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TECHNICAL BACKGROUND DOCUMENT

COST ANALYSIS FOR THE PROPOSED RULE ON ALTERNATIVES FOR GROUND-WATER MONITORING AT SMALL, DRY OR REMOTE MUNICIPAL SOLID WASTE LANDFILLS

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DRAFT Cost Analysis of the Proposed Rule for Alternatives for Ground-Water Monitoring at Small, Dry, Remote Municipal Solid Waste Landfills

Section 1. Background and Proposed Rule Requirements

On October 9, 1991, the Environmental Protection Agency (EPA) published its original criteria for Municipal Solid Waste Landfills (MSWLF) (40 CFR Part 258). This criteria provided an exemption for ground-water monitoring requirements for qualifying small, dry or remote MSWLFs. A 1993 decision by the U.S. Court of Appeals for the District of Columbia vacated this small, dry or remote MSWLF ground-water monitoring exemption. As a result of requiring full ground-water monitoring at small MSWLFs, annual waste disposal costs for communities being served by these small, dry or remote landfills have been projected to increase several hundred percent.

While the court decision does not allow for a total ground-water monitoring exemptions, it does provide for alternatives to ground-water monitoring requirements based on consideration of local landfill size, location, and climate. Therefore, EPA is proposing to provide approved states and tribes with additional flexibilities in determining ground-water regulations for small, dry or remote MSWLFs. Under this proposal, monitoring at eligible landfills could be conducted using a variety of existing geochemical and geophysical technologies capable for detecting and assessing potential contamination.

Section 2. Analytic Strategy

The following analysis estimates costs to small/dry municipal solid waste for (1) full 40 CFR Part 258 ground-water monitoring requirements costs (baseline), and (2) several possible alternatives to full ground-water monitoring requirements, including: using existing wells to sample ground-water; reducing the list of constituents being monitored for; sampling materials in the unsaturated zone; collecting soil gas samples from the unsaturated zone, surveying the electrical resistivity of the soil beneath the landfill, and using gypsum block to detect moisture beneath the landfill. These alternatives are a subset of options that could be chosen by the approved state or tribal government under the proposed rule.

In developing national costs of the proposed rule requirements, EPA assumed that individual landfills would be able to implement the most cost-effective alternative for that landfill. Instead of applying one alternative to all landfills (e.g. assuming that all landfills will collect soil gas samples), EPA applied the lowest cost option for each landfill type (1 ton per day, 10 tons per day, 5 year remaining life, 10 year remaining life, etc) to that universe of landfills, and then summed all these cost estimates to determine national annual costs.

Although full 40 CFR Part 258 ground-water monitoring requirements are considered the baseline in this cost analysis, these requirements are not scheduled to take effect until October 1995. Thus the cost savings presented in this analysis are not savings over current practices, but rather savings over what will be required in October 1995 if the proposed amendments are not promulgated.

Section 3 below explains how the universe of affected facilities was determined. Section 4 presents the methodology for determining facility costs for both the baseline and six alternative scenarios. Section 5 presents annual facility costs for the baseline and six alternative scenarios, and national annual costs of the baseline and of the aggregate of lowest-cost alternatives for each landfill type. Section 6 discusses limitations of this cost analysis, and Section 7 summarizes impacts to small entities.

Section 3. <u>Potentially Affected Universe</u>

EPA estimates that approximately 275 to 500 small/dry municipal solid waste landfills will be affected by this proposed rule. (Other municipal solid waste landfills are not affected by the proposal). In estimating the potentially affected universe, EPA first estimated the number of small/dry municipal solid waste landfills, and then determined the number expected to use alternatives to ground-water monitoring requirements. The Agency does not have data on the numbers of small/remote landfills therefore this cost analysis represents only landfills that are small/dry. However, the Agency believes that many of the small/remote landfills (i.e., landfills in Alaska) are also in dry areas and thus are captured in the universe estimate of small/dry landfills.

For the purposes of this analysis, "small landfill" is defined as a landfill which received less than 20 tons per day (TPD) for 260 days per year. "Dry landfill" is defined as a landfill located in an area receiving less than 25 inches of precipitation per year. Table 1 presents the categories and estimated number of small/dry landfills.

TABLE 1. ESTIMATED NUMBER OF SMALL/DRY LANDFILLS

Size (tons/ day)	State GWM[1] Regs?	Remaining Life (yrs)	Total # of Landfills	Landfills Affected by Rule (low end)	Landfills Affected by Rule (high end)
One	no	5	103	103	103
		10	31	31	31
		20	82	82	82
	yes	5	175	-	175
		10	41	-	41
		20	113	-	-

Size (tons/ day)	State GWM[1] Regs?	Remaining Life (yrs)	Total # of Landfills	Landfills Affected by Rule (low end)	Landfills Affected by Rule (high end)
Ten	no	5	41	41	41
		10	0	0	0
		20	21	21	21
	yes	5	41	-	-
		10	31	-	-
		20	72	-	-
TOTAL			751	278	494

[1] **Ground-water monitoring.**

Estimates of the number of small/dry landfills are extrapolated from EPA's 1986 Solid Waste (Municipal) Landfill survey results to the entire landfill universe as defined by the 1986 Census of State and Territorial Subtitle D Non-Hazardous Waste Programs. In the survey, owner/operators reported the expected year of landfill closure. These data are used to categorize landfills into expected lifespan increments. Small/dry landfills which reported expected closure prior to 1995 are assumed to have closed, and since regional landfills are most often less expensive on a cost per ton basis to build and operate, it is assumed these communities joined a regional disposal system. Landfills which were reported to have closure dates after 1995 are placed into three categories of closure, i.e., closure dates of 5, 10 and 20 years after 1995.

