

Investigation into Seasonal Differences of Municipal Solid Waste Combustion Ash Leachate

Thomas Kusterer
Montgomery County, Maryland
Division of Solid Waste Services
101 Monroe Street
Rockville, Maryland 20850

James Reynolds, Aron Trombka, Robert Willson
Montgomery County, Maryland
Division of Solid Waste Services
101 Monroe Street
Rockville, Maryland 20850

INTRODUCTION

Interests in the reuse and recycling of municipal solid waste (MSW) combustion ash have increased as practical uses for this material improve. Among factors that warrant further investigation as interests rise for ash reuse is the variability of ash and ash leachate characteristics due to seasonal variations in the composition of the waste stream combusted. Since the constituents of MSW can vary by season,⁽¹⁾ a logical assumption is that ash from the combustion of such waste also varies. Montgomery County, Maryland investigated the seasonal variations in the characterization of MSW ash and MSW ash landfill leachate from their Waste-to-Energy facility over a period of eighteen months.

BACKGROUND

Demographics

Montgomery County, Maryland, approximately 495 square miles in size, is located in the south-central portion of the state, northwest and immediately adjacent to Washington, DC. Population in 1996 was approximately 810,000⁽²⁾, the highest population of any Maryland jurisdiction and comparable to the population of Indianapolis or San Francisco. There are about 315,000 households in the County, with about 215,000 of those single-family households. There are approximately 20,000 businesses in the County. While the County is headquarters for companies such as Lockheed Martin and Marriott, most businesses are relatively small, with about 80 percent employing fewer than 100 individuals. There is very little manufacturing or heavy industry in the County. Most businesses are service oriented.

The Municipal Solid Waste Management System

Municipal solid waste generated in the County is managed through a comprehensive, integrated system that includes aggressive waste reduction measures, curbside and drop-off recycling services, waste-to-energy, composting and landfilling. The system employs five facilities including a materials recycling center for processing co-mingled recyclable material and newspapers; a yard waste composting facility; a transfer station complex that includes waste and recyclables drop-off by citizens, yard material grinding, small quantity hazardous waste drop-off, and MSW receiving and transfer to a rail transportation system; a waste-to-energy facility that receives waste only from the transfer station via the rail transportation system; and a landfill that provides disposal for non-processible waste and includes a separate ash monofill. All facilities are operated by the County or on their behalf through contracted operators.

The County generates approximately 900,000 tons per year of municipal solid waste, with about 540,000 tons from the residential sector and approximately 360,000 tons per year from the non-residential sector. Approximately 315,000 tons of waste -- a 35% recycling rate -- were recycled in 1995. Approximately 475,000 tons, are combusted in the County's waste-to-energy facility. The remainder, mostly from commercial generators, is exported from the County for disposal and/or recycling.

The County provides curbside recycling services for the collection of newspapers, mixed glass, aluminum and bi-metal cans, and High Density Polyethylene (HDPE) and Polyethylene Terephthalate (PET) plastic containers. The newspapers are kept separate from other materials during collection and are transferred to a private processing facility. The other materials are co-mingled during collection and are separated and processed at the County's Materials Recycling Center. The County intends to expand residential recycling and initiate a mixed paper collection program during the early part of 1998. County law also requires that commercial facilities and multi-family dwellings institute recycling programs. At a minimum, commercial facilities must recycle corrugated cardboard, office paper, newspaper,

aluminum and bi-metal cans, glass, plastic, and yard waste. The combination of residential, multi-family and commercial recycling programs has enabled Montgomery County to recycle approximately 35 percent of its waste stream. The County has a goal of achieving a 50 percent recycling rate by the year 2000.

WASTE COMPOSITION

A substantial portion of the current recycling rate is due to a yard waste ban which the County instituted in 1994. Yard waste is not accepted at disposal facilities and is now composted either by property owners, or is collected from residents and delivered to the County's yard waste compost facility. Therefore, the historic seasonal fluctuations previously associated with spring and summer surges of yard waste material have been largely removed from the disposal stream. County studies have shown that waste composition remains relatively consistent throughout the year, although volume decreases in winter months due to lower activity in general.

