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Temporal Chemical Data for Sediment, Water, and Biological Samples from the Lava Cap Mine Superfund Site, Nevada County, California—2006–2008

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Cover photographs. *Left:* Green and tan microbial streamers in mine adit drainage (LCD-1), Lava Cap Mine, June 2006. *Middle:* Bloom of iron-oxidizing bacteria in pond, tailings deposition area (LL2), February 2007. *Right:* Close-up of iron-oxidizing bacterial colony developed in seep below Lost Lake dam (LL1), June 2006. All photo credits: Andrea L. Foster.

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Temporal Chemical Data for Sediment, Water, and Biological Samples from the Lava Cap Mine Superfund Site, Nevada County, California—2006-2008.

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Background

Mining History and Events Leading to Placement on the National Priority (Superfund) List

The Lava Cap Mine is located about 6 km east of the city of Grass Valley, Nevada County, California, at an elevation of about 900 m (fig. 1). Gold was hosted in quartz-carbonate veins typical of the Sierran Gold Belt, but the gold grain size was smaller and the abundance of sulfide minerals higher than in typical deposits. The vein system was discovered in 1860, but production was sporadic until the 1930s when two smaller operations on the site were consolidated, a flotation mill was built, and a 100-foot deep adit was driven to facilitate drainage and removal of water from the mine workings, which extended to 366 m (Ash, 1941; Chandler, 1941). Peak production at the Lava Cap occurred between 1934 and 1943, when about 90,000 tons of ore per year were processed (Clark, 1970). To facilitate removal of the gold and accessory sulfide minerals, the ore was crushed to a very fine sand or silt grain size for processing. Mining operations at Lava Cap ceased in June 1943 due to War Production Board Order L-208 and did not resume after the end of World War II.

Two tailings retention structures were built at the Lava Cap Mine. The first was a log dam located about 0.4 km below the flotation mill on Little Clipper Creek, and the second, built in 1938, was a larger earth fill and rip-rap structure constructed about 2 km downstream, which formed the water body now called Lost Lake (fig. 1), (Ash, 1941; Chandler, 1941). The log dam failed during a storm that began on December 31, 1996, and continued into January 1997; an estimated 8,000-10,000 m^3 of tailings were released into Little Clipper Creek during this event. Most of the fine tailings were deposited in Lost Lake, dramatically increasing its turbidity and resulting in a temporary 1-1.5 m rise in lake level due to debris blocking the dam spillway. When the blockage was cleared, the lake level quickly lowered, leaving a “bathtub ring” of very fine tailings deposited substantially above the water line. The U.S. Environmental Protection Agency (EPA) initiated emergency action in late 1997 at the mine site to reduce the possibility of future movement of tailings, and began an assessment of the risks posed by physical and chemical hazards at the site.

The EPA’s assessment identified arsenic (As) as the primary hazard of concern. Three main exposure routes were identified: inhalation/ingestion of mine tailings, dermal absorption/ingestion of As

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in lake water from swimming, and ingestion of As-contaminated ground water or surface water (EPA, 2001). Lost Lake is a private lake which is completely surrounded by low-density residential development. Prior to the dam failure, the lake was used by the local residents for swimming and boating (Lee and Jones-Lee, 2003). An estimated 1,776 people reside within one mile of the lake, and almost all residents of the area use potable groundwater for domestic use (EPA, 2001). Risk factors for human exposure to As derived from mine wastes were high enough to merit placement of the mine site and surrounding area on the National Priority List (commonly called "Superfund"; EPA, 2001).

Figure 1 shows that the Lava Cap Mine Superfund site (LCMS) encompasses approximately 33 acres that include the mine site, the stretch of Little Clipper Creek between the mine and Lost Lake, the lake itself, and the area between the lake and the confluence of Little Clipper Creek with its parent stream, Clipper Creek (EPA, 2001). The area between the two creeks is named the "deposition area" due to the estimated 24 m thick layer of tailings that were laid down there during and after active mining (D. Towell, personal commun. June 2008). The lobate structure of Lost Lake is also due to deposition in this area (EPA, 2001). The deposition area and Lost Lake are together estimated to contain 382,277 m^3 of tailings (EPA, 2001).

The primary goals of the EPA have been to minimize tailings movement downstream of Lost Lake and to ensure that residents in the area have drinking water that meets national water quality standards. EPA has officially decided to construct a public water supply line to deliver safe water to affected residences (EPA, 2001), since some residential wells in the area have As concentrations above the current drinking water standard (10 ppb). However, some deeper monitoring wells in the deposition area have As concentrations that are as much as 100 times the As drinking water standard (EPA, 2001). Fracture-dominated groundwater flowpaths complicate measurement of the rate and direction of groundwater flow in the area. Investigations of groundwater movement at the LCMS are planned by the EPA, but have not been undertaken at the time of this writing.

Remediation Studies

Between 1996 and 2000, members of the USGS Mineral Resources Team worked with the California Department of Toxic Substances Control to characterize the degree to which the catastrophic log-dam failure and mine-tailings release affected downstream waterways (specifically Little Clipper Creek and Lost Lake) in terms of (1) metals loading to sediments and waters, and (2) the extent of As transformation from forms in sulfide minerals originally in the tailings to labile and oxidized forms (Foster and others, in press). During the course of this research, the investigators discovered that macroscopic microbial communities growing in tailings-impacted ponds and waterways scavenged As from water and accumulated it in biomass at concentrations greater than the original tailings material (5,000-10,000 mg/kg dry weight in microbial biomass relative to approximately 600 mg/kg As in Lava Cap tailings; Foster and Ashley, 2002). The EPA took interest in this work and, beginning in 2006, funded the USGS to identify members of these communities, obtain comprehensive data on As uptake by these communities, and to determine if the arsenic attenuation performed by indigenous microorganisms could used to complement other remediation technologies under consideration.

The indigenous microbial communities at the Lava Cap/Lost Lake site already meet several criteria for consideration as a passive bioremediation strategy. First, they are inherently optimized for growth at the site, and appear to be ubiquitous throughout the area. Second, in addition to sequestering As, they also remove large amounts of iron (Fe) and manganese (Mn) from waters. The latter two elements are of concern, because their concentration in adit water (which is already elevated) will be increased if a proposed zero-valent-iron treatment plant is the adopted solution for the removal of arsenic from mine-adit water. EPA has not yet finalized their strategy for treating adit water, but a final

remedy and design plan is anticipated by Spring 2010 (EPA, 2005). Third, the dried, arsenic-rich biomass occupies about 10 percent of the volume of the living biomass, which would presumably lower disposal costs.

Two morphotypes of microbial communities have been observed in the LCMS study area. Green algal or cyanobacterial slimes anchor to rocks in shallow drainages and float on the surface of ponds and of Lost Lake. Green slimes do not accumulate arsenic to very high concentrations (≤ 500 mg/kg) unless a significant amount of iron (hydr)oxide is entrained within the slime (Foster and others, in press). Orange-to-dark brown, weakly aggregated, biogenic iron (hydr)oxide-rich flocs are ubiquitous in the LCMS. They form massive colonies dominated by iron-oxidizing bacteria of the *Leptothrix* genus in near-neutral, slow-running reaches of creeks, at the sediment-water interface in ponds and streams, and as floating masses within aquatic plants. These colonies are most extensive in the drainage formed by water seeping out of the intact Lost Lake dam. They line the drainage for nearly 100 m, until it joins with lake water spilling over the dam. A passive bioreactor based on the Fe- and Mn-oxidizing, As-sequestering, *Leptothrix*-dominated microbial community would require low capital outlay, low maintenance, and low reagent costs because the waters in which these flocs form are primarily oligotrophic.

This report is a compilation of water and sediment chemical data generated by the 2006-2009 USGS study of indigenous, arsenic-sequestering microbial communities at the LCMS. Between June 2006 and March 2008 a total of 9 synoptic sampling efforts were conducted at specific sites (table 1). Each event consisted of the collection of basic water-chemistry parameters (pH, temperature, specific conductivity, oxidation/reduction potential (ORP), and dissolved oxygen), total or dissolved organic carbon, dissolved Fe^{2+}, alkalinity, filtered and unfiltered trace metals, and total arsenic. Most events also included the collection of data for dissolved arsenic species in waters. Where observed, samples of microbial mats were collected for subsequent chemical and genetic analyses; this report contains only the former. A field blank (ultrapure water) was processed in the field during all but one of the site visits in order to assess background concentrations of the measured constituents.

Samples were sent to the USGS Mineral Resources Program Central Region Analytical Laboratories (Denver, CO) for chemical analysis. Some analyses were completed in-house, and others were performed at SGS Minerals, the current contract laboratory for the USGS. Details of the QA/QC procedures followed for in-house analyses have been published and are referenced in the chapters to follow. The following provides an overview of SGS Minerals' QA/QC procedures for USGS samples. Analytical accuracy was measured by analysis of a reagent blank and a reference sample with every batch of 20 samples. Analytical and sample variance was measured by analysis of duplicate samples at the end of each sample set. USGS in-house reference samples were submitted to SGS along with samples at the rate of 10 percent. The returned data for the USGS reference samples were required to fall within the range of acceptance, which varied between ± 5 percent to ± 20 percent depending on the analytical method. The tabulated data in this report is not accompanied by a significant level of data interpretation because an interpretative article is planned for publication in the peer-reviewed scientific literature. The raw data are presented so that stakeholders (EPA and their contractors, the public, and other interested parties) can have the earliest possible access to the data.

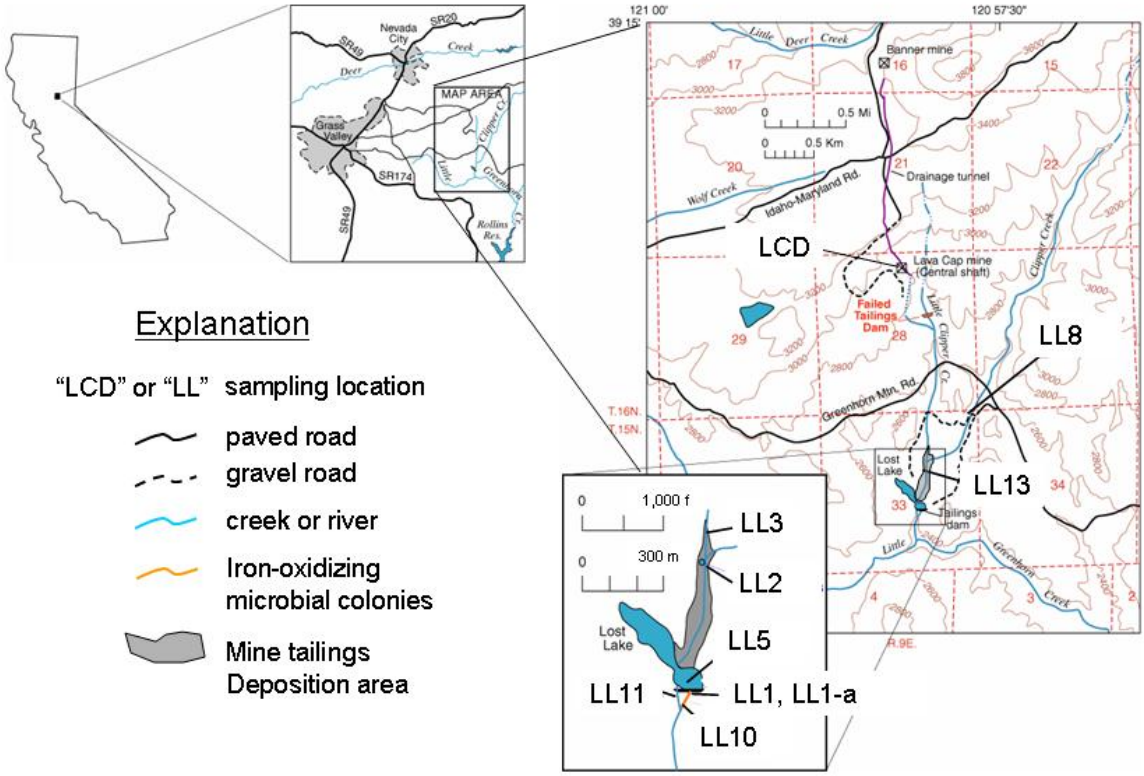

Figure 1. Regional to site level overview of the Lava Cap Mine Superfund site, Nevada County, California. An estimated 10,000 m^3 of tailings were released into Little Clipper Creek due to failure of a tailings dam (red polygon) located near the mine. Most of this material settled in the "deposition area" (gray shading) and in Lost Lake, a second tailings retention structure which already contained an estimated 382,277 m^3 of tailings deposited during the active mining period. Interaction of water with tailings produces conditions conducive to the growth of iron-oxidizing microbial communities; these are most extensively developed in water seeping out below the Lost Lake dam (brown line in inset) Sampling locations for the chemical data included in this report are indicated by the "LL" and "LCD" notation. Modified from (Foster and Ashley, 2002).

Table 1. Locations and descriptions of USGS sampling sites at the Lava Cap Mine Superfund site, Nevada County, California.

Sample Site	Latitude[1]	Longitude[2]	Site Description
LL1	39.286667	-120.992778	Seep at outflow point under intact rip-rap dam that forms Lost Lake
LL1a	39.286667	-120.992778	Perpetually saturated (spring-fed and/or dam-leakage fed?) pool of dark brown, biogenic iron (hydr)oxide 1-2 m from shallow drainage formed by LL1 seep water
LL2	39.369444	-120.978889	Surface water from shallow (3 -5 m depth) pond in tailings delta, Thurber property
LL3	39.370833	-120.976944	Little Clipper Creek, approximately 2 m upstream of its confluence with Clipper Creek
LL5	39.295278	-120.991944	South lobe of Lost Lake, on Giles' property
LL8	39.441667	-121.146111	Background site. Clipper Creek surface water, collected approximately 1 m upstream of bridge at Raccoon Mountain Road
LL10	39.286667	-120.992778	Dam seepage water approximately 3-5 m upstream of confluence with dam spillway water
LL11	39.286667	-120.992778	Dam spillway water just above confluence with dam seepage water
LL13	39.366111	-120.975833	2 m downstream of confluence with Little Clipper Creek
LCD1	39.227060	-120.968880	Mine adit drainage

[1]Horizontal coordinate information is referenced to "North American Datum of 1927 (NAD 27).
[2†]Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NAVD 29).