The landfills were then divided into two additional categories: those located in states with no ground-water monitoring requirements (36 percent of landfills) and those located in states with ground-water monitoring requirements (64 percent of landfills). As of 1991, all but 11 states had ground-water monitoring requirements.

Landfills were also assigned to one of two size categories. Landfills receiving between 5 and 20 TPD were assigned to a 10 TPD category for purposes of this cost analysis. Landfills receiving less than 5 TPD were assigned to a 1 TPD category.

After estimating the total number of small/dry landfills, EPA then determined which landfills would be expected to choose an alternative to baseline ground-water monitoring requirements. The 278 landfills which are located in states without existing ground-water monitoring requirements (and therefore have not invested in drilling wells) are most likely to choose an alternative. In the low end of the cost analysis, EPA assumed that all 278 landfills in states without ground-water monitoring requirements would use alternatives.

The smallest landfills with a short remaining life will be significantly impacted by ground-water monitoring requirements costs because they will have less of an opportunity to recover costs through tipping fees. For this reason, in the high end cost analysis, the 216 one ton per day landfills with 10 years or less remaining life are also assumed to choose alternatives to baseline ground-water monitoring requirements (even those in states with existing ground-water monitoring requirements). When combined with the landfills in states with ground-water monitoring requirements, the total estimated number of landfills expected to use alternatives is 494, in the high-end cost scenario.

Section 4. Methodology and Assumptions

Section 4.1 Ground-water Monitoring Requirements(Baseline)

The assumptions listed below are the same as those used in the original Regulatory Impact Analysis (RIA) for the October 9, 1991 Revised Criteria for Municipal Solid Waste Landfills (MSWLFs) (i.e., MSWLF RIA), except where indicated.

Note that although ground-water monitoring costs are considered baseline for the purpose of this analysis, the regulations requiring ground-water monitoring at small/dry landfills are not scheduled to take effect until October 1995.

- For the purposes of this analysis, it is assumed that ground-water monitoring would occur during operating life and for a 30 year post-closure care period. EPA recognizes, however, that approved states will have some flexibility in designing ground-water monitoring requirements (e.g., they may shorten the post-closure care period).
- Costs are scaled to 1993 dollars. Cost assumptions in the MSWLF RIA are in 1986 dollars. These were converted into 1993 dollars using the Engineering News-Record Construction Cost Index (an increase of 21 percent over the period).
- Costs include a hydrogeologic study to characterize the ground-water flow and quality at the site. The cost is $133,400 in 1993 dollars, regardless of site size.
- Capital costs for a 10 TPD facility (consisting of 5 well clusters with 3 wells each) are assumed to be $131,700 in 1993 dollars. The capital cost for a well system at a 1 TPD facility (consisting of 3 well clusters with 3 wells each) was assumed to be $81,300.
- Operating costs include sample collection and analysis cost of $436 per sample. Each individual well is sampled twice per year. The annual cost of sampling and maintenance for the 10 TPD landfills is $13,100 during the operating life and $14,400 over the 30-year post-closure period. The annual cost of sampling and maintenance for the 1 TPD landfills is $7,900 during the operating life and $8,700 over the 30-year post-closure period.
- Landfills in states without current ground-water monitoring requirements are expected to incur full costs of ground-water monitoring including hydrogeologic study, construction of well systems, sampling and operation and maintenance. Landfills in states with current ground-water monitoring requirements are assumed to incur costs of hydrogeologic study and sampling only.
- Costs for individual landfills are annualized using two approaches.

- For the low-end, it is assumed that the landfills have the opportunity to annualize the cost of the ground-water monitoring requirements over the lifespan of the existing landfill plus the lifespan of the new replacement landfill. This is based on the assumption that municipalities will have control over tipping fees and can recapture the cost of the ground-water monitoring requirements over an extended period of time.

- For the high-end, it is assumed that landfills would have to capture the cost of the ground-water monitoring requirements during remaining operating life. Thus, if a landfill remains open for only 5 more years, it would have to annualize the cost of the ground-water monitoring requirements over 5 years. This approach may be more realistic for privately owned landfills which will not have the opportunity to collect fees after the landfill closes.

o As in the MSWLF RIA, all costs are annualized using a three percent real discount rate.

Section 4.2 Scenario 1: Sample from Existing Wells

- The first alternative to baseline ground-water monitoring requirements is to sample existing wells and springs. Sampling and analysis are assumed to occur once per year and include all Appendix I constituents, with a minimum of 1 upgrade and 2 downgrade samples, and a hydrogeologic study.

- The hydrogeologic study cost is $133,400, consistent with costs used under baseline ground-water monitoring.

- Operating costs include sample collection and analysis costs of $436 per sample. A minimum of 3 wells (one up-gradient and two down-gradient) are sampled once per year. The annual cost for the 10 TPD and 1 TPD landfills is $1,310 during the operating life and $1,440 over the 30-year post-closure period. (Note: Sampling costs are lower than in the full ground-water monitoring baseline because (1) fewer samples are taken, and (2) fewer wells are required. Per sample costs are the same).