From 1994 through 1996, Montgomery County conducted quarterly characterization studies of municipal solid waste delivered to the County's Transfer Station. The intent of these studies was to generate data necessary to evaluate existing waste reduction, recycling and disposal programs, and to plan and implement new programs.

Waste sorters randomly selected 75 MSW samples during a one-week period in February, May, August and November. The minimum weight for each sample was 300 pounds, yielding a total weekly sample size of over 10 tons. Wastes were sorted by hand into over 50 categories for each of the three generating sectors: (1) single-family residential; (2) multi-family residential; and (3) non-residential.

Of the 75 samples taken each quarter, 30 were taken from vehicles delivering waste from the non-residential sector, 25 samples were taken from vehicles collecting from single-family residential homes, and 20 samples were taken from vehicles collecting from multi-family residential units exclusively. The County also calculated the aggregate composition of the full MSW disposal stream using weighted data from each of the three sectors.

Hazardous material segregated through the sampling included batteries, solvents, corrosives (typically cleaning fluids), fuels, and poisons (typically pesticides and herbicides). In each of the four seasonal samplings hazardous materials constituted less than one percent of the municipal solid waste processed by the County. Other major components of the waste stream also varied minimally from season to season.

Aggregated data for waste stream composition from calendar year 1995 is presented in Table 1. This is the only calendar year where sampling occurred in all four seasons.

LANDFILL LEACHATE

Landfill Design

The County is served by one active and permitted municipal solid waste landfill. The landfill became operational in June, 1982, and received approval for a vertical expansion in February, 1990. A separate area of the landfill was approved as a monofill for accepting ash from the waste-to-energy facility, and became operational with the waste-to-energy facility in May, 1995. The original landfill design included a

prepared floor with compacted soil that met a permeability of 6×10^{-6} cm/sec or less. A leachate collection system was constructed with a series of trenches filled with crushed stone and perforated lateral collection pipe. These pipes lead to trenches with perforated header pipes also embedded in crushed stone. The design for the vertical expansion incorporated this older design into a new perimeter collection system. Design of the vertical expansion consisted of geonet with filter fabric placed over an 80 mil HDPE liner that was placed predominately over the top of the original landfill. One foot of highly permeable rounded stone overlays the geonet.

Leachate flows by gravity to HDPE perforated collection pipes at the base of the new cells and then to lateral HDPE pipes. These lateral pipes subsequently direct leachate to manholes located outside the disposal area and then to a common leachate conveyance system that transports the material by gravity to a leachate lift-pump station. Leachate from the original area of the landfill and the vertical expansion are comingled in the header piping surrounding the fill area. However, leachate from the ash monofill remains separated until it intersects the primary conveyance system that directs the leachate to the leachate lift pump. At that intersection a manhole provides access for separate sampling of the ash leachate and the MSW leachate.

Leachate is then pumped into one of two double-lined open leachate storage lagoons that hold the leachate prior to on-site pre-treatment. A total of approximately 7,000,000 tons of MSW have been placed in the landfill since operations began in June, 1982 through December, 1996. Ash from the County's RRF, which began test burning in May, 1995, has been disposed in the dedicated ash disposal cell with approximately 200,000 tons of ash disposed to date. No daily or intermediate cover is required for the ash since litter and vector control are not of concern, and the ash moisture content is such that dusting of the ash is minimized.

The volume of leachate generated ranged from zero gallons per month to approximately 140,000 gallons per month before the landfill's expansion. The range of volume generated has been higher after the landfill's expansion because the new HDPE-lined cells are more effectively collecting leachate compared to the older soil-lined cells. For example, the amount of leachate generated at the landfill in 1996 has ranged from approximately 46,000 gallons in August to approximately 1,650,000 gallons in November, with a total leachate influent from the landfill of approximately 10,000,000 gallons in 1996.

