

Three Rs Managed Garbage Protects Groundwater Quality¹

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ABSTRACT

There is considerable misinformation on the public health and environmental benefits of the reduction, reuse and recycling (3Rs) of municipal solid wastes. This situation arises from the publication of several popular press articles that claim that there are no environmental benefits of practicing the 3Rs. The June 30, 1996 *New York Times Magazine* carried an article by John Tierney entitled "Recycling is Garbage" which is often cited as an authoritative source of information on the lack of environmental benefits of practicing the 3Rs. Since the publication of the Tierney article, there have been a number of other articles that attempt to support Tierney's theme. This paper presents a discussion of several of the fundamentally flawed bases of those who claim that the 3Rs do not produce significant benefits to public health and the environment.

The primary reason for supporting the 3Rs is the protection of groundwater quality from pollution by landfill leachate. In 1988 the US EPA proposed the Subtitle D regulations governing the landfilling of municipal solid wastes (MSW). The agency acknowledged at that time that the single composite liner that was proposed as the minimum liner would eventually fail which would lead to groundwater pollution by landfill leachate. Under threat of litigation by environmental groups to force the Agency to promulgate Subtitle D regulations, in 1991 the Agency adopted minimum Subtitle D regulations that allow the development of MSW landfills that at best will only postpone when groundwater pollution occurs at most landfill locations. One of the primary bases of the Tierney (and others) position of the lack of environmental benefit of the 3Rs is that MSW landfilling can be practiced in minimum Subtitle D landfills at far less cost than using 3Rs managed solid wastes. Tierney and others who advocate this position are considering only the initial tipping fee cost of disposal and ignore the long term "Superfund" like costs of the eventual cleanup of the polluted groundwater that will occur at most minimum Subtitle D landfills. This paper discusses this and other issues associated with the environmental benefits of the 3Rs.

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INTRODUCTION

The June 30, 1996, *New York Times Magazine* carried an article by John Tierney entitled “Recycling is Garbage.” As professionals who have been concerned with municipal landfill pollution of groundwaters for over 30 years and who spent 30 years teaching and conducting university graduate-level research on a variety of environmental issues including solid waste management and groundwater pollution control, we find that Mr. Tierney has significantly misrepresented the value of waste reduction and recycling as they relate to protecting the groundwater resources that will be available to future generations.

Mr. Tierney states,

“Believing that there was no more room in landfills, Americans concluded that recycling was their only option. Their intentions were good and their conclusions seemed plausible. Recycling does sometimes make sense—for some materials in some places at some times. But the simplest and cheapest option is usually to bury garbage in an environmentally safe landfill. And since there’s no shortage of landfill space (the crisis of 1987 was a false alarm), there’s no reason to make recycling a legal or moral imperative.”

Mr. Tierney also states that recycling diverts money from other, more significant environmental problems and that,

“Recycling may be the most wasteful activity in modern America: a waste of time and money, a waste of human and natural resources.”

“Today’s landfills for municipal trash are filled mostly with innocuous materials like paper, yard waste and construction debris. They contain small amounts of hazardous wastes, like lead and mercury, but studies have found that these poisons stay trapped inside the mass of garbage even in the old, unlined dumps that were built before today’s stringent regulations. So there’s little reason to worry about modern landfills, which by Federal law must be lined with clay and plastic, equipped with drainage and gas-collection systems, covered daily with soil and monitored regularly for underground leaks.”

We find that Mr. Tierney’s statement of “facts” is not valid in many aspects. While there are many valid reasons to criticize the highly inaccurate information that Mr. Tierney has presented on the benefits of recycling, the area that we wish to address is the pollution of groundwaters by municipal landfill leachate. Those knowledgeable about today’s landfilling practices know that today’s landfills, at best, in most situations only postpone for from a few years to a few decades the pollution of groundwaters by municipal solid waste (MSW) leachate. We also address, to a lesser extent, the other impacts of today’s Subtitle D landfills and the factors that

need to be considered in evaluating the true costs of landfilling MSW. Additional information on many of the topics discussed is provided in a comprehensive review by Lee and Jones-Lee.^{1,2}

THREE Rs MANAGED GARBAGE PROTECTS GROUNDWATER QUALITY

Long-term Reliability of Landfill Liner Systems

Municipal solid waste (MSW) management has evolved in the USA from open dumps to classical sanitary landfills. The landfilling approach adopted in this country in the early 1980s involves what has been appropriately termed “dry-tomb” landfilling. The dry tomb sanitary landfilling approach is basically an open dump where each day’s wastes are covered by a few inches of soil (classical sanitary landfill) and where compacted soil (clay) and plastic sheeting (flexible membrane liners - FML’s) are used to try to isolate the untreated municipal solid waste from moisture. This containment system is designed to try to collect and manage the leachate (garbage juice) generated within the “dry tomb” that results from the entrance of moisture into the “tomb.” Other countries and geographical areas, including some parts of Canada and western Europe, have chosen not to adopt the “dry tomb” method of MSW landfilling, typically because of the likelihood of the ultimate failure of the “dry tomb” containment (liner) system to prevent moisture from entering the landfill; and the failure of the system to collect all leachate generated in the landfill.

