Readers should be aware that the Environmental Protection Agency published final RCRA Subtitle D landfill regulations on September 11, 1991. References to the proposed Subtitle D regulations in this document should be checked against the final, September 11 regulations.

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SOLID WASTE LANDFILLS IN TENNESSEE'S MUNICIPAL SOLID WASTE DISPOSAL SYSTEM

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with appendices by:

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The University of Tennessee
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The Waste Management Research and Education Institute, a division of the Energy, Environment and Resources Center at the University of Tennessee, Knoxville, has been engaged in several research topics dealing with solid waste management and planning. Our intention is to distribute research findings to an interested audience of scholars, practitioners, government officials and citizens. This report is one in a series of reports on solid waste that has been and will be produced and distributed. Comments on this or any other of the reports are welcome.

Jack Barkenbus
Deputy Director

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TABLE OF CONTENTS

Introduction

Landfills are the most widely-used method of municipal solid waste disposal in both Tennessee and the nation. Roughly 84% of the municipal solid waste disposed of in permitted facilities across the nation in 1988 was landfilled--in Tennessee the percentage was even higher (94%) Because of this considerable reliance upon landfills, there is concern over the growing difficulty in finding replacements for landfills reaching capacity. Community or neighborhood resistance to the designation of new sites is throwing into question the assumption that new capacity will be present when the old runs out. Public officials who ignore warning signals do so at their own peril.

This report deals with a number of issues surrounding landfills. First it gives an overview of the landfill capacity situation today in Tennessee and looks out to the year 2000. Second, it recognizes that regulatory issues facing the construction of new landfills are at least as important as capacity questions in Tennessee. A section tracing regulatory development over the past few decades is included, and a subsequent section dealing with the nature of Tennessee's latest landfill regulations is included. New landfill regulations will make this disposal option more costly; and estimates of just how costly are provided. Lurking in the background are long-awaited federal regulations (Resource Conservation and Recovery Act, Subtitle D), expected to be promulgated by the Environmental Protection Agency (EPA). A brief comparison of the expected federal standards with Tennessee regulations will be provided. Regardless of whether landfills are

regulated under current state or future federal standards, landfilling in the future will differ significantly from landfilling of the past.

Overview

There are 96 permitted and active municipal solid waste landfills located across the state of Tennessee, as seen in Figure 1. The range in the amount of material being placed in these landfills is enormous, ranging from as little as one ton per day, to as much as 2795 tons per day. Most landfill operators do not know precisely how much material is entering their facilities since less than a third possess scales at this time. Nearly two-thirds of the existing landfills are estimated to be disposing of fewer than 120 tons per day (see Appendix A for a listing of individual landfills and their characteristics).

Just as there is variation in size, so too are there large differences in remaining life or capacity. Roughly a third have two years or less of remaining life. About half have less than five years of remaining life (see Figure 2). These numbers illustrate that there is no room for complacency when contemplating Tennessee's disposal situation.

A broader context on landfill capacity is seen in Figure 3. Disposal and generation were basically equivalent in 1989, at 5.4 million tons. This includes 324,000 tons of waste disposal capacity provided by incineration. Disposal capacity is likely to fall to 3.5 million tons in 1994, if no replacement capacity is forthcoming. If generation were to grow, as expected, to 5.7 million tons in 1994,

the gap between generation and disposal would amount to over 2 million tons. We know, however, that some replacement capacity is in the permitting process and is likely to be available by 1994. Roughly 700,000 tons of capacity from 20 new sites or existing site expansions should be on-line by 1994--additional capacity may be available by that date, but there is no certainty attached to this projection. Barring any reduction in generation, therefore, Tennesseans are looking at a possible discrepancy between generation and disposal of over 1.5 million tons. The gap is even more pronounced if we go out to the year 2000 on Figure 3. Clearly, vigorous efforts at source reduction and recycling are needed to reduce generation; but additional landfills must be found and developed as well.

Figure 4 illustrates that some regions are better off than others with respect to disposal capacity. Even within those better-off regions, however, there is at least one landfill with less than 2 years of life remaining. In summary, there is no typical disposal situation applicable to all Tennessee communities. A wide range of conditions exist. The situation is serious enough, however, that if renewed attention is not brought to bear on this issue, more and more communities will be facing crisis situations.

Regulatory Development

Solid waste began to be viewed as a national issue in the early 1960s. In 1965, Congress passed the Solid Waste Disposal Act which made technical and financial assistance available to state and local governments for planning and

developing disposal technologies and resource recovery. Tennessee received a federal grant in 1966 and with it, conducted a survey of all cities and counties pertaining to solid waste disposal methods.

The survey revealed that solid waste was going into approximately 270 sanctioned, open dumps across the state. Groundwater contamination elicited little concern at the time. Rather, the concerns of smoke, odors, flies, and rodents were paramount. The location of these dumps, largely placed close to population centers for convenience, exacerbated citizen dismay with these facilities.

Consequently, Tennessee passed the Solid Waste Disposal Act of 1969, empowering state government with regulatory authority over disposal for the first time. The Tennessee Department of Public Health established permit and operational standards for all solid waste disposal facilities, as regulations were promulgated in 1971. The regulations were primarily generic, requiring professional engineering and geologic judgments to be made on a site-by-site basis. The 1971 regulations remained the guiding force for Tennessee's regulatory bodies until March of 1990, when new regulations went into effect.

In 1976, Congress passed the Resource Conservation and Recovery Act (RCRA), which prohibited open dumping and established a cradle-to-grave system to manage hazardous waste. Subtitle C of RCRA pertains directly to hazardous waste and was adopted into law by Tennessee shortly after congressional passage. Subtitle D of RCRA was promulgated with the specific purposes of assisting and encouraging environmentally sound methods of waste disposal for

municipal nonhazardous waste, maximizing utilization of resources recovered from waste, and encouraging resource conservation.

Comprehensive Environmental Response, Compensation, and Liability Act (commonly known as Superfund) was passed in 1980, with Tennessee adopting Superfund laws in 1983. Superfund came about in large part due to the improper disposal practices covering both hazardous and solid waste. When disposal occurred in so-called landfills, or dumps prior to 1970, these facilities had little, if any, engineering controls to prevent the contamination of groundwater. Eventually, more and more was being learned about the adverse health effects of certain contaminants into the groundwater from these improper disposal methods.

The National Priority List (NPL) is a list of sites across the nation that have been designated for cleanup under the administration of the Superfund program. As of October 1989, this list was comprised of approximately 20 to 25% municipal landfills and dumps. For the state of Tennessee, there are 14 sites on the NPL as of February 1990. Of these, six sites have been identified as dumps. Cost for cleanup could escalate into millions of dollars depending on the extent of the contamination.

As a result of this situation, the Hazardous and Solid Waste Amendments of 1984 (HSWA) were passed as amendments to RCRA. They strengthened the Subtitle C (hazardous waste) regulations, as well as the Subtitle D (solid waste) regulations. The Subtitle D regulations are currently being revised and are expected to be promulgated sometime in 1991. These regulations will tighten

landfill engineering design and control. Prior to examining the possible nature of these federal regulations and the 1990 state regulations, discussion of what modern, engineered landfills entail is required.

Engineered Landfills

With more stringent regulations on the way, landfill technology will continue to progress toward an engineered system. To better understand why, it is necessary to deal with the issue of decomposition in a landfill. Municipal solid waste is predominantly organic in nature. It consists of such items as paper, food waste, yard waste, and even household hazardous waste (e.g., chemical products) that will biodegrade or decompose over a period of time in a landfill due to microbial activity. This biodegradation leads to the formation of methane, carbon dioxide, organic acids, and other chemicals and gases. If rainfall or other moisture enters the landfill, it accelerates the production of these organic acids or leachate (contaminated water). This leachate can contaminate groundwater if controls are not in place to stop its movement. Some factors that affect the quantity and composition of leachate are types of waste, age of the landfill, rainfall, and temperature.

Methane, a by-product of landfill decomposition, presents a significant explosive threat because it migrates through the soil and will accumulate in confined spaces. A 5 to 15 percent concentration of methane can cause an explosion. Engineering controls are needed for this aspect of landfill management.

Due to the concern over global warming, there is the possibility that, in the near future, tighter controls will be required to lessen the emissions of methane, carbon dioxide, and other gases presently being vented from the landfill. However, landfills contribute a negligible amount of these gases to the atmosphere, compared to fossil fuel burning.

Because of these concerns, engineering controls are used to alleviate the environmental impacts of the landfill decomposition process and its by-products. Liners are low-permeability membranes designed to limit leachate movement into groundwater. There are different types. Synthetic liners are sheets of various polyethylenes. The soil liner is basically clay that is either in-situ or imported and engineered (compacted and remolded).

Once the leachate is formed, it must be collected and treated. Within the landfill liner systems are leachate collection systems that collect and pump the leachate to a central point, where it can be treated either at the landfill or at a publicly-owned treatment works. In some cases, it will be recirculated back through the landfill to accelerate the rate of decomposition in the landfill.

Different liner and leachate collection system designs can be used. For example, a single liner system consists, of either a synthetic or clay liner overlain with a drainage layer of sand or gravel and a series of perforated collection pipes with sumps for collecting the leachate (see Figure 5). A double liner system consists of two synthetic liners or one synthetic liner atop a clay liner with the leachate collection system placed both above the top liner and between the two

liners (see Figure 6). A double-lined system is consistent with requirements for a hazardous waste landfill. Composite liners are simply a synthetic liner that is placed above an engineered clay liner with the leachate collection system atop the synthetic liner.

Before disposal begins, groundwater monitoring wells are drilled. The purpose is twofold. First, groundwater quality is checked before disposal begins, so a background level can be established. Second, after disposal begins, the wells are monitored on a routine basis in order to detect infiltration of leachate into the groundwater. This monitoring continues through the life of the landfill and a minimum of thirty years after the landfill is closed. Other controls, such as berms and dikes, are also employed to control surface-water problems.

Methane controls in the landfill involve the use of either passive or active venting systems. Passive systems are gravel trenches near the edge of the landfill or trenches running vertically within the landfill and PVC piping to flare the gas. Active systems use pump systems to draw the gas from the landfill and vent or flare the gas. Some landfills across the country, rather than venting the gas, are now putting the collected methane to use as an energy source.

Currently in Tennessee, of the 96 existing landfills, 36 use a natural or clay liner, four have synthetic liners, 28 have a leachate collection system, five have a gas management system, and 79 have a groundwater monitoring system.

Estimated Costs of Building and Operating New Landfills

Significant increases in landfill disposal costs can be anticipated as a result of 1990 Tennessee regulations and pending federal Subtitle D regulations. These increases result in large part from the movement to fully-engineered landfill designs; but they also arise from new post-operational requirements -- namely closure and post-closure responsibilities.

For a better understanding of cost estimates it is useful to have a breakout of cost categories according to the following: development, construction, operation, closure, and post-closure.

Typical cost components within each category are given below:

Table 1: Elements of Landfill Costs

Development

1. Site Selection Study
2. Site Feasibility Analysis
3. Market Investigation
4. Engineering Design
5. Environmental Assessment
6. Legal Services
7. Financial Services
8. Community & Government Relations Services
9. End-Use Planning
10. Land Purchase Options
11. Property/Boundary Survey & Control
12. Aerial Photogrammetry
13. Fees

Construction

1. Land Purchase
2. Site Development
3. Fill Configuration
4. Fill Volume
5. Bottom Liner
6. Leachate Management
7. Utilities
8. Gas Management
9. Stormwater Controls
10. Roadways
11. Buildings
12. Other Support Facilities
13. Administration
14. Contingency

Operations

1. Site Personnel & Management
2. Facility Overhead
3. Equipment Operations & Maintenance
4. Equipment Financing
5. Road Maintenance
6. Routine Environmental Monitoring
7. Engineering Services
8. Site & Equipment Insurance/Closure Bonding
9. On-Going Development & Construction Costs
10. Leachate Treatment & Municipal Sewer System
11. Leachate Pre-Treatment
12. Unanticipated Costs

Closure

1. Final Cover System
2. Runoff Controls
3. Gas Controls
4. Leachate Head Controls
5. Final Landscaping
6. Decontamination or Facility Removal
7. Engineering Construction Management
8. Administration

Post-Closure Care

1. Land Surface Care
2. Inspection/Record Keeping
3. Monitoring
4. Leachate Collection & Treatment
5. Maintenance (preventive/corrective)
6. Fees
7. Administration

Development Costs

Development costs are those typically associated with siting a facility. These costs are usually less than 10 percent of the total cost. Under both state regulations and the proposed Subtitle D regulations, more hydro-geological investigation may be required before a site is determined acceptable. Also, these investigations will provide state regulators and inspectors with information necessary for them to stipulate the type of design and legal fees. Anticipated costs associated with development and all other cost categories can be seen in Appendix B.

Construction Costs

Construction costs are increasing in large part due to the regulatory requirements for liners, leachate collection systems, gas management systems, and surface water drainage controls. Liners are the most costly feature in this category. If there is adequate liner material (clay) on site, costs for construction of this element may be as low as $70,000 per acre. If it must be brought in from off-site, however, costs per acre are likely to double. A typical rule of thumb used by industry for a single composite liner system is $100,000 per acre. In the state of New York, double liners are mandatory for each landfill with the costs ranging from $200,000 to $300,000.

Operational Costs

Operational costs make up the largest single element of landfill costs, although new regulations do not affect operational costs as much as construction and post-closure costs. The more stringent regulations do affect, however, the costs of maintenance, transportation and treatment of the leachate, environmental monitoring, and maintenance of the gas-control system. Typically, equipment will be the largest component of this category.

Closure

Closure has been defined under RCRA Subtitle D as "those actions to be taken by the owner or operator of a solid waste disposal facility to prepare the facility for long-term care and to make it suitable for other uses." In terms of landfills, this means, primarily, placing a clay or geomembrane "cap" over the disposal area. Annual costs for this phase are estimated in Appendix B; but generally, closure costs involve only a very small proportion of total costs.

Post-Closure

Post-closure or long-term care involves the maintenance and monitoring of landfills after they have been officially closed. Under new regulations, this period lasts a minimum of 30 years. In past decades there was no cost component associated with this phase, as operators simply walked away from the site. This is no longer considered responsible behavior. Costs depend on such things as the

amount of gas and leachate produced during the site life and within the post-closure period. Though a relatively new cost element, its magnitude in the context of total systems cost, can be substantial.

Total Costs

Total estimated costs cannot be rendered with precision, without knowledge of specific sites. Tennessee hosts a wide range of geologic features, all of which will greatly influence the costs of landfill construction, operation, and post-closure care. (West Tennessee contains better soil and geologic conditions for the construction of landfills). Nonetheless, "ballpark" estimates of total system costs can be made to give local officials an idea of the likely magnitude of expenditures facing them in the future, with respect to the landfill option.

Table 2 provides a range of likely costs, based upon varying landfill sizes and disposal quantities. The assumptions behind the figures provided in Table 2, can be found in Appendix B. We see that, for all but the smallest landfill, the cost per acre of a new landfill, with an in-situ clay liner, will amount to around $250,000; and a new landfill, with a composite liner, will be around $330,000. Per acre figures are not, however, an adequate means of determining total systems costs. These costs can only be determined when we account for the volume of material going into the landfills.

What we find is that an increase in daily tonnage will lead to significantly lower systems costs. This occurs because increasing tonnage only increases costs

by a small increment. In other words we have a spreading of relatively fixed capital and operating expenditures across a larger volume of materials. The larger tonnage deposited, the lower the cost per ton for disposal. That is why we see the large range in costs per ton in Table 2 -- from as low as $12.95 to as high as $71.06.

Economies of scale are evident but diminish significantly once beyond the 100 tons per day volume as shown in Figure 7. Since most Tennessee communities produce less than 100 tons per day, there are clear economic incentives to band together in regional landfills. Regionalization, of course, does imply increased transportation costs for most participants. The costs of this transportation, and perhaps the establishment of transfer stations, need to be evaluated by each local government.