Section 4.3 Scenario 2: Reduced List of Constituents

- The second alternative to baseline ground-water monitoring requirements is reduce the list of constituents being monitored. This option includes the complete cost of well construction and hydrogeologic study, but the sampling is conducted only once per year, and only for the ground-water contamination parameters listed in the Interim Status Standards for Subtitle C facilities (40 CFR 265.92 (b)(3)).

- The hydrogeologic study and well construction costs are the same as the full monitoring baseline.

- Operating costs include sample collection and analysis costs of $100 per sample.[1] Each individual well is sampled once each year. The annual cost for the 10 TPD landfill is $1,500 during the operating life and $1,650 over the 30-year closure period. The annual cost for the 1 TPD is $900 during the operating life and $990 over the 30-year closure period.

Section 4.4 Scenario 3: Sampling of Materials in the Unsaturated Zone[2]

[1]Sampling costs for pH, specific conductance, and total organic carbon were averaged from four vendor quotes obtained by Jim Brown, OSW, March 30, 1989. Sampling costs for total organic halogen were provided by DPRA on December 18, 1991. All costs were scaled to 1993 dollars.

[2]Costs for sampling and analysis of materials in the unsaturated zone based on vendor information obtained by DPRA, May 24, 1994. See Appendix A.

- The third alternative to baseline ground-water monitoring requirements is to draw samples of materials from the unsaturated zone beneath the landfill to test material for evidence of releases from the landfill.

- Samples are assumed to be taken: once each year for the remaining life and for the post-closure care period; every one hundred feet over the landfill area requiring nine sample locations at the 1 TPD landfill and twenty-five at the 10 TPD landfill; and at five-foot intervals to a depth of seventy feet below the surface.

- Sample analysis is assumed to occur in the field with hand-held photoionization detectors (PIDs) or flame ionization detectors (FIDs).

- **Scenario 3a** assumes the use of Geoprobes to collect the samples. Geoprobes are small diameter steel probe rods which are driven into the ground to collect soil or sediment samples. Complete costs to mobilize equipment and labor, draw the samples, do on-site analysis, and seal the holes are $33,800 for the 10 TPD landfills and $12,700 for the 1 TPD landfill. The costs remain the same for each year of the operating life and the post-closure care period.

- **Scenario 3b** assumes the use of a conventional hollow-stem auger to bore the hole and a split-spoon sampler to draw the samples. The auger bit is typically larger than the Geoprobe diameter and somewhat more prone to encounter obstructions. Complete costs to mobilize equipment and labor, draw the samples, do on-site analysis, and seal the holes are $38,400 for the 10 TPD landfills and $15,100 for the 1 TPD landfill. The costs remain the same for each year of the operating life and the post-closure care period.

Section 4.5 Scenario 4: Sample Soil Gas from the Unsaturated Zone [3]

- The fourth alternative to baseline ground-water monitoring requirements is to place permanent vapor sampling implants in the ground beneath the landfill to collect soil gas samples. Samples are drawn through a screen attached to tubing which has been placed in a permanent borehole. The implants would be installed in the first year and sampling would occur annually throughout the remaining life and post-closure care period.

- Boreholes are assumed to be drilled every one hundred feet over the landfill area requiring nine boreholes at the 1 TPD landfill and twenty-five at the 10 TPD landfill. Capital costs for the implants including installation and calibration would be $34,200 for the 10 TPD and $13,100 for the 1 TPD landfills.

[3] Costs for sampling and analysis of materials in the unsaturated zone based on vendor information obtained by DPRA, May 24, 1994. See Appendix A.

- Sample analysis would occur in the field using a mobile laboratory with a gas chromatograph. Annual costs for the landfill, including sample costs and labor, are $5,300 for the 10 TPD landfill and $2,700 for the 1 TPD landfill.

Section 4.6 Scenario 5: Resistivity Survey[4]

- The fifth alternative to baseline ground-water monitoring requirements is to survey the electrical resistivity of the soil surrounding a landfill. A change in the bulk electrical properties of the soil would indicate moisture and a possible leak.

- Field costs include the cost of a renting a resistivity meter ($83 per day) and the hourly wage for geologists to calibrate and read the meter. Assuming the geologists can cover 2,500 linear feet per day, and the path circumventing a 1 TPD landfill is 1,425 linear feet, the total field costs for a 1 TPD landfill is approximately $1,200. A 10 TPD is approximately 2,850 linear feet, resulting in a total field cost of $2,200.

- The costs of analyzing the data and preparing a report are essentially the same for the 1 TPD and 10 TPD landfills, approximately $9,200.

- Assuming one sampling event per year, annual costs are $10,400 for the 1 TPD landfill and $11,400 for the 10 TPD landfill.

Section 4.7 Scenario 6: Gypsum Block Monitoring[5]

- The sixth alternative to baseline ground-water monitoring requirements is the installation of gypsum blocks beneath the landfill to detect moisture. Traditionally gypsum blocks have been used in agriculture to measure soil moisture in order to determine irrigation rates.

- Because gypsum blocks deteriorate, EPA assumed they would be replaced every two years. Installation costs include drilling 10 angled borings to 25 feet, installing gypsum blocks and backfilling the boring, and setting and fine tuning the probes, resulting in a cost of $11,400

- Sampling and analysis occur semi-annually, costing approximately $3,000 per year.

