Ref. 14

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CEMENT CREEK

RECLAMATION FEASIBILITY REPORT

UPPER ANIMAS RIVER BASIN

1260037

Jim Her... nd Paul Krabacher

Colora... als and Geology

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Jim Herron, Bruce Stover and Paul Krabacher

Colorado Division of Minerals and Geology

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Edited by Anne Clift

Colorado Division of Minerals and Geology

Funded through Clean Water Act - 319 Grants

Special thanks to the Animas River Stakeholders

September, 1998

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INTRODUCTION

This report is intended to be a guidance document for use by the Animas River Stakeholders Group (ARSG) in prioritizing and planning water quality reclamation projects at mine sites in the Cement Creek basin in southwestern Colorado. The initial reconnaissance of the basin was performed by the Colorado Department of Public Health and Environment, Water Quality Control Division (WQCD) in 1991, 1992, and 1993. The water samples collected at that time bracketed the tributary streams of Cement Creek, but did not identify or sample individual sources. Based on those data, the Colorado Division of Minerals & Geology (DMG) conducted a more comprehensive reconnaissance to formulate a sampling plan for collecting and analyzing water quality and waste rock extract data. The DMG sampling program was conducted in 1996 and 1997 in accordance with this plan. The result of the DMG sampling program is this reclamation feasibility investigation. Using this report, the ARSG will prioritize the sites investigated and plan future reclamation work in the Cement Creek area.

The ultimate goal of this work is to improve the water quality and fisheries of the Animas River downstream of Silverton, Colorado by reclaiming abandoned mine sites upstream of Silverton. To achieve this goal, four reclamation feasibility investigations are planned for the Animas River watershed above Silverton. The first, which covered mining sites in the Mineral Creek area, was published in 1997. This report, which covers mining sites in the Cement Creek area, is the second to be published. The third, which will cover mining sites in the upper Animas River above the townsite of Eureka, is to be completed in 1999. Water quality sampling for that report will be completed in July 1998. The final report, which will cover mining sites in the Animas River between Silverton and the Eureka townsite is scheduled for completion in 2000.

GENERAL SITE DESCRIPTION

LOCATION

Cement Creek is located in San Juan County in the San Juan Mountains in southwestern Colorado. The creek is approximately eight miles long flowing from north to south into the Animas River at Silverton. Figure 1 is a general location map of the area.

Prospecting began in San Juan County in the 1860's. Mining began in the area in 1874. There are hundreds of abandoned mines and prospects in the Cement Creek drainage. Mining still continues today in the North Fork of Cement Creek.

Investigation of the water in Cement Creek was initiated as part of the effort to improve the water quality in the Animas River. The visual impact and unnatural color of Cement Creek targeted it for further investigation. Although there are numerous natural sources of metals in the basin, drainage from the abandoned mines in the area also contribute to the degradation of the water quality in Cement Creek and ultimately the Animas River. In addition, there are numerous waste rock piles,

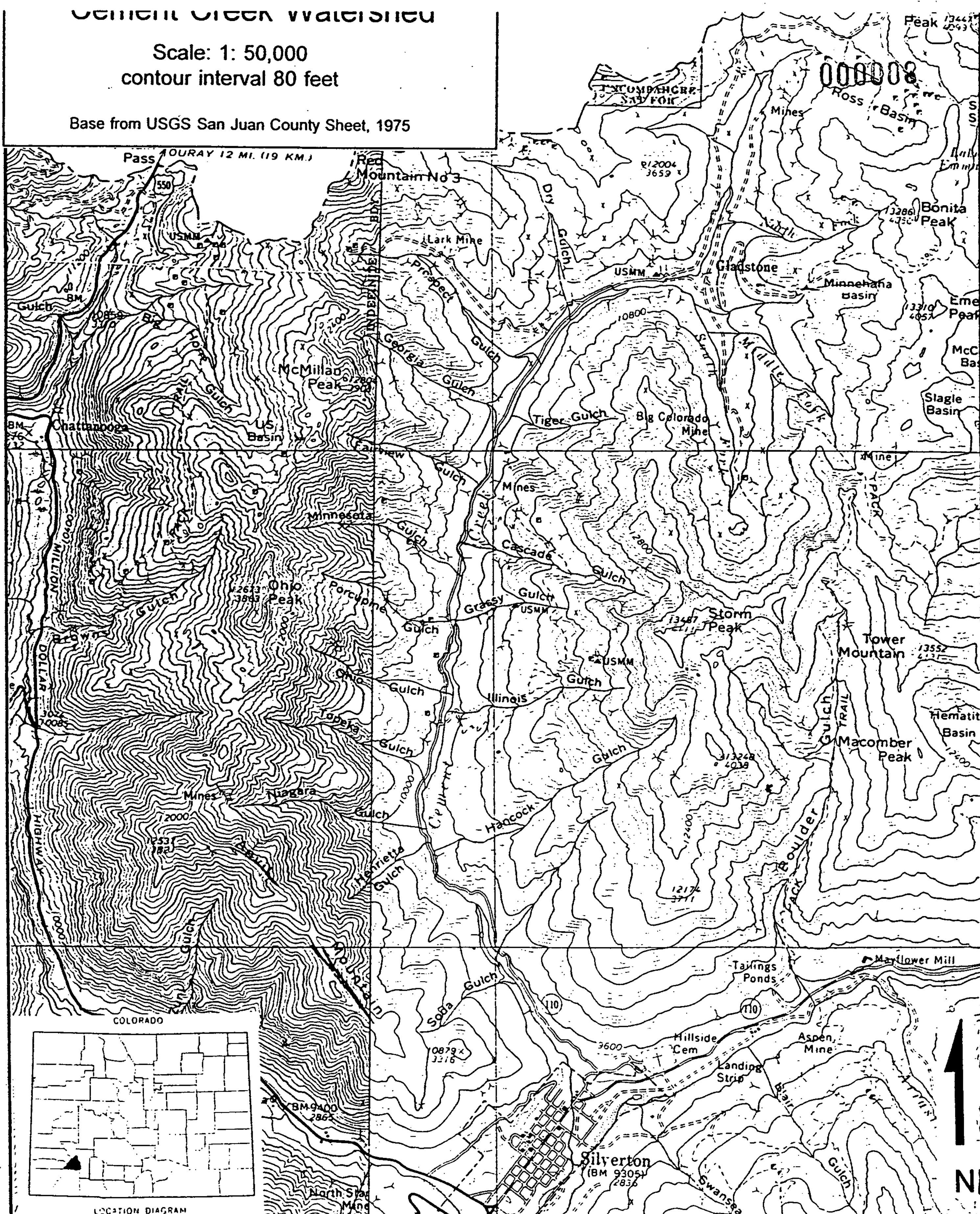

Cement Creek Watershed
Scale: 1: 50,000
contour interval 80 feet
Base from USGS San Juan County Sheet, 1975
000008
OURAY 12 MI. (19 KM.)
Pass
550
Red Mountain No 3
USMM
Lark Mine
Prospect
Dry
Gulch
Gladstone
Minnehaha Basin
Bonita Peak
Ross Basin
Mines
Big Horn Gulch
Georgia Gulch
McMillan Peak
Chattanooga
US Basin
Tiger Gulch
Big Colorado Mine
Middle Fork
Slagle Basin
Fairview Gulch
Mines
Minnesota Gulch
Cascade Gulch
Ohio Peak
Porcupine Gulch
Grassy Gulch
Storm Peak
Tower Mountain
Browns Gulch
Ohio Gulch
Illinois Gulch
Topeka Gulch
Hematite Basin
Macomber Peak
MILLION DOLLAR HIGHWAY
Mines
Niagara Gulch
Cement Creek
Hancock
Boulder Gulch
Henrietta Gulch
Soda Gulch
Mayflower Mill
Tailings Ponds
110
Hillside Cem
Aspen Mine
Landing Strip
Silverton
(BM 9305)
Swansea
North Star Mine
COLORADO
LOCATION DIAGRAM
N

Figure 1

000009

which contribute acidic water and high metals to the creek.

GEOLOGY

The Cement Creek watershed lies within the Silverton Caldera, a regionally prominent Tertiary-aged volcanic center within the larger San Juan Volcanic Depression.

Stratigraphy

The Tertiary-age Silverton Volcanic Group underlies the Cement Creek area. Included in the Silverton Volcanic Group are the Burns Formation and overlying Henson Formation. A stratigraphic column of the units in the area is shown on Figure 2.

The Burns Formation consists dominantly of medium to dark, brown and black, thick, massive rhyodacite and quartz latite flows and flow breccias. This sequence of rocks has been divided into several units, including a lower flow-layered amphibole-bearing member, a pebble-tuff unit, and an upper, massive pyroxene-bearing member (Burbank and Luedke, 1969).

The overlying Henson Formation consists of dark, dense, coarse-grained porphyritic and amygdaloidal flows and flow breccias, and fine-grained sandy tuffs of andesitic and rhyodacitic composition. Although there are many interesting local variations in texture, volcanic structures, and mineralogy of the dark volcanic flows in the area, they are generally too localized and discontinuous to map, and these variations are not important for this investigation.

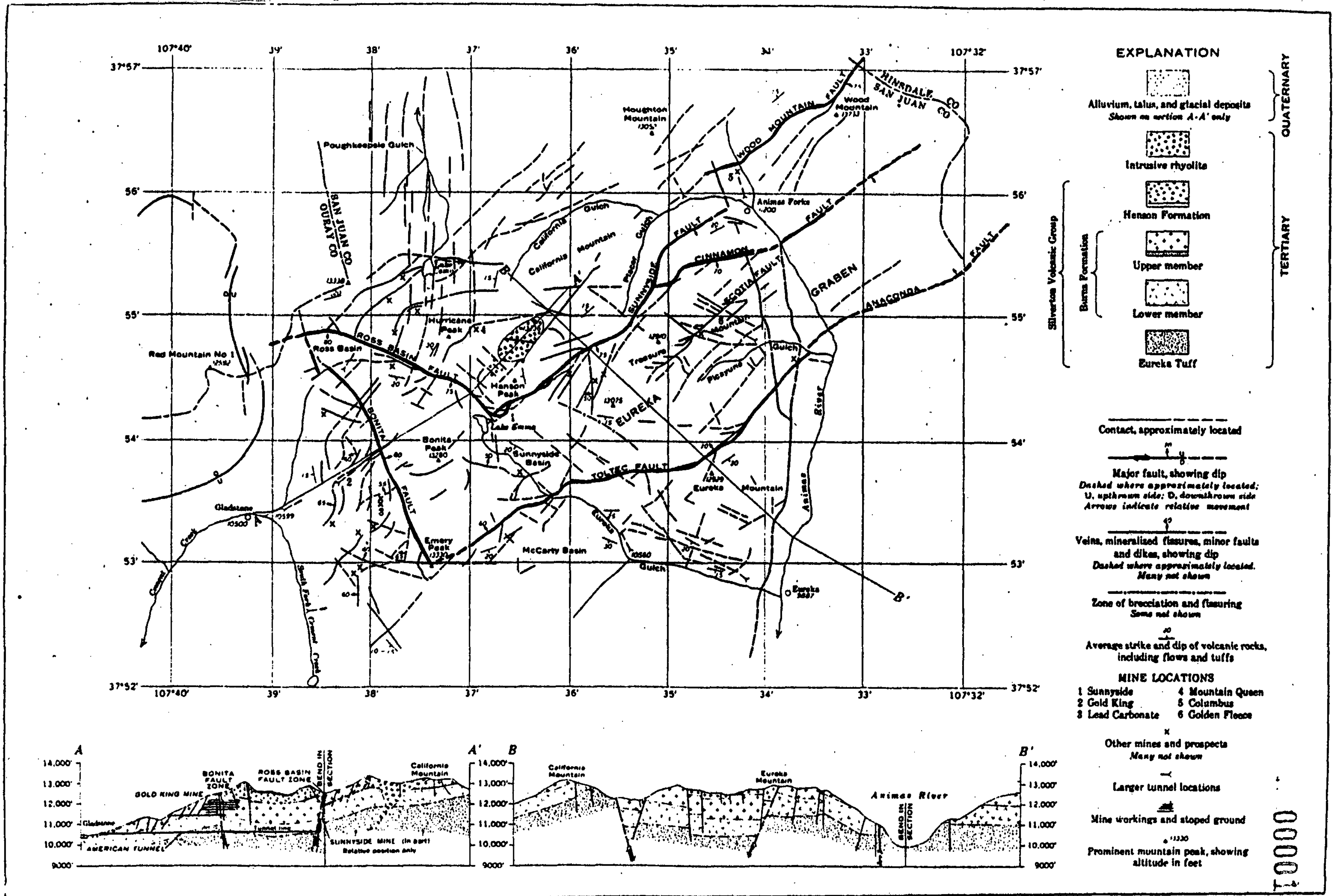
Structural Geology

Structurally, the Cement Creek basin lies in the northern part of the Silverton Volcanic Caldera. The basin is affected by both the ring-fault structure defining the western edge of the caldera and the Eureka Graben, which defines the down-dropped area within the caldera. The Eureka Graben is believed to have formed as the domed-up caldera rocks above active magma chambers relaxed and sagged back during periods of volcanic quiescence and magma retreat. During the various resurgences in volcanic activity through the late Tertiary, the faults bounding the graben were repeatedly reactivated. Today, the Eureka Graben is a boot-shaped graben bounded by a series of major, steeply dipping mineralized faults. (Burbank and Luedke, 1969)

Figure 2 is a map showing the structural geology of the area. The Cement Creek basin is situated inside the caldera, several miles east of the bordering ring-fault structure and at the southwest end of the Eureka Graben.

Hydrothermal Alteration

All the volcanic rocks in the San Juan Volcanic Depression were extensively propylitized and altered on a regional scale, prior to ore deposition. "Propylitic" alteration is a term used to describe a particular type of mineralogic and chemical changes which occurs by circulation of aqueous



GENERALIZED STRUCTURE MAP AND GEOLOGIC SECTIONS OF THE EUREKA, ANIMAS FORKS AND GLADSTONE AREAS, SAN JUAN COUNTY, COLORADO

Figure 2.
Plate 6 from USGS Prof. Paper 535, Burbanke and Luedke, 1969

hydrothermal solutions through the original volcanic rock mass. The addition of carbon dioxide and water to the rock mass results in mineralogical changes to the rocks. Propylitic alteration here is typified by the formation and addition of chlorite, calcite, and clays in weakly altered rocks, to epidote, albite, and chlorite in more intensely altered rocks. Propylitic alteration has resulted in a dull green or greenish gray color to virtually all of the Burns Formation rocks.

Rocks near the structural margin of the caldera and around volcanic breccia pipes have been highly altered by solfataric and hydrothermal processes. "Solfataric" processes have subjected the rock to attack and leaching by hot sulphurous gases and solutions moving upwards along the structural margin of the Silverton Caldera and Red Mountain graben. These hydrothermal processes have leached and "stewed" most of the base minerals from the rocks, while introducing such large amounts of sulphur that this type of solfatarically-altered terrain is readily distinguished from the surrounding regional propylitic alteration. Volcanic flows within the Red Mountain block forming the northwestern edge of the Cement Creek basin were so strongly altered and leached that little remains except silica, kaolinite, and sulfate and sulfide alteration products. Virtually all potential buffering minerals in the country rock have been leached away, leaving the quartz-allunite-pyrite alteration assemblage characteristic of the Red Mountain District. Bleaching of the rocks and subsequent surficial oxidation of the solfataric pyrite through geologic time has resulted in the brilliant red, orange, and yellow staining which characterizes the "Red" Mountains.

Wall rock adjacent to the vein deposits has been subjected to more intense but localized alteration processes. Wall rock alteration occurred episodically as the veins were reopened and subjected to successive phases of mineralization from solutions having often very different composition.

Manganese minerals are characteristic of alteration in the wall rocks of the major fault-fracture veins. Manganese from mineralizing solutions moving through the fissure veins has penetrated the wall rocks, leaving rhodonite and rhodocrosite alterations. Where weathered on the surface, these manganese-altered rocks often are conspicuous due to the characteristic black staining of manganese oxides (pyrolusite, psilomelane).

Surficial Geology

Many of the slopes in the Cement Creek basin are steep and prone to snow avalanches, rockfalls, and debris flows. Above timberline, rock outcrops dominate the landscape and soils are thin to patchy tundra varieties. Near the ridges bordering the basin are several active rock glaciers. The lower valley walls and valley floor are extensively mantled by talus deposits. Alluvial deposits are present on the valley floor in isolated patches.

BASELINE DATA COLLECTION

Water and waste rock samples were collected and analyzed to better understand the hydrology and chemistry of Cement Creek. Water quality data were collected by the WQCD in 1991, 1992 and 1993 during an initial reconnaissance of the area. Water samples were collected at 67 different sites along the creek. The locations of these sites are shown on Figures 3, 4 and 5 in smaller italicized underlined letters. The WQCD sampled these sites from one to four times during each of four sampling events. The samples collected were analyzed for various dissolved and total recoverable metals. The number of dissolved and total recoverable analytes varied with each sample event. These data are not included in this report, but are available from the WQCD at the Colorado Department of Public Health and Environment.

Based on the WQCD results, baseline water quality sampling was conducted by DMG in October 1996, and February and June 1997. Waste rock sampling was conducted by the DMG in August 1996. The sampling program, collection and analysis methods are discussed below. For sampling purposes, the Cement Creek basin was divided into three major areas. These include Upper Cement Creek upstream of about Gladstone, Prospect Gulch and Lower Cement Creek, downstream of Gladstone. The locations of these sampling areas are shown on Figure 1.

SAMPLING OF WATER QUALITY

The DMG sampled along Cement Creek during the low-flow and high-flow regimes to determine the extremes in the amount of heavy metals contributed by various sources. Water samples were taken on October 1, 1996 to obtain low-flow data, February 25, 1997 to obtain absolute low-flow data at accessible sites, and June 25 and 26, 1997 to obtain high-flow data. The results showed that the flows measured during February were higher than those measured during October.

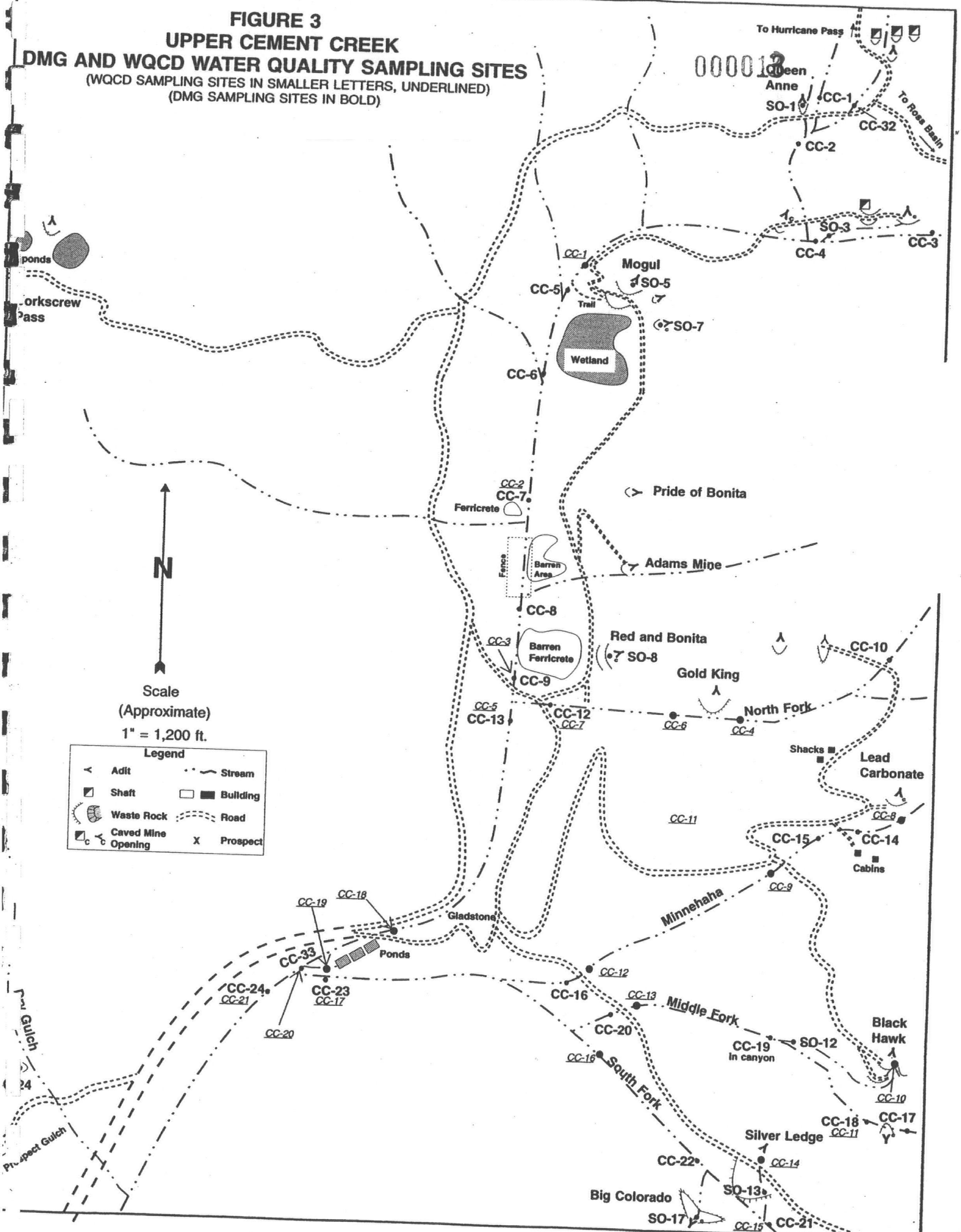
Water samples were taken in Cement Creek above and below sites identified as potential sources during reconnaissance investigations. The DMG sampling plan included collecting dissolved metal, total recoverable metal, and major cation and anion samples at 72 different locations in the Cement Creek watershed. A list of the sampling sites, their locations, the figures on which the location is shown and the time of year at which sampling was performed at that location is provided in Table 1. The locations of the sampling sites are shown on Figures 3, 4 and 5 in larger bold letters.

The low-flow (October 1996) and high-flow (June 1997) sampling events provide data on the range of metals loading in Cement Creek. The flow in Cement Creek during the low-flow sampling event was much lower than had been observed by the authors during any of the previous sampling events. Likewise, the flow in Cement Creek and its tributaries during the high-flow sampling event was higher than previously observed. The June 1997 samples were taken shortly after Cement Creek reached its peak flow in 1997.

Water quality samples were collected by teams comprised of individuals from various government agencies and volunteers. Raw depth-integrated samples were taken in the stream. The total recoverable metals samples were then transferred directly to pre-cleaned pre-acidified 250 ml. sample bottles; anion samples were transferred to pre-cleaned neutral 250 ml. sample bottles; and dissolved metals samples were taken by filtering the raw water through a 0.45 micron filter into a pre-cleaned pre-acidified 250 ml. sampling bottle. After sampling, the samples were placed in coolers, and the anion samples were iced. All sampling activities were completed at the sampling

FIGURE 3
UPPER CEMENT CREEK
DMG AND WQCD WATER QUALITY SAMPLING SITES

(WQCD SAMPLING SITES IN SMALLER LETTERS, UNDERLINED)
(DMG SAMPLING SITES IN BOLD)



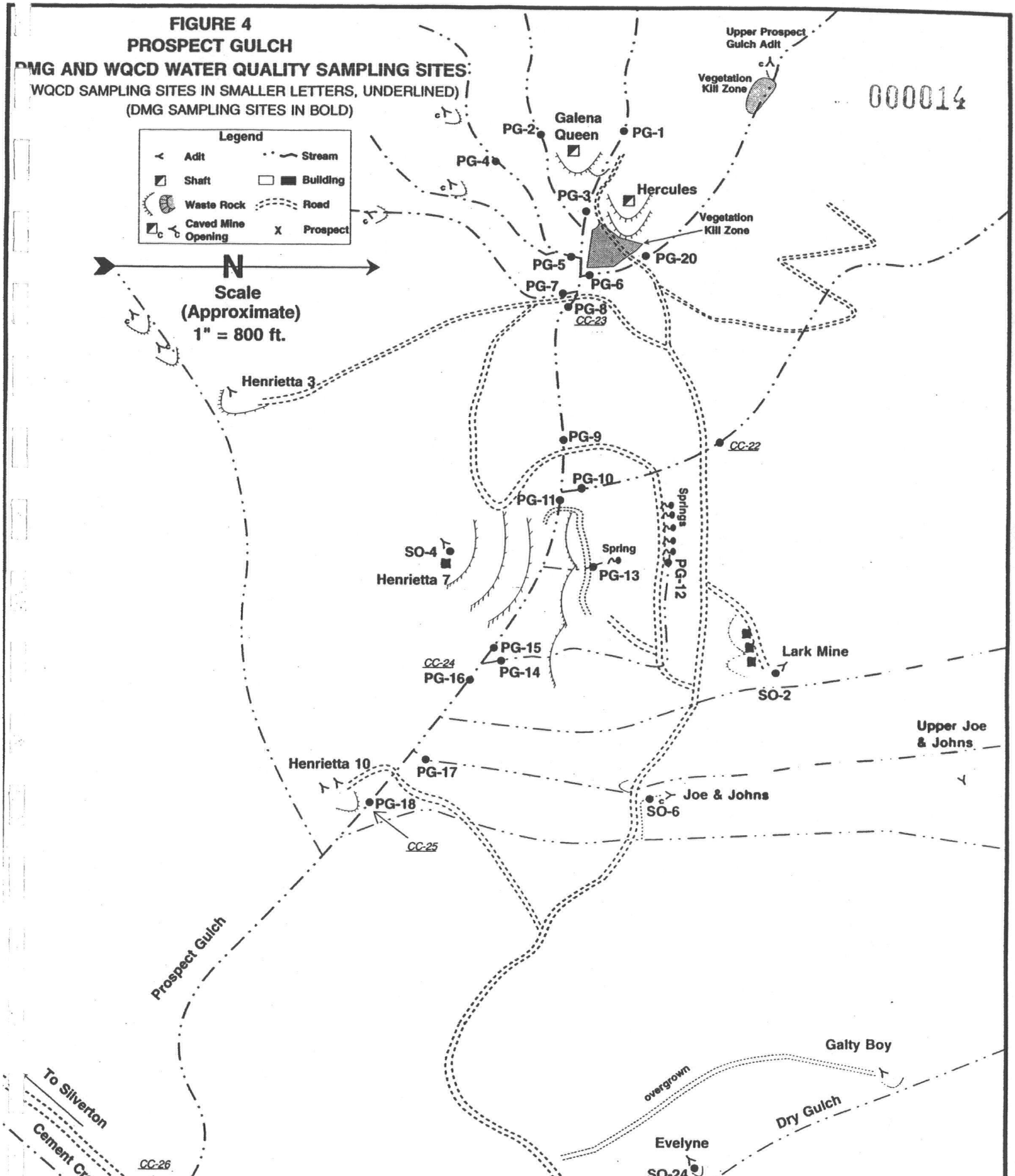


FIGURE 4
PROSPECT GULCH
DMG AND WQCD WATER QUALITY SAMPLING SITES
(WQCD SAMPLING SITES IN SMALLER LETTERS, UNDERLINED)
(DMG SAMPLING SITES IN BOLD)
Legend
Adit
Stream
Shaft
Building
Waste Rock
Road
Caved Mine Opening
Prospect
N
Scale
(Approximate)
1" = 800 ft.
000014
Upper Prospect Gulch Adit
Vegetation Kill Zone
Galena Queen
PG-1
PG-2
PG-4
PG-3
Hercules
Vegetation Kill Zone
PG-20
PG-5
PG-6
PG-7
PG-8
CC-23
Henrietta 3
PG-9
CC-22
PG-10
PG-11
Springs
SO-4
Henrietta 7
Spring
PG-13
PG-12
PG-15
PG-14
CC-24
PG-16
Lark Mine
SO-2
Upper Joe & Johns
Henrietta 10
PG-17
PG-18
Joe & Johns
SO-6
CC-25
Prospect Gulch
Galty Boy
overgrown
Dry Gulch
Evelyne
SO-24
To Silverton
Cement Creek
CC-26
CC-26
CC-27
CC-25
PG-19
To Gladstone

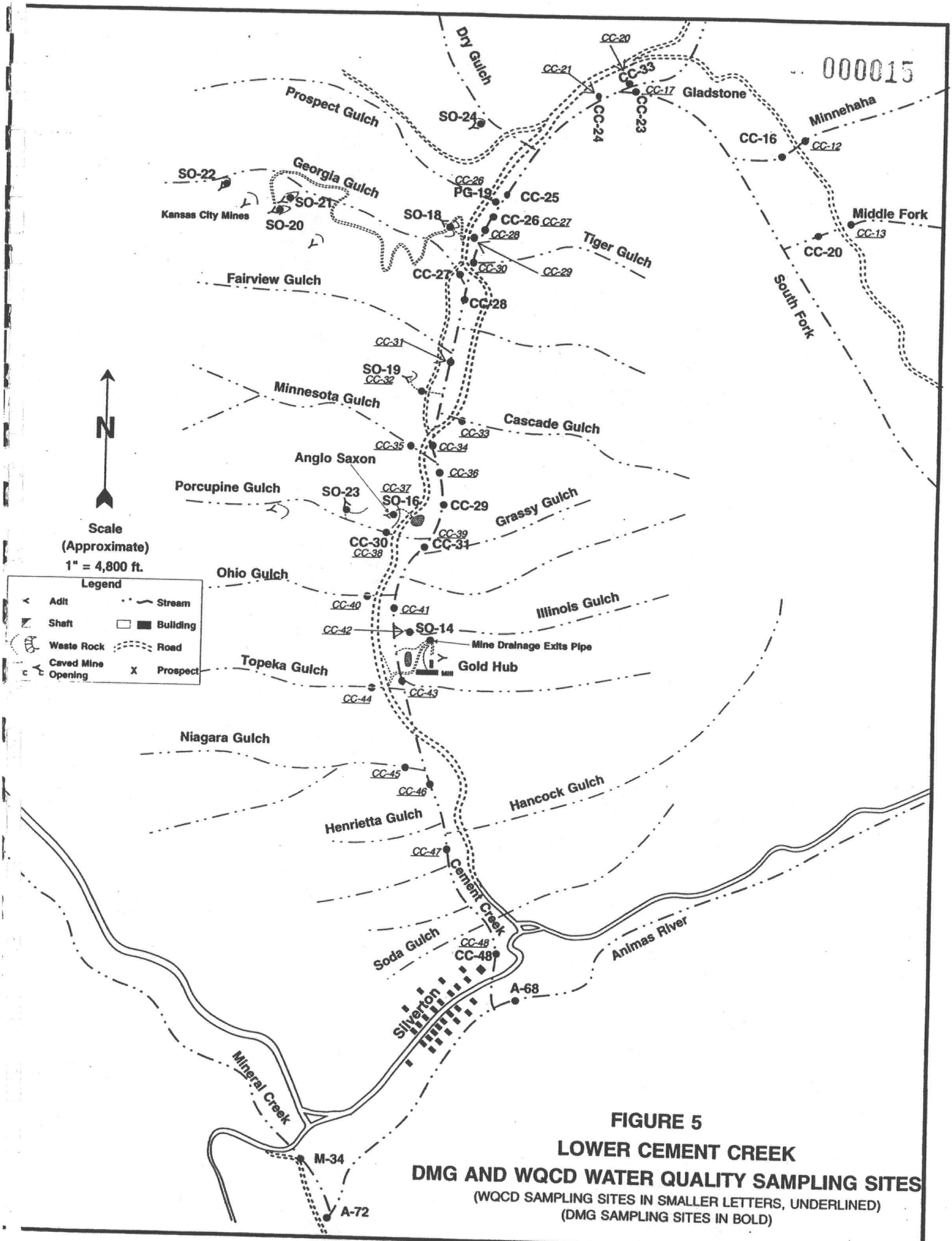


FIGURE 5

LOWER CEMENT CREEK

DMG AND WQCD WATER QUALITY SAMPLING SITES

(WQCD SAMPLING SITES IN SMALLER LETTERS, UNDERLINED)
(DMG SAMPLING SITES IN BOLD)

Table 1. DMG Sampling Program in 1996 and 1997

Sample No.	Location	Shown on Figure #	Oct. 1996	Feb. 1997	June 1997	Comments
A-68	Silverton Co.	5	X			
A-72	Silverton Co. G.S. Gage	5	X			
CC-1	Above Queen Anne	3	X		X	
CC-2	CC Below Queen Anne	3	X		X	
CC-3	Background Below Ross Basin	3	X		X	
CC-4	CC Below SO-3	3	X		X	
CC-5	CC Above Mogul	3	X		X	
CC-6	CC Below Mogul	3	X		X	
CC-7	CC Above Ferricrete	3	X		X	
CC-8	Below North Ferricrete	3	X		X	
CC-9	Below Lower Ferricrete	3	X		X	
CC-10	Background North Fork	3				No flow in Oct. 1996, under snow in June 1997
CC-12	North Fork above CC	3	X		X	
CC-13	Below North Fork	3	X		X	
CC-14	Minnehaha Background	3			X	No flow in Oct. 1996; had subsurface flow as evidenced by flow below CC-14 and CC-17 and flow above CC-27
CC-15	Minnehaha Below Lead Carbonate	3	X		X	
CC-16	Minnehaha Above SF	3, 5	X		X	
CC-17	Middle Fork Above Mine Blockage	3			X	No flow in Oct. 1996; had subsurface flow as evidenced by flow below CC-14 and CC-17 and flow above CC-27
CC-18	Middle Fork Below Mine Blockage	3				No flow in Oct. 1996, under snow in June 1997
CC-19	MF Below Blackhawk	3	X		X	
CC-20	MF Above SF	3, 5	X		X	
CC-21	SF Above Silver Ledge	3	X		X	
CC-22	SF Below Silver Ledge	3	X		X	
CC-23	SF Above CC	3, 5	X	X	X	
CC-24	CC Below SF	3, 5	X	X	X	
CC-25	CC Above Prospect Gulch	4, 5	X	X	X	
CC-26	CC Below Prospect	4, 5	X	X	X	
CC-27	Georgia Gulch Above Confluence	5			X	No flow in Oct. 1996; had subsurface flow as evidenced by flow below CC-14 and CC-17 and flow above CC-27
CC-28	CC Below Georgia Gulch	5	X		X	
CC-29	CC Above Porcupine Gulch	5	X	X	X	
CC-30	Porcupine Gulch Above CC	5	X	X	X	
CC-31	CC Below Porcupine	5	X	X	X	
CC-32	Below Hurricane Mine Complex	3			X	No flow in Oct. 1996
CC-33	CC Below Sunnyside Ponds	3, 5	X	X	X	
CC-48	Cement Creek Gage	5	X			
DG-1	Deadwood Gulch	-			X	Along segment 4A; Concentrations only
EP-1	Elk Park	-			X	Along segment 4A; Concentrations only
KC-1	Kendall Creek	-			X	Along segment 4A; Concentrations only
M-34	Mineral Creek Gage	5	X			

Table 1. DMG Sampling Program in 1996 and 1997 (continued)

Sample No.	Location	Shown on Figure #	Oct. 1996	Feb. 1997	June 1997	Comments
PG-1	Background-Upper Prospect	4	X		X	
PG-2	Background-Upper Prospect	4	X		X	
PG-3	Below Galena Queen	4	X		X	
PG-4	Background-Upper Prospect	4	X		X	
PG-5	Below Mine Drainages	4	X		X	
PG-6	Tributary Below Hercules	4	X		X	
PG-7	Tributary Below Draining Mine	4	X		X	
PG-8	Below Upper Mines	4	X		X	
PG-9	Below Mineralized Canyon	4	X		X	
PG-10	Undisturbed Tributary	4	X		X	
PG-11	Above Henrietta 7	4	X		X	
PG-12	Spring	4			X	No flow in Oct. 1996
PG-13	Spring	4			X	No flow in Oct. 1996
PG-14	Tributary Below Lark & Mine Waste	4			X	No flow in Oct. 1996
PG-15	Below Henrietta 7	4			X	Not sampled in Oct. 1996; bracketed PG-14 which was dry
PG-16	Below Tributary PG-14	4	X		X	
PG-17	Below Joe & Johns Tributary	4			X	No flow in Oct. 1996
PG-18	Above Henrietta 11	4	X		X	
PG-19	Prospect Gulch Above Confluence	4		X	X	Inadvertently not sampled in Oct. 1996
PG-20	Tributary Above Hercules	4			X	
SO-1	Queen Anne	3	X		X	
SO-2	Lark Mine	4			X	Added at Lark Mine in June 1997
SO-3	Grand Mogul	3	X		X	
SO-4	Henrietta 7 Mine	4			X	No flow in Oct. 1996
SO-5	Mogul	3	X		X	
SO-6	Joe & Johns	4	X		X	
SO-7	Mine South of Mogul	3			X	No flow in Oct. 1996
SO-8	Red & Bonita Mine	3			X	No flow in Oct. 1996
SO-12	Black Hawk Mine	3	X		X	
SO-13	Silver Ledge	3	X		X	
SO-14	Yukon Tunnel	5	X		X	
SO-16	Anglo Saxon	5	X		X	
SO-17	Big Colorado	3	X		X	
SO-18	Mammoth Tunnel	5	X		X	
SO-19	Adit Below Georgia Gulch	5	X		X	
SO-20	Kansas City Adit #1	5	X		X	
SO-21	Kansas City Adit #2	5			X	No flow in Oct. 1996
SO-22	Kansas City Mines	5				No flow in Oct. 1996, under snow in June 1997
SO-23	Porcupine Gulch Adit	5	X		X	
SO-24	Dry Gulch Adit (Adelaide)	3, 4, 5	X		X	
UK-1	1st East Trib. Below Deer Creek	-			X	Along segment 4A; Concentrations only

site. During the October 1996 and February 1997 sampling, the pH and electrical conductivities were taken in-stream at the sampling site. During the June 1997 sampling, pH and electrical conductivities were measured from a raw water sample collected at the stream sites, and measurements were taken directly from the flow for the mine drainage samples.

During the October 1996 and February 1997 sampling events, flow measurements were taken at the same time that the water quality samples were collected. Water quality sampling and flow measurements were taken by continually moving up the watershed during the day. During the June 1997 sampling event, all the water quality samples were taken in a one hour period between 10:00 a.m. and 11:00 a.m. This was done to limit the effects of diurnal flow variations in the streams. After the samples were taken, flow measurements were taken, then adjusted to the flow at 11:00 a.m., based upon duplicate flow measurements taken at various stations during the day and continuous measurements at the Cement Creek Gage (DMG sampling site CC-48 located near Silverton, as shown on Figure 5).

The October 1996 low-flow data is presented in Appendix 1 of this report. The February 1997 data is presented in Appendix 2. The June 1997 high-flow data is presented in Appendix 3. It should be noted that the metals data in the appendices are reported in grams per day, whereas throughout the text, these data are reported in pounds per day. This was done to enable the reader to visualize the amounts better. To convert pounds to grams, multiply the number of pounds by 453.6. Conversely, to convert grams to pounds, divide the number of grams by 453.6.

SAMPLING OF WASTE ROCK

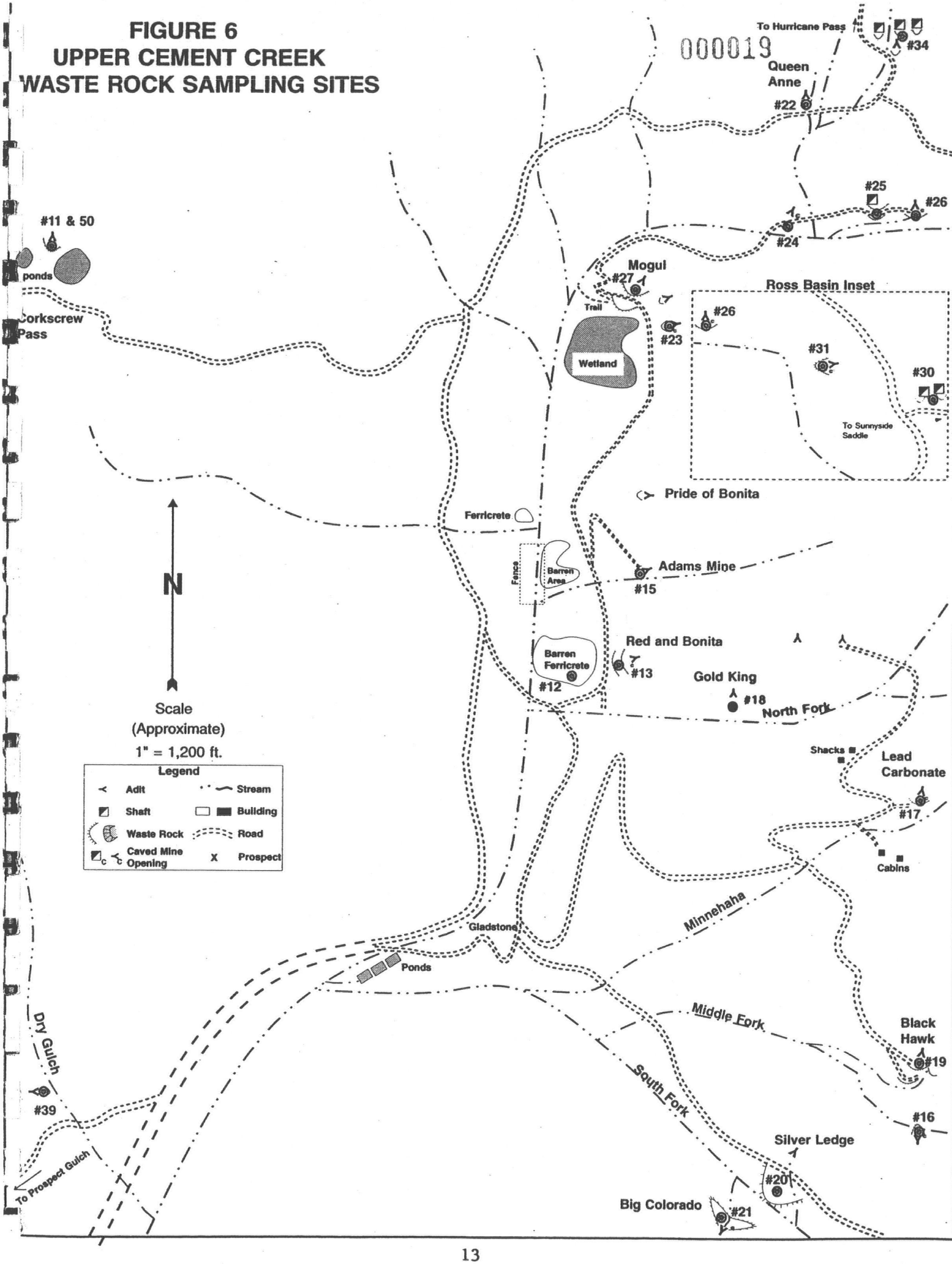
Waste rock samples were collected at 44 different locations in Cement Creek in August 1996. These locations are shown on Figures 6, 7 and 8. This investigation was conducted to provide information on waste rock piles sufficient to allow the Animas River Stakeholders Group to prioritize mine sites for reclamation, using the limited funds available. Samples were collected from 40 waste rock sites and four soil/outcrop sample sites in the Cement Creek watershed.

A 2:1, by volume, extract was collected in the field. The extract was analyzed for field parameters, then a portion was analyzed in the laboratory for heavy metals.

Waste rock and soil/outcrop samples were collected from a minimum of ten and maximum of twenty locations at each site. Acid-washed plastic 100 ml. beakers were used to remove the top two inches of material. The 10+ sub-samples from each site were composited in a 1-gallon recloseable plastic bag. The composited samples were thoroughly mixed in the field by inverting the bag numerous times. After mixing, 150 ml. of sample was removed and placed in a 1 liter plastic beaker along with 300 ml. of deionized water. The wetted sample was then vigorously mixed for 15 seconds, and plastic wrap was placed over the top. The sample was left to settle for 90 minutes, which is the amount of time it takes for the clay fraction to settle to the bottom of the beaker.

