Comments on "The Effectiveness of Municipal Solid Waste Landfills in Controlling Releases of Heavy Metals to the Environment," Prepared for The SWANA Applied Research Foundation Disposal Group Subscribers, Dated March 2004

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Abstract

The Solid Waste Association of North America (SWANA) Applied Research Foundation report which claims that heavy metals in municipal solid waste (MSW) landfill leachate do not represent a threat to cause groundwater pollution is based on a flawed approach for assessing the critical concentrations of heavy metals in MSW leachate that can be adverse to groundwater quality. This report uses the US EPA TCLP regulatory limit as a measure of the concentrations of heavy metals in MSW leachate that would not cause groundwater pollution. The TCLP regulatory limits were established to classify wastes as "hazardous" versus "nonhazardous." So-called "nonhazardous" waste components can generate leachate that is a significant threat to public health and the environment. The TCLP regulatory limits were arbitrarily established without proper regard to how constituents such as heavy metals in MSW leachate can impair the beneficial uses of groundwaters and surface waters. The SWANA-reported concentrations of heavy metals in today's MSW leachate are sufficient at some locations to cause significant adverse impacts on groundwater quality and surface water quality. Under Subtitle D landfilling practices, there is potential justification for limiting the concentrations of heavy metals in the municipal solid waste stream as part of an effort to reduce the heavy metal concentrations in MSW leachate.

The SWANA report was prepared by Jeremy O'Brien, P.E., SWANA's Director of Applied Research.

Specific Comments

The comments presented below on the Executive Summary are equally applicable to the same topic areas in the main body of the report.

Page vi states that the report is dedicated to Dr. Frederick G. Pohland and shows Pohland's classic diagram of the phases of municipal solid waste decomposition. Unfortunately, there are still individuals who assert that these diagrams have applicability to today's "dry tomb" landfills. Such claims reflect a lack of understanding of the processes that can take place in a landfill where the moisture content is limited.

Page 1 of the Executive Summary states,

> *"This report presents the findings of a year-long research project that investigated the effectiveness of municipal solid waste (MSW) landfills in controlling releases of heavy metals to the environment."*

As discussed below, this characterization of this report is inaccurate.

Page 1 presents Table ES-1, Tonnage Estimates for Three Heavy Metals Disposed in MSW Landfills in 2000. There is no reference, however, to the source of this information.

On page 2, Table ES-2 presents, for various heavy metals, the median, mean, and 90th percentile concentrations relative to the TCLP Regulatory Level. The text states,

> *"As indicated in Table ES-2, the mean concentrations of RCRA heavy metals reported in the LEACH 2000 database for non-hazardous waste landfills are at least 10 times less than the TCLP regulatory levels."*

While the text states that the concentrations of heavy metals in leachate are low, in fact, when a proper comparison is made between the critical concentrations of heavy metals in current municipal solid waste leachate as summarized in the SWANA report and critical concentrations for drinking water (MCLs), the concentrations of heavy metals are of significant concern with respect to pollution of groundwater that is used for domestic purposes. Also, with respect to those situations where leachate-polluted groundwaters enter surface waters, where there is a threat to aquatic life, the concentrations of several heavy metals in leachate as listed in this report are of significant concern. Those who understand how the US EPA established the TCLP critical levels know that these levels are not a valid assessment of the potential for heavy metals in municipal landfill leachate to cause groundwater and/or surface water pollution.

The SWANA leachate heavy metal report compares the concentrations of heavy metals found in leachate to the TCLP regulatory level. This regulatory level was arbitrarily established as 100 times the drinking water MCL. This multiplier was supposedly based on a study which justified that the normal attenuation of landfill leachate-associated constituents was a factor of 100. Several years ago the author (G. F. Lee) attempted to determine the technical basis for the origin of this attenuation factor. He was told by the US EPA headquarters senior staff that it was based on modeling that was done by the US EPA. He inquired about the availability of the model and the database used in the modeling. He was told that the model and the associated database could not be found and that the person who had done the modeling was unknown, but it was believed that he/she was no longer associated with the Agency. The facts are that an arbitrary factor of 100 used as an assumed attenuation for leachate-associated constituents before the water is consumed for domestic purposes or enters a surface waterbody can be grossly overprotective for some landfill aquifer systems and grossly underprotective for others.

