Comments on
"Remediation of Sydney Tar Ponds and Coke Ovens Sites Environmental Impact Statement, Sydney, Nova Scotia"

Dated December 2005

Comments submitted by
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May 15, 2006

The Sierra Club Cape Breton Group has requested that I conduct a critical review of the adequacy of the Environmental Impact Statement (EIS) for the proposed remediation of the Sydney Tar Ponds contaminated sediments and Coke Ovens Site contaminated soils in providing reliable information on the potential impacts and benefits of the Sydney Tarp Ponds Agency's (STPA's) proposed remediation project. My review focuses on the adequacy of the remediation approach in protecting public health and the environment from the residual pollutants in the "remediated" sediments for as long as they represent a threat.

Overall Assessment

Overall, I find that the Sydney Tar Ponds Agency's EIS for the proposed remediation of the contaminated sediments is highly deficient in providing the information that the governmental agencies and the public need to understand about the potential problems and benefits of the Agency's proposed approach of *in situ* mixing of cement or other materials with the contaminated sediments in preventing further pollution of surface and ground waters in the region and Estuary by the residual pollutants that will be present in the so-called "remediated" sediments. The Agency has failed to properly evaluate the potential for cement-based solidification/stabilization (S/S) to prevent continued release of pollutants such as PCBs, etc., that are a threat to public health and the environment. The Agency's proposed approach of creating a capped waste pile of "remediated" contaminated sediments ignores the inability of the proposed cap to prevent water infiltration into the remediated sediments, which can in turn leach pollutants from these sediments. This capped waste pile is not a secure approach for containing/managing residual pollutants that can be mobilized from the solidified sediments.

Similar problems exist with respect to remediation of the Coke Ovens Site contaminated soils, where the "remediated" soils will be capped by a thin layer of soil. This capped waste pile will continue to release residual pollutants in the Coke Ovens Site "remediated" soils, which are a threat to public health and the environment.

The Agency has failed to reliably report on the ultimate failure of various types of barriers (such as plastic sheeting) that are proposed to prevent migration of "remediated" contaminated sediments/soils from escaping from the capped waste piles into the environment, which will lead to long-term continued pollution of the Estuary.

Qualifications to Provide Comments

The expertise needed to critically review the proposed Sydney Tar Ponds and Coke Ovens Site sediment/soils remediation approach includes an in-depth knowledge of leaching from aquatic sediments and treated wastes; solidification/stabilization of wastes; landfill design, operation, maintenance and monitoring; impacts of pollutants on public health and the environment; environmental engineering; aquatic chemistry; biology and related areas. These are all areas in which I have been involved throughout most of my 45-year professional career.

I obtained a BA degree from San Jose State College in San Jose, California, in 1955. I obtained a Master of Science in Public Health (MSPH) from the University of North Carolina, Chapel Hill, School of Public Health in 1957. I obtained a PhD degree in Environmental Engineering from Harvard University in 1960. My areas of expertise include water supply water quality; water and wastewater treatment; water pollution control for groundwaters and for fresh and marine surface waters; and solid and hazardous chemical/waste impact investigation and management.

After obtaining my PhD degree in 1960, for 30 years I held university professorial positions at several US universities, including for 13 years at the University of Wisconsin, Madison. During my university graduate-level teaching and research career I conducted about $5 million in research and published about 500 papers and reports on this research. One of the areas of my research was studies on the ability of compacted clay and plastic sheeting (HDPE) landfill liners and caps to prevent moisture and landfill leachate from passing through them for as long as the wastes in a landfill/capped waste pile are a threat to pollute groundwaters underlying the landfill or capped waste pile. Another area in which I have been active in research and consulting is in the management of contaminated aquatic sediments.

In 1989 I retired from 30 years of university teaching and research and expanded my part-time private consulting activities to a full-time activity. Since then Dr. Anne Jones-Lee (my wife) and I have been the principals in our firm, G. Fred Lee & Associates. We work on advanced level water quality impact evaluation and management. Since 1989 we have published an additional approximately 600 papers and reports in the areas in which we are active. These publications are available from our website, www.gfredlee.com.

Work on Impacts of Landfills and Capped Waste Piles. One of the areas of our activity is evaluation of the potential public health, groundwater and surface water resource and environmental impacts of proposed landfills and landfill expansions, including capped waste piles. We have worked on about 85 landfills (see Appendix A, pages 7-8), including 12 hazardous waste landfills and eight landfills at Superfund sites. I have also served as an advisor to a hazardous waste landfill developer and to several companies, including IBM corporate headquarters on managing hazardous waste. Our work has also included advising governmental agencies on appropriate landfilling regulations. Attached to these comments as Appendix A is a summary of my academic and professional experience pertinent to my conducting this review of the proposed remediation of the Sydney Tar Ponds contaminated sediments and Coke Ovens Site soils.

Experience with Solidification/Stabilization and Leaching of Aquatic Sediments and Wastes. A key component of evaluation of solidification/stabilization (S/S) is an appropriate evaluation of the potential for leaching of pollutants in the S/S-treated waste. I have been involved in evaluation of release (leaching) of pollutants from sediments/soils since the early 1960s. At the University of Wisconsin, Madison, where I established and directed for 13 years the Water Chemistry Program, I devoted considerable effort to investigating the leaching/release of pollutants from aquatic sediments. This graduate degree program was designed to provide students, typically with a chemistry/chemical engineering background, an education in the sciences/engineering needed for careers in water quality management. The focus of this program was research on the aqueous chemistry of pollutants as they may impact a waterbody's water quality. The interaction of chemicals (pollutants) with sediments was a major focus of the over $5 million in university graduate-level research that I conducted during my 30-year university career.

During the 1970s, when I was Director of the Center for Environmental Studies at the University of Texas at Dallas, I conducted over $1 million in research on the release of pollutants from dredged sediments as part of the US Army Corps of Engineers Dredged Materials Research Program (DMRP). The DMRP was designed to evaluate the potential impact of open-water disposal of contaminated dredged sediments. Of particular concern was the release of some 30 potential pollutants (heavy metals, organics, nutrients, pesticides, PCBs, etc.) when suspended in the water column. The results of my DMRP research served as part of the basis for the US EPA and Corps of Engineers' regulatory approach governing the disposal of dredged sediments. A major part of this research was devoted to an evaluation of the Elutriate Test as a measure of leaching of chemicals from the polluted dredged sediments.

In the 1980s I held the position of Distinguished Professor of Civil and Environmental Engineering at the New Jersey Institute of Technology. I also held the position of Director of the Site Assessment and Remediation Division of a multi-university Hazardous Waste Research Center. In addition, I chaired the New Jersey Sea Grant water quality research program. One of the topics of my activities was an evaluation of the use of cement-based solidification of domestic wastewater sludges. Of particular concern was an evaluation of the Chemfix solidification process. I was also a part-time consultant to EBASCO Services, helping the staff conduct Superfund RI/FS investigations. Solidification/stabilization was one of the remediation approaches investigated, which included oil/tar waste.

An area of my university research was the reliability of the US EPA approach for classification of solid wastes as "hazardous" versus "nonhazardous." The US EPA developed the Extraction Procedure Toxicity Test (EP Tox Test) as a basis for determining whether solid waste should be classified as hazardous. This test is patterned after the dredged sediment elutriation test. While the dredged sediment elutriation conditions make sense for dredged sediment open-water disposal, similar conditions have no validity for the leaching of constituents in a solid waste landfill. The liquid-to-solid ratios used, redox conditions, pH and exposure surface area of the solid particles are all highly arbitrary.

The problems of the EP Tox Test became so well known that the US Congress ordered the US EPA to develop, as part of revising the Resource Conservation and Recovery Act (RCRA), a more reliable test for hazardous waste classification based on their leaching from the waste solids. This led to the development of the Toxicity Characteristic Leaching Procedure (TCLP). While the TCLP is somewhat improved over the EP Tox Test, it is still an arbitrary testing procedure for evaluation of the leaching of pollutants from solids and for hazardous waste classification.

The interpretation of what constitutes excessive leaching in the EP Tox Test and TCLP is an example of an arbitrary approach on the part of the US EPA in defining hazardous waste. The allowed attenuation factor (5-to-1 dilution is assumed) will, for some hydrogeological groundwater systems, be overprotective, and for others, underprotective. Yet the characteristics of the hydrogeology of the site are not taken into account in interpreting the results of the test to determine whether a waste can be placed in a nonhazardous waste landfill or capped waste pile.

In an effort to try to improve the reliability of hazardous waste classification based on leaching characteristics, Lee and Jones published a paper,

> Lee, G. F. and Jones, R. A., "Application of Site-Specific Hazard Assessment Testing to Solid Wastes," In: Hazardous Solid Waste Testing: First Conference, ASTM STP 760, American Society for Testing and Materials, pp 331-344 (1981).

This paper discussed the problems with the EP Tox Test reliably classifying a solid waste as a hazardous waste. This paper received the Charles B. Dudley Award - American Society for Testing and Materials award for contribution to Hazardous Solid Waste Testing.

The technical problems of the TCLP in evaluation of the leaching characteristics of pollutants associated with solid wastes and sediments carry over to evaluation of the leaching of pollutants from solids such as in S/S-treated wastes. Pollutants leached from a solid that passes the TCLP as "nonhazardous" can still be a significant threat to water quality. This situation is often overlooked in evaluating the adequacy of the treatment of S/S-treated wastes that are to be managed by placement in a capped waste pile and/or an inadequately located, designed, constructed, operated and maintained landfill.

Experience in Working with PCB Pollution Issues. In the 1960s, when I held the position of Professor of Water Chemistry and Director of the Water Chemistry Program at the University of Wisconsin, Madison, I had a number of graduate students do their masters theses and PhD dissertations on the occurrence, fate and effects of organochlorine pesticides in aquatic systems. As part of this work we discovered that what some other investigators were calling DDT residues in birds was not DDT, but was PCBs. My graduate students and I were among some of the first in the US to investigate PCB occurrence in aquatic systems, and their sources. I had several students do their masters theses and PhD dissertations on these issues.

Our pioneering work on PCBs gained national recognition, including my being interviewed by Walter Cronkite for the *CBS Evening News*. One of my graduate students whose PhD dissertation was devoted to PCB issues, Dr. Gilman Vieth, became employed by the US EPA and directed the Agency's work on PCBs in the 1970s, which led to the PCB regulations that were adopted as part of the Toxic Substances Control Act (TSCA).

Because of the widespread occurrence of PCBs in aquatic sediments, the US Army Corps of Engineers issued a contract to me to develop a review of PCBs in sediments that could affect the Corps' dredging of US waterway sediments to maintain navigation depth. This work resulted in the publication of

> Lee, G. F. and Jones, R. A., "Significance of PCBs in Dredged Sediment," Final Report to the US Army Engineer Waterways Experiment Station, Vicksburg, MS, August (1979).

PCBs were one of the organochlorine compounds that were investigated in the approximately one-million-dollar Corps of Engineers contract that I held, investigating the release of pollutants from contaminated dredged sediments. These studies included sediments from about 100 different sites across the US. Further, as part of the American Fisheries Society's review of the US EPA "Red Book" of Water Quality Criteria 1976, I served as a member of the PCB criterion review panel. In addition, on behalf of the US Public Health Service, I chaired a committee responsible for evaluating the need for a drinking water MCL for PCBs.

I have been involved in several situations concerned with PCB-polluted sediments, including the Hudson River and Hudson River Estuary near New York City. On several occasions I was asked by the US EPA Region 2 to provide advice on the approach that should be used to control excessive PCB accumulation in striped bass in the Hudson River. I was also involved as an advisor on PCB accumulation issues in the Upper Fox River in Wisconsin. My work on managing PCB-contaminated sediments included serving as an advisor to Outboard Marine Corporation on the pollution of Waukegan Harbor's (Wisconsin) pollution of sediments by PCBs. In addition, PCBs are an issue of concern at the UCD/DOE LEHR National Priority List Superfund site where I serve as the US EPA-sponsored Technical Assistance Grant advisor to the public on the adequacy of the site investigation and remediation.

Overall. The comments presented herein focus on a review of the STPA's EIS in providing reliable information to decision-makers and the public on the ability of the S/S-treated Tar Ponds contaminated sediments and Coke Oven Site remediated soils in preventing further releases of pollutants that are a significant threat to public health and the environment. I have considerable experience in reviewing environmental impact statements/reports. This experience includes the development of such statements/reports. I find that the Agency's EIS is largely designed to support the Agency's position that the S/S-treated Tar Ponds sediments will be protective of public health and the environment. However, this EIS fails to meet the full disclosure standards that typically apply to EIS/EIRs.

In summary, I have extensive experience in the technical issues that are pertinent to an in-depth review of the adequacy of the STPA's EIS in describing the potential impacts and benefits of the proposed Sydney Tar Ponds and Coke Oven Site remediation.

Specific Comments on the STPA EIS

Specific comments on the EIS are presented below.

Executive Summary. The Executive Summary (ES) page 2-3 states, *"The Project has two primary objectives. The first is to reduce the current ecological and health risk from existing soil, sediments, and water contamination. The risk of human exposure to contaminated material on the site is currently being managed through fencing and access controls. The existing risk to ecological receptors associated with releases to Sydney Harbour has been, in part, addressed through ongoing clean-up activities and natural processes. The implementation of the Project will further reduce the potential health and ecological risk by removing, treating, or isolating contaminants of concern."*

The key issue that needs to be addressed in this EIS is whether the proposed contaminated sediment remediation approach involving cement-based or other solidification/stabilization approaches will protect public health and the environment from pollutants in the remediated sediments that are proposed to be left in the Estuary under a soil cap. As discussed herein, the Agency's proposed remediation approach will not prevent further leaching of pollutants from the contaminated sediments, and the proposed capping of the remediated sediments will not prevent water from infiltrating into the S/S-treated sediments that will lead to further release of these pollutants to the environment.

While the Agency's proposed approach for remediation of the Tar Ponds sediments will likely reduce the rate of environmental pollution, this reduction will not likely be sufficient to conclude that the remediation approach is an adequate, effective approach for public health and environmental protection. Basically, this approach is a short-term, stop-gap approach that will enable the Agency to claim that it has "remediated" the Tar Ponds sediments, when in fact it has conducted a superficial, inadequate remediation approach. Adoption of this approach will almost certainly lead to the need to conduct significant additional remediation of the so-called "remediated" sediments in order to truly protect public health and the environment from the residual pollutants in the Tar Ponds sediments.

A far more effective approach for remediation of the Tar Ponds sediments and Coke Ovens Site contaminated soils would involve removal of the pollutants from the sediments/soils so that the residual contaminants in the remediated sediments/soils do not represent a threat to public health and the environment. While this approach is initially more expensive than that proposed by the Agency, in the long term it would be a more cost-effective remediation of the contaminated sediments/soils and, most importantly, could eliminate the long-term threat that the residual pollutants in the treated sediments/soils represent to public health and the environment.

ES page 2-5 states,

"The Tar Ponds have created a stigma for Sydney which has acted as a serious impediment to the attraction of new business and opportunities to the municipality. Remediation efforts are expected to result in considerable qualitative and tangible socio-economic benefits such as the transformation of unused vacant lands near the center of Sydney to an area suitable for passive and active recreation, commercial development, or light industrial land uses. It is anticipated that the remediated lands will stimulate renewed conviction in Sydney as a place to invest and grow commercial enterprise."

Such an optimistic statement about the potential benefits of the proposed remediation approach can readily be in significant error if it is found, as will likely be the case, that the S/S-treated contaminated sediments that are stored under a soil cap in the Estuary are still releasing chemicals at a sufficient rate to continue to pollute the environment. This situation could readily cause the public to conclude that the Agency has not properly evaluated the effectiveness of the S/S treatment of the Tar Ponds polluted sediments in protecting the public's interests.

ES page 2-6 states,

> *"Materials contaminated with PCBs and PAHs will be removed and safely destroyed using high temperature incineration. The remaining sediment in the Tar Ponds will be treated using solidification and stabilization. The top 0.5 metres (m) of remaining contaminated soil at selected areas on the Coke Ovens site will be treated using landfarming, a form of bioremediation.*
>
> *Both sites will then be capped using engineered containment systems designed to prevent human and environmental exposure to contaminants, and to prevent the movement of contaminants off site. Containment at the Tar Ponds and Coke Ovens sites will consist of groundwater control measures (e.g., vertical walls, interceptor trenches) installed at various locations around the site perimeters, and engineered covers consisting of semi-impervious, reinforced, multi-layered soil barriers designed to limit water penetration and facilitate future site uses.*
>
> *Wastewater generated during the excavation activities of the Tar Ponds and the drying of the sediments, as well as contaminated groundwater and surface water from the excavations and the landfarming activities at the Coke Ovens site will be treated in an on-site wastewater treatment plant.*
>
> *Final restoration and landscaping of both sites will be compatible with the natural surroundings and future use."*

The above description of the proposed remediation approach for the Tar Ponds and Coke Ovens Site sediments and soils fails to discuss the numerous technical problems with this proposed approach in achieving near-term and especially long-term public health and environmental protection. Those not knowledgeable in the details of this approach and its potential problems could be misled to believe that this is a technically valid, cost-effective approach for managing the PCBs, PAHs and other pollutants in the contaminated Tar Ponds sediments that are to be S/S-treated and then stored in a capped waste pile in the Estuary. However, as discussed below, the proposed remediation approach is fraught with significant technical problems and is subject to failure to prevent further pollution of the Estuary and the environment by residual pollutants in the remediated sediments. Further, the projected costs of remediation are artificially low since they do not adequately consider the long-term costs of having to perform further remediation on the S/S-treated, capped contaminated sediments.

ES page 2-6 further states,

"The operation phases of the Tar Ponds and the Coke Ovens sites have been defined as the ongoing operation of the remediated sites and the associated elements such as the engineered cap, and systems for surface water and groundwater control, water treatment, and monitoring. The operation is anticipated to extend over several decades.

Containment systems require long term monitoring to ensure their continued effectiveness. The remediation plan includes provisions for long term monitoring of air quality, water quality, soil, sediment, biota, and the performance of the containment system, and long-term maintenance of the sites.

Both the Tar Ponds and the Coke Ovens sites will operate indefinitely. The decommissioning phase for these sites therefore is only relevant for certain operational infrastructure features that will be phased out over time (e.g., groundwater collection and treatment systems).

The proposed remediation of the Tar Ponds and Coke Ovens sites is based on technologies that have been demonstrated to be safe and effective on similar contaminated sites."

The above discussion continues to mislead reviewers in understanding the deficiencies in the proposed approach with respect to being able to reliably monitor the effectiveness of the cap overlying the S/S-treated waste pile in preventing moisture from entering the waste pile that can mobilize pollutants in the sediments/soils. Also, as discussed below, the extent of required operation of the infrastructure features such as groundwater collection and treatment, and the associated monitoring, is significantly underestimated.

With respect to the proposed technology having *"…been demonstrated to be safe and effective on similar contaminated sites,"* this is a self-serving statement on the part of the Agency staff in support of an inadequately evaluated remediation approach. Contrary to the statements made, attempts to follow a similar approach have not been proven to be effective and safe for similar kinds of polluted materials. As discussed below, while this approach has been used at other locations, a critical review of the success of the remediation in providing true and effective long-term public health and environmental protection has not been conducted.

Review of Proposed Remediation Approaches for Tar Ponds Sediments and Coke Ovens Site Soils. Volume 1 Section 2 of the Agency's EIS provides additional details beyond those summarized above from the EIS Executive Summary on the proposed remediation approaches for the Tar Ponds sediments and Coke Ovens Site soils. Basically, for the Tar Ponds, the Agency is proposing to remove the upper one to two meters of Tar Ponds sediments to be transported to an off-site incinerator, where the sediments will be dried and incinerated to destroy PCBs and other organics. As stated on page 2-20 in Volume 1 of the EIS,

"The residual contaminated sediments at the North and South Tar Ponds will be solidified and stabilized in-place (this will take place after the removal of PCB contaminated sediments described in Section 2.2.1.3). Solidification involves the

addition of a reactive additive to the sediments. This could be a substance such as Portland cement, hydrated lime, lime kiln dust, or fly ash to increase strength, reduce permeability, and decrease contaminant mobility."

A review of this section of the EIS and elsewhere would lead those not knowledgeable in the topic to believe that S/S treatment technology is highly effective in immobilizing organic contaminants in treated wastes. Even a superficial review of the literature as provided by the Portland Cement Association of the US and the Cement Association of Canada would lead a reviewer to believe that S/S treatment of high-organic wastes, such as in the Tar Ponds, is highly effective in preventing leaching/release of pollutants from the S/S-treated wastes. However, Wiles and Barth (1992), in a paper, "Solidification/Stabilization: Is It Always Appropriate?" have discussed the fact that, while there has been some use of cement-based S/S for high-organic wastes, the evaluation of the effectiveness of this use for such wastes is lacking. They state in their Abstract,

"The increasing use of solidification/stabilization (S/S) technologies in the United States, especially for remediation of sites under the Superfund program, has raised several questions about the overall appropriateness of S/S. For many types of hazardous waste, notably for heavy metals, S/S usually gives excellent results for long-term immobilization, as measured by existing physical and chemical protocols. However, results of several studies, as well as data from remediation of several Superfund sites, have raised concerns about whether S/S is a valid technology for treating organic-bearing wastes. Even when applied to heavy metals, S/S requires careful choice of proper binders (recognizing the amphoteric behavior of certain metals) and good quality control throughout the process. Lack of good investigative procedures has diminished the value of data for evaluating S/S for some metals. Furthermore, studies also provide evidence that tests other than the regulatory extraction tests [for example, toxicity characteristic leaching procedure (TCLP)] will be required to evaluate the effectiveness of S/S, especially when applied to organic wastes. Suggestions are offered for improving treatability studies used for evaluating S/S applied to selected metals. Approaches are also provided for determining the appropriateness of S/S applied to organic contaminants."