Composite Extract

FIGURE 6
UPPER CEMENT CREEK WASTE ROCK SAMPLING SITES



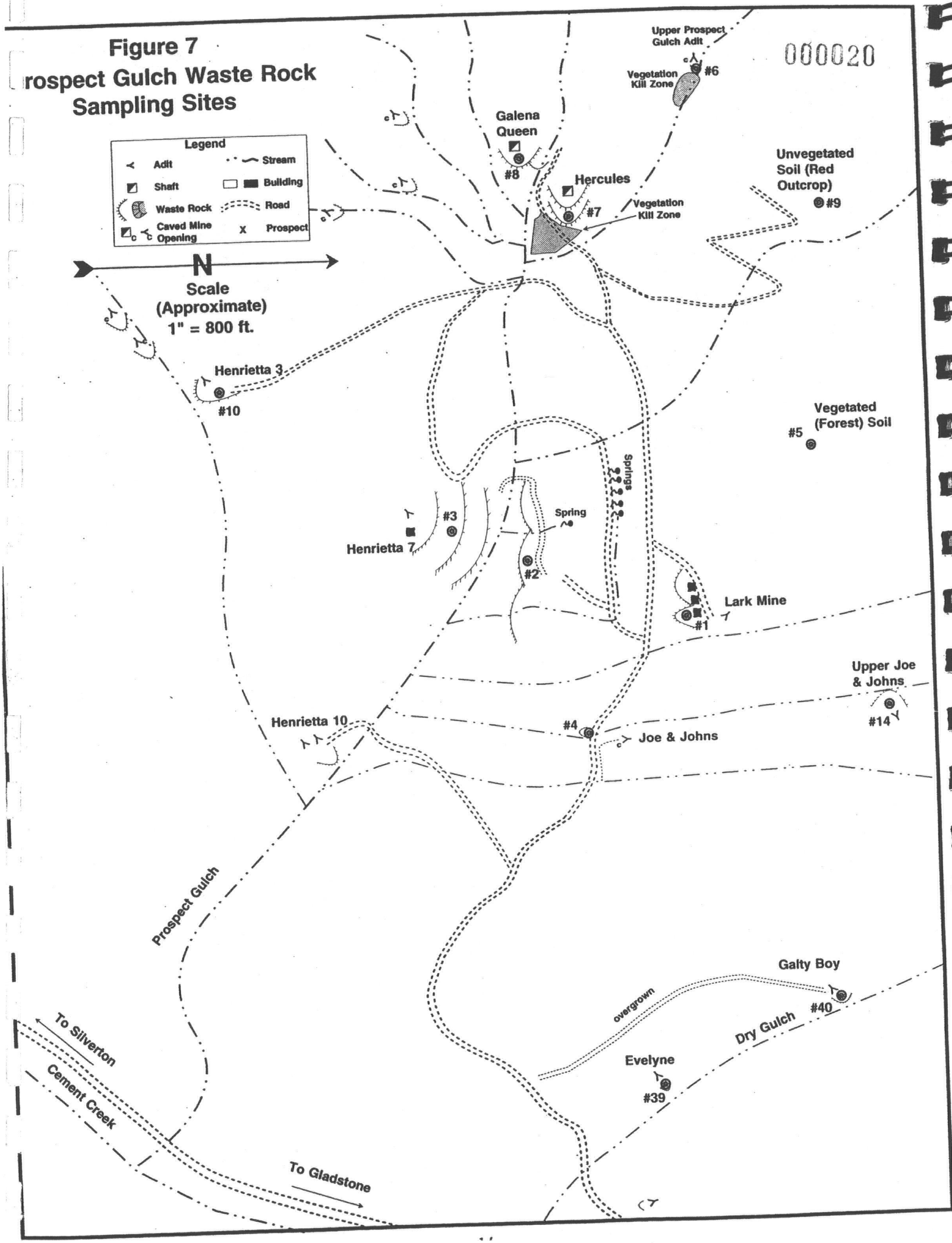


Figure 7
Prospect Gulch Waste Rock Sampling Sites

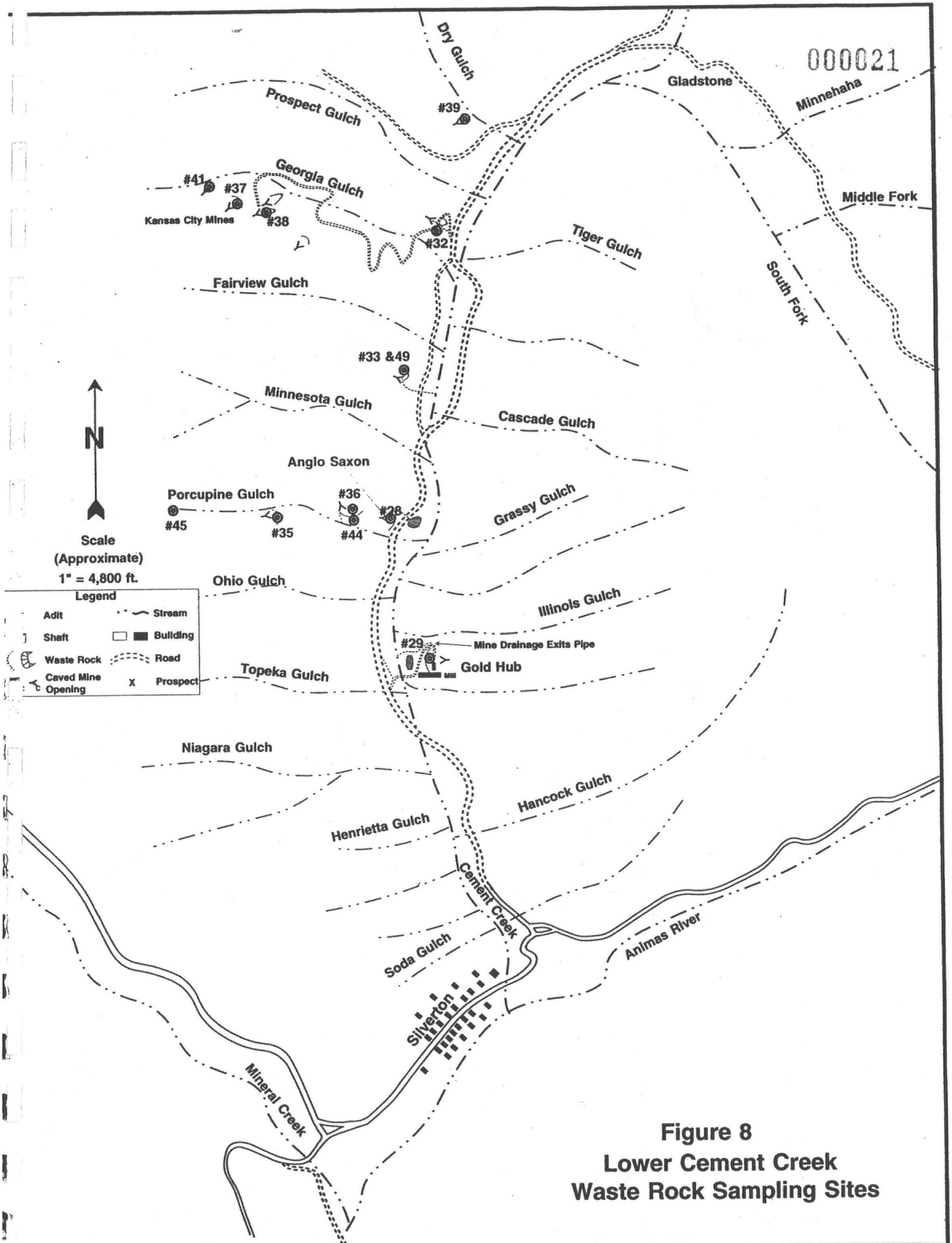


Figure 8
Lower Cement Creek
Waste Rock Sampling Sites

After 90 minutes, the liquid was filtered through very fine grade soil filters (approximately 2 microns). A portion of the liquid was used to measure the total alkalinity, pH, specific conductance, and sulfates. The remaining liquid was acidified with nitric acid for lab analysis. Total alkalinity was determined using a Hach digital titrator to reach a phenolthalein end-point. Specific conductance and pH were measured with a HyDAC instrument. Sulfates were measured using a Hach DR700 Colorimeter.

The data from the waste rock sampling are presented in Appendix 4. Results for total acidity, dissolved copper, iron and zinc are also reported on the maps on Figures 9, 10 and 11.

A brief discussion of the sampling results is warranted. Natural background samples were taken at four sites (#5, #9, #43, #45). Locations of these sampling sites are shown on Figures 7 and 8. Results for total acidity, dissolved copper, iron and zinc at these sites are shown on Figures 10 and 11. The total acidity and sulfate values for these samples are shown below.

Natural Soil and Outcrops

Site	Total Acidity (mg/l)	ICP Sulfate (mg/l)
#5 - Vegetated (Forest) Soil	18	7
#9 - Unvegetated Soil (Red Outcrop)	16	4
#43 - Ohio Gulch	60	87
#45 - Porcupine Gulch	2735	2517

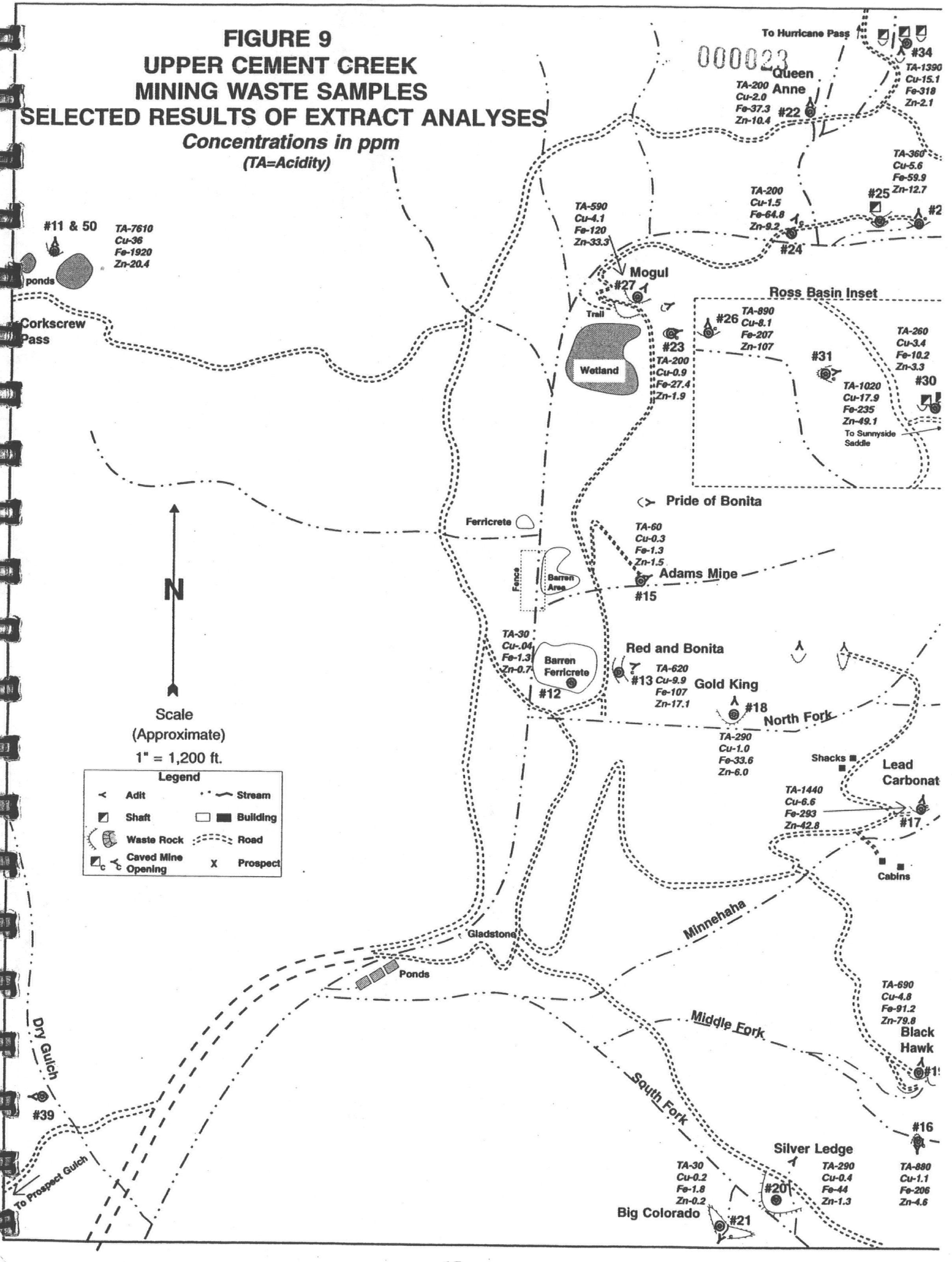
The total acidity and sulfate values from the natural soils and outcrops are less than 100 mg/l, except for Porcupine Gulch, which is two orders of magnitude higher. The sample taken at Porcupine Gulch consisted of solfatarically-altered outcrop material. These rocks have been so strongly altered and leached by hot sulphurous gases and solutions during Tertiary volcanism, that virtually all potential buffering minerals have been leached away, leaving only silica, kaolinite, and sulfate and sulfide alteration products. Subsequent surficial oxidation of the solfataric pyrite has caused the material to be high in sulfates and extremely acidic.

Average total acidity and sulfate values from the waste piles sampled in the Cement Creek area are 1000 and 1400 mg/l respectively. These data indicate that the waste rock piles produce two orders of magnitude more sulfate than the natural soils and outcrops (not including the solfatarically-altered material).

WATERSHED CHEMISTRY

The water chemistry of Cement Creek is very complex, because there are both natural metals

FIGURE 9
UPPER CEMENT CREEK
MINING WASTE SAMPLES
SELECTED RESULTS OF EXTRACT ANALYSES
Concentrations in ppm
(TA=Acidity)



000024

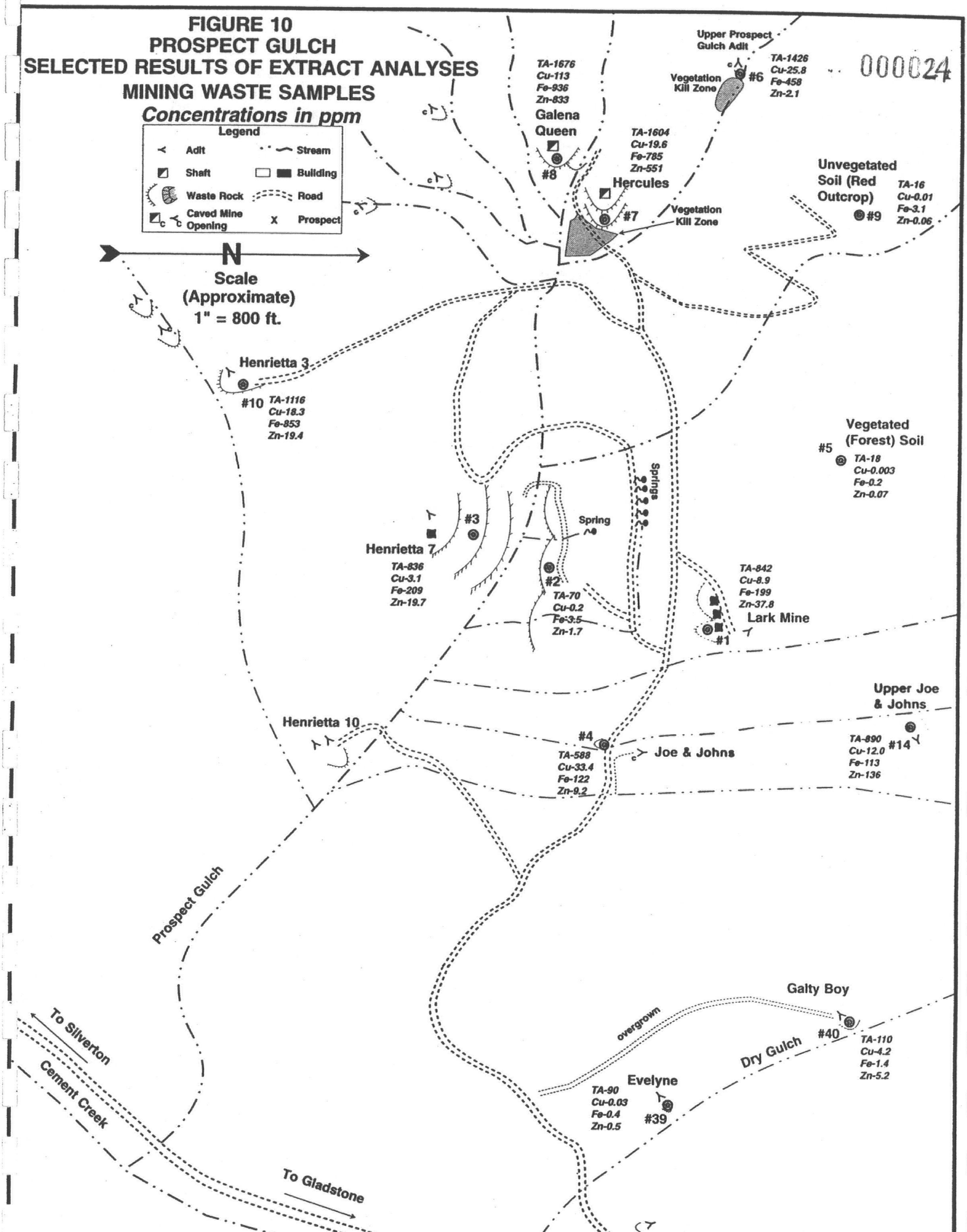


FIGURE 10
PROSPECT GULCH
SELECTED RESULTS OF EXTRACT ANALYSES
MINING WASTE SAMPLES
Concentrations in ppm

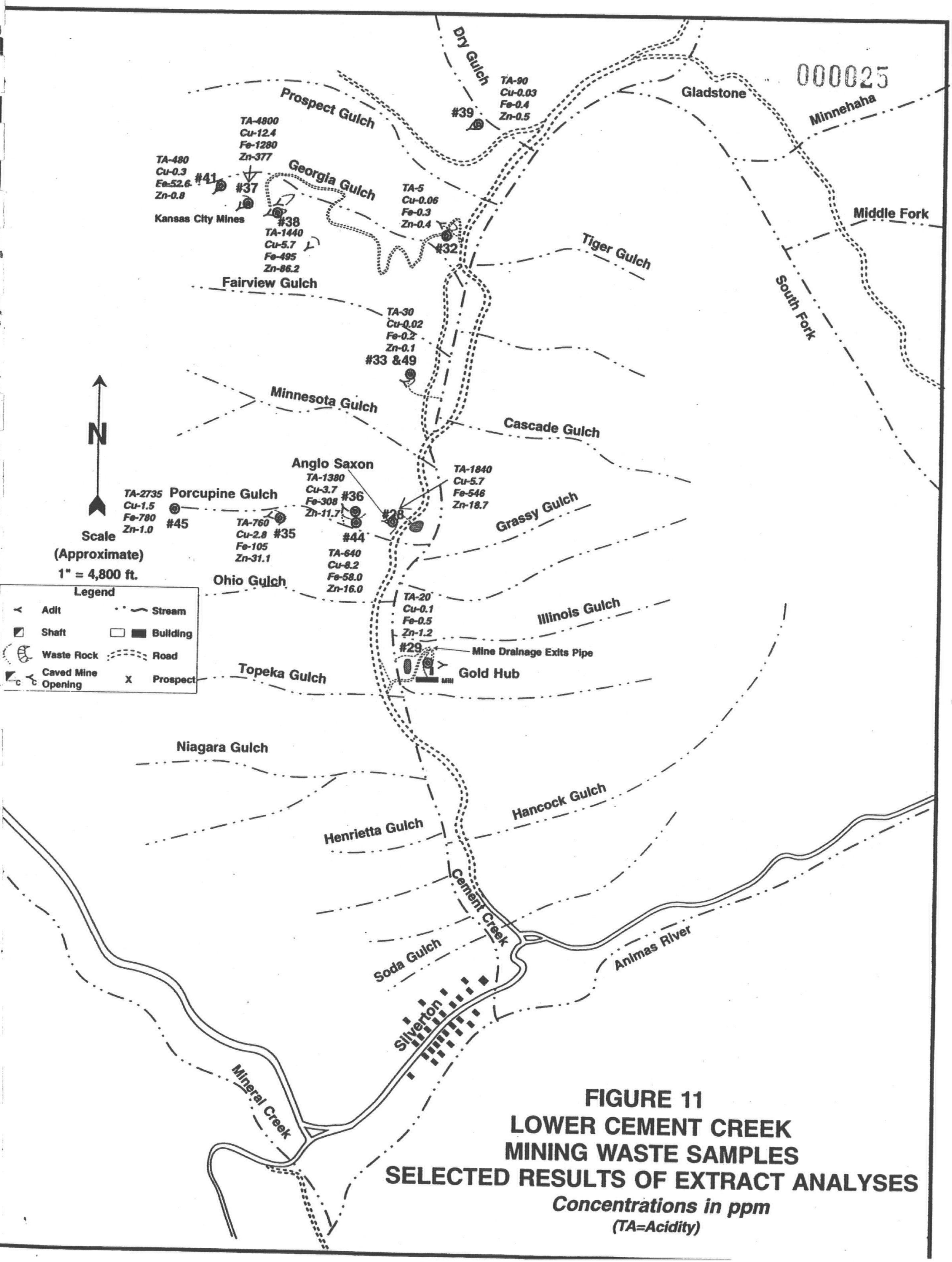


FIGURE 11
LOWER CEMENT CREEK
MINING WASTE SAMPLES
SELECTED RESULTS OF EXTRACT ANALYSES
Concentrations in ppm
(TA=Acidity)

loading and mining-related metals loading affecting the creek. Also, because of the varying geology within the Cement Creek watershed, the speciation of heavy metals in the tributaries varies in several major regions.

Water samples were tested for the concentration of many different metal types, but zinc, iron and copper are thought to be the principal metals impacting the aquatic life in the Animas River. Therefore, the focus in the following discussion will be on these three constituents. Upper Cement Creek and Prospect Gulch are the major source areas for zinc and copper. The South Fork of Cement Creek and Cement Creek below Gladstone are principally iron loaders, but also produce considerable zinc. The iron bogs between Gladstone and Georgia Gulch are a major source of iron.

Using the data collected, concentrations and loads of key metals were tabulated for each site. Concentration data are reported here in ug/l. Concentration data are useful primarily for evaluating the biological effects of the constituents in the water. Load data are reported here in grams or kilograms per day or pounds per day. Load indicates the total amount of constituent carried by the water. Load equals the concentration times the amount of flow, so it varies with the amount of flow. Load is useful in identifying source areas for the constituents. Both concentration and load are reported in Appendices 1, 2 and 3. It should be noted that the load data in the appendices are reported in grams per day, whereas load data in the text are discussed in pounds per day. This was done to enable the reader to visualize the amounts better. To convert pounds to grams, multiply the number of pounds by 453.6. Conversely, to convert grams to pounds, divide the number of grams by 453.6.

It is worthy to note that there is a water treatment system near Gladstone for the drainage from the American Tunnel. The location of this system is shown on Figure 3 as the series of settling ponds between WQCD sampling sites <u>*CC-18*</u> and <u>*CC-19*</u>. This treatment system, operated by Sunnyside Gold Corporation, consists of a lime neutralization system with settling ponds. During low-flow, virtually all the drainage in Cement Creek is passed through the treatment system. Therefore, all the flow in Cement Creek during the September 1996 and February 1997 sampling events was being treated by the Sunnyside Gold treatment system. During the high-flow sampling event, the majority of the flow in Cement Creek was bypassing the treatment system.

Figures 12 through 23 present the concentrations and loads of zinc, iron and copper found during high-flow sampling and low-flow sampling in Upper Cement Creek, Prospect Gulch and Lower Cement Creek. Load data on the figures are shown in kilograms/day, but discussed in the text in pounds/day. As previously mentioned, this is to enable the reader to better visualize these quantities. To convert pounds to kilograms, divide the number of pounds by 2.2046. Conversely, to convert kilograms to pounds, multiply the number of kilograms by 2.2046.

<u>CEMENT CREEK IN-STREAM ZINC</u>

During low-flow, there was virtually no zinc load from the headwaters of Cement Creek near Hurricane Pass, although the concentrations were 225 ug/l (Figures 12 and 13). There are a large

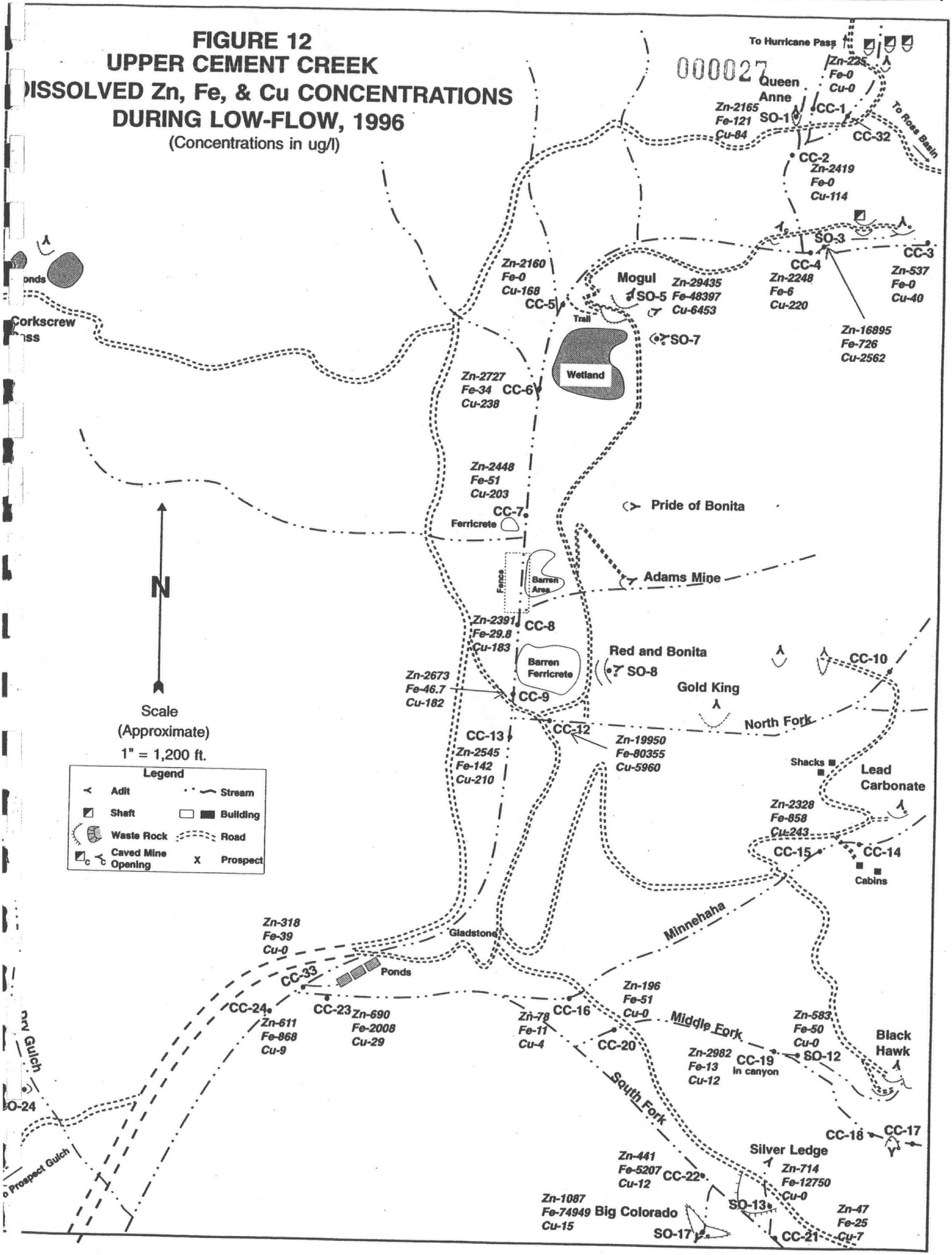


FIGURE 12
UPPER CEMENT CREEK
DISSOLVED Zn, Fe, & Cu CONCENTRATIONS
DURING LOW-FLOW, 1996
(Concentrations in ug/l)
000027
To Hurricane Pass
Zn-225 Fe-0 Cu-0
Queen Anne
Zn-2165 Fe-121 Cu-84 SO-1
CC-1
To Ross Basin
CC-32
CC-2 Zn-2419 Fe-0 Cu-114
SO-3
CC-4 Zn-2248 Fe-6 Cu-220
CC-3 Zn-537 Fe-0 Cu-40
Zn-16895 Fe-726 Cu-2562
Mogul
SO-5 Zn-29435 Fe-48397 Cu-6453
Zn-2160 Fe-0 Cu-168 CC-5
Trail
SO-7
Ponds
Corkscrew Pass
Wetland
Zn-2727 Fe-34 Cu-238 CC-6
Zn-2448 Fe-51 Cu-203 CC-7
Ferricrete
Pride of Bonita
N
Fence
Barren Area
Adams Mine
Zn-2391 Fe-29.8 Cu-183 CC-8
Barren Ferricrete
Red and Bonita
SO-8
CC-10
Gold King
Zn-2673 Fe-46.7 Cu-182 CC-9
Scale (Approximate)
1" = 1,200 ft.
North Fork
CC-12
CC-13 Zn-2545 Fe-142 Cu-210
Zn-19950 Fe-80355 Cu-5960
Shacks
Lead Carbonate
Legend
Adit
Stream
Shaft
Building
Waste Rock
Road
Caved Mine Opening
Prospect
Zn-2328 Fe-858 Cu-243
CC-15
CC-14
Cabins
Minnehaha
Zn-318 Fe-39 Cu-0
Gladstone
Ponds
CC-33
CC-24 Zn-611 Fe-868 Cu-9
CC-23 Zn-690 Fe-2008 Cu-29
Zn-78 Fe-11 Cu-4
CC-16
Zn-196 Fe-51 Cu-0
Middle Fork
CC-20
Zn-583 Fe-50 Cu-0 SO-12
Black Hawk
Zn-2982 Fe-13 Cu-12 CC-19 in canyon
Dry Gulch
SO-24
South Fork
CC-18
CC-17
Silver Ledge
To Prospect Gulch
Zn-441 Fe-5207 Cu-12 CC-22
Zn-714 Fe-12750 Cu-0
SO-13
Zn-1087 Fe-74949 Cu-15 Big Colorado
SO-17
Zn-47 Fe-25 Cu-7
CC-21

FIGURE 13
UPPER CEMENT CREEK
DISSOLVED ZINC, IRON, AND COPPER LO...
DURING LOW-FLOW, 1996
(Loads in Kg/day)

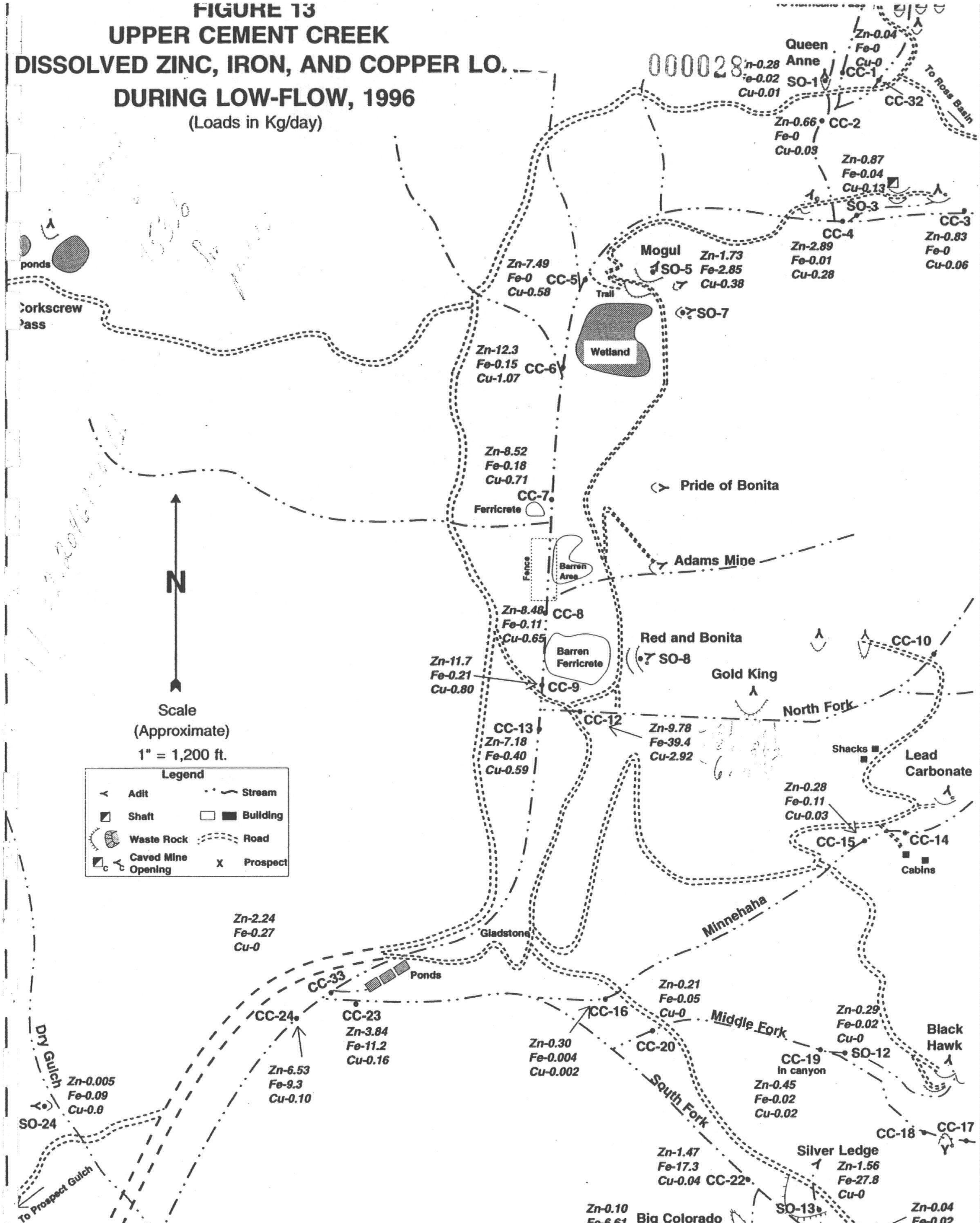


FIGURE 14
UPPER CEMENT CREEK
DISSOLVED Zn, Fe, & Cu CONCENTRATIONS DURING HIGH-FLOW, 1997
(Concentrations in ug/l)

000029

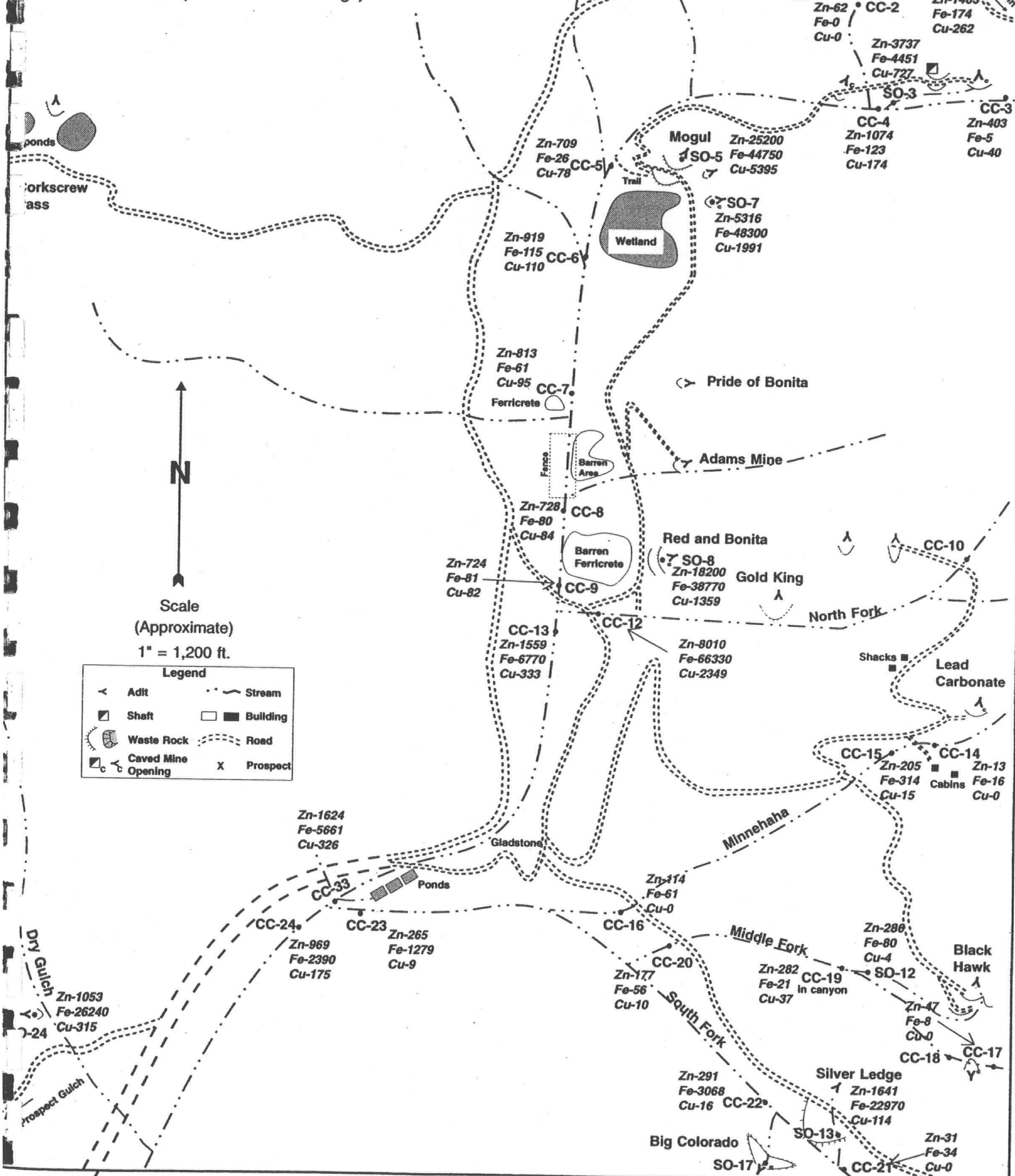


FIGURE 15
UPPER CEMENT CREEK DISSOLVED ZINC, IRON, AND COPPER LOADS DURING HIGH-FLOW, 1997
(Loads in Kg/day)

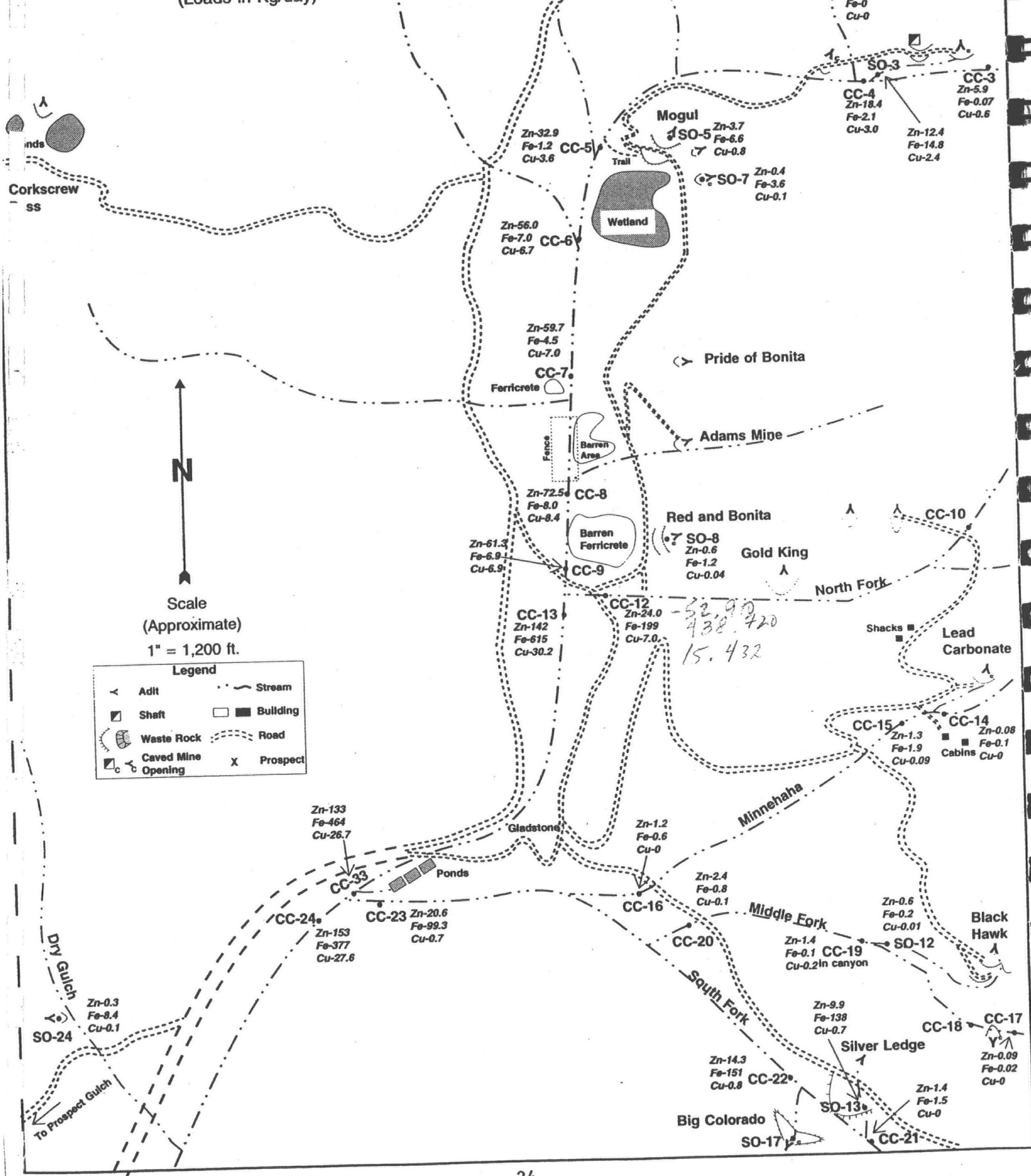
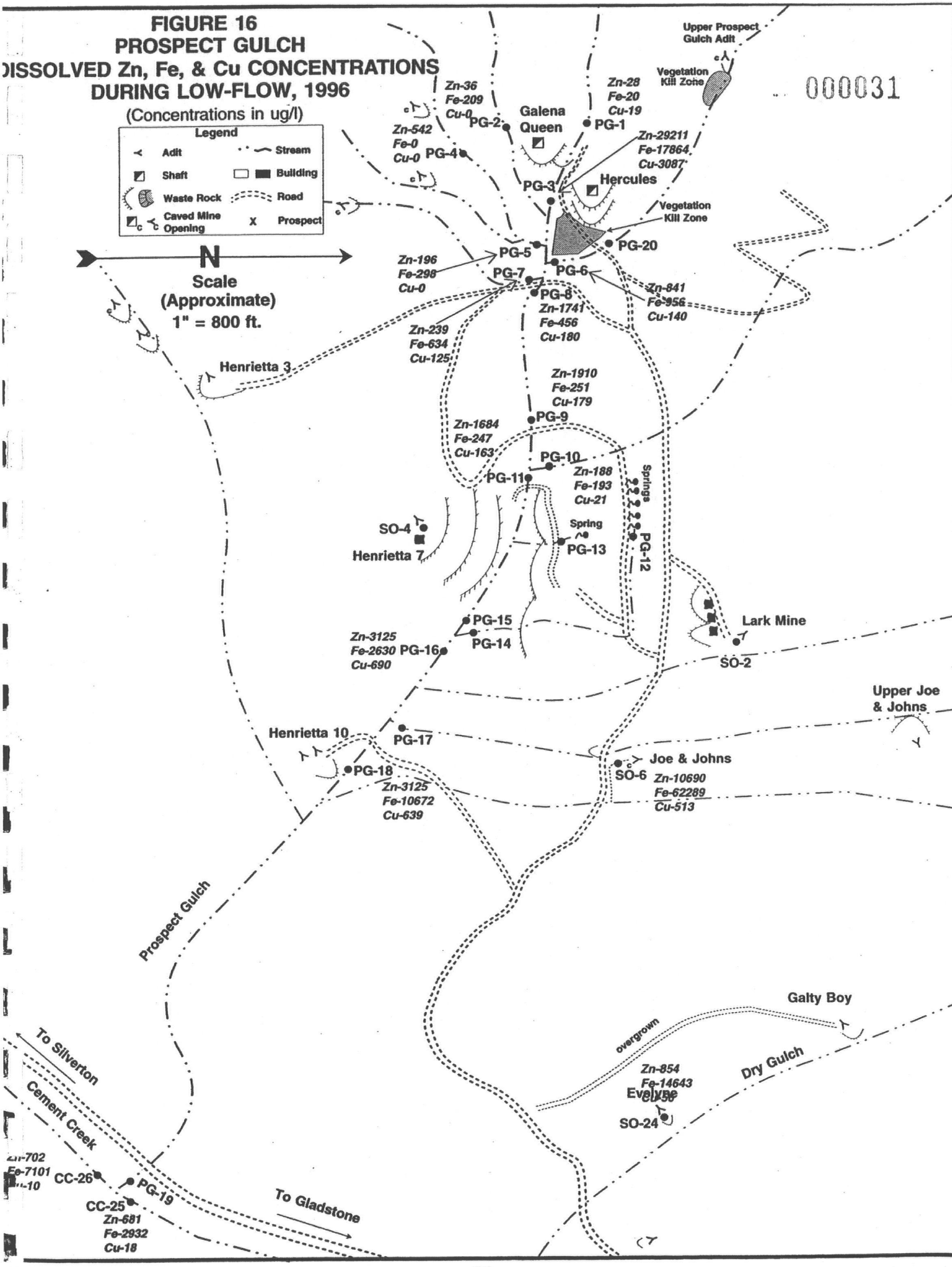


FIGURE 16
PROSPECT GULCH
DISSOLVED Zn, Fe, & Cu CONCENTRATIONS DURING LOW-FLOW, 1996
(Concentrations in ug/l)