The TCLP attenuation factor is an outgrowth of the US EPA's original EP Tox test used to classify waste as hazardous versus nonhazardous. It was widely recognized that the EP Tox test was not a valid approach for classifying waste as hazardous versus nonhazardous. The US

Congress ordered the US EPA to develop a more valid test. The US EPA developed the toxicity characteristic leaching procedure (TCLP), which addressed some of the problems of the EP Tox test. In the original proposal for the TCLP test, the US EPA included a site-specific evaluation to determine the attenuation factor that can be used to protect groundwaters and surface waters from pollution by landfill leachate-associated constituents. However, at the last minute, the Agency abandoned this approach in favor of continuation of the arbitrary attenuation factor of 100. Lee and Jones (1982) discussed a site-specific approach that should be used to evaluate whether a constituent in landfill leachate represents a significant threat to cause groundwater pollution. It is inappropriate for SWANA to assert that heavy metals in today's leachate do not represent a threat to groundwater quality and, for those situations where the groundwaters are connected to surface waters, especially for fractured rock systems, to surface waters and aquatic life. The leachate concentrations of heavy metals in Tables ES-2 and ES-3 support this conclusion.

Table ES-2 lists the mean concentration of lead in the LEACH 2000 Database for MSW Leachate as 0.133 mg/L (133 µg/L). There is, therefore, a substantial number of situations where MSW leachate contains lead above this concentration. Table ES-2 also lists the TCLP regulatory level for lead as 5 mg/L (5,000 µg/L). The 5,000 µg/L was based on US EPA's former allowed concentration of lead in drinking water of 50 µg/L. However, several years ago the US EPA decreased the required regulatory limit for lead in drinking water to 15 µg/L. Further, it is understood that 15 µg/L is not necessarily protective of young children from the adverse impacts of lead in their drinking water.

While the US EPA is requiring that cities with lead in their drinking water at concentrations above 15 µg/L initiate procedures to control the lead concentrations, the Agency has not changed the TCLP regulatory limit for lead in wastes, which causes a waste to be classified as a "hazardous waste," from 5,000 µg/L to 100 times the drinking water action level of 15 µg/L – i.e., 1,500 µg/L. This inconsistent approach in applying the TCLP regulatory limit results in the US EPA now allowing an attenuation factor of 333 for lead. From a public health perspective, where significant attenuation occurs in the aquifer system, the attenuation factor for lead, because of its hazard to young children, should be smaller, rather than larger, than for many other constituents.

Table ES-2 lists the mean concentration of arsenic in the LEACH 2000 Database for MSW Leachate as 0.441 mg/L. While Table ES-5 lists the US EPA National Primary Drinking Water Standard for arsenic as 0.05 mg/L (50 µg/L), the US EPA has adopted a drinking water MCL for arsenic of 10 µg/L. This value, however, was not adopted based on the concentrations of arsenic that are a significant threat to cause cancer in people who consume water with arsenic at this level, but on political considerations, in order to not have the current administration impose significant additional costs to water utilities to reduce the arsenic concentration in their drinking water to a properly assessed health-based concentration. The US EPA (2002) established a risk based water quality criterion for arsenic in water of 0.018 µg/L for drinking water and consumption of organisms that are taken from the water of concern. The drinking water component was the primary factor in establishing this water quality criterion. It is clear that the US EPA 10 µg/L drinking water MCL carries a much higher cancer risk than the US EPA normally accepts for drinking water.

A review of the literature on the cancer risk of arsenic in drinking water shows that the National Research Council (NRC, 2001) arsenic review estimated that a drinking water MCL for arsenic of 3 µg/L would produce a cancer risk of one additional cancer in 1,000 people. Normally, the additional cancer risk established for drinking water is one additional cancer in a million people who consume 2 liters (about 2 quarts) of water per day over their lifetime. The NRC states that the 10 µg/L arsenic MCL is estimated to lead to 23 additional bladder cancers and 18 additional lung cancers in 10,000 people. In the spring of 2003 the California Office of Environmental Health Hazard Assessment (OEHHA, 2003) established a public heath drinking water goal for arsenic of 0.004 µg/L.

It is clear that the mean concentration of arsenic in MSW leachate of 0.441 mg/L represents a significant public health risk to cause increased cancer in those whose well is polluted by MSW leachate. For mean arsenic concentrations reported in the LEACH 2000 database to be attenuated/diluted to achieve an acceptable concentration based on the regulatory approach typically used for carcinogens in drinking water and the OEHHA goal for arsenic of 0.004 µg/L would require an attenuation factor of about 100,000.