These plastic sheeting and compacted soil liners were chosen not because they had been demonstrated to have properties that would prevent leachate generation within the landfill and the collection of leachate for as long as the waste in the landfill would be a threat. They were selected because they were the next-cheapest thing to nothing (i.e., an unlined sanitary landfill of the type that was used prior to the adoption of the “dry-tomb” landfilling approach).

In the early 1980s, when the current landfilling approach began to evolve, environmental groups and legislators teamed up to dictate to the US EPA how they should design and monitor landfills to prevent leachate generation and/or to collect it once generated. Basically, the environmental groups and some members of Congress did not trust the US EPA to develop landfilling regulations that would carry out the congressionally defined mandate of protecting public health, the environment and groundwater resources from pollution by landfill-derived leachate for as long as the wastes in the landfill represent a threat. Congress instead adopted regulations that told the US EPA the details of how to design a landfill, with plastic sheeting and compacted clayliners. While the inability of compacted clay to prevent leachate from passing through it for as long as the wastes in the landfill represent a threat was fairly well understood at that time, the ability of the plastic sheeting (principally high density polyethylene) to prevent leachate from passing through it for as long as the wastes represent a threat was poorly understood.

It was known then that compacted clay layers would only postpone when leachate passed through them and, therefore, compacted clay liners of the type being used would not be effective barriers in preventing leachate from passing through the liner for as long as the wastes in the landfill would be a threat. In a “dry-tomb” type landfill, where there is limited moisture to interact with the waste, many of the components of the waste will be in a form that represents a threat to groundwater quality, effectively forever.

With respect to plastic sheeting liners, it was only a few years before information began to accumulate which showed that the plastic sheeting used as landfill liners had a finite period of time during which it could be expected to function effectively as a barrier to moisture entering the landfill, which generates leachate, and as an effective system for collecting leachate so that it could be removed in order to prevent groundwater pollution. By the late 1980s, it was clear that the “dry-tomb” landfilling approach for hazardous waste and MSW was a fundamentally flawed technology that, at best, only postponed when groundwater pollution occurred.

The US EPA Solid Waste Disposal Criteria³ 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 Landfills⁴ 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.”

These statements, while published by the US EPA in 1988, are valid today. While no one can predict how long a particular landfill liner system will function to prevent moisture from entering the landfill through the cover or collect the leachate within the landfill once moisture enters, there is no debatable issue about the fact that today’s hazardous waste and MSW landfills’ cover and liner systems will, under the current approach for landfilling, ultimately fail to protect groundwaters from pollution by landfill leachate.

While the US EPA⁵ claimed in the preamble to the Subtitle D regulations that these regulations would be protective at all locations including poor locations, when the basis for this claim is examined, it is found that it is based on a unreliable assessment of the threat that the pollution of groundwater by landfill leachate represents to public health, groundwater resources and the environment. The US EPA assumed that there would be only a few people who would acquire cancer from drinking groundwater polluted by the landfill leachate within several miles of the landfill over the next several hundred years.

Lee and Jones-Lee^{1,2,6,7} have summarized the deficiencies in the US EPA's Subtitle D regulations and Subtitle D landfills as being developed under these regulations. They have developed a set of questions that should be asked of any landfill applicant and regulatory agency that proposes to approve a minimum Subtitle D landfill. These questions, if reliably answered, will demonstrate that many of the sites where Subtitle D landfills are being developed are not suitable sites for this type of landfill. The minimum MSW Subtitle D landfill cover and single composite liner required by the US EPA or the double composite liner and landfill cover used in some states such as New York, Michigan, New Jersey, etc., will fail to prevent moisture from entering the landfill, which generates leachate and will ultimately lead to pollution of groundwaters in the vicinity of the landfill.

Contrary to the statements made by Tierney, today's landfills are not "safe." The regulatory approach adopted in the 1980s for hazardous waste and municipal solid waste landfilling for which Congress dictated landfill design is now a significant impediment toward revising landfilling regulations to consider what is known today about the ability of "dry-tomb" type landfills to protect groundwater resources from pollution by landfill leachate for as long as the wastes in the landfill represent a threat, i.e. effectively forever.