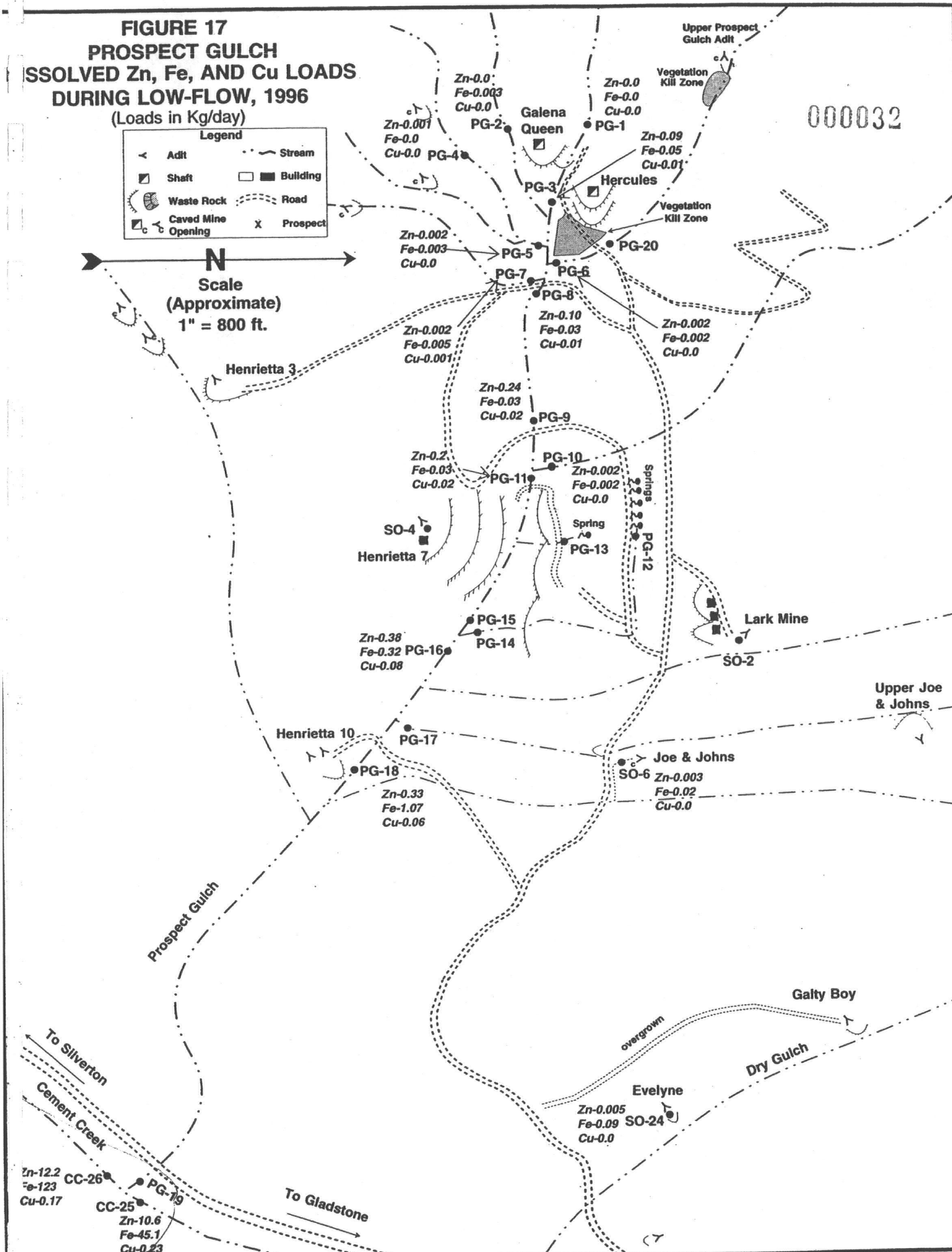
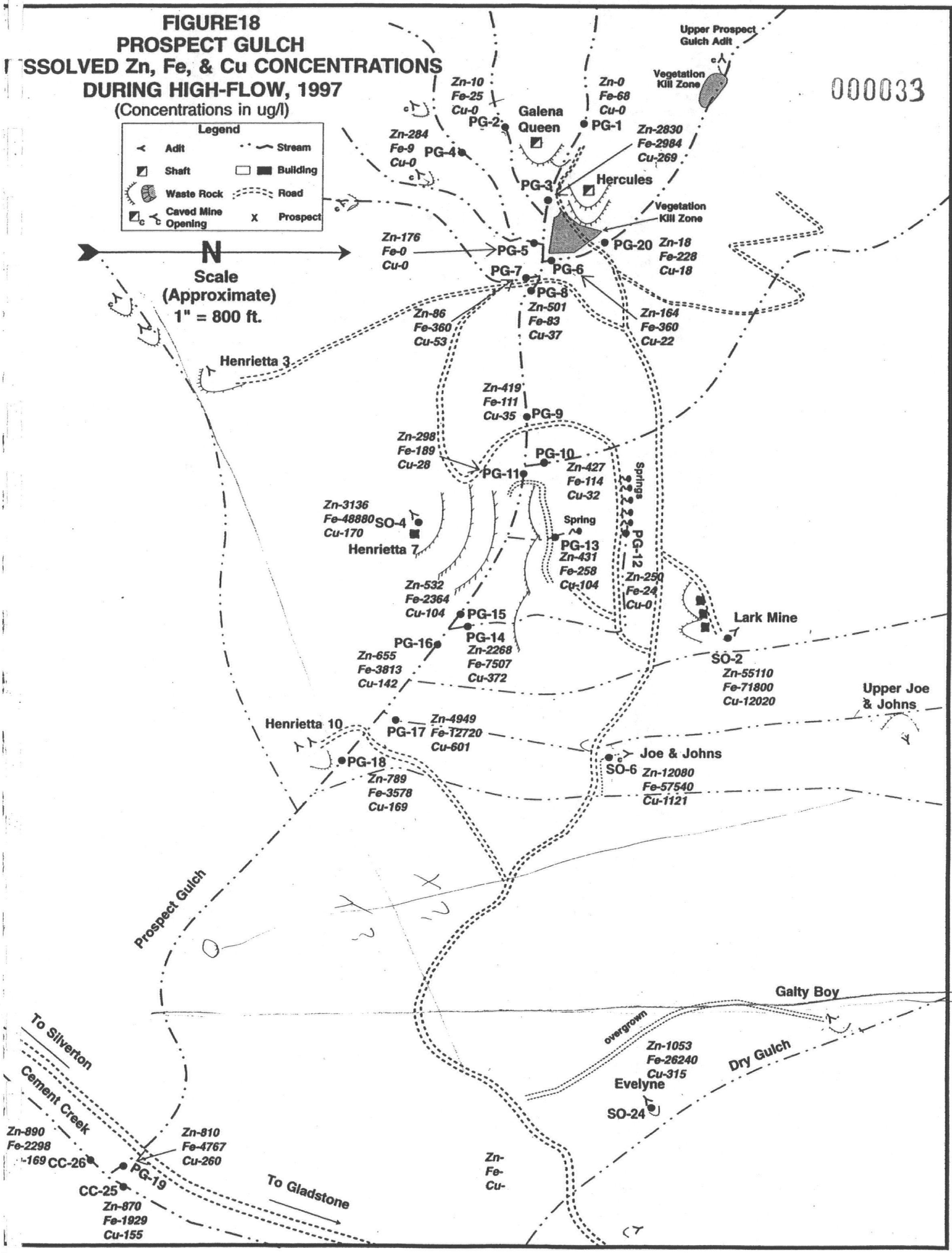


FIGURE 17
PROSPECT GULCH
ISSOLVED Zn, Fe, AND Cu LOADS
DURING LOW-FLOW, 1996
(Loads in Kg/day)
Legend
Adit
Stream
Shaft
Building
Waste Rock
Road
Caved Mine Opening
Prospect
N
Scale
(Approximate)
1" = 800 ft.
000032
Upper Prospect Gulch Adit
Vegetation Kill Zone
Zn-0.0
Fe-0.003
Cu-0.0
Zn-0.0
Fe-0.0
Cu-0.0
Galena Queen
PG-2
PG-1
Zn-0.001
Fe-0.0
Cu-0.0
PG-4
Zn-0.09
Fe-0.05
Cu-0.01
PG-3
Hercules
Vegetation Kill Zone
Zn-0.002
Fe-0.003
Cu-0.0
PG-5
PG-20
PG-7
PG-6
PG-8
Zn-0.10
Fe-0.03
Cu-0.01
Zn-0.002
Fe-0.005
Cu-0.001
Zn-0.002
Fe-0.002
Cu-0.0
Henrietta 3
Zn-0.24
Fe-0.03
Cu-0.02
PG-9
Zn-0.2
Fe-0.03
Cu-0.02
PG-10
PG-11
Zn-0.002
Fe-0.002
Cu-0.0
Springs
SO-4
Henrietta 7
Spring
PG-13
PG-12
Lark Mine
PG-15
PG-14
Zn-0.38
Fe-0.32
Cu-0.08
PG-16
SO-2
Upper Joe & Johns
Henrietta 10
PG-17
Joe & Johns
SO-6
Zn-0.003
Fe-0.02
Cu-0.0
PG-18
Zn-0.33
Fe-1.07
Cu-0.06
Prospect Gulch
Galty Boy
overgrown
Dry Gulch
Evelyne
Zn-0.005
Fe-0.09
Cu-0.0
SO-24
To Silverton
Cement Creek
Zn-12.2
Fe-123
Cu-0.17
CC-26
PG-19
CC-25
Zn-10.6
Fe-45.1
Cu-0.23
To Gladstone

FIGURE18
PROSPECT GULCH
[illegible]SSOLVED Zn, Fe, & Cu CONCENTRATIONS DURING HIGH-FLOW, 1997
(Concentrations in ug/l)



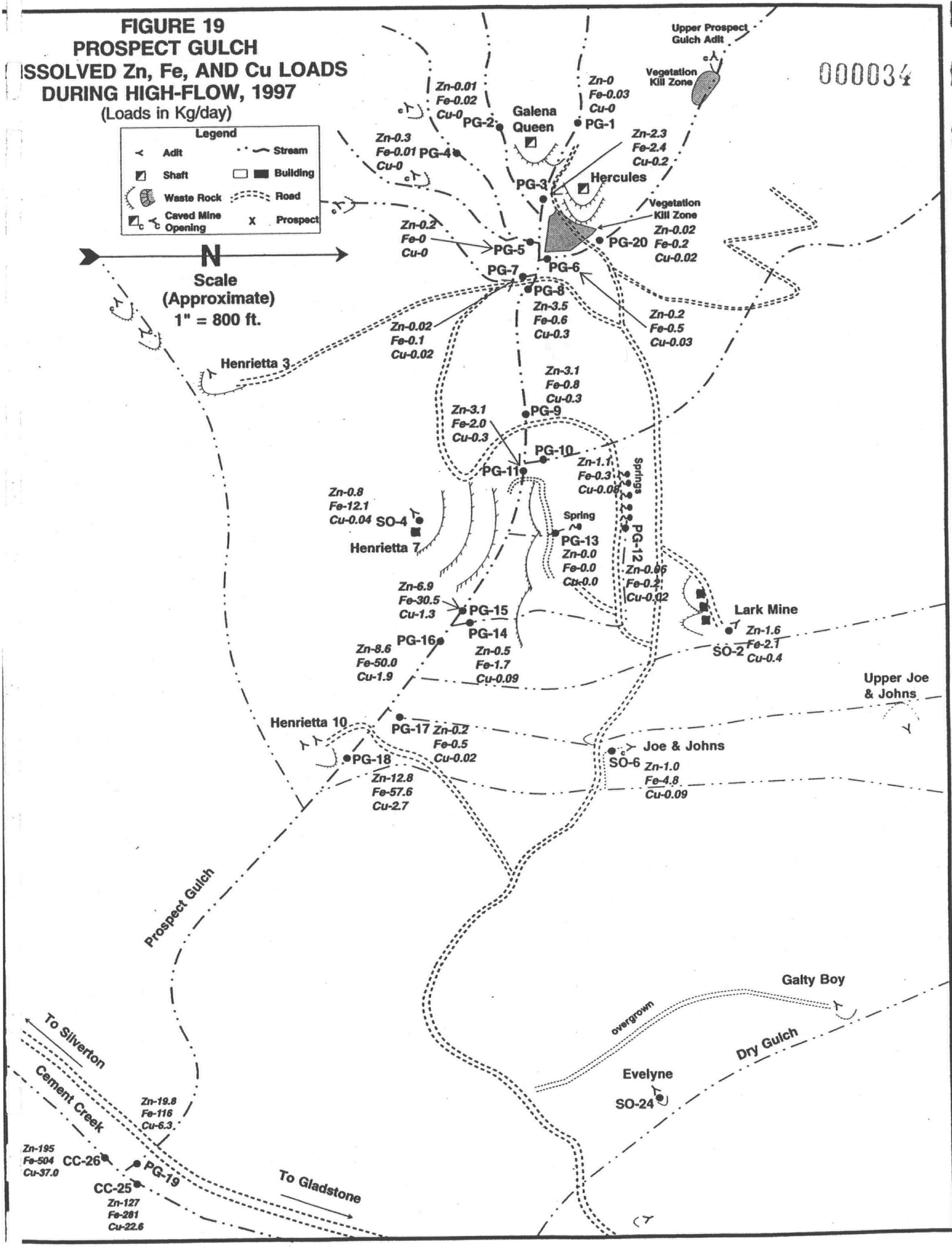


FIGURE 19
PROSPECT GULCH
DISSOLVED Zn, Fe, AND Cu LOADS
DURING HIGH-FLOW, 1997
(Loads in Kg/day)

000035

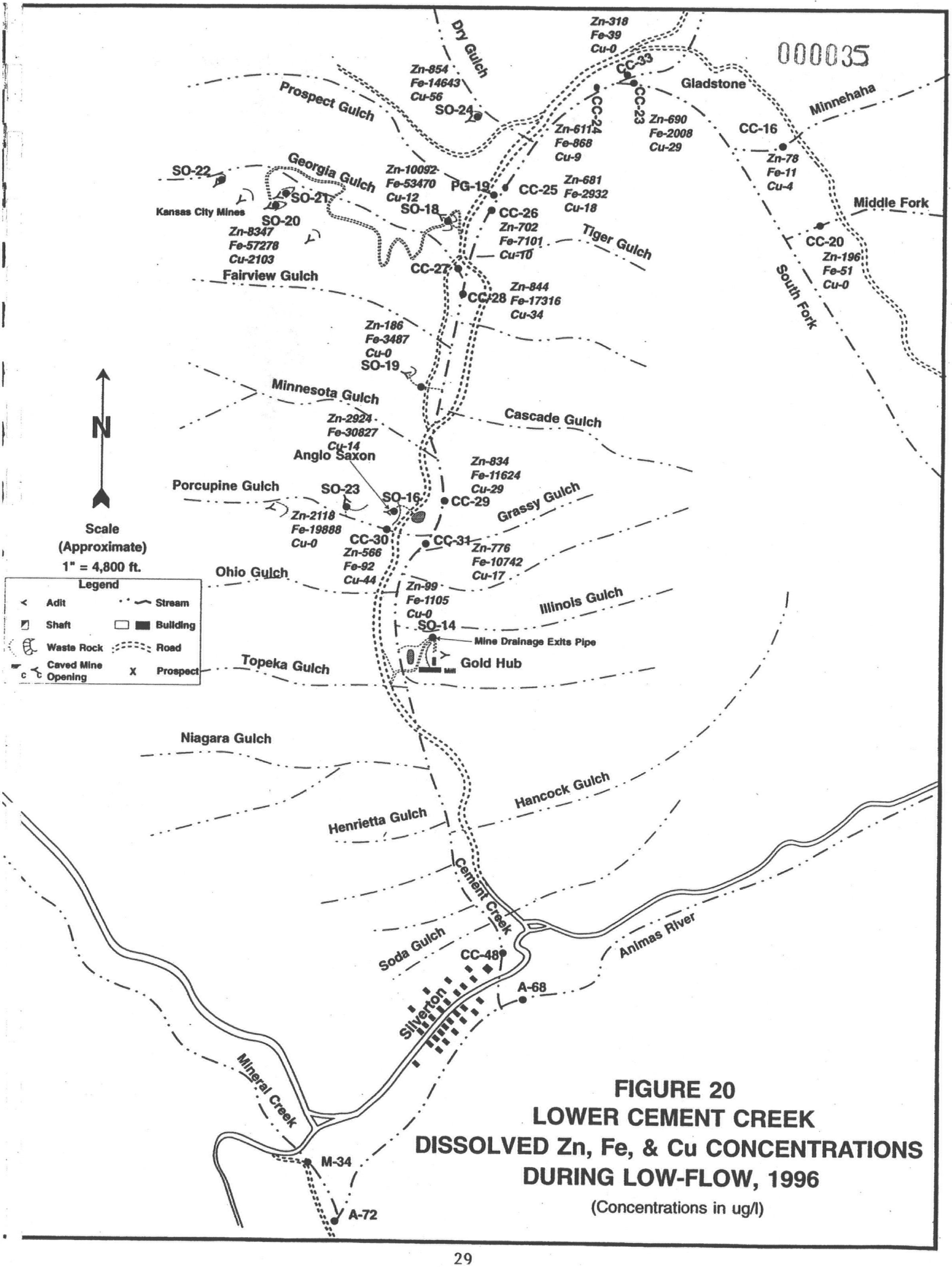


FIGURE 20
LOWER CEMENT CREEK
DISSOLVED Zn, Fe, & Cu CONCENTRATIONS
DURING LOW-FLOW, 1996
(Concentrations in ug/l)

000036

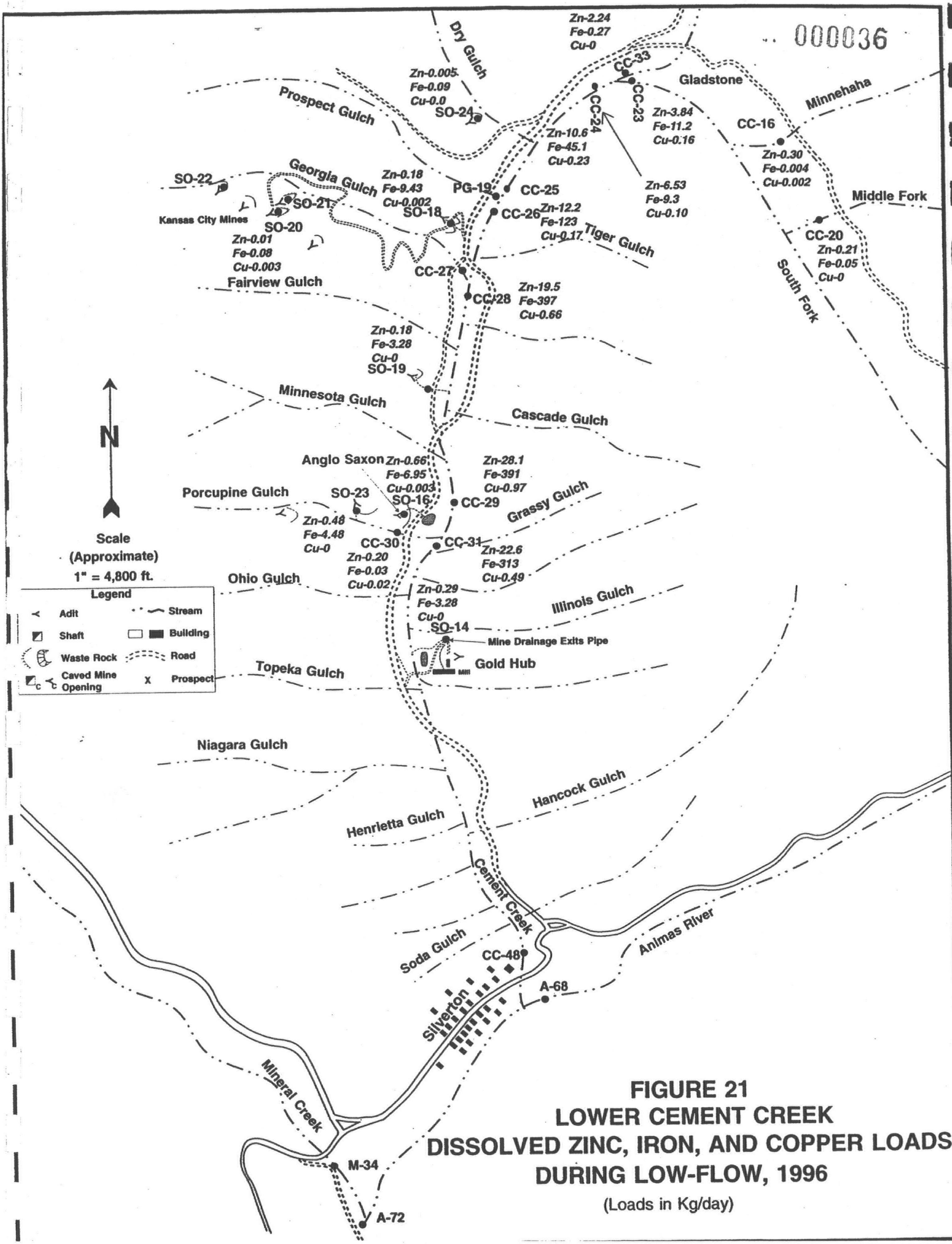


FIGURE 21
LOWER CEMENT CREEK DISSOLVED ZINC, IRON, AND COPPER LOADS DURING LOW-FLOW, 1996

(Loads in Kg/day)

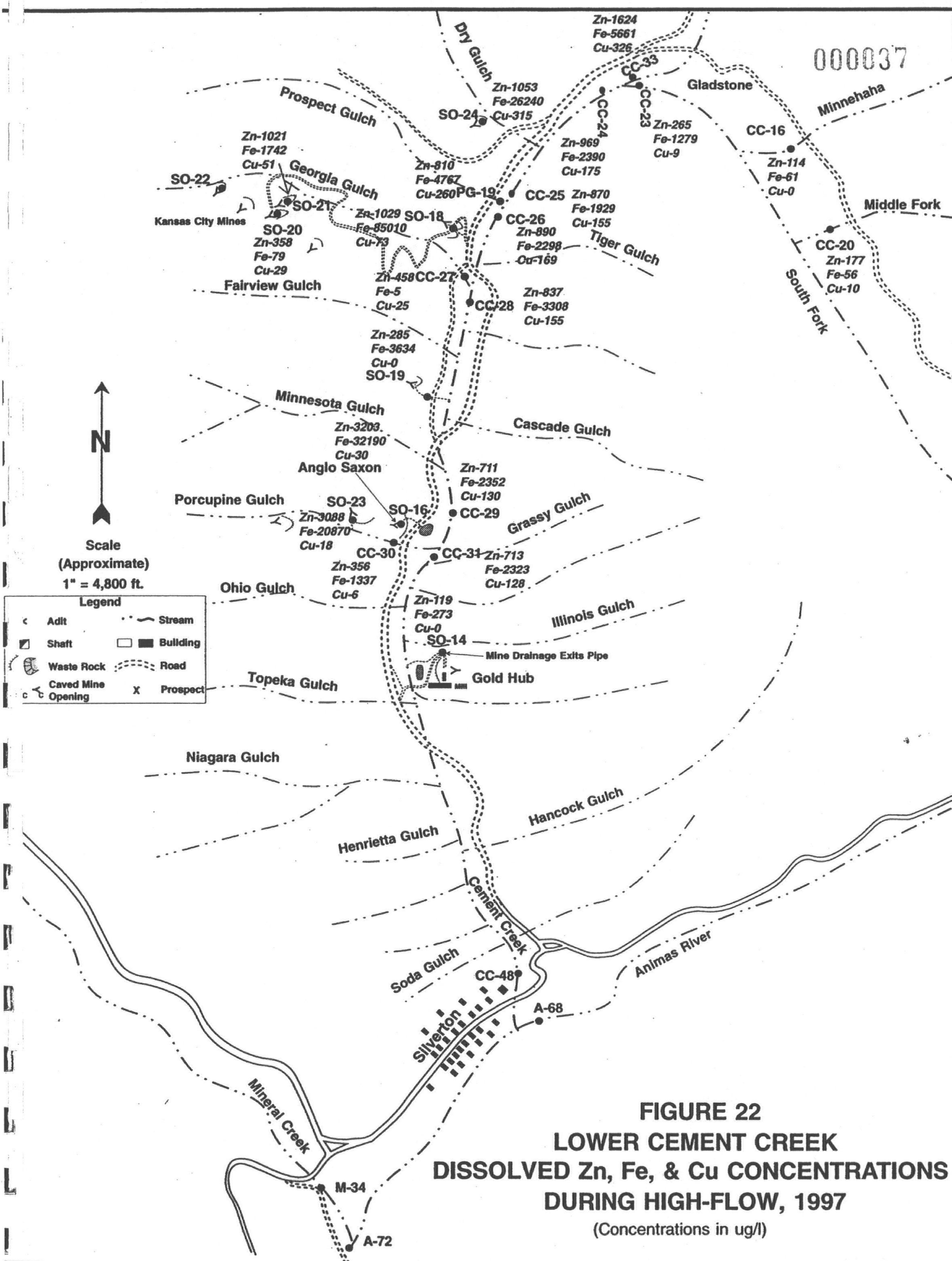


FIGURE 22
LOWER CEMENT CREEK
DISSOLVED Zn, Fe, & Cu CONCENTRATIONS
DURING HIGH-FLOW, 1997
(Concentrations in ug/l)

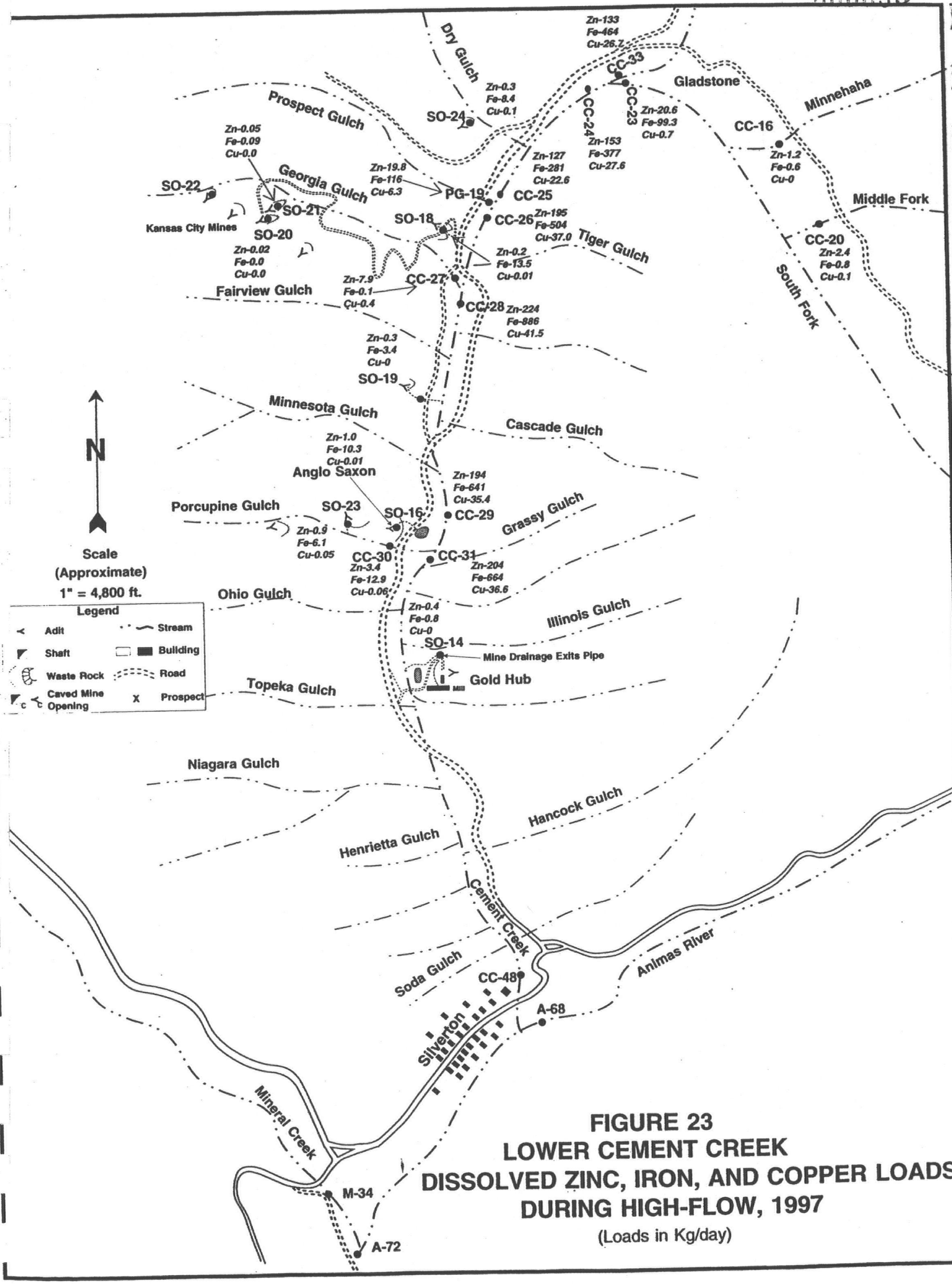


FIGURE 23
LOWER CEMENT CREEK
DISSOLVED ZINC, IRON, AND COPPER LOADS DURING HIGH-FLOW, 1997

(Loads in Kg/day)

number of prospects above sampling site CC-1, some with waste rock in or adjacent to the stream, that probably contribute zinc to the stream. At high-flow, there is a slightly higher zinc load, but concentrations are much lower (Figures 14 and 15).

At sampling site CC-2, below the draining Queen Anne Mine and the Columbia/Upper Queen Anne area (shown as three shafts northeast of the Queen Anne Mine on Figures 13 and 15), the zinc load increases during low-flow and high-flow. During low-flow, the zinc concentration increased dramatically, but it decreased during high-flow. The high-flow zinc load at site CC-32 is higher than at site CC-2. This may be due to the drainage from CC-32 bypassing site CC-2. At the time of sampling, the stream was totally covered with snow. The sampling site had to be moved about 50 yards upstream. Most of the load from the watershed above CC-2 is thought to be from the Columbia/Upper Queen Anne area.

Sampling site CC-3 was located as a background water quality site for upper Cement Creek from Ross Basin. However, low-flow and high-flow sampling shows that a significant zinc load comes from the area above. There are numerous prospects, a few small mines, and one large mine above this site. The large mine is approximately 200 yards above the sampling site (shown at waste rock sampling site #31 on Figure 6). A portion of the zinc load is thought to come from this large mine site, particularly during spring snow melt. It is recommended that a water quality monitoring station be added to bracket this area. The monitoring site should be set at the bottom of the cascade from Ross Basin. This is immediately above where white precipitate has been observed to form in the channel.

Sampling site CC-4 is located downstream of the acid rock drainage from the Grand Mogul Mine (sampled at site SO-3 on Figures 12 through 15). Zinc loads and concentrations increase dramatically during low-flow and high-flow. During high-flow, the measured dissolved zinc load was less at site CC-4 than site SO-3. The reason for this apparent discrepancy is unknown. It is unlikely that there was that much zinc precipitation between the sampling sites.

At sampling site CC-5, the zinc load increases during both low-flow and high-flow, while the concentrations decrease. During low-flow, the zinc load greatly increases through this stretch. This is probably partially due to several waste rock piles in and adjacent to the small tributaries to this portion of Cement Creek. This site should be upstream of any effects from the Mogul Mine (sampled at site SO-5 on Figures 12 through 15).

At sampling site CC-6, zinc concentrations and load increase, in proportion to the loads from the Mogul Mine and draining mine at site SO-7. The small tributary that joins Cement Creek immediately downstream of site CC-6 contains several minor waste rock piles, none of which were sampled.

Between sampling sites CC-6 and CC-9, it is difficult to assess contributions to the system because of flow-gaining and losing sections. During low-flow, zinc concentrations remain within +/- 10%, while zinc load varies between 18.7 and 27.1 lb/day. At high-flow, concentrations steadily decline in this reach, while all the loads, except at site CC-8, remain within +/- 10%. The measured flow at site CC-8 was much higher than measured at sites CC-7 or CC-9. If the data are interpolated between sites CC-7 and CC-9, there is virtually no load increase. The data indicate that zinc contributions through this stream section are insignificant.

Sampling sites CC-9 and CC-13 bracket the North Fork of Cement Creek. Loading analysis in this section is very difficult because a significant amount of the flow in Cement Creek and the North Fork goes underground in this area. During August 1996, all the flow from the North Fork was observed to infiltrate into the alluvial gravels prior to reaching Cement Creek. Also, the flow in Cement Creek was visibly reduced near the confluence with the North Fork. Below the Cement Creek/North Fork confluence, an inflow was observed above sampling site CC-13, but no other significant inflows were observed between the confluence and the Sunnyside Gold treatment system intake (between sites CC-13 and CC-33 on Figures 12 through 15). In addition, during high flow sampling in June 1997, the flow from the North Fork was evidently higher than the flow measured at site CC-12 as evidenced by the metals loading differential between the sites bracketing the North Fork. There was some dissolved metal increase due to dissolution of the suspended material as the pH decreased in Cement Creek following the low pH input from the North Fork. The North Fork contributes a larger zinc load to Cement Creek than any other tributary. Also, zinc concentrations reach their highest level below the confluence with the North Fork. The source areas in the North Fork were not investigated because the major mines are currently permitted.

Below sampling site CC-13 is the Sunnyside Gold Corporation (SGC) treatment system for the American Tunnel. During low-flow, virtually all the drainage in Cement Creek is passed through the treatment system. During high-flow, only a small portion is passed through the treatment system. Sampling site CC-33 is located below the outlet from the final treatment pond. At low-flow, the treatment system is removing at least 2/3 of the zinc load from upper Cement Creek, while during high-flow, there was only a slight reduction in loading.

Sampling site CC-24 is below the confluence of Cement Creek and the South Fork of Cement Creek. Historically, the South Fork has diluted the zinc concentrations from upper Cement Creek. During low-flow, because the SGC treatment system treats most of the flow from upper Cement Creek, water from the South Fork is diluted by upper Cement Creek. During high-flow, water from upper Cement Creek is diluted by water from the South Fork. The majority of the metals in the South Fork come from the draining Silver Ledge Mine.

Below the confluence with the South Fork, it is difficult to ascertain trends or changes in water quality because of the relatively large amount of flow and the numerous natural inflows. At low-flow, zinc loads and concentrations generally increase downstream of sampling site CC-24 (Figures 12 and 13). During high-flow, zinc loads increased downstream, but the concentrations, in general, are reduced (Figures 14 and 15). In both flow regimes, the largest increase in loading occurred between Prospect Gulch and Georgia Gulch. This increase is probably due to the natural iron springs (bogs) and subsurface flow from Prospect Gulch, although there is probably a greater contribution of metals from Georgia Gulch than has been measured. Much of the flow in Georgia Gulch has, subsequent to the completion of monitoring, been observed to flow underground through the alluvial fan. It is recommended that Georgia Gulch be monitored in at least two new areas. The first would be a background sample above the upper-most mine of the Kansas City Group. This site will be difficult to monitor during the spring because of high flow. The most important monitoring site may be in the canyon above the alluvial fan.

There were five tributaries in the headwaters of Prospect Gulch that were monitored during both low-flow and high-flow. Loads and concentrations are shown on Figures 16 through 19. All the tributaries have some mining activities within their respective watersheds.

Sampling sites PG-1 and PG-2 are located downstream of small prospects, with less than 100 cu. yds. of waste rock, in their respective watersheds. During both low-flow and high-flow, zinc concentrations at sites PG-1 and PG-2 were below the no effect concentrations (NEC) for aquatic life.

The principal zinc addition at low-flow and high-flow in the headwaters of Prospect Gulch occurs at the Hercules and Galena Queen Mines. The Galena Queen Mine is downstream of sites PG-1 and PG-2. Whereas water quality below the PG-1 site is affected by the Galena Queen Mine, there does not appear to be any visible effect on the drainage below the PG-2 site.

Between sampling sites PG-1 and PG-3, the stream passes over and through a portion of the waste rock of the Galena Queen Mine. This results in a 2-3 order of magnitude increase in zinc concentrations (Figures 16 and 18). The zinc loading attributable to this small area is approximately 0.2 lb/day of zinc per day during low-flow (Figure 15) and 5 lb/day of zinc per day during high-flow (Figure 17).

Mine drainage has been observed at the small mine located above sampling site PG-5. However, zinc concentrations indicate that this drainage is probably insignificant. The waste rock at that site appears to be principally unmineralized country rock. Sampling site PG-4 was established as a background site to assess the effects of the draining mine above site PG-5. However, during low-flow and high-flow, zinc concentrations were higher at this location than at site PG-5. This discrepancy is probably due to dilution by clean water inflows between sites PG-4 and PG-5.

Sampling site PG-7 is below a waste rock pile in the stream channel. It also appears that the mine adit occasionally drains, although there has been no drainage observed. At high-flow, the zinc concentrations at PG-7 was below NEC, however during low-flow, the concentrations were elevated.

Sampling site PG-20 was established to bracket the snowmelt contribution of the Hercules Mine. This site was not monitored during low-flow because it is unlikely that the Hercules Mine waste rock has any appreciable effect on water quality at that time of the year. At low-flow, the major mining effect on that small tributary is a small waste rock pile upstream of the Hercules that blocks the stream. At high-flow, the zinc concentrations at site PG-20 were below NEC.

Further downstream at sampling site PG-8 in Prospect Gulch, the zinc concentration drops due to dilution. The low-flow zinc load at PG-8 is consistent with the measured loads upstream, indicating that the Hercules waste rock has very little zinc contribution during low-flow. At high-flow, there is a greater zinc load at PG-8 than can be accounted for at the upstream monitoring sites. There is an increase in zinc concentration and loading between PG-20 and PG-6 directly attributable to the Hercules Mine. Based upon the water quality data, the zinc contribution from the Hercules Mine is estimated to be 2 lb/day during high-flow. The zinc contributions by the Hercules and Galena Queen Mines are probably higher at the beginning of snowmelt. At the time of the high-flow sampling, both waste rock piles were completely snow free, while the surrounding area had approximately 50% snow cover. This is most likely due to the higher than ambient temperatures in the waste rock from the exothermic acid production process. Approximately two weeks before the high-flow sampling, both waste rock piles were observed to be virtually snow free, while the surrounding area was covered with up to 5 ft. of snow.

Between sampling sites PG-8 and PG-9 is a mineralized canyon. This area is monitored principally to determine the natural inflows, but may include a mining-related source. A flowing spring occurs on a mineralized fracture immediately below site PG-8. There may be a connection with this spring and the Hercules shaft, where swirling water has been observed. During low-flow, zinc concentration and load increased between PG-8 and PG-9. This compares to a slight drop in zinc concentrations at the high-flow monitoring. The high-flow reductions may be partially due to an increase in pH, as compared to a slight drop in pH during low-flow.

Between sampling sites PG-9 and PG-11, the principal inflow is a tributary with no mine-related features, which originates at Red Mountain. During snowmelt, there is a small amount of drainage from the Henrietta 7 Mine that flows down the road, entering the stream between these sampling sites. The stream above PG-10 was monitored by WQCD in 1991-1993 above the main access road into Prospect Gulch. Between the WQCD site and PG-10, there are no mine-related features, other than the two roads which the drainage crosses. Low-flow and high-flow concentrations measured at PG-10 are higher than measured at the WQCD site. In fact, the concentrations measured at PG-10 were higher at high-flow than at low-flow. The WQCD data shows the opposite trend. The most likely explanation is that the roads are the principal cause of the apparent increase. Particularly during snowmelt, tributary water flowing down the roads is churned up by 4-wheel drive vehicles. This may explain the increase in zinc concentrations. The area between the WQCD sampling site and PG-10 should be investigated further.

It should be noted that the flow measurements for sites PG-16 and PG-18 were improperly taken. Therefore, the flow measurements and loading values reported in the appendix are based on addition of the measured in-flows at stations PG-14 and PG-17 to the flow at station PG-15.

At sampling site PG-16, downstream of the Henrietta 7 Mine, the zinc concentration and load are approximately double those at site PG-11. A portion of this is probably due to the drainage from the Henrietta 7 adit and possibly the Henrietta 8 adit, which is collapsed with no visible signs of drainage. However, the largest contribution is from leaching of the waste rock in that area. Much of the waste rock leaching occurs at the northern pile along the northern side of Prospect Gulch. There are several springs which flow perennially most years above the waste rock. Sampling site

PG-14 provides a direct measurement of the leaching effects, but there are numerous other small springs and seeps upstream, that are similar in chemistry to site PG-14. The zinc loading from the Henrietta 7 area is approximately 0.4 lb/day and 12 lb/day of zinc during low-flow and high-flow, respectively.

Between sampling sites PG-16 and PG-18, the zinc concentration and load increase during high-flow and remain relatively stable during low-flow. This is principally attributed to leaching of the waste rock at the Joe & Johns Mine and drainage from the Lark Mine. The drainage from the Lark Mine infiltrates into the waste rock, resulting in a zinc load greater than that measured directly in the mine drainage. The stream passing by the Joe & Johns Mine is mostly diverted by the Prospect Gulch access road. A portion flows underground through the waste rock, and was measured at sampling site PG-17. The actual zinc load from this tributary is greater than shown on Figure 17, because of subsurface flow in this tributary. A large portion of the input of 9+ lb/day of zinc could be removed by reclaiming the Lark and Joe & Johns Mines.

Between sampling sites PG-18 and PG-19, zinc concentrations increased slightly and zinc load increased by about 50% during high-flow. This is consistent with the data collected at WQCD sampling sites *CC-25* and *CC-26*, which were taken in roughly the same locations. Sampling site PG-19, near the confluence with Cement Creek, was inadvertently skipped during the low-flow sampling, but the WQCD data shows that the concentration decreased by a factor of about 2.5, while the load increased by about the same factor. The only mining-related surface discharge contributions between sites PG-18 and PG-19 are the drainage from the Joe & Johns Mine, a tributary with headwaters near the Henrietta 1, 2 and 3 Mines, and a small seeping mine adit downstream of PG-18.

CEMENT CREEK IN-STREAM IRON

The North Fork of Cement Creek, South Fork of Cement Creek, Prospect Gulch, and iron bogs below Prospect Gulch are the principal source areas for dissolved iron in the Cement Creek watershed. Except for localized areas, the headwaters of Cement Creek are not an important source of in-stream iron. At low-flow and high-flow, very little iron was found at sampling site CC-5 (Figures 12 through 15). The two localized exceptions are at sampling sites CC-32 and CC-4/SO-3. Most of the iron from these areas precipitates downstream. There is visible iron staining on the stream channels below both these sites.

At low-flow, iron concentrations steadily increase between sampling sites CC-5 and CC-9, then increase by a factor of three below the North Fork of Cement Creek (Figure 12). Between CC-5 and CC-6, there is a slight increase in iron loading from the Mogul Mine, although the dissolved iron load from the Mogul Mine drainage is an order of magnitude greater than the in-stream load at CC-6. This shows that the wetland receiving the mine drainage is removing most of the iron. Surprisingly, there is virtually no increase in concentration or load as Cement Creek flows through the ferricrete deposits between CC-7 and CC-9.

At high-flow, there is an increase in concentration and load between CC-5 and CC-6, due to the mine drainages from the Mogul Mine and site SO-7 (Figures 14 and 15). At this time of year, snowmelt from the surrounding area significantly reduces the residence time in the wetland. Between CC-6 and CC-7, the concentration and load drop. Between CC-7 and CC-9, the concentrations rise, while the load varies. The load variation is probably due to gaining and losing reaches of the stream.

The North Fork is the largest iron loader of all the tributaries in Cement Creek. At site CC-13, below the confluence with the North Fork, iron concentration and load at high-flow increase by two orders of magnitude from 15 to 1,356 lb/day. The most prominent iron staining in Cement Creek begins below the North Fork. As discussed for zinc, the load measured at CC-13 is three times higher than that measured at site CC-12 on the North Fork.

At CC-33, downstream of the SGC treatment system near Gladstone, iron concentrations and loads were significantly reduced. At CC-24, the South Fork of Cement Creek acts as a diluter during high-flow, with the reverse occurring during low-flow. This is because virtually all the drainage in upper Cement Creek is treated by SGC during low-flow.

Most of the dissolved iron in the South Fork comes from the draining Silver Ledge Mine. The Silver Ledge Mine is the single largest point source iron loader in Cement Creek. There is very little iron in the streamflow from Minnehaha and the Middle Fork.

Downstream of the South Fork, dissolved iron concentrations generally increase during low-flow and high-flow to sampling site CC-28, below Georgia Gulch (Figures 20 and 22). The one exception is the inflow from Dry Gulch, which dilutes the iron concentrations in Cement Creek during high-flow. The two largest increases in concentration and load downstream of the South Fork, occur below Prospect Gulch between sampling sites CC-25 and CC-26 and below the iron bogs located between sampling sites CC-26 and CC-28. Between sites CC-25 and CC-26, dissolved iron load increases by 172 lb/day at low-flow and 492 lb/day at high-flow. Between sites CC-26 and CC-28, dissolved iron load increases by 604 lb/day at low-flow and 842 lb/day at high-flow. Less than 5% of the iron in this segment (CC-26 to CC-28) can be attributed to mining-related surface discharges.

Downstream of sampling site CC-28, dissolved iron concentrations as measured in this study decrease until just upstream of the Cement Creek Gage (CC-48). WQCD data confirm this.

At the headwaters of Prospect Gulch, dissolved iron load at five of the six tributaries was minimal at both low-flow and high-flow (Figures 17 and 19). The one exception is the tributary measured at sites PG-6 and PG-20. The iron load at these stations was minimal during low-flow, but during high-flow, iron from the Hercules Mine and an unknown mine upstream amounted to 1.1 lb/day. Between stations PG-1 and PG-3, the iron concentrations increased two and three orders of magnitude at high-flow and low-flow, respectively. The iron loading from this area was 0.1 lb/day at low-flow and 5.5 lb/day at high-flow. At stations PG-5 and PG-7, iron concentrations were slightly elevated, which is probably due to subsurface drainage from the mine above each tributary. At site PG-8 on the mainstem of Prospect Gulch, dilution greatly reduced dissolved iron loading.

Between sampling sites PG-8 and PG-9, iron concentration decreased during low-flow and increased during high-flow (Figures 16 and 18). The dissolved iron load remained steady during low-flow, while there was a slight increase during high-flow (Figures 17 and 19).

From sampling site PG-9 to PG-11, iron concentration and load remained steady during low-flow. At high-flow, iron concentration increased and iron load more than doubled.

Between sampling sites PG-11 and PG-16, which bracket the Henrietta 7 Mine, dissolved iron concentrations and loads increased by at least one order of magnitude during both low-flow and high-flow.

At high-flow and low-flow, iron concentrations and load increased downstream to sampling site PG-19 at the confluence with Cement Creek. If all the iron attributable to mining-related surface discharge sources in Prospect Gulch was removed, at best, the iron load from Prospect Gulch could only be reduced by about 50%.

CEMENT CREEK IN-STREAM COPPER

The principal sources of copper in the Cement Creek watershed are upper Cement Creek upstream of Gladstone and Prospect Gulch. At the headwaters of Cement Creek near Hurricane Pass, the only in-stream copper measured was from the Columbia/Upper Queen Anne area at high-flow (upstream of sampling site CC-32 on Figures 12 through 15). During high-flow at site CC-32, 1.5 lb/day of copper was measured. At the headwaters from Ross Basin, copper was above detection limits at the upper site (CC-3), during both low-flow and high-flow. At sampling site CC-4, below the confluence of the acid rock drainage from SO-3, copper concentrations increased dramatically. Between sites CC-3 and CC-4, copper load increased from about 0.1 to 0.6 lb/day at low-flow and from about 1.3 to 6.6 lb/day at high-flow. Between sampling sites CC-4 and CC-5, copper concentrations declined, but copper load increased by about two times. These data are shown on Figures 12 through 15.

Between stations CC-5 and CC-6, dissolved copper concentrations increased during low-flow and high-flow. At low-flow, the increase in copper load between these two stations is consistent with the load from the Mogul Mine. At low-flow, there was no drainage from the mine at sampling site SO-7. At high-flow, the downstream loading increase is greater than what can be accounted for at these two draining mines. A portion of the increased loading is probably from snowmelt and mine drainage leaching through the waste rock, but the small tributary downstream of sampling site CC-5 may also be a partial source. This tributary should be investigated further.

From sampling site CC-6 to CC-9, dissolved copper concentrations declined during low-flow and high-flow. At low-flow, dissolved copper load decreased through this segment. At high-flow, dissolved copper load increased in flow-gaining areas and decreased in flow-losing areas.