TABLE 2

LANDFILL TECHNOLOGY
(LIFE CYCLE ANNUAL COST)

	25 acres	59 acres	65 acres	100 acres	200 acres
Volumes (tons per day)	25	50	100	200	500
Cost Per Ton-Private Financing					
Composite Liner	71.06	46.56	27.81	23.50	16.83
Clay Liner	60.25	35.74	22.01	17.99	12.95
Cost Per Ton - Public Financing					
Composite Liner	69.03	44.69	26.44	22.55	16.09
Clay Liner	59.08	34.73	21.22	17.56	12.56

New Tennessee Landfill Regulations and Proposed EPA Regulations

Tennessee Regulations

On March 18, 1990, the Tennessee Division of Solid Waste Management began operations under new state regulations for solid waste disposal and processing facilities. The regulations deal with six classes of disposal facilities; this discussion, however, will be limited to class 1 -- municipal solid waste landfills. A more complete summary of these regulations is provided in Appendix C.

Municipal solid waste regulations will cover both new and existing facilities. Existing facilities will not, however, be subject to further public notice and hearings when making permit modifications that are required due to the new rule.

Owners and operators of new facilities are required to submit a permit application consisting of two parts: the first part will contain pertinent information about the owner/operator and the location of the facility; the second will contain detailed engineering information concerning hydrogeology, operations, closure and post-closure.

New facility operators will be required to submit a closure/post-closure plan within 180 days of the Commissioner's notice to submit such a plan. They also must file and maintain financial assurance for the amount determined by the Commissioner. A minimum of $1,000 per acre of financial assurance is required. Existing facilities will have three years to submit a closure/post-closure plan.

As of March 18, 1990, all new facilities are subject to the following minimum standards:

(1) Buffer zones for new landfills must be located, designed, constructed, operated, and maintained such that the fill areas are at minimum:
- 100 feet from all property lines
- 500 feet from all residences
- 500 feet from all downgradient drinking water wells
- 200 feet from springs, streams, lakes, and other bodies of water
- There must also be a total site buffer and no appurtenances constructed within 50 feet of the property line.

(2) Leachate Migration Control Standards -- soil liners must be at least 3 feet thick; synthetic liners may be used, but only in conjunction with 3 feet of recompacted clay.

(3) Leachate Collection and Removal -- the leachate collection system must be designed, constructed, operated, and maintained, such that the leachate depth above the liner does not exceed one foot.

(4) Gas Migration Control Standards -- the concentration of explosive gases must not exceed 25 percent of gases' lower explosive limit.

(5) Groundwater Protection/Monitoring -- the extensive detection monitoring program will require more sampling and analysis in the first year of operation.

(6) Closure
- Notification of closure must be made at least 60 days prior to closure process
- Closure activities must be completed 180 days after the fill area has achieved final grade
- The depth of cover must be a minimum of 36 inches compacted soil; 12 inches must be for support of vegetative cover

(7) Post-Closure
- Must take place for 30 years following completion of closure
- Must be maintained to prevent erosion
- Must maintain leachate collection, removal, and treatment
- Must maintain and monitor gas collection and control system
- Must maintain and monitor ground and surface water monitoring system

As of March 18, 1990, all existing facilities were subject to the same standards listed above for waste handling, cover, closure and post-closure. Existing facilities are not subject to the same standards for leachate migration control and gas migration control until March 18, 1994. And they are not subject to the requirements covering floodplains, wetlands, karst terrain, airport safety, or the buffer zone.

EPA Subtitle D Regulations

In August 1988, EPA published its first draft of proposed regulations for governing the construction of landfills under Subtitle D of RCRA. Since then, these proposed regulations have undergone considerable public and agency review. The final subtitle D regulations are scheduled to be released imminently.

In what respect the Subtitle D regulations will differ from Tennessee's regulations remains to be seen. Tennessee's regulations were patterned after early drafts of Subtitle D regulations, so there may not be many significant differences. Until release of the final EPA regulations, however, no certainty can be provided.

We know that Tennessee regulations regarding liner and leachate collection control, differs somewhat from the 1988 EPA Subtitle D draft. EPA's proposal is based solely on risk-based performance standards. They do not specify what types of liners, leachate collection systems, or final cover systems should be used. In contrast, the Tennessee regulations contain design-based standards. Actually, Tennessee regulations are a mixture of design-based and performance-based

standards. For instance, a landfill sited in one area may require only a composite liner, while another, sited in a different geological or hydrogeological area, may require only a natural liner.

Appendix D presents some of the more important differences and similarities between past and present Tennessee regulations, and the proposed EPA Subtitle D regulation.

Alternative Concepts

Landfill Mining

Three communities currently use landfill mining -- or the excavation of solid waste from landfills -- as an alternative concept for solid waste management. In this process, recyclables are recovered, and the composted soil is used as cover material. The landfill is then appropriately lined, and brought up to modern design standards.

Collier County, Florida, is the first community to use this alternative. Old surface mining equipment was used to excavate approximately 500 tons of solid waste a day on an old 26-acre landfill. The county has cut the cost of daily cover in half by using the recovered dirt from the landfill mining process. The life of the landfill has also been extended indefinitely, because, if done properly, it is essentially a "perpetual processing facility."

Thompson, Connecticut is another community to adopt a landfill mining approach. The program started in 1988 on a landfill that contained solid waste

dating back to 1970. At a cost of $117,000, Thompson extended the life of its landfill by two years -- saving the city as much as $1 to $2 million in avoided landfill costs. Thus the process bought a little time and saved a lot of money. Unlike Collier County, Thompson will not landfill mine on a perpetual basis, due to the ever-increasing use of plastic that is ending up in the solid waste stream, and it is not amenable to mining.

The examples cited above, however, cannot be replicated everywhere. Careful consideration must be given to a number of factors. As noted above, success depends, in part, on what kinds of material are in the landfill. If the landfill has received solid waste from manufacturing facilities, or from sources that are unknown, one should proceed with caution, or forego landfill mining entirely. If significant quantities of hazardous materials are uncovered, expensive remedial cleanup may be required. In short, before communities opt for landfill mining, considerable research should be carried out.

Balefill Operations

Numerous Tennessee communities are either currently operating or considering operating baling equipment for the purpose of compacting solid waste and thereby reducing the volume of waste being disposed. Baling solid waste holds the promise of extending the life of the landfill (or balefill); but it does so at a cost--both capital and operational. While officials need to evaluate relative costs

and benefits in terms of their own particular circumstances, there are generally acknowledged advantages and disadvantages of baling that can be set forth.

In terms of advantages:

(1) Baling can attain a volume reduction of between 20-50% of the waste entering the landfill. An average landfill will attain an in-place density of about 1,000 lbs/yd^3 after compaction, while a balefill will attain around 1,500-1600 lbs/yd^3 density. Extending the life of a disposal facility can reduce the number of times officials must go through the politically difficult task of finding new disposal sites.

(2) Balefills require less cover dirt--roughly half of that used at conventional landfills. This is a major cost savings if dirt has to be brought to the disposal site.

(3) Balefill operations generally have better litter control.

(4) Balefills may produce less leachate and methane gas. At the current time, however, no regulatory relief is provided, as balefills, with few exceptions, must be engineered to conform to Tennessee landfill standards.

(5) Baling can be used to compact recyclables, as well as mixed waste, thereby providing considerable flexibility. Baling operations can also be conducted at a transfer station, thereby utilizing flatbed trucks or railcars for transportation should landfill regionalization occur.

In terms of disadvantages:

(1) Baling can come at considerable expense, particularly for smaller communities seeking to handle their wastes autonomously. There are considerable economies of scale in balefilling. Appendix E illustrates that the system costs of a 200-ton-per-day, 25-year-life balefill are comparable to a landfill of similar dimensions and life. If we are talking about a 70-ton-per-day, 25-year-life balefill, however, the tipping fee would have to rise to $92 to cover total systems costs--far higher than a landfill only option. Stand-alone baling costs (exclusive of transportation and disposal costs) are very sensitive to the amount of material run through the system.

(2) There is an inability to mix baled and non-baled waste at the landfill, unless equipment for each is purchased. Also, bales have to be broken apart to accommodate random inspection.

Conclusion

With the ever-increasing problem of solid waste disposal, it is evident that changes must be made. While the amount of solid waste has grown, statistics show that landfills, the predominant method of solid waste disposal, are decreasing in number. This is a nationwide problem from which Tennessee cannot escape. Roughly 94 percent of Tennessee's solid waste is now being landfilled, and the citizens of Tennessee need to be assured that there will be sufficient disposal capacity in the future, and that this capacity will be protective of public health.

Improper practices in the past have led to the passage of several federal laws and regulations. Both hazardous waste and solid waste management must now recognize and follow stringent environmental regulations. This has led to the requirement for engineered disposal facilities, containing liners, and leachate and gas collection systems. Equally important, public officials and the citizenry are increasingly becoming aware of the need for an integrated approach to solid waste management, involving source reduction and recycling. Only when waste has been reduced and recycled as much as possible, should material be sent to environmentally-safe disposal facilities.

All Tennessee landfills will have to be in compliance with new Tennessee regulations by 1994. Federal landfill regulations about to be promulgated could move the target date even more forward in time. While these regulations will make landfilling much more costly, they should, for the first time, be capturing the full costs of landfilling. We continue to pay the price today, through remediation, for not charging the full costs to society of past landfilling.

REFERENCES

Barkenbus, Jack, Managing Our Waste: Solid Waste Planning for Tennessee, University of Tennessee, Waste Management Research and Education Institute, February 1991.

R.W. Beck and Associates, "Local Officials Guide - Municipal Incinerators: 50 Questions Every Local Government Should Ask". December 1988.

Briggs, Jeffrey L. and Jon W. Hughes; "Using Risk-Based Algorithms in a Landfill Risk Analysis"; in Waste Age, March 1990.

Camp Dresser & McKee. "Review of Proposed Disposal Services Agreement for a Six-County Private Regional Landfill", County of Pitt, North Carolina, March 1990.

Environment Reporter, "Landfill Mining Retrieves Recyclables, Creates New Space for Communities in Bind", December 15, 1989, p. 1415.

EPA, Decision Maker's Guide in Solid Waste Management, Office of Solid Waste Management, 1989.

Franklin Associates, Inc., "Characterization of Municipal Solid Waste in the United States," 1988.

Glebs, R.T. and Ted Juszczyk; "Closure and Post-Closure Costs" in Waste Age, March 1990.

Glebs, R.T.; "Subtitle D: How Will it Affect Landfills?" in Waste Alternatives, December, 1988.

Kreith, F., "Solid Waste Management" National Conference of State Legislatures April 1989.

Lueck, Guada W.; "Landfill Mining Yields Buried Treasure!" in Waste Age, March 1990.

Office of Technology Assessment (OTA). "Facing America's Trash: What Next for Municipal Solid Waste?" Washington, D.C.: U.S. Government Printing Office, 1988.

O'Leary, P.R., P.W. Welsh, and R.K. Ham, "Managing Solid Waste." Scientific American 259: 1988, 36-42.

Nosenchuck, Norman H.; "Landfills and Landfilling - A Component of Integrated Solid Waste Management;" Director for Division of Solid Waste, New York State Department of Environmental Conservation; Expanded Remarks to Institute for Public Policy Studies at Vanderbilt University, March 15, 1990.

O'Connor, Patrick B.; "Integrated, Above-Ground Balefill Concept," Tennessee Valley Authority, 1987.

Parvin, Edward C., "Factors that Influence Landfill Economics;" Proceedings from the Technical Sessions of the First Annual Southeastern Regional Solid Waste Symposium, GRCDA, October 1989.

Repa, Edward; "Possible Subtitle D Changes" in Waste Age, April 1990.

Resource Recovery Division, Michigan Department of Natural Resources; "Balers for Volume Reduction, Recycling and Landfills," August 1980.

Robinson, William D., The Solid Waste Handbook: A Practical Guide, 1986.

Rulemaking Hearing Rules of Tennessee Department of Health and Environment, Division of Solid Waste Management; Chapter 1200-1-7 on "Solid Waste Processing and Disposal," March 1990.

Tennessee Valley Authority, Regional Solid Waste Management Planning, Training Session at Muscle Shoals, Alabama, June 1989.

U.S Environmental Protection Agency, 40 CFR Parts 257 and 258 Solid Waste Disposal Facility Criteria; Proposed Rule, Federal Register, Vol. 53, No. 168, August 30, 1988.

U.S. Environmental Protection Agency, "The Solid Waste Dilemma: An Agenda for Action," September 1988.

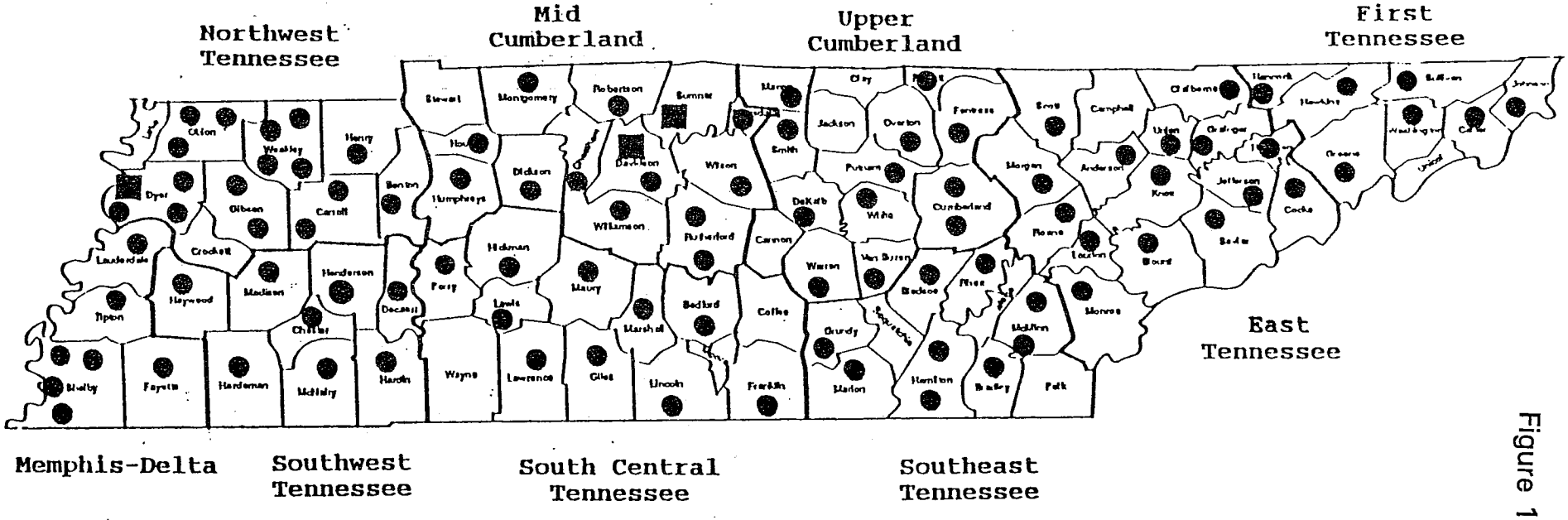


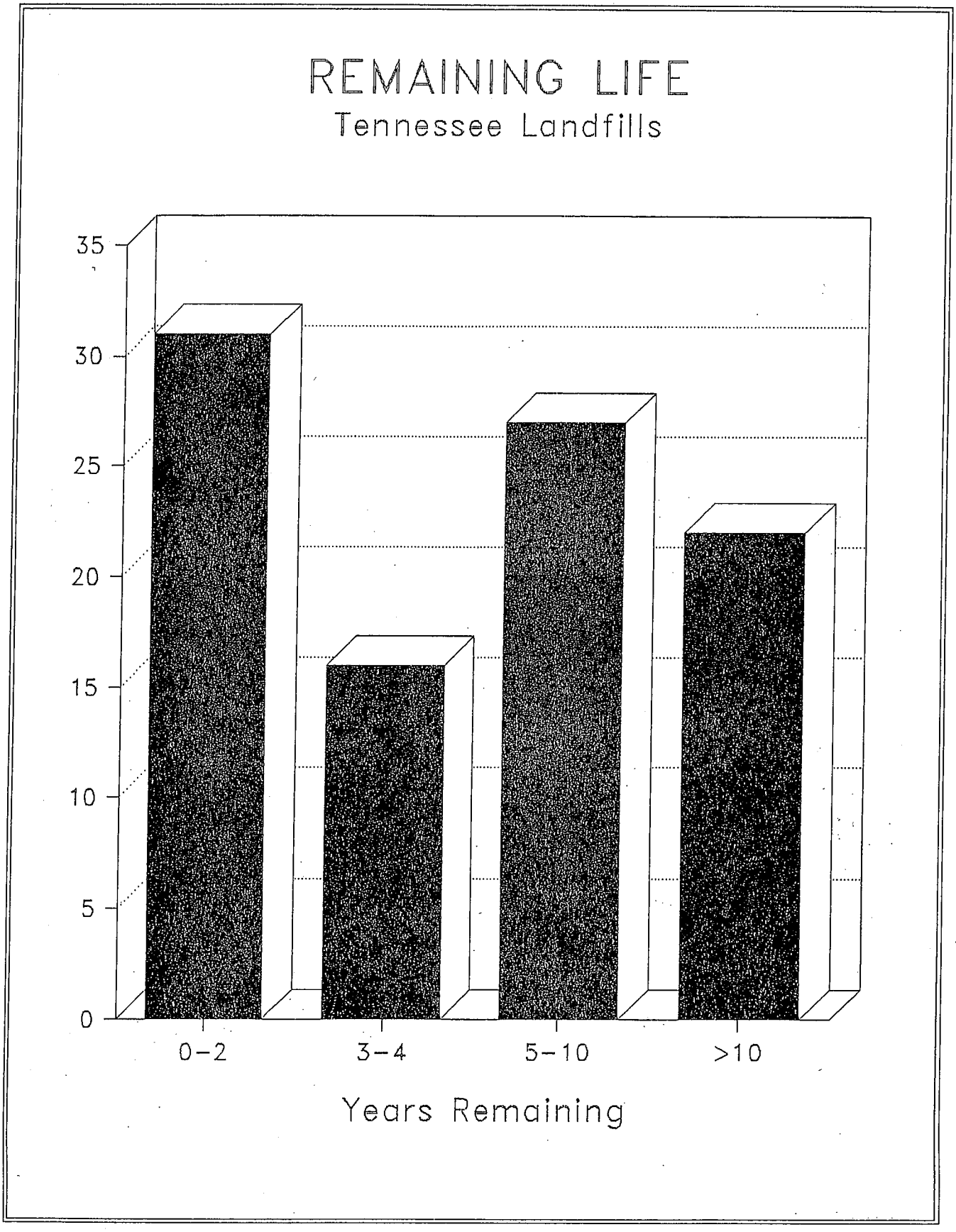
Figure 1

LOCATION OF SOLID WASTE DISPOSAL FACILITIES
IN TENNESSEE

● Sanitary Landfills (96)