The summary of the Wiles and Barth paper states,

"This paper discussed some approaches for determining whether or not organic contaminated soils should be treated by S/S technologies. The approaches are conservative and give little recognition to the physical characteristics of the solidified waste forms in the immobilization process. These approaches are also based upon technical rather than regulatory considerations after reviewing available information on the S/S of organic wastes. Several instances have been reported where processors have claimed treatment of organics by S/S. In most but not all of these, the experimental approach was too limited. Measuring organic content before treatment and after treatment without controls to collect and analyze air emissions is not acceptable. Many, if not all, of the volatile and semivolatile organics will "disappear" during the process

because they volatilize. Much more sound scientific evidence is required before S/S of organic contaminated waste can become routine practice."

Wiles and Barth, at the time they developed this paper, were with the US EPA Risk Reduction Engineering Laboratory in Cincinnati, Ohio. It was their responsibility to evaluate the effectiveness of S/S treatment of various types of wastes as part of the US EPA SITE (Superfund Innovative Technology Evaluation) program. In connection with conducting this review, I contacted Ed Barth regarding the current understanding of the effectiveness of using cement-based S/S to treat high-organic wastes such as those that are present in the Tar Ponds. He confirmed (Barth, pers. comm., 2006) that the situation today is no different than it was in 1992 when he and Wiles developed their paper on this issue. Basically, there are significant questions about whether cement-based S/S is an effective immobilization approach for high-organic wastes such as the Tar Ponds sediments. Therefore, the Agency's promotion for S/S for treating the Tar Ponds sediments based on the so-called widespread use of this approach is, at best, superficial and does not properly evaluate the effectiveness of such practice. This is an issue that the Agency should have discussed in a credible EIS, in order to inform regulatory decision-makers and the public about the potential problems associated with S/S of the Tar Ponds polluted sediments.

Based on information in the "2002 Technology Demonstration Program" and the "2005 Solidification Technical Memo Report" and several other reports, there are several aspects of the STPA's proposed S/S treatment of the Tar Ponds sediments that are of concern. These include the limited characterization of the chemical composition of the Sydney Tar Pond sediments and especially the heterogeneous composition of the sediments. This heterogeneity could readily impact the performance of the S/S in immobilizing the pollutants in the S/S-treated sediments.

An issue that apparently has not been considered/evaluated is that until recently raw domestic sewage was discharged to the Tar Ponds. This has introduced into the pond sediments sewage sludge and a wide variety of pollutants. From my own experience with the Chemfix process in attempting to use S/S on sewage sludge, the areas in the Tar Ponds where the sewage sludge has accumulated will have significantly different solidification characteristics and results. It does not appear that the areas of the ponds that have accumulated greater amounts of sewage sludge have been identified. These areas could require special solidification approaches to try to immobilize to the extent possible the pollutants associated with these areas.

Also of concern is that, in the demonstration study, the S/S-treated sediments leached pollutants to about the same extent as non-S/S-treated sediments. This could reflect the fact that the solubility of some of the organic pollutants in the sediments is controlled by water solubility of the chemicals, and that S/S treatment does not affect the release of pollutants. Basically, this could lead to a very long-term release of pollutants from the S/S-treated sediments into the infiltrating water that penetrates through the cap of the treated sediments.

The potential for the coal and coke in the sediments to have interacted with the tars/oils, producing a swollen solid material that behaves differently than coal or coke fines, is an unknown that needs to be evaluated with respect to long-term leaching characteristics.

The proposal to use *in situ* mixing of the S/S treatment agent is of major concern. Based on past experience related to this approach, there could readily be areas of the S/S-treated sediments that are not adequately mixed to achieve a uniformly treated sediment with low potential to leach pollutants when contacted by water.

Also of concern is the apparent low compressive strength of the S/S-treated sediments and that the S/S-treated sediments will not be a concrete monolith but be more granular. This will enable the water that infiltrates through the S/S-treated sediment cover to more readily leach pollutants from the treated wastes.

The EIS Section 2.2.1.5 "Containment of Residual Contaminants" states,

> *"An engineered surface cap will be placed over the Tar Ponds following removal of the PCB sediments and solidifying and stabilizing the remaining sediments. If applicable, a subaqueous cap will be placed over remaining sediments in excavated areas of the diversion channels. Low permeability vertical containment or interceptor walls (see Section 2.2.1.5) will be constructed along the shoreline of the Tar Ponds to prevent off-site groundwater from flowing onto the site and potentially contacting contained contaminants or bringing contaminants from outside sources onto the Project site.*
>
> *Containment technologies that effectively manage remaining exposure risks, can be implemented in a timely manner, and are generally economical. Capping and containment constitute one of the most common methods for dealing with hazardous wastes, especially at sites where large volumes of material need to be managed. This method has been successfully used throughout North America on sites similar to the Sydney Tar Ponds and Coke Ovens sites (STPA, 2004). Capping and containment were successfully used in Sydney on the old municipal landfill."*
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> *** * ***
>
> ***"Surface Cap***
> *The cap on the Tar Ponds site will be designed to contain residual contaminants, to reduce the possibility of human or ecological exposure to contaminants, and to limit the migration of contaminants off-site. The cap will limit the infiltration of precipitation through the cap and will limit the potential for plant roots, burrowing animals, etc. to physically penetrate the cap to the contaminated sediments.*
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> *The capping will be constructed using a combination of geotextiles, clay, and granular fill. An initial lift of approximately 0.5 to 1.0 m of clay and granular fill will then be spread across the fabric. As capping material is placed, the water depth will become shallower so that much of the Ponds will become exposed at low tide after the first lift is placed. In areas of the pond with standing water, even at low tide, alternate methods of material placement might be required for the initial lift. These will use placement by crane or even hydraulic sluicing or spraying of the material onto the geotextile. A second lift of granular fill will be placed to provide additional protection and ensure confinement of the sediments. Upon completion, the surface of the cap will either be*

raised so that it is above the high tide mark, or it will be left at an elevation where much of it will be inundated at high tide, similar to many salt marshes."

The statement quoted above,

> *"Capping and containment constitute one of the most common methods for dealing with hazardous wastes, especially at sites where large volumes of material need to be managed. This method has been successfully used throughout North America on sites similar to the Sydney Tar Ponds and Coke Ovens sites (STPA, 2004). Capping and containment were successfully used in Sydney on the old municipal landfill."*

is highly misleading with respect to capping being a successful method for preventing further pollution by the capped wastes. The ability of landfill liners and caps of the types used today to prevent precipitation (water) from entering the capped wastes, which can generate a leachate that can lead to surface and/or ground water pollution, is a topic that I have focused on as part of my professional career over the last 20 years. While the Agency's statement about capping being a widely used approach for landfills and waste piles is correct, what the Agency did not discuss is that it is well recognized that the cap (consisting of soil of the type that is proposed for the Tar Ponds and Coke Ovens sites "remediated" sediments/soils) is not an effective method for preventing water from entering the underlying wastes, which generates leachate that leads to further environmental pollution. In 2004 Dr. Anne Jones-Lee and I developed a comprehensive report,

> Lee, G. F. and Jones-Lee, A., "Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste," Report of G. Fred Lee & Associates, El Macero, CA, December (2004) updated March (2006).
> http://www.members.aol.com/apple27298/SubtitleDFlawedTechnPap.pdf

in which we discuss in one of the sections the problems with soil and/or soil and plastic sheeting caps in preventing infiltration of water into wastes for as long as the wastes under the cap are a threat to be leached by the water, which can lead to ground and/or surface water pollution. This report represents a synthesis and integration of the literature pertinent to understanding the ability of plastic sheeting and compacted clay as liners and caps for landfills and waste piles to prevent leakage of water into the landfill and release of leachate from the landfill to the nearby environment. Extensive references are provided in this review to the original literature upon which it is based.

The Agency should have evaluated the rate at which moisture falling on the surface of a soil cap of the type that is proposed for the "remediated" Tar Ponds sediments and Coke Ovens Site soils can penetrate through the cap. For example, Daniel (1990), in a presentation, "Critical Factors in Soils Design for Covers," that was part of a US EPA sponsored seminar, "Design and Construction of RCRA/CERCLA Final Covers," indicated that a cap with a permeability of 10^{-6} cm/sec, which I understand is the proposed design for the Tar Ponds "remediated" sediment cap, can allow penetration of moisture at the rate of about 1,000 gallons per acre per day (9,353 liters per hectare per day). Further, Daniel, in the same presentation, discussed the experience that occurred in the state of Wisconsin Omega Hills landfill Cover Study of soil caps for landfills, where, after three years,

- *"Upper 8 to 10 in.* [20.3 to 25.4 cm] *of Clay Was Weathered and Blocky*
- *Cracks up to ½ inch* [1.3 cm] *Wide Extended 35 to 40 inches* [89 to 102 cm] *into the Clay*
- *Roots Penetrated 8 to 10 inches* [20.3 to 25.4 cm] *into Clay in a Continuous Mat, and Some Roots Extended into Crack Planes as Deep as 30 in.* [76 cm] *into the Clay"*

There is no doubt about the fact that the Agency's proposed caps for the so-called "remediated" wastes for the Tar Ponds and Coke Ovens site soils will be highly ineffective in preventing moisture that occurs on the surface of the cap from penetrating through the cap into the underlying wastes. This moisture (water) will leach pollutants from the S/S-treated Tar Ponds sediments. A credible EIS providing full disclosure of issues to decision-makers and the public on the potential problems with the soil cap that the Agency has proposed for the Tar Ponds and the Coke Ovens site "remediated" sediments/soils would have discussed what is well established in the professional literature, that such caps can allow infiltration of large amounts of water into the wastes, which then can leach pollutants.

It is important to understand that the widespread use of capping of landfills and waste piles in the US reflects a situation where the US EPA and other regulatory agencies are allowing their use under conditions where it is understood by many of those who are experts in this topic area that such caps will not be effective in preventing moisture from entering the wastes. Unfortunately, in the US (as, apparently, is the situation now with the STPA), there is such public pressure on agencies to do something, that agencies allow what are obviously ineffective approaches for long-term containment of the wastes in a capped landfill or waste pile. Basically, this approach is part of an overall philosophy of adopting a short-term, "less expensive" approach for waste containment, whereby the costs and impacts of the ultimate failure of the containment system are passed on to future generations.

As discussed by Lee and Jones-Lee (2006), it is possible to construct leak detectable caps over landfills and waste piles that will prevent water from infiltrating through the cap into the wastes. This approach is not being used because it is more expensive in the initial construction of the cap and requires that those responsible for the cap operate and maintain the cap leak detection system for as long as the wastes under the cap are a threat, which, for most situations, will be forever.

Section 2.2.1.5 further states,

> ***"Groundwater Interceptor Installations***
> *Vertical barrier walls or interceptor trenches (or combination of both) will be used along the shoreline of the Tar Ponds site to control the movement of clean and contaminated groundwater and contaminants. These groundwater interceptor measures may be constructed of materials such as:*
> *• Sheet pile, which is available as vinyl or steel and will be driven from the surface to the final depth. Alternatively, depending on depth, the sheet pile can be placed in an excavated trench and backfilled. The sheet pile and clean backfill will be imported to the site.*

• Bentonite or cement walls, which are typically excavated, mixed, and backfilled with bentonite or cement. The equipment used is similar to conventional earth moving construction equipment (e.g., dozers, excavators). The bentonite, and possibly backfill, will be brought onto the site.
• Low permeability soil, where the depth to the confining layer is suitably shallow. Conventional earth moving equipment will be used to excavate a trench and backfill it with low permeability soil (e.g., clay). Clean low permeability soil will be imported to the site.
• A geomembrane or a geosynthetic clay liner could also be used as a vertical cutoff wall. In this case, an open trench will be excavated, the geomembrane or geosynthetic clay liner will be placed along the wall of the trench and the trench will be backfilled. The geomembrane or geosynthetic clay liner and clean backfill will be imported to the site. A rigorous construction quality assurance program will be established throughout any or all methods of construction."

The above discussion presents inadequate information on several significant potential problems with the Agency's proposed approach for controlling the flow of groundwater onto and from the treated Tar Pond sediments. Of particular concern is the potential to use geomembrane plastic sheets as a barrier for groundwater flow control. Such approaches can readily lead to an ineffective barrier as the plastic sheeting deteriorates. Considerable information exists on the breakdown of plastic sheeting (such as high-density polyethylene) due to free radical attack of the plastic sheeting polymers. Lee and Jones-Lee (2006), in their Flawed Technology review, have discussed the various issues pertinent to this breakdown. It is known that in some situations (such as near-surface situations like those which could be occurring within plastic sheeting barriers in the S/S-treated Tar Pond sediments), the breakdown can occur fairly rapidly. As summarized by Lee and Jones-Lee (2006), Rowe et al. (2003) of the Department of Civil Engineering, Queen's University, Kingston, Ontario, have reported on the failure of an HDPE lined leachate lagoon. Rowe et al. stated,

"A geomembrane – compacted clay composite liner system used to contain municipal solid waste (MSW) landfill leachate for 14 years is evaluated. Field observations of the geomembrane revealed many defects, including holes, patches, and cracks.

***

"Contaminant modelling of the entire lagoon liner suggests that the geomembrane liner most likely stopped being effective as a contaminant barrier to ionic species sometime between 0 and 4 years after the installation."

It is evident that under some situations there can be rapid failure of HDPE liners that are used in waste management, including landfill leachate lagoon liners, as well as groundwater barriers. This failure will lead to unreliable control of groundwater flow in the S/S-treated Tar Pond sediments, which may not readily be detected.

An issue that the Agency's EIS should have discussed is the permeation of plastic sheeting liners (groundwater barriers and subaqueous caps) by low-molecular-weight solvents. As discussed by Lee and Jones-Lee (2006), it has been known since the late 1980s that low-molecular-weight solvents, including benzene (which is found in the Tar Pond sediments), can rapidly penetrate through an HDPE liner. This penetration occurs through permeation, where the solvent will dissolve into the liner polymer matrix and, within a few days, pass through the liner into the groundwater on the downgradient side. This occurs without holes in the liner. To the extent that there are low-molecular-weight solvents in the Tar Pond sediments beyond the recognized BTX, the groundwater barriers constructed of HDPE and other types of plastic sheeting will not be effective in preventing offsite pollution.

With respect to the use of bentonite clay, mentioned in the EIS (quoted above) as a potential groundwater barrier, Lee and Jones-Lee (2006) have discussed some of the problems with bentonite barriers being effective barriers (landfill liners). Of particular concern is the fact that in a high calcium environment (such as could readily occur in cement-treated Tar Pond sediments), the calcium could interact with the bentonite, replacing sodium in the cation exchange sites, leading to shrinking and cracking of the bentonite barrier. Similar problems can exist for geosynthetic clay liners. Such liners typically have sodium bentonite as the clay in the liner. As summarized by Lee and Jones-Lee (2006), a number of investigators have found that geosynthetic clay liners experience calcium exchange for sodium, resulting in shrinking of the clay layer and cracking, which leads to failure of the liner. These are all issues that are well known in the literature and that should have been discussed in the EIS in order to inform regulatory decision-makers and the public about the potential problems of trying to construct inexpensive groundwater barriers associated with the Tar Pond remediated sediments. Such barriers will have to be periodically replaced, which will add to the ultimate costs of S/S treatment of the Tar Pond sediments. Further, and most importantly, it will lead to ineffective groundwater flow control, which can lead to environmental pollution by pollutants leached from the S/S-treated sediments by the water infiltrating through the cap into the treated sediments.

An issue not addressed in the EIS that could be very important in influencing the transport of S/S-treated sediment-associated pollutants to the environment is that groundwater flow in the Coke Ovens Site and Tar Pond areas occurs to some extent in fractured bedrock underlying these areas. King, et al. (200?) conducted a review of groundwater flow in the Coke Ovens Site and Tar Ponds areas. They reported in their abstract that,

> *"The conceptual model developed for the site has attempted to incorporate a complex stratigraphic profile, where groundwater flow and contaminant transport is strongly controlled by shallow fractured bedrock. This paper presents the conceptual model for groundwater flow and contaminant transport at the Sydney Tar Ponds site. Model simulations illustrate the complex flow patterns between bedrock and overburden, and between the bedrock units and surface water bodies. Results indicate that groundwater flow is dominated by discharge to the streams and the estuary."*

Groundwater flow through fractured bedrock can readily lead to transport of pollutants leached from the S/S-treated Tar Pond sediments from the treatment area to surrounding areas and the Estuary/Harbour. The Agency's proposed barriers in and around the treated sediments will not prevent pollutants leached from the treated sediments from being transported to the environment through fractured rock underlying the Tar Ponds. This transport could be enhanced by the Agency's proposed approach of constructing groundwater barriers, which could result in mounding of the groundwater inside the Tar Ponds treated sediment areas, which would increase the head, which could increase the flow of polluted groundwaters through the underlying fractured rock system. This area needs to be thoroughly investigated, since the flow of polluted groundwaters through the fractured rock could effectively negate the ability of the Agency's proposed approach for capturing and treating the pollutants leached from the S/S-treated Tar Pond sediments.

Section 2.2.1.6 "Wastewater Treatment" states,

> *"Water treatment will be required to handle contaminated water from several sources (see Section 2.9.2). Treatment will be required to ensure that:*
> *• liquid effluent discharges are in compliance with the pollution prevention provisions of the Fisheries Act; and*
> *• discharges will not cause an exceedance of the receiving environment water quality objectives.*
>
> *Wastewater will need to meet, at a minimum, the acute lethality test (Fisheries Act) and should not cause chronic effects. If discharged to a municipal sewer leading to a treatment plant, the wastewater will meet the appropriate sewer discharge standards. It is anticipated that specific discharge standards will be developed in conjunction with the appropriate regulatory agencies prior to the start-up of the remediation Project. Sampling and analysis will be conducted to ensure any required discharge criteria are met (see also Section 2.1.7).*

The Agency's suggestion that the treated wastewater *"… will need to meet, at a minimum, the acute lethality test and should not cause chronic effects"* raises questions about the adequacy of the treatment that is proposed to be conducted. Acute lethality testing is not adequate to protect public health and the environment from pollutants that are expected to be present in the ground and surface waters that are collected from the Tar Ponds and Coke Ovens Site areas. Of particular concern is the fact that PCBs and some of the other pollutants that are in the Tar Ponds and Coke Ovens Site sediments/soils tend to bioaccumulate in edible organisms and therefore are a threat to public health and higher trophic level organisms. It also should be recognized that the analytical methods for a number of pollutants are not sufficiently sensitive to measure the concentrations that can bioaccumulate to excessive levels in edible organisms. Special-purpose bioaccumulation testing will need to be done to be certain that the residual pollutants in the treated wastewaters do not lead to further bioaccumulation of hazardous chemicals in the food web associated with the waters receiving these wastewaters.

Much more detail on the approach that the Agency proposes to adopt for treatment of the waters associated with the Tar Ponds and Coke Ovens Site remediated areas needs to be provided before an evaluation can be made of the adequacy of this approach in protecting public health and the environment from further pollution by pollutants derived from these "remediated" sources.

Proposed Remediation of the Coke Ovens Site. Page 2-35 states,

> *"To facilitate remediation measures, groundwater and surface water controls will be implemented on the site. These controls will include rerouting of brooks away from the site and installation of vertical groundwater cut-off walls near the perimeter of the site. The*

redirected contaminated groundwater will be collected and pumped to a water treatment facility prior to discharge. Approximately 26,300 tonnes (13,500 m3) of PAH material from Coke Ovens Brook and the Inground *tar cell will be excavated and safely destroyed in a temporary, fully approved incinerator located off site. Selected remaining soils on the Coke Ovens site, contaminated with hydrocarbons, will then be bioremediated. The site will then be capped with soil to contain any further migration of contaminants and reduce the risk of exposure to both the community and environment."*

"2.3.1.4 Treatment of Selected Surface Soil Contamination (Landfarming)
Bioremediation using landfarming will be used over a period of 1 to 3 years to remediate the top 0.3 to 0.5 m of hydrocarbon-contaminated soil at selected areas on the Coke Ovens site. An estimated 253,700 tonnes (128,800 m3 at 0.5 m thickness) will be bioremediated (see Figure 2.3-2).

Bioremediation is commonly used to treat low-level coal tar and creosote impacted materials and is accepted as an effective method for remediating PAH contaminated wood treating sites (United States Environmental Protection Agency (USEPA), 1995). Landfarming is not expected to be effective at remediating heavier coal tar."

"Groundwater Interceptor Installations
Groundwater interceptor installations such as diversion trenches or vertical cut-off walls (or a combination of both) (see Figure 2.3-2) will be used on the Coke Ovens site to control the movement of clean groundwater from coming onto the site and contaminated groundwater and contaminants from leaving the site. Different designs, monitoring programs, and performance criteria will be used at different areas of the site depending on the objectives for the groundwater interceptor measures. For example:
- *cut off walls north and south of the Coke Ovens site will be installed to prevent the influx of clean groundwater;*
- *cut off walls west of the Coke Ovens site will be installed to prevent the movement of contaminants to SYSCO to the west; and*
- *cut off walls on Coke Ovens Brook will be installed to prevent the movement of coal tar from SYSCO into the Brook."*

Surface Cap
Following the excavation and bioremediation of the contaminated material from selected areas, the surface of the Coke Ovens site will be capped with a grading layer of native silty/clayey soils. A clean soil cover 0.3 m deep will be applied over the site.

The STPA proposed approach for remediation of the polluted soils at the Coke Ovens Site has many of the same potential problems discussed above for the Tar Ponds sediments in that the surface and groundwater diversions using new channels, vertical cutoff walls of the same types of materials as proposed for the Tar Ponds will experience the same problems breakdown and effectiveness as discussed above. As indicated by the Agency the landfarming of the Site polluted soils will not produce a non polluting residue. The proposed thinner cap for the landfarmed soils will allow large amounts of water to infiltrate into the underlying wastes generating a polluted leachate that will need to collected and treated.