Basic Water-Quality Parameters

The standard water-quality parameters of pH, temperature, dissolved oxygen, ORP, and conductivity were measured simultaneously using a HYDROLAB Minisonde 4a multiprobe connected to a HYDROLAB Surveyor interface by immersing the multiprobe in the water of interest and waiting 1-3 minutes until the reading stabilized (table 2). The internal circulator was not used during measurement. Calibrations were performed in the laboratory the day before planned field measurements, since the Hydrolab calibrations are typically stable for several days. Two-point pH calibration was performed using pH 4 and pH 7 buffers purchased from a chemical supplier. Two-point ORP calibration was performed using quinhydrone-saturated pH 4 and pH7 buffer solutions as described in the HYDROLAB manual (www.hydrolab.com). Two-point conductivity calibration was performed using deionized water as the "0" point and a 500 μS standard potassium chloride reference solution purchased from a chemical supplier. The dissolved oxygen probe was calibrated using tap water equilibrated with laboratory air and referenced to the barometric pressure of 760 mm Hg. Accuracy of the temperature probe was not determined.

Water-quality parameters were not collected in the field during the December 2006 sampling due to failure of the HYDROLAB Surveyor battery.

Table 2. Water-quality field parameters by site, all sampling dates.

[PW, pore water; n.d., not determined, n/a, not applicable]

	Collection date	Time	pH	Temperature	O_2	ORP	Conductivity
Unit	n/a	24 hour	-log[H+]	Degrees Celsius	mg/l	mV	µSiemens
parameter range	n/a	n/a	0 to 14	-5 to 50	0 to 50	-999 to 999	0 to 1 E+5
parameter accuracy ±	n/a	n/a	0.2	0.1	0.2 at < 20 mg/l	20	1 percent of reading
LL8	**Clipper Creek downstream of bridge at Raccoon Mtn Rd (background site)**						
606LL8	6/15/2006	1000	7.1	11.4	9.2	339	32.1
1006LL8	10/7/2006	1745	6.5	13.8	6.1	362	34.1
1106LL8	11/4/2006	1130	6.2	11.4	7.5	n.d	33.2
207LL8	2/3/2007	1300	6.9	5.2	10.3	238	32.6
307LL8	3/31/2007	1045	7.3	8.4	10.1	312	32.6
807LL8	8/10/2007	1530	6.4	17.9	1.9	436	44.8
1007LL8	10/20/2007	1130	6.7	11.3	5.3	389	40.7
308LL8	3/31/2008	1800	6.0	8.2	7.5	361	34.8
LL1	**Lost Lake dam seep-fed drainage**						
060LL1a	6/15/2006	1100	6.5	12.0	1.2	73	180.5
606LL1b	6/15/2006	1300	6.6	12.5	6.1	202	156.4
1006LL1c	10/7/2006	1400	6.2	13.6	0.9	8.2	189.5
1006LL1d	10/7/2006	1500	6.3	13.9	0.2	313	176.5
1106LL1	11/4/2006	1600	6.3	13.3	1.2	178	192.1
207LL1	2/3/2007	1000	6.7	11.9	1.0	170	193.1
207LL1core	2/3/2007	1130	7.6	n.d.	0.3	3.0	191.4
307LL1	3/31/2007	1330	6.9	11.4	5.3	150	139.1
307LL1PW	3/31/2007	1345	n.d	n.d.	n.d.	n.d.	n.d.
807LL1	8/10/2007	1700	6.3	13.8	1.9	216	187.9
1007LL1	10/20/2007	1615	6.9	13.2	0.7	189	219.7
308LL1	3/31/2008	1700	5.7	11.5	0.9	258	197.0
LL1 adjacent	**Shallow pool adjacent to main seep-fed drainage**						
207LL1a core1	2/3/2007	1130	7.6	n.d.	0.3	40	205.9
207LL1a	2/3/2007	1130	7.1	10.1	0.3	136	98.4
307LLIb	3/31/2007	1345	6.7	11.4	3.7	277	100.0
807LLIadj	8/10/2007	1722	6.4	15.6	2.4	262	98.4
1007LLIa	10/20/2007	1630	7.2	13.1	0.1	153	158.7
308LLIa	3/31/2008	1600	7.2	11.2	1.4	259	135.3
LL10	**Seep-fed drainage just before its confluence with spillway water**						
1006LL10	10/7/2006	1530	6.9	13.7	8.0	177	166.4
1106LL10	11/4/2006	1700	6.6	13.2	6.8	190	181.3
207LL10	2/3/2007	1030	7.1	11.0	7.3	206	173.4
307LL10	3/31/2007	1300	7.4	11.1	8.2	152	126.8
807LL10	8/10/2007	1745	6.8	14.0	6.4	191	177.9
1007LL10	10/20/2007	1515	7.5	12.8	4.8	183	117.5
LL11	**Spillway drainage before its confluence with seep-fed drainage**						
807LL11	8/10/2007	1715	6.4	16.4	.2	201	167.7
1007LL11	10/20/2007	1555	6.9	12.2	1.6	235	190.2
LL5	**Lost Lake, south lobe**						
1005LL5	10/7/2006	1205	7.3	15.6	7.2	212	215.1
308LL5	4/1/2008	1430	6.6	8.56	6.5	296	79.7

Table 2. Water-quality field parameters by site, all sampling dates.—Continued

[PW, pore water; n.d., not determined, n/a, not applicable]

	Collection date	Time	pH	Temperature	O_2	ORP	Conductivity
LL2	**Pond in tailings at the confluence of Clipper and Little Clipper Creeks (Frog Pond)**						
606LL2	6/14/2006	1600	7.1	14.9	4.2	172	355.2
1006LL2	10/7/2006	1600	7.2	12.9	3.0	216	431.2
1106LL2	11/4/2006	1345	6.9	8.4	1.2	133	461.4
1106LL2PW	11/4/2006	1345	n.d	n.d.	n.d.	n.d.	n.d.
207LL2	2/3/2007	1330	6.8	5.3	4.6	189	394
307LL2	3/31/2007	1612	8.1	15.6	3.7	140	393.9
807LL2	8/10/2007	1230	7.1	17.6	4.6	163	404
1007LL2	10/20/2007	1230	7.6	10.9	1.2	160	446.3
308LL2	3/31/2008	1700	6.8	13.1	6.1	289	417.5
LL3	**Little Clipper Creek before its confluence with Clipper Creek**						
807LL3	8/10/2007	1500	6.8	15.6	4.1	213	239.6
1007LL3	10/20/2007	1300	7.6	11.1	4.6	192	286.7
308LL3	4/1/2008	1730	6.7	8.2	7.0	265	185.3
LL13	**Clipper Creek below its confluence with Little Clipper Creek**						
1106 LL13	11/4/2006	1345	6.7	11.7	6.0	222	202
807LL13	8/10/2007	1544	6.8	15.6	4.1	n.d.	239.6
1007LL13	10/20/2007	1335	7.1	11.9	4.7	251	135.7
308LL13	4/1/2008	1745	6.3	7.6	7.7	285	75.4
LCD1	**Water emanating from flooded mine workings (mine adit)**						
606LCD-1	6/15/2006	1230	7.3	14.7	3.3	210	394.3

Major and Trace Elements in Water

Major and trace element concentrations in water samples were determined in the USGS Mineral Resources Program (Denver, CO) laboratories by using inductively coupled plasma-mass spectrometry (ICP-MS). Fifty-five elements were determined, except for the November 2006 samples, for which only 42 elements were determined. The methods used (including description of standards, 3 and 5 σ detection limits, correction factors, common interferences, calibrants, and QA/QC procedures) are described in USGS Open File Report 02-0223, Chapters H and K (Taggart, 2002). After collection of water in a 1 L acid-washed bottle, a 60 ml syringe was used to transfer unfiltered or filtered (0.45 μm) water samples to 4 oz (125 ml) acid-washed, screw-cap polyethylene (PE) bottles (USGS, Ocala Labs, FL). Both filtered and unfiltered samples were immediately acidified with 7.7 M ultrapure nitric acid to lower the pH below 2. The bottles were then filled to overflow and capped to have minimal headspace.

Although analyzed, several trace elements are not reported herein because they were either 1) not detected in any sample above the lower limit of determination (LOD; defined here as 5 times the standard deviation of the measured average blank), or 2) were detected only at very low levels (<10 percent above LOD). These elements are: Be, Bi, Ce, Cs, Dy, Er, Eu, Ga, Gd, Ge, Ho, La, Li, Lu, Nb, Nd, Rb, Sc, Sm, Ta, Tb, Th, Tl, Tm, Yb, and Zr. Tables 3 and 4 list the major elements in filtered and unfiltered water samples, respectively. Tables 5 and 6 list the reported trace elements in filtered and unfiltered water samples, respectively.

Dissolved ferrous iron was determined in the USGS Mineral Resources Program laboratories (Denver, CO) by colorimetry. The method (including standards, 3 and 5 σ detection limits, correction

factors, common interferences, calibrants, and QA/QC procedures) is described in USGS Open File Report 02-0223, Chapter W (Taggart, 2002). After collection of water in a 1 L acid-washed bottle, a 60 ml syringe with attached filter (0.45 μm) was used to transfer each sample to a 60 ml amber screw-cap PE bottle. After bottles were filled approximately halfway, 20 drops of ultrapure hydrochloric acid (37-38%) was added to lower pH below 2. Each bottle was then filled to the brim with filtered sample and capped in a manner that minimized headspace. Dissolved ferrous-iron concentrations are listed in table 3, along with the ICP-MS iron data for comparison.

Total arsenic and the inorganic arsenic oxyanions [arsenate (As(V)) and arsenite (As(III))] were determined using hydride-generation atomic absorption spectrophotometry (HGAAS) by Brooks Rand, Inc. (October, 2006 only) or by the USGS Mineral Resources Program laboratories in Denver, CO (all other dates). The collection method for total arsenic was as follows: a 60 ml syringe with attached filter (0.45 μm) was used to transfer filtered water to a 60 ml screw-cap PE bottle. After bottles were filled approximately halfway, 20 drops ultrapure hydrochloric acid (37-38%) was added to lower pH below 2 and to preserve the species distribution. The bottle was then filled to the brim with filtered sample and capped in a manner that minimized headspace.

Brooks Rand, Inc., laboratories used HGAAS with cryogenic trap precollection (EPA 1632 draft method) to determine total arsenic and As(III). Dissolved As(V) concentrations were calculated by computing the difference between the total arsenic and the As(III) concentrations. The Brooks Rand practical quantitation limit (the lowest level reliably achieved within lab-specific limits of precision and accuracy) for the October 2006 samples was 0.025 μg/l for As(III) and for total inorganic As.

At the USGS laboratories, HGAAS without cryotrapping was used for quantification of total arsenic and the oxyanion species; standards, 3 and 5 σ detection limits, correction factors, common interferences, standards, and QA/QC procedures are described in USGS Open File Report 02-0223, Chapter W (Taggart, 2002). Total arsenic, As(V), and As(III) were determined separately for the samples analyzed by the USGS (all samples after Oct. 2006), with the result that the sum of As(III) and As(V) species is not exactly equivalent to the total As determination. The USGS method detection limit was 2 μg/l for As(III), As(V), and for total As.

Arsenate and arsenite species were separated in the field for all samples collected after October 2006. Arsenic speciation was achieved by passing a 0.45 μm-filtered water sample through prepacked chromatography columns conditioned with methanol immediately prior to use as described in USGS Water Resources Investigation Report 2002-4144 (Garabino and others, 2002). The 10 ml elutriate containing As(III) (which is not retained by the column material) was preserved by adding sodium EDTA to a final concentration of 2.5 micromolar. Upon return to the lab (typically within 24 hrs), arsenate was eluted by passing 10 ml of 0.16 M HNO_3 through the column.

Total arsenic, arsenite, and arsenate values determined by all techniques are reported in table 7. Samples for which As speciation was determined by field chromatography show an average of 16% disagreement between the total As value and the sum of As(III) and As(V) species; the total As value is higher in almost all cases. Inefficient recovery of As(V) from the columns is the most likely explanation, but unanalyzed arsenic species may also contribute to the discrepancy (particularly for Lake and pond samples with high dissolved organic carbon). Previous unpublished work on As species in Lost Lake determined that organoarsenic species constituted as much as 4% of the total arsenic in that waterbody (R. Ashley, personal commun., Aug 1999).

Table 3. Major elements in filtered (0.45 micron) water samples as determined by inductively coupled plasma mass spectrometry (ICP-MS) or inductively coupled plasma atomic emission spectrometry (ICP-AES; November 2006 samples only) and colorimetry [ferrous iron (Fe^{2+})].