■ Incinerators (3)

Figure 2


REMAINING LIFE
Tennessee Landfills
35
30
25
20
15
10
5
0
0-2
3-4
5-10
>10
Years Remaining

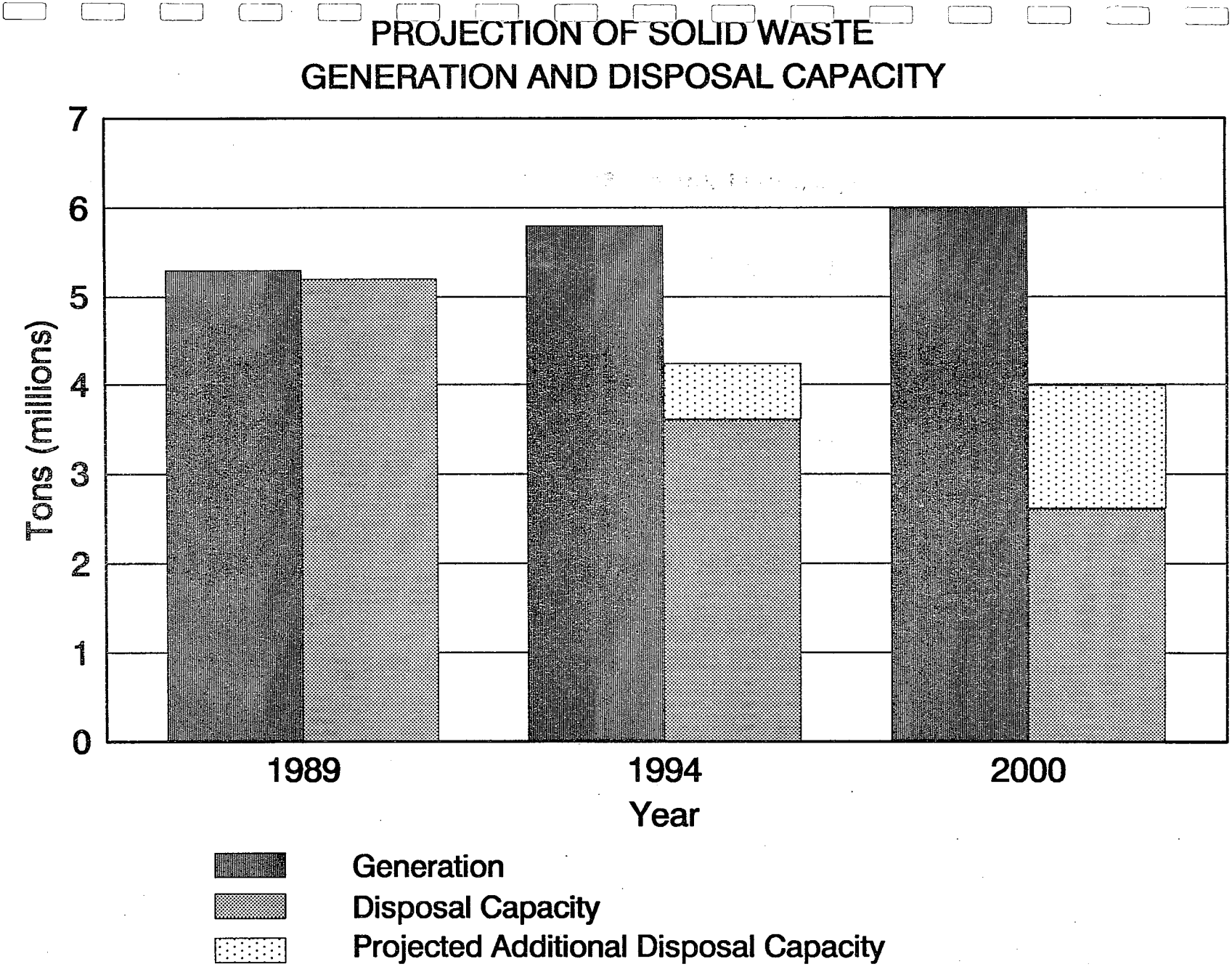
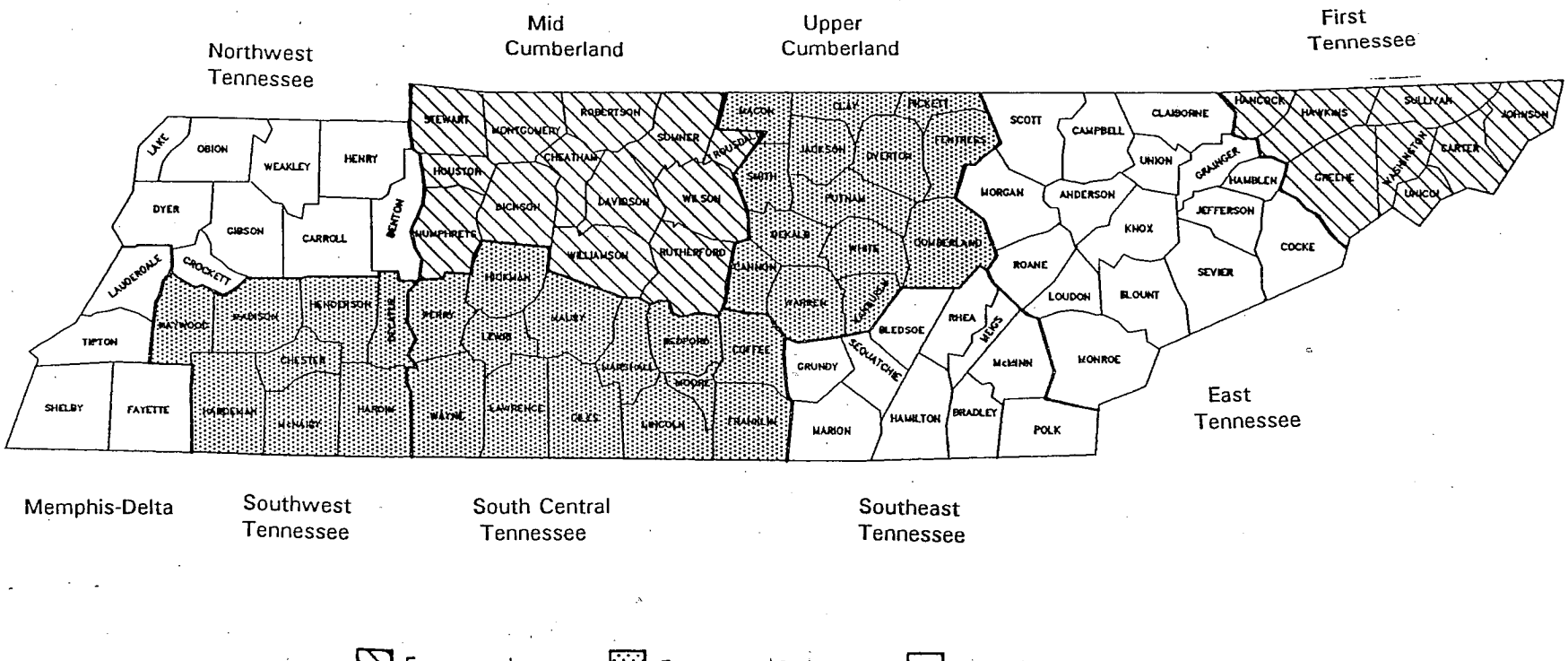
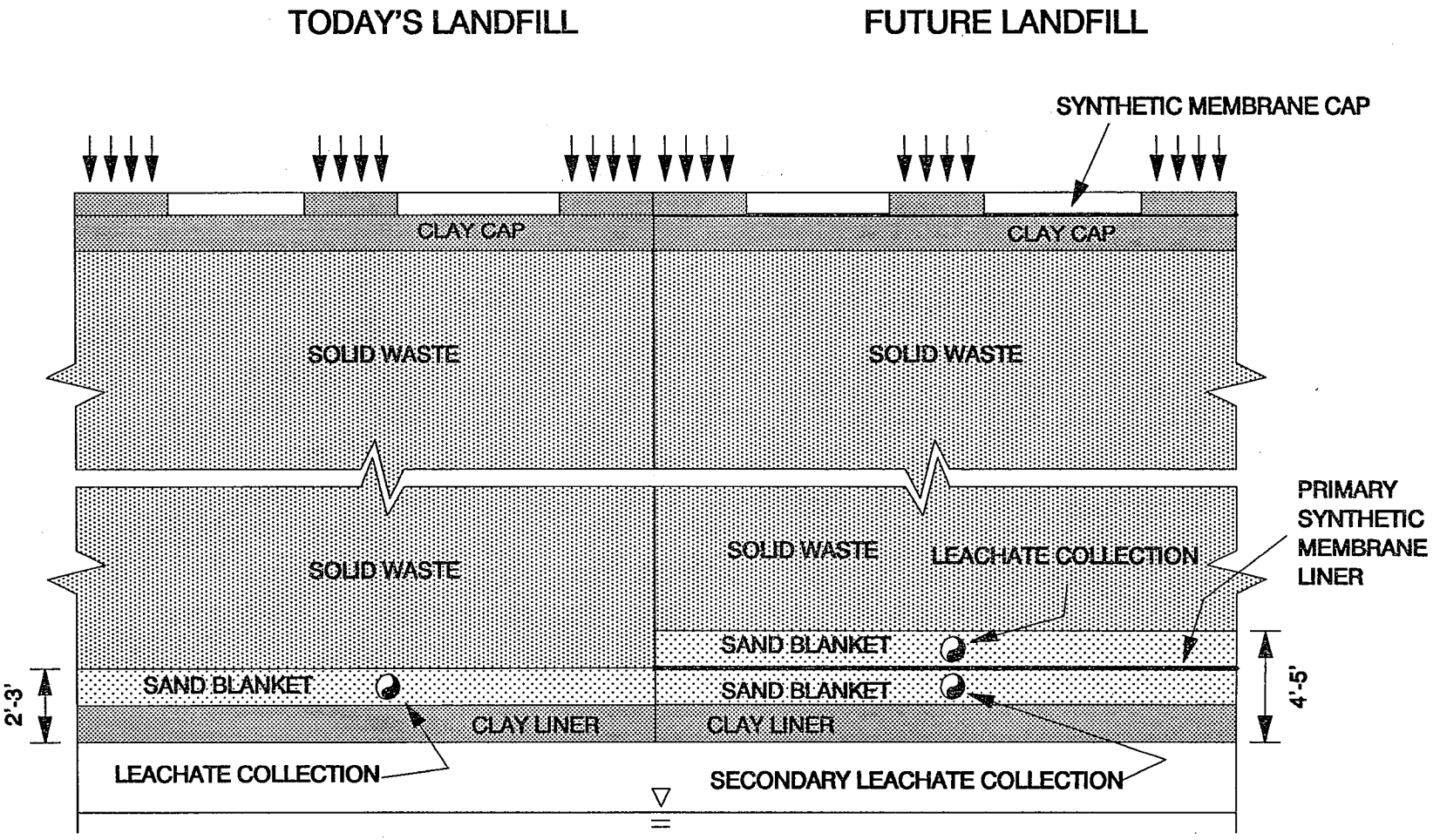

PROJECTION OF SOLID WASTE
GENERATION AND DISPOSAL CAPACITY
Tons (millions)
0
1
2
3
4
5
6
7
1989
1994
2000
Year
Generation
Disposal Capacity
Projected Additional Disposal Capacity

Figure 4: Expected Life of Tennessee Landfills, by Development District



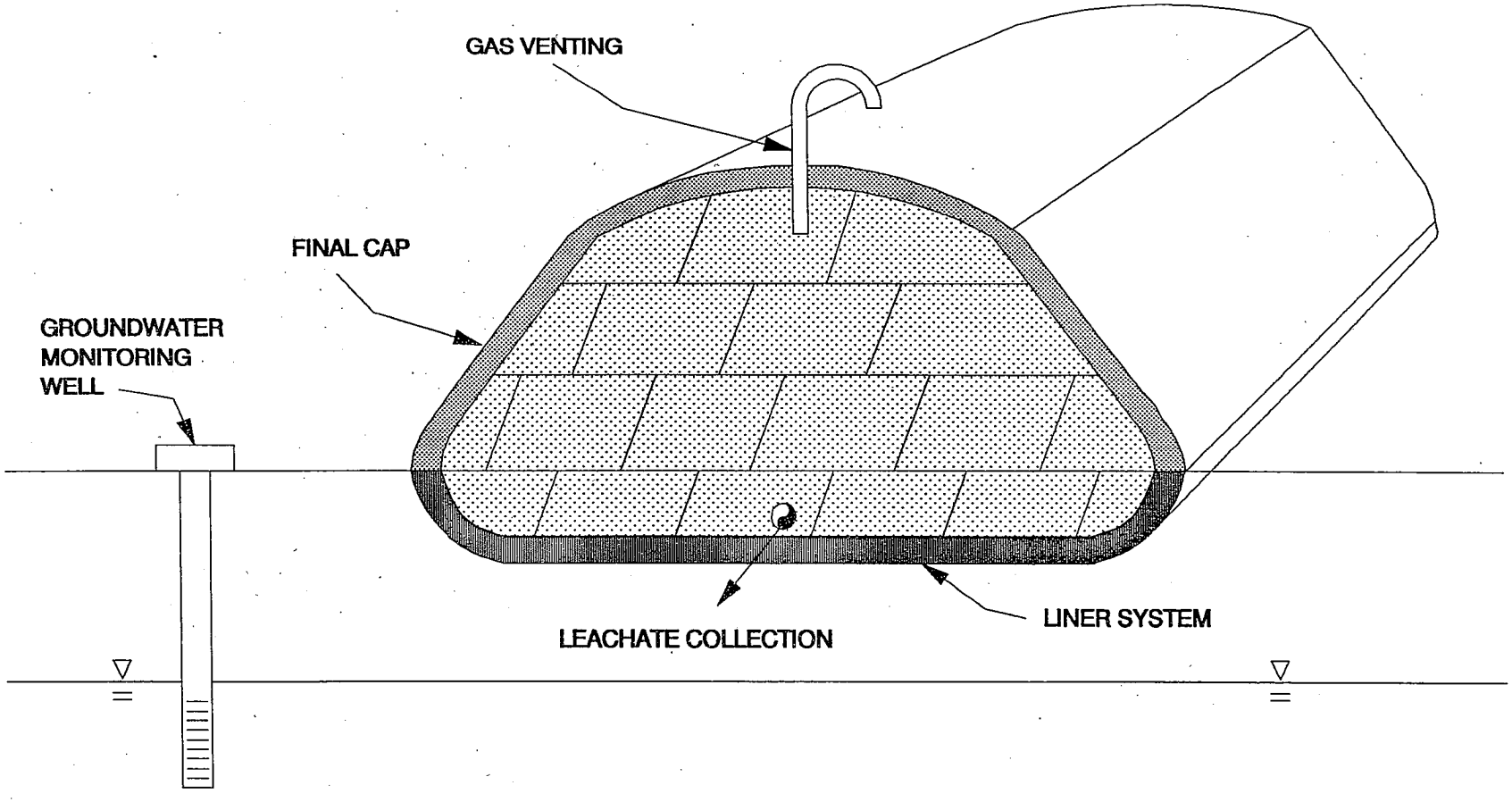
Note: The expected life of individual landfills will not necessarily correspond to the regional totals shown in this figure

