the Aber Road facility post-closure dedicated trust fund of sufficient magnitude to ensure that monitoring of leachate, leak detection system fluids, and underdrains will be conducted quarterly for as long as the wastes in the hazardous waste landfill cells represent a threat. For planning purposes, this period of time should be considered infinite.

- **Install Leak Detectable Covers on Landfill Cells.** BFI/CECOS' current landfill caps/covers for the hazardous waste cells and other waste management units are well-known to be inadequate to keep the wastes within the landfill cells from producing leachate due to precipitation infiltration through the cover for as long as the wastes in the subcells represent a threat. Further, the low permeability layers of the current hazardous waste landfill covers are not subject to inspection for the inevitable failure of the plastic sheeting layer in the cover in preventing moisture that penetrates the topsoil layer of the cover from entering the landfilled wastes and generating leachate.

  BFI/CECOS should be required to immediately implement a revised landfill cell closure which includes the installation of a leak detectable cover on each of the landfill cells, solid waste landfill and other waste management units. The purpose of this cover is to keep precipitation from entering the landfill cells.

  The leak detectable cover should be operated and maintained for as long as the wastes in the landfill cells will be a threat.

  As part of the revised post-closure funding for the BFI/CECOS Aber Road hazardous waste landfill cells and solid waste landfill facility, BFI/CECOS should immediately fund, through the transfer of funds to a non-refundable dedicated trust fund of sufficient magnitude to ensure that, in addition to meeting other post-closure needs, funds will be available, in perpetuity, to operate and maintain, with a high degree of reliability, the leak-detectable covers for each of the hazardous waste landfill cells, solid waste landfill, and other waste management units that have been closed as landfills at the BFI/CECOS Aber Road landfill facility.

- **Lowering the Groundwater Table.** Since BFI/CECOS chose to place hazardous wastes in landfill units that are located below the water table, and since a high water table surrounding the hazardous waste cells can lead to leachate generation that can cause groundwater pollution, BFI/CECOS should be required to immediately initiate pumping groundwaters around each hazardous waste cell and other waste management unit so that the groundwater table is lowered to at least five feet below the bottom of the waste management cell.

  Further, BFI/CECOS must develop a program of properly monitoring the pump groundwater to ensure that it is adequately treated to remove any waste-derived constituents both "hazardous" and "non-hazardous" before disposal.

  In addition, BFI/CECOS must fund a groundwater water level management program through development of a dedicated trust fund of sufficient magnitude to ensure that funds will be available to pump and treat as necessary the groundwaters around each of the waste management cells so that there is no possibility of the groundwaters entering the hazardous waste landfill cells or other waste management units that could generate leachate within the cell.

- **Maintenance of Less than One Foot of Leachate Head.** BFI/CECOS should continue to pump and appropriately manage leachate in each of the hazardous waste landfill cells to keep the leachate head at the point of pumping less than one foot. Eventually, when the wastes become dry due to the installation and operation of the leak detectable cover and the lowering of the water table to less than five feet below the bottom of the waste cell, there should be no leachate present in the landfill. During this time, attempts to pump leachate should be conducted weekly for two years and then monthly, if no leachate is found in the cell. If, after the waste cells are dry, leachate is found in the pumping of the leachate collection and removal system standpipes, then either the leak-detectable cover and/or groundwater draw-down system is not working properly to prevent moisture from entering the waste that generates leachate. Action should be taken to determine the cause of this failure and provide control of the moisture sources.

- **Failure to Prevent Groundwater Entering the Waste Cell.** If waste-derived constituents are found in the leak detection system or the underdrain system, during the time from when the revised closure requirements are implemented until the waste management units stop producing leachate, then the landfill containment has failed, and BFI/CECOS must take appropriate action, including, if necessary, waste exhumation from the cell to stop waste-derived constituents from entering the leak detection system and the underdrain.

- **Reliable Leak Detection Monitoring.** Since any groundwater in the leak detection systems for cells 9 and 10 and the underdrains for all cells tends to significantly dilute leachate entering the leak detection system or underdrain, and thereby mask the initial leakage of leachate through the liner system into the leak detection system or underdrain, the samples of groundwater taken from the leak detection system or underdrain during the time that the landfill subcells are drying out should be conducted on samples that have been concentrated by a factor of 10.

  Any off-gas volatiles released from the evaporative concentration of the samples should be trapped on activated carbon columns that are designed to collect low-molecular weight chlorinated solvents with a high degree of reliability. The off-gas volatiles collected on the activated carbon column should be eluted with appropriate solvents and analyzed by gas chromatography using an electron capture detector, as well as by high sensitivity GC/MS.

- **Reliable Groundwater Quality Monitoring.** Since the design of the leachate collection systems used in the hazardous waste management cells is subject to plugging by biological growths, migration of fine waste particles, and chemical precipitation, thereby blocking leachate transport to the sumps where it can be pumped out at the standpipes, there is a substantial likelihood that leachate could be generated within a subcell that would not be detected by monitoring the standpipes for leachate. This blocked leachate could pass through the liner system into the underlying leak detection system, where such systems exist in cells 9 and 10, or for all cells, into the underdrain system and to groundwater.

  With the installation and operation of the leak-detectable cover and groundwater table pump-down, the leak detection systems and underdrains should become dry. Any leachate that is generated due to the failure of BFI/CECOS to properly maintain a leak-detectable cover or groundwater pump-down could pass through the underdrain into the underlying vadose zone between the bottom of the waste management cell and the groundwater table and not be detected by sampling for leachate in the leachate collection system, in the leak detection system for cells 9 and 10, as well as the underdrain for all cells. This situation necessitates that a comprehensive groundwater monitoring system be developed that would have a high probability of detecting leachate-polluted groundwaters in the vicinity of each of the hazardous waste landfill subcells.

The groundwater monitoring system that is used to detect incipient leakage through the landfill containment system liner(s) should, in accord with regulatory requirements, have a high probability of detecting leachate-polluted groundwaters when it first reaches the point of compliance for groundwater monitoring. This point of compliance is located at the down-groundwater-gradient edge of the waste management subcell.

For the purpose of estimating the initial size of the leakage through the plastic sheeting liner system due to structural failure of this liner, it should be assumed that a hole, rip, or tear, or point of deterioration of one foot in length has occurred in the plastic sheeting liner which allows leachate of the extreme composition that has been found in the subcell previously to leak through the hole under one foot of head.

Further, it should be assumed that the hydraulic conductivity of the underlying compacted soil layer in the liner is 10^{-4} cm/sec. For statistical evaluation purposes, the high degree of reliability should be based on assuming that the plastic sheeting layer has developed a hole, rip, or tear, or point of deterioration along the down-groundwater-gradient edge of the subcell. The groundwater monitoring system well placement should be based on an analysis of the lateral and vertical spread of the leachate plume generated immediately under the point of leakage in the liner system to the location of the groundwater monitoring well.

Each of the geological strata underlying and/or hydraulically connected to the base of the landfill cells must be reliably monitored. This monitoring should consider the zones of capture of the monitoring wells relative to the spacing of monitoring wells perpendicular to the leachate plume flow path and the lateral and vertical extent of the leachate plumes located at the monitoring point. Nested sets of monitoring wells with limited screening to sample the groundwater in each of the strata should be used to minimize the dilution of the leachate plume with non-contaminated groundwaters as part of the sampling process. Because of the very large number of vertical monitoring wells that will be needed to reliably sample leachate-polluted groundwaters at each of the landfill cells, other approaches, such as horizontal monitoring wells, may need to be installed to achieve the reliability required by the regulations for public health, groundwater resource and environmental protection.

- **Neighbors' Well Sampling.** An off-site near the BFI/CECOS Aber Road facility "neighbors'" water well monitoring program should be initiated by BFI/CECOS to sample all neighbors' wells for incipient groundwater pollution.

This monitoring program should be conducted quarterly for at least three years. After that time the frequency of monitoring can be reduced to semi-annually, provided that the composition of the well water can be reliably predicted based on previous sampling of the well.

All wells, including up groundwater gradient wells and any new wells developed in the future located within one mile of the BFI/CECOS Aber Road facility, should be monitored for as long as there are wastes at the facility that are a threat to groundwater quality.

A full suite of conventional groundwater pollutants, VOCs and annually, Priority Pollutants, should be determined on the neighbors' well samples.

- **Reliable Surface Water Monitoring.** A significantly improved surface water quality monitoring program should be developed as part of a revised Post-Closure Monitoring Plan to determine if surface water runoff from the BFI/CECOS Aber Road facility-associated wastes that exist in the surface soils are transported to off-site waters. There has been a history of leachate spills at the Aber Road facility that contaminate the surface soils. Further, there is the potential for leachate to breakout through the sides of the landfill above the ground surface. These spills and leachate breakout can cause stormwater runoff from the site to be contaminated that can pollute-impair the use of Pleasant Run Creek, the East Fork of the Little Miami River and Harsha Lake for domestic water supply and other purposes.

A specific water quality and wildlife monitoring program should be initiated to be sure that the water, sediments and aquatic life that are associated with the "Wetlands" Islands pond ("Crescent Isle Lake") as well as other ponds on the site are not a threat to wildlife. Even if the waters in the on-site ponds are not discharged off-site, pollution of these waters can be adverse to wildlife that use the ponds as habitat. This monitoring should involve quarterly sampling and analysis for a suite of hazardous chemicals-Priority Pollutants. This program will need to be conducted for as long as there are wastes at the facilities that are a threat to public health and the environment.

The current groundwater and surface water water quality monitoring programs have largely ignored the groundwater transport of waste-derived constituents to Pleasant Run Creek. As part of developing a revised Post-Closure Plan, a comprehensive monitoring program associated with each of the Aber Road facility waste management units should be conducted along each of the groundwater pathways from under the waste management units to any location where wastes could be transported to surface waters.

Also, a detailed sampling of the Pleasant Run Creek and other surface waters that could receive leachate-polluted groundwater in the areas where there is a possibility of groundwater transport of wastes to surface waters should be conducted.

As part of the quarterly sampling of groundwater along each potential surface water discharge transport pathways, quarterly sampling of Pleasant Run Creek waters and sediments should be undertaken for a variety of conventional and Priority Pollutants. Further, aquatic life, such as benthic insects, and crustaceans, such as crayfish, as well as fresh water clams and fish that are naturally present or are incubated in Pleasant Run Creek and the East Fork of the Little Miami River, should be analyzed for the bioaccumulation of hazardous chemicals. Of particular concern are the heavy metals, especially mercury and the chlorinated hydrocarbon pesticides, PCBs and dioxins.

Groundwaters discharged from under the BFI/CECOS hazardous waste landfill cells could leave the BFI/CECOS facility and enter tributaries of the East Fork of the Little Miami River other than Pleasant Run Creek. A sufficient understanding of groundwater flow should be developed to determine if groundwaters associated with the BFI/CECOS hazardous waste landfill facility enters other tributaries of the East Fork of the Little Miami River. If there is a potential for this to occur, then the groundwater and surface water monitoring programs should be expanded to sample groundwaters along this flow path and surface waters at the point and downstream of where the groundwaters are expected to enter the surface water systems.

Samples of groundwater and Pleasant Run Creek waters should be tested for aquatic life toxicity using the US EPA standard three species chronic toxicity tests with the chronic endpoint. If toxicity is found then toxicity identification evaluation (TIE) should be conducted to determine the cause of the toxicity. Further forensic studies using a combination of toxicity tests and chemical analysis should be used to determine the source of the constituents responsible for the toxicity.

In addition to monitoring for chemical constituents, bioaccumulation of hazardous chemicals in aquatic life tissue and aquatic life toxicity in Pleasant Run Creek near the BFI/CECOS Aber Road facility, testing of this type should be conducted on a quarterly basis in the East Fork of the Little Miami River and Harsha Lake. It is possible that while the concentrations of hazardous chemicals derived from the BFI/CECOS Aber Road facility may not cause water quality problems in Pleasant Run Creek, they could contribute to water quality problems downstream waters when combined with other sources of hazardous chemicals.

Aquatic life organism assemblages should be assessed at bi-annual intervals at three Pleasant Run Creek upstream stations. Two additional monitoring stations upstream of station C-9 should be established about 100 meters and about 200 meters above station C-9. Also, several stations that are to be used for collecting aquatic organism assemblage information should be developed in the area where stormwater runoff and groundwater transport of Aber Road facility wastes could enter Pleasant Run Creek.

The current Pleasant Run Creek sampling stations C-6, C-10, and C-12 should be continued. An additional sampling station should be established below the confluence of the east and west branch of Pleasant Run Creek and C-6. Further, another sampling station should be established several hundred meters downstream of station C-6. A set of sampling stations should be established on the East Fork of the Little Miami River and on Pleasant Run Creek just above their confluence. Also, a sampling station of the East Fork of the Little Miami River about 200 to 500 meters below this confluence should be established. All of these stations should be sampled semi-annually for the aquatic organism assemblages present. If significant deviations from expected populations are found, then site-specific studies need to be undertaken to determine the cause of the altered organism assemblages.

Endocrine disrupters and other hazardous chemical constituents that could cause mutations and/or genetic damage are being found in surface waters, especially downstream of locations where complex mixtures of hazardous chemicals are discharged to surface waters. Since the hazardous waste deposited at the BFI/ CECOS hwl could readily contain endocrine disrupters, chemicals that cause mutations or genetic damage or other hazardous chemicals not now regulated, a special purpose monitoring program should be initiated on Pleasant Run Creek, the Little Miami River, the upground water supply reservoir for the Village of Williamsburg, and Harsha Lake, using the latest techniques available to determine if exotic hazardous chemicals are present in these waters that could be adverse to the public health of those who use the waters as a domestic water supply, as well as wildlife and aquatic life that are associated with these waters.

REVIEW OF THE ADEQUACY OF THE CLOSURE AND POST CLOSURE OF THE HAZARDOUS WASTE LANDFILL CELLS AT THE BFI/CECOS ABER ROAD FACILITY TO PREVENT GROUNDWATER AND SURFACE WATER POLLUTION BY HAZARDOUS WASTE LEACHATE FOR AS LONG AS THE WASTES IN THE LANDFILL CELLS WILL BE A THREAT

The first step in evaluating the ability of an existing landfill to comply with Ohio's groundwater quality protection regulations is to determine whether the landfill cell sites are hydraulically connected to groundwaters that are or could at any time in the future be used for domestic or other water supply purposes. Also of concern is whether there are pathways by which leachate-polluted groundwaters could enter surface waters and thereby be a threat to surface water-based domestic water supplies as well as to the environment. If there is groundwater hydraulically connected to the landfill, then it is necessary to evaluate whether natural barriers, such as thick, low permeability layers that do not have fractures, cracks, sandy lenses, etc., that could provide avenues for leachate transport, exist between the landfill base and the groundwaters that could potentially be polluted by landfill leachate at any time in the future while the wastes in the landfill represent a threat.

Leachate is the soup of hazardous and so-called non-hazardous but deleterious chemicals that are produced upon contacting hazardous waste with water and other leachate. The leaching of hazardous waste with water or even dilute acetic acid as is allowed in the US EPA hazardous waste classification TCLP procedures does not properly simulate the leaching of hazardous waste components that will occur in a hazardous waste landfill where leachate will come in contact with wastes and thereby solubilize/mobilize hazardous and deleterious components present in the waste.

If natural protection of groundwater quality is not present at a landfill location, then consideration must be given to the adequacy of the engineered landfill cell containment systems, such as liners and cell covers, to prevent leachate generation and to collect any leachate that is generated from moisture that enters into a hazardous waste cell so that it does not enter into the cells' underlying groundwater system. Further, the reliability of the landfill liner leakage and groundwater monitoring systems that are used for the hazardous waste landfill cells to detect leachate-polluted groundwater when it first occurs should also be evaluated. These issues have been evaluated for the BFI/CECOS Aber Road hazardous waste landfill facility. A summary of findings is presented below.

Suitability of BFI/CECOS Aber Road Facility Location for the Existing Hazardous Waste Landfill Cells

The BFI/CECOS Aber Road facility hazardous waste landfill cells and other waste management units located at this site are hydraulically connected to groundwaters that are being used now and will be used in the future as a domestic water supply source. Further, examination of the geological characteristics of the groundwater system underlying the hazardous waste landfill cells and the groundwater and surface water resources of the region that could be polluted by BFI/ CECOS hazardous waste, industrial waste, and solid waste landfill leachate, shows that there is no natural barrier between the landfill and the groundwaters and surface waters of concern.

Bennett & Williams (1999) provide a detailed discussion of the geology, hydrogeology and surface water hydrology of the BFI/CECOS Aber Road facility area. Their review shows that the hazardous waste, industrial waste, and solid waste landfill cells location area is such that the leakage of leachate from these cells will pollute groundwaters underlying the cells. The Aber Road facility is located in an area of geology/hydrogeology which reflects the complex glacial history of the region. The geology/stratigraphy of this area shows that it contains several sand and till layers, with sand layers being vertically connected at some locations. Further, there are buried paleosols with roots and burrows. The till layers are fractured, and in some cases discontinuous, and, therefore, do not provide barriers to vertical transport of leachate-polluted groundwater. The area is underlain by a weathered bedrock in which leachate-polluted groundwater could be transported in the weathered bedrock. Polluted groundwater can be expected to be transported via groundwater off-site through highly permeable geological strata to Pleasant Run Creek and thereby pollute Pleasant Run Creek waters and downstream waters, including several municipal domestic water supplies that use the East Fork of the Little Miami River as a water supply source. It also appears that groundwaters discharged from under the BFI/CECOS hazardous waste landfill cells could leave the BFI/CECOS facility and enter other tributaries of the East Fork of the Little Miami River than Pleasant Run Creek.

Clermont County's domestic water supply is dependent on three separate sources. The Pierce, Union, Batavia (PUB) wellfield is located in the Ohio River Valley aquifer and yields 15 million gallons per day (mgd). The Miami, Goshen, Stonelick (MGS) wellfield is located in the Little Miami aquifer and yields 2.2 mgd. Harsha Lake, which derives its water from the East Fork of the Little Miami River, currently provides approximately 40% of the County's daily average needs. With intake and treatment facilities designed at 10 mgd and expandable to 20 mgd, it comprises the largest potential water supply and a sizeable capital investment (over $28 million). With contractual water rights to 20 mgd and the right of first refusal to additional capacity which may become available from the Ohio Department of Natural Resources, the long-term protection of the quality of Harsha Lake and the entire East Fork of the Little Miami River watershed is a top priority of the County and essential to future County development.

Since surface water sources are especially vulnerable to pollution from runoff as well as groundwaters that discharge to streams, the County places a high priority on preventative measures to protect the County's water supply. It is far more effective to control pollution at its source than attempting to treat or remove a pollutant once it enters the source water. This is strongly reinforced by the US EPA's Source Water Protection initiatives promulgated under the 1996 Amendments to the Safe Drinking Water Act. The overall water quality initiatives of Clermont County have been and will continue to be focused around the protection of Harsha Lake as a critical drinking water source.

According to the Ohio EPA, during the period 1982 through 1987 approximately 300,000 tons of hazardous waste were buried at the BFI/CECOS landfill facility. Over 81,000 tons of PCBs were buried in one year at this facility. The total hazardous waste present at the facility is estimated to exceed 1 million 55 gallon barrel equivalents. There are massive amounts of hazardous chemicals buried in landfill cells at the BFI/CECOS hazardous waste landfill facility that, at best, will only prevent release of hazardous chemicals to the environment for a short period of time.

In summary, the BFI/CECOS Aber Road facility area is an unsuitable site for any type of landfill, and especially hazardous waste landfill cells. The complexity of the geology/hydrogeology of the area coupled with the high permeability interconnected sandy layers will allow transport of leachate-polluted groundwaters off-site with limited retardation of hazardous waste components. Further, the complexity of the hydrogeology of the area makes monitoring of polluted groundwaters extremely difficult to achieve with adequate reliability. The geologic characteristics of the area, coupled with the uncertainty of long-term (*ad infinitum*) funding for appropriate BFI/CECOS Aber Road facility post-closure monitoring, maintenance, and remediation, and the vulnerability of off-site ground and surface water resources, leads to the conclusion that the BFI/CECOS Aber Road facility represents threats to domestic water supplies, public health, and the environment of similar magnitude to national Superfund sites.

Deficiencies in BFI/CECOS Aber Road Facility Landfill Containment Design

BFI/CECOS Aber Road facility landfill cells and other waste management units closed as landfills have a variety of liner systems for waste containment. These include no liner for the solid waste landfill and industrial waste landfill cells 1 and 2, as well as various ponds that have been closed as landfills. The BFI/CECOS hazardous waste landfill cells 3 through 8 have been lined with a compacted soil layer (liner) and a plastic sheeting layer (flexible membrane liner – FML) in the form of a single composite liner. Cells 9 and 10 utilize a double composite liner system. A summary of the hazardous waste landfill cell construction is provided by Bennett & Williams (1999).

A review of current Ohio EPA and US EPA regulations governing the landfilling of hazardous waste shows that the landfill cell design used for cells 9 and 10 at the BFI/CECOS Aber Road facility would not be allowed today. This reflects the fact that in many cases the deficiencies in landfill cell design that were known in the early 1980s have finally now been addressed to some extent in current federal and state regulations. It is certainly inappropriate to assume that because the hazardous waste landfill cells at the BFI/CECOS facility met, or for that matter meet, minimum design requirements at the time of their construction, that their design will be protective of ground and surface water resources hydraulically connected to the landfill cells for as long as the wastes in the hazardous waste landfill cells will be a threat.

Many of the national Superfund sites are former landfills which were constructed without liners. As discussed herein, the BFI/CECOS hazardous waste landfill cells' waste containment systems (cell liners and covers) are well known to be deficient in providing public health and environmental protection for as long as the wastes in the cells will be a threat. Because of the fundamentally flawed landfill cell containment systems that exist at the BFI/CECOS Aber Road facility and the inability to reliably monitor the failure of these systems when it first occurs, extraordinary measures need to be taken in order to comply with regulatory requirements governing the closure of this facility. The current Closure and Post-Closure Plan's requirements fall far short of meeting current regulatory requirements for protecting public health and the environment from the landfilled hazardous waste. Modifying the BFI/CECOS Aber Road facility Closure and Post-Closure Plans should be immediately implemented while it is still possible to have BFI pay the cost of implementing Closure and Post-Closure Plan requirements that will provide for long-term public health and environmental protection. Failure to adopt this approach will almost certainly mean that the BFI/CECOS Aber Road facility will become a Superfund site. This could occur after significant damage has been done to Clermont County water supplies and environment.

