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Characterization of MWC Ashes and Leachates from MSW Landfills, Monofills, and Co-Disposal Sites

Volume II of VII
Leachate Baseline Report: Determination of Municipal Landfill Leachate Characteristics

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LEACHATE BASELINE REPORT: DETERMINATION OF MUNICIPAL LANDFILL LEACHATE CHARACTERISTICS
VOLUME II OF VII

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF SOLID WASTE
WASHINGTON, D.C.

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ACRONYMS AND DEFINITIONS

BNA	Base-neutral and Acid Extractables
BOD	Biological Oxygen Demand
CAS	Chemical Abstract Service
CB	Chlorobiphenyl
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COD	Chemical Oxygen Demand
Codisposal	Disposal together of municipal solid wastes and municipal solid waste combustion ashes
CP	Chlorinated Phenols
DWE	Deionized Water Extraction Test Method
EP	Extraction Procedure
EPA	U.S. Environmental Protection Agency
ESP	Electrostatic Precipitator
HSWA	Hazardous and Solid Waste Amendments
HWC	Hazardous Waste Combustion
LF	Landfill
MCL	Maximum Contaminant Level
Monofill	A landfill that contains only solid waste combustion ashes and residues
MSW	Municipal Solid Waste
MW	Monitoring Well
MWC	Municipal Waste Combustion
MWEP	Monofilled Waste Extraction Procedure, also known as SW-924
ND	Not Detected
NPDES	National Pollutant Discharge Elimination System
PAHs	Polynuclear Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls

ACRONYMS AND DEFINITIONS
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PCDDs	Polychlorinated dibenzo-p-dioxins
PCDFs	Polychlorinated dibenzofurans
POTW	Publically Owned Treatment Works
RCRA	Resource Conservation and Recovery Act
RDF	Refuse Derived Fuel
RPD	Relative Percent Difference
SS	Suspended Solids
SW-924	Deionized Water Extraction Test Method
TCLP	Toxic Characteristics Leaching Procedure Test Method
TDS	Total Dissolved Solids
TEF	Toxic Equivalency Factors
TNK	Total Nitrogen Kjeldahl
TOC	Total Organic Carbon
TSCA	Toxic Substances Control Act

1.0 INTRODUCTION

1.1 PURPOSE

This baseline report on municipal landfill leachate characteristics was written to provide support to the United States Environmental Protection Agency's (EPA's) study of the Subtitle D Program. The principal objective of this Phase I leachate baseline report, prepared by NUS Corporation (NUS), is to assist the EPA in developing data to evaluate the potential health and environmental effects of leachate from municipal landfills. This report summarizes existing leachate characteristic data supplied by the EPA, including concentrations of organic and inorganic parameters.

1.2 BACKGROUND INFORMATION

In 1979, EPA promulgated criteria for determining which Subtitle D (nonhazardous waste) disposal facilities pose a reasonable probability of adverse effects upon human health and the environment and therefore should be classified as "open dumps."

The Hazardous and Solid Waste Amendments (HSWA), enacted in 1984, require of the EPA the following actions: (1) to submit a report to Congress by November 8, 1987, addressing whether the Subtitle D criteria authorized by RCRA Sections 1008(a) and 4004 Criteria (40 CFR Part 257) are adequate to protect human health and the environment from groundwater contamination; (2) to recommend whether additional authorities are needed to enforce the criteria; and (3) to revise the criteria by March 31, 1988, for facilities that may receive hazardous household waste or wastes from small-quantity generators of hazardous waste.

Since 1984, concerns were raised regarding the chemical composition of leachate generated from municipal waste landfills. These concerns center on the detection of certain toxic metals and organics, and on the lack of available data for a comprehensive and defensible evaluation of the effects of leachates on human health and the environment.

1.3 REPORT ORGANIZATION

Section 2.0 discusses the literature sources used to prepare this report and their limitations. Section 3.0 contains the literature findings for organic and inorganic constituents. Appendix A contains range graphs and median frequency-of-occurrence histograms for the pollutants discussed in Section 3.0. Also included in Appendix A are three tables. Appendix B is a case-by-case list of the Wisconsin sites identified in this report. Appendix B also provides a summary of the information available regarding these sites, as obtained from the Wisconsin Department of Natural Resources Special Report.

2.0 LITERATURE REFERENCES

2.1 INTRODUCTION

The following literature references were used to compile this report.

- McGinley, P.M., and P. Kmet. Formation, Characteristics, Treatment, and Disposal of Leachate from Municipal Solid Waste Landfills. Wisconsin Department of Natural Resources Special Report, August 1, 1987.

- Sobotka & Co., Inc. Case history data compiled and reported in a July 1986 report to the U.S. EPA's Economic Analysis Branch of the Office of Solid Waste.

- Brown, K.W., and K.C. Donnelly. The Occurrence and Concentration of Organic Chemicals in Hazardous and Municipal Waste Landfill Leachate. Texas A & M University, Soil and Crop Sciences Department, College Station, Texas.

2.2 WISCONSIN DEPARTMENT OF NATURAL RESOURCES SPECIAL REPORT

The Wisconsin Department of Natural Resources report, which is the result of a 3-year effort, provides chemical characteristics of municipal solid waste leachate from 20 active Wisconsin landfills. Of significance is the fact that 14 out of 20 Wisconsin landfills sampled reported receiving industrial wastes. Some also reported receiving hazardous wastes.

According to the Wisconsin report, these 20 active landfills represent a wide variety of site designs, sizes, and operations. The report data were collected with the intent that the landfill contaminants could be identified; the range of these contaminants could be defined; and the impacts of time, site design, and site operation on leachate quality could be observed. By summarizing data from only leachate collection systems and leachate headwells, the report focused on the composition of leachate that could be leaving the base of the refuse in a full-scale, operating landfill.

The chemical results were obtained primarily from samples collected by the landfill owners, their consultants, or treatment plants treating the leachate. Occasionally, samples collected or results reported by other parties were available. Variability in results may be attributed to the fact that these samples were collected by different individuals, using different sampling and analytical procedures.

The way in which a sample was handled after collection may have a substantial impact on its chemical composition. The environment at the base of the refuse may have been considerably different from the surface, and the exposure to the atmosphere may have changed the redox potential, pH, color, and turbidity of the sample.

2.3 SOBOTKA & CO. REPORT

The information contained in the Sobotka study was to be used by the EPA's Economic Analysis Branch, a subdivision of the Office of Solid Waste. Several months of gathering literature of municipal leachate resulted in the information presented in the Sobotka report. The objectives of the Sobotka report were to gather active municipal landfill leachate data, primarily organics; characterize the releases; calculate the associated risks; and predict the cost of compliance that municipal landfill facilities may face. Data regarding municipal leachate were gathered over a period of several months from literature sources, such as the Wisconsin report, and from various state records. Data pertaining to 44 landfills were obtained. This information was collected from reference material and state records from 10 states, including the sites referenced in the Wisconsin report. The landfill locations, grouped by states, are as follows:

Eastern Alameda, California

Coffin Butte, Colorado
RPS Inc., Colorado

Litchfield, Connecticut
Shelton, Connecticut

Central, Delaware
Pigeon Point, Delaware

Perdido, Florida
South Dade, Florida
West Palm Beach, Florida
Unknown Site, Florida

Am Hoist, Minnesota
Bethel, Minnesota
Duluth, Minnesota
Koochiching, Minnesota
Lyon, Minnesota
Mecker, Minnesota
Pine Bend, Minnesota
Rochester, Minnesota

Hamm's Landfill, New Jersey
Landfill and Development, New Jersey
Ocean County Landfill, New Jersey

Killingsworth, Oregon
Riverbend, Oregon
Roseburg, Oregon
Short Mountain, Oregon

Tillamook, Washington

Dane, Wisconsin
Delafield, Wisconsin
Fond du Lac, Wisconsin
Green Bay (E), Wisconsin
Green Bay (W), Wisconsin
Janesville, Wisconsin
Marathon, Wisconsin
Muskego, Wisconsin
Omega Hills, Wisconsin
Outagamie, Wisconsin
Pheasant Run, Wisconsin
Polk, Wisconsin
Ridgeview, Wisconsin
Seven Mile Creek, Wisconsin
Superior, Wisconsin
Tork, Wisconsin
Winnebago, Wisconsin

2.4 TEXAS A & M UNIVERSITY REPORT

The Texas A & M University study was conducted by the Soil and Crop Sciences Department. This report was undertaken to compile chemical constituent and concentration data and to compare the risks associated with exposure to organic pollutants found in leachate from industrial and municipal waste landfills. The study focused on the organic constituents of landfill leachate from various sources. The data were combined to identify minimum and maximum concentrations of specific constituents found in leachate from municipal and industrial waste landfills. Data presented in this report included Texas A & M University data on three municipal landfills: Lyon Municipal Landfill, Meeker Municipal Landfill, and Rochester Landfill. Landfill locations were not given.

2.5 LITERATURE LIMITATIONS

The data contained in this baseline report have several limitations. The unknowns included sampling and handling procedures employed, analytical methods, and landfill conditions. For example, a landfill identified as receiving only municipal waste may have knowingly or unknowingly accepted industrial or hazardous waste. The ages of the landfills are also unknown. The Wisconsin report indicates that the landfills sampled were relatively young, but the other two sources do not identify the various landfill ages. The landfill design and refuse depths are also unknown. The Wisconsin report mentions that concentrations exhibited seasonal fluctuations. However, dates sampled are not given.

These three reports also do not indict whether the leachates were pure or had been diluted by natural resources prior to sampling. Leachate freshness is also not mentioned.

The major concern in using the data from Wisconsin report regarding municipal solid waste landfill leachate is the fact that 14 out of the 20 landfills reported receiving industrial waste material.

Because of these limitations, a comparison of these literature sources has not been done. The data have been presented for reference and to provide a baseline report.

3.0 CHEMICAL CHARACTERISTICS OF LEACHATE IN MUNICIPAL SOLID WASTE LANDFILLS

3.1 INTRODUCTION

The information provided in this section regarding the chemical characteristics of leachate in municipal solid waste landfills was obtained from studies conducted by the Wisconsin Department of Natural Resources, Sobotka & Co., Inc., and Texas A & M University, as detailed in Section 2.0. Since the Wisconsin study was the most extensive of the three studies, the majority of information in this section is based on the Wisconsin report.

The Wisconsin report contains numerous references to the landfills in Wisconsin from which leachate data were obtained. Table 3-1 summarizes landfill site data and identifies, by site identification number and name, the site references used throughout the text. Figure 3-1 illustrates the locations of these sites.

Table 3-2, excerpted from the Wisconsin report, lists contaminant concentration ranges in leachate as reported in various literature sources (George, 1972; Chian and DeWalle, 1977; Metry and Cross, 1977; and Cameron, 1978) from the early 1970s to July 1986. Also included are values obtained from the Sobotka & Co. report. These data are a summary of ranges developed from the analyses of leachate seeps, contaminated surface waters, contaminated groundwaters, and from test lysimeters.

Although Table 3-2 illustrates that a fair amount of data are reported in the literature, the extreme variability of these values limits its usefulness. The values from this table are included in the various upcoming sections.

The Wisconsin study also contains numerous range graphs and median frequency-of-occurrence histograms. These figures are included in Appendix A and are referenced throughout this report.

Table 3-1 Wisconsin Landfills with Leachate Analysis Results Included in this Report.

Site Number	Name	Site Type	Total Design Volume (million cubic yards)	Principal Waste Types	Date Filling Began	Site Size (acres)
11	WMI-Lauer I	ZS		MSW,IND	pre-1960	38
307	WMI-Polk	CL	0.5	MSW	1970	9
572	Land Reclamation	ZS	9.5	MSW,IND,HAZ	pre-1970	82
611	Winnebago Co.	ZS	5.5	MSW,IND	pre-1970	94
652	Tork	R	1.5	MSW,IND	1970	38
719	Delafield	CL	1.0	MSW	1975	13
1099	WMI-Metro	ZS	9.0	MSW,IND,HAZ	pre-1970	96
1678	WMI-Omega Hills	ZS	15.0	MSW,IND,HAZ	1971	166
1739	WMI-Pheasant Run	ZS	1.6	MSW,IND	pre-1967	35
2358	Fond du Lac Co.	ZS	0.5	MSW,IND	1978	16
2484	Outagamie Co.	ZS	3.2	MSW,IND	1975	47
2568	Brown Co. West	ZS	4.0	MSW,IND	1977	50
2569	Brown Co. East	CL	6.0	MSW	1976	30
2575	WMI-Ridgeview	NA	0.8	MSW,IND	1976	17
2627	City of Superior	ZS	0.6	MSW,IND	1976	20
2680	Dane Co.	NA	1.5	MSW	1977	49
2821	Eau Claire Co.	CL	1.2	MSW	1978	24
2822	City of Janesville	CL	0.7	MSW,IND	1978	18
2892	Marathon Co.	CL	1.5	MSW,IND	1980	10
2895	WMI-Muskego	CL	1.3	MSW	1980	29

Abbreviations:

Site Types
- NA: Natural Attenuation
- CL: Clay Lined
- ZS: Zone-of-saturation
- R: Retrofit

Principal Waste Types
- MSW: Municipal Solid Waste
- IND: Industrial Waste
- HAZ: Hazardous Waste

Source: Wisconsin Department of Natural Resources Report

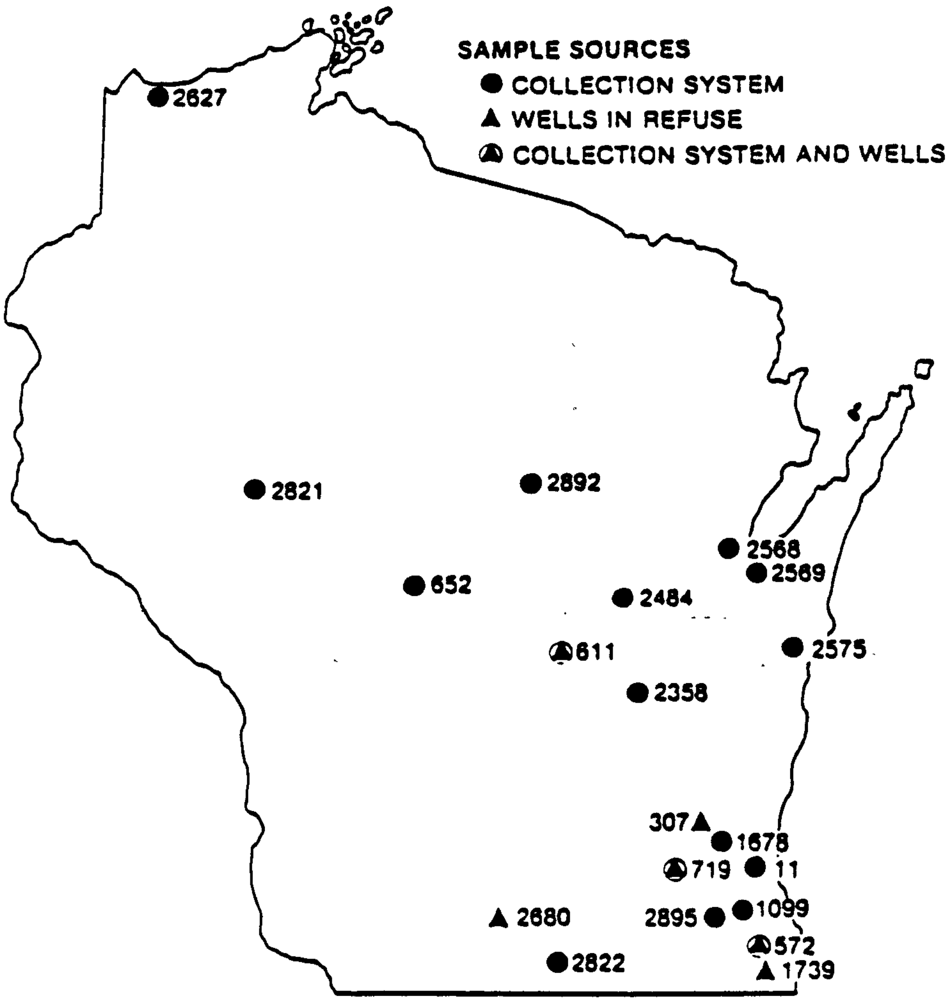

Figure 3-1 Municipal Solid Waste Landfills Included in this Report and their Locations.

Source: Wisconsin Department of Natural Resources Report

TABLE 3-2

CONTAMINANT CONCENTRATION RANGES IN LEACHATE REPORTED IN THE LITERATURE
[All Concentrations in mg/l (ppm)]

	George (1972)	Chian/ DeWalle (1977)	Metry/Cross (1975)	Cameron (1978)	Wisconsin Report (20 sites)	Sobotka Report (44 sites)
pH	3.7-8.5	3.7-8.5	3.7-8.5	3.7-8.5	5-8.9	5.4-8.0
Alkalinity	0-20,850	0-20,850	310-9,500	0-20,900	ND-15,050	0-7,375
Total Solids		0-59,200				1,900-25,873
TDS	0-42,276	584-44,900	100-51,000	0-42,300	584-50,430	1,400-16,120
Total Suspended Solids	6-2,685	10-700	13-26,500		2-140,900	28-2,835
Specific Conductance		2,810-16,800	100-1,200		480-72,500	
BOD	9-54,610	81-33,360	2,200-720,000	9-55,000	ND-195,000	7-21,600
COD	0-89,520	40-89,520	800-750,000	0-9,000	6.6-97,900	440-50,450
TOC		256-28,000			ND-30,500	5-6,884
Bicarbonate			3,260-5,730			
Hardness	0-22,800	0-22,800	35-8,700	0-22,800	52-225,000	0.8-9,380
Chlorides	34-2,800	4.7-2,467	47-2,350	34-2,800	2-11,375	120-5,475
Fluorides				0-2.13	0-0.74	0.12-0.790
Sulfates	1-1,826	1-1,558	20-1,370	0-1,826	ND-1,850	8-500
Sulfide				0-0.13		
Total-K-Nitrogen	0-1,416				2-3,320	47.3-938
NH_3-Nitrogen	0-1,106	0-1,106	0.2-845	0-1,106	10-1,200	11.3-1,200
Organic Nitrogen			2.4-550			4.5-78.2
NO_3-Nitrogen	0-1,300	0.2-10.29	4.5-18		10-250	0-50.95
Total Phosphorus	1-154	0-130			ND-234	
Ortho-Phosphorus		6.5-85	0.3-136	0-154		
Aluminum				0-122	ND-85	0.010-5.07
Arsenic				0-11.6	ND-70.2	0-0.08
Barium				0-5.4	ND-12.5	0.01-10
Beryllium				0-0.3	ND-0.36	0.001-0.01
Boron				0.3-73	0.867-13	
Cadmium		0.03-17		0-0.19	ND-.04	0-0 1
Calcium	5-4,080	60-7,200	240-2,570	5-4,000	200-2,500	95.5-2,100
Total Chromium				0-33.4	ND-5.6	0.001-1.0
Copper	0-9.9	0-9.9		0-10	ND-4.06	0.003-0.32

TABLE 3-2
CONTAMINANT CONCENTRATION RANGES
IN LEACHATE REPORTED IN THE LITERATURE
[All Concentrations in mg/l (ppm)]
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	George (1972)	Chian/ DeWalle (1977)	Metry/Cross (1975)	Cameron (1978)	Wisconsin Report (20 sites)	Sobotka Report (44 sites)
Cyanide				0-0.11	ND-6	0-4.0
Iron	0.2-5,500	0-2,820	0.12-1,700	0.2-5,500	ND-1,500	0.22-1,400
Lead	0-5.0	<0.10-2.0		0-5.0	0-14.2	0.001-1.11
Magnesium	16.5-15,600	17-15,600	64-547	16.5-15,600	ND-780	76-927
Manganese	0.06-1,400	0.09-125	13	0.06-1,400	ND-31.1	0.03-43
Mercury				0-0.064	ND-0.01	0-0.02
Molybdenum				0-0.52	0.01-1.43	
Nickel				0.01-0.8	ND-7.5	0.01-1.25
Potassium	2.8-3,770	28-3,770	28-3,800	2.8-3,770	ND-2,800	30-1,375
Sodium	0-7,700	0-7,700	85-3,800	0-7,700	12-6,010	
Titanium				0-5.0	<0.01	
Vanadium				0-1.4	0.01	
Zinc	0-1,000	0-370	0.03-135	0-1,000	ND-731	0.01-67

All concentrations in mg/1 except pH (std units) and Sp. Cond. (µmhos/cm).
ND = Not detected
Source: Wisconsin Department of Natural Resources Report

3.2 INDICATOR PARAMETER OBSERVATIONS

3.2.1 Dissolved Solids

Dissolved solids can be measured directly as Total Dissolved Solids (TDS) or as specific conductance. There is a direct correlation between these two measurements. Occassionally, only the in-situ measurement specific conductance is reported.

Factors affecting specific conductance values of leachate include

- Runoff of water into the collection system
- Landfill operational values
- Contact of leachate with the lower layers of refuse
- Groundwater dilution
- Age of landfill

Specific conductance ranges and median values from leachate samples from 18 Wisconsin municipal waste landfills are displayed in Figure A-1, Appendix A.

These relatively high specific-conductance values for leachate reflect the highly mineralized nature of municipal solid waste leachate.

The wide variation in specific conductance of leachate between the different Wisconsin sites and even within an individual site sampled at different times reflects the tremendous variability in the overall leachate strength. This variation makes it difficult to define a typical concentration range, but emphasizes the importance of identifying the variables that affect leachate quality.

No significant reduction in specific conductance has been observed at Wisconsin landfills with time, although this is not expected, since they are still active and relatively young.

The dissolved solids content of Wisconsin leachates puts them in the high-hazard classification for irrigation waters (EPA, 1973).

Comparison of Published Values for Ranges of Specific Conductance (µmhos/cm)

Chian, DeWalle	2,810-16,800
Metry, Cross	100-1,200
Wisconsin	480-72,500

3.2.2 Suspended Solids

Factors affecting leachate suspended solid values include the following:

- The degree of well development and the filtering action of the gravel pack
- Filters in leachate collection pipes
- Surface water runoff

Suspended solids analyses from 14 Wisconsin landfills are summarized in Figure A-2, Appendix A. The ranges are quite broad and reflect variability at most sites.

The suspended solids concentrations found in Wisconsin municipal solid waste (MSW) leachates are comparable to those reported in the literature for other leachates (Table 3-2).

Comparison of Published Values in mg/l (ppm)

Total Solids (mg/l)	
Chian, DeWalle	0-59,200
Sobotka	1,900-25,873
Total Dissolved Solids in mg/l (ppm)	
George	0-42,276
Chian, DeWalle	584-44,900
Metry, Cross	100-51,000
Cameron	0-42,300
Wisconsin	584-50,430
Sobotka	1,400-16,120
Total Suspended Solids in mg/l (ppm)	
George	6-2,685
Chian, DeWalle	10-700
Metry, Cross	13-26,500
Wisconsin	2-140,900
Sobotka	28-2,835

This great variation in values indicates that reporting of data in "averages" or "means" is meaningless and that data should be reported in ranges.

3.2.3 Organics

Factors affecting leachate organic concentration noted by the Wisconsin report include the following:

- Site age - The leachate's biological oxygen demand (BOD) decreases faster than the chemical oxygen demand (COD).
- A landfill's methanogenic bacterial community - This results in the depletion of easily degraded compounds, while refractory organics remain relatively inert and make the COD more resistant to change.
- Oxygen demand concentration patterns over time - This reflects some of the influences of site design and operational variations.
- BOD values - High values are usually found in the spring or summer.
- Dilution of leachate by surface water and rainwater.
- Variability over time.

The leachate BOD concentrations from 16 Wisconsin landfills are presented in Appendix A in Figure A-3. The number of samples per site ranged from 5 to 1,060, and the results were primarily reported by treatment plants that accepted the leachate. The COD ranges are presented in Figure A-4, although less extensive than the number of BOD samples. COD samples were obtained from 19 sites and were represented with 1 to 188 samples per site.

BOD values ranged from undetected to 195,000 mg/l (ppm). COD values ranged from less than 50 to 100,000 mg/l (ppm).

Comparison of Literature Values for BOD in mg/l (ppm)

George	9-54,610
Chian, DeWalle	81-33,360
Metry, Cross	2,200-720,000
Cameron	9-55,000
Wisconsin	ND-195,000
Sobotka	7-21,600

Comparison of Literature Values for COD in mg/l (ppm)

George	0-89,520
Chian, DeWalle	40-89,520
Metry, Cross	800-750,000
Cameron	0-9,000
Wisconsin	6.6-97,900
Sobotka	440-50,450

Comparison of Literature Values for TOC in mg/l (ppm)

Chian, DeWalle	256-28,000
Wisconsin	ND-30,500
Sobotka	5-6,884

ND - Not Detected

The extreme ranges of these parameters within each individual site and within different sites indicate the need to report these values in "ranges" rather than as "averages" or "means." Calculation of statistical parameters may also be meaningless.

3.2.4 pH

The following factors may affect leachate pH concentrations.

- Site conditions (nature of local soils).
- Surface water dilution/infiltrating groundwater.

- Refuse stability - Leachate pH generally rises from a low of about 5 to neutrality as the refuse stabilizes.

- Decreasing BOD - As the BOD decreases, the pH rises; this change reflects the reduction in organic acid concentration.

Figure A-5, in Appendix A, depicts the pH values of the monitored sites in Wisconsin. Evaluation of these data indicates that the overall range for pH is from 5 to 9.

The pH values reported for leachates at Wisconsin landfills were closer to neutral than pH 3.7, the value reported in the literature.

Comparison of Literature Values for pH (pH Units)

George	3.7-8.5
Chian, DeWalle	3.7-8.5
Metry, Cross	3.7-8.5
Cameron	3.7-8.5
Wisconsin	5-8.9
Sobotka	5.4-8.0

3.2.5 Alkalinity

Factors affecting leachate alkalinity concentrations include the following:

- Leachate from older stabilized fills with lower COD values had alkalinities largely attributable to the carbonate-bicarbonate system.

- Stronger COD leachates from younger fills had alkalinities derived from organic acids.

- As the refuse stabilizes and the concentrations of other parameters are reduced, the alkalinities are also expected to decrease.

The total alkalinity results from 14 Wisconsin landfills are presented in Appendix A, Figure A-6. The reported alkalinity concentrations in Wisconsin landfill leachates are well within the ranges reported as typical municipal landfill leachate.

Comparison of Literature Values for Alkalinity in mg/l (ppm)

George	0-20,850
Chian, DeWalle	0-20,850
Metry, Cross	310-9,500
Cameron	0-20,900
Wisconsin	ND-15,050
Sobotka	0-7,375

ND - Not Detected

Again, the extreme variation in values indicates the need to report data in ranges rather than as averages or means.

3.2.6 Hardness

Calcium and magnesium are the principal contributors to hardness, but iron, manganese, and possibly zinc are contributors. A plot of the range and median values for hardness from 14 Wisconsin landfills is shown in Appendix A, Figure A-7. This figure presents 404 values from collection systems and headwells.

The hardness values were much higher in leachates reported in the Wisconsin study than in published data, as were the pH values. These increased values result from the strata on which the Wisconsin sites are located.

Comparison of Literature Values for Hardness in mg/l (ppm)

George	0-22,800
Chian, DeWalle	0-22,800
Metry, Cross	35-8,700
Cameron	0-22,800
Wisconsin	52-225,000
Sobotka	0.8-9,380

3.3 MAJOR CONTAMINANTS

3.3.1 Nitrogen

The following factors affect leachate nitrogen concentration values:

- Newer sites and sites with dilute leachate have lower nitrogen concentrations.
- Deeper refuse sites tend to have higher nitrogen concentrations.

The analysis results for total-Kjeldahl-nitrogen and ammonia-nitrogen in Wisconsin landfill leachate are graphically depicted in Figures A-8 and A-9 in Appendix A. These figures show the ranges and median values for 9 and 11 sites, respectively.

The values reported for total-Kjeldahl-nitrogen, ammonia-nitrogen, and nitrate-nitrite-nitrogen are comparable to those reported for typical municipal solid waste leachate. Figure A-10 shows the range and median value for leachate nitrate nitrogen for the Wisconsin landfills.

Comparison of Literature Values in mg/l (ppm)

Total-Kjeldahl-Nitrogen	
George	0-1,416
Wisconsin	2-3,320
Sobotka	47.3-938
Ammonia-Nitrogen	
George	0-1,106
Chian, DeWalle	0-1,106
Metry, Cross	0.2-845
Cameron	0-1,106
Sobotka	11.3-1,200
Wisconsin	10-1,200
Organic-Nitrogen	
Metry, Cross	2.4-550
Sobotka	4.5-78.2
Nitrate-Nitrogen	
George	0-1,300
Chian, DeWalle	0.2-10.29
Metry, Cross	4.5-18
Sobotka	0-50.95
Wisconsin	0-250

3.3.2 Phosphorus

Figure A-11, in Appendix A, shows the range and median values for total phosphorus concentrations at 11 Wisconsin landfills. The ranges of phosphorus concentrations show that Wisconsin municipal waste leachates are generally comparable to other sites.

Comparison of Literature Values for Total Phosphorus in mg/l (ppm)

George	1-154
Chian, DeWalle	0-130
Wisconsin	ND-234

ND - Not Detected

3.3.3 Chloride

Chloride is a common constituent of solid waste and can be found in high concentrations in landfill leachate. The ranges and median values for leachate chloride concentrations from 15 Wisconsin landfills are presented in Figure A-12, Appendix A. For most sites the concentrations are below 2,500 mg/l (ppm), and the variation within a site is generally less than a range of 1,500 mg/l (ppm).

3.3.4 Sulfur

These factors affect leachate sulfur concentrations.

- The powerful precipitating ability of sulfides probably precludes the movement of sulfide out of the landfill in leachate.

Sulfate concentrations in Wisconsin landfill leachates ranged from less than 1 to more than 1,850 mg/l (ppm). Site median values fall within a relatively narrow range of 100 to 500 mg/l (ppm). The upper end of the leachate sulfate concentration range at most Wisconsin landfills exceeded 1,000 mg/l (ppm), and many values exceeded the Secondary Drinking Water Standard of 250 mg/l (ppm). The range of sulfate concentrations from 11 Wisconsin landfills is presented in Figure A-13 in Appendix A.

3.3.5 Calcium

Calcium concentrations of municipal solid waste (MSW) leachates in Wisconsin were available from 7 sites, with a total of 9 values. The concentrations reported ranged from 200 to 2,500 mg/l (ppm), and six of the nine values were evenly distributed between 200 and 700 mg/l (ppm). The overall concentration range is in general agreement with that reported in the literature for other MSW leachates, although the literature-reported extremes of 4,000-7,000 mg/l (ppm) were never reported at Wisconsin sites.

No drinking water standard exists for calcium. Wisconsin leachates are considered very hard, based on the calcium content alone.

Comparison of Literature Values for Calcium in mg/l (ppm)

George	5-4,080
Chian, DeWalle	60-7,200
Metry, Cross	240-2,570
Cameron	5-4,000
Wisconsin	200-2,500
Sobotka	95.5-2,100

3.3.6 Magnesium

In nine samples from seven landfills, the concentration of magnesium in Wisconsin MSW leachates ranged from 120 to 780 mg/l (ppm). Most of the magnesium concentrations of leachates reported in the literature were below 1,000 mg/l (ppm), although the overall range of 17-15,600 mg/l (ppm) (Table 3-2) showed extreme values considerably in excess of leachate concentrations found in Wisconsin.

No drinking water standard has been established for magnesium, but Wisconsin leachates generally exceed environmental concentrations (aquifers and surface water).

Comparison of Literature Values for Magnesium in mg/l) (ppm)

George	16.5-15,600
Chian, DeWalle	17-15,600
Metry, Cross	64-547
Cameron	16.5-15,600
Wisconsin	ND-780
Sobotka	76-927

ND - Not Detected

3.3.7 Sodium

Concentrations for sodium in Wisconsin landfills are reported in Figure A-14 in Appendix A. Sodium is the most commonly analyzed cation in Wisconsin municipal landfill leachate. Leachate concentrations ranged from 12 to 6,010 mg/l (ppm). Leachates exceeded the natural sodium concentrations in groundwater [range 0.0-107 mg/l (ppm), median 3.3 mg/l (ppm)] and surface waters [Wolf River: 2 mg/l (ppm), Lake Michigan: 4.5 mg/l (ppm)]. Primary Drinking Water Standards for sodium, based on dietary restrictions, were also exceeded 270 mg/l (ppm) (USEPA, 1976).

Comparison of Literature Values for Sodium in mg/l (ppm)

George	0-7,700
Chian, DeWalle	0-7,700
Metry, Cross	85-3,800
Cameron	0-7,700
Wisconsin	12-6,010

3.3.8 Potassium

Wisconsin leachate potassium concentrations were well in excess of the concentrations found naturally in state waters. The leachate range was from less than 20 to 2,800 mg/l (ppm).

Comparison of Literature Values for Potassium in mg/l (ppm)

George	2.8-3,770
Chian, DeWalle	28-3,770
Metry, Cross	28-3,800
Cameron	2.8-3,770
Wisconsin	ND-2,800
Sobotka	30-1,375

ND - Not Detected

3.3.9 Iron

The concentrations of iron found in leachates from Wisconsin landfills were usually in excess of the Secondary Drinking Water Standard of 0.3 mg/l (ppm). Many values were 100 to 1,000 times greater than this. They also exceed the typically encountered concentrations of iron in natural waters. Leachate iron concentrations were available from 17 Wisconsin landfills. Presented in Figure A-15 in Appendix A are 416 analysis results with 1 to 86 samples from each landfill.

Comparison of Literature Values for Iron in mg/l (ppm)

George	0.2-5,500
Chian, DeWalle	0-2,820
Metry, Cross	0.12-1,700
Cameron	0.2-5,500
Wisconsin	ND-1,500
Sobotka	0.22-1,400

ND-Not Detected

3.3.10 Manganese

Data on manganese concentrations in Wisconsin leachates are available from 11 landfills with 67 analysis results. The ranges and median histogram for these values are presented in Figure A-16.

The overall range was from undetected to 31 mg/l (ppm), although most values were between 2 and 10 mg/l (ppm). Nearly all the leachates analyzed exceeded the Secondary Drinking Water Standard of 0.05 mg/l (ppm).

Comparison of Literature Values for Manganese in mg/l (ppm)

George	0.06-1,400
Chian, DeWalle	0.09-125
Metry, Cross	13
Cameron	0.06-1,400
Wisconsin	ND-31.1
Sobotka	0.03-43

ND - Not Detected

3.4 INORGANIC CONSTITUENTS

Inorganic contaminants are broken into the following categories:

- Primary Drinking Water Standards
- Other Priority Pollutants
- Other Inorganics

It is also important to refer to the maximum concentration values established by the EPA indicating characteristics of EP toxicity. If these values are exceeded, the waste material is classified as hazardous. The values are as follows:

Arsenic	5.0 mg/l (ppm)
Barium	100.0 mg/l (ppm)
Cadmium	1.0 mg/l (ppm)
Chromium	5.0 mg/l (ppm)
Lead	5.0 mg/l (ppm)
Mercury	0.2 mg/l (ppm)
Selenium	1.0 mg/l (ppm)
Silver	5.0 mg/l (ppm)

3.4.1 Primary Drinking Water Standards

The Primary Drinking Water Standards were established by the EPA (and adopted by the State of Wisconsin), based on health considerations. The inorganic parameters for which primary drinking water standards have been established are listed in Table 3-3, along with pertinent environmental criteria. These parameters include arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, and fluoride. Analysis for these parameters in leachate has varied, and routine analysis is more

TABLE 3-3

NUMERICAL STANDARDS FOR PRIMARY DRINKING WATER STANDARDS
[All Concentrations in mg/l (ppm)]

Parameter	Drinking Water Standard (1)	USEPA 1980 Criteria for Human Health (2)	Wisconsin Water Quality Criteria (daily maximum) (3)	Maximum Concentration for Characteristic of EP Toxicity
Arsenic (As)	0.05	0.0000022	1.5	5.0
Barium (Ba)	1			100.0
Cadmium (Cd)	0.01	0.01	0.07	1.0
Chromium (Cr)	0.05	170(+ 3)	11.7	5.0
Lead (Pb)	0.05	0.05	1.07	5.0
Mercury (Hg)	0.002	0.000144	0.002	0.2
Selenium (Se)	0.01	0.01	1.03	1.0
Silver (Ag)	0.05	0.05	0.008	5.0
Fluoride (F)	1.4-2.4			
Nitrate (NO_3^-)	10			

Sources:

(1): U.S. Public Health Service, 1962.
(2): USEPA, 1980, criteria based on both water and organism ingestion.
(3): DNR files, 1984, for protection of Wisconsin warm-water fish and aquatic life (water hardness 100 mg/l-$CaCO_3$)

Wisconsin Department of Natural Resources Report the exception than the rule. The following subsections discuss the results available. The only other inorganic primary drinking water standard is for nitrate, which is examined in Section 3.3.1.