30-Year Post-Closure Maintenance Myth

Another significant deficiency of the Subtitle D regulations is that only 30 years of post closure (after landfilling has stopped) funding is required. There is no requirement that the landfill owner provide funding to pay for groundwater monitoring, landfill cover maintenance and the eventual groundwater pollution remediation. It is likely, considering the characteristics of municipal solid waste and the processes that take place in "dry tomb" landfills, that MSW in a "dry tomb" sanitary landfill will be a threat to public health, groundwater resources and the environment for as long as the landfill exists.^{8,9} The inorganics (metals, salts) and many organics will be a threat, effectively, forever. Lee and Jones-Lee¹⁰ have recommended that the minimum 30-year post-closure maintenance and monitoring period should be abandoned in favor of an expanded, perpetual, *ad infinitum* funded maintenance and monitoring. Hickman^{11,12} has urged that a dedicated trust fund be developed for all landfills to meet contingencies that may be encountered in the future.

Lee and Jones-Lee recommend that the post-closure maintenance and monitoring funding be developed from additional disposal fees. The funds should be placed in a dedicated trust that can only be used to meet the closure/post-closure maintenance and monitoring needs. They recommend the magnitude of the trust fund be sufficient to eventually exhume (mine) the wastes in the landfill and properly manage these wastes so they do not represent threats to public health, groundwater resources and the environment. Lee and Jones-Lee^{1,13} have reviewed the problems with current "dry tomb" landfill closure and post-closure maintenance and monitoring approaches and have recommended approaches for closure and post-closure maintenance for classical sanitary and "dry tomb" Subtitle D landfills.

Since, with few exceptions, both of the types of landfills (classical and “dry tomb” sanitary landfills) will pollute groundwaters and the aquifer system hydraulically connected to the landfill, the key to public health and environmental protection is the establishment of a leak-detectable cover that prevents moisture from entering the landfill after closure of the landfill. The current Subtitle D regulations allow the closure of a “dry tomb” sanitary landfill with a cover that does not necessarily keep the wastes dry so that the landfill does not generate leachate that can penetrate the landfill liners and pollute the groundwaters associated with the landfill. Leak-detectable covers are now available from Gundle Lining Systems, Inc., and Robertson Barrier Systems Corps of Vancouver, BC. The development of the funding necessary to operate and maintain the leak-detectable cover is also a key component of proper closure of “dry tomb” sanitary landfills.

Impacts of MSW Leachate Pollution of Groundwaters

Mr. Tierney implies that there are only a few components of MSW that represent threats to groundwater quality. He does not understand domestic water supply water quality issues or the composition of leachates produced by today’s MSW landfills. Jones-Lee and Lee¹⁴ have provided a discussion of the potential impacts of today’s MSW leachate on public health, groundwater resources, the environment and the interests of those within the sphere of influence of the landfill. Today’s MSW landfills, even with 50% diversion of the waste as it is practiced today, including extensive household hazardous waste collection/diversion, contains a wide variety of hazardous and deleterious chemicals that can render a groundwater unusable for domestic and many other purposes. The current groundwater quality protection regulations do not adequately or reliably address the wide variety of constituents in MSW leachate that can impair the use of a groundwater for domestic water supply purposes.

There is no doubt that, even with a highly effective household hazardous waste collection program and no illegal industrial and commercial hazardous waste disposal, MSW leachate would still be highly hazardous to individuals who use groundwaters polluted by leachate. There is no way to totally divert all hazardous and deleterious chemicals from MSW. Contrary to the statement made by Tierney, the “poisons” inside MSW are not trapped inside the garbage. All that Tierney needed to do to understand the fallacy of his statement is to examine the chemical characteristics of Subtitle D landfill leachate. Part of the hazardous chemicals, as well as a variety of highly deleterious chemicals, leave a landfill through the liner system and pollute groundwaters, rendering them unusable for domestic water supply purposes.

