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Project Summary

Environmental Impacts of Special Types of Landfills

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Monitoring was done for 1 year at a hillfill, balefill, millfill, strip mine landfill, and permitted sanitary landfill to determine the impact of each on water quality. Leachate generated by the hillfill was strongest during initial decomposition, but it was in the final stages of anaerobic degradation during the study period and therefore of low strength. The presence of a shallow water table and groundwater mounding within the hillfill resulted in a severe, localized impact on groundwater quality, but no impact on adjacent surface water. The balefill method channels water through the landfill producing low strength leachate. This low strength and the 30-meter separation distance between the landfill and water table results in minimal impact on groundwater quality. The millfill generated the strongest leachate during the study period because milling accelerated the decomposition of refuse. The millfill, however, had minimal, localized effect on groundwater resources. The strip mine landfill generated leachate of moderate strength and exerted a moderate impact on ground- and surface-water resources. The permitted sanitary landfill also produced leachate of moderate strength and exerted minimal, localized impact on water quality because of the attenuative properties of the surficial materials and a significant depth to water.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Solid waste generation and disposal represent a continuing environmental problem throughout the United States. The amount of solid waste being disposed of on land represents 90 percent of the total municipal solid waste. This solid waste is disposed in approximately 15,000 sites of which approximately one-third are permitted facilities. The Resource Conservation and Recovery Act (RCRA) requires the phasingout of open dumps during the 1980's, which will result in disposing of increased volumes of waste in existing sanitary landfills and/or the opening of large landfills.

Therefore, wherever suitable landfill sites are available, they must be used efficiently by placing more refuse in the site (i.e., increasing its height, or hillfills) or through volume reduction (i.e., milling or baling.) Large abandoned strip mines offer potential for resolving waste disposal problems in major metropolitan areas. The growing need to completely use available space at suitable waste disposal sites makes it necessary to evaluate and compare the standard sanitary landfill with alternative landfilling methods to determine the relative environmental impact, especially on ground- and surface-water resources.

The alternative methods of waste disposal (millfill, balefill, hillfill, and strip mine landfill) represent potential pollution sources as does the standard sanitary landfill. The characteristics of these methods that may promote or prevent pollution have not, however, been fully documented. The purpose of this study was to compare and evaluate volume reduction (millfill and balefill) and alternative methods of waste disposal (hillfill and strip mine landfill) with the sanitary landfill to (1) determine the relative environmental impact on water resources, (2) determine site characteristics that contribute to or, conversely, prevent pollution, and (3) provide projections of the probable usefulness of each method in a particular geographic area.

Site selection was initiated with a survey of known sites using alternative methods of waste disposal (hillfill, balefill, millfill, and coal strip mine landfill). The survey identified 17 hillfills, 15 balefills, 23 millfills, and 253 coal strip mine landfills east of the Mississippi River.

Each site was evaluated on a selection criteria encompassing many variables (depth to water, geology, hydrology, refuse-processing, site preparation). Site selection criteria included:

1. Availability of detailed engineering and scientific reports.
2. Availability of background analytical data.
3. Existence of monitor wells.
4. Availability of the site for study.
5. Accessibility of the site.
6. Status of litigation, if any.
7. Overall representative nature of the site.
8. The sites must be unlined.
9. Refuse must have reached field capacity and be generating leachate.
10. The sites must not accept large quantities of industrial wastes.
11. All sites must have similar climatology.

Survey data and site selection criteria were compared and reduced to a matrix that identified the principal characteristics of each site as they relate to the criteria and identified facilities appearing to meet the criteria. The operator of each site was contacted and a formal request made for their cooperation in conducting the study. To gain the cooperation of site owners, it was agreed that site names and locations would be held in confidence, so sites will be referred to only by the method of landfilling used and the general location.

Five sites were identified as principal candidates for study. Their existing hydrologic and analytical data were reviewed to define the direction of groundwater flow and contaminant enclaves. This information was used to determine whether additional monitor wells were necessary to refine the capabilities of the monitoring system that would assess groundwater quality and evaluate the environmental impact of the waste disposal sites on the groundwater quality. All sites except the sanitary landfill required additional wells. Because of a previous study, the sanitary landfill had an adequate network of wells. Monitoring wells were located at each of the other sites, upgradient and downgradient of the landfills, to define groundwater and contaminant movement. Drilling methods were developed for each site based on the prevailing geologic conditions. Air rotary drilling was used at the millfill and coal strip mine landfill; soil boring was used at the hillfill; and mud rotary drilling, at the balefill.