[PW, pore water; n.a., not analyzed]

	Al µg/L	Ca mg/L	Fe µg/L	Fe^{2+} µg/L	K mg/L	Mg mg/L	Mn µg/L	Na mg/L	P mg/L	SiO_2 mg/L
Field Blanks										
606FB	<2	<0.2	<50	20	<0.03	<0.01	<0.2	<0.01	<0.01	<0.2
1006FB	<2	<0.2	<50	280	<0.03	<0.01	<0.2	<0.01	<0.01	<0.2
1106FB	<2	<0.2	<50	<10	<0.03	<0.01	<0.2	0.50	<0.01	<0.2
1206FB	<2	<0.2	<50	<10	<0.03	<0.01	0.3	<0.01	<0.01	<0.2
207FB	8	<0.2	<50	<10	<0.03	<0.01	0.6	0.03	<0.01	<0.2
307FB	<2	<0.2	<50	390	<0.03	<0.01	0.2	<0.01	<0.01	<0.2
807FB	<2	<0.2	<50	40	<0.03	<0.01	<0.2	<0.01	<0.01	<0.2
1007FB	<2	<0.2	<50	<10	<0.03	<0.01	<0.2	<0.01	<0.01	<0.2
308FB	<2	<0.2	<50	20	<0.03	<0.01	<0.2	<0.01	<0.01	<0.2
LL8										
606LL8	4	3.2	<50	1320	0.47	1.07	0.7	1.76	<0.01	12.0
1006LL8	<2	3.0	<50	330	0.48	1.01	5.1	1.96	<0.01	11.1
1106LL8	4	3.1	<50	<10	0.53	1.16	0.9	2.21	<0.01	11.5
1206LL8	50	36.8	<50	<10	4.34	13.5	4.9	20.40	<0.01	115
207LL8	50	30.4	<50	<10	3.57	11.4	4.0	18.60	<0.01	103
307LL8	5	3.1	<50	410	0.41	0.94	0.5	1.57	<0.01	10.9
807LL8	2	3.5	<50	20	0.52	1.33	3.8	2.41	<0.01	12.6
1007LL8	9	3.1	<50	20	0.44	1.37	0.6	2.38	<0.01	12.1
308LL8	4	3.1	<50	40	0.38	1.02	0.6	1.62	<0.01	10.2
LL1										
606LL1a	<2	20.5	5,540	6,100	1.55	5.25	2,290	2.61	0.01	9.6
606LL1b	<2	19.0	3,780	3,500	1.40	4.79	1,920	2.54	<0.01	9.7
1006AFLL1a	<2	19.9	4,960	6,200	1.43	4.85	2,070	2.54	<0.01	9.2
1006AFLL1	2	20.7	158	n.d	1.79	5.02	510	2.71	<0.01	9.0
1106LL1	<2	21.6	4,900	6,360	1.52	5.76	1,940	3.02	<0.01	9.8
1206LL1	2	11.9	<50	<10	0.68	3.09	36.3	2.44	<0.01	10.0
207LL1	12	203	534,000	1,930	14.2	55.10	21,400	27.40	0.04	88.0
207LL1core	14	139	133,000	12,450	23.3	37.50	53,000	24.50	0.10	50.0
307LL1	<2	15.6	2,900	297	1.09	3.46	1,200	2.17	<0.01	9.9

Table 3. Major elements in filtered (0.45 micron) water samples as determined by inductively coupled plasma mass spectrometry (ICP-MS) or inductively coupled plasma atomic emission spectrometry (ICP-AES).— Continued

[PW, pore water; n.a., not analyzed]

	Al µg/L	Ca mg/L	Fe µg/L	Fe2+ µg/L	K mg/L	Mg mg/L	Mn µg/L	Na mg/L	P mg/L	SiO_2 mg/L
307LL1PW	n.a	n.a.	n.a.	270	n.a	n.a	n.a.	n.a.	n.a	
807LL1	2	20.5	4,840	4,800	1.53	5.21	2,050	2.99	<0.01	9.6
1007LL1	4	18.5	470	5,400	1.29	6.07	1,130	3.68	<0.01	9.8
308LL1	<2	21.3	4,830	5,050	1.45	5.33	1,980	2.70	<0.01	9.3
LL1 adjacent										
207LL1a core1	327	150	127,000	2,110	24.7	38.70	82,700	25.00	0.10	57
307LLIb	60	14.6	15,300	10,650	1.98	3.28	9,280	1.89	<0.01	6.9
807LLIadj	<2	14	3,020	40	2.03	3.08	11,500	1.78	< 0.01	7.1
1007LLIa	n.a.	n.a	n.a	560	n.a	n.a	n.a	n.a	n.a	n.a
308LLIa	<2	9.1	<50	30	0.60	2.3	7.2	1.80	<0.01	7.3
LL10										
1006LL10	<2	19.3	1110	1,460	1.41	4.69	1,610	2.46	<0.01	8.6
1106LL10	<2	20.7	2550	2,570	1.43	5.47	1,650	2.90	<0.01	9.4
1206LL10	22	140	10,800	720	9.39	38.50	7,060	25.40	< 0.01	95.1
207LL10	26	197	23,100	2,280	13.70	54.10	16,200	27.90	<0.01	86.1
307LL10	7.4	14.5	1,790	1,870	1.00	3.35	933	2.14	<0.01	10.1
807LL10	<2	19.9	3,540	2,750	1.45	5.07	1,640	2.92	< 0.01	9.4
1007LL10	<2	20.7	2,180	2,470	1.40	6.60	1,630	3.57	<0.01	9.8
1007LL10	<2	20.7	2,180	1,460	1.40	6.60	1,630	3.57	<0.01	9.8
LL 11										
807LL11	<2	17.9	3,070	2,480	0.89	4.64	998	2.92	<0.01	11.7
1007LL11	<2	21.4	4,940	n.d.	1.41	6.88	2,040	3.52	<0.01	10.2
LL5										
06AFLL51007	<2	<0.2	325	330	<0.03	<0.01	<0.2	<0.01	0.06	0.80
LL2										
606LL2	<2	60	<50	60	0.68	9.63	271	2.14	<0.01	9.8
1006LL2	<2	70.3	<50	660	1.80	9.12	301	1.94	<0.01	10.8
1106LL2	<2	71.6	375	440	3.10	10.50	1,310	1.91	<0.01	9.0
1106LL2PW	5	103	<50	1,790	3.00	<0.01	0.3	4.78	25.0	<0.2
1206LL2	22	508	<50	50	10.20	95.40	3,270	14.70	< 0.01	47.3

Table 3. Major elements in filtered (0.45 micron) water samples as determined by inductively coupled plasma mass spectrometry (ICP-MS) or inductively coupled plasma atomic emission spectrometry (ICP-AES).— Continued

[PW, pore water; n.a., not analyzed]

	Al µg/L	Ca mg/L	Fe µg/L	Fe2+ µg/L	K mg/L	Mg mg/L	Mn µg/L	Na mg/L	P mg/L	SiO_2 mg/L
207LL2	12	460	1,420	100	3.67	69.20	2,470	14.00	<0.01	49.3
307LL2	<2	69.2	1,380	590	0.47	9.04	174	1.83	<0.01	10.0
807LL2	<2	65.2	<50	<10	0.73	10.20	166	2.35	<0.01	11.7
1007LL2	<2	55	472	610	2.32	11.40	708	2.11	<0.01	7.8
308LL2	<2	68.2	<50	30	0.72	9.60	68	1.91	<0.01	8.7
LL3										
807LL3	<2	23.9	733	740	0.82	5.30	198	3.03	<0.01	12.1
1007LL3	13	32.2	360	400	1.34	9.01	94.4	4.88	<0.01	12.5
LL13										
807LL13	<2	29.8	492	440	0.93	6.68	184	3.64	<0.01	13.2
1007LL13	10	12.2	291	350	0.83	3.64	75.3	3.22	<0.01	12.8
Adit Discharge										
606LCD-1	8	60.6	1,010	870	0.93	8.29	313	3.36	<0.01	16.9

Table 4. Major elements in unfiltered water samples as determined by inductively coupled plasma mass spectrometry (ICP-MS) or inductively coupled plasma atomic emission spectrometry (ICP-AES; November 2006 samples only).

[PW, pore water; n.a., not analyzed]

	Al µg/L	Ca mg/L	Fe µg/L	K mg/L	Mg mg/L	Mn µg/L	Na mg/L	P mg/L	SiO_2 mg/L
Field Blanks									
606FB	<2	<0.2	<50	<0.03	<0.01	<0.2	<0.01	< 0.01	< 0.2
1006FB	<2	<0.2	<50	<0.03	<0.01	<0.2	<0.01	< 0.01	< 0.2
1106FB	<2	<0.2	<50	<0.03	<0.01	0.2	<0.5	< 0.01	< 0.2
207FB	21	<0.2	<50	0.06	<0.01	0.3	0.11	< 0.01	< 0.2
307FB	30	<0.2	<50	<0.03	<0.01	<0.2	0.04	< 0.01	< 0.2
807FB	<2	<0.2	<50	<0.03	<0.01	<0.2	0.01	< 0.01	< 0.2
1007FB	<2	<0.2	<50	<0.03	<0.01	<0.2	<0.01	< 0.01	< 0.2
LL8									
606LL8	9	3.3	<50	0.49	1.12	0.9	1.84	< 0.01	12.4
1006LL8	8	3.2	<50	0.51	1.04	5.5	2.14	< 0.01	11.4
1106LL8	8	3.2	<50	0.50	1.17	1.0	2.18	< 0.01	11.8
1206LL8	136	37.2	<50	4.35	13.70	7.3	20.90	< 0.01	117
207LL8	76	32.8	<50	3.68	11.60	11.6	19.00	< 0.01	104
307LL8	39	3.1	694	0.42	0.91	3.6	1.53	< 0.01	10.7
807LL8	6	3.5	<50	0.51	1.33	4.1	2.41	< 0.01	12.6
1007LL8	12	3.1	<50	0.46	1.27	0.8	2.20	< 0.01	11.8
LL1									
606LL1a	<2	20.8	5,770	1.55	5.16	2,300	2.65	0.01	9.7
606LL1b	<2	19	4,550	1.40	4.74	1,930	2.45	0.01	9.6
1006LL1c	<2	21.5	5,570	1.58	5.44	2,210	2.88	0.01	10.0
1006LL1d	1,430	28.6	43,900	2.09	6.34	12,600	3.04	< 0.01	21.5
1106LL1	<2	21.9	5,140	1.52	5.76	1,970	3.02	< 0.01	9.8
1206LL1	178	12.5	2,470	0.72	3.26	236	2.49	< 0.01	10.8
207LL1	15	208	52,700	14.60	56.70	22,000	27.9	0.02	89.4
307LL1	11	15.4	3,100	1.06	3.37	1,200	2.06	< 0.01	9.5
807LL1	2	19.4	6,000	1.45	4.92	1,950	2.84	< 0.01	9.5
1007LL1	<2	20.9	5,140	1.41	6.43	2,030	3.39	< 0.01	9.9
LL1adjacent									
307LLIb	60	14.6	15,300	1.98	3.28	9,280	1.89	<0.01	6.9
1007LLIa	14	18.3	1,990	1.27	5.71	1,120	3.43	< 0.01	9.6

Table 4. Major elements in unfiltered water samples as determined by inductively coupled plasma mass spectrometry (ICP-MS) or inductively coupled plasma atomic emission spectrometry.—Continued

[PW, pore water; n.a., not analyzed]

	Al µg/L	Ca mg/L	Fe µg/L	K mg/L	Mg mg/L	Mn µg/L	Na mg/L	P mg/L	SiO_2 mg/L
LL10									
1006LL10	4	20.7	8,100	1.5	5.10	1,690	2.73	0.03	9.9
1106LL10	<2	20.8	2,420	1.44	5.52	1,680	2.92	< 0.01	9.4
1206LL10	397	139	13,500	9.28	38.40	6,920	25.00	<0.01	93.9
207LL10	41	197	51,900	13.40	53.90	16,300	27.50	0.05	88.2
307LL10	<2	14.4	1,490	1.00	3.30	931	2.12	< 0.01	9.8
807LL10	<2	19.9	2,650	1.43	5.05	1,660	2.93	<0.01	9.5
1007LL10	<2	20.6	2,550	1.40	6.35	1,630	3.37	< 0.01	9.6
LL11									
807LL11	3	18.5	4,200	0.93	4.76	1,020	2.92	< 0.01	12.2
LL5									
1006LL5	5	27.1	<50	1.16	5.85	60.4	2.81	<0.01	2.8
LL2									
606LL2	<2	61.5	3,450	0.69	9.73	303	2.22	0.02	10.0
1006LL2	<2	74	1,110	1.95	10.20	316	2.17	0.01	12.0
1106LL2	2	71.8	2,420	3.12	10.60	1,340	1.95	< 0.01	9.2
1106LL2PW	5,310	107	11,800	1.13	15.70	1,260	3.14	0.10	20.3
1206LL2	43	502	5,270	9.92	94.70	3,260	14.4	<0.01	47.6
207LL2	63	469	6,390	3.74	72.00	2,560	14.5	< 0.01	51.3
307LL2	<2	68.6	<50	0.46	8.81	172	1.81	< 0.01	9.9
807LL2	<2	66.4	1,020	0.74	10.10	170	2.33	< 0.01	11.7
1007LL2	7	55	1,040	2.28	10.80	706	1.98	< 0.01	7.6
LL3									
1007LL3	115	31.9	516	1.33	8.62	94	4.66	< 0.01	12.6
LL13									
1007LL13	35	12.1	473	0.83	3.52	76.8	3.05	< 0.01	12.6
LCD-1									
06AFLC10615	19	61.9	1,210	0.97	8.64	326	3.51	0.02	17.5

Table 5. Trace elements in filtered (0.45 micron) water samples as determined by inductively coupled plasma mass spectrometry (ICP-MS) or inductively coupled plasma atomic emission spectrometry (ICP-AES; November 2006 samples only). All values in micrograms per liter (μg/L).