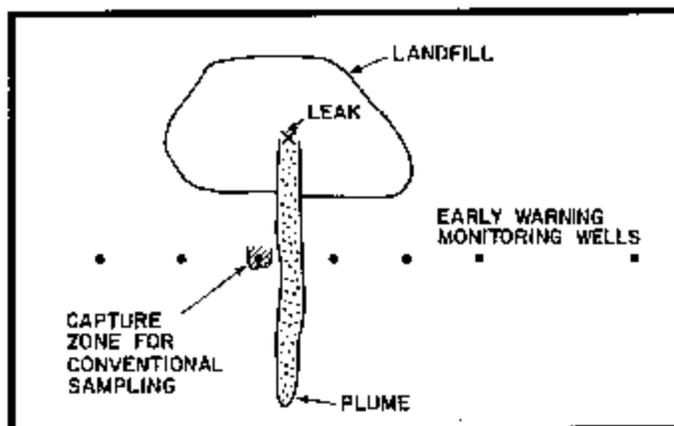
It can be concluded that the basic approach that must be used in managing solid waste in light of the current inadequate Subtitle D regulations is to reduce the magnitude of solid waste that must be disposed of to the maximum extent possible in order to reduce the number of landfills that will eventually pollute groundwaters. Also landfills should be sited where the inevitable pollution of groundwaters is of little or no consequence to the public, who at some time in the future may wish to use groundwaters in the region for domestic water supply purposes.

Reliability of Groundwater Monitoring to Detect Pollution

A key component of the landfilling regulations adopted in the early 1990s was the requirement for groundwater monitoring. The basic approach used by the US EPA for groundwater protection from pollution by landfill leachate was that the groundwaters downgradient from the landfill would be reliably monitored near the landfill in order to detect liner failure. In principle, the near-landfill detection of liner failure (i.e. leachate polluted groundwaters), would occur sufficiently early so that the amount of groundwaters polluted by leachate would be small and would not trespass under adjacent properties. The basic approach for monitoring the new lined landfills was to install a series of vertical monitoring wells spaced so that they would have a high reliability in detecting landfill leachate pollution of groundwater at the point of compliance for groundwater monitoring. In practice, however, the monitoring wells are spaced hundreds to a thousand or more feet apart along the downgradient groundwater edge of the landfill.

Cherry¹⁵ first pointed out that the groundwater monitoring system developed for unlined landfills of a few wells spaced hundreds of feet apart down groundwater gradient from the landfill is an unreliable approach for monitoring lined landfills. Lined landfills will initially leak leachate through the liner through limited size holes, rips, tears and points of deterioration that will produce finger-like plumes of leachate of limited lateral dimensions. This relationship is shown in Figure 1. Each of the typical monitoring wells has a zone of sampling of about one foot on each side. Therefore, the finger-like plumes of leachate can readily pass between the monitoring wells without being detected. Lee and Jones-Lee^{2,16} have discussed a groundwater protection strategy that involves the use of a double composite liner of the type used by the state of Michigan. The lower composite liner serves as the base of a leak detection system. When leachate is found in this system between the two composite liners, it is clear that the upper composite liner has failed and action must be taken to prevent groundwater pollution that will occur when the lower composite liner fails. Unfortunately, this approach is not used elsewhere.

Figure 1. Pattern of Landfill Leakage -Groundwater Contamination from Lined Landfills (after Cherry, 1990)



Lee and Jones-Lee¹⁷ have discussed the detection of landfill liner system failures. They point out that while often landfill proponents claim that there are no recorded instances of a Subtitle D landfill polluting groundwaters, they fail to point out that one of the primary reasons for this is the unreliability of the groundwater monitoring systems to detect the pollution of groundwaters by landfill leachate. Further, the widespread groundwater pollution that will ultimately occur from today's Subtitle D landfills would not be expected to be detected today because of the short time that Subtitle D landfills have been used.

It is appropriate to question whether today's landfills, with their plastic sheeting and compacted soil liners and monitoring systems that depend on vertical monitoring wells placed hundreds to a thousand or more feet apart, are significantly better than the classical unlined landfills that were used before the "dry-tomb" landfilling approach was implemented. At least with the classical sanitary landfills, the leakage of leachate to groundwater occurred at all locations under the landfill; therefore, it was relatively easy to detect, through monitoring, pollution of groundwaters by landfill leachate. With today's lined landfills and the finger-like plumes of polluted groundwater that are generated from them, the public, and some individuals such as Mr. Tierney, are lulled into believing that they are "safe" landfills, when in fact they are basically time bombs that will ultimately be significantly detrimental to future generations' health, groundwater resources and interests. The "dry-tomb" landfilling approach gives the public a false sense of safety that something permanent in groundwater quality protection is being done in managing solid wastes when it is not.

Unreliability of Landfill Gas Production in Closed Subtitle D Landfills

One of the areas of concern for impacts on public health and the environment with Subtitle D landfills is landfill gas production after the landfill is closed. Subtitle D allows the closure of a landfill with a plastic sheeting layer in the cover as the barrier to moisture entering the wastes. This plastic sheeting is buried below several feet of cover soil. While a plastic sheeting layer can be constructed in a landfill cover that will be an effective barrier to moisture entering the landfill, over time the plastic sheeting will deteriorate, develop holes and allow moisture to enter the wastes. Typically the approach used to detect problems with the cover involves visual inspection of the soil surface. This approach is not reliable for detecting leaks in the plastic sheeting layer.