To gain additional information on the attenuation properties of each site, particle size analyses were conducted on samples obtained during well drilling for the four sites located on unconsolidated material: the hillfill, balefill, millfill, and permitted sanitary landfill. Samples were tested according to the American Society for Testing and Materials (ASTM) D 422 to plot grain size distribution curves.

Chemical analytical parameters were determined (by the U.S. Environmental Protection Agency (EPA)) before the study and were limited to three anions, three cations, three nutrients, and three demand tests. After studying the historical data for each site, it was determined that each sample collected would be analyzed for alkalinity, acidity, sulfate, chlorides, total organic carbon (TOC), chemical oxygen demand (COD), total solids, total dissolved solids (TDS), nitrate nitrogen, ammonia nitrogen, phosphates, total Kjeldahl nitrogen (TKN), copper, iron, manganese, sodium, lead, and zinc. In addition, pH, temperature, and specific conductivity would be measured in the field for each sampling point.

Data from samples collected on a quarterly basis for a year were examined for seasonal fluctuations and to determine if the results of chemical analysis could be correlated with meteorological events. At each site, depth to water was first measured to assess groundwater flow direction. Then samples were collected after each well had been cleared to ensure that representative samples were obtained. After samples were obtained and field measurements of pH, temperature, and specific conductivity taken, the samples were filtered through No. 40 filter paper using a Buchner filtering funnel and flask. Samples were preserved according to EPA standard methods, iced, and shipped by air to the laboratory where EPA standard analytical procedures were followed.

The initial process of data interpretation involved reviewing historical (previously existing) analytical data for each site selected.

Methods of display (series of bar graphs (histograms), Stiff diagrams, and a nitrogen index) were developed to illustrate the results and to allow clear concise interpretation and comparison. Bar graphs illustrated the mean concentration of the general indicators of water quality including alkalinity, acidity, TDS, TKN, COD, and TOC. The relative height of each bar makes comparison among the monitoring points readily apparent for similar parameters.

To further illustrate effects on groundwater and surface water and on water quality variations, Stiff diagrams were constructed using the average concentrations of sodium, iron, manganese, zinc, chloride, sulfate, nitrate, and phosphate.

The nitrogen index was used to delineate redox (oxidation and reduction) zones in groundwater and to determine the location of reducing fronts as leachate migrates from the landfill. Ratios for the study period were calculated using mean values.

On the basis of the environmental impacts and the consideration of site characteristics, waste disposal methods were compared and contrasted to identify the suitability of each for use in various geographic areas.

Conclusions

Virtually all unlined solid waste disposal facilities impact negatively on ground- and surface-water resources to some extent. The factors that effectively mitigate the impacts of waste disposal facilities include methods of operation, site suitability (in particular, depth to groundwater), and engineering design. Based on the site selection process for the present study, the conventional permitted sanitary landfill is the most common method of waste disposal. The next most common method is using strip mine landfills, which are frequently found in Pennsylvania, Ohio, and Illinois. Millfills, balefills, and hillfills are relatively uncommon.

The landfills investigated in this study performed fairly well and exerted only minimal, localized adverse impacts on the surrounding groundwater and surface water; an exception is the hillfill. In general, contamination from each site was not significant beyond the property boundary. The effects of each landfill on groundwater quality could be compared with that of the background groundwater quality, but downgradient water quality was frequently within drinking water standards. Many differences observed in the study resulted from the method of landfilling and variations among site conditions, ages, and the amount of refuse emplaced in each land fill (Tables 1 and 2). The potential volume and strength of leachate were two primary factors that are direct functions of the method of landfilling.

The following are conclusions regarding each of the five methods of operations investigated.

Hillfill

Hillfilling is an effective method to reduce the areal extent of a landfill. It increases the volume of waste per unit area through an increase in height and decreases the potential volume of leachate because of steep slopes that reduce infiltration. Its relatively small base lends itself well to a leachate collection system. Since the hillfill that was studied was large, however, it had the greatest total potential volume of leachate. The leachate generated by the hillfill (1969 data) was the strongest. During 1978 and 1979, the hillfill was in the final stages of anaerobic degradation, however, and therefore generated a leachate of lower strength at that time. A hillfill may be less structurally stable than a permitted sanitary landfill and leachate breakouts between lifts and cells may occur. Gas production also may be a problem. In addition, the steep slopes increase runoff that contributes to erosion and causes maintenance problems.

