CONF930158--1

The submitted manuscript has been authored by a contractor of the U. S. Government under contract No. W-31-109-ENG-38. Accordingly, the U. S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for U. S. Government purposes.

INTERSTATE WASTE TRANSPORT -- EMOTIONS, ENERGY, AND ENVIRONMENT

by

DEBORAH ELCOCK[1]

ANL/EAIS/CP--76727

DE93 004807

Received OSTI

DEC 23 1992

ABSTRACT

Lawyers, legislators, local government officials, lobbying groups, waste disposal companies, and others have become embroiled in the debate over interstate waste transport restrictions. Those favoring restrictions argue that waste imports threaten disposal capacity of accepting states; waste transport causes additional noise, air pollution, traffic congestion, road repairs, and accidents; and unrestricted imports reduce incentives for exporting states to develop their own disposal capacity. Those against restrictions cite short-term capacity shortages, economies of scale that favor large, regional disposal facilities, geological conditions that make siting of new facilities difficult in some states, and the idea that restricting waste imports may set precedents for other commodities. Both sides witness the Not in My Back Yard (NIMBY) Syndrome and political crusading. The Supreme Court has ruled that states and counties cannot impose bans or differential fees on waste generated outside the jurisdiction in which it is disposed, as such actions violate the Commerce Clause of the U.S. Constitution.[2] Those rulings put additional pressure on Congress to allow states or local governments to restrict out-of-state municipal waste disposal. The interstate waste transport debate has evolved from one where potential environmental and cost impacts should be determining factors into one where politics and emotions have taken over.

An attempt has been made to return quantitative analysis to the debate. Moving from emotions and politics back to numbers, we have estimated potential energy, employment and environmental impacts associated with disposing a ton of municipal solid waste under three different disposal scenarios that reflect interstate and intrastate options. The results help provide a less emotional, more quantitative look at interstate waste transport restrictions.

---

[1] Work supported by the U.S. Department of Energy, Office of Domestic and International Energy Policy, under contract W-31-109-Eng-38.

[2] *Fort Gratiot Sanitary Landfill Inc., V. Michigan Department of Natural Resources* (US SupCt, No. 91-636, 60 LW 4438, 34 ERC 1728) and *Chemical Waste Management Inc. v. Alabama* (US SupCt, No.91-471, 60 LW 4433, 34 ERC 1721)

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

INTRODUCTION

The U.S. Department of Energy[3] reviews environmental legislative and regulatory actions for potential impacts on energy use, the environment, and on U.S. energy industries. In this context, reauthorization of the Resource Conservation and Recovery Act (RCRA), and the attendant issues associated with restricting interstate waste transport, are of interest. Unfortunately, the lack of comprehensive, consistent data on municipal solid waste (MSW) transport[4] makes direct analysis impossible. Therefore, we took a different approach -- we estimated and compared energy use, employment, and air pollution emissions associated with disposing one ton of MSW under three alternative disposal methods. These methods are: landfilling near (also referred to as 10-mile or local landfilling), landfilling a great distance (also referred to as 1,000-mile, long-haul, or long-distance disposal), and burning in a waste-to-energy (WTE) facility near point of waste generation. For each method, we considered facilities of three different capacities, for a total of nine scenarios. We estimated Btus consumed (or for WTE plants, Btus produced); full-time-equivalent (FTE) employees; and tons of carbon monoxide (CO), nitrogen oxide (NOx), sulfur oxide (SOx), particulate matter (PM) and hydrocarbon (HC) emissions associated with disposing one ton of MSW under each of the nine scenarios.

This paper presents the results of these comparisons. The first section describes the nine scenarios, and the second section presents the results. Appendix A details assumptions on equipment use and operation, fuel consumption, emissions factors, and employment assumptions. Appendix B presents the algorithms used to generate the per-ton estimates.

Our analysis provides insight on environmental impact and energy use -- issues important to the Department of Energy. It does not furnish all the data required to support a position for or against interstate waste transport. For example, the study addresses some, but not all, air pollutants, and it does not address water pollution. It does not consider economics, regional capacity issues, generation rates, existing transport patterns, etc. -- each of which is important in the interstate waste transport debate.

---

[3] Office of Domestic and International Energy Policy, Office of Environmental Analysis

[4] The regulatory program for MSW contributes to this data shortage. Managed under Subtitle D of RCRA, MSW is subject to minimal regulation at the Federal level, but to a myriad of individual state and local rules. Absent Federal data collection requirements, interstate shipment data is piecemeal and anecdotal.

MUNICIPAL SOLID WASTE DISPOSAL SCENARIOS

To reflect a range of impacts and to test sensitivity to capacity, we constructed nine waste disposal scenarios.[5] These scenarios represent three disposal methods, and for each method, three different capacities. The disposal methods are:

1. Landfilling 10 miles from point of generation, which represents an average hauling distance for local waste disposal;
2. Landfilling 1,000 miles from point of generation, which represents long-haul, interstate transport (the distance between New Jersey and Indiana is about 1,000 miles, for example, and represents a long-haul scenario often referenced in interstate waste transport debates); and
3. Burning in a WTE plant 10 miles from point of generation. (Because MSW is typically not shipped long distances for WTE disposal, we did not evaluate a long-haul WTE scenario.)

The three capacities considered for landfills are 50, 500, and 1,500 tons per day (tpd); for WTE plants, assumed capacities are 250, 1,500, and 2,250 tpd. These capacity assumptions are based on facility inventories and conversations with industry representatives. The 1,500-tpd capacity, common to each disposal method, allows direct comparisons among the three methods. The remaining options show the sensitivity of per-ton estimates to capacity.

Scenario Assumptions

Each scenario assumes MSW collection from the residential curbside via a packer truck. In the 10-mile landfill and WTE scenarios, the packer delivers the waste directly to the landfill or the WTE plant. In the 1,000-mile landfill scenarios, the packer delivers the waste to a 1,500-tpd transfer station -- a representative size, according to industry officials. Here it is transferred to a long-haul truck, which travels 1,000 miles to a landfill for final disposal. We assume no trash separation other than that conducted by the residential customer.