Overall the Agency's proposed approach for remediation of the Coke Ovens Site polluted soils will leave a legacy of polluted soils under a thin cap that will be a threat to cause further pollution by the residual wastes in these soils.

Unrecognized Pollutants

The Agency's EIS focuses on PCBs and PAHs, both of which are important environmental pollutants. However, a properly developed EIS for remediation of an area that has received a complex mixture of wastes for 100 years or so must include a discussion of what are known now to be unrecognized, unregulated pollutants that have been and continue to be discharged in municipal and industrial wastewaters. The US EPA, under the leadership of Dr. Christian Daughton, Chief, Environmental Chemistry Branch, US EPA National Exposure Research Laboratory, is conducting a major program devoted to investigating what are now called unrecognized pollutants.

Daughton made a presentation, "Ubiquitous Pollution from Health and Cosmetic Care: Significance, Concern, Solutions, Stewardship – Pollution from Personal Actions." This presentation covered information on pharmaceuticals and personal care products (PPCPs) as environmental pollutants. He also discussed the relationship between endocrine disrupters and PPCPs. In August 2005 the US EPA held a Workshop on Pharmaceuticals in the Environment. Recently the US EPA has announced the availability of the proceedings from this workshop at http://es.epa.gov/ncer/publications/meetings/drinking_aug23-25_03.html.

Daughton pointed out that there is a wide variety of chemicals that are introduced into domestic wastewaters and wastes, which are being found in the environment. These include various chemicals (pharmaceuticals) that are derived from usage by individuals and for pets, disposal of outdated medications in sewerage systems and solid waste streams, release of treated and untreated hospital wastes to domestic sewerage systems, transfer of sewage solids ("biosolids") to land, industrial waste streams, releases from aquaculture of medicated feeds, etc. Many of these chemicals are not new chemicals. They have been in wastewaters and municipal solid wastes for some time, but are only now beginning to be recognized as potentially significant water pollutants, and are certainly occurring in the Tar Ponds sediments due to the many years of discharge of untreated domestic and industrial wastewaters into the Tar Ponds. These chemicals are largely unregulated as water pollutants.

According to Daughton (2004),

> *"Since the 1970s, the impact of chemical pollution has focused almost exclusively on conventional "priority pollutants," especially on those collectively referred to as "persistent, bioaccumulative, toxic" (PBT) pollutants, "persistent organic pollutants" (POPs), or "bioaccumulative chemicals of concern (BCCs). The "dirty dozen" is a ubiquitous, notorious subset of these, comprising highly halogenated organics (e.g., DDT, PCBs). The conventional priority pollutants, however, are only one piece of the larger risk puzzle."*

Daughton has indicated that there are over 22 million organic and inorganic substances, with nearly 6 million commercially available. The current water quality regulatory approach addresses less than 200 of these chemicals, where in general PPCPs and many other chemicals are not regulated. According to Daughton, "*Regulated pollutants compose but a very small piece of the universe of chemical stressors to which organisms can be exposed on a continual basis.*" Additional information on PPCPs is available at www.epa.gov/nerlesd1/chemistry/pharma/index.htm.

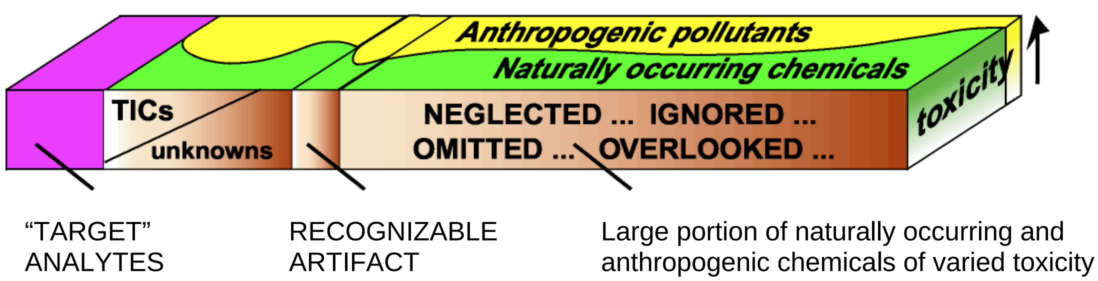
Daughton (2005) has discussed the inadequacy of water quality monitoring programs in identifying pollutants in wastewaters/stormwater runoff for the range of chemicals that could be impacting public health and the environment. In his presentation mentioned above, he stated,

"Further Truisms Regarding Environmental Monitoring

- *What one finds usually depends on what one aims to search for.*
- *Only those compounds targeted for monitoring have the potential for being identified and quantified.*
- *Those compounds not targeted will elude detection.*
- *The spectrum of pollutants identified in a sample represent but a portion of those present and are of unknown overall risk significance."*

Figure 1 presents a diagram of this situation. This figure is from the web page: "The Critical Role of Analytical Chemistry," C.G. Daughton, July 2002. http://www.epa.gov/nerlesd1/chemistry/pharma/critical.htm

Figure 1
Chemical Analysis Output for a Typical Environmental Sample



TICs = tentatively identified compounds, from: C.G. Daughton, US EPA (July 2002)

Background information on unrecognized/unregulated chemicals as environmental pollutants is available at http://www.epa.gov/nerlesd1/chemistry/pharma/ and at http://www.epa.gov/nerlesd1/chemistry/ecb-posters.htm.

Figure 1 shows that only a small part of the potential pollutants (far left purple area –Target Analytes and to some extent TICs) are searched for in the many thousands of potential pollutants that can be present in a complex mixture of waste chemicals such as has occurred at the Tar Ponds and Coke Ovens Site sediments/soils.

Periodically, previously unrecognized significant environmental pollutants are being found in surface waters or groundwaters. An example of this situation is polybrominated diphenyl ethers (PBDEs). Hooper (2003) of the Hazardous Materials Laboratory, Department of Toxic Substances Control, California EPA, stated,

> *"Over the past 25 years, tens of thousands of new chemicals (7 chemicals per day) are introduced into commerce after evaluation by USEPA. Few (100-200) of the 85,000 chemicals presently in commerce are regulated. We have reasons to believe that a much larger number than 200 adversely affect human health and the environment."*

As an example of unidentified hazardous chemicals in the environment, Hooper discussed finding PBDE (polybrominated diphenyl ether) in human breast milk and in San Francisco Bay seals. Archived human breast milk shows that this is a problem that has been occurring for over 20 years. According to McDonald (2003) of California Environmental Protection Agency, Office of Environmental Health Hazard Assessment,

> *"Approximately 75 million pounds of PBDEs are used each year in the U.S. as flame retardant additives for plastics in computers, televisions, appliances, building materials and vehicle parts; and foams for furniture. PBDEs migrate out of these products and into the environment, where they bioaccumulate. PBDEs are now ubiquitous in the environment and have been measured in indoor and outdoor air, house dust, food, streams and lakes, terrestrial and aquatic biota, and human tissues. Concentrations of PBDE measured in fish, marine mammals and people from the San Francisco Bay region are among the highest in the world, and these levels appear to be increasing with each passing year."*

Recently the California Office of Environmental Health Hazard Assessment (OEHHA 2006) has published a review on the potential for PBDEs to be environmental pollutants and the health hazards associated with them. Renner (2000) published a review on PBDEs, which provides additional information on their sources, occurrence and potential significance as environmental pollutants.

PBDEs are similar to PCBs and are considered carcinogens. Some of the PBDEs are being banned in the US and in other countries. PBDEs are present in the municipal solid waste stream and there can be no doubt that they are present in Tar Pond sediments due to past discharges of domestic wastewaters into the Tar Ponds.

The PBDE situation is not atypical of what could be expected based on the approach that is normally used to define constituents of concern in water pollution control programs. Based on the vast arena of chemicals that are used in commerce, many of which could be present in aquatic systems through wastewater discharges and so-called nonhazardous solid wastes, it is likely that many other chemicals will be discovered in the future that are a threat to aquatic ecosystems and public health through surface water and groundwater pollution.

The Agency, in its EIS, needs to discuss the fact that PCBs and PAHs are not the only pollutants found in Tar Ponds and Coke Ovens Site sediments/soils that can have a significant effect on public health and the environment. Any program for remediation of these areas and ongoing monitoring of the remediated (but not removed) wastes needs to recognize that a substantial effort needs to be made to expand the monitoring program for unrecognized, unregulated pollutants that could cause the need for further remediation of the areas.

The unrecognized, unregulated pollutant situation provides considerable impetus for adopting remediation technologies for the Tar Ponds and Coke Ovens Site sediments/soils that remove the polluted soils and sediments from the areas, properly treat them and adequately manage the residues. Failure to follow this approach could readily lead to the need for further remediation of these areas because of the failure of the Agency's proposed remediation approach to properly control releases of known pollutants, as well as unregulated, unrecognized pollutants that will be identified in the future.

Adequacy of the STPA EIS in Conforming to STP and Coke Oven Site EIS Guidelines
The Environmental Impact Statement Guidelines dated August 30, 2005, for the Environmental Assessment (EA) of the Sydney Tar Ponds and Coke Ovens Sites Remediation Project states on page 7 in part,

> "*An EA is a planning tool intended to identify the environmental effects, mitigation and follow-up measures that would be implemented to help ensure significant effects are avoided. An Environmental Impact Statement (EIS) is a document, which describes the EA effort.*
>
> *The EIS document produced by the Proponent will identify the potential environmental effects of the Project. The EIS will serve as the cornerstone of the Panel's review and evaluation of the potential effects of the Project. The EIS will also allow regulators and members of the public to understand the Project, the existing environment, and the potential environmental effects of the Project. The public (including Aboriginal peoples), interested parties and government representatives will be invited to comment on the completeness and accuracy of the EIS in addressing these Guidelines, and to submit materials for the Panel to consider. Should the Panel deem further information necessary, it may arrange for additional studies, which it will include in the Public Registry. The Panel will consider all materials included in the Registry in evaluating the Project."*

As repeatedly noted in these comments, the STPA EIS fails to conform to the EIS guideline requirement of enabling "… *regulators and members of the public to understand the Project, the existing environment, and the potential environmental effects of the Project."* This EIS is a pro-project document that fails to inform regulators and the public of the potentially significant near-term and especially long-term public health and environmental problems with the ability of the proposed Tar Ponds sediment and Coke Ovens Site soils remediation approaches to provide adequate control of releases of hazardous chemicals from these areas. The EIS misleads the regulators and the public into believing that many of the remediation components will work as designed for as long as the remediated sediments/soils will be a threat to release pollutants to the environment.

One of the most significant fundamental problems with the Agency's approach in informing regulators and the public about the potential efficacy of the use of S/S for Tar Pond sediment remediation is that, because S/S has been used for other types of wastes, it will be reliable for remediation of the Tar Ponds polluted sediments. However, the Agency did not critically evaluate/report on the political and other factors that allow the use of S/S at other locations and the fact that, even where used, albeit for organic-type wastes, there has not been adequate long-term evaluation of the effectiveness of this use.

Comments on EIS Volume 7 Devoted to Contaminant Fate Modeling of Sydney Harbour: Remediation of the Sydney Tar Ponds and Coke Ovens Sites

Volume 7 of the EIS presents STPA's efforts in developing a contaminant fate model that can be used to predict the impact of the proposed S/S remediation of the Tar Ponds during the remediation process and following it. There are several aspects of this modeling effort that need comment.

First, I have over 40 years of experience in developing, evaluating and using environmental chemistry fate-transport models of the type that STPA is attempting to use for the Tar Pond sediment remediation process. While such models can be tuned to fit an existing database, such as STPA has done for the releases of selected pollutants from the Tar Pond sediments, such models rarely have any significant predictive capability for assessing pollutant concentration occurrence under altered conditions. As is pointed out by STPA in discussing their modeling effort, such models represent a gross oversimplification of the actual processes that occur in the modeled system that govern the transport, transformations and impacts of chemical pollutants on aquatic ecosystems. In addition, STPA has had to make a number of assumptions about the magnitude of releases that can occur during remediation of the Tar Pond sediments. These assumptions could be in significant error.

The key issue that must be understood is that a highly detailed proactive monitoring program must be conducted during the remediation process to detect incipient potentially significant water quality problems that could do further damage to the Estuarine ecosystem. This should not be a passive-type monitoring program where data are collected and then analyzed somewhat later, but should be an active program, where the data are critically analyzed as they are collected, and appropriate action is taken when there are initial indications of potential problems, including additional site-specific monitoring to further investigate a particular situation.

It is my experience that there is need for outside independent oversight of the remediation process and its associated monitoring. One cannot rely on the project proponents or those who work for the agency sponsoring the Project to provide adequate oversight and control of the Project's potential impacts. A technical panel of experts not associated with any of the agencies responsible for the Project, and who do not expect at some time in the future to derive funds from these agencies, should provide this oversight. This panel should be funded by the Project in such a way as to enable the panel participants to be active in the Project without jeopardizing their funding by those who are sponsoring or supporting the Project.

I am particularly concerned about the fact that so many of the key aspects of the proposed Tar Pond sediment and Coke Ovens Site soil remediation Project are yet to be defined. This is a very dangerous situation, where governmental agencies who are committed to fulfilling their statements about implementing a remediation program for these areas can overlook important issues in the name of keeping the Project within the timeframe and budget allowed. There must be strong, independent oversight of all aspects of the Project by qualified individuals who will have the authority to stop work if necessary in order to adequately protect public health and the environment.

I am also highly concerned that the remediation objectives for pollutants are to be defined by the agencies involved in the Project. At this time it is not possible to evaluate the proposed Project with respect to determining whether adequate environmental and public health protection will be achieved, since the protection guidelines are yet to be developed.

In reviewing Volume 7, I find that STPA has used a number of technically invalid approaches for assessing the water quality/ecological significance of contaminant release from the Tar Pond sediments. Throughout Volume 7 reference is provided to the so-called "NOAA" guidelines:

> NOAA (National Oceanographic and Atmospheric Administration). 1999. Screening Quick Reference Tables. Hazmat Report 99-1.

While STPA claims that the values listed in this source are endorsed by NOAA, those who understand the development of these values know that some of the values in this source are out of date and/or technically unreliable. Further, NOAA has not officially adopted these values as credible values, but has simply published a report listing them. With respect to water quality criteria and STPA's use of "NOAA" screening values, a review of these values shows that they are based on a report published by the US EPA in the mid-1990s. Those knowledgeable in this topic area know that the US EPA (2002):

> US EPA, "National Recommended Water Quality Criteria: 2002," EPA-822-R-02-047, US Environmental Protection Agency, Washington, D.C., November (2002).
> http://epa.gov/waterscience/criteria/nrwqc-2006.pdf

is the most up-to-date source of information on critical concentrations of chemicals for impact on aquatic life and excessive concentrations in water that lead to excessive concentrations of hazardous chemicals in edible organisms. STPA's EIS, dated December 2005, should have used US EPA (2002) as a source of information on water quality criteria, rather than an outdated secondary source that was compiled by a NOAA staff member.

The most significant error made by STPA in their EIS is their use of the co-occurrence (coincidence) approach for assessing the potential impacts of contaminants associated with aquatic sediments. STPA's EIS Volume 7 lists as a reference for their so-called sediment quality guidelines,

> Long, E.R., D.D. MacDdonald, S.L. Smith and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management 19: 81-97.

It is well known that the Long et al. approach is obviously not a technically valid approach for assessing the critical concentrations of a chemical for adverse impacts on aquatic life. Munawar, Chief Editor of Aquatic Ecosystem Health & Management and a Research Scientist with Fisheries & Oceans Canada at CCIW, Burlington, Ontario, organized the Fifth International Conference on Sediment Quality Assessment (SQA5), which was held in Chicago, IL, in October 2002. At this conference, a series of keynote speakers discussed the unreliability of the so-called co-occurrence (or more properly called "coincidence") approach that has been used by Long and Morgan, Long and MacDonald and others to estimate the impact of a chemical or chemicals on aquatic life. Jones-Lee and Lee (2005),

> Jones-Lee, A. and Lee, G. F., "Unreliability of Co-Occurrence-Based Sediment Quality Guidelines for Contaminated Sediment Quality Evaluation at Superfund/Hazardous Chemical Sites," Journal *Remediation* 15(2):19-34 (2005).
> http://www.members.aol.com/annejlee/SQGSuperfund2.pdf

have reviewed the presentations at SQA5 and provided a detailed discussion of why co-occurrence-based so-called sediment quality guidelines like those in the NOAA screening tables should not be used for any purpose, much less to determine whether a concentration of a chemical in sediments is potentially adverse to aquatic-life-related beneficial uses of the waterbody in which the sediments are located. The fundamental problem with co-occurrence (coincidence)-based values is that they are based on total concentrations of chemicals, rather than bioavailable forms. Further, these approaches do not consider additive and synergistic effects for the measured chemicals, and the potential adverse impacts of unmeasured chemicals. It has been known since the 1970s that there is no relationship between the total concentration of a chemical in sediments and its potential to cause aquatic life toxicity. As discussed by Jones-Lee and Lee (2005), O-Connor, Director of NOAA Status and Trends, has published several reports discussing the unreliability of the Long and Morgan and MacDonald approach for estimating aquatic life toxicity.

Over the past two years, as part of the Bay Protection and Toxic Cleanup Program (BPTCP), the state of California Water Resources Control Board has been conducting a $2.5-million study devoted to developing sediment quality objectives for the State's enclosed bays and estuarine waters. The results of this study have again clearly demonstrated that co-occurrence-based approaches for sediment quality evaluation, in which there is an attempt to relate the total concentration of chemicals to impacts on aquatic life, are unreliable. What can be said about this approach is that normally, but not always, a sediment with elevated concentrations of a variety of potential pollutants is likely to have aquatic life toxicity and possibly can have altered benthic organism assemblages. It is explicitly clear that such findings provide no reliable information on the water quality significance of a specific chemical associated with aquatic sediments. It should be noted that the US EPA considered the potential for using the co-occurrence-based sediment quality guidelines as a guideline for regulating contaminated sediments. The Agency concluded that this approach is unreliable and should not be used.

The California Water Resources Control Board has determined that the approach that should be used to determine whether a contaminant in a sediment is adverse to aquatic life or a source of bioaccumulatable chemicals requires the use of the triad approach, in which chemical concentrations, aquatic life toxicity measured on the sediment, and aquatic organism assemblage information are used. The chemical part of this triad must include toxicity investigation evaluations (TIEs) to determine whether a specific chemical or group of chemicals present in a sediment is responsible for sediment toxicity and/or altered benthic organism assemblages. Information on the California Water Resources Control Board's development of sediment quality objectives is available at http://www.swrcb.ca.gov/bptcp/sediment.html.

Lee and Jones-Lee, in their presentation at the Fifth International Conference on Sediment Quality Assessment (SQA5),

> Lee, G. F. and Jones-Lee, A., "Appropriate Incorporation of Chemical Information in a Best Professional Judgment 'Triad' Weight of Evidence Evaluation of Sediment Quality," Presented at the 2002 Fifth International Conference on Sediment Quality Assessment (SQA5), In: Munawar, M. (Ed.), *Aquatic Ecosystem Health and Management* 7(3):351-356 (2004). http://www.gfredlee.com/BPJWOEpaper-pdf

discussed the approach that should be used to evaluate sediment quality, focusing on how chemical information on the concentrations of chemicals in sediments should be incorporated into the triad. The emphasis must be on evaluation of the cause of toxicity, and not the total concentration of a chemical in sediments.

Another important deficiency in the STPA EIS Volume 7 is the failure to evaluate the potential for persistent organic chemicals such as PCBs that are present in a sediment to bioaccumulate through the food web to excessive concentrations in edible organisms of the area. The critical concentrations in sediments for this situation are typically lower than the concentrations that are adverse to aquatic life living in the sediments. The co-occurrence-based approach for developing sediment quality guidelines does not incorporate food web accumulation issues.

With respect to the remediation of the Sydney Tar Pond sediments, the continued accumulation of PCBs in edible organisms of the Estuary/Harbour has to be one of the most important issues that needs to be addressed in terms of evaluating the success of the S/S treatment of the Tar Pond sediments. As discussed elsewhere in these comments, according to the US EPA (2002), concentrations of PCBs in the water column above 0.000064 µg/L can bioaccumulate to excessive levels in edible aquatic life. The US EPA does not have critical concentrations for PCBs in sediments that, through food web accumulation, would lead to excessive concentrations in edible fish and shellfish. In order to evaluate this situation, it is necessary to perform site-specific studies of whether PCBs and other pollutants in sediments can bioaccumulate to excessive levels in higher trophic level organisms that are a threat to public health and/or fish-eating birds and animals. These are the issues that must be carefully evaluated as part of developing remediation objectives for S/S treatment of the Tar Pond sediments.

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Preliminary Draft 5/4/06
Comments on
STPA Response to Joint Panel Request for Additional Information,
Transcripts of April 29 and May 1, 2006, Public Hearing and the
May 12, 2004 Memorandum of Agreement
Comments Submitted by G. Fred Lee, PhD, PE, DEE
May 15, 2006

The Sydney Tar Ponds Agency (STPA 2006), in a letter dated March 29, 2006, provided "STPA Response to Joint Panel Request for Additional Information, March 16, 2006." These responses provide additional information on the characteristics of the S/S remediation of the Tar Pond sediments and Coke Ovens Site soils. Presented below are my comments on selected aspects of the STPA responses and testimony at the Public Hearing.