The hillfill had the most severe environmental impact on groundwater resources but no impact on adjacent surface water Its impact was localized because of a minimal groundwater gradient and attenuation attributable to the presence of clay at the site. Leachate did not contaminate the bedrock aquifer but moved downward into the shallow aquifer. Degradation of the groundwater resources was primarily caused by the shallow depth to water and the groundwater mounding occurring within the hill. Leachate is impounded within the hill as a result of the construction of a relatively impermeable clay base. Because of the head of leachate within the hillfill, it is possible that leachate migrates outward from the base of the landfill through ruptures in the clay.

Balefill

Baling is the most effective method of volume reduction; it results in the highest density of refuse, void space is reduced, and structural stability is increased. It effectively reduces the area required for landfilling and minimizes the amount of cover material required. Among the five sites investigated, the balefill contained the greatest total weight of refuse and the greatest density of refuse. Although the balefill should have the lowest potential volume of leachate per unit basal area because of its large basal area, it has the second highest total potential leachate volume.

Less equipment is needed at the site, and it is more easily maintained; only a forklift and small front-end loader are necessary. In addition, if the baling facility is centrally located for collection trucks, there will be less driving time and fuel consumption. Resource recovery is facilitated at the baling plant; as refuse travels along conveyor belts, metals and corrugated cardboard are easily removed for recycling.

The disadvantages of baling refuse include equipment costs, which may be partially offset by the economic advantages previously discussed. Careless operation and stacking at the balefill site may forfeit much of the benefit of volume reduction. Finally, if refuse bales are placed near water or in an area where groundwater may reach them during wet periods, there will be considerable pollution potential.

The leachate generated had the lowest concentration of any among the five landfills studied, and this was attributable to the high density of refuse that causes a rapid channeling of water through the bales. The site has had a minimal, localized impact on groundwater resources, indicating a lower level of contamination when compared with that of the permitted sanitary landfill. The minimal impact can be attributed to a combination of low strength leachate and a separation distance in excess of 30 m (100 ft) between the base of the landfill and the water table.

Millfill

Millfilling achieves a high density of refuse and is an effective volume reduction method that minimizes the area required for landfilling and, although such was not the practice at the site studied, does not require daily cover. It is structurally more stable and has less settlement than a permitted sanitary landfill because of its relative density. The increased volume of refuse within a smaller area and the rapid decomposition producing higher concentrations of leachate facilitate leachate collection and treatment. This method can be advantageous because proper site selection and a substantial separation between the millfill and the groundwater result in rapid decomposition and a shorter time period needed for stabilization with the landfill.

The public is generally more receptive to a millfill site bacause blowing papers, vectors, and odors are reduced. Less cover material is needed, and there are more efficient transport and landfilling procedures.

A major disadvantage of this method is the cost of running a milling facility. In addition, if not properly separated from groundwater, or surface water, or both, the strong leachate produced could have a severe effect on the environment.

The leachate generated by the millfill, based on the one sample that could be collected, was the strongest among the leachates analyzed during the study period. The increased surface area of milled refuse accelerates physical and chemical decomposition; leachate is produced more quickly and is characteristically of greater strength. The leachate is comparable to the initial leachate concentration generated by the hillfill. It has had a minimal localized effect on groundwater resources and comparably less impact that the permitted sanitary landfill which, in part, may be because of the distance between the fill and the monitor wells. The millfill has not significantly polluted the aquifer, and the water supply at the landfill remains potable. Because daily cover is applied, the millfill examined in this study appears to behave more similarly to a permitted sanitary landfill

Table 1. *Characteristics Contributing to the Impact of Each Landfill on Ground and Surface Water*