[PW, pore water; FB, field blank. Note that detection limits differ for the two methods]

	As	Ba	Cd	Co	Cr	Cu	Mo	Ni	Pb
Field Blanks									
606FB	<1	<0.2	<0.02	<0.02	<1	<0.5	<2	<0.4	<0.05
1006FB	<1	<0.2	<0.02	<0.02	<1	<0.5	<2	<0.4	<0.05
1106FB	<1	0.3	<0.02	<0.02	<1	<0.5	<2	<0.4	<0.05
207FB	<1	3.2	<0.02	0.02	<1	1.3	2.0	0.5	0.09
307FB	<1	<0.2	<0.02	<0.02	<1	<0.5	<2	<0.4	0.07
807FB	<1	<0.2	<0.02	<0.02	<1	<0.5	<2	<0.4	<0.05
1007FB	<1	0.24	<0.02	<0.02	<1	<0.5	<2	<0.4	<0.05
308FB	<1	<0.2	<0.02	<0.02	<1	<0.5	<2	<0.4	<0.05
LL8									
606LL8	<1	12.1	0.14	<0.02	<1	<0.5	<2	<0.4	<0.05
1006LL8	<1	14.8	<0.02	0.03	<1	<0.5	<2	<0.4	<0.05
1106LL8	<1	14.1	<0.02	0.02	<1	0.5	<2	<0.4	0.08
1206LL8	3.3	136	<0.02	0.21	<1	3.2	<2	0.6	0.08
207LL8	2.0	111	<0.02	0.08	<1	1.6	<2	0.6	<0.05
307LL8	<1	11.4	<0.02	<0.02	1.4	1.3	<2	<0.4	0.20
807LL8	<1	17.2	<0.02	0.04	<1	<0.5	<2	<0.4	<0.05
1007LL8	<1	14.4	<0.02	<0.02	<1	<0.5	<2	<0.4	<0.05
308LL8	<1	11.5	<0.02	<0.02	<1	0.5	<2	<0.4	<0.05
LL1									
606LL1a	40.3	90.0	<0.02	1.45	<1	<0.5	<2	<0.4	<0.05
606LL1b	28.6	76.5	<0.02	1.23	<1	<0.5	<2	<0.4	<0.05
1006LL1c	44.2	82.3	<0.02	1.37	1.5	<0.5	<2	0.4	<0.05
1006AFLL1d	5.8	32.3	0.05	0.14	<1	0.7	<2	<0.4	<0.05
1106LL1	38.2	84.4	<0.02	1.34	<1	<0.5	<2	<0.4	<0.05
1206LL1	48.3	22.8	0.04	0.47	<1	1.3	<2	<0.4	0.61
207LL1core	431	3290	<0.02	11.70	9.4	1.1	18.8	14.1	0.10
207LL1	375	902	<0.02	13.40	<1	0.9	2.3	<0.4	<0.05
307LL1	26.8	57.6	<0.02	0.80	1.8	<0.5	<2	1.0	<0.05
807LL1	43.3	82.3	<0.02	1.34	1.0	<0.5	<2	0.4	<0.05
1007LL1	7.2	64.9	<0.02	0.74	<1	<0.5	<2	<0.4	<0.05

Table 5. Trace elements in filtered (0.45 micron) water samples as determined by inductively coupled plasma mass spectrometry (ICP-MS) or inductively coupled plasma atomic emission spectrometry (ICP-AES; November 2006 samples only). All values in micrograms per liter (μg/L). —Continued

[PW, pore water; FB, field blank. Note that detection limits differ for the two methods]

	As	Ba	Cd	Co	Cr	Cu	Mo	Ni	Pb
308LL1	38.0	89.8	<0.02	1.27	<1	<0.5	<2	<0.4	<0.05
LL1 adjacent									
207LL1a core1	349	2590	0.58	24	12.2	20.4	13.1	17.7	1.1
307LLIb	67.1	280	0.03	2.97	4.2	1.0	<2	1.2	<0.05
807LLIadj	1.0	16.5	<0.02	<0.02	<1	<0.5	<2	<0.4	<0.05
308LLIa	<1	19.0	<0.02	<0.02	<1	<0.5	<2	<0.4	<0.05
LL10							<2		
1006LL10	15.8	65.4	<0.02	1.05	<1	<0.5	<2	<0.4	<0.05
1106LL10	25.5	73.6	<0.02	1.17	<1	<0.5	<2	<0.4	<0.05
1206LL10	166	422	0.04	5.25	<1	3.4	<2	0.8	0.58
207LL10	196	711	0.06	9.81	<1	4.2	<2	<0.4	0.10
307LL10	22.3	46.4	<0.02	0.64	1.3	<0.5	<2	0.8	<0.05
807LL10	27.9	69.8	<0.02	1.08	<1	<0.5	<2	0.4	<0.05
1007LL10	19.3	77.3	<0.02	1.08	<1	<0.5	<2	<0.4	<0.05
1007LL10	19.3	77.3	<0.02	1.08	<1	<0.5	<2	<0.4	<0.05
LL11									
807LL11	63.6	42.6	0.02	1.32	<1	<0.5	<2	0.9	<0.05
1007LL11	36.9	90.9	<0.02	1.36	<1	<0.5	<2	<0.4	<0.05
LL5									
1006LL5	1.0	<0.2	<0.02	<0.02	<1	<0.5	<2	<0.4	<0.05
LL2									
606LL2	87.4	47.4	<0.02	0.45	<1	<0.5	<2	0.9	<0.05
1006LL2	88.2	57.1	<0.02	0.37	2.3	<0.5	<2	1.0	<0.05
1106LL2	171	52.9	0.06	1.73	<1	<0.5	<2	<0.4	<0.05
1106LL2PW	1,010	68.9	0.26	11.30	<1	1.4	0.87	8.8	448
1206LL2	2,190	273	1.03	4.44	<1	7.8	13.7	3.2	0.93
207LL2	897	253	0.12	5.82	<1	2.4	5.5	2.6	0.20
307LL2	71.0	32.6	<0.02	0.68	5.2	<0.5	<2	2.1	0.20
807LL2	83.4	62.8	<0.02	0.24	2.1	<0.5	<2	0.9	<0.05
1007LL2	258	42	0.12	1.41	<1	1.0	<2	1.4	<0.05
308LL2	60.6	26.7	<0.02	0.30	2.2	<0.5	<2	1.0	<0.05

Table 5. Trace elements in filtered (0.45 micron) water samples as determined by inductively coupled plasma mass spectrometry (ICP-MS) or inductively coupled plasma atomic emission spectrometry (ICP-AES; November 2006 samples only). All values in micrograms per liter (µg/L). —Continued

[PW, pore water; FB, field blank. Note that detection limits differ for the two methods]

	As	Ba	Cd	Co	Cr	Cu	Mo	Ni	Pb
LL3									
807LL3	69.8	43.8	<0.02	0.52	<1	<0.5	<2	0.6	<0.05
1007LL3	61.8	59.6	0.02	0.21	<1	0.8	<2	0.4	<0.05
LL13									
807LL13	75.0	51.4	<0.02	0.30	<1	<0.5	<2	0.8	<0.05
1007LL13	24.1	34.5	<0.02	0.31	<1	0.5	<2	<0.4	<0.05
LCD-1									
606LC1	555	50.3	<0.02	1.14	<1	<0.5	<2	1.8	<0.05

Table 5. Trace elements in filtered (0.45 micron) water samples as determined by inductively coupled plasma mass spectrometry (ICP-MS) or inductively coupled plasma atomic emission spectrometry (ICP-AES; November 2006 samples only). All values in micrograms per liter (µg/L). —Continued

[PW, pore water; FB, field blank. Note that detection limits differ for the two methods]

	Sb	Se	Sr	Ti	U	V	W	Y	Zn
Field Blanks									
606FB	<0.3	<1	<0.5	<0.5	0<0.1	<0.5	<0.5	<0.01	2.2
1006FB	<0.3	<1	<0.5	<0.5	<0.1	<0.5	<0.5	<0.01	5.1
1106FB	<0.3	<1	<0.5	<0.5	<0.1	<0.5	<0.5	<0.01	2.5
207FB	<0.3	<1	0.6	<0.5	<0.1	<0.5	3.52	<0.01	25
307FB	<0.3	<1	<0.5	<0.5	<0.1	<0.5	<0.5	<0.01	2.4
807FB	<0.3	<1	<0.5	<0.5	<0.1	<0.5	<0.5	<0.01	2.9
1007FB	<0.3	<1	<0.5	<0.5	<0.1	<0.5	<0.5	<0.01	1.1
308FB	<0.3	<1	<0.5	<0.5	<0.1	<0.5	<0.5	<0.01	2.3
LL8									
606LL8	<0.3	<1	32.3	<0.5	<0.1	<0.5	<0.5	0.02	0.8
1006LL8	<0.3	<1	31.2	<0.5	<0.1	<0.5	<0.5	0.01	2.9
1106LL8	<0.3	<1	30.7	<0.5	<0.1	<0.5	<0.5	0.02	1.5
1206LL8	<0.3	<1	362	<0.5	<0.1	2.6	<0.5	0.49	38
207LL8	<0.3	<1	293	<0.5	<0.1	2.1	<0.5	0.2	6.4
307LL8	<0.3	<1	29	<0.5	<0.1	<0.5	<0.5	0.02	1.0
807LL8	<0.3	<1	35.5	<0.5	<0.1	<0.5	<0.5	0.01	3.1
1007LL8	<0.3	<1	31.7	<0.5	<0.1	<0.5	<0.5	0.07	1.0
308LL8	<0.3	<1	30.3	<0.5	<0.1	<0.5	<0.5	0.02	1.8
LL1									
606LL1a	<0.3	<1	162	<0.5	<0.1	<0.5	<0.5	0.08	1.9
606LL1b	<0.3	<1	150	<0.5	<0.1	<0.5	<0.5	0.04	1.1
1006LL1c	<0.3	<1	162	<0.5	<0.1	<0.5	<0.5	0.08	5.3
1006AFLL1d	<0.3	<1	167	<0.5	<0.1	<0.5	<0.5	0.01	2.3
1106LL1	<0.3	<1	170	<0.5	<0.1	<0.5	<0.5	0.09	1.7
1206LL1	<0.3	<1	87.5	1.9	<0.1	1.3	<0.5	0.24	5.5
207LL1core	<0.3	6.1	1,360	<0.5	<0.1	1.7	0.59	0.21	7.9
207LL1	<0.3	<1	1,630	<0.5	<0.1	<0.5	1.79	0.92	8.8
307LL1	<0.3	<1	119	<0.5	<0.1	0.6	<0.5	0.05	18
807LL1	<0.3	<1	168	<0.5	<0.1	<0.5	<0.5	0.07	6.1
1007LL1	<0.3	<1	144	<0.5	<0.1	<0.5	<0.5	0.01	1.6
308LL1	<0.3	<1	166	<0.5	<0.1	<0.5	<0.5	0.09	1.6

Table 5. Trace elements in filtered (0.45 micron) water samples as determined by inductively coupled plasma mass spectrometry (ICP-MS) or inductively coupled plasma atomic emission spectrometry (ICP-AES; November 2006 samples only). All values in micrograms per liter (µg/L). —Continued

[PW, pore water; FB, field blank. Note that detection limits differ for the two methods]

	Sb	Se	Sr	Ti	U	V	W	Y	Zn
LL1 adjacent									
207LL1a core1	<0.3	5.6	1,270	3.7	0.1	4.7	2.4	1.72	121
307LLIb	<0.3	<1	119	<0.5	<0.1	1.1	<0.5	1.07	14
807LLIadj	<0.3	<1	73.4	0.5	<0.1	<0.5	<0.5	0.01	0.6
308LLIa	<0.3	<1	66.4	<0.5	<0.1	<0.5	<0.5	0.02	0.6
LL10									
1006LL10	<0.3	<1	158	<0.5	<0.1	<0.5	<0.5	<0.01	1.8
1106LL10	<0.3	<1	163	0.9	<0.1	<0.5	<0.5	0.02	2.0
1206LL10	<0.3	1.4	1,060	3.2	<0.1	<0.5	<0.5	0.61	15
207LL10	<0.3	< 1	1,560	<0.5	<0.1	<0.5	0.79	0.24	26
307LL10	<0.3	<1	107	<0.5	<0.1	<0.5	<0.5	0.05	3.1
807LL10	<0.3	<1	164	<0.5	<0.1	<0.5	<0.5	0.03	4.5
1007LL10	<0.3	<1	165	<0.5	<0.1	<0.5	<0.5	0.02	2.3
1007LL10	<0.3	<1	165	<0.5	<0.1	<0.5	<0.5	0.02	2.3
LL 11		<1							
807LL11	<0.3	<1	143	<0.5	<0.1	<0.5	<0.5	0.03	4.9
1007LL11	<0.3	<1	168	<0.5	<0.1	<0.5	<0.5	0.08	1.0
LL5									
1006LL5	<0.3	<1	<0.5	<0.5	<0.1	<0.5	<0.5	<0.01	<0.5
LL2									
606LL2	0.33	<1	338	<0.5	<0.1	<0.5	<0.5	0.01	0.8
1006LL2	<0.3	<1	366	<0.5	<0.1	0.6	<0.5	<0.01	10
1106LL2	2.76	<1	325	<0.5	0.1	<0.5	<0.5	<0.01	10
1106LL2PW	<0.1	0.6	<0.2						
1206LL2	84.2	5.8	2,390	<0.5	1.1	<0.5	<0.5	0.13	91
207LL2	15.1	2.2	2,010	<0.5	0.4	<0.5	<0.5	0.03	37
307LL2	1.52	<1	308	<0.5	0.1	1.3	<0.5	0.01	3.0
807LL2	<0.3	<1	352	<0.5	<0.1	0.6	<0.5	<0.01	2.0
1007LL2	6.02	<1	272	<0.5	0.1	<0.5	<0.5	<0.01	15.3
308LL2	2.79	<1	319	<0.5	<0.1	0.6	<0.5	0.02	1.7

Table 5. Trace elements in filtered (0.45 micron) water samples as determined by inductively coupled plasma mass spectrometry (ICP-MS) or inductively coupled plasma atomic emission spectrometry (ICP-AES; November 2006 samples only). All values in micrograms per liter (μg/L). —Continued

[PW, pore water; FB, field blank. Note that detection limits differ for the two methods]

	Sb	Se	Sr	Ti	U	V	W	Y	Zn
LL3									
807LL3	<0.3	<1	174	0.5	<0.1	<0.5	<0.5	<0.01	6.0
1007LL3	0.31	<1	221	0.7	<0.1	<0.5	<0.5	0.03	2.7
LL13									
807LL13	<0.3	<1	210	0.7	<0.1	<0.5	<0.5	<0.01	7.6
1007LL13	<0.3	<1	90.4	<0.5	<0.1	<0.5	<0.5	0.03	1.7
LCD-1									
606LC1	<0.3	<1	368	1.0	0.1	<0.5	1.3	0.18	8.5

Table 6. Trace elements in unfiltered water samples as determined by inductively coupled plasma mass spectrometry (ICP-MS) or inductively coupled plasma atomic emission spectrometry (ICP-AES; November 2006 samples only). All values in micrograms per liter (μg/L).

