



**SYNTHETIC PRECIPITATION LEACHING PROCEDURE  
(SPLP) LEACHATE CHEMISTRY DATA FOR SOLID MINE-  
WASTE COMPOSITE SAMPLES FROM SOUTHWESTERN  
NEW MEXICO, AND LEADVILLE, COLORADO**

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## **Abstract**

This report details chemistry data derived from leaching of mine-waste composite samples using a modification of E.P.A. Method 1312, Synthetic Precipitation Leaching Procedure (SPLP). In 1998, members of the U.S. Geological Survey Mine Waste Characterization Project collected four mine-waste composite samples from mining districts in southwestern New Mexico (CAR and PET) and near Leadville, Colorado (TUC and MII). Resulting leachate pH values for the four composites ranged from 5.45 to 8.84 and ranked in the following order: CAR < TUC < MII < PET. Specific conductivity values ranged from 85  $\mu\text{S}/\text{cm}$  to 847  $\mu\text{S}/\text{cm}$  in the following order: PET < MII < CAR < TUC. Geochemical data generated from this investigation reveal that leachate from the CAR composite contains the highest concentrations of Pb, Zn, Ni, Mn, Cu, Cd, and Al

## **Introduction**

Assessing acid and metal mobility from abandoned mine-waste piles is an area of concern for Federal land management agencies and others. Drainage and runoff from these piles can present water quality concerns similar to acid mine drainage. Mine-waste piles that contain metal and sulfide reservoirs can become sources of acidic drainage when exposed to surface conditions of oxygen and water. Continuing work on Abandoned Mine Lands projects has demonstrated the need for rapid, accurate characterization of these waste materials in order to aid in the screening, geochemical assessment, and prioritization of a large number of mine-waste piles for remediation. One of the methods currently used to characterize mine-waste material is E.P.A. Method 1312 Synthetic Precipitation Leaching Procedure (SPLP). Because this test has been used in many studies involving mine-waste it was the method we chose for the geochemical characterization of the samples in this study. It is important to note, that we have observed while conducting this and other studies, that some of the procedures required when using EPA Method 1312, such as particle size reduction, end-over-end rotary agitation, and extended extraction time (18 hours) probably remove most realistic approximations of simulating runoff from mine-waste.

## **Purpose of Investigation**

The purpose of this investigation is two-fold: First, it provides our collaborators an assessment of EPA Method 1312 leachate chemistry data for solid mine-waste composite samples collected from four different mine-waste sites. Second, data from this investigation were used for comparative studies as part of a larger effort to develop a field leach test (Hageman and Briggs, in press) which is designed and used as a screening tool for evaluation of historic mine-waste piles.

## **General Methods**

Leachate chemistry data for solid mine-waste composite samples were obtained by leaching the mine-waste material using a modification of the EPA Method 1312 Synthetic Precipitation Leaching Procedure (SPLP). For this study, four solid mine-waste composite samples were collected from historic mine-waste piles using the technique described in Smith and others (in press). The composite samples were then prepared for use in leach studies. The leachate from the experiments was filtered and aliquots were taken for metal, anion, and acidity analyses. Measurements were made for pH and specific conductivity on unfiltered aliquots of leachate.

## **Sampling Locations**

In the summer of 1998, four mine-waste pile composite samples were collected from historic dumps in three mining districts in the western United States. The Carlisle (CAR), Steeple Rock District, and the Petroglyph (PET), Hillsboro District, were collected in southwestern New Mexico: The Tucson (TUC) and Main Iron Incline (MII) were both collected from the Leadville District in central Colorado.

## **Geology**

***Carlisle mine, Steeple Rock District, New Mexico:*** The ore of this base and precious-metal mine was along faults in prophyllitically-altered andesite of Tertiary age. Ore minerals were mostly galena and sphalerite with minor chalcopyrite (McLemore, 1993). Significant Au and Ag are associated with galena and minor fluorite. Hydrothermal alteration minerals are dominantly quartz, jarosite, and kaolinite. The andesite host rock contains abundant chlorite, calcite, and significant amounts of disseminated pyrite. Secondary gypsum, anglesite, and gunningite are present in the waste.

***Petroglyph mine, Hillsboro District, New Mexico:*** The mineralization of this quartz vein lies between unnamed Ordovician and Mississippian limestones and the origin of the hydrothermal fluids is thought to be related to a Cretaceous quartz monzonite intrusive nearby. Sulfides are pyrite, sphalerite, and galena (Hedlund, 1977; 1985). Other minerals found include wulfenite, strontianite, cerussite, and mimetite. Major gangue minerals are calcite, dolomite, and quartz.