Moisture in the solid wastes is the key to landfill gas production. Dry wastes do not produce landfill gas. The closure of a Subtitle D landfill with a plastic sheeting layer in the cover that prevents moisture from entering the landfill will stop landfill gas production. As discussed by Lee and Jones-Lee,¹⁸ this situation leads to an inability to reliably predict landfill gas production over the period of time that the wastes are a threat to produce landfill gas. Since much of the solid wastes placed in a landfill today is present in plastic bags that are crushed but not shredded, the period of time that a Subtitle D landfill will be a threat to produce gas can be well beyond the 30 year postclosure care period. This period will be much longer than that which typically occurs in a classical sanitary landfill.

A Subtitle D “dry tomb” landfill may not produce landfill gas for many years while the plastic sheeting layer is an effective moisture barrier. However, at some time in the future landfill gas production will start again. This could readily occur after the minimum 30 year postclosure care period when there is no money for landfill gas monitoring, maintenance and operation of the landfill gas collection system. The uncontrolled release of landfill gas that could readily occur with closed Subtitle D landfills is a significant threat to public health, public safety and the environment.

Flawed Technological Approach

It is obvious that the “dry-tomb” type of landfilling is fundamentally flawed if the purpose of landfilling is to manage MSW while protecting groundwater resources from pollution by hazardous and deleterious chemicals that render groundwaters unusable for domestic water supply purposes. It is important to note that several countries, such as some parts of Canada and western Europe, will not allow the construction of “dry-tomb” type landfills for managing municipal solid wastes because of their inevitable failure to protect public health, groundwater resources and the interests of those who own or use properties near a landfill.

With respect to Mr. Tierney’s statement about “safe landfills,” it is quite clear that there is no such thing as a safe landfill of the type being developed today, where the landfill is sited in an area where there are groundwaters that are or could at any time in the future be used for domestic water supply purposes. With few exceptions associated with landfills sited at locations where there is no useable groundwater associated with the landfill, today’s landfills will not prevent groundwater pollution and, therefore, are not safe.

Justified NIMBY

Mr. Tierney states in his article that,

“Landfills are scarce in just a few places, notably the Northeast, partly because of local economic realities (open land is expensive near cities) but mainly because of local politics. Environmentalists have prevented new landfills from opening by propounding another myth... Our garbage will poison us.”

Once again, Mr. Tierney has not reliably discussed the issues of justified concern to those who own or use properties near existing or proposed landfills. Anyone who has ever spent any time around a municipal landfill knows that, with very few exceptions, today’s landfills are poor neighbors. In addition to polluting groundwaters, today’s landfills that meet current regulatory requirements release a wide variety of hazardous and obnoxious materials that are significantly detrimental to those within the sphere of influence of the landfill.

As discussed by Lee and Jones-Lee,^{19,20} the direct sphere of influence of many municipal landfills for such problems as odors, dust, blowing trash, birds, truck traffic and decreased property value is often several miles from the landfill. Current regulatory requirements do not require that those who develop landfills control these releases from the landfill so they do not trespass onto adjacent property owners' lands. Landfill owners/operators are able to construct a landfill within a very short distance of the landfill-adjacent property owners' property line. There is, therefore, inadequate distance between where wastes are deposited and constituents are released from the deposited wastes and the properties of adjacent property owners/users. This leads to a highly justified NIMBY ("Not In My Back Yard.")

The authors have yet to find a single person who would welcome having an MSW landfill sited within a few hundred yards of their property line. This NIMBY is justified. Until such time as effective regulatory requirements are developed and, most importantly, implemented-enforced where adequate bufferlands between where the wastes are deposited and the adjacent property line occur (a mile or more) there will be significant justified opposition to siting landfills in a region. The issue is not just "poisons" as Mr. Tierney states; the issue that must be addressed in eliminating a justified NIMBY is the control of all of the hazardous and obnoxious impacts of landfills on the landfill owners' properties.

Importance of Recycling in Preventing Groundwater Pollution

The deficiencies in Subtitle D landfills have significant implications for the importance of recycling/diversion of wastes from the landfill through reuse, reduction and recycling. It is generally found that it is relatively easy for communities to divert 25% of the MSW stream through recycling, reduction and reuse of waste components. It is also fairly well established that, with aggressive use of the 3Rs, it is possible to achieve a 50% reduction/diversion of the MSW stream. This means that, since each landfill has a finite capacity for accepting waste, if the rate of filling of today's landfills is reduced by 50%, there will therefore be 50% less need for new landfills. With each new landfill there is a certain inevitable groundwater pollution, except for the few landfills sited at locations where there are no useful groundwaters hydraulically connected to the base of the landfill. Such situations are indeed rare. Most landfills sited today are located where groundwater pollution is inevitable, i.e., it is only a matter of time.