Expected Performance of BFI/CECOS Landfill Liner Systems. While the liners used by BFI/CECOS for the hazardous waste landfill cells met minimum or just above minimum regulatory requirements at the time they were constructed, it was known then and, for that matter, today that just meeting minimum regulatory requirements for landfill liner design will not prevent leachate generated within the landfill from leaving the landfill through the liner for as long as the wastes in the landfill will be a threat. The leachate that passes through the liner system can pollute groundwaters and surface waters hydraulically connected to the base of the landfill cells.

While it is possible to construct single composite or double composite-lined landfill liner systems that will not leak sufficient leachate at the time of construction at a rate to pollute large amounts of groundwaters, ultimately the plastic sheeting layer of a landfill liner will deteriorate to the point where it will be ineffective in collecting leachate where it can be removed from the landfill. This deterioration will eventually allow transport of leachate through the liner on its way toward the groundwater resources hydraulically connected to the landfill that could be used for domestic water supply purposes. Further, compacted soil (clay layers) used in landfill liners are well-known to experience increased permeability with time over that originally designed and constructed.

The US EPA (1988a) as part of promulgating RCRA Subtitle D regulations in which the Agency proposed to adopt a single composite liner of the type that BFI/CECOS used in the Aber Road site hazardous waste landfill cells 3 through 8, stated,

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

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

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

The US EPA 1988 assessment of the inability of a minimum Subtitle D single composite liner to prevent groundwater pollution by landfill leachate is still applicable today to Subtitle C (hazardous wastes) and C (municipal solid waste) landfill liner systems. If anything, today there is more widespread recognition that single or double composite-lined landfilling will not protect groundwaters from pollution by landfill leachate for as long as the wastes in the landfill will be a threat.

Lee and Jones (1992) and Lee and Jones-Lee (1996a, 1998a) have presented a review of the literature on what is known about the properties of flexible membrane liners (FML) and clay liners to prevent landfill leachate from passing through them for as long as the wastes in the landfill will be a threat. Peggs (1998) has recently discussed the inevitable failure of plastic sheeting layers used in landfill covers and liners. Shackelford (1994) has presented a comprehensive review of the potential for waste and compacted soil interactions that alter the hydraulic conductivity of liners. Table 1 summarizes some of the causes of landfill plastic sheeting and clay liner failure.

Table 1

Causes of Liner Failure

Plastic Sheeting FMLs	Soil/Clay Liners
Holes at Time of Liner Construction Holes Developed in Waste Placement Stress-Cracks	Desiccation Cracks Differential Settling Cracks Cation Exchange Shrinkage (for Expandable-Layer Clays)
Free-Radical Degradation	
Permeable to Low-Molecular-Weight Solvents – Permeation	Inherent Permeability
Inherent Diffusion-Based Permeability	
Finite Effective Lifetime – Will Deteriorate and Ultimately Become Non-Functional in Collecting Leachate and as a Barrier to Prevent Groundwater Pollution	*Highly Permeable – Allow Large Amount of Leakage under Design Conditions and Subject to Cracking and Other Failure Mechanisms*

Lee and Jones-Lee discuss each of the failure mechanisms presented in Table 1. They conclude that hazardous waste landfill liners of the type that are used at the BFI/CECOS Aber Road facility, while possibly providing short-term protection of groundwater quality, are not reliable for long-term protection and will ultimately fail to prevent leachate from passing through them.

Hsuan and Koerner (1995) have reported on the initial phase of long-term (10-year) studies that are underway devoted to examining the rates of deterioration of flexible membrane liners. The focus of the Hsuan and Koerner work is on the breakdown of the polymers in the plastic sheeting liners. They predict that this breakdown will occur due to free radical polymer chain scission in 40 to 120 years. These estimates are indicated by Koerner to consider only some of the mechanisms that could cause breakdown. It is possible that breakdown could begin much earlier. Even if the breakdown of the plastic sheeting polymers took 100 years or so, there is still no question that ultimately the plastic sheeting in the flexible membrane liners will break down, leading to an inability to prevent large amounts of leachate from passing through it causing groundwater pollution in the landfill area.

Lee and Jones-Lee (1998a), as part of preparing an updated review of their 1992 "flawed technology" report, contacted the US EPA administration to ascertain if this administration had changed the conclusion reached by the US EPA 1988 administration that a single composite liner would, at best, only delay when groundwater pollution occurs by landfill leachate. Dellinger (1998) who heads the Office of Solid Waste for the US EPA indicated that the Agency still concludes that a single composite liner will ultimately fail to prevent leachate transport through it.

The BFI/CECOS hwl cells 9 and 10 use a double composite liner system which is basically two single composite liners stacked upon each other with a leak detection system between the two composite liners. This design does not eliminate the fundamentally flawed nature of a composite liner-lined landfill. Each of the two composite liners in the BFI/CECOS hwl cells 9 and 10 will experience the same ultimate failure to prevent leachate from passing through the liners and ultimately polluting groundwaters.

This discussion about the long-term performance of composite-lined landfill liner systems assumes that high-quality construction has occurred and that, as part of placing wastes in the landfill, the integrity of the landfill liner is protected. However, BFI/CECOS has had a number of documented problems with the failure of landfill liner systems in cells 3 and 4/5 long before such failure would be expected. This failure is almost certainly due to inadequate construction and/or inadequate protection of the landfill liner during filling of the landfill cells.

An area of growing concern with respect to plastic sheeting-lined landfills is that dilute aqueous organic solvents of the type present in BFI/CECOS hazardous waste landfill leachate can rapidly permeate through an intact, without holes, HDPE liner. This is a chemical transport process in which the low molecular weight organics dissolve into the liner and exit on the downgradient side. Sakti, *et al.* (1991) and Park, *et al.* (1996a,b) have reviewed the available information on this topic and have conducted extensive research on it. They found that an HDPE liner would have to be over three inches thick to prevent permeation of certain organics through it within a period of 25 years. Buss, *et al.* (1995) have reviewed the information on the mechanisms of leakage through synthetic landfill liner materials. They discuss the importance of permeation of organics through plastic sheeting liners as a landfill liner leakage mechanism that does not require deterioration of the liner properties.

Leachate Density and DNAPLs. A review of the chemical characteristics of the BFI/CECOS hazardous waste landfill cell leachate reported to the Ohio EPA shows that it is highly variable in composition. This pattern is to be expected because of the large variety of wastes disposed of at the site and the unpredictable pattern of their interaction with water to produce leachate associated with drum disposal of the wastes. As discussed herein, the leakage from the drums due to corrosion and other factors governing the production of leachate and its flow through the hazardous waste cells would cause the leachate to be of variable composition. Large changes in leachate composition can occur and have occurred over short periods of time.

In addition to the greatly elevated concentrations of hazardous waste chemicals in the leachate, at times the leachate total salt content has been reported to be considerably greater than that of seawater. Such leachate has a significantly greater density than that of water and will affect leakage rates through the liner and the flow patterns of the leachate in the underlying cell drains and groundwaters. The dense leachate that penetrates through the liner system would, upon entering the underdrain, sink to the bottom of it, and pass into the underlying groundwaters with limited mixing with the underdrain waters. This would lead to pulses of leachate-derived pollutants moving through the groundwater system.

Examination of the organic solvent (VOCs), total organic halogens (TOX), and other organic chemical content of the leachate shows that, at times, greatly elevated concentrations of these chemicals are present. This is of concern since many of these chemicals, including PCB oils, tend to form dense non-aqueous phase liquids(DNAPLs). Pankow and Cherry (1996) in their book, <u>Dense Chlorinated Solvents and other DNAPLs in Groundwater,</u> provide discussions of the potential for DNAPL formation and the potential significance of DNAPLs in affecting the transport of pollutants, such as VOCs and PCBs, in groundwaters. This situation further complicates the complex flow patterns of leachate-polluted groundwaters associated with the leakage of BFI/CECOS hazardous waste cell containment systems.

The high density leachate and the potential for DNAPL formation can lead to the transport of highly hazardous chemicals in the groundwater system underlying the cells in directions that are not predictable based on normal, static head-driven groundwater transport. Of particular concern is the potential for dense leachate and/or DNAPLs to be transported in the bedrock system to the glacial valley that lies to the north of the site. The bedrock contours (Bennett & Williams, 1999) are such that dense leachate and DNAPLs could be transported north and northwest of the site. Thus, the monitoring program and the Post-Closure Plan should include provisions to determine if this type of transport has occurred or occurs at any time in the future that the wastes in the BFI/CECOS hazardous waste landfill cells are a threat should be developed.

Inherent Permeability (Leakage) of Landfill Liner Systems. A critical review of the literature and other information associated with the development of the compacted soil/clay and plastic sheeting layers that are used as landfill containment liners and caps shows that the currently used materials in landfill liner cells have not been found and would not be expected to prevent hazardous and other deleterious constituents present in the wastes from penetrating through the liner and causing groundwater pollution. Clay liners were selected in the 1970s as liners for hazardous chemical waste ponds without consideration of their potential to interact with certain waste constituents or their inherent design permeability (leakage rates). A landfill clay liner with one foot of head that has a design permeability of 10^{-7} cm/sec will allow the passage of many waste components through the liner at the rate of about one inch per year. That translates to about 100 gallons/acre/day.

Workman and Keeble (1989), who at the time of publication of a paper, "Design and Construction of Liner Systems," were two BFI employees, presented a nomograph that shows that a three-foot-thick clay liner with the permeability of 10^{-7} cm/sec with about one foot of head (leachate depth) that functions as designed can be expected to have breakthrough in about eight years. The BFI/CECOS landfill liner systems have clay liners that are only two feet thick. While these liners were designed to have permeabilities of 10^{-7} cm/sec at the time of construction, it is well-known that permeabilities of clay liners of this type increase significantly within a few years after construction.

The design-associated leakage rates are an inherent property of clay liners. This property is being largely ignored by the regulatory agencies and, in the case of the BFI/CECOS site, the Ohio EPA in establishing Post-Closure Plan requirements for the BFI/CECOS hazardous waste landfill facility. In addition to this inherent permeability are the wide variety of failure mechanisms discussed by Lee and Jones (1992) and Lee and Jones-Lee (1998a) and summarized herein, including for the BFI/CECOS hazardous waste landfill cells with high pH, the dissolution of the clay's structure by the high pH leachate discussed below. Since many of the waste components in the BFI/CECOS hazardous waste cells will be a threat forever, it is clear that it is only a short time compared to the time that the wastes are a threat that the clay liner underlying each of the hazardous waste cells can be expected to prevent groundwater pollution by hazardous waste components.

A review of the history of the development of liners for hazardous waste landfill cells shows that when it was realized that clay-lined landfill cells had a finite period of time before they failed to prevent the leakage of hazardous waste components into underlying groundwaters, plastic sheeting liners (flexible membrane liners-FMLs) were introduced instead of clay liners. Again, the situation was one of there not being a body of literature that demonstrated that plastic sheeting of the type that was being used in the early 1980s as landfill liners would be expected to perform in such a manner as to prevent groundwater pollution by landfill leachate for as long as the waste components in the landfill would be a threat.

Basically, the situation that has evolved in selecting liner materials is that compacted soil ("clay") was initially selected as a landfill liner system because it was the next cheapest thing to nothing, i.e., no liner. Compacting soil as a liner for a hazardous waste cell is relatively inexpensive compared to other approaches for lining hazardous and solid waste cells. When it was evident that clay liners would not function effectively to prevent groundwater pollution, the US EPA and other regulatory agencies adopted the next next cheapest thing to nothing (plastic sheeting layers) as a landfill liner. While there are other materials that could have been selected to line waste management cells, they were more expensive.

It was soon found in the early 1980s that plastic sheeting liners had a number of significant problems, such as stress cracks, that made them unreliable as a landfill liner system that would prevent groundwater pollution for as long as the wastes in the landfill would be a threat. This led to the development of a composite liner where both compacted soil and plastic sheeting are used. While composite liners if properly constructed have a low rate of initial leakage compared to either clay liners or plastic sheeting liners, they have many problems that cause them to leak at a rate higher than ideally predicted. This led the US EPA to recommend a double composite liner system for hazardous waste landfills. Even the double composite liner, however, will ultimately fail to prevent leachate-associated constituents from passing through the liner into the underlying groundwater system, leading to groundwater pollution.

Daniel and Shackelford (1989) have reviewed the inherent leakage rates of plastic sheeting layers and clay liners. They point out that even though plastic sheeting layers have low permeabilities to water on the order of 10^{-12} cm/sec compared to clay liners which have a permeability of about 10^{-7} cm/sec at the time of construction, the thin layer of plastic that is used, coupled with its inherent chemical diffusion coefficients, causes plastic sheeting liners of the type used in the BFI/CECOS hazardous waste landfill cells to have diffusion controlled breakthrough times for hazardous waste components of about two to three years. The clay liners, however, in the BFI/CECOS hazardous waste landfill cells would be expected to have diffusion controlled breakthrough times of about 10 years.

The diffusion of hazardous waste components through plastic sheeting liners discussed by Daniel and Shackelford occurs through a different mechanism than the permeation of organic solvents (VOCs) through HDPE liners discussed herein. The permeation (pass-through) phenomenon for certain kinds of hazardous waste leachate components occurs within a few days, not years. Both permeation by VOCs and the inherent permeability of HDPE and clay liners that were used in the BFI/CECOS hazardous waste landfill cells have been largely ignored by the Ohio EPA in protecting groundwaters from pollution by BFI/CECOS hazardous waste landfill leachate.

As stated by Daniel and Shackelford (1989), *"No material is impervious, and the question of which liner is more effective, like most questions, is ultimately related to one of economics and the realities of construction practices."* Basically, regulatory agencies, such as the US EPA which has set the national standard, have been adopting landfill liner systems that will, in time, obviously fail to prevent groundwater pollution. The US EPA stated this fact in their 1988 discussion of the ultimate failure of composite liners quoted above.

In order to address this situation, the US EPA has established regulatory requirements for RCRA landfill cell monitoring that require detection of landfill liner leakage at the point of compliance for groundwater monitoring. The basic problem with this approach is that the administration of the RCRA requirements is left up to state regulatory agencies, such as the Ohio EPA, in establishing the groundwater monitoring system that is to be used. As discussed below, the groundwater monitoring systems that are being allowed by the Ohio EPA fail to consider how the landfill liner systems will leak and the ability to reliably detect this leakage by a few vertical monitoring wells, each with one foot radius zone of capture spaced 300 or more feet apart. This is obviously a fundamentally flawed approach that does not comply with regulatory requirements for protection of groundwater quality, public health and the environment.

Failure to Review Leachate Characteristics Relative to Liner Leakage. One of the issues of concern in evaluating the ability of a landfill liner system to prevent groundwater pollution by landfill waste components is whether the components of the leachate could interact with the liner leading to increased rates of leakage of leachate through the liner. Bennett & Williams (1999) provide a summary of the leachate characteristics data that BFI/CECOS have reported to the Ohio EPA over the last 15+ years.

As part of an effort to try to immobilize certain heavy metals, BFI/CECOS added caustic-alkali chemicals to the wastes for the purpose of increasing the pH of the leachate. Certain heavy metals are insoluble (less mobile) at high pH. A review of the leachate characteristic data that BFI/CECOS has reported to the Ohio EPA over the years shows that certain of the subcells at certain times have very high pH values. There are many values of pHs greater than 10 and occasionally for a period of time, leachate pH values greater than 12 and sometimes as high as14 have been reported by BFI/CECOS to the Ohio EPA. Apparently neither BFI/CECOS nor the Ohio EPA understood the well-known fact that high pH values will dissolve constituents from clays which will increase the permeability of the hazardous waste cell clay liner. The adverse impact will be to increase the rate of leakage through the liner above the inherent rates of leakage that occur based on design permeability, as well as the leakage that will occur due to deterioration of the clay liner properties that normally occurs in hazardous waste landfill cell liners.

The literature has numerous examples in the clay mineralogy publications as well as in hazardous waste landfill liner publications about the impacts of high pH on clays. Shackelford (1994) in a paper entitled, "Waste Soil Interactions that Alter Hydraulic Conductivity," published in <u>Hydraulic Conductivity and Waste Contaminant Transport in Soil</u> ASTM STP 1142 states under the heading "Acid-Base Reactions," *"Acids and bases are known to dissolve clay minerals."* Daniel and Shackelford (1989) state in a paper, "Containment of Landfill Leachate with Clay Liners," published in <u>Sanitary Landfilling</u> (Academic Press), *"Strong acids and bases can dissolve solid material in the soil, form channels and increase k."* "*k*" refers to the hydraulic conductivity of the soil.

Mitchell and Jaber (1990) in a paper entitled, "Factors Controlling the Long-Term Properties of Clay Liners," published in <u>Waste Containment Systems: Construction, Regulation, and Performance</u>, Geotechnical Special Publication No. 26 (ASCE) state,

"Bases promote solutioning of the silica tetrahedral layers and, to a lesser extent, alumina octahedral layers of the clay minerals. Removal of the dissolved material can cause increases of

hydraulic conductivity; whereas, precipitation of this material can cause pore clogging and hydraulic conductivity decreases."

The understanding of how high pH and low pH can alter the structure of clays and cause its dissolution is not new. This has been known and well publicized for many years prior to the time that BFI/CECOS initiated their hazardous waste landfilling at the Aber Road site. Grim in his classic book Clay Mineralogy (1953) discussed work of others that had taken place some years before on this topic in which the adverse effects of acids and bases on clay structure were found.

Ohio EPA as part of approving the Closure and Post-Closure Plans for the BFI/CECOS Aber Road facility ignored the characteristics of the leachate relative to what is published in the substantial waste management containment system literature on this topic--that high pH leachate of the type that BFI/CECOS had been reporting to the Ohio EPA for a number of years would be adverse to maintaining the integrity of the clay liner component of the hazardous waste landfill cells.

As discussed herein, the characteristics of the liner system that BFI/CECOS used for its hazardous waste cells are such that if the liner performs perfectly as designed, there still will be sufficient hazardous chemical migration associated with the inherent rates of migration of many of the hazardous components in the leachate through the plastic sheeting and clay liner to cause groundwater pollution. Further, the permeation of the plastic sheeting layer by low molecular weight solvents, such as VOCs, which are present in high concentrations in the leachate will enable VOC transport through the intact (without holes) plastic sheeting layer within a short period of time. This permeation will lead to groundwater pollution by VOCs, many of which are known to be carcinogens or cause other human diseases. Also the characteristics of the leachate in some subcells are such that the leachate will dissolve the basic clay structure in the clay liner used in each of the subcells, ultimately causing this liner to deteriorate.

It appears that as part of the development of the Closure and Post-Closure Plans, the Ohio EPA did not critically review the characteristics of the BFI/CECOS hazardous waste landfill cells' containment systems in light of what was well-known at the time of the development of the BFI/CECOS hazardous waste landfill facility Closure and Post-Closure Plans about

- the effects of high pH on the integrity of clay liners,
- the inherent diffusion of hazardous waste components through plastic sheeting and clay liners,
- the permeation of low molecular weight organic solvents present in the leachate through the liner's plastic sheeting layer,
- the potential importance of leachate density-driven and DNAPLs in affecting leachate transport through the liners.

Such a review would have led to the conclusion that BFI/CECOS' hazardous waste landfill cells represent a time bomb of hazardous chemicals that is a highly significant threat to public health, groundwater resources and the environment near the BFI/CECOS site and downstream along Pleasant Run Creek, the East Fork of the Little Miami River and Harsha Lake which serve as a water supply for about 30,000 people.

Reliable Reporting on FML Properties. One of the problems with addressing the inherent leakage and ultimate breakdown of the liner system is the failure of landfill applicants and their consultants to reliably report on the long-term stability problems with flexible membrane liners. There are several examples in the literature such as Fluet *et al.* (1992), Tisinger and Giroud (1993) and Flood (1994) where individuals who primarily work for landfill applicants inadequately and/or unreliably report on the ultimate breakdown of flexible membrane liners. As discussed by Lee and Jones-Lee (1993a, 1995b), a common approach used by landfill consultants is to claim that the liner system will be "protective." However, they fail to discuss their definition of the duration of time in which the liners will be protective and fail to mention the fact that, ultimately, this protective definition that they use will result in groundwater pollution beyond the time that they are considering to be of significance. Often this time is considered to be only 30 years beyond the closure of the landfill.

Long-Term Integrity of BFI/CECOS' Hazardous Waste Landfill Cell Covers. Hazardous waste landfill cells are required to be covered by a low permeability layer which is to function as an effective barrier that can minimize moisture from entering the landfill and thereby generating leachate that can lead to groundwater pollution. BFI/CECOS has used compacted soil and a plastic sheeting layer as the low permeability cover system for its hazardous waste landfill cells at the Aber Road facility. As discussed by Lee and Jones (1992) and Lee and Jones-Lee (1995a,c, 1998a) as well as in references cited therein, it is extremely difficult to construct a landfill cover that will maintain its integrity as originally constructed for as long as the wastes in the landfill will be a threat.

The basic problem is that a landfill cover is subject to severe stresses associated with differential settling of the waste components. These stresses cause cracks in the low permeability layers of the cover. There have already been problems of differential settling leading to poor drainage on some of the BFI/CECOS Aber Road facility hazardous waste landfill cells.

There are several aspects of how landfilling occurs in the BFI/CECOS landfill cells which will contribute to failure of the low permeability layers of the landfill cover at a rate even greater than that normally expected for hazardous waste landfills. These relate to the fact that the wastes in these landfills were buried to a substantial extent in 55-gallon drums. Soil or other waste was deposited around the drums as uncompacted fill, and apparently a layer of soil was placed over the daily landfill waste. This has led to a highly unstable situation with respect to differential settlement where in those areas where the drums are still intact and are maintaining their structural integrity, there would be limited settlement and stress on the low permeability layer of the cover. However, over time, with the corrosion of the drums and the loss of the structural integrity, there will be collapse and the opportunity for settlement which will affect the integrity of the cap. This settlement will not necessarily be translated to major changes in the cover top soil layer until well advanced.

Another problem with the landfilling practice was that BFI/CECOS was allowed to move the vertical partitions (berms - dirt walls) separating the subcells as a function of the types of wastes being received in the course of filling the cell. These dirt walls are typically four feet thick and from 40 to 60 feet high. The practice of starting out with a certain distribution of subcells based on three types of wastes and then moving the subcell partitions based on the placement of an HDPE liner on top of a soil layer that covers buried drummed wastes and then constructing a new subcell vertical wall at a different location leads to a highly unstable structural situation within the landfill cells. With the eventual corrosion of barrels, there will be the failure of the vertical walls separating subcells to maintain their integrity, resulting in the collapse of these walls as the drums corrode. This will lead to mixing of leachate and waste types.