[PW, pore water; FB, field blank. Note that detection limits differ for the two methods]

	As	Ba	Cd	Co	Cr	Cu	Mo	Ni	Pb
Field Blanks									
606FB	<1	0.34	<0.02	<0.02	<1	<0.5	<2	<0.4	<0.05
1006FB	<1	0.47	<0.02	<0.02	<1	<0.5	<2	<0.4	<0.05
1106FB	<1	0.71	<0.02	<0.02	<1	7.5	<2	<0.4	0.4
1206FB	2.0	< 0.2	<0.02	0.06	<1	<0.5	<2	0.7	<0.05
207FB	2.0	1.3	<0.02	0.07	<1	0.58	<2	0.4	<0.05
307FB	<1	<0.2	<0.02	<0.02	2.0	0.56	<2	<0.4	0.4
807FB	<1	<0.2	<0.02	<0.02	<1	<0.5	<2	<0.4	<0.05
1007FB	<1	<0.2	<0.02	<0.02	<1	<0.5	<2	<0.4	<0.05
LL8									
606AFLL8	<1	12.6	0.16	<0.02	<1	<0.5	<2	<0.4	<0.05
1006AFLL8	<1	14.9	<0.02	0.04	<1	<0.5	<2	<0.4	<0.05
1106LL8	<1	14.3	<0.02	<0.02	<1	0.5	<2	<0.4	<0.05
1206LL8	3.4	132	<0.02	0.1	<1	2.8	<2	<0.4	< 0.05
207LL8	<1	109	0.06	0.1	<1	3.0	<2	0.7	0.4
307LL8	<1	11.4	<0.02	0.08	<1	1.4	<2	0.7	0.2
807LL8	<1	17.2	<0.02	0.05	<1	<0.5	<2	<0.4	<0.05
1007LL8	<1	14.1	<0.02	<0.02	<1	0.66	<2	<0.4	<0.05
LL1									
606AFLL1a	41.4	89.3	<0.02	1.49	<1	<0.5	<2	<0.4	<0.05
606LL1b	33.2	76.6	<0.02	1.28	<1	<0.5	<2	<0.4	<0.05
1006LL1c	47.6	87.7	<0.02	1.43	1.4	<0.5	<2	0.5	<0.05
1006LL1d	12.9	577	2.73	26.2	2.2	34.8	<2	10.1	10.2
1106LL1	41.2	85.9	<0.02	1.37	<1	<0.5	<2	<0.4	0.06
1206LL1	8.8	14.7	< 0.02	.04	<1	<0.5	<2	<0.4	<0.05
207LL1	397	903	<0.02	13.6	<1	0.96	2.3	<0.4	0.07
307LL1	24.4	57.1	<0.02	0.82	<1	0.50	<2	1.3	0.06
807LL1	50.7	81.3	<0.02	1.30	<1	<0.5	<2	<0.4	<0.05
1007LL1	38.2	91.3	<0.02	1.33	<1	<0.5	<2	<0.4	<0.05
LL1 adjacent									
307LLIb	11.3	224	< 0.02	2.83	4.1	0.50	<2	0.8	<0.05
1007LLIa	18.5	65.4	<0.02	0.78	<1	<0.5	<2	<0.4	<0.05

Table 6. Trace elements in unfiltered water samples as determined by inductively coupled plasma mass spectrometry (ICP-MS) or inductively coupled plasma atomic emission spectrometry (ICP-AES; November 2006 samples only). All values in micrograms per liter (μg/L).—Continued

[PW, pore water; FB, field blank. Note that detection limits differ for the two methods]

	As	Ba	Cd	Co	Cr	Cu	Mo	Ni	Pb
LL10									
1006LL10	60.2	74.1	<0.02	1.13	<1	<0.5	<2	0.4	<0.05
1106LL10	26.4	73.5	<0.02	1.19	<1	<0.5	<2	<0.4	<0.05
1206LL10	138	418	0.07	4.92	<1	2.6	<2	<0.4	0.09
207LL10	343	758	0.09	10.2	<1	1.4	2.2	<0.4	0.10
307LL10	17.8	46.9	<0.02	.61	1.4	<0.5	<2	0.4	0.08
807LL10	34.3	71.2	<0.02	1.06	<1	<0.5	<2	<0.4	<0.05
1007LL10	21.3	77.7	<0.02	1.04	<1	<0.5	<2	<0.4	<0.05
LL11									
807LL11	92.1	44.4	0.03	1.38	1	<0.5	<2	0.9	<0.05
LL5									
1006AFLL5	16.1	49.0	<0.02	.07	<1	<0.5	<2	0.6	<0.05
LL2									
606AFLL2	833	56.2	<0.02	0.51	<1	<0.5	<2	0.9	<0.05
1006AFLL2	276	64.0	0.02	0.39	2.6	<0.5	<2	1.0	<0.05
1106LL2	480	57.4	0.11	1.86	<1	0.55	<2	<0.4	0.06
1106LL2PW	1,770	147	2.59	22.1	4.7	41	<2	29.1	62.2
1206LL2	1,210	262	0.83	4.36	<1	7.7	13.6	3.6	0.10
207LL2	1,630	271	0.22	6.11	<1	3.2	5.0	4.3	0.30
307LL2	284	34.3	<0.02	.68	4.9	<0.5	<2	2.2	<0.05
807LL2	283	65.8	<0.02	.26	2.3	<0.5	<2	1.0	<0.05
1007LL2	351	43.6	0.16	1.43	<1	0.82	<2	1.3	0.07
LL3									
1007LL3	69.5	60.3	0.02	0.26	<1	1.0	<2	0.5	0.07
LL13									
1007LL13	30.9	34.6	<0.02	0.32	<1	0.66	<2	<0.4	<0.05
LCD-1									
606LC1	607	53.5	<0.02	1.18	<1	0.67	<2	1.8	<0.05

Table 6. Trace elements in unfiltered water samples as determined by inductively coupled plasma mass spectrometry (ICP-MS) or inductively coupled plasma atomic emission spectrometry (ICP-AES; November 2006 samples only). All values in micrograms per liter (μg/L). —Continued

[PW, pore water; FB, field blank. Note that detection limits differ for the two methods]

	Sb	Se	Sr	Ti	U	V	W	Y	Zn
Field Blanks									
606FB	<0.3	<1	<0.5	<0.5	<0.1	<0.5	<0.5	<0.01	0.7
1006FB	<0.3	<1	<0.5	<0.5	<0.1	<0.5	<0.5	<0.01	9.2
1106FB	<0.3	<1	<0.5	<0.5	<0.1	<0.5	<0.5	<0.01	8.9
1206FB	<0.3	1.4	<0.5	<0.5	<0.1	<0.5	<0.5	<0.01	1.2
207FB	<0.3	<1	0.6	<0.5	<0.1	<0.5	<0.5	<0.01	12.6
307FB	<0.3	<1	<0.5	<0.5	<0.1	<0.5	<0.5	<0.01	17.7
807FB	<0.3	<1	<0.5	<0.5	<0.1	<0.5	<0.5	<0.01	4.9
1007FB	<0.3	<1	<0.5	<0.5	<0.1	<0.5	<0.5	<0.01	<0.5
LL8									
606AFLL8	<0.3	<1	32.4	<0.5	<0.1	<0.5	<0.5	0.02	0.9
1006AFLL8	<0.3	<1	30.7	<0.5	<0.1	<0.5	<0.5	0.02	37.7
1106LL8	<0.3	<1	31.4	<0.5	<0.1	<0.5	<0.5	0.02	2.2
1206LL8	<0.3	<1	351	<0.5	<0.1	2.0	<0.5	0.35	14.8
207LL8	<0.3	<1	294	<0.5	<0.1	1.3	<0.5	0.18	51.9
307LL8	<0.3	<1	29.2	<0.5	<0.1	<0.5	<0.5	0.03	27.7
807LL8	<0.3	<1	35.2	<0.5	<0.1	<0.5	<0.5	0.02	1.1
1007LL8	<0.3	<1	31.9	<0.5	<0.1	<0.5	<0.5	0.08	0.6
LL1									
606AFLL1a	<0.3	<1	165	<0.5	<0.1	<0.5	<0.5	0.09	1.1
606LL1b	<0.3	<1	148	<0.5	<0.1	<0.5	<0.5	0.07	1.1
1006LL1c	<0.3	<1	169	<0.5	<0.1	<0.5	<0.5	0.09	2.6
1006LL1d	<0.3	<1	253	7.4	0.45	0.6	<0.5	14	158
1106LL1	<0.3	<1	173	<0.5	<0.1	<0.5	<0.5	0.10	3.6
1206LL1	<0.3	<1	83.2	<0.5	<0.1	<0.5	<0.5	0.01	3.1
207LL1	<0.3	<1	1,670	0.9	<0.1	<0.5	1.66	0.94	12.5
307LL1	<0.3	<1	117	<0.5	<0.1	<0.5	<0.5	0.10	10.9
807LL1	<0.3	<1	160	<0.5	<0.1	<0.5	<0.5	0.10	1.9
1007LL1	<0.3	<1	171	<0.5	<0.1	<0.5	0.50	0.10	1.1

Table 6. Trace elements in unfiltered water samples as determined by inductively coupled plasma mass spectrometry (ICP-MS) or inductively coupled plasma atomic emission spectrometry (ICP-AES; November 2006 samples only). All values in micrograms per liter (μg/L). —Continued

[PW, pore water; FB, field blank. Note that detection limits differ for the two methods]

	Sb	Se	Sr	Ti	U	V	W	Y	Zn
LL1 adjacent									
307LLIb	<0.3	<1	114	<0.5	<0.1	0.6	<0.5	0.01	7.2
1007LLIa	<0.3	<1	143	<0.5	<0.1	<0.5	<0.5	0.08	1.5
LL10									
1006LL10	<0.3	<1	161	<0.5	<0.1	<0.5	<0.5	0.17	1.2
1106LL10	<0.3	<1	164	<0.5	<0.1	<0.5	<0.5	0.02	2.0
1206LL10	<0.3	<1	1,080	<0.5	<0.1	<0.5	<0.5	0.31	17.6
207LL10	<0.3	<1	1,580	0.6	<0.1	<0.5	1.35	1.05	27
307LL10	<0.3	<1	108	<0.5	<0.1	<0.5	<0.5	0.03	3.6
807LL10	<0.3	<1	163	<0.5	<0.1	<0.5	<0.5	0.07	1.2
1007LL10	<0.3	<1	167	<0.5	<0.1	<0.5	<0.5	0.04	1.1
LL11									
807LL11	<0.3	<1	145	<0.5	<0.1	<0.5	<0.5	0.05	3.6
LL5									
1006AFLL5	<0.3	<1	190	<0.5	<0.1	<0.5	<0.5	<0.01	4.6
LL2									
606AFLL2	0.38	<1	341	<0.5	<0.1	<0.5	<0.5	0.03	1.9
1006AFLL2	<0.3	<1	364	<0.5	<0.1	0.7	<0.5	0.01	3.6
1106LL2	2.78	<1	333	<0.5	0.14	<0.5	<0.5	0.02	14.9
1106LL2PW	3.86	<1	476	11.1	0.57	17.9	<0.5	7.12	204
1206LL2	84.0	5.9	2,400	<0.5	1.13	<0.5	<0.5	0.04	96.8
207LL2	14.1	2.8	2,090	0.9	0.44	1.0	<0.5	0.08	48.1
307LL2	1.59	<1	312	<0.5	0.12	1.3	<0.5	0.02	1.7
807LL2	0.3	<1	351	<0.5	<0.1	0.7	<0.5	0.02	1.8
1007LL2	5.55	<1	275	<0.5	0.14	<0.5	<0.5	0.02	16.8
LL3									
1007LL3	0.30	<1	224	2.2	<0.1	<0.5	<0.5	0.08	3.2
LL13									
1007LL13	<0.3	<1	91.3	0.6	<0.1	<0.5	<0.5	0.05	2.2
LCD-1									
606LC1	<0.3	<1	378	1.1	0.11	<0.5	1.31	0.34	4.4

Table 7. Arsenic species and total arsenic in filtered water samples as determined by hydride-generation, graphite-furnace atomic absorption spectrometry and field chromatographic separation (except for October 2006 samples, for which total arsenic and arsenic oxoanion species were calculated by Brooks Rand Labs, Inc., using a more sensitive method, as described in the text).

[All values in micrograms per liter (μg/L). The inorganic arsenic species [As(III), As(V)] and total arsenic were determined separately for all samples except for the Oct 2006 samples; for those, As(V) was calculated as As tot – As(III). PW, pore water; n.d., not determined; FB, field blank, INS, insufficient sample. Note that detection limits differ for the two methods]

	As(III) inorg	As(V)	Total As (inorg)
Field Blanks			
1006FB	<0.01	<0.01	<0.01
1106FB	<1	<1	<1
1206FB	<1	<1	<1
207FB	<1	<1	<1
307FB	<1	<1	<1
807FB	n.d.	n.d.	<1
308FB	<1	<1	<1
LL8			
1006LL8	.02	.045	.06
1106LL8	<1	<1	<1
1206LL8	<1	<1	<1
207LL8	<1	<1	<1
307LL8	<1	<1	<1
807LL8	n.d.	n.d.	1
308LL8	<1	<1	<1
LL1			
1006LL1	50.1	2.3	52.4
1106LL1	31	5.1	38
1206LL1	<1	9.3	11
207LL1	26	3.8	45
207LL1PW	n.d.	3.8	45
307LL1	19	3.8	28
307LL1PW	n.d	n.d.	4.1
807LL1	n.d.	n.d.	51
308LL1	36	2	41
LL1 adjacent			
207LL1a	22	2.1	28
307LLIb	23	2.2	28
807LLIa	n.d.	n.d.	1.0
308LL1a	<1	<1	<1
LL10			
1006LL10	15.40	<0.01	15.2
1106LL10	14	3.3	21
1206LL10	6.9	2.5	14
207LL10	17	3.3	23
307LL10	13	2.2	17
807LL10	n.d.	n.d.	34
308LL10	INS	2	11

Table 7. Arsenic species and total arsenic in filtered water samples as determined by hydride-generation, graphite-furnace atomic absorption spectrometry and field chromatographic separation.—Continued

[All values in micrograms per liter (μg/L). The inorganic arsenic species [As(III), As(V)] and total arsenic were determined separately for all samples except for the Oct 2006 samples; for those, As(V) was calculated as As tot – As(III). PW, pore water; n.d., not determined; FB, field blank, INS, insufficient sample. Note that detection limits differ for the two methods]

	As(III) inorg	As(V)	Total As (inorg)
LL 11			
807LL11	n.d.	n.d.	82
LL5			
1006LL5	0.94	20.2	21.1
LL2			
1006LL2	13.3	62.8	76.1
1106LL2	32	110	130
1106LL2PW	960	110	1,100
1206LL2	2.5	94	120
207LL2	50	22	100
307LL2	7.5	53	71
807LL2	n.d.	n.d.	88
308LL2	1	64	50
LL3			
807LL3	n.d.	n.d.	95
LL13			
807LL13	n.d	n.d.	90

Filtered Alkalinity, Anions, and Dissolved Organic Carbon

Alkalinity and major anion (sulfate, chloride, nitrate, and fluoride) concentrations were determined in the USGS Mineral Resources Program laboratories (Denver, CO) using automated endpoint titration using sulfuric acid and ion chromatography, respectively. The methods used by USGS (including description of standards, 3 and 5 σ detection limits, correction factors, common interferences, standards, and QA/QC) are fully described in USGS Open File Report 02-0223, Chapters E and V (Taggart, 2002).