FIGURE 5. LANDFILL AND LINERS



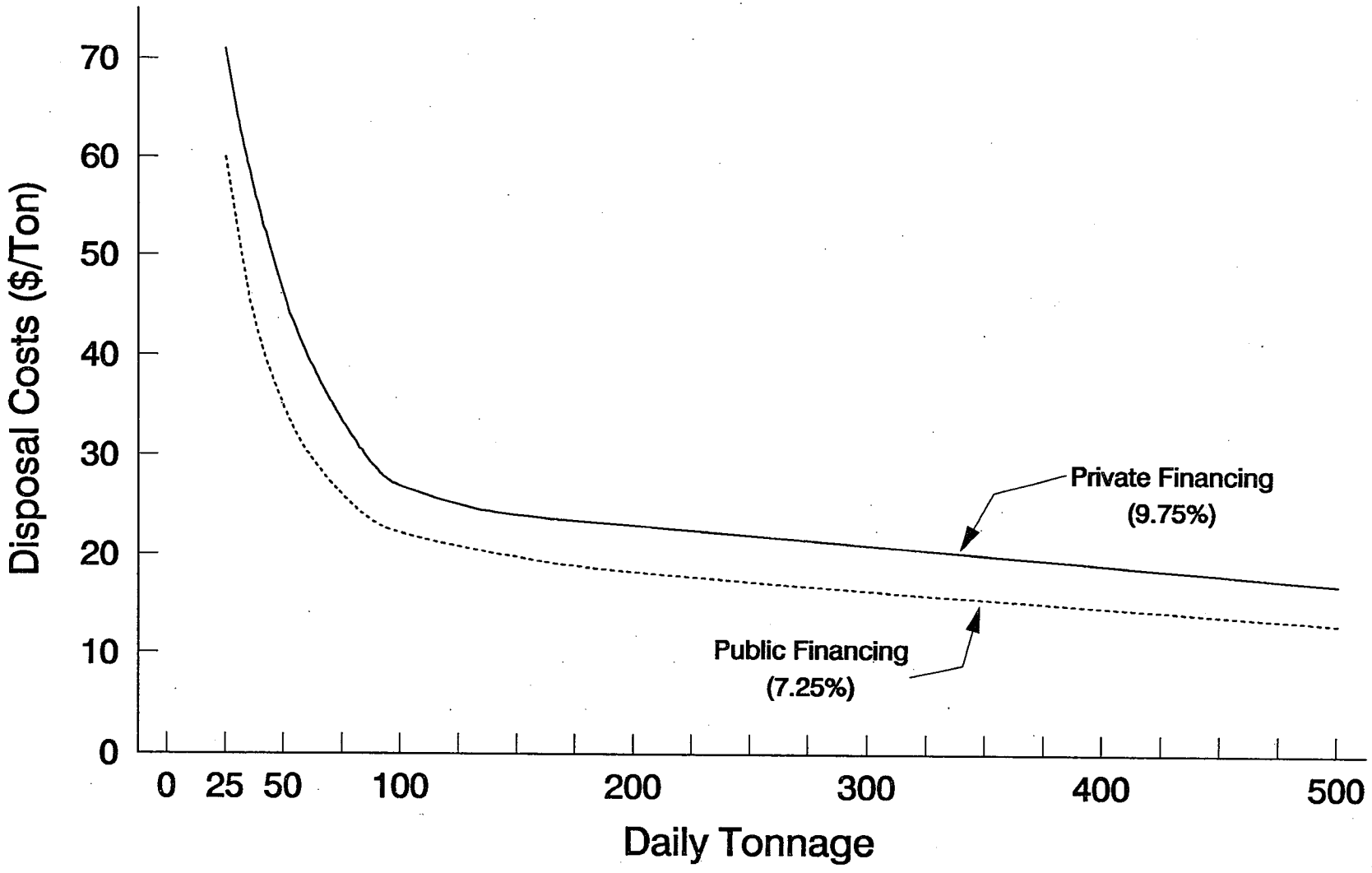
NEWPORT NEWS SOLID WASTE WORKSHOP January 23, 1988

FIGURE 6. LANDFILL SCHEMATIC



NEWPORT NEWS SOLID WASTE WORKSHOP January 23, 1988

FIGURE 7. LANDFILL DISPOSAL COSTS AS A FUNCTION OF QUANTITIES ENTERING THE LANDFILL



APPENDIX A

MUNICIPAL SOLID WASTE LANDFILLS

IN TENNESSEE

Landfill Disposal Data by Development District

Landfill Name	County	Tons Per Day	Life Remaining	Acres In Use	Ownership	Scales	Tipping Fees
First Tennessee							
Carter Co. - Elizabethton	Carter	100	13	7	Public	Yes	Yes
Greeneville-Greene Co.	Greene	120	6	30	Public	No	Yes
Hancock Co.	Hancock	10	2	6	Public	No	Yes
Carter Valley	Hawkins	141	2	3	Private	No	No
Johnson Co.	Johnson	18	4	3	Public	Yes	Yes
Sullivan Co.	Sullivan	450	1	40	Private	Yes	Yes
Johnson City Regional	Washington	489	2	12	Public	Yes	Yes
East Tennessee							
Chestnut Ridge	Anderson	987	8	34	Private	Yes	Yes
Blount Co.	Blount	320	23	268	Public	Yes	Yes
Clairborne Co.	Claiborne	104	3	40	Public	No	No
Cocke Co.	Cocke	87	2	2	Public	Yes	Yes
Grainger Co.	Grainger	91	10	10	Public	No	Yes
Hamblen Co.	Hamblen	270	30	5	Public	Yes	Yes
Jefferson Co.	Jefferson	100	1	5	Public	Yes	Yes
Twin Oaks	Knox	495	2	7	Private	No	Yes
Matlock Bend	Loudon	239	17	20	Public	Yes	Yes
Monroe Co.	Monroe	100	5	25	Public	Yes	Yes
Morgan Co.	Morgan	90	1	8	Public	No	No
Roane Co.	Roane	206	3	69	Public	No	Yes
Scott Co.	Scott	70	10	20	Public	No	No
Gatlinburg	Sevier	140	0	7	Private	Yes	Yes
Union Co.	Union	21	20	30	Public	No	No
Upper Cumberland							
Crossville City	Cumberland	147	14	2	Public	No	Yes
Cumberland Co.	Cumberland	40	16	6	Public	No	No
DeKalb Co.	DeKalb	63	1	3	Public	No	No
Fentress Co.	Fentress	20	3	5	Public	No	No
Red Boiling Springs	Macon	46	14	3	Public	No	Yes
Stockton	Overton	41	4	7	Private	No	Yes
Pickett Co.	Pickett	1	0	7	Public	No	No
Putnam Co.	Putnam	193	10	4	Public	No	Yes
Smith Co.	Smith	40	10	5	Public	Yes	Yes
Van Buren Co.	Van Buren	9	4	3	Public	No	Yes
McMinnville	Warren	88	1	9	Public	Yes	Yes
White Co.	White	41	4	1	Public	No	Yes

Landfill Name	County	Tons Per Day	Life Remaining	Acres In Use	Ownership	Scales	Tipping Fees
Southeast Tennessee							
Bledsoe-Sequatchie	Bledsoe	63	13	30	Public	No	No
Bradley Co.	Bradley	210	4	50	Public	Yes	Yes
Grundy Co.	Grundy	10	10	33	Public	No	No
Hamilton Co.	Hamilton	150	9	32	Public	Yes	Yes
Summitt	Hamilton	1100	15	50	Public	Yes	Yes
Marion Co.	Marion	100	30	0	Public	Yes	Yes
McMinn Co.	McMinn	145	2	10	Public	Yes	Yes
Mine Road	McMinn	67	9	N/A	Private	N/A	N/A
Rhea Co.	Rhea	60	0	5	Public	Yes	Yes
Mid-Cumberland							
Cheatham Co.	Cheatham	60	1	27	Public	No	Yes
Bordeaux	Davidson	1500	0	10	Public	No	Yes
Dickson Co.	Dickson	275	10	29	Public	No	No
Houston Co.	Houston	3	1	6	Public	No	No
Humphreys Co.	Humphreys	43	2	7	Private	No	Yes
Bi-County	Montgomery	355	0	13	Public	No	Yes
Robertson Co.	Robertson	110	4	0	Public	No	Yes
Jefferson Pike	Rutherford	663	8	20	Private	No	Yes
Rutherford Co.	Rutherford	400	0.5	N/A	Public	N/A	N/A
Trousdale Co.	Trousdale	38	2	3	Public	No	No
Williamson Co.	Williamson	177	8	5	Public	No	Yes
Wilson Co.	Wilson	151	10	25	Public	No	No
South Central Tennessee							
James Brinkley	Bedford	330	6	6	Private	No	Yes
Franklin Co.	Franklin	108	2	25	Public	Yes	Yes
Pulaski	Giles	46	1	2	Public	No	Yes
Centerville	Hickman	30	11	11	Public	No	No
Solid Waste Balefill	Lawrence	90	25	2	Public	Yes	No
Hohenwald	Lewis	40	4	10	Public	Yes	No
Lincoln Co.	Lincoln	54	5	1	Public	Yes	No
Lewisburg	Marshall	30	0	1	Public	Yes	Yes
Maury Co.	Maury	150	2	30	Public	No	Yes
Perry Co.	Perry	50	10	8	Public	No	No

Landfill Name	County	Tons Per Day	Life Remaining	Acres In Use	Ownership	Scales	Tipping Fees
Northwest Tennessee							
Benton Co.	Benton	69	3	16	Public	No	No
Huntingdon	Carroll	41	6	2	Public	No	Yes
McKenzie City	Carroll	74	3	2	Public	No	Yes
Jere T. Kirk	Dyer	99	25	2	Private	No	Yes
Newbern	Dyer	23	1	5	Public	No	Yes
Dyersburg	Dyer	80	16	1	Public	No	Yes
Milan	Gibson	80	4	12	Public	Yes	Yes
Humboldt	Gibson	100	10	15	Public	Yes	Yes
Paris-Henry Co.	Henry	68	11	12	Public	No	Yes
Gratio	Obion	7	7	5	Private	No	No
Barker Brothers	Obion	176	30	0	Private	No	Yes
South Fulton	Obion	17	8	20	Public	No	Yes
Barker Brothers	Weakley	32	7	N/A	Private	N/A	N/A
Tri-City	Weakley	22	20	40	Public	Yes	Yes
Greenfield	Weakley	21	3	20	Public	No	No
Martin City	Weakley	69	2	4	Public	No	Yes
Southwest Tennessee							
Chester Co.	Chester	18	4	3	Public	No	Yes
Decatur Co.	Decatur	30	2	20	Public	No	Yes
City of Bolivar	Hardeman	95	6	1	Public	No	Yes
Savannah-Hardin Co.	Hardin	126	5	45	Public	No	No
Haywood Co.	Haywood	46	8	10	Public	No	No
Lexington-Henderson Co.	Henderson	58	30	2	Public	No	No
Jackson-Madison Co.	Madison	300	1	7	Public	Yes	Yes
McNairy Co.	McNairy	61	12	1	Public	No	No
Memphis Delta							
Fayette Co.	Fayette	38	2	7	Public	No	No
Lauderdale Co.	Lauderdale	90	25	100	Public	No	Yes
Shelby Co.	Shelby	252	1	0	Public	No	Yes
Holmes Road	Shelby	2795	8	50	Private	No	Yes
North Shelby	Shelby	1200	20	35	Private	No	Yes
Arlington	Shelby	25	8	7	Private	No	Yes
Tipton Co.	Tipton	109	4	15	Public	No	Yes

APPENDIX B

MODEL LANDFILL CALCULATIONS FOR ALTERNATIVE FACILITY SIZE

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February 6, 1991

MODEL LANDFILL CALCULATIONS FOR ALTERNATIVE FACILITY SIZE

This brief paper presents a cost estimate for alternative size landfill sites based on an annual life cycle cost model. The analysis includes cost estimates at five different levels of capacity: 25, 50, 65, 100, and 200 acre facilities. Several assumptions have been made in this analysis, and the alteration of any of these can have a significant impact on the final cost per ton of a facility. Assumptions pertain to depth of fill above the liner, refuse compaction rate, average daily volume of refuse, and type of liner. In the planning and development of a sanitary landfill, local officials will have to pay close attention to these cost factors if they are to minimize total cost of the facility.

Several factors are applicable to all size facilities. First, it has been assumed in these calculations that operations will begin in 1991, and that there will be a thirty year post closure period. The interest rate for private capital financing is 9.75%; for public capital financing, it is 7.25%. It has been assumed that 20% of a site will be developed and constructed in the initial phase. The development of a sanitary landfill is an ongoing construction program, and we have shown these continuing development and construction costs as a separate component. For the model developed here, it is assumed that a composite liner will cost $100,000 per acre. For a clay liner, the assumed cost is $70,000 per acre on-site. An off-site clay liner could approach $80,000 per acre. Although not developed here, a double liner could approach $300,000 per acre. An inflation rate of 5% is

used in the analysis. Equipment is assumed to have a 25% salvage value, and straight line depreciation over 10 year useful life is used. The prices and operating expenses for equipment have been obtained from Caterpillar, Inc., and R. S. Means, Inc. The estimates for closure and post-closure costs are based upon a life cycle cost analysis. It was assumed in this analysis that there would be a thirty-year post-closure period. A discount rate of three percent was used for this analysis. Items included in the closure costs are the type of cover, gas venting, and leachate collection. These costs were predicted to run about 0.85/ton in real terms. For post-closure costs, items include monitoring, leachate treatement, and cover. The costs range from 1.55-1.75/ton in the analysis.

For the 25 acre facility, there is a total site area of 30 acres with a 25 acre fill area. Twenty-five tons per day would be received at this facility. A compaction rate of 800 pounds per cubic yard, 286 days per year in operation, and 0.5 projected loss for cover are assumed. The average depth of fill used for the 25 acre facility is 22 feet. These assumptions result in an estimated life of 24.8 years for this facility. It is assumed for the 25 acre facility that personnel requirements are one supervisor and two operators or laborers.

Similar assumptions are used for the 50 acre facility. For this facility, there is a total site area of 65 acres with a 50 acre fill area. Fifty tons per day would go to this facility. A compaction rate of 800 pounds per cubic yard, 286 days per year in operation, and 0.5 projected loss for cover are

assumed. The average depth of fill for the 50 acre facility is 22 feet. This results in an estimated life of 24.8 years for this facility. It is assumed for the 50 acre facility that personnel requirements are one supervisor and two operators or laborers.

For the 65 acre facility, there is a total site area of 90 acres with a 65 acre fill area. One hundred tons per day would be tipped at this facility. A compaction rate of 1000 pounds per cubic yard, 286 days per year in operation, and 0.4 loss for cover are assumed. The average depth of fill for the 65 acre facility is 30 feet. This results in an estimated life of 25.4 years for this facility. It is assumed for the 65 acre facility that personnel requirements include one supervisor, two operators, and one laborer.

For the 100 acre facility, there is a total site area of 125 acres with a 100 acre fill area. The fill rate is two hundred tons per day. A compaction rate of 1000 pounds per cubic yard, 286 days per year in operation, and 0.4 loss for cover are assumed. The average depth of fill for the 100 acre facility is 30 feet. This results in an estimated life of 25.4 years for this facility. It is assumed for the 100 acre facility that personnel requirements include one supervisor, three operators, and one laborer.