The County pre-treats the leachate generated by the landfill before disposing of the liquid in a sanitary sewer. The County selected a biological process system that uses a fixed film process for reduction of the leachate's organic content. The selected system also incorporates elements of physical and chemical treatment. The process system selected, and now operational, is capable of processing up to 30,000 gpd at 1,500 mg/l BOD concentrations. The system has the hydraulic capacity of handling up to 60,000 gpd. Biological activity occurs in two 36 foot by 9 foot by 8.5 foot bioreactors. Each bioreactor has four cells where organic reduction occurs. Each of the eight cells currently uses aerobic treatment to decompose organic constituents, with the capability for conversion to anaerobic treatment if leachate conditions warrant. Reactors are made of coated carbon steel and enclose corrugated polyvinylchloride sheets laminated together at opposite angles so that a cross flow matrix occurs. This design creates almost 105,000 square feet of effective surface area media. The media is the site for organism attachment and growth.

Untreated leachate is pumped from one of the two synthetically double-lined open storage lagoons, through a feed line to centrifugal influent pumps. Gentle agitation via the flocculation mixer creates growth and aggregation of particles, including metals. As much as 90 percent removal of metals can occur through this

precipitation process. Clarified leachate from the precipitation process spills over a weir and flows by gravity to a splitter box. The splitter box directs equal liquid flow to the two bioreactors. Clarified effluent from the bioreactors flows by gravity to a 400 gallon effluent holding tank, where a horizontal centrifugal pump sends the pre-treated leachate to the synthetic double-lined storage lagoon. Pre-treated leachate is pumped into tanker trucks from the storage lagoon and hauled to a sanitary sewer where it is discharged for final treatment.

Sampling Protocol

Although the County is not required to sample ash leachate, it wanted to gather data regarding this material and began sampling in September, 1995. Samples of untreated ash leachate are taken monthly from a manhole that enables access for sampling the ash leachate separate from the other leachate. Sixteen constituents in the leachate are analyzed monthly (Table 2). Two constituents -- antimony and fats, oil and grease were detected in minimal concentrations, and are not included in Table 2. Grab samples are taken for fats, oil and grease analysis, while all other samples are composite samples. Samples are collected in 3.8 liter plastic containers, and then transported to a state-certified laboratory. Chain-of-custody controls are maintained through the conclusion of constituent analyses.

Ash Field Leachate Results and Discussion

Table 2 shows monthly sampling results for 14 constituents analyzed in the County's ash field leachate for the period between September, 1995 (when the ash leachate sampling program began) through December, 1996. There is no readily apparent pattern in constituent levels due to season or other factors. Most metals have been at non-detectable levels since April, 1996 (when the metal sampling program was broadened to include antimony, arsenic, cooper, chromium, mercury and nickel). Where there seems to be some evidence of possible seasonal effects -- total dissolved solids' levels are higher in October-December, 1995 than those in other months -- there is no replication of this phenomena in October-December, 1996. Levels for the latter period are similar to those of other months and seasons.

Values for the ash leachate constituents appear to be in the range reported in the literature (Table 3). County data presented in Table 3 is the mean for all observations of the particular constituent since the sampling program began for that particular constituent. Generally speaking, metal concentrations in the County's ash leachate appear to be in the lower part of the range reported in the literature. Table 4 displays 1996 data by season. The three month periods listed in the table are meant to correspond to the four seasons. The mean and standard deviation for these observations are also provided. No other statistical analyses were performed for these data because of the limited number of observations and the possibility that they might not provide an accurate representation of the actual situation. Indeed, there are some data where the standard deviation is larger than the mean (e.g., Biochemical Oxygen Demand) and other data where the standard deviation is comparable to the mean (e.g., Chemical Oxygen Demand (COD) and Total Suspended Solids (TSS)). Comparing the mean and standard deviation provides a casual method of finding changes in the constituents.