The STPA response to IR-02, page 2, in the second footnote to Table IR-02.2, referring to both the Tar Ponds Trenches and Cap and the Coke Ovens Surface Cap, states, *"1 metre of Clayey Till Material to provide a permeability of* 1×10^{-6} *cm/sec and 0.1 m of topsoil."*

Greg Gillis, Senior Vice President of AMEC Earth and Environmental (the lead consultant on the EIS report), beginning on page 37 of the April 29th hearing transcript (Transcript-1) (JRP 2006a) stated,

> *"We want to create, through stabilization and solidification, a low permeable solid monolith. And the monolith is going to be a large solid structure that has been created through stabilization and solidification.*
>
> *Groundwater is going to be diverted around the monolith. We're going to control groundwater, both coming from the side and from the bottom.* ***We're not going to allow any infiltration of surface water so in effect we're going to seal the stabilized and solidified materials off from the pathways of surface water and groundwater*** [emphasis added]. *And we're going to have a new creek channel to divert water and to allow surface water and groundwater effluent to move through the creek channel around the -- out into Sydney Harbour."*

Gillis, on Transcript-1 pages 38 and 39, stated,

> *"So you're going to have a series of these cells, as it were, throughout both the north and south tar pond. This material will be capped and sealed from both groundwater and surface water. Here is a picture of the cap design. And what you got, is you got liners here -- what you need to do when you're capping something is you need not only to control the water getting in but you need to give a pathway for any water that does get in and you can see the pathway here is granular fill so that you can get material out if water does get in. So you got a liner, topsoil, clay fill here which acts as a liner, another liner, some granular fill and then solidified treatment matrix. And down here at the bottom is a clay or till and bedrock.*

Now one other element that you might notice on this screen -- and I realize it's a bit distant -- we have these interceptor trenches that go vertically down into the till itself. And what they are for, they are to release any pressure from groundwater that comes up from the bottom to make sure that that material can be controlled so it doesn't affect the monoliths themselves. So that's the cap design for the Tar Ponds."

Gillis, on Transcript-1, pages 39 and 40, stated, in discussing the Coke Ovens Site remediation,

"In the coke oven, we're going to precontaminants [pretreat?] *using land farming, a form of bioremediation. We allow the materials to -- any kind of volatiles to release and break down some substances. Destruction of tar cell contaminants. There's about twenty-five thousand cubic metres of PEH contaminated materials in the tar cells. We're going to total containment of the contaminants.*

We're going to cap them and seal them [emphasis added]. *We're going to have groundwater diversions, again, to make sure the groundwater, we don't take materials or contaminants off the site or bring contaminants to the site.* ***We're not going to allow any infiltration of surface water. We're going to have a cap, again, over the Coke Ovens area to make sure that we can control surface water and deal with it*** [emphasis added]. *And to assist us with that, we're going to reroute surface water and drainage. We found that some of the existing surface water channels have contamination in their bottom and so what we're doing is we're rerouting some of the surface water drainage."*

As discussed in my comments on the EIS, the surface caps for the Tar Pond sediments and Coke Ovens soils, with a permeability of 10^{-6} cm/sec, can allow on the order of 1,000 gallons per acre per day (9,353 L/ha/day) of infiltration through it if there is moisture on top of the cap. The actual rate of infiltration depends to some extent on the depth of the moisture on the cap. While, as quoted above, Mr. Gillis in his testimony to the Panel on April 29th, repeatedly claimed that the surface caps for the S/S-treated Tar Pond sediments and the landfarmed Coke Ovens Site soils will **prevent** water from infiltrating into the underlying wastes, in fact the proposed caps will allow substantial amounts of water to infiltrate into the wastes if the caps maintain their design permeability of 10^{-6} cm/sec. However, as discussed by Lee and Jones-Lee (2006), soil caps of this type are well known to develop cracks and areas of higher permeability than the design permeability. There is no doubt that the STPA proposed caps for the two sites will be highly unreliable in preventing water that is present on the cap from penetrating into the underlying wastes.

With respect to Mr. Gillis' statement, "*And we're going to have a new creek channel to divert water and to allow surface water and groundwater effluent to move through the creek channel around the -- out into Sydney Harbour,"* as discussed in the comments on the EIS, there are significant questions about the long-term ability of the various surface water and groundwater diversion structures to manage surface and ground waters in such a way as to prevent their contamination by landfarmed Coke Ovens Site soils and Tar Pond S/S-treated sediments for as long as the residual wastes in these areas are a threat to public health and the environment.

STPA's response to IR-02, page 2 states, *"The current design specification for the cap consists of the following layers:*

- *A geosynthetic clay liner (GCL) will be placed directly on the final grade of the solidified sediments. The purpose of the liner is to isolate the solidified sediments from infiltrating precipitation. A GCL is included in preference to other potential liner materials based on constructability, cost, and resistance to movement of overlying fill materials placed on it.*
- *A clayey till layer, of variable thickness, will be placed on top of the GCL. The thickness of the layer will be dependant on the final grade of the site and will vary from several metres to less than a metre (a minimum of 0.3 m). It will be placed and compacted as necessary to provide a permeability of 1×10^{-6} cm/sec. The purpose of the clayey till is to further isolate the solidified sediments from infiltrating precipitation, to provide physical separation between the solidified sediments and the finished grade, and to protect the underlying GCL.*
- *The top surface of the cap will consist of a 0.1 m lift of topsoil, to provide a base for establishing a vegetative cover.*
- *The top surface of the cap will be hydroseeded to provide an erosion resistant vegetative cover.*
- *The surface cap will be graded with a minimum 0.5% slope towards the channel, to ensure adequate drainage."*

Lee and Jones-Lee (2006) and my comments on the EIS have discussed the potential problems with geosynthetic clay liners being a long-term effective barrier to preventing water and/or leachate from passing through the liner. Some types of clays used in landfill liners, with an expandable lattice structure, exhibit strong shrink/swell properties dependent on the type of cation on the clay's ion exchange sites. With sodium at the exchange site, the clay is in a swollen state. However, in contact with water with high calcium/magnesium compared to sodium concentrations, the calcium and magnesium will replace the sodium on the clay, and the clay will shrink, leading to higher permeability and possible failure through cracking. Auboiroux et al. (1999) have investigated the impact of calcium exchange for sodium in bentonite geosynthetic clay liners for landfills. They stated,

> "*Results suggest that while GCL's may be considered as useful materials for reinforcing compacted clay layers at the base of landfills, they should not be considered as "equivalent" to compacted clay layers, at least in terms of pollutant breakthrough times."*

Guyonnet et al. (2005) reported that,

> *"… calcium carbonate in the bentonite, formed during activation of the calcium bentonite, may redissolve during contact with a dilute permeant, releasing calcium ions that exchange with sodium in the clay. This exchange leads to obliteration of a so-called "gel" phase ~beneficial in terms of low permeability and to the development of a more permeable 'hydrated-solid' phase.*"

James et al. (1997), in a study of the use of a GCL as a liner to enhance the cover over a reservoir, reported that, "*The evidence demonstrates that calcium from calcite, contained in the GCL bentonite, exchanged with sodium and, in so doing, contributed to shrinkage and cracking."*

The US EPA (2001) has reviewed the properties of geosynthetic clay liners, where a number of the potential advantages and potential problems with substituting a geosynthetic clay liner for two feet (0.61 m) of compacted clay have been discussed. A key problem with geosynthetic clay liners is that they are so thin that they have limited structural integrity. This can be especially important when the GCL layer is placed over an unstable base, such as the S/S-treated Tar Pond sediments. As discussed below, the limited compressive strength of the S/S-treated Tar Pond sediments, coupled with a variety of mechanisms that can lead to degradation of the concrete-solidified Tar Pond sediments, will likely lead to differential settling of the wastes and structural integrity problems for the GCL layer.

While regulatory agencies in the USA are allowing GCLs in landfills to substitute for two feet (0.61 m) of clay with a permeability of 10^{-7} cm/sec, there is increasing evidence that this is not a technically valid approach for preventing water/leachate from passing through the liner into the wastes or out of the landfill into the groundwater system. It is certainly inappropriate for the STPA (Gillis) to assume that the use of a GCL layer in the caps for the Tar Pond sediments and Coke Ovens Site soils will prevent moisture from entering the underlying wastes that can leach pollutants from the treated wastes for as long as the wastes in these areas will be a threat to pollute surface and ground waters.

Another important aspect of this situation is that, since the GCL is buried under a "clayey till layer," which will vary in thickness from several metres to less than a metre (a minimum of 0.3 m) and a topsoil layer of 0.1 m thickness, it will not be possible through visual inspection of the surface of the cap to detect failure of the GCL layer which will allow increased rate of infiltration of water through the layer into the underlying wastes.

STPA should be required to provide detailed discussion of how the failure of the GCL layer to maintain its design permeability will be detected over the period of time that the pollutants in the Tar Ponds S/S-treated sediments Coke Ovens Site soils will be a threat to be leached and transported offsite to surface and ground waters of the area.

STPA (2006), in its response to IR-06, page 4, Table 2.13-6 – Alternative Means for Containment of Remaining Contaminants, states,

> *"However, it should be noted that the Project no longer contemplates the use of a subaqueous cap as it is no longer applicable."*

As discussed in my comments on the EIS, subaqueous caps composed of HDPE are similar to liners used in landfills with respect to their long-term ability to prevent leachate from passing through them into the underlying groundwater system. If STPA decides to use subaqueous caps of HDPE, then there will be need to reliably discuss the ultimate failure of such caps.

The STPA response to IR-10, page 1 states,

> *"Based upon experience in Canada (Point Tupper, Nova Scotia) and at other land farming/bioremediation operations it is expected that in one 6-month construction*

season, a 90% reduction of light hydrocarbon soil concentrations will be achieved in the surface soils on the Coke Ovens site. No appreciable degradation is expected for the PAH compounds and many of the heavier hydrocarbons.

The controlling variables of UV degradation, bioremediation and volatilization of contaminants are difficult to quantify prior to going to the field. As a result, it is difficult to model landfarming degradation rates."

The above statement indicates that STPA understands that the landfarmed Coke Ovens Site soils will still contain a variety of hazardous pollutants that are a threat to public health and the environment.

STPA response to IR-12, bottom of page 3 states,

"A further assumption underlying this decision is that additional remediation measures to be applied to the Tar Ponds, including containment by S/S treatment and capping, as well as implementing groundwater control measures, will immobilize and isolate any PCBs remaining in the Tar Ponds from potential receptors and pathways."

It is totally inappropriate for STPA to **assume** that the proposed S/S treatment and groundwater control measures will "*…immobilize and isolate any PCBs remaining in the Tar Ponds from potential receptors and pathways."* A more reasonable, technically valid assessment is that the S/S treatment, coupled with the groundwater flow control measures, will only partially immobilize any PCBs, and for that matter a variety of other recognized, as well as unrecognized, pollutants in the S/S treated sediments. Basically, the Agency has opted for an initial-lower-cost remediation approach in order to be able to claim that it is fulfilling its obligation to develop treatment, with the result that the long-term public health and environmental problems of the residual S/S-treated pollutants in the Tar Pond sediments will have to be borne by future generations in the Sydney Estuary and Harbour area.

On IR-17, page 1, it is stated that,

"In IR-17, the Panel requested the following information:

Indicate which VECs have a temporal boundary of 25 years, and explain how the anticipated environmental effects for that VEC related to the 25 year boundary.

Indicate how contaminants that remain at both Tar Ponds and Coke Ovens sites are expected to change over the 25 year period following completion of the project. Detail the expected decay rates of the contaminants and provide information on the decay pathways within a spatial and temporal framework. Identify the potential need for further mitigation, monitoring and maintenance following the expiration of the 25 year period identified in the MOA, and indicate the criteria to be used to determine whether further mitigation, maintenance and monitoring of both sites may be required following completion of the project.

The Panel is of the view that more information needs to be provided. In a table, indicate which VECs have a temporal boundary of 25 years or less, and explain how the persistence of the anticipated environmental effects of each VEC relate to the identified temporal boundary. In quantitative terms, indicate how contaminants that remain at both Tar Ponds and Coke Ovens sites are expected to change over the 25 year period following completion of the construction phase of the project. In quantitative terms, detail the expected decay rates of the contaminants and provide information on the decay pathways within a spatial and temporal framework.

Response:
VEC-specific temporal and spatial boundaries encompass those periods during which, and areas within which, the VECs are likely to interact with or be influenced by the Project. These have been defined for each VEC, and the potential interactions of the Project within these temporal boundaries have been characterized and assessed within the EIS. Table IR-17.1 indicates which VECs are likely to have temporal boundaries less than 25 years or more than 25 years, and the expected environmental effects after 25 years. Environmental effects less than 25 years are presented in Sections 6.0 and 7.0 of the EIS."

STPA (2006) response to IR-17, page 2, Table IR-17.1 VEC Temporal Boundaries and Effects After 25 Years, presents the following information:

"Groundwater Resources
- *The groundwater on the site is currently contaminated. The remediation is designed to contain the groundwater, to avoid contaminating groundwater in the surrounding areas. Any groundwater on the site that is intercepted will be treated by an on-site water treatment system. The containment system that is designed to isolate the contaminated groundwater quality on the site will operate in perpetuity. The treatment of groundwater that is collected on-site will continue for 25 years. Following this 25 year timeframe, the requirement for the continuation of this treatment system for on-site contamination will be reviewed in the context of data collected as part of the monitoring program."*

Again, the STPA is providing inadequate and unreliable information on what can be expected from the groundwater and surface water control systems that the Agency is proposing to use at the Tar Ponds and Coke Ovens sites. If properly constructed, such barriers can initially be effective in preventing offsite transport of leached pollutants from S/S-treated sediments. However, the proposed barriers are all subject to failure. A number of them cannot be visually inspected to detect when failure occurs. There can be little doubt that, during the very long period of time (hundreds of years or more) that the pollutants in the S/S-treated sediments will be a threat to public health and the environment, the barriers that the Agency has proposed will fail to contain the polluted groundwaters that are generated through infiltration of surface water into the S/S-treated sediments. Further, there is the potential for the S/S-treated sediments to pollute infiltrating surface waters and groundwaters that will migrate away from the area through the fractured rock groundwater flow system at the site. This fractured rock groundwater flow can pass under the barriers and, therefore, pollutant transport would not be controlled by this approach.

> *"Surface Water Resources*
> - *Potential risks to surface water quality from the on-site contamination will be maintained at levels that will not be detrimental to aquatic life (an improvement on current conditions)."*

The inadequacy of the STPA approach for managing polluted surface waters is discussed in my comments on Mr. Shosky's reply to a question in the May 1 transcript (Transcript-2) (JRP 2006b) from Dr. LaPierre:

Pages 16 and 17 (Transcript-2, page 234) state,

> *"DR. LAPIERRE: I just want to make sure I understood correctly. Now, if groundwater was to seep in under the monolith, as you've indicated it would move up through the drainage system, and then through that drainage system, it would move towards the ditch, and once it gets to the ditch you have monitoring points, but that ditch is open to the ocean. Now, if contaminated water gets in the ditch, and it was contaminated, how can you stop it from going to the ocean?*
>
> *MR. SHOSKY: That's a very good question. How would we stop -- and I believe we're all talking -- so that we all are on the same page as far as talking points -- we're talking about at each one of these lateral locations, how would we stop water from just being discharged? Our current thought on that, right now, is that these areas will be valved, and that we will have a -- and water will not be released to free flow without being trapped first and tested to determine whether or not it's clean, or dirty, and would require monitoring along these lines during the life of the project. That's our current thought on that right now. So, there would be mechanisms to stop it. One of the earlier things we contemplated was a larger interceptor trench along this entire area here, but we felt that if we found contamination at that point, we would not be able to isolate it and treat it. In this case, if we find the problem here, we can isolate it and treat it. If we find it here, we can isolate it and treat it. So, we felt we had more control over isolation and treating, focusing our resources on a smaller source problem than a larger potential problem if not controlled properly."*

One of my areas of work and expertise is managing water quality impacts of stormwater runoff from urban, industrial and agricultural areas. As shown on my website, www.gfredlee.com, I have published extensively on these issues. Of particular concern is the situation that can develop during storms, where very high flows can occur in a short period of time, which can mobilize contaminants that have accumulated in drainageway sediments during low-flow conditions. Typically, under low-flow conditions, pollutants released from the containment area soils/sediments and runoff from surrounding lands would tend to accumulate in the drainageway sediments. In order to capture and treat what could be highly polluted first-flush stormwater runoff from the drainage ditches, a very large area/volume would be needed to store the runoff during major runoff events. Further, the treatment works to treat this runoff adequately before its release to the environment would likely have to be much larger than STPA currently contemplates.

These problems may not show up during the 25-year Project required maintenance period, and therefore, according to the Memorandum of Agreement (MOA, commented on below), to the extent that they occur after the end of this period due to the inevitable failure of the HDPE liner and barrier systems, Nova Scotia would be responsible for having to capture, monitor and treat the polluted water from the ditches during high-flow events. This could greatly increase the cost of maintenance of the Coke Ovens Site soils and Tar Pond area sediments that would be required to prevent environmental pollution by the residual pollutants at these locations.

"Soil Quality

- *Contaminated soils at the Coke Ovens sites will be bioremediated and/or removed from contact with receptors. Contaminants at the Tar Ponds site will be solidified/stabilized so that they will not be released into the environment. The contaminants at both sites will also be contained within engineered systems."*

The statement that the "*Contaminants at the Tar Ponds site will be solidified/stabilized so that they will not be released into the environment"* is an overly optimistic assessment of what S/S treatment of these sediments will likely achieve. The evidence is that the S/S-treated Tar Pond sediments will still leach/release a variety of pollutants, at sufficient concentrations to be a threat to public health and the environment, that will be transported in the groundwater system to offsite areas when the groundwater containment system/barriers and the drainage ditches no longer function as designed. Basically, the Agency has failed to properly evaluate the leaching/release of a variety of pollutants from the S/S-treated Tar Pond sediments. These issues are discussed further in a subsequent section of these comments.

"Marine Habitat and Biota

- *There is expected to be a long-term improvement in the marine environment. After 25 years a new layer of uncontaminated sediment at the mouth of Muggah Creek will have covered previous contaminated sediment, thus improving the benthic habitat in the South Arm of Sydney Harbour."*

As discussed in these comments, the proposed management of pollutants in the Tar Pond sediments will likely reduce the current flux of pollutants from these sediments to the marine environment; however, the residual flux that will eventually occur due to failure of the containment system could readily be sufficient to continue to pollute the marine environment with hazardous chemicals.

Under Table IR-17.1, beginning on the bottom of IR-17 page 3, it is stated,

> *"As reflected in the EIS, the potential effects on VECs are primarily related to the short-term construction related activities. The longer-term operation activities of the Project will have reached this equilibrium point before 25 years, and as described in the EIS, these will likely result in positive effects on existing environmental conditions.*

Decay of all matter is measured in half-life, which is defined as the time required for the disappearance or decay of one-half of a given component in a system. The half-lives for some soil contaminants have been estimated by the OEHHA (2002) as shown in Table IR-17.2. Assumptions for soil half-life used in the HHRA (Vol. 5) are also included in Table IR-17.2. Metals take a long time to decay, but PAHs, PCBs and dioxins and furans have a significantly shorter half life, particularly if they are exposed to air or UV radiation. The values provided in the Table IR-17.2 are theoretical estimates based on other studies and no site specific decay rates have been determined for the Tar Ponds and Coke Ovens sites. Based on these figures, the remaining treated sub-soils at the Coke Ovens site after capping should not provide a risk to human or animal receptors after 25 years, even if they are exposed."

The above discussion reflects a lack of understanding of the environmental chemistry of a number of pollutants of concern in the treated Coke Ovens Site soils and Tar Pond sediments. One of my areas of expertise is aquatic chemistry, which deals with the sources, transformations, transport and environmental and public health impacts of pollutants. I taught graduate-level courses in aquatic chemistry for 30 years at several major US universities. I published over 1,000 papers and reports on these and other issues over my 45-year professional career. I can unequivocally state that metals do not decay. They may be leached from the soil and thereby transported by waters moving through the soils/sediments. With respect to the estimates of the decay of organics, there is no rational basis for the STPA statement, "*… the remaining treated sub-soils at the Coke Ovens site after capping should not provide a risk to human or animal receptors after 25 years, even if they are exposed."* There can be little doubt, based on what is known about the behavior of various pollutants in soils and sediments and in landfills, that there will be residual pollutants at the Coke Ovens Site capped landfarmed soils that will be a threat to public health and the environment 25 years after completion of the Project.

Below Table IR-17.2 (middle of page 4), it is stated,

> *"At the Tar Ponds site, the solidification/stabilization process will lock the contaminants into the monolith. Solidification/stabilization techniques are designed, and have been proven, to eliminate or greatly reduce the mobility of contaminants in soils. According to the EPA (2001):*
>
> > *'Solidification/stabilization refers to a group of cleanup methods that prevent or slow the release of harmful chemicals from polluted soil or sludge. These methods usually do not destroy the chemicals—they just keep them from moving into the surrounding environment. Solidification refers to a process that binds the polluted soil or sludge and cements it into a solid block. Stabilization refers to changing the chemicals so they become less harmful or less mobile. These two methods are often used together to prevent exposure to harmful chemicals. Solidification involves mixing polluted soil with a substance, like cement, that causes the soil to harden. The mixture dries to form a solid block that can be left in place or removed to another location. The solidification process prevents chemicals from spreading into the surrounding environment. Rain or other water cannot pickup or dissolve the chemicals as it moves through the ground.*

Solidification does not get rid of the harmful chemicals, it simply traps them in place.'

In essence, although there will be no decay per se, the substances in the Tar Ponds will become inert and unavailable to the environment after stabilization/solidification and capping of the sites. Leaching of contaminants from the stabilized areas will be minimal and monitoring will be ongoing. Although there may be concern regarding deterioration and loss of strength and physical properties if the solidified materials are subjected to freeze thaw conditions, as long as there is adequate thickness of cover and protection over top of the solidified materials, there should be negligible deterioration with time.