For the 200 acre facility, there is a total site area of 250 acres with a 200 acre fill area. The fill rate is five hundred tons per day. A compaction rate of 1,000 pounds per cubic yard, 286 days per year in operation, and 0.4 lost for cover are assumed. The average depth of fill for the 200 acre facility is 30 feet. This results in an estimated life of 27 years for this

facility. It is assumed for the 200 acre facility that personnel requirements include one supervisor, four operators, one gate person, and one laborer.

The model landfill calculations assume a constant fill rate throughout the life of the facility. This is a rather unrealistic assumption. It would be roughly correct; however, if one assumes that recycling, composting, or other resource recovery programs will offset any increase in waste generation due to population increases and other socio-economic factors. Higher fill rates will lower costs/ton, and increase facility life; lower fill rates will do the opposite.

The results show that the disposal cost per ton exhibits significant economies of scale. They are extremely high for the small facilities, but level off at lower rates at the higher ton per day facilities. This is due to high capital costs being amortized over very low volumes for smaller facilities. At very high volume facilities, capital cost can be amortized over very large refuse volumes.

Table 1 summarizes the cost-per-ton results for each size category. Separate calculations have been made by type of liner and method of finance. The detailed analysis of each option is presented in Illustrations 1-20.

The reader should be aware that the costs, shown in Table 1 and given as Illustrations 1-20, assume traditional public ownership of the facility. As a result, there is no consideration of capital consumption allowances for plant and equipment, depletion allowances for land, or profit.

Inclusion of capital consumption allowances, depletion allowances, and profit factors, which would be appropriate if private ownership is assumed, would increase the costs shown approximately 20 percent (5 percent of which is profit). The level of profit is determined exclusive of retained earnings which is reflected in the capital allowance component. The cost for a publicly-owned facility operating on a non-profit enterprise basis should be increased by a 15 percent factor only.

In Table 2, the columns labeled (1) are taken directly from Illustrations 1-20. These are the traditional public ownership cases. For example, a 100/ton day facility with a composite liner financed by means of Aa tax-exempt municipal bonds would require a tipping fee of $22.01 to break even. If tax-exempt financing were not available, this fee would be $27.81. Likewise, this same facility, if constructed by a private company on a for-profit basis, would require a fee of $33.37 while a public non-profit enterprise facility would require $25.31 (assuming tax-free financing).

REFERENCES

Joyce, Jr., Leonard E. "How to Calculate Waste Disposal Costs." Waste Age, March 1989, pp. 32-40.

Parvin, Edward C., P.E. "Factors that Influence Landfill Economics." 1990 (Mimeograph).

Walsh, James. "Sanitary Landfill Costs, Estimated." Waste Age, March and April 1990, (March, pp. 50-54, April, pp. 84-93).

TABLE 1

ESTIMATED ANNUAL LANDFILL COSTS PER TON ($)

TONS/DAY	COMPOSITE LINER FINANCING		CLAY LINER FINANCING	
	PRIVATE	PUBLIC	PRIVATE	PUBLIC
25	71.06	63.72	69.03	60.87
50	46.56	39.27	44.69	37.82
100	27.81	25.17	26.44	24.17
200	23.50	19.84	22.55	19.12
500	16.83	14.68	16.09	14.13

TABLE 2

A FULL RANGE OF ESTIMATED ANNUAL LANDFILL COSTS PER TON ($)

TONS /DAY	COMPOSITE LINER FINANCING				CLAY LINER FINANCING			
	Private Aa Financing		Public Aa Financing		Private Aa Financing		Public Aa Financing	
	(1)	(2)	(1)	(3)	(1)	(2)	(1)	(3)
25	71.06	85.27	63.72	69.29	69.03	82.84	60.87	67.97
50	46.56	55.87	39.27	41.10	44.69	53.63	37.82	39.94
100	27.81	33.37	25.17	25.31	26.44	31.73	24.17	24.40
200	23.50	28.20	19.84	20.69	22.55	27.06	19.12	20.19
500	16.83	20.20	14.68	14.89	16.09	19.31	14.13	15.66

(1) Cost estimates do not include capital consumption allowance, depletion allowance, or profit factors. See Illustrations 1-20.

(2) Cost estimates for private entities include a 20% increment over (1) for capital consumption allowance, depletion allowance, and profit.

(3) Cost estimates for publicly owned non-profit enterprises include a 15% increment over (1) for capital consumption allowance and depletion allowance.

ILLUSTRATION 1
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
30 acre site
25 acre fill area
25 tons per day
24.8 year life
5% inflation rate
0.5 loss for cover
Composite liner
Aa Private debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (30 acres @ $2,000/acre)	$60,000	
	Engineering and site development	75,000	
	Legal, hearings, and regulatory fees	25,000	
	Administrative and support services	25,000	
	Unanticipated costs	25,000	
	Subtotal	210,000	
2.	CONSTRUCTION COSTS		
	5 acres initial @ $100,000/acre	500,000	
	Total development and construction	710,000	
	Amortization of 1 & 2 @ 9.75%		$76,500
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		75,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	45,000	
	Site personnel costs	67,000	
	Insurance and other benefits	11,100	
	Equipment operations	126,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	90,000	
	Subtotal		339,100
5.	CLOSURE		6,000
6.	POST CLOSURE		11,500
	TOTAL ANNUAL COSTS:		508,100
	TIPPING FEE: $/TON		71.06
	LANDFILL COST: $/ACRE		504,000

ILLUSTRATION 2
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
30 acre site
25 acre fill area
25 tons per day
24.8 year life
5% inflation rate
0.5 loss for cover
Clay liner
Aa Private debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (30 acres @ $2,000/acre)	$60,000	
	Engineering and site development	75,000	
	Legal, hearings, and regulatory fees	25,000	
	Administrative and support services	25,000	
	Unanticipated costs	25,000	
	Subtotal	210,000	
2.	CONSTRUCTION COSTS		
	5 acres initial @ $70,000/acre	350,000	
	Total development and construction	560,000	
	Amortization of 1 & 2 @ 9.75%		$60,000
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		39,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	45,000	
	Site personnel costs	67,000	
	Insurance and other benefits	11,100	
	Equipment operations	126,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	90,000	
	Subtotal		339,100
5.	CLOSURE		6,000
6.	POST CLOSURE		11,500
	TOTAL ANNUAL COSTS:		455,600
	TIPPING FEE: $/TON		63.72
	LANDFILL COST: $/ACRE		452,000

ILLUSTRATION 3
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
30 acre site
25 acre fill area
25 tons per day
24.8 year life
5% inflation rate
0.5 loss for cover
Composite liner
Aa Public debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (30 acres @ $2,000/acre)	$60,000	
	Engineering and site development	75,000	
	Legal, hearings, and regulatory fees	25,000	
	Administrative and support services	25,000	
	Unanticipated costs	25,000	
	Subtotal	210,000	
2.	CONSTRUCTION COSTS		
	5 acres initial @ $100,000/acre	500,000	
	Total development and construction	710,000	
	Amortization of 1 & 2 @ 7.25%		$62,000
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		75,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	45,000	
	Site personnel costs	67,000	
	Insurance and other benefits	11,100	
	Equipment operations	126,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	90,000	
	Subtotal		339,100
5.	CLOSURE		6,000
6.	POST CLOSURE		11,500
	TOTAL ANNUAL COSTS:		493,600
	TIPPING FEE: $/TON		69.03
	LANDFILL COST: $/ACRE		489,700

ILLUSTRATION 4
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
30 acre site
25 acre fill area
25 tons per day
24.8 year life
5% inflation rate
0.5 loss for cover
Clay liner
Aa Public debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (30 acres @ $2,000/acre)	$60,000	
	Engineering and site development	75,000	
	Legal, hearings, and regulatory fees	25,000	
	Administrative and support services	25,000	
	Unanticipated costs	25,000	
	Subtotal	210,000	
2.	CONSTRUCTION COSTS		
	5 acres initial @ $70,000/acre	350,000	
	Total development and construction	560,000	
	Amortization of 1 & 2 @ 7.25%		$48,600
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		30,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	45,000	
	Site personnel costs	67,000	
	Insurance and other benefits	11,100	
	Equipment operations	126,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	90,000	
	Subtotal		339,100
5.	CLOSURE		6,000
6.	POST CLOSURE		11,500
	TOTAL ANNUAL COSTS:		435,200
	TIPPING FEE: $/TON		60.87
	LANDFILL COST: $/ACRE		432,000

ILLUSTRATION 5
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
65 acre site
50 acre fill area
50 tons per day
24.8 year life
5% inflation rate
0.5 loss for cover
Composite liner
Aa Private debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (65 acres @ $2,000/acre)	$130,000	
	Engineering and site development	100,000	
	Legal, hearings, and regulatory fees	35,000	
	Administrative and support services	25,000	
	Unanticipated costs	25,000	
	Subtotal	315,000	
2.	CONSTRUCTION COSTS		
	10 acres initial @ $100,000/acre	1,000,000	
	Total development and construction	1,315,000	
	Amortization of 1 & 2 @ 9.75%		$141,700
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		150,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	45,000	
	Site personnel costs	67,000	
	Insurance and other benefits	11,100	
	Equipment operations	126,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	90,000	
	Subtotal		339,100
5.	CLOSURE		12,000
6.	POST CLOSURE		23,000
	TOTAL ANNUAL COSTS:		665,800
	TIPPING FEE: $/TON		46.56
	LANDFILL COST: $/ACRE		330,000

ILLUSTRATION 6
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
65 acre site
50 acre fill area
50 tons per day
24.8 year life
5% inflation rate
0.5 loss for cover
Clay liner
Aa Private debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (65 acres @ $2,000/acre)	$130,000	
	Engineering and site development	100,000	
	Legal, hearings, and regulatory fees	25,000	
	Administrative and support services	35,000	
	Unanticipated costs	25,000	
	Subtotal	315,000	
2.	CONSTRUCTION COSTS		
	10 acres initial @ $70,000/acre	700,000	
	Total development and construction	1,015,000	
	Amortization of 1 & 2 @ 9.75%		$109,400
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		78,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	45,000	
	Site personnel costs	67,000	
	Insurance and other benefits	11,100	
	Equipment operations	126,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	90,000	
	Subtotal		339,100
5.	CLOSURE		12,000
6.	POST CLOSURE		23,000
	TOTAL ANNUAL COSTS:		561,500
	TIPPING FEE: $/TON		39.27
	LANDFILL COST: $/ACRE		578,500

ILLUSTRATION 7
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
65 acre site
50 acre fill area
50 tons per day
24.8 year life
5% inflation rate
0.5 loss for cover
Composite Liner
Aa public debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (65 acres @ $2,000/acre)	$130,000	
	Engineering and site development	100,000	
	Legal, hearings, and regulatory fees	25,000	
	Administrative and support services	35,000	
	Unanticipated costs	25,000	
	Subtotal	315,000	
2.	CONSTRUCTION COSTS		
	10 acres initial @ $ 100,000/acre	1,000,000	
	Total development and construction	1,315,000	
	Amortization of 1 & 2 @ 7.25%		$114,900
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		150,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	45,000	
	Site personnel costs	67,000	
	Insurance and other benefits	11,100	
	Equipment operations	126,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	90,000	
	Subtotal		339,100
5.	CLOSURE		12,000
6.	POST CLOSURE		23,000
	TOTAL ANNUAL COSTS:		639,000
	TIPPING FEE: $/TON		44.69
	LANDFILL COST: $/ACRE		317,000

ILLUSTRATION 8
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
65 acre site
50 acre fill area
50 tons per day
24.8 year life
5% inflation rate
0.5 loss for cover
Clay Liner
Aa public debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (65 acres @ $2,000/acre)	$130,000	
	Engineering and site development	100,000	
	Legal, hearings, and regulatory fees	25,000	
	Administrative and support services	35,000	
	Unanticipated costs	25,000	
	Subtotal	315,000	
2.	CONSTRUCTION COSTS		
	10 acres initial @ $ 70,000/acre	700,000	
	Total development and construction	1,015,000	
	Amortization of 1 & 2 @ 7.25%		$88,700
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		78,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	45,000	
	Site personnel costs	67,000	
	Insurance and other benefits	11,100	
	Equipment operations	126,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	90,000	
	Subtotal		339,100
5.	CLOSURE		12,000
6.	POST CLOSURE		23,000
	TOTAL ANNUAL COSTS:		540,800
	TIPPING FEE: $/TON		37.82
	LANDFILL COST: $/ACRE		268.300

ILLUSTRATION 9
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
90 acre site
65 acre fill area
100 tons per day
33.0 year life
5% inflation rate
0.4 loss for cover
Composite Liner
Aa private debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (90 acres @ $2,000/acre)	$180,000	
	Engineering and site development	150,000	
	Legal, hearings, and regulatory fees	50,000	
	Administrative and support services	60,000	
	Unanticipated costs	50,000	
	Subtotal	490,000	
2.	CONSTRUCTION COSTS		
	13 acres initial @ $100,000/acre	1,300,000	
	Total development and construction	1,790,000	
	Amortization of 1 & 2 @ 9.75%		$182,000
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		144,900
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	48,750	
	Site personnel costs	89,000	
	Insurance and other benefits	26,700	
	Equipment operations	136,500	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	97,500	
	Subtotal		398,350
5.	CLOSURE		24,000
6.	POST CLOSURE		46,000
	TOTAL ANNUAL COSTS:		795,350
	TIPPING FEE: $/TON		27.81
	LANDFILL COST: $/ACRE		306,000

ILLUSTRATION 10
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
90 acre site
65 acre fill area
100 tons per day
33.0 year life
5% inflation rate
0.4 loss for cover
Clay Liner
Aa private debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (90 acres @ $2,000/acre)	$180,000	
	Engineering and site development	150,000	
	Legal, hearings, and regulatory fees	50,000	
	Administrative and support services	60,000	
	Unanticipated costs	50,000	
	Subtotal	490,000	
2.	CONSTRUCTION COSTS		
	13 acres initial @ $70,000/acre	910,000	
	Total development and construction	1,400,000	
	Amortization of 1 & 2 @ 9.75%		$150,000
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		101,400
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	48,750	
	Site personnel costs	89,000	
	Insurance and other benefits	26,700	
	Equipment operations	136,500	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	97,500	
	Subtotal		398,400
5.	CLOSURE		24,000
6.	POST CLOSURE		46,000
	TOTAL ANNUAL COSTS:		719,800
	TIPPING FEE: $/TON		25.17
	LANDFILL COST: $/ACRE		237,500

ILLUSTRATION 11
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
90 acre site
65 acre fill area
100 tons per day
33.0 year life
5% inflation rate
0.4 loss for cover
Composite Liner
Aa public debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (90 acres @ $2,000/acre)	$180,000	
	Engineering and site development	150,000	
	Legal, hearings, and regulatory fees	50,000	
	Administrative and support services	60,000	
	Unanticipated costs	50,000	
	Subtotal	490,000	
2.	CONSTRUCTION COSTS		
	13 acres initial @ $100,000/acre	1,300,000	
	Total development and construction	1,790,000	
	Amortization of 1 & 2 @ 7.25%		$143,000
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		144,900
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	48,750	
	Site personnel costs	89,000	
	Insurance and other benefits	26,700	
	Equipment operations	136,500	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	97,500	
	Subtotal		398,350
5.	CLOSURE		24,000
6.	POST CLOSURE		46,000
	TOTAL ANNUAL COSTS:		756,250
	TIPPING FEE: $/TON		26.44
	LANDFILL COST: $/ACRE		290,900

ILLUSTRATION 12
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
90 acre site
65 acre fill area
100 tons per day
33.0 year life
5% inflation rate
0.4 loss for cover
Clay Liner
Aa public debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (90 acres @ $2,000/acre)	$180,000	
	Engineering and site development	150,000	
	Legal, hearings, and regulatory fees	50,000	
	Administrative and support services	60,000	
	Unanticipated costs	50,000	
	Subtotal	490,000	
2.	CONSTRUCTION COSTS		
	13 acres initial @ $70,000/acre	910,000	
	Total development and construction	1,400,000	
	Amortization of 1 & 2 @ 7.25%		$121,500
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		101,400
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	48,750	
	Site personnel costs	89,000	
	Insurance and other benefits	26,700	
	Equipment operations	136,500	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	97,500	
	Subtotal		398,400
5.	CLOSURE		24,000
6.	POST CLOSURE		46,000
	TOTAL ANNUAL COSTS:		691,300
	TIPPING FEE: $/TON		24.17
	LANDFILL COST: $/ACRE		228,200