3.4.1.1 Arsenic

Precipitation and absorption of ions may be a significant mechanism controlling the presence of arsenic in landfill leachate.

In Figure A-17, Appendix A, 112 arsenic analysis results from 13 Wisconsin landfills are presented. Of the 13 sites, 3 (1099, 1678, and 1739) had values that exceeded the Primary Drinking Water Standard of 0.05 mg/l (ppm). All of these sites accepted municipal solid waste and industrial waste. Two also accepted hazardous waste material. All other sites had median leachate arsenic concentrations below 0.02 mg/l (ppm). The concentration of arsenic found in Wisconsin leachates is generally equal to or lower than the few concentrations reported in the literature for other sites.

Comparison of Literature Values for Arsenic in mg/l (ppm)

Cameron	0-11.6
Wisconsin	ND-70.2
Sobotka	0-0.08

ND - Not Detected

3.4.1.2 Barium

Barium concentrations in Wisconsin landfill leachates exceeded the detection limits at 8 of the 11 sites where barium was analyzed. Two of the sites, where barium was not detected, had detection limits within the commonly detected range. Overall, barium concentrations found in Wisconsin landfill leachates ranged from nondetected to 12.5 mg/l (ppm), based on the analysis of 73 leachate samples. The range for each site is shown in Figure A-18.

Leachate barium concentrations exceeded the Primary Drinking Water Standard of 1 mg/l (ppm) at Sites 11, 1099, 1678, 1739, 2822, and 2895. Site 2895 accepted only municipal solid waste. All others reported accepting industrial waste, with two sites also accepting hazardous waste (see Table 3-1 for site descriptions and Figure 3-1 for site locations).

Comparison of Literature Values for Barium in mg/l (ppm)

Cameron	0-5.4
Wisconsin	ND-12.5
Sobotka	0.01-10

ND - Not Detected

3.4.1.3 Cadmium

The cadmium analysis results of leachates from 16 Wisconsin landfills are presented in Figure A-19, where the ranges and median values are indicated. Results from 158 analyses were available, ranging from 1 to 31 results at each site.

Leachates from most sites exceeded the Primary Drinking Water Standard of 0.01 mg/l (ppm). Most leachates analyzed were within the range of 0.01 to 0.1 mg/l (ppm).

Comparison of Literature Values for Cadmium in mg/l (ppm)

Chian, DeWalle	0.03-17
Cameron	0-0.19
Wisconsin	ND-0.4
Sobotka	0-0.1

ND - Not Detected

3.4.1.4 Chromium

In Figure A-20, the ranges and medians for leachate total chromium analysis from 16 Wisconsin landfills are presented.

The overall concentrations of chromium in the leachates ranged from undetected to 5.6 mg/l (ppm). The majority of these values were above the Primary Drinking Water Standard of 0.05 mg/l (ppm). Leachates exceed the typical wastewater concentration of 0.125 mg/l (ppm). Leachates also exceed typical Wisconsin groundwater levels.

Comparison of Literature Values for Chromium in mg/l (ppm)

Cameron	0-33.4
Wisconsin	ND-5.6
Sobotka	.001-1.0

ND - Not Detected

3.4.1.5 Lead

The results of 142 Wisconsin landfill leachate lead analyses from 15 sites were reported and are presented in Figure A-21.

The leachate lead concentrations ranged from nondetectable to 12.6 mg/l (ppm). These concentrations are considerably in excess of concentrations typically found in the environment. The Primary Drinking Water Standard is 0.05 mg/l (ppm).

The median lead concentrations are arranged in a frequency-of-occurrence histogram in Figure A-21. It is apparent that new sites (2892) and sites with relatively weak leachates (0011) have lead concentrations typically less than 0.1 mg/l (ppm). Newer sites with medium-strength leachates (2895) may have lead concentrations from 0.1 - 0.3 mg/l (ppm), and sites with high-strength leachates and a history of industrial waste co-disposal (1678) may have leachate lead concentrations typically greater than 0.3 mg/l (ppm) and potentially as high as 10 mg/l (ppm). Table 3-1 lists site descriptions and Figure 3-1 depicts their location.

Typical municipal wastewaters, according to the Wisconsin Report, have lead concentrations of 0.050 to 0.100 mg/l (ppm). Landfill leachates in Wisconsin have 5 to 10 times this amount.

Comparison of Literature Values for Lead in mg/l (ppm)

George	0-5.0
Chian, DeWalle	<0.10-2.0
Cameron	0-5.0
Wisconsin	0-14.2
Sobotka	0.001-1.11

3.4.1.6 Mercury

Although mercury typically has the lowest concentrations of any Primary Drinking Water Standard in leachate, its great toxicity makes its evaluation important.

The concentration ranges of mercury in Wisconsin landfill leachate are presented as ranges and medians in Figure A-22. The Primary Drinking Water Standard for mercury is 0.002 mg/l (ppm), and this level was exceeded or attained at least once by leachates from six sites.

Site median values show that although mercury concentrations can exceed the Primary Drinking Water Standard, typical concentrations, ranging from 0.0001 to 0.001 mg/l (ppm), are below this standard.

Comparison of Literature Values for Mercury in mg/l (ppm)

Cameron	0-0.064
Wisconsin	ND-0.01
Sobotka	0-0.02

ND - Not Detected

3.4.1.7 Selenium

Selenium analysis results for Wisconsin landfill leachates are presented in Figure A-23. Analysis of leachate for selenium was performed on 121 samples from nine landfills in Wisconsin.

Concentration ranges extended to 1.85 mg/l (ppm). It is apparent that selenium concentrations do not typically exceed the Primary Drinking Water Standard of 0.01 mg/l (ppm). Two sites whose medians did were 572 and 1739 (Table 3-1; Figure 3-1). Both of these sites are older and accepted industrial waste material. Site 572 also accepted hazardous wastes. Because selenium is more soluble as the pH increases, most soils containing selenium are alkaline.

3.4.1.8 Silver

The concentrations of silver found in Wisconsin landfill leachates are presented in Figure A-24. The overall concentrations detected ranged to 0.196 mg/l (ppm), and three sites had values at or above the Primary Drinking Water Standard of 0.05 mg/l (ppm).

3.4.1.9 Fluoride

Leachate fluoride concentrations for the Wisconsin landfills ranged from nondetectable to 0.74 mg/l (ppm). These leachate fluoride concentrations never exceeded the Primary Drinking Water Standard of 1.4-2.4 mg/l (ppm).

3.4.2 Other Priority Pollutant Inorganics

The inorganic compounds on the priority pollutant list include eight constituents in addition to those previously described. These eight are antimony, beryllium, copper, cyanide, nickel, thallium, zinc, and asbestos. Although these compounds are recognized as toxic, many of their environmental impacts are still being evaluated.

Table 3-4 provides a summary of these parameters. Concentrations of the parameters in environmental criteria and treatment systems are shown. A discussion of each contaminant follows.

3.4.2.1 Antimony

Antimony analysis of MSW leachates was available for six Wisconsin sites with 1-21 values each site, for a total of 76 analyses. They ranged from nondetected to 3.19 mg/l (ppm), as shown in Figure A-25. The individual values were distributed throughout this range, with site medians ranging from nondetected to 0.56 mg/l (ppm).

The USEPA (1979) has proposed a maximum concentration in water of 0.146 mg/l (ppm) for protection of human health. Where detected, all antimony concentrations exceeded this level.

3.4.2.2 Beryllium

The overall range encountered at the Wisconsin landfills was from nondetected to 0.36 mg/l (ppm), as shown in Figure A-26.

TABLE 3-4

NUMERICAL STANDARDS FOR OTHER PRIORITY POLLUTANT INORGANICS
[All Concentrations in mg/l (ppm)]

Parameter	Secondary Drinking Water Standard (1)	USEPA 1980 Criteria for Human Health (2)	Wisconsin Water Quality Criteria (daily maximum) (3)
Antimony (Sb)		0.146	13
Beryllium (Be)		0.0000068	1.7
Copper (Cu)	1	1	0.026
Cyanide (Cn)		0.2	0.095
Nickel (Ni)		0.0134	2.7
Thallium (Tl)		0.013	1.41
Zinc (Zn)	5	5	0.46

Sources:
(1): U.S. Public Health Service, 1962
(2): USEPA, 1980, criteria based on both water and organism ingestion
(3): Department of Natural Resources (DNR) files, 1984, for protection of Wisconsin warm-water fish and aquatic life (water hardness 100 mg/l-$CaCO_3$)

Wisconsin Department of Natural Resources Report

The median beryllium concentrations in leachates from all sites were below 0.005 mg/l (ppm). The proposed drinking water standard for beryllium is 0.000087 mg/l (ppm).

Comparison of Literature Values for Beryllium in mg/l (ppm)

Cameron	0-0.3
Wisconsin	ND-0.36
Sobotka	0.001-0.01

ND - Not Detected

3.4.2.3 Copper

Copper analyses are available for 17 Wisconsin sites with 1-25 values each. The 138 values are plotted in range and median graphs in Figure A-27. Overall copper concentrations detected ranged from less than 0.01 mg/l (ppm) to 4.06 mg/l (ppm). Copper values in Wisconsin aquifers range from 0.0-2.4 mg/l (ppm).

Comparison of Literature Values for Copper in mg/l (ppm)

George	0-9.9
Chian, DeWalle	0-9.9
Cameron	0-10
Wisconsin	ND-4.06
Sobotka	0.003-0.32

ND - Not Detected

3.4.2.4 Cyanide

Cyanide analyses of MSW leachates were reported for eight Wisconsin sites. A total of 86 values were reported, with the number of values ranging from 1-17 per site. The values varied from less than 0.001 to 0.99 mg/l (ppm) (Figure A-28). The median cyanide concentrations are shown in a frequency-of-occurrence histogram in Figure A-28. Site 572 had a median concentration of 0.25 mg/l, and the other sites all had median concentrations below 0.1 mg/l (ppm). Site 572 (Table 3-1; Figure 3-1) is an older site and has reported accepting municipal, industrial, and hazardous wastes. Two sites exceeded the maximum allowable cyanide concentration in drinking water of 0.2 mg/l (ppm).

Comparison of Literature Values for Cyanide in mg/l (ppm)

Cameron	0-0.11
Wisconsin	ND-6
Sobotka	0-4.0

ND - Not Detected

3.4.2.5 Nickel

Leachate nickel analysis results were available for 16 Wisconsin landfills with 1 to 24 values each, for a total of 133 analyses. The overall range detected was from less than 0.01 to 7.5 mg/l (ppm). Leachates that contained maximum concentrations of nickel exceeding 1 mg/l (ppm) came from three codisposal sites, (572, 1099, 1678) and from a site containing primarily municipal refuse (2575). Table 3-1 lists important details about these sites and Figure 3-1 shows their location. The ranges of leachate nickel are shown in Figure A-29.

The U.S. EPA (1980) has proposed a water quality standard of 0.013 mg/l (ppm) for nickel. Nearly all leachate analyses exceeded this level.

Comparison of Literature Values for Nickel in mg/l (ppm)

Cameron	0.01-0.8
Wisconsin	ND-7.5
Sobotka	0.01-1.25

ND - Not Detected

3.4.2.6 Thallium

Thallium analyses of municipal solid waste leachates were available for six Wisconsin sites with 1-19 values each, for a total of 70 values. The overall range encountered was from less than 0.001 to 0.78 mg/l (ppm), with individual analyses widely spread throughout this range (Figure A-30).

The USEPA (1979) proposed a drinking water standard for thallium of 0.013 mg/l (ppm). Several leachates exceed this value.

3.4.2.7 Zinc

Zinc analysis results of Wisconsin leachates were available for 17 sites with 1-30 values each for a total of 158 values. The overall range detected was from less than 0.01 to 731 mg/l (ppm). The individual site ranges and median values have been plotted in Figure A-31.

The Secondary Drinking Water Standard is 5 mg/l (ppm). Leachate zinc concentrations frequently exceed the Secondary Drinking Water Standard and always exceed the aquatic life criterion [0.07 mg/l (ppm)].

Comparison of Literature Values for Zinc in mg/l (ppm)

George	0-1,000
Chian, DeWalle	0-370
Metry, Cross	0.03-135
Cameron	0-1,000
Wisconsin	ND-731
Sobotka	0.01-67

ND - Not Detected

3.4.2.8 Asbestos

Results of the one leachate analysis for asbestos fibers at Site 2822 revealed nondetectable concentrations (1.03×10^6 fibers per liter).

3.4.3 Other Inorganic Contaminants

In addition to the parameters previously discussed, several municipal solid waste leachates in Wisconsin have been analyzed on a nonroutine basis for a wide variety of other potential contaminants. Some parameters have only been analyzed at one site on a one-time basis, whereas others may have been analyzed several times.

Considering the variability demonstrated by other parameters for which there are considerably more data, the probable variability of these contaminants in different leachates is high.

A summary of the test results for all parameters discussed in this section is presented in Table 3-5 along with comparative information from the literature. A brief discussion of each contaminant follows.

3.4.3.1 Aluminum

Aluminum analysis of leachates was performed at five Wisconsin landfills on a total of nine samples. Three Wisconsin landfills, 572, 2569, and 2822 (Table 3-1; Figure 3-1), reported leachate aluminum concentrations below 1 mg/l (ppm). Site 2569 reports accepting only municipal waste; Site 2822 reports accepting municipal and industrial wastes; and Site 572 reports accepting municipal, industrial, and hazardous wastes. Another site, 307, reported leachate aluminum concentrations of 4.5 and 5.6 mg/l (ppm); and a third site, 1099, reported a concentration of 85 mg/l (ppm). This site accepted municipal, industrial, and hazardous wastes.

These leachate aluminum concentrations at Wisconsin landfills are comparable to the leachate aluminum concentration range of 0-122 mg/l (ppm) reported by Cameron (1978).

Comparison of Literature Values for Aluminum in mg/l (ppm)

Cameron	0-122
Wisconsin	ND-85
Sobotka	0.010-5.07

ND - Not Detected

A maximum aluminum concentration in drinking water supplies has not been established, but a 5 mg/l (ppm) limit has been recommended by the EPA (1973) for livestock and irrigation waters. Only one leachate substantially exceeded this limit--the report for Site 1099 [85 mg/l (ppm)]. Site 1099 data (Table 3-1) indicates this site accepted municipal, industrial, and hazardous wastes.

3.4.3.2 Boron

Seven landfills in Wisconsin have analyzed leachate for boron, and a total of 15 analytical results are available. Overall boron concentrations ranged from

TABLE 3-5

SUMMARY OF RESULTS FOR OTHER INORGANIC CONTAMINANTS
[All Concentrations in mg/l (ppm)]

Parameter	Wisconsin Landfill Leachates		Range in Other Leachates
	Number of Samples	Range of Concentrations	
Aluminum (Al)	9	0.01-85	0-122
Boron (B)	15	0.867-13	0.3-73
Cobalt (Co)	1	<0.25	0.004-0.07
Molybdenum (Mo)	7	0.01-1.43	0-0.52
Tin (Sn)	3	0-0.08	0
Titanium (Ti)	1	<0.01	0-5
Vanadium (V)	1	0.01	0-1.4
Yttrium (Y)	1	<0.017	

Source: Wisconsin Department of Natural Resources Report

nondetected to 13 mg/l (ppm). Site maximums were commonly from 4 to 8 mg/l (ppm).

A drinking water standard has not been proposed for boron, but the EPA (1973) has recommended a maximum boron content in livestock waters of 5 mg/l (ppm) and in irrigation waters of 0.75 mg/l (ppm). The two leachates tested were at the livestock limit and were well in excess of the irrigation limit.

3.4.3.3 Molybdenum

Molybdenum analysis was performed on leachates from three Wisconsin landfills. Five results from Site 1678 (which accepted municipal, industrial, and hazardous wastes, as indicated in Table 3-1) and one each from Sites 11 (accepted municipal and industrial wastes) and 572 (accepted municipal, industrial, and hazardous wastes) are available. The overall range of molybdenum concentrations in these leachates was from 0.01 to 1.43 mg/l (ppm). This concentration range is similar to, although somewhat larger than, the range reported by Cameron (1978) for leachates of 0 to 0.52 mg/l (ppm).

The concentrations exceeded the recommended levels for short-term irrigation waters of 0.05 mg/l (ppm) (EPA, 1973).

Comparison of Literature Values for Molybdenum in mg/l (ppm)

Cameron	0-0.52
Wisconsin	0.01-1.43

3.4.3.4 Cobalt and Vanadium

The values detected for these elements in a one-time analysis of leachate from a Wisconsin site were less than 0.25 mg/l (ppm) for cobalt and 0.01 mg/l (ppm) for vanadium. These elements are considered moderately mobile in soils.

Comparison of Literature Values for Vanadium in mg/l (ppm)

Cameron	0-1.4
Wisconsin	0.01

3.4.3.5 Tin, Titanium, and Yttrium

Three analytical results for tin and one each for titanium and yttrium were available from Wisconsin municipal solid waste landfill leachates. Of these elements, only tin was present above detection limits. No data on other municipal solid waste leachates or municipal wastewaters was available with which to compare these results.

Comparison of Literature Values for Titanium in mg/l (ppm)

Cameron	0-5.0
Wisconsin	<0.01

3.4.4 Sobotka Literature Data

Table 3-6 summarizes the inorganic leachate concentration values Sobotka & Co., Inc., obtained through its literature search. The sites are listed in Section 2.3.

3.5 TRACE ORGANICS

3.5.1 Introduction

Leachate samples from nine Wisconsin landfills were analyzed for priority pollutant organic compounds. In Table 3-7, the priority pollutant organics detected in Wisconsin leachates are listed. The analytical results for these sites and the frequency of detection in leachates from other states is also shown.

From Table 3-7 it is apparent that approximately one half of the priority pollutant organic compounds were present in leachates and wastewaters. Generally, the volatiles, aromatic solvents, phenols, and phthalate esters were present. Few of the polycyclic aromatic hydrocarbons and none of the nitrosamines were detected. Pesticides and PCBs were also not commonly detected.

Within each of the major classes of organic compounds, the physical properties and nature of the toxicities can be similar. The results of the organic analyses have been divided into major classes reflecting these similarities. These groups are

Table 3-6 Sobotka Report: Inorganic Data From 44 Case Studies (all concentrations in mg/l)

CONSTITUENT	PIDGEON POINT DE	CENTRAL DE	LITCHFIELD CT	SHELTON CT	EASTERN ALAMEDA CA
pH	7.12	6.2	6.4		7.8
Total solids					
Total suspended solids	51.55	310			
Total dissolved solids	4761	7944.5		1408	1400
Total alkalinity	3090			766	970
Biological oxygen demand	117.25	2290		7	
Chemical oxygen demand	1110	3410	4160	440	
Total organic carbon	4530	950			-5
Total kjeldahl nitrogen	427.5				
Total nitrogen		534.5			
Ammonia	279	324.75		11.7	
Nitrite		0.2	0.007	0.31	
Nitrate	0.74	0.2	3.5	0.3	0.56
Organic nitrogen		78.2			
Sulfate					40
Flouride					0.76
Chloride		695	300	440	330
Cyanide		0.004	0	-0.005	
Aluminum					
Arsenic	0.02	0.01	0		-0.001
Barium	0.28		0.5		0.2
Cadmium	0.02	0.02	0.012	0.005	-0.0001
Total Chromium	0.15	0.19	0.015	0.001	-0.02
Copper		0.35	0.05	0.025	-0.05
Iron	8.65	590	350	24.4	0.22
Lead	0.09	0.3	0.06	0.05	-0.001
Magnesium	125.5	99.5			76
Manganese	0.68			0.92	2.2
Mercury	0.0004	0.0004	0.005		-0.001
Nickel		0.24	0.04	0.05	
Selenium	0.01	0.005	0.02		-0.001
Sodium				183	270
Zinc	0.08	57	0.12	0.57	-0.01
Total phosphate				0	
Hardness					0.8
Calcium	95.5				190
Potassium				20	49
Antimony		0.47			
Beryllium		0.01			
Silver	0.02	0.02	0.032		-0.01
Thallium		0.08			
Conductivity		3987	7840	2700	2600
Nitrate + Nitrite					
Boron					
Cobalt			0.04		
Hexavalent chromium					

Negative values indicate detection limits for compounds not detected
Blanks indicate no analysis was performed

Source: Sobotka Report

Table 3-6 continued

CONSTITUENT	WEST PALM BEACH FLA	SOUTH DADE FLA	PERDIDO FLA	UNKNOWN SITE FLA	RPS INC. CO
pH				7.55	6.79
Total solids					
Total suspended solids					
Total dissolved solids	4325			7506.5	4810
Total alkalinity				7375	
Biological oxygen demand					
Chemical oxygen demand	507.5	3867		2944	2100
Total organic carbon				630	1000
Total kjeldahl nitrogen				938	
Total nitrogen					
Ammonia	180	822.5		921.5	40
Nitrite					
Nitrate	0.02			50.95	
Organic nitrogen		62.5			
Sulfate	55.5			130	5
Flouride	0.35				
Chloride	492.5			5475	192
Cyanide					
Aluminum					
Arsenic	-0.01			0.02	
Barium	0.215				
Cadmium	-0.005	0.0007		-0.007	
Total Chromium	0.01	0.02			
Copper				0.12	
Iron				5.77	
Lead	0.01	0.03	1.05	-0.[illegible]	
Magnesium			927		
Manganese			1.06		
Mercury	0.0005	0.006			
Nickel			1.07	0.34	
Selenium	0.005				
Sodium			929		
Zinc			1.09	1.66	
Total phosphate				8.7	
Hardness					
Calcium					
Potassium			937		
Antimony			1.1		
Beryllium					
Silver	-0.01				
Thallium					
Conductivity	3246				5[illegible]
Nitrate + Nitrite		0.69			
Boron					
Cobalt					
Hexavalent chromium					

Negative values indicate detection limits for compounds not detected

Table 3-6 continued

CONSTITUENT	COFFIN BUTTE CO	KILLINGS-WORTH OR	RIVER-BEND OR	ROSEBURG OR	SHORT MOUNTAIN OR
pH	7.3	7.38	6.69	6.7	8
Total solids					
Total suspended solids					
Total dissolved solids					
Total alkalinity	1344	2370	4600	1034	591
Biological oxygen demand	2330				161
Chemical oxygen demand	4080	720	6835	460	472.5
Total organic carbon			6730		135
Total kjeldahl nitrogen					36
Total nitrogen					
Ammonia	60	32.2	1200	14.4	50
Nitrite	0.03				
Nitrate	0.77				
Organic nitrogen					
Sulfate	237	123	346	105	3.7
Flouride					
Chloride	302	404.7	1468.9	258	480
Cyanide					
Aluminum					
Arsenic					
Barium					
Cadmium					-0.001
Total Chromium					
Copper					0.003
Iron	47.5	7.59	210	1.7	2.85
Lead					-0.005
Magnesium	122				91.5
Manganese	41.75				
Mercury					
Nickel					0.04
Selenium					
Sodium	250				
Zinc	5.19				0.11
Total phosphate	0.42				
Hardness	1956	927.65	5780	1200	[illegible]
Calcium	516				[illegible]
Potassium	131.75				
Antimony					
Beryllium					
Silver					
Thallium					
Conductivity	4884	5423.5	10900	2660.5	3068
Nitrate + Nitrite				-0.02	0.03
Boron					
Cobalt					
Hexavalent chromium					

Negative values indicate detection limits for compounds not detected

Table 3-6 continued

New Jersey

CONSTITUENT	TILLAMOOK WA	NJ0051128 OCEAN COUNTY LANDFILL NJ	NJ0053449 HAMM S LANDFILL NJ	NJ00[illegible]509 LANDFILL & DEVELOPMENT NJ
pH	7.2	5.6		6.5
Total solids				
Total suspended solids		292		
Total dissolved solids				9008
Total alkalinity				
Biological oxygen demand		9044		2550
Chemical oxygen demand		15820		11000
Total organic carbon				
Total kjeldahl nitrogen				
Total nitrogen				
Ammonia		152		226
Nitrite				
Nitrate				
Organic nitrogen				
Sulfate				57
Flouride				0.4
Chloride	159			[illegible]
Cyanide				0.02
Aluminum				
Arsenic	0.02			0.08
Barium	0.34			0.425
Cadmium	0.02			0.04
Total Chromium	0.05			0.02
Copper				0.15
Iron	14.1			220
Lead	0.14			0.04
Magnesium				
Manganese	0.57			3.4
Mercury	0.0007			0.0008
Nickel				0.2
Selenium	0.01		0.01	0.01
Sodium	871			344
Zinc	1.8		0.65	0.85
Total phosphate		2.13		
Hardness	568			
Calcium				
Potassium				
Antimony				
Beryllium			0.005	
Silver	0.01			0.05
Thallium			0.08	
Conductivity				
Nitrate + Nitrite	0.12			
Boron				
Cobalt				
Hexavalent chromium				

Negative values indicate detection limits for compounds not detected

Table 3-6 continued

Wisconsin

CONSTITUENT	2484 OUTAGAMIE WI	2568 GREEN BAY WEST (DECASTER) WI	2569 GREEN BAY EAST (DECLEENE) WI	2375 RIDGEVIEW WI	2627 SUPERIOR WI
pH	7.18	6.4	6.45	6.3	7.1
Total solids			5860		9300
Total suspended solids	268		156	650	
Total dissolved solids	7676	4178	9300		
Total alkalinity	6380	1504	2770		4390
Biological oxygen demand	1645	3048	8236	12000	
Chemical oxygen demand	2118'	3365	8530		5220
Total organic carbon	486				
Total kjeldahl nitrogen	309				235
Total nitrogen					
Ammonia	336		228		209
Nitrite					-0.2
Nitrate	-0.1		0		-0.2
Organic nitrogen					
Sulfate	255				
Flouride					
Chloride	1400	840	1040		
Cyanide				-4	
Aluminum			-1		
Arsenic	-0.01				-0.01
Barium	-2				
Cadmium	-0.03		-0.05	0.06	0.009
Total Chromium	1		-0.1	0.4	0.28
Copper	0.1		-0.1	0.1	0.12
Iron	15.85	4	29.5	385	
Lead	0.3		-0.5	-0.5	0.25
Magnesium	200		210.5		
Manganese	1.4		2.87		
Mercury	-0.001				0.0003
Nickel	0.18		-0.1	1.25	0.1
Selenium	-0.05				
Sodium		321	508		
Zinc	2		0.42	10	3.13
Total phosphate	1.08		1.31	4.6	
Hardness	2240	1825	3670		
Calcium	321		425		
Potassium	560		46.5	31	
Antimony					
Beryllium					
Silver	-0.03				
Thallium					
Conductivity	15485	4390	7635		6800
Nitrate + Nitrite					
Boron					
Cobalt					
Hexavalent chromium				-0.05	

Negative values indicate detection limits for compounds not detected

Table 3-6 continued **Wisconsin**

CONSTITUENT	307 POLK WI	611 WINNEBAGO WI	652 YORK WI	719 DELAFIELD WI	1759 PHEASANT RUN WI
pH	5.7	6.5	6.32	7.21	6.8
Total solids	16780			10790	
Total suspended solids	1410	28	140	365	1805
Total dissolved solids	16120	2180		12646	
Total alkalinity	5350	2650		5750	2430
Biological oxygen demand	21600	740	630	5860	533.5
Chemical oxygen demand	50450	3520	1156	7370	2990
Total organic carbon		427			
Total kjeldahl nitrogen				710	
Total nitrogen					
Ammonia		34		517	
Nitrite				0.112	
Nitrate	1.38	1.4		0.21	
Organic nitrogen				4.5	
Sulfate	155			500	
Flouride					
Chloride	885	330		980	759
Cyanide			0.005		
Aluminum	5.07				
Arsenic		-0.01	0.002		0.07
Barium	0.3				2.59
Cadmium		-0.01	0.015	-0.01	0.05
Total Chromium	0.53	-0.06	0.06		0.23
Copper	0.32	-0.04	0.03	-0.01	0.3
Iron	359	2.1		246	169
Lead		-0.01	0.1		1.11
Magnesium	547	120			
Manganese	25.9	0.03		3.1	
Mercury		-0.001	0.0006		-0.0002
Nickel		-0.07	0.14	0.2	0.3
Selenium			-0.02		0.09
Sodium	1198			12	
Zinc	54	-0.01	0.15	1.6	47.7
Total phosphate		0.52		2.48	1.31
Hardness	4160	1481	3590		1050
Calcium	1970	200			
Potassium	1375	75			
Antimony			0.56		
Beryllium			0.008		
Silver			0.009		-0.05
Thallium			0.1		
Conductivity	8183	3540	5804	10150	5000
Nitrate + Nitrite					
Boron	7.13				
Cobalt					
Hexavalent chromium			-0.003		

Negative values indicate detection limits for compounds not detected

Table 3-6 continued

Wisconsin

CONSTITUENT	2680 DANE WI	2821 SEVEN MILE CREEK WI	2822 JANESVILLE WI	2892 MARATHON WI	2895 MUSKEGO WI
pH	5.4	5.9	6.15	6.68	
Total solids			25873		
Total suspended solids			2835		275
Total dissolved solids		5400			
Total alkalinity	4290	2000		960	
Biological oxygen demand			3500	1150	2360
Chemical oxygen demand	33500	15500	9520	2835	2640
Total organic carbon					
Total kjeldahl nitrogen				48.61	479.5
Total nitrogen					
Ammonia	170			26.08	419
Nitrite					-0.01
Nitrate				0.75	0.14
Organic nitrogen					
Sulfate		210	200	140	
Fluoride					
Chloride	1770	700	300	180	
Cyanide			0.083		0.02
Aluminum			0.01		
Arsenic		-0.02	0.001	-0.005	0.015
Barium		-10	5	-0.01	0.6
Cadmium		-0.1	0.07	-0.01	0.015
Total Chromium		-0.1	0.05	0.01	0.18
Copper		-0.1	0.09	0.05	0.053
Iron	500	1400	150	66.2	
Lead		-0.5	0.07	0.015	0.12
Magnesium	780	150			
Manganese		22	1.35		1.8
Mercury		-0.02		-0.0005	0.001
Nickel		-0.1	0.02	-0.01	0.27
Selenium		-0.02			0.002
Sodium	1200	570			
Zinc		2.4	0.84	0.03	1.96
Total phosphate					117.13
Hardness	9380	3900		1780	
Calcium	2100	350			
Potassium	400	160			107.5
Antimony			-0.002		0.009
Beryllium			-0.01		0.001
Silver		-0.05			0.008
Thallium			0.31		0.004
Conductivity	15100	7900	9250	2840	
Nitrate + Nitrite					
Boron		5.1			4.05
Cobalt					
Hexavalent chromium					

Negative values indicate detection limits for compounds not detected

Table 3-6 continued

CONSTITUENT	Wisconsin: 572 LR WI	Wisconsin: 2358 FOND DU LAC WI	Minnesota: BETHEL MN	Minnesota: KOOCHICHING MN	Minnesota: ROCHESTER MN
pH	6.7	6.6	7.4		5.9
Total solids			1900		
Total suspended solids	330				
Total dissolved solids					10100
Total alkalinity	2875		470		
Biological oxygen demand	3000		1700		
Chemical oxygen demand	5708'	2060			
Total organic carbon	1123				6894
Total kjeldahl nitrogen	47.3				
Total nitrogen					
Ammonia					757
Nitrite			-0.01		
Nitrate	0.125				
Organic nitrogen					
Sulfate	8.4	108	32		
Flouride	0.74		0.12		
Chloride	923	795	120		975
Cyanide	0.25				
Aluminum	0.31				
Arsenic	0.002				0.021
Barium	0.225				
Cadmium	0.05				
Total Chromium	0.64				0.11
Copper	0.17				0.07
Iron	211	46.65			1200
Lead	0.03				0.27
Magnesium	312.1				
Manganese	0.5				43
Mercury	0.0002				
Nickel	1.08				
Selenium	0.02				
Sodium	771.4	580.5			
Zinc	22				13
Total phosphate	3.8				
Hardness	2096	1845			
Calcium	693.4				
Potassium					
Antimony					
Beryllium	-0.002				
Silver	0.008				
Thallium					
Conductivity	10005	6375	2700		13400
Nitrate + Nitrite					
Boron	4.6		0.99		
Cobalt	-0.25				
Hexavalent chromium					

Negative values indicate detection limits for compounds not detected

Table 3-6 continued

Minnesota

CONSTITUENT	PINE BEND MN	HECKER MN	LYON MN	DULUTH MN	AM HOIST MN
pH				6.8	
Total solids					
Total suspended solids					
Total dissolved solids					
Total alkalinity					
Biological oxygen demand					
Chemical oxygen demand					1100
Total organic carbon				110	
Total kjeldahl nitrogen					
Total nitrogen					
Ammonia				63.9	200
Nitrite					
Nitrate					
Organic nitrogen					
Sulfate				17	
Flouride					
Chloride				310	950
Cyanide					
Aluminum					
Arsenic	0.012				
Barium					
Cadmium	-0.01			0.0005	0.03
Total Chromium	0.013				
Copper	0.05			0.03	0.13
Iron	475			46	220
Lead	0.12			0.006	
Magnesium					120
Manganese	0.26				
Mercury					
Nickel	0.06				0.47
Selenium					
Sodium					
Zinc	0.15			0.18	34
Total phosphate					
Hardness					
Calcium					320
Potassium					
Antimony					
Beryllium					
Silver					
Thallium					
Conductivity				5400	
Nitrate + Nitrite				0.04	
Boron				0.63	
Cobalt					
Hexavalent chromium					

Negative values indicate detection limits for compounds not detected

Table 3-7 Analytical Results of Priority Pollutant Organic Compounds Detected in Wisconsin Landfills