Since the engineered containment system does not involve a destruction of contaminants, monitoring beyond the 25 years time span may be conducted to monitor the integrity of the cap and solidified/stabilized sediments. The decision whether or not to continue monitoring after 25 years will consider the monitoring results obtained for individual parameters during the 25 years period after completion of the remediation works. In particular, the Project's monitoring results for environmental media (groundwater quality, surface water quality, sediment quality and surface soil quality) will be used to determine future monitoring efforts. If monitoring at or near the end of the 25 year-period indicates that contaminant levels exceed regulatory standards and/or SSTLs, further monitoring may be required. In contrast, if contaminant levels have remained within prescribed standards, monitoring efforts could be reduced or perhaps terminated. In addition, the performance records for the individual components, i.e., the cap, containment system, drainage features, treatment plants and stabilized/solidified sediments will be used when considering the type, location, frequency and duration of future monitoring.

References
Office of Environmental Health Hazard Assessment (OEHHA). 2002. Technical Support Document of Exposure Assessment and Stochastic Analysis. OEHHA, State of California.
United States Environmental Protection Agency (EPA). 2001. A Citizen's Guide to Solidification/Stabilization. EPA-542-F-01-024."

There are a number of aspects of these STPA statements that need to be considered in evaluating their adequacy and reliability in properly describing the situation that will develop as a result of S/S treatment of the Tar Pond sediments. STPA has relied on US EPA documents that provide information on the number of solidification/stabilization projects that have been conducted at hazardous chemical sites in the USA. Those familiar with the US EPA, especially under the current administration, know that the Agency has adopted the development of propaganda as a means of supporting its positions on environmental issues.

A prime somewhat relevant example of this is their position on the ability of minimum design US EPA Subtitle D landfills to serve as an effective containment system for landfilled municipal solid wastes. Lee and Jones-Lee (2006) have chronicled the US EPA's position on the protective nature of plastic sheeting and compacted soil/clay liners in containing municipal solid waste in the dry tomb type environment for as long as these wastes represent a threat to public health and the environment. As reviewed by Lee and Jones-Lee (2006), in 1988 the US EPA, as part of adopting the RCRA Subtitle D regulations governing municipal solid waste landfilling, stated in the draft regulations (US EPA, 1988a),

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

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

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

With this background of the ultimate long-term failure of the landfill containment system, it is appropriate to inquire as to why the US EPA adopted a fundamentally flawed approach for landfilling of wastes which only temporarily contains the waste components within the landfill. This situation arose out of the fact that environmental groups had filed suit against the US EPA for failure to develop municipal and industrial "nonhazardous" solid waste landfilling regulations. This led the Agency to promulgate the Subtitle D regulations (US EPA 1991), based on a single composite liner (plastic sheeting HDPE and compacted clay) and equivalent landfill cover, even though it was understood in the early 1990s that at best this approach could only postpone when groundwater pollution occurs by landfill leachate.

For a number of years following the adoption of the Subtitle D regulations, US EPA management indicated that the problems with Subtitle D landfills discussed in the draft regulations still existed, and acknowledged that ultimately the liner system will fail to prevent groundwater pollution. Lee and Jones-Lee (1998), 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 (Clay 1991). Dellinger (1998), then head of the Office of Solid Waste and Emergency Response for the US EPA, indicated that the Agency still concluded that a single composite liner will ultimately fail to prevent leachate transport through it.

Recently, under the current administration, the US EPA has been espousing on its website a different position, intimating that minimum Subtitle D landfill liner systems – which have not changed – now will be protective. Lee (2003) discussed the unreliable information that is now being provided by the US EPA on the ability of a minimum Subtitle D landfill's design, closure and postclosure care to protect public health and the environment for as long as the wastes in a dry tomb type landfill will be a threat. As discussed below, the US EPA's revised position is not based on a technically valid assessment of the length of time that the waste in a municipal solid waste dry tomb landfill will be a threat to generate leachate when contacted by water and the duration that a minimum Subtitle D single composite liner can be expected to collect all leachate generated in the landfill and thereby prevent groundwater pollution by it.

The Agency now claims, through a report by Bonaparte et al. (2002) that the Agency commissioned, that minimum Subtitle D landfill containment systems will be protective of groundwater resources from pollution by landfill leachate. However, as discussed by Lee and Jones-Lee (2006), this claim is based on an unreliable assessment by Koerner, one of the authors of the US EPA report, that municipal solid waste in a dry tomb landfill will only be a threat to produce leachate for a couple hundred years. His Arrhenius-equation-based extrapolation of limited laboratory studies predicts that decay of the HDPE liner does not occur until after municipal solid wastes are no longer a threat. However, the Koerner statement about the decay of municipal solid waste in a dry tomb type landfill is obviously not technically valid to those who understand the processes that take place in a municipal solid waste dry tomb type landfill, and his extrapolation of the expected durability of HDPE liners represents an extreme example, likely unreliable, of extrapolating limited-scope laboratory-based studies conducted at a higher temperature than environmental conditions that exist in a landfill environment. What is unequivocally known is that HDPE liners will decay over time and that heavy metals, salts and some organics (possibly most) in municipal solid waste will be present to produce leachate when contacted by water whenever the landfill cover fails to prevent water from infiltrating into the landfill.

The municipal solid waste landfill example presented above of the current administration's propaganda on environmental issues is just one of several that can be cited of where the US EPA, under the current administration, is weakening its position on environmental protection.

The issue with respect to S/S-treated wastes is not how many times the S/S treatment approach has been used, but, where used, whether it has been effective in producing a treated waste that no longer represents a threat to public health and the environment through release of contaminants. For heavy metals in waste with low organic content, cement-based S/S treatment can be effective, provided that the treated wastes are properly isolated from the environment; however, as discussed in my comments on the STPA EIS, Wiles and Barth (1992) have noted that the use of S/S treatment for high-organic wastes has not been demonstrated to be effective in preventing mobilization of these wastes' components to the environment. As discussed in my comments on the STPA EIS, Wiles and Barth, at the time they developed this paper, were with the US EPA Risk Reduction Engineering Laboratory in Cincinnati, Ohio. It was their responsibility to evaluate the effectiveness of S/S treatment of various types of wastes as part of the US EPA SITE (Superfund Innovative Technology Evaluation) program. In connection with conducting my review of the adequacy of the STPA EIS, I contacted Ed Barth regarding the current understanding of the effectiveness of using cement-based S/S to treat high-organic wastes such as those that are present in the Tar Ponds. He confirmed (Barth, pers. comm., 2006) that the situation today is no different than it was in 1992 when he and Wiles developed their paper on this issue. Basically, there are significant questions about whether cement-based S/S is an effective immobilization approach for high-organic wastes such as the Tar Pond sediments. It is inappropriate for the STPA to indicate as quoted above that, because S/S treatment has been widely used for inorganic wastes and at a few locations for higher organic content wastes, "*Solidification/stabilization techniques are designed, and have been proven, to eliminate or greatly reduce the mobility of contaminants in soils*" as applied to S/S treatment of the Tar Pond sediments.

STPA, in its response to IR-60 on the effectiveness of S/S treatment of Tar Pond sediments in immobilizing PCBs, PAHs and other constituents, presents the Earth Tech (2005) report. I have reviewed this report, and find that it does not present adequate information that supports the STPA position that S/S treatment of Tar Pond sediments will be effective in immobilizing pollutants in these sediments. As discussed in the section where I summarize my qualifications, I have been responsible for conducting well over a million dollars of US Army Corps of Engineers research on the leaching of pollutants from aquatic sediments. Further, I have been active in evaluating the leaching of contaminants from hazardous chemical sites treated soils. I, therefore, understand how to conduct such studies and to present the results in such a way as to inform reviewers of the conclusions. The Earth Tech (2005) report states,

> *"Leachate Testing*
> *Leachate analysis for the North and South Tar Ponds and the Tar Cell were typically below USEPA and NSDEL concentrations. The leachate results were also below the NSDEL criteria prior to and after blending additives. In addition, additive blending did not increase the leachability of PCBs in the North and South Tar Pond samples."*

The Earth Tech (2005) study has not adequately and reliably assessed the potential for PCBs and other contaminants in the S/S-treated Tar Pond sediments to be released in water that comes in contact with the treated sediments at sufficient concentrations to be a threat to public health and the environment when the associated water escapes from the Tar Pond sediment containment system. There are several aspects of this study that need to be understood with respect to its adequacy in addressing issues with respect to the efficacy of S/S treatment of Tar Pond sediments, the most important of which is the approach that Earth Tech (and, for that matter, STPA) uses to assess whether the treated sediments immobilize PCBs, PAHs and other pollutants in the sediments to a sufficient extent to be protective of the environment. Earth Tech (2005) has used as a criterion for leachability the US EPA Toxicity Leaching Characteristic Procedure (TCLP). Those who understand the development and appropriate use of this procedure know that the results are in no way applicable to the situation that will exist in the S/S-treated Tar Pond sediments.

As summarized in my statement of qualifications, I have considerable expertise and experience in evaluating the TCLP as a reliable test for assessing leachability of pollutants from solid wastes. The TCLP should only be used to decide whether a waste must be managed in a hazardous waste landfill, versus a municipal solid waste landfill. Further, a waste that passes the TCLP test (i.e., is classified from a regulatory perspective as "nonhazardous") can still contain significant amounts of hazardous chemicals that are a threat to public health and the environment when released from the waste. Wiles and Barth (1992) have commented on the inappropriateness of using the TCLP to judge the leachability of S/S-treated organic wastes, where they state,

> *"Technically, the TCLP and similar extraction test methods are not adequate for identifying all classes of organics that might be available for escape to the environment.*
>
> * * *

Furthermore, studies also provide evidence that tests other than the regulatory extraction tests [for example, toxicity characteristic leaching procedure (TCLP)] will be required to evaluate the effectiveness of S/S, especially when applied to organic wastes."

Examination of the data presented in the Earth Tech report shows that, for PCBs, the MDL (analytical method detection limit) was 0.05 µg/L. The concentrations of PCBs in the leachate for the North and South Tar Pond sediments were either less than 0.05 or less than 0.25 µg/L, indicating that the analytical methods used were unable to measure the amounts of PCBs present in the TCLP extract from the S/S–treated sediment samples. From these data, Earth Tech concludes, *"Leachate analysis for the North and South Tar Ponds and the Tar Cell were typically below USEPA and NSDEL concentrations."* It is clear that the authors of the Earth Tech report, as well as STPA staff who accepted this report, do not understand basic issues pertinent to evaluating the potential significance of PCB concentrations in S/S-treated sediment samples. A cursory review of the TCLP shows that the US EPA has not established a pass/fail concentration of PCBs with respect to placing a PCB-containing waste into a municipal landfill. Even for those parameters for which the Agency has established a pass/fail concentration (such as for some heavy metals), it is totally inappropriate to use the TCLP pass/fail criteria to judge the adequacy of the S/S-treatment of Tar Pond sediments.

During the 1970s under the Nixon administration, I was involved as an advisor to the President's Council on Environmental Quality (CEQ) in helping to formulate regulatory approaches for hazardous chemicals in the environment. CEQ was concerned about the fact that a number of chemicals (such as DDT and other organochlorine pesticides, PCBs and mercury) were being found as widespread environmental pollutants. It was determined at that time that there was need to develop a regulatory approach to screen the use of chemicals (such as a replacement for PCBs in electrical transformers) to be certain that the replacement of one type of hazardous chemical would not result in another hazardous chemical being used, creating a whole new suite of problems.

During the mid- to late 1970s, a group of about 25 individuals representing the US EPA, chemical companies and academia, including myself, met annually for several years to develop guidelines for screening new or expanded-use chemicals for potential environmental impacts. This led to what is now known as the principles of risk/hazard assessment that are standard practice today in human health and ecological hazard assessment. Further, at the federal level, the US Congress adopted the Toxics Substances Control Act (TSCA), which had as its primary goal the screening of new or expanded-use chemicals for potential environmental impacts.

The basic approach used in the risk/hazard assessment is to estimate the expected environmental concentrations for a new or expanded-use chemical through chemistry fate modeling. These concentrations then are compared to critical concentrations for potential public health and/or environmental impacts. In the late 1970s/early 1980s I published several papers on the application of risk/hazard assessment approaches to evaluating the potential impacts of new and existing chemicals, including,

Lee, G. F. and Jones, R. A., "A Risk Assessment Approach for Evaluating the Environmental Significance of Chemical Contaminants in Solid Wastes," In:

Environmental Risk Analysis for Chemicals, Van Nostrand, New York, pp 529-549 (1982).

This paper discussed the overall approach that should be followed in evaluating the risk/hazard that leaching from solid wastes represents to public health and the environment. An application of this approach has been developed by Dr. J. Marshack, of the California Central Valley Regional Water Quality Control Board, in,

Marshack, J. B., "Designated Level Methodology for Waste Classification and Cleanup Level Determination," Staff report of the California Regional Water Quality Control Board, Central Valley Region, Rancho Cordova, CA, October 1986, Updated June (1989).
http://www.waterboards.ca.gov/centralvalley/available_documents/guidance/dlm.pdf

According to Marshack (1989) in his classification of a waste as "inert,"

> *"The lower boundary of this category is described only as the limit above which a waste could impair water quality at the site of discharge. This boundary can be more clearly defined by establishing 'Designated Levels' for specific constituents of a waste which provide a site specific indication of the water quality impairment potential of the waste.* [The Marshack (1989)] *report provides a methodology for calculating such levels. Designated Levels are calculated by first determining the bodies of water that may be affected by a waste and the present and probable future beneficial uses of these waters. Next, site-specific 'water quality goals' are selected, based on background water quality or accepted criteria and standards, to protect those beneficial uses. Finally, these water quality goals are multiplied by factors which account for environmental attenuation and leachability. The result is a set of Soluble and Total Designated Levels which are applicable to a particular waste and disposal site and which, if not exceeded, should protect the beneficial uses of waters of the State. Wastes having constituent concentrations in excess of these Designated Levels are assumed to pose a threat to water quality and are, therefore, classified as 'designated wastes' and directed to waste management units which isolate these wastes from the environment."*

As discussed by Lee and Jones-Lee (2006), according to this approach, inert wastes would be those that do not contain soluble components at concentrations that, when deposited at a particular location, would leach constituents that, through the Designated Level Methodology, would be considered a threat to ground and surface water quality in the disposal area. Implementation of this approach requires a site-specific evaluation of the leaching characteristics of the types of wastes that are proposed to be classified as inert wastes, the hydrogeology of the proposed inert waste deposition area, as well as information on the present and probable future designated beneficial uses of the ground and surface waters that would be impacted by materials potentially released from the inert wastes.

A process similar to the Marshack Designated Level Methodology should be used to evaluate whether PCBs, PAHs and other pollutants in the S/S-treated Sydney Tar Pond sediments could be considered a continued threat to public health and the environment through release of contaminants to the waters infiltrating to the treated sediments. A key component of this evaluation is an estimate of the critical concentration below which PCBs and other pollutants would not represent a threat to public health and the environment. This concentration is certainly not the US EPA TCLP pass/fail concentration that the Agency uses to determine the type of landfill in which the waste is to be deposited. A critical concentration for PCBs, according to the US EPA's (2000) "Water Quality Criteria for Priority Toxic Pollutants for the State of California," for protection of freshwater aquatic life is 0.014 µg/L. For marine aquatic life the criterion is 0.03 µg/L for a four-day exposure. For protection of human health from excessive bioaccumulation of PCBs in edible organisms, the criterion is 0.000064 µg/L, in order to achieve a 1×10^{-6} cancer risk. What these values mean is that when the concentration of total PCBs exceed these values in water, there is a potential for adverse effects to aquatic life and/or excessive bioaccumulation of PCBs in edible organisms which is a threat to cause cancer in people who use these organisms as food. A comparison between the Earth Tech (2005) detection limits to determine whether excessive PCBs are leached from the S/S-treated sediments and the US EPA water quality criterion shows that Earth Tech's analytical detection limit for the leaching of PCBs is almost 4,000 times too high to protect humans from consuming organisms that have bioaccumulated excessive PCBs derived from the S/S-treated sediments. As part of making this evaluation it would be necessary to estimate the attenuation/dilution that would occur between the point of release of PCBs from the S/S-treated sediments and the point where edible aquatic organisms could be present that could bioaccumulate the PCBs derived from these sediments. It is evident that very small amounts of release of PCBs from S/S-treated sediments have the potential to cause significant water quality problems in the Estuary.

In addition to the Earth Tech (2005) studies on leaching from S/S-treated Tar Pond sediments, IT Corporation conducted similar studies on a limited number of Tar Pond sediment samples. Vaughan Engineering (2002) has summarized the IT Corporation solidification studies. IT Corporation (and, for that matter, Vaughan Engineering) has incorrectly attempted to use the TCLP as a pass/fail on leachability of various pollutants (not including PCBs) from S/S-treated Tar Pond sediments. Further, the analytical methods used in the IT Corporation studies were not adequate to measure PCB concentrations at potentially significant levels. **Overall, STPA has failed to properly evaluate the efficacy of S/S-treatment of Tar Pond sediments in producing a result that would not be a threat to public health and the environment as a result of leaching of PCBs and, for that matter, other pollutants from the S/S-treated sediments when they come in contact with water.** As discussed at several places in these comments, STPA's approach of assuming that their surface and ground water containment/control system will work perfectly for as long as the S/S-treated sediments will be a threat to release PCBs, etc., and thereby capture all such release, is highly inappropriate based on the types of materials and the monitoring that STPA proposes to use.

STPA (2006), in their response to IR-32, page 1 states,

> ***"Information Request (IR-32 Follow-up):***
> *The response to IR-32 states that a sand layer will be placed in the constructed channel for leveling purposes and as a bedding for a HDPE liner. Indicate whether the HDPE liner will be used on the sides and bottom of the channel.*

Response:
The HDPE liner will be placed on the bottom and on both sides of the channel between the stabilized sediments and the clean crushed rock to inhibit groundwater contact with the sediments and to prevent physical erosion of the sediments."

Again, STPA has failed to discuss the significant potential for short-term failure of the HDPE liner to maintain its integrity for as long as the S/S-treated sediments are a threat and there is need to divert groundwaters and surface waters away from the S/S-treated sediments and capture groundwater that has interacted with the treated sediments. As discussed in my comments on the STPA EIS, Rowe et al. (2003) of the Department of Civil Engineering, Queen's University, Kingston, Ontario, have found that an HDPE liner in a somewhat similar type of situation (an HDPE lined leachate lagoon) failed within a couple of years after installation.

It is evident that under some situations there can be rapid failure of HDPE liners that are used in waste management, including landfill leachate lagoon liners, as well as groundwater barriers. This failure will lead to unreliable control of groundwater flow in the S/S-treated Tar Pond sediments, which may not readily be detected. It should be noted that much of the information cited in the Lee and Jones-Lee (2006) Flawed Technology review on the problems with HDPE liners (including the Rowe et al. reference) is readily available on the Internet. STPA has not adequately and reliably evaluated the expected performance of HDPE liners.

STPA, in its response to IR-37, page 1 states,

"Issue (IR-37):
Section 7.2.2 of the EIS Guidelines requires the STPA to describe permanent or temporary structures that will be constructed as part of the project.

Information Request (IR-37):
Provide the Panel sufficient detail on the design, composition, installation, and projected lifespan of the following components that would allow the Panel to undertake an analysis on how these components could influence the potential environmental effects of the project:
1. sheet piles including information on the depths of these structures
2. portable dams
3. all proposed liners whether geotextile geomembrane, geosynthetic or others
4. vertical barrier walls
5. diversion and/or interception trenches
6. containment curtains
7. materials to be used in cap/dams (clay, fill, etc.)

Response:
The functional design and materials selected will meet the requirements of the construction period and the longer term operations and maintenance of the site. These design features and their anticipated lifespans were fully considered in the EIS for the assessment of potential environmental effects and human health risks. Responses to the itemized list in the request for additional information, is presented below.

1. Steel sheet piling (SSP) – SSP will be used to create barriers for several purposes during construction of remedial measures. The installation or the purpose is temporary in all cases, so lifespan is not significant. The depth of SSP installation will depend on the geotechnical conditions, but it will typically be installed through the sediment and into competent till. Generally, the embedment should be 50% of the freestanding height in competent till. In this case embedment depth is estimated at 3.5 metres. If areas are encountered where the bedrock is higher, preventing appropriate embedment, toe pinning will be required. A cursory review of available information indicates favourable conditions, however a full geotechnical investigation will be necessary prior to the detailed design. The specific SSP installations include:

a) Channel walls: The new channel for surface water flows will be constructed using SSP as a barrier between the channel and the pond sediments. After the SSP installation, the channel will be excavated and reconstructed. The SSP channel wall will be driven for the full length along the west side of the North and South ponds. Approximately 2,500 lineal metres of SSP will be required to construct the channel walls. An additional amount is required to construct sectional barriers (bulkheads), but much of this steel can be re-used. The channel construction will be completed by creating an interface between the SSP wall and the S/S treated sediments. A zone of Rock Fill / Rip Rap will be placed so that it extends from the upper surface of the cap down into the clean till that currently underlies the contaminated sediments. A high density polyethylene (HDPE) liner will be placed on the interface between the solidified sediments and the rock fill / rip rap zone, to inhibit groundwater contact with the sediments, and to prevent physical erosion of the sediments. Once the channel and the solidification/stabilization (S/S) treatment/capping is completed, the SSP will be cut off at elevation –1.0 meter below low water. This will provide a rip rap slope on both banks of the finished channel. There will be no SSP subject to corrosion or deterioration. It is anticipated that the SSP will have a lifespan of approximately 25 years. The HDPE liner component of the structure has a manufacturer's guarantee of approximately 30 years, but it is expected to function for a much longer time span. While these structures have a lengthy lifespan, the function of these structures is primarily for construction (e.g., retaining or supporting features). The functionality of remediation design is not dependant on them remaining in place. These structures could be removed upon completion of construction, but there is no disturbance created by leaving them in place.