At sampling site CC-13, downstream of the North Fork, dissolved copper concentrations increased at both low-flow and high-flow. Copper load at site CC-13 showed a decrease during low-flow. This is a problem because much of the drainage from the North Fork probably flowed underground and entered Cement Creek below sampling site CC-13. At high-flow, the dissolved copper load increased by about five times. The in-stream loading increase was over three times that measured at site CC-12, indicating that much of the flow at site CC-12 was subsurface.

Treatment of the flow in upper Cement Creek by SGC at the treatment system near Gladstone reduced copper concentrations to below detection limits at sampling site CC-33 during low-flow. At high-flow, copper concentrations and loading at that site were only reduced slightly.

At sampling site CC-24, the low-flow copper concentrations were back to headwaters levels. The high-flow copper concentration was reduced by the inflow from the South Fork. The high-flow dissolved copper load increased in accordance with the load addition from the South Fork. During both low-flow and high-flow, the South Fork is a relatively insignificant source of copper.

Low-flow copper concentrations generally increased downstream of sampling site CC-24 to site CC-28, then declined through station CC-31. The one exception is below Prospect Gulch (CC-26) where there was a decrease. Low-flow data collected by the WQCD indicate that copper concentrations at the mouth of Prospect Gulch are less than 10 ug/l. Without the SGC treatment system in upper Cement Creek, it is likely that concentrations would decline throughout this segment.

High-flow dissolved copper concentrations showed a general decline in Cement Creek downstream of the South Fork (Figure 22). There was a slight increase in concentration below Prospect Gulch. High-flow dissolved copper loading declined between sites CC-24 and CC-25, then increased through site CC-28. Downstream of Prospect Gulch (between sites CC-25 and CC-26), the high-flow copper load increased by about 32 lb/day. Between sites CC-26 and CC-28, the high-flow copper load increased by 10 lb/day. The source of much of the increased load between CC-26 and CC-28 is unknown, but may possibly come from the iron springs (bogs) in that area. Downstream of site CC-28, the dissolved copper load declined.

In the headwaters of Prospect Gulch, copper concentrations in the tributaries monitored by stations PG-6 and PG-7 showed elevated concentrations of dissolved copper during low-flow and high-flow. However, the dissolved loads are relatively insignificant. Between sites PG-1 and PG-3, the low-flow and high-flow concentrations increased dramatically (Figures 16 and 18). At low-flow, the copper load is insignificant, but at high-flow, the copper load is about 0.4 lb/day (Figures 17 and 19).

Copper concentrations do not increase until site PG-16 downstream of the Henrietta 7 Mine. Low-flow dissolved copper loading at site PG-16 is only about 0.2 lb/day. High-flow dissolved copper loading at site PG-16 is about 4 lb/day. Low-flow copper concentrations and loads decrease downstream after that point. High-flow copper concentrations and loads increase below site PG-16.

The high-flow dissolved copper load at the mouth of Prospect Gulch was 14 lb/day. This compares to an increase in the copper load in Cement Creek downstream of Prospect Gulch 32 lb/day as discussed above. Of this load, only about 6 lb/day of copper load from Prospect Gulch can be directly attributed to mining-related surface discharge in Prospect Gulch.

RECLAMATION OPTIONS

There are many different types of mining-related disturbances in the Cement Creek watershed, which affect the water quality in the creek. A thorough understanding of the hydrologic system is necessary to determine which reclamation options would be best at a particular site. Reclamation of the area will be complicated and several reclamation options may be required at some sites to provide the most efficient system of cleanup.

One of the most complex situations involves the reclamation of mine drainages. These situations usually involve collection and treatment of the adit discharge. In the case of draining mines in the Cement Creek watershed, a moderate to high potential for fracture-flow groundwater-minepool interactions exists because of the complex geology and extensive mining that has occurred. If a treatment system is contemplated to address adit discharges, it will be necessary not only to understand the chemistry and hydrology of the adit discharge, but also to determine any potential groundwater loadings which leave the site through fractures that are not seen as surface flows at the portal. The fractured, jointed, highly altered nature of the bedrock could be allowing seepage from the adit to enter the groundwater system. A treatment system could work well on the adit discharge, but fail to meet metals removal goals in the stream due to unidentified groundwater pathways to the creek. In that case, simply sticking pipes into the portals would not be adequate to collect all the water which needs to be treated. It may be necessary to re-enter the adit to some point beyond fracture influences where a grout-sealed bulkhead water-inlet can be placed to collect and prevent the infiltration of adit flows into fractured bedrock.

Reclamation and treatment methods considered in this feasibility investigation include:

1) Hydrologic Controls (Preventative Measures) - diversion ditches, mine waste removal and consolidation, stream diversion, bulkhead seals, revegetation.

2) Passive Treatment - anoxic limestone drains, settling ponds, sulfate reducing wetlands, aqueous lime injection, limestone water jet, oxidation wetlands, aeration, powered mechanical neutralization systems, dilution, electro-kinetics, and land application.

A short description of each method is given below.

HYDROLOGIC CONTROLS

Most hydrologic controls are preventative measures in that they inhibit or prevent the process of acid formation and/or heavy metal dissolution. If it is possible to prevent water from entering a mine, or coming into contact with sulphide ores or wastes, this can be the best, most cost effective reclamation approach. Unfortunately, very few cases are found where preventative measures can be effectively implemented to completely prevent mine drainage.

Diversion ditches are effective where run-on water is degraded by flowing over or through mine waste, or into mine workings. Diversion ditches can also be used to intercept shallow ground water that may enter mine waste. In some cases, mine discharge can be improved by flowing through the waste rock. Mine drainage must be sampled above and below a waste rock pile to determine whether or not the waste rock is degrading the water quality.

Mine waste removal and consolidation is effective where there are several small mining waste piles in an area, or where there is a large pile in direct contact with flowing water. The method is simply to move reactive material away from water sources.

Stream diversion is similar to mine waste removal and consolidation. It involves moving the water sources away from reactive materials. In most cases, it is usually preferable to move mining waste rather than move the stream, since the relocated stream can require considerable maintenance, particularly following high-flow events.

Bulkhead Seals are another type of preventative measure. For most inactive mines, bulkhead seals are expensive and require considerable geologic and engineering investigation and characterization. Sites which have simple geology, sound rock, and limited subsurface workings may be amenable to this approach. In the long term, bulkhead seals can be cost effective for these types of sites.

Revegetation is often used in combination with other hydrologic controls above. Revegetation by itself can be a very effective method of reducing heavy metals concentrations, particularly where much of the metals are contributed by erosion of mining waste into a stream. Revegetation also reduces the amount of water that infiltrates a waste pile, thereby reducing leachate production. The roots of growing plants also have been shown to produce carbonates through respiration.

PASSIVE TREATMENT

Anoxic limestone drains are the simplest method of introducing alkalinity into mine discharges. Anoxic limestone drains (ALD) are constructed by placing coarse limestone (3/4" - 3") inside an adit or in a fully sealed trench outside a discharging mine. In order for an ALD to function properly, the mine discharge must be devoid of oxygen. In the absence of oxygen, limestone will not become coated by iron and other metal hydroxides, which can shorten the useful life of limestone. In addition, the mine drainage should be relatively low in dissolved aluminum. Aluminum has been shown to precipitate in ALDs, causing plugging. It is theorized that very coarse limestone (4-6") should provide large enough pore spaces to minimize or prevent clogging by aluminum. The disadvantage of using larger limestone is the reduced surface area to react with the mine drainage. After the mine drainage exits the ALD, aeration causes precipitation of metals. The increase in pH due to ALDs is site specific, but generally does not exceed two standard units.

Settling ponds are often overlooked as an effective treatment method. Settling ponds are particularly effective for treating near neutral mine drainages high in total suspended solids (TSS). Aeration of a near neutral pH mine drainage by means of a series of drops, followed by a settling pond can effectively remove iron and other metals that co-precipitate with iron. Settling ponds should be designed for a 24-hour or greater retention time wherever possible.

Sulfate reducing wetlands are often called bioreactors. These systems treat water through bacterial reduction of heavy metals. Sulfate reducing bacteria (SRBs) utilize the oxygen in sulfates for respiration, producing sulfides. The sulfides then combine with heavy metals to form relatively insoluble metal sulfides. The bacteria derive their energy from a carbon source such as cow manure or mushroom compost. There are many other substrates which are an acceptable source of carbon, but most have a low hydraulic conductivity which can result in short circuiting of the system by the formation of preferential flow paths.

Sulfate reducing bacteria cannot survive in a drainage with pH below 4.5. Highly acidic drainages will require a pH increase before the effluent enters the bioreactor.

Sulfate reducing wetlands should generally not be constructed near population centers. These systems commonly produce excess hydrogen sulfide, which can cause undesirable odors up to ¼ mile from the system. When initially started, organics in the substrate discolor the treated water for several months, making water quality appear, to the layman, to be worse than the water entering the system.

Aqueous lime injection is a passive method to introduce neutralizing agents into mine drainage. This system requires a clean water source. Clean water is passed through a pond containing neutralizing agent, then the high pH effluent is mixed with the mine drainage before it enters a settling pond. This system can be cost effective if alkaline wastes such as kiln dusts or fly ash are available. Although still in the experimental phase, this method holds promise for some mine sites.

Limestone water jets are an aerobic method of accelerating the dissolution of limestone. In situations where mine drainage flows down a steep slope, the discharge can be piped, and the resultant head can produce a high pressure water jet. The high pressure jet can be either sprayed onto loose crushed limestone, or passed upward through a vessel containing limestone. In both situations, the limestone does not become coated because of abrasion by the water jet, and agitation of the surrounding clasts. The system using a vessel can result in higher alkalinity in the effluent due to greater abrasion. Both system types are in the experimental phase.

Oxidation wetlands are what most people think of as "wetlands". They differ from sulfate reducing systems in that metals are precipitated through oxidation, and aquatic plants must be established. This treatment method is applicable where the pH of a mine drainage is approximately 6.5 or higher, and where metals concentrations in the drainage are primarily a problem during the summer months. Aeration is an important part of this system. The plant materials provide aeration and, when they die, provide adsorption surfaces, along with sites for algal growth.

Aeration is best used where the mine drainage pH is about 6.5 or above. Aeration promotes metal precipitation through oxidation processes. Aeration can be accomplished by mechanical means, or simply by channeling the drainage over rough slopes. Mechanical methods require some source of power, which may be generated through wind, solar cells, or hydro-power. Aeration methods normally include a settling pond below the aeration component.

Mechanical injection of neutralizing agents involves a powered mechanical feeder/ dosing system for dispensing neutralizing agents. This type of system requires frequent maintenance, may produce significant quantities of metal sludges, and should be considered "semi-passive". Power for the feeder can come from wind, solar, or hydro-power. At the Pennsylvania Mine in Summit County, a turbine running in the mine drainage stream demonstrated that hydropower is practical in some situations. Mechanical systems are generally considered only where there are no options for truly passive alternatives.

Any high pH material can be used in this type of system. Because of cost effectiveness and sludge characteristics, the most common neutralizing agent used is finely ground limestone.

Dilution is often overlooked as a treatment method. It can be a cost effective method of treatment, because the neutralizing agent is simply uncontaminated water. Clean water is mixed with the mine drainage in a settling pond, and the resulting pH increase initiates the precipitation of metals. A drawback to this method is that the percentage of metals precipitated is significantly less than most other methods. Metals removal is site specific, but generally less than 50%. This method is most effective in removing iron, aluminum, copper, cadmium, and lead, but has only slight effectiveness for zinc and manganese.

Electro-Kinetics is a newer semi-passive method to remove metals from mine drainage. There are several forms of this treatment currently being developed. The electro-kinetic method discussed in this report uses a low-maintenance, self-regenerating resin to remove metals from mine discharge. Different metals can be separated by using ion specific resins. Electricity is used to strip metals from the resins, producing a sludge, and allowing reuse of the resin.

Land Application is a method designed to use natural metals attenuation processes in soils and subsoils to remove metals. Plant uptake, evaporation and transpiration, and soil exchange capacity act to tie up and remove metals. This method is most effective where mine discharge can be spread over a large area to infiltrate into relatively thick soils or unconsolidated deposits. Drainage should be neutral or near neutral to avoid plant toxicity. This alternative is also effective for discharges with high iron and/or aluminum, and where pH is approximately 4.5 or above.

MINE SITE CHARACTERIZATIONS

ROSS BASIN SITES

Location

The headwaters of Cement Creek begin in Ross Basin two miles upstream from Gladstone, as shown on Figure 1. Ross Basin is a cirque which lies between the slopes of Hurricane Peak on the north, and Bonita Peak on the south. Sunnyside Saddle forms the cirque head wall. Elevations in Ross Basin drainage range from 13,447 ft. on Hurricane Peak to 11,280 ft. at the Mogul Mine, which marks the lower end of the steep-walled cirque basin. Several mine sites in Ross Basin have been selected by DMG and ARSG for reclamation feasibility studies, including the Queen Anne, Columbia Mine on Hurricane Pass, workings on the Grand Mogul Vein in Ross Basin, and the Mogul Mine at the lower end of Ross Basin. These sites are shown on Figures 3 and 6. The mine workings are generally situated on privately owned patented lode mining claims. Coordinates of each site are given in the individual site descriptions which follow below.

The area is characterized by rugged, steep, high alpine terrain well above timber line. Winters are long with snow depths averaging 440 inches, and the summer growing season is short. Average annual precipitation for the past 3 years is 45 inches, 37 inches occurring as snowfall (Sunnyside Gold Corporation, 1996).

Geologic Setting

The regional geologic setting of the Cement Creek area is discussed at the beginning of this report. More specific information about the Ross Basin area is included below.

Bedrock Geology
The Ross Basin area is situated near the center of the Silverton Caldera. Bedrock consists dominantly of the massive rhyodacite and quartz latite flows and flow breccias of the Silverton Group Burns Formation. All of the members of the Burns Formation are present in the Ross Basin watershed. The overlying Henson Formation, consisting of porphyritic and amygdaloidal flows and flow breccias, and fine-grained sandy tuffs, crops out on the upper slopes of Bonita Peak and Sunnyside Saddle. (Burbank and Luedke, 1969)

Structural Geology
Structurally, Ross Basin lies in the north-central part of the Silverton Caldera, within the major, steeply dipping mineralized faults of the Eureka Graben (Burbank and Luedke, 1969). Figure 2 shows the structural geology of the area.

The Ross Basin Fault forms the top of the boot-shaped graben's "toe". It trends southeastward from just north of the main Cement Creek valley, along the northern wall of Ross Basin, and continues through the Sunnyside Saddle into the Lake Emma basin. Near Lake Emma, it makes an almost right-angled junction with the northeast-trending Sunnyside Fault. Dips on the Ross Basin Fault are from 75° to 80° south, with the south block (hanging wall), being downthrown. Displacement is greatest at the junction with the Sunnyside fault, and decreases westward through Ross Basin.

A second major parallel and curving strand of the Ross Basin Fault structure splits off south into the hanging wall in lower Ross Basin. Heavily mineralized and persistent over several thousand feet, it is known as the Grand Mogul Vein. It runs along the foot of the north valley wall just above the floor of the basin. This vein has been extensively mined in both upper and lower Ross Basin, and was stoped to the surface in several locations.

Numerous mineralized fractures (veins) branch off and cut nearly perpendicularly across the two main southeast-trending fault strands. These north-northeast trending veins form a series of repeating narrow fault blocks eastward along the slopes of Hurricane Peak, continuing northwards into the upper part of Poughkeepsie Gulch, and through the Hurricane Pass area in the high north branch of Ross Basin near the Queen Anne Mine.

Hydrothermal Alteration

All the volcanic rocks in the Ross Basin area, and indeed the entire San Juan Caldera region, were extensively propylitized and altered on a regional scale, prior to ore deposition. Propylitic alteration here is typified by the formation and addition of chlorite, calcite, and clays in weakly altered rocks, to epidote, albite, and chlorite in the stronger phases. It has resulted in a dull green or greenish gray color to virtually all of the Burns Formation rocks. Wall rock adjacent to the vein deposits has been subjected to more intense but localized alteration processes Quartz, sericite, and pyrite are common mineralogical products of wall rock alteration associated with the siliceous sulfide veins in the Ross Basin area.

Manganese minerals, such as rhodonite and rhodocrosite, are also characteristic of alteration in wall rock of the major fault-fracture veins. Where weathered on the surface, these manganese-altered rocks often are conspicuous due to the characteristic black staining of manganese oxides (pyrolusite, psilomelane).

Ore Mineralization

Ore mineralization in the Ross Basin area occurs as siliceous sulphide veins associated with the extensive system of open fissures created along the major Eureka Graben structure. Although the mineralized faults and fissures can often be traced for hundreds of feet to several miles, economic ore deposits ("ore shoots"), occur on a much more restricted basis due to localized influences of structure and mineralizing solutions. Many of the most productive ore shoots of the district are found within the Ross Basin and Sunnyside fault veins.

The most common sulfide minerals of the veins are pyrite, chalcopyrite, sphalerite, galena, and tetrahedrite. Tennanite also occurs, and free gold is associated with localized shoots and in siliceous gangues, such as rhodonite ("pink", as the miners called it). (Ransome, 1901). Gold has also been found associated with the base metal sulphides in some veins. Silver is associated with

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argentiferous tetrahedrite and sometimes with silver sulfo salts and sulfobismuthites (Burbank and Luedke,1969).

Gangue minerals associated with the veins in Ross Basin consist dominantly of quartz, rhodonite, rhodocrosite, calcite, fluorite, and minor barite. There is thus a better potential for buffering capacity associated with the veins of Ross Basin than in veins in Prospect Gulch-Georgia Gulch and upper Mineral Creek.

Sulphide minerals found on the mine dumps of the Grand Mogul vein workings and the main Mogul Mine dump included pyrite, galena, and sphalerite. There was abundant calcite, rhodonite, and quartz as well. The Grand Mogul vein is considered by some local workers to be one of the only veins in the district which might be successful as a lead-zinc mining operation.

Surficial Geology

Slopes around upper Ross Basin are steep, and prone to snow avalanches and rockfalls. Much of the lower valley walls and valley floor are mantled by talus deposits. There is also an active rock glacier near the upper basin headwall on the north slope of Bonita Peak, which is believed to have an ice core. As the basin is generally at and well above tree line, soils are thin to patchy tundra varieties, with rock outcrops dominating the landscape.

The avalanche danger in Ross Basin is high. Many avalanche chutes exist on both sides of the valley, and it is common to see huge piles of snow in the runout zones on the valley floor persist well into August of each year. It appears that past avalanches have damaged or destroyed all the structures which may have remained in the basin. Nothing is left standing, and wood and timber debris has been spread all along the valley floor.

Upper Cement Creek runs through extensive talus deposits in Ross Basin. There are only small isolated patches of true stream alluvium.

Ross Basin Area Mine Site Descriptions

The volcanic rocks of the Burns Formation are cut by numerous mineralized faults and fissures which have been prospected and mined for sulphide ores. The mine sites included for feasibility assessments in the Ross Basin area are described below, and shown on Figures 3 and 6.

Ross Basin Upper Site

Location

This site is located in Ross Basin, about ½ mile above the Queen Anne Mine, north of the road to Sunnyside Saddle at an elevation of 12,600 ft. This site is believed to be on the M.E. Harrison claim. This site was sampled as waste rock site #30 shown on Figures 6 and 24. The site is located at LAT. N37°54'30.9", LONG. W107°37'21.2".

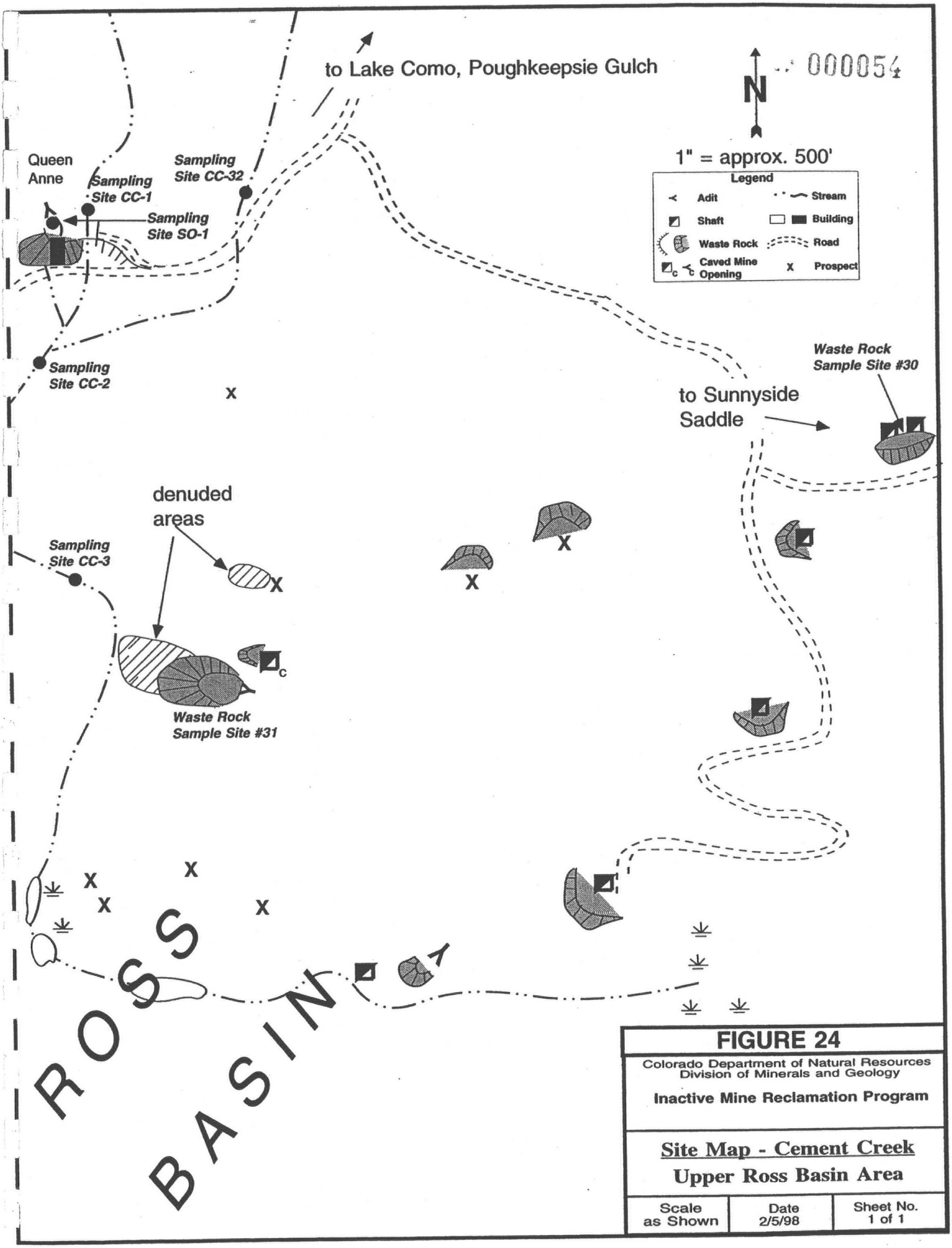

FIGURE 24

Colorado Department of Natural Resources
Division of Minerals and Geology

Inactive Mine Reclamation Program

Site Map - Cement Creek
Upper Ross Basin Area

Scale	Date	Sheet No.
as Shown	2/5/98	1 of 1

Workings
Two capped shafts and associated stopes were mined along a vein outcrop. The waste rock was cast to the south side of the shafts and collapsed stopes. There is no surface discharge from the mine workings.

Mine Wastes
The shallow waste rock pile covers an area of approximately 50 ft. by 250 ft. The waste rock is generally coarse material from the oxidized portion of the vein. The dump primarily contains gossen, but there is some unoxidized waste containing massive pyrite along with some galena and sphalerite. The dump contains approximately 1,800 cu. yds. of material. A small kill zone extends downgradient from the dump. Total acidity and sulfates are shown below.

Ross Basin Upper Site

Total Acidity (mg/l)	ICP Sulfate (mg/l)
260	386

Historic Structures
There are no structures or equipment, other than scattered debris.

Geologic Constraints to Reclamation
This site is generally outside of avalanche paths, being in a saddle area. Bedrock is at or near the surface over most of the site, though there is some loose talus and scree north of the site on the slopes of Hurricane Peak. There are some localized deposits of shallow topsoil nearby, but a large area would have to be disturbed for a borrow area. The extreme elevation makes revegetation difficult.

Water Quality Impacts
The only area of concern at this site is the mine waste. This waste rock had the highest concentration of lead and the second highest concentration of silver in the leachates tested in Cement Creek. Even with a large amount of oxidized material, this waste rock was still acid forming (Figure 9). The total acidity of the waste rock was 260 mg/l. This waste rock is visually similar to other small piles in the vicinity.

Reclamation Options
Reclamation recommended for this site is to grade the material back into the shallow stopes, then cover the waste with a portion of the topsoil under the waste rock. The topsoil will likely have to be amended with limestone to neutralize the acidity from years of leaching.

The other waste rock piles similar to the material in the upper pile are located near small prospect shafts. These shafts should be investigated to determine whether the waste rock can be simply placed back in the mine opening. If this solution can be used, the waste rock material can then be covered and revegetated. Alternately, the waste rock can be amended in-place.

Ross Basin Lower Site

Location
This site is located on a steep slope in Ross Basin about ¾ mile above the Mogul Mine main adit below the access road into Ross Basin at an elevation of 12,200 ft. This site is believed to be on the Jane claim. This site was sampled as waste rock site #31 shown on Figures 6 and 24. There is no access road to the site. The site is located at LAT. N37°54'26.1", LONG. W107°37'34.1".

Workings
A collapsed mine adit and associated waste rock pile comprise this site. There is no surface discharge from the mine workings.

Mine Wastes
The dump at the portal is steep sided, containing approximately 900 cu. yds. of fine to coarse sulphide mine waste consisting mostly of massive pyrite, with some rhodonite, calcite, and quartz. The dump lies on the top margin of a colluvial debris slope. Runoff and seepage from the wastes infiltrates rapidly into the surface, continuing a few yards down slope where it enters the headwater stream. Ore minerals in the waste rock include pyrite, galena and sphalerite, principally in a quartz matrix. Leachate analysis indicates that this waste rock is acid forming. Total acidity and sulfates are shown below.

Ross Basin Lower Site

Total Acidity (mg/l)	ICP Sulfate (mg/l)
1020	1165

Historic Structures
There are no structures or equipment, other than scattered debris.

Geologic Constraints to Reclamation
This site is located on a steep slope adjacent to vertical or near vertical cliffs. The site is probably subject to small localized avalanches during the winter. Bedrock is at or near at the surface over most of the site, though there is colluvial debris below. There are some localized deposits of shallow topsoil nearby, but a large area would have to be disturbed for a borrow area. The extreme elevation makes revegetation difficult.

Water Quality Impacts
The only area of concern at this site is the mine waste. A large area of vegetation has been killed by leachate from the waste rock pile. White precipitate was observed in the stream below this pile. Leachate analysis of the waste rock shows high levels of zinc and copper (Figure 9). This site may be partially responsible for the elevated levels of zinc and copper found at sampling site CC-3 below. As was recommended in the in-stream chemistry section, another sampling station should

be established above the potential area of influence of this pile to determine whether this site is responsible or partially responsible for the elevated metals at site CC-3.

Reclamation Options

Due to the steep slope of this site, the reclamation recommended is to amend the waste rock in-place. Organic material and limestone can be incorporated into the shallow waste rock, then the site can be revegetated.

There are several small waste rock piles in the vicinity that appear to be similar to the waste rock at this site. The other waste rock piles are located near small prospect shafts. These shafts should be investigated to determine whether the waste rock can be simply placed back in the mine opening. If this solution can be used, the waste rock material can then be covered and revegetated. Alternately, the waste rock can be amended in-place.

Grand Mogul - East Adit

Location

This site is located in Ross Basin about ½ mile above the Mogul Mine main portal near the base of the north basin wall at an elevation of 11,800 ft. Access is via a narrow, steep 4-wheel drive trail which leads up Ross Basin from the Mogul Mine. This site is believed to be on the Grand Mogul and Narrow Gauge claims. The site was sampled as water quality station SO-3 and as waste rock sampling site #26 and is shown on Figures 3, 6 and 25. The site is located at LAT. N37°54'31.3", LONG. W107°37'41.9".

Workings

An adit driven northeast into the basin wall connects to workings on the Grand Mogul Vein 50 ft. from the portal. The Grand Mogul Vein strikes N.75°W. The adit continues through the Grand Mogul Vein and cross-cuts to intersect the Ross Basin Fault vein 300 ft. from the portal. There are several levels within the Grand Mogul Vein. The workings on the Ross Basin Fault extend eastward to connect with the Brenneman and Washington ore shoots in the Sunnyside Mine on the 3D level. There is no surface discharge from the collapsed adit, but there is discharge from the toe of the waste rock pile.

Mine Wastes

The dump at the portal contains approximately 9,000 cu. yds. of fine to very coarse bouldery sulphide mine waste consisting mostly of pyrite and quartz, with chalcopyrite, sphalerite, and some galena. The dump is moderately to completely cemented on both the slopes and the top. A kill zone extends outwards a little way from the dump, but as the dump is constructed on extremely permeable talus materials, most of the runoff and seepage from the wastes infiltrates rapidly. Total acidity and sulfates are shown below.

000258

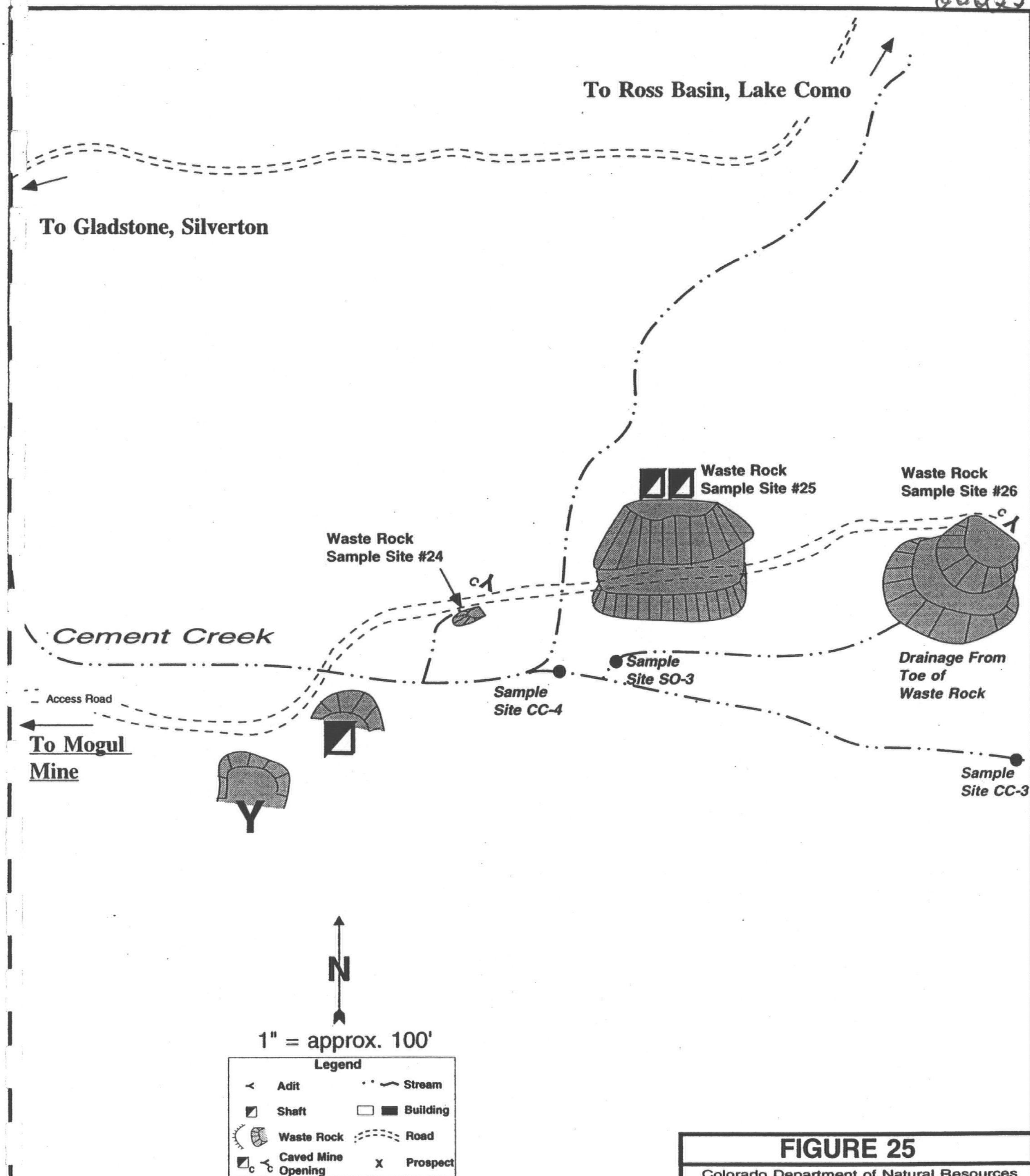

FIGURE 25

Colorado Department of Natural Resources
Division of Minerals and Geology

Inactive Mine Reclamation Program

Site Map - Cement Creek
Upper Mogul Area

Scale	Date	Sheet No.
as shown	2/2/98	1 of 1

Grand Mogul - East Adit Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
890	1,052

Historic Structures
There are no structures or equipment, other than scattered debris. There apparently was a shack or other structure on the dump in 1955, but it has since been destroyed by avalanches.

Geologic Constraints to Reclamation
This site is prone to avalanches and rockfalls from the steep slopes of Hurricane Peak above the site. There is a lot of loose talus and scree at the site, but no suitable soils or capping materials. Bedrock outcrops dominate the site. The extreme elevation makes revegetation difficult. Access is also somewhat difficult, and will need to be improved from the Mogul Mine, as only narrow jeep-type vehicles can pass through the narrow part of the canyon just above the Mogul.

Water Quality Impacts
The drainage from this mine site is one of the largest loaders of dissolved and total metals in the watershed. It is not known whether the source of discharge from the toe of the waste rock pile is mine drainage or is a spring under the waste rock pile. It appears more likely that the water source is mine drainage, due to the high metal content. The acid rock drainage is one of the three largest dissolved aluminum, cadmium, copper, lead and zinc loaders during low-flow and high-flow. Also, during high-flow, this drainage is one of the three highest iron and manganese loaders. Compared to all the other mine drainages, this site produces approximately 51% of the dissolved copper, 42% of the cadmium, 27% of the lead, 21% of the aluminum and 36% of the zinc at high-flow.

The measured loading at SO-3 during high-flow, was approximately 27 lb/day of zinc, 33 lb/day of iron and 5 lb/day of copper. At low flow, loading from this source dropped to 2 lb/day of zinc, less than 0.1 lb/day of iron and 0.3 lb/day of copper. Totaling all the metals measured, this site produces approximately 90 lb/day of dissolved metals during high-flow and approximately 4 lb/day during low-flow.

As would be expected from the water quality, the waste rock extract was high in copper and zinc. The waste rock is acid forming, within the range of other total acidity measurements for waste rock in the area. Snow drifting on the waste rock probably accounts for a portion of the drainage measured at high-flow.

Reclamation Options
Before any definite reclamation measures are developed, the source of the acid rock drainage flowing from the waste rock pile must be determined. This can be done by drilling into the mine workings or driving a well point through the collapsed adit to determine whether there is water in the adit. If the mine workings is the source of water, the adit should be opened up, so the drainage can be diverted from the waste rock pile and characterized. If the source of the drainage is a

000060

spring, either the waste rock must be moved to a relatively drier site, or the spring flow must be intercepted and diverted away from the waste rock.

If the source is mine drainage, it is likely that some type of alkaline addition will have to be done to raise the pH. The current pH is borderline for iron and copper to precipitate in a settling pond, and too low for a sulfate reducing wetland to be effective. Because of the elevation, it is doubtful that a sulfate reducing wetland would be an effective option at this site. Also, because of the remoteness and elevation of the site, there are few low-cost, low-maintenance options available.

With our present knowledge of the site, the most likely alternative is to construct a large anoxic limestone drain, followed by a settling pond. This system could be enhanced to provide for further metals removal by constructing a lime pond to add alkaline water to the settling pond. A portion of the relatively cleaner water from the stream above, can be diverted through a buried pipeline to the lime pond. The amount of water diverted should be roughly equal to the flow from the mine site. Based upon the flow measured in June 1997, the settling pond volume would have to be approximately 20,000 cu. yds. to attain a minimum residence time of 24 hours and allow for 50% sediment volume. To put this in context, the settling pond would have to cover slightly over 1.5 acres at 8 ft. in depth. There is sufficient area to construct a pond of this size in the area, but, because of the slope of the surrounding area, several ponds would have to be constructed. In addition, further disturbance would be required to construct the lime pond. The lime pond should have a minimum capacity of 1,000 cu. yds. to achieve a minimum water residence time of 2 hours, assuming that the pond is half-filled with lime. A smaller pond system could be constructed that will provide treatment for all the year except high-flow, and partial treatment during high-flow.

Because of the porous talus and scree above the mine site, the waste rock receives virtually no run-on. If a settling pond system is constructed, this pile can be covered with a portion of the waste rock, which should reduce the metals leaching from snowmelt and rain storms. There would be sufficient cover material generated by settling pond construction to cap all the waste rock in the immediate vicinity.

Grand Mogul Stope Complex

Location

This site is located in Ross Basin about 1/3 mile above the Mogul Mine near the base of the north basin wall at an elevation of 11,760 ft. It lies just west of the Grand Mogul - East Adit site described above. Access is via a narrow, steep 4-wheel drive trail which leads up Ross Basin from the Mogul Mine. This site is believed to be on the Grand Mogul and Narrow Gauge claims. The waste rock at this site was sampled as site #25 shown on Figures 6 and 25. The site is located at LAT. N37°54'40.1", LONG. W107°37'49".

Workings

A short adit driven northeast into the basin wall directly intersects stope workings on the Grand Mogul Vein, which is well exposed. The Grand Mogul strikes N.75°W., and has here been stoped to the surface along a distance of several hundred ft. Several levels of workings are visible within

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the stope. These workings extended northward and cross-cut over into the Ross Basin Fault, where they continue eastward to connect with the Brenneman and Washington ore shoots in the Sunnyside Mine on the 3D level. The workings also extend underground ½ mile westward to the main Mogul Mine portal. The lower parts of the workings are obscured by snow which remains throughout the year in the stope. Water from snowmelt on the south-facing slopes runs directly into the open stope, and there are several large areas of green, turquoise, and black colored oxidation stains associated with the seepage zones.

Mine Wastes

The dump at the portal and below the collar of the stope contains approximately 8,000 cu. yds. of fine to coarse sulphide mine waste consisting mostly of pyrite, rhodonite, and quartz. There are large cobbles and boulders of sulphide ore minerals and rhodonite below the collar of the stope. A kill zone extends outwards a little way from the dump, but because the dump is constructed on extremely permeable talus materials, most of the runoff and seepage from the wastes infiltrates rapidly.

Total acidity and sulfates are shown below. Although this dump has virtually the same mineralogy as the east dump discussed above, the waste rock is much coarser on the surface. This is the principal reason the total acidity and sulfates (shown below) are lower than the east dump.

Grand Mogul Stope Complex Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
360	536

Historic Structures

There are no structures or equipment, other than scattered debris. A few iron rings and drill steels have been set into the rock face of the vein footwall. An old ore car and tracks can be seen on one of the levels in the stope. This mine was reportedly worked mainly from 1900 to 1906 or 1907.

Geologic Constraints to Reclamation

This site is prone to avalanches from the slopes of Hurricane Peak. Access will need to be improved from the Mogul Mine, as only narrow jeep-type vehicles can pass through the narrow part of the canyon just above the Mogul. There is a lot of loose talus and scree at the site, but no suitable soils or capping materials. The extreme elevation makes revegetation difficult.

Water Quality Impacts

The principal identified water quality impact from this site is from the waste rock. Snowmelt and rain storms leach metals from the waste rock. A portion of the metals measured at water quality station SO-3 during high-flow were probably from this waste rock pile. The waste rock extract analysis shows this material is acid forming, with elevated levels of zinc and copper.

The stope at this site is filled with ice and snow during the winter. The snowmelt water is probably

000062

a portion of the mine drainage that emits from the Mogul Mine, or may be the source of water flowing near waste rock sampling site #24 (Figure 6). If snow accumulation in the workings can be stopped, there should be a benefit to water quality.

Reclamation Options
The reclamation recommended for this site is to backfill the open stopes with the waste rock. Lime should be added to the stope over a period of several weeks before backfilling to help melt the snow and ice in the stope and neutralize the acidity. Initially, larger waste rock material must be placed in the bottom of the stope to wedge against the sides and form a stable plug. Lime and/or fly ash should be added as backfilling takes place to continue neutralizing the acidity and help to cement the backfill materials. At the top of the backfill, a lime-cement mixture should be added to reduce infiltration of water through the backfill. The final slope of the backfill should be at least 2h:1v to facilitate proper runoff.

Mine North of Mogul

Location
This site is located in Ross Basin about 1/4 mile above the Mogul Mine near the base of the north basin wall at an elevation of 11,700 ft. It lies just west of the Grand Mogul Stope Complex described above. Access is via a narrow, steep 4-wheel drive trail which leads up Ross Basin from the Mogul Mine. This site is believed to be on the Cross Cut claim. The waste rock at this site was sampled as site #24 shown on Figures 6 and 25. The site is located at LAT. N37°54'42.2", LONG. W107°38'02.3".

Workings
A short adit was driven northeast into the basin wall. The collapsed adit shows no signs of drainage, but a spring emits near the edge of the waste rock pile, across the access road. The flow from the spring had a pH of 5.4 and an electrical conductivity of 154 umhos/cm. The observed flow is between 5 and 10 gpm.

Mine Wastes
The waste rock pile contains approximately 400 cu. yds. of fine to coarse sulphide mine waste consisting mostly of pyrite and quartz. Total acidity and sulfates are shown below.

Mine North of Mogul Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
200	348

Historic Structures
There are no structures or equipment, other than scattered debris.

Geologic Constraints to Reclamation

000063

This site is prone to avalanches from the slopes of Hurricane Peak. Access will need to be improved from the Mogul Mine, because only narrow jeep-type vehicles can pass through the narrow part of the canyon just above the Mogul Mine. There is a lot of loose talus and scree at the site, but no suitable soils or capping materials. The extreme elevation makes revegetation difficult.

Water Quality Impacts

Water quality impacts from this site are thought to be minimal. Extract analyses shows the waste rock is mildly acid forming, and is relatively low in metals compared to other sites in the area. The mine drainage or spring that emits from the edge of the pile has not killed the adjacent vegetation, and exhibits minor amounts of iron precipitate.

Reclamation Options

No reclamation is currently recommended at this site. If the Grand Mogul Stope Complex is reclaimed, the mining waste from this site could be consolidated with it. The spring/mine drainage should be monitored at least one time to determine whether any further investigations are warranted.

Queen Anne Mine

Location

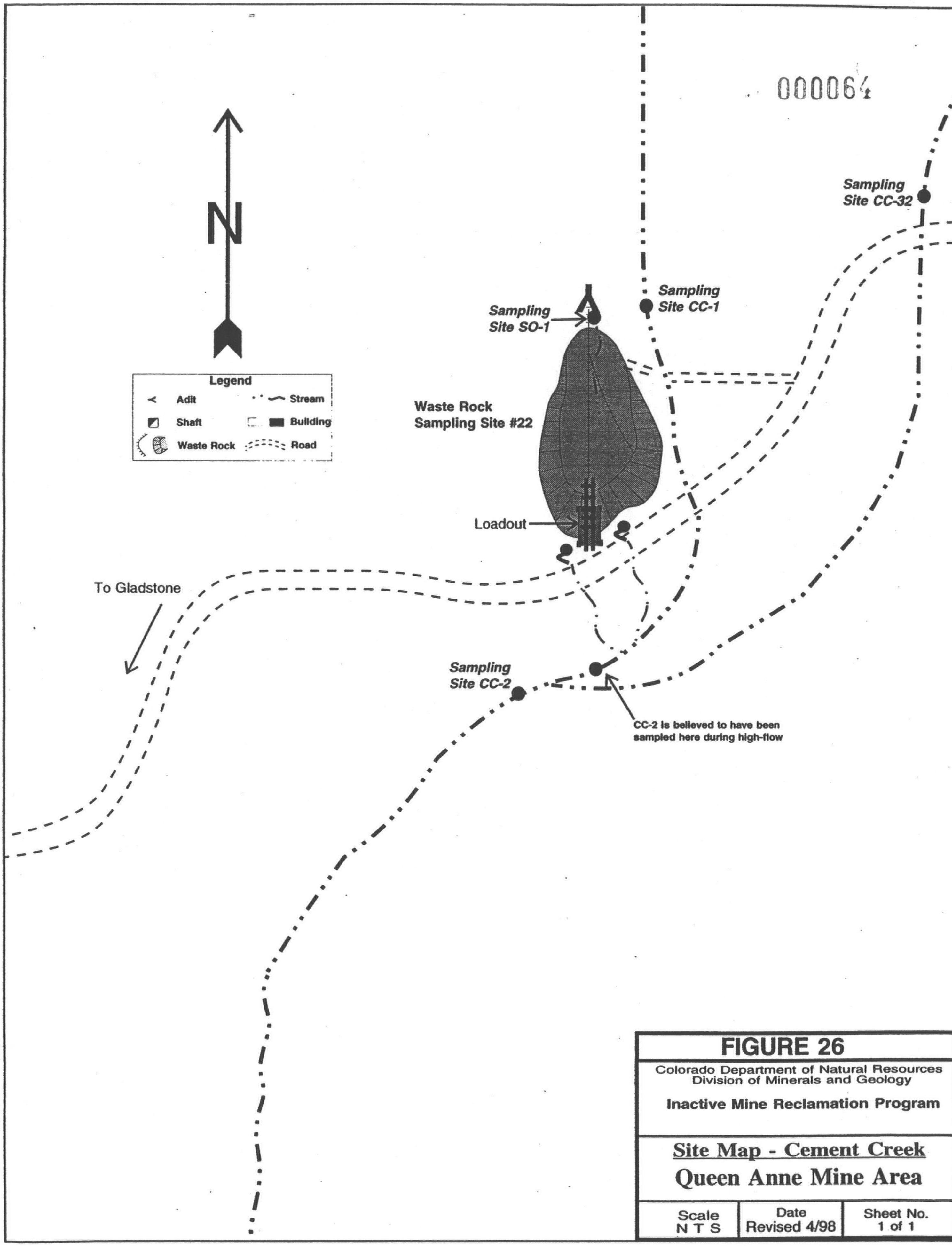
This mine is located in the northern steep branch of Ross Basin 2-3/4 miles above Gladstone adjacent to County Rd. 10, just before Hurricane Pass. It lies at an elevation of 12,240 ft. This site is believed to be on the Queen Anne and Rose No. 1 claims. The mine drainage was sampled as station SO-1 shown on Figure 3. The waste rock was sampled as site #22 shown on Figure 6. These sample sites are also shown on the site map, Figure 26. The site is located at LAT. N37°54'53.0", LONG. W107°37'42.7".