There are instances where constituents seem to vary significantly from the mean and from other seasonal concentrations. COD in July-September and in October-December is less concentrated than its mean concentration and also compared to concentrations in other season. There is a similar pattern in TSS concentrations. A comparison of these data with constituent levels in pretreated leachate shows similar patterns (Table 5). Whatever factors causing these concentration variations in the ash leachate seem to be affecting the general leachate population. Other factors besides potential seasonal variation in waste characteristics that might affect leachate concentrations are age of the landfill and its waste, types of waste

in the landfill, precipitation and volumes of raw leachate discharged from the landfill to the storage lagoons. It is difficult to ascertain a pattern of seasonal waste effects based on current landfill leachate data. More historical leachate data will help to clarify the question of possible seasonal effects from waste characteristics.

ASH CHARACTERIZATION

WTE Facility Design

Montgomery County's WTE facility is a mass-burn design with three 600 tpd units. The facility utilizes the Martin grate technology, and is operated by Ogden Martin Systems of Montgomery, Inc. The facility employs a semi-dry scrubber and reverse air baghouse as its principal air emissions control equipment. Fly ash is conveyed in enclosed augers from the baghouse, in reverse direction of the gas path, collecting spent scrubber residue and ash from various areas of the boiler. Fly ash and bottom ash are combined below the boiler and conveyed to a single ash storage pit before being removed for off-site disposal. In addition, dolomitic lime is introduced to the fly ash to help ensure that metals do not leach from the ash in unacceptable concentrations.

Acid gases are also controlled by injection of dry lime directly into the furnace area of the boiler. The furnace dry lime injection (FDLI) system operates in standby mode, and is secondary to the semi-dry scrubber. It functions in hand with the scrubber through a continuous emissions monitoring (CEM) system. The CEM reads the concentrations of SO_2 in the gas path at the scrubber exit. As acid gas concentrations rise in the scrubber exit, the feed mechanism of the scrubber is signaled and the system begins feeding additional lime into the scrubber. If the lime feed rate in the scrubber rises beyond a set point, the FDLI system is signaled and dry hydrated lime begins to feed into the boiler at a rate that is set to "catch" the rising concentrations and reduce them to a level managed only by the scrubber. Once controlled, the FDLI system is put back into a standby mode.

NO_x is controlled by a selective non-catalytic reaction (SNCR) which utilizes aqueous ammonia to reduce NO_x . Ammonia is injected into the furnace area of the boiler above the point of the FDLI nozzles.

Mercury and other organics and trace metals are controlled through the injection of dry activated carbon into the gas path before the scrubber inlet. The scrubber and baghouse help to control these parameters as well.

The CEM system reads seven parameters – CO , CO_2 , O_2 , NO_x , SO_2 , HCl , and opacity – on a continuous basis. Data is averaged over various time periods, depending on the permit requirements for that parameter. The CEM system continuously sends signals to the operating equipment and control mechanisms to actively influence the feed rates of all reagents in the air emission control system and related operations such as fuel feed rate and combustion air volumes.

Sampling Protocol

In accordance with the requirements of the Maryland Department of the Environment (MDE), an ash characterization program was implemented at the facility. Discussions with MDE and USEPA staff, and the use of their guidance documents, formed the basis of the County's sampling protocol that was developed before the facility came on line in 1995. The program follows the widely used protocol

identified in USEPA documentation.⁽³⁾⁽⁴⁾⁽⁵⁾ Sampling has been conducted every calendar quarter since the facility became operational. In each sampling event the full complement of TCLP metal and organics testing was performed.

Combined ash is sampled across the width of a vibrating conveyor just before it is fed into containers for transport off site. This location is consistent with USEPA's January 1995 decision regarding the point of generation at WTE facilities, and properly represents the ash that leaves the site for disposal. The facility stores its ash in a pit before it is processed for ferrous metal recovery and containerized for transport. Because the pit can be excavated faster than the ash enters it, a determination was made as to how frequently ash is to be sampled to ensure a representative sample over an operating shift of the boilers. Sampling is scheduled to provide fourteen grab samples for each operating shift, based on the excavation rate of the pit. Because operations are based on a 12-hour shift, sampling represents a 24-hour operating period.