* * *

3. Liners - The proposed liners for works at the site include HDPE, geosynthetic clay liner (GCL) and geotextile (fabric). These liners carry a manufacturers 30 year warranty. Installation will be performed by companies qualified to install the liner materials following all QA/QC criteria, which is required by the manufacturer. The expected lifespan of these materials meets the requirements of the construction and not required for long-term functionality of the remediation design.

4. Vertical barrier walls - Vertical barrier walls are a means of controlling groundwater flow. They will be used to prevent influx of clean groundwater from areas north and south of the Coke Ovens site. The design criterion for this structure is a permeability of

$1x10^{-6}$ cm/s. The walls will consist of bentonite/soil slurry placed in a 1 meter wide trench excavated through the fill and seated into the top 0.5 m of the till unit. Bentonite/soil slurry is preferred for the following reasons:

- *It is a robust material that will provide an effective low permeability barrier;*
- *The use of bentonite/soil slurry will minimize the opportunity for gaps between the wall and adjacent fill, because the slurry will settle into any gaps;*
- *Bentonite/soil slurry is easy to place and construct, even in the presence of the heavy debris that occurs in the fill; and*
- *Bentonite/soil slurry walls will last indefinitely.*

5. Diversion and/or interceptor trenches - Diversion/interceptor trenches will be used in two locations for specific purposes as described here. In both areas, these structures will be permanent and will continue to function in perpetuity.

a) Tar Ponds - The objectives for vertical groundwater control structures in the vicinity of the Tar Ponds are 1) to prevent off-site groundwater from flowing onto the Tar Ponds site and potentially contacting the contained sediments and 2) to control the movement of clean and contaminated groundwater and contaminants. The preferred design uses trenches to control groundwater and to minimize groundwater contact with contaminated sediments. The trench design provides the capability for sampling groundwater from discrete zones. The trench design includes the following:

- *A network of trenches will be excavated through the S/S treated sediments and 1.0 m into the underlying till unit. The trenches will have a nominal width of 1 m and a maximum depth of approximately 4.5 m with an average depth of approximately 2.5 m. The trenches will be backfilled with 1 cm nominal granular fill, up to the top of the solidified sediments. A GCL will be placed over the trench as part of the capping procedure (see cap design provided in IR-02 Follow-up).*
- *The trenches are designed to promote entry of deep groundwater from the till and bedrock units below the sediments and shallow groundwater from along the shoreline, where the fill unit overlies the sediments. The entry of both shallow and deep groundwater into the trenches is intended to minimize groundwater contact with the sediments and, consequently, to minimize the potential for groundwater to become contaminated before discharging to the trenches.*
- *A HDPE liner will be placed between the granular trench backfill and the solidified sediments, on the Tar Ponds side of the trench, and positioned to cover the exposed faces of the solidified sediments, to minimize groundwater contact with the sediment.*
- *Sampling wells will be installed near the channel end of each trench, to allow recovery of groundwater samples in the post-construction period. If unacceptable levels of groundwater contamination are detected within a discrete section of the trench system, contingency action may be required, including the collection and treatment of this contaminated groundwater. It is expected, based on previous studies, that groundwater in the trenches will not contain unacceptable concentrations.*

b) Coke Ovens - Vertical cutoff walls and/or interceptor trenches are included in the remedial design to achieve beneficial control of groundwater at the west end of the Coke Ovens Site. The specific objective for the groundwater control on the western *perimeter is to prevent movement of contaminants offsite. This objective is addressed by the inclusion of infiltration trenches in the old Coke Oven Brook channel and along the northwest side of the Coke Ovens site as described here.*

- *An interceptor trench will be installed at the bank of Coke Oven Brook to collect discharging groundwater. The trench will be installed in the base of the till unit (if present) or immediately above the shallow bedrock. A sufficient grade (0.05%) will be established in the trench and water will be collected in a sump structure on the west side of the site. The interceptor trench will consist of granular material and will be installed adjacent to the Coke Oven Brook as part of the Coke Oven Brook sediment removal. The perforated trench will be bedded in sand, with sand backfill. The surface layer will be integrated with the Coke Ovens surface cap, in order to isolate surface water as much as possible from the interceptor trench, and includes the placement of an HDPE liner on a sand bed with gravel/cobblestone backfill. At approximately 50 m spacing, intermediate sump points or catchbasins will also be installed to assist in managing sediment buildup in the system;, to allow for intermediate sampling of collected water and to assess the necessity of treatment. If the water collected is deemed to be of acceptable quality, it could be discharged directly to the Brook without treatment.*
- *The Domtar interceptor wall will be designed to capture groundwater flowing west from the Domtar area. The wall will extend approximately 200 m along the western perimeter of the Domtar area and be set to the base of the overburden unit or to competent bedrock. The interceptor wall will be fitted with a bottom perforated pipe in bedding sand which slopes to the south and backfilled with a sand/granular B mixture. The upper portion of the wall will be completed with a clay cap to minimize surface infiltration.*

6. *Containment curtains – This structure is a floating fabric curtain that is weighted along the bottom and is designed to capture suspended solids in the water column. This type of structure will only be used during construction activities in the Tar Ponds that may result in increased levels of suspended sediments (e.g., excavation of sediments, driving of sheet piles, etc.). This technique is commonly used for in-water work.*

7. *Cap/dam materials (clay, granular, till, etc.) – Capping materials will be native materials (clay, granular and topsoils), sourced locally. The cap will be placed on top on any liner materials that are in place. The final thickness of the cap will be evaluated during the detailed design phase of the Project, but is expected to be variable and is ultimately dependant on the final grade. The final grading may require the placement of materials that are several metres in thickness to less than a metre (0.3 m) in some locations. The objective of the final thickness and performance will be to create a protective layer over the liner. The caps will be inspected annually for 25 year period following completion of the Project and maintenance will be dependant on the final land use of the site. Properly maintained, the cap should last indefinitely."*

The above discussion of the elaborate system that STPA plans to construct, operate and, for some components, maintain in perpetuity, is largely dependent on the integrity of the HDPE liners. STPA's statement regarding the integrity of the HDPE liners refers to the manufacturer's 30-year warranty. If the warranty is typical of HDPE liner warranties, the warranty requires that the operator of a system detect the points of failure and excavate the material around these failure areas so that the liner manufacturer can gain access to the failure points for repair. Further, this warranty is often prorated over the warranted life. In a landfill situation, such a warranty is essentially worthless, since it requires that a landfill owner detect where the liner is leaking under all the wastes and then remove all the wastes in the area of leakage. It is apparently STPA's position that, since the wastes will become innocuous after 25 years, a 30-year warranty is all that is needed. The issues of what this warranty really means and how it can be implemented need to be further spelled out. In addition, since the solidified wastes will be a threat to leach pollutants, effectively, forever, does Nova Scotia, who becomes the ultimate operator of this water diversion/collection system, fully understand the complexity and difficulty of maintaining this system in perpetuity?

The bentonite slurry wall mentioned above can be the source of many problems in maintaining its integrity. Slurry walls are well known to have chronic problems of cracking near the water table. Further, the bentonite, if it is a sodium bentonite, can experience shrink-swell properties associated with the high calcium that will be in the groundwater in contact with the cement-based solidified sediments. Lee (1999), in a "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," presented a comprehensive review of the potential problems of clay-based slurry walls in being reliable, effective cut-off walls for preventing pollutants and groundwater from passing through them. Selected excerpts from the Lee (1999) review are presented below.

> 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 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 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. 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 walls 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."

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.

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.

In summary, the state of technology regarding the use of slurry walls as a barrier to the transport of groundwater through the wall is such that slurry walls cannot be considered as a reliable barrier for containing groundwater. Further, there are significant questions about the STPA proposed slurry wall to be an effective near-term, and especially long-term, barrier to the movement of contaminated groundwater and/or clean groundwater into the Coke Ovens Site.

STPA, in its response to IR-42, page 1 states,

"Issue (IR-42):
References are made within the EIS and in the STPA's responses to public comments regarding the use of stabilization and solidification in other remediation projects. For example, the following reference is made in response to public comment 48 (STP-0090 in the public registry): 'The design of the remediation Project includes the use of technologies that have established, and successful track records for the remediation of similar sites around the world.'

Information Request (IR-42):
Provide detailed information regarding the combined use of containment and stabilization/solidification at a minimum of three remediation projects with particular reference to:

1. *similarities in the nature of the materials to be treated (for this Project, primarily organically enriched estuarine sediments).*

2. similarity of the contaminants (based on constituents and concentrations) used in the referenced stabilization and solidification projects to the contaminants at the Tar Ponds and Coke Ovens sites
3. Performance expectations particularly with respect to longevity.
4. Maintenance and monitoring requirements for the referenced stabilization and solidification projects.
5. Whether encapsulation was implemented for the referenced projects

Response:
Contaminated site remediation is typically designed around the specific objectives and conditions for the location. Since no two sites will be the same comparisons are based on approximate similarities.

Several projects are presented in Table IR-42.1, which provides a direct comparison of the five points requested. The information presented in this table is available in the public domain. In addition to these projects, members of our Project team have had extensive experience with other sites around the world where S/S has been applied successfully as a treatment technology.

Table IR-42.2 provides additional S/S projects that are can be compared to the Project. Note that several projects from Table IR-42.1 are also included in Table IR-42.2. These projects are highlighted in Table IR-42.2."

As discussed in these comments as well as those on the EIS, the nature of hazardous chemical site remediation, especially for high-organic wastes, is such that the use of S/S treatment should not be considered as having been adequately and reliably evaluated with respect to its prevention of further pollution of the areas in the vicinity of the solidified wastes. Those familiar with hazardous chemical site remediation know that a wide variety of factors (such as accomplishing "remediation") influences the adoption of a remediation approach, which may have limited applicability to assessing its effectiveness in preventing further pollution by the wastes. As discussed above, Wiles and Barth (1992) have discussed the significant technical problems in assuming that repeated use of S/S treatment of organic-type wastes is proof that it is effective in preventing further pollution. Further, at many locations (possibly most), "successful" solidification projects are based on achieving a leachability less than a TCLP regulatory criterion. As noted above, this is a technically invalid approach for assessing the success of an S/S project in protecting public health and the environment from constituents that can be leached from the S/S-treated wastes.

STPA, in its response to IR-54, page 1 states,

"Issue (IR-54):
The Panel requires more information on solidification and stabilization.

Information Request (IR-54):
Detail, in a quantitative manner, how Portland cement was chosen as a preferred material for solidification.

Indicate whether the modeling of the volatilization of contaminants due to the addition of binding agents accounted for different reagents with varying amounts of heat generated during the setting reaction. Indicate whether volatile emissions mitigation techniques were included in the modeling and present the results.

Provide additional information on the expected geotechnical specifications of the stabilized solidified sediments that would support long-term performance objectives.

Response:
Portland cement has been demonstrated to be an effective binding agent on S/S projects throughout North America. As a result, Portland cement is a starting point for the analysis required to determine an appropriate treatment agent. Additional solidification testing was completed for different potential binding agents (Quicklime, slag, flyash, Portland cement), on selected samples from the Tar Pond sediments. The purpose of this additional testing was as follows:

- *determine the hydraulic permeability of the solidified materials;*
- *determine the structural compressive strength of the solidified materials;*
- *provide field observations of the relevant materials prior to and post mixing/ solidification;*
- *undertake laboratory analytical testing of the materials pre and post mixing and carry out analytical testing by Toxicity Characterization Leachate Procedure (TCLP) on pre and post mixed samples to assess leachate potential;*
- *utilize solidification additives which are readily obtainable and cost effective (i.e. no proprietary mixtures) to allow for more competition during the construction phases of the project; and*
- *design the mix ratios for the various types of additives nominated with consideration of engineering properties (permeability and compressive strength) and monitoring of leachate/chemical targets."*

The unreliability of STPA's response to the Panel's IR-54 has been discussed in detail above and will not be repeated here, other than to reiterate that the use of S/S treatment is not tantamount to proof of effectiveness, TCLP is not a reliable procedure for evaluating the effectiveness of S/S treatment, etc.

STPA's response to IR-55, page 1, states,

"Issue (IR-55):
The Panel requires more information on how capping would be carried out as part of the project.

Information Request (IR-55):
The Panel requests that more information be provided on how the final design and implementation of the two caps will be responsive to potential problems that may arise.

Indicate how technical designs will consider the difficulties with saltwater intrusion, groundwater flow through shallow bedrock, including mounding, nonaqueous phase layer (NAPL) migration and the generation and migration of gas under a capping layer.

The information should detail the potential interactions of a separate gas or liquid (NAPL) phase with synthetic liners. Provide information on whether any generated gas will accumulate or be released, both of which may be influenced by a low permeability layer and may have negative consequences (with reference to the information provided in response to IR-45).

Response:
The two designs have a number of features which help to control or eliminate the potential problems mentioned above. Critical design features include:

1. *Solid stable matrix - Prevents subsidence and cap failure. A low permeability monolith is created which will not allow water (including salt water) to intrude into the matrix.*
2. *Portland cement additive - Allows for S/S to achieve the desired goals, allows for heat of reaction to occur, which drives off a portion of the volatiles (see response to IR-54) and improves the material handling characteristics. As a result, gas is not expected to be generated from the S/S treated materials (please see response to IR-45).*
3. *Synthetic liners – Synthetic liners have been specified in areas where there is potential for contact with NAPL and gases. According to manufacturers specifications, these liners are designed to withstand contact with these materials.*
4. *Cover systems - Both engineered caps work in conjunction with the other project design features to be responsive and to ensure longevity of the overall remediation design. They have been included to complement the design and to assist in reducing the Project's long term maintenance requirements. These cover systems also ensure that no rainfall will infiltrate into the monolith over time. Properly maintained, the cap will function indefinitely.*
5. *Hydraulic flow features - Due to its design (low permeability), water will not enter the monolith. To ensure that the monolith containment design remains functional over time, a number of groundwater flow control and redirection features have been included which will minimize groundwater intrusion."*

Again, STPA has repeated its statements about how *"These cover systems also ensure that no rainfall will infiltrate into the monolith over time"* and that the caps will prevent moisture from entering the capped sediments/soils *"indefinitely."* As discussed in these comments, those familiar with the types of liners that are proposed for the caps know that such statements are unreliable; there are well known, significant problems with the long-term ability of such capping approaches to maintain their design characteristics for as long as the capped wastes represent a threat to be leached by infiltrating water.

The STPA statement quoted above, *"A low permeability monolith is created which will not allow water (including salt water) to intrude into the matrix,"* is a mischaracterization of the S/S-treated Tar Pond sediments. There can be little doubt that, over time, surface water and groundwater will penetrate into the so-called "monolith" that will leach pollutants in sufficient concentrations to represent a threat to continued pollution of the Estuary.

STPA, in their response to IR-60, page 1 states,

> ***"Issue (IR-60):***
> *In response to PC 35.4.2 and PC 49.2.17, STPA indicated that there has been additional stabilization and solidification testing by STPA and that the testing has indicated that stabilization and solidification will be successful in treating the sediments. In response to PC 49.2.21, STPA indicates that there has been additional testing of the leachability characteristics of Tar Ponds sediments by STPA.*
>
> ***Information Request 2 (IR-60):***
> *The Panel requests copies of the test results described above.*
>
> ***Response:***
> *The full test results are attached.*
>
> *Results from the additional solidification testing indicated that additive mixtures with selected percentages of slag and cement met strength and permeability goals for the solidification pilot test in the North and South Tar Pond samples. In addition, additive blending did not increase the leachability of PCBs in the North and South Tar Pond samples."*

Included in this response to IR-60 is the report,

> **Solidification: Technical Memo Report, Remedial Predesign Project, Sydney Tar Ponds and Coke Ovens Sites, Sydney Tar Ponds Agency Sydney, Nova Scotia**
> Earth Tech Canada Inc., Markham, Ontario, November 1 (2005).

Presented above is a detailed discussion of the unreliability of this report and its predecessor, the IT Corporation study, on the solidification of Tar Pond sediments. I wish to comment on the statement about *"… additive blending did not increase the leachability of PCBs…."* As discussed above, all assessments of leachability are based on using inadequate analytical method detection limits, where it was not possible to determine the leachability of the S/S-treated sediments.

Comments on Public Hearing Transcripts
Note: Comments on statements made by STPA during the Public Hearing have to some extent been incorporated into discussion of the IR responses presented above. The comments presented below are on additional issues or further demonstrate inadequate and unreliable information presented by STPA during the hearing. In the comments presented below on the transcripts, reference is made to the volume and page number from the printed transcript (Transcript-1 refers to the April 29 hearing, Transcript-2 refers to the May 1 hearing, etc.).

Twenty-five Year "Walk-Away" Period

At the Public Hearing there was considerable discussion by the Panel about the MOA-specified 25-year Project period and whether, at the end of this period, the S/S-treated Tar Pond sediments would no longer be a threat to public threat and the environment. Excerpts from the transcripts pertinent to this issue are presented below.
Transcript-1, beginning on page 70 states,

> THE CHAIRPERSON: Is this remediation -- is it then -- is it permanent in the sense that no one will ever have to revisit the contamination problem on the site or to rework it in any way?
>
> MR. POTTER: That would be correct. The only long-term action necessary would be to continue the long-term monitoring, ensuring that the planned remediation is meeting its objectives in terms of the performance.
>
> THE CHAIRPERSON: And is the -- I mean, certainly not initially you can't -- you would not characterize this as being a walk-away solution, but do you anticipate that at some point in the -- that this -- that the project will be -- that the Agency will be able to simply walk away from the -- from the solutions that you're proposing -- walk away in terms of no more monitoring, no more mitigation?
>
> MR. POTTER: The commitment in the MOA is to continue monitoring 10 years after completion of the remediation work. The agreement does not go beyond that point. I think at that point in time, it would have to be reassessment undertaken of what conditions we're finding at the site and appropriate action taken at that point in time, which you know, I couldn't speculate on 21 years out. So I'm not sure what might take place at that point in time, but certainly the intent is that at the end of that 25 years of monitoring, there'd be a reassessment of the success of the project and if there was any need for further action.
>
> THE CHAIRPERSON: But as you've -- as you have designed the project, your assumption is that at the end of 25 years, there's a reasonable chance that you will in fact be able to -- excuse me emphasizing this walk away, but I think it's important -- that you will be able to walk away from the project in terms of monitoring mitigation -- and I should have added maintenance. I mean, will maintenance requirements of this project be -- largely be complete by the end of 25 years?
>
> MR. POTTER: Yes.
>
> THE CHAIRPERSON: Or is there a -- how much uncertainty do you have?
>
> MR. POTTER: There is -- I guess it's hard to put a figure on the certainty. There's a high degree of probability that at the end of 25 years after extensive monitoring and reviewing the data, that the site will be no longer presenting a problem and we can, as you say, walk away. That's certainly the -- would be the desire. That's -- the design is based on that, that you know, we would hope that after 25 years, we would be in a position to say, "Yes,

this -- you know, 25 years of confirmation monitoring and sampling is confirming that the work has been completed.

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THE CHAIRPERSON: All right. Before we get to that, though, I just want to make sure I'm getting it absolutely clear. So that around about 25 years, maybe before, maybe a little bit later, but around about that time, there would be no requirement to do any further maintenance to any of the containment structures or elements of the project. In other words, no more maintenance of the cap, no more maintenance of the ground water intercepting structures.

MR. POTTER: That's correct.

In the above exchange between the Panel Chairperson and Mr. Potter, Mr. Potter states that after 25 years the remediation that is proposed will enable STPA (and, for that matter, Nova Scotia, who, according to the MOA, assumes responsibility after 25 years) to "walk away." Based on my over 40 years of professional experience investigating issues of this type, I unequivocally state that such an assessment by Mr. Potter is technically invalid. At some time in the future, the groundwater and surface water management/containment system will deteriorate in its ability to effectively control water flow. This could occur during the first 25 years. It certainly will occur during the period of time that the capped S/S-treated sediments will be a threat to generate leachate that could escape from the treated sediment area to the Estuary. STPA has not properly analyzed the long-term problems of the proposed remediation approach. The monitoring during the initial phase following the completion of remediation could readily give an incorrect assessment of the long-term problems that will exist with the STPA approach for remediation of the Tar Pond sediments. A detailed discussion of this issue has been provided in the comments on the EIS and in the above comments on the IR responses.

Transcript-1, beginning on page 78, states,

THE CHAIRPERSON: So -- this is my final point on this. So you say the hope is -- so is this a hope or is this a -- you're pretty confident about your prediction that in round about 25 years, the contaminants will have decayed to such an extent that in fact you will not longer need to either monitor or maintain those interception and containment encapsulation structures?

MR. SHOSKY: Madame Chairman, my name is Don Shosky and I'm part of the engineering team. With confidence, the way that the design is contemplated at this point, I think you do have the walk-away solution that you're looking for. The design itself is set up in such a fashion as that a contained -- engineered contained system will be in place to contain the contaminants that are solidified and designed to intercept any ground water that may be migrating towards the large -- basically large concrete monolith that's anticipated to be there. The capping materials themselves are an extra added -- added protection. The monolith itself should be able to withstand many years of free spa [sic] events. Any of those sorts of problems associated with migration -- potential migration through the monolith are eliminated because of the low permeability of the monolith.