Landfill	Years since completion	Area of fill	Total weight of refuse	Average volume per unit area	Approximate density of refuse	Method of operation and cover-to-refuse ratio
Hillfill	8 (operated from 1965-71)	16 ha (40 ac)	272,340 tonnes[a] (300,000 tons)	47,500 m^3/ha (25,000 yd^3/ac)	355 kg/m^3 [a] (600 lbs/yd^3)	Above-grade landfill refuse cells. 1:1
Balefill	5 (operated from 1971-74)	4 ha (9 ac) 12 ha (30 A)	337,800 tonnes (372,155 tons)	250,000 m^3/ha (130,000 yd^3/ac)	800 kg/m^3 (1,350 lbs/yd^3)	Baled refuse, stacked. 1:9
Millfill	Active (since Dec. 1973)	7 ha (18 ac)	317,700 tonnes (350,000 tons)	127,840 m^3/ha (64,800 yd^3/ac)	653 kg/m^3 (1,100 lbs/yd^3)	Covered, milled; area filled. 1:7
Strip mine landfill	Active (since June 1971)	5.7 ha (14 ac)	105,000 tonnes (116,000 tons)	69,957 m^3/ha (37,027 yd^3/ac)	263 kg/m^3 (450 lbs/yd^3)	Refuse filled in strip mine excavation. 1:4
Permitted sanitary landfill	4 (operated from 1971-75)	4 ha (10 ac)	38,800 tonnes (42,750 tons)	25,155 m^3/ha (13,104 yd^3/ac)	386 kg/m^3 (652 lbs/yd^3)	Trench method. 1:1

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[a] Estimated value.

[b] *Chemical interference suspected.*

[c] *Chemical interference.*

[d] *Boone County test cell 2D - mean value of analyses from 4 years following completion of cell.*

[e] *No historical data is available for the millfill, the strip mine landfill, or the permitted sanitary landfill.*

Table 2. *Impact of Five Sites Shown by Representative Downgradient Wells*

Parameter[a]	Hillfill[b]		Balefill[c]	Millfill[c]	Strip mine landfill[d]		Permitted sanitary landfill[e]	
					min	max	min	max
alkalinity	589	899	370	394	243	318	279	581
TOC	22.4	52.0	33.6	9.4	6.8	8.8	5.9	10.1
COD	52.0	131.8	71.5	8.7	11.7	17.3	0.55	14.3
TDS	922	1360	424	396	623	817	455	607
TKN	2.04	5.14	0.25	0.14	0.28	1.60	0.14	0.37
Na	12.1	115.1	24.3	7.78	6.5	50.0	5.9	66.7
DTW[f]	0		35 (115)	6.1 (20)	24.4 (80)		15.2 (50)	
distance[g]	42.7 (140)		0	133.2 (437)	42.1 (138)		0	
Avg % clay	4%		3%	4%	—		9%	
PVL[h]	27,057 (21.93)		20,032 (16.02)	15,232 (12.86)	13,059 (10.52)		7,072 (5.80)	

[a] *Chemical analyses expressed in mg/L.*

[b] *Downgradient wells, MP #4, #5, #9, and #10 showing minimum and maximum values.*

[c] *Downgradient well, MP #2.*

[d] *Downgradient wells, MP #5 and #7 showing minimum and maximum values.*

[e] *Downgradient wells, MP #2 and #5 showing minimum and maximum values.*

[f] *Depth to water below landfill base in m (ft).*

[g] *Approximate distance between landfill and well(s) in m (ft).*

[h] *Potential volume of leachate in m^3 (ac-ft).*

Sediment type underlying landfill rom surface to bedrock) and average % clay	Depth to water from base of landfill	Average annual precipitation + deviation during study period	Potential volume of leachate	Strength of Leachate^d		
					1978-79 study in mg/L	historical data in mg/L
l sorted sands & gravels, n (40 ft). Poorly sorted 12 m (40 ft). 4%	Mounded in hillfill	86.49 cm (34.05 in) +27.23 cm (10.72 in)	27,057 m^3 (21.93 ac-ft)	COD	2,992	(39,680)
				TDS	3,084	(19,144)
				Na	380	(900)
				SO_4	12,000	(680)
dy till, 15 m (50 ft). ial drift (clay, sand, el), 9-37 m (30-120 ft). vial sands & gravels, m (328 ft). 3%	35.1 m (115 ft)	65.88 cm (25.94 in) + 9.74 cm (3.84 in)	20,032 m^3 (16.02 ac-ft)	COD	967	(718)
				TDS	3,801	(2,241)
				Na	572	(1,079)
				SO_4	2,040	(---^{a})
ial outwash (sands & els), 15 m (50 ft). 4%	6.1 m (20 ft)	83.69 cm (32.95 in) + 0.06 cm (0.02 in)	15,232 m^3 (12.86 ac-ft)	COD	23,690	
				TDS	19,500	
				Na	828	
				SO_4	519	
ey decomposed spoil, 5 m (5-16 ft).	24.4 m (80 ft)	104.10 cm (40.98 in) + 6.92 cm (2.71 in)	13,059 m^3 (10.52 ac-ft)	COD	9,580	
				TDS	11,145	
				Na	1,500	
				SO_4	---^{b}	
5 m (16 ft). 9%	15.2 m (50 ft)	78.60 cm (30.94 in) + 4.94 cm (1.94 in)	7,072 m^3 (5.80 ac-ft)	COD	17,799^c	
				SC	8,320^c	
				Na	281^c	
				SO_4	171^c	