***Tucson and Main Iron Incline mines, Leadville District, Colorado:*** These two wastes are from different parts of the same mining complex on Iron Hill east of Leadville. The Tucson waste is near the vertical Louisville shaft on the top of Iron Hill; the Main Iron Incline waste is near the base of Iron Hill. The gold, silver and lead mineralization is replacement deposits of Tertiary age in the Mississippian Leadville Limestone below the white porphyry and above the gray porphyry. Ore minerals were of two types. One was highly oxidized consisting of lead sulfates and carbonates and associated silver-rich manganese and iron oxides. At depth the ore became sulfide rich and consisted chiefly of

galena with minor pyrite and sphalerite (Blow, 1889). Dolomite is the dominant gangue mineral and gypsum is common in the wastes.

## **Methods**

### **Collection of Mine Waste Grid Composite Samples**

At each site, members of the United States Geological Survey's Mine Waste Characterization Project laid out an informal grid that contained most of the material in the waste pile. The grids consisted of at least 30 evenly-spaced cells for sampling. Approximately 30 sub-samples or increments were randomly collected from each grid cell by sampling the weathered surface material (upper 15 cm) using stainless steel trowels, small hand shovels, and three-prong scrapers. During collection, all fragments > 4 cm were discarded. Increments from each cell were combined in a 1-gallon plastic bucket. After collection, the composite from each cell was placed in a plastic washtub and mixed. A sub-sample of the cell composite was placed in a soil bag and saved as a cell composite. The remaining cell composite material was placed into 5-gallon bucket(s) to be mixed with other cell composites to form the mine-waste pile composite sample. This material was then transported back to the laboratory. Each sample was spread out on clean plastic tarps to dry at room temperature. To insure complete drying, samples were completely turned daily with a small plastic scoop until visibly dry (approximately 2 to 3 days depending upon ambient humidity). After drying, each composite was mixed for 5 minutes in a large stainless steel V-Blender to break up friable clods. The composite material was then sieved with a 2 mm screen, with the < 2 mm fraction being recombined and thoroughly homogenized by mixing in the V-Blender for 30 minutes. The > 2 mm fraction was discarded. After homogenization, the < 2 mm composite material was split into 1 gallon cardboard ice cream containers. The tops of the containers were sealed with tape for storage.

### **Modified E.P.A. Method 1312 (SPLP)**

The Synthetic Precipitation Leaching Procedure (SPLP) (U.S. EPA Method 1312; U.S. Environmental Protection Agency, 1986; 1994 update) is a method designed to evaluate the impact of contaminated soils on groundwater. The extraction fluid consists of slightly acidified de-ionized water that is formulated to simulate natural precipitation. A mixture of 60/40 H<sub>2</sub>SO<sub>4</sub>/HNO<sub>3</sub> (by weight) is used to achieve the appropriate pH for the extraction fluid. The pH of the de-ionized water is adjusted with the 60/40 H<sub>2</sub>SO<sub>4</sub>/HNO<sub>3</sub> mixture, depending on which side of the Mississippi River the soils originate from, to either pH 4.2(+/-) 0.05 (east of the Mississippi) or pH 5.0 (+/-) 0.05 (west of the Mississippi). The SPLP procedure mandates that for mine wastes, the more acidic pH 4.2 extraction fluid be used.

The SPLP extraction method for 100% solids and no volatiles was utilized for this study. A sample that is 100% solids requires reduction of particle size to <1 cm (if necessary), and extracting the solid at a 20:1 ratio (100g of mine-waste composite material / 2,000g extraction fluid) on an end-over-end rotary agitator for 18 hours. The

solid/liquid slurry is then filtered through a 0.7  $\mu\text{m}$  borosilicate glass fiber filter utilizing a pressure filtration unit.

For this study, we used the pH 4.2 extraction fluid and modified the SPLP procedure by sieving and using only the <2mm fraction of the sample. Because of sieving there was no need for particle size reduction.

Clean extraction vessels (Nalgene® high-density polyethylene 2-liter bottles) were rinsed twice with 10 ml of pH 4.2 extract solution. One hundred grams of each sample (< 2mm fraction) was weighed and placed in an extractor vessel, two liters of pH 4.2 extraction solution was slowly added to the vessel. Teflon® tape was wrapped around the bottle threads to create a tight seal. The extractor vessels were secured in an Analytical Testing Rotary Agitator (model DC-20B) and rotated end-over-end for eighteen hours at twenty-eight revolutions per minute.

Following extraction, the samples were filtered through a 0.7  $\mu\text{m}$  borosilicate glass fiber filter (Gelman Sciences Inc. P/N 66257, TCLP glass fiber filter, 0.7  $\mu\text{m}$  pore size, and 142-mm diameter). The filtration unit used was a Gelman Sciences Hazardous Waste pressure filtration unit (Gelman Sciences Product No. 15046). The filters were placed in position and acid washed with 1 liter of IN  $\text{HNO}_3$  followed by three one liter de-ionized water rinses prior to filtration of the samples. A small aliquot of the unfiltered leachate was taken for pH and specific conductivity measurements. After filtration, aliquots of filtrate-were preserved for analysis.