- The total annualized cost of gypsum block installation, sampling and analysis is $8,000 pe

Section 5. Results

Section 5.1 Annual Cost Per Facility

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[4] Costs for conducting a resistivity survey based on vendor information obtained by EPA, December 12, 1994. See Appendix A.

[5] Costs for conducting gypsum block sampling based on information from the Texas Natural Resource Conservation Commission obtained by EPA, December 27, 1994. See Appendix A.

Facility costs are presented in Table 2. These costs are dependent on several factors, including the size of the landfill (tons per day), and the remaining life of the landfill (which determines the time period available to recapture costs).

For the low-end, it is assumed that the landfills had the opportunity to annualize the cost of the ground-water monitoring requirements over the lifespan of the existing landfill plus the lifespan of the new replacement landfill. This is based on the assumption that municipalities[6] will have control over tipping fees and can recapture the cost of the ground-water monitoring requirements over an extended period of time.

For the high-end, it is assumed that landfills would have to capture the cost of the ground-water monitoring requirements during remaining operating life. Thus, if a landfill remained open for only 5 more years, it would have to annualize the cost of the ground-water monitoring over 5 years. This approach may be more realistic for privately owned landfills which will not have the opportunity to collect fees after the landfill closes. Ground-water monitoring baseline costs listed in Table 2 are for facilities located in states with no existing ground-water monitoring requirements. Facilities in state with ground-water monitoring would incur the cost of a hydrogeologic study and of sampling only.

[6] According to the 1986 Solid Waste (Municipal) Landfill Survey, 81% of municipal solid waste landfill were owned by municipalities.

TABLE 2. ANNUALIZED FACILITY COSTS FOR 10 TPD AND 1 TPD LANDFILLS UNDER VARIOUS SCENARIOS

Size (tons per day):	10			1		
Remaining life (years)	5	10	20	5	10	20
GW monitoring (baseline):	$36,000 (L) $124,000 (H)	$34,000 (L) $69,000 (H)	$33,000 (L) $41,000 (H)	$24,000 (L) $87,000 (H)	$23,000 (L) $48,000 (H)	$23,000 (L) $29,000 (H)
Use existing wells (scenario 1):	$9,000 (L) $36,000 (H)	$8,000 (L) $19,000 (H)	$7,000 (L) $11,000 (H)	$9,000 (L) $36,000 (H)	$8,000 (L) $19,000 (H)	$7,000 (L) $11,000 (H)
Indicator parameters (scenario 2):	$17,000 (L) $65,000 (H)	$15,000 (L) $35,000 (H)	$13,000 (L) $20,000 (H)	$14,000 (L) $51,000 (H)	$12,000 (L) $28,000 (H)	$10,000 (L) $16,000 (H)
Geoprobe samples (scenario 3a):	$42,000 (L) $159,000 (H)	$40,000 (L) $91,600 (H)	$38,000 (L) $59,000 (H)	$16,000 (L) $60,000 (H)	$15,000 (L) $34,000 (H)	$14,000 (L) $22,000 (H)
Drill samples (scenario 3b):	$47,000 (L) $180,000 (H)	$45,000 (L) $104,000 (H)	$43,000 (L) $66,000 (H)	$19,000 (L) $71,000 (H)	$18,000 (L) $41,000 (H)	$17,000 (L) $26,000 (H)
Unsaturated zone monitoring (scenario 4):	$8,000 (L) $32,000 (H)	$8,000 (L) $18,000 (H)	$7,000 (L) $12,000 (H)	$4,000 (L) $16,000 (H)	$4,000 (L) $9,000 (H)	$4,000 (L) $6,000 (H)
Resistivity survey (scenario 5):	$11,400 (L) $11,400 (H)	$11,400 (L) $11,400 (H)	$11,400 (L) $11,400 (H)	$10,400 (L) $10,400 (H)	$10,400 (L) $10,400 (H)	$10,400 (L) $10,400 (H)
Gypsum block (scenario 6)	$10,000 (L) $10,000 (H)	$9,000 (L) $9,000 (H)	$9,000 (L) $9,000 (H)	$10,000 (L) $10,000 (H)	$9,000 (L) $9,000 (H)	$9,000 (L) $9,000 (H)

Section 5.2 National Annual Costs

National annual costs (presented in Table 3) were developed by applying the baseline ground-water monitoring requirement facility costs and the facility costs of the lowest-cost alternatives from Table 2 to the municipal solid waste landfill universe from Table 1 (with reduced ground-water monitoring costs for landfills in states with existing requirements).

In developing national annual costs of the alternatives, EPA assumed that individual landfills will be able to implement the most cost-effective alternative for that landfill. Instead of applying one alternative to all landfills (e.g. assuming that all landfills will collect soil gas samples), EPA applied the lowest cost option from table 2 for each landfill type (1 ton per day, 10 tons per day, 5 year remaining life, 10 year remaining life, etc) to that universe of landfills, and then summed all these cost estimates to determine national annual costs. In most cases, the lowest-cost alternative was unsaturated zone monitoring, with monitoring of gypsum blocks close second.

TABLE 3.