High- and low-range dissolved organic carbon (DOC) were determined by Huffman Laboratories, Golden CO. High-range DOC had a reporting limit of 1 mg/L, and low range DOC had a reporting limit of 0.1 mg/L. DOC was analyzed by Huffman Labs using Standard Methods 5310C (<10 mg/L) or 5310B (>10 mg/L; Federation,1998). Both methods involve sample filtration at 0.45 μm, acidification, and purging to remove carbonate. Organic carbon is then oxidized to CO_2 and analyzed. Method 5310C employs measurement by infrared absorption; method 5310B uses high-temperature combustion and measurement by coulometric titration.

Sampling and preservation protocols were as follows. After collection of water in a 1-liter acid-washed bottle, two subsamples were taken using a 60 ml syringe. For alkalinity samples, unfiltered water was transferred to a 125 ml PE bottle; for anion samples, 0.45 μm-filtered water was transferred to a 125 ml PE bottle. Whenever possible, water for organic carbon analysis was collected by dipping a washed and baked 2- or 4-oz amber glass screw-top bottle directly into source water, otherwise, the 60 ml syringe was used to transfer water from the source to the sample bottle. All samples were collected in such a way as to minimize headspace. All DOC analyses were conducted on waters that were not filtered in the field, but were filtered at the analytical laboratory after storage.

Alkalinity, anion, and organic-carbon samples were all stored on ice in the field. Whenever possible, these temperature-sensitive samples were shipped on ice within 48 hrs of collection, but due to unforeseen circumstances, some were held longer than this recommended time. Upon receipt at the USGS Denver analytical facility, or at Huffman Labs, the samples were stored at 4-8ºC until analysis.

Table 8. Alkalinity, selected anions, and organic-carbon values for water samples. All values in milligrams per liter (mg/L).

[Dissolved organic carbon (DOC) was determined on 0.45-micron-filtered samples. n.d., not determined; PW, pore water]

	Alkalinity ($CaCO_3$)	Cl	F	NO_3	SO_4	DOC
Field Blanks						
606FB	7.4	< .08	<.08	<.08	<1.6	<1[1]
1006FB	1.72	< .08	<.08	<.08	<1.6	.17
1106FB	2.65	<.08	<.08	<.08	<1.6	.04
1206FB	n.d.	<.08	<.08	<.08	<1.6	n.d
207FB	2.23	<.08	<.08	<.08	9.3	.43
307FB	<.01	<.08	<.08	<.08	<1.6	n.d.
807FB	1.98	<.08	<.08	<.08	<1.6	n.d.
1007FB	1.57	1	.11	<.08	<1.6	.63
308FB	2.14	<.08	<.08	<.08	<1.6	.12
LL8						
606LL8	33.3	2.5	<.08	.46	3.1	<1[1]
1006LL8	14.2	2.6	.1	.7	4	.34
1106LL8SW	15.2	2.5	.1	<.08	4	2.29
1206LL8	16.1	3	<.08	1.3	3	n.d
207LL8	15.1	2.6	<.08	1.1	3.5	.42
307LL8	12	n.d	.47	539	13	.22
807LL8	16.4	3.2	<.08	.9	3.6	n.d.
1007LL8	15.9	5.1	.3	1.8	5.2	n.d.
308LL8	13.8	2.4	1.2	1.5	2.5	.36
LL1						
606LL1a	70.6	2.5	<.08	<.08	7.5	<1[1]
606LL1b	66.5	2.5	<.08	.3	7.2	<1[1]
1006LL1c	77.2	3	.12	<.08	9.5	.58
1006LL1d	n.d	n.d	n.d	n.d	n.d	n.d
1106LL1	75.1	3	.1	<.08	13	.47
1206LL1	33.8	3.3	<.08	1.5	14	n.d
207LL1	77.4	3	<.08	<.08	12	.67
207LL1PW	n.d.	n.d.	n.d.	n.d.	n.d.	52
307LL1	55.6	2.5	<.08	1.2	9	.54
807LL1	76.1	3.5	.10	.5	9	n.d.
1007LL1	84.5	4	<.08	.6	11	.78
308LL1	74.2	2.5	1.0	1.4	12	.56
LL1 adjacent						
207LL1a PW	n.d.	n.d.	n.d.	n.d.	n.d.	47
307LLIb	75.8	2.5	.20	1.2	6.5	.58
807LLIadj	33.3	3.6	<.08	<.08	11	n.d.
1007LLIa	73.1	3.1	<.08	.9	13	.93
308LLIa	24.8	n.d.	n.d.	n.d.	n.d.	n.d.

[1]High-range DOC (Jun ’06 samples only) has lower limit of quantitation of 1 mg/l; low-range DOC has lower limit of quantitation of 0.1 mg/L.

Table 8. Alkalinity, selected anions, and organic-carbon values for water samples. All values in milligrams per liter (mg/L).—Continued

[Dissolved organic carbon (DOC) was determined on 0.45-micron-filtered samples. n.d., not determined; PW, pore water]

	Alkalinity ($CaCO_3$)	Cl	F	NO_3	SO_4	DOC
LL10						
1006LL10	74.1	2.9	.11	.8	9.7	.65
1106LL10	211	3	.12	1	14	.43
1206LL10	47.4	3	.11	1.3	13	n.d
207LL10	72.5	2.8	<.08	1.2	12	.55
307LL10	51.5	2.5	<.08	1.2	9	n.d.
807LL10	73.6	3.5	.09	.5	9	n.d.
1007LL10	79.4	3.3	<.08	.7	11	.77
LL 11						
807LL11	69.6	3.5	<.08	<.08	6.1	n.d.
1007LL11	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
LL5						
1006LL5	75.4	2.6	.11	.6	27	2.08
LL2						
606LL2	184	2.3	<.08	<.08	3.8	2[1]
1006LL2	221	2.7	.1	<.08	8.9	2.97
1106LL2SW	81.2	2	.1	<.08	13	6.72
1106LL2PW	299	13	<.08	8	41	3.78
1206LL2	159	3.1	<.08	1.7	18	n.d
207LL2	146	1.9	<.08	<.08	9.4	1.26
307LL2	207	2.5	<.08	<.08	< 1.6	.42
807LL2	211	2.1	<.08	<.08	3.7	n.d.
1007LL2	191	2.3	.14	<.08	14	9.13
308LL2	209	3	.09	<.08	6	1.22
LL3						
807LL3	67.7	2.9	<.08	.5	24	n.d.
1007LL3	78.4	4	<.08	1.4	52	2.69
LL13						
807LL13	74.2	2.9	.1	.5	38	n.d.
1007LL13	35.1	3	<.08	1.	17	1.54
LCD-1						
606LC1	144	3	<.08	<.08	68	<1[1]

[1]High-range DOC (Jun ’06 samples only) has lower limit of quantitation of 1 mg/l; low-range DOC has lower limit of quantitation of 0.1 mg/L.

Chemical Data for Sediments, Biogenic Iron (Hydr)oxide Flocs, and Photosynthetic Mats

During fieldwork at the LCMS from 2006-2008, 80 samples of sediment, iron (hydr)oxide-rich microbial flocs and green algal slimes were collected from surface seeps, creeks, and ponds. The distinction between floc and sediment in table 9 is not definitive, and it is based primarily on morphology. The term “Fe (hydr)oxide floc” refers to material that has a clearly biogenic, flocculant morphology, forming pillowy, rounded masses suspended in the water column. These are characteristic for the presence of sheathed bacteria of the genus *Leptothrix* that specialize in the oxidation of Fe and Mn at near-neutral pH (Foster and Ashley, 2002). Light microscopy indicates that additional, as-yet unidentified microbes inhabit the flocs, and may also participate in Fe and Mn oxidation (Foster and Ashley, 2002). In contrast, the term “sediment” as used in the table below, refers to material that was probably biogenic in origin, but whose morphology has been altered by burial or compaction. In table 9 the term “sediment” also refers to material derived from biotic and abiotic sources, such as the heterogeneous tailings-rich, sandy material sampled at LL2 (Frog Pond).

The samples were analyzed by SGS Laboratories under contract with the USGS Mineral Resources Program, using the following methods: coulometric titration for carbonate (CO_3), total organic carbon and total sulfur by combustion, and 42 major and trace elements by ICP-MS-AES. The methods used by SGS (including description of standards, 3 and 5 σ detection limits, correction factors, and common interferences) are the same as those described in USGS Open File Report 02-0223, Chapters G, I, Q, R, and S (Taggart, 2002). Where necessary, samples were ground to powder consistency in an agate mortar and pestle. A multi-acid (HCl-HNO_3-$HClO_4$-HF) digestion preceded the ICP-MS-AES analyses; the other methods did not require sample pretreatment. Duplicates of selected samples were run in order to assess analytical variability. Table 9 lists analytical results for CO_3, TOC, S, and the major elements, and table 10 lists analytical results for the trace elements.

Table 9. Carbonate, total organic carbon, and major elements in sediments, biogenic iron (hydr)oxide flocs, and photosynthetic mats.

[n.d., not determined; dup, duplicate. All values in weight percent]

	Description	CO3	TOC	Al	Ca	Fe	K
LL1							
606LL1M1	Fe (hydr)oxide floc	n.d.	n.d.	.31	.51	38.6	.08
606LL1M2	Fe (hydr)oxide floc	n.d.	n.d.	.22	.47	40.4	.08
606LL1M3	Fe (hydr)oxide floc	n.d.	n.d.	.23	.52	38.8	.06
1006LL1M1	Green algal slime above Fe (hydr)oxide floc	n.d.	n.d.	.2	.06	5.85	.02
1006LL1M2	Fe (hydr)oxide floc under algae	n.d.	n.d.	.12	.53	39.6	.05
1006LL1S1	Sed core 1: middle portion	n.d.	1.51	5.48	.3	5.3	2.08
1006LL1S1b	Fe (hydr)oxide floc	n.d.	n.d.	5.83	.36	5.84	1.94
1006LL1S2	Sed core 1 bottom	n.d.	1.71	4.96	.29	9.4	1.85
1006LL1S2b	Fe (hydr)oxide floc	n.d.	n.d.	4.72	.38	12.6	1.63
1006LL1S3a	Sed core1-top 1/2	n.d.	1.58	4.5	.41	9.63	1.76
1006LL1S3a-dup		.17	n.d.	4.42	.42	8.36	1.8
1006LL1S3b	Sed core1-bottom 1/2	n.d.	n.d.	4.85	.28	5.64	1.88
1106LL1S	Fe (hydr)oxide floc	.42	4.28	4.05	.45	13.1	1.56
1106 LL1S-dup		n.d.	n.d.	3.95	.559	12.1	1.52
1206LL1S	Fe (hydr)oxide sed. From bag horizon	.28	3.89	4.54	.4	9.96	1.72
1206LL1S-dup		n.d.	n.d.	4.28	.416	9.15	1.66
207LL1b	Fe (hydr)oxide floc, orange	n.d.	n.d.	2.71	.655	22.6	.83
307LL1	Fe (hydr)oxide floc, tan (active colony)	n.d.	n.d.	2.39	.62	35.2	.81
307LL1-1	Fe (hydr)oxide floc, orange		1.64	2.29	.625	24.4	.81
307LL1-2	Fe (hydr)oxide floc, orange	n.d.	n.d.	2.41	.473	24.3	.87
807LL1	Fe (hydr)oxide floc, orange	n.d.	n.d.	1.65	.51	37.9	.57
1007LL1	Fe (hydr)oxide floc, orange	n.d.	3.18	n.d.	n.d.	n.d.	n.d.
1106LL1M1	Fe (hydr)oxide floc, dk. brown	n.d.	9.37	2.99	.39	28.8	.85
1106LL1M1	Fe (hydr)oxide floc, dk. brown	n.d.	n.d.	3.01	.399	19	.87
1206LL1S2	Fe (hydr)oxide sed, dk. brown	.25	4.24	2.26	.71	35.5	.47
1206LL1S2	Fe (hydr)oxide sed, dk. brown	n.d.	n.d.	2.88	.29	33.8	1.01
1206LL1S2-dup		n.d.	n.d.	3.07	.307	19	1.08
207LL1a	Fe (hydr)oxide floc, dk. brown	n.d.	6.78	1.48	.768	27.7	.37
307LL1b	Fe (hydr)oxide floc, dk. brown	n.d.	4.60	3.15	.41	36.1	.96
307LL1b-dup	brown	n.d.	3.94	3.07	.41	21.6	.91
LL1-adjacent							
807LL1adj	Fe (hydr)oxide floc, dk. Brown	n.d.	n.d.	2.71	.58	37.5	.88
807LL1adj-dup		n.d.	n.d.	2.44	.62	21.3	.87
1007LL1b	Fe (hydr)oxide floc, dk. brown	n.d.	6.19	2.75	.62	22.7	.85

Table 9. Carbonate, total organic carbon, and major elements in sediments, biogenic iron (hydr)oxide flocs, and photosynthetic mats.—Continued

[n.d., not determined; dup, duplicate. All values in weight percent]