In those situations where the subcell wall (berm) was moved to a location where its foundation is corroding 55-gallon drums with an underlying HDPE liner layer, the liner will not only deteriorate, but it will also develop cracks due to the stress on the liner arising from the unstable base of wastes under the liner. The leachate from the upper part of the subcell will penetrate through the HDPE liner into the underlying other type of subcell buried waste. It will lead to mixing of cell leachates which will in some areas defeat the purpose of the segregation of the wastes into the three subcells. Further, it will create an unstable situation for the landfill cover which will lead to cracks which will not be detected by the inspection system being used. There is obvious need for a significantly different approach for assessing the integrity of the cover low permeability layer than is being used in the Post-Closure Plan.

Another problem arising out of moving the subcell partition approach for landfilling is the potential for the HDPE liner to create ponding within the landfill that can lead to breakout/leakage of leachate through the sides of the landfill cells. The cells constructed at the Aber Road site have from 11 to 15 feet of wastes above the ground surface. If this breakout occurs above the ground surface, leachate seeps could occur which would pollute surface waters. If it occurs below the surface, then pollution of the groundwaters through the sides of the landfill would occur.

While it is often claimed by landfill owners and some of their consultants that any problems that develop in the landfill cover can be detected by visually inspecting the cover, the facts are that the low permeability layer of the cover is buried below several feet of fill which is often a drainage layer. This layer is overlain by a topsoil layer. The visual inspection of the cover only examines the topsoil layer and does not examine the integrity of the low permeability layer which is the barrier to moisture entering a landfill that leads to leachate generation.

Ultimately, the plastic sheeting layer and compacted soil layer in the BFI/CECOS hwl cells will develop cracks which will allow moisture to penetrate into the wastes and generate leachate. Further, the plastic sheeting layers in the landfill cell covers will deteriorate over time and fail to prevent precipitation that passes through the topsoil layer from entering the cell and generating leachate. These cracks and points of deterioration of the landfill cell low permeability layer will not be detectable by the visual inspection methods being used as part of the post-closure monitoring and maintenance of the BFI/CECOS Aber Road hazardous waste landfill facility.

Duration of Leachate Generation. Freeze and Cherry (1979) of the University of British Columbia and the University of Waterloo, respectively, in their book, Groundwater, discuss that landfills developed in the Roman Empire about 2,000 years ago are still producing leachate. Belevi and Baccini (1989), two Swiss scientists who have examined the expected contaminating lifespan of Swiss landfills, have estimated that Swiss landfills will leach lead from the waste at concentrations above drinking water standards for over 2,000 years. As discussed in the referenced materials which summarize the literature on this topic, the hazardous waste landfill cells and solid waste landfill at the BFI/CECOS Aber Road facility will be a threat to groundwater resources for long periods of time, effectively forever. These issues are discussed further in the papers, "Landfilling of Solid & Hazardous Waste: Facing Long-Term Liability" (Lee and Jones-Lee, 1994a) and "Groundwater Pollution by Municipal Landfills: Leachate Composition, Detection and Water Quality Significance" (Jones-Lee and Lee, 1993).

While the Jones-Lee and Lee (1993) discussion focuses on municipal solid waste landfills, similar issues arise and situations occur for hazardous waste landfills of the type that BFI/CECOS have developed at the Aber Road site. Whether lead or some other hazardous/deleterious chemical is in a "dry tomb" type municipal solid waste landfill or "dry tomb" type hazardous waste landfill does not, for many constituents, affect the overall period of time that the constituent will be hazardous in that type of landfill.

In summary, the plastic sheeting and compacted clay liners and landfill covers that BFI/CECOS has used in hazardous waste landfill containment systems. will not prevent leachate generation or effectively collect all leachate that is generated within the landfill for as long as the wastes in the landfill represent a threat. Further, the ultimate failure of this liner system will allow releases of hazardous and deleterious constituents to occur from the Aber Road facility hwl cells that ultimately will pollute groundwaters underlying these cells.

Review of Existing Leachate and Underdrain Characteristics

A review of the Aber Road facility leachate and underdrain chemical characteristic data that have been developed by BFI/CECOS and reported to the Ohio EPA (as compiled by Bennett & Williams, 1999) shows that the leachate being produced in each of the hazardous waste cells has a tremendous potential to pollute groundwaters and surface waters causing widespread, significant damage to public health, groundwater quality and the environment. A summary of the chemical characteristics of underdrain, leak detection systems, and groundwater detection monitoring wells is presented below.

Chemical Characteristics of Underdrain Waters. The BFI/CECOS hazardous waste landfill cells were constructed with a six inch sand layer and drainage pipes under the liner system. This approach arose out of a US EPA Region 5 requirement for hazardous waste cells that accept PCB wastes. The Toxic Substances Control Act (TSCA) requires that landfills that accept PCB wastes have at least 50 feet of separation between the bottom of the waste cell and the high point of the groundwater table. The US EPA Region 5 has been allowing hazardous waste landfill owners to circumvent this requirement by constructing an underdrain under the landfill cells for those sites where there is a high groundwater table. This is the approach that was followed at the BFI/CECOS hazardous waste landfill site.

While not a RCRA or Ohio EPA required monitoring point, the chemical characteristics of the underdrains are required to be monitored by TSCA. Examination of the underdrain chemical characteristic data (Bennett & Williams, 1999) for the BFI/CECOS hazardous waste landfill cells that were reported to the Ohio EPA shows, as expected, that hazardous waste constituents have been, at times, present in the underdrain fluids sampled by BFI/CECOS. There are repeated detects for total organic halogens, VOCs and other constituents likely derived from the wastes in the underdrain water sample analytical results. Further, a number of the underdrains have had PCBs present in them indicating the PCBs have leaked from the wastes in the cells into the underdrains.

Expected Leakage Patterns into the Underdrains. It appears that fundamental errors are being made by the Ohio EPA in review of the BFI/CECOS leachate and underdrain chemical data where BFI/CECOS has been able to convince the Ohio EPA staff responsible for review of the monitoring data that have been generated over the years, that the detects of hazardous chemicals in the underdrains do not represent leakage from these cells. However, a critical review of the characteristics of the monitoring program relative to the expected pattern of leaks that should be occurring from the BFI/CECOS hazardous waste landfill cells into the underdrains, shows that the monitoring program is grossly inadequate to reliably characterize the pollution of the underdrain waters that is occurring and that will over time become increasingly significant if the current Closure and Post-Closure Plans' requirements continue to be implemented.

Of particular concern is that the Ohio EPA staff have made a significant error in allowing BFI/CECOS to reduce the number of parameters and the frequency of sampling of leachate in the cell leachate collection standpipes and the underdrains. This approach is the opposite of what should have been done. To allow BFI/CECOS to cut back on the number of parameters monitored in the leachate and in other areas from what was monitored during the active life of the hazardous waste landfill cells because certain constituents are not found in the leachate reflects a lack of understanding of how waste components will be incorporated into leachate.

Much of the waste at the BFI/CECOS landfills is present in 55-gallon drums. They will corrode externally and internally, depending upon the characteristics of the wastes within the drums, at different rates. The extent of corrosion and thereby the interaction of the waste components with percolating water through the landfill will be dependent on the location within the cells, the water percolation patterns, the characteristics of the waste that influence the percolating water (leachate), the internal flow patterns within the landfill cells, the rainfall patterns, evapotranspiration, seasonal effects on groundwater table elevation, etc.. The net result is that the characteristics of the leachate would be expected to be variable at locations within each cell and over time.

Much of this variability will be hidden by the collection of the leachate at standpipes where leachate from various locations will be blended together. This variability will be essentially lost based on the current sampling approach where individual hazardous waste landfill cells are only sampled once every six years. One of the mandatory requirements of the revised post-closure monitoring is to greatly increase individual sampling of each subcell to the extent that this is possible in order to better characterize the leachate in each part of each landfill cell.

The <u>average</u> composition of the leachate as being generated now will not be the driving force that leads to groundwater pollution. It will be the leachate at any particular location that penetrates the liner system in a particular area in a landfill cell that will cause the pollution of the underdrain waters and groundwaters by hazardous chemicals derived from the wastes. The degree of this pollution will be highly variable. The underdrain characteristic data are what is expected in terms of variability for the initial leakage of hazardous constituents from these landfill cells.

The current sampling used for characterizing leachate, as well as the leak detection system fluids and the underdrains, results in significant dilution of the initial leakage points of leachate through the liner system into the underdrains. Since the rate of leakage for any particular location in the liner system will be variable, it would be expected that the observed pattern during the initial failure of the liner system would show a variable composition with a pattern similar to what has been observed.

Characteristics of Leak Detection System Fluids. Examination of the leak detection data for cells 9 and 10, where leak detection systems were installed in the liner system, shows that these cells have allowed the passage of hazardous constituents through the upper composite liner into the leak detection system. This is what is expected and what has been observed with the other cells which do not have leak detection systems but have underdrains which can, to some extent, serve as a leak detection system for the single composite liner used in cells 6 through 8.

Characteristics of Detection Monitoring Well Waters. Even though the groundwater monitoring is grossly inadequate and does not meet regulatory requirements, there have been detects of VOCs in the very few monitoring wells that are being used to detect groundwater pollution by the landfill cells. This pattern of irregular detects of hazardous constituents is the pattern that would be expected for the initial leakage from the BFI/CECOS hazardous waste landfill cells.

Deficiencies in BFI/CECOS Hazardous Waste Landfill Groundwater Monitoring

The US EPA, as part of developing national landfilling regulations for solid waste and hazardous waste landfills, established monitoring requirements that if properly implemented would detect the inevitable failure of the landfill liner systems to prevent leachate that passes through the liner and pollutes groundwaters underlying the waste management cells from causing off-site pollution. The Ohio EPA groundwater monitoring requirements that are applicable to the BFI/CECOS hwl are set forth in the Post-Closure Plan.

The CECOS International "Approved RCRA Post-Closure Plan for Closed Hazardous Waste Disposal Units," dated September 23, 1994, states on page 1-1 of the Introduction to Appendix B, "Facility Monitoring Programs," revised March 1994:

"1.2 Regulatory Setting

CECOS has operated the facility as an interim status hazardous waste disposal facility under the Resource Conservation and Recovery Act (RCRA) since November 18, 1990. Various forms of interim status groundwater monitoring programs were implemented at the facility through 1989. In 1989, in anticipation of receiving a RCRA operating permit in the future, the facility implemented a groundwater monitoring program meeting the principal requirements of detection monitoring under permit status (OAC 3745-54-98). The program also met the groundwater monitoring requirements of the Toxic Substances Control Act (TSCA) for Cells 6, 7, 8, 9, and 10."

Page 2-15 of the Post-Closure Plan states:

"*2.1.2 Sampling Frequency*

The RCRA groundwater monitoring network listed in Table 2-1 will be sampled semi-annually (OAC 3745-54-98(D)) through the closure and post-closure care period."

This Post-Closure Monitoring Plan was approved by Ohio EPA.

Ohio EPA regulation 3745-54-98 Detection Monitoring Program states:

"An owner or operator required to establish a detection monitoring program under rules 3745-54-90 to 3745-54-99 and 3745-55-01 to 3745-55-02 of the Administrative Code shall, at a minimum, discharge the following responsibilities:"

3745-54-97 General Groundwater Monitoring Requirements states:

"The owner or operator shall comply with the following requirements for any ground water monitoring program developed to satisfy rules 3745-54-98 and 3745-54-99 of the Administrative Code, or rule 3745-55-01 of the Administrative Code.

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

(2) Represent the quality of ground water passing the point of compliance; and

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

(D) The ground water monitoring program shall include consistent sampling and analysis procedures that are designed to ensure monitoring results that provide a reliable indication of ground water quality below the waste management area…"

Bennett & Williams (1999) have summarized the post-closure groundwater monitoring system allowed for the BFI/CECOS hwl cells. A review of the existing groundwater monitoring shows that, in general, a single vertical monitoring well located just down hydraulic groundwater gradient from a hazardous waste cell is being allowed to be used to comply with the US EPA and Ohio EPA requirement of

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

(D) The ground water monitoring program shall include consistent sampling and analysis procedures that are designed to ensure monitoring results that provide a reliable indication of ground water quality below the waste management area…"

Examination of the post-closure detection monitoring well array relative to being able to detect early leakage from the landfill cells shows that the currently allowed monitoring system in which essentially one or possibly two vertical monitoring wells spaced near the down groundwater gradient edge of a landfill cell has a low probability of detecting initial leakage from that cell. Each of the monitoring wells have zones of capture of groundwater of about one foot on each side, i.e. associated with the purging of the wells by three borehole (well) volumes. This purging will draw waters in the zones sampled from only about a foot or so from the well.

The placement of the monitoring wells and their number is such that for cells 6 through 10 there are only a few feet at the point of compliance where leakage from the cells can pass by the point of compliance and be detected by the monitoring wells that are being sampled. For each cell there are at least 300, and for some cells over 500, feet of the down groundwater gradient edge of the cells which are not being sampled at the point of compliance at this time. Substantial leachate plumes associated with leakage through the cell liners can and likely are occurring that are not being seen by the grossly inadequate groundwater monitoring system that was allowed by the Ohio EPA in the closure of the BFI/CECOS hazardous waste landfill cells.

Dr. Cherry (1990) of the University of Waterloo was the first to point out that the groundwater monitoring system of the type that BFI/CECOS has adopted for post-closure monitoring of the Aber Road facility hazardous waste cells involving vertical monitoring wells spaced hundreds of feet apart along the downgradient edge of the landfill cells have a low probability of detecting leachate leakage from the landfill that can pollute groundwater before widespread pollution occurs. Lee and Jones-Lee (1994b; 1998b) have published review articles on the deficiencies in reliably monitoring groundwater pollution at lined landfills in which they have utilized Cherry's findings to point out that minimum double composite-lined and single composite-lined landfills that utilize vertical monitoring wells of the type that BFI/CECOS are using are not reliable for monitoring landfill pollution of groundwaters by the landfill before widespread pollution occurs.

This situation can be understood by the fact that the initial large scale leakage through the flexible membrane liner of the composite liner for BFI/CECOS hwl cells 3 through 10 will be through holes, rips, tears or points of deterioration within the flexible membrane liner. Such leaks will produce finger plumes of limited dimensions compared to the spacing of groundwater monitoring wells. This means that except for a narrow area upgradient from the groundwater monitoring well, the landfill cell can leak large amounts of leachate through the liner and not be detected by the monitoring well. The vast majority of leaks will not be detected by the monitoring well network currently in place. The groundwater monitoring approach used by BFI/CECOS for post-closure monitoring of groundwater pollution by landfill leachate at the hwl cells at the Aber Road facility is a fundamentally flawed technological approach for protecting groundwaters from pollution by hazardous waste landfill leachate.

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

There may be an attempt to argue that leaks through the upper composite liner in the double composite-lined BFI/CECOS hwl cells 9 and 10 would be detected by the leak detection system between the two composite liners and therefore the unreliability of the groundwater monitoring system to detect leaks through the liners is of limited consequence in protecting groundwater quality. However, such an argument is not technically valid for the period of time that the waste in the landfill will be a threat. The key component of the leak detection system between the two composite liners is the plastic sheeting flexible membrane liner which serves as the upper component of the lower composite liner. It is this component that conveys leachate that passes through the upper component liner to a sump where the presence of leachate in the leak detection system can be assessed.

Ultimately, however, the flexible membrane liner base of the leak detection system will deteriorate to the point where it is no longer an effective barrier to leachate passing through it. Under these conditions, the leaks that occur through the upper composite liner will enter the leak detection system and pass through it into the lower composite liner without being detected in the leak detection system. It is for this reason that the leak detection system that BFI/CECOS has used in hwl cells 9 and 10 is not reliable for detecting the failure of the double composite liner system to contain waste components for as long as the waste in the landfill will be a threat.

The BFI/CECOS Aber Road facility hwl cells contain underdrains consisting of a sand layer in which there are imbedded pipes that are connected to a riser pipe that can be pumped to sample the chemical characteristics of the underdrain waters. These underdrains contain groundwater which is derived from the high groundwater table in the vicinity of the hazardous waste cells. In principle, sampling of the underdrain waters could be considered a leak detection system for composite liner failure. However, there are a number of significant problems with this approach. One of the most important of these is the fact that large amounts of leakage of leachate into the underdrains would have to occur before it could be detected due to the substantial volume of groundwater that would be present in the underdrains. This groundwater will dilute the underdrain pollution by liner leakage and thereby mask the groundwater pollution that is occurring where leachate passing through the liner also passes through the underdrain into the underlying groundwater system.

Another problem with both the leak detection system and the underdrains reliably detecting liner leakage is that both systems are subject to plugging by biological growths and chemical precipitation and waste fines. This plugging can serve as a barrier to leachate polluted groundwaters being transported to the riser pipe where they can be sampled by pumping. The literature on the plugging of leachate collection systems has been reviewed by Lee and Jones-Lee (1992), where they point out that this plugging is one of the major areas of concern with the long-term, reliable functioning of leachate removal and liner leak detection systems.

Therefore, neither the leak detection system nor the sampling of the underdrain waters is a reliable method of detecting when the inevitable large scale failure of the liner system occurs in accord with US EPA and Ohio EPA groundwater monitoring regulations.

The monitoring system that exists now at the BFI/CECOS Aber Road hazardous waste landfill facility appears almost to have been designed not to detect initial leakage and groundwater pollution by hazardous chemicals. It would be difficult to have a groundwater pollution detection monitoring system for the hazardous waste landfill cells that is less effective than the current system. The Ohio EPA, as part of developing closure and post-closure requirements for the BFI/CECOS Aber Road hazardous waste landfill facility cells 6 through 10, has not adequately considered the ability of the detection monitoring wells to detect leakage from the landfill cells in accord with both RCRA and Ohio EPA requirements.

Because of the threat represented by the hazardous waste leachate in each of the landfill cells, there is need to implement effective measures to reliably detect leachate migration from the BFI/CECOS Aber Road hazardous waste landfill facility cells. Unless effective steps are taken in the near future there will be significant damage to public health and the environment, including the domestic water supply for over 30,000 people in Clermont County who rely on the East Fork of the Little Miami River in Williamsburg and Harsha Lake as their domestic water supply source.

Inadequate Protection of Surface Water Quality

The geology/hydrogeology of the BFI/CECOS Aber Road facility provides pathways for transport of hazardous and deleterious waste components that enter the groundwaters under the hwl cells to off-site groundwaters and to surface waters through groundwater discharge to

Pleasant Run Creek and possibly other surface waters. This pathway will transport hazardous waste constituents to the East Fork of the Little Miami River and Harsha Lake. As part of the Aber Road facility's Closure and Post-Closure Plans, Ohio EPA is allowing BFI/CECOS to conduct an inadequate surface water quality monitoring program to detect when surface water pollution of Pleasant Run Creek and the East Fork of the Little Miami River occurs by BFI/CECOS Aber Road facility-derived wastes. In addition to groundwater transport of hazardous waste components to surface waters, there will be surface water transport of any spilled waste leachates, as well as any leachates that break out through the sides of the landfills above the surface soils. The pollution of surface waters by BFI/CECOS Aber Road facility wastes is a significant threat to domestic water supplies, recreational use of the East Fork of the Little Miami River, Harsha Lake and the environmental resources along Pleasant Run Creek and the East Fork of the Little Miami River. The post-closure surface water monitoring requirements are inadequate to reliably detect when surface water pollution by BFI/CECOS facility-derived hazardous waste of Pleasant Run Creek, the East Fork of the Little Miami River and Harsha Lake occurs.

The post-closure monitoring requirements should be changed to more appropriately reflect the potential for hazardous waste leachate migration from the hwl cells through the groundwater pathways that can cause pollution of surface waters in Pleasant Run Creek and the East Fork of the Little Miami River by hazardous wastes.

BFI/CECOS Proposed Reductions in Sampling Program

Over the past several years BFI/CECOS has found a number of statistically significant hits (elevated concentrations) of water quality monitoring indicator parameters in groundwater wells. BFI/CECOS staff have written several letters to the Ohio EPA stating that these hits do not represent leakage from the hazardous waste cells. Further, they state that the parameters for which the hits have occurred should be taken off the indicator parameter list. Ohio EPA has supported the removal of certain indicator parameters from the statistical evaluation that is performed to determine whether the hazardous waste landfill cells are leaking leachate to the surrounding groundwaters. This approach is inappropriate in light of the inadequate groundwater and leachate monitoring that is being allowed as part of the BFI/CECOS Aber Road facility Post-Closure monitoring Plan.

Arsenic. In a letter from C. Dall, BFI/CECOS to D. Schregardus, Director, Ohio EPA, (June 2, 1998) RE: "Demonstration Report" C. Dall states *"On July 30, 1997, CECOS International, Inc., notified Ohio EPA of analytical results confirming statistically significant detections in ground water of specific conductance, dissolved calcium and dissolved arsenic..."* at the Aber Road hazardous waste landfill facility. Attached to C. Dall's letter was is a BFI report, "Groundwater Quality Demonstration Report," prepared by Civil and Environmental Consultants, Inc. (CEC) dated June 2, 1998. This report on page iii, Executive Summary, first paragraph, states that statistically significant concentrations of dissolved arsenic, dissolved calcium and specific conductance were found in the Upper Sand, 880 Zone, Channel Sand and Bedrock/Till Interface (BTI) groundwater monitoring zones for the samples collected in October 1997.

Page iv of this report states,

"It appears that the significant detections of dissolved arsenic are a result of naturally occurring conditions in the groundwater. Research by the USEPA and Ohio EPA indicate that geochemical changes in the groundwater occur in the vicinity of landfills and other types of

waste units, resulting in reducing conditions, that end up with dissolution and mobilization of arsenic in groundwater. Because of the resultant 'false positives' for dissolved arsenic (where statistically significant detections are not the result of leakage from a regulated unit), it is recommended that dissolved arsenic be removed as an indicator parameter."

A critical review of the available data shows that there is inadequate information to conclude that the elevated arsenic in the groundwaters is not derived from hazardous waste cell leakage. In order to determine what factor(s) are causing the elevated arsenic levels, a more comprehensive and reliable leachate, underdrain and groundwater monitoring program is necessary.

While the statistically significant arsenic may or may not have been due to releases from a hazardous waste landfill cell, CECOS' suggestion--that construction of a landfill cell which results in geochemical changes that mobilize arsenic is permissible--is totally inappropriate. Arsenic is a hazardous constituent that is a significant threat to domestic water supplies. The US EPA has a major program underway devoted to reducing the allowed drinking water maximum contaminant level for arsenic because of the recognized cancer risk associated with its presence in domestic water supplies. The stratigraphic layers where the arsenic is being found at this site are areas where it can eventually contribute to arsenic in surface waters through discharges to Pleasant Run Creek.