## **Analytical Methods**

Similar analytical methods and procedures were used for all samples. U.S. Geological Survey employees using U.S.G.S. instrumentation and equipment performed all preparation and analyses of samples. Following, is a detailed explanation of the analytical techniques and procedures used, the sample requirements, and other key parameters.

### **pH**

Laboratory measurements were taken on unfiltered aliquots of leachate using an Orion Model 230-A pH meter and an Orion Combination pH electrode. (Orion Electrode # 915600). The meter was calibrated prior to each set of measurements and checks were obtained on other buffers between readings to insure all buffers read and recorded to  $\pm 0.02$  pH units. The pH analysis requires no sample treatment but the sample solution must be measured immediately.

### **Specific Conductance**

Laboratory measurements of specific conductance ( $\mu\text{S}/\text{cm}$ ) were taken on unfiltered aliquots of leachate using a Myron L Portable Conductivity Meter (Model DC4). Prior to initial use, the meter was calibrated with commercially obtained conductivity standards. Prior to each set of observations, aliquots of commercially obtained 100  $\mu\text{S}/\text{cm}$  and 1000  $\mu\text{S}/\text{cm}$  standards are checked and their values recorded. Conductivity analysis requires no sample treatment and again, the sample should be analyzed immediately.

### **Metals Analysis**

Concentrations of metals were determined by inductively coupled plasma - mass spectroscopy (ICP-MS) (Lamothe and others, 1999) after screening of samples using inductively coupled plasma - atomic emission spectroscopy (ICP-AES) (Briggs and Fey, 1996). For this report, ICP-MS data are used for discussion and conclusions because this method provides more elements and lower detection limits.. Preservation of the samples for metals analysis requires that the sample be filtered and acidified to pH < 1.5 with Ultrex® II Ultrapure HNO<sub>3</sub>. Maximum hold time for the sample is 180 days.

### **Anion Analysis**

Anions were determined by ion chromatography (IC) using a modification of the method d'Angelo and Ficklin, (1996). Anions measured were fluoride, chloride, nitrate, and sulfate. Preservation of the sample for anion analysis requires filtration and then refrigeration at 4°C. Sample must be analyzed within 28 days.

### **Quality Control**

Table 1 shows the frequency and control limits of laboratory control checks used for leachate samples obtained from leach experiments in this study. A brief description and definition of each type of quality control check follows. Results of quality control checks are presented in Appendix A.

**Table 1. Laboratory Quality Control Checks**

<u>Quality Control Check</u>	<u>Frequency</u>	<u>Control Limits</u>
1. Preparation Blank	one per analytical batch	<IDL or unprocessed extraction fluid chemistry
2. Analytical Batch Duplicates	one per analytical batch	± 20% RPD
3. Reference Standards	one set per analytical grouping	± 20% RPD

#### ***Preparation Blank***

A preparation blank is a sample of the appropriate volume of extraction fluid that is carried through the entire experimental process including analysis. The preparation blank is used to determine whether any added reagents, equipment, procedures, or processes introduce any contaminants to the samples. For laboratory studies, at least one preparation blank is run with each analytical batch.

#### ***Analytical Batch Duplicates***

Analytical batch duplicates consist of two identical splits of a site composite that are carried through the entire experimental process, including analysis in order to determine the precision of the analytical results. For laboratory studies, at least one duplicate is run with each analytical batch.

### ***Reference Standards***

USGS Water Resources Division (WRD) water standards were submitted with each group of samples as a check on the analytical method. Standards for major cations and for trace metals were submitted with sample groups undergoing ICP-MS and ICP-AES analysis.

## **Data**

### **EPA Method 1312 Leachate Chemistry Data**

Selected leachate chemistry data for each site composite is listed in Table 2. The complete set of ICP-MS data for all elements and all samples analyzed are listed in Appendix B.

### **pH**

pH values for the composites ranged from 8.84 (PET) to 5.45 (CAR). Other pH values were 6.99 (TUC) and 8.55 (MII). All four mine-waste composite samples showed an increase in pH from the starting extraction fluid pH of 4.20. The sample pH values ranked CAR < TUC < MII < PET.

### **Specific Conductance**

Values for specific conductivity measurements ranged from, 85  $\mu\text{S}/\text{cm}$  (PET) to 847  $\text{US}/\text{cm}$  (TUC) with (MII) and (CAR) falling between these values at 233  $\mu\text{S}/\text{cm}$  and 500  $\mu\text{S}/\text{cm}$  respectively. Sample specific conductivity values ranked PET < MII < CAR < TUC.