than to the classic millfill, which is uncovered.

Strip Mine Landfill

The strip mine landfill had the lowest refuse density of the five sites investigated. Because of the existing strip pits, previously excavated cover material (spoil), and existing access roads, however, a strip mine landfill can be operated at a relatively lower cost than a permitted sanitary landfill or either method of volume reduction landfilling. Land reclamation being simultaneously accomplished is an additional benefit. Another possible advantage might be the presence of established rail service to major cities that would facilitate the long-range transport of wastes from metropolitan areas.

Excavation creates substantial highwalls in many strip mines so that the volume of refuse per area may be increased in comparison with that at a permitted sanitary landfill. Steep slopes may minimize infiltration and therefore decrease the potential volume of leachate generated. The leachate tends to neutralize acidity from acid mine drainage. Underclays that often are present beneath coal limit leachate migration.

Disadvantages of strip mine landfilling include the absence of significant soil thickness for the attenuation of leachate; this increases the pollution potential of the landfill. The complex hydrogeologic conditions associated with coal mining frequently increase the potential for contamination. Examples are the presence of perched water tables, underclays, and impermeable shales as well as a potential for the channeling of contamination through fractures and bedding planes. The steep slopes often found at strip mine landfills may promote erosion and maintenance problems not found at permitted sanitary landfills, balefills, or millfills.

A strip mine landfill would be subject to blowing paper, vectors, and odor problems similar to those of the conventional type landfill. Because of the remoteness of most strip mining areas, however, less public reaction may be anticipated, but the transportation of refuse from the place of generation to the landfill site may involve greater distances than at other types of landfills.

The leachate generated was of moderate strength and lower in concentration than that initially generated by the hillfill or millfill. The leachate exerted a moderate impact on groundwater and surface water resources. Because attenuative soils generally are not present, there is the greatest potential for contamination. The site, however, did not have a significantly adverse impact on the groundwater because: (1) a substantial separation exists between the base of the landfill and the water table; (2) the base of the landfill was backfilled with spoil material before initiating landfilling operations; and (3) the slopes increase the amount of runoff and decrease infiltration because the completed areas of the landfill have been restored to approximate original contour.

Permitted Sanitary Landfill

Permitted sanitary landfilling is an engineered method of disposing of solid wastes on land by spreading them in thin layers, compacting them to the smallest practical volume, and covering them with soil each working day in a manner that protects the environment. The planning and applying of sound engineering principles and construction techniques make the sanitary landfill an acceptable alternative to open or burning dumps.

The primary advantage of a permitted sanitary landfill is the relatively low operation cost. Disadvantages include the large area required for landfilling and the cost of suitable land. Subsidence limits the possible subsequent uses of the land. In addition, vectors, blowing paper, and odors are problems common to this method of landfilling and often incur negative public reactions.

Among the sites investigated, the permitted sanitary landfill had the least amount of refuse and the lowest potential volume of leachate due to its small areal extent. It exerted a minimal localized impact on the surface and groundwater resources in its vicinity. Immediately beneath and adjacent to the landfill, degradation of groundwater was noticeable; however, there was no contamination to adjacent surface water. The minimal impact of the permitted sanitary landfill leachate on groundwater may be attributed to a combination of the attenuative properties of the surficial materials at the site and a significant depth to water.

When projecting the applicability of the methods of landfilling discussed in this report, a primary consideration is the potential contamination of surface and ground waters. Among the factors that must be considered when siting landfills, climate is the most important since it determines the amount of recharge to an area. The amount of recharge is also affected by topography and vegetation.