In the WTE scenarios, the packer truck dumps the waste at the WTE plant, where wheeled loaders position it for burning in the furnace. Heat from the burning trash generates electricity, which local power companies purchase. Most operating and planned WTE plants use a mass-burn technique to generate electricity, and we assume mass burn

---

[5] We wanted to test the sensitivity of energy use and air emissions to size of facility because in earlier work we found economies of scale in construction and operations and maintenance costs for both landfill and WTE plants. (Elcock, D., Argonne National Laboratory, unpublished information (May, 1992).)

in this study. Long-haul trucks transport residual incinerator ash to a landfill for final disposal, which is assumed to be 30 miles from the WTE plant. The 30-mile distance is a best guess average -- current disposal locations range from on-site to hundreds of miles away.

Appendix A provides details on equipment capacity, operating hours, load factors, horsepower, fuel efficiency, etc. used to generate per-ton energy, employment, and emissions estimates.

The next section summarizes per-ton estimates of energy use, employment, and air emissions for each disposal method. The differences in per-ton estimates among disposal methods is much greater than the differences in per-ton estimates among capacities. Appendix B shows the results for all nine scenarios.

PER-TON ENERGY USE, EMPLOYMENT, AND EMISSIONS FOR THREE DISPOSAL SCENARIOS

This section summarizes Btus consumed (or produced), employment, and air emissions on a per-ton basis for a 1,500-tpd plant under the three disposal methods described above. In all cases, per-ton estimates include operations only, and do not reflect construction or post-closure activities.

Energy Consumption

In each scenario, packer trucks consume energy as they haul trash from curbside to landfill, transfer station, or WTE plant. In the landfill scenarios, equipment at the landfill consumes energy. Transfer station equipment and long-haul trucks consume additional energy in the 1,000-mile scenarios.

In the WTE scenarios, packer trucks, wheeled loaders that move trash within the WTE plant, long-haul trucks that transport ash from the WTE plant to point of disposal, and equipment used to move ash at the landfill all consume energy. The WTE plant itself also consumes energy, but less than it produces.

Estimates of Btus consumed per ton of trash reflect energy content of fuel[6], fuel efficiencies, load capacities, hours of operation, power, size, and amount of equipment used in the various stages of waste disposal. Table I shows energy consumption for each phase (e.g. curbside collection, ash transport, etc.) of the three 1,500-tpd disposal scenarios. Of the three, long-distance landfilling consumes the most energy: 2,828 thousand Btus per ton. Local

[6] Refers to the diesel fuel used by equipment to move trash as well as the fuel (in the form of MSW) burned in the WTE plant.

landfilling consumes 154 thousand Btus per ton, and WTE scenario a net 1,496 thousand Btus per ton.

Table I. Energy Consumption for 1,500 TPD Capacity Disposal Scenarios
(in Thousands of Btus per Ton)

Disposal Phase	10-Mile Landfill	1,000-Mile Landfill	WTE Plant
Packer truck	132	132	132
Transfer station	NA	7	NA
Long haul	NA	2,667	NA
Landfill	21	21	NA
Non-electric equipment at WTE plant	NA	NA	3
WTE plant	NA	NA	-1,655
Ash haul	NA	NA	19
Ash disposal	NA	NA	5
Total	154	2,828	-1,497

Notes: NA indicates disposal phase is not applicable to scenario. Components may not sum due to rounding. A negative number indicates net energy produced.

Table II shows that variations in energy use with capacity are not significant relative to variations in energy use with disposal method.

Table II. Variations in Energy use with Capacity
(in Thousands of Btus per Ton)

Capacity (tpd)	10-mile Landfill	1,000-Mile Landfill	WTE plant
50	221	2,895	NA
250	NA	NA	-1,492
500	172	2,846	NA
1,500	154	2,828	-1,497
2,250	NA	NA	-1,497

Notes: NA indicates capacity is not applicable to scenario. A negative number indicates net energy produced.

Appendix A shows the assumptions, and Appendix B shows the calculations used to generate Tables I and II.

Employment

We estimated the number of full-time-equivalent (FTE) employees associated with each phase of each disposal scenario using data from industry representatives for various types of equipment, hours of use, and overall employment at WTE plants and landfills of varying capacities. We estimated employment for on-site, direct jobs only; we did not estimate indirect employment. Appendix A presents detailed assumptions and data sources. Table III shows per-ton employment for each 1,500-tpd disposal method. By far the highest number of employees is for long-haul disposal: long-haul disposal requires about twice as many employees per ton as either local landfill or WTE disposal. Per-ton employment for WTE is slightly higher than for local landfill disposal.

Table III. Employment for 1,500-TPD Capacity Disposal Scenarios (in FTE Employees per Ton)

Disposal Phase	10-Mile Landfill	1,000-Mile Landfill	WTE Plant
Packer truck	0.00070	0.00070	0.00070
Transfer station	NA	0.00003	NA
Long haul	NA	0.00096	NA
Landfill	0.00008	0.00008	NA
Non-electric equipment at WTE plant	NA	NA	included in WTE plant
WTE plant	NA	NA	0.00010
Ash haul	NA	NA	0.00001
Ash disposal	NA	NA	0.00002
Total	0.00078	0.00177	0.00083

Note: NA indicates disposal phase is not applicable to scenario.

Table IV shows variations in per-ton employment with size of facility. In each case, employment decreases as capacity increases. Regardless of capacity, however, long-haul disposal uses the highest number of employees.

Table IV. Variations in Employment with Capacity
(in FTE Employees per Ton of Trash)

Capacity (TPD)	10-mile Landfill	1,000-Mile Landfill	WTE plant
50	0.00098	0.00197	NA
250	NA	NA	0.00112
500	0.00082	0.00181	NA
1,500	0.00078	0.00177	0.00083
2,250	NA	NA	0.00082

Note: NA indicates capacity is not applicable to scenario.

Emissions

The sources of air pollution are the same as those of energy consumption. We estimated emissions of CO, NOx, SOx, PM, and HC based on emission factors derived from the Environmental Protection Agency[7] for each phase of each disposal scenario.[8] Table V shows total air pollution emissions based on EPA emission factors for each

[7] Compilation of Air Pollution Emission Factors, Volume 2. Mobile Sources (4th Edition), September, 1985; Compilation of Air Pollutant Emission Factors Volume 1. Stationary Point and Area Sources, (Fourth Edition), Supplement B., September 1988; and Supplement A to Compilation of Air Pollutant Emission Factors, Volume II. Mobile Sources, January 1991.