Additional arsenic in Pleasant Run Creek is a threat to the domestic water supply for Clermont County residents. Whether the elevated arsenic levels are attributable to leakage from the cells or, as BFI/CECOS' consultant speculates, related to the fact that BFI/CECOS have constructed landfill cells or conducted other operations at the Aber Road facility which have mobilized arsenic, BFI/CECOS should be required to start a comprehensive groundwater evaluation program to determine the extent of arsenic mobilization that has occurred.

The situation with respect to dissolved arsenic is an example of the gross inadequacies in the sampling program at the BFI/CECOS Aber Road facility. If a proper sampling program had been required, where a complete suite of common cations and anions, as well as the other parameters listed in Tables 2 , 3 and 4 in these comments, are measured, it would be possible to make an assessment as to whether the arsenic is a result of geochemical changes or due to the facility releases.

The concentrations of dissolved arsenic found in these samples are well above the concentrations that the US EPA has been discussing as possible new MCLs for arsenic. The data on page 17 of the CEC report show that the arsenic concentrations in leachate from hazardous waste cells 6, 8, 9 and 10 are extremely high. Based on this alone, arsenic should not be removed from the parameters that are routinely evaluated on a statistical significance basis.

Turbidity and the Need to Monitor for Total as Well as Dissolved Metals. Page 18 of the CEC report, Section 4.3.2. Natural Groundwater Conditions, discusses the turbidity in these monitoring well samples. It is clear that the development of the monitoring wells and their sampling is not being done correctly if the samples are turbid. As a result of including particulates in these samples, the aquatic chemistry of the constituents in the groundwater is being changed through sorption reactions. It is not possible from the information available to determine for some parameters that are affected by turbidity what is actually moving in the groundwaters near the BFI/CECOS hazardous waste landfill cells.

Table 1 in the CEC report presents total and dissolved arsenic which shows that there is appreciable arsenic associated with particulates in some samples. BFI/CECOS should not be allowed to monitor only for dissolved constituents; total as well as dissolved metals and other constituents should be measured. The monitoring wells are not adequately constructed, developed and sampled to say that some of the particulate metals and other constituents that are in the groundwaters are not due to originally dissolved constituents but are sorbed onto particulates as part of sampling.

Calcium and Specific Conductance. C. Dall in an October 29, 1997 letter to D. Schregardus of the Ohio EPA, SUBJECT: "Post-Closure Plan Modification Application" states that dissolved calcium concentrations and specific conductance were showing statistically significant increases in certain groundwater monitoring wells. C. Dall states on the bottom of page 1 of her letter,

"Calcium is a metal that naturally occurs in the ground water system at the Aber Road facility at relatively high and variable concentrations. It is not a conservative element and its solubility in water changes in response to changing conditions (pH, Eh, temperature). As the sediments that comprise the aquifer are highly calcareous, variations in dissolved levels are to be expected spatially between upgradient and downgradient locations and temporally with changing conditions brought about by dewatering and cell construction activities. Given this and the fact that using this compound for statistical analysis results in a false-positive detection, it is requested that dissolved calcium be removed as an Indicator Parameter."

As with arsenic, it is not possible from the data available to conclude that the hits of dissolved calcium are not related to hazardous waste cell releases. A more comprehensive groundwater monitoring program is necessary to determine the cause of the elevated calcium and specific conductance concentrations. The approach of deleting an indicator parameter because it shows a statistically significant concentration in a detection monitoring well is inappropriate. What should be done is to require that a more appropriate groundwater monitoring program be conducted to determine, with a high degree of reliability, the origin of any elevated concentration of a waste constituent in the groundwater monitoring wells.

Further, if BFI's construction of hazardous waste landfill cells has altered the site so that the concentration of calcium in the groundwaters is increasing, then this represents an impairment of the use of the groundwater. Increased calcium is part of an increase in hardness which is detrimental to groundwater quality use for domestic purposes.

In C. Dall's October 9, 1997 letter is a report, "Ground Water Quality Demonstration Report, Aber Road Secure Landfill Facility, Clermont County, Ohio" Prepared by Ground Water Associates, Inc, Sunbury, Ohio, dated October 9, 1997. Page 11, end of the first paragraph, states,

"However because no apparent water quality deterioration is indicated by the data, the statistically significant elevated specific conductance concentrations in the channel sand monitoring wells likely reflects the inability of the selected statistical methods to account for spatial variability within the formation."

The problem is not the statistical techniques; it is the inadequate groundwater monitoring. Variability is not addressed through statistics. Statistics can only describe the magnitude of variability. Variability is addressed through increased monitoring wells, frequency of sampling and an increased number of monitored parameters.

Sulfate. Attached to C. Dall's letter is a report, "Ground Water Quality Demonstration Report, Aber Road Secure Landfill Facility, Clermont County, Ohio" Prepared by Ground Water Associates, Inc, Sunbury, Ohio, dated October 9, 1997. Page 9, third paragraph, states that sulfate is the predominant dissolved ion contributing to the elevated specific conductance in the groundwater from certain wells. There are insufficient data to make a proper mass balance on the relationship between various dissolved ions in the water and their contribution to specific conductance. This is one of the deficiencies in the existing groundwater monitoring programs.

On the bottom of page 9 there is a discussion about the geochemical factors that may be occurring at the site where sulfide minerals are being oxidized to sulfate which are attributed to spatial variability and chemical equilibria associated with landfill construction activities. It is of concern that BFI/CECOS consultants used geochemical changes involving reducing conditions to explain hits for arsenic and then oxidizing conditions to explain hits in elevated specific conductance. These kinds of speculations cannot be accepted as adequate explanations of the elevated concentrations of certain indicator parameters in the detection monitoring wells. A more comprehensive and reliable monitoring program is needed to determine the origin of the elevated concentrations of indicator parameters that are being found in the groundwaters near the BFI/CECOS Aber Road facility hazardous waste landfill cells.

Page 10, bottom of the first full paragraph, discusses the groundwater migration through the "stagnation zones". Again, it appears that BFI/CECOS through the arrangement of the hazardous waste landfill cells may have altered the groundwater characteristics sufficiently so that they are creating impairment of groundwater use through the dissolution of constituents in the aquifer that can pollute groundwaters. It is important to emphasize that whether the increased concentration of certain constituents is due to hazardous waste cell leakage or geochemical changes arising from the construction of the hazardous waste landfills is unknown at this time.

Total Organic Halogen (TOX). The June 4, 1998 letter from C. Dall of BFI/CECOS to D. Schregardus, Director, Ohio EPA, Subject: Revised Post-Closure Plan Modification Application presents a revised Post-Closure Plan for groundwater monitoring at the BFI/CECOS Aber Road hazardous waste landfill facility.

Page 2, last paragraph, under TSCA Post-Closure Monitoring, states *"At this point in time, CECOS has included the changes in the FMP, which primarily effect* [sic] *Section 5. Particularly, Total Organic Halogen (TOX) has been removed as an indicator parameter for TSCA monitoring."* There will be chlorinated organics which would not be detected by VOC measurements that could be detected by TOX measurements. Examination of the characteristics of the leachate in the hazardous waste cells shows that some samples show appreciable TOX that is not accounted for by the VOCs measured. TOX should not be removed as an indicator parameter. Both TOX and VOCs should be determined as described in these comments.

Seasonal Variability. Accompanying C. Dall's June 4, 1997 letter is a proposed, "Facility Water Monitoring Programs" revised May 1998. This section applies to the waste management units in the slurry wall area and the effectiveness of the slurry wall.

Page 2-21, Section 2.3.2 Seasonability of Data, indicates that there is significant variability which is seen in quarterly sampling. This kind of situation points to the need for more frequent sampling, not less frequent sampling, in order to properly describe this variability and to take it into account when detecting leakage from the landfill cells. Under situations such as this, it may be necessary to adopt monthly sampling, rather than even quarterly sampling that is recommended in this report.

Pooling of Data. Page 2-21, third paragraph, states *"By pooling the data on a seasonal basis, CECOS will be able to obtain sufficient background data using only a single sample for each event from each upgradient monitoring well as originally intended."* This approach is strongly contrary to reliable groundwater monitoring. There should be no pooling of data; rather there should be an increased number of wells, an increased frequency of sampling and an increased number of parameters analyzed to properly describe the system that is being monitored. As discussed herein, the pooling of data results in the loss of important information that can be used to detect individual cell/subcell leaks that can lead to development of appropriate remediation programs to correct the leaks.

Adequacy of Complying with US EPA RCRA and Ohio EPA Closure and Post-Closure Requirements

Section 3745-55-11, Closure Performance Standard states:

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

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

The US EPA RCRA Subpart G – Closure and Post-Closure in §265.111 "Closure performance standard" establishes the following requirements for closure of hazardous waste landfills.

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

(a) Minimizes the need for further maintenance, and

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

Section §264.310 "Closure and post-closure care" requires:

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

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

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

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

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

The Ohio EPA and US EPA RCRA requirements for the closure of a hazardous waste landfill are explicit in requiring protection of **public heath and the environment** for as long as the wastes are a threat. There is no financial or time limitation on this required protection. The current BFI/CECOS Aber Road facility hwl Closure and Post-Closure Plans do not comply with Ohio EPA and US EPA RCRA regulations governing the closure of the Aber Road facility hwl cells, since these Plans do not provide for protection of public health and the environment for as long as the wastes in the hazardous waste cells will be a threat. These Closure and Post-Closure Plans basically only postpone when there will be significant public heath and environmental damage associated with the release of hazardous waste from the Aber Road facility hwl cells.

§264.117 "Post-closure care and use of property" requires:

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

This section does not limit the post-closure period to 30 years; it only specifies that 30 years is the minimum period for which post-closure care must be provided. In order to comply with RCRA and Ohio EPA requirements for public health and environmental protection, post-closure care must be provided for as long as the wastes in the landfill will be a threat, not just for the 30 years that BFI/CECOS states in the Closure and Post-Closure Plans that they are responsible for post-closure monitoring and maintenance.

The Ohio Administrative Code, in 3745-55-17 "Post-Closure Care and Use of Property" states

"(A)(2)(b) Extend the post-closure care period applicable to the hazardous waste management unit or facility if he finds that the extended period is necessary to protect human health and the environment (e.g., leachate or groundwater monitoring results indicate a potential for migration of hazardous wastes at levels which may be harmful to human health and environment)."

Lee and Jones-Lee (1992, 1995c, 1998a) have discussed the error that was made by Congress in the 1970s in establishing the RCRA 30-year minimum post-closure care period. That 30-year period was based on classical sanitary landfills which produced gas for 30 or so years. Those responsible for this value did not understand the difference between landfill gas generation in a classical sanitary landfill and leachate generation in such landfills as well as in "dry-tomb" landfills of the type being developed today. "Dry-tomb"-type landfills of the type that BFI/CECOS have developed at the Aber Road facility will be a threat to cause groundwater pollution, effectively forever. Post-closure monitoring and maintenance requirements for these landfill cells must recognize that *ad infinitum* funding for post-closure care monitoring, maintenance and eventually groundwater remediation will be needed to protect public health and the environment in accord with US EPA RCRA and state of Ohio EPA regulations.

The Ohio EPA-allowed Closure and Post-Closure Plans for the BFI/CECOS Aber Road facility are significantly deficient in ensuring that funds will be available to carry out the post-closure monitoring and maintenance requirements set forth in the US EPA RCRA and Ohio EPA regulations for as long as the wastes in the Aber Road facility hwl cells are a threat to public health and the environment. While it might be asserted that at the end of the 30-year post-closure care period for which funds are now available with a fair degree of certainty that it will be possible to gain additional funding from BFI to continue post-closure monitoring and maintenance, there are significant questions about whether BFI or, for that matter, any garbage company that is now active in the field will be in business in 30 years. As discussed by Lee and Jones (1992) and Lee and Jones-Lee (1992, 1993b and 1998a), garbage companies like BFI are amassing massive liabilities associated with their landfills. With few exceptions, these landfills will all eventually pollute groundwaters in their vicinity and therefore have to be managed as a "Superfund" site in which the landfill owner, as well as those who deposited wastes in the landfill, will be responsible for Superfund-like costs for site remediation.

The US Congress General Accounting Office (GAO 1990) in a report to Congress entitled, "Hazardous Waste Funding of Postclosure Liabilities Remains Uncertain," discussed the fact that current US EPA RCRA regulations do not mandate that the landfill owner/operator will, in fact, provide the necessary funding for post-closure care activities to ensure that the wastes in the landfill do not result in groundwater pollution for as long as the waste components will be a threat. The GAO has issued a number of other reports on the inadequacies of current hazardous waste management landfilling practices. For example, GAO (1995a) has discussed the fact that 74% of the hazardous waste facilities in the US have had releases to groundwater. The majority of these facilities were constructed prior to the development of the current landfill liner containment systems. However, in time the plastic sheeting and compacted clay-lined landfills will also have significant releases to groundwater. Further, the GAO concluded that many of the hazardous waste facilities did not have adequate groundwater monitoring systems.

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

The GAO (1995b) report discussed that many state regulatory agencies do not have the funds necessary to carry out the mandated regulatory functions of inspection and periodic reevaluation of the adequacy of the remediation of a site needed to ensure that the site is not a significant threat to public health, groundwater resources, and the environment. The GAO reviews on the uncertainty of long-term funding for post-closure monitoring and maintenance of hazardous waste landfills point to a significant problem with current US EPA RCRA Subtitle C regulations, namely that the health, welfare and long-term interests of the public who reside on or use properties within the sphere of influence of the BFI/CECOS Aber Road facility hwl cells, which include Pleasant Run Creek and the East Fork of the Little Miami River corridor as well as Harsha Lake, are not protected under the current Closure and Post-Closure Plans adopted by the Ohio EPA.

Clermont County and the public, justifiably, have great concern about the inadequate closure of the BFI/CECOS Aber Road facility with particular reference to long-term funding for site monitoring and maintenance.

It is important as part of establishing revised Closure and Post-Closure Plans that BFI establish financial assurance that has a high probability of being available at any time in the future while the wastes in the Aber Road facility are a threat in order to be able to address all plausible worst-case scenario failures of the landfill containment system. Hickman (1992, 1995, 1997) has discussed the importance of using a dedicated trust fund as the financial assurance instrument for landfill post-closure monitoring and maintenance funding. As he points out, all financial instruments being allowed under RCRA and state regulations have uncertainties as to whether or not they will be available when needed during the infinite post-closure care period.

**REVIEW OF THE APPROVED RCRA POST-CLOSURE PLAN
FOR CLOSED HAZARDOUS WASTE DISPOSAL UNITS
CECOS INTERNATIONAL, INC. ABER ROAD SITE
REVISION MARCH 4, 1994**

The transmittal letter for the "Approved RCRA Post-Closure Plan for Closed Hazardous Waste Disposal Units CECOS International, Inc. Aber Road Site" from C.S. Dall, District Manager, BFI/CECOS is dated November 8, 1996. This letter indicates on page 1 of the "Response to Comments" that CECOS will conduct formal inspections and maintenance of the groundwater monitoring wells on an annual basis. However, the Closure Plan, page 3-25 states that the inspection of the monitoring wells is indicated to be conducted semi-annually. In light of the potential problems with groundwater monitoring at this site and the unreliability of the existing monitoring system, the inspection and maintenance of groundwater monitoring wells should be done quarterly, not annually.

The April 25, 1996 Post-Closure Plan transmittal letter to D. Schregardus, of the Ohio EPA states that CECOS is submitting two copies of a RCRA Facility Closure Report that indicates that closure was completed in accord with the approved Closure Plan. Page 1-1 of the Post-Closure Plan states in the first paragraph that BFI/CECOS has prepared this Post-Closure Plan in accordance with OAC 3745-66-18 and 40 CFR 265-118. As discussed herein, this Closure Plan falls far short of meeting the requirements set forth in these regulations.

Page 1-1, last paragraph, states, *"Upon completion of closure of the entire facility, those portions of the facility closed as land disposal units will enter the 30 year period of post-closure care and maintenance, in accordance with OAC 3745-66-17."*

Further, page 1-16, second paragraph, states *"Following the end of the post-closure period, or upon discontinuation of the use of the Leachate Treatment System this unit* [Leachate Treatment System] *will be closed pursuant to OAC 3745-55-97..."* These kinds of statements are misleading in that they try to give an impression that there will be an end to the post-closure period. In fact, the post-closure period for the BFI/CECOS hwl cells will almost certainly never end if it is based on when the wastes in these cells are no longer a threat, since the wastes in the cells will be a threat to public health and the environment in perpetuity. There are components in these wastes, such as heavy metals and many of the organics, which will never degrade and become nontoxic and non-leachable. There will always be the potential for these hazardous constituents to migrate to groundwater, and through groundwaters, off-site to surface waters. This situation will necessitate that a highly effective post-closure monitoring and maintenance program be implemented and operated in perpetuity.

On page 2-2, second paragraph, 2.1 "Leachate Standpipe Monitoring" states *"Once every six years, CECOS will sample leachate wastewaters from each standpipe for analysis of the compounds contained on Table 2-1 per EPA approved procedures."* This is a grossly deficient frequency of sampling that should not have been allowed as part of adoption of the Post-Closure Monitoring Plan. The leachate standpipes for each of the subcells should be sampled quarterly. Further, the leachate monitoring parameter list presented in Table 2-1 needs to be significantly expanded to include a variety of conventional pollutants and other constituents which will be used as indicators of the potential for groundwater pollution associated with landfill cell leakage.

Page 2-2, last paragraph, states that BFI/CECOS will sample all leachate standpipes and analyze for the compounds in Table 2-2 once every six years. The constituents listed in Table 2-

2 are far fewer than the conventional constituents as well as the Priority Pollutants that should be analyzed in the leachate at no less than quarterly, semi-annual, or annual intervals as presented in Table 2 of these comments on the deficiencies in the Post-Closure Plan. Further, the regulatory levels shown in Table 2-2 which are derived from the TCLP test have no meaning in evaluating the potential for the leachate generated in any Aber Road facility hwl subcell to pollute groundwaters.

Page 2-10, first paragraph, states that the leachate standpipes listed in Table 1-1 will be sampled every six years and analyzed for the constituents in Table 2-1 and 2-2. As stated herein, that is a significant flaw in the Closure and Post-Closure Plan for the BFI/CECOS landfill facility. Each of the subcell standpipes should be sampled every quarter, where a comprehensive list of chemical constituents present in the waste are determined.

Page 2-10, first paragraph, states,

"The leachate standpipe sampling and analysis will continue to be conducted as shown above (each standpipe sampled once every six years) through the end of the 30-year post-closure period. Therefore, each standpipe will be sampled five times throughout the 30 year post-closure period."

The 30-year post-closure period is the minimum period required under RCRA; in fact, the post-closure period during which the wastes in the BFI/CECOS Aber Road hwl facility will be a threat, will be forever. Therefore, the post-closure period for these hwl cells will be forever, not the minimum period that BFI/CECOS are trying to foster as their period of responsibility for managing the hazardous wastes at the Aber Road facility. Most importantly, the planning of the post-closure period with particular reference to funding must include assured funding to monitor and maintain the hazardous waste landfill cells for as long as there are waste components in these cells that could be a threat to public health and the environment.

Page 2-11 states that BFI/CECOS could not establish through circulating leachate a constant composition of leachate. The first paragraph under 2.2.1 "Leachate Sampling," states, *"Because of this, a composite sampling strategy will be used in the future."* Rather than using a composite sampling strategy, what should be done is to sample discreet samples over time in order to examine the range of concentrations of constituents that are found in the leachate at the time of sampling. It is the high extremes of this range that establish the potential for migration of hazardous waste components through the liner, not the average composition based on a composite sample.

Page 2-12, Section 2.2.2. "Leachate Analysis," indicates that Table 2-4 lists the analytical test methods for each parameter. Examination of Table 2-4 shows that a limited number of parameters are required to be analyzed by BFI/CECOS. This list should be greatly expanded to include the full range of conventional constituents/pollutants and other constituents which help characterize leachate chemical composition, and the Priority Pollutants, including those parameters listed in Table 2-1. Further, Table 2-4 should list the analytical methods' detection limits (practical quantitation limits) so that it is possible to evaluate whether the appropriate analytical methods are being used for leachate characterization.

Pages 2-20 through 2-22 discuss management of leachate levels and pumping in the various hwl cells. From this discussion, it appears that the Ohio EPA has been allowing BFI/CECOS to pursue, at less than an adequate rate, the removal of leachate from various hwl cells. BFI/CECOS should be required as part of the Closure and Post-Closure Plans to install the necessary systems and implement operating procedures to reduce leachate within each landfill cell to no more than one foot above the lowest point of the plastic sheeting layer used as a cell liner. If additional points of removal of leachate are needed, then they should be installed immediately.

Page 2-34, last sentence, indicates that the monthly TSCA standpipe monitoring will be discontinued. The termination of TSCA standpipe sampling should not be allowed. There is need for quarterly TSCA standpipe monitoring in order to evaluate the characteristics of the leachate from the TSCA cells.

Page 3-9, first paragraph, states that the groundwater monitoring wells will be inspected quarterly or semi-annually. However, at the beginning of the document, C. Dall of BFI/CECOS indicated that the groundwater monitoring wells would be inspected annually. This inconsistency should be clarified.

Page 3-18 discusses the inspections of the landfill cell covers where it is stated in the bulleted paragraph at the bottom of the page,

"Erosion of Top or Sides of Cover--Check for barren areas void of vegetation and grooves or channels where surface run-off has removed the vegetation exposing the soil cover. During extended periods of dry weather or drought conditions the soil cover may crack due to loss of moisture below the vegetation. Erosion of the cover is most likely to occur during the early stages of vegetation growth, particularly during the wet part of the year. Once the roots have taken hold and the vegetation is established, the likelihood of erosion is substantially decreased. Areas where the slope changes gradient will be inspected for ponding or evidence of erosion."

The next bulleted item on page 3-21, discusses "Differential Settling or Subsidence of the Cover," and the third bulleted item under the listing of Cover Inspection is "Poorly Vegetated Areas and Unwanted Vegetation." At no place in this Post-Closure Plan is there a discussion of how the integrity of the low permeability layer within the hazardous waste landfill cell covers will be evaluated. Since the ability of the landfill cover low permeability layer to keep large amounts of moisture from entering the landfill cells that generate leachate that can lead to groundwater pollution is a key to proper closure of the landfill, the failure to discuss how the integrity of the low permeability layer of the landfill cover is to be inspected is a significant omission which must be addressed as part of the Closure and Post-Closure Plans. Also, there is no discussion of how boots around any pipes that extend through the cover will be inspected to ensure that their integrity is maintained and they do not serve as pathways for precipitation to enter the wastes. BFI/CECOS has already had problems of this type at the Aber Road facility.