Compound																									Wisconsin Leachates Summary		Other States Leachates					
Site ID	11	11	572	611	1088	1099	1099	1678	1678	1678	1678	1678	1678	1678	1678	2568	2569	2822	2895	2895	2895	2895	2895	2886			OH	CO	MN	OK	DE	RI
Sample Source	CS(R3)	CS(R3)	CS(R)	CS	CS	CS(R1A)	CS(R2)	CS	CS(R2)	CS(R5)	CS(R1)	CS(R2)	CS(R4)	CS(R5)	CS(R6)	CS	CS	CS	CS	CS(R3)	CS(1)	CS(R3)	HW(68)	HW(77)								
Sampling Date	Mar-82	Oct-82	Jan-81	Dec-80	Dec-80	Apr-82	Apr-82	Dec-80	Mar-82	Mar-82	Apr-82	Oct-82	Oct-82	Oct-82	Oct-82	Mar-84	Mar-84	Nov-81	Dec-80	Apr-82	Apr-82	Feb-84	Feb-84	Feb-84	Max Conc (ug/l)	% Det	(1)	(2)	(3)	(4)	(5)	(6)
	concentrations in parts per billion(micrograms per liter)																															
Halogenated Ethers																																
2-Chloroethyl Vinyl Ether	<10	<10	<10		<320	<10	<10	<400	2	1100	<10	<10	<10	<10	<10	<1	<1	<100	<320	<10	<10	<10	<10	<500	1100	9%					x	
Bis(2-chloroethoxy)Methane	<10	<10	<10		<100	<10	25	<50	<10	<10	<10	<10	<10	<10	<10	<1	<1	<10	<100	<10	18	<10	<10	<10	25	9%						
Bis(Chloromethyl)Ether	<10	<10	250		<500	<10	<10	<500	<10	<10	<10	<10	<10	<10	<10	<1	<1		<500	<10	<10				250	5%						
Halogenated Aliphatics																																
Methylene Chloride	<10	<10	2300	106	20000	450	<10	2800	1500	430	4900	835	1520	7	1480	540	780	2500	1100	1900	<10	92	<10	2600	20000	79%	200	200	1300			x
1,2-Trans-Dichloroethylene	<10	24	1300		<250	<10	<10	2200	1300	<10	<10	1620	86	168	2760	17	55		96	<10	<10	26	<10	1600	2760	59%	44	62	88			
1,1-Dichloroethane	<10	<10	6300		<250	<10	5	510	<10	64	<10	419	264	134	720	110	61	570	<250	160	<10	<10	<10	1800	6300	57%	10	194	46		x	x
Trichloroethylene	<10	<10	160		<250	<10	<10	600	370	<10	43	542	56	16	1120	33	26	<100	<250	180	<10	<10	<10	<500	1120	48%		53			x	x
Tetrachloroethylene	<10	<10	26		<250	<10	<10	60	<10	<10	215	141	232	2	620	11	25	<100	<250	<10	<10	<10	<10	<500	620	39%		162			x	x
1,1,1-Trichloroethane	<10	<10	2400		<250	<10	<10	<250	<10	<10	640	84	198	<10	310	16	18	<100	<250	<10	<10	<10	<10	<500	2400	30%	20	227	7.6			
1,2-Dichloropropane	<10	<10	54		<250	<10	<10	<250	<10	<10	<10	2	4	86	50	5	3	<100	<250	<10	<10	<10	<10	<500	86	30%			81			
Chloroethane	<10	<10	170		<250	<10	<10	<250	860	<10	<10	<10	<10	<10	27	16	20		<250	<10	<10	<10	<10	400	860	27%		18	0			
Trichlorofluoromethane	<10	<10	15		<250	74	<10	<250	<10	<10	<10	54	110	<10	<10	6	11	<100	<250	<10	<10	<10	<10	<500	110	26%	8	78	15			x
Chloroform	<10	<10	71	14.8	<250	<10	<10	<250	<10	<10	<10	<10	8	<10	<10	27	31	1300	<250	<10	<10	<10	<10	<500	1300	25%	17	0			x	x
1,1,2-Trichloroethane	<10	<10	<10		<250	<10	<10	<250	<10	<10	<10	352	30	<10	<10	<1	<1	500	<250	<10	<10	<10	<10	<500	500	13%			125			x
1,2-Dichloroethane	<10	<10	13		<250	<10	<10	<250	<10	<10	<10	<10	<10	<10	<10	1	<1	11000	<250	<10	<10	<10	<10	<500	11000	13%			5.5			x
Dichlorodifluoromethane	<10	<10	180		<250	<10	<10	<250	450	<10	<10	<10	<10	<10	<10	<1	<1	<100	<250	<10	<10				450	10%		65	0			
1,3-Dichloropropylene	<10	<10	18		<250	<10	<10	<250	<10	<10	<10	<10	<10	<10	30	<1	<1	<100	<250	<10	<10	<10	<10	<500	30	9%		0				
Vinyl Chloride	<10	<10	61		<250	<10	<10	<250	<10	<10	<10	<10	<10	<10	47	<1	<1	<100	<250	<10	<10	<10	<10	<500	61	9%		14	0			x
1,1,2,2-Tetrachloroethane	<10	<10	<10		<250	<10	<10	<250	<10	<10	<10	<10	<10	<10	<10	<1	<1	210	<250	<10	<10	<10	<10	<500	210	4%		0	250			x
Methyl Bromide	<10	<10	170		<250	<10	<10	<250	<10	<10	<10	<10	<10	<10	<10	<1	<1	<100	<250	<10	<10	<10	<10	<500	170	4%			0			
Methyl Chloride	<10	<10	170		<250	<10	<10	<250	<10	<10	<10	<10	<10	<10	<10	<1	<1	<100	<250	<10	<10	<10	<10	<500	170	4%			0			
Monocyclic Aromatics																																
Toluene	190	460	1600		280	8	<10	1400	1900	<10	1740	700	419	790	1430	56	79	280	420	720	390	420	28	3200	3200	91%	1500	20	600		x	x
Benzene	270	67	19		<250	310	470	<250	600	580	1080	120	9	46	100	4	4	<100	<250	440	380	18	<10	<500	1080	74%	28	11	540		x	x
Ethylbenzene	<10	245	250		<250	<10	<10	150	500	<10	<10	880	38	238	1270	6	7	100	<250	<10	<10	67	4800	<500	4900	57%	52	0	820			x
Isophorone	<10	<10	<10		4000	4	<10	16000	500	210	160	224	76	<10	524	<50	<50	<10	<250	<10	160	15	<10	<10	16000	48%						
1,4-Dichlorobenzene	8	<10	<10		<100	<10	37	<20	<10	<10	<10	5	4	4	8	<50	<50	<20	<100	<10	1	<10	<10	<10	37	30%	8		16			x
Chlorobenzene	<10	4	<10		<250	<10	<10	<250	<10	<10	<10	5	3	1	7	<50	<50	<100	<250	<10	<10	<10	<10	<500	7	22%	20		60			x
1,2-Dichlorobenzene	<10	<10	<10		<100	<10	<10	<20	13	<10	<10	9	<10	<10	9	<50	<50	<20	<100	<10	<10	<10	<10	<10	13	13%			32			x
Nitrobenzene	<10	<10	40		<100	<10	<10	120	<10	<10	<10	<10	<10	<10	<10	<50	<50	<20	<100	<10	<10	<10	<10	<10	120	9%						

Table 3-7 continued

Compound																								Wisconsin Leachates Summary		Other States Leachates					
Site ID	11	11	572	611	1099	1099	1099	1678	1678	1678	1678	1678	1678	1678	1678	2560	2560	2022	2095	2095	2095	2095	2095	2095			OR	CO	MN	OK	DE	MI
Sample Source	CS(R3)	CS(R3)	CS(M)	CS	CS	CS(R1A)	CS(R2)	CS	CS(R2)	CS(R5)	CS(R1)	CS(R2)	CS(R1)	CS(R5)	CS(R6)	CS	CS	CS	CS	CS(R3)	CS(I)	CS(R3)	MW(68)	MW(77)	Max Conc (ug/l)	% Det	(1)	(2)	(3)	(4)	(5)	(6)
Sampling Date	Mar-82	Oct-82	Jan-81	Dec-80	Dec-80	Apr-82	Apr-82	Dec-80	Mar-82	Mar-82	Apr-82	Oct-82	Oct-82	Oct-82	Oct-82	Mar-84	Mar-84	Nov-81	Dec-80	Apr-82	Apr-82	Feb-84	Feb-84	Feb-84								
	concentrations in parts per billion(micrograms per liter)																															
Polycyclic Aromatics																																
Naphthalene	13	<10	19		<100	<10	<10	<50	<10	8	<10	41	<10	<10	68	<50	<50	<10	<100	2	10	<10	<10	<10	68	30%						x
2-Chloronaphthalene	<10	<10	<10		<100	<10	<10	<20	<10	<10	<10	<10	<10	<10	46	<50	<50	<10	<100	<10	<10	<10	<10	<10	46	4%						
Phenols																																
Phenol	<25	19	221		<25	13	<25	5790	3700	1230	1800	11300	1080	51	11050	500	110	<10	293	39	350	<25	<25	<2500	11300	70%	2300	272000				x
Pentachlorophenol	<25	<25	<25	3	<25	<25	<25	<75	<25	<25	<25	<25	<25	<25	<25	<50	<50	<10	<25	<25	<25	45	470	<2500	470	13%						
2,4-Dimethylphenol	<25	<25	<25		<25	<25	<25	<75	10	<25	<25	<25	<25	<25	<25	<50	<50	<10	<25	<25	<25	<25	28	<2500	28	9%		0				x
4-Nitrophenol	<25	<25	<25		<25	<25	<25	<75	<25	<25	<25	<25	<25	<25	<25	<50	<50	17	<25	<25	<25	<25	<25	<2500	17	4%						
Phthalate Esters																																
Diethyl Phthalate	<10	<10	43		200	71	3	300	300	170	330	254	<10	<10	107	69	<50	<20	150	28	62	<10	11	120	330	70%		12		x		
Bis(2 ethylhexyl)Phthalate	<10	<10	34		150	<10	<10	50	<10	<10	<10	<10	<10	<10	<10	<50	<50	110	150	<10	<10	<10	32	<10	150	26%		12			x	
Di-N-Butyl Phthalate	<10	<10	12		100	<10	<10	<20	<10	<10	49	<10	<10	<10	<10	<50	<50	<10	150	<10	<10	<10	<10	<10	150	17%		0		x	x	
Butyl Benzyl Phthalate	<10	<10	<10		125	<10	<10	<20	<10	<10	21	<10	<10	<10	<10	<50	<50	<50	150	<10	<10	<10	<10	<10	150	13%		0		x		
Dimethyl Phthalate	<10	<10	55		<100	<10	<10	30	<10	<10	<10	<10	<10	<10	<10	<50	<50	<20	<100	<10	<10	<10	<10	<10	55	9%						
Miscellanious																																
Acrolein	<100	<100	<10		<1500	<100	<100	<1500	<100	<100	<100	<100	<100	<100	<100	<10	<10	<10	270	<100	<100	<100	<100	<5000	270	4%		0				

Sources:
(1): Spencer, 1984. Maximum concentration in leachates from three Oregon landfills
(2): Shuckrow et al., 1982. Maximum concentration from leachate seep at Marshall Landfill, Boulder Colorado
(3): Sabel and Clark, 1983. Maximum concentration in leachates from six Minnesota landfills
(4): Robertson et al., 1974. Compounds detected in groundwater beneath the Norman landfill in Oklahoma
(5): DeWalle and Chian, 1981. Compounds detected in leachate from the Army Creek landfill in Delaware
(6): Shuckrow et al., 1982. Compound detected in groundwater near the Ott/Story landfill in Michigan

Notes:
All concentrations in parts per-billion(micrograms per liter)
CS indicates sample from leachate collection system
MW indicates sample from leachate headwell
0 denotes compound detected at concentration below detection limit
x denotes compound detected above detection limit

Source: Wisconsin Department of Natural Resources Report

- Halogenated ethers and aliphatics
- Phthalate esters
- Phenols
- Monocyclic and polycyclic aromatics
- Polychlorinated biphenyls (PCBs)
- Pesticides and herbicides

The emphasis in the following sections is on those chemicals detected in leachates from the Wisconsin landfills.

3.5.2 Halogenated Ethers and Aliphatics

Of the organic compounds on the priority pollutant list, 33 are chlorinated or brominated ethers and short-chain hydrocarbons. Most of these compounds are volatile, persistent, and nonaccumulative and many are carcinogenic. Nearly two-thirds, or 21, of these compounds have been identified in the leachates from Wisconsin landfills.

Methylene chloride was the most commonly identified of these compounds, detected in 19 of 24 leachate samples. Typical concentrations of methylene chloride were 50-5,000 mg/l (ppm). Methylene chloride is a known laboratory contaminant and, since data were not validated, one must use caution when drawing conclusions regarding the presence of this contaminant in leachate.

At Site 1099 (Table 3-1), the methylene chloride value was 20,000 mg/l (ppm). This is an older site where municipal, industrial, and hazardous materials were disposed.

Methyl chloride, methyl bromide, and chloroform were detected in several Wisconsin leachates. These compounds may also be carcinogenic and hence have exceeded the human health criterion, where discovered.

Another commonly detected halogenated aliphatic in both Wisconsin and literature leachates is 1,1-dichloroethane. Thirteen of the twenty-three leachate samples had detectable concentrations of 1,1-dichloroethane. Concentrations ranged from nondetectable to 6,300 mg/l (ppm) in Wisconsin leachates. The high value of

6,300 mg/l (ppm) was in a leachate from Site 572 (Table 3-1). Typical concentrations, where detected, were from 100-750 mg/l (ppm).

The 1,2 isomer of dichloroethane was detected in only three Wisconsin leachates. The high concentration was 11,000 mg/l (ppm). 1,2-dichloroethane is a suspected carcinogen and, as such, any detectable concentration exceeds the ambient-water-quality criteria level. The concentration associated with a 10^{-6} risk is less than 1 mg/l (ppm), a concentration level exceeded in the three leachates. The high value of 11,000 mg/l (ppm) was obtained from Site 2822, which is an industrial and municipal waste landfill (Table 3-1).

Several other chlorinated, two-carbon, organic compounds were frequently detected in Wisconsin landfill leachates. 1,2-Trans-dichloroethylene, trichloroethylene, and tetrachloroethylene were detected in 13 of 22, 11 of 23, and 9 of 23 leachate samples, respectively. All of these compounds are suspected carcinogens, and as such, they exceed the ambient criterion concentration for human consumption. EPA's 10^{-6} factors were also exceeded where these compounds were detected, and where they were not found, the EPA risk concentration was below the reported detection limit. The maximum concentrations of these compounds found in Wisconsin leachates ranged from 2,760 mg/l (ppm) for trans-1,2-dichloroethylene and 1,120 mg/l (ppm) for trichloroethylene, to 620 mg/l (ppm) for tetrachloroethylene.

Several other halogenated aliphatics were found in nearly a third of the leachate samples from Wisconsin landfills. These compounds, 1,1,1-trichloroethane and 1,2-dichloropropane, were also both found in Minnesota leachates, and trichloroethane was found in one of three Oregon leachates (Table 3-7).

The concentrations of 1,1,1-trichloroethane ranged from nondetectable to 24,000 mg/l (ppm), but that was the only analysis above 700 mg/l (ppm). 1,2-Dichloropropane was found at concentrations ranging to 86 mg/l (ppm) and in several of the samples where it was detected at concentrations below the detection limit of 10 mg/l (ppm).

The other chlorinated aliphatics and ethers detected in at least one Wisconsin leachate are shown in Table 3-7 with their concentration ranges and a comparison to other leachates. Where detected, these compounds are found in concentrations that do not exceed the ambient water quality criterion for noncarcinogenic effects. In instances where the compound is carcinogenic, it exceeds the criterion level of zero, where detected.

3.5.3 Phthalate Esters

Five of the six phthalate esters on the EPA priority pollutant list were detected in leachates from Wisconsin landfills. One of these phthalates, diethyl phthalate, was detected in 16 of 23 leachate samples. Three other commonly detected phthalates, bis(2-ethylhexyl), di-n-butyl, and butyl benzyl, were detected in 6 of 23, 4 of 23, and 3 of 23 leachate samples, respectively.

Phthalates are common laboratory contaminants, and since the data evaluated here were not validated, use of these data should be made with caution.

The concentrations of phthalate esters found in Wisconsin leachates never exceeded the ambient water quality criteria established to prevent toxic effects in humans. Water quality criterion levels were typically 100 to 1,000 times the concentrations found in Wisconsin leachates.

3.5.4 Phenols

The priority pollutant analysis of leachates from Wisconsin landfills has identified four of the 11 phenols and cresols on the list in Wisconsin leachates. Chloro-, nitro-, and methylphenols were identified in several leachates, whereas phenol itself was found in 16 of 23 leachate samples. The substituted phenols were never found at concentrations in excess of 500 mg/l (ppm) and were always less than the EPA criteria for human health. The concentrations of phenol itself in Wisconsin leachates ranged as high as 11,300 mg/l (ppm), a concentration level exceeding the EPA human health criterion. Higher values of phenol in leachate were found at Site 1678 (Table 3-1), the industrial waste codisposal site. At Site 2895 (Table 3-1), a municipal waste landfill, phenol concentrations from 39 to 350 mg/l (ppm) were detected.

In addition to the priority pollutant analysis for specific phenols, total phenols were determined in leachates from eight landfills in Wisconsin. These data are presented in Table A-1. Overall the total phenol concentration ranged from nondetected to 234 mg/l (ppm), although typical values ranged from 1 to 20 mg/l (ppm).

3.5.5 Monocyclic and Polycyclic Aromatics

Of the 33 aromatic compounds on the priority pollutant list, ten were detected in leachates from Wisconsin. Most of these were monocyclic aromatics, and the only polycyclic aromatics detected were napthalene and chloronapthalene.

Aromatic compounds detected in at least one fourth of the leachates analyzed were benzene, chlorobenzene, 1,4-dichlorobenzene, isophorone, and toluene. Table 3-7 shows the analytical results of leachates from Wisconsin landfills, including both the range of concentrations and frequency of detection of all these compounds.

Toluene, benzene, and isophorone were commonly detected aromatic compounds. Benzene, a carcinogen, exceeded the ambient water quality standard wherever it was detected.

The other aromatic compounds in Wisconsin leachates that exceeded the ambient water quality criterion were ethylbenzene and the rarely found nitrobenzene. Napthalene, the only polycyclic aromatic compound detected frequently in Wisconsin leachates, was found in 7 of 23 leachate samples. There is no information on napthalene concentrations in other states' leachates, although the concentrations in Wisconsin leachates ranged to 68 mg/l (ppm). Several sites in Wisconsin detected napthalene but at concentrations less than the detection limit. The apparent concentrations are shown in Table 3-7.

The more common aromatic solvents found in leachates from Wisconsin were those commonly detected in several leachates (Table 3-7). In addition, xylenes were detected frequently in leachates from landfills in Minnesota and Oregon. Little information on xylene concentrations in Wisconsin leachates was available, although xylene was found in leachates from Sites 2568 (municipal and industrial wastes; Table 3-1) and 2569 (municipal waste only), the only sites for which it was analyzed.

The maximum concentrations of priority pollutant aromatic compounds in Wisconsin leachates usually exceeded the maximums found in other states, a fact which may be due to the very contaminated leachate at several sites and the availability of more data.

3.5.6 Polychlorinated Biphenyls

In Table A-2, the results of PCB analysis for Wisconsin leachates are shown. Seven PCB isomers are on the priority pollutant list, and total PCB analysis has been reported by several other landfills not in conjunction with a priority pollutant examination.

Only one Wisconsin leachate (Site 1099, which accepted municipal, industrial, and hazardous waste materials; Table 3-1) revealed a detectable concentration of a PCB isomer of 2.8 mg/l (ppm) for PCB-1016.

Because aqueous transport is the primary means of movement of leachate out of landfilled refuse, the low aqueous solubility and strong absorption onto sediments would be expected to minimize the movement of PCBs. That, in conjunction with the lack of abundance of PCBs, is probably the primary mechanism controlling its concentration in the leachate.

3.5.7 Pesticides and Herbicides

The results of leachate analysis for pesticides and herbicides are broken into three categories, which reflect similarities in the composition of these compounds. The major classifications are chlorinated hydrocarbon insecticides, organ-phosphorus insecticides, and chlorophenoxy herbicides. Table A-2 shows these groupings and the members of these groups for which leachate analysis results are available.

Pesticides were never detected in Wisconsin leachates except for one analysis from Site 2822, which accepted municipal and industrial waste (Table 3-1) and which showed 4.6 mg/l (ppm) of delta-BHC. The herbicide 2,4-D was found in two leachate samples from Sites 572 and 1099--both of which accepted municipal, industrial, and hazardous waste material--at concentrations of 7 and 1,800 mg/l (ppm), respectively.

3.5.8 Sobotka Organic Literature Data

Table 3-8 summarizes the organic leachate concentration data Sobotka & Co., Inc., obtained through its literature search. As indicated in Section 2.3, data were obtained from 44 sites in 10 states.

3.5.9 Texas A & M Organic Literature Data

Tables 3-9 and 3-10 summarize the data obtained from the Texas A & M University study. These data provide a comparison of the types and quantities of organic chemicals detected in three municipal landfill leachates.

The main site pollutants for each individual site were as follows:

- Lyon Municipal Landfill: Ethanol and 1-butanol
- Meeker Municipal Landfill: Methyl ethyl ketone and 1,1-dichloroethane
- Rochester Municipal Landfill: Ethanol, butanol, methyl ethyl ketone, and 2-propanol

The locations of these landfills were not identified. Table 3-9 identifies and lists the concentrations of numerous organic compounds identified in municipal leachate or groundwater plume. Table 3-10 summarizes organic contaminant concentrations from the leachate of three municipal landfills.

3.6 SUMMARY

An examination of leachate quality from 20 Wisconsin landfills has shown, in agreement with reported findings in the literature, that municipal landfill leachate is contaminated with highly variable concentrations of a wide variety of inorganic and organic constituents.

In Table 3-11, the range of contaminants found in Wisconsin landfill leachates is shown in the order of detected concentration. It is apparent from this list that leachates are highly mineralized with common salts and can also contain trace quantities of many metals and other contaminants of environmental significance. Leachates from municipal refuse can also contain large quantities of organic materials because of the large quantities of organic material in refuse.

Table 3-8 Sobotka Report: Organic Data from 44 Case Studies (all concentrations in parts per billion)

CONSTITUENT	PIDGEON POINT DE	CENTRAL DE	LITCHFIELD CT	SHELTON CT	EASTERN ALAMEDA CA
Acetone					
Benzene	26				-2
Chloroform			100		-2
1,2 Dichloroethane			-5		-5
Dichloromethane	5		3300		-2
Methyl ethyl ketone					
Methyl isobutyl ketone					
Phenol	•	1400			-15
Tetrahydrofuran					
Toluene	12.75				-2
Ethyl benzene	42.25				-5
m-Xylene					
1,4 Dichlorobenzene					-2
Trichlorofluoromethane					
1,1 Dichloroethane			140		-2
trans 1,2 Dichloroethene					4
1,1,1 Trichloroethane			80		-5
1,2 Dichloropropane					-5
Chlorobenzene	237				-2
cis 1,2 Dichloroethene					
Chloromethane					-10
Chloroethane					-5
Dichlorodifluoromethane					
1,1,2 Trichloroethane					-7
1,1,2,2 Tetrachloroethane					-7
4 Nitrophenol					-40
Pentachlorophenol					-2
Vinyl chloride					-5
bis (2-Ethylhexyl) phthalate					-2
Diethyl phthalate					-2
Di-n-butyl phthalate					-4
Dimethyl phthalate					-4
Naphthalene					4
Tetrachloroethene	80				-2
Trichloroethene	1		-2		
Bromomethane					-10
Carbon tetrachloride					-2
bis (2-Chloroethoxy) methane					-2
Isophorone					-10
Nitrobenzene					-2
Dibromomethane					
2 Propanol					
Ethyl acetate					
1 Butanol					
p-Xylene + o-Xylene					
Endrin					
Toxaphene					
Delta BHC					

Source: Sobotka Report

Negative values indicate detection limits for compounds not detected
Blanks indicate no analysis was performed

Table 3-8 continued

CONSTITUENT	WEST PALM BEACH FLA	SOUTH DADE FLA	PERDIDO FLA	UNKNOWN SITE FLA	RPS INC. CO
Acetone					
Benzene				4.3	
Chloroform					
1,2 Dichloroethane				-0.03	
Dichloromethane					
Methyl ethyl ketone					
Methyl isobutyl ketone					
Phenol		724.5		29.5	
Tetrahydrofuran					
Toluene					
Ethyl benzene					
m-Xylene					
1,4 Dichlorobenzene					
Trichlorofluoromethane					
1,1 Dichloroethane					
trans 1,2 Dichloroethene					
1,1,1 Trichloroethane				0.03	
1,2 Dichloropropane					
Chlorobenzene					
cis 1,2 Dichloroethene					
Chloromethane					
Chloroethane					
Dichlorodifluoromethane					
1,1,2 Trichloroethane					
1,1,2,2 Tetrachloroethane					
4 Nitrophenol					
Pentachlorophenol					
Vinyl chloride				-0.13	
bis (2-Ethylhexyl) phthalate					
Diethyl phthalate					
Di-n-butyl phthalate					
Dimethyl phthalate					
Naphthalene					
Tetrachloroethene				94.52	
Trichloroethene					
Bromomethane					
Carbon tetrachloride				397.5	
bis (2-Chloroethoxy) methane					
Isophorone					
Nitrobenzene					
Dibromomethane					
2 Propanol					
Ethyl acetate					
1 Butanol					
p-Xylene + o-Xylene					
Endrin					
Toxaphene					
Delta BHC					

Negative values indicate detection limits for compounds not detected

Table 3-8 continued

CONSTITUENT	COFFIN BUTTE CO	KILLINGS-WORTH OR	RIVER-BEND OR	ROSEBURG OR	SHORT MOUNTAIN OR
Acetone					
Benzene					
Chloroform					
1,2 Dichloroethane					
Dichloromethane					
Methyl ethyl ketone					
Methyl isobutyl ketone					
Phenol					
Tetrahydrofuran					
Toluene					
Ethyl benzene					
m-Xylene					
1,4 Dichlorobenzene					
Trichlorofluoromethane					
1,1 Dichloroethane					
trans 1,2 Dichloroethene					
1,1,1 Trichloroethane					
1,2 Dichloropropane					
Chlorobenzene					
cis 1,2 Dichloroethene					
Chloromethane					
Chloroethane					
Dichlorodifluoromethane					
1,1,2 Trichloroethane					
1,1,2,2 Tetrachloroethane					
4 Nitrophenol					
Pentachlorophenol					
Vinyl chloride					
bis (2-Ethylhexyl) phthalate					
Diethyl phthalate					
Di-n-butyl phthalate					
Dimethyl phthalate					
Naphthalene					
Tetrachloroethene					
Trichloroethene					
Bromomethane					
Carbon tetrachloride					
bis (2-Chloroethoxy) methane					
Isophorone					
Nitrobenzene					
Dibromomethane					
2 Propanol					
Ethyl acetate					
1 Butanol					
p-Xylene + o-Xylene					
Endrin					
Toxaphene					
Delta BHC					

Negative values indicate detection limits for compounds not detected

Table 3-8 continued

CONSTITUENT	TILLAMOOK WA	NEW JERSEY SITES: NJ0051128 OCEAN COUNTY LANDFILL NJ	NJ0053449 HAMM'S LANDFILL NJ	NJ00[illegible]509 LANDFILL & DEVELOPMENT NJ
Acetone				
Benzene			9	
Chloroform				
1,2 Dichloroethane				
Dichloromethane		1030	60	
Methyl ethyl ketone				
Methyl isobutyl ketone				
Phenol		29800	30	-500
Tetrahydrofuran				
Toluene		320	10	
Ethyl benzene			10	
m-Xylene				
1,4 Dichlorobenzene				
Trichlorofluoromethane				
1,1 Dichloroethane				
trans 1,2 Dichloroethene		230		
1,1,1 Trichloroethane		200	1	
1,2 Dichloropropane				
Chlorobenzene				
cis 1,2 Dichloroethene				
Chloromethane				
Chloroethane				
Dichlorodifluoromethane		369		
1,1,2 Trichloroethane				
1,1,2,2 Tetrachloroethane				
4 Nitrophenol				
Pentachlorophenol				
Vinyl chloride				
bis (2-Ethylhexyl) phthalate				
Diethyl phthalate				
Di-n-butyl phthalate				
Dimethyl phthalate				
Naphthalene				
Tetrachloroethene				
Trichloroethene		5		
Bromomethane				
Carbon tetrachloride			6	
bis (2-Chloroethoxy) methane				
Isophorone				
Nitrobenzene				
Dibromomethane				
2 Propanol				
Ethyl acetate				
1 Butanol				
p-Xylene + o-Xylene				
Endrin	0.04			
Toxaphene	1			
Delta BHC				

Negative values indicate detection limits for compounds not detected

Table 3-8 continued

WISCONSIN SITES

CONSTITUENT	307 POLK WI	611 WINNEBAGO WI	652 YORK WI	719 DELAFIELD WI	1769 PHEASANT RUN WI
Acetone					
Benzene					
Chloroform		14.8			
1,2 Dichloroethane					
Dichloromethane		106			
Methyl ethyl ketone					
Methyl isobutyl ketone					
Phenol					
Tetrahydrofuran					
Toluene					
Ethyl benzene					
m-Xylene					
1,4 Dichlorobenzene					
Trichlorofluoromethane					
1,1 Dichloroethane					
trans 1,2 Dichloroethene					
1,1,1 Trichloroethane					
1,2 Dichloropropane					
Chlorobenzene					
cis 1,2 Dichloroethene					
Chloromethane					
Chloroethane					
Dichlorodifluoromethane					
1,1,2 Trichloroethane					
1,1,2,2 Tetrachloroethane					
4 Nitrophenol					
Pentachlorophenol		3			
Vinyl chloride					
bis (2-Ethylhexyl) phthalate					
Diethyl phthalate					
Di-n-butyl phthalate					
Dimethyl phthalate					
Naphthalene					
Tetrachloroethene					
Trichloroethene					
Bromomethane					
Carbon tetrachloride					
bis (2-Chloroethoxy) methane					
Isophorone					
Nitrobenzene					
Dibromomethane					
2 Propanol					
Ethyl acetate					
1 Butanol					
p-Xylene + o-Xylene					
Endrin					
Toxaphene					
Delta BHC					

Negative values indicate detection limits for compounds not detected

Table 3-8 continued

WISCONSIN SITES

CONSTITUENT	2680 DANE WI	2821 SEVEN MILE CREEK WI	2822 JANESVILLE WI	2892 MARATHON WI	2895 MUSKEGO WI
Acetone					
Benzene			-100		410
Chloroform			1300		-10
1,2 Dichloroethane			11000		-10
Dichloromethane			2500		1000
Methyl ethyl ketone					
Methyl isobutyl ketone					
Phenol			-10		293
Tetrahydrofuran					
Toluene			280		555
Ethyl benzene			100		-10
m-Xylene					
1,4 Dichlorobenzene			-20		5.5
Trichlorofluoromethane			-100		-10
1,1 Dichloroethane			570		95
trans 1,2 Dichloroethene					-10
1,1,1 Trichloroethane			-100		-10
1,2 Dichloropropane			-100		-10
Chlorobenzene			-100		-10
cis 1,2 Dichloroethene					
Chloromethane			-100		-10
Chloroethane					-10
Dichlorodifluoromethane			-100		-10
1,1,2 Trichloroethane			500		-10
1,1,2,2 Tetrachloroethane			210		-10
4 Nitrophenol			17		-25
Pentachlorophenol			-10		-25
Vinyl chloride			-100		-10
bis (2-Ethylhexyl) phthalate			110		-10
Diethyl phthalate			-20		45
Di-n-butyl phthalate			-10		-10
Dimethyl phthalate			-20		-10
Naphthalene			-10		5
Tetrachloroethene			-100		-10
Trichloroethene					
Bromomethane			-100		-10
Carbon tetrachloride			-100		-10
bis (2-Chloroethoxy) methane			-10		14
Isophorone			-10		85
Nitrobenzene			-20		-10
Dibromomethane					
2 Propanol					
Ethyl acetate					
1 Butanol					
p-Xylene + o-Xylene					
Endrin			-1		-0.2
Toxaphene			-1		-5
Delta BHC			4.6		-0.08

Negative values indicate detection limits for compounds not detected

Table 3-8 continued

CONSTITUENT	572 LR WI	2358 FOND DU LAC WI	BETHEL MN	KOOCHICHING MN	ROCHESTER MN
	WISCONSIN SITES		MINNESOTA SITES		
Acetone				7500	11000
Benzene					
Chloroform	71			-4	
1,2 Dichloroethane	13			-4	
Dichloromethane	2300			260	
Methyl ethyl ketone				8300	23000
Methyl isobutyl ketone				270	560
Phenol	221				
Tetrahydrofuran				260	-5
Toluene	1600			52	510
Ethyl benzene	250			78	530
m-Xylene				21	79
1,4 Dichlorobenzene	-10			-7.7	
Trichlorofluoromethane	15			-4	
1,1 Dichloroethane	6300			13	
trans 1,2 Dichloroethene	1300			-4	
1,1,1 Trichloroethane	2400			-4	
1,2 Dichloropropane	54			-10	
Chlorobenzene	-10			-10	
cis 1,2 Dichloroethene				-4	
Chloromethane	170				
Chloroethane	170				
Dichlorodifluoromethane	180				
1,1,2 Trichloroethane	-10			-4	
1,1,2,2 Tetrachloroethane	-10			-40	
4 Nitrophenol	-25				
Pentachlorophenol	-25				
Vinyl chloride	61				
bis (2-Ethylhexyl) phthalate	34				
Diethyl phthalate	43				
Di-n-butyl phthalate	12				
Dimethyl phthalate	55				
Naphthalene	19				
Tetrachloroethene	26			-40	
Trichloroethene				1.2	
Bromomethane	170				
Carbon tetrachloride	-10			-4	
bis (2-Chloroethoxy) methane	-10				
Isophorone	-10				
Nitrobenzene	40				
Dibromomethane				-10	
2 Propanol				10000	6900
Ethyl acetate				42	-50
1 Butanol				320	360
p-Xylene + o-Xylene				18	50
Endrin	-0.05				
Toxaphene	-0.1				
Delta BHC	-0.01				

Negative values indicate detection limits for compounds not detected

Table 3-8 continued

MINNESOTA SITES

CONSTITUENT	PINE BEND MN	MECKER MN	LYON MN	DULUTH MN	AM HOIST MN
Acetone				140	
Benzene					
Chloroform		-10	-2		
1,2 Dichloroethane		-10			
Dichloromethane		64	200		
Methyl ethyl ketone				110	
Methyl isobutyl ketone				10	
Phenol					
Tetrahydrofuran				18	
Toluene				7.5	
Ethyl benzene				12	
m-Xylene				26	
1,4 Dichlorobenzene					
Trichlorofluoromethane		-10	15		
1,1 Dichloroethane		35	46		
trans 1,2 Dichloroethene		17	3.9		
1,1,1 Trichloroethane		-10	7.6		
1,2 Dichloropropane		13	2		
Chlorobenzene		60	-5		
cis 1,2 Dichloroethene		190			
Chloromethane					
Chloroethane		-5			
Dichlorodifluoromethane					
1,1,2 Trichloroethane		-10	-2		
1,1,2,2 Tetrachloroethane		-100	-20		
4 Nitrophenol					
Pentachlorophenol					
Vinyl chloride					
bis (2-Ethylhexyl) phthalate					
Diethyl phthalate					
Di-n-butyl phthalate					
Dimethyl phthalate					
Naphthalene					
Tetrachloroethene		-100	-20		
Trichloroethene		43	43		
Bromomethane					
Carbon tetrachloride		-25	-5		
bis (2-Chloroethoxy) methane					
Isophorone					
Nitrobenzene					
Dibromomethane		-25	5		
2 Propanol				94	
Ethyl acetate				-5	
1 Butanol				-50	
p-Xylene + o-Xylene				12	
Endrin					
Toxaphene					
Delta BHC					

Negative values indicate detection limits for compounds not detected

Table 3-8 Continued WISCONSIN SITES

CONSTITUENT	2484 OUTAGAMIE WI	2568 GREEN BAY WEST (DECASTER) WI	2569 GREEN BAY EAST (DECLEENE) WI	2375 RIDGEVIEW WI	2627 SUPERIOR WI
pH	7.18	6.4	6.45	6.3	7.1
Total solids			5840		9300
Total suspended solids	268		156	650	
Total dissolved solids	7676	4178	9300		
Total alkalinity	6380	1504	2770		4390
Biological oxygen demand	1645	3048	8236	12000	
Chemical oxygen demand	2118'	3365	8530		5220
Total organic carbon	486				
Total kjeldahl nitrogen	309				225
Total nitrogen					
Ammonia	336		228		209
Nitrite					-0.2
Nitrate	-0.1		0		-0.2
Organic nitrogen					
Sulfate	255				
Flouride					
Chloride	1400	840	1040		
Cyanide				-4	
Aluminum			-1		
Arsenic	-0.01				-0.01
Barium	-2				
Cadmium	-0.03		-0.05	0.06	0.009
Total Chromium	1		-0.1	0.4	0.06
Copper	0.1		-0.1	0.1	0.12
Iron	15.85	4	29.5	385	
Lead	0.3		-0.5	-0.5	0.25
Magnesium	200		210.5		
Manganese	1.4		2.87		
Mercury	-0.001				0.0003
Nickel	0.18		-0.1	1.25	0.1
Selenium	-0.05				
Sodium		321	508		
Zinc	2		0.42	10	3.13
Total phosphate	1.08		1.31	4.6	
Hardness	2240	1825	3670		
Calcium	321		425		
Potassium	560		46.5	31	
Antimony					
Beryllium					
Silver	-0.03				
Thallium					
Conductivity	15485	4390	7635		6800
Nitrate + Nitrite					
Boron					
Cobalt					
Hexavalent chromium				-0.05	

Negative values indicate detection limits for compounds not detected

Table 3-9 Concentration of Selected Organic Compounds Identified in Municipal Landfill Leachate or Groundwater Plume.