Workings

The Queen Anne adit is driven on a N.14°E. trending vein, which intersects a second vein, striking N.50°E., dipping 75° SE, about 500 ft. from the portal. Where these veins intersected, a dog-leg shaped ore shoot with good values in silver and lead was mined. The adit portal is adjacent to a stream, and continues into the mountainside where it eventually crosses beneath this same stream. The portal discharges between 20 and 40 gpm of water into the top of a steep dump, where much of it infiltrates.

Mine Wastes

The dump at the portal is steep-sided, containing approximately 5,000 cu. yds. of bright yellow and orange fine to coarse sulphide mine waste consisting mostly of massive pyrite, with some rhodonite, calcite, and quartz. The dump lies on talus, and along the margin of a colluvial debris slope. Runoff and seepage from the wastes infiltrates rapidly into the surface, continuing a few yards downslope where it enters the headwater stream. Ore minerals in the waste rock include pyrite, galena and sphalerite, principally in a quartz matrix. Waste rock leachate analysis indicates that this waste rock is mildly acid forming, but compared to other waste rock in Cement Creek, it should be considered a low priority. Total acidity and sulfates are shown below.


000064
N
Legend
Adit
Stream
Shaft
Building
Waste Rock
Road
Sampling Site CC-32
Sampling Site CC-1
Sampling Site SO-1
Waste Rock Sampling Site #22
Loadout
To Gladstone
Sampling Site CC-2
CC-2 is believed to have been sampled here during high-flow
FIGURE 26
Colorado Department of Natural Resources
Division of Minerals and Geology
Inactive Mine Reclamation Program
Site Map - Cement Creek
Queen Anne Mine Area
Scale
N T S
Date
Revised 4/98
Sheet No.
1 of 1

000065

Queen Anne Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
560	274

Historic Structures

There is an ore bin and loadout structure standing at the end of the dump. Although it is currently in moderately good condition, it is steadily deteriorating. The structure is a favorite photo location for the thousands of tourists who pass by the site on 4-wheel drive tours each year. Tracks lead into the adit portal, but there are no other structures or equipment remaining on site.

Geologic Constraints to Reclamation

This site is generally outside of avalanche paths, being close to the top of Hurricane Pass. There is a lot of loose talus and scree at the site, but also some finer grained colluvium on the west margin of the site which might make a borrow area for suitable soils or capping materials. The extreme elevation makes revegetation very difficult.

The mine workings could be picking up water where they cross under the headwaters stream. Based on site geometry and the strike of the vein, the back (roof) of the adit appears to be less than 25 ft. beneath the stream bed, perhaps allowing near surface joints and fractures to deliver water into the workings.

Water Quality Impacts

The water quality impacts from the Queen Anne Mine site come from the waste rock pile and draining mine. The mine drainage flows over and into the waste rock pile. A portion of the mine drainage emerges at the toe of the waste rock pile and some flows under the road into the headwaters of Cement Creek. Compared to the other draining mines, this site produces less than 1% of the dissolved metals. At high flow, dissolved metals amounted to approximately ¾ lb/day. At low-flow, the amount of dissolved metals was approximately 1 lb/day. Dissolved zinc load made up more than 50% of the total load measured at the adit.

The waste rock is acid forming. Extract analyses show that the waste rock is a source of zinc, copper and iron. In-stream sampling at CC-2 indicates that there is an increase in concentration and loading of zinc and copper below this site during low-flow (Figures 12 and 13). At the time of the high-flow sampling, dilution from the surrounding undisturbed area greatly affected the results. The zinc load measured at site CC-2 is lower than what was measured at site CC-32, which is upstream. It is likely that the drainage at site CC-32 was not measured at site CC-2 at high-flow, because the CC-2 monitoring station had to be moved upstream due to deep snow. The high-flow CC-2 sampling site may have been above the confluence with CC-32. If this is true, the waste pile produces as much as 2/3 lb/day of zinc. This is consistent with the 3/4 lb/day of zinc indicated by the low-flow data. A portion of the unaccounted load at CC-2, during low-flow, probably comes from subsurface flow from the Columbia/Upper Queen Anne mine area, which is northeast of the Queen Anne Mine.

000066

Reclamation Options
The first reclamation activity recommended for this site is to divert the mine drainage to the west around the waste rock. The mine drainage diversion would also act as a diversion for upland run-on water. Construction of the ditch should include installation of a culvert under the road below the mine site, to reduce "Texas Crossing" impacts by 4-wheel drive vehicles.

Mine drainage treatment at this site will be difficult because of access and the elevation of the site. The pH of the mine drainage is near neutral, so alkaline addition methods are probably not appropriate. The mine workings appear to be accessible, which would allow testing of the inflows to determine whether all or a portion of the sources in the mine could be sealed off. The water temperature at the adit is marginal, at best, for construction of a sulfate reducing system. In order to find sufficient space for construction of a sulfate reducing system, the mine drainage would have to be piped. There is insufficient area on the waste rock pile to construct a sulfate reducing system without destroying the historic loadout structure. Alternatively, the mine workings could be investigated to determine whether a sulfate reducing system can be installed inside the mine workings.

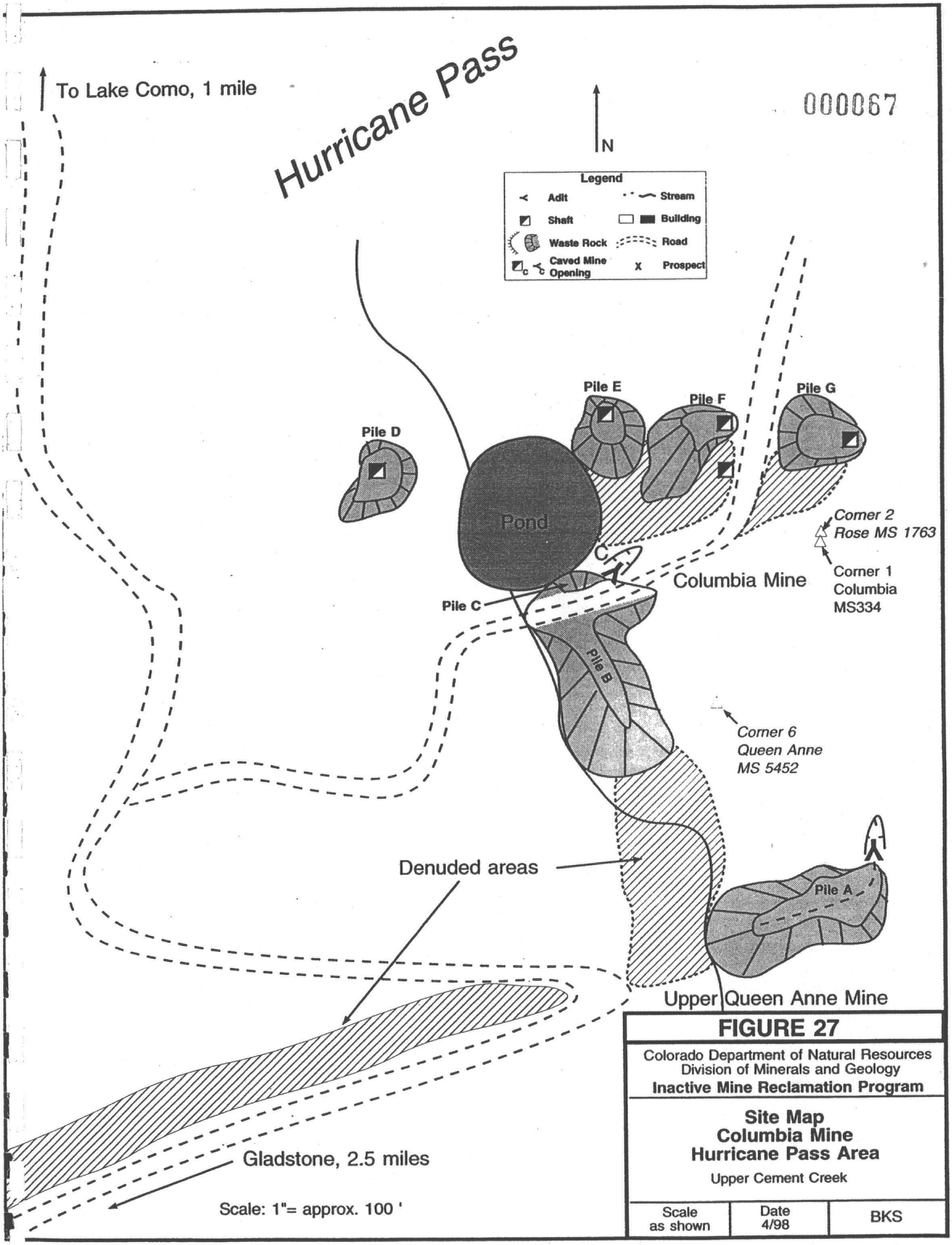
The waste rock at this site should be considered a lower priority than many others in the Cement Creek watershed. The only known reclamation option to treat the waste rock and maintain the historic loadout is to cement the waste rock in place.

Columbia Mine and Upper Queen Anne Complex

Location
This mine complex is located on top of Hurricane Pass, adjacent to County Rd. 10, at an elevation of 12,515 ft. This site is believed to be contained within the Columbia, Adelpheh, Alpha, Rose, and Queen Anne claims. Water quality station CC-32 is located approximately 1/4 mile below this mining complex. The site is in the area of waste rock sampling site #34 on Figure 6. Figure 27 is a site map. The site is located at LAT. N37°55'04.7", LONG. W107°37'37.4".

Workings
The Columbia Mine and adjacent mining sites consist of an adit and five shafts which developed silver-lead ores similar to those at the nearby Queen Anne Mine. The workings opened a series of steeply east-dipping intersecting spur veins which split northwards from the Queen Anne vein . The veins occur as mineralized faults which have offset and tilted the volcanic flows 25° to 35° NW in a series of narrow, north-trending fault blocks across the Hurricane Pass area. As in the Queen Anne, dog-leg ore shoots formed locally where north-northeast trending veins intersected and switched to more east-west trending fissures.

The upper Queen Anne adit drifted on the northeastern extension of the main Queen Anne vein, beyond where the Columbia vein complex branches off. Both the upper Queen Anne and Columbia adits are collapsed, and neither one is draining. The Columbia shafts have all been capped or backfilled.



To Lake Como, 1 mile
Hurricane Pass
N
000067
Legend
Adit
Shaft
Waste Rock
Caved Mine Opening
Stream
Building
Road
Prospect
Pile D
Pile E
Pile F
Pile G
Pond
Corner 2
Rose MS 1763
Corner 1
Columbia
MS334
C
Columbia Mine
Pile C
Pile B
Corner 6
Queen Anne
MS 5452
Denuded areas
Pile A
Upper Queen Anne Mine
Gladstone, 2.5 miles
Scale: 1"= approx. 100 '
FIGURE 27
Colorado Department of Natural Resources
Division of Minerals and Geology
Inactive Mine Reclamation Program
Site Map
Columbia Mine
Hurricane Pass Area
Upper Cement Creek
Scale as shown
Date 4/98
BKS

Mine Wastes

There are seven mine dumps at this site, as shown on Figure 27. The dumps associated with the shafts are small, the largest being only 1,500 cu. yds. (Table 2) The largest dumps are those of the Columbia and Upper Queen Anne adits.

Table 2. Hurricane Pass Mine Dump Data

Dump Map Designation	Approx. Volume (Cu. yds.)
Upper Queen Anne -A	900
Columbia Adit - B	2,000
Columbia Adit - C	300
Columbia Shaft - D	1,000
Columbia Shaft - E	1,500
Columbia Shaft - F	1,000
Columbia Shaft - G	700
Total Estimated Volume	7,400

The dumps are all of similar nature, and consist of bright yellow and orange fine to coarse sulphide mine waste composed mostly of pyrite, rhodonite, and quartz. Three of the shaft dumps lie adjacent to a small pond occupying a depression in the hummocky saddle of Hurricane Pass. The pond drains southwards into Ross Basin, running along the toes of both the Columbia and upper Queen Anne dumps. Runoff and seepage from the wastes runs into the pond and the pond outlet stream. There is a prominent kill zone below the Columbia adit dump, and a lesser one below the "G" shaft's dump.

Total acidity and sulfates of a composite sample from the dumps are shown below.

Columbia Mine and Upper Queen Anne Complex

Total Acidity (mg/l)	ICP Sulfate (mg/l)
1,390	1,441

Historic Structures

There are no structures or equipment remaining at these sites, only some scattered wooden and iron debris, and several posts marking claim corners.

Geologic Constraints to Reclamation
This site is generally outside of avalanche paths, being on top of Hurricane Pass in a flat saddle area. Bedrock is at or near surface over most of the site, though there is some loose talus and scree east of the site on the slopes of Hurricane Peak. There are no suitable soils or capping materials. The extreme elevation makes revegetation difficult.

Water Quality Impacts
The major area of concern is the complex of mine waste rock in and adjacent to the drainage. Because of the heavy snow pack, there is considerable leaching of the waste rock during the period of May through July. It is also likely that there is some leaching during thunderstorms and snowmelt events in the late summer and early fall. There are several perennial snowfields upstream of this site. During the June 1997 high-flow sampling event, the waste rock piles were completely covered with snow to depths exceeding 10 ft.

Sampling site CC-32 is located approximately ¼ mile downstream of the mining complex, east of the Queen Anne Mine. This sampling site is at the bottom of a large iron-stained kill zone below this area. The water quality data from June 1997 shows that this site was producing approximately 33 pound of metals per day including 8 pounds of zinc, 11 pounds of manganese, 11 pounds of aluminum, 1.5 pounds of copper and 1 pound of iron.

The waste rock analyses indicate that leachable copper and iron should be higher, but were probably diluted by adjacent snowmelt at the time of the water quality sampling. Also, the iron and copper may have been precipitating with all the dilution.

Reclamation Options
It is recommended that a combination of options, including consolidation and encapsulation of the waste rock or in situ cementation, be used for reclamation at this site. Because of the deep snow pack at this site, simple encapsulation and revegetation would not be completely effective in eliminating the source. In addition, this area is along one of the major 4-wheel drive roads in the area. To maintain the historic "flavor" of the area, the waste rock directly in the drainage should be consolidated with one or more of the upland piles. The waste rock pile should then be cemented in-place by injecting a cement/fly ash mixture. The consolidated piles could be treated as the material is moved. The cementation will limit the water and airflow through the pile, effectively eliminating this source. A thin veneer of waste rock will have to be left untreated to maintain the historic integrity of the site. Run-on controls should be constructed around the waste piles to limit the water/waste rock contact. The areas where waste rock is removed should be treated with agricultural grade limestone and revegetated.

Mogul Mine

Location
This mine is located just below Ross Basin about 1½ miles above Gladstone on the east side of Cement Creek at an elevation of 11,428 ft. Access is via a narrow, rocky 4-wheel drive trail, which

leads from Gladstone north along Cement Creek. This site is believed to be on the Theresa or Young claim. Drainage from the Mogul Mine was sampled as water quality station SO-5 and the waste rock was sampled as site #27, as shown on Figures 3 and 6. A site map is shown on Figure 28. The mine is located at LAT. N37°54'41.2", LONG. W107°38'19.4".

Workings

The Mogul Mine was an extensive operation which developed ore bodies in the Ross Basin Fault and branching Grand Mogul Vein. The main period of mining was from 1900 to 1907. A large mill, built at Gladstone in 1906, was connected to the Mogul Mine by an aerial bucket tram.

The main adit level drifted northeast on a spur vein striking N. 75° E., dipping 65° N., eventually intersecting the Grand Mogul Vein. The adit level totals about 2,800 feet of drifts on these geologic structures. A crosscut to the northeast, 2,400 ft. from the portal, connects to workings on the Ross Basin Fault in Ross Basin. The main Mogul level continues eastward on the Ross Basin Fault to connect with the Brenneman and Washington ore shoots in the Sunnyside Mine on the 3D level. There was reportedly over 20,000 feet of workings in the Mogul operation (Burbank and Luedke, 1969). The portal continues to drain 10-30 gpm of zinc-laden water, which runs along the edge of the dump into Cement Creek.

The Grand Mogul Vein, which is well exposed in Ross Basin, strikes N. 75° W. within the Eureka Graben. It has been stoped to the surface along a distance of several hundred feet near the Grand Mogul Stope Complex described above. Several levels of workings above the Mogul adit level are visible within the stope. The lower parts of the workings are obscured by snow which remains in the stope throughout the year. Water from snowmelt on the south-facing slopes of Ross Basin runs directly into the open stope, and presumably continues 1,600 ft. west to the Mogul portal.

There is an inclined shaft which may connect to the Mogul adit 850 ft. northeast from the portal. The shaft collar is 201 ft. above the Mogul level on the same vein. It was constructed adjacent to Cement Creek, and includes a diversion dam and pipe intake through its side which may have been used to deliver water for drilling to the main Mogul adit level, though this connection has not been verified. The shaft is still open, but the pipe intake has been disconnected. If this shaft connects to the Mogul, it could be allowing groundwater from Cement Creek 25 ft. away to enter the mine workings. The shaft and open stope described above are potential inflow sources to the Mogul workings, and should be investigated to determine if source control approaches are feasible. Source control approaches include methods of preventing water from flowing into the mine, such as stream diversion, lining the stream, or shallow fracture grouting.

Mine Wastes

The dump at the Mogul Mine was surveyed and found to contain approximately 25,000 cu. yds. of fine to coarse sulphide mine waste. The dump is constructed over talus and bedrock. Two large bedrock outcrops protrude from the lower dump slope below the access road.

000071

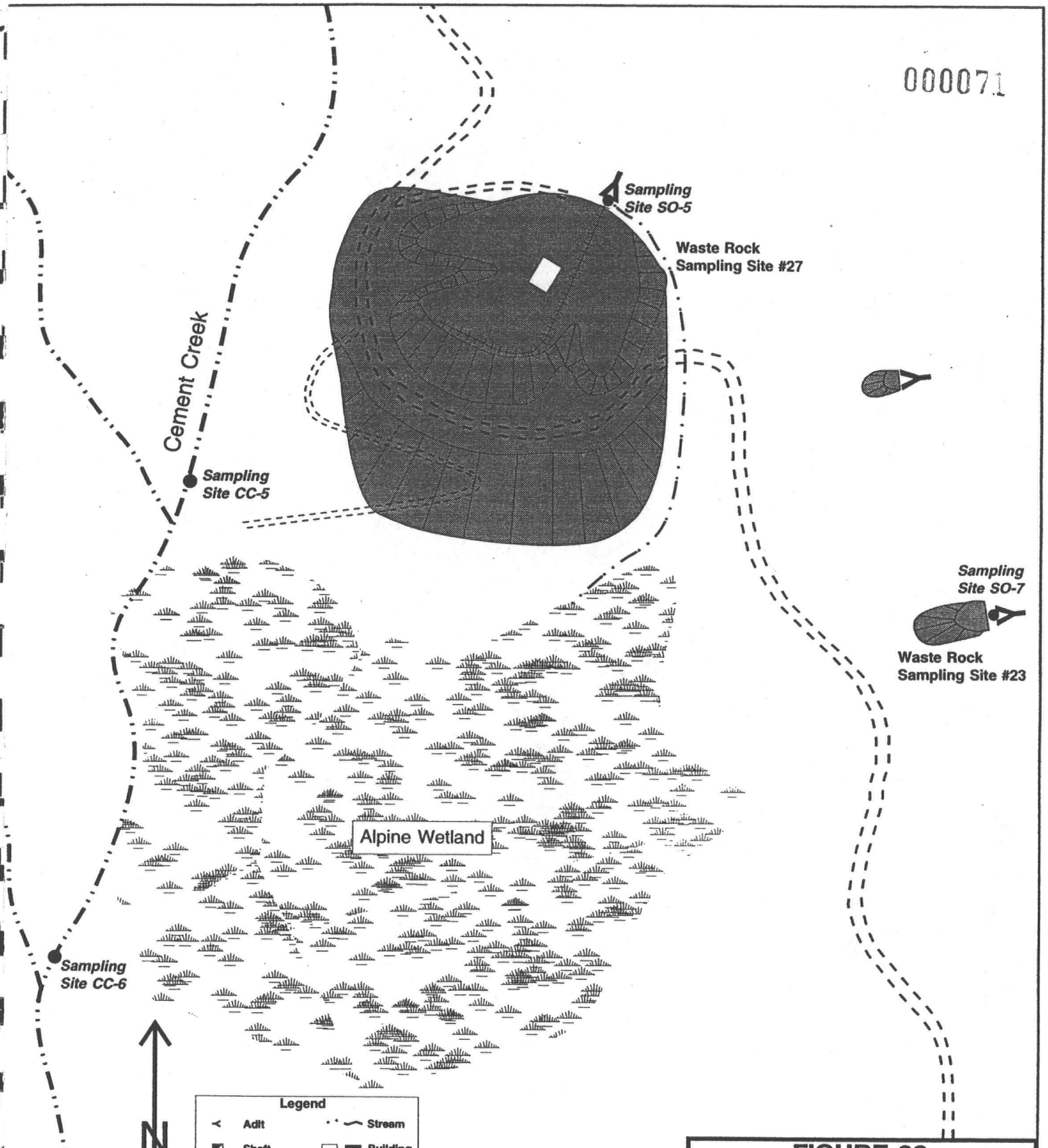


FIGURE 28

Colorado Department of Natural Resources
Division of Minerals and Geology

Inactive Mine Reclamation Program

Site Map - Cement Creek

Mogul Mine Area

Scale	Date	Sheet No.
n.t.s.	Revised 4/98	1 of 1

The ore from this mine was reportedly very high in pyrite and sphalerite, and difficult to mill profitably. This is reflected in the dump, which is largely pyritic, and contains large cobbles and boulders of pyrite, sphalerite, and galena in stockworks of quartz, rhodonite, and calcite. Some fairly high grade specimens of sphalerite remain.

A kill zone extends from the dump 150 ft. to the edge of a natural wetland. Flows from the Mogul portal and a collapsed prospect adit at the edge of a talus field 600 ft. south combine into a stream which runs along the margin of the natural wetland, eventually entering Cement Creek.

Total acidity and sulfates of the dump are reported below.

Mogul Mine Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
590	581

Historic Structures

There is a small, modern, sheet metal-clad tool shed near the mine portal, and an old foundation on the north edge of the dump. Tracks lead from the portal to the edge of the dump, where broken timbers and scattered wooden debris mark the former location of the loadout. There are no other structures or equipment, other than scattered debris, presumably marking foundations of collapsed buildings.

Geologic Constraints to Reclamation

This site is generally not prone to avalanches because there are no long continuous slopes above. Minor avalanches occur over the mine portal, which is commonly covered with snow through August. Sections of the 4-wheel drive road will need to be improved from Gladstone to allow equipment access. There is a lot of loose talus and scree at the site, but no suitable soils or capping materials. The large natural wetland area developed in gently sloping alluvial and colluvial materials below the mine dump on the banks of Cement Creek might be augmented, and useful as a potential passive treatment option. As with all the Ross Basin sites, extreme elevation makes revegetation difficult.

Potential surface water inflows to the workings via the open stope and shaft described above should be investigated. These features could be allowing water to directly enter the mine workings, significantly contributing to the total portal discharge.

Water Quality Impacts

The mine drainage from the Mogul Mine is one of the largest dissolved metals loaders in Cement Creek, compared to the other mine drainages. At low-flow, Mogul Mine drainage is the largest loader of dissolved copper, lead, cadmium and zinc, of all the mine drainages. At low-flow, the adit drainage contains about 13 pounds of metals per day including about 4 pounds of zinc, 6 pounds of iron, and 1 pound of copper per day. At high-flow, the mine drainage is one of the top three loaders of copper, cadmium and zinc. At high-flow, the loading amounts jump to about 28 pounds of metals per day including about 8 pounds of zinc, 14.5 pounds of iron and 2 pounds of copper per day.

The mine drainage has recently been diverted around the mine waste by the owner. Prior to the diversion, the pH and electrical conductivity of the mine drainage worsened as it passed over and through the waste rock. The mine drainage flows into a large wetland area and enters the stream in numerous locations. By comparing the increase in metals loading at station CC-6 to the load at station CC-5 and the load from the Mogul Mine and draining mine south of the Mogul, the metals removal efficiency can be assessed. The results from both the low-flow and high-flow sampling indicate that the wetland is being effective in iron removal. At low-flow, lead is also apparently removed by the wetland, but appears to be subsequently flushed out during high-flow. All other metals appear to pass through the wetland. Aluminum appears to increase as the mine drainage passes through the wetland. This is probably due to leaching of the clays by the acidic water.

Extract analyses show that the waste rock is high in zinc, lead and copper. The lowest pH (1.2) of all the waste rocks analyzed in the Cement Creek area was from this site. The waste rock receives some upland run-on water and receives water from portions of the road into Ross Basin.

Reclamation Options

Eliminating contamination of run-on water should be the priority for reclamation at this site. Diversion ditches should be constructed on the northern side of the mine site. A portion of the diversion ditch would have to be constructed by hand because the slope is too steep for equipment. This will only stop some of the impacts of the waste rock at this site, because snow accumulation on the waste rock will continue to leach metals from the waste rock.

The Mogul Mine is very prominent and very visible from the 4-wheel drive roads across the canyon. As such, to maintain the historic flavor of the area, the waste pile should be left in place. To reduce the water quality impacts from the site, a cement/fly ash mixture can be injected into the waste rock to limit the infiltration of water. The same mixture can be applied to the surface of the waste rock. Some regrading of the pile will be necessary to allow for equipment access, but the final contours can be similar to the present contours. The waste rock that has eroded into the wetland should be moved onto the main pile.

The mine drainage from this site will be somewhat difficult to treat. The low pH of the mine drainage (2.6-2.9) eliminates many of the treatment options. The mine drainage is almost saturated with oxygen. In August 1996, the dissolved oxygen in the drainage was measured at 7.7 mg/l, with saturation at 8.7 mg/l. The high dissolved oxygen and low pH virtually eliminates the use of a sulfate reducing wetland for reclamation.

The pH of the mine drainage is very favorable for construction of an anoxic limestone drain. It has been reported that the majority of the mine drainage comes from one drift off the main haulage tunnel (Hennis, 1998). This drift could be filled with limestone and a bulkhead could be constructed to flood that portion of the mine workings. The bulkhead should reduce the oxygen supply to the drainage, causing the water to become anoxic. At best, this may raise the pH of the drainage to the 4-5 range, which would be adequate to remove the iron, lead and a portion of the copper and zinc. This would also raise the pH to a level where a sulfate reducing wetland would function during at least part of the year. The temperature of the mine drainage is probably too low for optimal sulfate reducing bacteria activity during the winter months.

Another treatment option is to construct a pneumatically agitated limestone pond to raise the pH. This involves constructing a lined pond filled with limestone. The mine drainage is passed through the pond in an up-flow configuration. At the bottom of the pond, two sets of perforated pipes are placed under a coarse cobble layer. One set of pipes is to convey the mine drainage. The other set of pipes is attached to a large capacity air compressor, powered either by wind or solar, or possibly both. Periodically, the compressed air will be released, which will clean the metals that have accumulated on the limestone. The limestone pond must be followed by a settling pond. With sufficient residence time, the pH of the drainage should be brought to near neutral.

Mechanical injection of neutralizing agents is also an option that should be considered. This option would either require installation of electrical lines to the mine or construction of a small hydro-electric plant. There is sufficient elevation difference to pipe a portion of Cement Creek from above the mine site and power a small plant. A lime addition plant could be constructed with sufficient neutralizing agent volume to last for a whole year. The biggest drawback is that yearly or more frequent maintenance would be required.

Whatever system is constructed, the wetland presently receiving the mine drainage should be rejuvenated by adding limestone. The wetland can provide some additional treatment during the summer months. A low ground pressure spreader could possibly be used to spread limestone during the late summer or early fall, or the limestone could be spread by helicopter. There are several channels through the wetlands that should be blocked off, by hand, to prevent short-circuiting of the flow through the wetland.

Mine South of Mogul

Location
This site is located approximately 300 yards south of the Mogul Mine east of the access road to the Mogul at an elevation of 11,400 ft. Access is via a narrow, rocky 4-wheel drive trail which leads from Gladstone north along Cement Creek. This site is believed to be on the Gold Point claim. This mine was sampled as water quality station SO-7, shown on Figure 3, and the waste rock was sampled as site #23, shown on Figure 6. A map of the site is shown on Figure 28. The mine is located at LAT. N37°54'30.6", LONG. W107°38'16.2".

Workings
A short adit was driven northeast into the basin wall. The collapsed adit commonly drains about 13 gpm of metals-laden water from late spring through early summer.

Mine Wastes
The waste rock pile contains approximately 800 cu. yds. of fine to coarse sulphide mine waste consisting mostly of pyrite and quartz. The fine fraction of the waste rock contains some sphalerite and galena, and very little pyrite. The coarse material on the waste pile is estimated to be a minimum of 25% pyrite with some chalcopyrite. Total acidity and sulfates are shown below.

Mine Dump South of Mogul

Total Acidity (mg/l)	ICP Sulfate (mg/l)
200	236

Historic Structures
There are no structures or equipment, other than scattered debris.

Geologic Constraints to Reclamation
This site is prone to avalanches. Sections of the 4-wheel drive road will need to be improved from Gladstone to allow equipment access. There is a lot of loose talus and scree at the site, but no suitable soils or capping materials. The large natural wetland area developed in gently sloping alluvial and colluvial materials below the mine dump on the banks of Cement Creek might be augmented, and useful as a potential passive treatment option. As with all the Ross Basin sites, extreme elevation makes revegetation difficult.

Water Quality Impacts
The principal water quality impact from this site is the seasonal mine drainage. Compared to the other mine drainages, this mine produces about 1.5% of the metals. Of the principal metals of concern, this mine site produces 3% of the copper from all the mine drainages. The measured metal loading was about 1 pound of zinc, 8 pounds of iron and 1/4 pound of copper per day. The mine drainage flows from the mine adit into the surrounding talus, and enters the same wetland as the Mogul Mine. It is likely that there is more mine drainage than has been measured, since the collapsed portal is directly in the large talus. The mine drainage has cemented portions of the talus and waste rock with iron and manganese precipitates along the southern part of the waste pile. The talus is probably providing some treatment of the drainage.

Extract analyses show that the waste rock is mildly acid forming, and is relatively low in metals compared to other sites in the area. Most of the large pyritic materials show few signs of acid dissolution. There may be impurities in the pyrite that make it less prone to weathering. The waste rock at this site is thought to be a minor source of metals to Cement Creek. If the mine drainage is treated, the wetland below the site may treat any metal-laden drainage from the waste rock.

Reclamation Options
The mine adit should be reopened to determine if there is perennial drainage from the mine. The apparently seasonal drainage from this site makes it a lower priority than other perennially draining mines. If the Mogul mine drainage is treated, this drainage can be piped to the same treatment

system.

CEMENT CREEK- BONITA PEAK AREA

Location

The "Cement Creek-Bonita Peak area" as used here includes five sites on the west side of Bonita Peak, southwest of the Bonita Peak Fault. This area is just south of the previously described Ross Basin area, and much of the geologic setting is similar. Mine sites selected by DMG and ARSG for reclamation feasibility studies include the Adams Mine and Red & Bonita Mine on the east side of Cement Creek 1/2 mile above Gladstone on the west foot slope of the mountain, the Lead Carbonate Mine on the upper slopes of Bonita Peak in Minnehaha Basin, and the Black Hawk sites on the Middle Fork of Cement Creek. The locations of these sites are shown on Figures 3 and 6. The sites are situated on privately owned patented lode mining claims. Coordinates of each site are given in the individual site descriptions which follow below.

The area is characterized by rugged, steep, high alpine terrain just below timber line at the Adams and Red & Bonita sites, and well above timberline at the Lead Carbonate and Black Hawk mines. Winters are long with snow depths averaging 440 inches. The summer growing season is short. Average annual precipitation for the past 3 years is 45 inches, 37 inches occurring as snowfall (Sunnyside Gold Corporation, 1996).

Geologic Setting

The regional geologic setting of the Cement Creek area is discussed at the beginning of this report. More specific information about the Cement Creek-Bonita Peak area is included below.

Bedrock Geology

The Cement Creek-Bonita Peak area is situated near the center of the Silverton Caldera. Only the upper massive pyroxene-bearing member of the Silverton Group Burns Formation is present in the Cement Creek-Bonita Peak area. The upper slopes of Bonita Peak east and above the four sites are comprised of the overlying Henson Formation.

A highly mineralized volcanic breccia body lies just north of the Red & Bonita Mine and south of the Adams Mine on the east valley wall of Cement Creek. Exposures are poor due to overlying talus and colluvial deposits, however, the breccia body was reportedly exposed in mine workings (Burbank and Luedke, 1969). The country rock has been brecciated and highly pyritized within the pipe. Subsequent oxidation of this pyritized mass by groundwater is believed to be responsible for forming the unusual iron oxide deposits on the slopes and within the wetlands along Cement Creek near the Red & Bonita Mine.

Structural Geology

Structurally, the Cement Creek-Bonita Peak area lies in the north-central part of the Silverton Caldera, adjacent to the Eureka Graben (Burbank and Luedke, 1969). This boot-shaped graben is bounded by a series of major, steeply dipping mineralized faults which define and outline the down-dropped structure within the caldera complex, (Figure 2), as described in the geology section at the beginning of this report.

The Bonita Fault forms the boot-shaped graben's "sole" on its southwest margin, and lies 2,500 ft. east of the Cement Creek sites, and 1,000 ft. east of the Lead Carbonate Mine. It trends northwest-southeast on a curving strike from the head of Gray Copper Gulch just north of the main Cement Creek valley, across Cement Creek near the Mogul Mine, and continues across the west shoulder of Bonita Peak just above the Lead Carbonate Mine. It terminates near the summit of Emery Peak 3,500 ft. northeast of the Black Hawk workings, where it forms a nearly right-angled junction with the northeast-trending Toltec Fault. Dips on the Bonita Fault are from 75° to 80° NE, with the northeast block (hanging wall), being downthrown.

The upper Burns Formation southwest of the Bonita Fault has been tilted southwestward, and is broken by numerous small faults and sheeted zones in parallel and diagonal orientation to the main Bonita structure. These types of mineralized fractures have been developed by mines in the area of upper Cement Creek, and in the Middle Fork area.

The Lead Carbonate vein lies in the footwall of the Bonita block (Figure 2), and trends northeastward, nearly perpendicular to the northwest strike of the Bonita Fault. Repeated downward movement of the Bonita block in the hanging wall is believed to have caused dilation of this major fracture, forming the structure for the Lead Carbonate ore body (Burbank, 1951).

Hydrothermal Alteration

All the volcanic rocks in the Cement Creek-Bonita Peak area were extensively propylitized and altered on a regional scale, prior to ore deposition. In this area of the Silverton Caldera, propylitic alteration is typified by the formation and addition of chlorite, calcite, and clays in weakly altered rocks, to epidote, albite, and chlorite in the stronger phases. Propylitic alteration has resulted in a dull green or greenish gray color to virtually all of the Burns Formation rocks.

Wall rock adjacent to the vein deposits has been subjected to more intense but localized alteration processes. Quartz, sericite, and pyrite are common mineralogical products of wall rock alteration associated with the siliceous sulfide veins in the Cement Creek-Bonita Peak area .

Manganese minerals, such as rhodonite and rhodocrosite, are also characteristic of alteration in wall rock of the major fault-fracture veins. Where weathered on the surface, these manganese-altered rocks often are conspicuous due to the characteristic black staining of manganese oxides (pyrolusite, psilomelane).

Ore Mineralization

Ore mineralization in the Cement Creek-Bonita Peak area occurs as quartz-pyrite veins associated with the system of open fissures created southwest of the Bonita block of the major Eureka Graben structure. Although the mineralized faults and fissures can often be traced for hundreds to thousands of feet, economic ore deposits or 'ore shoots' occur on a much more restricted basis due to localized influences of structure and mineralizing solutions.

The most common sulfide minerals of the veins are pyrite, chalcopyrite, sphalerite, galena, and tetrahedrite. Tennanite also occurs, and free gold is associated with localized shoots, and in the siliceous gangue minerals, such as rhodonite. Gold has also been found associated with the base metal sulphides in some veins. Silver is associated with argentiferous tetrahedrite, and sometimes with silver sulfo salts and sulfobismuthites (Burbank and Luedke,1969). The Adams Mine ores reportedly contained enough hübnerite, a sulfide of tungsten, to be mined profitably for a short time.

Gangue minerals associated with the veins consist dominantly of quartz, rhodonite, rhodocrosite, calcite, fluorite, and minor barite. Not all the veins have the manganese gangues, as these are preferentially found in the major fault structures.

Surficial Geology

Upper Cement Creek Sites

Cement Creek runs in a broad valley bordered by a nearly continuous apron of talus on both sides. The stream is braided in many sections, but has formed continuous alluvial deposits and low terraces through the area. There are some isolated ferricrete deposits, as well as extensive, boggy wetland areas developed on gentle colluvial slopes adjacent to the stream.

Slopes bordering Cement Creek are steep, but heavily timbered and generally outside of avalanche paths. The exception is a steep ravine coming down the west slope of Bonita Peak adjacent to the Adams Mine. It is a major avalanche track, and is also a source area for debris flows, which have formed a debris fan on the valley floor of Cement Creek.

Minnehaha Basin

Minnehaha Basin is a glacial cirque well above timberline with a steep west-facing head wall, and gently west sloping basin floor. The lower slopes below the steep rocky basin walls are covered with an almost continuous apron of loose, blocky talus. Glacial till and outwash mantle the gently sloping basin floor. These poorly drained unconsolidated clayey and gravelly deposits support a high-alpine wetland/ meadow community. A rock glacier, 700 ft. long, lies in the shadow of the south basin wall, and has moved out across the till deposit. Much of the upper basin is subject to moderate avalanche hazards, mostly from the head wall and off Bonita Peak.

Middle Fork Cement Creek

The Black Hawk sites lie above timberline in a steep walled northwest-facing basin. Most of the upper valley is choked with loose talus and scree which completely covers the valley floor and extends far up the basin walls. The stream flows subsurface beneath the talus field below the mine sites. An active debris flow fan is encroaching on the south side of the Black Hawk Dump. Rockfalls and talus flows continually block the access road to these sites. An active rock glacier also exists just south of the Black Hawk Mine on the north side of the creek.

Cement Creek-Bonita Peak Area Mine Site Descriptions

The mine sites included for reclamation feasibility assessments in the Cement Creek-Bonita Peak area are described below, and shown on Figures 3 and 6.

Adams Mine

Location
This mine is located one mile above Gladstone on the east side of Cement Creek. The portal elevation is 11,299 ft. Access is via a narrow, rocky 4-wheel drive trail which leads from Gladstone north along Cement Creek. This site is believed to be on the Adams and Horseshow claims. This site was sampled as waste rock site #15, as shown on Figure 6. The Adams mine is located at LAT. N37°53'59.3", LONG. W107°38'31.6".

Workings
The Adams Mine adit is an east-bearing crosscut which intersects two veins. The first strikes N.28°E., dipping 80° E., and is intersected a few feet inside the portal. This vein was only prospected a few feet. The second and main vein is intersected 225 ft. from the portal, and strikes north-south, dipping steeply east. It has been followed on both sides of the crosscut, and stoped above in places to a height of 25 ft.. The portal is open, intact, and was not draining when visited in mid August. Staining did indicate that it may drain in the spring during the runoff. The workings were generally dry, and in relatively stable condition.

Mine Wastes
The lower two-thirds of the 800 cubic yard dump consists of unmineralized country rock from development of the cross cut. The toe of the dump lies in the stream coming off the west slope of Bonita Peak, and is being eroded during high flows. There is a some sulphide ore and pyrite waste in the upper part and on top of the dump. Minerals found include pyrite, quartz, hübnerite, occasional sphalerite, and possibly adularia.

The dump is constructed over permeable talus and debris flow deposits. There is no kill zone or staining below, and most of the dump appears relatively benign. Total acidity and sulfate values (shown below) confirm this.

Adams Mine Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
60	49

Historic Structures
There are no structures remaining at the site. The portal gate has been vandalized, allowing access, and heavy rails still exist in the adit and out to the dump. The remains of a small shack are located just north along the access road in a forested area. There are a few timber props and

stulls in the stope workings, and a couple of old plastic buckets inside the northern drift. No historic structures were observed at two other nearby adits.

Geologic Constraints to Reclamation

This site is adjacent to a huge avalanche chute which probably runs most winters. The dump is usually littered with broken tree limbs and debris. Sections of the 4-wheel drive road will need to be improved from Gladstone to allow equipment access. There is a lot of loose talus and scree at the site, but no suitable soils or capping materials.

Water Quality Impacts

The waste rock extract analyses indicate that this site is a very minor source of metals to Cement Creek. The pH and electrical conductivity of the small stream that flows past the toe of the waste rock does not change as it passes this site.

Reclamation Options

This mine site does not warrant any reclamation at this time. The waste rock extract analyses show that the waste rock is similar to the surrounding undisturbed areas.

Red & Bonita Mine

Location

This mine is located just about ½ mile above Gladstone on the east side of Cement Creek just beyond the confluence of the North Fork of Cement Creek at an elevation of 10,948 ft. Access is via a fairly good 4-wheel drive road which leads from Gladstone north along Cement Creek. This site is believed to be on the Belcher claim. This site was bracketed by stream sampling sites CC-8 and CC-9, the mine drainage was sampled as water quality site SO-8 and the waste rock was sampled as site #13. Figures 3 and 6 show the locations of these sampling sites. The Red & Bonita adit is located at LAT. N37°53'51.3", LONG. W107°38'34.9"

Workings

The main Bonita adit was a cross cut driven eastward into the mountainside to explore and develop a series of veins in the ground southwest of the Bonita Fault. The veins strike north and northeast, and dip steeply west. Workings may also have explored and developed parts of the pyritized breccia pipe located some 600 ft. north of the portal, but this is conjectural, based on materials found in the dump.

Judging from the size of the dump, there were several thousand feet of workings. A second adit upslope and to the north at an elevation of 11,200 ft. may also have supplied ore to the operation, but its dump is relatively small, suggesting it was probably only a prospect. The mine included a mill situated in the wetlands area below the main portal, adjacent to the creek. Old maps indicate this mill was still standing in the 1930's.

The main adit has collapsed at the portal, but still drains approximately 5 gpm of zinc-laden water during high-flow. The flow quickly infiltrates into the top of the dump, continuing to Cement Creek as subsurface flow. There are bright red and orange iron hydroxide precipitates along the surface drainage before it disappears.

Mine Wastes

The dump at the Red & Bonita Mine was surveyed, and is estimated to contain approximately 6,000 cu. yds., most of which appears to be coarse, pyritized and altered country rock. The bedrock here has been intruded by the volcanic breccia pipe and associated veins described above. The Bonita workings were apparently driven through large areas of pyritized and solfatarically-altered country rock associated with intrusion of the pipe. The ore from this mine was apparently high in pyrite, and there are parts of the dump which contain much finer-grained quartz-pyrite vein matter. Some galena and sphalerite can be found scattered in these finer grained wastes. There was almost no calcite or other buffering gangue minerals noted in the dump. A portion of the waste rock is country rock. Secondary sulfides and oxyhydroxides stain the country rock. There are some small trees growing in the portions of the pile containing principally country rock.

The dump itself is very permeable, and extends out over talus deposits. An extensive and visually striking kill zone extends from the toe of the dump 500 ft. through the wetlands area to Cement Creek. The wetland plant community has been completely destroyed, exposing extensive areas of natural iron oxide soils related to the geochemical weathering and oxidation of the nearby pyritized breccia pipe. Above and below this barren ferricrete area or kill zone, the wetland community reappears.

It is probable that much of the ferricrete area is related to tailings disposal from the Red & Bonita milling operations. The tails from the mill were simply run "out the back door" across the wetlands to the creek, consistent with general practice at the time. The oxidized tailings are difficult to distinguish from the underlying natural soils.

Total acidity and sulfates of the waste rock are reported below.

Red & Bonita Mine Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
620	581

Historic Structures

Not much is left at this site. There is a small timber-cribbed section of the dump adjacent to the road, and a few timbers in the dump mark the former location of the loadout. A small, square, hollow, timbered structure resembling a shaft collar exists on top of the dump on the extreme southern edge, but it is filled with dump debris a few feet down, and seems to have been a loading or sorting bin. There are no other structures or equipment, other than scattered debris, and tracks leading out of the collapsed adit. The remains of a mill, including scattered, burned wooden and

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iron debris along with some pyrite concentrates, are located approximately 50 yards south of the mine.

Geologic Constraints to Reclamation

This site is generally safe from avalanches. Slopes above are heavily timbered with mature spruce and fir. Access for equipment is good. There is a lot of loose talus and scree at the site, but no suitable soils or capping materials. The large natural wetland area developed in gently sloping alluvial and colluvial materials below the mine dump on the banks of Cement Creek, might be augmented and useful as a potential passive treatment option.

Water Quality Impacts

The Red & Bonita Mine appears to only have seasonal drainage from the mine adit. Although the metals concentrations are high, the overall load from the mine drainage is small. Compared to the other mine drainages in Cement Creek, the Red & Bonita produces less than 1% of the metals. The dissolved metal load at the adit during the high-flow sampling was about 1.5 pounds of zinc, 2.5 pounds of iron and less than 0.1 pounds of copper per day. The mine adit should be reopened to determine whether there is any perennial flow from this site.

As previously discussed, it appears that leachate from the mine wastes and/or mine drainage has killed the wetland vegetation over a large area below the mine site. Exposure of the ferricrete may be causing a larger impact. There is a noticeable increase in iron and zinc concentration as Cement Creek flows past the barren area during low-flow. The in-stream loading between sites CC-8 and CC-9 indicates that this site produces about 7 pounds of dissolved zinc per day during low flow. Most of the iron coming from this site appears to be particulate, based upon the differences between the total and dissolved fractions at the upstream and downstream sites. During high-flow, there is a slight increase in concentration of iron and zinc remains relatively unchanged. Samples should be taken from the main channel flowing from the ferricrete to determine what the metals loading is from this site.