### **Metals (ICP-MS)**

#### ***Aluminum (Al)***

Aluminum concentrations ranged from 3.2  $\mu\text{g}/\text{L}$  (TUC) to 160  $\mu\text{g}/\text{L}$  (CAR). Other values were 4.9  $\mu\text{g}/\text{L}$  (PET) and 30  $\mu\text{g}/\text{L}$  (MII). The blank had an aluminum concentration of 1.6  $\mu\text{g}/\text{L}$ .

#### ***Arsenic (As)***

Arsenic was detected in only one sample. (PET) had a concentration of 9.0  $\mu\text{g}/\text{L}$ .

#### ***Cadmium (Cd)***

Cadmium was detected in all of the samples. Values ranged from 0.11  $\mu\text{g}/\text{L}$  (PET) to 460  $\mu\text{g}/\text{L}$  (CAR). Other values were 1.3  $\mu\text{g}/\text{L}$  (MII) and 310  $\mu\text{g}/\text{L}$  (TUC). The blank had a cadmium concentration of 0.04  $\mu\text{g}/\text{L}$ .

#### ***Cobalt (Co)***

Cobalt concentrations were 0.02  $\mu\text{g}/\text{L}$  (PET), 0.09  $\mu\text{g}/\text{L}$  (MII), 0.6  $\mu\text{g}/\text{L}$  (TUC),

and 24 µg/L (CAR). Cobalt was not detected in the blank.

### ***Chromium (Cr)***

Chromium was not detected in any of the samples or the blank.

### ***Copper (Cu)***

Copper values range from 2 µg/L at (MII) to 240 µg/L at (CAR). Values were 2.5 µg/L at (TUC) and 3.7 µg/L at (PET). Copper was not detected in the blank.

### ***Iron (Fe)***

(MII) had a total iron concentration of 51 µg/L. All other sites including the blank were found at < 50 µg/L which is the detection limit for iron by ICP-MS.

### ***Manganese (Mn)***

Concentrations of manganese ranged from 2.6 µg/L (PET) to 960 µg/L (CAR). Midrange values were 31 µg/L at (MII) and 650 µg/L at (TUC). Manganese concentration was 0.2 µg/L in the blank.

### ***Nickel (Ni)***

Nickel concentration was highest in leachate from the (CAR) site at 22 µg/L. Nickel concentrations from the other sites were 0.5 µg/L (PET), 0.8 µg/L (MII), and 5.6 µg/L at (TUC), Nickel was not detected in the Blank.

### ***Lead(Pb)***

Concentration of lead in the four composites ranged from 1.7 µg/L (PET) to 500 µg/L (CAR). (MII) had a lead concentration of 4.0 µg/L, and (TUC) 43 µg/L. The blank had a lead concentration of 0.5 µg/L.

### ***Zinc (Zn)***

Concentrations for zinc ranged from 3.6 µg/L (PET) to 17000 µg/L (CAR). Other values were 50 µg/L for (MII), and 9100 µg/L for the (TUC) composite. The blank had a zinc concentration of 18 µg/L.

### ***Sulfate (SO<sub>4</sub>)***

Sulfate concentration ranged from 3.9 ppm (PET) to 490 ppm (TUC). Concentrations for (CAR) and (MII) were 240 ppm and 90 ppm, respectively. Sulfate concentration in the Blank was 5.9 ppm.

### ***Alkalinity (CaCO<sub>3</sub>)***

Alkalinity values for these samples ranged from 19 mg/L CaCO<sub>3</sub> (CAR) to 51 mg/L CaCO<sub>3</sub> (PET). Values for the other two sites were 35 mg/L CaCO<sub>3</sub> (MII) and 41 mg/L CaCO<sub>3</sub> (TUC). The blank was not analyzed for alkalinity.

## Summary

Four mine-waste pile composite samples collected from historic mine sites in the summer of 1998 were leached using a modified version of E.P.A. Method 1312 (SPLP). Composite leachate pH values ranged from 5.39 to 8.82 and ranked in the following order: CAR < TUC < MII < PET. Specific conductance values for the samples ranged from 85  $\mu\text{S}/\text{cm}$  to 847  $\mu\text{S}/\text{cm}$  in the following order: PET < MII < CAR < TUC. For selected elements, the most severe leachate geochemical profile is produced by the CAR composite. Leachate derived from this material had the lowest pH, second-highest conductivity, and the highest concentrations of Pb, Zn, Ni, Mn, Cu, Cd, and Al. The most benign leachate geochemical profile was produced by the PET composite, which had the highest pH, lowest specific conductivity, and lowest concentrations of the metals listed above.

