

Potential Environmental Problems Associated with Hong Kong's "New" Landfills

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As part of serving as an advisor to the Hong Kong Environmental Protection Department (EPD) on Hong Kong Harbor contaminated sediment evaluation and management issues, the author (Dr. G. Fred Lee) was provided with an Environmental Protection Department booklet entitled, Environment Hong Kong 1995 - A Review of 1994. This booklet contained a section entitled, "Landfills: Old and New," by Benny Y.K. Wong which discusses the EPD's program for restoration of 13 old landfills and the development of three new landfills (WENT Landfill, SENT Landfill, and NENT Landfill). Upon review of this section, it was found that unreliable information was provided on the ability of the three new landfills to protect public health and the environment for as long as the wastes in the landfills will represent a threat.

These comments were stimulated by the highly unreliable information that was provided in the Environment Hong Kong 1995 discussion of the ability of the three new landfills to prevent groundwater and, in this case Hong Kong marine waters, pollution by landfill leachate.

Professional Expertise and Experience

Over the past 30 years, the author of these comments has been involved in evaluating the potential impacts of municipal solid waste and hazardous waste landfills on public health, groundwater resources, surface water quality and the environment. He is highly active in review of landfills located in the US and other countries. This work typically involves a detailed review of proposed or existing landfill design, proposed operation, closure and post-closure care relative to the potential for the wastes in the landfill to generate leachate that will lead to groundwater pollution. Appended to these comments is a list of the authors papers and reports pertinent to providing background information as well as a summary of the authors expertise and experience in conducting reviews of this type. Additional information on the ability of the author to undertake this type of review is available upon request.

Unreliable Information

On page 59 of the Environment Hong Kong 1995 Wong article is a statement,

"The new landfills are developed as total containment sites which incorporate 'state of the art' liners so that they will not leak. As the sites are lined, the landfill gas and leachate can be collected and treated prior to discharge from the sites. To ensure that the landfills are functioning correctly, extensive monitoring of all water, air and noise emissions from the site is carried out."

It further states,

"In this way, the contractor solely responsible for the shortcomings in relation to construction or operation and any corrective actions which are necessary can be taken quickly."

Upon reading the above-quoted statements, the author became intrigued as to what type of landfill liner system and groundwater monitoring system was being used at these landfills that would justify such a statement. In all of the work that has done on landfills in various parts of the world, the author has never found a landfill that could fulfill those requirements for as long as the wastes in the landfill represented a threat. In order to investigate this matter further, the author was able to obtain information on the design of the three new landfills. A summary of this information is provided below.

The west new territory's WENT Landfill is being designed and operated by Swire BFI Waste Services Ltd. The liner system consists of a 2 mm HDPE plastic sheeting liner underlain by a 6 mm bentonite matting. Swire BFI is responsible for maintenance and environmental control and monitoring of the landfill site for 30 years.

The southeast new territory's SENT Landfill is being developed by Green Valley Ltd. in which Pacific Waste Management Ltd. carries 50% equity with Citic Pacific Limited 30%, and Sun Hung Kai Properties Limited 20%. This landfill will be lined with a 2 mm HDPE primary liner, a 6 mm composite bentonite matting and a 1.5 mm HDPE secondary liner. The contractor will be responsible for an after-care period for maintenance and remediation work of the landfill for 30 years.

The NENT Landfill is being developed by a French waste management firm, SICA, and firms in Hong Kong and China. This landfill contractor will also have responsibilities for 30 years of monitoring and maintenance of the site after landfill closure. The liner for this landfill will consist of a 2 mm HDPE plastic sheeting layer and a bentonite layer. Monitoring of leakage of leachate from the landfill will be through a series of monitoring wells installed at 100 meter intervals around the landfill site perimeter.

Therefore, the WENT and NENT Landfills are single composite-lined landfills which, instead of having the conventional two feet of compacted clay with the permeability of 10^{-7} cm/sec, a geosynthetic clay layer (bentonite mat) is used as the backing for the HDPE plastic sheeting layer. The SENT Landfill is of the same design, except that there is an additional 1.5 mm HDPE secondary liner underlying the primary composite liner.

All three landfills contain leachate collection systems above the composite liner. The functioning of these systems is dependent on the integrity of the plastic sheeting layer. The US EPA Solid Waste Disposal Criteria (August 30, 1988a) state,

"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 Criteria for Municipal Solid Waste Landfills (July 1988b) state,

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

The situation today has not changed and, in fact, there is no doubt that the HDPE plastic sheeting in these landfills will eventually deteriorate to the point so that it will no longer be an effective barrier to the transport of leachate through it. The bentonite mat which serves as a backup to the plastic sheeting layer in the composite liner used in these landfills will, through advective and diffusional transport, allow passage of leachate through them which can lead to groundwater pollution.