The waste rock at this site is acid forming, and has elevated levels of copper, iron and zinc. The lead measured in the extract was one of the highest concentrations found in Cement Creek. There is probably some run-on water that flows through the waste pile from the slopes above.

Reclamation Options

It should be determined if there is any perennial flow from the mine workings. A well point could be driven through the collapsed portion of the mine, or the adit can be reopened. If the mine drainage is seasonal, reclamation of the barren ferricrete area can serve as the treatment system for this site. If there is perennial drainage, characterization of the drainage will be necessary before a treatment plan can be developed.

In addition, some of the drainage may be entering the groundwater system through the loose, unconsolidated colluvium and scree at the portal or through fractures in the mine tunnel rather than exiting the portal as surface flow. The mine workings should be reopened and investigated to determine the presence of additional flow and to assess whether it is necessary to capture and

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treat that flow.

Diversions should be constructed to route upland runoff from the waste rock pile. The diversions should be constructed so the water exits onto one of the vegetated areas above and below the barren ferricrete area. In addition, ground limestone should be added to this pile or the pile should be injected with a mixture of fly ash and cement to reduce the spring snowmelt effects.

Even though the metals loading from the barren ferricrete is unknown, the approximately 4 acres of unvegetated area should be reclaimed. The reclamation would involve application of approximately 30 ton of lime per acre, application of approximately 6,000 cu. yds. of organic matter such as compost, or peat/manure mixture, and then revegetating the area. This would help prevent further dissolution of the ferricrete, and will provide some treatment for the mine drainage and direct runoff from the Red & Bonita Mine. It is recommended that the ferricrete area not be regraded, which will allow the eroded portions of the ferricrete to be covered to a greater depth with the chosen substrate. Sulfate reduction should occur in these deeper areas, which will remove metals from the drainage.

Lead Carbonate Mine and Mill

Location

This mine is located in Minnehaha Basin on its north side, one mile due northeast of Gladstone. The main portal is at an elevation of 11,856 ft. Access is via a fairly good 4-wheel drive road which leads up the mountain from Gladstone, then follows Minnehaha Creek into the cirque basin. This site is believed to be on the Lead Carbonate claim. This site was bracketed by water quality sites CC-14 and CC-15, and the waste rock was sampled as site # 17. These sites are shown on Figures 3 and 6. The Lead Carbonate Mine is located at LAT. N37°53'28.2", LONG. W107°37'55.1".

Workings

The Lead Carbonate Mine was first opened in the early days of mining in the district. A gold-bearing quartz vein striking northeast was prospected in the footwall of the Bonita Fault, but only a few hundred feet of workings were driven. The mine was reopened in 1946, and for several years after, was one of the only producers in the area. A 50 ton mill was constructed at the site in 1947. Ore from the Lead Carbonate averaged 0.79 oz gold, and 9.7 oz silver per ton, 6.05% lead, 5.9% zinc, and 1.03% copper (King and Allsman, 1950).

The main Lead Carbonate adit is a crosscut driven N.23°E. for a distance of 700 ft., where it intersects the Lead Carbonate vein. The Lead Carbonate vein was drifted in both directions from the cross cut, running 400 ft. northwest, and 150 ft. southeast, where it joins the Mocking Bird vein. (Burbank and Luedke, 1969)

Good ore was found in the Mocking Bird vein at the junction with the Lead Carbonate vein. The ore shoot here was developed on four internal levels, and stoped from 50 to 200 ft. above the main level along a 450-foot length. A winze developed this shoot on sublevels at 50 and 205 ft. below the main level. (Burbank and Luedke, 1969)

The main adit level is caved at the portal, and is not draining. Several smaller upper prospect adits have also collapsed.

Mine Wastes

The dump at the Lead Carbonate Mine and mill site is estimated to contain 3,500 cu. yds., most of which appears to be fine, clayey to coarse sandy pyritic quartz waste. Some galena and sphalerite can be found scattered in these finer-grained wastes. There are some sections which contain coarse blocky pyrite and quartz. No calcite or rhodonite could be found on the dump.

The dump extends out across talus and into the glacial till on the basin floor. An extensive kill zone extends from the toe of the dump 500 ft. through the wetlands area to Minnehaha Creek. The wetland plant community has been completely destroyed and mantled with fine pyritic materials. Total acidity and sulfate values (shown below) confirm that the waste rock is acid forming.

Much of the kill zone appears related to tailings disposal from the small mill which crushed and processed ore in the late 1940s. The tails from the mill were simply run out into the wetland/ meadow area.

Lead Carbonate Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
1,440	1,210

Historic Structures

Part of the loadout structure remains on the dump, but the mill was dismantled and moved away. The loadout is of heavy timber construction, and is situated above a bench level in the dump, where the back of the mill may have been constructed. Alternatively, ore could have been loaded into trucks on this bench.

There are burned remains of an old stamp mill anvil. The stamp anvils are constructed of heavy timber clad with iron plates on the east end of the dump. The remains of a collapsed shack lie adjacent to the collapsed portal and tracks still lead from the portal out onto the loadout structure. Scattered wooden and metal debris litters the site.

Geologic Constraints to Reclamation

This site is generally safe from avalanches. Slopes above extend only 240 ft. higher, and do not collect much snow, or allow it to move very far. Access for equipment is good. There is a lot of loose talus and scree at the site. There are suitable soils for capping materials, but borrowing them would disturb the remaining wetlands/ meadow area which has developed on the glacial till and outwash.

Water Quality Impacts

The water quality impact from this site is from the waste rock and scattered mill tailings. The mill tailings are principally in the relatively flat meadow area, but have been deposited up to 1,500 ft. below the mine site. Stream sampling site CC-14 is a relatively undisturbed portion of the stream originating from above the Lead Carbonate Mine. Site CC-15 is below the confluence with the drainage that originates near the Lead Carbonate Mine and flows over and through the mill tailings. During the low-flow sampling, the flow at site CC-14 was too low to be sampled. It is thought that most years, there is perennial flow at this site. Most of the metals measured at site CC-15 during low-flow are thought to be directly attributable to the Lead Carbonate area. At low-flow, the metals load at this site was approximately 0.6 pounds of zinc and 0.25 pounds of iron per day. During high-flow, the metals loading was about 2.5 pounds of zinc, 4 pounds of iron, and 0.2 pounds of copper per day at this site.

Most of the waste rock is in a relatively high and dry location. A portion near the loadout is in the wetland area. The waste rock is acid forming with elevated levels of lead, copper, iron, and zinc.

Reclamation Options

The waste rock should be consolidated, along with the thicker portions of mill tailings, then covered with nearby colluvium, and revegetated. The mill tailings contaminated area should be amended with 40-60 mesh ground limestone, then revegetated. The reclamation can be completed without affecting the historic loadout structure.

Black Hawk Mine

Location

This mine is located on the north valley wall of the Middle Fork of Cement Creek, at a portal elevation of 11,563 ft. Access is via a fairly good jeep road which leads up the mountain from Gladstone to Minnehaha Basin, then on a poorly maintained, narrow jeep trail across steep talus slopes to the mine. This site is believed to be on the Black Hawk claim. The Black Hawk Mine drainage was sampled as site SO-12, immediately above the confluence with the Middle Fork of Cement Creek, as shown on Figure 3. The waste rock was sampled as site # 19, as shown on Figure 6. The Black Hawk Mine and an unknown mine to the south were bracketed by sampling stations CC-17 and CC-19 (Figure 3). A site map is shown on Figure 29. The Black Hawk mine is located at LAT. N37°52'55.3", LONG. W107°38'06.6".

Workings

The Black Hawk Mine opened a series of veins diagonally oriented to the Bonita Fault on the west shoulder of Emery Peak. The adit drifted on a vein striking N.84°E. dipping steeply north. This vein intersected three others within 600 ft. of the portal. These gold-bearing quartz veins lie in the footwall, 2,000 ft. south of the margin of the Bonita block, near the "heel" of the boot-shaped Eureka Graben (Figure 2). (Burbank and Luedke, 1969)

The adit is driven into the base of a nearly vertical slope just above the upper contact of the talus field, which blankets the entire valley floor. A second adit a few feet north of the main haulage adit

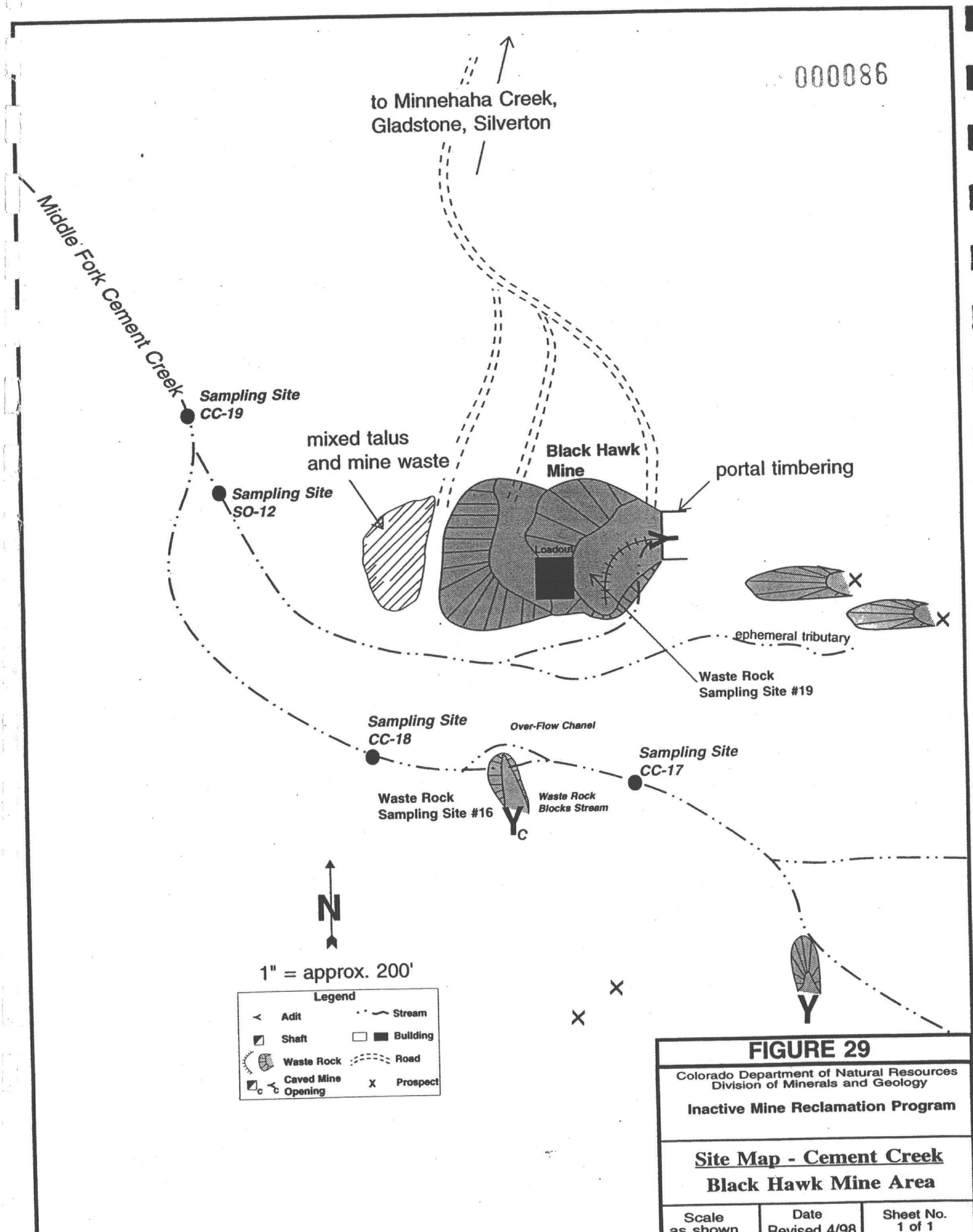

FIGURE 29

Colorado Department of Natural Resources
Division of Minerals and Geology

Inactive Mine Reclamation Program

Site Map - Cement Creek

Black Hawk Mine Area

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as shown	Revised 4/98	1 of 1

may have been a manway or ventilation heading, and is thought to connect with the main haulage adit. Judging from the size of the dump, there were several thousand feet of underground workings.

The main adit is still open and draining. The second adit is caved, but still draining through the blockage. Both discharges join, flow over the dump and into the Middle Fork of Cement Creek. and Flow ranges from 90 to 380 gpm. The majority of flow is coming from the main adit.

Mine Wastes
The dump at the Black Hawk Mine is constructed in two levels or tiers, as shown on Figure 29. Survey work indicates it contains approximately 12,000 cu. yds., however, much of the lower tier appears to consist of native talus and slide rock. The upper level consists of coarse to fine sulfide mine waste, fine pyritic quartz waste, and some blocky stockpiled ore. Much of the lower level may be talus which was dozed and graded to create the lower bench for loading ore. This talus and slide rock has become mixed with mine wastes during handling and loading of ore.

The dump extends out across talus on the basin floor. Runoff infiltrates into the loose talus immediately, flowing beneath the talus field to the creek.

Total acidity and sulfates of the waste rock are shown below.

Black Hawk Mine Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
690	1,348

Historic Structures
Part of the loadout structure remains on the dump, as does a large, tipped-over steel ore bin. The loadout is of heavy timber construction, and is situated above the lower bench level in the dump. Tracks from the portal split at a switch, with one track leading to a waste dump on the south end of the upper dump level, and the other spur leading out onto the loadout structure.

Geologic Constraints to Reclamation
This site is prone to severe avalanche hazards. An active debris flow ravine borders the dump on the south side, and it is also an avalanche path in winter. Rockfalls and talus slides are common occurrences, often closing the access road. The entire site area is situated in loose, blocky talus deposits. There are no soils or stable areas nearby. Access is poor from Minnehaha Creek, and would have to be improved for equipment to reach the site.

Water Quality Impacts
The Black Hawk Mine drainage is a minor source of metals. During low-flow, the mine drainage contributes less than 1% of the metals from draining mines, and during high-flow, supplies less than 2% of the metals. During low-flow, the mine drainage and drainage from the waste rock

measured at station SO-12 was about 0.6 lb/day. Iron and copper loadings were less than 0.05 lb/day. During high-flow, the loadings at station SO-12 were approximately 1.3 pounds of zinc, 0.4 pounds of iron and 0.1 pounds of copper per day. The metals concentrations in the drainage are generally low, in comparison to other mine drainages, but because of the high- flow, the metal load, particularly for zinc, is higher than some.

The waste rock extract for this site had the highest concentrations of aluminum and manganese, and had the second highest lead levels. Copper and zinc levels were elevated. There should be very little run-on water from the slopes above, due to the coarse talus. There is probably less leaching of the waste rock at this site than most of the other waste piles. Even though the highest aluminum and manganese concentrations were found in this waste rock, there was virtually no aluminum in the drainage, and manganese was below NEC concentrations. This waste pile is thought to be a minor water quality problem. The mine drainage crosses only a small portion of the waste rock. The flow channel seems to be well cemented. The mine drainage is probably not leaching much heavy metal from the waste rock.

Reclamation Options
No reclamation of the waste rock is currently recommended. The mine drainage, as discussed above, is felt to be a minor source of metals. If any treatment is to be done, it is recommended that a settling pond be constructed above the confluence of the mine drainage with the Middle Fork. At this point, the mine drainage has become aerated by the steep, rocky channel. Most of the iron, copper, and a portion of the zinc can be removed in the pond. Because of the large volume of drainage, the pond will have to have a capacity of approximately 3,000 cu. yds.

Unknown Mine South of the Black Hawk Mine

Location
This mine site is located on the headwaters of the Middle Fork of Cement Creek, 500 ft. southwest of the main Black Hawk Mine. The portal elevation is 11,480 ft. Access is via a fairly good jeep road which leads up the mountain from Gladstone to Minnehaha Basin, then on a poorly maintained, narrow 4-wheel drive trail across steep talus slopes to the mine. This site is believed to be on the Black Hawk or an unpatented claim. The waste rock pile was sampled as site # 16 shown on Figure 6. A site map is shown on Figure 29. The mine site is located at LAT. N37°52'45.3", LONG. W107°38'16.2".

Workings
This adit developed a quartz-pyrite vein in the footwall of the Bonita block, 4,000 ft. southwest of the Bonita Fault. The mineralized fracture forms an upside-down Y-shaped structure in plan view. The adit drifted south along the stem of the Y for roughly 500 ft., at which point it split into southwest-striking and southeast-striking branches. The dip on the structure in the "stem" progressively increases from 50° west at the split, to 70° west in the southwest branch. Dip in the southeast striking branch is 80° west. Extensions of this southeast striking vein structure can be traced on the surface along the west side of the upper headwaters of the Middle Fork, and through the saddle at the top of the valley into the headwaters of the South Fork of Eureka Gulch to the

east. Based on the size of the dump, it is estimated that there was only 600 to 700 ft. of drift workings on this vein structure.

The adit portal is heavily timbered, but is being overwhelmed by talus moving down from the slopes above. It is in bad shape, too shaky to permit inspection, and about ready to cave. There is only a small opening remaining. The adit does not have a surface discharge, because the outer part is driven through talus and any flows are infiltrating before they get to the portal.

Mine Wastes

The dump at this mine is approximately 1000 cu. yds. and is composed mostly of fine to gravelly-sized pyrite and quartz vein waste from drift development. There is only a minor component of country rock materials. The multi-lobed dump extends out across talus on the basin floor. The Middle Fork of Cement Creek runs along the entire northern toe of the waste, and is visibly eroding materials at two locations. The stream continues north and enters the talus field which blankets the valley floor.

Total acidity and sulfates of the waste rock are reported below.

Dump at Unknown Mine South of Black Hawk Mine

Total Acidity (mg/l)	ICP Sulfate (mg/l)
880	1,061

Historic Structures

Only tracks leading from the portal remain at this site. Everything else has been destroyed by avalanches. There is scattered wood and metal debris on the dump.

Geologic Constraints to Reclamation

This site is prone to severe avalanche hazards. An active debris flow ravine borders the dump on the north side, and has completely buried and destroyed the last section of access road to the site. Avalanches run down the valley wall and impinge directly on the site. Rockfalls and talus slides are common occurrences. The entire site area is situated in loose, blocky talus deposits. There are no soils, borrow areas, or stable slopes nearby.

Water Quality Impacts

The waste rock pile at this site completely blocks the main drainage channel of the headwaters. During high-flow, a portion of the streamflow bypasses the blockage through a side channel. The stream was observed to have iron precipitate below the blockage. Sampling sites CC-17 and CC-18 were chosen to determine the metals loading from this site. However, at the time of the low-flow sampling, all the flow at these two sampling sites was underground. The stream surfaced above the confluence with the Black Hawk Mine drainage and increased in flow up to that confluence. At the high-flow sampling, station CC-18 was under approximately 20 ft. of snow, from an earlier avalanche.

By subtracting the high-flow load measured at stations CC-17 and SO-12 from the load measured at CC-19, we should get an indication of the metals loading from this site. Those data indicate that about 1.5 pounds of zinc, 3 pounds of iron, and 0.2 pounds of copper per day are contributed by this site. Much of the increased zinc loading at station CC-19 during low-flow is probably attributable to this site. The waste rock extract analyses do not show any exceptionally high metals, but given the location of this waste pile, do confirm the water quality data.

Reclamation Options

The obvious solution to this metals source is to remove the mine waste from the stream channel. The reclamation can be done either as partial removal or complete removal. If partial removal is chosen, the portion of the waste in the stream channel should be consolidated with the main part of the pile. If complete removal is chosen, the most obvious location to put the waste rock is at the Black Hawk Mine. If a settling pond is constructed for the Black Hawk Mine, the excavated material can be used to cap the waste rock at this site or the consolidated waste rock at the Black Hawk.

SOUTH FORK AREA

Location

The "South Fork area" as used here includes two mines on the South Fork of Cement Creek one mile south of Gladstone. The South Fork area is just south of the previously described Cement Creek-Bonita Peak area, and much of the geologic setting is similar. Mine sites selected by DMG and ARSG for reclamation feasibility studies include the Big Colorado and Silver Ledge Mines. These sites are shown on Figures 3 and 6. The sites are situated on privately owned patented lode mining claims. Coordinates of each site are given in the individual site descriptions which follow below.

The South Fork of Cement Creek sites are characterized by rugged, steep, high alpine terrain just below timber line. Winters are long with snow depths averaging 440 inches. The summer growing season is short. Average annual precipitation for the past 3 years is 45 inches, 37 inches occurring as snowfall (Sunnyside Gold Corporation, 1996).

Geologic Setting

The regional geologic setting of the Cement Creek area is discussed at the beginning of this report. More specific information about the South Fork area is included below.

Bedrock Geology

The South Fork area is situated near the center of the Silverton Caldera. Only the upper massive pyroxene-bearing member of the Silverton Group Burns Formation is present in the South Fork area. The summit of the 12,164 ft. unnamed peak above the Big Colorado Mine is comprised of the overlying Henson Formation, which strikes east-west and dips 15° south in that area.

Structural Geology
Structurally, the South Fork area lies in the north-central part of the Silverton Caldera, in an area between two major structural elements. It is one mile east of the southwest margin of the Eureka Graben, defined here by the Bonita Fault, and 3 miles east of the ring-fault structure which defines the western margin of the caldera along Mineral Creek. Figure 2 shows these structures in relation to the South Fork area. (These structures have been described above in the geology section at the beginning of this report.)

Strikes and dips of planar flow structures in the upper Burns Formation in the South Fork area are varied over short distances. Dips range from 10° NW at the Big Colorado Mine, to 36° SW at the Silver Ledge Mine. At the Silver Ledge Mine, the rocks have been broken by numerous small faults and sheeted zones, in roughly parallel and diagonal orientation to the main Bonita structure one mile east. At the Big Colorado Mine, several fractures and faults are oriented on a trend which extends westward into the Prospect Gulch fault structure, which forms the south margin of the Red Mountain block. These fractures were subsequently mineralized, and have been mined in the South Fork area.

Hydrothermal Alteration
All the volcanic rocks in the South Fork area were extensively propylitized and altered on a regional scale, prior to ore deposition. In this area of the Silverton Caldera, propylitic alteration is typified by the formation and addition of chlorite, calcite, and clays in weakly altered rocks, to epidote, albite, and chlorite in the stronger phases. Propylitic alteration has resulted in a dull green or greenish gray color to virtually all of the Burns Formation rocks.

Wall rock adjacent to the vein deposits has been subjected to more intense but localized alteration processes. Quartz, sericite, and pyrite are common mineralogical products of wall rock alteration associated with the siliceous sulfide veins in the South Fork area.

Ore Mineralization
Ore mineralization in the South Fork area occurs in similar fashion as that previously described for the Cement Creek-Bonita Peak area. Numerous quartz-pyrite veins have been formed in the system of open fissures created southwest of the Bonita Fault block of the major Eureka Graben structure. Although the mineralized faults and fissures are generally less persistent in length here, probably because of greater distance from the graben structure, they can often be traced for hundreds of feet. Economic ore deposits within the veins are also less frequent, occurring on a much more restricted basis than in areas more closely associated with the major fault structures farther north and east.

The most common sulfide minerals of the veins are pyrite, chalcopyrite, sphalerite, galena, and tetrahedrite. Tennanite also occurs, and free gold is associated with localized shoots, and in the siliceous gangues, such as rhodonite, though these are much less common in veins of the South Fork area. Gold has also been found associated with the base metal sulphides in some veins. Silver is associated with argentiferous tetrahedrite.

Gangue minerals associated with the veins consist dominantly of quartz, rhodonite, rhodocrosite, calcite, fluorite, and minor barite. Not many of the veins in the South Fork area have the manganese gangues, as these are preferentially found in and near the major fault structures bounding the Eureka Graben.

Surficial Geology

The South Fork of Cement Creek lies in a steep narrow valley bordered by a nearly continuous apron of talus and coalescing debris-flow fans. The stream is so choked and constantly overrun with talus and debris flow sediments that it does not form a true alluvial channel until nearly reaching Gladstone. Just below the Silver Ledge Mine on the east valley wall, a landslide deposit has moved into the valley, deflecting the creek westward into talus deposits.

South Fork Area Mine Site Descriptions

The mine sites included for reclamation feasibility assessments in the South Fork area are described below, and shown on Figures 3 and 6.

Big Colorado Mine

Location

This mine is located one mile southeast of Gladstone on the south side of the South Fork of Cement Creek. The portal elevation is 11,059 ft. Access is via a jeep road which leads from Gladstone southeast up the creek valley. This site is believed to be on the Elkton Millsite and Gold Thread claim. This mine drainage was sampled at station SO-17, shown on Figure 3. This site was bracketed by surface water sampling sites CC-21 and CC-22, also shown on Figure 3. The waste rock was sampled as site #21, shown on Figure 6. A site map is included on Figure 30. The Big Colorado Mine is located at LAT. N37°52'40.3", LONG. W107°38'44.5".

Workings

The Big Colorado adit is a west-bearing drift which opened at least two and possibly three vein structures. The main vein strikes northwest and branches into a closely spaced cluster of north, northeast trending spur veins. The second and possibly third veins strike west and N.66°W., respectively. The size of the dump and nature of the materials suggest an extensive amount of underground workings, most of which appear to have been driven in barren country rock, probably exploring for ore bodies.

The adit is completely collapsed at the surface, but still draining 7 to 18 gpm across and into the dump. Metal sulfates have built up travertine-like terraces of precipitates radiating outward from the collapsed portal.

Mine Wastes

The double-lobed dump at the Big Colorado is one of the largest in the Cement Creek drainage.

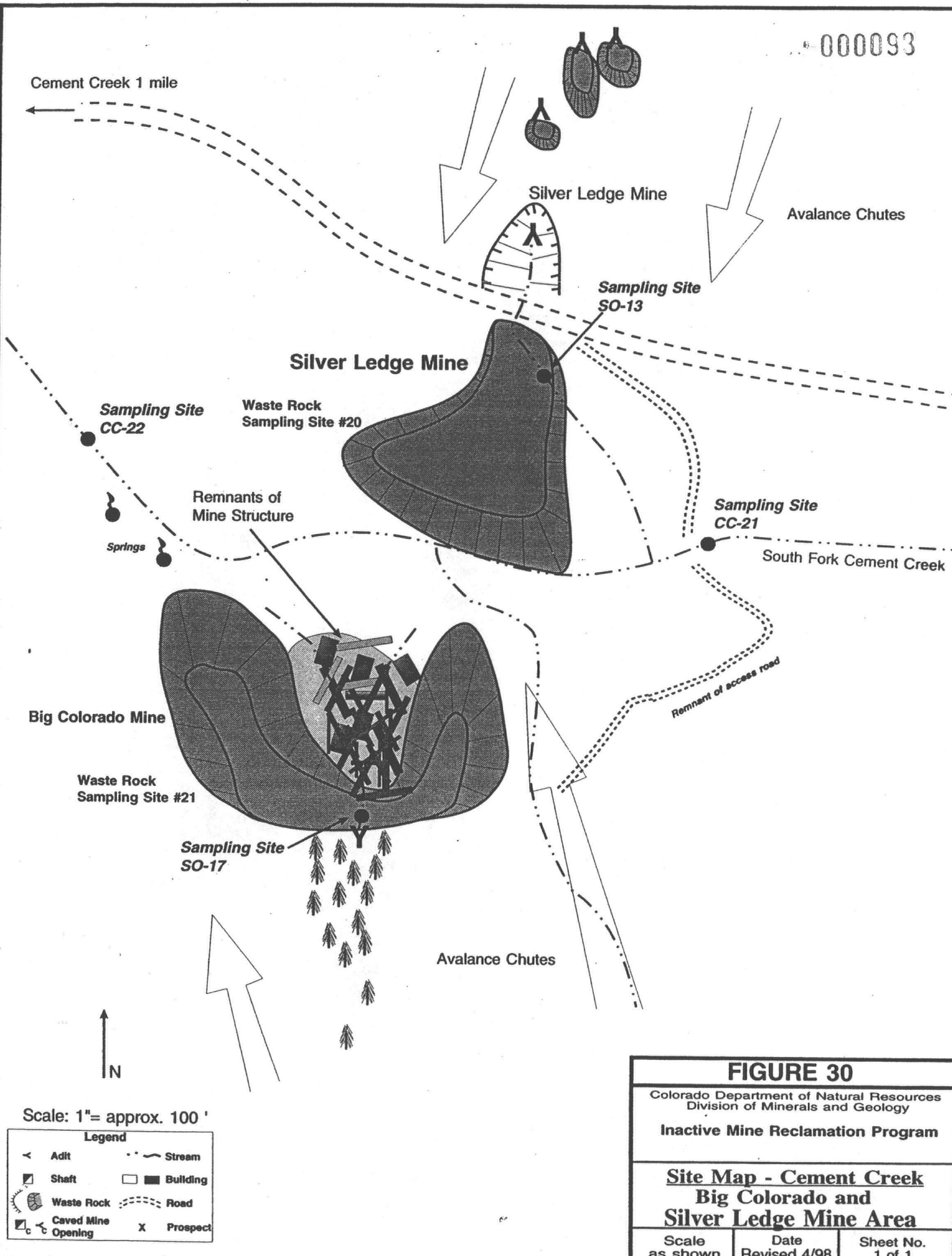

FIGURE 30

Colorado Department of Natural Resources
Division of Minerals and Geology

Inactive Mine Reclamation Program

Site Map - Cement Creek
Big Colorado and
Silver Ledge Mine Area

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Survey work indicates there are approximately 27,000 cu. yds. of waste rock. The dump is dominantly unmineralized country rock, containing a disproportionately small amount of sulphide vein waste. A mill was constructed at the mouth of the portal in the center of the two waste rock lobes on either side, but very few mill tailings materials are present. This suggests either the mill was destroyed by avalanches before much ore was processed, or more likely, this mining operation never succeeded in producing economic ore values. There is some sulphide ore and pyrite waste in the upper part and on top of the dump. Minerals found include pyrite, quartz, hübnerite, occasional sphalerite, and possibly adularia.

The dump is constructed over permeable talus and debris flow deposits. There is no kill zone or staining below, and most of the dump appears relatively benign. Total acidity and sulfate values, shown below, confirm this.

Big Colorado Mine Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
30	62

Historic Structures

There are no standing structures at the site. The mill has been completely flattened by massive avalanches moving down the steep slopes above the site. A large pile of rotting timber and boards, scattered debris, and iron artifacts are all that is left of the structure.

Geologic Constraints to Reclamation

This site is situated between two major avalanche chutes. Avalanches have repeatedly destroyed mining structures. An active debris fan encroaches on the eastern lobe of the dump, and causes problems for access to the portal area. There is a lot of loose talus and cobbly debris at the site, but no suitable soils or capping materials. Almost all the areas in this valley are subject to geologic hazards of some type.

Water Quality Impacts

The mine drainage from this site is principally an iron source. Iron precipitates as the drainage flows down the slope. Travertine-like iron deposits have built up near the collapsed mine adit and on the collapsed remains of the loadout structure. The mine drainage has never been observed to flow on the surface to the creek. There is also no iron staining to indicate that the drainage has ever reached the South Fork as surface flow. The drainage splits into numerous small channels and infiltrates the colluvium.

At low-flow, the measured loads at the adit were approximately 0.2 pounds of zinc, 14.5 pounds of iron and less than 0.1 pound of copper per day. The dissolved metals sample from high-flow leaked in transport, so no analyses were possible. However, the total recoverable metals concentrations were similar to those found at low-flow. Flow measurement was difficult at the high-flow sampling. The mine drainage was flowing from numerous points around the collapsed adit. It is thought that the actual flow was in excess of the amount measured. The flow from this adit appears to remain stable throughout the year.

The waste rock at this site is lower in metals than some of the natural sites. There is very little mineralization in the waste rock. It appears that most of the material in the waste pile is country rock.

Reclamation Options
Because the mine drainage infiltrates into the colluvium and debris flow materials, virtually all the iron is probably removed, before the water enters the stream. Probable sites where the water enters the stream are moss-covered, with significant manganese precipitate. This tends to indicate that the mine drainage is being effectively treated naturally. If manganese is dropping out, there is a strong probability that most of the zinc is dropping out also. Also, the waste rock does not appear to be a significant source of metals. Therefore, it is recommended that this site be eliminated from consideration for treatment.

Silver Ledge Mine

Location
This mine is located one mile southeast of Gladstone on the north side of the South Fork of Cement Creek, directly across from the Big Colorado Mine. The site is located at LAT. N37°52'39.1", LONG. W107°38'38.6". The portal elevation is 11,000 ft. Access is via a jeep road which leads from Gladstone southeast up the creek valley. This site is believed to be on the Silver Ledge Millsite claim. This mine drainage was sampled at station SO-13, shown on Figure 3. The site was bracketed by stream stations CC-21 and CC-22, also shown on Figure 3. The waste rock was sampled as site # 20, shown on Figure 6. A site map is shown on Figure 30.

Workings
The Silver Ledge adit is an east-bearing crosscut which opened at least two vein structures. The main vein strikes N.10°W., dipping 75°W, and branches on its southern end into a closely-spaced set of short east-west striking vein clusters. The second vein set strikes northwest and dips 77°SW.

The adit is heavily timbered and still open. The portal has partially collapsed back into the slope about 30 ft., and continues for at least another 50 to 70 ft. through unconsolidated colluvium and glacial debris before reaching bedrock. It is clogged with debris and precipitates, but still partly open near the top of the timbering. This adit is the lower level of the mine; a second adit level 220 ft. above is completely collapsed at the surface.

The lower adit is draining up to 700 gpm of metals-laden water. This discharge is sufficient to wash out the collapses which have occurred near the portal. The mine drainage flows across the dump before entering the creek. Interestingly, this adit is shown with a stream flowing out of it on 1935 USGS topographic base maps.

Mine Wastes
The Silver Ledge dump is quite large, and spread out along the creek banks. Because the adit is only 35 ft. above creek level, it forced the miners to spread material out over a larger area, and dump materials directly into the stream. The South Fork of Cement Creek runs through the toe of this waste material for over 270 ft. Much of the original wastes have been eroded by the creek. Survey work indicates there are approximately 6,800 cu. yds. of waste rock. The dump contains a lot of clayey and sandy quartz-pyrite sulphide vein waste mixed with altered country rock. Minerals found include pyrite, quartz and occasional sphalerite.

The dump is constructed over permeable talus and debris flow deposits. Total acidity and sulfates are reported below.

Silver Ledge Mine Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
290	276

Historic Structures
There are no structures or equipment at this site. Some partial foundations were found on a lower terrace northwest of the portal.

Geologic Constraints to Reclamation
This site is situated below a timbered area which is not prone to snow slides, however, the dump is in the run out zone for avalanches moving down the south side of the creek. An active debris fan encroaches on the southern end of the dump. There is a lot of loose talus and cobbly debris at the site. An area of unconsolidated soils exists upslope of the dump, and could possibly be a source of capping materials, or a potential repository area for at least part of the dump.

Water Quality Impacts
The Silver Ledge Mine is the largest mine drainage source of metals identified in Cement Creek. At low-flow, the mine drainage produces about 80 pounds of metals per day, including about 3.5 pounds of zinc, 61 pounds of iron, 11 pounds of manganese, and 3.5 pounds of aluminum per day. At low-flow, the Silver Ledge is a minor source of copper. The mine drainage accounts for over 38% of all the metals from draining mines in Cement Creek.

At high flow, the mine drainage produces about 400 pounds of metals per day, accounting for almost 55% of the metals from draining mines in Cement Creek. The measured daily load included about 22 pounds of zinc, 304 pounds of iron, 1.5 pounds of copper, 38 pounds of aluminum, and 32 pounds of manganese per day.

The in-stream effects from this mine drainage at both low-flow and high-flow are dramatic. The zinc concentrations increase at site CC-21 from 47 ug/l to 441 ug/l at low-flow and from 31 to 291 ug/l at high-flow. The iron concentrations are more dramatic, increasing by two orders of magnitude between the upstream and downstream stations. Even though there was a drop in the measured flow between stations CC-21 and CC-22, there was still a greater load than can be accounted for by the mine drainages from the Silver Ledge and Big Colorado Mines. This may be due to inflows from iron springs in the vicinity of the Silver Ledge Mine.

The mine waste is in direct contact with the stream, and the stream actively erodes the pile during high-flow. There is very little, if any, run-on water that contacts the pile, because the South Fork road intercepts most of the drainage. There is probably some leaching of metals through the pile. There were some secondary sulfide deposits that were observed in August 1996 near the edge of the stream. Other than the portion being eroded by the stream, there is probably little water quality degradation from this waste pile.

Reclamation Options

The waste rock in direct contact with the stream should either be removed, or buttressed with riprap, cribbing, or otherwise protected from erosion by the stream. Construction of erosion protection is probably the most cost effective method.

The mine drainage can be treated by constructing a series of sediment ponds. The high ratio of iron to zinc will aid precipitation of zinc along with the iron. A series of ponds with a total capacity of approximately 6,000 cu. yds. would have to be constructed to allow 24 hours minimum residence time, plus half the volume for sediment accumulation. This would allow for approximately 3 years of sediment volume, assuming no consolidation of the sediments. The estimated sediment volume per year is 600 cu. yds. Aeration drops should be included between the settling ponds. Where the drop is steep enough, limestone can be added to the channel to provide a small amount of additional alkalinity.

PROSPECT GULCH-GEORGIA GULCH AREA

Location

The headwaters of Prospect Gulch begin 1½ miles west of Cement Creek, and drain the south slopes of Red Mountain No. 3. Elevations in the Prospect Gulch drainage range from 12,890 ft. on Red Mountain No. 3, to 10,360 ft. at the confluence with Cement Creek one mile southwest of Gladstone. Georgia Gulch has similar elevations and aspect, and lies south of Prospect Gulch below McMillan Peak.

Mine sites selected by DMG for reclamation feasibility studies include the Upper Prospect Gulch Adit, Galena Queen, Hercules, Lark, Henrietta, and Joe & Johns sites in Prospect Gulch, and the Kansas City Mines in Georgia Gulch. These sites are shown on Figures 4 and 7.

The area is characterized by rugged, steep, high alpine terrain at and above timber line. Winters are long with snow depths averaging 440 inches. The summer growing season is short. Average annual precipitation for the past 3 years is 45 inches, 37 inches occurring as snowfall (Sunnyside Gold Corporation, 1996).

Geologic Setting

The regional geologic setting of the Cement Creek area is discussed at the beginning of this report. More specific information about the Prospect Gulch-Georgia Gulch area is included below.

Bedrock Geology

The Prospect Gulch-Georgia Gulch area is situated just inside the northwestern margin of the Silverton Caldera. Caldera rocks in the Upper Prospect Gulch-Georgia Gulch area consist dominantly of medium to dark brown and black, thick, massive rhyodacite and dacite flows and flow breccia of the Silverton Group Burns Formation, and rhyodacitic flows, breccias and tuffs of the overlying Henson Formation, which form the slopes and summit of Red Mountain No. 3 in the upper drainage basin.

Two late-stage intrusive quartz latite porphyry plugs lie northeast of the Hercules and Galena Queen Mines on the south upper slopes of Red Mountain No. 3. The intrusive plugs lie on and adjacent to the bounding fault of the down-dropped “Red Mountain Block”, (Burbank and Luedke, 1969), and are similar in structure and nature to the other numerous late-stage intrusive plug-type quartz latite bodies associated with the margin of the Silverton Caldera and Red Mountain block structure.

A highly mineralized volcanic breccia pipe lies beneath the Hercules and Galena Queen Mines These volcanic breccia pipes are the hosts for rich silver sulphide ore deposits known in the Red Mountain Pass district. The pipe and several associated veins were developed by the Hercules and Galena Queen workings. The Henrietta workings also reportedly developed a blind (not exposed at the surface) breccia pipe known as the “Surprise Chimney” (Steve Fearn, Personal Communication, 1994.)

Structural Geology

Structurally, the Prospect Gulch-Georgia Gulch area lies within the Silverton Caldera on its northwest margin, one mile east of the complex system of ring-fracture faults related to its subsidence, and adjacent to the south margin of the down-faulted Red Mountain block, as shown on Figure 2. Numerous mineralized faults (veins) in upper Prospect Gulch trend parallel or sub-parallel to the main ring fault trend of N.22°E.

A curved fault forming the southern margin of the Red Mountain block runs along the north side of Prospect Gulch, crossing below the main Prospect Gulch road just above the Lark Mine. Springs and boggy areas between the main road and access road to the Henrietta 7 appear to delineate a branch off this fault, which continues along the north bank of the creek to just below the Joe & Johns Mine. The main fault strikes N.50°W. along the north bank of the gulch above the Lark Mine, swinging to N.85°W near the Lark Mine. The Lark Mine portal lies just south of the surface fault trace, and the adit probably cuts the fault within 300 ft. from the portal. This unmineralized fault separates down-dropped rocks of the highly-altered Henson formation to the north from less altered Burns formation rocks. Dips could not be measured, but the fault appeared to be near vertical to steeply dipping to the north. There may be from 600 to 1000 ft. of downward displacement on this fault, as reported by Burbank and Luedke (1969). This structure may extend eastward down the gulch, crossing Cement Creek into the South Fork/ Big Colorado area, as indicated by a series of mineralized fractures which follow this trend.

Within the down-dropped Red Mountain block, and truncated by the curved boundary fault described above, is a complex of small quartz latite intrusive bodies cut by a set of northwest trending veins. These veins were prospected by several adits and shallow pits. The veins appear to be a mineralized set of closely-spaced faults, each with a downward sense of movement to the northeast.

An intrusive clastic dike, which strikes N.47°W. and dips 55°N., cuts across the easternmost vein in this series, near the portal of a prospect adit above the Lark Mine. This dike has sharp contacts, and consists of a fracture filling of rounded to angular fragments of country rock and Precambrian basement clasts. These clastic dikes are believed to have been formed by explosive, forceful injection of debris during the waning stages of volcanic activity (Burbank and Luedke, 1969).

Hydrothermal Alteration
Due to the proximity of the caldera structural margin within a mile to the west of the Prospect Gulch-Georgia Gulch area, much of the rockmass here has been highly altered by solfataric and hydrothermal processes. Solfataric processes have subjected the rock to attack and leaching by hot sulphurous gases and solutions moving upwards along the structural margin of the Silverton Caldera and Red Mountain graben. These hydrothermal processes have leached and "stewed" most of the base minerals from the rocks, as described in the geology section in the beginning of this report. Volcanic flows within the Red Mountain block forming the northern side of Prospect Gulch were so strongly altered and leached that little remains except silica, kaolinite, and sulfate and sulfide alteration products. Virtually all potential buffering minerals in the country rock have been leached away.

Ore Mineralization
Ore mineralization in the upper Prospect Gulch breccia pipes and associated veins is typical of the Red Mountain Pass District one mile to the west. These features can be considered as belonging to that district from an ore geology perspective. The pipes are reflective of the quartz-alunite epithermal deposits. The most common ore minerals include enargite, pyrite, sphalerite, galena, bornite, chalcopyrite, proustite, pyargerite, stromeyerite, covellite, and chalcocite (Burbank, 1951). Sulphide minerals found on the mine dumps of the Galena Queen/ Hercules and Henrietta Mines include pyrite, enargite, covellite, and chalcopyrite. The deposits were mined in veins, breccia pipes, and as disseminations in wall rock, intensely altered to silica, alunite, and clays.

Gangue minerals associated with the chimney sulphides consist dominantly of barite, fluorite, and the products of rock alteration, namely clays, quartz, and heavily pyritized wall rock. Virtually all potential buffering minerals have been leached away.

The Lark, Joe & Johns, and Kansas City Mines developed vein deposits within somewhat different mineralization than found in the chimney/ breccia pipe deposits. Vein ores consist of pyrite, chalcopyrite, sphalerite, and galena, sometimes with tetrahedrite and tennanite. Silver was associated with argentiferous tetrahedrite, and less commonly with silver sulfo salts. Free gold occurred in shoots scattered in siliceous gangues, or associated with the base metal ore minerals. (Burbank and Luedke, 1964)

Gangue minerals associated with veins in the area normally include quartz, rhodonite, rhodochrosite, calcite, fluorite, and barite. There is generally more potential for the presence of buffering minerals in vein deposits, but because the Prospect Gulch-Georgia Gulch area has been so heavily altered by solfataric processes near the margins of the caldera structure, the veins here are mineralogically similar to the chimney ores, and buffering minerals are often depleted. (Burbank and Luedke, 1964)

Surficial Geology

Slopes around upper Prospect Gulch-Georgia Gulch are steep, and prone to avalanches and debris flows. Several steep ravines between the Lark and Joe & Johns Mine sites have well-formed debris cones where they impinge on the main gulch. The upper slopes of Red Mountain No. 3 are mantled with thick aprons of scree and talus, which feed the source areas for the debris flow ravines. Much of the area around the Lark Mine is composed of colluvial debris transported down from the slopes of Red Mountain No. 3. Because this material is stained bright red and yellow, it resembles oxidized mine dump material. In actuality, it is a natural highly oxidized and leached deposit. Tests show this colluvial material to be so highly leached and oxidized through geologic time, that it is not a source of significant metals release. There is actually much less mine waste at the Lark Mine site than it appears, because of the naturally red-colored debris around the site. This gravelly, cobbly debris could be a source for fill or construction materials, though it would not make suitable capping material unless heavily amended for vegetation.

The avalanche danger in Prospect Gulch and Georgia Gulch is high to moderate. Several avalanche chutes exist on the south side of Prospect Gulch in the area of the Henrietta Mine. It appears that past avalanches have damaged or destroyed structures on the Henrietta 7 dump, and also at the Henrietta 10 dump. Most, if not all, the slopes above timberline in the upper basin are subject to avalanches in the winter, as are the debris flow ravines near the Lark and Joe & Johns Mine sites.

Slopes below McMillan Peak in Georgia Gulch at the Kansas City Mines are extreme avalanche hazard areas. No structures remain standing, and avalanches often run all the way down Georgia Gulch to Cement Creek. Access to the Kansas City Mines is usually blocked well into mid-August by the melting remains of snow slides in the upper part of the gulch.