## References

- Blow, A. A., 1889, The geology and ore-deposits of Iron Hill, Leadville, Colorado: *in* Transactions of American Institute of Mining Engineers, v. 18. Pp. 145-181.
- Briggs, P.H., Fey, D.L., 1996, Twenty-four elements in natural and acid mine waters by inductively coupled plasma-atomic emission spectrometry, in, Arbogast, B.F., ed., Analytical methods manual for the Mineral Resources Program, U.S. Geological Survey Open-File Report 96-525, p. 95-102
- d'Angelo, W.M., Ficklin, W.H., 1996, Fluoride, chloride, nitrate, and sulfate in aqueous solution by chemically suppressed ion chromatography, in, Arbogast, B. F., ed., Analytical methods manual for the Mineral Resources Program, U.S. Geological Survey Open-File Report 96-525, p. 149-153
- Hageman, Philip L., Briggs, Paul H., 2000, A Simple Field Leach for Rapid Screening and Qualitative Characterization of Mine-Waste Dump Material on Abandoned Mine Lands. In Proceedings of the Fifth International Conference on Acid Rock Drainage, Denver, Colorado, May 21 — 24,2000, Society for Mining, Metallurgy, and Exploration, Inc. v. 2, p. 1463-1476
- Hedlund, D.C., 1977, Mineral Resources of the Hillsboro and San Lorenzo quad ranges, Sierra and Grant Counties, New Mexico: Miscellaneous Field Studies Map, MF-900-B.
- Hedlund, D.C., 1985, Economic geology of some selected mines in the Hillsboro and Lorenzo quadrangles, Grant and Sierra Counties, New Mexico: Open-File Report, 85-0456, p. 76.
- Lamothe, Paul J., Meier, Allen L., and Wilson, Stephen, 1999, The determination of forty-four elements in aqueous samples by inductively coupled plasma-mass spectrometry, U. S. Geological Survey Open-File Report 99-151.
- McLemore, Virginia T., 1993, Geology and Geochemistry of the Mineralization and Alteration in the Steeple Rock District, Grant County, New Mexico and Greenlee County, Arizona: Doctoral Thesis, University of Texas at El Paso, TX, United States.
- Smith, Kathleen S., Ramsey, Charles A., and Hageman, Philip L., 2000, Sampling Strategy for the Rapid Screening of Mine-Waste Dumps on Abandoned Mine Lands. In Proceedings of the Fifth International Conference on Acid Rock Drainage, Denver, Colorado, May 21-24, 2000, Society for Mining, Metallurgy, and Exploration, Inc. v. 2, p. 1453-1462

U.S. Environmental Protection Agency. 1994. Test method for evaluating solid Waste, physical/chemical methods (SW-846), 3<sup>rd</sup> edition, update 2B. Environmental Protection Agency, National Center for Environmental Publications, Cincinnati, OH 45268, telephone 800.553.6847, order #EPASW-846.3.2B. Accessed (8/1/99) at URL: <http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm>.

## **Appendices**

### **Appendix A. Quality Control Checks**

Table A-1. Performance Blank Analytical Results

Table A-2. WRD Reference Standard T-147 Results

Table A-3. Analytical Batch Duplicate Results

### **Appendix B. EPA Method 1312 (SPLP) Leachate Chemistry Data**

Table B-1. ICP-MS Results for All Samples

Table B-2 ICP-AES Screening Results for All Samples

## Quality Control Checks

All data generated from the laboratory was subject to quality control checks to provide information on the quality and usability of the data. The majority of the quality control procedures used were based on standard USGS QA/QC protocols. Known reference standards were submitted and analyzed with the samples. In addition, a preparation blank and an analytical batch duplicate were included with each analytical set.

### Performance Blanks

Performance blank analytical results (ICP-MS) are presented in Table A-1. As we have seen in other leach studies conducted as part of this project, filtration of leachate using borosilicate glass fiber filters have shown enhanced post-filtration concentrations of (Ba) and (Zn) (M. Montour, unpublished data). Consistent with this finding, the performance blank analyzed with this set of samples had post-filtration concentration of (Ba) at 27.0  $\mu\text{g/L}$ , and Zn at 18  $\mu\text{g/L}$ . Other elements that showed moderate increases were (Al) at 1.6  $\mu\text{g/L}$ , (Mn) 0.2 mg/L, and (Pb) at 0.5  $\mu\text{g/L}$ . All other elements were at or below detection limits.

### Reference Standard WRD T-147

Analytical results (ICP-MS) for T-147 are found in Table A-2. Almost all elements fell within the relative percent difference (RPD) control limits of 20%. Three elements exceeded the control limit: Al, Se, and Zn.

### Analytical Batch Duplicates

Analytical data (ICP-MS) for the batch duplicate can be found in Table A-3. Some elements (Be, Bi, Ta, Th, V, and Zr) with concentrations at or near their detection limit exceeded the relative percent difference (RPD) control limit of 20%. In addition to these elements, Er, Mo, and W exceeded the control limit. \* Indicates that a different pH meter was used for this sample.