Stollenwerk and Colman (2004) of the USGS have found that municipal landfill leachate-pollution of groundwaters leads to the mobilization of arsenic from the aquifer solids. The organics in leachate lead to reducing conditions in the groundwater, which reduce the ferric hydrous oxide concentrations in the aquifer that bind naturally occurring arsenic in the aquifer. Therefore, not only can MSW leachate contain concentrations of arsenic that will pollute groundwaters, rendering them hazardous and unusable for domestic and many other purposes, but leachate-polluted groundwaters can also mobilize natural constituents in the aquifer, such as arsenic, that then become a threat to public health and the environment.

As discussed by Lee and Jones (1981), the US EPA's approach for classification of wastes as hazardous versus nonhazardous was a political approach designed to limit the size of the waste stream that would have to be managed as hazardous waste. This has resulted in significant amounts of hazardous chemicals occurring in municipal solid waste leachate that are a threat to public health and the environment. The magnitude of this threat depends on the characteristics of the hydrogeological regime to which the base of the landfill is connected and the proximity of the landfill waste deposition areas to adjacent properties. As discussed by Lee and Taylor (1998), hazardous or deleterious chemicals present in groundwater systems consisting of homogeneous sand or silts will eventually become less of a threat, through natural attenuation and dilution to what are believed to be non-critical concentrations for known pollutants. This process can occur over a distance of several miles from the landfill. However, for landfills sited above fractured rock or cavernous limestone aquifer systems, the leachate-polluted groundwater can move for considerable distances down groundwater gradient, with little or no dilution/attenuation.

Since these same fractured rock or limestone systems can serve as the domestic water supply for many individuals, there is a significant potential for the pollution of groundwaters that are used for domestic purposes with concentrations of heavy metals that exceed maximum contaminant levels (MCLs). Further, since landfills are allowed to be sited near streams where

there is inadequate distance for dilution/attenuation to occur in a homogeneous aquifer system before leachate-polluted groundwater is discharged to the stream, stream pollution can occur. Also, since landfills are allowed to be sited at locations where the underlying aquifer system is in fractured rock and cavernous limestone, there could be rapid transport of essentially undiluted, minimally attenuated heavy metals in the leachate-polluted groundwater as it enters the stream. These impacts on stream water quality may not be manifested in concentrations of pollutants that are seen in the stream's water column, but could occur to benthic organisms in the region where the leachate-polluted groundwater enters the stream sediments.

While the focus of the SWANA report is heavy metals, it should be understood that there is a vast arena of unregulated potentially hazardous and deleterious chemicals in municipal landfill leachate. Lee and Jones-Lee (2004) have discussed unrecognized and largely unregulated chemicals that are present in municipal solid wastes, including perchlorate derived from spent roadside flares and polybrominated diphenyl ethers (PBDEs) that have been used as flame retardants on a variety of products that are disposed of in MSW landfills. Of particular concern are the pharmaceuticals and personal care products (PPCPs) that are disposed of in the municipal solid waste stream. Daughton (2004), Chief, Environmental Chemistry Branch, US EPA National Exposure Research Laboratory, who heads up the US EPA program on unregulated hazardous chemicals in wastewaters and solid waste, has indicated 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 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. They 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."* Daughton has indicated that one of the routes of environmental exposure is through trash placed in municipal solid waste landfills. He specifically singles out "leaching from municipal

landfills" as an origin of PPCPs in the environment. He characterizes municipal landfills as "pollution postponement." Additional information on PPCPs is available at www.epa.gov/nerlesd1/chemistry/pharma/index.htm.

Page 3 of the SWANA report, mid-page, presents a discussion on the US EPA's conclusions regarding the potential for municipal solid waste leachate to lead to surface water pollution through the onsite treatment and discharge of the leachate at POTWs. However, the Agency's review of this issue is not in accord with what is found at a number of POTWs that the author is familiar with. There are heavy metal discharge problems from some POTWs where the concentrations of heavy metals in the wastewater discharge exceed US EPA water quality criteria and state standards based on these criteria. It is possible that the heavy metals derived from municipal landfill leachate, when added to a POTW's existing heavy metal load, could cause the POTW to experience increased violations of discharge limits based on exceedence of water quality standards. There are some POTWs that will not accept municipal landfill leachate because of its potential to cause violations of their NPDES permit discharge limits.

The SWANA leachate heavy metals report provides a somewhat deceptive approach toward presenting the hazards of heavy metals in leachate, in that it makes a comparison to an average concentration of heavy metals in leachate, rather than the maximum or near-maximum concentration, which would be more appropriate from the perspective of public health protection. A person whose well is polluted by landfill leachate is more concerned about the concentrations that could be adverse to their health, which is not the average concentration. A similar situation occurs repeatedly when consultants working for landfill applicants provide the average transport rate from the landfill to a water supply well, and not the worst-case situation that could occur based on the hydrogeological investigation of the site. The public whose well is potentially polluted by leachate wants to know the fastest potential for pollution – i.e., not the average, but the worst-case situation. It is important to understand that the worst-case situation, based on site studies and leachate composition, could readily be worse than those that have been found at a site.