Chemical	Concentration Range (mg L^{-1})[1] Municipal Landfill
Acetic Acid	DT
Acetone	3.4-1300
C_5-Acid	140
C_6-Acid	82
Acrolein	170
Aldrin	-
Aniline	.01-.870
Benzene	.004-1300
Benzendicarboxylic acid	.06
Benzene hexachloride	4.6
Biphenyl napthalene	-
Bis(chloromethyl) ether	12.4-250
Bis(2 ethylhexyl)phthalate	34-150
Bis-2-hydroxypropyl ether	DT
Bromodichloromethane	-
Bromoethane	170
Bromoform	.0002
2-Butanol	.120-46
Butoxyethanol	DT
Butylbenzyl phthalate	DT
Butylcarbobutoxymethyl phthalate	DT
Butyric acid	1.5
Camphor	0.9
Caproic acid	.0011
Caprylic acid	.0006
Carbon tetrachloride	-
o-chloroaniline	.140
Chlorobenzene	.0046-60
Chlorodibromoethane	-
Chloroform	.0011-1300
Chloromethane	170

Table 3-9 continued

Chemical	Concentration Range (mg L^{-1})[1] Municipal Landfill
4-chloro-3-nitrobenzamide	4.2
Chloronitrobenzene	.720
Chloronitroltoluene	.120
2-chlorophenol	.003
Cis-1,2,dichloroethylene	.19
p-Cresol	.014-15
Cyanide	-
Cyclohexane carboxylic acid	.0028
Cyclohexanol	.001
Diacetone alcohol	.011
Dibromochloromethane	.0039
Dibutylphthalate	12-150
2,6-dichlorobenzamine	.89-30
Dichlorobenzene	.014-16
Dichloroethane	.0021-1,100
1,2-Dichloroethane	.015
1,2-dichloroethene	190-.470
1,1-dichloroethylene	DT
Dichloromethane	.015-20,000
2,4-dichlorophenol	-
Dichloropropane	.002-54
Dichloropropene	-
Dicyclohexyl phthalate	.0002
1,2-diethylbenzene	-
N,N-diethylformamide	DT
Diethylphthalate	.004-300
Dimethylphenol	30-55
Di-n-butyl phthalate	DT
Dioctyl phthalate	.002
Diphenylamine	.190
2,4-dinitrophenol	.099

Table 3-9 continued

Chemical	Concentration Range (mg L^{-1})[1] Municipal Landfill
2,6-Di-t-butylbenzonquinone	DT
Ethanol	23-110,000
2-ethoxy-ethanol	-
1-ethoxy-propane	-
Ethyl acetate	.018-.290
Ethyl benzene	.003-820
Ethyl carbamate	DT
1-ethyl-2,4,-dimethylbenzene	-
1-ethyl-3,5-dimethylbenzene	-
2-ethyl hexanal	2.6
2-ethyl hexanol	22.0
2-ethyl hexanoic acid	.0042
N-ethyl-o-toluene sulfonamide	DT
N-ethyl-p-toluene sulfonamide	0.1
Fluorene	.0012
Freon	-
Heptachlor	-
Heptanoic acid	.001
Heptanone	600-800
Hexachlorobutadiene	-
Hexachlorocyclohexane	-
Hexane	5-900
2-Hexanone	0.148
Isobutyric acid	49
Isophorone	4,000-6000
Isovaleric acid	.0007
Methanol	160
Methyl acetone	160
2-methyl-2-butanol	-
Methyl chloride	.064-1.3
3-methylcyclopentane-1,2-diol	DT

Table 3-9 continued

Chemical	Concentration Range (mg L^{-1})[1] Municipal Landfill
Methyl ethyl ketone	0.47-27,000
Methyl isobutyl ketone	0.176-200
Methyl naphthalene	.033
4-methyl-2-pentanol	-
4-methyl-2-pentanone	-
Methylpyridine	DT
Naphthalene	.110-19
o-nitroaniline	180
p-nitroaniline	37
Nitrobenzene	.25
o-nitrophenol	11
Palmitic acid	.042
Pentane	640
Pentanol	11.7
Pentachlorophenol	-
Phenol	.46-5790
Polycholorinated biphenyls	2.8
1-propanol	1.9-3400
2-propanol	-
Propionic acid	-
Stearic acid	.009
Tetrachloroethane	210
Tetrachloroethylene	.017-.24
Tetrahydrofuran	.14-.430
Tetramethylthiourea	.019
Toluene	.059-1,600
p-Toluenesulfonamide	DT
Toxaphene	-
Trans-1,2,-dichlorothylene	.004-.088
1,2,4-trichlorobenzene	-
1,1,1-Trichloroethane	.0042-.0056
1,1,2-Trichloroethane	.39-.87

Table 3-9 continued

Chemical	Concentration Range (mg L^{-1})[1] Municipal Landfill
Trichloroethane	.005-35
Trichloroethene	.125
Trichloroethylene	2.1
Trichlorofluoroethane	-
Trichlorofluoromethane	15
Trichloromethane	-
Tributly phosphate	.0012
Triethyl phosphate	.0003-.015
Tri-n-butyl phosphate	1.7
Trimethylbenzene	.22
Valeric acid	.0011
Vinyl chloride	0.02-61
Xylene	.029-170

Concentration range: DT=detected but concentration not determined.

Source: Texas A & M University Report

TABLE 3-10

CONTAMINANT CONCENTRATION FROM LEACHATE OF THREE MUNICIPAL LANDFILLS
[Concentrations in mg/l (ppm)]

Parameter	Lyon Municipal Landfill	Meeker Municipal Landfill	Rochester Municipal Landfill
Benzene[(a)]	0.036	0.270	0.54
Butanol[(a)]	25	0.120	10.
Chlorobenzene		0.060	
Cis-1,2-Dichloroethylene		0.190	0.47
1,1-Dichloroethane[(a)]	0.046	0.035	0.026
1,2-Dichloroethane			0.006
1,2-Dichlorobenzene[(a)]	0.019	0.032	0.010
1,4-Dichlorobenzene[(a)]			0.014
Dichloromethane[(a)]	0.200	0.064	1.3
1,2-Dichloropropane	0.002	0.013	0.081
Ethanol[(a)]	110.		23.
Ethyl Acetate	0.290	0.018	0.130
Ethyl Benzene	0.015	0.820	0.250
Methyl Ethyl Ketone	0.650	9.8	27.
Methyl Isobutyl Ketone	0.087	0.410	0.710
1-Propanol[(a)]	37.	0.076	11.
2-Propanol[(a)]	41.	1.9	26.
Tetrachloroethylene[(a)]			0.250
Tetrahydrofuran	0.280	0.140	0.430
Toluene[(a)]	0.180	0.390	0.6
Trans-1,2-Dichloroethylene[(a)]	0.0038	0.017	0.088
Trichloroethane[(a)]	0.0076		
Trichloroethylene[(a)]	0.043	0.043	0.125
Xylene[(a)]	0.092	0.32	0.198

Source: Texas A&M University Report
(a) = potential carcinogens

Table 3-11 Overall Summary from the Analysis of Municipal Solid Waste Leachates in Wisconsin

Parameter	Overall Range (1)	Typical Range (range of site medians) (1)	Number of Analyses
TDS	584-50430	2180-25873	172
Specific Conductance	480-72500	2840-15485	1167
Total Susp Solids	2-140900	28-2835	2700
BOD	ND-195000	101-29200	2905
COD	6.6-97900	1120-50450	467
TOC	ND-30500	427-5890	52
pH	5-8.9	5.4-7.2	1900
Total Alkalinity(CaCO3)	ND-15050	960-6845	328
Hardness(CaCO3)	52-225000	1050-9380	404
Chloride	2-11375	180-2651	303
Calcium	200-2500	200-2100	9
Sodium	12-6010	12-1630	192
Total Kjeldahl Nitrogen	2-3320	47-1470	156
Iron	ND-1500	2.1-1400	416
Potassium	ND-2800	ND-1375	19
Magnesium	120-780	120-780	9
Ammonia-Nitrogen	ND-1200	26-557	263
Sulfate	ND-1850	8.4-500	154
Aluminum	ND-85	ND-85	9
Zinc	ND-731	ND-54	158
Manganese	ND-31.1	0.03-25.9	67
Total Phosphorus	ND-234	0.3-117	454
Boron	0.87-13	1.19-12.3	15
Barium	ND-12.5	ND-5	73
Nickel	ND-7.5	ND-1.65	133
Nitrate-Nitrogen	ND-250	ND-1.4	88
Lead	ND-14.2	ND-1.11	142
Chromium	ND-5.6	ND-1.0	138
Antimony	ND-3.19	ND-0.56	76
Copper	ND-4.06	ND-0.32	138
Thallium	ND-0.78	ND-0.31	70
Cyanide	ND-6	ND-0.25	86
Arsenic	ND-70.2	ND-0.225	112
Molybdenum	0.01-1.43	0.034-0.193	7
Tin	ND-0.16	0.16	3
Nitrite-Nitrogen	ND-1.46	ND-0.11	20
Selenium	ND-1.85	ND-0.09	121
Cadmium	ND-0.4	ND-0.07	158
Silver	ND-1.96	ND-0.024	106
Beryllium	ND-0.36	ND-0.008	76
Mercury	ND-0.01	ND-0.001	111

(1): All concentrations in mg/l except pH(std. units) and sp. cond.(umhos/cm)

Source: Wisconsin Department of Natural Resources Report

The wide variation in leachate quality at Wisconsin landfills can, in part, be attributed to strength-controlling factors. Shallower depths of refuse and dilution by surface water, for instance, will result in lower leachate parameter concentrations. Correlations shown between specific conductance and the concentrations of major leachate contaminants indicate that a general model of contamination is possible. Such a model reflects the uniformity of municipal solid waste and the similarities in Wisconsin sites. As these sites age and the contaminants respond differently to the changing landfill environment, these ratios are expected to change.

The similarities in Wisconsin sites and waste composition allow an order of magnitude approximation to the concentrations found in leachate to be made. In Table A-3, these ranges are summarized for many leachate contaminants.

A perspective on the magnitude of the concentrations of contaminants found in Wisconsin leachates can be obtained from the results shown in Table 3-12. This table compares the median and maximum concentrations in Wisconsin leachates to the Primary Drinking Water Standards and enables the leachate concentrations to be described as multipliers of the standards. From Table 3-12, where data are available, it can be seen that the median leachate concentrations exceed the Primary Drinking Water Standards routinely for cadmium, chromium, and lead; less frequently for arsenic, barium, and selenium; and never for nitrates and silver.

The maximum leachate concentrations exceeded all of the Primary Drinking Water Standards in at least one instance. Very high multipliers of the drinking water standards were encountered at some sites, particularly at the larger sites and those with a history of industrial waste codisposal.

Leachate median and maximum concentrations have also been expressed as multipliers of the Secondary Drinking Water Standards in Table 3-12. The secondary standards were commonly exceeded for chloride, iron, manganese, and total dissolved solids (approximated by specific conductance). The secondary drinking water multipliers are highest for iron.

Table 3-12 Comparison of Leachate Concentrations with Drinking Water Standards

Primary Drinking Water Standards

Site Number	Arsenic (0.05mg/l) Median (mg/l)	Arsenic Times DWS	Barium (1.0 mg/l) Median (mg/l)	Barium Times DWS	Cadmium (0.01mg/l) Median (mg/l)	Cadmium Times DWS	Chromium (0.05mg/l) Median (mg/l)	Chromium Times DWS	Lead (0.05mg/l) Median (mg/l)	Lead Times DWS	Mercury (0.002mg/l) Median (mg/l)	Mercury Times DWS	Selenium (0.01mg/l) Median (mg/l)	Selenium Times DWS	Silver (0.05mg/l) Median (mg/l)	Silver Times DWS
11	0.009	0	0.84	1	0.006	1	0.03	1	0.069	1	0.0001	0	0.001	0	0.0075	0
307			0.30	0			0.528	11								
572	0.002	0	0.225	0	0.05	5	0.64	13	0.03	1	0.0002	0	0.02	2	0.0008	0
611	ND	0			ND	0	ND	0	ND	0	ND	0				
652	0.002	0			0.015	2	0.059	1	0.1	2	0.0006	0	ND	0	0.009	0
719					ND	0										
1099	0.015	0	1.3	1	0.021	2	0.31	6	0.29	6	0.0003	0	0.001	0	0.013	0
1678	0.225	5	1.3	1	0.039	4	0.34	7	0.46	9	0.0006	0	0.006	1	0.024	0
1739	0.07	1	2.69	3	0.05	5	0.23	5	1.11	22	ND	0	0.09	9	ND	0
2358																
2484	ND	0	ND	0	ND	0	1	20	0.3	6	ND	0	ND	0	ND	0
2568																
2569					ND	0	ND	0	ND	0						
2575					0.06	6	0.4	[illegible]	ND	0						
2627	ND	0			0.009	1	0.06	1	0.25	5	0.0003	0				
2680																
2821	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0
2822	0.001	0	5.0	5	0.07	7	0.05	1	0.07	1						
2892	ND	0	ND	0	ND	0	0.01	0	0.015	0	ND	0				
2895	0.015	0	0.6	1	0.015	2	0.18	4	0.13	3	0.001	1	0.002	0	0.008	0

Site Number	Arsenic Max (mg/l)	Arsenic Times DWS	Barium Max (mg/l)	Barium Times DWS	Cadmium Max (mg/l)	Cadmium Times DWS	Chromium Max (mg/l)	Chromium Times DWS	Lead Max (mg/l)	Lead Times DWS	Mercury Max (mg/l)	Mercury Times DWS	Selenium Max (mg/l)	Selenium Times DWS	Silver Max (mg/l)	Silver Times DWS
11	0.015	0	2.1	2	0.015	2	0.06	1	0.2	4	0.0025	1	0.005	1	0.02	0
307			0.44	0			0.568	11								
572	0.03	1	0.75	1	0.4	40	5.6	112	0.44	9	0.002	1	0.032	3	0.01	0
611	ND	0			ND	0	ND	0	ND	0	ND	0				
652	0.014	0			0.060	6	0.180	4	0.340	7	0.0084	4	0.033	3	0.050	1
719					ND	0										
1099	0.059	1	2.12	2	0.100	10	2.560	51	1.200	24	0.0100	5	0.035	4	0.029	1
1678	*70.2	1404	11.5	12	0.16	16	1.85	37	1.4	28	0.0076	4	0.054	5	0.083	2
1739	1.29	26	12.5	13	0.17	17	2.01	40	*14.2	284	0.0004	0	*1.85	185	0.07	1
2358																
2484	ND	0	ND	0	ND	0	1	20	0.3	6	ND	0	ND	0	ND	0
2568																
2569					ND	0	ND	0	ND	0						
2575					0.2	20	0.7	14	1	20						
2627	ND	0			0.009	1	0.06	1	0.25	5	0.0003	0				
2680																
2821	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0
2822	0.001	0	5.0	5	0.09	9	0.26	5	0.07	1						
2892	ND	0	ND	0	ND	0	0.02	0	0.03	1	ND	0				
2895	0.04	1	1.25	1	0.3	30	0.53	11	0.43	9	0.0042	2	0.034	3	0.196	4
Avg. for Medians		0.5		1.1		2.1		4.8		3.8		0.1		1.3		0.1
Avg. for Maximum		110.2		3.2		9.4		19.2		26.5		1.5		22.7		1.0

*Value exceeds U.S. EPA Maximum Concentration of Contaminants for Characteristic of EP Toxicity

Table 3-12 continued

Secondary Drinking Water Standards

Site Number	Chloride (250 mg/l) Median (mg/l)	Times DWS	Copper (1.0 mg/l) Median (mg/l)	Times DWS	Iron (0.3 mg/l) Median (mg/l)	Times DWS	Manganese (0.05 mg/l) Median (mg/l)	Times DWS	Sulfate (250 mg/l) Median (mg/l)	Times DWS	TDS (500 mg/l) Median (mg/l)	Times DWS	Zinc (5.0 mg/l) Median (mg/l)	Times DWS
11			0.02	0	10.3	34					9000	18	0.152	0
307	885	4	0.321	0	359	1197	25.9	518	155	1	8183	16	54.0	11
572	923	4	0.17	0	211	703	0.5	10	8.4	0	10005	20	22	4
611	350	1	ND	0	2.1	7	0.03	1	112	0	3540	7	ND	0
652			0.029	0							5804	12	0.153	0
719	980	4	ND	0	246	820	3.1	62	500	2	10150	20	1.6	0
1099	2651	11	0.049	0	6.12	20	1.45	29	271.5	1	10600	21	1.65	0
1678	2270	9	0.09	0	113	377	2.83	57	200	1	13750	28	28.9	6
1739	759	3	0.3	0	169	563					5000	10	47.7	10
2358	795	3			46.65	156			108	0	6375	13		
2484	1400	6	0.1	0	15.85	53	1.4	28	255	1	15485	31	2	0
2568	840	3			4	13					4390	9		
2569	1040	4	ND	0	29.5	98	2.87	57			7635	15	0.42	0
2575			0.1	0	385	1283							10	2
2627			0.12	0							6800	14	3.13	1
2680	1770	7			500	1667					15100	30		
2821	700	3	ND	0	1400	4667	22	440	210	1	7800	16	2.4	0
2822	300	1	0.09	0	150	500	1.35	27	200	1	9250	19	0.84	0
2892	180	1	0.05	0	66.2	221			140	1	2840	6	0.03	0
2895			0.058	0			1.795	36					1.96	0

Site Number	Chloride Max (mg/l)	Times DWS	Copper Max (mg/l)	Times DWS	Iron Max (mg/l)	Times DWS	Manganese Max (mg/l)	Times DWS	Sulfate Max (mg/l)	Times DWS	TDS Max (mg/l)	Times DWS	Zinc Max (mg/l)	Times DWS
11			0.04	0	10.3	34					9000	18	0.54	0
307	1275	5	0.399	0	626	2087	30.5	610	1400	6	11080	22	69.4	14
572	1876	8	0.56	1	1500	5000	9.8	196	200	1	17500	35	42.3	8
611	1440	6	ND	0	670	2233	0.03	1	911	4	22500	45	ND	0
652			0.122	0							16320	33	13.1	3
719	2200	9	ND	0	1240	4133	19	380	750	3	72500	145	1.6	0
1099	11375	46	0.270	0	788	2627	31.1	622	1850	7	32000	64	162	32
1678	5700	23	0.26	0	1050	3500	26.7	534	1670	7	28000	56	72.5	15
1739	1600	6	4.06	4	879	2930					17200	34	731	146
2358	1630	7			269	897			108	0	10800	22		
2484	1500	6	0.1	0	210.0	700	1.4	28	411	2	19400	39	2	0
2568	1690	7			62.6	209					14000	28		
2569	2520	10	ND	0	322	1073	2.93	59			24500	49	0.82	0
2575			0.15	0	610	2033							22	4
2627			0.12	0							6800	14	3.13	1
2680	2310	9			860	2867					19100	38		
2821	1100	4	ND	0	1500	5000	22	440	720	3	11500	23	3.4	1
2822	540	2	0.16	0	400	1333	1.35	27	300	1	12200	24	0.84	0
2892	625	3	0.06	0	432	1440			747	3	8700	17	0.05	0
2895			0.181	0			2.35	47					26.4	5
Avg. for Medians		4.2		0.1		728.2		115.0		0.8		16.9		2.1
Avg. for Maximum		10.0		0.4		2241.0		267.6		3.3		39.2		13.5

Source: Wisconsin Department of Natural Resources Report

Table 3-12 also illustrates how the maximum value for arsenic at Site 1678 (Table 3-1) exceeded the EPA maximum concentration limit of 5.0 mg/l (ppm). This indicates the leachate would be classified as a hazardous waste because of its value of 70.2 mg/l (ppm). The EPA maximum concentration limits are listed below.

Contaminant	Maximum Concentration (mg/l)
Arsenic	5.0
Barium	100.0
Cadmium	1.0
Chromium	5.0
Lead	5.0
Mercury	0.2
Selenium	1.0
Silver	5.0
Endrin	0.02
Lindane	0.4
Methoxychlor	10.0
Toxaphene	0.5
2,4-D	10.0
2,4,5-TP Silvex	1.0

Table 3-12 also illustrates that Site 1739 (Table 3-1) exceeded the EPA maximum concentration limit for lead, which is 5.0 mg/l (ppm). Site 1739 had a maximum value of 14.2 mg/l (ppm). Site 1739 on Table 3-12 also shows a maximum value of 1.85 mg/l (ppm) for selenium. The EPA maximum concentration limit of selenium is 1.0 mg/l (ppm). Either one of these two parameters would classify the leachate as hazardous waste. Site 1678 reports accepting municipal, industrial, and hazardous wastes, whereas Site 1739 reports accepting municipal and industrial wastes.

Appendix B, Table B-1 summarizes each Wisconsin site regarding parameters and site characteristics that were discussed in the Wisconsin report.

Tables 3-13 and 3-14 are Sobotka tables that provide a summary of municipal leachate concentrations. They list minimum, maximum, and median values for

Table 3-13 Sobotka Report: Data Summary of Organic MSW Leachate Concentrations

(All values in ppm)

CONSTITUENT	MIN	MAX	MEDIAN
Acetone	0.140	11.000	7.500
Benzene	0.002	0.410	0.017
Chloroform	0.002	1.300	0.010
1,2-Dichloroethane	0.000	11.000	0.0075
Dichloromethane	0.002	3.300	0.230
Methyl ethyl ketone	0.110	28.000	8.300
Methyl isobutyl ketone	0.010	0.660	0.270
Phenol	0.010	28.800	0.257
Tetrahydrofuran	0.005	0.260	0.018
Toluene	0.002	1.600	0.166
Ethyl Benzene	0.005	0.580	0.038
m-Xylene	0.021	0.079	0.026
1,4-Dichlorobenzene	0.002	0.020	0.0077
Trichlorofluoromethane	0.004	0.100	0.0125
1,1-Dichloroethane	0.002	6.300	0.0655
trans-1,2-Dichloroethene	0.004	1.300	0.010
1,1,1-Trichloroethane	0.000	2.400	0.010
1,2-Dichloropropane	0.002	0.100	0.010
Chlorobenzene	0.002	0.237	0.010
cis-1,2-Dichloroethane	0.004	0.190	0.097
Chloromethane	0.010	0.170	0.055
Chloroethane	0.005	0.170	0.0075
Dichlorodifluoromethane	0.010	0.369	0.095
1,1,2-Trichloroethane	0.002	0.500	0.010
1,1,2,2-Tetrachloroethane	0.007	0.210	0.020
4 Nitrophenol	0.017	0.040	0.025
Pentachlorophenol	0.003	0.025	0.003
Vinyl chloride	0.000	0.100	0.010
bis (2-Ethylhexyl) phthalate	0.006	0.110	0.022
Diethyl phthalate	0.002	0.045	0.0315
Di-n-butyl phthalate	0.004	0.012	0.010
Dimethyl phthalate	0.004	0.055	0.015
Naphthalene	0.004	0.019	0.008
Tetrachloroethene	0.002	0.100	0.040
Trichloroethene	0.001	0.043	0.0035
Bromomethane	0.010	0.170	0.055
Carbon tetrachloride	0.002	0.398	0.010
bis(2-Chloroethoxy) methane	0.002	0.014	0.010
Isophorone	0.010	0.085	0.010
Nitrobenzene	0.002	0.040	0.015
Dibromomethane	0.005	0.025	0.010
2-Propanol	0.094	10.000	6.900
Ethyl acetate	0.005	0.050	0.042
1-Butanol	0.050	0.360	0.220
p-Xylene + o-xylene	0.012	0.050	0.018
Endrin	0.000	0.001	0.0001
Toxaphene	0.000	0.005	0.001
Delta BHC	0.000	0.005	0.008

Source: Sobotka Report

Table 3-14 Sobotka Report: Data Summary on Inorganic MSW Leachate Concentration

(All values in ppm)

CONSTITUENT	MIN	MAX	MEDIAN
pH	5.4	8.0	6.690
TS	1900.0	25873.0	10040.0
TSS	28.0	2835.0	301.0
TDS	1400.0	16120.0	6453.3
Tot alkalinity	0.0	7375.0	2430.0
BOD	7.0	21600.0	2330.0
COD	440.0	50450.0	3387.5
TOC	5.0	6884.0	558.0
TKN	47.3	938.0	309.0
NH_3	11.3	1200.0	200.0
NO_2	0.007	0.20	0.020
NO_3	0.000	50.950	0.340
Organic N	4.5	78.2	62.5
Sulfate	8.0	500.0	108.0
Fluoride	0.120	0.790	0.400
Chloride	120.0	5475.0	695.0
Cyanide	0.000	4.000	0.020
Al	0.010	5.070	0.655
As	0.000	0.080	0.010
Ba	0.010	10.000	0.383
Cd	0.000	0.100	0.015
Cr (total)	0.001	1.000	0.060
Cu	0.003	0.320	0.070
Fe	0.22	1400.00	66.20
Pb	0.001	1.110	0.080
Mg	76.0	927.0	143.0
Mn	0.030	43.00	1.60
Hg	0.000	0.020	0.0006
Ni	0.010	1.250	0.160
N	12.0	1200.0	539.0
Zn	0.010	67.000	1.350
Tot Phosphate	0.00	117.18	1.72
Hardness	0.8	9380.0	1845.0
Ca	95.5	2100.0	336.0
K	30.0	1375.0	48.0
Sb	0.002	1.100	0.470
Be	0.001	0.010	0.0065
Ag	0.008	0.050	0.020

Source: Sobotka Report

inorganic and organic constituents respectively. This information is also presented in Table 3-2, which provides a comparison of literature values to the concentration values presented in the Wisconsin and Sobotka studies.

Comparing the endrin and toxaphene values in Table 3-13 to the maximum EPA concentration values for EP toxicity (Subtitle D), neither substance exceeded the limit. Endrin must not exceed 0.02 mg/l (ppm) and toxaphene must not exceed 0.5 mg/l (ppm). In both of these comparisons, the leachate should be considered hazardous for these specific parameters, since the EPA's EP toxicity limits dictate whether a substance would be classified as a hazardous waste.

Comparing the arsenic, barium, cadmium, chromium, lead, mercury, and silver values in Table 3-14 to maximum EPA concentration values for EP toxicity, indicates that the limits were not exceeded.

In the Wisconsin report data, endrin and toxaphene were not detected (limit <10 ppb) in one Wisconsin leachate sample.

Also listed in the EP toxicity maximum concentrations are 2,4-D, (2-4-Dichlorophenoxy-acetic acid) and 2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid). Detected in two leachate analysis (limit F10 ppb) was 2,4-D. See Table A-2 for values.

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Cameron, R. D., 1978. "The Effects of Solid Waste Landfill Leachates on Receiving Waters." Journal of the American Water Works Association, pp. 173-176, March.

Chian, E. S., and F. B. DeWalle, 1977. Evaluation of Leachate Treatment: Volume I – Characterization of Leachate and Volume II – Biological and Physical-Chemical Processes. EPA-600/2-77-186a and 1866.

EPA (U.S. Environmental Protection Agency), 1973. Water Quality Criteria, 1972. EPA/R-73-033.

George, J. A., 1972. Sanitary Landfill – Gas and Leachate Control, The National Perspective. USEPA, Office of Solid Waste Management Programs.

Metry, A. A., and F. L. Cross, 1975. Leachate Control and Treatment. Volume 7, Environmental Monograph Series, Technomic Publishing Company, Westport, Connecticut.

APPENDIX A

RANGE GRAPHS AND MEDIAN FREQUENCY-OF-OCCURRENCE HISTOGRAMS

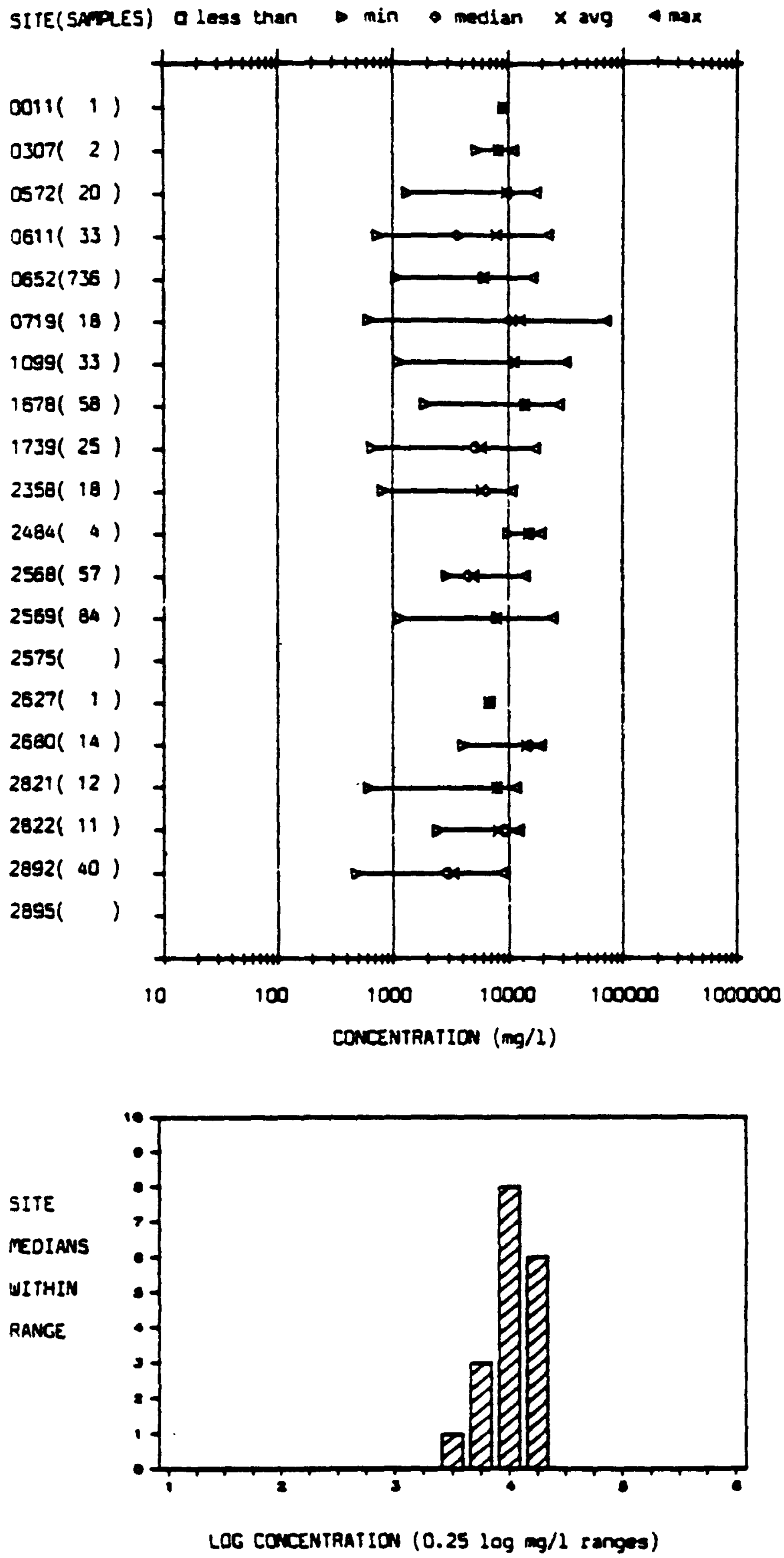
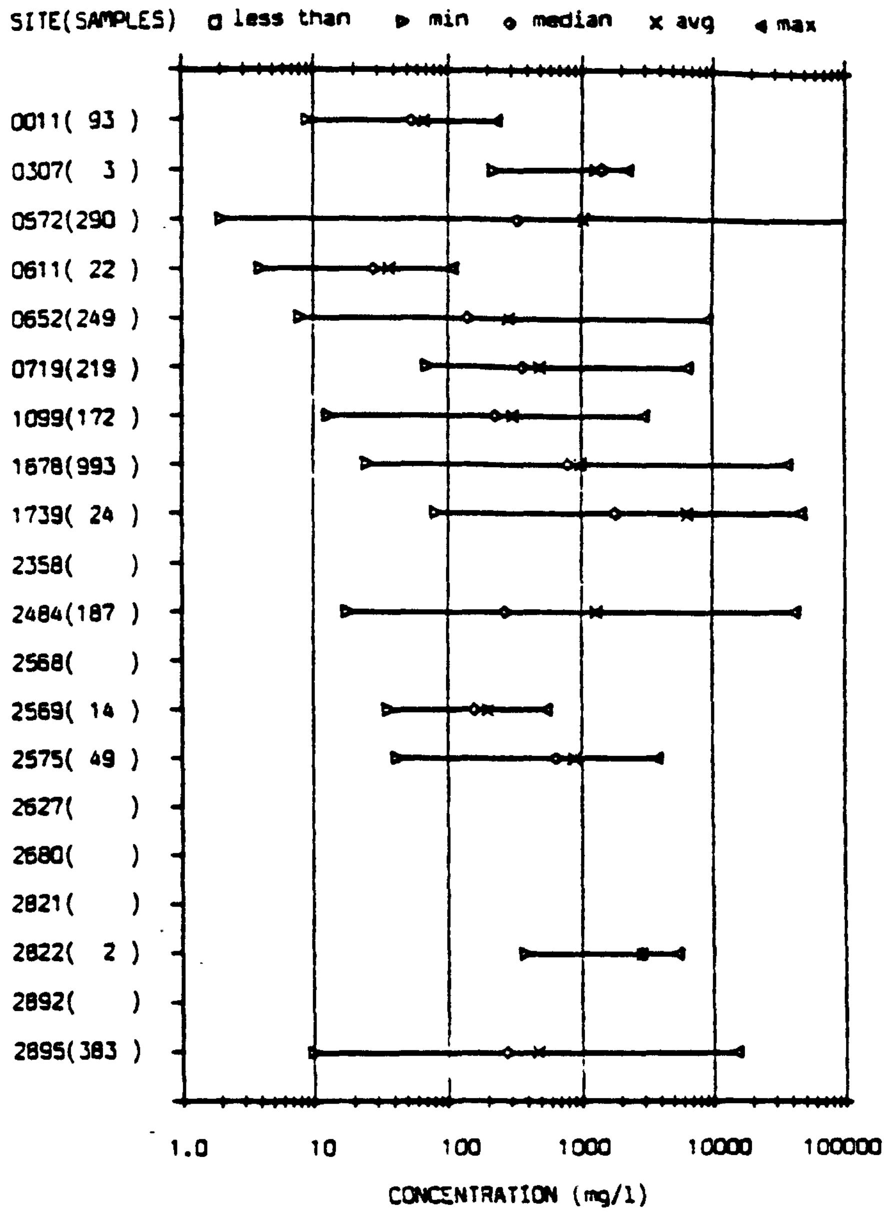


Figure A-1 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Specific Conductance.



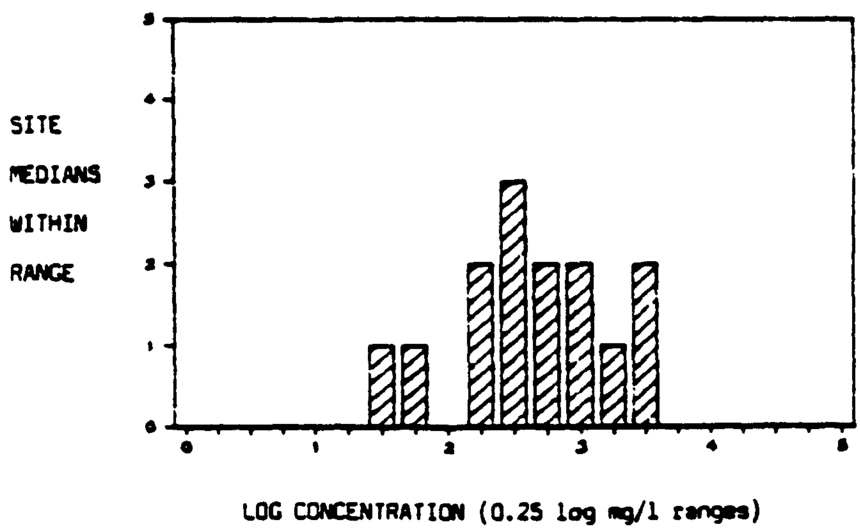
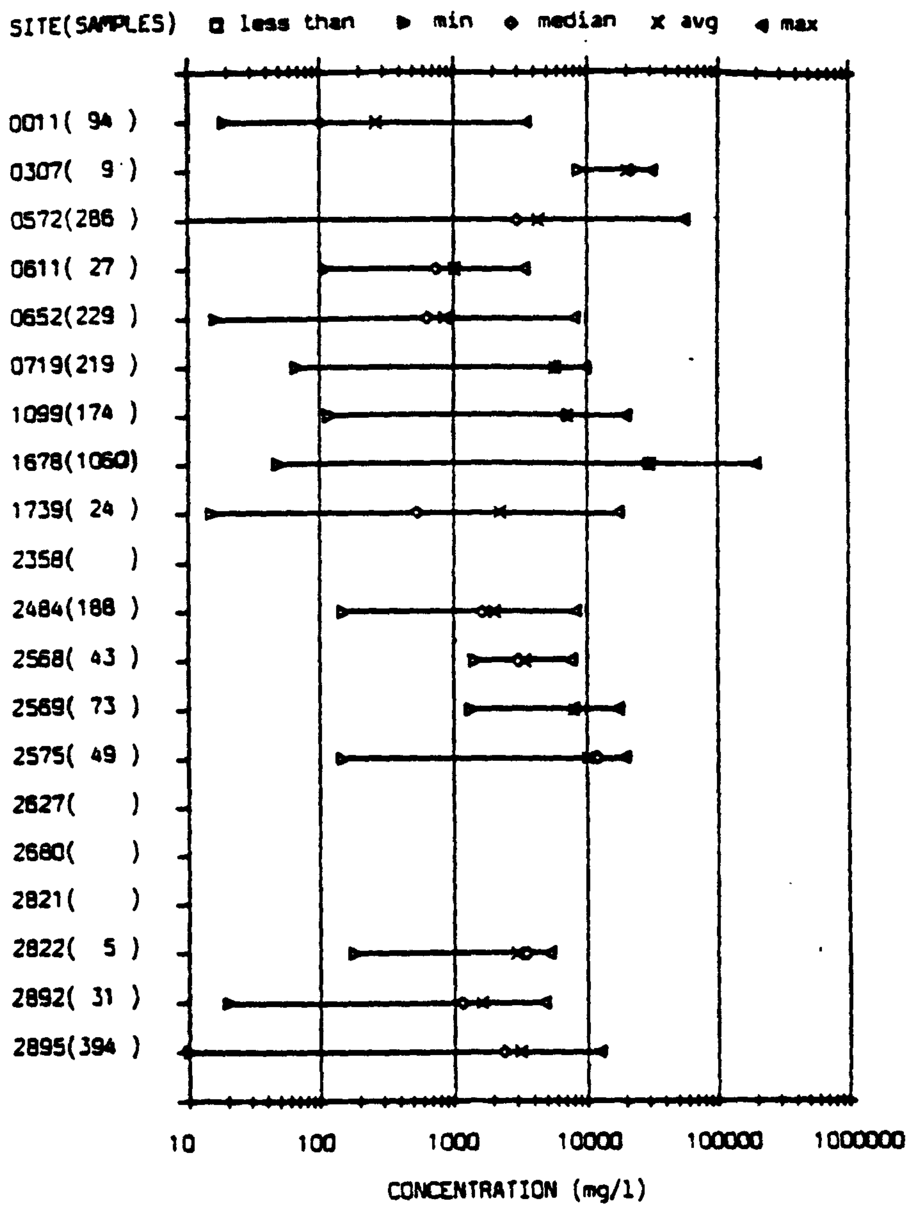


Figure A-2 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Total Suspended Solids Concentrations.