The grab samples that represent a single shift are combined to form a shift composite sample. Collecting for two shifts per day, fourteen shift composite samples are collected over the course of seven days of sampling. Each shift composite sample is derived by properly mixing, and quartering the grab samples for that shift. Four sub-samples are created from each shift composite sample. The sub-samples are mixed, screened for sizing material -3/8" and +3/8 -2", crushed where required and screened again, and weighed. Sample aliquots for TCLP extraction are prepared by mixing proportional amounts from both sizes of material.

All samples are labeled and protected throughout the process using chain of custody procedures. Laboratory procedures follow established protocol for TCLP testing and reporting.

TCLP Results and Discussion

Ash from Montgomery County's WTE facility continues to test as a non-hazardous material. As expected, organic compounds, herbicides and pesticides are non-detectable. The test results of the metals analyses are summarized in Table 6. Montgomery County has chosen to report and use all test data for calculation of the upper confidence interval (UCI) – including statistical outliers that are determined based on Chauvenet's Criterion. Their inclusion in the data raise the respective UCI for that analyte and that test event.

A review of the data suggests that three metals (Arsenic, Selenium and Silver) have not been detected in any test. One metal (Barium) has been detected twice, and Chromium has been detected once, all at levels that were approximately one-half of one percent or less of their regulatory thresholds.

Cadmium and Lead, generally the most closely observed analytes, were both detected. However it is worth noting that Lead was reportable in only two events (29%), and at only 6.4% to 8.8% of its regulatory threshold. Statistical outliers, based on Chauvenet's Criterion, are included in the data for Lead in both test events where it was detected. Cadmium was reportable in all seven events at levels that ranged from 1.9% to 46.6% of its regulatory threshold. Statistical outliers are included in the data for Cadmium in all but the May and August test events.

Mercury was detected in four of seven test events, but at levels that range from 0.3% to 1.9% of its regulatory threshold. It appears that capturing Mercury from the gas stream has indeed resulted in its deposit in the ash. However, because Mercury control technology is not operating on many WTE plants with a scrubber and baghouse, additional data is needed to substantiate this observation.

Because most tests did not result in consistent detection of analytes, Cadmium is the only analyte that can be compared seasonally. As with landfill leachate data, it is difficult to ascertain a pattern of seasonal effects on ash leachate by comparing the Cadmium results.

CONCLUSIONS

Data collected to date from the Montgomery County waste-to-energy facility do not clearly indicate seasonal effects on the leachate from the ash or leachate from the ash disposal cell, at least with respect to the parameters of regulatory concern which have been reviewed herein. One reason for this may be that the output of a waste disposal facility is in good measure a function of the input to that facility. The composition of waste entering Montgomery County facilities has not demonstrated marked seasonal variations. Given the consistency of the waste stream and the effect that lime has in stabilizing ash from the combustion process, the lack of hazardous constituents in ash leachate, and the general lack of definable seasonal variations is not necessarily surprising.

Montgomery County will continue periodic testing of ash residue and landfill leachate. A more substantial database will evolve over the next few years which will enable review of these findings.

References

1. Handbook of Solid Waste Management, F. Kreith, Editor-in-Chief, McGraw Hill, New York, 1994, Page 3.33.
2. Maryland National-Capital Park and Planning Commission, Washington, DC, personal communications, December 11, 1995.
3. Sampling and Analysis of Municipal Refuse Incinerator Ash, US Environmental Protection Agency, May 1994.
4. Guidance for the Sampling and Analysis of Municipal Waste Combustion Ash for the Toxicity Characteristic, EPA 530-R-95-306, US Environmental Protection Agency, June 1995.
5. Manual SW-946 - Test Methods for Evaluating Solid Waste - Physical/Chemical Methods, US Environmental Protection Agency, March 1992.
6. Introduction to Environmental Statistics, Environmental Protection Agency.