Extensive boggy, colluvial deposits exist around the Galena Queen/ Hercules site where the basin slopes are less steep, and the gulch widens out into a cirque-like basin. These deposits are characterized by thick, black soils developed on fine to coarse gravelly and cobbly colluvial materials. Colluvial and alluvial soils exposed along some of the upper slopes and along first order streams in the upper "cirque" basin have locally been cemented with iron oxide, forming ferricrete deposits.

Thin, patchy alluvial gravels are present along Prospect Gulch, but are generally just a discontinuous veneer on bedrock.

Prospect Gulch-Georgia Gulch Mine Site Descriptions

The volcanic caldera flows and intrusive quartz latite plugs in upper Prospect Gulch are cut by numerous mineralized faults, fissures (veins), and breccia pipe bodies which have been prospected and mined for sulphide ores. The mine sites included for feasibility assessments are described below, and shown on Figures 4 and 7.

Upper Prospect Gulch Adit

Location
This mine is located in upper Prospect Gulch about 1/4 mile above the Galena Queen Mine on the lower south slope of Red Mountain No. 3. It lies at an elevation of 11,880 ft., at the end of County Rd. 35. This site is believed to be on the J.S.P. claim. The waste rock at this site was sampled as site #6, shown on Figure 7. Water quality sampling site PG-20 was located below the site and above the Hercules mine, to measure the effects from this waste pile (Figure 4). This site is located at LAT. N37°53'40.0", LONG. W107°41'23.6". The site is shown on Figure 31, which is entitled 'Site Map - Galena Queen and Hercules Mine Area'.

Workings
An adit driven N.80°W. prospected two closely-spaced sulphide veins which strike N.21°E., and dip 71°NW. Drifts were apparently driven at almost right angles off the adit on these veins. There is no surface discharge from the collapsed adit portal, which is situated adjacent to a local first order stream.

Mine Wastes
The dump at the portal contains approximately 300 cu. yds. of fine to coarse sulphide mine waste consisting almost entirely of pyrite and quartz, along with galena, covellite, and some sphalerite. A kill zone extending 170 ft. downslope from the dump has completely destroyed the vegetation, exposing 2 ft. of thick, black organic soils. The dump was placed across a small stream, which has incised through the northern side of the dump. Dump sulfides are continuing to be eroded by the stream. Total acidity and sulfates are reported below.

Dump at Upper Prospect Gulch Adit

Total Acidity (mg/l)	ICP Sulfate (mg/l)
1,426	1,908

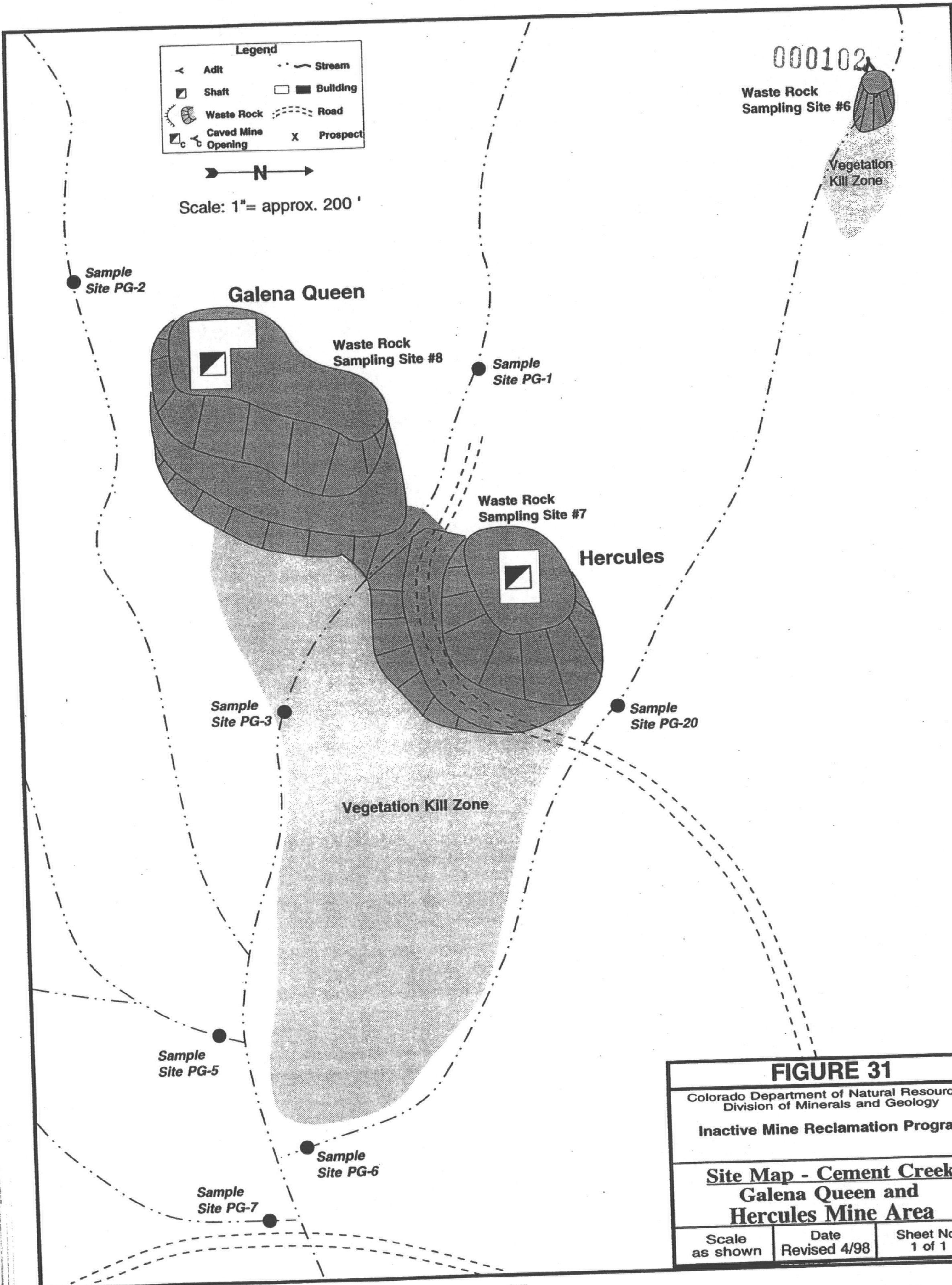


FIGURE 31

Colorado Department of Natural Resource
Division of Minerals and Geology

Inactive Mine Reclamation Progran

Site Map - Cement Creek
Galena Queen and
Hercules Mine Area

Scale	Date	Sheet No.
as shown	Revised 4/98	1 of 1

000103

Historic Structures
There are no structures or equipment at this site except for an old steel tank of welded construction which lies below the dump. This tank may have rolled down or been discarded from the road to the summit of Red Mountain No. 3 above the site, and may not be related to the mining at this site.

Geologic Constraints to Reclamation
This site is prone to avalanches from the slopes of Red Mountain No. 3. There is no access beyond the Galena Queen Mine except by trail. Access would have to be improved from the Galena Queen.

Water Quality Impacts
This waste rock pile completely blocks the small first order tributary to Prospect Gulch. At low-flow, the effects of this blockage are measured at sampling site PG-6, because the Hercules Mine is dry. During high-flow, when there is drainage off the Hercules waste pile, the effects from this site are measured at station PG-20. At low-flow, zinc, iron and copper concentrations are elevated far above background levels, but the flow is so low that the loads are in grams per day. During high-flow, dissolved iron loading from this site is about 0.5 lb/day, while copper and zinc loads are about 20 grams per day.

Although the loading from this site appears small, the loading amount per unit area or volume is great. Waste rock analyses show this site to have one of the three highest extract concentrations of copper in the Cement Creek area.

Reclamation Options
Reclamation at this site is straight-forward. The waste rock must be removed from the stream channel. A disposal area can be excavated on the ridge above the mine site, then covered with the excavated material, or be moved to a constructed disposal area.

Galena Queen/ Hercules Mine Sites

Location
The Galena Queen/ Hercules Mine sites are located in upper Prospect Gulch near the end of County Rd. 35 at LAT. N37°53'31", LONG. W107°41'17". The mines lie at an elevation of 11,660 ft. The Galena Queen Mine is believed to be on the Galena Queen claim. The Hercules Mine is believed to be on the Galena Queen and Hercules claims. The Galena Queen Mine is bracketed by surface water stations PG-1 and PG-3. The surface water effects from the Hercules Mine are bracketed by stations PG-20 and PG-6 and also to some extent by stations PG-3 and PG-8. These sampling site locations are shown on Figure 4. The Galena Queen waste rock was sampled as site #8. The Hercules waste rock was sampled as site #7. Both these waste sampling sites are shown on Figure 7. A site map is shown on Figure 31.

Workings
Mining at this site developed a breccia pipe "chimney" ore body through two vertical shafts, the eastern shaft known as the Hercules, and the upper western shaft called the Galena Queen.

000104

Stoping west of the Galena Queen shaft indicates that a west-striking vein associated with the chimney was drifted on underground. Interestingly, this same vein can be traced west across the ridge about one mile, where it was worked by the San Antonio Mine at the Carbon Lakes site (not discussed in this report).

A large prospect pit was also excavated on the northern edge of the mineralized outcrop adjacent to the Hercules dump. Swirling water can be seen and heard about 50 ft. down in the Hercules shaft.

Mine Wastes

As the site lies on gentle ground near the center of the upper basin, a roughly circular mine dump has been built up and out from the collar of each shaft. The toe of the upper Galena Queen dump encroaches on the lower Hercules dump such that the footprint of mine waste has the form of a figure eight. Survey work measured the dump volumes at 7,200 cu. yds. for the Galena Queen, and 4,680 cu. yds. for the Hercules. Materials are highly pyritic, and there is a distinct kill zone below the combined dump footprint. The largest kill zone is below the Hercules pile.

The Galena Queen is aptly named. The gray waste rock contains significant quantities of both massive and disseminated galena and sphalerite. The waste containing disseminated galena and sphalerite often is associated with pyrites, enargite and covellite. The waste rock is highly cemented where dry. Popcorn sulfur was observed on the top of the waste pile. Sodium sulfate salts were also quite common. The temperature generated by acid production results in this site being snow-free before the surrounding area. Downstream from where the stream flows over and through the waste rock in between the two piles, there is considerable iron staining on the streambed.

The gray waste rock at the Hercules Mine contains pyrite, galena, enargite and sphalerite in a quartz matrix. The only secondary sulfides observed were on the top of the waste pile, although there appears to be some free sulfur. When dry, this waste pile is almost completely cemented with sulfate salts.

Total acidity and sulfates for both the Galena Queen and Hercules dumps are shown below.

Galena Queen and Hercules Dumps

Site	Total Acidity (mg/l)	ICP Sulfate (mg/l)
Galena Queen	1,676	5,153
Hercules	1,604	5,033

Historic Structures

There are timber head frames remaining at both shaft collars. The Galena Queen's shaft house, complete with boiler and steam hoist, still remain, though all in poor condition. The shaft house structure is timber-framed, covered with relatively new corrugated sheet metal. A lot of the metal siding and roof are missing. Both shafts have been capped with steel grating. Some cribbing in the surface expression of the stope also remains.

Geologic Constraints to Reclamation

This site is situated near the center of the gently-sloping upper basin area. It is just beyond the run out zones for most avalanches, which is why the shaft head frames are still standing. Access for equipment would have to be improved across the stream just below the Hercules dump. If the dumps are ever removed, they could be reconstructed to preserve historic values using the red and yellow colored native debris from the foot slopes near the Lark Mine. Most visitors would never know the difference.

Water Quality Effects

All the water quality effects from these mines is the result of water interaction with the waste rock. Between stations PG-1 and PG-3, the small stream passes over and through a portion of the waste rock from the Galena Queen Mine. At PG-3, the metals concentrations, at both low-flow and high-flow, increase by 2 to 3 orders of magnitude. At low-flow, the metals loadings are minimal (zinc-0.2 lb/day, iron-0.1 lb/day, and copper-0.02 lb/day). At high-flow, the loading from this site increases to about 5 pounds of zinc, 5 pounds of iron, and 0.5 pounds of copper per day.

At low-flow, there is very little metals loading from the Hercules waste pile, except during thunderstorms. At high-flow, the metal loading attributable to the Hercules is about 1 pound of zinc, ¾ pound of iron, and less than 0.03 pounds of copper per day. At the time the high-flow samples were taken, the waste rock was completely snow-free. The heat generated by acid formation makes snow on these waste piles melt earlier than the surrounding areas. The metals loading from these waste piles during snowmelt is probably much greater, earlier in the season. Also, during thunderstorms, the metals loading from these piles probably increases greatly. To date, there have been no storm-flow samples taken from this site.

There are some probable effects due to run-on water from the slopes above. There probably is more water entering the Galena Queen dump than the Hercules dump. The Hercules waste pile is near the top of a ridge, so receives little run-on water. The Galena Queen pile receives some additional water that flows down an old road onto the pile.

The Galena Queen waste rock extract had the highest concentrations of cadmium, copper, and zinc of all the waste piles sampled in the Cement Creek area. Also, the arsenic, iron, nickel, sulfur, and vanadium concentrations were in the top three highest measurements.

The Hercules waste rock extract had arsenic and zinc concentrations in the top three measurements. The copper concentrations were also very high.

Reclamation Options

To eliminate the run-on water effects, diversion ditches should be constructed around both of the waste piles. A portion of the diverted water will have to outlet in the stream between sampling stations PG-1 and PG-3. The waste rock in that stream channel must be removed and consolidated within the existing pile. Presently, DMG plans to remove this material and construct the diversion ditches during the summer of 1999 under a federal Office of Surface Mining grant.

The possibility of processing the wastes in these piles to remove the heavy metals should be investigated. Although the metals values are probably too low to completely pay for the processing, they may offset the overall cost of reclaiming this area. There is no apparent evidence of ground water flows through either pile. Therefore, the waste can be reclaimed in-situ. If processing is not feasible, the surface pile could be mixed with fly ash to reduce leaching, or a fly ash-cement mixture could be injected into the waste rock. The scattered waste rock would have to be consolidated with the main pile, and the slopes would have to be reduced to allow for equipment operation.

Henrietta Mine

Location

The Henrietta Mine is located on the south side of Prospect Gulch and is accessible from County Rd. 35. There are portals into at least six levels of this mine, including the 100, 200, 300, 700, 800 and 1000 levels. These portals and the associated waste dumps will be denoted in one of two ways in this report. As an example, the 800 level of the Henrietta Mine will be referred to as either the Henrietta 8 or the 800 level. Other levels within the mine are labelled accordingly. The Henrietta 7 (700 level), which is the main entrance to the mine, is located at LAT. N37°53'31.8", LONG. W107°40'58.1". The locations of some of the portals are labelled on Figure 4.

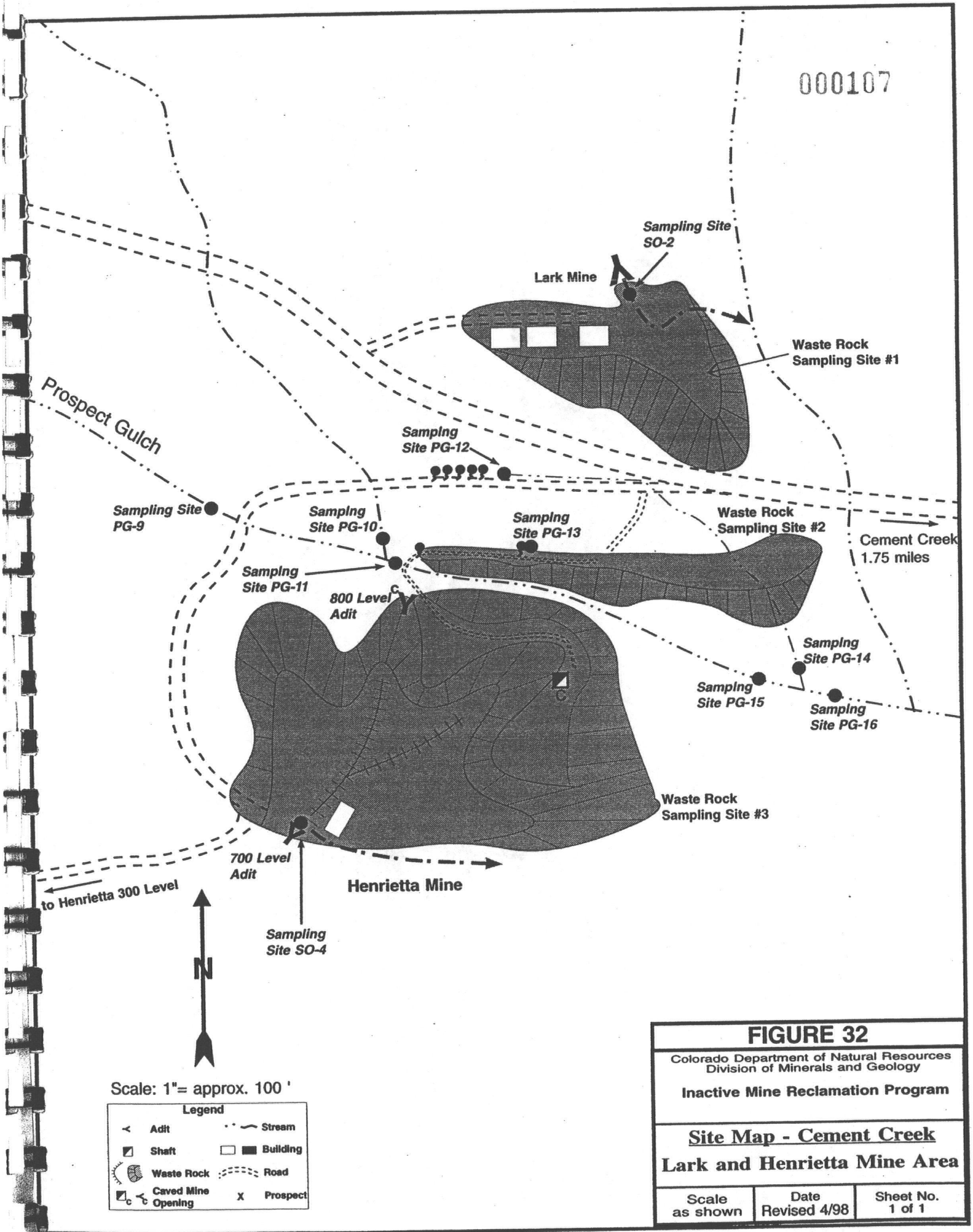
The Henrietta 7 mine drainage was sampled at station SO-4 and is bracketed by stream stations PG-11 and PG-16. The Henrietta 7 waste rock was sampled as site #3. The Henrietta 8 (800 level) waste rock was sampled as site #2. The Henrietta 3 (300 level) waste rock was sampled as site #10. The locations of water and waste rock sampling sites at the Henrietta Mine are shown on Figures 4 and 7 respectively. These sites are also shown on Figure 32.

It should be noted that the flow measurements for sites PG-16 and PG-18 were improperly taken. Therefore, the flow measurements and loading values reported in the appendix are based on addition of the measured in-flows at stations PG-14 and PG-17 to the flow at station PG-15.

The Henrietta 7 and 8 level adits are believed to be on the Mineral King claim. The waste rock from the Henrietta 7 and 8 is believed to be partially on the Mineral King claim and partially on unpatented claims. The Henrietta 3 is believed to be on the Lizzie claim. The Henrietta 1 and 2 levels are believed to be on the Henrietta claim.

Workings

The main or 700 level portal is on the south side of Prospect Gulch at an elevation of 11,360 ft. The 800 level portal is topographically below and slightly north of the 700 level portal on the same side of Prospect Gulch. The 300 level portal is located near the very top of the valley wall 400 ft. higher on the same vein. The 100 and 200 level adits, located south and topographically above the 300 level, are both collapsed. The 1000 level portal is located east and downstream of the


000107
Sampling Site SO-2
Lark Mine
Waste Rock Sampling Site #1
Prospect Gulch
Sampling Site PG-12
Sampling Site PG-9
Sampling Site PG-10
Sampling Site PG-13
Waste Rock Sampling Site #2
Cement Creek 1.75 miles
Sampling Site PG-11
800 Level Adit
Sampling Site PG-14
Sampling Site PG-15
Sampling Site PG-16
Waste Rock Sampling Site #3
700 Level Adit
Henrietta Mine
to Henrietta 300 Level
Sampling Site SO-4
N
Scale: 1"= approx. 100 '
Legend
Adit
Stream
Shaft
Building
Waste Rock
Road
Caved Mine Opening
Prospect
FIGURE 32
Colorado Department of Natural Resources
Division of Minerals and Geology
Inactive Mine Reclamation Program
Site Map - Cement Creek
Lark and Henrietta Mine Area
Scale as shown
Date Revised 4/98
Sheet No. 1 of 1

Henrietta 7 also on the south side of Prospect Gulch. Because of the map scale, the 100, 200, 300 and 1000 level portals are not shown on Figure 32. They are shown only on Figures 4 and 7.

The Henrietta Mine developed a set of veins and a hidden (blind) "chimney" ore body through a series of adits driven southwest on at least 4 levels. The mine followed two steeply-dipping main vein structures, one striking about N.18°W., and the other roughly N.20°E. This latter vein continues to the southeast into Georgia Gulch, where it was also prospected by the upper workings of the Kansas City Mines.

According to local workers familiar with the mine, a chimney-type ore body which did not crop out on the surface was encountered in the workings on the 700 and 800 levels. Known as the "Surprise Chimney", it caused some excitement and sparked renewed interest and exploration of the property. In 1977, a full face-tunnel boring machine ("Alpine Miner") was used to bore a 5 ft. wide by 7.5 ft. high tunnel, 1,800 ft. into a new level designated the Henrietta 10, located ¼ mile downstream, and 200 ft. lower in elevation than the main 700 level. This cross cut was designed to get under and develop the Surprise Chimney, however, no ore was ever milled before funds ran out (Marshall, Zanoni, and Melcher, 1996).

Mine Wastes

A large compound dump is located at the adit portals of the 700 and 800 levels. Prospect Gulch divides the dump into two parts. Most of the dump lies on the south side of Prospect Gulch below the 700 level portal (denoted here as the 'south pile'). A smaller part of the dump lies to the north of Prospect Gulch (denoted here as the 'north pile'). The entire dump was surveyed and is estimated to contain approximately 30,000 cu. yds. of waste materials. The dump is made up of at least three different ages of materials from the two portals, as indicated by relative weathering and oxidation of the different parts of the dump. Older materials are located near the creek level and around the lower caved 800 level portal. Newer waste rock dating from the last operations in the 1970's have been placed on the upper east side of the dump at the 700 level.

Waste rock materials are highly pyritic, and include some small areas of base-metal and possibly silver ores which were never shipped. An access road traverses up the dump in a set of switchbacks to the 700 level portal. Loadouts from the 700 and 800 levels extend out to the access road.

The north pile is located at Lat. N37°53' 30.3" Long. W107°40' 53.7". The north pile is long and narrow and lies along the north banks of Prospect Gulch. The toe of the waste rock is in Prospect Gulch for approximately half the length of the pile. Two perennial springs saturate approximately 1/3 of this pile. In addition, two intermittent drainages flow onto and through this pile. One of the drainages is fed by a series of springs along the access road to the Henrietta 7 Mine. During most years, these springs have been observed to flow throughout the summer months. However, in 1996, the springs were virtually dry in August, September and October. The spring and runoff water visually appears to be degraded as it passes through the waste rock.

Waste rock sample #2 is a composite sample taken in 10 locations from the north pile. The north

000103

pile waste rock contains considerable country rock at the surface. Much of the country rock contains fine disseminated pyrite. Sphalerite and galena were present in the mineralized portion of the waste rock. Secondary iron sulfides were observed in most of the samples.

The south pile is located immediately north of the Henrietta 7 adit at Lat. N37° 53' 31.8" Long. W107° 40' 58.1". There are three distinct lobes to this waste pile. The lower lobe is principally coarse material on the surface containing disseminated sphalerite. The middle lobe is finer-textured on the surface with abundant secondary sulfides. The upper lobe is fine-textured, with one area containing low grade lead-zinc ore. Waste rock sample #3 is a composite sample taken in 11 locations at the south pile. The northwest portion of this pile is directly in contact with the stream near the 800 level adit. The drainage from the mine apparently infiltrates quickly into a drainage ditch and passes through the waste rock. A spring located on the west side of the pile appears to partially flow through the pile.

The main 700 and 800 level dumps are steep, and are being eroded by the creek. Some sections appear to be over steepened by erosion at the toe, and subject to mass failure into the creek.

There is also a waste rock dump at the Henrietta 10 portal at an elevation of 11,080 ft. This dump is estimated to originally have contained around 2,500 cu. yds. of waste rock from the cross cut tunneling operation mentioned above. However, due to the position of the portal in a steep-walled section of the gulch, much of the waste had to be dumped directly into the stream, and was washed away. At this time, only about 650 to 700 cu. yds. remain at this site. This waste rock was not sampled.

There are also some older, very steep, but smaller waste piles high on the valley slope at the Henrietta 1, 2 and 3 portals. The Henrietta 1 and 2 waste rock piles were not sampled. The Henrietta 3 portal is located adjacent to an active avalanche chute/drainage southwest of the Henrietta 7, at Lat. N37° 53' 18.5" Long. W107° 41' 01.7". This waste rock appears to be similar to the Henrietta 1 and 2 piles located above this site. The volume of waste rock is difficult to estimate at this site since portions of the pile have been covered with excavated surficial material, however, there appears to be less than 2,000 cu. yds.. Much of the waste pile is at the angle of repose resting on a very steep slope. The waste rock is a combination of grey and yellow material. The gray areas contain galena with some sphalerite and covellite. The yellow areas contain pyrite, principally in 1 mm crystals.

Total acidity and sulfate values for the dumps sampled are shown below.

000110

Henrietta Mine Dumps

Site	Total Acidity (mg/l)	ICP Sulfate (mg/l)
Henrietta 3 level	1,116	2,960
North Pile	70	76
South Pile	836	923

Historic Structures

A partially collapsed portal shed and damaged shack of lumber and corrugated tin still exist at the 700 level portal. Heavy snows and avalanches have smashed most of the structures so that the top of the dump is covered with wooden debris. Pipes, rail, and other metal parts and debris litter the dump. Rails still lead out of the grated 700 level portal onto the timber cribbed tipping point/ loadout structure. There are also two timber crib walls constructed in the dump to hold the access road slopes open.

The timber portal shed at the Henrietta 10 has been damaged by avalanches and the portal is collapsed just beyond it. Heavy rail still exits the portal and leads to the dump point right in the creek.

Geologic Constraints to Reclamation

The Henrietta 7 and 10 level areas are subject to moderate avalanche danger. Structures at both locations appear to have been damaged or destroyed by snow slides in the past. The gulch begins to take on a narrow, steep-sided canyon form near the Henrietta 7, forcing the mine dumps to be very steep, somewhat unstable, and spread out along the valley slopes. There is little room available between the portals and the creek for regrading, or run-on and runoff controls. The entire toe length of the waste rock piles encroaches into Prospect Gulch, and would have to be moved and excavated upwards to clear the stream channel.

Collection of the water flowing from the 700 level adit for treatment could be problematic. The fractured, jointed, highly altered nature of the bedrock could be allowing seepage from the adit to enter the groundwater system. It may be necessary to re-enter the adit to some point beyond fracture influences to place a grout-sealed bulkhead water-inlet where water can be collected. This could prevent infiltration of adit flows into fractured bedrock.

Water Quality Impacts

There are several separate sources of heavy metals from this site. The principal water quality impact seems to come from the waste piles. The overall effect between sampling stations PG-11 and PG-16 is metals loading of about 0.4 pounds of zinc, 0.6 pounds of iron, and 0.15 pounds of copper per day at low-flow. At high-flow, the loading through this segment increases to about 12 pounds of zinc, 122 pounds of iron, and 2 pounds of copper per day. Most of the low-flow metals loading is thought to come from the north waste pile. This pile is kept continually saturated by springs and seeps.

000111

The Henrietta 7 Mine apparently only drains during the spring. As discussed above, there may be some perennial flow from the adit through fracture systems. During high-flow, the adit drainage was measured to load about 2 pounds of zinc, 27 pounds of iron, and 0.1 pounds of copper per day. The mine drainage quickly infiltrates the diversion around the waste pile, and likely flows through the waste pile. Based upon the waste rock extract analyses, the mine drainage probably leaches additional metals from the waste rock.

Waste rock analyses show that there are more leachable metals in the south pile than the north pile. The north pile contains more country rock on the surface. Chemical analysis of the waste rock indicates that both waste rock piles contain relatively low metals compared to all the other sample sites. However, because of continuous contact with water, this site is a priority for reclamation.

As previously stated, there are several springs and seeps that flow through the north waste rock pile, and at least one spring that flows onto the south pile. In addition, there is considerable upland runoff that flows over and through the waste piles. The effect of one of these springs was measured by sampling stations PG-12 and PG-14. The loading differential between these two sites shows a loading of about 2 pounds of zinc, 3 pounds of iron, and 0.2 pounds of copper per day.

The Henrietta 3 waste rock pile had a higher acid forming potential than the waste from the north and south piles. The water quality effects from this pile are leaching of metals from upland runoff. A small stream fed by a permanent snowfield flows onto and through this pile. The steep slope of the pile and the steep slopes below the pile made it impractical to sample the small stream below the pile. The Henrietta 1 and 2 waste rock piles are located directly in the small drainage that flows into Prospect Gulch below the Henrietta 10 portal.

Reclamation Options

The most cost-effective measure to control metals pollution from this mine site is to construct diversion ditches. The metals contribution from the Henrietta 3 pile can be virtually eliminated by constructing a diversion above the site. Diversions can be constructed by hand methods above the Henrietta 1 and 2 waste piles. Much of the flow from the slopes above the Henrietta 7 portal is currently intercepted by the mine drainage diversion ditch. However, water flows down the Henrietta 3 access road onto the south waste pile. Drainage ditches along the road have become ineffective, and should be improved to carry all the flow.

Diversion ditches could be constructed to intercept the upland flow and spring flow above the north pile, but portions of the ditches would probably become maintenance nightmares. Therefore, it is recommended that the waste rock in the north pile be completely removed. This waste can be consolidated in the south pile. After revegetation, the low-flow metals loading should be virtually eliminated.

The portion of the south pile that is in continual contact with the stream should be moved. To

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maintain the historic appeal of this site, it is recommended that the consolidated waste pile be cemented in place, by injection of a fly ash/cement mixture. This will significantly reduce water and air flow through the waste rock.

The Henrietta 800 level adit should be investigated to determine if there is mine drainage flowing underground from the collapsed portal.

Treatment of the mine drainage from the Henrietta 7 adit is somewhat problematic because of the apparent seasonal nature of the drainage. At a minimum, the existing diversion ditch should be lined to prevent the mine drainage from flowing through the waste rock. A combination anoxic limestone drain and sulfate reducing system would likely become ineffective, because the limestone would become coated as the flow ceases, and the metals removed by the sulfate reducing system would re-oxidize when the flow ceased. A small neutralization system can be constructed with a flow sensor to treat the mine drainage during the spring months. The system would probably have to be electrically powered, so the electrical lines to the mine would have to be repaired. A small settling pond could be constructed in the forested area east of the mine adit.

Lark Mine

Location

The Lark Mine is located on the north side of Prospect Gulch, 1½ miles up County Rd. 35 from Cement Creek. It is north of the north waste pile at the Henrietta Mine at an elevation of 11,320 ft. The portal is at LAT. N37°53'35.9", LONG. W107°40'49.6". The Lark adit is believed to be on an unpatented claim. The mine drainage was sampled at station SO-2 during high-flow, and the waste rock pile was sampled as site #1. These sampling locations are shown on Figures 4 and 7 and on the site map on Figure 32.

Workings

The Lark adit was driven northwards under Red Mountain No. 3 to explore steeply-dipping veins and disseminated mineralization within the highly altered Red Mountain structural block. The adit is estimated to have penetrated the near vertical to steeply north-dipping bounding fault of this structure within 300 ft. from the portal. There are many other prospect pits and adits, and even some modern drill holes higher up the slopes on the Lark property, however, it is believed these operations never progressed much beyond an exploration effort. There appears to have been at least two other older portals developed during past operations at this site, both of which are now totally collapsed and difficult to locate.

The newest adit was constructed through a long section of loose, unconsolidated scree and colluvium which mantles the lower foot slopes of Red Mountain No. 3. The adit was open and was grated by DMG in the late 1980's. Although now collapsed, the adit still drains a small amount of water, which quickly seeps into the colluvium and scree. Numerous springs and boggy areas at the base of the mountain slope suggest the unmineralized bounding fault structure which runs through the site may be a source of groundwater seepage to Prospect Gulch.

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Mine Wastes
The apparent size and nature of the Lark "mine dump" is misleading to the untrained eye. What at first appears to be a large and extensive dump with several structures built on top of it is actually the outslopes of a bench cut into the red and yellow-stained colluvium and scree which thickly mantle the foot slopes of Red Mountain No. 3. True mine waste materials here are confined to the smaller amount of light gray to white material located around the tipping point or "loadout" east of the mine buildings. The buildings and all of the bench are constructed on graded, native colluvial materials stained bright red and yellow through weathering and oxidation processes described above.

Mine wastes around the loadout were surveyed and measured to determine volume. There are approximately 3,500 cu. yds. of sulphide mine waste, including some relatively high grade-looking base metal ores. A composite sample was taken at 10 sites where waste rock was not mixed with colluvium. Sphalerite, galena, silver sulfides, and fine disseminated pyrite and chalcopyrite were present in the waste rock. The waste pile is located on a relatively dry south-facing slope. The east toe of the dump encroaches into a debris flow ravine on the east side of the site.

Total acidity and sulfates of the waste rock are shown below.

Lark Mine Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
842	935

Historic Structures
Three timber, log, and tin-clad shacks remain on the Lark site. One of these was last used as a core storage shed for drilling done on the slopes above during the late 1970's (dates on core boxes). There is also a timber-cribbed structure at the dump tipping point. The absence of any signs of track or ties, coupled with the shape of the dump suggest the last operations were conducted with modern rubber-tired diesel equipment.

Remains of an old tram line lead from the Lark Mine upslope to a higher level collapsed portal. This tram line is marked only by old cables lying in the heavy pine forest above the site, and the nearly obliterated remains of a terminal facility. There are no towers still standing, and the tram line is very short by San Juan standards.

Geologic Constraints to Reclamation
The Lark site is generally safe from avalanches, as is evident from the structures which remain. A heavy stand of mature spruce and fir exist on the slopes above the mine, indicating that snow slides generally do not affect the site.

There is an abundant supply of unconsolidated gravelly scree and colluvium, and bedrock appears to be relatively deep. The bench area is large enough, and could be a favorable, protected site in

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which to develop a waste repository for other mine dumps in upper Prospect Gulch (although probably the Henrietta waste dumps would include too much material to deposit in this area). These native colluvial materials are highly permeable, however, and would have to be amended or sealed to provide capping or liner materials.

Springs and wet, marshy areas are prevalent west of the waste dump. These suggest that there is a natural ground water system at this site, possibly related to the major fault structure which lies beneath the area. This could be problematic for a waste repository, and groundwater conditions would have to be evaluated during a siting study.

Water Quality Impacts

The principal water quality effect from this mine is the seasonal mine drainage. Although the flow from the adit was low, the mine drainage had one of the highest concentrations of zinc, iron, and copper. Compared to the other mine drainages as high-flow, the Lark produced slightly over 1% of the dissolved metals, but produced almost 5% of the zinc and 7.5% of the copper. The mine drainage flows into the small tributary to the east before contacting any of the waste rock. The mine adit should be reopened to determine whether there is any perennial flow from this site.

There was little visual evidence that leaching and runoff from the waste rock represents a significant water quality problem. An intermittent drainage, located immediately east of the waste rock pile, does not appear to be impacted. Waste rock at the Lark Mine dump had one of the highest lead concentrations in the extract in the Cement Creek area. Copper and zinc concentrations were also high.

Reclamation Options

The seasonal nature of the mine drainage from the Lark Mine makes treatment somewhat problematic, similar to the drainage situation at the Henrietta Mine (700 level). In that case, a neutralization treatment system was suggested as the only known viable treatment method. This type of system should also work for the drainage from the Lark Mine.

In addition, some of the drainage may be entering the groundwater system through the loose, unconsolidated colluvium and scree at the portal or through fractures in the mine tunnel rather than exiting the portal as surface flow. The mine workings should be reopened and investigated to determine the presence of additional flow and to assess whether it is necessary to capture and treat that flow.

The waste rock does not appear to be a significant source of heavy metals. It is recommended that no reclamation be performed on the waste rock pile.

Joe & Johns Mine

Location

The Joe & Johns Mine is located 1½ miles from Cement Creek adjacent to the Prospect Gulch road (County Rd. 35). The portal is at an elevation of 11,200 ft., at LAT. N37°53'28.6", LONG.

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W107°40'43.4". It is east-southeast of the Lark Mine. The mine drainage from the lower adit was sampled as station SO-6, and the waste rock was sampled as site #4. The waste rock from the upper adit was sampled as site #14. These sampling sites are shown on Figures 4 and 7.

Workings

An adit was driven north into the valley wall to explore a steeply-dipping vein system striking almost due north. The adit is thought to have penetrated the near vertical to steeply north-dipping bounding fault of the Red Mountain block about 600 ft. from the portal. There are a cluster of other adits higher up the slopes on the Joe & Johns claims, and it is possible that the workings were interconnected. At one time, the main Joe & Johns adit was used for supplying drilling water to nearby mining operations (BLM permit records).

At present, the collapsed adit drains an average of 2 to 15 gpm of metals-contaminated water.

Mine Wastes

Most of the waste rock from this mine has been eroded and/or covered with debris flow material. The quantity of waste rock can only be determined by exploratory drilling or excavation. The waste pile is located directly in an intermittent drainage. A composite waste rock sample was taken from 10 locations over an area of approximately 20 ft. x 30 ft. at one exposure south of the Prospect Gulch road. The waste rock was highly cemented, making sampling difficult. The waste rock was observed to contain sphalerite and galena.

The upper Joe & Johns Mine dump is located in the same drainage as the lower mine. The toe of the waste pile extends to the thalweg of the intermittent stream/avalanche chute. There is evidence of erosion of the mine waste in the drainage channel. The mineralogy of this mine waste is very similar to the lower dump. Total acidity and sulfates are shown below.

Joe & Johns Mine Dumps

Site	Total Acidity (mg/l)	ICP Sulfate (mg/l)
Upper Joe & Johns	890	1,085
Lower Joe & Johns	588	614

Historic Structures

A timber engine house and Imperial type 10 steam engine remain on the Joe & Johns site.

Water Quality Impacts

At both the low-flow and high-flow sampling, the zinc, iron, and copper concentrations of the mine drainage were extremely high. The low-flow loadings from this mine drainage were all less than 0.05 lb/day. At low-flow, the Joe & Johns produced only 0.02% of the dissolved metals from mine drainages. At high-flow, the metal loadings were about 2 pounds of zinc, 11 pounds of iron and 0.2 pounds of copper per day. At high-flow, this mine drainage produced approximately 2% of the dissolved metals from mine drainages in Cement Creek.

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The mine drainage flows down a channel into the road drainage ditch and enters the tributary to the east of the mine site. Sampling site PG-17 actually measures the effects of the waste pile blocking the stream and possibly some effects from the upper Joe & Johns waste pile. At low-flow, there was only seepage at PG-17. At high-flow, the metals loading from this small tributary was about 0.5 pounds of zinc, 11 pounds of iron, and 0.05 pounds of copper per day. Most of this probably comes from the lower Joe & Johns waste pile.

The waste rock from both the upper and lower piles had the highest extract concentrations of silver in the Cement Creek area. Both waste rock piles were also high in zinc and copper.

Reclamation Options

The Joe & Johns site is slated for initial reclamation work in 1998. A contract to open the collapsed portal, collect the flow and direct it east around the waste rock pile has been awarded. This will be followed by more in-depth characterization of the mine drainage.

The recommended treatment for this mine drainage is a combination of an anoxic limestone drain, settling pond and sulfate reducing wetland. A bulkhead should be constructed in the adit after it is opened. Limestone should be placed behind the bulkhead. The mine workings will be flooded behind the bulkhead, which should make the drainage anoxic. Prior to opening the adit, the dissolved oxygen content of the mine drainage should be measured to determine if it is currently anoxic. The anoxic limestone drain should raise the pH high enough for sulfate reducing bacteria to survive. From the bulkhead, the mine drainage should be piped to the ridge below the road, where a settling pond can be constructed. Most of the iron and some of the other metals should precipitate in the settling pond. Since most of the metals loading occurs during the warmer months, the temperature of the water should be warm enough to "polish" the metals with a sulfate-reducing wetland. During the winter months however, the sulfate reducing wetland will probably not function, due to cold temperatures. It is recommended that the system be set up to bypass the settling pond during the winter months. This would allow warm water to flow straight to the sulfate-reducing wetland and may enable it to function during the winter.

The waste rock in the drainage at the lower site should be removed. One possibility for a disposal area is at the Lark Mine. A disposal area near the Lark Mine adit could be excavated, then the consolidated mine waste covered with the excavated material. The portion of the upper Joe & Johns waste pile in the stream channel should be removed and consolidated with the portion of the pile outside the stream channel.

Kansas City Mines

Location

The Kansas City Mines are located near the head of Georgia Gulch on the steep north face of McMillan Peak. The site lies at an elevation of 11,768 ft. at LAT. N37°52'55.3", LONG. W107°41'05.0". The site is accessible via a long access road constructed up Georgia Gulch from the Cement Creek road. This site is believed to be on the Kansas City and Henrietta claims.

000117

Two draining mine adits at the main level, referred to as the Kansas City #1, were sampled at stations SO-20 (main adit) and SO-21 (sublevel adit), shown on Figure 5. Station SO-22 at a prospect also shown on Figure 5, was not sampled, because mine drainage was not observed in the fall and was covered by snow in the spring. Three of the four waste rock piles were sampled at sites # 37, 38, and 41, and are shown on Figure 8. A site map on Figure 33, also shows these sampling sites.

Workings
The Kansas City Mines developed a set of veins through a series of adits driven southwest on at least 3 levels. The portal on the main level (Kansas City #1) is on the south side of Georgia Gulch at an elevation of 11,768 ft. A sublevel adit is northeast and below the main level adit at the same site. The upper level portal (Kansas City #2) is located approximately 500 ft. north-northwest of the main adit, 200 ft. higher up the slope. A fourth prospect adit is still farther northwest, adjacent to Georgia Gulch, at an elevation of 11,880 ft.

The individual adits followed three steeply-dipping parallel vein structures. The main level and sub level adits drifted S.32°W. on a vein dipping steeply east. Both portals are still open and discharging mine drainage.

The upper level 200 ft. higher drifted S.32°W. on the extension of the Henrietta 7 vein, which can be traced from Prospect Gulch into this area of Georgia Gulch, and continues through McMillan Peak. This adit is collapsed at the portal. The prospect adit highest up the gulch drifted S.32°W. on a vein dipping 85° east. This adit contains standing water.

Mine Wastes
A moderately-sized combined dump is located at the adit portals of the main and sublevels. This dump is estimated to contain approximately 5,000 cu. yds. of waste materials. The dump is composed of oxidized highly pyritic waste materials, and includes some small areas of base-metal ores. There is a significant kill zone below this set of dumps. This pile was sampled as waste rock sampling site #38.

The waste rock dump at the upper level (Kansas City #2), at an elevation of 12,000 ft. is estimated to contain about 2,500 cu. yds. of fine, clayey oxidized and leached vein materials from the drift workings. A large kill zone extends for about 200 ft. below this pile to just below the access road. This pile was sampled as waste rock sampling site # 37.

The prospect adit dump is estimated to contain about 1,000 cu. yds. of materials similar in nature to the dump just described at the upper level. The toe is being eroded by the creek in Georgia Gulch, which runs along its toe for approximately 50 ft. Some sections appear to be oversteepened by erosion at the toe, and subject to sliding into the creek. The alpine vegetation grows up to the toe of this pile, although there are visible signs that the vegetation within about 50 ft. of the pile is stressed. This pile was sampled as waste rock sampling site #41.

000118

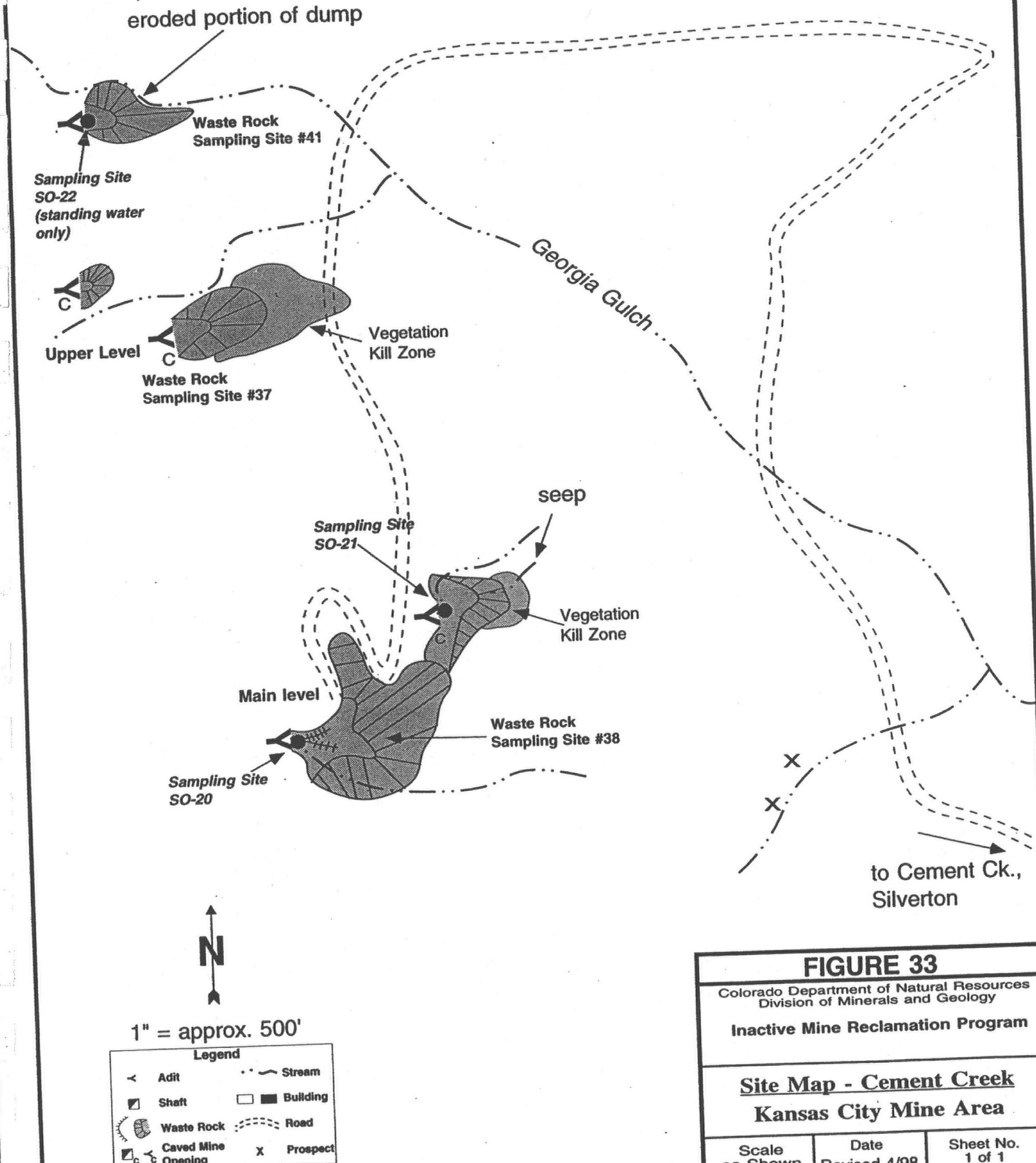

FIGURE 33

Colorado Department of Natural Resources
Division of Minerals and Geology

Inactive Mine Reclamation Program

Site Map - Cement Creek

Kansas City Mine Area

Scale	Date	Sheet No.
as Shown	Revised 4/98	1 of 1

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Total acidity and sulfates for each waste pile are reported below.