NATIONAL ANNUALIZED COSTS, LOWEST-COST ALTERNATIVE AND NATIONAL ANNUAL COST SAVINGS

Baseline Ground-Water Monitoring National Annual Costs	$7.2 - $26.6 million
Lowest-Cost Alternative Total	$1.3 - $4.4 million
National Annual Cost Savings Over Baseline Ground-Water Monitoring (1993) dollars.	$5.9 - $22.2 million

EPA recognizes that, because of site-specific factors, and/or State regulatory decisions, some landfills may not be able to use the most cost effective alternative. National annualized costs for each alternative (assuming that all landfills choose the same alternative) can range from $1.3 million to $33.6 million. EPA does not expect any one alternative to be chosen by all landfills, and anticipates that cost effectiveness will be a major consideration for choosing alternatives. Therefore, national costs are expected to fall within the lower end of the range. For an estimate of total national costs for each alternative, see Appendix C.

Section 6. Limitations

- For all the alternatives to ground-water monitoring requirements, EPA assumed that the landfills were truly located in arid areas and that no contamination would occur. If contamination is detected, further analysis would be required. Thus, if contamination occurs during the active life and post closure care period of the landfill, the cost savings would be reduced, or even eliminated.

- Similarly, the cost estimate for an alternative does not include the cost of responding to a false positive. EPA does not have data on the rate of false positives for the different monitoring alternatives, but responding to a false positive would add to the annual costs of the alternative and reduce the national savings.

- Under the proposed rule, approved state and tribal governments will have considerable flexibility in selecting the best alternative to ground-water monitoring requirements for the small/dry landfills. This analysis estimates the costs of some of the more likely scenarios, but other alternatives are also possible. Nor is the state or tribal authority obliged to choose the lowest-cost alternative.

- The ground-water monitoring well costs presented in this analysis represent an estimated "average" cost. Ground-water monitoring wells are assumed to extend to a depth of 140 feet. This depth was a reasonable assumption to develop the national costs estimates for the MSWLF RIA. However, EPA recognizes that the water table in some areas is deeper, and that ground-water monitoring wells in these areas may be more costly to construct.

  - EPA contacted four well digging companies to determine potential costs for sinking wells to additional depths. These companies quoted costs of approximately $35 to $50 dollars per foot for well construction.[7] Thus, the difference in cost of a well cluster extending to 140 feet versus a well cluster extending to 300 feet would be approximately 25% more for the well construction costs. The first year costs for the ground-water monitoring system (which includes the hydrogeologic study and construction costs) would increase approximately 8 percent for a 1 TPD landfill and 11 percent for a 10 TPD landfill.

  - Sinking the ground-water monitoring wells to additional depths would likewise continue to increase costs. One commentor from Nevada indicated that the depth to ground water can be over 1,000 feet. The cost of digging a well in this situation could result in significant costs for some communities.

  - Likewise, construction costs in remote areas, where it may be expensive to bring in equipment, may also be higher than the estimates used in this analysis. In these situations, alternatives to ground-water monitoring would result in even higher cost savings.

[7] Sources: West Hazmat Drilling, Pleasanton, CA; Hydro Group, Boston, MA; DPRA, Inc., St. Paul, MN; HF Drilling, Cypress, CA. Based on phone interviews September 1993.

- Although ground-water monitoring requirements were used as the baseline in this cost analysis, in some cases it may be less expensive to close the landfill and transfer the wastes to a large, regional landfill. (See Appendix B). In those cases, the baseline costs would be reduced and therefore the resultant savings of alternatives would also be reduced. Due to the remoteness of the landfills affected by the proposed rule, however, the Agency believes that ground-water monitoring is the most likely baseline.

Section 7. Potential Small Entity Impacts

The Regulatory Flexibility Act of 1980 requires federal agencies to assess the effects of proposed regulations on small entities and to examine alternatives to the proposed regulations that may reduce adverse economic effects on significantly impacted entities (5 U.S. Code 601 *et. seq.*). For the purposes of this analysis, EPA assumes that all communities served by the landfills affected by the proposed rule are small.

Because the proposed rule would reduce the regulatory burdens of the existing Part 258 criteria, it will impose no additional economic impact to small entities. Below is a summary of small entity impacts of the baseline ground-water monitoring requirements and an explanation of how those impacts will be reduced under the proposed rulemaking.

In the MSWLF RIA, a threshold of $100 in 1986 dollars per household per year (or $121 in 1993 dollars per household per year) was used to identify moderate impacts to small communities.

A range of total costs per household of baseline ground-water monitoring and of the lowest-cost option are presented in Table 4, based on two landfill sizes, three remaining life timeframes, and with two different payback assumptions. Partial costs for ground-water monitoring (which were assigned to landfills in states with current requirements) are also presented.

Household costs are estimated by using the MSWLF RIA assumptions that landfills receive waste 260 days/year and that the average household generates 2.58 tons per year. Thus it is assumed that a 10 TPD landfill serves approximately 1,000 households and a 1 TPD landfill serves 100 households. As discussed in the methodology, the low-end, which assumes landfills can annualize the costs over a time period longer than the operating life of the landfill, particularly if it is short, may be appropriate for many municipalities. The high-end, which assumes that the costs must be captured during the existing life of the landfill, will potentially represent the situation of private landfills and some municipalities.