Table 1. Waste Stream Composition. ⁽¹⁾

Material Type	Percent by Weight
Paper Products	44
Organics	30
Plastics	10
Glass	4
Ferrous Metals	3
Wood	3
Inert Materials	3
Yard Waste	2
Non-ferrous Metals	1
Hazardous Materials	<1

(1) Aggregated data from 1995. Paper, plastics, metals, glass and yard waste result from portions of the waste stream not captured by recycling programs.

Table 2. Montgomery County (MD) Landfill Ash Leachate Analytical Results (mg/L).

Month	pH	BOD	COD	TDS	TSS	Sulfates	Chlorides	Cadmium	Lead	Arsenic	Chromium	Copper	Mercury	Nickel
1995														
September	6.0	40	870	20,000	37	220	9,800	0.02	0.04	NS	NS	NS	NS	NS
October	6.2	16	1,200	37,000	66	520	20,000	0.05	0.86	NS	NS	NS	NS	NS
November	6.2	780	1,800	48,000	96	530	23,000	0.02	0.50	NS	NS	NS	NS	NS
December	6.7	110	2,000	80,000	48	860	42,000	0.05	0.60	NS	NS	NS	NS	NS
1996														
January	8.3	240	550	21,000	270	320	14,000	ND	0.30	NS	NS	NS	NS	NS
February	6.1	1,200	1,700	82,000	950	780	47,000	ND	1.00	NS	NS	NS	NS	NS
March	6.3	320	2,100	40,000	370	470	35,000	ND	ND	NS	NS	NS	NS	NS
April	6.0	160	1,100	32,000	310	450	16,000	ND	0.10	ND	ND	0.01	ND	0.14
May	6.1	75	620	21,000	33	290	12,000	ND	ND	ND	0.02	ND	ND	0.07
June	5.9	72	500	28,000	530	220	13,000	ND	ND	ND	ND	ND	ND	ND
July	6.2	70	340	38,000	160	500	19,000	ND	ND	ND	ND	ND	ND	ND
August	6.5	ND	200	23,000	70	240	13,000	ND	ND	ND	ND	0.06	ND	ND
September	6.5	15	140	20,000	240	240	10,000	ND	ND	ND	0.02	0.02	ND	ND
October	6.5	5	280	23,000	37	600	12,000	ND	ND	ND	ND	0.02	ND	ND
November	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
December	7.3	100	260	23,000	76	150	10,000	ND	ND	ND	ND	ND	ND	ND

NS- Not Sampled

ND- Not Detected within Methodology Limits

Table 3. Comparison of Montgomery County (MD) Landfill Ash Leachate Inorganic Constituents for 1996 with Literature Reported Results for Ash Leachate (mg/L).

Source	pH	Chloride	Sulfate	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel
Montgomery County	6.45	19,720	426	0	ND	0.003	0.007	0.227	ND	0.014
Bagchi-a	8.47-9.94	33-305	105-1,440	<0.2	0.004-0.3	0.01-0.044	.026-0.103	0.15-0.6	<0.0002	0.01-0.03
CORRE Study-b	6.41	NA	1,259	ND-0.4	ND-0.004	ND-0.032	ND-0.012	ND-0.054	ND	NA

NA-Not Analyzed

ND- Not Detected within Methodology Limits

a-"Design, Construction and Monitoring of Sanitary Landfill," A. Bagchi, John Wiley and Sons, 1990, p. 41.

b- "Characterization of Municipal Waste Combustion Ash, Ash Extracts and Leachates," U.S. Environmental Protection Agency, EPA 530-SW-90-029A, March 1990, p. 7-21

Table 4. Seasonal Average of Ash Leachate Inorganic Constituents, 1996 (mg/L).