The ultimate deterioration of the plastic sheeting layer, coupled, with the very long time during which leachate can be generated in these landfills which could pollute groundwaters and the nearshore marine waters, means that ultimately the leachate collection systems will fail to prevent leachate generated within the landfill from being collected by the leachate collection system and removed from the landfill.

Based on the information provided, the SENT Landfill contains a groundwater underdrain system. While no discussion of this system is provided, it appears that this landfill is located where there is a high groundwater table, and the apparent groundwater diversion system is an attempt to drain away the groundwaters so they do not enter the landfill or disrupt the integrity of the liner system.

All three landfills will depend on vertical monitoring wells around the perimeter of the landfill to detect leachate penetration through the liner system. The contractors for all three landfills will have responsibilities for after-care (monitoring and maintenance) of the site for only 30 years after landfill closure.

While the Wong article in Environment Hone Kong 1995 states that these landfills will be total containment sites which incorporate state-of-the-art liners that "...will not leak," the facts are that the liner systems that are being used in these landfills are the conventional US EPA Subtitle D minimum design for the WENT and NENT Landfills. The SENT Landfill has the additional HDPE liner which provides an additional plastic sheeting layer that must be penetrated by leachate before pollution of the environment in the vicinity of the landfill can take place. The 2 mm thick plastic sheeting layer is slightly

thicker than the conventional minimum US EPA Subtitle D liner design for HDPE which is 1.5 mm.

Contrary to the statements made in the Wong Environment Hong Kong 1995 article, this landfill design will not result in a total containment of leachate for as long as the wastes in the landfill represent a threat. Appended to this report is a recently published article by the author and his associate, Dr. Anne Jones-Lee, which discuss the expected performance of this type of landfill design. As indicated, it is likely that this landfill liner system will leak leachate at the time of construction. Over time, the plastic sheeting layer(s for the SENT Landfill) will deteriorate, ultimately allowing leachate that will be generated in the landfill to readily pass through the liner.

While no information is available to the author on the nature of the cover of these landfills, it appears from the information available on the NENT Landfill that the covers will allow moisture to enter the landfill at a slow rate and, thereby, generate leachate. The leachate generation period will likely be hundreds to a thousand years or more, i.e. the wastes in these landfills will be a threat to groundwater and Hong Kong marine water pollution for very long periods of time.

The 30-year after-care period specified in the contract will enable the contractors to be relieved of responsibility for further monitoring, maintenance and remediation at the end of 30 years. In the US, the 30-year post-closure period is the minimum, where it is understood that the owners/operators of landfills responsibilities can be extended for as long as the wastes in the landfill represent a threat. Lee and Jones-Lee (1994a) in "Landfilling of Solid & Hazardous Waste: Facing Long-Term Liability," discussed the long-term liabilities associated with the closure of landfills of this type. There is no doubt from the information provided that the Hong Kong Environmental Protection Department will inherit a massive legacy of groundwater and nearshore marine pollution due to the development of these landfills.

The groundwater monitoring system that has been proposed using vertical monitoring wells spaced a hundred or so meters apart has a low probability of detecting leachate pollution of the groundwater system before widespread pollution beyond the point of monitoring occurs. As discussed in the enclosed paper by Lee and Jones-Lee (1994b), "A Groundwater Protection Strategy for Lined Landfills," which is based on the work of John Cherry at the University of Waterloo (Cherry 1990), the initial leakage through the liner system produces finger plumes of leachate of a few meters in width. The vertical monitoring wells used to monitor pollution of leachate will have zones of capture on each side of about one foot, with the result that the monitoring wells will have a low probability of detecting leachate-polluted groundwaters until widespread pollution occurs.

The characteristics of municipal landfill leachate are such that small amounts of leachate can cause pollution of large amounts of nearshore marine waters that can be adverse to aquatic life (Jones and Lee, 1993). The information provided indicates that some sampling of nearshore marine waters will be conducted as part of landfill monitoring.

While the details of this sampling program were not provided, it is highly unlikely that it will be sufficient to address the adverse impacts that the leachate-polluted groundwaters would have on aquatic life in the nearshore marine waters where the leachate-polluted groundwaters enter the bay. The sampling of the open waters of the bay may not detect adverse impacts of leachate on benthic and epibenthic aquatic organisms that reside in the region where the leachate-polluted groundwaters enter the bay.

From an overall perspective, the so-called "new" landfills will differ from the old landfills from a groundwater pollution perspective in that rather than pollution beginning to occur shortly after the filling of the landfill, the new landfills groundwater pollution will be delayed for a period of time, possibly several decades, if high quality construction of the liner system occurs and no punctures occur at the time of placement of wastes in the landfill. Ultimately, however, the new landfills will also pollute groundwaters as are the existing "older" landfills. This groundwater pollution then will lead to nearshore marine pollution which will ultimately require the expenditure of large amounts of funds in order to try to stop this pollution.