ILLUSTRATION 13
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
125 acre site
100 acre fill area
200 tons per day
25.4 year life
5% inflation rate
0.4 loss for cover
Composite Liner
Aa private debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (125 acres @ $2,000/acre)	$250,000	
	Engineering and site development	200,000	
	Legal, hearings, and regulatory fees	75,000	
	Administrative and support services	100,000	
	Unanticipated costs	25,000	
	Subtotal	650,000	
2.	CONSTRUCTION COSTS		
	20 acres initial @ $100,000/acre	2,000,000	
	Total development and construction	2,650,000	
	Amortization of 1 & 2 @ 9.75%		$284,400
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		300,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	82,500	
	Site personnel costs	111,000	
	Insurance and other benefits	33,300	
	Equipment operations	230,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	165,000	
	Subtotal		621,800
5.	CLOSURE		46,000
6.	POST CLOSURE		92,000
	TOTAL ANNUAL COSTS:		$1,344,200
	TIPPING FEE: $/TON		23.50
	LANDFILL COST: $/ACRE		342,000

ILLUSTRATION 14
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
125 acre site
100 acre fill area
200 tons per day
25.4 year life
5% inflation rate
0.4 loss for cover
Clay Liner
Aa private debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (125 acres @ $2,000/acre)	$250,000	
	Engineering and site development	200,000	
	Legal, hearings, and regulatory fees	75,000	
	Administrative and support services	100,000	
	Unanticipated costs	50,000	
	Subtotal	650,000	
2.	CONSTRUCTION COSTS		
	20 acres initial @ $70,000/acre	1,400,000	
	Total development and construction	2,050,000	
	Amortization of 1 & 2 @ 9.75%		$219,300
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		156,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	82,500	
	Site personnel costs	111,000	
	Insurance and other benefits	33,300	
	Equipment operations	230,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	165,000	
	Subtotal		621,800
5.	CLOSURE		46,000
6.	POST CLOSURE		92,000
	TOTAL ANNUAL COSTS:		1,135,100
	TIPPING FEE: $/TON		19.84
	LANDFILL COST: $/ACRE		283,800

ILLUSTRATION 15
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
125 acre site
100 acre fill area
200 tons per day
25.4 year life
5% inflation rate
0.4 loss for cover
Composite Liner
Aa public debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (125 acres @ $2,000/acre)	$250,000	
	Engineering and site development	200,000	
	Legal, hearings, and regulatory fees	75,000	
	Administrative and support services	100,000	
	Unanticipated costs	25,000	
	Subtotal	650,000	
2.	CONSTRUCTION COSTS		
	20 acres initial @ $100,000/acre	2,000,000	
	Total development and construction	2,650,000	
	Amortization of 1 & 2 @ 7.25%		$229,900
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		300,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	82,500	
	Site personnel costs	111,000	
	Insurance and other benefits	33,300	
	Equipment operations	230,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	165,000	
	Subtotal		621,800
5.	CLOSURE		46,000
6.	POST CLOSURE		92,000
	TOTAL ANNUAL COSTS:		1,289,600
	TIPPING FEE: $/TON		22.55
	LANDFILL COST: $/ACRE		327,600

ILLUSTRATION 16
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
125 acre site
100 acre fill area
200 tons per day
25.4 year life
5% inflation rate
0.4 loss for cover
Clay Liner
Aa public debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (125 acres @ $2,000/acre)	$250,000	
	Engineering and site development	200,000	
	Legal, hearings, and regulatory fees	75,000	
	Administrative and support services	100,000	
	Unanticipated costs	50,000	
	Subtotal	650,000	
2.	CONSTRUCTION COSTS		
	20 acres initial @ $70,000/acre	1,400,000	
	Total development and construction	2,050,000	
	Amortization of 1 & 2 @ 7.25%		$177,800
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		156,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	82,500	
	Site personnel costs	111,000	
	Insurance and other benefits	33,300	
	Equipment operations	230,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	165,000	
	Subtotal		621,800
5.	CLOSURE		46,000
6.	POST CLOSURE		92,000
	TOTAL ANNUAL COSTS:		1,093,600
	TIPPING FEE: $/TON		19.12
	LANDFILL COST: $/ACRE		273,400

ILLUSTRATION 17
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
250 acre site
200 acre fill area
500 tons per day
27.0 year life
5% inflation rate
0.4 loss for cover
Composite Liner
Aa private debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (250 acres @ $2,000/acre)	$500,000	
	Engineering and site development	300,000	
	Legal, hearings, and regulatory fees	125,000	
	Administrative and support services	100,000	
	Unanticipated costs	75,000	
	Subtotal	1,100,000	
2.	CONSTRUCTION COSTS		
	40 acres initial @ $100,000/acre	4,000,000	
	Total development and construction	5,100,000	
	Amortization of 1 & 2 @ 9.75%		$536,300
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		500,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	142,500	
	Site personnel costs	153,000	
	Insurance and other benefits	46,000	
	Equipment operations	400,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	285,000	
	Subtotal		1,026,500
5.	CLOSURE		115,000
6.	POST CLOSURE		229,000
	TOTAL ANNUAL COSTS:		2,406,800
	TIPPING FEE: $/TON		16.83
	LANDFILL COST: $/ACRE		325,000

ILLUSTRATION 18
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
250 acre site
200 acre fill area
500 tons per day
27.0 year life
5% inflation rate
0.4 loss for cover
Clay Liner
Aa private debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (250 acres @ $2,000/acre)	$500,000	
	Engineering and site development	300,000	
	Legal, hearings, and regulatory fees	125,000	
	Administrative and support services	100,000	
	Unanticipated costs	75,000	
	Subtotal	1,100,000	
2.	CONSTRUCTION COSTS		
	40 acres initial @ $70,000/acre	2,800,000	
	Total development and construction	3,900,000	
	Amortization of 1 & 2 @ 9.75%		$417,000
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		312,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	142,500	
	Site personnel costs	153,000	
	Insurance and other benefits	46,000	
	Equipment operations	400,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	285,000	
	Subtotal		1,026,500
5.	CLOSURE		115,000
6.	POST CLOSURE		229,000
	TOTAL ANNUAL COSTS:		2,099,500
	TIPPING FEE: $/TON		14.68
	LANDFILL COST: $/ACRE		283,400

ILLUSTRATION 19
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
250 acre site
200 acre fill area
500 tons per day
27.0 year life
5% inflation rate
0.4 loss for cover
Composite Liner
Aa public debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (250 acres @ $2,000/acre)	$500,000	
	Engineering and site development	300,000	
	Legal, hearings, and regulatory fees	125,000	
	Administrative and support services	100,000	
	Unanticipated costs	75,000	
	Subtotal	1,100,000	
2.	CONSTRUCTION COSTS		
	40 acres initial @$100,000/acre	4,000,000	
	Total development and construction	5,100,000	
	Amortization of 1 & 2 @ 7.25%		$431,000
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		500,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	142,500	
	Site personnel costs	153,000	
	Insurance and other benefits	46,000	
	Equipment operations	400,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	285,000	
	Subtotal		1,026,500
5.	CLOSURE		115,000
6.	POST CLOSURE		229,000
	TOTAL ANNUAL COSTS:		2,301,500
	TIPPING FEE: $/TON		16.09
	LANDFILL COST: $/ACRE		310,700

ILLUSTRATION 20
MODEL LANDFILL COST ANALYSIS

ASSUMPTIONS
250 acre site
200 acre fill area
500 tons per day
27.0 year life
5% inflation rate
0.4 loss for cover
Clay Liner
Aa public debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (250 acres @ $2,000/acre)	$500,000	
	Engineering and site development	300,000	
	Legal, hearings, and regulatory fees	125,000	
	Administrative and support services	100,000	
	Unanticipated costs	75,000	
	Subtotal	1,100,000	
2.	CONSTRUCTION COSTS		
	40 acres initial @$70,000/acre	2,800,000	
	Total development and construction	3,900,000	
	Amortization of 1 & 2 @ 7.25%		$338,300
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		312,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	142,500	
	Site personnel costs	153,000	
	Insurance and other benefits	46,000	
	Equipment operations	400,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	285,000	
	Subtotal		1,026,500
5.	CLOSURE		115,000
6.	POST CLOSURE		229,000
	TOTAL ANNUAL COSTS:		2,020,800
	TIPPING FEE: $/TON		14.13
	LANDFILL COST: $/ACRE		272,800

APPENDIX C

-SUMMARY-

STATE SOLID WASTE PROCESSING AND DISPOSAL REGULATIONS

Geneil Hailey, P.E.

University of Tennessee
County Technical Assistance Service

May, 1990

This summary of Tennessee's Solid Waste Processing and Disposal Regulations was prepared according to those promulgated on May 18, 1990. Subsequent to this, certain revisions were made to these regulations and became effective September 20 1991.

Most of the changes were minor and were editorial and typographical in nature. However, certain substantive changes were made including:

- ☞ There is no longer permit by rule for construction/demolition and/or yard waste disposal facilities.

- ☞ There is a permit by rule for coal-ash provided the ash and fill area meet the requirement outlined in the regulations.

For a complete list of the modifications to these regulations, contact:

The Tennessee Department of Environment and Conservation
Division of Solid Waste Management
4th Floor, Customs House
701 Broadway
Nashville, TN 37247-3530
(615) 741-3424

The University of Tennessee
County Technical Assistance Service

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- Summary -
State Solid Waste Processing and Disposal Regulations

May 1990

Prepared by

Geneil Hailey, P.E.
Solid Waste Management Consultant

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THE UNIVERSITY OF TENNESSEE
COUNTY TECHNICAL ASSISTANCE SERVICE

226 Capitol Boulevard Building
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Nashville, Tennessee 37219-1804
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April 30, 1990

Dear County Official:

As of March 18, 1990, the State of Tennessee Division of Solid Waste Management began operating under new regulations regarding solid waste disposal and processing facilities. These regulations include significant revisions and formal declarations of policy relative to Tennessee's old solid waste regulations. These new regulations comprise six rules, 1200-1-7-.01 through 1200-1-7-.06 promulgated as Rule Chapter 1200-1-7, Solid Waste Processing and Disposal of the rules and regulations of the State of Tennessee.

Attached is a summary of the new rules and regulations regarding solid waste management. It is hoped that this summary will facilitate your review of these regulations. ***Every effort has been made to ensure accuracy in this summary, however, should discrepancies arise between the text of this summary and the regulations, the regulations always prevail.***

We would like to express our appreciation to the division of solid waste management for their assistance in preparing this summary. As always, if we can be of any further assistance to you on your solid waste management issues, please do not hesitate to call.

Very truly yours,

Robert M. Wormsley
Executive Director

* This Technical Bulletin was produced with Recycled Paper

SUMMARY
STATE SOLID WASTE PROCESSING AND DISPOSAL REGULATIONS

Rule 1200-1-7-.01 SOLID WASTE MANAGEMENT SYSTEM: GENERAL

Purpose - This rule provides definitions of terms and categories of waste disposal facilities, general standards, variances and waivers, and an overview of information applicable to these topics.

Classification of Disposal Facilities - Disposal facilities in Tennessee will now be identified according to classes I-VI.

> Class I Disposal Facility refers to a sanitary landfill which serves a municipal, institutional, and/or rural population and is to be used for disposal of domestic wastes, commercial wastes, institutional wastes, farming wastes, discarded automotive tires and dead animals.

This refers to city, county or private landfills servicing a city, county, or community and has specific standards associated with buffer zones, leachate migration control, gas migration control, waste handling and cover, and ground-water protection and monitoring.

> Class II Disposal Facility refers to a landfill which receives waste which is generated by one or more industrial or manufacturing plants and is used or to be used for the disposal of solid waste generated by such plants, which may include industrial wastes, commercial wastes, domestic wastes, institutional wastes, farming wastes, demolition/construction wastes, discarded automotive tires, and dead animals. Also, a Class II disposal facility may serve as a monofill for ash disposal from the incineration of municipal solid waste.

This specifically refers to landfills which are used only by industries or manufacturing plants or exclusively for disposal of ash from incinerated municipal solid waste. These landfills also have specific standard requirements in the same categories listed for Class I facilities but generally are allowed more flexibility depending upon a case by case analysis of wastes to be disposed, site characteristic, etc.

> Class III Disposal Facility refers to a landfill which is used or to be used for the disposal of farming waste, landscaping wastes, and/or certain special wastes having similar characteristics.

These facilities also have specific standard requirements associated with them but they are generally less stringent than those for Class I or Class II disposal facilities.

Class IV Disposal Facility refers to a landfill which is used or to be used for the disposal of demolition/construction waste and/or certain special waste having similar characteristics as inert waste.

These facilities have specific standard requirements as well, but due to the more inert nature of this type of waste are generally the least stringent.

All Class I - IV facilities disposing of special wastes must have tested this waste according to the Toxic Constituent Leachate Procedure (TCLP) which replaces the previous E. P. Toxicity Test, and have received written permission to dispose of such waste from the commissioner.

Class V Disposal Facility refers to a landfarming facility.

Class VI Disposal Facility refers to a surface impoundment used for disposal of solid waste.

Specific requirements for Class V and VI facilities have not been outlined at this point.

It should also be noted that requests for variances or waivers will be processed as part of the final permit or as a permit modification.

RULE 1200-1-7-.02 PERMITTING OF SOLID WASTE PROCESSING AND DISPOSAL FACILITIES

Purpose - This rule establishes the procedures, documentation, and other requirements for a person to receive and retain a permit to operate a solid waste processing or disposal facility in Tennessee.

Permits by Rule - This section of the solid waste regulations has been expanded to identify classes of activities deemed to have a permit by rule if certain conditions are met. A permit by rule is a situation where no formal permitting process is required if the facility is eligible for such a permit. Existing facilities have within 90 days of the effective date of these regulations to file for a permit and new facilities within 30 days of beginning operation.

This is basically only applicable to processing facilities, Class III, and Class IV disposal facilities if they are less than five acres in areal extent and meet the outlined criteria and adhere to the requirements set forth in this rule paragraph (1), subparagraph (c,) part 2. The operator of such a facility must notify the Department of Health and Environment as per the requirements of this part.

Application for a Permit - Applicants for a solid waste disposal permit no longer have to prepare a feasibility study.

Existing facilities shall not be subject to further public notice and public hearings when making permit modifications that are necessary to comply with these new regulations.

The format and contents for a permit application are defined in this rule, paragraph (2), subparagraph (d). The permit application is divided into two parts. Part I consists of forms supplied by the Department with accompanying instructions as well as general information regarding the owner(s), operator(s), and the facility, including: location; type of waste to be handled, zoning authority for the facility location; how the facility is zoned; topography; and wells, springs, and other surface water bodies in the area.

Part II of the permit application is defined in detail in Rule 1200-1-7-.04, paragraph (9). It consists of a hydrogeologic report, engineering plans, narrative description of the facility and operations, and closure/post-closure plan.

If upon receiving a permit, the facility does not initiate construction and/or operation within one year of the date of the permit, the permittee may not initiate construction and or operation of the facility unless recertification by the commissioner in writing has been received. The procedure for obtaining recertification is defined in this rule, paragraph (2), subparagraph (e).

A detailed description for processing the permit is found in paragraph (3).

The terms of a permit are found in paragraph (4).

The regulations regarding the transfer, modification, revocation and reissuance, and termination of permits is found in paragraph (5).

RULE 1200-1-7-.03 REQUIREMENTS FOR FINANCIAL ASSURANCE

Purpose/Scope - This rule establishes requirements for establishing and maintaining acceptable financial assurance for the proper operation, closure and post-closure care of certain solid waste disposal facilities in Tennessee. These financial assurance requirements are to ensure that adequate financial resources are available to the Commissioner to ensure proper operation, closure and post-closure care. This rule also establishes criteria and procedures to be used by the Commissioner in setting the amount of financial assurance required and in use and release of these funds.