Page 6, second paragraph states,

> *"Attenuating mechanisms in MSW landfills that limit the leaching of RCRA heavy metals include the formation of relatively insoluble heavy metal precipitates due to the presence of sulfide, carbonate, and hydroxide ions and the adsorption and/or absorption of the heavy metals within the waste mass."*

The concentrations of several heavy metals reported in the LEACH 2000 Database are well above those that would be expected based on solubility products and the characteristics of leachate if sulfides, carbonates and hydroxides controlled heavy metal concentrations in landfill leachate. The author of the SWANA report has failed to discuss the fact that municipal landfill leachate contains a wide variety of organic constituents and some inorganic constituents that can lead to complexation of metals which would make them soluble and transported in leachate. Further, it is beginning to be recognized that municipal landfill leachate has appreciable quantities of colloidal materials, which can include heavy metals, as constituents that act as though they are dissolved and transported through landfill liner systems and in groundwater

systems. The concentrations of heavy metals present in MSW leachate that are reported in the LEACH 2000 Database are a clear indication that heavy metals in MSW are leachable and mobile at concentrations that are a threat to public health and the environment.

Page 7, under "Effectiveness of Landfill Pollution Control Systems," states that,

> *"Landfill liner systems substantially prevent the leaking of leachate from the landfill to the land upon which the landfill is constructed. Based on recent investigations, these liners appear to have a 'half life' (i.e., a timeframe during which a 50% change in the material properties of the liner occurs) of 970 years. Therefore, the integrity of the liner system can be expected to last through the timeframe when significant quantities of leachate are being generated."*

This is more of the unreliable information that is produced by SWANA and others on the ability of landfill liner systems such as minimum Subtitle D liners, to prevent groundwater pollution by landfill leachate for as long as the wastes in the landfill will be a threat. Many of the waste components, including many heavy metals, will be a threat forever in a "dry tomb" landfill. The statement, "*… the integrity of the liner system can be expected to last through the timeframe when significant quantities of leachate are being generated*," is fundamentally flawed. There is no valid basis for such a statement. First, the authors of this statement do not understand the characteristics of dry tomb type landfills. Once the landfill is closed and a low-permeability cover is installed over the landfill, the wastes in the landfill will remain dry (are "entombed") and do not leach or decompose. The dry tomb type landfill is a threat to generate gas and leachate forever.

The 970-year estimate of the "half-life" of a landfill liner is similar to the estimates that were made by Koerner in the Bonaparte et al. (2002) report. The fundamental flaw with this assessment is that the approach used to project the period of time that the landfill liner system will prevent moisture from entering the landfill and leachate generated in the landfill from passing through the liner and polluting groundwaters involves the use of the Arrhenius equation to extrapolate from a few years of laboratory-based studies conducted under conditions that are different from those that occur in a landfill, to 1,000 years in the landfill liner environment. Those who understand physical chemistry and free radical degradation of HDPE know that such extrapolations have little technical validity.

The Bonaparte et al. (2002) report acknowledges that the plastic sheeting layers used in a Subtitle D landfill will eventually fail to prevent moisture from entering the landfill and to prevent leachate from leaving the landfill and polluting groundwater. As discussed in Lee (2002), the wastes in today's municipal solid waste landfills will be a threat to cause groundwater pollution forever, and the liner systems used in Subtitle D landfills have a finite period of time when they can function reliably to create a dry tomb that will be protective of groundwater quality. Therefore, groundwater pollution by Subtitle D landfills is inevitable for all landfills sited where there are groundwaters hydraulically connected through a vadose zone to the base of the landfill.

Page 8 of the Executive Summary, in the first sentence, states,

> *"Based on a review of recent studies and published literature, it is concluded that MSW landfills can provide for the safe, efficient, and long-term management of disposed products containing RCRA heavy metals without exceeding limits that have been established to protect public health and the environment."*

As discussed above, this statement is based on an inaccurate assessment of the potential for heavy metals in MSW to be released in landfill leachate at concentrations that are a threat to public health and the environment. The SWANA report states,

> *"However, as evidenced in this report, modern MSW landfills can provide an effective 'safety net,' as well as an environmentally sound means of disposal, for those products containing heavy metals that are not diverted through waste reduction and recycling programs."*

However, the facts are that minimum Subtitle D landfills at best only postpone when significant groundwater pollution occurs. There can readily be situations where the heavy metals in leachate will lead to groundwater and surface water pollution that is a significant threat to public health and the environment. The SWANA leachate heavy metal report is not a credible or reliable source of information on this issue. Lee and Jones-Lee (2004) have recently developed an overview discussion of the expected performance of minimum Subtitle D landfills.