[8] We also considered estimating emissions based on emission standards for phases for which standards have been promulgated. (There are no emission standards for off-highway construction equipment, i.e., landfill equipment.) However, using standards rather than emission factors results in higher emissions per ton. This is because actual WTE plant emissions are usually about 20 percent less than the standards, according to EPA. (Stevenson, E., EPA, Standards Development Branch, Emissions Standards Division, Personal Communication, June, 1992) Actual emissions from mobile sources are also less than the standards, according to the Society of Automotive Engineers (Needham, J., May, M., Doyle, D., Faulkner, S., and Ishiwata, H., Society of Automotive Engineers, "Injection Timing and Rate Control -- A Solution for Low Emissions", Paper No. 900854, 1990.)

1,500-tpd disposal option. Appendix B shows emissions for individual phases within each scenario.

Table V. Air Pollution Emissions for 1,500-TPD Disposal Scenarios (in Grams of Emissions per Ton of Trash)

Pollutant	10-Mile Landfill	1,000-Mile Landfill	WTE Plant
CO	48	1,025	1,058
NOx	91	1,094	1,709
SOx	10	60	506
PM	10	132	182
HC	12	223	59

Clearly, local landfill disposal produces the lowest levels of air emissions per ton of trash. For SOx, landfill disposal -- even with long-haul transport -- produces significantly fewer emissions than WTE disposal. PM and NOx emissions are somewhat higher for WTE disposal compared with long-distance disposal. On the other hand, WTE plants produce far fewer HC emissions than long-haul transport and disposal. The difference in CO emissions between long-haul and WTE disposal is not significant. Indeed, as shown in Table VI, smaller landfills can produce more CO per ton than WTE plants, whereas larger landfills can produce less -- but the differences are minimal.

Table VI. Comparison of Air Pollutant Emissions, Long-haul Landfill and WTE Disposal Scenarios (in Grams of Emissions per Ton of Trash)

Pollutant	1,000-mile Landfill			WTE Plant		
	50 TPD	500 TPD	1,500 TPD	250 TPD	1,500 TPD	2,250 TPD
CO	1,074	1,047	1,025	1,063	1,058	1,058
NOx	1,345	1,155	1,094	1,727	1,709	1,709
SOx	82	67	60	508	506	506
PM	148	138	132	183	182	182
HC	254	229	223	61	59	59

Note: Emissions for 10-mile landfill scenarios are not shown because they are so much lower than those from the other two methods, regardless of capacity. Appendix Table B-11 shows emissions for the 10-mile scenario by disposal phase and capacity.

Appendix A shows the assumptions and Appendix B shows the calculations used to generate Tables V and VI.

Summary and Conclusions

From an energy perspective, the favored disposal method is WTE. The average 1,500-tpd WTE plant produces nearly 1,500,000 Btus per ton of waste disposed. The least favored method is long-haul, which consumes about 18 times as much energy as local landfill disposal. A 1,500-tpd landfill 10 miles from point of generation consumes roughly 150,000 Btus per ton, and at 1,000 miles from point of generation, it consumes about 2,800,000 Btus per ton.

Employment required for long-haul disposal is more than double that for either local landfill or WTE disposal, assuming each facility processes 1,500 tpd. To keep employment down and save costs, a municipality would choose WTE or local landfilling (each requiring about 0.008 FTE per ton) over long-distance landfilling. To create jobs, society may choose long-haul transport, which uses about 0.0018 FTE per ton.

From the air quality perspective, local landfilling is favored over long-haul or WTE disposal. For each air pollutant reviewed, per ton emissions from local landfilling are significantly lower than the alternatives, regardless of facility capacity. Comparing long-haul and WTE disposal, per ton emissions from long-haul are lower for three of the five pollutants reviewed (SOx, NOx, and PM) than for WTE disposal. For CO, there is no significant difference, and for HC, WTE emissions are lower than long-haul emissions.

Table VII summarizes per-ton energy, employment, and emissions comparisons for each 1,500-tpd disposal scenario.

Table VII. Summary Per-ton Comparisons
(1,500-TPD Capacity Facilities)

	10-Mile Landfill	1,000-Mile Landfill	WTE
Energy Consumed (thousands of Btus/ton)	154	2,828	-1,497
Employment (FTE/ton)	0.00078	0.00177	0.00082
Air Emissions (grams/ton)			
CO	48	1,025	1,058
NOx	91	1,094	1,708
SOx	10	60	506
PM	10	133	182
HC	12	223	59

Note: Negative number indicates net energy produced.

The above examination provides a starting point for further analysis into the interstate waste transport debate. Looking at each factor (e.g., energy) separately, we can select the optimal method. But with no index to compare a job to a ton of air pollutant to a thousand Btus of energy produced, we need more information before concluding that one method is better than the others. For example, existing local air quality conditions could dictate whether additional pollution generated by a new WTE plant would weigh against the energy produced by the plant. Also, individual companies and/or municipalities must evaluate the tradeoffs between labor and capital in today's economy. Other issues relate to

overall energy supply. If foreign supplies become more costly, we may need to evaluate the Btu content of specific waste streams to determine tradeoffs between burying those I and using them as fuel. Asking and trying to answer these kinds of questions will lead to better decision making by moving the debate away from emotions and politics towards quantitative assessment.

Ms. Elcock is a Policy Analyst with Argonne National Laboratory in the Washington, D.C. Office.

Appendix A. Assumptions

Scenario Assumptions

Ten-Mile Landfill Scenarios:

- Trash picked up at curbside by 10-ton capacity garbage/packer truck (Class 8A truck).
- Trash hauled in packer/garbage truck 10 miles to landfill. Truck returns empty, implying a 20-mile roundtrip.
- Trash moved and covered via heavy-duty diesel earthmoving equipment according to the schedule in Table A-1.

One Thousand-Mile Landfill Scenarios:

- Trash picked up at curbside by 10-ton capacity garbage/packer truck (Class 8A).
- Trash hauled in packer/garbage truck 10 miles to transfer station pit. Truck returns empty, implying a 20-mile roundtrip.
- Trash transferred in station from pit to tractor trailers, via two 350-horsepower bulldozers.
- Trash hauled in 20-ton capacity tractor-trailer type truck (Class 8B truck) 1,000 miles to landfill. Truck returns empty, implying a 2,000-mile roundtrip.
- Trash moved and covered via heavy-duty diesel earthmoving equipment according in Table A-1.

WTE Scenarios:

- Trash picked up at curbside by 10-ton capacity garbage/packer truck (Class 8A)
- Trash hauled in garbage/packer truck 10 miles to WTE plant. Returns empty, implying 20-mile round trip.
- Trash moved via front-end loader (number and type depends on plant capacity) from drop-off point to incinerator, within the WTE plant.
- Trash burned in WTE plant and heat is converted to electricity.
- Ash hauled 30 miles to landfill for final disposal. Truck returns empty, implying a 60-mile roundtrip.
- Ratio of ash to trash input by is .237 by weight.[9]

---

[9] Berenyi, E., and Gould, R., Resource Recovery Yearbook 1988-89, Government Advisory Associates, 1989.