Season	pH	BOD	COD	TDS	TSS	Sulfates	Chlorides	Cadmium	Lead	Arsenic	Chromium	Copper	Mercury	Nickel
January-March	6.9	587	1,450	47,667	530	523	32,000	ND	0.43	0	NS	NS	NS	NS
April-June	6	102	740	27,000	291	320	13,667	ND	0.03	ND	0.01	0	ND	0.07
July-September	6.4	28	227	27,000	157	327	14,000	ND	ND	ND	0.01	0.03	ND	0
October-December	6.9	53	270	23,000	57	375	11,000	ND	ND	ND	0	0.01	ND	0
Mean	6.6	192	672	31,167	259	386	17,667	ND	0.12	0	0	0.01	0	0.02
Standard Deviation	0.34	205	440	8,645	159	73	7,474	ND	0.16	0	0	0.01	0	0.03

Table 5. Comparison of Select Inorganic Constituents by Season, Ash Leachate and Pretreated Leachate, 1996 (mg/L).

Season	ash leachate pH	pretreated pH	ash leachate COD	pretreated COD	ash leachate TDS	pretreated TDS	ash leachate TSS	pretreated TSS	ash leachate Cadmium	pretreated Cadmium	ash leachate Lead	pretreated Lead
January-March	6.9	7.1	1,450	287	47,667	4,933	530	85	ND	0.02	0.43	ND
April-June	6.0	7.5	740	213	27,000	6,567	291	73	ND	ND	0.03	ND
July-September	6.4	7.3	227	153	27,000	7,233	157	28	ND	ND	ND	ND
October-December	6.6	6.9	270	143	23,000	6,033	57	61	ND	ND	ND	ND
Mean	8.6	7.2	672	199	31,167	6,192	259	62	ND	0.01	0.12	ND
Standard Deviation	0.33	0.22	440	51	8,645	753	159	19	ND	0.01	0.17	ND

ND - Not Detected within Methodology Limits

Table 6. Montgomery County, Maryland MWC Ash Characterization Comparison of TCLP Statistical Results for Metal Analytes (1)

Analyte	90% UCI ⁽²⁾ Jul 95	90% UCI ⁽²⁾ Dec 95	90% UCI ⁽²⁾ Feb 96	90% UCI ⁽²⁾ May 96	90% UCI ⁽²⁾ (3) Aug 96	90% UCI ⁽²⁾ Nov 96	90% UCI ⁽²⁾ Feb 97	Regulatory Threshold
Arsenic	ND/0.06	ND/0.06	ND/0.5	ND/0.5	ND/0.5	ND/0.5	ND/0.5	5.0
Barium	ND/0.5	0.47	ND/10	ND/10	ND/10	ND/10	0.55	100.0
Cadmium	0.019	0.122	0.166	0.414	0.434	0.125	0.466	1.0
Chromium	0.018	ND/0.2	ND/0.5	ND/0.5	ND/0.5	ND/0.5	ND/0.5	5.0
Lead	ND/0.1	0.32	ND/0.5	ND/0.5	0.44	ND/0.5	ND/0.5	5.0
Mercury	0.0038	ND/0.0006	0.0012	0.0006	0.0006	ND/0.0005	ND/0.0005	0.2
Selenium	ND/0.06	ND/0.06	ND/0.1	ND/0.1	ND/0.1	ND/0.1	ND/0.1	1.0
Silver	ND/0.04	ND/0.04	ND/0.5	ND/0.5	ND/0.5	ND/0.5	ND/0.5	5.0

All units expressed as milligrams per liter (mg/l)

ND = Non-Detectable

(1) All other analytes were non-detectable. Statistical outliers (based upon Chauvenet's Criterion) are included in the data, resulting in higher UCI levels. Laboratory detection levels for non-detectable results are reported after the ND/.

(2) 90% Upper Confidence Interval as a single-tailed distribution is equivalent to an 80% Upper Confidence Interval as a two-tailed distribution, i.e., there is only a ten percent chance that the result could be higher.

(3) Testing of archived split sample for Lead showed lower concentrations. Worse case results are reported.