TABLE 4. COSTS PER HOUSEHOLD FOR 10 TPD AND 1 TPD LANDFILLS UNDER VARIOUS SCENARIOS

Size (tons per day):	10	10	10	1	1	1
Remaining life (years)	5	10	20	5	10	20
GW monitoring costs in States with No GWM requirements (baseline):	$35 (L) $120 (H)	$33 (L) $68 (H)	$32 (L) $41 (H)	$240 (L) $860 (H)	$230 (L) $470 (H)	$220 (L) $280 (H)
GW monitoring costs in States with GWM requirements (baseline):	$20 (L) $66 (H)	$19 (L) $37 (H)	$18 (L) $23 (H)	$120 (L) $390 (H)	$110 (L) $220 (H)	$100 (L) $140 (H)
Costs of lowest-cost alternative:	$8 (L) $9 (H)	$8 (L) $9 (H)	$7 (L) $9 (H)	$40 (L) $98 (H)	$38 (L) $87 (H)	$36 (L) $56 (H)

As table 4 demonstrates, under baseline ground-water monitoring requirements, most 1 TPD landfills will be above the $121 threshold in the lower-bound and exceed this threshold in the upper-bound by a magnitude of up to 7. One TPD landfills located in states which currently require ground-water monitoring do not exceed the threshold in the lower-bound but still exceed the threshold in the upper-bound. Based on these estimates, landfills approximately 1 TPD or smaller, in many instances, will face significant cost impacts if they remain open and comply with the baseline ground-water monitoring requirements.

Under the lowest-cost alternatives allowed under the proposed rule, however, annual cost per household is reduced drastically, with even the upper-bound costs falling well below the $121 threshold, thus lessening the likelihood that small communities would be significantly impacted.

Appendix A: Vendor Information on Geoprobes, Conventional Drilling, Permanent Vapor Sampling Implants, Resistivity Surveys, and Gypsum Block Monitoring

1. GEOPROBES

Geoprobes are small diameter (one-inch) steel probe rods with a steel point which are hydraulically driven into the ground for collecting soil or sediment samples. They cannot penetrate rock, and therefore, are not suitable for sampling bedrock. According to the vendor contact, Geoprobes can be driven up to 140 feel below grade. After the soil core samples have collected, the hole is sealed with a grout mixture.

Periodic Costs

Sampling Costs (Source: Matrix Technology; Minneapolis, MN)

1 acre = $12,700
4 acre = $33,800

Sampling Oversight Costs (Source: DPRA; Minneapolis, MN)

1 acre = $3,100
4 acre = $7,700

Cost of Analysis (Source: Pace, Inc; Minneapolis, MN)[8]

Scenario 1: Use hand-held field photoinoization (PID) or flame ionization detector (FID) as soil samples are taken in field, no "hotspots" detected.

No additional cost

Scenario 2: Use hand-held field PID or FID as soil samples are taken in field, "hotspots" detected, and samples sent to lab for VOC screening analysis @ $180 sample

1 acre = $180 - $1,620 (1 - 9 samples)
4 acre = $180 - $4,500 (1 - 25 samples)

Scenario 3: Use hand-held field PID or FID as soil samples are taken in field, "hotspot" detected, and samples sent to lab for analysis of all 40 CFR Part 258.40 Table 1 constituents @ $833/sample.

1 acre = $833 - $7,497 (1-9 samples)
4 acre = $833 - $20,825 (1-25 samples)

[8] The cost analysis used scenario 1.

Assumptions

- o One hundred foot spacing between probes
  - 1 acre = 9 probes
  - 4 acre = 25 probes
- o 200 miles one-way to landfill
- o Probes advanced to a depth of 70 feet
- o Sampling cost includes the following items:
  - Mobilization/demobilization based on a 400-mile roundtrip
  - Soil sampling at five-feet intervals with a 2 person crew @ $1600 per 8-hr day
    - 1 acre = 6.3 days
    - 4 acre = 17.5 days
  - Probe abandonment with a grout mixture @ $1/ft
    - 1 acre = 630 ft (9 probes @ 70 ft/ea)
    - 4 acre = 1,750 ft (25 probes @ 70 ft/ea)
  - Per Diem @ $95 /person/day
    - 1 acre = 7 days
    - 4 acre = 18 days
- o Sampling oversight by consultant (may or may not be necessary, depending on the subcontractor conducting the sampling)
  - Engineering assistant/field technician @$40/hr
  - Per diem @ $95/day
  - Mileage @ $0.35/mile
- o Soil analysis of 40 CFR Part 258.40, Table 1 constituents by contract lab
  - $180/sample VOC's (Methods 8010 and 8020)
  - $ 20/sample Arsenic
  - $ 20/sample Lead
  - $ 20/sample Selenium
  - $ 13/sample Barium
  - $ 13/sample Cadmium
  - $ 13/sample Silver
  - $ 45/sample Hexavalent chromium
  - $ 25/sample Fluoride
  - $ 39/sample Mercury
  - $ 30/sample Nitrate
  - $ 165/sample Pesticides (Method 8080)

- $ 250/sample Herbicides (Method 8150)

2. CONVENTIONAL DRILLING

Conventional drilling consists of boring through the landfill and subsoils with a hollow-team auger and obtaining soil samples from a split-spoon sampler. The principle is the same as Geoprobes in that soil samples are obtained by coring through the soil. Conventional drilling is typically a two inch diameter core, whereas, Geoprobe core sample diameters are less than one inch. The sampling cost for conventional drilling versus Geoprobes are somewhat similar ($12,700 and $33,800 for 1 acre and 4 acres respectively, for Geoprobes, versus $15,100 and $38,400 for 1 acre and 4 acres, respectively, for conventional drilling), however, with the smaller diameter it is easier to penetrate through material than with conventional drilling. There is a greater probability of encountering obstructions with a hollow-stem auger than a Geop