	Description	CO3	TOC	Al	Ca	Fe	K
LL2							
1006LL2S1	Gray, tailings-rich sed. just below waterline	.55	1.12	4.90	1.35	1.89	1.87
1006LL2S2	Brown, tailings-rich sed. sed w/plant material	n.d.	n.d.	6.34	1.06	2.82	2.06
1006LL2S3	Gray, tailings-rich sed. just below waterline	n.d.	1.41	6.00	1.09	2.73	1.90
1006LL2S3-dup		n.d.	n.d.	5.99	1.06	2.62	1.95
1006LL2M1	Green algal slime floating on water	n.d.	n.d.	.02	.86	.37	.17
1106LL2S	Gray, tailings-rich sed. just below waterline	n.d.	n.d.	5.46	1.77	2.27	2.23
1106LL2S3	Gray, tailings-rich sed. just below waterline	.36	n.d.	n.d.	n.d.	n.d.	n.d.
1106LL2M1	Subaqueous Fe (hydr)oxide floc, tan (active colony) in plants	.35	10.2	1.17	1.32	36.2	.25
1106LL2M2	Green algal slime floating on water	n.d.	n.d.	.02	1.96	.47	.27
1106LL2M3	Subaqueous Fe (hydr)oxide floc, orange at sed-water interface (plant roots)	n.d.	7.04	3.78	2.05	18	.88
1206LL2S	Gray, tailings-rich sed. just below waterline at bags	.73	1.44	5.31	1.78	2.16	2.20
1206LL2S-dup		n.d.	n.d.	5.16	1.81	2.05	2.12
307 LL2	Gray, tailings-rich sed. just below waterline at bags	n.d.	n.d.	5.18	1.81	2.30	1.86
307LL2-dup		n.d.	n.d.	5.31	1.82	2.09	1.87
807LL2M2	Subaqueous Fe (hydr)oxide floc, tan (active colony) in plants	n.d.	8.72	4.14	4.60	15.9	.85
807LL2M2	807LL2M2	n.d.	n.d.	3.95	4.80	13.7	.88
LL8	Background site						
1106LL8M1	Green algal slime, floating	n.d.	n.d.	1.02	.37	.75	.61
LL10							
1006LL10M1	Fe (hydr)oxide floc, orange	n.d.	n.d.	.22	.19	12.9	.03
1106LL10M1	Fe (hydr)oxide floc, orange	n.d.	n.d.	.35	.55	38.2	.10
1106LL10M2	Fe (hydr)oxide floc, orange	n.d	2.68	.25	.76	37.3	.13
1106LL10M2-dup		n.d.	n.d.	.26	.79	30.6	.12
1206LL10S	Fe (hydr)oxide floc, orange	n.d	4.78	.90	.70	30.5	.18
1206LL10S1	Fe (hydr)oxide floc, tan	n.d	3.16	1.00	.42	32.9	.21
1206LL10S1-dup		n.d.	n.d.	1.08	.41	36.4	.23
1206LL10S2	Fe (hydr)oxide floc, orange	n.d.	n.d.	.86	.64	36.9	.17
1206LL10S3	Fe (hydr)oxide floc, orange	n.d.	n.d.	1.22	.67	38.0	.24
1206LL10S4	Fe (hydr)oxide floc, orange	n.d.	n.d.	.31	.68	30.0	.08

Table 9. Carbonate, total organic carbon, and major elements in sediments, biogenic iron (hydr)oxide flocs, and photosynthetic mats.—Continued

[n.d., not determined; dup, duplicate. All values in weight percent]

	Description	CO_3	TOC	Al	Ca	Fe	K
807LL10	Fe (hydr)oxide floc, orange		1.52	.20	.75	37.2	.06
807LL10	Fe (hydr)oxide floc, orange	n.d.	n.d.	.24	.78	33.5	.07
1007LL10	Fe (hydr)oxide floc, orange	n.d.	.85	.31	1.34	30.2	.10
LL11							
1006LL11M1	*Leptothrix* floc without Fe (hydr)oxide, beige	n.d.	n.d.	.33	.10	3.95	.05
807LL11	*Leptothrix* floc without Fe (hydr)oxide, tan	n.d.	n.d.	.84	.67	33.8	.23
1007LL11	*Leptothrix* floc without visible Fe (hydr)oxide, tan	n.d.	6.17	1.73	.54	29.6	.43
LL3							
807LL3	Fe (hydr)oxide floc, orange	n.d.	n.d.	.44	.83	36.3	.09
LL13							
1007LL13	Fe (hydr)oxide floc, orange	n.d.	6.12	3.22	.68	25.7	.58
807LL13	Fe (hydr)oxide floc, orange	n.d.	3.87	.44	.60	34.7	.09
807LL13 dup		n.d.	n.d.	.52	.72	31.6	.12
LCD-1							
606LC1M2	tan/brown "streamers" anchored to rocks, fast flowing water	n.d.	25.2	1.65	1.98	25.1	.40
606LC1M2 dup		n.d.	n.d.	1.60	1.97	17.6	.40
606LC1M1	dark green algae in shallow drainage	n.d.	14.7	.81	1.26	17.7	.25

Table 9. Carbonate, total organic carbon, and major elements in sediments, biogenic iron (hydr)oxide flocs, and photosynthetic mats.—Continued

[n.d., not determined; dup, duplicate. All values in weight percent]

	Description	Mg	Mn	Na	P	S
LL1						
606LL1M1	Fe (hydr)oxide floc	.02	.155	.01	.191	.08
606LL1M2	Fe (hydr)oxide floc	.01	.084	.01	.196	.14
606LL1M3	Fe (hydr)oxide floc	.02	.344	.02	.155	.04
1006LL1M1	Green algal slime above Fe (hydr)oxide floc	<.01	.014	.01	.026	.01
1006LL1M2	Fe (hydr)oxide floc under algae	.02	.834	.02	.180	.06
1006LL1S1	Sed core 1: middle portion	.57	.333	.24	.062	.05
1006LL1S1b	Fe (hydr)oxide floc	.54	.453	.22	.068	.04
1006LL1S2	Sed core 1 bottom	.48	.102	.21	.074	.06
1006LL1S2b	Fe (hydr)oxide floc	.48	.133	.21	.081	.05
1006LL1S3a	Sed core1-top 1/2	.49	19.3	.2	.064	.03
1006LL1S3a-dup		.496	29.0	.211	.066	n.d.
1006LL1S3b	Sed core1-bottom 1/2	.5	.154	.2	.059	.02
1106LL1S	Fe (hydr)oxide floc	.42	22.02	.17	.074	.06
1106 LL1S-dup		.447	35	.186	.079	.09
1206LL1S	Fe (hydr)oxide sed. From bag horizon	.47	17.24	.2	.072	.07
1206LL1S-dup		.465	27	.183	.070	n.d.
207LL1b	Fe (hydr)oxide floc, orange	.294	20.8	.109	.143	n.d.
307LL1	Fe (hydr)oxide floc, tan (active colony)	.25	25.1	.1	.145	.08
307LL1-1	Fe (hydr)oxide floc, orange	.268	40.2	.105	.140	n.d.
307LL1-2	Fe (hydr)oxide floc, orange	.26	23.4	.109	.147	n.d.
807LL1	Fe (hydr)oxide floc, orange	.18	25.8	.07	.165	.05
1007LL1	Fe (hydr)oxide floc, orange	n.d.	n.d.	n.d.	n.d.	.09
1106LL1M1	Fe (hydr)oxide floc, dk. brown	.29	.773	.11	.151	.18
1106LL1M1	Fe (hydr)oxide floc, dk. brown	.308	.757	.113	.142	.12
1206LL1S2	Fe (hydr)oxide sed, dk. brown	.2	12.37	.07	.147	0.2

Table 9. Carbonate, total organic carbon, and major elements in sediments, biogenic iron (hydr)oxide flocs, and photosynthetic mats.—Continued

[n.d., not determined; dup, duplicate. All values in weight percent]

	Description	Mg	Mn	Na	P	S
1206LL1S2	Fe (hydr)oxide sed, dk. brown	.29	.487	.11	.134	.17
1206LL1S2-dup		.323	.471	.135	.134	n.d.
207LL1a	Fe (hydr)oxide floc, dk. brown	.174	32.6	.053	.157	n.d.
307LL1b	Fe (hydr)oxide floc, dk. brown	.31	.847	.12	.164	.24
307LL1b-dup	brown	.30	.844	.12	.156	n.d.
LL1-adjacent						
807LL1adj	Fe (hydr)oxide floc, dk. Brown	.28	21	.10	.143	.09
807LL1adj-dup		.29	35.2	.12	.139	.10
1007LL1b	Fe (hydr)oxide floc, dk. brown	.29	21.1	.11	.136	.10
LL2						
1006LL2S1	Gray, tailings-rich sed. just below waterline	.78	.042	.20	.044	.06
1006LL2S2	Brown, tailings-rich sed. sed w/plant material	.79	.051	.25	.057	.11
1006LL2S3	Gray, tailings-rich sed. just below waterline	.79	.045	.23	.055	.08
1006LL2S3-dup		.75	.048	.24	.056	n.d.
1006LL2M1	Green algal slime floating on water	.11	.024	1.47	.072	.23
1106LL2S	Gray, tailings-rich sed. just below waterline	.86	.051	.23	.052	.04
1106LL2S3	Gray, tailings-rich sed. just below waterline	n.d.	n.d.	n.d.	n.d.	n.d.
1106LL2M1	Subaqueous Fe (hydr)oxide floc, tan (active colony) in plants	.15	24.51	.04	.014	.10
1106LL2M2	Green algal slime floating on water	.16	.054	2.63	.072	.31
1106LL2M3	Subaqueous Fe (hydr)oxide floc, orange at sed-water interface (plant roots)	.44	.143	.19	.110	.15
1206LL2S	Gray, tailings-rich sed. just below waterline at bags	.86	.053	.23	.051	.05
1206LL2S-dup		.82	.050	.22	.051	n.d.
307 LL2	Gray, tailings-rich sed. just below waterline at bags	.75	.050	.20	.057	
307LL2-dup		.78	.039	.21	.054	.09
807LL2M2	Subaqueous Fe (hydr)oxide floc, tan (active colony) in plants	.44	.741	.14	.122	.15
807LL2M2	807LL2M2	.46	11	.17	.126	n.d.

Table 9. Carbonate, total organic carbon, and major elements in sediments, biogenic iron (hydr)oxide flocs, and photosynthetic mats.—Continued

[n.d., not determined; dup, duplicate. All values in weight percent]

	Description	Mg	Mn	Na	P	S
LL8	Background site					
1106LL8M1	Green algal slime, floating	.34	.017	.05	.111	.13
LL10						
1006LL10M1	Fe (hydr)oxide floc, orange	.02	.408	.01	.040	.01
1106LL10M1	Fe (hydr)oxide floc, orange	.04	13.57	.02	.145	.05
1106LL10M2	Fe (hydr)oxide floc, orange	.05	61.46	.02	.116	.04
1106LL10M2-dup		.08	11.8	.02	.113	n.d.
1206LL10S	Fe (hydr)oxide floc, orange	.10	59.7	.04	.129	.09
1206LL10S1	Fe (hydr)oxide floc, tan	.09	.840	.04	.123	.07
1206LL10S1-dup		.07	.920	.03	.128	.05
1206LL10S2	Fe (hydr)oxide floc, orange	.07	28.11	.03	.142	.07
1206LL10S3	Fe (hydr)oxide floc, orange	.10	44.88	.04	.111	.06
1206LL10S4	Fe (hydr)oxide floc, orange	.03	45.78	.03	.117	.03
807LL10	Fe (hydr)oxide floc, orange	.04	36.5	.01	.109	.03
807LL10	Fe (hydr)oxide floc, orange	.06	35.4	.02	.112	n.d.
1007LL10	Fe (hydr)oxide floc, orange	.10	17.2	.02	.103	n.d.
LL11						
1006LL11M1	*Leptothrix* floc without Fe (hydr)oxide, beige	.03	.081	.02	.025	.02
807LL11	*Leptothrix* floc without Fe (hydr)oxide, tan	.11	.443	.06	.155	.08
1007LL11	*Leptothrix* floc without visible Fe (hydr)oxide, tan	.19	.535	.07	.155	n.d.
LL3						
807LL3	Fe (hydr)oxide floc, orange	.09	.405	.03	.103	.1
LL13						
1007LL13	Fe (hydr)oxide floc, orange	.31	.240	.11	.149	n.d.
807LL13	Fe (hydr)oxide floc, orange	.06	.995	.02	.070	.08
807LL13 dup		.10	15.6	.04	.088	n.d.
LCD-1						
606LC1M2	tan/brown "streamers" anchored to rocks, fast flowing water	.21	.491	.04	.399	.19
606LC1M2 dup		.21	.348	.04	.353	n.d.
606LC1M1	dark green algae in shallow drainage	.16	.065	.04	.456	.22

Table 10. Trace elements in sediments, biogenic iron (hydr)oxide flocs, and photosynthetic mats by inductively-coupled plasma mass spectrometry-atomic emission spectrometry.