Table A-1. Number of Pieces of Equipment, by Landfill Capacity

Equipment	Approximate Rated Horsepower	50 TPD	500 TPD	1,500 TPD
Track-Type Tractor	345	0	1	2-3
Wheeled Tractor /Compactor	345	0	1	2
Scraper	460	0	2	2-3
Motor Grader	150	0	0	1
Wheeled Loader	250	0	0	1
Track-Type Loader	175, 250[10]	2	1	0

EQUIPMENT ASSUMPTIONS

Assumptions regarding types, numbers, and sizes of non-highway equipment used in the scenarios are based on discussions with equipment and waste disposal industry representatives.[11] Highway vehicle (packer and long-haul truck) data and assumptions were provided by Argonne National Laboratory.[12]

Landfill Scenario Equipment

Packer/garbage truck:

Fuel efficiency: 2.1 miles per gallon
Load capacity: 10 tons
Btu content of diesel fuel: 138,700 Btu/gallon
Travel distance: 10 miles one-way; 20 miles roundtrip.
Workers per truck: 2.0
Workdays per week: 5.5
Workweeks per year: 52

---

[10] The smaller horsepower loaders are used at the smaller facilities.

[11] Claypool, C., Alban Tractor Co., Inc., Baltimore, MD, Personal Communication, June, 1992; Legler, J. NSWMA, Personal Communication, June, 1992; and Repa, E., NSWMA, Personal Communication, June, 1992.

[12] Mintz, M., Argonne National Laboratory, Personal Communication, June, 1992. Data based on U.S. Department of Commerce, Bureau of the Census, The Truck Inventory and Use Survey, 1989, Public Use Tape.

Transfer station:

Transfer station capacity: 1,500 tpd
Equipment required: 2 bulldozers
Horsepower: 350 hp/bulldozer
Workers per transfer station: 10-12
Load factor for bulldozers: 0.7
Btu per horsepower hour: 2,545
Hours equipment operated per year: 2,400
Days per week transfer station operates: 5.5
Workweeks per year: 52

Long-haul MSW Transportation Truck:

Fuel efficiency: 5.2 miles per gallon
Load capacity: 20 tons
Btu Content of diesel fuel: 138,700 Btu/gallon
Travel distance: 1,000 miles one-way; 2,000 miles roundtrip from transfer station to landfill
Workers per truck: 1.0
Workdays per week: 5.0
Weeks per year: 52

Landfill Earth-Moving Equipment

Number of hours per year equipment operated: 2,400
Number of days per week landfill operated: 5.5
Number of weeks per year: 52
Number of pieces of equipment: Varies with landfill capacity; See Table A-1.

WTE SCENARIO EQUIPMENT ASSUMPTIONS:

Packer/garbage truck: (same as for landfill)

Wheeled loader in WTE plant:

General:
Load factor: 0.5
Hours operated per year: 2,400
Btu per horsepower-hour: 2,545
Rated horsepower per flywheel horsepower: 1.15

250-tpd capacity plant:
1 170-flywheel hp loader
rated horsepower: 195.5

1,500-tpd capacity plant:
2 170-flywheel hp loaders
total rated horsepower: 391.0

2,250-tpd capacity plant:
2 220-flywheel hp loaders
total rated horsepower: 506.0

WTE plant:

Percent of time WTE plant operating at full capacity: 85%[13]
Net kilowatt-hours of electricity produced per ton of MSW input: 485[14]

Truck Used to Haul Ash:

Fuel efficiency: 5.2 miles per gallon
Load capacity: 20 tons
Btu Content of diesel fuel: 138,700 Btu/gallon
Travel distance: 30 miles one-way; 60 miles round trip from WTE plant to landfill
Workers per truck: 1.0
Workdays per week: 5.0
Workweeks per year: 52

EMPLOYMENT-RELATED ASSUMPTIONS

Workers at Landfills[15]		Workers at WTE Plants[16]	
Capacity	Workers	Capacity	Workers
50-tpd	4	250-tpd	30
500-tpd	17	1,500-tpd	45
1,500-tpd	35	2,250-tpd	60

[13] Berenyi, E., and Gould, R., 1991 Resource Recovery Yearbook, Government Advisory Associates, 1991.

[14] ibid.

[15] Rohr, J., Waste Management, Personal Communication, June, 1992.

[16] Anderson, R., Wheelabrator Technologies, Personal Communication, June, 1992, and Wood, J., Wheelabrator Technologies, Personal Communication, March, 1992.

EMISSIONS-RELATED ASSUMPTIONS

Table A-2. Emission Factors Used in Calculations

Emitter	CO	NOx	SOx	PM	HC
Packer truck	9.7 g/mi	9.8 g/mi	0.12 g/mi	1.53 g/mi	2.1 g/mi
Long-haul truck	9.7 g/mi	9.8 g/mi	0.48 g/mi	1.21 g/mi	2.1 g/mi
Bulldozers at transfer stations	2.28 g/hphr	8.15 g/hphr	0.867 g/hphr	0.411 g/hphr	0.37 g/hphr
Loaders at WTE plants	2.71 g/hphr	8.81 g/hphr	0.86 g/hphr	0.81 g/hphr	0.97 g/hphr
WTE plants	998.8 g/ton	1,634.4 g/ton	499.4 g/ton	172.5 g/ton	45.4 g/ton
Ash haulers	9.7 g/mi	9.7 g/mi	0.48 g/mi	1.21 g/mi	2.1 g/mi
Track-type tractor	2.15 g/hphr	7.81 g/hphr	0.85 g/hphr	0.69 g/hphr	0.75 g/hphr
Wheeled tractor/ compactor	7.34 g/hphr	11.91 g/hphr	0.85 g/hphr	1.27 g/hphr	1.76 g/hphr
Scraper	2.45 g/hphr	7.46 g/hphr	0.90 g/hphr	0.79 g/hphr	0.55 g/hphr
Motor grader	1.54 g/hphr	7.14 g/hphr	0.97 g/hphr	0.63 g/hphr	0.36 g/hphr
Wheeled loader	2.71 g/hphr	8.81 g/hphr	0.86 g/hphr	0.81 g/hphr	0.97 g/hphr
Track-type loader	2.26 g/hphr	9.30 g/hphr	0.85 g/hphr	0.66 g/hphr	1.11 g/hphr

Sources: See Table A-3.