> The capping materials themselves are all natural types of materials contemplated at this point. They're not manmade in the sense that they would break down of themselves over a period of time. They're anticipated to be clays. The trenches themselves for the interception are all made out of natural materials as well -- just gravel, clay, and things of that nature that allow long-term durability.
>
> THE CHAIRPERSON: But you only -- you only am I saying this correctly? You would only walk away in terms of monitoring and maintenance from an encapsulation system, a containment system, at the point at which you are confident that what is containing is no longer a risk? You don't -- it's not a question of, "Well, this -- this cap and this monolith has lasted so far, 25 years, therefore -- you know, the contaminants are still there, but we can -- it's lasted this long, so we can be pretty confident it'll go on for another hundred years because..." Would that be a logical assumption? I'm not -- not sure it would. What you're saying is when you walk away, you walk away because you are confident that the contaminants no longer represent a risk -- the contaminants that you've been containing and encapsulating. Is that correct?
>
> MR. SHOSKY: That's correct. However, I think it's important to understand that you would have years of operating understanding of that system, and we're not at this point yet to the detailed design phase where that monolith would be looked at for periods of time beyond 25 years and projecting the types of additional problems that may occur. But the way that it appears right now from the way the systems are laid out, I believe you'll have that walk-away solution that you're looking for in 25 years.

As discussed above with respect to Mr. Potter’s response to questions on the 25-year “walk-away” period, a more reliable assessment of the potential public health and environmental threat that the S/S-treated Tar Pond sediments represent at 25 years would be that this is an infinitesimally small part of the total time that the S/S-treated sediments will be a threat to public health and the environment. The pollutants will still be there and will still be leachable to some as yet undefined extent. They will still have the potential to be transported through the “monolith.” The escape of the polluted waters from the treated sediment area will be ever-increasing over time, due to the failure of the water management system to function as designed.

This situation is analogous to a situation that has developed with respect to closed, capped municipal solid waste landfills. As discussed by Lee and Jones-Lee (2006), private landfill companies have developed an effort to convince regulatory agencies that once a landfill is closed and the leachate generation rates significantly decrease associated with the installation of an “impervious” cap over the landfill, and the landfill is in a dormant state with respect to leachate and gas generation, the owners of the landfill can be relieved of their responsibility for ongoing monitoring and maintenance. However, in time the dormant conditions in the dry tomb type landfill will cease when the “impervious” cap over the landfill fails to prevent moisture (water) from entering the wastes. The water interacts with the wastes to produce leachate and landfill gas. If at that time the landfill owner is no longer responsible for monitoring and maintaining the landfill system, including removing leachate, and the liner system has failed, significant environmental pollution can occur, only now there is no entity responsible for monitoring and remediation of the pollution.

Lee and Jones-Lee (2006) have provided detailed discussion of these issues, in which they reference a review of long-term funding needs for closed landfills by the California Integrated Waste Management Board (CIWMB 2004). The Board staff concluded that the initial low leachate production rate once a low-permeability cap has been installed on a closed landfill is only a temporary situation, where in time, as the integrity of the cap deteriorates due to natural causes, landfill gas and leachate production will again occur. A similar condition can occur with respect to the S/S-treated Tar Pond sediments, where there will be a period of time (if high-quality construction is achieved) when the water management system will be effective; however, there is no doubt that over time the components of the water management system will deteriorate in their ability to control water flow. This can lead to increased leaching from the S/S-treated sediments and escape from the treated area to the Estuary.

Mr. Shosky’s statement,

> *“The trenches themselves for the interception are all made out of natural materials as well -- just gravel, clay, and things of that nature that allow long-term durability,”*

ignores that HDPE is a substantial component of the barriers in the trenches. This is not a natural material, and it does decay. Further, the issue of clays being a natural material is not particularly pertinent to this discussion. The issue is not its composition, but its ability to retain the design permeability over time. As discussed herein and in my comments on the EIS, the clay components can lose their ability to reduce the rate of water penetrating through them due to stresses on the GCL, cation exchange reactions, etc.

Groundwater Control Issues

Transcript-1, beginning near the bottom of page 97, states,

> DR. LAPIERRE: And I guess this question -- but it may come back later on -- I'm trying to get my head around how much of the groundwater table is going to be diverted by your pilings and how much is still going to be infiltrate into that Coke Ovens site. You're reducing it but there'll still be some groundwater. And I guess the question that I have is, how -- for how long will these chemicals that are in place -- you're capping the top to ensure the water doesn't get in, but you still have water infiltrating at the bottom and moving through that groundwater. Now, will your sheet piling increase the pressure, will it increase the conductivity to the fractured bedrock?
>
> MR. SHOSKY: Again, depending on how much detail you want on this answer, I can give you a brief answer now and would have to take a more detailed quantitative presentation for you as an undertaking, but you are correct in assuming that there is water, it's a dynamic system, it's not one where it's going to be totally cut off and isolated in that sense, but there will be water moving into the area which we anticipate through our modelling to be collected and monitored over time. And the water that comes up from the bottom, we've also included some provisions for monitoring that as well. So, it is a dynamic system, it's not one that will be -- I don't want to use the word "stale" or "stagnant." That's the way that the design is contemplated at this point. I'm happy to

> provide additional information on that in a quantitative form as an undertaking, because perhaps a graphic depiction or something like that would be more useful to explain it.

As discussed elsewhere in my comments, the interaction between the bedrock aquifer and the Coke Ovens as well as Tar Ponds area sediments is an issue that needs further discussion, since this is part of the water at the sites that is apparently not going to be controlled.

Beginning on the bottom of page 12 of the May 1 Transcript (Transcript-2, page 230) Mr. Shosky, in response to the Panel's request that he provide further information on the movement of groundwater in the area of the Tar Ponds, states

> So, in detail, here, these trenches are physically isolated from the monolithic material around it, by virtue of using a high density polyethylene liner system, which has a very, very low permeability.
>
> If you all recall from Saturday's discussion this material here was roughly a clay type of material. It has 10 to the minus 6 permeability as a minimum. That was also underlain by a GC -- what we call a GCL -- which was the clay sandwiched between two sets of fabric, which has a permeability of 10 to the minus. Three orders of magnitude difference. The high density polyethylene liners that are part of this trench system have a permeability of 10 to the minus 14 centimetres per second. Very, very safe conditions from an isolation perspective. So, in relationship to the surrounding hydrogeologic conditions, what the conditions were before the monolith was built, just to give you an idea, we are changing the monolith to make it a permeability of 10 to the minus 6, to that minimum, although our testings show that we were successful in getting 10 to the minus 8 permeability of material here. The sediments left untreated are about 10 to the minus 3. So, there's almost three orders of magnitude more able to transmit water before solidification than after solidification.

Mr. Shosky's statements, as far as they go, are in accord with the data available; however, again, STPA, and specifically Mr. Shosky, has failed to reliably inform the Panel and the public about the ultimate failure of the HDPE liner system, where the initial *"10 to the minus 14 centimetres per second permeability"* will increase significantly. As discussed in the Lee and Jones-Lee (2006) Flawed Technology review, there is no question about the fact that, ultimately, the HDPE liner will deteriorate due to free radical attack and possibly other mechanisms, with the result that its low initial permeability properties will be lost. Under these conditions, to the extent that groundwaters of the area are moving toward the Tar Pond S/S-treated sediments, they will pass into the treated sediments and mix with the water infiltrating through the cap, to leach pollutants from the S/S-treated sediments. As discussed in my comments on the EIS, there are situations where HDPE liners have failed to be effective barriers to transport of water and pollutants through them within a few years after installation. Further, as I have repeatedly pointed out in my comments, the ability to detect the failure of the HDPE-based barrier is difficult without an elaborate monitoring system, far beyond what STPA is apparently proposing.

Mr. Shosky stated on several occasions that generally the groundwaters are moving toward the Tar Ponds. There are, however, as discussed in my comments, situations where the groundwaters are moving away from the Tar Ponds. Here again, any HDPE barriers that are developed to attempt to control this flow will ultimately become ineffective, with the result that there will be transport of pollutants leached from the S/S-treated sediments to off site, through groundwater movement.

Pages 16 and 17 (Transcript-2, page 234) state,

> DR. LAPIERRE: I just want to make sure I understood correctly. Now, if groundwater was to seep in under the monolith, as you've indicated it would move up through the drainage system, and then through that drainage system, it would move towards the ditch, and once it gets to the ditch you have monitoring points, but that ditch is open to the ocean. Now, if contaminated water gets in the ditch, and it was contaminated, how can you stop it from going to the ocean?
>
> MR. SHOSKY: That's a very good question. How would we stop -- and I believe we're all talking -- so that we all are on the same page as far as talking points -- we're talking about at each one of these lateral locations, how would we stop water from just being discharged? Our current thought on that, right now, is that these areas will be valved, and that we will have a -- and water will not be released to free flow without being trapped first and tested to determine whether or not it's clean, or dirty, and would require monitoring along these lines during the life of the project. That's our current thought on that right now. So, there would be mechanisms to stop it. One of the earlier things we contemplated was a larger interceptor trench along this entire area here, but we felt that if we found contamination at that point, we would not be able to isolate it and treat it. In this case, if we find the problem here, we can isolate it and treat it. If we find it here, we can isolate it and treat it. So, we felt we had more control over isolation and treating, focusing our resources on a smaller source problem than a larger potential problem if not controlled properly.

One of my areas of work and expertise is managing water quality impacts of stormwater runoff from urban, industrial and agricultural areas. As shown on my website, www.gfredlee.com, I have published extensively on these issues. Of particular concern is the situation that can develop during storms, where very high flows can occur in a short period of time, which can mobilize contaminants that have accumulated in drainageway sediments during low-flow conditions. Typically, under low-flow conditions, pollutants released from the containment area soils/sediments and runoff from surrounding lands would tend to accumulate in the drainageway sediments. In order to capture and treat what could be highly polluted first-flush stormwater runoff from the Coke Ovens Site treated soil and Tar Pond sediment drainage ditches, a very large area/volume would be needed to store the runoff during major runoff events.

Further, the treatment works to treat this runoff adequately before its release to the environment would likely have to be much larger than STPA currently contemplates. These problems may not show up during the 25-year Project required maintenance period, and therefore, to the extent that they occur after the end of this period due to the inevitable failure of the HDPE liner and barrier systems, Nova Scotia would be responsible for having to capture, monitor and treat the polluted water from the ditches during high-flow events. This could greatly increase the cost of maintenance of the Coke Ovens Site soils and Tar Pond area sediments that would be required to prevent environmental pollution by the residual pollutants at these locations.

Comments on Memorandum of Agreement

In the May 12, 2004, Memorandum of Agreement (MOA) for the Project, which is signed by the Government of Canada and the Province of Nova Scotia, page 2 under the description of what the Project shall include states,

> *"Provision for the ongoing future maintenance and monitoring of the sites for 25 years after completion of the Project."*

Those who drafted the MOA clearly did not have an adequate understanding of the period of time that the landfarmed Coke Ovens Site soils and Tar Ponds S/S-treated sediments would be a threat to release contaminants to the environment. Further, those who drafted the MOA did not understand that the so-called containment systems for both areas have limited periods of time during which the caps and barriers can significantly slow down the infiltration of water into the treated wastes, the entrance of groundwater into the areas, and the exit of water from these treated areas.

This situation is somewhat similar to the situation in the USA with respect to the Resource Conservation and Recovery Act (RCRA) specifying that assured postclosure funding for hazardous and municipal solid waste landfills is to be provided by the landfill developer to cover monitoring and maintenance of the landfill for 30 years. As discussed by Lee and Jones-Lee (2006) in their Flawed Technology review, it is now widely recognized that the US Congress made a significant error in developing a 30-year period as the period for mandatory postclosure funding (monitoring and maintenance) for landfills. In fact, modern landfills developed in the USA can be expected to be a threat to pollute the environment, effectively, forever. Thirty years of minimal postclosure funding is an infinitesimally small part of the time that postclosure funding will be needed if there is to be any significant effort to control releases of hazardous and deleterious chemicals from the landfill.

Some US states, such as California, are attempting to address this situation so that funds will, in fact, be available to meet the very high costs of *ad infinitum* monitoring, maintenance, and eventual groundwater remediation when the liner systems fail to prevent release of pollutants to the environment.

In the USA, the typical approach for developing a landfill only considers the required 30-years postclosure care funding as part of landfill true costs. The true costs of a landfill can be far greater than the initial construction and 30-year maintenance costs. A similar situation is apparently being developed under this MOA, where the decision-makers were misled into believing that a Project for remediation of the Coke Ovens Site soils and Tar Pond sediments could be developed for $400 million which would have a high degree of reliability of controlling releases of the pollutants from the sites that cause further pollution of the Estuary.

Section 1.8 on the bottom of page 2 of the MOA states, *"Upon issuance of the appropriate Certificate of Project Completion by the Independent Engineer appointed pursuant to Section 3, certifying that the Project has been completed in accordance with the Project Description (as may have been jointly amended during the implementation of the Project to address unforeseen issues or that result from the joint Environmental Assessment) Nova Scotia shall accept full ownership of the sites, except in the event any validated third party claims or interests therein have been established, and shall be responsible for any contemplated future development and any future impact to or on the sites from such development, as well as for all ongoing future maintenance and monitoring of the sites."*

Annex A, under "1. Management Accountability Principles" states, in the third bulleted item, that the Project *"will have appropriate mechanisms in place to permit long term management, monitoring and corrective action, where necessary."*

Section 1.8 and this provision of Annex A of the MOA obligates Nova Scotia to provide the very large amount of post-25-year funding for ongoing monitoring and maintenance of the treated soils and sediments. A situation could develop where Nova Scotia would be in denial with respect to acknowledging that the containment systems for controlling surface and ground waters are not effective in preventing continued environmental pollution. This could lead to years of continued pollution before Nova Scotia finally acknowledges that the remediation approach adopted in 2006 was a stop-gap, short-term, ineffective approach for controlling the release of contaminants from the Coke Ovens site landfarmed soils and Tar Pond S/S-treated sediments. At that point Nova Scotia could be responsible for developing a new, more reliable and effective approach for removal and treatment of the residual pollutants from the two areas.

Proven Technology that has been Successfully Employed for Projects of Similar Size and Nature. The first two bullets on pages 1 and 2 of the MOA state that the Project shall include:

"the removal and destruction of PCBs from the tar ponds as well as the removal and destruction of the contents of the tar cell on the coke ovens site with a proven technology such as high temperature incineration in a single use dedicated facility;

the in-place treatment of the remaining contaminated material using proven technology such as bioremediation, solidification or other appropriate technology."

A key issue in evaluating the appropriateness of S/S treatment of Tar Pond sediments is whether this approach meets the MOA requirement of a *"proven technology."*

On page 16 of the May 3 transcript (Transcript-4, page 679) Mr. Swain of Public Works Canada testified on Day 4 of the hearing,

"*It's also an appropriate time to raise a related but distinctly different principle and that's of technical feasibility. It's also referred to by the Canadian Environmental Assessment Act and the EIS guidelines.*

In this regard, the MOA is specific with regard to undertaking the Project using proven technology. As the federal lead department for the initiative, PWGSC takes this to mean technology previously successfully employed for projects of a similar size and nature. In this regard, we feel it's crucial that this be taken into consideration as the Panel develops related recommendations."

As part of my review of the use of S/S treatment of wastes I purchased the symposium proceedings of two of the most respected conferences devoted to S/S treatment: : the ASTM conferences on "Stabilization and Solidification of Hazardous, Radioactive, and Mixed Wastes" (Gilliam and Wiles, 1992; 1996). These proceedings include a wealth of articles on various aspects of evaluating the efficacy and reliability of S/S treatment of wastes. I examined these articles with specific regard to the information on what is known about the appropriateness of using the TCLP to evaluate the adequacy of S/S stabilization of wastes. I also examined what has been reported about the understanding about the reliability of S/S treatment to permanently immobilize pollutants. Presented below are excerpts from articles on these issues that reflect the fundamental and undisputed finding that the TCLP cannot be considered to be a reliable approach for understanding or estimating the expected release of contaminants from S/S-treated solid wastes in the short term or the long term.

Kirk (1996), a chemical engineer with the US EPA Risk Reduction Engineering Laboratory in Cincinnati, OH, presented a summary of US EPA research on S/S treatment of waste in terms of its long-term durability. In her review of the progress and findings of those projects she stated,

"Successful performance of solidification and stabilization treatment technologies largely depends on the ability of the treated waste to endure long term exposure to physical and chemical stresses. The available test methods to assess durability of treated wastes rely on results from laboratory tests; these procedures rely on freeze/thaw cycles, elevated temperature, and exposure to various solutions to simulate the stresses exerted on a solidified/stabilized (S/S) waste form over time. Unfortunately, none of the methods has been verified as replicating field behavior. In addition, the speciation of contaminants is a critical factor in determining long-term immobilization. Research is needed to cover areas which will address the issues associated with long-term performance of S/S waste forms."

"To date, there has been little or no verification of these tests [leach test results] *to ensure that they accurately predict behavior of the treated material in the field setting.* [Conner 1990].*"*

Kirk noted that RCRA 1976 & HSWA 1984…

"*… are U.S. Environmental Protection Agency (EPA) standards for the management of both hazardous and non-hazardous wastes [reference to US EPA, "Stabilization/Solidification of CERCLA and RCRA Wastes," EPA/625/6-89/002, US EPA Risk Reduction Engineering Laboratory, Cincinnati, OH (1989).] Provisions in these regulations require that land disposal of hazardous waste be preceded by treatment with the best demonstrated available technology (BDAT). Therefore, S/S treatment is* *used as a BDAT for hazardous wastes that cannot be destroyed by chemical, thermal, or biological means* [Conner 1990].

Even though S/S has been used for over 30 years there is no direct evidence of long-term material durability in the field. The durability of a S/S waste is dependent on how well it endures long term exposure to environmental stresses. A number of physical and chemical tests haven been applied to S/S wastes to determine the durability of the material. Generally, these tests are short term tests and do not give a full correlation to field performance. [Conner 1990].*"*

Kirk (1996) reviewed a study of the long-term durability of S/S wastes through accelerated aging & weathering tests using chemical tests: ANS 16.1 & TCLP. ANS 16.1 leach test results indicated that leaching of heavy metals is diffusion-controlled.; S/S process effectively fixed the heavy metals. However, she reported that from the TCLP test it was found,

"The porosity of the sample core was essentially the same as that of unleached controls, but the porosity of the leached layer increased significantly (Fig 2).

These results suggested that any successful durability test or predictive model will have to account for significant chemical and structural changes over time that influence leaching rate. Even with an incomplete understanding of the processes, studies such as this can indicate the relative durability of alternative formulations."

From field evaluation studies she concluded,

"The durability of S/S wastes remains unclear, in part [due] to the relative time that the technology has been used, and to the lack of information on the sites using it."

Kirk reported on a study to identify physical and chemical changes in field-disposed treated wastes:

"Soil samples obtained less than a few centimeters away from the monolith contained leached binder constituents (Ca) and metal contaminants (Pb and Cd)." "Therefore, due to variations in the metal concentrations, mix ratio, and cement/soil/water, actual field scale remediation may be difficult to control."

With reference to a US EPA project at the University of New Hampshire she stated,

"A variety of bulk chemical analyses and leaching tests have also been applied to determine the concentration and chemical behavior of selected metals. These techniques have often been applied to waste materials. Because contaminant metals often exist in low concentrations and in multiple amorphous forms, these analyses provide limited insight into the nature of the waste and its expected behavior [Conner 1990].*"*

Kirk (1996) stated with regard to the results of a Rutgers University study of effectiveness of S/S processes to treat ashes which included TCLP testing, *"Evaluation of S/S process design, performance, and treatment efficiency should be based on a matrix of several testing protocols. No single test, such as TCLP, can provide all the information required to evaluate contaminant release potential, contaminant release rate, and physical durability. An appropriate test matrix to evaluate S/S processes should include tests that will address these factors."*

"Physical durability or possessing a monolithic structure does not ensure acceptable performance with respect to contaminant release."

and,

"TCLP was not a good indicator of release from untreated and treated residues for several reasons. Variable end-point pH for the extraction resulted in wide variation in estimated metals release because of pH-dependent solubility constraints. The low liquid-to-solid ratio for the TCLP (20:1) also may have resulted in solubility limitations for many elements of concern. Finally, TCLP does not provide for determination of the total release of soluble salts and anions."

Erickson and Barth (1996), both with the US EPA Office of Research and Development in Cincinnati, OH, discussed the evaluation of contaminant leachability factors by comparing treatability study data for S/S materials. Treatability test data were compiled into a database listing contaminant concentration and matrix, and effects of S/S treatment on 18 metals. Because of the expense and time involved in treatability testing, they tried to use existing data to see if they could be extrapolated to other situations. They concluded,

"Overall, however, the existing data do not indicate how to predict S/S performance without conducting treatability tests on new materials being considered for treatment."

They did not give consideration to the appropriateness of TCLP.

Means et al. (1996) (authors with Battelle Memorial Institute and the US EPA Municipal Waste Technology Section, Risk Reduction Engineering Laboratory) summarized, chapter by chapter, the topical content of the TRD [US EPA, Technical Resource Document: Solidification/Stabilization and Its Application to Waste Materials, EPA/530/R-93/012, US EPA Office of Research and Development, Washington, D.C. (1993).]. Means et al. stated, *"The performance of stabilized wastes generally is measured in terms of leaching and extraction tests,"* and *"Leaching tests measure the potential of a stabilized waste to release contaminants to the environment."*

Under "Status of S/S Technology" (Ch. 4 of the TRD) "Leaching Mechanisms," Means et al. stated,

"However well the S/S waste is stabilized and isolated from the hydrosphere in disposal, some transport of contamination from the S/S-treated waste into the groundwater

eventually will occur. Complete immobilization of contaminants is not a realistic expectation."

With regard to "Long-Term Performance," Means et al. stated,

"A significant unresolved S/S technology issue is how well the S/S-treated waste maintains its immobilization properties over time. Although the long-term durability of cement is well proved in conventional construction, some amount of release is virtually inevitable. S/S materials can be deposited in landfills to provide secondary barriers between natural waters and the wastes. Contaminant release begins when these secondary barriers permit natural waters to come into contact with the waste forms. The question is not whether S/S wastes eventually will release contaminants into the environment, but whether the rate of release is environmentally acceptable.