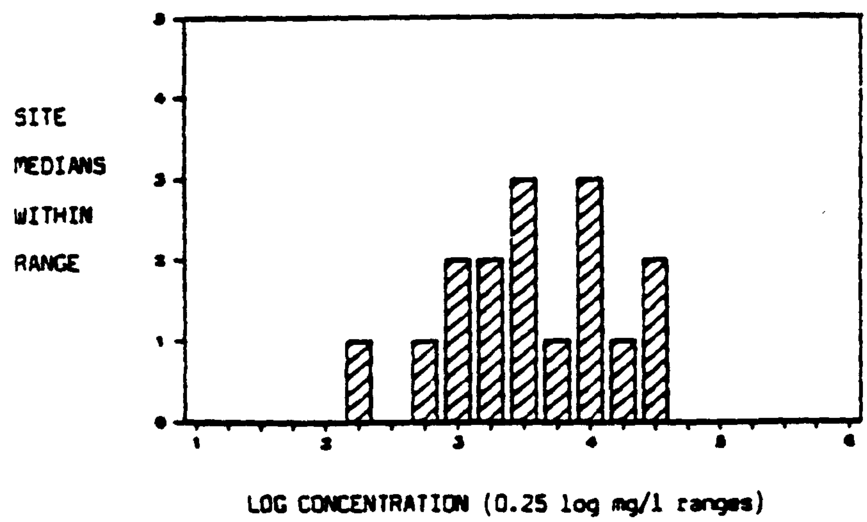


Figure A-3 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Biochemical Oxygen Demand(BOD).

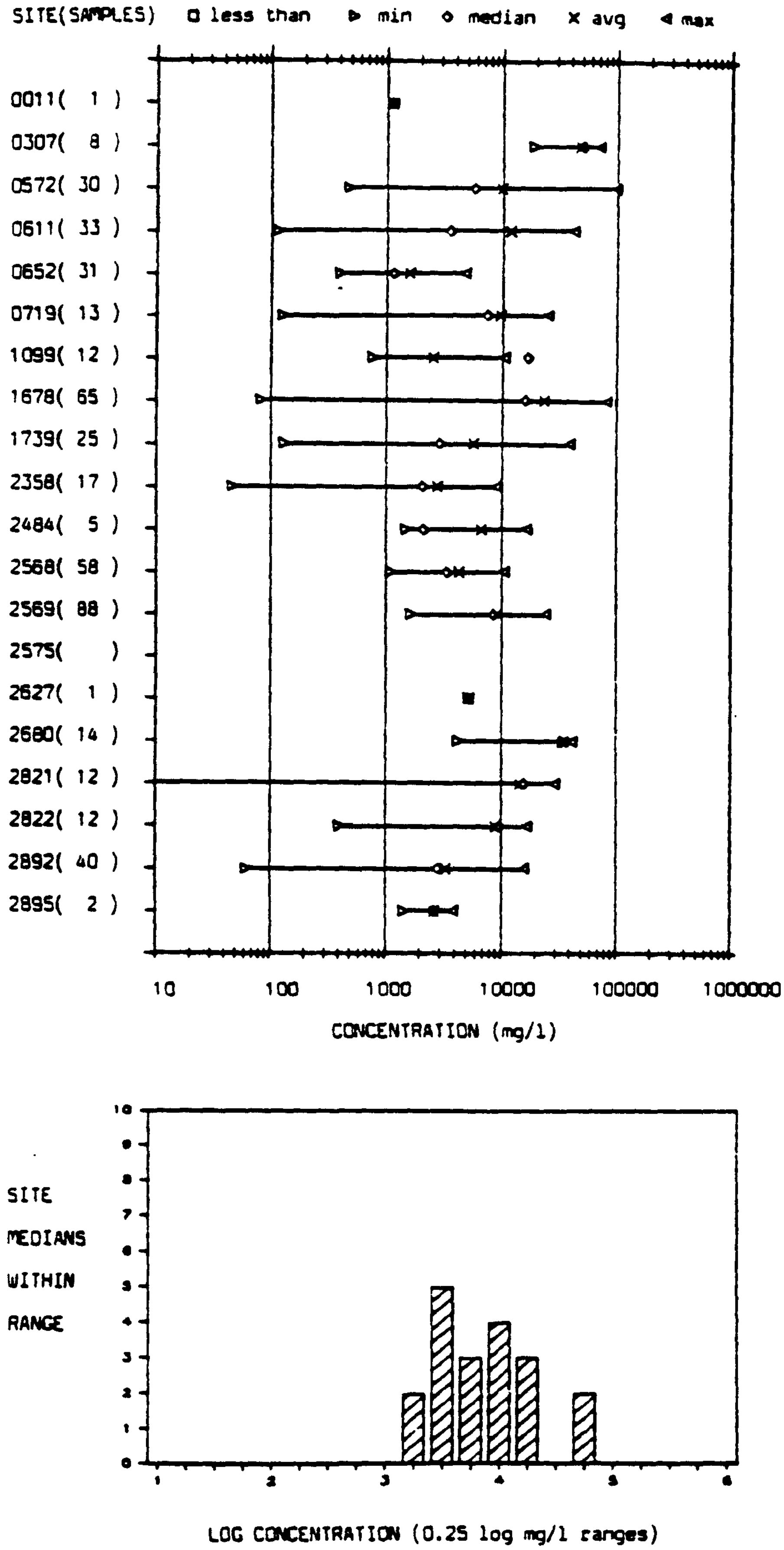
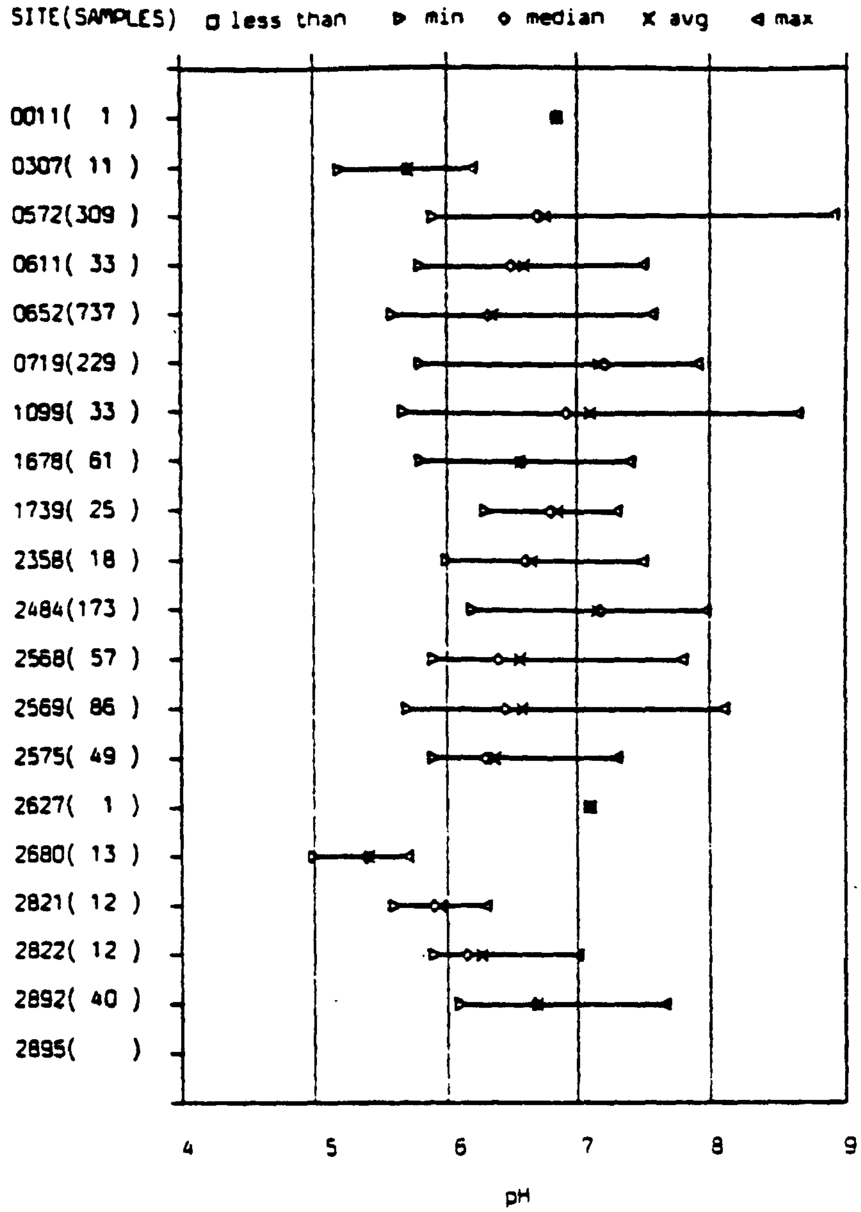


Figure A-4 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Chemical Oxygen Demand(COD).



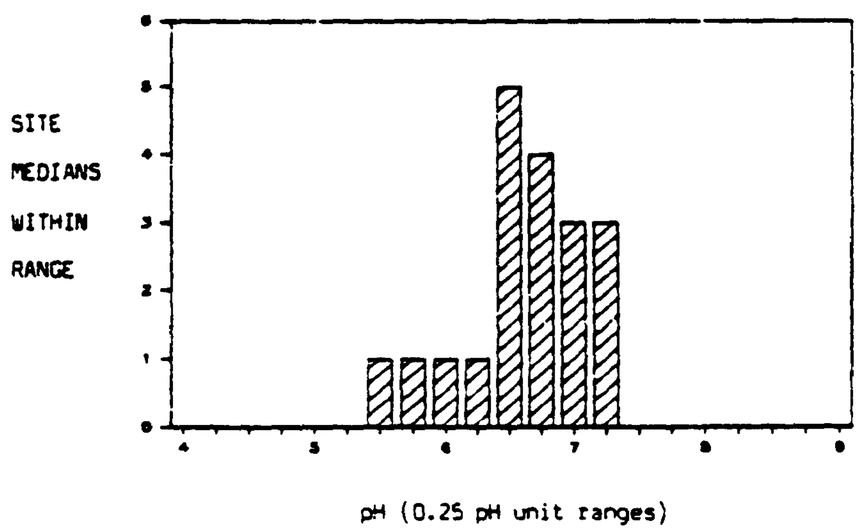


Figure A-5 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate pH.

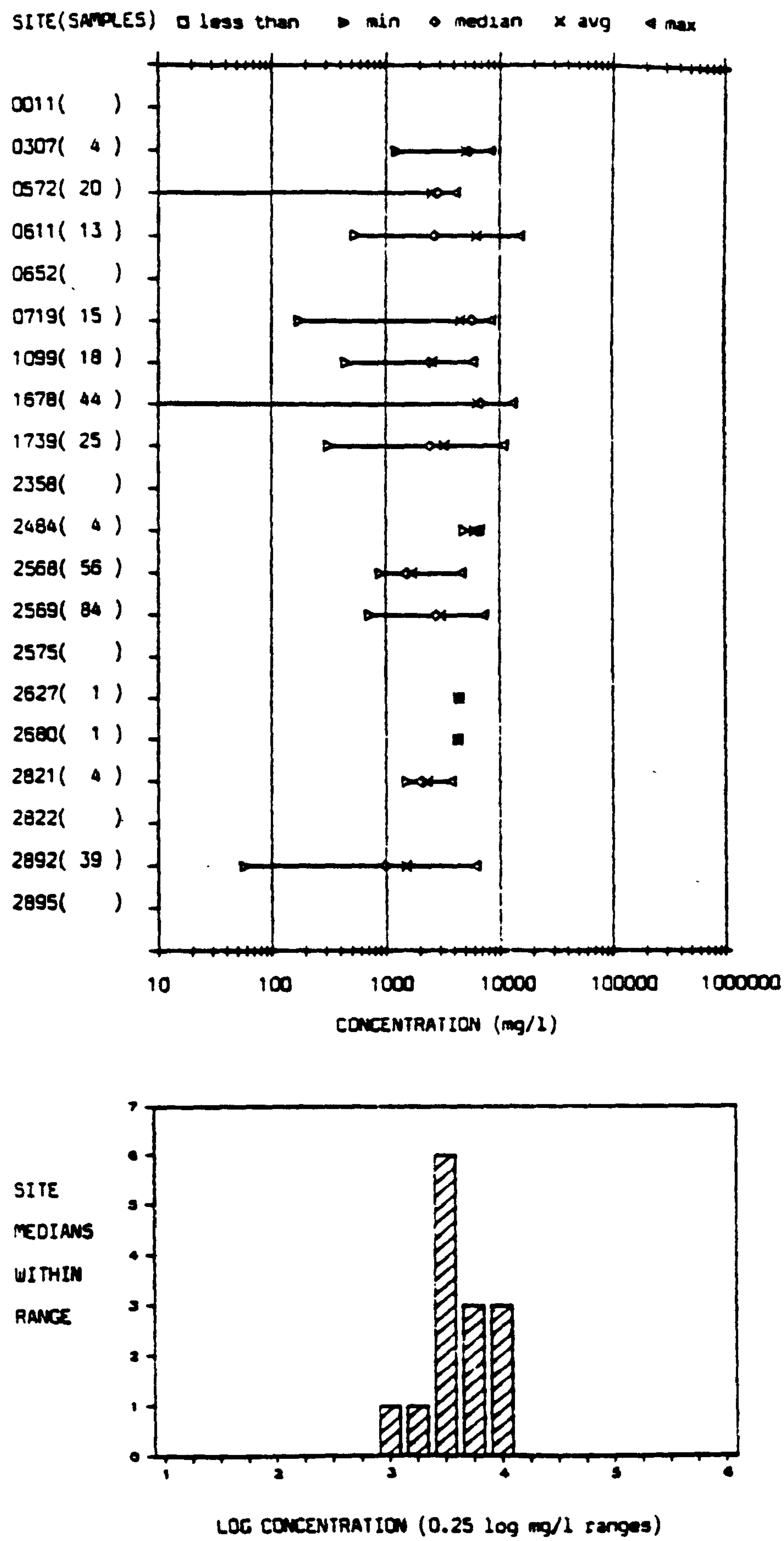
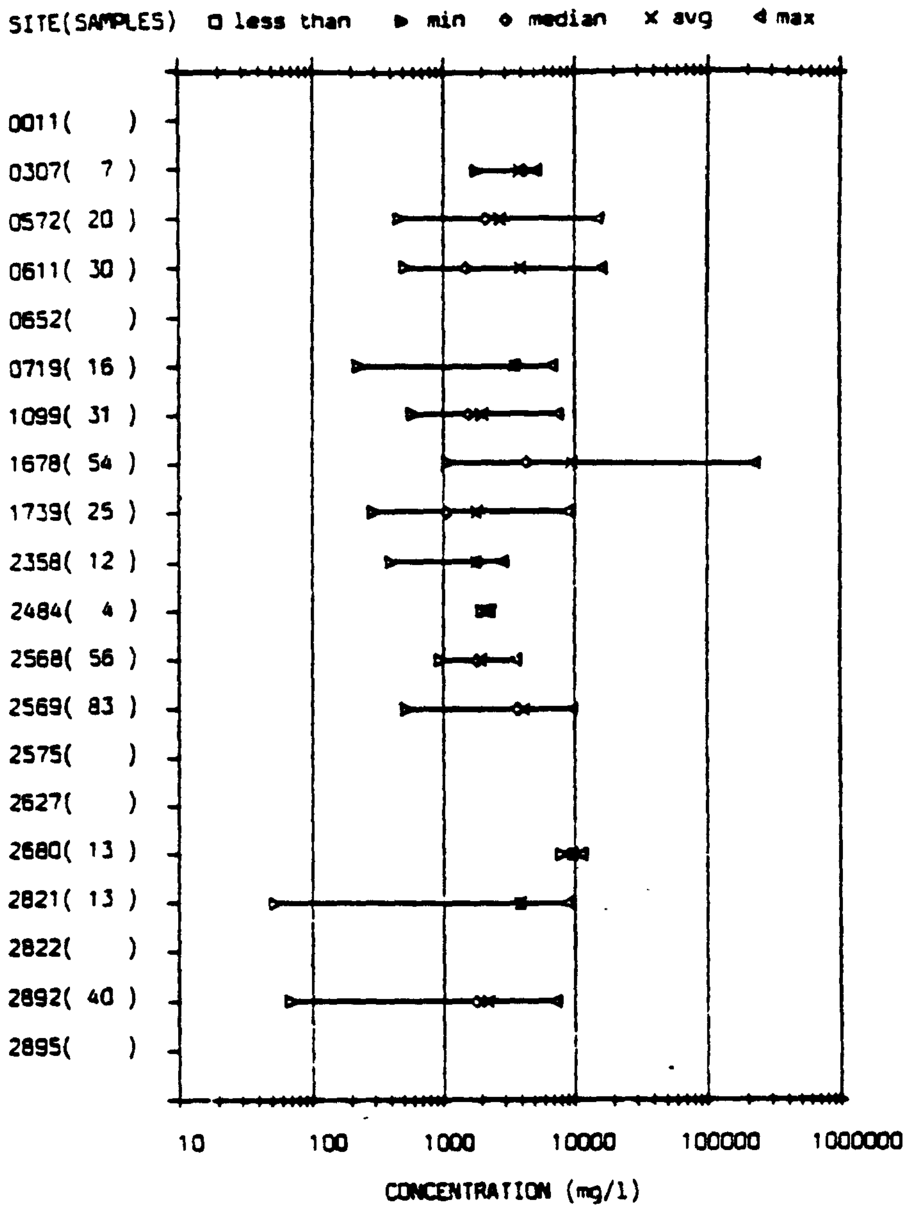


Figure A-6 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Total Alkalinity.



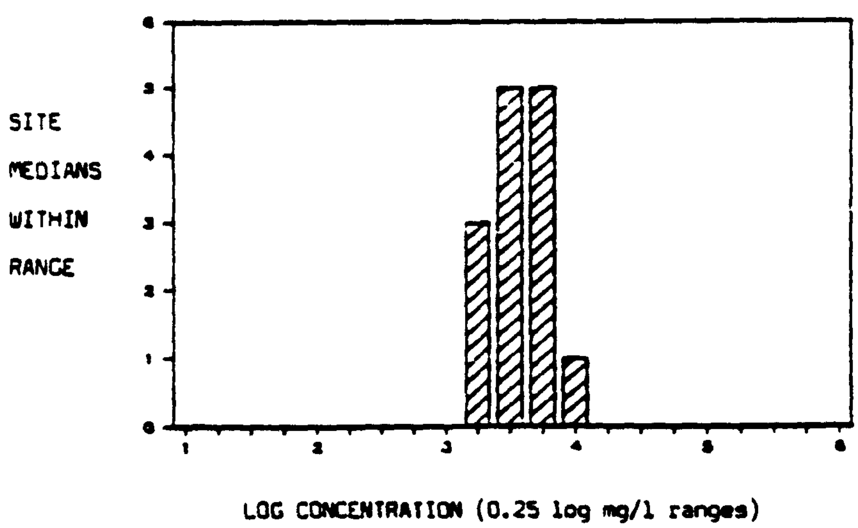
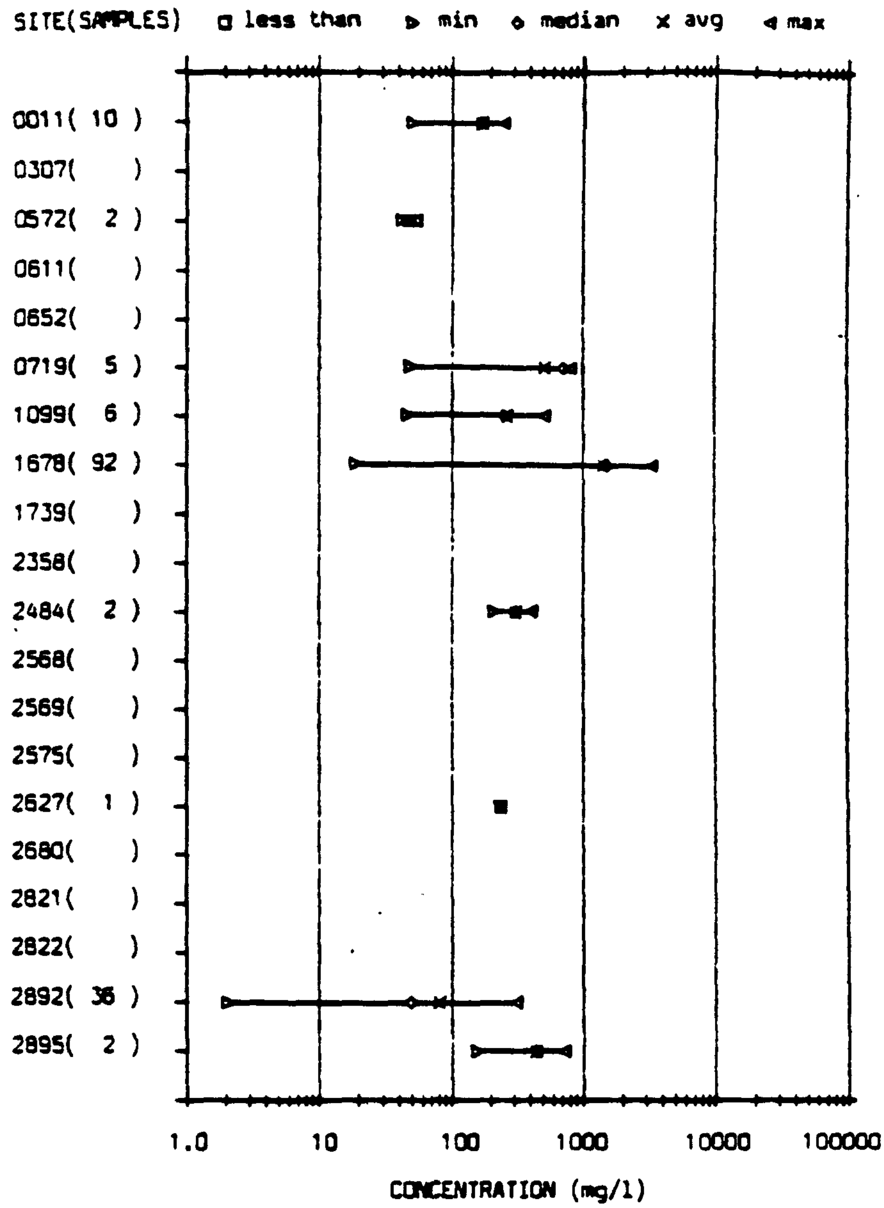


Figure A-7 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Hardness.



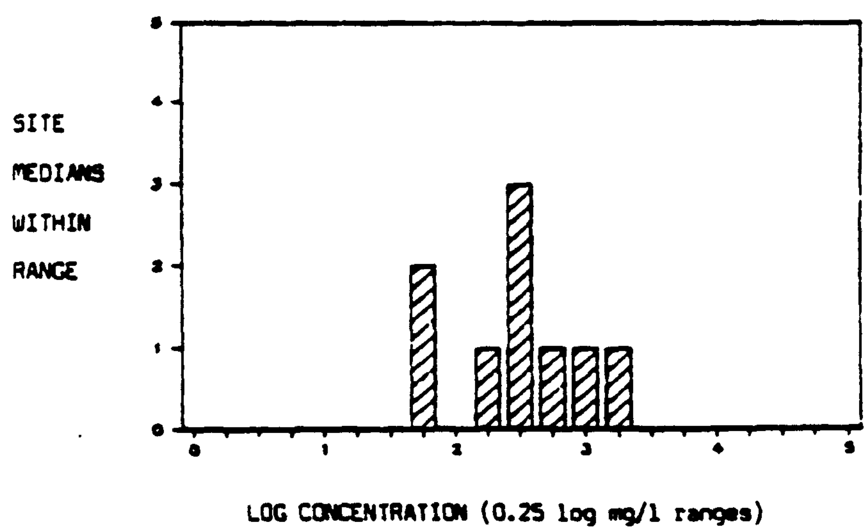
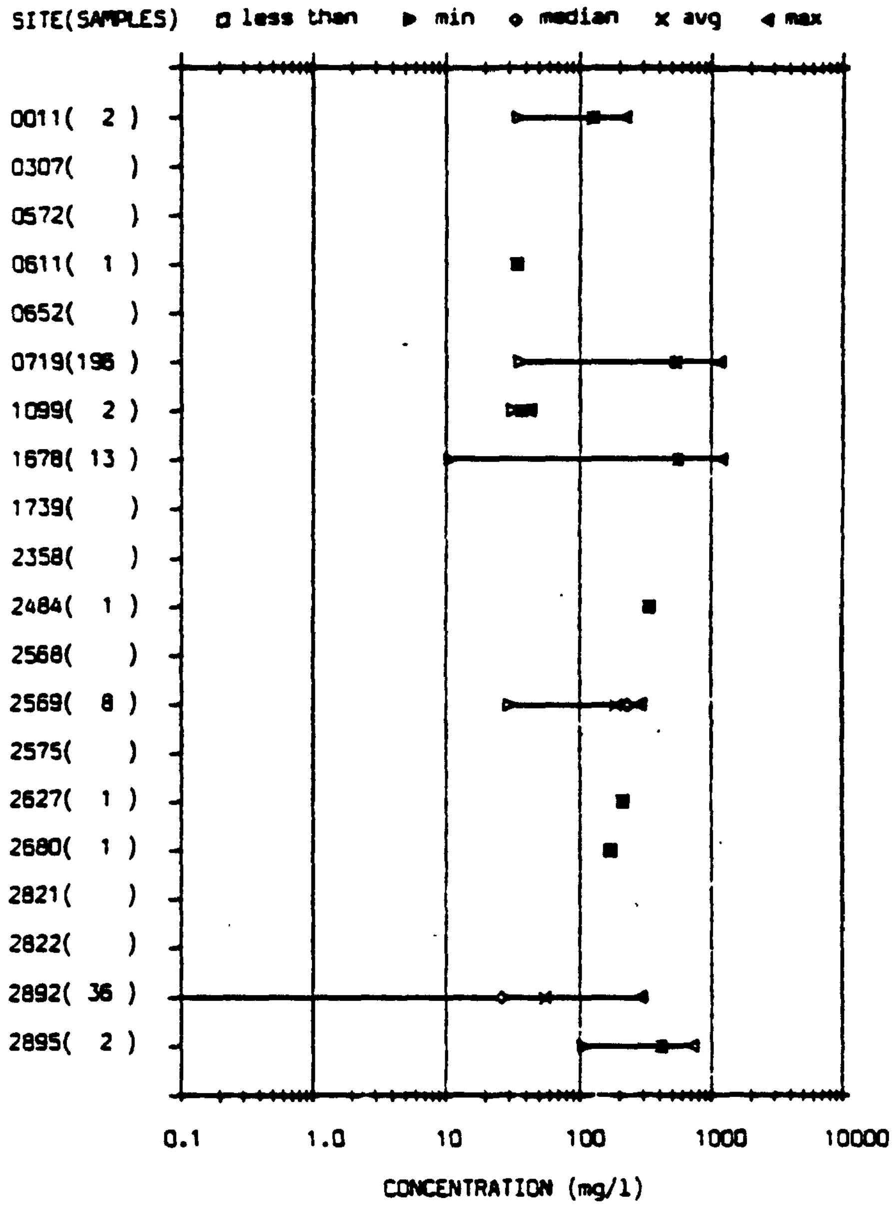


Figure A-8 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Total Kjeldahl Nitrogen.



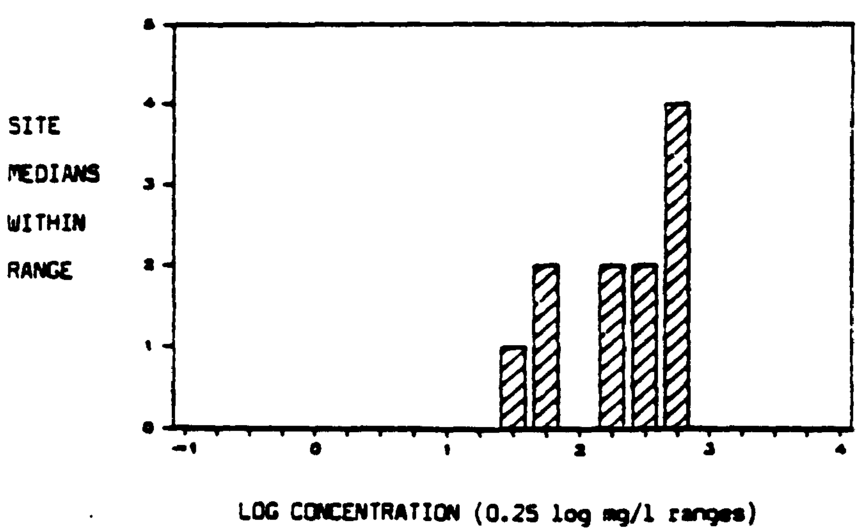


Figure A-9 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Ammonia Nitrogen.

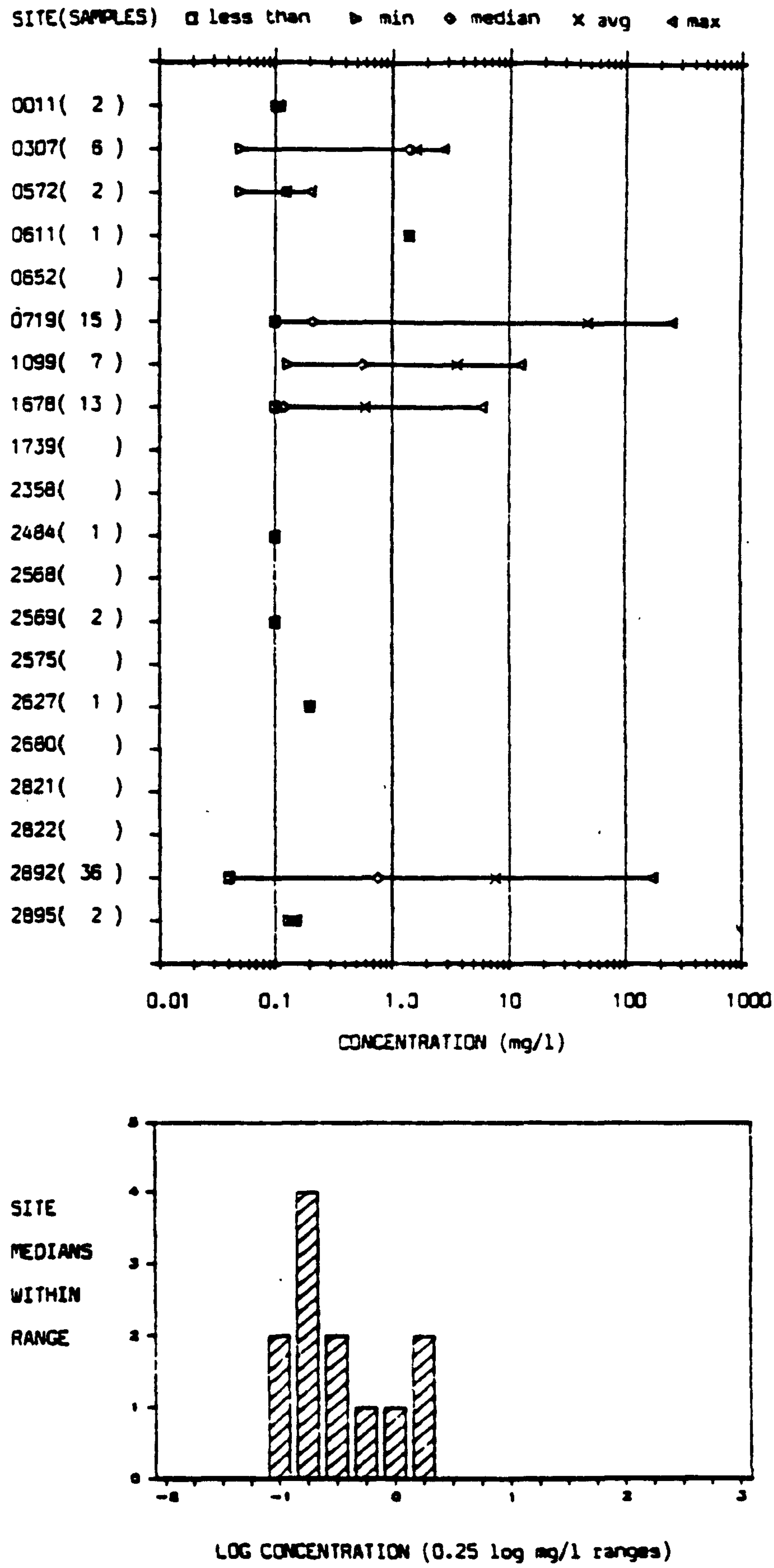
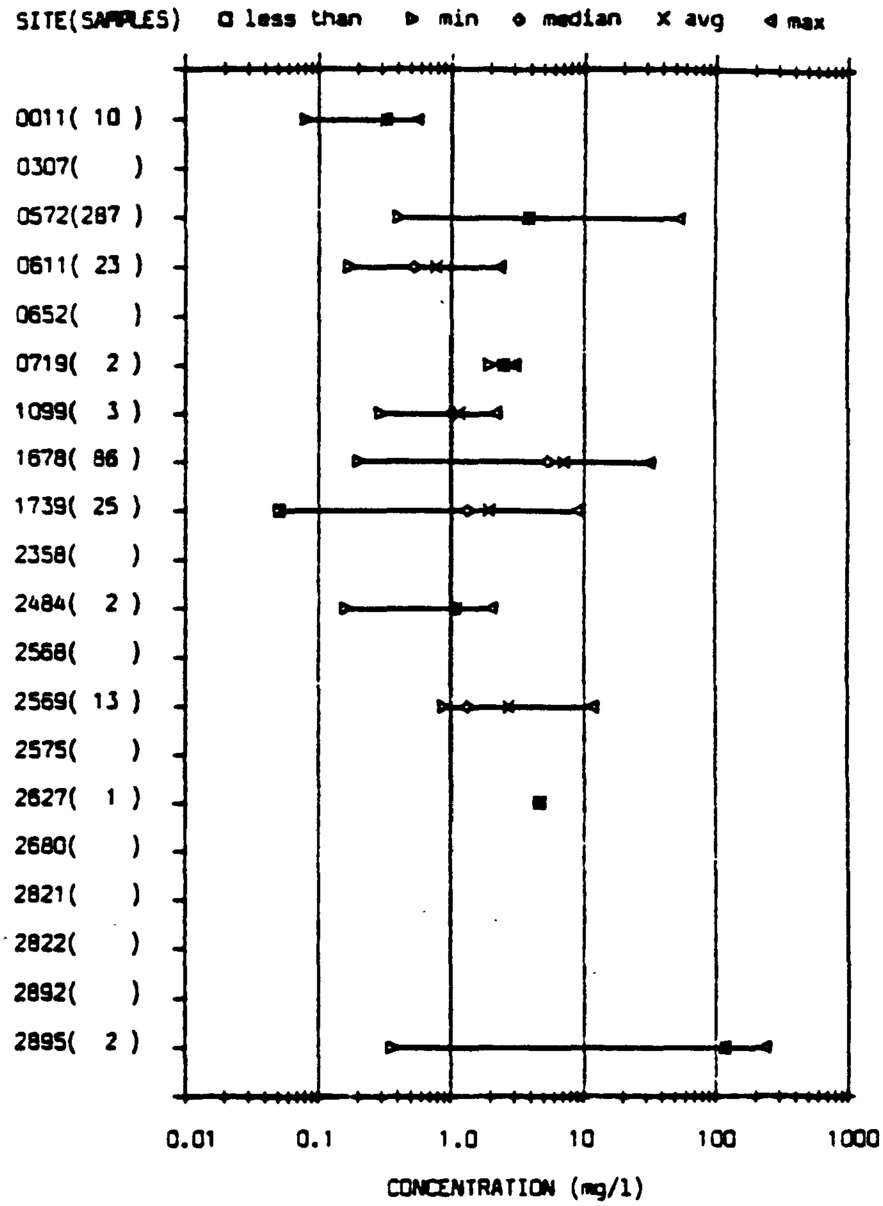


Figure A-10 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Nitrate Nitrogen.