The geology, soils, and topography of a region determine the capacity of the natural surroundings of a landfill site to accept and attenuate pollutants. The type of bedrock (and/or surficial geologic deposits) beneath a landfill are of basic importance because they determine the characteristic soils and topography of an area. Geology also influences groundwater movement. Depending on the type of bedrock and the climate, physical and chemical weathering processes produce varying conditions such as shallow depth to bedrock (shallow soils), thick saprolite, and problems such as sinkholes in limestone terrain.

Desirable conditions for a landfill site, because they promote attenuation, include the presence of thick saprolite, thick deposits of glacial till, other glacial sediments containing clay, and other unconsolidated sediments containing significant amounts of clay. The presence of sand or gravel and the absence of soil or unconsolidated sediment are undesirable conditions.

The characteristics of the groundwater in an area is a primary concern. A substantial distance between the base of a landfill and the top of the water table is imperative. All types of landfills have a great potential for the severe contamination of groundwater resources if they are located above the apparent level of the water table. Seasonal variations and the tendency for mounding of groundwater within landfills must be considered. The natural quality of the groundwater should also be considered. If it has already been degraded by geologic conditions (e.g., acid mine drainage) or if the groundwater is saline as in coastal areas, a landfill will have a relatively diminished impact since such groundwater cannot be considered for use without treatment.

Finally, the population of an area should be considered; density determines the amount of refuse produced and the rate at which it is produced and affects the availability and cost of useful land. Considerations of population may affect the preference for using volume reduction compared with using conventional methods of landfilling.

The combination of the factors presented above makes certain methods of landfilling more desirable in particular geographic areas of the country or where certain socioeconomic conditions prevail.

Recommendations

Hillfills are particularly suitable for densely populated areas since the volume of refuse per acre is reduced. Since the potential volume of leachate is also reduced, hillfills may be preferred over other methods of landfilling in humid regions; care must be taken, however, to avoid areas with a shallow depth to groundwater.

Balefilling is also a preferred method for densely populated regions because it too is a method of volume reduction. Because a balefill produces leachate of low strength and has a relatively low potential for contamination, balefilling might be the best method of landfilling for the humid south, especially in areas with a shallow depth to water, and in sandy coastal areas with relatively little potential for attenuation. The benefits of balefilling generally are not applicable to arid regions because such areas are usually less populated and because the potential volume of leachate in such regions would be small for any type of landfill.

Because it produces a strong leachate, millfills would be best located in areas having thick deposits of unconsolidated sediments containing significant amounts of clays. The glaciated northeast, the Great Lakes region, and the Piedmont province in both the northeast and the humid south are examples of areas suitable for millfills. They characteristically have geologic materials that can attenuate the relatively strong and rapidly produced leachate of a millfill, provided there is a substantial depth to water beneath the landfill. Millfilling reduces the volume of refuse and the size of the area needed for landfilling; these considerations are advantageous in the densely populated eastern portions of the country.

Strip mine landfills are limited to areas of the country that have been strip mined. Those located in the arid west have the benefit of a climate that tends to limit the potential volume of leachate. Strip mine landfills are advantageous primarily because strip mining areas are sparsely populated and the previous site development for mining offers certain economic benefits.

The conventional method of landfilling solid waste is applicable throughout the country, but particularly in sparsely populated arid areas where landfilling by the trench method would offer the advantage of relatively low cost. The conventional method of landfilling is also desirable in glaciated regions and in older eroded mountainous regions where saprolite is found. The permitted sanitary landfill (trench method) is not recommended for the humid south or coastal plain regions because of the shallow depth to water typical of such areas. Excavations for trenches decrease the distance to the water table and thus increase the pollution potential of the landfill.

Based on the environmental impacts of each of the five sites studied, it appears that all five methods are environmentally acceptable methods of operation if site characteristics allow for the natural renovation of leachate. It must be emphasized that site characteristics, particularly depth to water, are crucial to the ultimate impact of any landfill, regardless of the method of operation. The results of this study suggest that balefilling and millfilling offer significant benefits when these methods are used under optimal site specific circumstances. Because of their capital cost, however, a relatively dense level of population is required to support the associated processing facilities.

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The complete report, entitled "Environmental Impacts of Special Types of Landfills," (Order No. PB 82-231 432; Cost: $22.50, subject to change) will be available only from:

National Technical Information Service
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