Table A-3. Data Sources for Emission Factors

Emitter	CO	NOx	SOx	PM	HC
Packer truck	AP42-91	AP42-91	Stodol-sky	Sie-nicki	AP42-91
Long-haul truck	AP42-91	AP42-91	Stodol-sky	Sie-nicki	AP42-91
Bulldozers at transfer stations	AP42-85	AP42-85	AP42-85	AP42-85	AP42-85
Loaders at WTE plants	AP42-85	AP42-85	AP42-85	AP42-85	AP42-85
WTE plants	AP42-88	AP42-88	AP42-88	AP42-88	AP42-88
Ash haulers	AP42-91	AP42-91	Stodol-sky	Sie-nicki	AP42-91
Track-type tractor	AP42-85	AP42-85	AP42-85	AP42-85	AP42-85
Wheeled tractor/ compactor	AP42-85	AP42-85	AP42-85	AP42-85	AP42-85
Scraper	AP42-85	AP42-85	AP42-85	AP42-85	AP42-85
Motor Grader	AP42-85	AP42-85	AP42-85	AP42-85	AP42-85
Wheeled Loader	AP42-85	AP42-85	AP42-85	AP42-85	AP42-85
Track-type loader	AP42-85	AP42-85	AP42-85	AP42-85	AP42-85

AP42-91: EPA, Compilation of Air Pollution Emission Factors, Volume 2, Mobile Sources, Supplement A, January, 1991.

AP42-88: EPA, Compilation of Air Pollution Emission Factors, Volume 1, Stationary Point and Area Sources. Fourth Edition, Supplement B, September, 1988.

AP42-85: EPA, Compilation of Air Pollution Emission Factors, Volume 2, Mobile Sources, Fourth Edition, September, 1985.

Stodolsky: Based on data supplied by F. Stodolsky, Argonne National Laboratory. See Appendix B for specific algorithms and assumptions.

Sienicki: Sienicki, E., Navistar International Transportation Corporation, Personal Communication, June, 1992.

Other Emissions-related Assumptions:

Btu Content of diesel fuel: 138,7000 Btu/gallon[17]
Weight of fuel: 6.7 lb/gallon[18]
Conversion rate of Sulfur to Sulfur oxides: 82 percent reduction in sulfur results in 80 percent reduction in Sulfur oxides. Therefore conversion rate = .82/.80 or 1.025 lb SOx to 1 lb. S[19]
Grams per pound: 454
Sulfur content of diesel fuel: 0.3%[20]
Sulfur to fuel molecular weight ratio: 32/114

---

[17] Mintz, M., Argonne National Laboratory, Personal Communication, June, 1992.

[18] Stodolsky, F., Argonne National Laboratory, Personal Communication, June, 1992.

[19] Stodolsky, F., Argonne National Laboratory, Personal Communication, May, 1992. Based on data from California Air Resources Board, Proposed Adoption of Regulations Limiting the Sulfur Content and the Aromatic Hydrocarbon Content of Motor Diesel Fuel, October, 1988.

[20] Stodolsky, F., Argonne National Laboratory, Personal Communication, June, 1992.

Appendix B. Per-ton Calculations

Per-ton Btu Calculations

Packer Truck:
138,700 Btu/gal x 1 gal/2.1 miles x 1/10 tons x 20 miles = 132,095 Btus/ton

Long-Haul Truck:
138,700 Btu/gal x 1 gal/5.2 miles x 1/20 tons x 2,000 miles =2,667,308 Btus/ton

Transfer Station:
2 bulldozers x 350 hp/bulldozer x .7 x 2,400 hours/year x 2,545 Btu/hphr x (1 yr/(1,500 tons/day x 5.5 days/week x 52 weeks/yr) = 6,977 Btu/ton

Earth Moving Equipment at Landfills

50-TPD Landfill:

Number of tons per year disposed at landfill:
5.5 days/week x 52 weeks/year x 50 tons/day = 14,300 tons/year

Table B-1. Calculation of Btus for Equipment Operations at 50-TPD landfill

	Track-Type Loader
No. of pieces	2
Rated horsepower (per piece)	207
Load Factor	0.5
Actual Horsepower	104
Hours per year	2,400
Hp-hrs per year	496,800
Btus per year	1.264×10^9

Total Btus per year: 1.264×10^9
Total Btus per ton disposed: 1.264×10^9 Btus/14,300 tons/year = 88,417 Btu/ton

500-TPD Landfill

Number of tons per year disposed at landfill:
5.5 days/week x 52 weeks/year x 500 tons/day = 143,000 tons/year

Table B-2. Calculation of Btus for Equipment Operations at 500-TPD Landfill

	Track-type tractor	Wheeled Tractor/ Compactor	Scraper	Track-Type Loader
No. of pieces	1	1	2	1
Rated horsepower (per piece)	345	345	460	242
Load Factor	0.5	0.5	0.5	0.5
Actual Horsepower	173	173	230	121
Hours per year	2,400	2,400	2,400	2,400
Hp-hrs per year	414,000	414,000	1,104,000	289,800
Btus per year	1.054×10^9	1.054×10^9	2.810×10^9	7.375×10^8

Total Btus per year: 5.654×10^9
Total Btus per ton disposed: 5.654×10^9 Btus/143,000 tons/year = <u>39,542 Btu/ton</u>

1,500-TPD Landfill

Number of tons per year disposed at landfill:
5.5 days/week x 52 weeks/year x 1,500 tons/day = 429,000 tons/year

Table B-3. Calculation of Btus for Equipment Operations at 1,500-TPD Landfill

	Track-type tractor	Wheeled Tractor/ Compactor	Scraper	Motor Grader	Wheeled Loader
No. of pieces[21]	2.5	2	2.5	1	1
Rated horsepower (per piece)	345	345	460	144	253
Load Factor	0.5	0.5	0.5	0.33	0.33
Actual Horsepower	173	173	230	48	83
Hours per year	2,400	2,400	2,400	2,400	2,400
Hp-hrs per year	1,035,000	828,000	1,380,000	114,048	200,376
Btus per year	2.634×10^9	2.107×10^9	3.512×10^9	2.902×10^8	5.100×10^8

Total Btus per year: 9.054×10^9
Total Btus per ton disposed: 9.054×10^9 Btus/429,000 tons/year = 21,104 Btu/ton

Energy at WTE plant

Assumptions:

Net kwh/ton of energy produced: 485 kwh/ton
One kwh equals 3,413 Btu.
Non-electric equipment (used to move trash) operates 2,400 hours per year.
Non-electric equipment requirements:
250-tpd plant: one 170 flywheel hp wheeled loader
1,500-tpd plant: two 170 flywheel hp wheeled loaders
2,250-tpd plant: two 220 flywheel hp wheeled loaders
Rated horsepower per flywheel horsepower: 1.15
Average load factor for non-electric equipment: .5
WTE plants on-line average: 85%.
Ratio of ash to MSW input, by weight: 0.237

[21] A fraction indicates that on average, 2 or 3 pieces of these types of equipment are used at a 1,500-tpd facility.