Section 3-24 discusses quarterly inspections of the hwl cell covers which focus on assessing differential settlement. There is no discussion of the key issue, namely the inspection of the integrity of the low permeability layers within the cover. As discussed herein, it is not possible through visual inspection of the cover topsoil layer to detect cracks, rips, tears, or points of deterioration that will ultimately occur in the plastic sheeting layer. Without an actual inspection of the integrity of the plastic sheeting layer it will not be possible to detect when it fails to prevent large amounts of moisture from entering the wastes and generating leachate.

The problem of not being able to inspect the integrity of plastic sheeting layers in landfill covers is well understood. This is why, as discussed by Lee and Jones-Lee (1995c, 1998a) several companies have developed leak-detectable covers for municipal solid waste and hazardous waste landfills. As discussed herein, the Closure and Post-Closure Plans for the BFI/CECOS hazardous waste landfill cells must be modified to require that each of the cells be retrofitted with leak-detectable covers that will be operated and maintained in perpetuity to maintain the low-permeability integrity of the landfill cell covers.

Page 3-25 discusses the semi-annual inspections of the groundwater monitoring wells, yet page 1 of the "Response to Comments," under "Comment 2," states, *"CECOS will conduct formal inspection and maintenance of ground water monitoring wells on an annual basis."* When will this inspection be done--semi-annually or annually? It should be done quarterly.

Page 4-1 "Maintenance Plan," Section 4.1.1 "Cover Erosion," second paragraph, states *"Cracking or other damage to the cover will be repaired before the eroding area is repaired."* The Post-Closure Plan states on page 4-2, *"The surface will then be graded to allow proper drainage. If the synthetic cover membrane is damaged, the surrounding area will be excavated to expose the complete blemish. The synthetic membrane will be patched, using a method suggested by the manufacturer, and recovered with the drainage layer, 3-feet of topsoil material (ODOT 653.02) and a vegetative layer."*

This is another of the superficial discussions of issues that occurs in this Post-Closure Plan. This discussion is designed to mislead the reader into believing that cracks in the plastic sheeting layer of the cover which is the key component of preventing moisture from entering the landfill can be detected through visual inspection of a topsoil layer which is located about three feet above the top of the plastic sheeting layer. It is clear that significant cracking of the plastic sheeting layer in the landfill covers can occur which would not be manifested as major visual cracks in the topsoil layer.

BFI/CECOS must be required as part of the revised Closure and Post-Closure Plans to develop a reliable leak-detectable cover system for the hazardous waste landfill cells that can readily detect when the plastic sheeting layer of this cover is no longer functioning to prevent moisture from entering the landfill. As discussed herein, leak-detectable covers are available.

Page 4-4, Section 4.2.2 "Leak Detection System," should mention that this section applies only to hwl cells 9 and 10, since the other hwl cells do not have leak detection systems. Further, the list of parameters that are to be analyzed in the fluids obtained from the leak detection system needs to include a complete suite of conventional and other common constituents present in leachate, as well as Priority Pollutants such as those listed in Table 2 of these comments.

Page 4-6, second paragraph, states *"During the active life of the facility, any failure of leachate discharge piping will result in an immediate deactivation of the affected line."* "Active life" is an inappropriate term for this facility. The active life of this facility was terminated in 1988 with the cessation of waste receipt. The term should be "post-closure care period."

Pages 4-6 and 4-7 discuss the monitoring of the gas venting system. In addition to using a HNu photoionization analyzer, the gases emitted from the gas venting system should be smelled by individuals with sensitive olfactory systems for any obnoxious odors. If obnoxious odors are found, then changes in the activated carbon canisters should be implemented.

Page 5-1, in Section 5 "Contingency Plans for Damage or Releases Caused by Containment System Failure, or Severe Storms," states in the first paragraph "Cover System

Failure," *"Final cover failure may result from severe erosion, cracking caused by differential settling or slumping, or penetration by deep-rooted vegetation, or burrowing animals."* BFI/CECOS has failed to mention that the plastic sheeting layers in the cover will develop cracks from a variety of other mechanisms such as stress cracks that will not be detected by the inspection program that is part of the BFI/CECOS hazardous waste landfill Post-Closure Plan.

This same paragraph states, *"In the event that final cover failure results in the migration of waste residues to surface water, CECOS will initiate the following response actions immediately upon discovery:"* BFI/CECOS has failed to indicate how they are going to discover these failures. Clearly it will not be from the monitoring program that is incorporated into the Post-Closure Plan. Also, why is BFI/CECOS only going to initiate responses to cover failure if wastes are found in surface waters? The more likely releases associated with cover failure will eventually be the pollution of groundwaters. The section on page 5-1 is written around the premise that the only way that cover failure will be manifested in surface water pollution is through the discharge of water containing wastes through the cover. While this is possible through leachate breakout through the above-ground sides of the landfill cells, in general it is unlikely that this will be the primary source of pollution of surface waters. The primary pathway for pollution of surface waters will be through groundwater transport from the base of the hazardous waste landfill cells to Pleasant Run Creek.

Page 9-1 states under 9.2 "Financial Assurance" that BFI/CECOS is providing financial assurance for post-closure care by the use of financial tests and a corporate guarantee. As discussed elsewhere in these comments, BFI's corporate guarantee is not considered to be of great value and reliability, especially over the time that the wastes in the Aber Road facility will be a threat. BFI has developed massive financial liabilities that they obviously cannot meet, which will ultimately cause the company to become bankrupt. A review of BFI's financial stability at this time shows that it has been and continues to be in serious financial trouble. This situation will almost certainly become worse over time as the liabilities associated with the development of hazardous waste and municipal solid waste landfills that will pollute groundwaters begin to emerge.

As discussed in other sections of these comments, BFI should be required to develop a cash-based, non-refundable dedicated trust of sufficient magnitude to address all plausible worst-case scenario failures that could occur at the Aber Road facility, including exhumation of all wastes from this site and proper management at an appropriate site using appropriate methods that will protect public health and the environment.

Page A-4 states, *"The Upper Sand consists of discontinuous sand lenses that occur within the Upper Till between ground surface and EL 890 feet MSL."* This discussion is somewhat superficial in that many of the sand lenses that occur at the site have vertical connections to other strata.

Appendix B presents the post-closure care facilities' water monitoring programs. BFI/CECOS states on page 1-1 of Appendix B that in 1989 BFI/CECOS initiated a detection monitoring program under permit status OAC-3745-54-98 which also meets groundwater monitoring requirements of the Toxic Substances Control Act (TSCA) for cells 6, 7, 8, 9 and 10.

Appendix B, page 2-1, Section 2 "Detection Monitoring Program," lists the "major components of the program" as including *"Groundwater samples will be collected semi-annually from the site groundwater monitoring network, except for supplemental quarterly monitoring at*

8 selected wells in the Pre-RCRA Area to satisfy TSCA requirements (Section 2.1)." This monitoring program is inadequate from several perspectives, including that the groundwater monitoring at appropriate monitoring wells should be conducted quarterly, not semi-annually.

Further, a greatly expanded groundwater monitoring well array should be developed for each of the BFI/CECOS hwl cells (subcells) that has a high probability of detecting the leachate pollution of groundwater that will inevitably occur through leakage through the cell liner systems. Also, there is an inadequate suite of constituents being monitored to reliably detect leakage of the hwl cell liner systems.

Page 2-8, Section 2.1 "Groundwater Monitoring Network," second sentence, *states "A list of these 69 wells is found in Table 2-1. This total includes both background wells and downgradient wells."* This statement, while possibly true, is misleading. A critical examination of the actual groundwater monitoring that is occurring associated with the potential flow paths of leachate-polluted groundwaters under certain of the hazardous waste cells shows that for some cells only one groundwater monitoring well which has a zone of groundwater capture of about one foot is expected to monitor many acres of landfilled hazardous waste. For several of the hazardous waste cells there is several hundred feet at the point of compliance for groundwater monitoring where leachate that leaks through the liner system could pass and not be detected by any of the detection monitoring wells.

By far the most significant deficiency in the Ohio EPA's Approved Post-Closure Plan for the BFI/CECOS Aber Road hwl facility is the inadequate groundwater monitoring programs. Ohio EPA staff, as part of approving the program, have failed to carry out their responsibilities of properly evaluating the reliability of this groundwater monitoring program to comply with US EPA RCRA and Ohio EPA requirements:

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

(2) Represent the quality of ground water passing the point of compliance; and

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

(D) The ground water monitoring program shall include consistent sampling and analysis procedures that are designed to ensure monitoring results that provide a reliable indication of ground water quality below the waste management area…"

As discussed herein, the groundwater monitoring system being allowed to be conducted by BFI/CECOS at the Aber Road hwl facility is best described as superficial and basically a facade in terms of its reliability of being able to detect groundwater pollution by landfill leachate when leachate first penetrates through the liner system.

BFI/CECOS' Post-Closure Plan states on page 2-8, under Section 2.1.1 "Monitoring Well/Cell Relationship,"

"Because several distinct disposal units are monitored in four different water bearing zones at the Aber Road Facility, the site does not fit neatly into the 'one upgradient well/three downgradient well' model originally envisioned in the RCRA groundwater monitoring regulations."

Basically, this is a statement of the complex geology and hydrogeology of the Aber Road facility that makes this site an unsuitable site for solid waste and/or hazardous waste landfills. The complexity of the hydrogeology at this site should have ruled out the use of this site as a location for any type of landfill. Now that a number of landfill cells have been developed at the site, as long as these cells contain wastes, the monitoring of these cells will require an extraordinary groundwater monitoring system well beyond that which is required in the Closure and Post-Closure Plans for the Aber Road facility if the groundwater monitoring is to comply with US EPA RCRA requirements and Ohio EPA requirements of protecting public health and the environment from pollution by landfill leachate for as long as the wastes at the Aber Road facility represent a threat.

Pages 2-10 through 2-13 present Tables 2-1 and 2-2 covering the detection monitoring program well network. Examination of these tables relative to the complex hydrogeology and stratigraphy of the Aber Road facility shows that these tables are misleading with respect to providing information on the reliability of the groundwater monitoring network to detect hazardous waste cell leachate-polluted groundwaters at the position of the groundwater monitoring wells that are associated with a number of the hazardous waste management cells. As discussed herein, for each of the cells, there is hundreds of feet along the point of compliance for groundwater monitoring for each cell where leachate-polluted groundwaters can pass and not be detected by the groundwater monitoring well(s) established for that cell.

Page 2-15, Section 2.1.2 "Sampling Frequency" states, *"The RCRA groundwater monitoring network listed in Table 2-1 will be sampled semi-annually..."* As indicated in these comments, the groundwater monitoring network should be sampled quarterly for at least three years or until such time as there is a sufficient database to reliably predict the composition of the water at each sampling location based on past data. Further, the parameters for potential pollutants, conventional pollutants and other chemical characteristics of the water should be significantly expanded to the full suite of constituents listed in Table 3 of these comments, in order to characterize the groundwaters at each sampling location relative to the characteristics of the leachate in the hazardous waste landfill cells that can pollute the groundwaters at that location.

Page 2-15 discusses some semi-annual detection monitoring. The frequency of monitoring should be increased to quarterly monitoring.

Page 2-16 discusses the indicator parameters which are listed in Table 2-3. The indicator parameters listed in Table 2-3 are not adequate to reliably characterize the pollution of groundwaters by landfill leachate. This list should be expanded to the full suite of conventional groundwater constituents, potential pollutants and Priority Pollutants as well as any exotic chemicals that are known to be deposited in a particular hazardous waste landfill cell/subcell. Further, Table 2-3 indicates that only dissolved metals are being analyzed. Both total and dissolved metals should be analyzed since, depending on the quality of well construction and sampling techniques, the groundwater sampled at any particular well could readily have dissolved constituents converted to particulate constituents in the sampled waters as the result of inappropriate well construction, maintenance, and sampling.

As discussed in these comments, BFI/CECOS has been petitioning Ohio EPA for removal of certain parameters from the detection monitoring program since they claim that the parameters are not reliable for detection monitoring. If the monitoring program allowed at the site as part of the Closure Plan had been set up properly, where a full suite of conventional constituents, such as the common cations and anions, were routinely analyzed, it would be possible to determine whether some of the monitoring parameters that are now showing statistically significant increases are appropriate parameters for detecting cell leakage. As outlined in the groundwater monitoring section of these comments, the data that is being generated now in the post-closure monitoring is largely uninterpretable because of the limited number of parameters being monitored, the lack of information on the specific composition of the hazardous waste subcell leachates, and the inadequate number of monitoring wells being used.

Page 2-23, Table 2-5 lists chloroform with an MCL of 100 µg/L. Chloroform does not have an MCL of 100 µg/L. Trihalomethanes which include a variety of halogenated organics have an MCL of 100 µg/L. That MCL, however, is an artifact of balancing adequacy of disinfection vs. cancer risk. While there is no MCL for chloroform, if there were one, it would likely, based on its potential to cause cancer, be on the order of 1 µg/L, not 100 µg/L.

Page 3-1 of the RCRA Post-Closure Plan, first paragraph, states that groundwaters in the vicinity of the Pre-RCRA area industrial waste cells 1 and 2 and the Intermediate Landfill areas had been polluted by volatile organic compounds. The 880 Zone and Upper Sand both had detectable concentrations of hazardous chemicals. This situation is of particular concern since these types of chemicals can readily pass through the slurry wall by diffusion. This issue is discussed further in a subsequent section of these comments.

Page 3-6 presents Table 3-2 "Pre-RCRA Area Monitoring Well Network." Table 3-2 lists the "Quarterly Analytical Parameters" where VOCs, PCBs, total organic carbon and total organic halogens are to be analyzed. This program is deficient in characterizing the potential for pollutants in the waste that have been placed in industrial cells 1 and 2 and the Intermediate Landfill that can cause off-site groundwater pollution. In addition to the VOCs, the other Priority Pollutants, as well as common constituents and the Priority Pollutants not included in the VOC should be analyzed.

Page 5-1 begins Section 5 "Surface Streams, Underdrain, and Leak Detection System Water Monitoring." Page 5-2 presents a map showing the surface water sampling locations. As discussed herein, the surface streams, underdrain, and leak detection system water monitoring are deficient in reliably assessing the potential for groundwater pollution and the surface water pollution by BFI/CECOS Aber Road facility hazardous wastes that has occurred in the past and will occur in the future.

A review of the surface water monitoring sampling stations as presented on page 5-2 in Figure 5-1 shows that additional surface water monitoring stations are needed to more appropriately characterize the potential impact of stormwater runoff and groundwater discharge to Pleasant Run Creek. A revised post-closure surface water monitoring program is provided in the subsequent section of these comments.

Page 5-3 indicates in the second paragraph under Section 5.1.2 "Surface Water Monitoring" that the parameters listed in Table 2-3 will be analyzed quarterly on the surface water samples. Table 2-3 is presented on page 2-17 which is the indicator parameter list. This list needs to be expanded to the full suite of conventional constituents, conventional pollutants, and Priority Pollutants presented in Table 3 of these comments. The Priority Pollutants with the conventional constituents and conventional pollutants, as well as the constituent indicator parameter list presented in Table 2-3, should be analyzed quarterly. The indicator parameter list should include TOX as a monitoring parameter, since there are organochlorine compounds present in the leachate that will not be measured as VOCs.

Page 5-3, Section 5.1.2 "Surface Water Monitoring," second paragraph, indicates that a TSCA surface water stream sampling program will be conducted on a semi-annual basis where the same stream locations for the RCRA sampling are analyzed for pH, specific conductance, TOX and PCBs. The frequency of that sampling should be quarterly, with specific sampling to collect stormwater runoff from the site.

RECOMMENDED MONITORING PROGRAM FOR THE BFI/CECOS ABER ROAD FACILITY

Presented below is a recommended monitoring program for the BFI/CECOS Aber Road facility, focusing on characterizing the leachate in the RCRA hazardous waste landfill cells, groundwater pollution from the inevitable leakage from these cells, stormwater runoff from the Aber Road facility, and an evaluation of the potential impacts of the groundwater pollution and stormwater pollution that will occur in Aber Road facility off-site waters.

Leachate Characteristics and Liner Leakage Monitoring

The current approach in which the Ohio EPA is allowing BFI/CECOS to significantly reduce the monitoring associated with the hazardous waste landfill cells as part of post-closure monitoring must be immediately reversed so that a far more comprehensive monitoring program on the characteristics of the leachate generated in each of the cells' subcells, as well as in the leak detection systems, where such systems exist in cells 9 and 10, and the underdrains, is implemented.

The full suite of potential pollutants, based on the characteristics of the waste placed in each cell/subcell, should be monitored quarterly for a period of five years. If after five years the composition of the leachate in each of the subcells and the chemical characteristics of the leak detection system and underdrain waters, where such systems exist, can be predicted with a high degree of reliability, then BFI/CECOS may petition the Ohio EPA for approval for a reduced monitoring program to monitor for subcell leachate and the characteristics of the leak detection system and underdrain waters semiannually.

The parameters listed in Table 2 should be monitored quarterly in each of the subcells' leachate standpipes, leak detection system risers, and the underdrain waters when there is water in the underdrains and the leak detection system. Eventually the underdrains and leak detection systems should become dry with the installation/operation of a leak-detectable cover on the hazardous waste cells and pumping down of the water table near the hazardous waste landfill cells.

Since any groundwater in the leak detection systems for cells 9 and 10 and the underdrains for all cells tends to significantly dilute leachate entering the leak detection system or underdrain, and thereby masks the initial leakage of leachate through the liner system into the leak detection system or underdrain, the samples of groundwater taken from the leak detection system or underdrain during the time that the landfill subcells are drying out should be conducted on samples that have been concentrated by a factor of 10.

Any off-gas volatiles released from the evaporated concentration of the samples should be trapped on activated carbon columns that are designed to collect low-molecular weight chlorinated solvents with a high degree of reliability. The off-gas volatiles collected on the activated carbon column should be eluted with appropriate solvents and analyzed by gas chromatography using an electron capture detector, as well as by high-sensitivity GC/MS.

Because of the high salt content of the leachate and its associated high density and the potential for DNAPLs to be present in the leachate, the groundwater monitoring program should consider the potential for density-driven leachate to pass through the liner system into the cell underdrains and through the underdrains into the groundwaters.

TABLE 2 – LEACHATE MONITORING PARAMETERS		
Parameter	**Units**	**Monitoring Frequency**
Field Parameters		
Leachate Elevation(prior to pumping)	Ft. & 100ths, MSL	Quarterly
pH		Quarterly
Specific Conductance	µmhos/cm at 20 C	Quarterly
Temperature	degrees F	Quarterly
Laboratory Analysis		
Bicarbonate Alkalinity	mg/L as $CaCO_3$	Quarterly
Carbonate	mg/L as $CaCO_3$	Quarterly
Chloride	mg/L	Quarterly
Fluoride	mg/L	Quarterly
Nitrate Nitrogen	mg/L N	Quarterly
Ammonia Nitrogen	mg/L N	Quarterly
Total Organic Nitrogen	mg/L N	Quarterly
Sulfate	mg/L	Quarterly
Total Dissolved Solids (TDS)	mg/L	Quarterly
Inorganics[1]	mg/L	Quarterly
Total Organic Carbon (TOC)	mg/L	Quarterly
Total Organic Halides (TOX)	mg/L	Quarterly
Volatile Organic Compounds (EPA Method 8260)	µg/L	Quarterly
Semi-volatile Organic Compounds (EPA Method 8270)	µg/L	Semi-annually
Chlorinated Herbicides (EPA Method 8150)	µg/L	Semi-annually
Organochlorine Pesticides and PCBs (EPA Method 8080)	µg/L	Semi-annually
Dioxins and Dibenzofurans (EPA Method 8280)	ng/L	Annually
Organophosphorus Compounds (EPA Method 8141)	µg/L	Annually
Carbamate Pesticides (EPA Method 8321)	µg/L	Annually
Gross Alpha Radiation	pci/L	Quarterly
Gross Beta Radiation	pci/L	Quarterly
Gamma Radiation	pci/L	Quarterly

1 Inorganics (total and dissolved): Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Cyanide, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver, Sulfide, Thallium, Tin, Vanadium, and Zinc.
The temperature at which specific conductance values are measured is to be reported.

BFI/CECOS should contribute funds to the Aber Road facility post-closure dedicated trust fund of sufficient magnitude to insure that monitoring of leachate, leak detection system fluids, and underdrains can be conducted quarterly for as long as the wastes in the hazardous waste landfill cells represent a threat. For planning purposes, this period of time should be considered infinite.

Groundwater Detection Monitoring Program

Quarterly, BFI/CECOS should monitor all groundwater detection monitoring wells and all background monitoring wells for the monitoring parameters listed in Table 3. In addition to the existing detection monitoring wells currently being used in the post-closure monitoring of the BFI/CECOS Aber Road facility, a greatly expanded set of detection monitoring wells should be developed.

The groundwater monitoring system that is used to detect incipient leakage through the landfill containment system liner(s) should have a high probability of detecting leachate-polluted groundwater at the point of compliance for groundwater monitoring, which is at the down-groundwater-gradient edge of the waste management subcell.

For the purposes of estimating the initial size of the leakage through the plastic sheeting liner system, it should be assumed that a hole, rip, or tear, or point of deterioration of one foot length has occurred in the plastic sheeting liner which allows leachate of the composition that has been found in the subcell previously to leak through the hole under one foot of head. Further, it should be assumed that the hydraulic conductivity of the underlying compacted soil layer in the liner is 10^{-4} cm/sec. For statistical evaluation purposes, a 95% reliability should be based on assuming that the plastic sheeting layer has developed a hole, rip, or tear, or point of deterioration along the down-groundwater-gradient edge of the subcell. The groundwater monitoring system well placement should be based on an analysis of the lateral and vertical spread of the leachate plume generated immediately under the point of leakage in the liner system to the location of the groundwater monitoring well.

Each of the geological strata underlying and/or hydraulically connected to the base of the landfill cells must be reliably monitored. This monitoring should consider the zones of capture of the monitoring wells relative to the spacing of monitoring wells perpendicular to the leachate plume flow path and the lateral and vertical extent of the leachate plumes located at the monitoring point. Nested sets of monitoring wells with limited screening to sample the groundwater in each of the strata should be used to minimize the dilution of the leachate plume with non-contaminated groundwaters as part of the sampling process.

Because of the eventual transport of hazardous waste and deleterious constituents derived from the BFI/CECOS hazardous waste and other waste management units located at the Aber Road facility by groundwaters, it is essential that a comprehensive groundwater monitoring program be developed that can reliably detect the movement of hazardous/deleterious chemicals along groundwater pathways that can lead to off-site groundwater and surface water pollution. A substantially expanded groundwater monitoring program must be developed that can detect groundwater pollution in each of the groundwater pathways to the point where the polluted groundwaters would be discharged to Pleasant Run Creek.