Periodic Cost

Sampling Costs: (Source: American Engineering Testing; Minneapolis, MN)

1 acre = $15,100
4 acre = $38,400

Sampling Oversight Costs: (Source: DPRA; Minneapolis, MN)

1 acre = $3,100
4 acre = $7,700

Cost of Analysis: (Source: Pace, Inc; Minneapolis, MN)[9]

Scenario 1: Use hand-held field PID or FID as soil samples are taken in field, no "hotspots" detected

No additional cost

Scenario 2: Use hand-held field PID or FID as soil samples are taken in field, "hotspots" detected, and samples sent to lab for VOC screening analysis @ $180/sample

- 1 acre = $180 - $1,620 (1 - 9 samples)
- 4 acre = $180 - $4,500 (1 - 25 samples)

Scenario 3: Use hand-held field PID or FID as soil samples are taken in field, "Hotspots" detected, and samples sent to lab for analysis of all 40 CFR Part 258.40 Table 1 constituents @ $833/sample

[9] In the cost analysis, scenario 1 was used.

- 1 acre = $833 - $7,497 (1 - 9 samples)
- 4 acre = $833 - $20,825 (1 - 25 samples)

<u>Assumptions</u>

o One hundred foot spacings between boreholes
  - acre = 9 boreholes
  - acre = 25 boreholes

o 200 miles one-way to landfill

o Drilling advanced to a depth of 70 feet and two-inch diameter

o Sampling cost includes the following items:

- Mobilization/demobilization base on a 400-mile roundtrip
- Drilling two-inc diameter borehole @$14/ft
- Borehole abandonment with a grout mixture @$5/ft
  - 1 acre = 630 ft (9 borehole @70 ft/ea)
  - 4 acre = 1,750 ft (25 boreholes @70 ft/ea)
- Per diem @95 person/day
  - 1 acre = 7 days
  - 4 acre = 18 days

o Sampling oversight by consultant (may or may not be necessary, depending on the subcontractor conducting the sampling)

- Engineering assistant/field technician @$40/hr
- Per diem @$95/day
- Mileage @ $0.35/mile

o Soil analysis of 40 CFR Part 258.40, Table 1 constituents by contract lab
- $180/sample VOC's (Methods 8010 and 8020)
- $ 20/sample Arsenic
- $ 20/sample Lead
- $ 20/sample Selenium
- $ 13/sample Barium
- $ 13/sample Cadmium
- $ 13/sample Silver
- $ 45/sample Hexavalent chromium
- $ 25/sample Fluoride
- $ 39/sample Mercury

- $ 30/sample Nitrate
- $ 165/sample Pesticides (Method 8080)
- $ 250/sample Herbicides (Method 8150)

3. PERMANENT VAPOR SAMPLING IMPLANTS

(Source of all cost information: Matrix Technology; Minneapolis, MN)

Vapor sampling implants are permanent tubes installed in the ground for collection of soil gas samples. The implants consist of tubing (polyethylene, teflon, or stainless steel) and a stainless steel wire screen. The tubing and screen is installed in a borehole and backfilled with a glass bead pack around the screen, a glass bead/bentonite seal above the screen, and bentonite/grout above the seal to ground surface. Soil gas samples are collected periodically and analyzed on-site in a mobile laboratory.

Capital Cost

1 ac $13,100
4 ac = $34,200

Periodic Cost

1 ac = $2,700
4 ac = $5,300

Capital Cost Assumptions

o One Hundred fool spacings between implants
  - 1 acre = 9 implants
  - 4 acre = 25 implants

o 200 miles one-way to landfill

o Implants installed to a depth of 70 feet

o Implants screen (six inches long by 0.25 inch diameter) constructed of stainless steel and the riser constructed of low-density polyethylene tubing. A glass bead pack placed around the screen, a glass-bead/bentonite seal placed above the pack, and neat cement grout placed as a seal to the surface.

o A stake placed in the ground next to the tubing identifying the inplant location

o Mobilization/demobilization based on a 400-mile roundtrip

o Implant installation based on 2-person crew @ $1,050/implant

o Lab calibration

- o Soil gas sampling conducted on-site in mobile laboratory with gas chromatograph
  - One gas sample/implant
  - Analyzed for benzene, 1,4-dichlorobenzene, 1,1-dichloroethylene, trichloroethylene, carbon tetrachloride, 1,1,1-trichloroethane, and vinyl chloride
  - $150/sample

- o Per diem @ $95/person/day
  - 1 acre = 6 days
  - 4 acre = 16 days

Periodic Cost Assumption

- o Mobilization/demobilization based on a 400-mile roundtrip

- o Lab Calibration

- o Soil gas sampling conducted on-site in mobile laboratory with gas chromatograph
  - One gas sample/implant
  - Analyzed for benzene, 1,4-dichlorobenzene, 1,1-dichloroethylene, Trichloroethylene, carbon tetrachloride, 1,2-dichloroethane, 1,1,1-trichloroethane, and vinyl chloride
  - $150/sample

- o Per diem @95/person/day
  - 1 acre = 1 day
  - 4 acre = 2 days

- o If "hotspots" are detected, soil sampling would be conducted (see Geoprobes or conventional drilling for costs)

4. RESISTIVITY SURVEY (Source EMCOM; Ft. Worth, Texas)

Resistivity surveys involve monitoring changes over time of the bulk electrical properties of the soil beneath the landfill using a resistivity meter. A change in the electrical properties of the soil would indicate the presence of moisture and therefore potential contamination.