Ash transported 30 miles to 1,500-tpd landfill; truck returns empty (for a 60-mile roundtrip).
Fuel efficiency for truck hauling ash: 5.2 miles/gallon

Energy produced:

Net kwh per ton: 485
485 kwh/ton x 3,413 Btu/ton = 1,655,305 Btu/ton

WTE industry representatives indicate that the number of kilowatt-hours produced per ton is not significantly affected by plant capacity. A more significant determinant of net energy production is the Btu content of the fuel.

Non-electric energy used at WTE plant:

250-tpd capacity plant:

170 hp x 1.15 x .5(load factor) = 97.75 hp
97.75 hp x 2,400 hours/year x 2,545 Btu/hphr = 597.1 x 10^6 Btu/year
597.1 x 10^6 Btu/year x 1 year/(250 tpd x 365 days/year x .85)

= 7,698 Btu/ton

1,500-tpd plant:

2 x 170 hp x 1.15 x .5(load factor) = 195.5 hp
195.5 hp x 2,400 hours/year x 2,545 Btu/hphr = 1,194 x 10^6 Btu/year
1,194 x 10^9 Btu/year x 1 year/(1,500 tpd x 365 days/year x .85)

= 2,566 Btu/ton

2,250-tpd plant:

2 x 220 hp x 1.15 x .5(load factor) = 253.0 hp
253.0 hp x 2,400 hours/year x 2,545 Btu/hphr = 1.545 x 10^9 Btu/year
1.545 x 10^9 Btu/year x 1 year/(2,250 tpd x 365 days/year x .85)

= 2,214 Btu/ton

Energy used to transport ash from WTE plant to Landfill:

138,700 Btu/gal x 1 gal/5.2 miles x 1/20 tons ash = 1,334 Btu/ ton-mile of ash.
1,334 Btu/ ton-mile ash x 60 miles = 80,019 Btu/ton ash
80,019 Btu/ton ash x .237 ton ash/ton MSW = 18,965 Btu/ton MSW.

Energy used at landfill for ash disposal (1,500-tpd landfill):

21,104 Btu/ton ash disposed x .237 ton ash disposed/ton MSW = 5,002 Btu/ton MSW

Total energy consumption for each landfill scenario is summarized in Table B-4, and total energy produced for each WTE scenario is summarized in Table B-5.

Table B-4. Energy Consumption for Landfill Scenarios (Thousand Btus per Ton of Trash)

Capacity (TPD)	Packer Truck	Transfer Station	Long Haul	Landfill	Total
Landfill - 10 miles					
50	132.1	0	0	88.4	220.5
500	132.1	0	0	39.5	171.6
1,500	132.1	0	0	21.1	153.2
Landfill - 1000 miles					
50	132.1	7.0	2,667.3	88.4	2,894.8
500	132.1	7.0	2,667.3	39.5	2,845.9
1,500	132.1	7.0	2,667.3	21.1	2,827.5

Table B-5. Energy Consumption for WTE Plant Scenarios (in Thousands of Btus per Ton of Trash)

Capacity (TPD)	Packer Truck	Non-electric Equipment at WTE plant	WTE plant - net electric energy consumed	Ash haul	Ash Disposal	Total
250	132.1	7.7	-1,655.3	19.0	5.0	-1,491.5
1,500	132.1	2.6	-1,655.3	19.0	5.0	-1,496.6
2,250	132.1	2.2	-1,655.3	19.0	5.0	-1,497.0

Note: A negative number indicates that net energy is produced.

Per-ton Employment Calculations

Packer/garbage truck:

(2 FTE/year)/(10 tons/day x 5.5 days/week x 52 weeks/year) = 0.00070 FTE/ton

Long-haul truck:
(1 FTE/year)/(20 tons/2,000 mi x 50 mi/hr x 2,080 hr/yr)) = 0.00096 FTE/ton

Transfer station:
11 FTE/(1,500 tpd x 5.5 days/week x 52 weeks/year) = .00003 FTE/ton

Landfill:

50 TPD: 4 FTE/(50 x 5.5 x 52) = .00028 FTE/ton
500 TPD: 17 FTE/(500 x 5.5 x 52) = .00012 FTE/ton
1,500 TPD: 35 FTE/(1,500 x 5.5 x 52) = .00008 FTE/ton

WTE plant:

250-TPD:
30 FTE/(250 TPD x 365 days/year x .85) = 0.00039 FTE/ton

1,500-TPD plant:
45 FTE/(1,500 TPD x 365 days/year x .85) = 0.00010 FTE/ton

2,250-TPD plant:
60 FTE/(2,250 TPD x 365 days/year x .85) = 0.00009 FTE/ton

WTE ash haul truck:

1 FTE/year x 1 trip/20 tons x 60 miles/trip x 1 hour/50 miles x 1 year/2080 hours x .237 tons ash/ton MSW = 0.00001 FTE/ton

Ash disposal at 1,500 TPD landfill:

.00008 FTE/ton ash x .237 ton ash/ton MSW = 0.00002 FTE/ton MSW

Total employment estimates for each landfill scenario are shown in Table B-6, and total employment estimates for each WTE scenario are shown in Table B-7.