S/S technologies for waste treatment have been in use for only a few decades, so the number and duration of studies on field-disposed S/S wastes are limited. Decisions about the acceptability of particular S/S products must be based on the available shorter-term field data, laboratory tests, and models of leaching behavior."

Means et al. stated with regard to Chapter 5: S/S Technology Shortcomings and Limitations, Treatability and Performance Testing Issues,

"Tests that have been developed to assess technology performance are not applicable to every disposal scenario. Testing methodologies must be tailored to the specific nature of the S/S-treated waste. Personnel involved in Treatability testing should be aware of the various tests' limitations when interpreting the data.

The long-term performance of treated waste is not clearly understood, and no definitive test procedures exist to measure or assess this property. The Toxicity Characteristic Leaching Procedure (TCLP) is not an adequate measure of long-term leaching. Monitoring data from field disposal sites are needed to detect the premature deterioration of solidification or stabilization of previously processed wastes. Because of the uncertainties surrounding long-term performance, wastes previously treated using S/S and disposed of may have to be retrieved and retreated in the future."

Stegmann et al. (1996), with the Wastewater Technology Centre, Burlington, Ontario, reported on electric arc furnace dust solidified with activated blast furnace slag binder. Comparing lab and field performance test results, they were trying to develop standard evaluation procedures. They stated,

"Although this work has provided an extensive background database of state-of-the-art solidified waste properties, a relationship between properties measured in the laboratory and the behaviour of solidified wastes in the field has yet to be established, and is the focus of ongoing work at WTC."

Butcher et al. (1996) of the Centre for Environmental Control and Waste Management, Imperial College, London, investigated the leaching of a synthetic Stabilized/Solidified waste containing heavy metals in a laboratory setting using flow-through systems. They noted,

> *"Although many methods have been developed for determining the leaching of wastes [6], when they are applied to this type of material none have been found to be totally suitable."*

Continuing with regard to the TCLP, they noted, *"Whilst these are easy to perform, cheap and fairly reproducible [9], when applied to solidified wastes they have a number of disadvantages,"* and, *"This may lead to an unduly optimistic assessment of the longer term leaching properties of the waste form."*

Lawson et al. (1996) tested *in situ* S/S for treating coal tar contaminated soils and river sediments in Wisconsin, using Portland cement/fly ash/organophilic clay/sodium silicate/powdered activated carbon grout mixtures. The affected soils and sediments contained volatile organic compounds (VOCs), principally benzene; PNAs including naphthalene, phenanthrene, and pyrene; and phenolic compounds. Included in their evaluation were TCLP and ASTM leaching tests. They reported from the results of the ASTM leaching analysis, *"Benzene was not effectively controlled by any of the formulations. Naphthalene also was not effectively controlled, although its mobility was reduced by some formulations."*

Wiles and Barth (1992) of the US EPA, in discussing the application of S/S treatment to organic wastes stated, in their Abstract,

> *"The increasing use of solidification/stabilization (S/S) technologies in the United States, especially for remediation of sites under the Superfund program, has raised several questions about the overall appropriateness of S/S. For many types of hazardous waste, notably for heavy metals, S/S usually gives excellent results for long-term immobilization, as measured by existing physical and chemical protocols. However, results of several studies, as well as data from remediation of several Superfund sites, have raised concerns about whether S/S is a valid technology for treating organic-bearing wastes. Even when applied to heavy metals, S/S requires careful choice of proper binders (recognizing the amphoteric behavior of certain metals) and good quality control throughout the process. Lack of good investigative procedures has diminished the value of data for evaluating S/S for some metals. Furthermore, studies also provide evidence that tests other than the regulatory extraction tests [for example, toxicity characteristic leaching procedure (TCLP)] will be required to evaluate the effectiveness of S/S, especially when applied to organic wastes. Suggestions are offered for improving treatability studies used for evaluating S/S applied to selected metals. Approaches are also provided for determining the appropriateness of S/S applied to organic contaminants."*

The summary of the Wiles and Barth paper states,

> *"This paper discussed some approaches for determining whether or not organic contaminated soils should be treated by S/S technologies. The approaches are conservative and give little recognition to the physical characteristics of the solidified waste forms in the immobilization process. These approaches are also based upon technical rather than regulatory considerations after reviewing available information on the S/S of organic wastes. Several instances have been reported where processors have claimed treatment of organics by S/S. In most but not all of these, the experimental approach was too limited. Measuring organic content before treatment and after treatment without controls to collect and analyze air emissions is not acceptable. Many, if not all, of the volatile and semivolatile organics will "disappear" during the process because they volatilize. Much more sound scientific evidence is required before S/S of organic contaminated waste can become routine practice."*

Wiles and Barth, at the time they developed this paper, were with the US EPA Risk Reduction Engineering Laboratory in Cincinnati, Ohio. It was their responsibility to evaluate the effectiveness of S/S treatment of various types of wastes as part of the US EPA SITE (Superfund Innovative Technology Evaluation) program. In connection with conducting this review, I contacted Ed Barth regarding the current understanding of the effectiveness of using cement-based S/S to treat high-organic wastes such as those that are present in the Tar Ponds. He confirmed (Barth, pers. comm., 2006) that the situation today is no different than it was in 1992 when he and Wiles developed their paper on this issue. Basically, there are significant questions about whether cement-based S/S is an effective immobilization approach for high-organic wastes such as the Tar Pond sediments. Therefore, the STPA promotion for S/S for treating the Tar Pond sediments based on the so-called widespread use of this approach is, at best, superficial and does not properly evaluate the effectiveness of such practice. This is an issue that the Agency should have discussed in a credible EIS, in order to inform regulatory decision-makers and the public about the potential problems associated with S/S of the Tar Pond polluted sediments.

Mattus and Gilliam (1994) of the Oak Ridge National Laboratory, Oak Ridge, TN, conducted a comprehensive review of the literature regarding cement-based waste-form development to identify waste species that pose problems for the use of the technology, and at what concentrations those species render the process unfeasible. They concluded, *"The literature search has confirmed that the knowledge of cement-based waste-form chemistry has not progressed to the point where this is possible."*

In the course of their review of organic species that may interfere with various waste-form properties, they made the following statements, observations, and conclusions:

> *"In the context of the FFCA [Federal Facility Compliance A – cement] project, waste streams loaded with organics are supposed to be thermally treated to destroy the organic species before the waste is solidified in the cement-based matrix;"*
>
> *"Many researchers, when reporting results of studies using S/S to immobilize organic wastes, arrive at a common conclusion: that is, S/S technologies are generally not appropriate to treat organic-bearing wastes (Wiles and Barth, 1992; Brown et al., 1992)."*

"Many authors discuss the inability of the available tests such as the TCLP to evaluate the retention of organics in cement-based waste forms, due to the fact that many organics are not miscible in water or acetic acid solution."

"Interpretation of results [from US EPA SITE program tests on the treatability of real contaminated wastes containing organics] *is usually inconclusive regarding the presence of organic species, according to de Piercin (1990) and Brown et al. (1992). They reported results obtained from three EPA Superfund sites that illustrate this problem. They state that very little scientific literature claims that S/S is effective for treating organic wastes."*

"Some studies investigated the mechanism of retention of organic species in cement products. Wiles and Barth (1992), for example, reported that organics are unlikely to form insoluble precipitates; neither do organics enter into the structure of cement hydrates. Therefore, physical encapsulation will be the principal way to contain organics in cement-based waste forms. They conclude that S/S processes, 'should follow some earlier stage of treatment for removal and/or destruction of the volatile and semivolatile constituents.'"

Since phenols are major components of coal tar, Mattus and Gilliam's accounts of studies by Vipulanandan and Krishnan (1990) and Shukla et al. (1992) are of interest. Mattus and Gilliam (1994) stated,

"Vipulanandan and Krishnan (1990) incorporated 0.5 and 2% by weight pure phenol in Type I Portland cement. The addition of 2% phenol increased the set time by a factor of 3. TCLP leaching tests recovered up to 100% of the organics in the leachate, proof that phenol is not chemically bound to the cement structure."

"Shukla et al. (1992) showed that the leaching performance of PCP and phenol is better when the cure time is increased."

The literature review concluded:

"What is clear from the literature search is that cement-based waste forms, sometimes referred to as a 'low-tech option,' are anything but simple from the standpoint of waste-form chemistry. Indeed, cement waste-form chemistry is extremely complex and is poorly understood even for some simple systems of a single waste constituent in a cement-water paste."

"The literature search has clearly established that no definitive waste characterization requirements exist. … Consequently, the approach to waste characterization needs presented is to request 'screening type' characterization."

More quotes will likely follow as more of the articles from the ASTM S/S symposia are reviewed.

It can be concluded that S/S projects, such as that proposed for treatment of the Tar Pond sediments, will reduce the rate of pollution of the environment by the chemicals (flux of chemicals) in the S/S-treated wastes. S/S treatment, especially of organic wastes, may not necessarily stop environmental pollution by the treated wastes, especially if there is water flowing around or through the S/S-treated wastes.

Based on a review of the literature it is concluded that S/S treatment of wastes including inorganic heavy metal wastes is not a **proven technology** with respect to producing a permanently non-leachable treated waste that will not pollute the environment.

Additional Issues of Concern

At several locations in the transcript of the hearing, members of the public have raised questions about the adequacy of the proposed S/S treatment of the Tar Pond sediments in treating all of the polluted sediments that need to be treated to immobilize PCBs and other pollutants. Of particular concern is the apparent fact that steel mill slag was placed on polluted Tar Pond sediments. It appears from the information available that STPA does not consider the areas where this has occurred as part of the area of the Tar Pond sediments that will be S/S treated. It also appears that tidal flow in the Tar Pond area is interacting with areas of the Tar Pond sediments, such as those buried under the slag piles, and thereby providing a transport mechanism for PCBs and other pollutants associated with the sediments in these areas. Clearly there is need to remediate all of the Tar Pond sediments that contain pollutants that are a threat to public health and the environment, including those sediments that are located under slag piles.

Another issue is that of STPA's failure to evaluate the potential for continued release of methane from the anaerobic fermentation of sewage sludge and other organic deposits that are intermixed with and apparently underlie the Tar Pond sediments that are proposed to be S/S treated. Methane generation will continue to occur in the Tar Pond sediment area after treatment. The potential effects of methane release on the success of the treatment needs to be evaluated.

A third area of concern is the fact that the S/S treatment of the Tar Pond sediments will release low molecular weight organics from the treated sediments to the atmosphere. The potential for this release to be a source of atmospheric pollutants in the area needs to be evaluated.

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Appendix A

Dr. G. Fred Lee, PE$_{(TX)}$, DEE
AAEE Board Certified Environmental Engineer

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

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

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

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

For a 30-year period, he held university graduate-level teaching and research positions in departments of civil and environmental engineering at several major United States universities, including the University of Wisconsin-Madison, University of Texas at Dallas, and Colorado State University. During this period he taught graduate-level environmental engineering courses in water and wastewater analysis, water and wastewater treatment plant design, surface and ground water quality evaluation and management, and solid and hazardous waste management. He has published over 1,100 professional papers and reports on his research results and professional experience. His research included, beginning in the 1970s, the first work done on the impacts of organics on clay liners for landfills and waste piles/lagoons.

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

In the 1970s, while he was Director of the Center for Environmental Studies at the University of Texas at Dallas, he was involved in the review of a number of municipal solid and industrial (hazardous) waste landfill situations, focusing on the impacts of releases from the landfill on public health and the environment.

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

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

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

Dr. Lee's expertise includes surface and ground water quality evaluation and management. This expertise is based on academic course work, research conducted by Dr. Lee and others and consulting activities. He has served as an advisor to numerous governmental agencies in the US and other countries on water quality issues. Further, he has served on several editorial boards for professional journals, including *Ground Water, Environmental Science and Technology, Environmental Toxicology and Chemistry,* etc. Throughout his over-45-year professional career, he has been a member of several professional organization committees, including chairing the American Water Works Association national Quality Control in Reservoirs Committee and the US Public Health Service PCBs in Drinking Water Committee.

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

In 1989, he retired after 30 years of graduate-level university teaching and research and expanded the part-time consulting that he had been doing with governmental agencies, industry and community and environmental groups into a full-time activity. A principal area of his work since then has been assisting water utilities, municipalities, industry, community and environmental groups, agricultural interests and others in evaluating the potential public health and environmental impacts of proposed or existing hazardous, as well as municipal solid waste landfills. He has been involved in the review of approximately 85 different landfills and waste piles (tailings) in various parts of the United States and in other countries, including 12 hazardous waste landfills, eight Superfund site landfills and five construction and demolition waste landfills. He has also served as an advisor to a hazardous waste landfill developer and to IBM corporate headquarters and other companies on managing hazardous wastes.

Dr. Anne Jones-Lee (his wife) and he have published extensively on the issues that should be considered in developing new or expanded municipal solid waste and hazardous waste landfills in order to protect the health, groundwater resources, environment and interests of those within the sphere of influence of the landfill. Their over 120 professional papers and reports on landfilling issues provide guidance not only on the problems of today's minimum US EPA Subtitle D landfills, but also on how landfilling of non-recyclable wastes can and should take place to protect public health, groundwater resources, the environment, and the interests of those within the sphere of influence of a landfill/waste management unit. They make many of their publications available as downloadable files from their web site, www.gfredlee.com.

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

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

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

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

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

Throughout Dr. Lee's 30-year university graduate-level teaching and research career and his subsequent 16-year private consulting career, he has been active in developing professional papers and reports that are designed to help regulatory agencies and the public gain technical information on environmental quality management issues. Drs. Lee and Jones-Lee have provided a number of reviews on issues pertinent to the appropriate landfilling of solid wastes. Their most comprehensive review of municipal solid waste landfilling issues is what they call the "Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste," which was originally developed in 1992, and redeveloped and updated in the fall of 2004. Between the two versions they have published numerous invited and contributed papers that provide information on various aspects of municipal solid waste landfilling, with emphasis on protecting public health and the environment from waste components for as long as they will be a threat. The "Flawed Technology" review has been periodically updated, including the most recent update in March 2006, which can be found on their website at
http://www.members.aol.com/apple27298/SubtitleDFlawedTechnPap.pdf.

This review provides a comprehensive, integrated discussion of the problems that can occur with minimum-design Subtitle D landfills and landfills developed in accord with state regulations that conform to minimum Subtitle D requirements. The "Flawed Technology" review contains a listing of the various reviews that Drs. Lee and Jones-Lee have developed, as well as peer-reviewed literature. Over 40 peer-reviewed papers are cited in "Flawed Technology" supporting issues discussed in this review.

SUMMARY BIOGRAPHICAL INFORMATION

NAME: G. Fred Lee

ADDRESS: 27298 E. El Macero Dr.
El Macero, CA 95618-1005

DATE & PLACE OF BIRTH: July 27, 1933, Delano, California, USA

TELEPHONE: 530/753-9630 (home/office)

E-MAIL: gfredlee@aol.com

WEBPAGE: http://www.gfredlee.com

EDUCATION

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

ACADEMIC AND PROFESSIONAL EXPERIENCE

Current Position:

Consultant, President, G. Fred Lee and Associates

Previous Positions:

- Distinguished Professor, Civil and Environmental Engineering, New Jersey Institute of Technology, Newark, NJ, 1984-89
- Senior Consulting Engineer, EBASCO-Envirosphere, Lyndhurst, NJ (part-time), 1988-89
- Coordinator, Estuarine and Marine Water Quality Management Program, NJ Marine Sciences Consortium Sea Grant Program, 1986
- Director, Site Assessment and Remedial Action Division, Industry, Cooperative Center for Research in Hazardous and Toxic Substances, New Jersey Institute of Technology et al., Newark, NJ, 1984-1987
- Professor, Department of Civil and Environmental Engineering, Texas Tech University, 1982-1984
- Professor, Environmental Engineering, Colorado State University, 1978-1982
- Professor, Environmental Engineering & Sciences; Director, Center of Environmental Studies, University of Texas at Dallas, 1973-1978
- Professor of Water Chemistry, Department of Civil & Environmental Engineering, University of Wisconsin-Madison, 1961-1973

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

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

PUBLICATIONS AND AREAS OF ACTIVITY

Published over 1,100 professional papers, chapters in books, professional reports, and similar materials. The topics covered include:

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

Publications of G. Fred Lee & Associates since the mid-1980s are available from www.gfredlee.com. Of particular relevance to the comments presented herein are the publications on

- landfill and waste pile issues (http://www.gfredlee.com/plandfil2.htm),
- contaminated sediments (http://www.gfredlee.com/psedqual2.htm),
- hazardous chemical sites (http://www.gfredlee.com/phazchem2.htm, and
- surface water quality (http://www.gfredlee.com/pwwqual2.htm).

LECTURES

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

GRANTS AND AWARDS

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

GRADUATE WORK CONDUCTED UNDER SUPERVISION OF G. FRED LEE

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

ADVISORY ACTIVITIES

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

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

Arizona *(State Landfilling Regulations)*	Verde Valley - Copper Tailings Pile Closure Mobile – Southpoint Landfill
California *(State Landfilling Regulations)*	Colusa County - CERRS Landfill San Gabriel Valley - Azusa Landfill (Superfund Site) City of Industry - Puente Hills Landfill North San Diego County, 3 landfills San Diego County - Gregory Canyon Landfill El Dorado County Landfill Yolo County Landfill Half Moon Bay - Apanolio Landfill Pittsburg - Keller Canyon Landfill Chuckwalla Valley - Eagle Mountain Landfill Mountain View – Mountain View Landfill Barstow - Hidden Valley (Hazardous Waste) Mohave Desert - Broadwell Landfill (Hazardous Waste) Cadiz - Bolo Station-Rail Cycle Landfill University of California-Davis Landfills (4) (3 Superfund Site) San Marcos - San Marcos Landfill Placer County - Western Regional Sanitary Landfill Placer County – Turkey Carcass Disposal Pits Imperial County - Mesquite Landfill Los Angeles County - Calabasas Landfill and Palos Verdes Landfill Contra Costa County – Concord Naval Weapons Station Tidal LF (Superfund) Nevada County - Lava Cap Mine Area Landfill (Superfund Site) Sylmar - Sunshine Canyon Landfill Roseville - Roseville Landfill
Colorado (*State Landfilling Regulations)*	Last Chance/Brush – (Hazardous Waste Landfill) Denver - Lowry (Hazardous Waste Landfill) Telluride/Idarado Mine Tailings
Delaware	Various MSW landfills – Evaluate past disposal of industrial wastes
Florida	Alachua County Landfill
Georgia	Meriwether County – Turkey Run Landfill Hancock County – Culverton Plantation Landfill
Illinois (*State Landfilling Regulations*)	Crystal Lake - McHenry County Landfill Wayne County Landfill Kankakee County – Kankakee Landfill Peoria County – Peoria Waste Disposal (Hazardous Waste)
Indiana (*State Landfilling Regulations*)	Posey County Landfill New Haven-Adams Center Landfill (Hazardous Waste)
Louisiana	New Orleans vicinity - Gentilly Landfill
Michigan (*State Landfilling Regulations*)	Menominee Township - Landfill Ypsilanti- Waste Disposal Inc. (Hazardous Waste - PCB's)
Minnesota	Reserve Mining Co., Silver Bay - taconite tailings Wright County - Superior FCR Landfill
Missouri	Jefferson County - Bob's Home Service (Hazardous Waste)

New Jersey	Fort Dix Landfill (Superfund Site) Cherry Hill – GEMS (Superfund Site) Lyndhurst - Meadowlands Landfill Scotch Plains – Leaf Dump
New York	Staten Island - Fresh Kills Landfill, Niagara Falls Landfill – (Hazardous Waste), New York City – Ferry Point Landfill
North Dakota	Turtle River Township - Grand Forks Balefill Facility Landfill
Ohio	Clermont County - BFI/CECOS Landfill (Hazardous Waste) Huber Heights - Taylorville Road Hardfill Landfill (C&DD) Morrow County – Washington and Harmony Townships C&DD Landfills
Pennsylvania	Pottstown – Pottstown Landfill
Rhode Island	Richmond – Landfill (C&D)
South Carolina	Spartanburg - Palmetto Landfill
Texas	Dallas/Sachse – Landfill Fort Worth - Acme Brick Landfill (Hazardous Waste) City of Dallas - Jim Miller Road Landfill Pasadena – Mobil Mining and Minerals industrial waste pile
Vermont	Coventry, Vermont - Coventry Landfill
Washington	Tacoma - 304th and Meridian Landfill
Wisconsin	Madison and Wausau Landfills
INTERNATIONAL LANDFILLS	
Belize	Mile 27 Landfill
Ontario, Canada (*Prov. Landfilling Regulations*)	Greater Toronto Area - Landfill Siting Issues Kirkland Lake - Adams Mine Site Landfill Pembroke - Cott Solid Waste Disposal Areas
Manitoba, Canada	Winnipeg Area - Rosser Landfill
New Brunswick, Canada	St. John's - Crane Mountain Landfill
England	Mercyside Waste Disposal Bootle Landfill
Hong Kong	Three New MSW Landfills
Ireland	County Cork - Bottlehill Landfill County Clare - Central Waste Management Facility, Ballyduff
Korea	Yukong Gas Co. - Hazardous Waste Landfill
Mexico (*Haz. Waste Landfilling Reg.*)	San Luis Pontosi Landfill- (Hazardous Waste)
New Zealand	North Waikato Regional Landfill
Puerto Rico	Salinas - Campo Sur Landfill

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

http://www.gfredlee.com

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

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

Stormwater Runoff Water Quality Science/Engineering Newsletter

G. Fred Lee Advisory Services

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

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

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

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

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

Louisiana Environmental and Action Network, Baton Rouge, LA
OUTRAGE and POWER, Kankakee, IL
John Cobey et al., Morrow County, OH