The SWANA report fails to address one of the most significant deficiencies in Subtitle D landfilling – namely, the unreliability of the groundwater monitoring systems that are allowed by state and federal agencies to detect polluted groundwaters at the point of compliance for groundwater monitoring before widespread offsite groundwater pollution occurs. Lee and Jones-Lee (1998) have discussed the inability of the typical groundwater monitoring system used at Subtitle D landfills to comply with regulatory requirements of detecting leachate-polluted groundwaters when they first reach the point of compliance for groundwater monitoring.

Potential Benefits of Restricting Heavy Metal Inputs to MSW Landfills

While, according to the SWANA report, the total heavy metal content of the municipal solid waste stream has been decreasing, primarily associated with the decreased disposal of lead acid batteries in MSW landfills, there is concern about the increased disposal of consumer electronics in the municipal solid waste stream. The SWANA report indicates that, *"The EPA estimates that over 1.9 million tons of consumer electronics were disposed of in the U.S. in 2000."* This has led the US EPA to develop several reports (US EPA 2000, 2001) discussing the potential for electronics waste prevention, reuse and recycling. The US EPA (2000) report provides information on current activities for minimizing the disposal of consumer electronic equipment in municipal landfills. The US EPA (2001) report provides sources of information regarding MSW recycling/reuse by various entities.

The issue of whether controlling heavy metals in the municipal solid waste stream through recycling, reuse, etc., is an effective means of controlling the heavy metals in landfill leachate, needs investigation. Certainly, reducing the amount of heavy metals that enters the municipal solid waste stream is in the direction of controlling heavy metals in the leachate.

Whether recycling, reuse or banning of heavy-metals-associated waste is an effective means of controlling heavy metals in leachate is unknown at this time. Further studies are needed to evaluate whether control of specific metallic products (such as consumer electronics) could significantly lessen the potential public health and environmental risk associated with heavy metals in MSW leachate.

Lee and Jones-Lee (2000) and Lee (2004) have discussed one of the potential benefits of restricting the composition of the municipal solid waste stream as an effort to improve the protection of groundwater quality by pollution from landfill leachate. As they discuss, reducing the size of the municipal solid waste stream prolongs the life of current Subtitle D landfills, thereby extending the time when it becomes necessary to either expand existing landfills or site new landfills. This is an important pollution prevention effort, since, with few exceptions, today's Subtitle D landfills will eventually pollute groundwaters with landfill leachate. Reducing the number of new or expanded Subtitle D landfills, which receive MSW that has had the readily recyclable, reusable waste components removed from the waste stream and which are not sited, designed, constructed, operated, closed and receive postclosure monitoring and maintenance in such a way as to prevent groundwater pollution by landfill leachate for as long as the waste in the landfill will be a threat, is a major step in protecting groundwater resources from pollution by landfill leachate.

Overall

The SWANA leachate heavy metals report's conclusion that heavy metals do not represent a threat to public health and the environment is fundamentally flawed, since this report does not reliably report on the substantial number of situations where landfills can be sited under Subtitle D regulations which will generate leachate that will ultimately pass through the landfill liner system into the underlying groundwater system. Since Subtitle D regulations do not require adequate buffer lands between where wastes are deposited and adjacent properties where a property owner could place a water supply well, there is a significant potential for some landfill location situations to cause offsite groundwater pollution by heavy metals, as well as a wide variety of other known and unknown, unregulated potentially hazardous chemicals that are present in the municipal solid waste stream and occur in leachate. Overall, the text is significantly deficient in addressing the long-term issues of a "dry tomb" landfill in providing reliable assessments of the ability of the landfill liner systems and groundwater monitoring systems that are allowed in minimum Subtitle D landfills to prevent groundwater pollution for as long as the wastes in the landfill will be a threat.

Contrary to the implications of the SWANA report that heavy metals in municipal solid waste landfill leachate do not represent a threat to public health and the environment, the US EPA, state regulatory agencies and consumer electronics recycling and reuse advocates should persist with efforts to restrict the deposition of consumer electronic equipment in municipal solid waste landfills, in order to reduce the heavy metal content of the municipal solid waste stream.

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