No mention is made in the materials provided about any contingency funds being developed as part of the development of these landfills to potential address the inevitable pollution of the environment by leachate generated in the landfills. As discussed in the enclosed reports and papers, Lee and Jones-Lee, "Landfill Post-Closure Care: Can Owners Guarantee the Money Will Be There?" (1993a), the author recommends that a dedicated trust fund of sufficient magnitude to address all plausible worst-case scenario failures for the liner system be developed. This trust should be developed during the time of active filling as part of the disposal fees for the use of the landfill. It should be designed as a self-generating fund which would ensure that adequate funds will be available in perpetuity to address all plausible worst-case scenario failures of the landfill liner and groundwater monitoring systems.

If such a fund is not now being developed, then the Hong Kong Government should immediately start to develop such a fund by adding additional cost to the disposal fees to ensure that during the active life of the landfill sufficient funds will be generated to address plausible worst-case scenario failures of the landfill liner system and the pollution of groundwater systems and the nearshore marine environment.

It appears that the Hong Kong Environmental Protection Department may have been provided with highly unreliable information on the ability of this type of landfill liner design and monitoring system to contain landfill leachate and detect leakage of leachate through the liner system for as long as the wastes in the landfill will be a threat. This situation is not atypical of what frequently occurs in the US where landfill applicants and their consultants do not provide regulatory agencies and the public with reliable information on the properties of the liner systems and, especially the fact, that they will ultimately deteriorate and be ineffective in collecting leachate that leads to groundwater pollution. Lee and Jones-Lee (1993b) have discussed the fact that landfill applicants and their consultants often do not discuss at all, or reliably discuss, the long-term properties of HDPE liners relative to the period of time that the wastes in the landfill will be a

threat. Also, they do not provide reliable information on the ability of the groundwater monitoring systems used to detect leachate that passes through the liner before widespread pollution occurs. This issue is discussed by Lee and Jones-Lee (1995a) in, "Environmental Ethics: The Whole Truth." This is a serious problem in the US and, evidently, has occurred in Hong Kong as well.

Recommendations

The first step in beginning to address the errors that were made in developing these three landfills is for the EPD management to acknowledge that errors were, in fact, made and that it is only a matter of time until the so-called "total containment" landfills start polluting the nearshore marine waters of concern to Hong Kong by landfill leachate. If there is any doubt about the inevitable failure of the liner system and groundwater monitoring system that has been developed for these landfills, then the Environmental Protection Department should appoint an independent panel of experts who are highly knowledgeable in the topic and who will reliably report on the potential for nearshore marine pollution associated with each of the landfills.

The second step after acknowledging that there are potentially highly significant pollution problems that need to be addressed is to conduct a detailed analysis of the hazards that pollution of the nearshore marine waters by landfill leachate from each of the landfills represents. This will require a comprehensive understanding of the hydrogeologic characteristics of the aquifer system connected to the bottom of the landfill which could transport landfill leachate to the nearshore marine waters. From this information, a plan can possibly be developed to intercept the leachate before it reaches marine waters. The potential cost of the nearshore marine pollution control program can be estimated based on the proposed remediation plan. A remediation funding mechanism can potentially be developed, such as a dedicated trust derived from waste disposal fees, to eventually address the groundwater pollution problems when they occur.

Further, a much more reliable groundwater monitoring system can be installed which would detect initial leakage of leachate through the liner system earlier than the groundwater monitoring system that is currently being used. In addition, since these landfills have only recently (in the last couple of years) started to accept wastes, it may be possible to redesign substantial parts of them with a system that would provide for much more reliable waste containment than the proposed design. A report entitled, "Recommended Design, Operation, Closure and Post-Closure Approaches for Municipal Solid Waste and Hazardous Waste Landfills," (Lee and Jones-Lee 1995b) provides information on such a design.

As discussed by Lee and Jones-Lee (1995c), "Overview of Landfill Post Closure Issues," for those landfills sited above the groundwater table, it is possible that a leak detectable cover could be installed on the landfill that would, if operated and maintained in perpetuity, prevent moisture from entering the landfill and generating leachate which would pass through the liner system polluting the groundwaters and nearshore marine waters. If this approach is to be used, it is important for Hong Kong EPD to develop a

plan now which would ensure that adequate funds are available to install leak detectable covers and, most importantly, to operate and maintain these covers in perpetuity.

Additional Information

If there are questions about these comments or if there is need for further information on any aspect of them, please contact the author. He has published extensively on this topic. Copies of his papers and reports are available upon request. A listing of selected references is provided below. These references contain numerous references to literature articles on the topic areas discussed herein.

References for Supplemental Information

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

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

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