**Table A-1 Performance Blank Analytical Results (metals by ICP-MS)**

	BLANK	
pH	pre-filter	4.33
SPEC. Cond. ( $\mu\text{S}/\text{cm}$ )	pre-filter	25
F(ppm)		<0.1
Cl (ppm)		<0.1
NO <sub>3</sub> (ppm)		<2
SO <sub>4</sub> (ppm)		5.9
Ag (ug/L)		<3
Al (ug/L)		1.6
As(un/U		<3
Ba(ug/L)		27
Be (ug/L)		<0.05
Bi (ug/L)		0.005
Ca (ug/L)		<0.05
Cd (ug/L)		0.04
Ce (ug/L)		<0.01
Co (ug/L)		<0.02
Cr (ug/L)		<1
Cs (ug/L)		< 0.01
Cu (ug/L)		<0.5
Dy (ug/L)		< 0.005
Er (ug/L)		< 0.005
Eu (ug/L)		< 0.005
Fe (ug/L)		<50
Ga (ug/L)		0.02
Gd(ug/L)		< 0.005
Ge (ug/L)		<0.02
Ho (ug/L)		< 0.005
K (mg/L)		<0.03
La (ug/L)		<0.01
Li (ug/L)		<0.1
Lu (ug/L)		<0.1
Mg (mg/L)		<0.01
Mn (mg/L)		0.2
Mo (ug/L)		<0.2
Na(mg/L)		0.02
Nb (ug/L)		<0.02
Nd (ug/L)		<0.01
Ni (ug/L)		<0.1
P (mg/L)		<0.01
Pb (ug/L)		0.5
Pr (ug/L)		<0.01
Rb (ug/L)		0.02
Sb (ug/L)		<0.1

Sc (ug/L)	<0.1
Se (ug/L)	<5
Si (mg/L)	<0.2
Sm (ug/L)	<0.01

Sr (ug/L)	<0.5
Ta (ug/L)	0.03
Tb (ug/L)	< 0.005
Th (ug/L)	< 0.005
Ti (ug/L)	<0.1
Tl (ug/L)	<0.05
Tm (ug/L)	< 0.005
U (ug/L)	< 0.005
V (ug/L)	<0.1
W (ug/L)	<0.02
Y (ug/L)	< 0.01
Yb (ug/L)	< 0.005
Zn (ug/L)	18
Zr (ug/L)	<0.05

**Table A-2 Reference Standard T147 - Relative Percent Difference (RPD)  
(metals by ICP-MS)**

Element/Units	ICP-MS (Det. Lim)	T-147	MPV	RPD
Ag ug/L	< 3	< 3	7.6	NA
Al ug/L	< 0.1	18.6	14	28.2
As ug/L	< 3	< 3	2.4	NA
Ba ug/L	< 0.1	78	73	6.6
Be ug/L	< 0.05	16.8	16	4.9
Ca mg/L	< 0.05	41	41	0.0
Cd ug/L	< 0.02	16.7	15.9	4.9
Cr ug/L	< 1	12.8	12.8	0.0
Cu ug/L	< 0.5	12.1	11.4	6.0
Fe ug/L	< .50	< 50	8.4	NA
K mg/L	< 0.03	3.5	3.5	0.0
Li ug/L	< 0.1	18.6	18	3.3
Mg mg/L	< 0.01	8.5	8.2	3.6
Mn ug/L	< 0.01	18.6	17.2	7.8
Mo ug/L	< 0.2	9.8	11.8	18.3
Ma mg/L	< 0.01	53.0	52.6	0.8
Hi ug/L	< 0.1	15.2	13.6	11.1
Pb ug/L	< 0.05	13.3	13.8	3.7
Sb ug/L	< 0.1	10.5	10.5	0.0
Se ug/L	< 5	13.5	10.1	28.8
Si mg/L	< 0.2	11.8	11.2	5.2
Sr ug/L	< 0.5	.320	310	3.2
Tl ug/L	< 0.05	18.4	20	8.3
U ug/L	< 0.005	3.2	3.2	0.0
V ug/L	< 0.1	16.4	15.2	7.6
Zn ug/L	< 0.5	18.1	14	25.5