Since the groundwater resources of an area are crucial to future generations' water supplies, it is essential that their quality be protected. This is especially important in light of the fact that there is no cleanup of MSW leachate-polluted groundwaters to acceptable drinking water quality once they have been polluted by MSW leachate. Such groundwaters and the associated aquifer areas must be considered permanently damaged and lost effectively forever as a domestic water supply.

Economics of Recycling

Mr. Tierney devotes considerable space to a discussion of the economics of recycling, where he claims that recycling is not cost-effective in terms of benefit to society. Mr. Tierney's analysis of the economics of recycling is fundamentally flawed in that he fails to consider the perpetual monitoring and maintenance costs as well as the Superfund costs of cleaning up the groundwater pollution associated with landfill liner systems that at best only delay when groundwater pollution occurs. Further, he fails to address the significant costs associated with the adverse impacts of landfills on those who own or use properties within the sphere of influence of the landfill. Today's society has been able to force landfills and their impacts on nearby property owners.

As discussed by Lee and Jones-Lee,^{19,20} with the exception of a few impacts such as altered viewshed, truck traffic, etc. it is possible to develop landfills with sufficient bufferlands and control systems to eliminate most of the justified NIMBY. However, the development of such landfills would require a significant increase in the cost of landfill management of wastes. These costs are now being passed on to nearby owners and users of properties near landfills. This is one of the major reasons for justified NIMBY.

A proper economic analysis considers not only the short term active life issues of concern to today's public, but also the long-term issues of concern to the health, welfare and interest of future generations. Fundamentally, today's landfills enable the current society to dispose of their garbage by landfilling at far less than the real cost of landfilling. A substantial part of the true costs and the associated detriments are being passed on to future generations. It is possible to develop appropriate landfills today that can manage the non-recyclable components of waste at a cost of about 10 to 20 cents per person per day more than is currently being paid for MSW management under Subtitle D regulations.

A fundamentally flawed premise in Mr. Tierney's discussion is that the cost of recycling MSW components is not justified. The facts are that a proper economic analysis would likely show that it is prudent public policy to subsidize 3R activities in order to reduce the magnitude of the true costs of the landfilling of MSW. It is inappropriate to assume that the costs of landfilling are properly reflected in the tipping fees being paid at today's minimum Subtitle D landfills. These tipping fees are kept artificially low by failing to address the true active life costs to those within the sphere of influence of the landfill as well as the true long term costs to groundwater resources, public health and the environment.

Need for Federal Landfilling Regulation (RCRA) Revisions

A critical review of today's MSW and hazardous waste landfilling situations shows that there is an urgent need to revise RCRA (federal regulations governing landfilling of wastes) to address the well-known, highly significant deficiencies in both hazardous waste and MSW landfilling approaches. While, as discussed by Lee and Jones-Lee,^{1,21} "dry-tomb" landfilling

can be made to work if significantly different approaches are taken toward design, closure and long-term funding of these landfills, it is unlikely that today's and future generations will, in fact, provide the funds necessary to properly operate and maintain "dry-tomb" landfills for as long as the wastes represent a threat. For this reason, there is growing recognition that the "dry-tomb" landfilling approach must be abandoned as soon as possible.

Those landfills that have been constructed under current regulations, with the plastic sheeting and compacted clay liners, should be recognized as eventual polluters of groundwaters similar to the classical unlined sanitary landfills. Funds should be set aside from disposal fees, while the landfills are actively receiving waste, to face the inevitable groundwater pollution problems that will have to be addressed.

Today's landfilling regulations should be changed so that it will be possible to construct landfills as biological and chemical reactors, where shredded MSWs are placed in double composite-lined landfills in which leachate, and then eventually clean water, is added to the landfill while the liner system is still effective in collecting leachate, in order to remove those components of the waste that will inevitably be leachable as precipitation enters the landfill in the future. This "wet cell" approach for landfilling is readily implementable, and its costs, while initially somewhat higher, in the long-term are far cheaper than the "dry-tomb" approach.²² The components of the waste that represent long-term threats are removed by this approach through deliberate fermentation and leaching of the waste under controlled conditions.