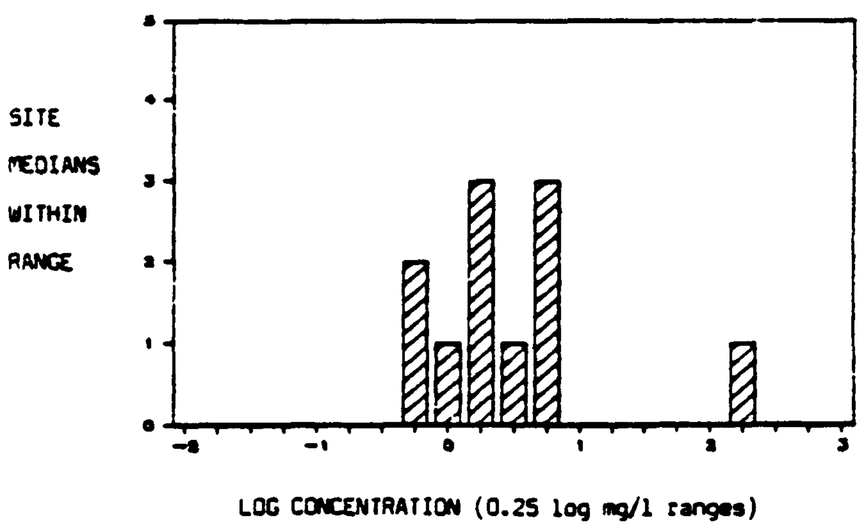
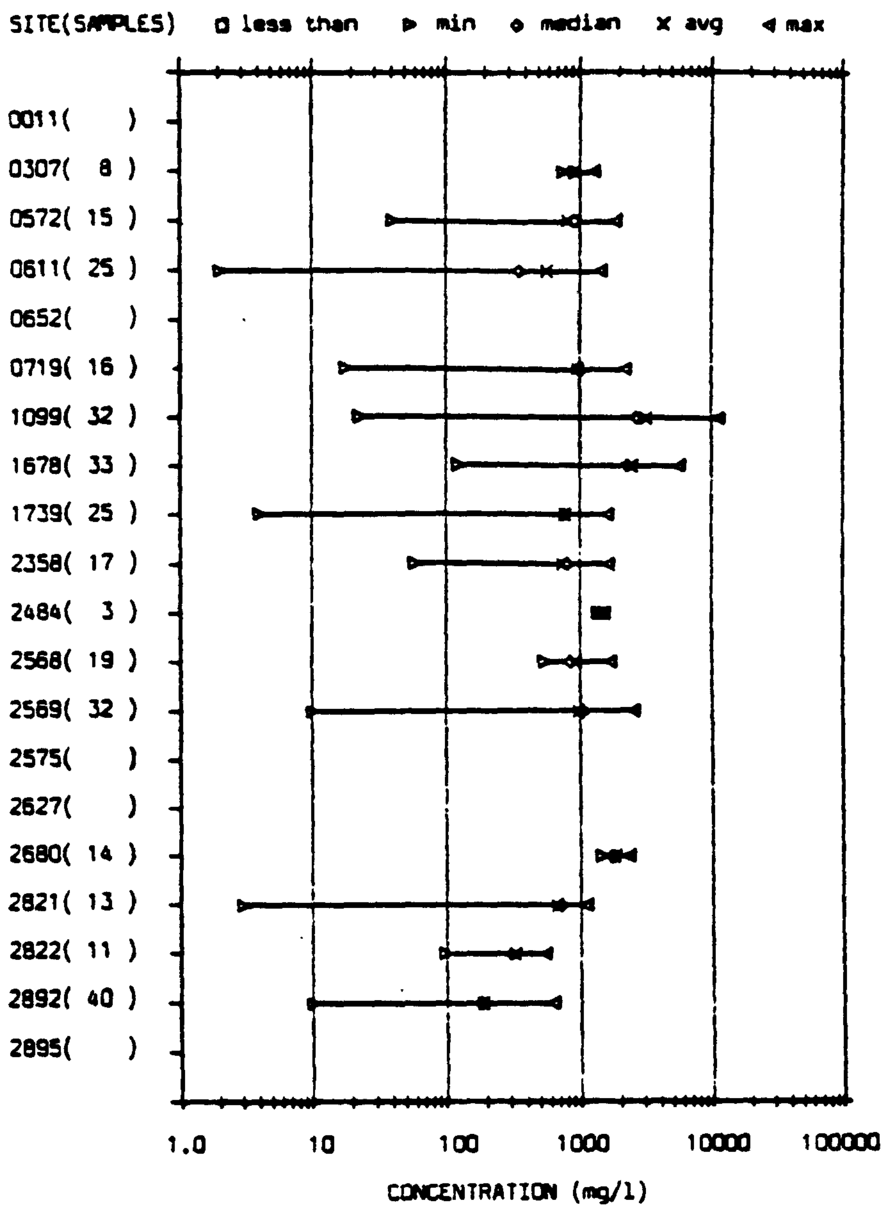


Figure A-11 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Total Phosphorus.



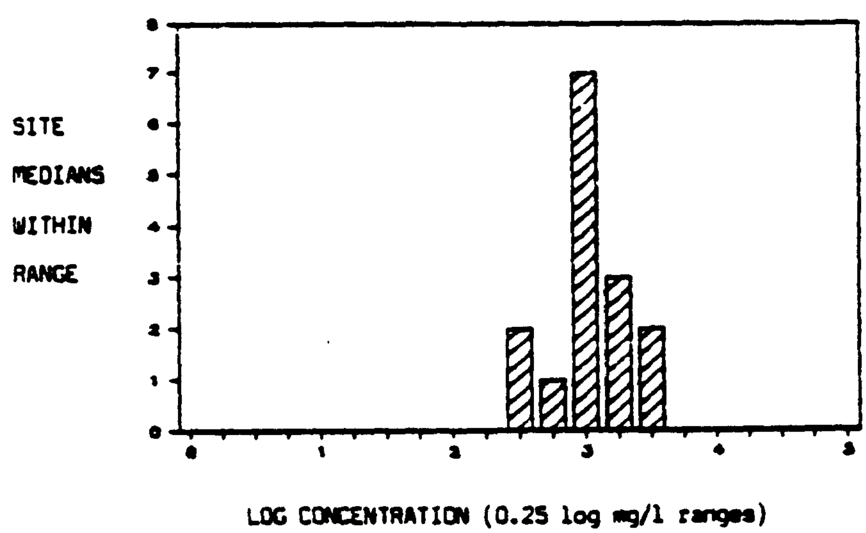
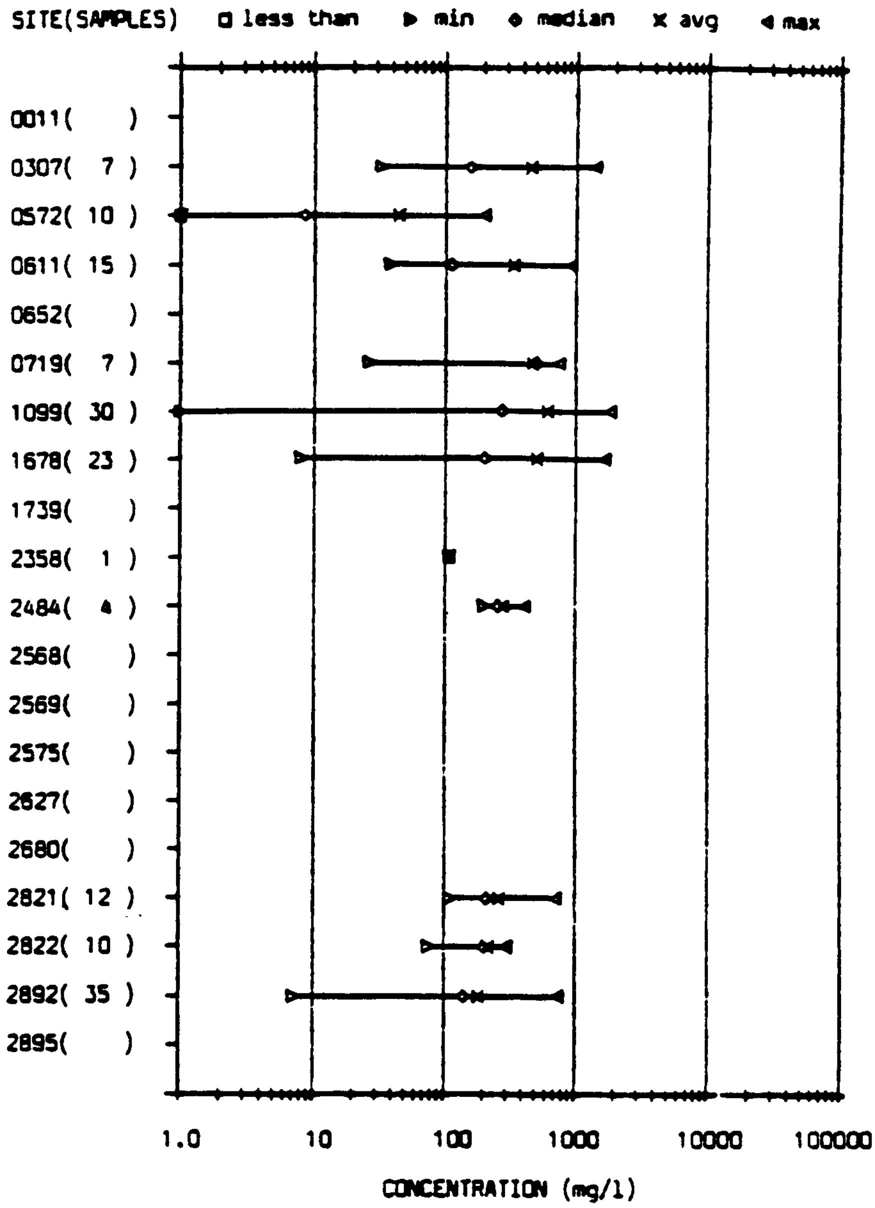


Figure A-12 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Chloride.



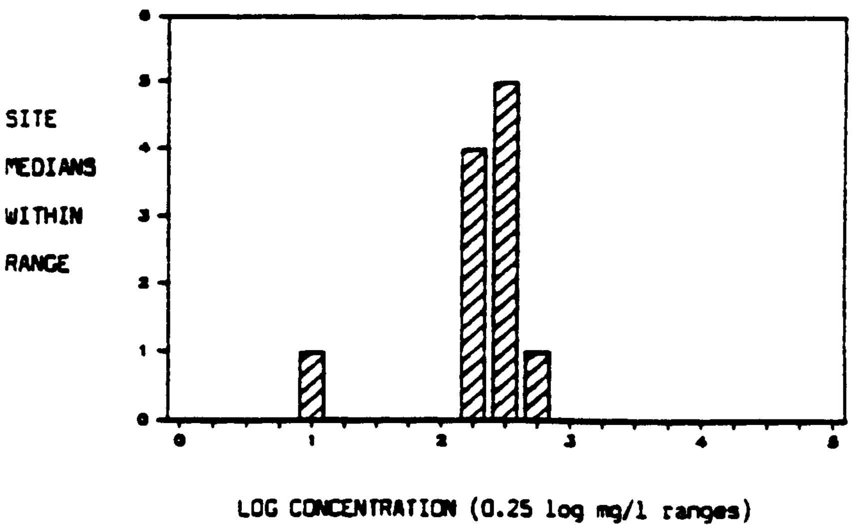
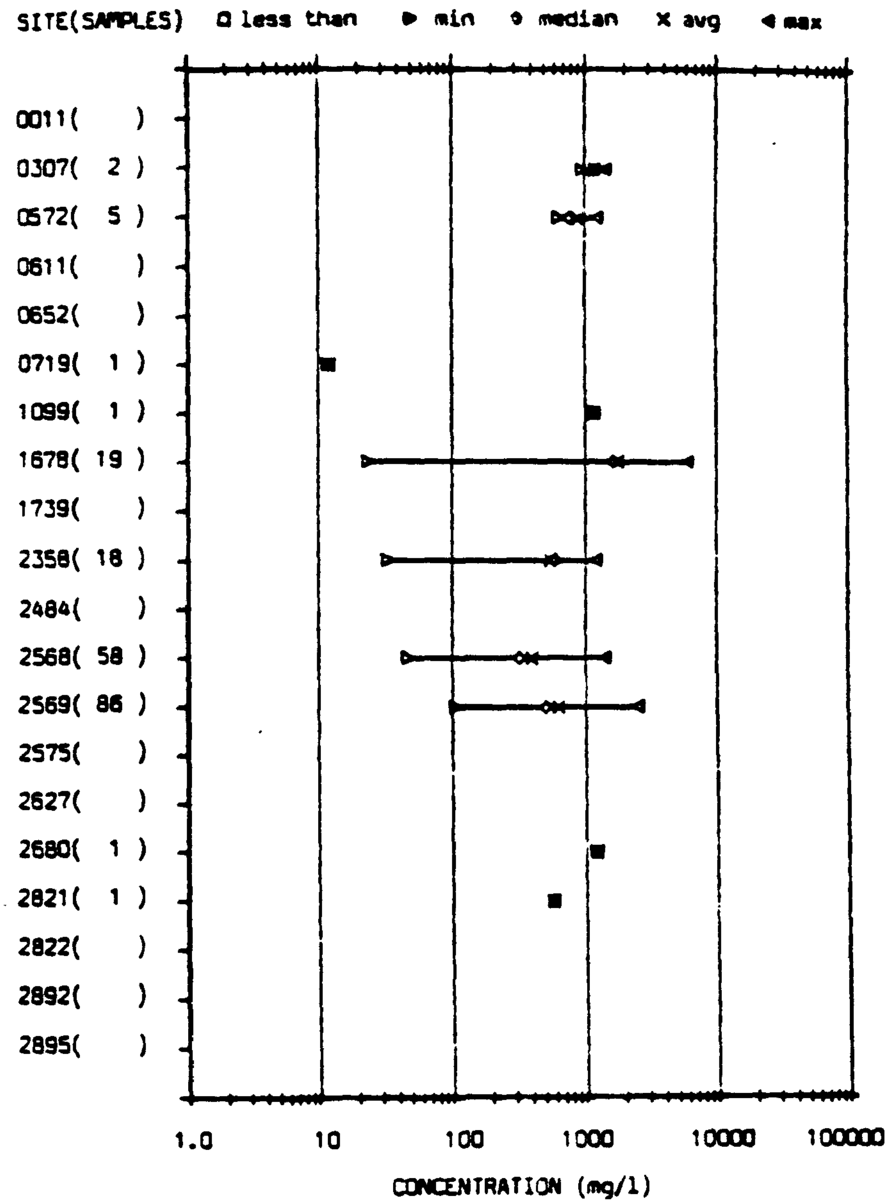


Figure A-13 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Sulfate.



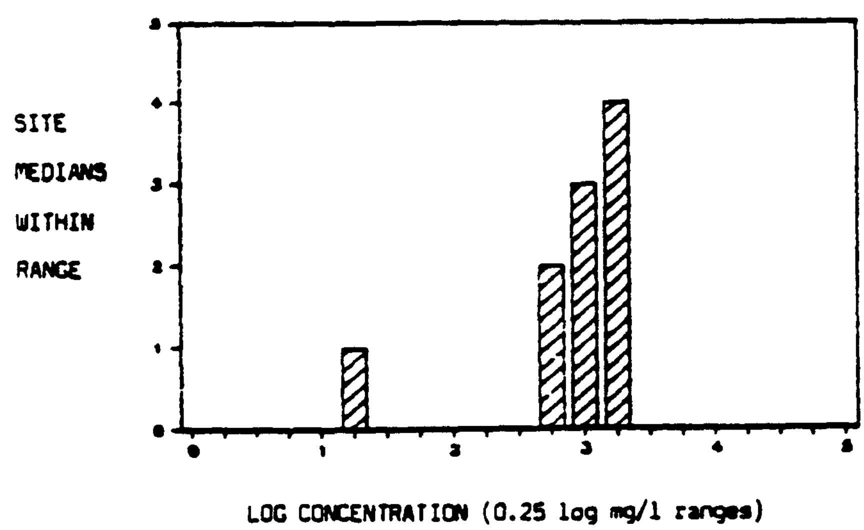
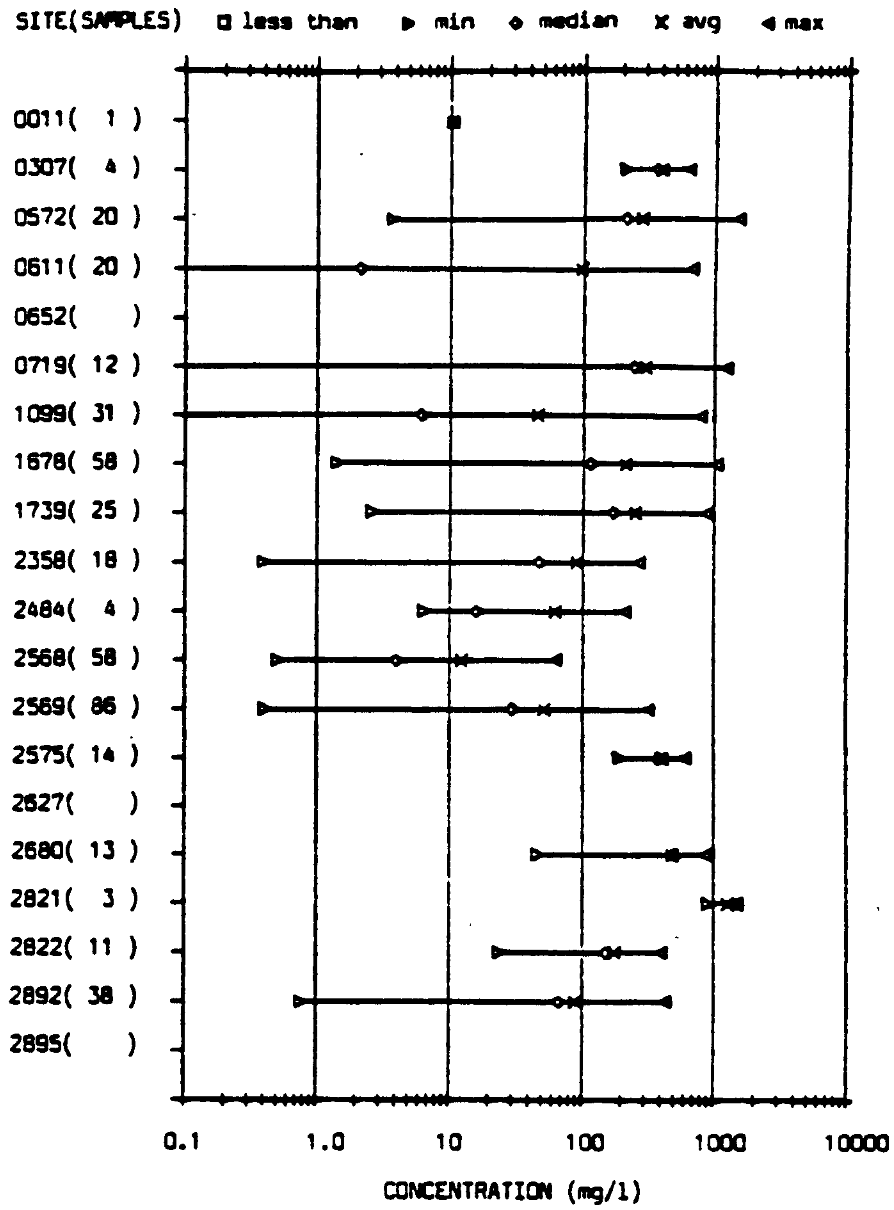


Figure A-14 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Sodium.



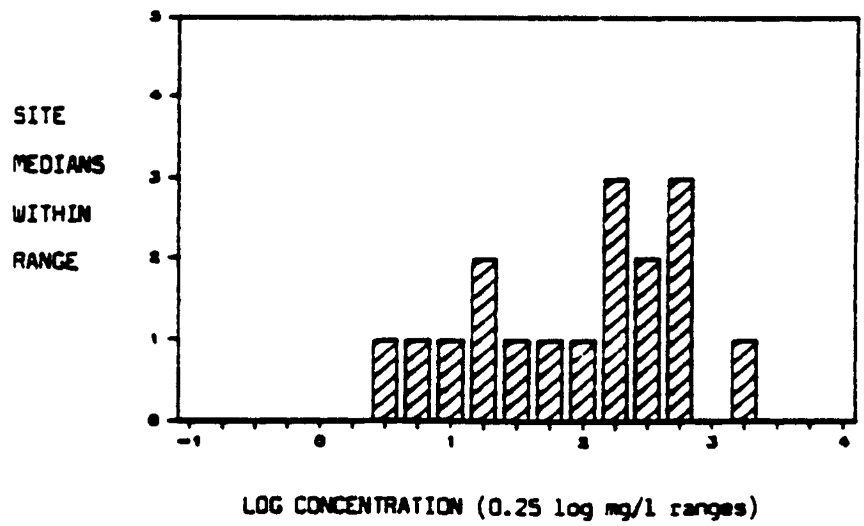


Figure A-15 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Iron.

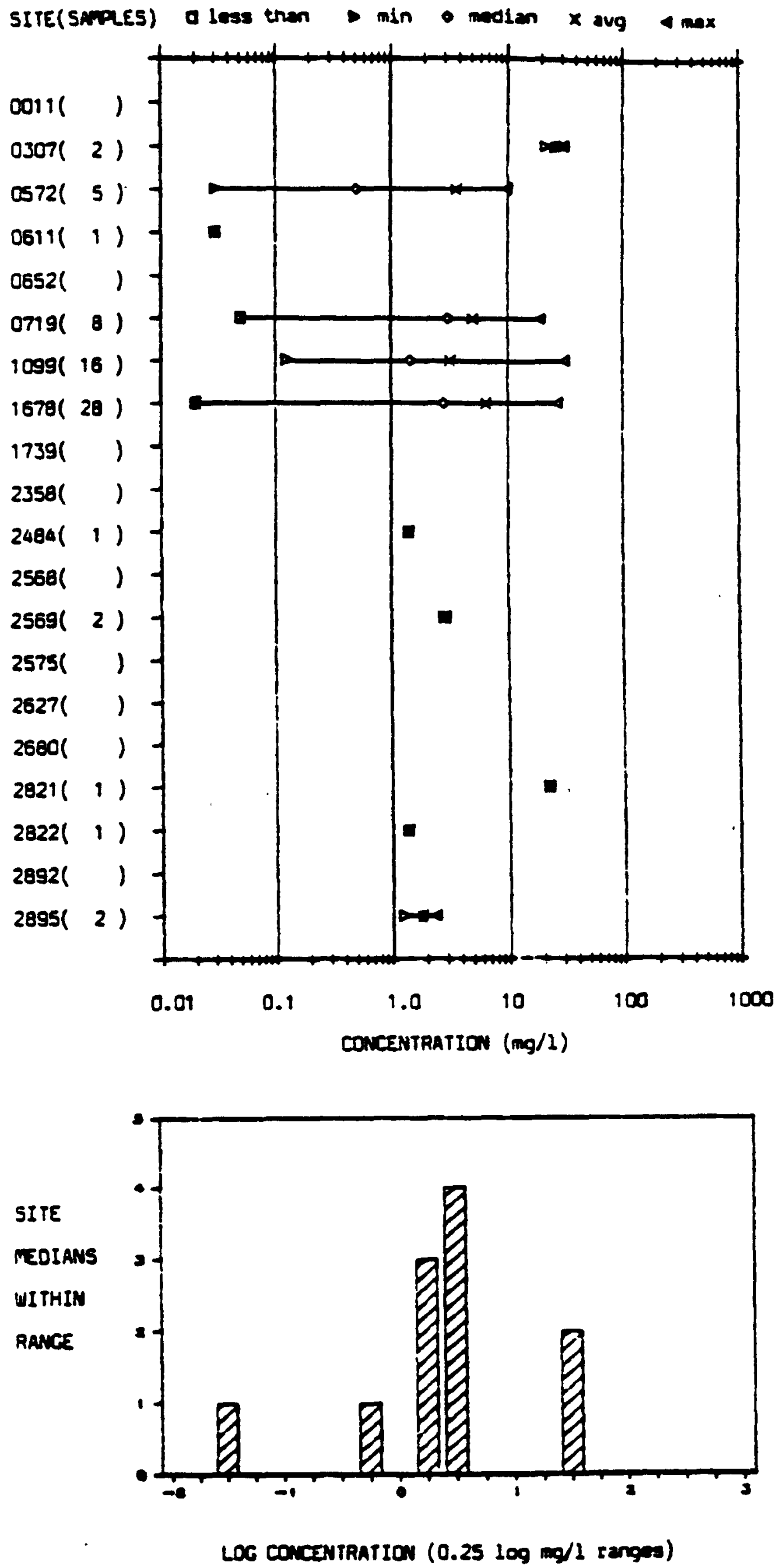
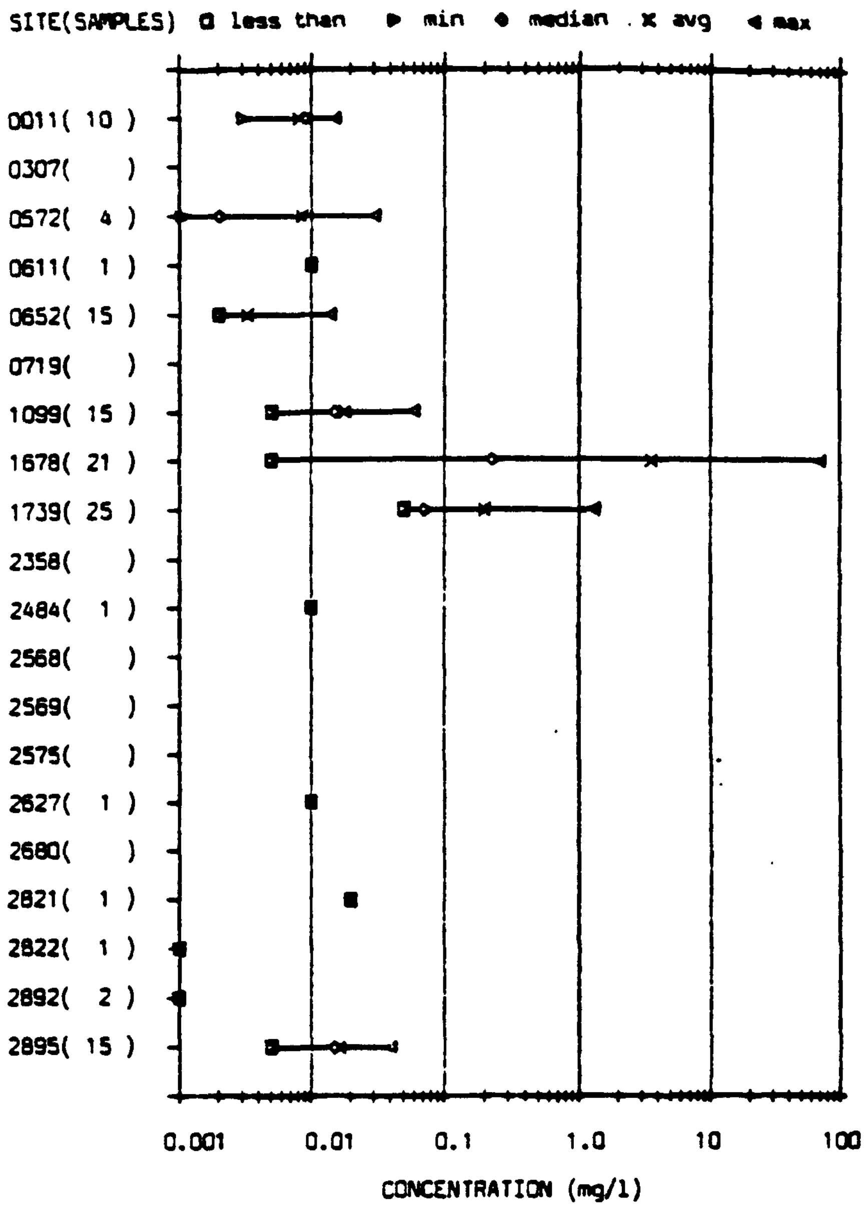


Figure A-16 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Manganese.



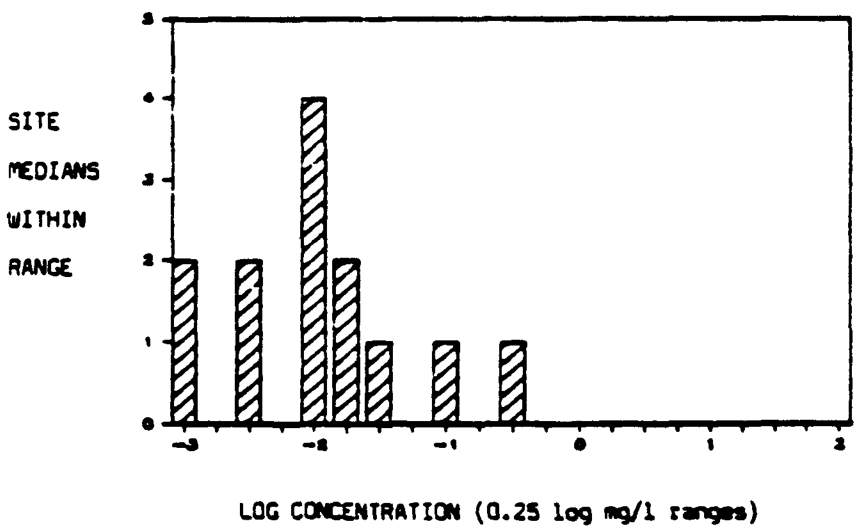
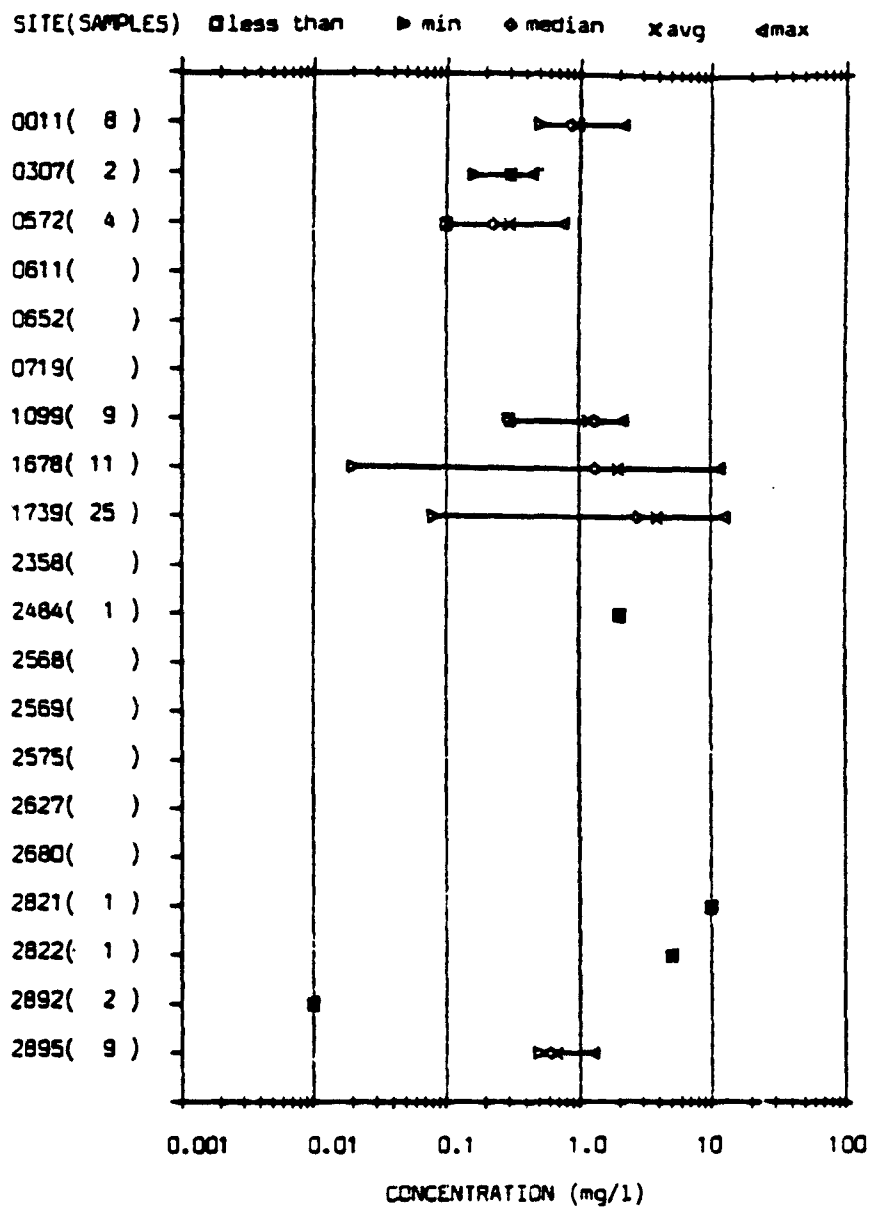


Figure A-17 Range Graph(above) and Median Frequency-of -occurrence Histogram(below) for Leachate Arsenic.



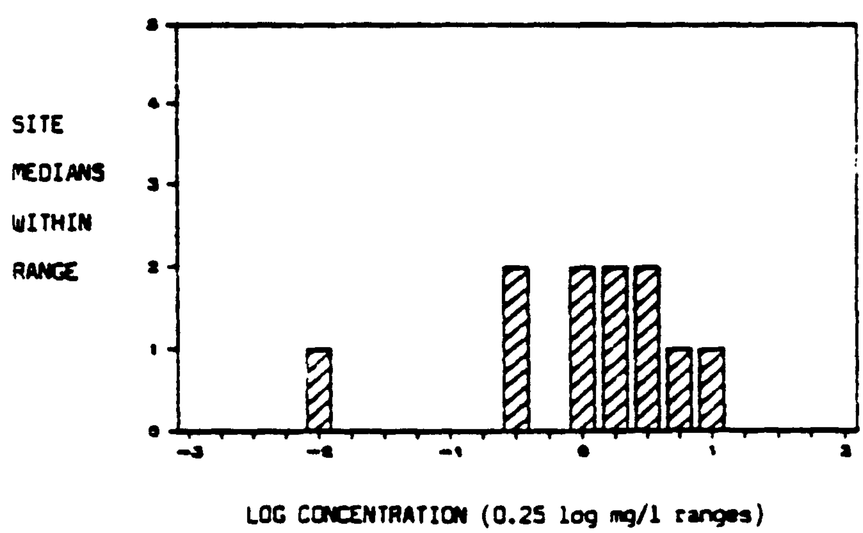
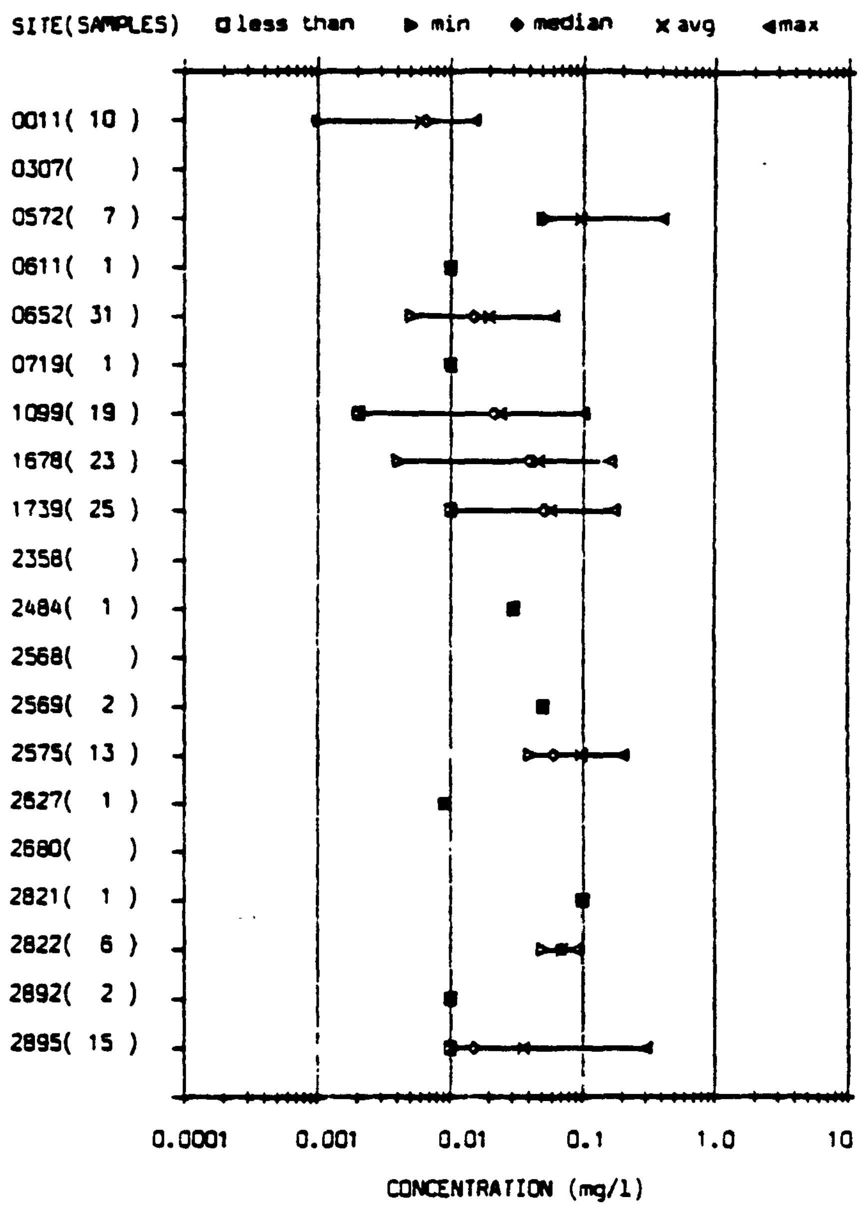


Figure A-18 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Barium.