Table B-6. Employees at Landfill Scenarios
(Full-time-equivalent Employees per Ton of Trash)

	Packer Truck	Transfer Station	Long Haul	Land-fill	Total
Landfill - 10 miles					
50 TPD	0.00070	0	0	.00028	0.00098
500 TPD	0.00070	0	0	.00012	0.00082
1,500 TPD	0.00070	0	0	.00008	0.00078
Landfill - 1,000 miles					
50 TPD	0.00070	0.00003	.00096	.00028	0.00197
500 TPD	0.00070	0.00003	.00096	.00012	0.00181
1,500 TPD	0.00070	0.00003	.00096	.00008	0.00177

Table B-7. Employees at WTE plants
(Full-time-equivalent Employees per Ton of Trash)

Capac-ity (TPD)	Packer	WTE plant	Ash haul	Ash dis-posal	Total
250	0.00070	0.00039	0.00001	0.00002	0.00112
1,500	0.00070	0.00010	0.00001	0.00002	0.00083
2,250	0.00070	0.00009	0.00001	0.00002	0.00082

Per-ton Emissions Calculations

Landfills

Packer Truck

CO: 9.7 g/mi x 20 mi. x 1/10 ton = 19.4 g/ton
NOx: 9.8 g/mi x 20 mi. x 1/10 ton = 19.6 g/ton
SOx: 6.7 lb/gal x 1 gal/2.1 mi x 1.025 lb S/1 lb SOx x 454 g/lb x .0008 lb S/lb fuel = 1.19 g/mi.
1.19 g/mi x 20 mi x 1/10 ton = 2.38 g/ton
PM: 1.53 g/mi x 20 mi x 1/10 ton = 3.1 g/ton
HC: 2.1 g/mi x 20 mi x 1/10 ton = 4.2 g/ton

Transfer Station

CO: 2.28 g/hphr x 2 bulldozers x 350 hp/bulldozer x .7 x 2,400 hr/yr x (1/(1,500 ton/day x 5.5 day/week x 52 weeks/year)) = 6.25 g/ton
NOx: 8.15 g/hphr x 2 bulldozers x 350 hp/bulldozer x .7 x 2,400 hr/yr x (1/(1,500 ton/day x 5.5 day/week x 52 weeks/year)) = 22.34 g/ton
SOx: 0.867 g/hphr x 2 bulldozers x 350 hp/bulldozer x .7 x 2,400 hr/yr x (1/(1,500 ton/day x 5.5 day/week x 52 weeks/year)) = 2.38 g/ton
PM: 0.411 g/hphr x 2 bulldozers x 350 hp/bulldozer x .7 x 2,400 hr/yr x (1/(1,500 ton/day x 5.5 day/week x 52 weeks/year)) = 1.13 g/ton
HC: 0.37 g/hphr x 2 bulldozers x 350 hp/bulldozer x .7 x 2,400 hr/yr x (1/(1,500 ton/day x 5.5 day/week x 52 weeks/year)) = 1.01 g/ton

Long-Haul Truck

CO: 9.7 g/mi x 2,000 mi. x 1/20 ton = 970 g/ton
NOx: 9.8 g/mi x 2,000 mi. x 1/20 ton = 980 g/ton
SOx: 6.7 lb/gal x 1 gal/5.2 mi x 1.025 lb S/1 lb SOx x 454 g/lb x .0008 lb S/lb fuel = 0.48 g/ton
0.48 g/mi x 2,000 mi x 1/20 ton = 48.0 g/ton
PM: 1.21 g/mi x 2,000 mi x 1/20 ton = 121 g/ton
HC: 2.1 g/mi x 2,000 mi x 1/20 ton = 210 g/ton

Land-fill Operations

50-TPD Landfill

For each type of equipment shown in Table B-1, the number of horsepower hours per year (from Table B-1) is multiplied by the appropriate emission factor (i.e., CO, NOx, SOx, PM, and HC) in grams per horsepower hour (from Table A-2). The results (in grams per year) are divided by the number of tons disposed at a 50-tpd landfill in one year, or 14,300. (5.5 days/week x 52 weeks/year x 50 tons/day). Resulting per-ton emissions are shown in Table B-8.

Table B-8. Emissions for 50-TPD Landfill
(in Grams per Ton)

	Track-type Loader	Total
CO	78.5	78.5
NOx	323.1	323.1
SOx	29.6	29.6
PM	22.8	22.8
HC	38.6	38.6

500-TPD Landfill

For each type of equipment shown in Table B-2, the number of horsepower hours per year (from Table B-2) is multiplied by the appropriate emission factor (i.e., CO, NOx, SOx, PM, and HC) in grams per horsepower hour (from Table A-2). The results (in grams per year) are divided by the number of tons disposed at a 500-tpd landfill in one year, or 143,000. (5.5 days/week x 52 weeks/year x 500 tons/day). The resulting per-ton emissions are shown in Table B-9.

Table B-9. Emissions for 500-TPD Landfill (in Grams per Ton)

	Track-type tractor	Wheeled Tractor/ Compactor	Scraper	Track-type Loader	Total
CO	6.2	21.3	18.9	4.6	51.0
NOx	22.6	34.5	57.6	18.8	133.5
SOx	2.5	2.5	7.0	1.7	13.7
PM	2.0	3.7	6.1	1.3	13.1
HC	2.2	5.1	4.2	2.2	13.7

Note: Components may not sum due to rounding.

1,500-TPD Landfill

For each type of equipment shown in Table B-3, the number of horsepower hours per year (from Table B-3) is multiplied by the appropriate emission factor (i.e., CO, NOx, SOx, PM, and HC) in grams per horsepower hour (from Table A-2). The results (in grams per year) are divided by the number of tons disposed at a 1,500-tpd landfill in one year, or 429,000. (5.5 days/week x 52 weeks/year x 1,500 tons/day). The resulting per-ton emissions are shown in Table B-10.

Table B-10. Emissions for 1,500-TPD Landfill
(in Grams per Ton)

	Track-type tractor	Wheeled Tractor Compactor	Scraper	Motor Grader	Wheeled Loader	Total
CO	5.2	14.2	7.9	0.4	1.3	28.9
NOx	18.8	23.0	24.0	1.9	4.1	71.8
SOx	2.1	1.6	2.9	0.3	0.4	7.3
PM	1.7	2.5	2.5	0.2	0.4	7.2
HC	1.8	3.4	1.8	0.1	0.5	7.5

Note: Components may not sum due to rounding.

Total air emissions for the combined activities in the ten-mile landfill scenarios are shown in Table B-11.