MPV = Most Probable Value

RPD = Relative Percent Difference

**Table A-3 Analytical Batch Duplicates - Relative Percent Difference (RPD)  
(metals by ICP-MS)**

	CAR	CARDUP.	RPD
pH pre-filter	5.45	5.85*	7.1
SpecCond.(µS/cm) pre-filter	500	484	3.3
Alkalinity, CaCO3 (mg/L)	19	20	5.1
F (ppm)	1	1	0.0
Cl (ppm)	<0.1	<0.1	ND
SO <sub>4</sub> (ppm)	240	230	4.3
NO <sub>3</sub> (ppm)	26	1.5	53.7
Ag (ug/L)	<3	<3	NO
Al (ug/L)	160	160	0.0
As (ug/L)	<3	<3	ND
Ba (ug/L)	62	55	120
Be (Ug/L)	0.1	02	66.7
Bi (ug/L)	0.02	0.01	66.7
Ca (mg/L)	82	80	25
Cd (ug/L)	460	460	0.0
Ce (ug/L)	3.6	3.7	27
Co (ug/L)	24	24	0.0
Cr (ug/L)	<1	<1	ND
Cs (ug/L)	0.4	0.4	0.0
Cu (ug/L)	240	240	0.0
Dy (ug/L)	0.39	0.35	10.8
Er (ug/L)	0.15	0.19	23.5
Eu (ug/L)	0.13	0.15	14.3
Fe (ug/L)	<50	<50	ND
Ga (ug/L)	0.51	0.5	20
Gd (ug/L)	0.56	0.61	8.5
Ge (ug/L)	0.04	<.02	NA
Ho (ug/L)	0.07	0.08	13.3
K (mg/L)	2.4	25	4.1
La (ug/L)	20	1.9	5.1
Li (ug/L)	6.1	6	1.7
Lu (ug/L)	<0.1	<0.1	ND
Mg (mg/L)	6.1	6	1.7
Mn (ug/L)	960	980	0.0
Mo (ug/L)	26	0.86	100.6
Na (mg/L)	029	029	0.0
Nb (ug/L)	0.06	0.05	182
Nd (ug/L)	22	22	0.0
Ni (ug/L)	22	22	0.0
P(mg/L)	<0.01	<0.01	ND
Pb (ug/L)	500	580	14.8

Pr (ug/L)	0.48	0.5	4.1
Rb (ug/L)	13	13	0.0
Sb (ug/L)	0.24	02	182
Sc (ug/L)	0.3	0.3	0.0
Se (ug/L)	<5	<5	ND
Si (mg/L)	1.5	1.5	0.0
Sm (ug/L)	0.44	0.47	6.6

	CAR	CARDUP	RPD
Sr (ug/L)	150	150	0.0
Ta (ug/L)	0.09	0.07	25.0
	0.08	0.09	11.8
Th (ug/L)	0.04	0.03	28.6
Ti (ug/L)	4.1	3.9	5.0
Tl (ug/L)	<0.05	<0.05	ND
Tm (ug/L)	0.02	0.02	0.0
U (ug/L)	0.009	0.01	10.5
V (ug/L)	020	0.10	66.7
W (ug/L)	4.70	1.7	93.8
Y (ug/L)	3.0	3.1	3.3
Yb (ug/L)	0.07	0.06	15.4
Zn (ug/L)	17000	17000	0.0
Zr (ug/L)	0.10	0.07	35.3

## **Appendix B-1 Leachate Chemistry Data for All Sites (ICP-MS)**

		PET	CAR	CARDup.	MII	TUC	Blank
pH	pre-filter	8.84	5.45	5.85*	8.55	6.99	4.33
Spec. Cond. ( $\mu$ S/cm)	pre-filter	85	500	484	233	847	25
Alkalinity, CaCO <sub>3</sub> (mg/L)		51	19	20	35	41	NA
F ppm		0.2	1	1	0.2	0.2	<0.1
Cl ppm		<0.1	<0.1	<0.1	0.2	0.2	<0.1
SO <sub>4</sub> ppm		3.9	240	230	90	490	5.9
NO <sub>3</sub> ppm		1.2	2.6	1.5	. nm	nm	<2
Ag ug/L		<3	<3	<3	<3	<3	<3
Al ug/L		4.9	160	160	30	3.2	1.6
As ug/L		9	<3	<3	<3	<3	<3
Ba ug/L		73	62	55	100	80	27
Be ug/L		<0.05	0.1	0.2	<0.05	<0.05	<0.05
Bi ug/L		0.09	0.02	0.01	< 0.005	< 0.005	0.005
Ca mg/L		12	82	80	34	160	<0.05
Cd ug/L		0.11	460	460	1.3	310	0.04
Ce ug/L		<0.01	3.6	3.7	0.1	0.04	<0.01
Co ug/L		0.02	24	24	0.09	0.6	<0.02
Cr ug/L		<1	<1	<1	<1	<1	<1
Cs ug/L		<0.01	0.4	0.41	0.03	0.06	<0.01
Cu ug/L		3.7	240	240	2	2.5	<0.5
Dy ug/L		< 0.005	0.39	0.35	0.02	0.006	<0.005
Er ug/L		< 0.005	0.15	0.19	<0.005	< 0.005	< 0.005
Eu ug/L		0.007	0.13	0.15	0.02	0.01	< 0.005
Fe ug/L		<50	<50	<50	51	<50	<50
Ga ug/L		<0.02	0.51	0.5	<0.02	<0.02	0.02
Gd ug/L		< 0.005	0.56	0.61	0.02	0.01	< 0.005
Ge ug/L		<0.02	0.04	<0.02	0.02	0.04	<0.02
Ho (ug/L)		< 0.005	0.069	0.083	< 0.005	< 0.005	< 0.005
K mg/L		2.5	2.4	2.5	2.4	2.7	<0.03
La (ug/L)		<0.01	2	1.9	0.06	0.07	<0.01
Li (ug/L)		<0.1	6.1	6	1.4	1.3	<0.1
Lu ug/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Mg mg/L		2.3	6.1	6	6.8	19	<0.01
Mn (ug/L)		2.6	960	960	31	650	0.2
Mo (ug/L)		63	2.6	0.86	1.6	0.27	<0.2
Na (mg/L)		0.11	0.29	0.29	0.94	1.1	0.02
Nb (ug/L)		0.08	0.06	0.05	<0.02	<0.02	<0.02
Nd (ug/L)		<0.01	2.2	2.2	0.06	0.03	<0.01