ASSUMPTIONS
1 sampling event per year
2,500 linear feet sampled/day
8 hours/day
1 TPD landfill=1,425 linear feet
10 TPD landfill=2,850 linear feet
meter $82.80/day

executive rate	$110/hr
senior geologist	$90/hr
geologist	$75/hr
tech writer	$55/hr
clerical	$37/hr

FIELD COSTS

	1 TPD	10 TPD
meter	$82.80	$165.60
senior geologist	$410.40	$720.00
geologist	$600.00	$1,200.00
mileage	$105.00	$105.00
TOTAL	$1,198.20	$2,190.60

ANALYSIS AND REPORTING COSTS (same for both 1TPD and 10TPD)

1 hr executive	$110
36 hrs senior geologist	$3,240
55 hrs geologist	$4,125
18 hrs technical writer	$990
17 hrs clerical	$629
materials	$100
TOTAL	$9,194

5. GYPSUM BLOCK MONITORING (Source: Texas Natural Resource Conservation Commission)

Traditionally gypsum blocks have been used in agriculture to measure soil moisture in order to determine irrigation rates. The porous nature of the blocks facilitates absorption of liquid from the surrounding soil. This changes the electrical properties of the gypsum blocks, which can be measured by an attached meter. The Texas Natural Resource Conservation Commission is currently testing their feasibility in detecting leachate from landfills.

Installation costs (occur every 2 years):

Description	Units	Unit Costs	Total Cost/Installation
Drill 10 angled borings to 25 ft	250 ft	$25/ft	$6,250
Install gypsum blocks	30 blocks	$15/block	$450
Supervise Installation (geologist)	40 hours	$60/hour	$2,400
Set up and tune probes	20 hours	$60/hour	$1,200
Travel/Per diem	4 days	$275/day	$1,100
Total			$11,400

Semi-Annual Monitoring (includes mobilization/demobilization): $3,000/year

Appendix B: Closure and Transfer Costs

If a landfill is unable to satisfy ground-water monitoring requirements, one compliance option is to close the landfill and transfer the waste to a regional landfill. The remoteness of the landfills affected by this rule tends to preclude this option, but in some cases it may be possible.

This appendix summarizes the costs of closing the landfill, building a transfer station at the site, and transporting the waste to a large, regional landfill.

Closure costs (prior to the effective date of the ground-water monitoring requirements) include the costs of covering the landfill and inspecting and maintaining the cover. The cover consists of 18 inches of fill and 6 inches of topsoil, and is graded and planted. The landfill is assumed to be inspected annually and maintained for 30 years.

- Closure cost for a 10 ton per day landfill is $196,800. Cover maintenance has a present value of $6,000 over 30 years.

- Closure cost for a 1 ton per day landfill is $46,900. Cover maintenance has a present value of $1,400 over 30 years.

Transfer station costs were available only for a 10 ton per day facility. The cost of $33 per ton assumes construction of a facility at an existing site (no land costs) and amortization of capital costs over 20 years.

Transportation costs of $.073 per ton-mile were bases on long-haul vehicles traveling between the transfer station and the regional landfill. A one-way distance of 65 miles was assumed.

Disposal costs of $15 per ton were based on average tipping fees for the West Central and Mountain States as reported in the Solid Waste Digest for September 1993.

Resulting annual costs per facility (annualized over 20 years at a 3 percent discount rate) range from $18,100 for the one ton per day landfill to $162,400 for the ten ton per day landfill. Assuming 2.58 tons per year of municipal solid waste generated per household, cost per household range from $161 (10 TPD) to $180 (1 TPD).

Appendix C: National Annual Costs for Baseline and for Alternative Scenarios

As explained in Section 5 of the cost analysis, EPA assumed for the purposes of the analysis that individual landfills will be able to implement the most cost-effective alternative for that landfill. Instead of applying one alternative to all landfills (e.g. assuming that all landfills will collect soil gas samples), EPA applied the lowest cost option from table 2 for each landfill type (1 ton per day, 10 tons per day, 5 year remaining life, 10 year remaining life, etc) to that universe of landfills, and then summed all these cost estimates to determine national annual costs.

However, because of site-specific factors, and/or State regulatory decisions, some landfills may not be able to use the most cost effective alternative. Below is a summary of annual national annual costs for the baseline and each alternative. EPA does not expect any one alternative to be chosen by all landfills. However, by examining national annual costs of each alternative, a better sense of the possible range of costs can be obtained.

ANNUALIZED NATIONAL COSTS UNDER VARIOUS SCENARIOS

Scenario	Low-End Cost	High-End Cost
GW monitoring (baseline):	$7.2 million	$26.6 million
Use existing wells (scenario 1):	$2.4 million	$14.0 million
Indicator parameters (scenario 2):	$3.6 million	$20.7 million
Geoprobe samples (scenario 3a):	$5.7 million	$28.6 million
Drill samples (scenario 3b):	$6.7 million	$33.6 million
Unsaturated zone monitoring (scenario 4):	$1.3 million	$7.0 million
Resistivity survey (scenario 5):	$3.0 million	$5.2 million
Gypsum block (scenario 6)	$2.3 million	$4.7 million
Aggregate of Lowest-Cost Alternatives for Each Landfill Type	$1.3 million	$4.4 million