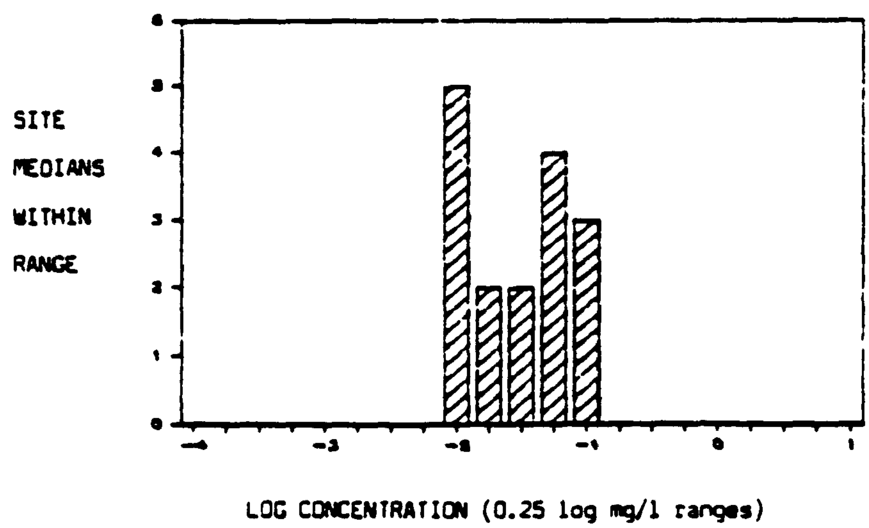
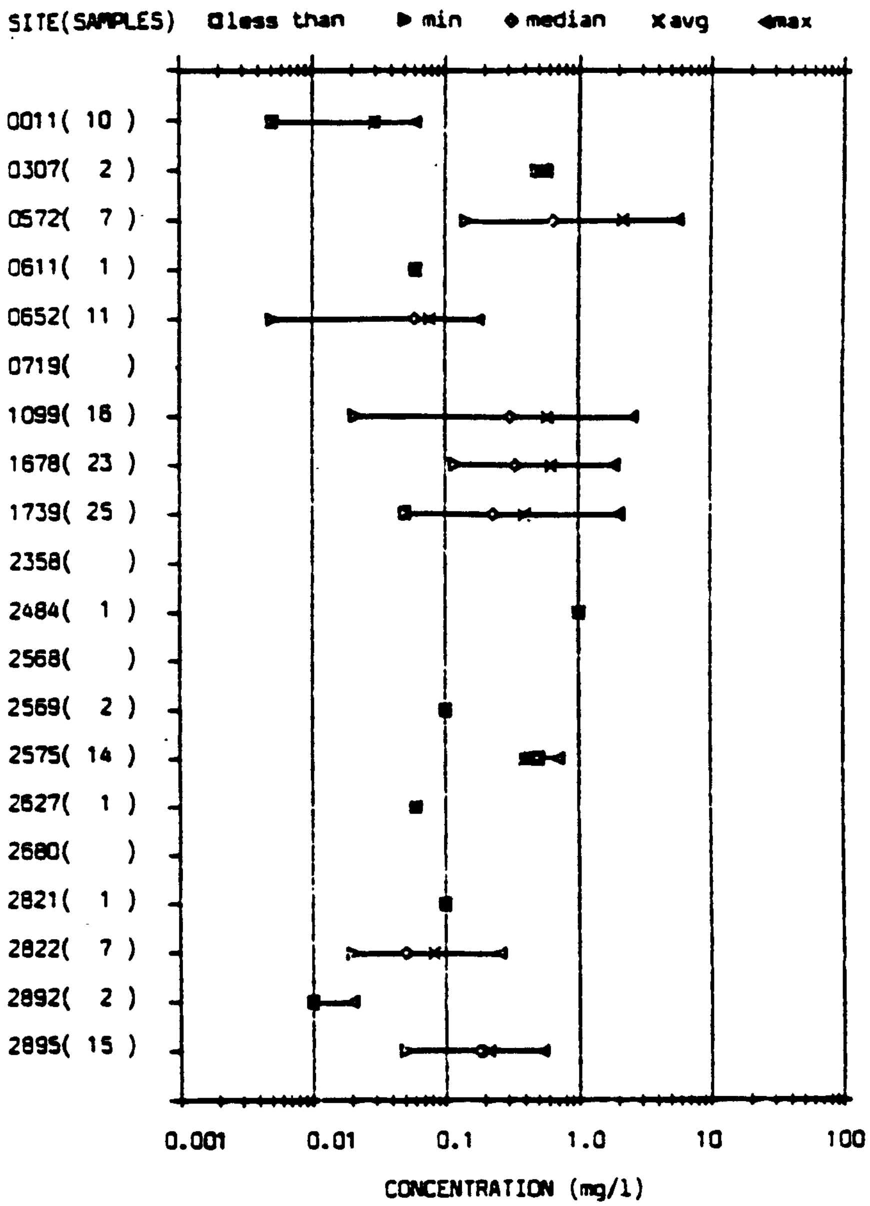


Figure A-19 Range Graph(above) and Median Frequency-of -occurrence Histogram(below) for Leachate Cadmium.



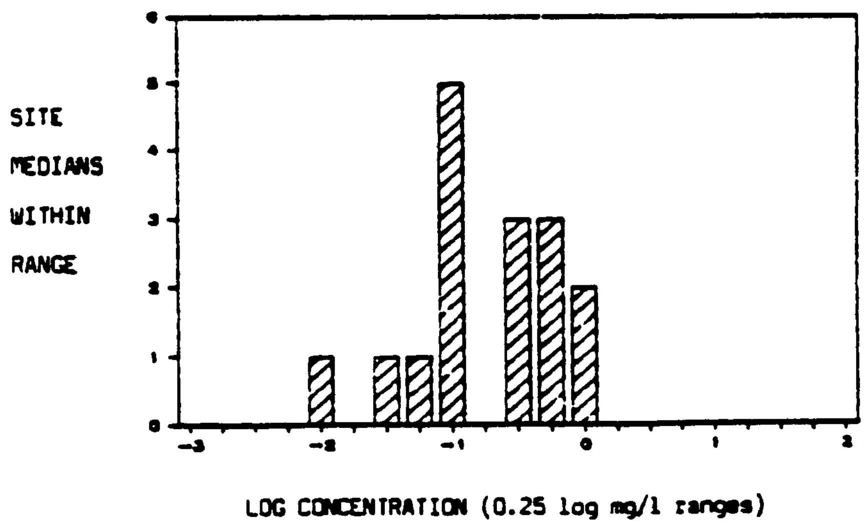


Figure A-20 Range Graph(above) and Median Frequency-of--occurrence Histogram(below) for Leachate Total Chromium.

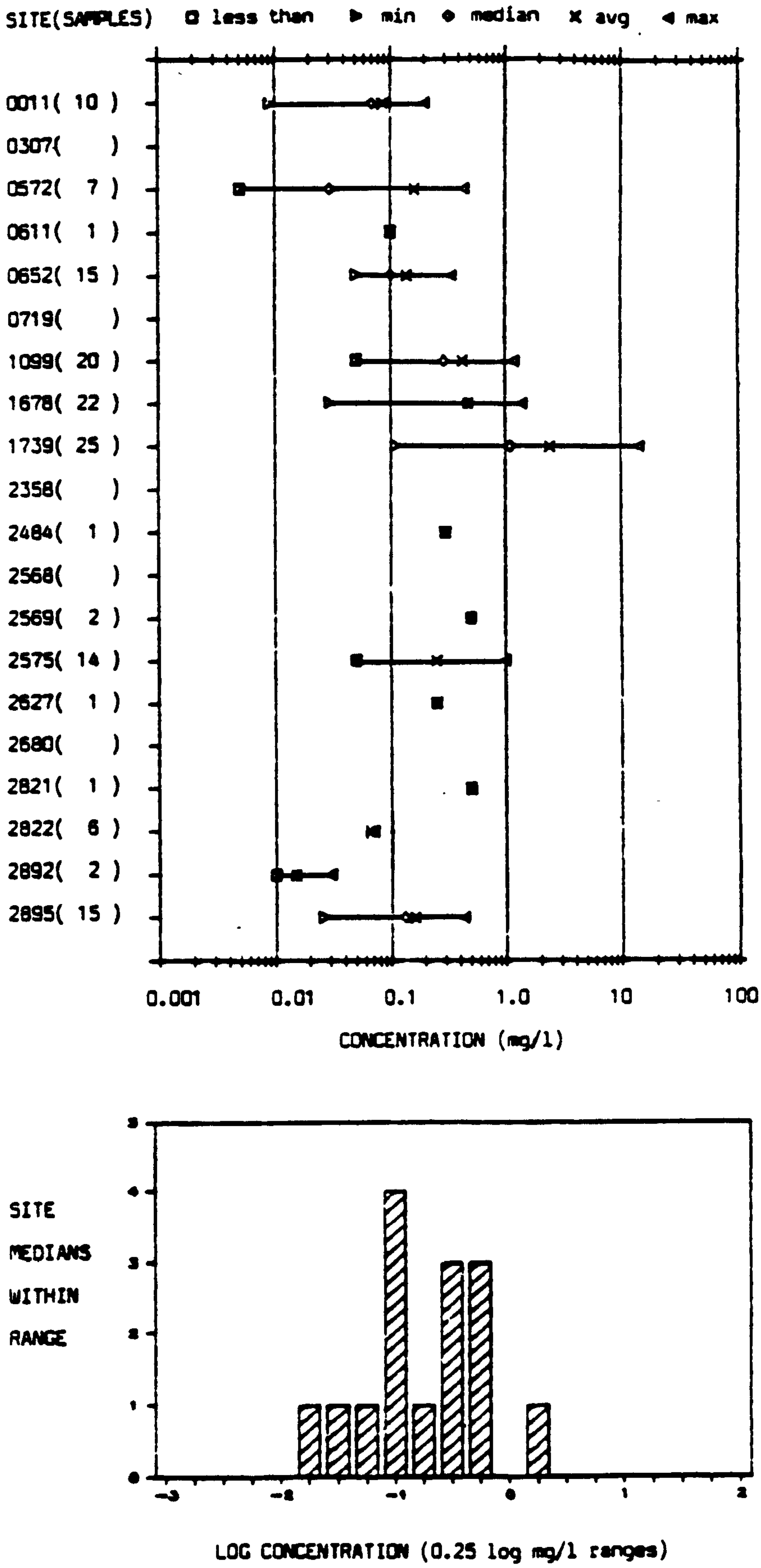


Figure A-21 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Lead.

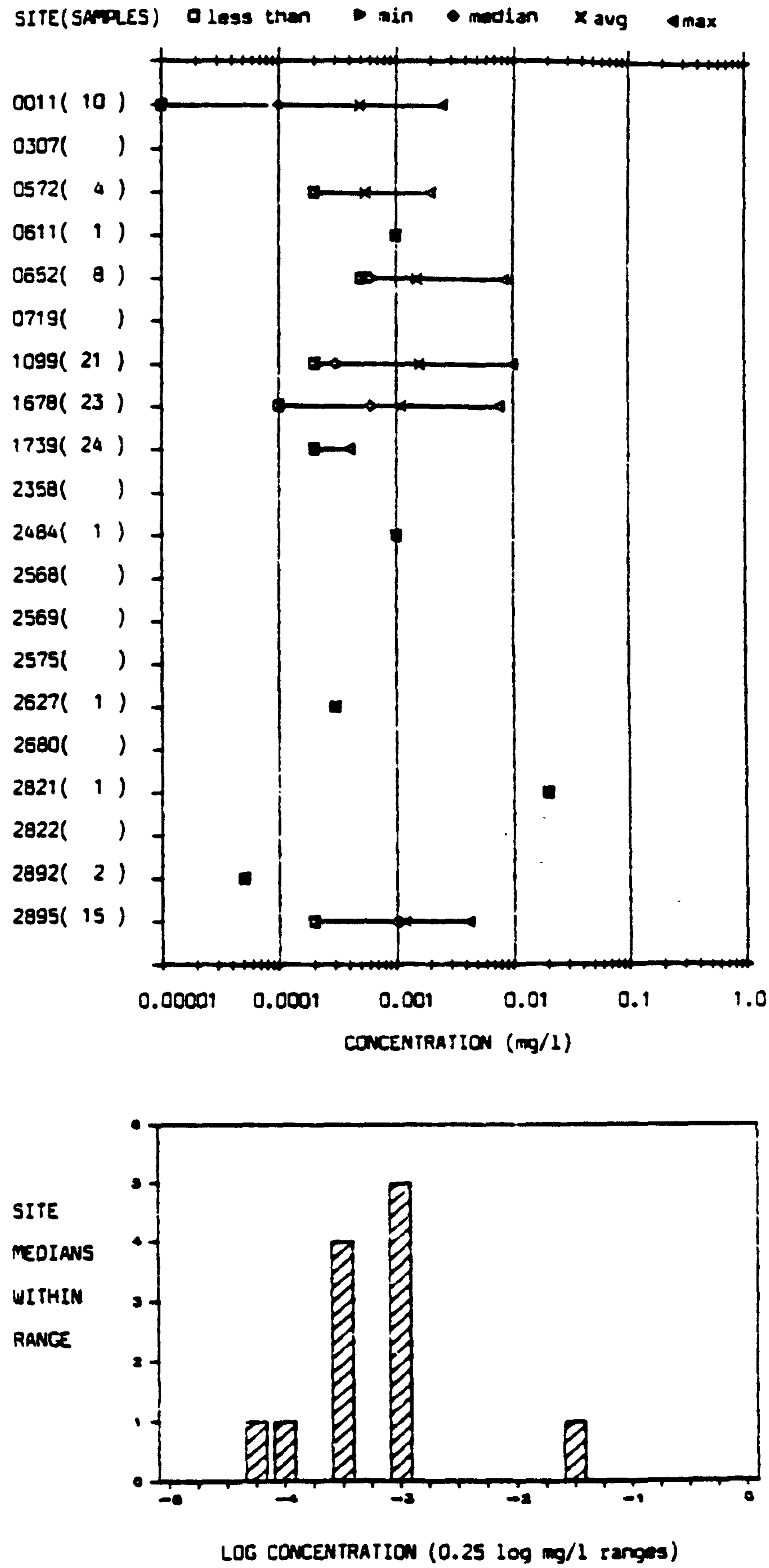
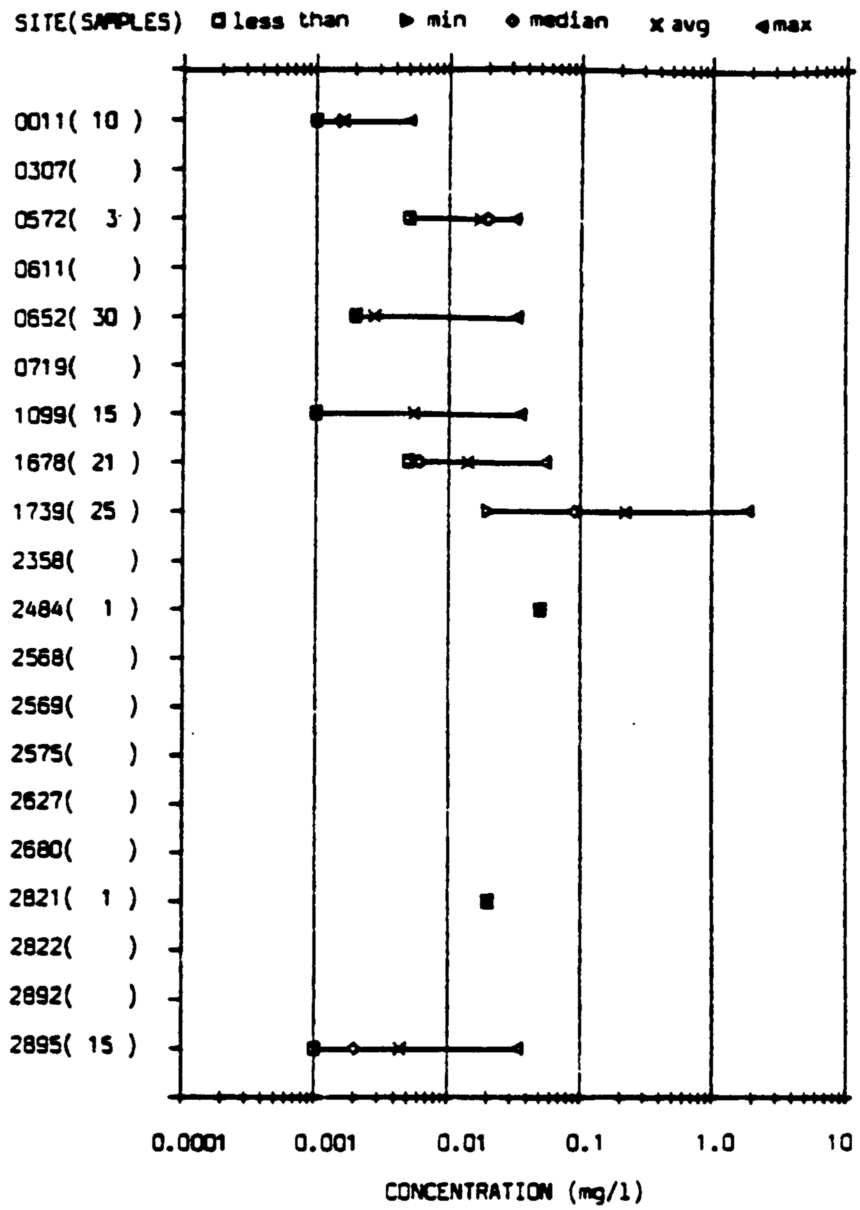


Figure A-22 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Mercury.



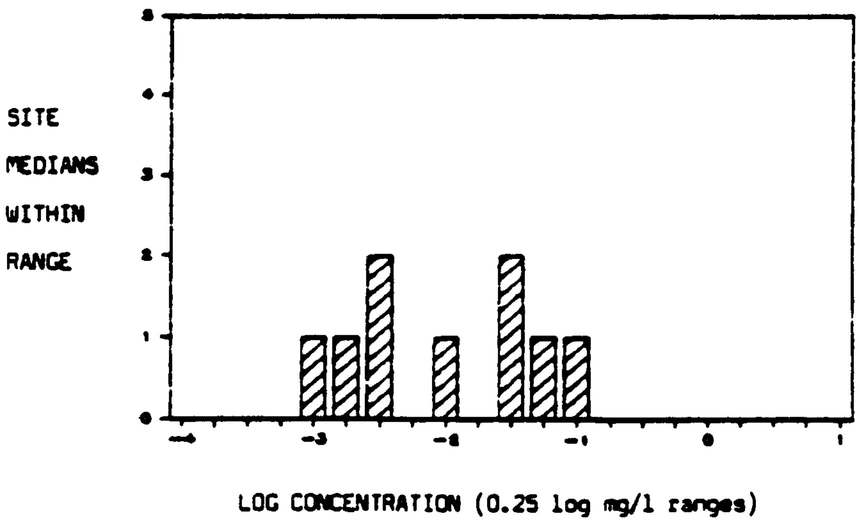
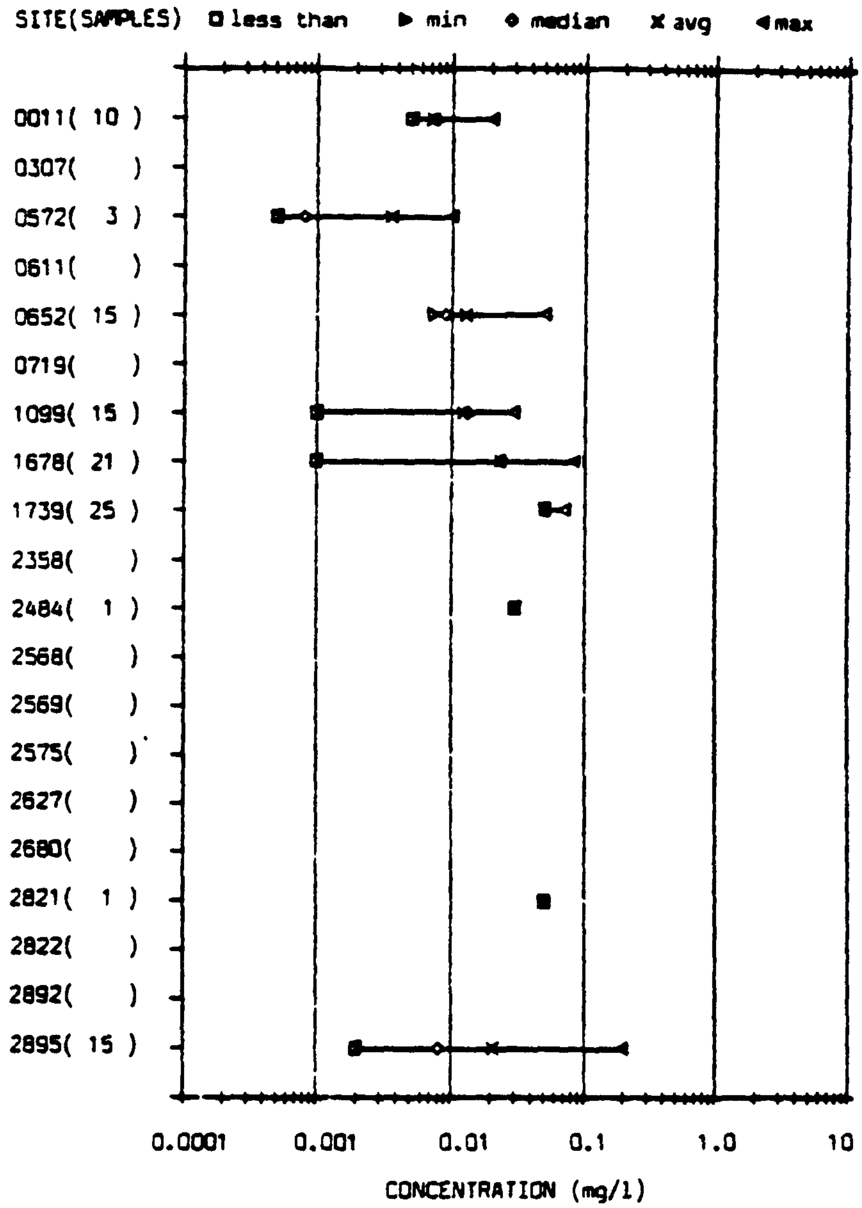


Figure A-23 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Selenium.



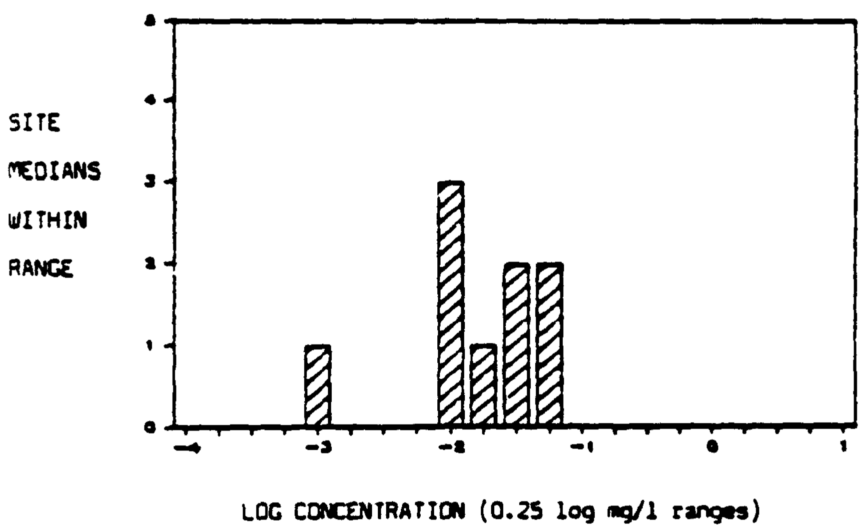
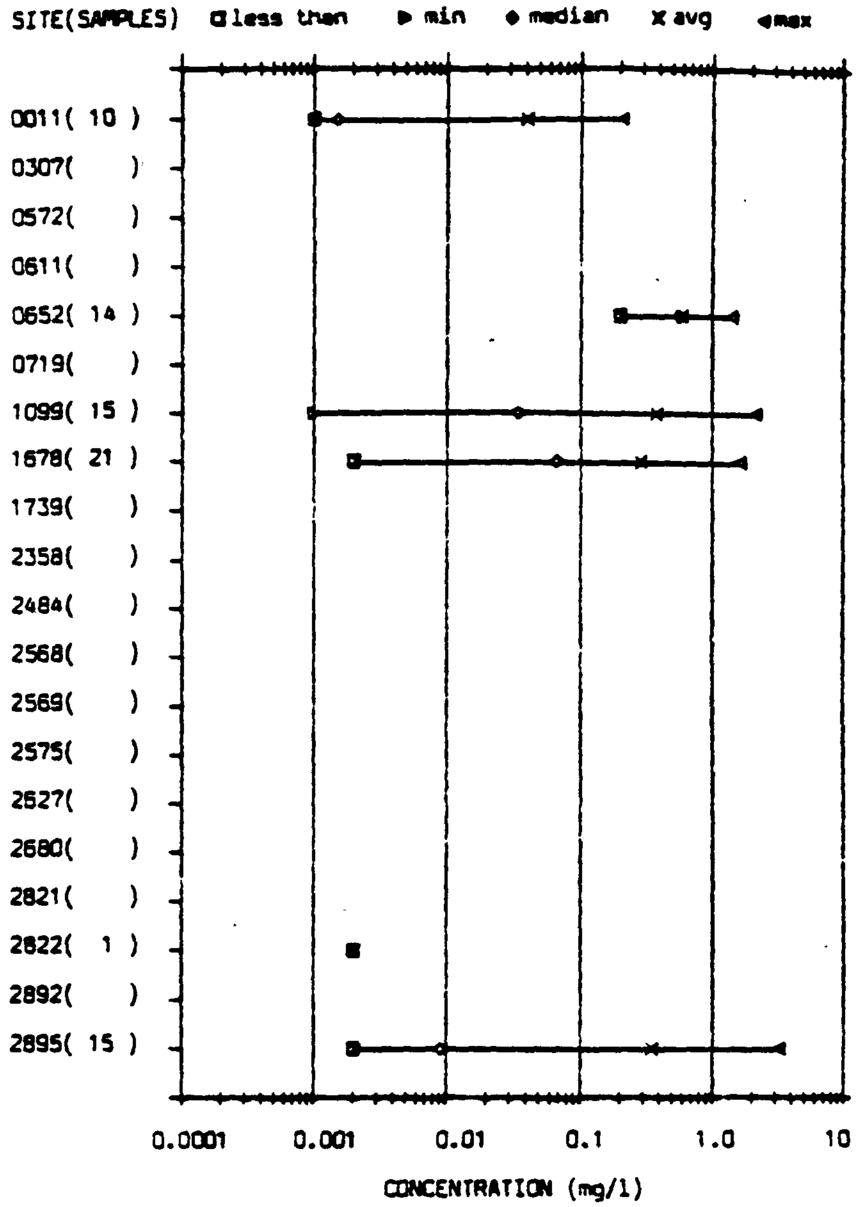


Figure A-24 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Silver.



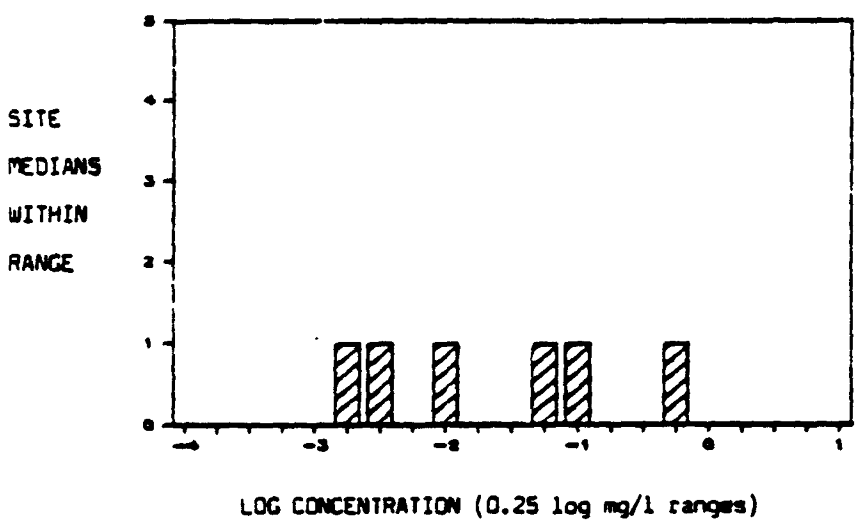


Figure A-25 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Antimony.

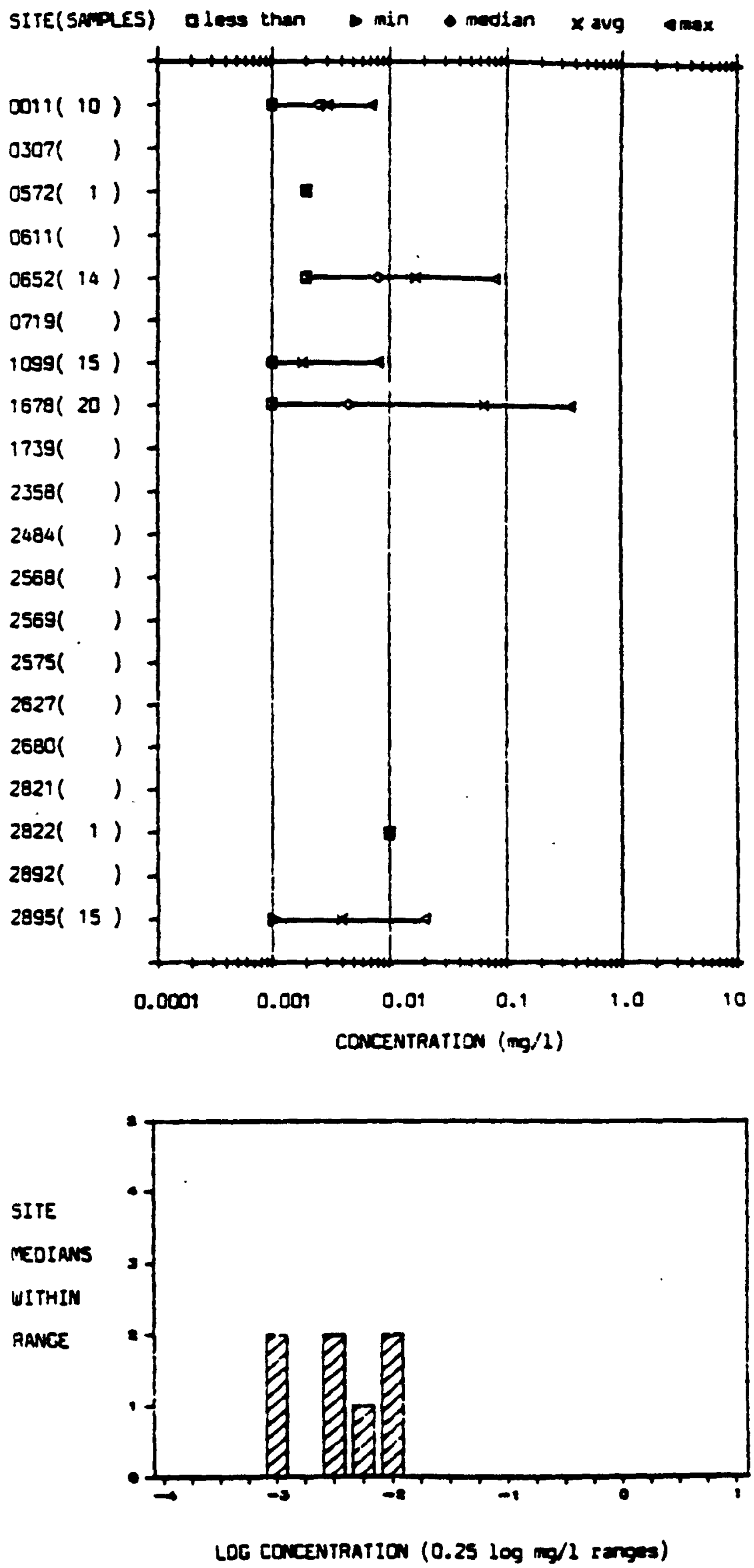
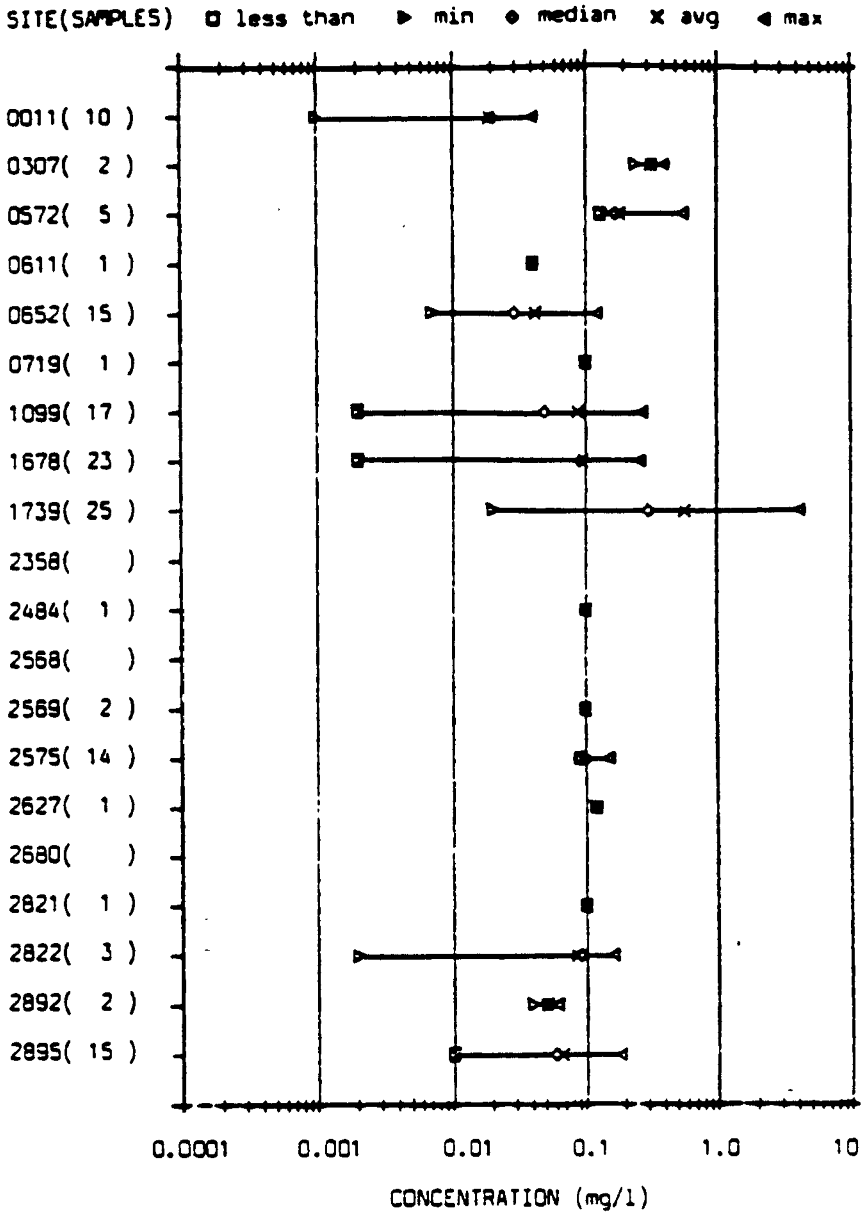


Figure A-26 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Beryllium.