The potential for density-driven transport of leachate through the underdrains into the underlying groundwater system and through this system to the bedrock and then near the surface of the bedrock down bedrock-surface gradient requires that a special-purpose sampling program be developed that would include monitoring wells in the most likely flow paths from each of the BFI/CECOS hazardous waste landfill cells to the bedrock glacial valley that lies to the north of the Aber Road facility. Of particular concern would be the transport of VOCs and PCBs as DNAPLs along this flow path.

Because of the high cost of the closely spaced monitoring wells needed at the point of compliance for groundwater monitoring to detect finger-like leachate plumes that can arise from holes, rips, tears and points of deterioration in the landfill liner FML, consideration may wish to be given to using horizontal monitoring wells (Keller, 1994) in each of the horizontal pathways downgradient from the hazardous waste landfill cells to detect leachate-polluted groundwater plumes. The placement of such horizontal wells, as well as the screening of vertical wells, needs to consider the density of the leachate that could be present arising from the high salt content of the leachate at some times.

Groundwater sampling should include an accurate determination of the groundwater surface elevation and field parameters (pH, temperature, electrical conductivity, turbidity) for all monitoring wells. BFI/CECOS should measure groundwater elevations prior to purging and sampling the wells to fulfill the groundwater gradient and direction requirements. For each monitored groundwater stratum, BFI/CECOS should measure the water level in each well (in feet and hundredths, MSL) and determine groundwater gradient and direction at least quarterly, including the times of expected highest and lowest water level elevations for the respective groundwater stratum. BFI/CECOS should display this information on a water table contour map and/or groundwater flow net for the site and submit the map with the quarterly monitoring report.

BFI/CECOS should measure groundwater elevations for all background and downgradient wells for a given groundwater stratum within a period of time short enough to avoid temporal groundwater flow variations which could preclude accurate determination of groundwater gradient and direction.

BFI/CECOS should perform appropriate statistical or non-statistical analysis when the monitoring data are available.

Neighbors Well Sampling

The inevitable leakage of the BFI/CECOS hazardous waste landfill cells and the other waste management units at the Aber Road facility that will pollute groundwaters underlying the waste management units and the readily available pathways for transport of hazardous and deleterious wastes off-site from this facility, requires that special precautions be made to protect off-site groundwater quality. Since the pollution of groundwaters under the Aber Road facility is a threat to groundwater quality under adjacent/nearby properties near the BFI/CECOS Aber Road facility, a "neighbors" water well monitoring program should be initiated by BFI/CECOS to sample all neighbors' wells for incipient groundwater pollution. This monitoring program should be conducted quarterly for at least three years for the monitoring parameters listed in Table 3. After that time the frequency of monitoring can be reduced to semiannually, provided that the composition of the well water can be reliably predicted based on previous sampling of the well.

The data analysis should be conducted for the purpose of detecting incipient groundwater pollution by Aber Road facility wastes and their transformation products before actual

TABLE 3 – GROUNDWATER MONITORING PARAMETERS		
Parameter	**Units**	**Monitoring Frequency**
Field Parameters		
Groundwater Elevation	Ft. & 100ths, MSL	Quarterly
pH		Quarterly
Specific Conductance	µmhos/cm at 20 C	Quarterly
Temperature	degrees F	Quarterly
Turbidity	Turbidity units	Quarterly
Dissolved Oxygen	mg/L	Quarterly
Laboratory Analysis		
Anions/Cations[1]	mg/L	Quarterly
Threshold Odor	Threshold Odor No.	Quarterly
Chloride	mg/L	Quarterly
Fluoride	mg/L	Quarterly
Total Organic Nitrogen	mg/L N	Quarterly
Ammonia	mg/L N	Quarterly
Total Dissolved Solids (TDS)	mg/L	Quarterly
Phenols	mg/L	Quarterly
2,4-dimethylphenol	mg/L	Quarterly
meta & para methylphenol	mg/L	Quarterly
Inorganics[2]	mg/L	Quarterly
Total Organic Carbon (TOC)	mg/L	Quarterly
Total Organic Halides (TOX)	mg/l	Quarterly
Volatile Organic Compounds (EPA Method 8260)	µg/L	Annually
Semi-volatile Organic Compounds (EPA Method 8270)	µg/L	Annually
Chlorinated Herbicides (EPA Method 8150)	µg/L	Annually
Organochlorine Pesticides and PCBs (EPA Method 8080)	µg/L	Semi-annually
Organophosphorus Compounds (EPA Method 8141)	µg/L	Annually
Carbamate Pesticides (EPA Method 8321)	µg/L	Annually
Gross Alpha Radiation	pci/L	Quarterly
Gross Beta Radiation	pci/L	Quarterly
Gamma Radiation	pci/L	Quarterly

Legend for Table 3 – Groundwater Monitoring

1 Anions/Cations: Bicarbonate, Carbonate, Nitrate, Sulfate, Calcium, Magnesium, Potassium, and Sodium.
2 Inorganics (total and dissolved): Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Cyanide, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver, Sulfide, Thallium, Tin, Vanadium, and Zinc.

The temperature at which specific conductance values are measured is to be reported.

impairment of the groundwater quality in the monitored wells occurs. The approach that is sometimes used, of asserting that it is permissible to pollute domestic groundwater supplies up to drinking water MCLs for the regulated constituents, is not protective of public health due to the large number of unregulated hazardous constituents in hazardous wastes of the type that BFI/CECOS landfilled at the Aber Road facility.

All wells including up-groundwater-gradient wells and any new wells developed in the future located within one mile of the BFI/CECOS Aber Road facility should be monitored as long as there are wastes at the facility that are a threat to groundwater quality. If, after three years, the groundwater table and flow direction as determined by groundwater elevation monitoring at the Aber Road facility and the off-site monitoring wells is stable, then the frequency of groundwater monitoring of those wells which are not in the flow path of leachate-polluted groundwaters that could arise from the Aber Road facility can be reduced to annually. If the direction of groundwater flow changes as a result of the development of high-volume off-site production wells, then additional groundwater wells will need to be monitored within the potential sphere of influence of the BFI/CECOS Aber Road facility.

Surface Water Monitoring

A significantly improved surface water quality monitoring program should be developed as part of a revised post-closure monitoring plan to determine if surface water runoff from the BFI/CECOS Aber Road facility associated with waste that exists in the surface soils or that is released from the landfill cells above the ground surface is transported to off-site waters. There has been a history of leachate spills at the Aber Road facility that contaminate surface soils. Also, there is the potential for breakout of hazardous waste leachate through the above-ground sides of the landfill cells. These spills and leachate cell above-ground breakout can cause stormwater runoff from the site to be contaminated that can pollute-impair the use of Pleasant Run Creek, the East Fork of the Little Miami River and Lake Harsha for domestic water supply and other purposes.

The stormwater runoff patterns from the Aber Road facility should be identified with particular attention to major pathways where major stormwater runoff locations from the facility are identified as sampling points during stormwater runoff events. Of concern are the storm sewers that are located on the Aber Road facility. Each of these storm sewer dischargers that lead to the discharge of stormwater and/or groundwater off-site of the facility should be sampling locations that are sampled as part of the quarterly sampling of stormwater runoff from the facility, as well as the special-purpose sampling that is to take place during stormwater runoff events.

BFI/CECOS should collect surface water runoff samples from at least one storm runoff event each season (fall, winter, spring, and summer). BFI/CECOS should collect samples from all existing and additional surface water sampling stations and analyze at the frequency and for the monitoring parameters specified in Table 4. During periods of extended limited precipitation (a month would be appropriate) BFI/CECOS should sample the first stormwater runoff event during the next precipitation runoff event.

The current post-closure groundwater and surface water water quality monitoring programs have largely ignored the groundwater transport of waste-derived constituents to Pleasant Run Creek. As part of developing revised Closure and Post-Closure Plans, a comprehensive groundwater monitoring program associated with each of the Aber Road facility waste management units should be conducted along each of the groundwater pathways from under the waste management units to any location where wastes could be transported to surface waters. Also a detailed sampling of Pleasant Run Creek in the areas (outcrops) where there is a possibility of groundwater transport of wastes to surface waters should be conducted.

Additional Pleasant Run Creek Sampling Locations. At this time, data from the so-called upgradient Pleasant Run Creek sampling location, C-9, indicates that the water is “polluted.” Therefore, this location is not a suitable reference site for assessing the potential water quality impacts of the BFI/CECOS Aber Road facility stormwater runoff and groundwater discharges to surface waters. The source of this pollution has not been identified. From the information available it is possible that the Aber Road facility is the source of this pollution. BFI/CECOS should be required to undertake studies to determine the source of this pollution.

Two additional monitoring stations upstream of station C-9 should be established at sampling points about 100 meters and about 200 meters above station C-9. If these stations also show that Pleasant Run Creek waters are polluted at those locations, then the source of this pollution should be determined by BFI/CECOS.

At this time C-2 is the only sampling point along the west branch of Pleasant Run Creek between C-9 and C-10. At least two additional Pleasant Run Creek sampling stations should be established between C-9 and C-10. These stations should be located in areas where it is possible that stormwater runoff from the Aber Road facility, storm sewer discharges from the facility, and groundwater discharges occur to Pleasant Run Creek.

The current Pleasant Run Creek sampling stations C-6, C-10, and C-12 should be maintained. An additional sampling station should be established about 100 meters below station C-6. Further, another sampling station should be established several hundred meters downstream of station C-6. A set of sampling stations should be established on the East Fork of the Little Miami River and on Pleasant Run Creek just above their confluence. Also, a sampling station of the East Fork of the Little Miami River about 200 to 500 meters below this confluence should be established.

The Little Miami River should be sampled in the upground water supply reservoir for the Village of Williamsburg and in Lake Harsha. This is justified based on the fact that it is the concentration of constituents in these reservoirs that will ultimately determine the impact on domestic water supply water quality, as well as the aquatic life resources in these areas.

It appears that groundwaters discharged from under the BFI/CECOS hazardous waste landfill cells could leave the BFI/CECOS facility and enter tributaries of the East Fork of the Little Miami River other than Pleasant Run Creek. A sufficient understanding of groundwater flow should be developed to determine if groundwaters associated with the BFI/CECOS hazardous waste landfill facility enter other tributaries of the East Fork of the Little Miami River. If there is a potential for this to occur, then the groundwater and surface water monitoring programs should be expanded to sample groundwaters along this flow path and surface waters at the point and downstream of where the groundwaters are expected to enter the surface water systems.

Chemical Constituent/Pollutant Surface Water Monitoring. In addition to quarterly sampling groundwater along each potential surface water transport pathway near the point of discharge to surface waters, quarterly sampling of Pleasant Run Creek waters and sediments, both east and west branch and below the confluences of the east and west branch, should be undertaken for the parameters listed in Table 4. The sediments that accumulate behind the stream gaging weirs on each branch of Pleasant Run Creek should be sampled annually and analyzed for the parameters listed in Table 4.

Taste and Odor Characteristics. The inclusion of the threshold odor characteristics to Tables 3 and 4 represents an important component of appropriately conducted hazardous waste and deleterious waste impact evaluation and management for protection of domestic water supply water quality. To a BFI/CECOS "neighbor" property owner/user, the pollution of groundwaters that are being used under their property by BFI/CECOS hazardous and deleterious waste by odorous compounds is of significant concern to them.

Excessive Bioaccumulation of Hazardous Chemicals. Aquatic life such as benthic aquatic insects, clams and crustaceans such as crayfish, and fish in Pleasant Run Creek, East Fork of the Little Miami River, and Lake Harsha should be analyzed for excessive bioaccumulation of hazardous chemicals. Of particular concern are the heavy metals, especially mercury, and the chlorinated hydrocarbon pesticides, PCBs and dioxins. The bioaccumulation monitoring should be conducted annually in the fall of the year. The analytical methods that are used for the excessive bioaccumulation of hazardous chemicals within aquatic life tissue should have detection limits that can reliably detect a cancer or other health risk at a one-in-a-million risk level, assuming a fish tissue consumption rate of one meal per week. The US EPA, "Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Vol. II, Risk Assessment and Fish Consumption Limits, Second Edition," EPA 823-B-97-004, U.S. Environmental Protection Agency, Office of Water, Washington, D.C., July (1997), and Vol. I, "Fish Sampling and Analysis," EPA 823-R-93-002, August (1993), should be used for assessing excessive bioaccumulation in aquatic life tissue that could be caused by releases of hazardous waste constituents from the BFI/CECOS Aber Road facility.

Aquatic Life Toxicity Testing. Samples of groundwater and Pleasant Run Creek waters should be tested for aquatic life toxicity using the US EPA standard three species chronic toxicity tests with the acute and chronic endpoints. The test organisms should include fathead minnow larvae (*Pimephales promelas*), zooplankton (*Ceriodaphnia dubia,*) and algae (*Selanastrum capricornutum*) using the procedures described by Lewis, P.A., Klemm, D.J., Lazorchack, J.M., Norberg-King, T., Peltier, W.H. and Heber, M.A. "Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms," Environmental Monitoring Systems Laboratory, Cincinnati, OH; Environmental Research Laboratory, Duluth,

TABLE 4 – SURFACE WATER MONITORING PARAMETERS		
Parameter	**Units**	**Monitoring Frequency**
Field Parameters		
pH		Quarterly
Specific Conductance	µmhos/cm at 20 C	Quarterly
Temperature	degrees F	Quarterly
Turbidity	Turbidity units	Quarterly
Dissolved Oxygen	mg/L	Quarterly
Laboratory Analysis		
Anions/Cations[1]	mg/L	Quarterly
Threshold Odors	Threshold Odor No.	Quarterly
Total Dissolved Solids (TDS)	mg/L	Quarterly
Total Suspended Solids (TSS)	mg/L	Quarterly
Total Organic Carbon (TOC)	mg/L	Quarterly
Total Organic Halides (TOX)	mg/L	Quarterly
Inorganics[2]	mg/L	Quarterly
Volatile Organic Compounds (EPA Method 8260)	µg/L	Quarterly
Semi-volatile Organic Compounds (EPA Method 8270)	µg/L	Quarterly
Chlorinated Herbicides (EPA Method 8150)	µg/L	Quarterly
Organochlorine Pesticides and PCBs (EPA Method 8080)	µg/L	Quarterly
Organophosphorus Compounds (EPA Method 8141)	µg/L	Quarterly
Carbamate Pesticides (EPA Method 8321)	µg/L	Quarterly
Gross Alpha Radiation	pci/L	Quarterly
Gross Beta Radiation	pci/L	Quarterly
Gamma Radiation	pci/L	Quarterly

1 Anions/Cations: Ammonia, Bicarbonate, Carbonate, Chloride, Fluoride, Nitrate/Nitrite, Sulfate, Calcium, Magnesium, Potassium, Sodium, total and soluble Orthophosphate.

2 Inorganics (total and dissolved): Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Cyanide, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver, Sulfide, Thallium, Tin, Vanadium, and Zinc.

The temperature at which specific conductance values are measured is to be reported.

MN; Region 4, Environmental Services Division, Athens, GA; Office of Water, Washington, D.C.; Environmental Monitoring Systems Laboratory, Cincinnati, OH; Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, OH (1994). If toxicity is found then toxicity identification evaluation (TIE) should be conducted to determine the cause of the toxicity following US EPA procedures. Further forensic studies using a combination of toxicity tests and chemical analysis should be used to determine the source of the constituents responsible for the toxicity.

Sediment toxicity testing should be conducted quarterly using *Hyalella asteca* as a test organism following the US EPA "Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates," EPA/600/R-94-024, June, (1994).

In addition to monitoring for chemical constituents, bioaccumulation of hazardous chemicals in aquatic life tissue and aquatic life toxicity in Pleasant Run Creek near the BFI/CECOS Aber Road facility, testing of this type should be conducted on a quarterly basis in the East Fork of the Little Miami River and Lake Harsha. It is possible that while the concentrations of hazardous chemicals derived from the BFI/CECOS Aber Road facility may not cause water quality problems in Pleasant Run Creek, they could contribute to water quality problems in downstream waters when combined with other sources of hazardous chemicals.

Aquatic Organism Assemblages. Aquatic life organism assemblages should be assessed at biannual intervals at the Pleasant Run Creek existing and proposed new sampling stations using procedures developed by the US EPA, "Biological Criteria, Technical Guidance for Streams and Small Rivers, Revised Edition," Office of Water 4304, EPA 822-B-96-001, May (1996).

If any of the sampling stations show pollution/impairment of aquatic organism assemblages, aquatic life toxicity, excessive bioaccumulation of hazardous chemicals, or the presence of elevated-above-background concentrations of hazardous chemicals in water or sediments, then BFI/CECOS should be required to conduct studies to define the cause/source of the use impairment and/or elevated concentrations of hazardous chemicals.

Endocrine Disrupters. It is well known that there are a variety of unregulated hazardous chemicals present in hazardous wastes and so-called non-hazardous wastes which cause biological responses in test organisms. As an example, endocrine disrupters are being found in surface waters, especially downstream of locations where complex mixtures of hazardous wastes are discharged to surface waters. Also of concern are exotic chemicals that could affect aquatic life and human population genetics. Since the hazardous waste deposited at the BFI/CECOS hwl could readily contain endocrine disrupters or other hazardous chemicals not now regulated, a special-purpose monitoring program should be initiated on Pleasant Run Creek, the Little Miami River, the upground water supply reservoir for the Village of Williamsburg, and Lake Harsha, using the latest techniques available to determine if exotic hazardous chemicals are present in these waters that could be adverse to the public health of those who use the waters as a domestic water supply, as well as wildlife and aquatic life that are associated with these waters.

Wildlife Habitat Pond Monitoring. A specific water quality and wildlife monitoring program should be initiated to insure that the water, sediments and aquatic life that are associated with the "Wetlands" Islands pond ("Crescent Isle Lake") as well as other ponds on the site is not a threat to wildlife. Even if the waters in the on-site ponds are not discharged off-site, pollution of these waters can be adverse to wildlife that use the ponds as habitat. This monitoring should involve quarterly sampling and analysis for the parameters listed in Table 3. This program will need to be conducted for as long as there are wastes at the facilities that are a threat to public health and the environment. In addition to sampling the waters in these ponds, wildlife biologists should examine the wildlife for impaired reproduction, deformed offspring, or other indications of sub-lethal effects of hazardous substances on wildlife. Particular attention should be given to wildlife reproduction and the characteristics of their young.

Justification for Increased Sampling Locations, Frequency of Sampling, and Parameters Analyzed

The BFI/CECOS Aber Road facility, has one of the most inadequate and unreliable groundwater and surface water quality monitoring programs in place at any hazardous waste site. Further, there is a disturbing trend evolving where BFI/CECOS is apparently able to convince the Ohio EPA that the grossly inadequate groundwater and surface water quality monitoring that is being conducted at the Aber Road facility should be further curtailed. As discussed herein, rather than being curtailed, this monitoring program, must be immediately modified and expanded in order to have any reasonable prospect of protecting public health, groundwater resources and surface-based domestic water supplies of the East Fork of the Little Miami River. The recommended monitoring program presented in these comments represents a synthesis of the author's professional experience in working to protect public health, groundwater resources, domestic water supplies and the environment.

Unreliable Assessment of Hazardous Waste Leachate Plume Characteristics. The current monitoring programs are premised on the mistaken notion that this is a geologically simple site with homogeneous hydrogeological characteristics, where the characteristics of the waste leachate will be constant over time. In fact, the characteristics of the waste leachate will be highly variable over time, and the complexity of the hydrogeology dictates that a comprehensive groundwater and surface water monitoring program be conducted beyond that typically associated with less complex hazardous waste landfill sites.

It almost appears that this monitoring program has been designed to not find initial large-scale leakage from the BFI/CECOS hazardous waste landfill cells until after BFI/CECOS has been relieved of responsibility for monitoring and maintenance of this site by the director of the Ohio EPA. It is difficult to envision a less appropriate or less adequate monitoring program for a site that contains over 35 acres with over a million drummed-equivalents of landfilled hazardous waste at a geologically and hydrogeologically unsuitable site for a hazardous waste or a solid waste landfill. If BFI/CECOS and its consultants conducted an analysis of the reliability of the groundwater and surface water monitoring programs to comply with regulatory requirements of providing protection of public health, groundwater resources, and the environment, they did not incorporate this information into the Closure/Post-Closure Plan. Further, it is clear that the Ohio EPA staff, management, and director did not perform their responsibility for protection of public health, groundwater resources, surface domestic water supplies and the environment by evaluating the reliability of the groundwater and surface water monitoring programs that they approved for the post-closure monitoring of the BFI/CECOS site.

A regulatory agency that approves a hazardous waste landfill cell/site groundwater monitoring program must, if it is carrying out its public responsibilities, evaluate the potential for leachate to leak through the liner system during the period of time that the wastes in the landfill cells will be a threat. It must also evaluate the ability to promptly detect this leakage in accord with regulatory requirements for the protection of public health and the environment. The existing monitoring well network has only a few down-groundwater-gradient monitoring wells. These wells, based on the normal approach for purging the wells as part of sampling, will have zones of capture of about one foot on each side of the well. This means that , where monitoring wells are allowed to be spaced 400 feet apart, there are 398 feet between wells where leachate polluted groundwater derived from cell leakage could pass and not be detected at the point of compliance for groundwater monitoring.

As discussed herein, rather than leaking uniformly across the bottom of the hazardous waste cells, which would result in large, readily detectable plumes of hazardous constituents, the plastic sheeting-lined landfill cells will initially leak in large amounts from tears, rips, cracks or points of deterioration in the plastic sheeting layer. As discussed by Cherry (1990) this will produce finger-like plumes of leachate, especially in the highly permeable sand layers that underlie the BFI/CECOS hazardous waste landfill cells. There will be limited lateral spread of the leachate-polluted groundwater plumes from the point of release for considerable distances down-groundwater-gradient.

Cherry and his associates at the University of Waterloo found, in a sand aquifer system, that the lateral spread of a two-foot wide source of a tracer released into the groundwater would only spread to about ten feet over a distance of approximately 450 feet. While the actual lateral and vertical spread of a leachate plume associated with initial large-scale leakage through a landfill liner system will be dependent on the characteristics of the aquifer system into which the leakage occurs, it is evident that in sand aquifer systems of the type that underlies the BFI/CECOS site landfill cells, finger-like plumes of leachate of limited lateral dimensions will be produced which will, in the majority of cases, have the ability to pass by the point of compliance of the groundwater monitoring without being detected by the groundwater monitoring wells located at that point.