Basically, operators of Class I-IV solid waste disposal facilities, unless permitted by rule, will be required to have an approved closure/post-closure care plan by the Department of Health and Environment. The contents of this plan are detailed in paragraph (2). As of the effective date of these regulations, the Commissioner of Health and Environment will begin to request closure/

post-closure plans from existing facilities. The operators of these facilities will have 180 days from the date of the commissioner's notice to submit this plan. The operator of a facility, however, may voluntarily submit this plan at any time.

All existing facilities will be required to have a closure/post-closure plan within three years of the effective date of these regulations.

Additionally, operators of Class I-IV solid waste disposal facilities, unless permitted by rule, will be required to file and maintain financial assurance with the Commissioner of Health and Environment. The amount of financial assurance required of the operator shall be established by the Commissioner based upon the estimated cost of operating the facility for a 30-day period plus the estimated closure and post closure care costs included in the approved closure/post-closure care plan. This required amount may be adjusted as the plan is amended. In no case, however, shall the amount of financial assurance be less than $1,000 per acre or the fraction thereof affected by the facility operation.

For facilities being developed or to be developed according to a phased development plan, the commissioner may establish the amount of financial assurance required on a parcel-by-parcel basis.

The acceptable mechanisms of financial assurance are identified in paragraph (3), subparagraph (d). The rest of paragraph (3) addresses the following issues:

Subparagraph

(e) Use of Multiple Financial Mechanisms;
(f) Use of a Financial Mechanism for Multiple Facilities;
(g) Substituting Alternate Financial Assurance;
(h) Incapacity of Operator or Financial Institutions;
(i) Maintenance/Release of Financial Assurance;
(j) Forfeiture of Financial Assurance;
(k) Effect on Transfer of Permits;
(l) Wording of the Instruments guaranteeing proper operation and performance of closure and/or post-closure care.

RULE 1200-1-7-.04 SPECIFIC REQUIREMENTS FOR CLASS I, II, III, AND IV DISPOSAL FACILITIES

The purpose of this rule is to establish:

1. The standards which Class I through IV facilities must meet to obtain a permit ,and
2. The specific information required in Part II of the permit application.

On March 18, 1990, new facilities were subject to all applicable requirements.

Unless it is already in the permit (or in the already submitted construction and operational plans) as of the effective date of this rulemaking, any new unit or lateral expansion to be added to an existing facility shall, on the effective date of this rulemaking, be subject to all applicable requirements.

Existing facilities shall on the effective date of this rulemaking, be subject to the following subparagraphs of paragraph (2).

Subparagraph	
(a)	Overall Performance Standard
(b)	Control of Access and Use
(c)	Fire Safety
(d)	Blowing Litter
(e)	Personnel Services
(f)	Communications
(g)	Operating Equipment
(h)	Availability of Cover Material
(i)	Run-on, Run-off, and Erosion Control
(j)	Dust Control
(k)	Waste Restrictions
(l)	Sealing of Bore Holes
(m)	Endangered Species
(o)	Permanent Benchmark
(s)	Random Inspection Program
(t)	Future Planning

as well as, paragraph (6) waste handling and cover standards, (7) ground-water protection/monitoring standards; and paragraph (8) closure and postclosure standards.

By March 18, 1994, existing facilities shall be subject to applicable requirements of paragraph (4) leachate migration control standards and paragraph (5) gas migration control standards.

Existing facilities shall <u>not</u> be subject to the following subparagraphs of paragraph (2):

subparagraph	
(n)	Location in Floodplains
(p)	Wetlands
(q)	Karst Terrain
(r)	Airport Safety

and paragraph (3) buffer zone standards.

All facilities shall be subject to applicable requirements of paragraph (9) when applying for a permit or permit modification.

This paragraph establishes the requirements for the part II permit application.

Some of the more significant requirements of paragraph (2) General Facility Standards are as follows:

Subparagraph (i) Run-on, Run-off, and Erosion Control
The operator must design, construct, operate, and maintain a run-on and run-off control system including collection and holding facilities capable of handling the peak flow or discharge from a 24-hour, 25-year storm.

Additionally, holding facilities must be designed to detain at least the water volume resulting from a 24-hour, 25-year storm and capable of diverting through emergency spillways at least the peak flow resulting from a 24-hour, 100-year storm.

Run-on and run-off must be managed separately from leachate unless otherwise approved by the commissioner.

Subparagraph (n) Location in Floodplains
Facilities must not be located in the 100-year floodplain unless it will not restrict the flow of the 100-year flood nor reduce the temporary water storage capacity of the floodplain and is designed, constructed, operated, or maintained to prevent washout of any solid waste.

Subparagraph (o) Permanent Benchmark
There must be installed on-site a permanent benchmark (e.g., a concrete marker) of known elevation.

Subparagraph (p) Wetlands
Facilities must not be located in a wetland.

Subparagraph (r) Airport Safety
Disposal facilities located within 5,000 ft. of any runway used by piston aircraft or 10,000 ft. of runways used by turbojet shall not pose a bird hazard to aircraft.

Paragraph (3), Buffer Zone Standards for Siting New Class I, II, III or IV Landfills, contains the following minimum requirements:

1. 100 ft. from all property lines;
2. 500 ft. from all residences, unless the owner of the residential property agrees in writing to a shorter distance;
3. 500 ft. from all wells determined to be downgradient and used as a drinking water source by humans or livestock;
4. 200 ft. from the normal boundaries of springs, streams, lakes, and other bodies of water (except that this standard shall not apply to any wet weather conveyance nor to bodies of water constructed and designed to be a part of the facility);
5. A total site buffer with no constructed appurtenances within 50 ft. of the property line.

Paragraph (4), Leachate Migration Control Standards, contains the minimum standards for liners, geologic buffers, leachate control systems, and cap for disposal facilities. A summary of some of the more significant items in these standards are found in the

following figure Cross-Section of a Solid Waste Landfill, and Table of Terms.

Paragraph (5), Gas Migration Control Standards, sets forth the requirements for the design, construction, operation, and maintenance of gas at Class I, II, III, and IV disposal facilities.

Paragraph (6), Waste Handling and Cover Standards, establishes the standards for waste placement in the disposal facility as well as cover requirements for daily, intermediate, and final cover for Class I through IV facilities.

Paragraph (7), Ground Water Protection / Monitoring Standards, are extensively detailed in this paragraph. Most specifically detailed is a more extensive detection monitoring program which will require considerably more groundwater sampling and analysis during the first year of a facility's operation.

Paragraph (8), Closure and Post-Closure Standards, establishes the closure/post-closure standards for Class I through IV disposal facilities. This paragraph establishes 30 years as the period of time for post closure care.

Paragraph (9), Contents of the Part II Permit Application, establishes the information that must be included in the Part II permit applications for Class I through IV disposal facilities.

1200-1-7-.05 SPECIFIC REQUIREMENTS FOR CLASS V DISPOSAL FACILITIES

No specific requirements for these facilities have been identified at present.

1200-1-7-.06 SPECIFIC REQUIREMENTS FOR CLASS VI DISPOSAL FACILITIES

No specific requirements have been identified for these facilities at present.

Cross Section of a Solid Waste Landfill

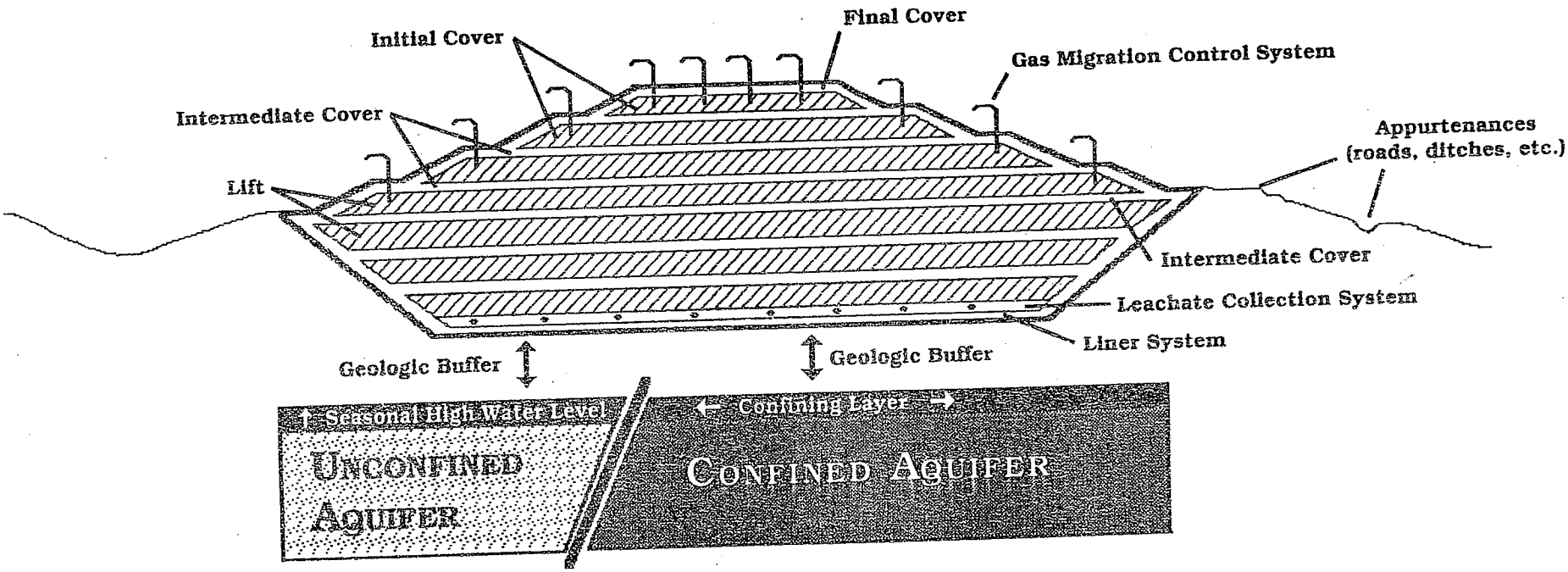

TABLE OF TERMS

Appurtenances - Constructed fixtures around the fill area required for the necessary operation of a landfill facility but not associated with the actual construction of the fill area and placement of refuse. Examples of appurtenances would be roads, stormwater ditches, swales, or berms.

Aquifer:

Confined Aquifer - A water bearing geologic formation sandwiched between two impermeable formations.

Unconfined Aquifer - A water bearing geologic formation without a confining upper impermeable formation which is subject to or influenced by atmospheric pressure.

Confining Layer - An impermeable geologic formation that serves to confine water movement.

Cover:

Initial Cover- A six inch layer of compacted soil required to cover compacted solid waste primarily at Class I solid waste disposal facilities at the end of each operating day.

Final Cover-The cover that must be applied to areas of Class I,II, III, and Class IV disposal facilities no later than 180 days after any fill areas or portion of the fill area has achieved final grade. This cover layer must meet the following requirements for the following classes of facilities:

Class I and Class II- Depth of final cover must be 36 inches of compacted soil of which 12 inches shall be for support of vegetative cover. This cover must be at least as impermeable as the bottom liner of the facility.

Class III and Class IV - Unless deemed insufficient for a particular class III or IV facility, final cover for these facilities is determined to be at least 30 inches of compacted soil, 18 inches of which is a low permeability layer overlain by a 12 inch protective layer capable of sustaining a vegetative cover.

Intermediate Cover - This cover must meet the following requirements for the following classes of facilities:

Class I - A cover layer one foot deep of compacted material applied between lifts and intermittently over areas which may remain exposed for over thirty days.

Class II - The cover depth and frequency will be specified in the permit.

Class III - Unless otherwise specified by the commissioner, cover must be applied every 14 days.

Class IV - Unless otherwise specified by the commissioner, cover must be applied every 30 days.

Gas Migration Control System - A system of standpipes, ditches, trenches, piping, wells, etc. used to:

(1) prevent the buildup of gas pressure under the final cover,

(2) prevent the concentration of explosive gases exceeding 25 percent of the lower explosive limit for the gases,

(3) prevent the concentration of explosive gases at the property boundary from exceeding the lower explosive limit for the gases.

Geologic Buffer - A geologic formation or engineered structure that separates the landfill bottom liner from the seasonal high water table. This buffer must meet the following performance standards for the following facilities:

Class I - (1) Ten feet of material with a maximum hydraulic conductivity of 1×10^{-5} centimeters per second material between the bottom of the liner to the seasonal high groundwater table of the uppermost unconfined aquifer or the top of the formation of a confined aquifer. Or, (2) five feet of material with a maximum hydraulic conductivity of 1×10^{-6} centimeters per second material between the bottom of the liner and the seasonal high water table of the uppermost unconfined aquifer or the top formation of a confined aquifer.

Class II - The geologic buffer requirements for this type of facility are the same as for a Class I facility.

Class III - Five feet of material with a maximum saturated hydraulic conductivity of 1×10^{-6} centimeters per second between the base of the fill and the seasonal high groundwater table or the top formation of a confined aquifer.

Class IV - Five feet of material with a maximum saturated hydraulic conductivity of 1×10^{-5} centimeters per second between the base of the fill and the seasonal high water table of an unconfined aquifer or the top of the formation for a confined aquifer.

Leachate Collection System - A system of pipes, ditches, tanks, pumps, etc. designed to collect, store, or transport leachate (water which has come in contact with or filtered through refuse) for acceptable treatment and disposal. A leachate collection and removal system is required immediately above the liner. In Class I and Class II facilities this system must be main-tained such that the leachate depth over the liner does not exceed one foot as a result of infiltration from a 25-year 24-hour storm and leachate collection reservoirs must have sufficient capacity to store the volume of leachate expected to be generated in 30 days. While it is not specifically described in the regulations, it is a matter of policy within the division that the Leachate Collection System include a layer of drainage media directly over the liner system.

Lift - Landfills are usually constructed in layers of compacted refuse and cover material. A lift is one vertical thickness of a compacted refuse layer.

Liner System - A liner composed of natural or synthetic material used to prevent the migration of waste or waste constituent out of the facility to the adjacent subsurface soil or ground water or surface water at anytime during the active life of the facility and the postclosure care period. Class I and II facilities must have liners designed to meet a minimum performance standard of three feet of soil recompacted to achieve a maximum hydraulic conductivity of 1×10^{-7} centimeters per second. Synthetic liners can be used but only in conjunction with a compacted earth liner which must be at least three feet thick and achieve a maximum hydraulic conductivity of 1×10^{-6} centimeters per second.

APPENDIX D

SUMMARY OF CURRENT AND PROPOSED SOLID WASTE REGULATIONS

Mary Dunsmore

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

	PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
I. LOCATION RESTRICTIONS			GENERAL STANDARDS FOR ALL LANDFILLS
	•No specific requirements	•10,000 feet from airport runway used by turbojet aircraft.	•Same
		•5,000 feet from airport runway used by piston-type aircraft	•Same
		•Facility located in the 100-year floodplain cannot restrict flow, reduce water storage capacity of floodplain, or result in washout of solid waste so as to pose a hazard to human health and the environment.	•Shall not restrict the flow of a 100-year flood, result in washout of solid waste from the 100-year flood, or reduce the temporary water storage capacity of the 100-year floodplain, unless measures are taken to provide alternate storage capacity.

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
	•Not in wetlands unless it can be demonstrated that there is no practicable alternative with less adverse impact.	
	•Not within 200 feet of a fault that has had displacement in Holocene time.	•Facilities must not be located in a wetland.
	•Not within a "seismic impact zone" unless all containment structures, including liners, leachate collection systems, and surface water control systems are designed to	•Shall demonstrate there is no potential for surface collapse, that groundwater flow and no significant degradation to groundwater resources for facilities located in karst terrain.

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
	resist the maximum horizontal acceleration in lithified material for the site.	
	•Not within an unstable area unless it has been demonstrated that engineering measures have been incorporated into the unit's design to ensure the stability of the structural components of the unit.	
	•Must comply with all applicable Federal rules, laws, regulations or other requirements.	•Shall not cause or contribute to the taking of endangered or threatened species or result in the destruction or

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
		adverse modification of the critical habitat of endangered or threatened species. •No closer than 100 feet from all property lines. •No closer than 500 feet from downgradient wells that are a source of drinking water by humans or livestock. •No closer than 200 feet from spring, stream, and lake boundaries

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

	PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
			•A total site buffer with no constructed appurtenances within 50 feet of the property line.
II. OPERATING CRITERIA			
A. Surface Water Drainage Control System	•All surface water shall be diverted around the operations area.	•Landfill unit must contain a run-on control system to prevent flow onto active portion of the landfill during peak discharge from a 25-year storm.	•Same
		•Landfill unit must contain a run-off control system from the active portion of the landfill to	•Same •Holding facilities associated with run-on and run-off

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
	collect and control at least the water volume from a 24-hour, 25-year storm.	control systems must be designed to detain at least the water volume resulting from a 24-hour, 25 year storm and to divert through emergency spillways at least the peak flow resulting from a 24-hour, 100-year storm. •Collection and holding facilities for run-on and run-off must be emptied or otherwise managed expeditiously after storms to maintain design capacity of the system.