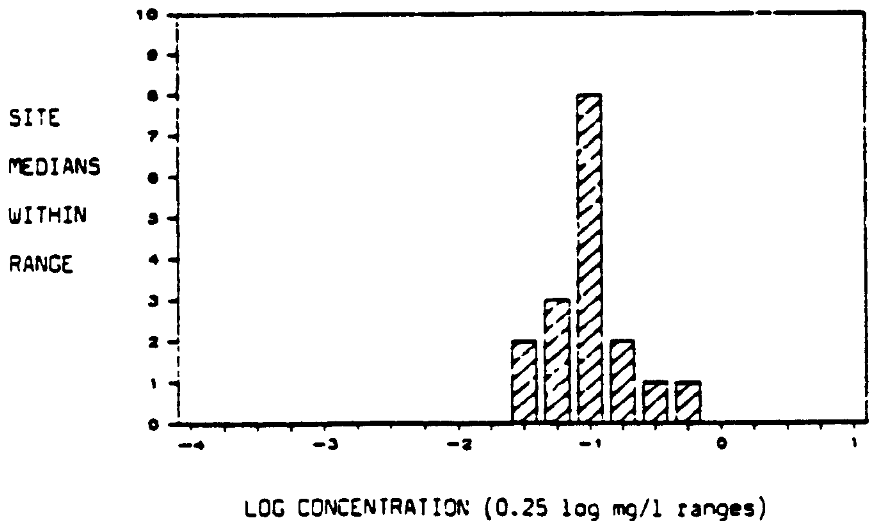
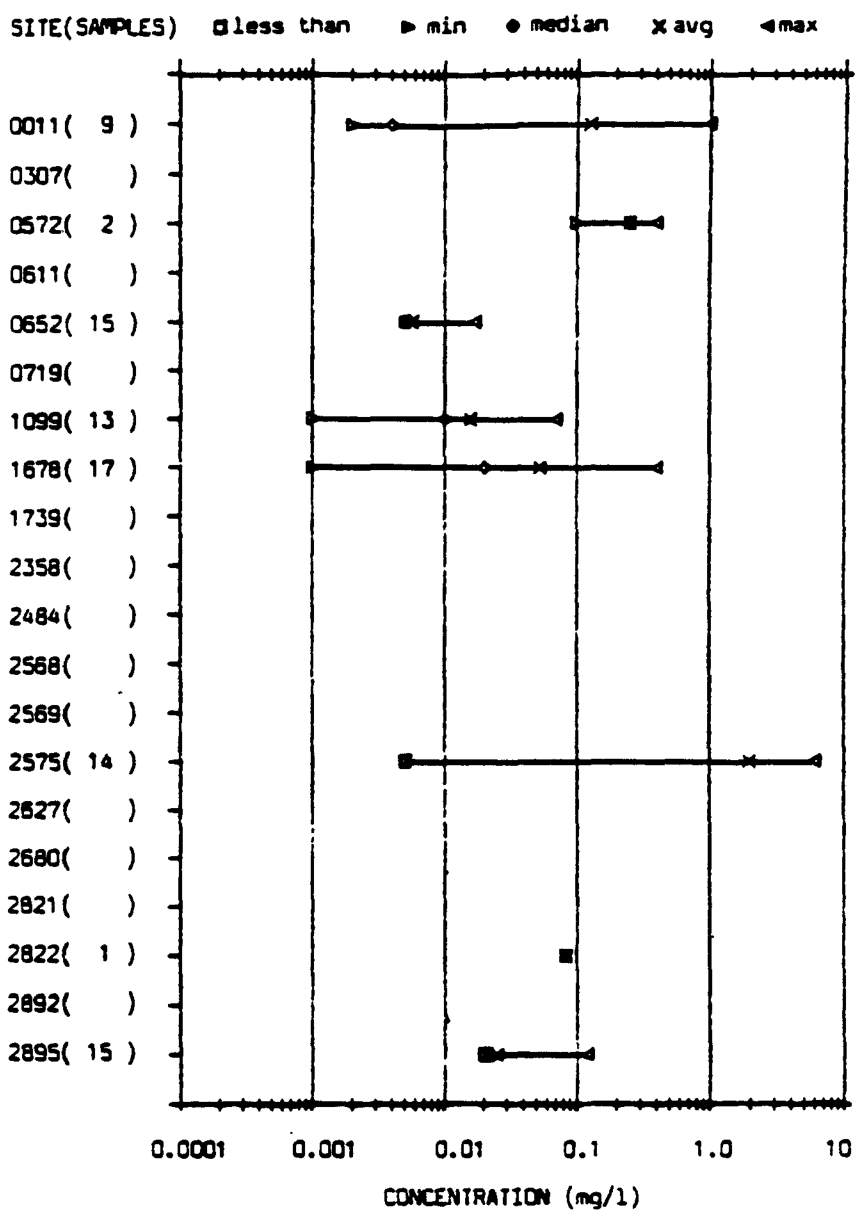


Figure A-27 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Copper.



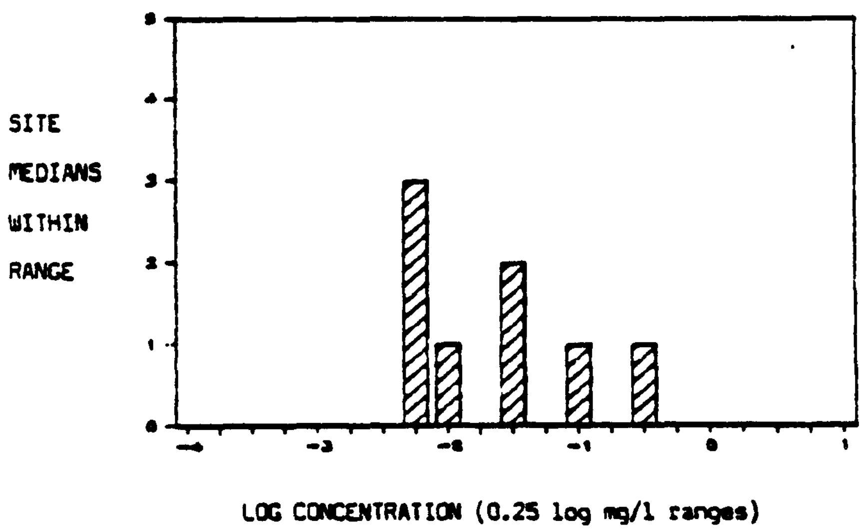
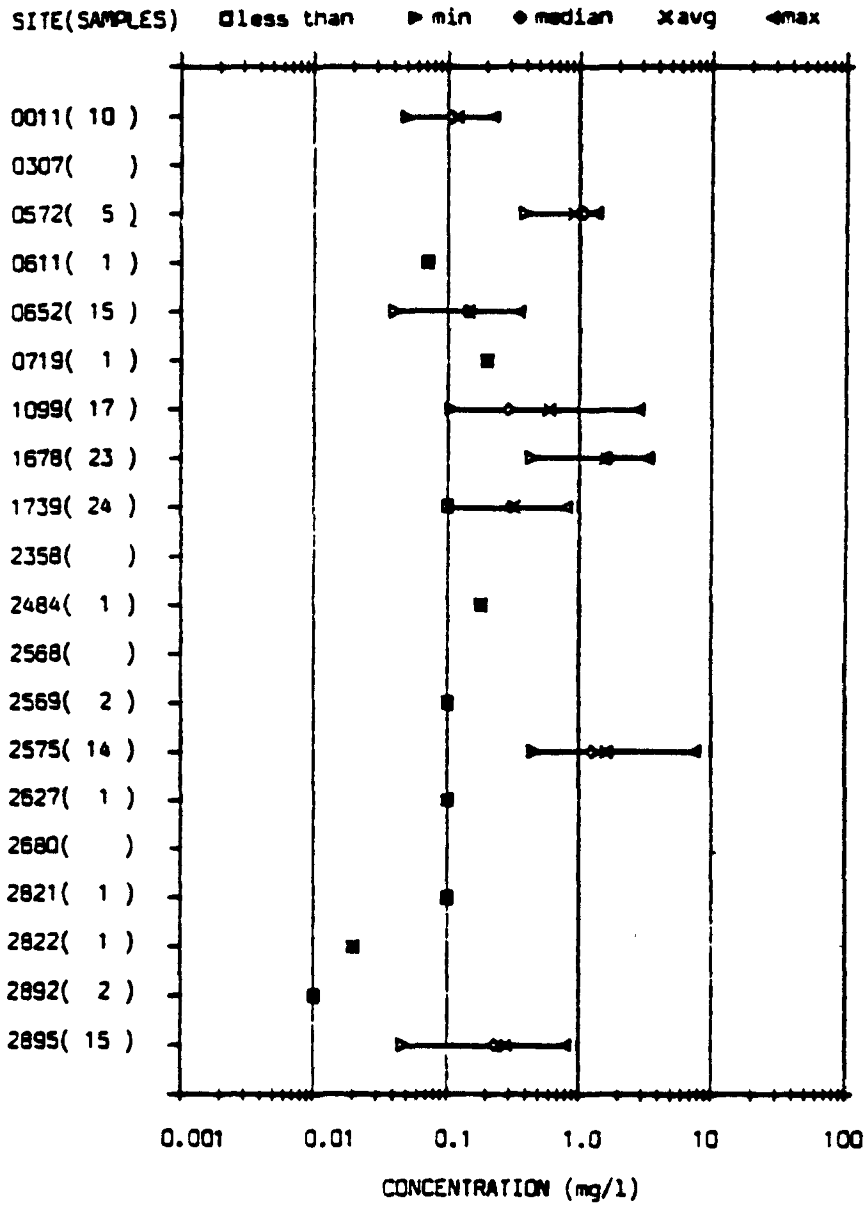


Figure A-28 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Cyanide.



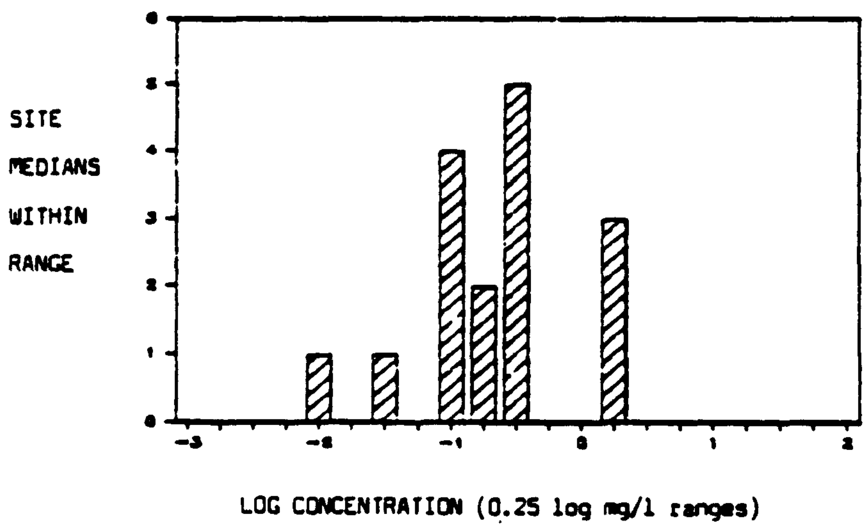
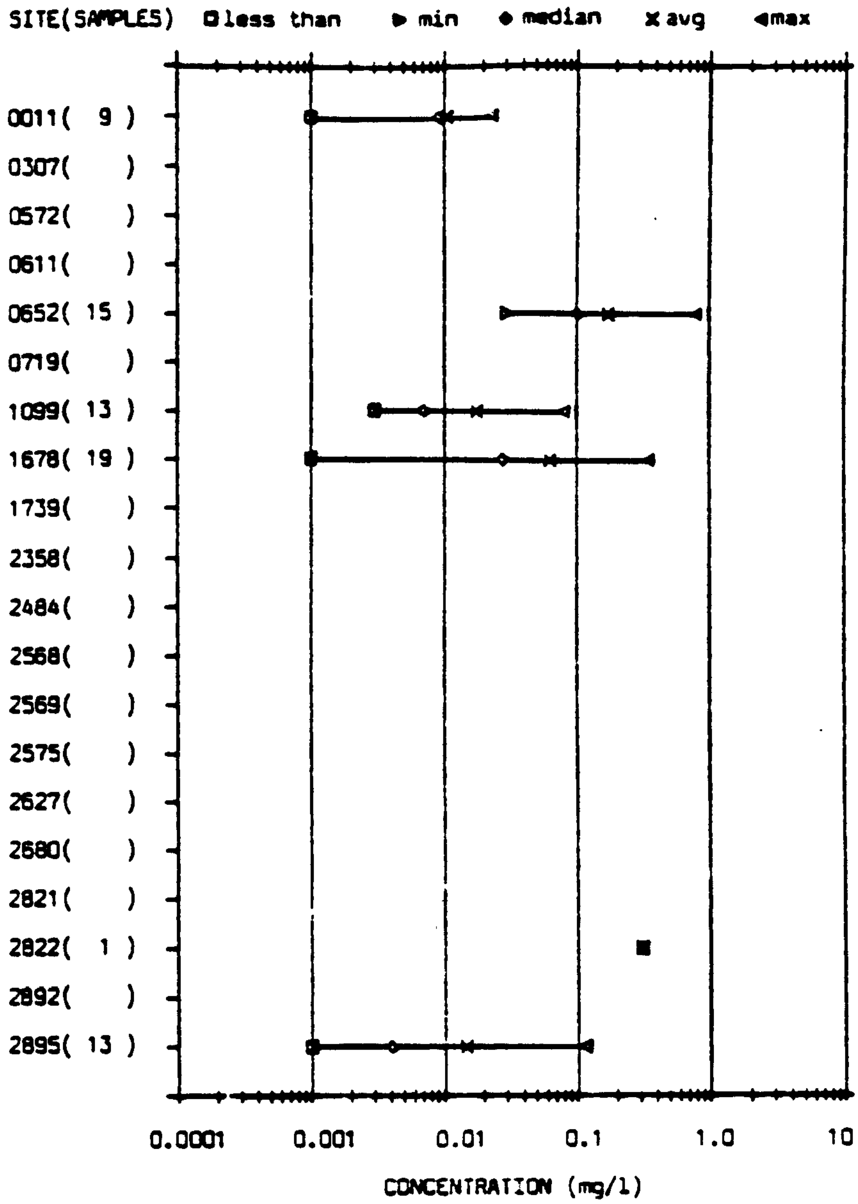


Figure A-29 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Nickel.



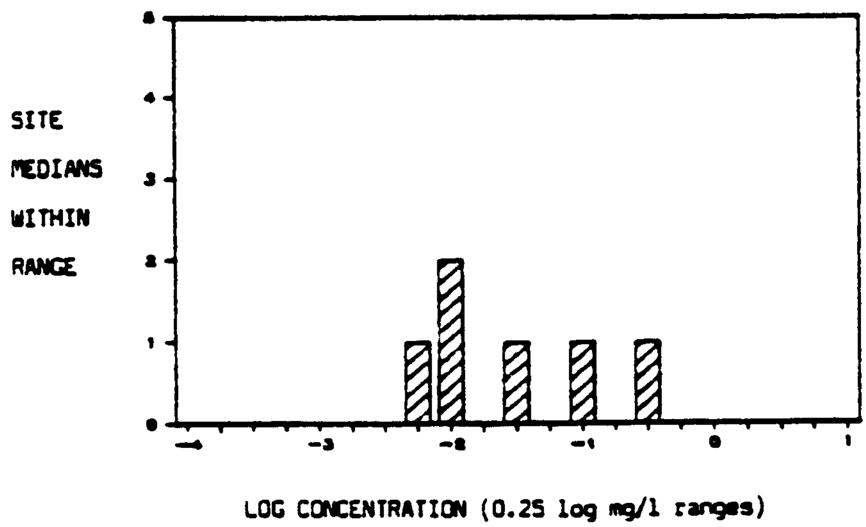
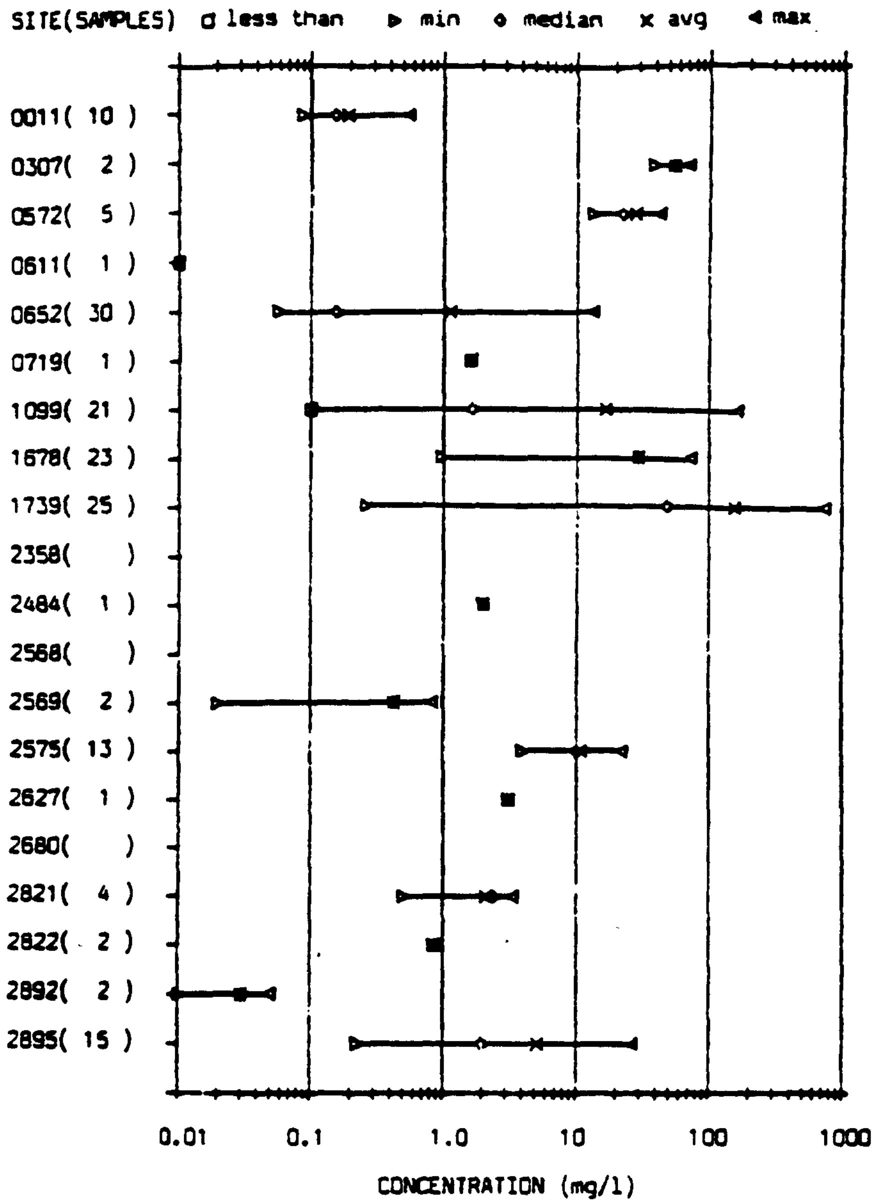


Figure A-30 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Thallium.



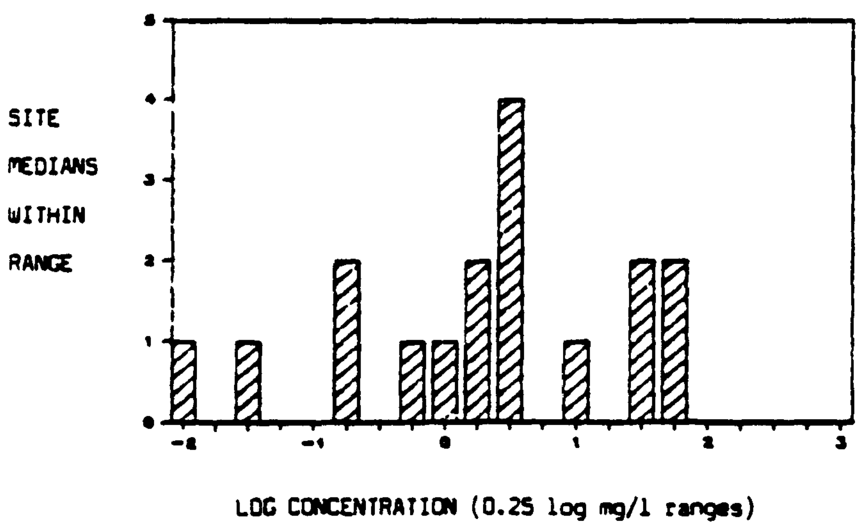


Figure A-31 Range Graph(above) and Median Frequency-of-occurrence Histogram(below) for Leachate Zinc.

Table A-1 Total Leachate Phenol Analysis Results

Site ID	Sample Source (1)	Sample Date	Total Phenol Concentration (mg/l)
0011	CS(M3)	31-Mar-82	0.18
0011	CS(M3)	20-Oct-82	234
0572	CS(M)	24-Jul-79	4.77
0572	HW(B12)	14-Jan-81	112
0572	HW(B20)	14-Jan-81	0.48
0572	HW(B21)	14-Jan-81	0.52
0652	CS(M)	14-Oct-80	9.5
0652	CS(M)	24-Oct-80	20
0652	CS(M)	30-Oct-80	32
0652	CS(M)	18-Nov-80	36
0652	CS(M)	16-Dec-80	28
0652	CS(M)	15-Jan-81	24.2
0652	CS(M)	08-Apr-81	2.9
0652	CS(M)	08-Jul-81	16
0652	CS(M)	30-Sep-81	11
0652	CS(M)	28-Dec-81	6.3
0652	CS(M)	04-Mar-82	8.9
0652	CS(M)	09-Jun-82	6.5
0652	CS(M)	19-Sep-82	1.9
0652	CS(M)	06-Dec-82	2.73
0652	CS(M)	24-Mar-83	17.23
1099	CS(M1A)	07-Apr-82	0.246
1099	CS(R2)	06-Apr-82	0.145
1099		19-Dec-80	3.8
1678	CS(R6)	20-Oct-82	15.3
1678	CS(R5)	20-Oct-82	3.0
1678	CS(R2)	20-Oct-82	18.5
1678	CS(M1)	20-Oct-82	6.79
1678	CS(M1)	27-Apr-82	3.84
1678	CS(R5)	31-Mar-82	8.47
1678	CS(R2)	31-Mar-82	16.0
1678	CS(c)	19-Dec-80	18.0
2627		22-May-81	5.2
2822		25-Nov-81	8.36
2895	CS	19-Dec-80	2.5
2895	CS(R3)	19-Dec-80	0.438
2895	CS(T)	19-Dec-80	1.1

(1): Abbreviations
CS: Collection System(R-Riser, MH-Manhole, T-Tank, c-Composite Sample)
HW: Headwell

Source: Wisconsin Depa
of Natural Resources Re

Table A-2 Leachate Analysis Results for Polychlorinated Biphenyls, Pesticides and Herbicides

Compound	Number of Leachate Analysis	Number of Samples with a Detectable Concentration (det limit <10ppb)	Sites where Detected (conc range) (ppb)
Polychlorinated Biphenyls			
1242	18	0	
1254	18	0	
1221	18	0	
1232	15	0	
1248	18	0	
1260	18	0	
1016	18	1	1099(2.8)
Unspecific	27	3	1739(6.9-310)
Chlorinated Hydrocarbon Insecticides			
Aldrin	21	0	
Alpha-BHC	18	0	
Beta-BHC	18	0	
Gamma-BHC	21	0	
Delta-BHC	18	1	2822(4.6)
BHC	3	0	
Chlordane	20	0	
DDT	21	0	
DDE	21	0	
DDD	21	0	
Dieldrin	21	0	
Endosulfan(a and b)	20	0	
Endosulfan Sulfate	19	0	
Endrin	23	0	
Endrin Aldehyde	20	0	
Heptachlor	21	0	
Heptachlor Epoxide	21	0	
Toxaphene	22	0	
Methoxychlor	1	0	
Mirex	1	0	
Organophosphorus Insecticides			
Methylparathion	1	0	
Ethylparathion	1	0	
Chlorophenoxy Herbicides			
2,4-D	2	2	572(7), 1099(1800)
2,4,5-TP	2	0	
2,3,7,8-TCDD	1	0	

Includes data from sites: 11,572,719,1099,1678,1739,2568,2569,2627,2822,2895.

Source: Wisconsin Department of Natural Resources Report

Table A-3 Typical Orders-of-Magnitude Concentration Ranges Of Contaminants in Municipal Solid Waste Landfill Leachates In Wiscon

mg/l Range	Parameters
1,000 - 100,000	BOD, COD, Alkalinity, Hardness, TDS
100 - 1,000	TSS, Total-N, Chlorides, Sulfates, Sodium, Iron
10 - 100	Zinc
1.0 - 10	Manganese, Total-P, Barium
0.1 - 1.0	Nitrate-N, Chromium, Lead, Copper
0.01 - 0.1	Arsenic, Cadmium, Selenium, Silver, Antimony, Cy Nickel, Thallium
0.001 - 0.01	Beryllium
0.0001 - 0.001	Mercury

Source: Wisconsin Department of Natural Resources Report

APPENDIX B

WISCONSIN CASE HISTORY INFORMATION

TABLE B-1

WISCONSIN CASE HISTORY INFORMATION

Site Number: 0011
Site Name: WMI-Lauer I, WI
Site Type: Zone-of-saturation
Total Design Volume (million cubic yards): Not available
Principal Waste Types: MSW, IND
Date Filling Began: pre-1960
Site Size (Acres): 38

- Leachate barium concentrations exceeded the drinking water standard of 1 mg/l

Site Number: 0307
Site Name: WMI-Polk, WI
Site Type: Clay Lined
Total Design Volume (million cubic yards): 0.5
Principal Waste Types: MSW
Date Filling Began: 1970
Site Size (Acres): 9

- Older site - lower and more consistent suspended solids concentrations.
- Leachate oxygen demand medians greater than 20,000 mg/l.
- Median chronium concentrations above 0.2 mg/l.
- Aluminum concentrations of 4.5 and 5.6 mg/l.

Site Number: 0572
Site Name: Land Reclamation, WI
Site Type: Zone-of-saturation
Total Design Volume (million cubic yards): 9.5
Principal Waste Types: MSW, IND, HAZ
Date Filling Began: pre-1970
Site Size (Acres): 82

- Patterns of leachate oxygen demand over time, complicated by operational conditions.
- Chromium concentration above 1.5 mg/l.
- Median selenium concentrations exceed drinking water standard.
- Median cyanide concentration of 0.25 mg/l (maximum cyanide concentration in drinking water is 0.2 mg/l).
- Leachate nickel concentrations exceeded 1 mg/l.
- Leachate aluminum concentration below 1 mg/l.

- The 1,2 isomer of dichloroethane was detected.
- Halogenated ethers and aliphatics detected more frequently than the other landfills.
- Herbicide 2,4-D detected: 7 µg/l - Primary drinking water standard is 100 µg/l.
- 42% of the suspended solids were volatile.

Site Number: 0611
Site Name: Winnebago Co., Winnebago, WI
Site Type: Zone-of-saturation
Total Design Volume (million cubic yards): 5.5
Principal Waste Types: MSW, IND
Date Filling Began: pre-1970
Site Size (Acres): 94

- Site with one of the lower leachate nitrogen (200-500 mg/l) concentrations.
- Weakest leachate for specific conductance.

Site Number: 0652
Site Name: Tork, WI
Site Type: Retrofit
Total Design Volume (million cubic yards): 1.5
Principal Waste Types: MSW, IND
Date Filling Began: 1970
Site Size (Acres): 38

- More dilute leachate - lower and more consistent suspended solids concentrations.
- Leachate silver concentration of 0.05 mg/l (high).

Site Number: 0719
Site Name: Delafield, Delafield, WI
Site Type: Clay lined
Total Design Volume (million cubic yards): 1.0
Principal Waste Types: MSW
Date Filling Began: 1975
Site Size (Acres): 13

- Highest total kjeldahl and ammonia nitrogen concentrations (over 1,000 mg/l)
- Refuse up to 50 feet deep

Site Number: 1099
Site Name: WMI-Metro, WI
Site Type: Zone-of-saturation
Total Design Volume (million cubic yards): 9.0
Principal Waste Types: MSW, IND, HAZ
Date Filling Began: pre-1970
Site Size (Acres): 96

- Leachate chloride concentrations in excess of 4,000 mg/l (possibly due to refuse depth).
- Arsenic analysis exceeded drinking water standard of 0.05 mg/l (maximum concentration of 0.059 mg/l).
- Leachate barium concentrations exceeded the drinking water standard of 1 mg/l.
- Chromium concentrations above 1.5 mg/l.
- Leachate nickel concentration exceeded 1 mg/l.
- Leachate aluminum concentration of 85 mg/l.
- Methylene chloride concentration of 20,000 mg/l exceeded the ambient water quality standard for the noncarcinogenic effects of methylene chloride which is 12,400 mg/l.
- Detectable concentration of PCB-1016 was found - 2.8 µg/l.
- Herbicide 2,4-D was found - 1,800 ug/l - Primary drinking water standard is 100 µg/l.
- Maximum leachate concentrations exceeded all the primary drinking water standards in at least one instance.

Site Number: 1678
Site Name: WMI-Omega Hills, WI
Site Type: Zone-of-saturation
Total Design Volume (million cubic yards): 15.0
Principal Waste Types: MSW, IND, HAZ
Date Filling Began: 1971
Site Size (Acres): 166

- Large co-disposal site.
- Leachate oxygen demand medians greater than 20,000 mg/l.
- Highest total kjeldahl and ammonia nitrogen concentrations (over 1,000 mg/l).
- Leachate chloride concentrations in excess of 4,000 mg/l (possibly due to refuse depth.
- Highest chloride concentration of 11,375 mg/l.
- Leachate sulfide range of <1 to 7.2 mg/l.
- Arsenic analysis exceeded drinking water standard of 0.05 mg/l one value of 70.2 mg/l, next highest 1.05 mg/l).

- File records indicate pesticides were disposed of here.
- Leachate barrium concentrations exceeded the drinking water standard of 1 mg/l.
- Chromium concentrations above 1.5 mg/l.
- Leachate lead concentrations typically greater than 0.3 mg/l and potentially as high as 10 mg/l.
- Leachate silver concentration of 0.083 mg/l (high).
- Highest beryllium concentration.
- Leachate nickel concentrations exceeded 1 mg/l.
- Halogenated ethers and aliphatics detected more frequently than the other sites.
- Higher values of phenol.
- The maximum leachate concentrations exceeded all of the primary drinking water standards in at least one instance.

Site Number: 1739
Site Name: MWI - Pheasant Run, WI
Site Type: Zone-of-saturation
Total Design Volume (million cubic yards): 1.6
Principal Waste Types: MSW, IND
Date Filling Began: pre-1967
Site Size (Acres): 35

- Arsenic analysis exceeded drinking water standard of 0.05 mg/l (maximum concentration: 1.29 mg/l).
- Chromium concentrations above 1.5 mg/l.
- Leachate lead concentration in excess of 2 mg/l.
- Leachate selenium concentrations exceeded 0.1 mg/l (high value of 1.85 mg/l).
- Leachate silver concentration of 0.07 mg/l (high).
- Copper concentrations exceeded drinking water standard of 1 mg/l.
- Maximum leachate concentrations exceeded all of the primary drinking water standards in at least one instance.

Site Number: 2358
Site Name: Fond du Lac Co., WI
Site Type: Zone-of-saturation
Total Design Volume (million cubic yards): 0.5
Principal Waste Types: MSW, IND
Date Filling Began: 1978
Site Size (Acres): 16

- Wide variability in leachate specific conductance over time

Site Number: 2484
Site Name: Outagamie Co., WI
Site Type: Zone-of-saturation
Total Design Volume (million cubic yards): 3.2
Principal Waste Types: MSW, IND
Date Filling Began: 1975
Site Size (Acres): 47

- Reduction in initially high BODs of 6,000-8,000 mg/l to highs typically less than 5,000 mg/l.
- High BOD values each year in the spring or summer.
- Patterns of leachate oxygen demand complicated by operational conditions.
- Median chromium concentrations above 0.2 mg/l.

Site Number: 2568
Site Name: Brown Co. West, Green Bay West, WI
Site Type: Zone-of-saturation
Total Design Volume (million cubic yards): 4.0
Principal Waste Types: MSW, IND
Date Filling Began: 1977
Site Size (Acres): 50

- Had detectable concentration of 1,1-dichloroethane.
- The 1,2 isomer of dichloroethane was detected.
- Xylene detected (one of 2 sites tested).

Site Number: 2569
Site Name: Brown Co. East, Green Bay East, WI
Site Type: Clay lined
Total Design Volume (million cubic yards): 6.0
Principal Waste Types: MSW
Date Filling Began: 1976
Site Size (Acres): 30

- Leachate aluminum concentration below 1 mg/l
- Detectable concentration of 1,l-dichloroethane
- Xylene detected (one of 2 sites that were tested)

Site Number: 2575
Site Name: WMI-Ridgeview, WI
Site Type: Natural Attenuation
Total Design Volume (million cubic yards): 0.8
Principal Waste Types: MSW, IND
Date Filling Began: 1976
Site Size (Acres): 17

- Median chromium concentrations above 0.2 mg/l

Site Number: 2627
Site Name: City of Superior, WI
Site Type: Zone-of-saturation
Total Design Volume (million cubic yards): 0.6
Principle Waste Types: MSW, IND
Date Filling Began: 1976
Site Size (Acres): 20

Site Number: 2680
Site Name: Dane Co., WI
Site Type: Natural Attenuation
Total Design Volume (million cubic yards): 1.5
Principal Waste Types: MSW
Date Filling Began: 1977
Site Size (Acres): 49

- Specific conductance can be as high as 19,000 umhos/cm.
- Dissolved solids - strongest leachate, from headwell.
- Leachate oxygen demand medians greater than 20,000 mg/l.
- Leachate headwell in 20 feet of refuse.
- The well is a source of undiluted leachate since the leachate is not collected, it remains in contact with waste for a long time. The leachate strength is therefore slowly increasing, and leachate is very contaminated.

Site Number: 2821
Site Name: Eau Claire Co., Seven Mile Creek, WI
Site Type: Clay lined
Total Design Volume (million cubic yards): 1.2
Principal Waste Types: MSW
Date Filling Began: 1978
Site Size (Acres): 24

- Wide variability in leachate specific conductance over time

Site Number: 2822
Site Name: City of Janesville, Janesville, WI
Site Type: Clay lined
Total Design Volume (million cubic yards): 0.7
Principal Waste Types: MSW, IND
Date Filling Began: 1978
Site Size (Acres): 18

- Increase in concentration of oxygen-demanding material in leachate over years.
- Leachate barium concentrations exceeded the drinking water standard of 1 mg/l.
- Leachate aluminum concentration below 1 mg/l.
- The 1,2 isomer of dichloroethane was detected.
- Pesticides detected: 4.6 µg/l of delta-BHC.

Site Number: 2892
Site Name: Marathon Co., Marathon, WI
Site Type: Clay lined
Total Design Volume (million cubic yards): 1.5
Principal Waste Types: MSW, IND
Date Filling Began: 1980
Site Size (Acres): 10

- Increase in the concentration of oxygen-demanding material in leachate over the years.
- Site with one of the lowest leachate nitrogen (200-500 mg/l).
- Higher % levels of organic nitrogen.

Site Number: 2895
Site Name: WMI - Muskego, WI
Site Type: Clay Lined
Total Design Volume (million cubic yards): 1.3
Principal Waste Types: MSW
Date Filling Began: 1980
Site Size (Acres): 29

- Leachate barium concentrations exceeded the drinking water standard of 1 mg/l.
- Highest concentration of silver.
- Detectable concentration of 1,l-dichloroethane.
- Phenol values from 39 to 350 µg/l were detected.