Ni (ug/L)	0.5	22	22	0.8	5.6	<0.1
P mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pb ug/L	1.7	500	580	4	43	0.5
Pr (ug/L)	<0.01	0.48	0.5	0.01	<0.01	<0.01
Rb (ug/L)	1.2	13	13	0.62	1.5	0.02
Sb (ug/L)	0.44	0.24	0.2	0.2	<0.1	<0.1
Sc (ug/L)	0.4	0.3	0.3	<0.1	0.8	<0.1
Se (ug/L)	<5	<5	<5	<5	<5	<5
Si (mg/L)	4.1	1.6	1.6	1.9	2.8	<0.2
Sm (ug/L)	<0.01	0.44	0.47	0.02	0.01	<0.01
Sr (ug/L)	32	150	150	54.3	120	<0.5
Ta (ug/L)	0.08	0.09	0.07	<0.02	<0.02	0.03
Tb (ug/L)	< 0.005	0.081	0.087	< 0.005	< 0.005	< 0.005
Th (ug/L)	0.02	0.04	0.03	0.06	0.02	< 0.005
Ti ug/L	0.5	4.1	3.9	1.3	6.3	<0.1
Tl (ug/L)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Tm (ug/L)	< 0.005	0.02	0.02	< 0.005	< 0.005	< 0.005
U ug/L	0.08	0.009	0.010	0.08	0.08	< 0.005
V ug/L	0.5	0.2	0.1	0.20	<0.1	<0.1
W ug/L	49	4.7	1.7	0.20	0.20	<0.02
Y ug/L	<0.01	3.0	3.1	0.07	0.06	<0.01
Yb ug/L	< 0.005	0.07	0.08	< 0.005	0.009	< 0.005
Zn ug/L	3.6	17000	17000	50	9100	18
Zr ug/L	0.09	0.1	0.07	0.07	<0.05	<0.05

**Table B-2 Leachate Chemistry Data (ICP-AES) for All Sites**

	PET 1312	CAR 1312	CAR 1312 Dup.	MII 1312	TUC 1312	Blank
Al ppm	<0.01	0.14	0.14	0.01	<0.01	<0.01
Ag ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
As ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
B ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ba ppm	0.07	0.06	0.05	0.09	0.07	0.03
Be ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Bi ppm	–	–	–	–	–	–
Ca ppm	11	75	71	31	130	<0.1
Cd ppm	<0.01	0.44	0.44	<0.01	0.29	<0.01
Ce ppm	–	–	–	–	–	–
Co ppm	<0.01	0.02	0.02	<0.01	<0.01	<0.01
Cr ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cu ppm	<0.01	0.23	0.23	<0.01	<0.01	<0.01
Fe ppm	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
K ppm	2.3	2.2	2.2	2.3	2.5	<0.5
La ppm	–	–	–	–	–	–
Li ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mg ppm	2.1	5.8	5.6	6.0	17	<0.1
Mn ppm	<0.01	0.98	0.96	<0.01	0.60	<0.01
Mo ppm	0.06	<0.04	<0.04	<0.04	<0.04	<0.04
Na ppm	<0.1	0.28	0.27	0.86	1.0	<0.1
Ni ppm	<0.01	0.02	0.02	<0.01	<0.01	<0.01
P ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pb ppm	<0.08	0.56	0.67	<0.08	<0.08	<0.08
Sb ppm	–	–	–	–	–	–
Si ppm	3.6	1.5	1.5	1.8	2.5	<0.5
Sn ppm	–	–	–	–	–	–
Sr ppm	0.03	0.13	0.13	0.05	0.11	<0.01
Th ppm	–	–	–	v	–	–
Ti ppm	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
V ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
W ppm	–	–	–	–	–	–
Y ppm	–	–	–	–	–	–
Zn ppm	<0.01	18	18	0.04	9.0	0.02
Zr ppm	–	–	–	–	–	–