Inadequate Frequency of Sampling. As discussed herein, there were a number of fundamental errors made by the Ohio EPA in approving the BFI/CECOS monitoring programs, one of the most important of which is that the Ohio EPA only requires sampling of the leachate characteristics once every six years. It is difficult to understand how the Ohio EPA could consider this frequency of sampling as adequate for this type of site where there are estimated over one million of 55-gallon drum equivalents of hazardous waste, all of which, over time, will corrode/rust out at different rates and will allow moisture to enter the waste, that will produce leachate and enter the groundwaters. This will cause the leachate to be of variable composition. This variability cannot be assessed through sampling the leachate once every six years.

As discussed herein, it is important to know the characteristics of the leachate since it is the extreme concentrations in the leachate within any cell/subcell that is the driving force for the penetration of many hazardous waste components through the liner. By measuring the concentrations of waste constituents in the leachate of each subcell compared to the concentrations of the constituents in the groundwaters as measured by the monitoring wells, it may be possible to identify which cell/subcell is leaking and then focus remedial attention on that subcell.

This review will also show that the current approved groundwater and surface water monitoring programs do not assure that leaks will be promptly detected and therefore must be significantly expanded to include an increased number of monitoring wells at appropriate locations, an increased number of monitoring parameters and an increased frequency of monitoring of each of the landfill subcells' leachate standpipes, leak detection systems for cells 9 and 10, underdrains, and of the significantly expanded groundwater and surface water monitoring locations. The revised monitoring program should be based on:

- critically evaluating how initial leakage from the hazardous waste landfill cells will occur,
- the characteristics of the leachate plumes that will be developed from this initial leakage,
- the groundwater well spacing and frequency of sampling necessary to detect this initial leakage in accord with RCRA and Ohio EPA regulatory requirements,
- the ability to detect surface water pollution along the numerous, significant high-permeability paths that exist under the hazardous waste landfill cells that can lead to surface water pollution though discharge of groundwater to the east branch and west branch of Pleasant Run Creek and any other surface waters of the area.

The groundwater and surface water quality monitoring programs recommended in these comments is based on properly characterizing current leachate produced in each of the hazardous waste landfill cells/subcells, as well as the leachate-polluted groundwaters that would be present in the leak detection systems for cells 9 and 10 and the underdrains for all of the hazardous waste landfill cells. Without a detailed, periodic characterization of the leachate produced in each subcell, it will not be possible to characterize the ultimate source of the groundwater pollution, namely, the leakage of this leachate through the liner system. It should be understood that a very small amount of some types of hazardous waste can pollute very large amounts of groundwaters above drinking water standards. Rather than taking a sample of leachate every six years as is currently allowed by the Ohio EPA, this leachate should be characterized at least quarterly. Since the hazardous waste cells contain drummed waste where the corrosion-leakage of hazardous waste from these drums will occur over time, it is essential that at least quarterly monitoring of the characteristics of the leachate occur.

Although the leachate might be stable in composition for a number of years, the corrosion of one or more drums of waste could cause the leachate characteristics to significantly change toward an even more hazardous level. It is certain that at some time in the future (next week, next year, ten years from now or 100 years from now) leachate will be produced in the BFI/CECOS hazardous waste landfill cells/subcells which will be of significantly different character than the leachate produced today. This leachate may, in fact, be a greater threat to public health and the environment than today's leachate. It is obvious that leachate characteristics in each of the subcells should be determined at frequent intervals for as long as the waste in each subcell represents a threat to cause pollution of groundwaters underlying the cell. For planning purposes, this should be considered to be effectively forever.

A similar frequent sampling program must be conducted in the leak detection system for hazardous waste cells 9 and 10 and the underdrains of all cells. As discussed herein, while the underdrain sampling is somewhat of a leak detection system, it is not an adequate leak detection system that can be relied on to determine when leachate-polluted groundwaters enter the leak-detection system and pass through it on the way to the underlying groundwaters.

As discussed herein, the frequency of analysis is dictated based on the fact that there exist an estimated over one million drum-equivalents of wastes which have somewhat different characteristics, and which will, over time, release constituents to the leachate and the underlying groundwaters that would not be detected by the current monitoring programs. This situation dictates that a frequent monitoring program be conducted in each of the areas where hazardous waste components could be present at some time in the future.

As indicated, several components of the recommended monitoring program include a provision for reducing the quarterly sampling to less frequent sampling after reliably establishing the current characteristics of each of the media being monitored. However, before adopting a less frequent sampling program, it is necessary to develop a reliable database on the characteristics of the BFI/CECOS landfill facility that are pertinent to the inevitable groundwater and surface water pollution that will occur at this site under the current closure/post-closure requirements. Without this database it is not possible to reliably detect when groundwater pollution begins to occur and to assess whether surface and groundwater pollution has already occurred.

Inadequate Number of Monitoring Wells. Because of the complexity of the groundwater flow paths to off-site groundwaters and surface waters, it is essential that each of these flow paths and the surface waters potentially impacted by the hazardous waste derived from the BFI/CECOS Aber Road facility hazardous waste landfill cells be monitored at frequent intervals to detect initial transport of hazardous waste to off-site groundwaters and surface waters. This will require a greatly increased number of monitoring wells that are appropriately located.

In addition to monitoring wells being located at each of the conventional groundwater flow paths based on static head considerations, monitoring wells should be installed to detect density-driven flow of leachate-derived wastes. Both density due to salts and DNAPLs should be considered in locating monitoring wells and their associated screened intervals. The characteristics of the bedrock surface contours should be considered in developing a monitoring well array to detect density-driven leachate-polluted groundwaters.

Inadequate Number of Parameters. With respect to the number of parameters that should be monitored, it is obvious that all of the potential pollutants that may potentially be present in the waste must be analyzed at a fairly frequent interval. the 55-gallon drums in which the waste were deposited in the cells will eventually corrode/rust-out and allow moisture that enters the landfill cells to interact with the wastes and produce leachate. It is essential that a comprehensive, frequent monitoring program be used to characterize the leachate in each of the sub-cells within the leak detection systems for cells 9 and 10 and the underdrains and the groundwater monitoring wells throughout the site.

In addition to monitoring the Priority Pollutants and other components of the wastes that were accepted by BFI/CECOS for disposal at this site, the conventional pollutants which represent a threat to surface and groundwater quality, as well as the non-conventional/ unregulated pollutants, (for which there are no water quality standards) must be monitored. Because the non-conventional/unregulated pollutants are not readily determined, the detection of them by chemical analysis is not readily achieved. Therefore, in order to detect them, biological assessments in terms of aquatic life toxicity, bioaccumulation, altered aquatic organism assemblages, endocrine disrupters, and chemicals that cause genetic impacts should be monitored.

Those familiar with groundwater monitoring near hazardous waste sites understand that today's chemically-based approach, where a few regulated chemicals are monitored compared to the thousands to tens of thousands of chemicals that represent threats to public health, groundwater resources and the environment that are present at the BFI/CECOS hazardous waste disposal facility, is sufficiently deficient and not protective of public health and the environment. Lee and Jones-Lee (1994c), in a paper, "Does Meeting Cleanup Standards Mean Protection of Public Health and the Environment?" presented at the Superfund XV Conference, discussed some of the deficiencies associated with investigating the hazards of chemicals present at a hazardous chemical site such as the BFI/CECOS hazardous waste landfill site. The chemically based approach used today for site hazard characterization can readily fail to detect hazardous conditions. It is essential that biological effects-based monitoring, such as that recommended in this revised monitoring program, be an important component of any hazardous chemical site monitoring program.

The US Congress General Accounting Office (GAO) has indicated that there are in excess of 75,000 chemicals used in US commerce today. The current US EPA and state regulatory agency laundry list of chemicals that are analyzed associated with a hazardous waste site represents 100 to possibly 200 of these chemicals. There are thousands to tens of thousands of chemicals present in industrial hazardous waste, of the type that were disposed of at the BFI/CECOS hazardous waste landfill facility, that need to be monitored, either directly or by their impacts, through biological assessment techniques in order to protect public health and the environment.

In addition to monitoring for potentially hazardous chemicals in leachate, leak detection systems, underdrains, and in the groundwater monitoring wells there is need to monitor for conventional constituents, such as the major cations and anions. As discussed by Lee and Jones (1983), appropriately monitoring for the major cations and anions is an important approach for determining whether leakage of leachate from hazardous, industrial and municipal waste landfills is occurring. Recently, BFI/CECOS has been petitioning the Ohio EPA to amend its post-closure monitoring program to eliminate some of the common constituents, as well as less common constituents, such as arsenic, as monitoring parameters since they are tripping the statistical techniques being used to assess upgradient vs. downgradient pollution of groundwaters by the hazardous waste management cells. BFI/CECOS argues that the exceedances of the concentrations in the downgradient wells compared to the so-called upgradient wells does not represent leakage from the hazardous waste cells. The facts are that such inadequate monitoring programs are being conducted that it is not possible to reliably determine whether the exceedances associated with conventional parameters (major cations and anions) are, in fact, related to landfill cell leakage.

The major cations and anions which typically are conservative (non-reactive) in their behavior in many groundwater systems must be analyzed as a means of determining whether statistically significant increases in a particular parameter represent initial indications of leakage through the landfill liner system and groundwater pollution, or are simply an artifact of the inappropriate characterization of the ambient groundwaters that exist in the vicinity of the hazardous waste landfill cells that have been constructed by BFI/CECOS.

With respect to analyzing groundwaters and surface waters for so-called non-hazardous conventional pollutants, as recommended in the revised monitoring program, such an approach is justified in terms of protecting both off-site groundwater and surface water quality. Non-conventional, currently classified as "non-hazardous," waste constituents can cause severe impacts on domestic water supply water quality. It is essential that parameters which are indicative of potential impacts on domestic water supply water quality, such as tastes and odors, etc., be routinely monitored.

The recent finding that the gasoline additive MTBE is causing severe taste problems in domestic water supplies, which are costing water utilities and the public large amounts of funds to control, is an indication of why there is need to monitor for more than the minimum parameters associated with a hazardous waste storage facility in order to protect surface and groundwater quality for use for domestic purposes. It is imperative that the groundwater and surface water monitoring programs be significantly revised to insure that public health, groundwater resources, domestic water supplies and the environment are protected from pollution for as long as the wastes in the BFI/CECOS hazardous waste landfill cells represent a threat.

Adequacy of Ohio EPA Review of the BFI/CECOS Closure/Post-Closure Plan

On September 23, 1994, the Director of the Ohio EPA, Donald Schregardus, sent a letter to BFI/CECOS delineating 21 conditions that had to be met in order for the BFI/CECOS hazardous waste facility Post-Closure Plans to be approved by the Ohio EPA. Presented below is a discussion of the adequacy of the Ohio EPA review of the BFI/CECOS Post-Closure Plan.

Overall, the Ohio EPA's review of the Post-Closure Plan failed to address many of the key issues that should have been addressed in a critical, in-depth review of this Plan requirements to protect public health and the environment. The substantial literature which provides a technical base of information to assess the adequacy of the Aber Road hazardous waste landfill containment system design was largely ignored.

As discussed herein, a critical review of the ability of the plastic sheeting and compacted soil liners and covers for the hazardous waste cells leads to the conclusion that it is only a matter of time until the BFI/CECOS hazardous waste management cell containment system fails to prevent large amounts of hazardous waste components from migrating into the groundwater system underlying each of the cells. Further, a critical review of the geological and hydrogeological characteristics of the BFI/CECOS Aber Road facility site leads to the conclusion that there is no natural protection of off-site surface and groundwater resources from pollution by hazardous waste leachate. There are a number of well-defined pathways by which leachate-polluted groundwaters can move from underneath the various hazardous waste landfill cells to off-site surface and groundwater resources. It should have also been obvious that the presence of hazardous waste leachate from the BFI/CECOS Aber Road facility in Pleasant Run Creek represents a significant threat to Clermont County's existing, as well as future, domestic water supplies. Further, at the time that the Ohio EPA conducted this review of the Post-Closure Plan, there had been several papers published in the literature on the unreliability of groundwater monitoring systems based on a few wells spaced hundreds of feet apart along the downgradient edge of a hazardous waste landfill management cell to detect leachate that penetrates through the plastic sheeting layer of the liner system before off-site groundwater and surface water pollution occurs.

Page 1 of the Ohio EPA comments, under Comment 1, states that the BFI/CECOS Post-Closure Plan review was conducted in accord with certain regulatory requirements. However, as discussed herein, a comparison between the regulatory requirements at the federal and state of

Ohio levels vs. the Post-Closure Plan submitted by BFI/CECOS and approved by the Ohio EPA shows that the Post-Closure Plan does not conform to either federal or state regulatory requirements for protection of public health, groundwater resources, the environment, and the interests of the people of Clermont County.

While the Ohio EPA commented on some aspects of the groundwater monitoring programs, they failed to address the fundamental issue that should be addressed in any technically valid, critical review of the adequacy of a hazardous waste landfill site closure and post/closure plan to reliably detect leachate releases when they first occur at the point of compliance for groundwater monitoring. As stated herein, the regulations at the federal and state level require reliable detection of initial releases through the use of a groundwater monitoring program.

As discussed by Cherry (1990), considering the characteristics of initial leakage through plastic sheeting-lined landfill cells, in which finger-like plumes of leachate are produced, and the approximately one-foot radius zones of capture of monitoring wells like those approved for the BFI/CECOS hazardous waste landfill site, the characteristics of initial large-scale leachate releases through the plastic sheeting layer show that the monitoring well array approved by the Ohio EPA is basically a facade that has a very low probability of detecting leachate-polluted groundwaters before significant off-site pollution occurs. This issue – the ability of the monitoring well network to detect leakage before significant offsite pollution occurs – and the adequacy of the hazardous waste landfill cell containment systems to prevent leakage of hazardous chemicals for as long as the wastes in the cell are a threat, are the kinds of issues that should have been considered by the Ohio EPA.

Page 7, comment 10, states *"CECOS shall add a statement to the effect that any situation affecting human health or the environment will be dealt with **immediately**."* (emphasis added). In order to address a situation that potentially affects human health and the environment, it is necessary to have a comprehensive, reliable monitoring program that can immediately detect landfill liner leachate leakage. The monitoring programs that have been approved for the BFI/CECOS site by the Ohio EPA falls far short of enabling BFI/CECOS or the Ohio EPA to take **immediate** action to protect public health and the environment.

Future Hazardous Waste Cell 2 Incompatible Waste Releases. A review of the BFI/CECOS Post-Closure Plan, as well as the Ohio EPA's comments on this Plan, shows that there has been inadequate consideration given to inevitable waste landfill cell 2 incompatible waste/water-type reactions. Waste cell 2 developed a geyser of hazardous waste that was discharged through the landfill cover into the environment, apparently as the result of phosphorus trichloride reacting with water to produce a violent/explosive-like reaction where large amounts of hazardous substances were released. Can there be any doubt that the wastes in barrels that are going to corrode in the hazardous waste landfill the BFI/CECOS facility will eventually lead to similar kinds of reactions in the future? Does anyone naively believe that that phosphorus trichloride reaction with water was an isolated incident that could not occur again in the future?

Basically, the drummed wastes in the BFI/CECOS hazardous waste landfill cells represent a "time bomb" for potential significant problems for public health, groundwater resources and the environment. In time, the waste containers will corrode, allowing moisture to enter the wastes and leachate generated by this moisture to mix with leachate from other barrels There can readily be hazardous waste in the estimated over one million of 55-gallon drum equivalents that are buried in the over 35 acres of hazardous waste landfill cells at the BFI/CECOS facility that, upon the inevitable corrosion of the containers will lead to either incompatible wastes coming in contact with each other, or reactions with water that will cause large-scale emissions of hazardous substances to the environment.

A credible post-closure plan for the BFI/CECOS site must include a detailed discussion of how the cell 2 type of situation will be addressed when it occurs in order to fully protect the public and the environment from its consequences. Further, as part of the worst-case scenario evaluation of what can occur in the various hazardous waste landfill cells at the BFI/CECOS facility, a discussion of this situation should be part of the Post-Closure Plan. The public is entitled to this information and protection.

A revised Post-Closure Plan should be developed which, among other topics, specifically addresses the potential for the cell 2-type incompatible waste/water situation to develop and, most importantly, the actions that can and should be taken if it occurs. To assume, as is apparently being done, that such violent reactions cannot occur or that they are not a threat to the residents of adjacent/nearby properties to the BFI/CECOS facility is contrary to the public's interests and represents a significantly deficient review of the Post-Closure Plan for the BFI/CECOS hazardous waste landfill facility.

Inappropriate Landfilling Approach for the BFI/CECOS Aber Road Site. One of the issues that should have been addressed as part of the Post-Closure Plan monitoring and maintenance review for the BFI/CECOS Aber Road facility is how this facility can be closed and adequate receive post-closure monitoring and maintenance for as long as the wastes represent a threat, and protect public health, groundwater resources and the environment. A review of existing landfilling regulations involving the use of "dry tomb"-type landfills where there is an attempt to isolate the wastes from moisture for as long as the wastes represent a threat, shows that a key component of this landfilling approach is the true isolation of the wastes from moisture forever.

A review of the hydrogeological characteristics of the BFI/CECOS hazardous waste landfill cells shows that there are two sources of moisture that can interact with the wastes that can lead to the production of leachate and the ultimate pollution of groundwaters. One of these is through the landfill cover. As discussed herein, the landfill cover system that has been used to close each of the hazardous waste landfill cells depends on a plastic sheeting layer (FML) to prevent moisture from entering the landfill that can generate leachate that can lead to groundwater pollution. It is well-known that there will be failure of the plastic sheeting layer over the lifetime that the wastes in the BFI/CECOS hazardous waste landfill cells are a threat.

Leak Detectable Cover. The failure of the integrity of plastic sheeting layers in landfill covers to prevent moisture from entering a landfill and the unreliability of detecting this failure is well-recognized in the hazardous waste landfill field. This situation has resulted in a number of companies developing leak-detection systems for landfill liners and covers (Robertson, 1990; Nasko and Andrezal, 1993; Peggs, undated). Lee and Jones-Lee (1995c; 1997; 1998a) have summarized the information available on detectable landfill covers, where they point out that the Robertson system based on a sandwiched FML system to which a vacuum is applied is commercially available. Further, the electrically-based systems described by Nasko and Andrezal (1993) and Peggs (undated) can be implemented today and have a high reliability of detecting when there is failure of the plastic sheeting layer in the low permeability component of a landfill cover.

By installing a leak-detectable cover system on each of the BFI/CECOS Aber Road facility hazardous waste landfill cells and operating the system in perpetuity, i.e. for as long as the wastes are a threat, it will be possible to shut off a source of moisture that leads to corrosion of the metallic hazardous waste storage drums, the production of leachate, and the potential for wastes that are incompatible with water to lead to explosions of the cell 2 type.

The installation costs of the Robertson-type landfill cover, as well as the other leak detection systems, are not significantly greater than a conventional landfill cover. The apparent reason that landfill owners and operators do not adopt this approach is that it requires that the leak detection systems be operated and maintained in perpetuity, i.e. for as long as the wastes represent a threat. Installing such a system could be interpreted to represent an admission that the minimum 30-year post-closure care funding will not be adequate to meet post-closure care needs for as long as the wastes are a threat.

The closure requirements for the BFI/CECOS site should be modified so that BFI/CECOS is required to install leak-detectable covers on each of the hazardous waste landfill cells as well as the other waste management units. Further, BFI/CECOS should be required to develop a dedicated trust fund based on cash payments to the fund that will be of sufficient magnitude to operate and maintain the leak-detectable cover system for as long as the wastes at the BFI/CECOS Aber Road facility hazardous waste landfill are a threat. Without these revised landfill cover requirements, moisture will enter into the wastes through the cover, producing leachate that will, in time, lead to off-site groundwater and surface water pollution. The groundwater pollution will affect the BFI/CECOS neighbors as well as Clermont County residents who depend on the East Fork of the Little Miami River and the reservoirs constructed on this river, such as Lake Harsha, as a domestic water supply. The people in Clermont County are entitled to this level of protection.

Groundwater Pumpdown. In addition to shutting off the moisture supply through the cap, there is need to eliminate the possibility of moisture entering the landfill through the high groundwater table that exists around the BFI/CECOS Aber Road facility hazardous waste landfill cells. While there has been some discussion of the potential for this high groundwater table to lead to an inward gradient which would prevent the outward migration of hazardous waste components into the surrounding groundwaters, such a discussion is fundamentally flawed from several perspectives. As discussed herein, there are a variety of mechanisms by which hazardous waste leachate produced in the landfill cells can lead to groundwater pollution under conditions where there is a high groundwater table surrounding the hazardous waste landfill cells. The BFI/CECOS hazardous waste landfill cells are not true inward gradient landfills in which there is controlled inward migration of leachate into the cells which is removed from the landfill by pumping leachate for as long as the wastes in the landfill represent a threat. Further, the high density of the cell leachate in some cells at some time due to salts as well as the potential for DNAPL formation, leads to the potential for transport of leachate through the cell liners under inward gradient.

In order to avoid the possibility of groundwater entering the hazardous waste cells, the groundwaters in the vicinity of each of the hazardous waste cells should be pumped so that the water table is at least five feet below the bottom of the landfill cell. This is the approach that is typically required for hazardous waste and solid waste management landfills. Such an approach, if implemented effectively in perpetuity, would keep groundwaters from generating leachate within the BFI/CECOS hazardous waste landfill cells. It is a readily implementable approach that should be part of the true cost of landfilling of hazardous waste at the Aber Road facility.

Since a groundwater table pump-down system around each well will require substantial funds in perpetuity to maintain the water table below the levels that generate leachate within a hazardous waste landfill cell, BFI/CECOS should be required to develop a dedicated trust fund of sufficient magnitude based on cash payments to the fund that will insure that funds will have a high probability of being available in perpetuity to reliably operate the groundwater table pump-down system.

As part of revising the Post-Closure Plan for the BFI/CECOS hazardous waste landfill facility, BFI/CECOS should be required to design, construct, implement and operate, for as long as the wastes in the hazardous waste landfill cells represent a threat, a leak-detectable cover and a groundwater pump-down system that will have a high degree of reliability in preventing moisture from entering the "dry tomb" type landfill cells for as long as the wastes in these cells represent a threat. For planning purposes, this should be considered forever.

Slurry Wall Reliability

BFI/CECOS, under an Administrative Order of Consent issued by the US EPA to BFI/CECOS on October 12, 1994, required that BFI/CECOS develop a slurry wall around the pre-RCRA waste cells 1 and 2, Intermediate Landfill, RCRA cells 3 and 4/5, and Firepond 1 for the purpose of stopping the off-site migration of VOCs and other waste constituents that have polluted the groundwaters in the vicinity of these waste management units. This slurry wall was constructed of a soil-bentonite clay mixture. The slurry wall has been keyed into a purported low permeability subsoil layer below the Upper Sand and 880 Zone Sand.