Today's landfilling regulations are badly out-of-date and represent an early 1980s understanding of the ability of landfill liner systems and groundwater monitoring systems being used to prevent pollution of groundwaters by landfill leachate for as long as the wastes in the landfill represent a threat. Specifically, there is need to change RCRA and/or state regulations to

- require that a double-composite liner be used for both Subtitle C and D landfills where the lower composite liner is a leak detection system for the upper liner.
- require that, when the landfill owner/operator cannot stop leachate from occurring in the leak detection system between the two composite liners, the wastes in the landfill must be removed (mined) from the landfill.
- require the closure of Subtitle C and D landfills with leak detectable covers that are operated and maintained for as long as the landfill exists.
- eliminate the minimum 30-year post-closure care and maintenance period and require that post-closure care be provided for as long as the wastes in the landfill represent a threat, which is understood in a "dry-tomb" type landfill to be forever.
- require that an adequate dedicated trust fund be developed from disposal fees to ensure that funds will in fact be available when needed for perpetual monitoring and maintenance in order to meet any plausible worst-case contingencies that could occur at a landfill, including waste exhumation and groundwater cleanup, to the extent possible.

- allow *in situ* treatment (fermentation and leaching) initially utilizing leachate recycle followed by clean water leaching of shredded wastes in double composite-lined landfills.
- ensure that all justifiable NIMBY impacts associated with landfills (such as odor, dust, fugitive trash, gull impacts, etc.) are controlled within the property boundaries of the landfill owner.

Because of the high perpetual, *ad infinitum* costs associated with “dry-tomb” landfilling that provide for true protection of public health, groundwater resources and the environment, it is recommended that the “dry-tomb” landfilling approach be abandoned as soon as possible in favor of a waste treatment approach that produces residues that do not represent long-term threats to groundwater quality, public health and the environment.

Adoption of the recommended approach for MSW management which maximizes the use of the 3Rs will significantly change the economics of the 3Rs. As long as the myth that Tierney attempted to support continues to exist that the landfilling of MSW can be safely done in a minimum Subtitle D landfill at the costs that are being paid today, society will continue to fail to properly support MSW waste stream component reduction, recycling and reuse. There is an urgent need to stop the current trend of reducing the magnitude of 3R waste diversions arising out of the flawed economic analyses that are being used today to evaluate the benefits of the practice of the 3R’s in MSW management.

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Dr. G. Fred Lee is President and Dr. Anne Jones-Lee is Vice-president of G. Fred Lee and Associates. They specialize in addressing advanced technical aspects of water supply water quality, water and wastewater treatment, water pollution control, and solid and hazardous waste impact evaluation and management. One of the areas of their specialization is evaluation of existing or proposed municipal solid waste or hazardous waste landfills. They have published extensively on this work. Many of their recent papers and reports are available from their website, www.gfredlee.com.

3 R's Managed Garbage Helps Protect Groundwater Quality

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Myths of Today's Landfills

- “Today's Landfills Are Safe”
- “3-R Activities Are Expensive and Unneeded”
- Subtitle D Single Composite Liner Is Adequate to Protect Groundwater Resources for as Long as Wastes Are a Threat

Reduce ! Reuse ! Recycle

Practice of “3R's” Will Help Protect Groundwater Quality

US EPA (1988) “Solid Waste Disposal Criteria” 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.”

US EPA (1988) “Criteria for Municipal Solid Waste Landfills” 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.”

Although Published by the US EPA in 1988, These Statements Are Still Valid Today

Subtitle D Landfills “Protective?”

In Preamble to Subtitle D Regulations, US EPA (1991) Claimed That Subtitle Landfills Would Be Protective at All Locations, Including Poor Locations

- Political Statement Based on Unreliable Assessment of Threat That Groundwater Pollution by Landfill Leachate Represents to Public Health, Groundwater Resources, and Environment
- US EPA Assumed There Would Be Only a Few People Who Would Develop Cancer from Drinking Groundwater Polluted by the Landfill Leachate within Several Miles of the Landfill over the Next Several Hundred Years

Landfill “Safety” Is Based on Assumption That Only a Few People Would Be Exposed to Landfill-Polluted Groundwater

The Facts

At Most Locations, Today’s Landfilling Approaches Only Postpone Inevitable Groundwater Pollution - Create Tomorrow’s “Superfund” Sites

Today’s Municipal Solid Waste Stream Contains Variety of Hazardous and Otherwise Deleterious Chemicals

Today’s Landfills Will Be Threat to Groundwater Quality **Forever**

Plastic-Sheeting and Compacted Clay Liners and Covers Will Eventually Fail to Prevent Leachate-Pollution of Groundwater