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

		PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
				•Must take erosion control measures as necessary to control erosion of the site.
B.	Surface Water Require-ments	•No specific requirements.	•Shall not cause a discharge of pollutants that violates any requirements of the Clean Water Act, including requirements of NPDES, Section 402. •Shall not cause a discharge of a nonpoint pollution that violates any requirement or an area or statewide water quality management plan approved under Section 208 or 319	•No specific requirements.

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

	PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
		of the Clean Water Act.	
C. Cover Requirements	•Daily Cover-At least 6 inches of compacted cover material shall be placed on all exposed solid waste by the end of each working day.	•Disposed solid waste must be covered with suitable materials at the end of each operating day, or at more frequent intervals if necessary to control fires, odors, blowing litter, and scavenging.	•Compacted solid waste must be covered at the end of each day with an initial cover consisting of at least a six-inch layer of compacted soil or an adequate depth of other material as approved by Commissioner.
	•Intermediate Cover-In all but the final lift of a sanitary landfill, 12 inches of compacted cover material shall be		•Except for those completed portions to be finally closed, all surfaces which will be left exposed for a period of over 30

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

	PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
	placed on all surfaces which will be left exposed for a period of over 1 month.		days must be covered by an intermediate cover consisting of at least 1 foot of compacted soil or other material approved by the Commissioner.
D. Standards for Waste Placement	•Unloading-Shall be controlled and restricted to an area such that the material can easily be incorporated into the working face with available equipment.	•No specific requirements.	•The unloading of solid wastes at the disposal area must be confined to the smallest practicable area.
	•Spreading and Compacting-Shall be spread in layers of approximately 2		•Promptly upon unloading, solid wastes shall be spread in shallow (less than 3-foot)

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

	PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
	feet depth prior to compaction.		layers and compacted to the maximum practicable density.
E. Procedures to Exclude the Receipt of Hazardous Waste	•Handling of Special Wastes- Dead animals, sewage solids or liquids, and other materials which are either hazardous or hard to manage shall be disposed of in a sanitary landfill only if special provisions are made for such disposal and are approved by the Department.	•A program must be implemented to detect and prevent disposal of hazardous waste and PCBs; the program must include, at a minimum: -Random load inspections; -Inspection of suspicious loads; -Inspection records; -Training of facility personnel to recognize hazardous waste; and	•Program implemented such that there is a random inspection of 5% of daily incoming loads; inspection of suspicious loads; training of facility personnel to recognize a regulated hazardous waste; procedures for notifying proper authorities if a regulated hazardous waste is identified at the facility and

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
	-Procedures for notifying proper authorities if hazardous waste is discovered.	records of all inspections. •A special waste application must be submitted to TDHE and include a chemical and physical description of the solid waste, the amounts of and frequencies such solid waste is to be managed at the facility, a description of the processes or operations generating the waste and an identification of the facility which such person wants to handle his waste.

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

	PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
III. DESIGN CRITERIA			
A. Performance Standards	•Geologic conditions shall be such as not to permit pollution of groundwater; site shall not be subject to flooding.	•New units must be designed with liners, leachate collection systems, and final cover systems, as necessary to ensure that the design goal is met. •The State must establish a design goal for new units. •The unit design shall, at a minimum achieve a groundwater carcinogenic risk level (due to continuous lifetime exposure)	•Class I and II landfills must be designed with liners, leachate collection systems, gas collection (if necessary) and final cover systems. •Class III and IV must design on the basis of five-foot layer of geologic buffer and maximum saturated hydraulic conductivity of 10^{-6} cm/s and 10^{-5} cm/s, respectively, between base of fill and seasonal high

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
	within the 1x10-4 to 1x10-7 range.	water table of aquifers. Both must design with final cover and gas collection system on Class III (if necessary) but not Class IV.
	•The compliance boundary may be established by the State, but may not exceed 150 meters from the waste management unit boundary.	•The unit design must ensure that underground drinking water sources not be contaminated or significantly limit the present or future uses of the groundwater at the compliance boundary after closure. •Compliance boundary is the waste management boundary of

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

	PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
			facility or the imaginary boundary circumscribing the waste management boundaries of several units.
B. Design Period	•No specific requirements	•Operating life plus a minimum of 30 years post closure care.	•Class I and Class II: Operating life plus a minimum of 30 years past closure care. •Class III and Class IV: Operating life plus 2 years.
C. Liner Systems	•No specific requirements	•Liner system required, as necessary, to meet design goal.	•Minimum of 3 foot of recompacted soil to achieve a maximum hydraulic conductivity of 1 x 10^{-7} cm/sec.

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

	PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
D. Leachate Collection Systems	•No specific requirements	•Leachate collection systems required, as necessary, to meet design goal.	•Leachate collection systems must be designed to operate for the entire design period. •Must be designed and operated as an integrated system with liners. •Must not exceed a head of leachate one foot above the liner. •Have sufficient capacity to store the volume of leachate expected to be generated in 30 days.
E. Gas Management Systems	•No specific requirements	•Methane gas generated by the facility may not	•Must be designed, constructed, operated and

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
	exceed 25% of the lower explosive limit for methane in facility structures. •The concentration of methane gas may not exceed the lower explosive limit at the facility boundary. •A routine methane monitoring program must be implemented. •If methane gas levels exceed the limits indicated, all necessary steps must be taken to insure the immediate protection of human health.	maintained such that any gases generated by decomposition or other reaction of solid waste are collected and vented, recovered, or otherwise managed such that: -There is no buildup of gas pressure under the final cover such that the functions of such cover are compromised; -The concentration of explosive gases in facility structures does not exceed 25% of the LEL for the gases; and -The concentration of explosive gases at the property

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

	PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
			boundary does not exceed the lower explosive limit for the gases.
F. Final Cover	•A depth of at least 24 inches of compacted cover material shall be placed on the fill not later than 1 week after final lift is completed.	•Units must be designed with final cover systems, as necessary, to insure that the design goal is met.	•Class I and II facilities--the depth of final cover shall be at least 36 inches of compacted soil of which a minimum of 12" shall be for the support of vegetative cover. •Class III and IV facilities--the depth of final cover shall be at least 30 inches of compacted soil of which 18 inches are a low permeability layer overlain by a 12

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

	PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
			inch protective layer. •All classes may use other low permeability layer overlain by final protective layer with approval by the Commissioner.
IV. MONITORING REQUIREMENTS			
A. Groundwater Monitoring	•No specific requirements.	•Consistent groundwater sampling during the active life and post closure care period to provide an accurate representation of groundwater quality at the background and downgradient wells.	•Same

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

	PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
B. Leachate Monitoring	•No specific requirements.	•No specific requirements.	•Collected leachate must be managed in accordance with any other applicable state and local regulations.
C. Landfill Gas Monitoring	•No specific requirements.	•A routine methane monitoring program must be implemented. •The minimum frequency of monitoring must be quarterly.	
V. POST CLOSURE CARE	•All cracked, eroded and uneven areas in final cover shall be repaired to the Department's satisfaction during the year following completion of the fill.	•Post closure care period in two phases. •Phase 1 of the post closure care period to last a minimum of 30 years and consist of: -Maintaining integrity and effectiveness of final cover;	•Post closure care period of 30 years for Class I and II and 2 years for Class III and IV landfills. •During this period, final contours and drainage system, vegetative cover and erosion/sedimentation control

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

		PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
			-Maintaining and operating leachate collection system; -Groundwater monitoring; and -Maintaining and operating gas monitoring system. •Phase 2 of the post closure care period to be a length of time determined by the State and consist of: -Groundwater monitoring; and -Gas monitoring.	leachate monitoring and maintenance, gas monitoring and maintenance and groundwater monitoring and maintenance.
VI.	FINANCIAL ASSURANCE	•No specific requirements.	•Financial assurance required for all landfill owners/operators except an owner/operator who is a State/Federal	•Operators of existing and new facilities must file and maintain financial assurance unless the operator is an

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
	government entity where debt and liabilities are those of the State or U.S. •Closure cost must be adjusted annually for inflation. •Closure cost estimate and amount of financial assurance must be increased if changes in the post closure plan or landfill conditions increase the maximum costs of post closure care. •The financial assurance	agency of the State of Tennessee or Federal Government. •The amount of financial assurance required of the operator shall be established by the Commissioner based upon the estimated cost of operating the facility for a 30-day period plus the estimated closure and post-closure care costs. •Required amount may be adjusted as Closure/post-closure plan is amended.

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

		PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
			mechanisms must insure that the amount of funds insured is sufficient to cover the costs of closure, post closure care, and corrective action for known releases.	•Financial assurance may be provided through a surety bond, personal bond supported by securities or cash, corporate guarantee or municipality or county contract of obligation.
VII.	REMEDIAL ACTIONS	•Should any liquids or gases which might contaminate ground or surface water or create a hazard or nuisance be released from a registered sanitary landfill, then those measures necessary to eliminate the contamination or	•If any constituent is detected at statistically significant levels above the Groundwater Protection Standard, the owner/operator must establish and implement: -A corrective action groundwater	•At any time during groundwater investigation, assessment, or any time deemed necessary by the Commissioner, he may require the operator to develop a corrective action plan or he may require the operator to take

SUMMARY OF CURRENT AND PROPOSED
SOLID WASTE REGULATIONS

PAST TENNESSEE REGULATIONS	PROPOSED U.S. EPA SUBTITLE D REVISIONS	CURRENT TENNESSEE REGULATIONS
nuisance shall be initiated immediately by the registrant. All discharges shall comply with the "Water Quality Control Act of 1971" and the provisions of the "Tennessee Air Quality Control Act."	monitoring program; -The corrective action remedy; -Notify all persons who own the land or reside on the land that directly overlies the contaminant plume; and -Take any action deemed necessary by the State to protect human health and the environment.	specific actions for assessment or specific corrective actions he deems necessary and appropriate.

APPENDIX E

COST COMPARISON OF LANDFILLS WITH BALEFILL TECHNOLOGY

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April 20, 1991

LANDFILL WITH BALEFILL TECHNOLOGY

As a measure of comparison with a sanitary landfill of comparable size, a cost model is developed for a 200 tons per day facility. For this model, we have used the same cost data for the 200 tons per day landfill only model, and have estimated the additional capital and operating costs associated with a balefill.

There are two major advantages associated with a balefill operation. There is a greater rate of compaction and there is a substantial reduction in the dirt cover with a balefill operation. Because the rate of compaction is substantially higher with a balefill, there is increased savings due to the extension of the life of the landfill. With a balefill, the present regulations do not require a cover for the vertical face. This cover is required for a stand-alone sanitary landfill. The major disadvantage of the balefill is the increased costs associated with its construction and operation.

In the landfill only case, a compaction rate of 1000 pounds per cubic yard was used, while a compaction rate of 1550 pounds per cubic yard was used for the balefill scenario. In addition, a 15% loss for cover was used in comparison to a 40% loss for cover in the landfill only case.

The final results show that the tipping fee required for a 200 tons per day sanitary landfill with a balefill operation was 20.55/ton as compared with a tipping fee of $23.50 for the landfill only case (assuming composite liners for both). All calculations are done on a net present value basis.

For a relatively small community disposing of only 70 tons per day,

the costs of balefilling rise sharply--up to $92.20. Since a 70 tons per day landfill will experience costs per ton roughly half of that figure, balefilling is not cost competitive at that size.

Finally, a cost model for a community baling its solid waste and then sending its waste to a regional (200-500 tpd) landfill is given. For a 70 ton per day community, baling will add a little over $8 to the disposal and transportation charges related to regional disposal.

LANDFILL ONLY MODEL
200 TPD - 25 YEAR LIFE

ASSUMPTIONS
125 acre site
100 acre fill area
200 tons per day
25.4 year life
1000 lbs/cubic yard compaction rate
0.4 loss for cover
Composite liner
Aa Private debt financing

			ANNUAL COST
1.	DEVELOPMENT		
	Land cost (125 acres @ $2,000/acre)	$250,000	
	Engineering and site development	200,000	
	Legal, hearings, and regulatory fees	75,000	
	Administrative and support services	100,000	
	Unanticipated costs	25,000	
	Subtotal	650,000	
2.	CONSTRUCTION COSTS		
	20 acres initial @ $100,000/acre	2000,000	
	Total development and construction	2,650,000	
	Amortization of 1 & 2 @ 9.75%		$284.400
3.	ONGOING DEVELOPMENT AND CONSTRUCTION		300,000
4.	OPERATIONS AND MAINTENANCE COSTS		
	Equipment costs	82,500	
	Site personnel costs	111,000	
	Insurance and other benefits	33,300	
	Equipment operations	230,000	
	Miscellaneous: facility overhead, leachate treatment, environmental monitoring, and other costs	165,000	
	Subtotal		621,800
5.	CLOSURE		46,000
6.	POST CLOSURE		92,000
	TOTAL ANNUAL COSTS:		$1,344,200
	TIPPING FEE: $/TON		23.50

SANITARY LANDFILL WITH BALEFILL OPERATION
200 TPD - 26.5 YEAR LIFE

ASSUMPTIONS
90 acre site
65 acre fill area
200 tons per day
26.5 year life
1550 lbs/cubic yard compaction rate
0.15 loss for cover
Composite liner ($100,000/acre)

LANDFILL

			ANNUAL COST
1.	Development	490,000	
2.	Construction	1,300,000	
	TOTAL DEVELOPMENT COST	1,790,000	
	Amortization of 1 and 2		$191,500
3.	On-Going Development and Construction		144,900
4.	Operations and Maintenance		398,350
5.	Closure		24,000
6.	Post Closure		46,000
	TOTAL ANNUAL LANDFILL COSTS		804,750

BALEFILL

1A.	Capital Costs	1,390,000	
	Amortization of Capital Costs:		
	5 year equipment	50,000	12,750
	10 year equipment	640,000	102,000
	20 year equipment	700,000	81,000
2A.	Operations and Maintenance		175,000
	TOTAL ANNUAL BALEFILL COSTS:		370,750
	TOTAL ANNUAL SYSTEM COSTS:		1,175,500
	TIPPING FEE: $/TON		20.55

SANITARY LANDFILL WITH BALEFILL OPERATION
70 TPD - 25 YEAR LIFE

ASSUMPTIONS
30 acre site
25 acre fill area
70 tons per day
25 year life
1300 lbs/cubic yard compaction rate
0.2 loss for cover
Composite liner
Aa Private debt financing

	LANDFILL		ANNUAL COST
1.	Development	210,000	
2.	Construction	500,000	
	TOTAL DEVELOPMENT COST	710,000	
	Amortization of 1 and 2		76,500
3.	On-Going Development and Construction		75,000
4.	Operations and Maintenance		339,100
5.	Closure		6,000
6.	Post Closure		11,500
	TOTAL ANNUAL LANDFILL COSTS		508,100
	BALEFILL		
1A.	Capital Costs	575,000	
	Amortization of Capital Costs:		
	10 year equipment	305,000	48,400
	20 year equipment	270,000	31,300
2A.	Operations and Maintenance		88,000
	TOTAL ANNUAL BALEFILL COSTS:		167,700
	TOTAL ANNUAL SYSTEM COSTS:		675,800
	TIPPING FEE: $/TON		92.20

BALING ONLY MODEL

70 TPD

SHIPPING TO REGIONAL LANDFILL

			ANNUAL COST
BALING			
1A	Capital Costs	575,000	
	Amortization of Capital Costs		
	10 Year Equipment	305,000	48,400
	20 Year Equipment	270,000	31,300
2A	Operation and Maintenance		88,000
	TOTAL ANNUAL BALING COSTS		167,700
	BALING EXPENSE: $/TON		8.36
	TIPPING FEE AT REGIONAL LANDFILL: $/TON		12.95-21.00
	TRANSPORTATION COSTS: $/TON		2.72-3.89
	TOTAL DISPOSAL SYSTEMS COST: $/TON		$24.03-33.25