A series of pump down wells have been installed next to the slurry wall in order to lower the groundwater table on the inside of the slurry wall. The purpose of this system is to create a barrier to advective transport of groundwater pollutants outside the slurry wall. While a slurry wall pumpdown system can, if <u>properly</u> designed, constructed and operated, stop off-site migration of VOC-polluted groundwater, there are significant questions about the ability of the actual slurry wall to prevent off-site groundwater and surface water pollution by the hazardous waste management units located inside the slurry wall.

The slurry wall consists of mixing soils of the area with bentonite clay. Limited information has been made available on the characteristics of these soils and especially their susceptibility to attack by low pH waters. It is likely that there is substantial rock flour (ground-up rock) in these soils which would be composed primarily of limestone. Limestone is subject to attack-dissolution by waters with a pH of less than 7. The groundwaters in some areas of this site have a pH of less than 7. If there is appreciable limestone in the slurry wall soils, then there is significant potential for the slurry wall to become even more permeable than would be expected based on its design and construction.

Slurry walls can serve to retard/retain large-scale movement of groundwaters in certain gross applications such as construction site dewatering. However, they are significantly deficient in preventing migration of pollutants in leachate-contaminated groundwater. The American Society for Testing and Materials (ASTM) published the proceedings of a conference entitled, *"Slurry Walls: Design, Construction and Quality Control,"* (Paul *et al.*, 1992). The proceedings contain two papers (Grube, 1992, and Khera and Tirumala, 1992) that provide information directly pertinent to understanding the ability of slurry walls of the type the BFI/CECOS has constructed at the Aber Road site to prevent off-site migration of polluted groundwaters. Also, Evans, (1994, and Day, (1994) in ASTM STP 1142 Hydraulic Conductivity and Waste Contaminate Transport in Soil have provided additional information on the expected performance of slurry walls.

Grube (1992) discussed the experience with and expected performance of clay-based slurry walls. He pointed out that the hydraulic effectiveness of slurry walls used to try to prevent pollutant migration must be of a substantially higher quality than that applied for conventional geotechnical purposes where groundwater cutoff is necessary for routine construction site dewatering. In commenting on the lack of field performance data on the effectiveness of slurry walls, Dr. Grube (who at the time was Research Project Manager in the area of landfill liners and slurry walls, US EPA, Cincinnati) stated,

"Published data from these installations are not uniform in approach, field methods, parameters tested, or data analysis. This is because of the lack of standardized performance assessment methods. At the present time, there is little Agency [US EPA] *interest in supporting development of standard methods to evaluate groundwater cut-off structure performance* [slurry walls]. *This is because of the expected relatively short performance lifetime of a cut-off wall in environmental applications, the stigma of a slurry trench as a simple containment structure (with its corresponding least preference as a waste management option), and dedication of scarce resources to waste minimization and related efforts."*

It can be concluded from Dr. Grube's summary of the US EPA's position that slurry walls of the type that BFI/CECOS has constructed cannot be expected to be effective in preventing hazardous waste constituents inside the slurry wall from migrating off-site.

In a study of slurry walls made of soil/sodium bentonite mixtures, Khera and Tirumala (1992) found that a number of chemicals caused the permeability of slurry walls to increase significantly. Of particular concern in this regard was water containing high levels of calcium relative to sodium. That condition can cause shrinkage of the bentonite clays that can greatly increase permeability of a slurry wall. This is an issue of concern at the BFI/CECOS Aber Road hazardous waste landfill facility. The calcium impact on the permeability of slurry walls is one example of the potential problems where constituents in groundwaters could affect slurry wall integrity. A review of the literature shows that there are a wide variety of factors that can cause slurry walls of various types to fail to be effective barriers to the transport of leachate-contaminated groundwater through them.

Evans (1994) in a discussion on the potential for defects in vertical cutoff wells states,

"No discussion of the hydraulic conductivity of vertical barriers would be complete without mention of the potential for defects, i.e. areas of high hydraulic conductivity. A defect is defined as that portion of the cutoff wall where the hydraulic conductivity is beyond the limits of that expected due to the statistical variability of the cutoff wall materials. The potential defects in slurry trench cutoff walls are many and have been described elsewhere (Evans 1993; Evans 1990; McCandless et al. 1993). The probability that any given defect will be detected in any given verification testing program is small. Most testing programs use laboratory tests of field prepared samples to verify the hydraulic conductivity of the cutoff. Even where field tests are used, it may not be economically feasible to conduct enough in situ permeability tests to reduce the probability of missing a defect to a reasonably small number."

Day (1994) in a discussion of "The Compatibility of Slurry Cutoff Wall Materials with Contaminated Groundwater" states,

"Slurry cutoff walls are frequently relied upon to block groundwater flows from toxic waste sites and landfills. The long-term effectiveness of slurry cutoff wall materials is critical to the successful containment of these facilities and the protection of groundwater resources. A variety of laboratory indicator tests have been attempted by engineers and academia to make compatibility determinations but at present there has been little published experience to show which tests produce meaningful results and how these tests can be used to demonstrate compatibility."

In summary, the current state of technology regarding the use of slurry walls as a barrier to the transport of polluted groundwaters through the wall is such that slurry walls cannot be considered as a reliable barrier for containing polluted groundwater.

An understanding of the physical, chemical, and hydrogeological properties of slurry walls made of soil-bentonite clay mixtures shows that they do not necessarily provide effective barriers to the transport of hazardous waste-polluted groundwater. One of the common problems with slurry walls is that polluted groundwater can travel through and/or around slurry walls. Further, while the slurry wall is purported to be keyed into a "low permeability" layer, from the geological information available for the Aber Road facility, the extent to which this keying occurs may not be sufficient to intercept all pathways that could transport leachate-contaminated groundwaters from under the slurry wall to off-site groundwater and surface waters. As discussed by Bennett and Williams (1999) the stratigraphy of the Aber Road site is such that there may be vertical pathways (such as sand columns, cracks in lower permeability till layers) that can allow the transport of leachate polluted groundwaters to lower stratigraphic units which can serve as a pathway under a slurry wall.

It is also well-known that slurry walls have relatively high permeabilities compared to what is needed to be a significant barrier to the transport of leachate-contaminated groundwater through them. Slurry walls, such as those made of soil-clay mixtures, if properly constructed, typically at the time of construction, have permeabilities on the order of 10^{-6} cm/sec (Millett *et al*., 1992; Khera and Tirumala, 1992). While the laboratory testing results of the soil-bentonite mixture that was used in the slurry wall was reported (Parsons, 1998) to have permeabilities of less than 10^{-7} cm/sec, the testing procedures used are not reliable for evaluating the permeability of the in-place slurry wall. It will have considerably higher permeabilities than those reported by Parsons (1998), Inc, the BFI/CECOS consultant for the slurry wall development.

This means that even if the slurry wall were free of cracks and other anomalous areas of higher permeability, leachate-contaminated groundwater will pass through the slurry wall within a few years, unless there is a large inward advective transport of groundwater from outside the slurry wall into the slurry walled area. Based on the review by Gray (1999) and Bennett and Williams (1999), there is concern about the slurry wall and about the pumpdown well spacing relative to maintaining an inward gradient in all areas between pumpdown wells. There could be areas next to the pumpdown wells where there is a strong inward gradient across the slurry wall and areas of outward gradients between the pumpdown wells.

One of the major aspects of the slurry wall system that is of concern is the lack of assured funding to continue to operate and maintain the slurry wall pumpdown system for as long as the wastes within the slurry wall represent a threat. BFI/CECOS should be required to develop a dedicated trust fund based on cash transfers to the fund that can be used to insure that this slurry wall groundwater pollution containment system is operated and maintained effectively forever.

Another of the concerns about the slurry wall is the potential for cracks to develop in it. Seasonal changes in the water table elevation can cause moisture changes in the slurry wall at the water table, which can lead to cracking of the upper layers of the slurry wall. These cracks do not necessarily re-heal to the same original designed/constructed permeability when the water table is elevated above the crack.

Further, cracking will likely occur in the cap of the slurry wall constructed at the BFI/CECOS facility. Compacted clay layers of this type are well-known to develop significant cracks within a few years after construction. Montgomery and Parsons (1994) in Wisconsin found, in a study of compacted soil layers that were designed to simulate clay layers in landfill covers, that cracks up to 0.5 inches wide which extended to 35-40 inches into the clay layer developed within three years.

Shackelford (1988), Gray (1995) and Gulick *et al.* (1996) have discussed the importance of considering diffusion as a mode of transport of pollutants through slurry walls. For the reasons described above as well as the analyses performed by Gray (1999) and Bennett & Williams (1999), it is concluded that the BFI/CECOS Aber Road facility slurry wall will not be an effective barrier to the transport of pollutants from inside the slurry wall to outside the wall.

Ultimate Failure of Groundwater Well Abandonment Grout

BFI/CECOS has abandoned about 200 wells at the Aber Road site. The method used in abandoning these wells (grouting), while conventional, will not necessarily prevent the interconnection of water-bearing strata through the abandoned wells. It is well known that the procedures that have been and continue to be used today that involve the abandonment of a well through grouting can ultimately fail to prevent inter-layer transport of polluted groundwaters. Grouting can, if properly implemented, create an effective seal which can prevent the well from serving as a conduit between various permeable layers. However, at a site like the Aber Road facility, ultimately, through chemical reactions, cracks can develop in the grout that will allow transport of polluted groundwaters through an abandoned well.

The Ohio EPA review of the BFI/CECOS Closure/Post-Closure Plan should have discussed that there are a large number of abandoned wells that exist at this site which, prior to grouting, served as a conduit for polluted groundwater to move vertically at the site. Further, in time, these abandoned wells, even though grouted, will ultimately serve as conduits further connecting the permeable strata underlying the hazardous waste cells. The groundwater monitoring program for the BFI/CECOS site must recognize that the abandoned, as well as some of the existing groundwater monitoring wells, will serve as conduits that will allow polluted groundwaters to move vertically.

Radioactive Wastes

The monitoring programs should include the measurement of radioactivity. The procedures that were used by BFI/CECOS to screen for radioactivity in the waste entering the Aber Road facility were not effective. The first of these, which employed a geiger counter to screen the trucks as they entered the facility, would only detect high levels of gamma radiation; it would not detect alpha and many radioactive isotopes that emit beta radiation. The second of these, having an employee walk over the top of the surface of the landfill area with a geiger counter, would not detect many hazardous radioisotopes present in the landfill cells. Accordingly, analysis of the individual cell leachate, underdrains, and groundwater must include regular measurement of radioactivity. In order to provide public health and environmental protection, it will be necessary to monitor for gross alpha, gross beta and gamma radiation at quarterly intervals.

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Other papers and reports developed by Dr. Lee pertinent to these comments are available from his web site: http://members.aol.com/gfredlee/gfl.htm.

QUALIFICATIONS TO UNDERTAKE REVIEW

Dr. G. Fred Lee is president of G. Fred Lee & Associates, an environmental consulting firm located in El Macero, California. For 30 years Dr. Lee held university faculty graduate-level teaching and research positions at the Universities of Wisconsin, Madison and Texas at Dallas, and at Colorado State University. In 1989 he retired from university graduate level teaching and research as a Distinguished Professor of Civil and Environmental Engineering at the New Jersey Institute of Technology. While holding university professorial teaching and research positions, Dr. Lee taught university graduate level environmental engineering courses devoted to landfill design and evaluation of the impact of landfills on public health and the environment.

Since retiring from university teaching he has been active in presenting one- and two-day short-courses to professional engineers and scientists on landfills and groundwater quality protection issues. He has made these presentations through the University of California Extension Programs for the University of California Berkeley, Los Angeles, Riverside, Santa Barbara and Davis. Also, he has presented these short-courses under the sponsorship of the American Society of Civil Engineers, the American Water Resources Association and the National Ground Water Association in New York City, NY; Atlanta, GA; Chicago, IL; Reno and Las Vegas, NV; Tucson, AZ; and Seattle, WA. Dr. Lee is frequently an invited lecturer on landfill issues and has been an American Chemical Society (ACS) tour speaker on these and other issues over the past 20 years. He has discussed landfill and groundwater quality protection issues at about 60 ACS local section meetings throughout the US.

Dr. Lee holds a PhD degree from Harvard University in environmental engineering and environmental sciences and a Master of Science in Public Health degree from the University of North Carolina. He obtained a bachelor's degree from San Jose State University.

Dr. Lee has conducted over $5 million in university graduate-level research on various aspects of water quality and solid and hazardous waste management. This research has included pioneering work on the ability of landfill liners to prevent leachate from passing through them for as long as the wastes in the landfill represent a threat. He has published more than 850 papers and reports on his work. A listing of many of his recent papers and reports pertinent to landfills and groundwater quality protection issues is appended to this report.

He has served as an advisor to numerous governmental agencies and industries in the US and other countries on water quality and solid and hazardous waste management issues. A list of landfill projects that he has been involved with is appended to these comments. These projects in general involve work on behalf of municipalities, water utilities and others in evaluating the potential impact of a proposed or existing landfill on public health, groundwater resources and the environment as well as the interests of those who own or use properties within the sphere of influence of a landfill.

Dr. Lee is a registered Professional Engineer in Texas and a Diplomate in the American Academy of Environmental Engineers.

Dr. Lee has over 35 years experience in addressing the impact of municipal solid waste and industrial hazardous waste landfills on public health and the environment, pollution of groundwater by landfills, evaluation of the ability of landfill liners and liner systems to prevent groundwater pollution, and monitoring of groundwater quality near landfills. His work includes evaluation and management of the adverse impacts of municipal solid waste (MSW) and industrial hazardous and non-hazardous waste landfills and the development of approaches to eliminate adverse impacts on those who own or use properties near a landfill. He has extensive academic and professional background, understanding and expertise in the chemical characteristics of wastes and their potential to pollute air and groundwater; landfill processes; impact of chemicals on beneficial uses of surface and groundwater; and the nature, transport, and transformation of chemical contaminants in surface and groundwater systems.

Dr. Lee's work on landfill pollution of groundwaters began in the 1970s while he was Professor of Water Chemistry at the University of Wisconsin, Madison in the Department of Civil and Environmental Engineering. From that time he has been involved in the review of approximately 50 existing or proposed landfills, helping an entity or group evaluate the potential for groundwater pollution and other adverse impacts of a landfill.

His work on hazardous waste management started in the early 1970s when he held a Professorship of Engineering at the University of Texas at Dallas. In the early 1980s, he helped develop and then directed the Center for Environmental Studies at the University of Texas, Dallas. One of his major research areas in this position was devoted to groundwater quality protection from hazardous chemicals, such as those used by industry. Under sponsorship of the US EPA National Groundwater Research Center, Dr. Lee undertook the first research ever initiated on the ability of compacted clay liners to prevent organics from being transported through the liner. This led to the discovery of the impact of organics on clay liners. It was the work of Dr. William Green, who was a post-doctorate fellow working in Dr. Lee's program, that showed that organic solvents of the type that then were being disposed of in various types of lagoons and in landfills could interact with clay liners, causing them to shrink and crack, allowing rapid transport of the organics through the liner. This work initiated a series of investigations supported by the US EPA and others on the appropriateness of using clay liners for waste lagoons and landfills.

In about 1980, Dr. Lee began to work on behalf of Brush, Colorado, helping this community review the potential of a then-proposed hazardous waste landfill that would be constructed in the municipal water supply groundwater well field area to pollute the groundwaters of the region by landfill leachate. At that time, the landfills were being designed with only compacted clay liners. He pointed out that the proposed liner system for this landfill would not prevent groundwater pollution. His work on this landfill situation led to the development of a professional paper entitled, "Is Hazardous Waste Disposal in Clay Vaults Safe?" This paper was co-authored by R.A. Jones and was published in the *Journal of the American Waterworks Association*. In 1984 it was judged by the Water Resources Division of that Association as the best paper published in the journal during 1982. This paper discussed the fact that hazardous waste landfills of the type being developed at that time would not protect groundwaters from pollution by landfill leachate.

By the mid-1980s, plastic sheeting liners were beginning to be used for landfills and waste management lagoons. At that time, Dr. Lee held a Distinguished Professorship in Civil and Environmental Engineering at the New Jersey Institute of Technology. One of his research areas was devoted to assessing the ability of plastic sheeting liners to prevent leachate from passing through them. This work led to the conclusion that HDPE liners, which are similar to liners being used today, would for a period of time prevent leachate from passing through them in liner systems that are properly constructed. Ultimately, however, these liners would fail, and leachate would pass through the liner, polluting groundwaters associated with the landfill. Further, then, as now, because of the limited experience with the use of these liners and the fact that problems were beginning to be found with their integrity over much shorter periods of time than would be expected based on normal deterioration of plastics, there was considerable concern about how well these liners would perform over the long-term. It was about that time that stress cracks were beginning to be observed in HDPE liners.

It is well-known now that over time HDPE and other plastic sheeting liners deteriorate and eventually become ineffective as a liner material. Dr. Lee has published extensively on this topic in which he has prepared comprehensive literature reviews on it. A list of his references on this topic is appended to this report. Further, his papers provide extensive reference to the literature covering the work of others on this topic. Dr. Lee's papers, available from his web site, http://members.sol.com/gfredlee/gfl.htm, provide backup information to the statements made in this report on the ability of plastic sheeting liners to prevent leachate passing through them for as along as the wastes in the landfill will be a threat. His recent papers;

"Assessing the Potential of Minimum Subtitle D Lined Landfills to Pollute: Alternative Landfilling Approaches," Proc. of Air and Waste Management Association 91st Annual Meeting, San Diego, CA, available on CD ROM as paper 98-WA71.04(A46), 40pp, June (1998).

and

"Deficiencies in Subtitle D Landfill Liner Failure and Groundwater Pollution Monitoring," Presented at the NWQMC National Conference *Monitoring: Critical Foundations to Protect Our Waters*, US Environmental Protection Agency, Washington, D.C., July (1998)

summarize the most recent information of many of the problems with hazardous and solid waste landfill containment systems and their monitoring.

As discussed herein, while HDPE and other types of plastics can provide for short-term containment of wastes in a properly designed and constructed landfill, these liner systems will deteriorate and ultimately fail to prevent leachate from passage through them. It began to be recognized in the mid-1980s that the "dry tomb" landfilling approach that was originally adopted in the early 1980s, which is the same type of landfilling approach that BFI/CECOS used at the Aber Road facility was a fundamentally flawed technology that would not protect groundwater from pollution by landfill leachate for those landfills sited, like the landfill cells that BFI/CECOS has developed at the Aber Road facility, where there are high-quality groundwaters hydraulically connected to the landfill.

In the early 1980s, Dr. Lee worked as an advisor to several governmental agencies in developing landfilling regulations. This work included advising the state of California Water Resources Control Board on the development of Chapter 15 governing the landfilling of wastes within the state. Dr. Lee also served as an advisor to a state of Texas legislative committee on managing hazardous wastes. Dr. Lee served as an advisor to Governor Lamm of the state of Colorado on the Lowry Hazardous Waste Landfill issues. In 1984, Dr. Lee was awarded a contract by the state of Michigan Toxic Substances Control Commission devoted to review of the state's landfilling regulations.

Dr. Lee' s recent experience in evaluation of the potential for a hazardous waste landfill to pollutant groundwater include assisting Ypsilanti, MI evaluate the threat that the Wayne Disposal Industries hazardous waste treatment and landfill disposal facility represents to the

Ypsilanti groundwater-based domestic water supply. He has also recently assisted New Haven, IN evaluate the threat that a Waste Management of Indiana hazardous waste landfill represents to the New Haven groundwater-based domestic water supply.

Dr. Lee also has approximately 40 years of experience working on domestic water supply water quality with emphasis on protection of water supply water quality through management of activities within a water supply's watershed. He is past chair of the American Water Works Association Quality Control in Reservoirs Committee.

Dr. Lee has extensive experience in work with PCBs in the environment. While teaching at the University of Wisconsin, Madison, his graduate students worked under his supervision on determining the sources, fate and potential water quality significance of PCBs. He is also familiar with the public health and water quality significance of PCBs. He served as chairman of a US Public Health Service committee reviewing the need for developing PCB drinking water standards.

The author, Dr. G. Fred Lee, has been involved in surface and groundwater sampling program development and results evaluation for approximately 40 years. He pioneered in new developments, published papers and presented lectures and short-courses on the topic of adequate/reliable surface and groundwater monitoring and interpretation of monitoring results. In 1983 at a National Water Well Conference held in Columbus, Ohio, Dr. Lee was one of the first to discuss the inadequacies of the typical groundwater quality monitoring programs that were being used at hazardous waste landfills. At this conference he presented a paper, "Water-Quality Monitoring at Hazardous Waste Disposal Sites: Is Public Health Protection Possible through Monitoring Programs?" (Lee and Jones, 1983). Further, Dr. Lee has pioneered in developing surface water quality monitoring programs for hazardous chemical sites where he presented a paper, "Stormwater Runoff Water Quality Evaluation and Management Program for Hazardous Chemical Sites: Development Issues," at the American Society for Testing and Materials Superfund Risk Assessment In Soil Contamination Studies conference which was held in January 1998 (Lee and Jones-Lee, 1998c).

In addition, he has been recently asked by the editor of the journal, *Remediation*, (published by Wiley & Sons) to develop a paper discussing appropriate monitoring of surface waters associated with hazardous chemical sites. A preprint of this paper, "Evaluation of Surface Water Quality Impacts of Hazardous Chemicals," (Lee and Jones-Lee, 1999) which will appear in *Remediation* is available from Dr. Lee's web site. His background and extensive expertise in analytical chemistry, aquatic chemistry, aquatic water quality-oriented biology/toxicology, public health and environmental engineering enable him to provide high degrees of expertise and experience developing and, for existing surface and groundwater quality monitoring programs, evaluating the adequacy of water quality and environmental monitoring programs that are designed for public health, groundwater resource and environmental protection.

Dr. Lee is qualified to undertake a critical review of the adequacy of closure and post-closure monitoring and maintenance of the BFI/CECOS hazardous waste landfill cells, solid waste landfill, industrial waste landfills and other waste management units at the Aber Road facility to provide public health, groundwater resource and environmental protection from hazardous waste-associated constituents, including PCB wastes, for as long as the wastes in the landfill represent a threat.

DR. LEE'S RECENT PUBLICATIONS DEVOTED TO LANDFILL IMPACTS AND SOLID AND HAZARDOUS WASTE MANAGEMENT AND SUPERFUND INVESTIGATIONS

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