Groundwater Monitoring Systems Relied upon to Detect Groundwater Pollution by Liner Failure, Highly Unreliable

Will Lead to Pollution of Adjacent-Property Groundwater

30-yr Post-Closure Maintenance Myths

Significant Deficiencies in Subtitle D Regulations

- Only 30 yrs of Post-Closure Funding Is Required
No Requirement for Landfill Owner to Provide Funding to Pay for Groundwater Monitoring, Landfill Cover Maintenance or Remediation of Eventual Groundwater Pollution
- Do Not Adequately Consider That MSW in a “Dry Tomb” Sanitary Landfill Will Be a Threat to Public Health, Groundwater Resources, and Environment for as Long as the Landfill Exists Because of
Characteristics of Municipal Solid Waste
Processes That Take Place in “Dry Tomb” Landfills

Facts

Inorganics (Metals, Salts) and Many Organics Will Be a Threat, Effectively, Forever

Minimum 30-yr Post-Closure Maintenance and Monitoring Period Should Be Abandoned in Favor of an Expanded, Perpetually Funded Program for Monitoring, Maintenance and Eventual Groundwater Remediation

Need for Revision of Federal Landfilling Regulation (RCRA)

- Require Double-Composite Liner for Both Subtitle C and D Landfills; Lower Composite Liner Is Leak Detection System for Upper Liner
Required in 10 States
- Require Removal of Wastes (Mining) from Landfill When Owner/Operator Cannot Stop Leachate Leakage into Leak Detection System between Two Composite Liners

- Require Closure of Subtitle C and D Landfills with Leak-Detectable Covers That Are Operated & Maintained for as Long as Landfill Exists
- Require Post-Closure Care for as Long as the Wastes in Landfill Represent a Threat - For “Dry Tomb” Type Landfill, Understood to Be Forever
Eliminate Minimum 30-yr Post-Closure Care & Maintenance Language
- Require Dedicated Trust Fund Be Developed from Disposal Fees to Be of Sufficient Magnitude to Ensure That Funds Will, in Fact, Be Available When Needed for Perpetual Monitoring & Maintenance to Meet Any Plausible Worst-Case Contingencies That Could Occur at a Landfill, Including Waste Exhumation & Groundwater Clean-up to Extent Possible
- Allow/Encourage *in situ* Treatment (Fermentation/Leaching) Initially Utilizing Leachate Recycle, Followed by Clean-Water Leaching of Shredded Wastes in Double Composite-Lined Landfills
- Ensure That All Justifiable NIMBY Impacts (e.g., Odor, Dust, Fugitive Trash, Gull Impacts) Are Controlled within Landfill Property Boundaries
Provide Adequate Bufferland between Landfilled Wastes & Adjacent Property Line - at Least 1 mi Needed at Most Sites

Urgently Needed

Revision of RCRA and State Landfilling Regulations to Develop Landfills to Manage Non-3-R Waste Constituents That Will:

- Address Justifiable NIMBY, and
- Protect Groundwaters from Use-Impairment for as Long as Wastes in Landfill Will Be a Threat

Will Increase Initial Cost of Landfilling of Wastes
Cheaper in Long Term

“3 R’s” Important Part of Reducing Groundwater Pollution

Each New Landfill Creates Certain Inevitable Groundwater Pollution (Except for the Very Few Landfills Sited at Locations Where There Are No Useful Groundwaters Hydraulically Connected to Base of Landfill)

Most Landfills Sited Where Groundwater Pollution Is Inevitable - Only Matter of Time
Practice of 3-R’s Reduces Need for New & Expanded Landfills

Less Groundwater Pollution

Deficiencies in Subtitle D Landfills Have Significant Implications for Importance of Recycling/Diversion of Wastes from Landfill through ***Reuse, Reduction, Recycling***

Economics of Recycling

Cost (Tipping Fee) of MSW Management in Today's Landfills Artificially Low
Fails to Consider Costs Associated with Active Life Impacts of Landfill on Nearby
Property Owners/Users
Leads to Justifiable NIMBY

Only Addresses Some Initial 30-Year Post-Closure Costs

Does Not Address Infinite Period of Time during Which Landfilled Wastes Will Be Threat
Passes True Costs and Impacts of MSW Management by Landfilling on to:

- Current Owners/Users of Nearby Property and
- Future Generations

Conclusion

- Principal Deterrent to Implementing 3R's: Lower Initial Cost of Minimum Subtitle D Landfilling
- Proper Economic Analysis of Appropriately Landfilled Wastes Will Likely Show That Subsidizing 3-R Activities Is Prudent Public Policy for MSW Management

For Additional Information, Consult www.gredlee.com.