Table B-11. Emissions for Landfill Scenarios - 10 miles
(in Grams per Ton of Trash)

	Packer Truck	Transfer Station	Long Haul	Landfill	Total
50 TPD					
CO	19.4	0	0	78.5	97.9
NOx	19.6	0	0	323.1	342.7
SOx	2.4	0	0	29.6	32.0
PM	3.1	0	0	22.8	25.9
HC	4.2	0	0	38.6	42.8
500 TPD					
CO	19.4	0	0	51.0	70.4
NOx	19.6	0	0	133.5	153.1
SOx	2.4	0	0	13.7	16.1
PM	3.1	0	0	13.1	16.2
HC	4.2	0	0	13.7	17.9
1,500 TPD					
CO	19.4	0	0	28.9	48.3
NOx	19.6	0	0	71.8	91.4
SOx	2.4	0	0	7.3	9.7
PM	3.1	0	0	7.2	10.3
HC	4.2	0	0	7.5	11.7

Total air emissions for the combined activities in the 1,000-mile landfill scenarios are shown in Table B-12.

Table B-12. Emissions for Landfill Scenarios - 1,000 miles
(Grams per Ton of Trash)

	Packer Truck	Transfer Station	Long Haul	Landfill	Total
50 TPD					
CO	19.4	6.3	970.0	78.5	1,074.2
NOx	19.6	22.3	980.0	323.1	1,345.0
SOx	2.4	2.4	48.0	29.6	82.4
PM	3.1	1.1	121.0	22.8	148.0
HC	4.2	1.0	210.0	38.6	253.8
500 TPD					
CO	19.4	6.3	970.0	51.0	1,046.7
NOx	19.6	22.3	980.0	133.5	1,155.4
SOx	2.4	2.48	48.0	13.7	66.6
PM	3.1	1.1	121.0	13.1	138.3
HC	4.2	1.0	210.0	13.7	228.9
1,500 TPD					
CO	19.4	6.3	970.0	28.9	1,024.6
NOx	19.6	22.3	980.0	71.8	1,093.7
SOx	2.4	2.4	48.0	7.3	60.1
PM	3.1	1.1	121.0	7.2	132.4
HC	4.2	1.0	210.0	7.5	222.7

Waste-to-Energy Plants

Packer Truck

CO: 9.7 g/mi x 20 mi. x 1/10 ton = 19.4 g/ton
NOx: 9.8 g/mi x 20 mi. x 1/10 ton = 19.6 g/ton
SOx: 6.7 lb/gal x 1 gal/2.1 mi x 1.025 lb SOx/1 lb S x 454 g/lb x .0008 lb S/lb fuel =
1.19 g/mi
1.19 g/mi x 20 mi x 1/10 ton = 2.4 g/ton
PM: 1.53 g/mi x 20 mi x 1/10 ton = 3.1 g/ton
HC: 2.1 g/mi x 20 mi x 1/10 ton = 4.2 g/ton

Non-Electric Energy Equipment (Wheeled Loader)

250-TPD Facility

CO: 2.71 g/hphr x 97.75 hp x 2,400 hr/yr x (1/(250 x 365 days/yr x .85) = 8.2 g/ton
NOx: 8.81 g/hphr x 97.75 hp x 2,400 hr/yr x (1/(250 x 365 days/yr x .85) = 26.7 g/ton
SOx: 0.86 g/hphr x 97.75 hp x 2,400 hr/yr x (1/(250 x 365 days/yr x .85) = 2.6 g/ton
PM: 0.81 g/hphr x 97.75 hp x 2,400 hr/yr x (1/(250 x 365 days/yr x .85) = 2.4 g/ton
HC: 0.97 g/hphr x 97.75 hp x 2,400 hr/yr x (1/(250 x 365 days/yr x .85) = 2.9 g/ton

1,500-TPD Facility

CO: 2.71 g/hphr x 195.5 hp x 2,400 hr/yr x (1/(1,500 x 365 days/yr x .85) = 2.7 g/ton
NOx: 8.81 g/hphr x 195.5 hp x 2,400 hr/yr x (1/(1,500 x 365 days/yr x .85) = 8.9 g/ton
SOx: 0.86 g/hphr x 195.5 hp x 2,400 hr/yr x (1/(1,500 x 365 days/yr x .85) = 0.9 g/ton
PM: 0.81 g/hphr x 195.5 hp x 2,400 hr/yr x (1/(1,500 x 365 days/yr x .85) = 0.8 g/ton
HC: 0.97 g/hphr x 195.5 hp x 2,400 hr/yr x (1/(1,500 x 365 days/yr x .85) = 1.0 g/ton

2,250-TPD Facility

CO: 2.71 g/hphr x 253.0 hp x 2,400 hr/yr x (1/(2,250 x 365 days/yr x .85) = 2.7 g/ton
NOx: 8.81 g/hphr x 253.0 hp x 2,400 hr/yr x (1/(2,250 x 365 days/yr x .85) = 8.9 g/ton
SOx: 0.86 g/hphr x 253.0 hp x 2,400 hr/yr x (1/(2,250 x 365 days/yr x .85) = 0.9 g/ton

PM: 0.81 g/hphr x 253.0 hp x 2,400 hr/yr x (1/(2,250 x 365 days/yr x .85) = 0.8 g/ton
HC: 0.97 g/hphr x 253.0 hp x 2,400 hr/yr x (1/(2,250 x 365 days/yr x .85) = 1.0 g/ton

WTE Plant
Emission factors for WTE plants are in grams per ton (Table A-2); therefore additional calculations are not required.

Ash Haul

CO: 9.7 g/mi x 60 mi. x 1/20 ton = 29.1 g/ton
NOx: 9.8 g/mi x 60 mi. x 1/20 ton = 29.4 g/ton
SOx: 6.7 lb/gal x 1 gal/5.2 mi x 1.025 lb SOx/1 lb S x 454 g/lb x .0008 lb S/lb fuel =
0.48 g/mi
0.48 g/mi x 1/20 tons x 60 miles = 1.4 g/ton
PM: 1.21 g/mi x 60 mi x 1/20 ton = 3.6 g/ton
HC: 2.1 g/mi x 60 mi x 1/20 ton = 6.3 g/ton

Ash Disposal (1,500-TPD Landfill)

CO: 29.0 g/ton ash x .237 ton ash/ton MSW = 6.9 g/ton MSW
NOx: 71.8 g/ton ash x .237 ton ash/ton MSW = 17.0 g/ton MSW
SOx: 7.3 g/ton ash x .237 ton ash/ton MSW = 1.7 g/ton MSW
PM: 7.3 g/ton ash x .237 ton ash/ton MSW = 1.7 g/ton MSW
HC: 7.6 g/ton ash x .237 ton ash/ton MSW = 1.8 g/ton MSW

Total air emissions for the combined activities in WTE plant scenarios are shown in Table B-13.

END

DATE
FILMED
3/31/93