[n.d., not determined; dup, duplicate. All values in milligrams per kilogram (mg/kg)]

	As	Ag	Ba	Cd	Co	Cr	Cu	Ga	Li
LL1									
606LL1M1	1,540	<1	348	.4	3.6	9	17.5	.72	1
606LL1M2	2,810	<1	335	.7	9.4	13	31.5	1.25	1
606LL1M3	2,660	<1	420	.3	6.8	5	6.4	1.18	1
1006LL1M1	507	<1	44	6.6	.9	20	1.9	.4	2
1006LL1M2	3,720	<1	507	.4	18.5	72	280	1.37	<1
1006LL1S1	1,010	6	570	.6	13.6	53	42	15	18
1006LL1S1b	1,120	10	642	.9	18.9	55	53.9	15.3	18
1006LL1S2	1,660	6	459	1.1	10.2	45	42.9	14	15
1006LL1S2b	1,940	7	470	1.7	11.5	45	46.9	12.5	16
1006LL1S3a	1,440	7	1,060	.7	25.8	39	59.9	13	15
1006LL1S3a-dup	1,190	8	1,000	2	24	69	58	14	13
1006LL1S3b	789	7	497	.6	8	48	41.3	11.9	17
1106LL1S	1,560	5	1,050	.8	30.1	40	32.6	12.3	13
1106 LL1S-dup	1,360	6	1,070	3	26	57	37	15	12
1206LL1S	1,400	5	993	1.1	29.6	46	37.7	14.3	14
1206LL1S-dup	1,100	8	960	2	24	64	33	14	12
207LL1b	2,100	3	902	4	31	63	42	18	9
307LL1	3,090	3	1,090	.9	35.3	21	52.7	7.44	9
307LL1-1	2,500	4	1,020	4	34	65	63	18	8
307LL1-dup	2,820	3	729	3	24	61	42	19	8
807LL1	2,660	4	1,370	.5	36.6	16	17.8	6.02	6
LL1 adjacent									
1106LL1M1	2,200	3	547	1	23.3	26	49.8	7.57	10
1106LL1M1-dup	1,820	5	508	3	23	73	57	15	10
1206LL1S2	2,400	2	623	1.4	34.8	23	52.5	7.08	8
1206LL1S2	3,140	3	460	1	16.8	26	33.9	7.58	10
1206LL1S2-dup	2,350	5	457	3	16	70	37	18	10
207LL1a	2,560	<2	1,080	4	39	61	38	18	5
307LL1b	2,660	3	558	1.3	21.9	27	58.9	7.85	11
307LL1b-dup	2,270	3	530	3	21	58	58	18	10
807LL1adj	2,320	2	1,210	1	34.5	25	33.8	8.42	10
807LL1adj-dup	2,410	2	1,280	<2	37	58	41	20	9
1007LL1b	2,020	<2	868	4	28	62	37	17	9

Table 10. Trace elements in sediments, biogenic iron (hydr)oxide flocs, and photosynthetic mats by inductively-coupled plasma mass spectrometry-atomic emission spectrometry.—Continued

[n.d., not determined; dup, duplicate. All values in milligrams per kilogram (mg/kg)]

	As	Ag	Ba	Cd	Co	Cr	Cu	Ga	Li
LL2									
1006LL2S1	430	7	454	1.2	9.6	70	41.4	11.4	20
1006LL2S2	711	10	525	1.5	13.3	53	51	16.6	20
1006LL2S3	701	6	512	1.7	10.5	47	48.3	14.1	20
1006LL2S3-dup	580	7	495	<2	10	60	42	17	19
1006LL2M1	483	<1	5,460	1.1	2.2	2	5	.21	<1
1106LL2S	661	7	448	4.2	8	52	43.7	13.6	17
1106LL2M1	16,891	1	1,060	1.9	39.2	36	36.4	5.66	5
1106LL2M2	677	<1	5,030	.3	3.1	<1	1.5	.15	<1
1106LL2M3	29,011	4	648	3.4	17.3	32	44.4	9.84	13
1206LL2S	654	7	438	3.5	7.5	49	38.8	14.2	16
1206LL2S-dup	490	8	444	3	6	76	39	14	15
307 LL2	660	7	461	3	11	84	41	15	19
307LL2-dup	723	5	468	2.3	11.9	44	44.9	13.8	20
807LL2M2	18,150	3	683	2.4	35.5	29	45.1	11	13
807LL2M2-dup	23,000	4	695	<2	34	67	50	19.	13
LL8									
1106LL8M1	43	<1	106	.3	3.2	12	26.3	2.58	4.0
LL10									
1006LL10M1	922	<1	228	5.9	7.1	22	2.7	.89	1.
1106LL10M1	2,900	<1	687	.4	21.2	5	7.9	2.28	1.
1106LL10M2	3,220	<1	2,140	.5	70	5	7.1	6.69	1.
1106LL10M2-dup	2,510	2	1,870	5	54	51	10	17	<1
1206LL10S	2,500	<2	1,190	4	39	57	18	20	3.
1206LL10S1	2,630	<2	540	4	15	53	14	21	4
1206LL10S1-dup	3,380	<1	564	.5	19.5	10	13	3.78	3
1206LL10S2	3,080	<1	1,050	.7	40.1	10	15	4.98	3
1206LL10S3	2,890	1	1,440	.6	55	12	15.8	7.3	4
1206LL10S4	3,030	<1	1,590	.4	53.4	7	3.7	5.04	1
807LL10	3,280	<1	1,240	.3	37.6	2	141	2.61	<1
807LL10	2,900	<2	1,180	5.	37	46	6	21	<1
1007LL10	2,420	7	2,290	5	78	44	16	13	<1

Table 10. Trace elements in sediments, biogenic iron (hydr)oxide flocs, and photosynthetic mats by inductively-coupled plasma mass spectrometry-atomic emission spectrometry.—Continued

[n.d., not determined; dup, duplicate. All values in milligrams per kilogram (mg/kg)]

	As	Ag	Ba	Cd	Co	Cr	Cu	Ga	Li
LL11									
1006LL11M1	623	<1	59	6	3	22	3.9	.73	2
807LL11	6,830	<1	354	1.7	14.2	9	14.9	2.55	3
1007LL11	6,480	3	532	5	32	57	34	20	6
LL3									
807LL3M	22,200	<1	329	1.4	28	4	13.6	1.63	2
LL13									
1007LL13	7,210	<2	483	4	18	70	58	22	11
807LL13	10,300	<1	391	1.2	60.1	6	41.6	1.83	2
807LL13-dup	14,000	<2	474	<2	74	45	24	26	2
LCD-1									
606LC1M2	47,000	3	643	2.3	50.9	13	107	3.89	5
606LC1M2-dup	32,500	4	594	8	39	60	107	13	5
606LC1M1	39,000	1	1,580	2.7	8	7	63	1.73	2

Table 10. Trace elements in sediments, biogenic iron (hydr)oxide flocs, and photosynthetic mats by inductively-coupled plasma mass spectrometry-atomic emission spectrometry.—Continued

[n.d., not determined; dup, duplicate. All values in milligrams per kilogram (mg/kg)]

	Mo	Ni	Pb	Rb	Sb	Sr	V	W	Y	Zn
LL1										
606LL1M1	8.1	6.7	2.4	2.2	2.1	84	42	36	6.1	41
606LL1M2	21	13	6.6	3.4	3.6	77	26	75	11.8	81
606LL1M3	11	4.2	3.7	2.7	2.6	89	25	60	10.7	21
1006LL1M1	3.4	2.4	1.8	.9	.3	9.6	4	11	2.9	6
1006LL1M2	20	4.6	63	1.9	4.5	87	21	68	11.6	174
1006LL1S1	4	16	42	77	11	56	146	58	11.9	102
1006LL1S1b	4.3	21	49	73	16	66	155	62	12.4	119
1006LL1S2	8.5	14	46	71	14	54	129	90	12.6	105
1006LL1S2b	9.7	16	37	61	13	69	123	66	12.9	127
1006LL1S3a	6.7	12	26	63	14	66	113	59	9.3	103
1006LL1S3a-dup	5	21	32	<1	<1	69	103	<1	9	91
1006LL1S3b	4.1	12	28	74	12	48	123	80	9.6	82
1106LL1S	8.7	16	28	60	9.4	74	109	62	10.3	92
1106 LL1S-dup	6	22	29	<1	<1	79	94	<1	10	93
1206LL1S	8	17	34	74	11	69	123	58	11	116
1206LL1S-dup	5	17	24	<1	<1	67	100	<1	9	113
207LL1b	12	20	18	<1	<1	86	79	<1	21	122
307LL1	16	5.4	12	30	11	86	73	69	16.8	100
307LL1-1	13	8	18	<1	<1	88	68	<1	16	92
307LL1-dup	13	7	16	<1	<1	73	68	<1	13	81
807LL1	16	<.5	10	23	9.5	76	50	70	11.5	69
LL1 adjacent										
1106LL1M1	9.8	12	18	34	8.4	48	91	58	35.6	111
1106LL1M1-dup	9	18	20	<1	<1	49	83	<1	31	110
1206LL1S2	14	18	24	24	8.6	64	83	52	42.7	104
1206LL1S2	11	5.9	18	40	7.9	35	78	64	17.4	110
1206LL1S2-dup	9	11	19	<1	<1	38	77	<1	17	97
207LL1a	13	12	15	<1	<1	92	69	<1	25	103
307LL1b	11	9.7	19	38	9.3	48	90	62	29.5	139
307LL1b-dup	9	14	19	<1	<1	49	82	<1	27	102
807LL1adj	13	7.6	14	34	8.5	80	79	59	16.5	123
807LL1adj-dup	12	11	18	<1	<1	81	82	<1	18	118
1007LL1b	11	12	17	<1	<1	80	77	<1	20	118

Table 10. Trace elements in sediments, biogenic iron (hydr)oxide flocs, and photosynthetic mats by inductively-coupled plasma mass spectrometry-atomic emission spectrometry.—Continued

[n.d., not determined; dup, duplicate. All values in milligrams per kilogram (mg/kg)]

	Mo	Ni	Pb	Rb	Sb	Sr	V	W	Y	Zn
LL2										
1006LL2S1	5	29	30	71	21	73	116	87	9.3	164
1006LL2S2	2	28	48	76	18	79	151	79	13.2	161
1006LL2S3	1.8	24	32	75	15	75	137	97	12.1	182
1006LL2S3-dup	2	30	32	<1	<1	73	124	<1	11	142
1006LL2M1	1.5	2.2	<0.5	1.9	.21	54	<1	.4	.1	80
1106LL2S	1.4	24	59	74	17	94	133	130	12	345
1106LL2M1	14	18	37	13	13	144	50	46	29.4	162
1106LL2M2	1.4	1.8	.5	3	.24	60	<1	.1	.1	63
1106LL2M3	2.2	31	37	39	31	165	91	60	10.5	350
1206LL2S	1.6	21	52	77	18	97	126	104	12.3	290
1206LL2S-dup	<2	22	49	<1	<1	90	116	<1	11	288
307 LL2	2	34	32	<1	<1	78	118	<1	11	218
307LL2-dup	2	28	31	80	40	79	122	104	11.1	232
807LL2M2	2.7	29	24	37	21	184	93	38	10.4	235
807LL2M2-dup	2	30	28	<1	<1	183	83	<1	10	240
LL8										
1106LL8M1	4.5	16	3.2	12	.32	45	30	.2	3.9	40
LL10										
1006LL10M1	2.9	5.5	1.5	1.3	.32	32	6	17	3.7	14
1106LL10M1	13	5.9	5.2	5	2.6	90	27	60	11.2	39
1106LL10M2	22	9	3.6	6.6	2.9	134	23	55	9.8	43
1106LL10M2-dup	10	12	13	<1	<1	127	13	<1	8	40
1206LL10S	10	10	12	<1	<1	100	27	<1	10	58
1206LL10S1	8	<3	7	<1	<1	73	28	<1	10	47
1206LL10S1-dup	12	7.2	9.2	11	4.2	74	42	63	12.4	50
1206LL10S2	15	10	8.1	8.8	3.9	99	37	63	12.4	59
1206LL10S3	17	12	9.1	12	5.7	106	40	56	11.2	57
1206LL10S4	17	6.7	1.6	4	2.9	121	24	52	9.7	45
807LL10	11	<.5	3.9	2.9	2.3	111	16	52	8	71
807LL10	8	3	8	<1	<1	117	14	<1	8	37
1007LL10	8	6	16	<1	<1	171	14	<1	8	47

Table 10. Trace elements in sediments, biogenic iron (hydr)oxide flocs, and photosynthetic mats by inductively-coupled plasma mass spectrometry-atomic emission spectrometry.—Continued

[n.d., not determined; dup, duplicate. All values in milligrams per kilogram (mg/kg)]

	Mo	Ni	Pb	Rb	Sb	Sr	V	W	Y	Zn
LL11										
1006LL11M1	.8	4.5	2.3	2.	0.38	13	9	7.7	2.2	19
807LL11	8.7	3.1	5.9	9.6	4.9	93	41	12	7.6	121
1007LL11	8	16	15	<1	<1	79	58	<1	10	219
LL3										
807LL3	7.2	<0.5	4.5	3.9	4.1	100	39	15	4	110
LL13										
1007LL13	9	17	16	<1	<1	107	103	<1	13	123
807LL13	11	1.1	3.6	4.1	4	80	44	5.4	4.6	84
807LL13-dup	10	4	10	<1	<1	91	49	<1	6	88
LCD-1										
606LC1M2	3.3	22	32	15	11	229	38	22	38.8	330
606LC1M2-dup	3	27	34	<1	<1	236	38	<1	38	312
606LC1M1	2.6	10	8.9	7.4	5.8	156	18	9.7	33.5	223

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References

Ash, S.H., 1941, Mining practices and safety at the Lava Cap Gold Mining Corporation mines, Nevada City-Grass Valley district, California: US Bureau of Mines Technical Paper 619, 36 p.

Chandler, J.W., 1941, Mining methods and costs of the Lava Cap Gold Mining Corporation, Nevada City: California Division of Mines Report 37, 409-425 p.

Clark, W.B., 1970, Gold districts of California: California Division of Mines and Geology Bulletin 193, 186 p.

USEPA, 2009, Lava Cap Mine: *http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/ce6c60ee7382a473882571af007af70d/7f29f3b3740158ca88257007005e944f!OpenDocument* (last accessed March 10, 2010).

USEPA, 2001, Public draft remedial investigation report: Lava Cap Mine Superfund site. *http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/3dc283e6c5d6056f88257426007417a2/90830441ca74946d8825727b006d7711!OpenDocument* (last accessed March 10, 2010).

Foster, A.L., and Ashley, R.P., 2002, Characterization of arsenic species in microbial mat communities in the vicinity of the Lava Cap gold mine, Nevada City, CA: Geochemistry: Exploration, Environment, and Analysis, v. 2, p. 253-261.

Foster, A.L., Ashley, R.P., and Rytuba, J.J., in press, Arsenic species in weathering tailings and biogenic solids at the Lava Cap Mine Superfund Site, Nevada County, Calif.: submitted to Geochemical Transactions.

Garbarino, J.R., Bednar, A.J., and Burkhardt, M.R., 2002, Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory; Arsenic speciation in natural-water samples using laboratory and field methods: USGS Water-Resources Investigations Report 2002-4144, 40 p.

Lee, G.F., and Jones-Lee, A., 2003, Occurrence of public health and environmental hazards and potential remediation of arsenic-containing soils, sediments, surface water and groundwater at the Lava Cap Mine NPL Superfund site in Nevada County, California, *in* Chappell, W.R. and others, eds, Arsenic Exposure and Health Effects V: New York, Elsevier, p 79-91 p.

Taggart, J.E., ed., 2002, Analytical methods for chemical analysis of geologic and other materials: USGS Open File Report 02-0223, (variously paginated). *http://pubs.usgs.gov/of/2002/ofr-02-0223/* (last accessed April 20, 2010).