Dumps at Kansas City Mines

Site	Total Acidity (mg/l)	ICP Sulfate (mg/l)
Kansas City #1 (Main level)	1,440	1,926
Kansas City #2 (Upper level)	4,800	5,992
Kansas City Prospect	480	1,872

Historic Structures

There are no structures or equipment at any of the Kansas City portals. Anything left has been destroyed by avalanches. Pipes, rail, and other metal parts and debris litter the dump. Tracks still lead out of the main level portal onto the dump. The remains of a house are located across the stream, north of the upper level adit.

Geologic Constraints to Reclamation

The Kansas City Mines area is subject to extreme avalanche danger. Nothing is left at any of the portals due to snowslides in the past. The narrow, steep-sided canyon is exposed to rockfalls and avalanches from all sides. Slopes are steep, and bedrock is shallow. Access is good at the present time, however the road cannot be expected to last many years, and is beginning to wash out in several areas. The road is normally blocked by the remains of snowslides well into August.

Water Quality Impacts

Water quality analyses indicate that these mines are not a significant source of metals to Cement Creek. The metals loading measured at the adits during low-flow and high-flow are all below 0.1 lb/day. However, near the mouth of Georgia Gulch, the zinc loading at high-flow was about 17 lb/day. A large portion of this is probably due to background, but it is also likely that leaching of metals from the waste rock during snowmelt is responsible for much of the zinc loading.

Additional sampling will be necessary to determine the metals contribution from this site. It is recommended that two additional sites be sampled during high-flow. The upper site should be above the prospect adit, and the lower site in the canyon above the alluvial fan. A large portion of the flow from this area is thought to flow underground through the alluvial fan. Furthermore, at the June 1997 sampling, the mine adits were still completely covered with snow. It is likely that the mine drainage increases in quantity after the adits are snow-free. It is thought that the mine drainage was diluted by snowmelt water when sampled in June 1997.

The Kansas City #1 (waste rock sampling site #38) and Kansas City #2 (waste rock sampling site #37) had some of the highest metals concentrations found in the waste rock extracts in the Cement Creek area. The Kansas City #2 dump extract had one of the highest total acidity measurements in the area studied. The waste pile at the prospect adit had much lower metals concentrations in the extract, and had the highest calcium content of any of the dumps sampled.

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Reclamation Options
No treatment of the mine drainages is currently recommended. Reclamation of the waste rock piles at the main level and sublevel will be difficult due to the extremely steep slopes. Both waste piles lay on the edge of a cliff. A portion of the waste rock has been dumped over the cliff or washed over the cliff by avalanches.

Consolidation of the mining wastes at the four adits appears to be the best solution to this possible metals source. The best location for disposal is on the south side of the canyon at approximately the same elevation as the waste piles. The scree/colluvium can be excavated on one of the gentler slopes to form the disposal site. The excavated material can then be used to cover the waste rock. The waste rock at the prospect adit should probably be used as a bottom and top layer. This waste rock is relatively fine, and much less acid forming. The prospect waste rock should be amended with lime or limestone.

LOWER CEMENT CREEK AREA

Location
The Lower Cement Creek area as used here includes several sites along the main stem of Cement Creek between Gladstone and Silverton. Mine sites along Lower Cement Creek selected by DMG and ARSG for reclamation feasibility studies include the Galty Boy, Evelyne Mine, Mammoth Tunnel, BLM Adit, Anglo Saxon and Gold Hub Mines. The locations of these mines are shown on Figures 5 and 8. These sites are situated on privately owned patented lode mining claims. Coordinates of each site are given in the individual site descriptions.

The area is characterized by rugged, steep, high alpine terrain below timberline. Winters are long with snow depths averaging 440 inches. The summer growing season is short. Average annual precipitation for the past 3 years is 45 inches, 37 inches occurring as snowfall (Sunnyside Gold Corporation, 1996).

Geologic Setting

The regional geologic setting of the Cement Creek area is discussed at the beginning of this report. More specific information about the Lower Cement Creek area is included below.

Bedrock Geology
The Lower Cement Creek area is situated 2½ miles east of the western margin of the Silverton Caldera. Caldera rocks in the Lower Cement Creek area consist dominantly of medium to dark, brown and black, thick, massive rhyodacite and dacite flows and flow breccia of the Silverton Group Burns Formation, and rhyodacitic flows, breccias and tuffs of the overlying Henson Formation, which form the slopes and summits of some of the higher peaks above the valley.

Structural Geology
Structurally, the Lower Cement Creek area lies within the Silverton Caldera. The area parallels

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Mineral Creek, 2½ miles to the west, which marks the zone of a complex system of ring-fracture faults related to caldera subsidence. Widely scattered mineralized stringers and faults (veins) in the Lower Cement Creek area trend parallel or sub-parallel to the main ring fault trend of N.22°E. Because the area is south of the complex structure and fracture systems associated with the Eureka Graben, and several miles west of the caldera margin, there are far fewer principal veins and mineralized structures, which limited economic mining activities.

Hydrothermal Alteration

All the volcanic rocks in the Lower Cement Creek area were extensively propylitized and altered on a regional scale, prior to ore deposition. In this area of the Silverton Caldera, propylitic alteration is typified by the formation and addition of chlorite, calcite, and clays in weakly altered rocks, to epidote, albite, and chlorite in the stronger phases. Propylitic alteration has resulted in a dull green or greenish gray color to virtually all of the Burns Formation rocks in the Lower Cement Creek area.

Due to the proximity of the caldera structural margin to the west of Cement Creek, many local areas of the rockmass in the upper headwaters of tributary streams draining the west side of the valley have been highly altered by solfataric and hydrothermal processes. Solfataric processes have subjected the rock to attack and leaching by hot sulphurous gases and solutions moving upwards along the structural margin of the Silverton Caldera. These hydrothermal processes have leached and "stewed" most of the base minerals from the rocks. Volcanic flows in the Ohio Peak - Anvil Mountain area and on the northern side of Prospect Gulch were so strongly altered and leached that little remains except silica, kaolinite, and sulfate and sulfide alteration products. Virtually all potential buffering minerals in the country rock have been leached away, leaving the quartz-allunite-pyrite alteration assemblage characteristic of the Red Mountain District. Bleaching of the rocks and subsequent surficial oxidation of the solfataric pyrite through geologic time has resulted in the brilliant red, orange, and yellow staining which characterizes these areas of alteration.

Ore Mineralization

Economic ore mineralization in the Lower Cement Creek area veins is typically weak, compared to other areas farther north and northeast in the Cement Creek watershed. The veins in solfatarically altered areas are reflective of the quartz-alunite epithermal deposits. The most common ore minerals include enargite, pyrite, sphalerite, galena, bornite, chalcopyrite, proustite, pyargerite, stromeyerite, covellite, and chalcocite (Burbank, 1951). Sulphide minerals found on the mine dumps of the Anglo Saxon include pyrite, enargite, covellite, and chalcopyrite. The deposits were mined in veins, and as disseminations in wall rock, intensely altered to silica, alunite, and clays.

Gangue minerals associated with veins in solfatarically-altered areas consist dominantly of barite, fluorite, and the products of rock alteration, namely clays, quartz, and heavily pyritized wall rock. Virtually all potential buffering minerals have been leached away.

Vein ores in Lower Cement Creek area in non-solfatized rock consist of pyrite, chalcopyrite, sphalerite, and galena, sometimes with tetrahedrite and tennanite. Occasional silver was associated with argentiferous tetrahedrite, and less commonly with silver sulfo salts. Very rare free gold occurred in isolated shoots scattered in siliceous gangues, or associated with the base metal ore minerals.

Gangue minerals associated with veins in the Lower Cement Creek area normally include quartz, rhodonite, rhodochrosite, calcite, fluorite, and barite. There is generally more potential for the presence of buffering minerals in vein deposits which are not associated with solfatized rocks. Solfataric processes near the western margins of the lower Cement Creek valley watershed have depleted base mineral constituents in the country rocks, and buffering minerals are depleted.

Surficial Geology

Slopes around Lower Cement Creek are steep, and prone to avalanches and debris flows. Almost all the steep ravines between Gladstone and Silverton have well-formed debris cones and fans where they impinge on Cement Creek. The upper slopes of Ohio and Storm Peaks are mantled with thick aprons of scree and talus, which act as source areas for debris flows moving down the many steep gulches and ravines which empty into Cement Creek. Much of this natural talus and slope debris material is stained bright red and yellow, resembling oxidized mine dump material. Tests show most of this colluvial material to be so highly leached and oxidized through geologic time, that it is not a source of significant metals releases.

The avalanche danger in Lower Cement Creek is high to moderate. Numerous avalanche chutes exist on both the east and west sides of the creek almost all the way down to Silverton. Snowslides often run all the way down to Cement Creek in several areas, though they are more prevalent in the upper parts of the tributaries above the valley.

Extensive boggy, colluvial and landslide deposits exist in the upper reaches of Porcupine and Ohio gulches below Ohio Peak. These deposits are characterized by thick, black soils developed on fine to coarse gravelly and cobbly and bouldery colluvial materials. Colluvial and alluvial soils exposed along some of the upper slopes and along first order streams in the upper tributary gulches have locally been cemented with iron oxide, forming ferricrete deposits, as have many of the terrace gravels and colluvial deposits along Cement Creek.

Alluvial gravels are present along Cement Creek. Ferricrete deposits have resulted from iron-rich groundwater redepositing hematite and other iron compounds in the interstitial spaces of alluvial and terrace gravels. The "cemented" nature of gravel and colluvium outcrops along the creek gave rise to its name.

Lower Cement Creek Mine Site Descriptions

The mine sites included for feasibility assessments are the Galty Boy Mine, Evelyne Mine, Mammoth Tunnel, BLM adit, Anglo Saxon and Gold Hub Mines. These are described below and shown on Figures 5 and 8.

Galty Boy Mine

Location

The Galty Boy Mine is located on the west side of Dry Gulch 1/4 mile above Cement Creek, where County Rd. 35 crosses the stream channel of Dry Gulch. The mine is at an elevation of 10,980 ft. at LAT. N37°53'31.9", LONG. W107°39'52.2". This site is believed to be on the Gold Dollar claim. The waste rock pile was sampled as site #40, shown on Figure 7.

Workings

A collapsed adit was driven west into the hillside approximately 50 ft. above Dry Gulch. There is no visible drainage from the mine adit.

Mine Wastes

The Galty Boy Mine dump was estimated to contain approximately 1,000 cu. yds. of material. The toe of the waste pile is located in the streambed, and a portion has been eroded away. It also appears that some of the waste rock has been moved downslope by avalanches. The waste rock contains some pyrite and hübnerite.

Total acidity and sulfates are shown below.

Galty Boy Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
110	76

Historic Structures

There are no structures at this site. There is some wooden debris and metal on the mine dump.

Geologic Constraints to Reclamation

The Galty Boy site is prone to avalanches. The large, steep open slope above the site could result in some large destructive slides, as evidenced by the apparent movement of waste rock down the slope. Rockfalls and talus slides are common occurrences, as shown by slides into the old access road. The entire site area is situated in loose, blocky talus deposits. There are no soils or stable areas nearby. Access is poor from the Prospect Gulch road, and would have to be improved for equipment to reach the site.

Water Quality Impacts

Water quality impacts from this site are minimal. The waste rock analyses indicate that there are very few metals leached from this pile. The material eroded into Dry Gulch probably does provide some metals, but Dry Gulch has surface flow for only a short period during the spring.

Reclamation Options

This site has minimal impacts to water quality. Any work done on the waste pile would be costly,

000124

since the access road into the site is overgrown, filled in, and washed out in places. The entrance to the road, from the Prospect Gulch road, is now a 20 foot vertical face. The waste rock does not appear to be a significant source of heavy metals. It is therefore recommended that no reclamation be performed on the waste rock pile.

Evelyne Mine

Location

The Evelyne Mine is located on an unpatented claim on the west side of Dry Gulch approximately 100 yards above where County Rd. 35 crosses the stream channel of Dry Gulch. The mine is at an elevation of 10,600 ft. at LAT. N37°53'03.3", LONG. W107°39'17.9". The mine drainage was sampled as station SO-24, shown on Figure 5. The waste rock pile was sampled as site #39, shown on Figure 8.

Workings

An adit was driven west into the hillside approximately 100 ft. above Dry Gulch. The mine adit drains approximately 2-60 gpm of iron-rich water.

Mine Wastes

A small waste pile, consisting mostly of country rock, is located along the steep slope outside the adit. Much of the waste rock has been cemented with iron oxyhydroxides from the mine drainage. Very little mineralization was found in the waste rock. The waste rock extract analyses, a portion of which are shown below, indicate that the metals concentrations, in general, are only slightly above background samples. The only remarkable characteristic of this dump is that the waste rock had one of the higher chromium concentrations found in Cement Creek.

Evelyne Mine Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
90	64

Historic Structures

There are no structures at this site. There is some wooden debris on the mine dump.

Geologic Constraints to Reclamation

The Evelyne site is not prone to avalanches. The slope above the site is forested with mature spruce and fir. The entire site area is situated in steep, loose talus and colluvium. There are no soils or stable areas nearby. Access is poor from the Prospect Gulch road and would have to be improved for equipment to reach the site.

Water Quality Impacts

Water quality impacts from this site at low-flow are minimal. At low-flow, the adit drains approximately 2 gpm. This flow increases to about 60 gpm during high-flow. At high-flow, the metals loading from the adit were about 0.6 pound of zinc, 18 pounds of iron, and 0.2 pound of copper per day. The mine drainage quickly infiltrates the waste rock and talus/colluvium below the mine site. No surface flow has been observed to enter Dry Gulch.

The waste rock analyses indicate that there are very few metals leached from this pile.

Reclamation Options

During most of the year, this site has minimal impacts to water quality. Much of the iron is probably removed by flowing through the talus/colluvium, even at high-flow. Treatment of this drainage is somewhat problematic because the adit is located on a steep slope. There are no areas nearby, without crossing the Dry Gulch channel, where a treatment system could be constructed. If a suitable site can be located, most of the metals in the mine drainage can be removed with a settling pond. The mine drainage would have to be piped down the steep slope to the settling pond, or follow the old access road to the southwest. Another option to be considered is bulkheading the adit. The surrounding rock appears to have many fractures, but the rock inside the adit may be tighter. The mine workings should be investigated to determine if this is an option.

The waste rock does not appear to be a significant source of heavy metals. The waste rock appears to be removing metals from the mine drainage. It is recommended that no reclamation be done on the waste rock pile.

Mammoth Tunnel

Location

The Mammoth Tunnel is located on the west side of Cement Creek near the mouth of Georgia Gulch. The road to the Kansas City Mines crosses this mine site. The Mammoth Tunnel is at an elevation of 10,400 ft. at LAT. N37°52'42.3", LONG. W107°40'10.7". The tunnel is believed to be on the Dooley claim. The mine drainage was sampled as station SO-18, shown on Figure 5. The waste rock pile was sampled as site #32, shown on Figure 8.

Workings

An adit was driven west into the hillside approximately 100 ft. above Cement Creek. The mine adit drains approximately 20-30 gpm of iron-rich water. This adit is a cross cut, reportedly driven to intercept lower levels of ore at the Henrietta Mine. According to verbal reports (Fearn, 1994), the tunnel was abandoned before reaching the Henrietta.

Mine Wastes

As would be expected, the waste pile consists mostly of country rock. The waste rock is very coarse with iron oxyhydroxide staining on the exposed portions. Very little mineralization was found in the waste rock. The waste rock extract analyses, a portion of which are shown below, indicate that metals concentrations, in general, are only slightly above background samples. The only remarkable characteristic of this dump is that the waste rock had one of the higher cobalt concentrations found in Cement Creek.

Mammoth Tunnel Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
5	86

Historic Structures
There is one small wooden building covered with corrugated sheet metal on the waste pile. There is some wooden debris on the mine dump.

Geologic Constraints to Reclamation
The Mammoth Tunnel site is not prone to avalanches. The slope above the site is forested with mature spruce and fir. The entire site area is situated in steep, loose talus and colluvium. There are some debris flow materials nearby that could be used as a cover material. The slopes below the mine are fairly gentle.

Water Quality Impacts
Dissolved zinc and iron loadings from this site remain fairly constant throughout the year. It is likely that the tunnel intercepted a fracture or series of fractures that connect to the natural iron springs. The zinc load from this drainage is about 0.5 lb/day, while the iron load ranges from 20 to 30 lb/day. The copper load from this site is less than 0.1 lb/day. Since the metal load varies very little through the year, the overall effect of this site is the greatest at low-flow. At low-flow, this mine contributes the second highest dissolved metal load of all the draining mines (approximately 11%), including about 15% of the iron and 16% of the nickel. At high-flow, this site contributes the third highest dissolved metal load (approximately 4.5 lb/day) in the Cement Creek area The mine drainage flows over the waste rock onto the alluvial fan at the mouth of Georgia Gulch. Most of the mine drainage infiltrates into the fan material before it reaches Cement Creek.

The waste rock analyses indicate that there are very few metals leached from this pile. Visual observations indicate that the waste rock is supplying some treatment to the mine drainage.

Reclamation Options
The majority of the metals in this mine drainage can be removed by constructing a series of settling ponds. The high ratio of iron to zinc and other metals should aid in co-precipitation of the other metals. The mine drainage is anoxic as it wells up from the top of the collapsed adit. The dissolved oxygen measured in August 1996 was 0.6 mg/l with saturation at 7.6 mg/l. It is recommended that a lined channel be constructed with a series of drops to aerate the drainage. This should be followed by a series of settling ponds connected by a channel with aeration drops. The settling ponds should have a combined capacity of approximately 400 cu. yds.. The estimated amount of sediment generated each year is 70 cu. yds., assuming no consolidation. The settling pond system should be set up to allow one pond to dry each year. The sediment volume should shrink by 80 to 90 % upon drying. After the sediment has dried, it can either be removed, or left to accumulate over a period of years. If additional metals removal is desired, the effluent from the last sediment pond can be passed through a sand/limestone filter. This will remove most of the

remaining zinc and manganese, and increase the pH of the final effluent.

It is recommended that no reclamation be done on the waste rock pile. The waste rock does not seem to be a significant source of heavy metals and actually appears to be removing metals from the mine drainage.

BLM Adit Near Fairview Gulch (Elk Tunnel)

Location
This mine is located on an unpatented claim on the west side of Cement Creek near Fairview Gulch. A side road on the west side of Cement Creek between Georgia Gulch and Minnesota Gulch is used to access this site. The mine is at an elevation of 10,200 ft. at LAT. N37°52'9.0", LONG. W107°40'27.4". The mine drainage was sampled at water quality sampling station SO-19, shown on Figure 5. The waste rock pile was sampled as sites #33 and #49, shown on Figure 8.

Workings
An adit was driven west into the hillside approximately 100 ft. above Cement Creek. The mine adit drains approximately 170 gpm of iron-rich water. This adit is suspected to be a cross cut to a vein located further up the slope.

Mine Wastes
The waste pile is approximately 1,100 cu. yds. and consists mostly of country rock. The waste rock is very coarse with iron oxyhydroxide staining on the exposed portions. Very little mineralization was found in the waste rock. The waste rock extract analyses, a portion of which are shown below, indicate that the metals concentrations, in general, are within the range of background samples. The only remarkable characteristic of this dump is that the waste rock had one of the higher antimony concentrations found in Cement Creek. Combined with the high arsenic in the water, these facts suggest that the ore mined here was probably an arsenic/antimony sulfide such as enargite or tetrahedrite.

Dump at BLM Adit

Total Acidity (mg/l)	ICP Sulfate (mg/l)
3	26

Historic Structures
There is one small wooden building on the mine dump. The building is in the process of collapsing. Most of the roof has already collapsed. There is some wooden debris on the mine dump.

Geologic Constraints to Reclamation
This site is not prone to avalanches. The slope above the site is forested with mature spruce and fir. The entire site area is situated in steep colluvium. There are debris flow materials nearby that could be used as a cover material.

Water Quality Impacts
Like the Mammoth Tunnel to the north, dissolved zinc and iron loading from this site remains fairly constant throughout the year. It is likely that the mine tunnel intercepted a fracture or series of fractures that connect to the natural iron springs. The zinc load from this drainage ranges from about 0.4 to 0.7 lb/day, while the iron load is about 7 lb/day. The copper concentrations in the mine drainage are below detection limits. Since the metal load varies very little through the year, the overall effect of this site is the greatest at low-flow. At low-flow, this mine contributes about 5% of the metals from all the draining mines, including about 21% of the arsenic and 9% of the manganese. At high-flow, this site contributes about 1.5% of the metals from draining mines, including 9% of the arsenic and 4.5% of the manganese. The mine drainage flows over a portion of the waste rock onto colluvium, down a steep iron-stained channel into Cement Creek.

The waste rock analyses indicate that there are very few metals leached from this pile.

Reclamation Options
The majority of the metals in this mine drainage can be removed by constructing a series of settling ponds. A series of ponds could be constructed along the historic access road to the site. The high ratio of iron to zinc and other metals should aid in co-precipitation of the other metals. The settling ponds should have an aggregate capacity of approximately 1,300 cu. yds.. The estimated amount of sediment generated each year is 20 cu. yds., assuming no consolidation. The settling pond system should be set up to allow one pond to dry each year. The sediment volume should shrink by 80 to 90 % upon drying. After the sediment has dried, it can either be removed, or left in the bottom to accumulate over a period of years. If additional metals removal is desired, the effluent from the last sediment pond can be passed through a sand/limestone filter. This will remove most of the remaining zinc and manganese, and increase the pH of the final effluent.

The waste rock does not appear to be a significant source of heavy metals. It is recommended that no reclamation be performed on the waste rock pile.

Anglo Saxon Mine

Location
The Anglo Saxon Mine is adjacent to State Route 110 on the west side of lower Cement Creek about 3 miles upstream from Silverton. This mine consists of two adits, a main adit and the Porcupine Gulch adit. The main adit is located at LAT. N37°51'25.5", LONG. W107°40'40.5" at an elevation of 10,080 ft. The main mine adit drainage was sampled as station SO-16. The waste rock at the main adit was sampled as site #28. The Porcupine Gulch adit is located at LAT. N37°51'32.3", LONG. W107°40'46.6" in Porcupine Gulch, approximately 500 ft. above the Cement Creek Road, at an elevation of 10,200 ft. The Porcupine Gulch adit was sampled as station SO-23. The waste rock at the Porcupine Gulch adit was sampled as sites #36 and 44. These sites are bracketed by water quality sampling stations CC-29 and CC-31 along Cement Creek.

The Anglo Saxon adits are believed to be located on the Anglo Saxon Placer and Anglo Saxon 1, 2 and 3 claims. Locations of water quality sampling sites are shown on Figure 5. Locations of waste rock sampling sites are shown on Figure 8. A site map is shown on Figure 34.

Workings

This site includes two adits driven northwest, which prospected quartz-sulphide veins. The main adit, just above the road level, is collapsed at the surface, but still discharges about 40-60 gpm of metals-laden water. The discharge flows across a partly eroded dump, then cascades down to the road, flowing under it in a culvert to a constructed settling pond, before continuing to Cement Creek. The second adit is about 500 ft. up Porcupine Gulch on the north side, 200 ft. higher than the main adit in elevation. This adit has been buried by talus and colluvium. A spring issues from the collapsed portal, discharging 40-55 gpm. Most of the water in Porcupine Gulch during low-flow periods is discharge from this mine portal.

Mine Wastes

The dump at the main portal contains approximately 2,200 cu. yds. of mostly fine to medium grained sulphide mine waste consisting almost entirely of pyrite and altered country rock, mixed with quartz. Cribbing supports the dumps "toe", preventing it from falling into the road, which runs adjacent to it.

A thick deposit of orange ferric hydroxides has formed on the main adit dump where discharge from the portal has flowed across it. This orange sludge deposit continues over the dump, then under the road, where it has settled out in a constructed pond, and in natural wetland areas along Cement Creek.

The dump at the Porcupine Gulch adit has steep sides, contains about 1,600 cu. yds., and is being eroded by Porcupine Gulch during high flows. The top portion of the dump is principally crystalline iron pyrite. The side slopes are primarily country rock, with massive crystalline pyrite, along with some hübnerite and fluorite.

Total acidity and sulfates for the waste piles are reported below.

Anglo Saxon Mine Dumps

Site	Total Acidity (mg/l)	ICP Sulfate (mg/l)
Main Adit	1,840	2,004
Porcupine Adit-Top of Pile	1,380	1,219
Porcupine Adit-Side slopes	640	659

Historic Structures

There is an old shack and collapsed portal shed on the lower dump at the main adit. The shack appears to be fairly modern, constructed of 2x4 boards and corrugated tin. The portal shed, of timber post and cap construction and lagged on the inside, has collapsed. The cribbing which

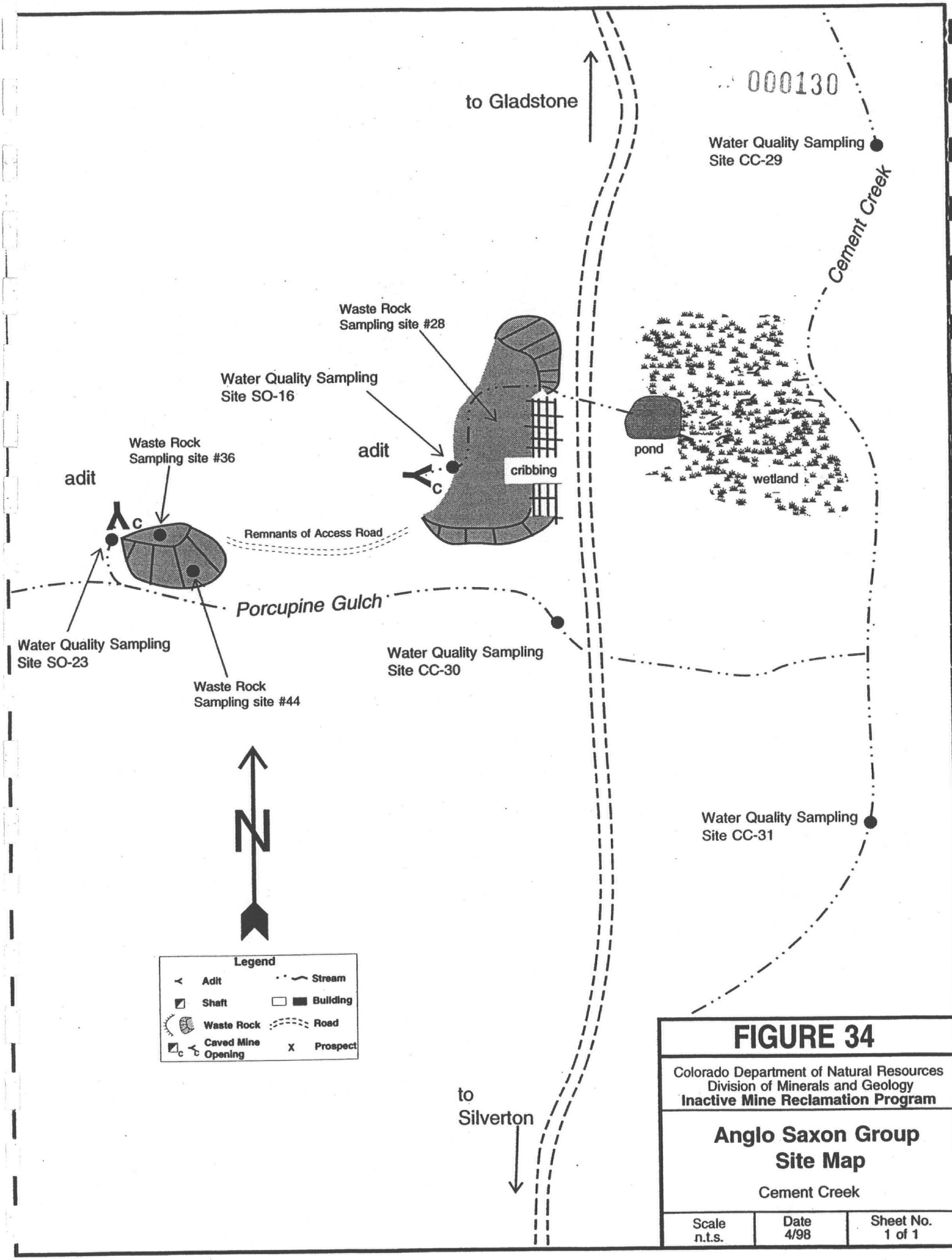

FIGURE 34

Colorado Department of Natural Resources
Division of Minerals and Geology
Inactive Mine Reclamation Program

Anglo Saxon Group Site Map

Cement Creek

Scale	Date	Sheet No.
n.t.s.	4/98	1 of 1

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supports the dump along the road appears to be leaning outward, and is in a deteriorating condition. Rails lead out from the collapsed portal.

There are no structures at the Porcupine Gulch portal.

Geologic Constraints to Reclamation

This site is generally outside extreme avalanche danger. Exceptionally large slides might move down Grassy Gulch on the opposite side of the valley and run across Cement Creek, but this would be an unusual occurrence.

There is a large, active debris fan at the mouth of Porcupine Gulch, immediately adjacent to the site. This debris fan runs occasionally, and is a maintenance problem for road crews. It does not directly affect the lower site, except potential access routes and areas on the south side of the lower site. It does complicate access to the upper adit site, as it would have to be crossed at some point, and such a crossing and adjacent roads would eventually be destroyed by debris flows.

Water Quality Impacts

The drainage from the main adit is the third largest loader of dissolved metals during low-flow, and the fourth largest dissolved metals loader during high-flow. The majority of the dissolved load is iron. During low-flow, the dissolved metal load is about 21.5 lb/day, including about 1.5 pounds of zinc and 7 pounds of iron per day. There is very little copper in the mine drainage. At high-flow, the main adit produces about 31 pounds of dissolved metals per day, including about 2 pounds of zinc and 23 pounds of iron per day. During low-flow, it appears that the wetland and small settling pond remove most of the iron. However, during high-flow, there appears to be no attenuation of iron.

The drainage from the Porcupine Gulch adit produces about 16.5 pounds of dissolved metals per day at low-flow, including 1 pound of zinc and about 10 pounds of iron. During low-flow, most of the iron and about half the zinc precipitates in the stream channel of Porcupine Gulch. At high-flow, the mine drainage produces about 25 pounds of dissolved metals per day, including 2 pounds of zinc, 13 pounds of iron and 0.1 pounds of copper.

The waste rock analyses show that the waste rock at the main adit is acid forming, high in iron and zinc, and high in copper, which does not show up in the mine drainage. The waste rock also had high titanium and vanadium concentrations. There does not appear to be much upland runoff that flows onto the waste pile. Most of the material above this site is highly porous.

The waste pile at the Porcupine Gulch adit is, overall, similar to the main level waste pile. The mine waste is high in iron, zinc, and copper. However, there is probably some upland runoff that flows onto the waste rock at this site. In addition, some of the waste rock has been eroded from the toe of the pile in the past.

Reclamation Options

The majority of the metals in both mine drainages can be removed by constructing a series of

000132

settling ponds. The high ratio of iron to zinc and other metals should aid in co-precipitation of the other metals. The settling ponds at the main adit should be constructed southeast of the adit, near Porcupine Gulch. The main adit will have to be opened here to allow the drainage to oxygenate in the workings. With the adit collapsed, the mine drainage is anoxic. There is insufficient room at this site to aerate the water before it enters the settling pond. The settling ponds for the Porcupine Gulch adit can be constructed along the terrace toward the main adit. The settling ponds at the main adit should have an aggregate capacity of approximately 600 cu. yds.. The settling ponds at the upper adit should have an aggregate capacity of approximately 500 cu. yds.. The estimated amount of sediment generated each year is about 60 cu. yds. at the main adit and about 50 cu. yds. at the upper adit, assuming no consolidation. The settling pond system should be set up to allow one pond to dry each year. The sediment volume should shrink by 80 to 90 % upon drying. After the sediment has dried, it can either be removed, or left to accumulate over a period of years. If additional metals removal is desired, the effluent from the last sediment pond can be passed through a sand/limestone filter. This will remove most of the remaining zinc and manganese, and increase the pH of the final effluent.

If settling ponds are constructed at these mines, the excavated material can be used to cover the mine waste. At the main adit, it is recommended that only the top of the mine waste be reclaimed. This site is viewed by many tourists during the summer. Leaving the slopes in their present condition will maintain the historic flavor of this site. The entire waste rock pile at the Porcupine Gulch adit should be covered and revegetated, after moving about 300 cu. yds. of waste rock from the toe of the slope. Upland diversions should also be constructed at this site.

Gold Hub Mine

Location

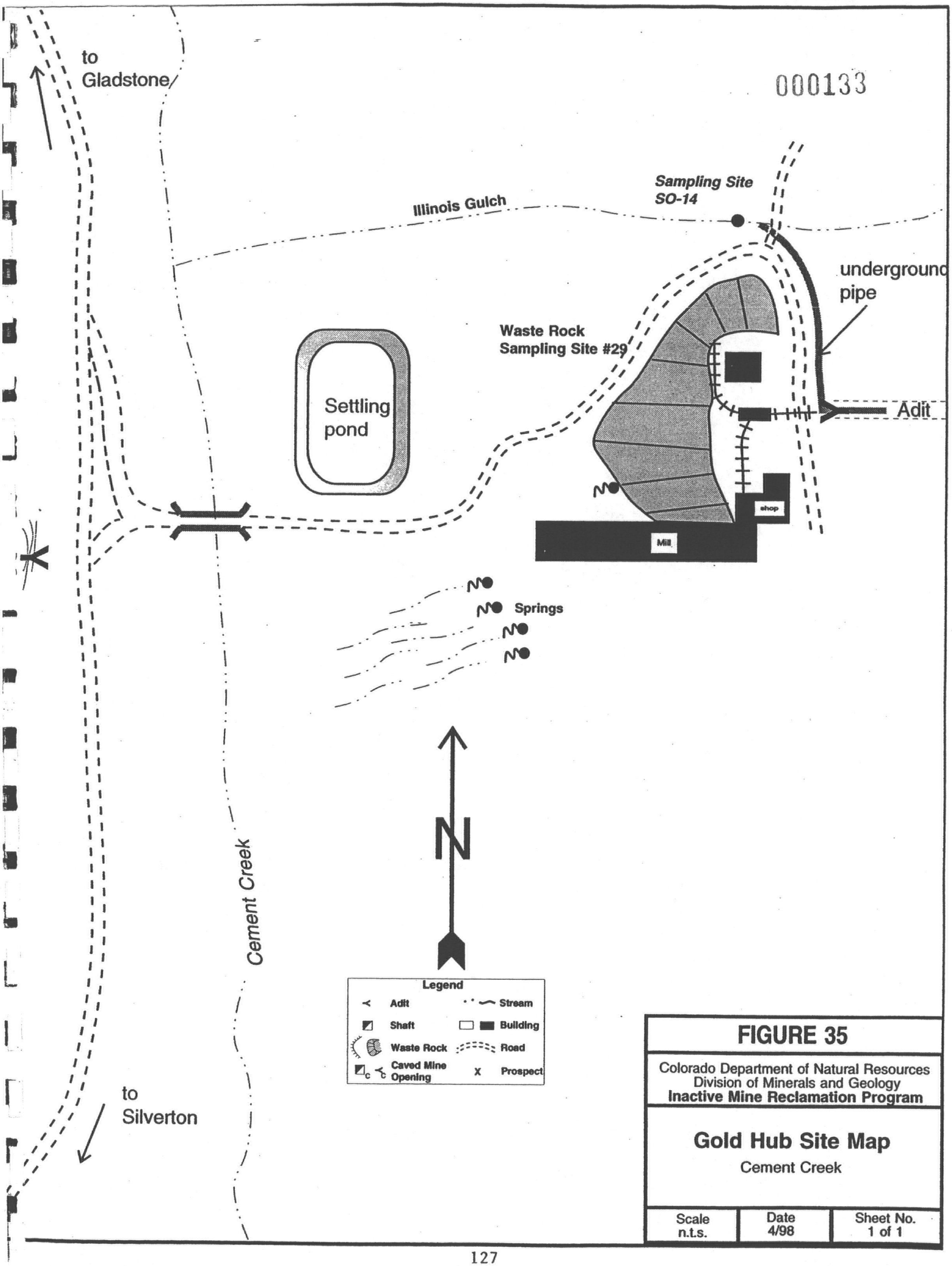
This mine is at an elevation of 10,080 ft. at LAT. N37°51'3.6", LONG. W107°40'31.5". It lies on the east side of lower Cement Creek along State Route 110 about 2½ miles upstream from Silverton. Access is via an old bridge across Cement Creek. The mine drainage at this site was sampled at water quality sampling station SO-14, shown on Figure 5. The waste rock at this site was sampled at station #29, shown on Figure 8. These sites are also shown on the site map on Figure 35.

Workings

The adit at this mine appears to be a crosscut driven east beneath Storm Peak to explore mineralized veins. Little is known about the workings, other than that they are extensive, based on the size of the dump and mining infrastructure at the site. The portal is intact, but flooded to a depth of 2½ ft., discouraging access. Water flows out of the portal in a pipe to a ditch constructed on the top of the dump, then drains back into the adit, where a sump has been constructed just inside. This sump collects the mine water, then runs it underground in a pipe, to a discharge point in Illinois Gulch adjacent to the site. Discharge from this adit was measured at about 550 gpm.

Mine Wastes

A large dump at the portal contains approximately 18,000 cu. yds. of mostly altered and barren country rock. It has some areas mixed with sulphide vein wastes, particularly near the mill. There


to
Gladstone
000133
Sampling Site
SO-14
Illinois Gulch
underground
pipe
Waste Rock
Sampling Site #29
Settling
pond
Adit
shop
Mill
Springs
Cement Creek
Legend
Adit
Stream
Shaft
Building
Waste Rock
Road
Caved Mine
Opening
Prospect
to
Silverton
FIGURE 35
Colorado Department of Natural Resources
Division of Minerals and Geology
Inactive Mine Reclamation Program
Gold Hub Site Map
Cement Creek
Scale
n.t.s.
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are also some small stockpiles of base-metal sulphide ores on top of the dump, near an ore shed.

Much of the waste pile is wet throughout the year. Several springs issue from below the waste pile. These springs may be the result of water leaching through the waste pile. Water from the springs was not sampled.

Waste rock extract analyses were conducted on a composite sample containing both country rock and ore waste. Total acidity and sulfates of that composite sample are shown below.

Gold Hub Mine Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
20	97

A thick accumulation of orange ferric hydroxides has been deposited in a series of settling ponds constructed below the dump, adjacent to Cement Creek, as shown on Figure 35. The portal discharge used to flow through this pond, but has since been diverted to Illinois Gulch. It is not clear whether the ponds were constructed as part of the milling operation, or for settling and treatment of the mine discharge.

Historic Structures

There is a fairly intact set of mine buildings and infrastructure at this site. A large modern multi-level sheet-metal clad mill exists on the south side of the dump. A maintenance shop and motor storage shed has partially collapsed near the portal. Tracks lead from the portal to the top of the mill, as well as out to the dump tipping area. An open storage shed is constructed on the north side of the dump, adjacent to the ore stockpiles. There is also an empty steel fuel tank, and scattered lumber and metal debris. The mine appears to have been in operation in the recent past, so there may be little historical value in the remaining structures.

Geologic Constraints to Reclamation

This site is generally outside avalanche danger areas. A heavy, mature forest covers the steep west-facing slopes above the property. Snowslides are not known to move down Illinois Gulch.

There is a small active debris fan at the mouth of Illinois Gulch, immediately to the north of the site. This debris fan runs occasionally, but does not directly affect the site.

A moderate to high potential for fracture-flow groundwater-minepool interactions might complicate the potential mine drainage reclamation strategies at this site. The fractured, jointed, highly altered nature of the bedrock could be allowing seepage from the adit to enter the groundwater system. If a treatment system is contemplated to address adit discharges, it will be necessary to determine any potential groundwater loadings which leave the site and are not seen as surface flows at the portal. Collection of these water flows from the adit for treatment could also be problematic. If this is the case, it may be necessary to re-enter the adit to a point beyond fracture influences and place a grout-sealed bulkhead water-inlet to collect the flow before it escapes into the fractured bedrock.

Water Quality Impacts
The amount of drainage from this mine is very high, but, in general, the heavy metal concentrations are low. The exception is iron concentrations at low-flow. At low-flow, the mine drainage produces about 7% of the dissolved metals from draining mines in Cement Creek, and about 1% during high-flow. At low-flow, the dissolved metals amount to about 17 lb/day including 0.6 pounds of zinc and 7 pounds of iron per day. At high-flow, the mine drainage produces about 7 pounds of dissolved metals, including 1 pound of zinc and 2 pounds of iron per day.

The waste rock sample taken at this site was a composite sample including both the country rock and ore waste. Waste rock extract analyses show that the metals content of the waste rock is generally low. However, it is likely that the ore waste is considerably higher in heavy metals than what is reported here for the combined material.

Much of the waste rock pile is wet throughout the year. Runoff from the area above the mine site has been observed to flow onto the waste rock during snowmelt and thunderstorms. This water plus the mine drainage or spring flow could have a greater overall effect on water quality than the mine drainage. Water quality samples should be taken at the springs below the waste pile to determine the metals loading from this source.

Reclamation Options
This mine was active in the recent past and the DMG has revoked the reclamation bond for this site. However, the amount of money in the reclamation bond probably will only cover proper securing of the mine adit.

The only treatment recommended for the mine drainage is to clean out the existing settling pond, and divert the mine drainage into it through lined drainage ditches. This should remove most of the iron and aluminum and a portion of the zinc and manganese. Diversion ditches should be constructed to route upland flow away from the waste rock pile.

OTHER SITE OF INTEREST

Corkscrew Pass Mine

Location
This unnamed mine is located near the top of Corkscrew Pass on the Cement Creek side at LAT. N37°54'26.9", LONG. W107°39'35. The mine is located on the drainage divide, near two alpine ponds. The west pond flows into Red Mountain Creek, and the east pond flows into Cement Creek. The collapsed adit has not been observed to drain. Leachate from the waste rock colors the water in the east pond red. This pond is fed by a snowfield on the talus slope above the mine. During snowmelt, the pond overflows into a tributary of Cement Creek. During late summer and early fall, the water level in the pond slowly drops. The waste rock at this mine was sampled as

site #11 and 50, shown on Figure 6. The mine site is believed to be on the Judson or Newport claim.

Workings

An adit was driven north into the hillside at the base of talus near the top of Corkscrew Pass. The adit is collapsed and not draining.

Mine Wastes

There are approximately 1,300 cu. yds. of waste rock at this site. The principal mineral found in the waste pile was iron pyrite. The pyrite is often in 1-5 mm crystals. There is some sphalerite, enargite, arsenopyrite and galena in the waste rock.

Total acidity and sulfates for this waste pile are reported below. The leachate from this waste pile had the greatest acidity of all the waste piles tested in Cement Creek. Arsenic and iron levels were the highest of all the samples tested. The leachate showed that copper and aluminum levels are also high.

Corkscrew Pass Dump

Total Acidity (mg/l)	ICP Sulfate (mg/l)
7,610	7,160

Historic Structures

There are no structures at this site. The remains of a building rest at the adit entrance.

Geologic Constraints to Reclamation

This mine sits near the top of a ridge on the south slope of Red Mountain No. 1, so there is not much avalanche danger. The mine site is situated in rocky outcrops, talus, and large blocky colluvial material. There are no suitable cover materials or topsoil nearby. Access is poor, and would have to be improved for equipment to reach the site.

Water Quality Impacts

Because of the distance to Cement Creek, natural attenuation of metals probably makes this site a minor source. There is some visual evidence that the metal-laden drainage in the alpine pond occasionally does overtop and flow toward Cement Creek.

Reclamation Options

This site is an excellent area to test cementation of waste rock in-place. The access to the site is the only problem. Equipment to cement the waste rock will have to be carried in a small truck. The water quality in the pond should be tested before any work is done on this site to determine reclamation success.

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RECOMMENDATIONS FOR FURTHER INVESTIGATION

This investigation focused only on the metals contributions of surface mine waste and surface mine portal discharge sources in the Cement Creek basin. The mining-related groundwater sources were not considered here and have not, as yet, been investigated. Groundwater flow from the mines currently provides an unquantified pathway for contamination to enter the creek. Data on groundwater quality and quantities are essential to understand the hydrologic system and metals migration in Cement Creek. It is therefore recommended that drillholes and wells be placed near some of the mines exhibiting likely interactions with the groundwater system to collect additional data. Some of the mines in this category include the Grand Mogul-East Adit, Mogul Mine, Mine South of Mogul, Red & Bonita Mine, Henrietta Mine, Lark Mine, Georgia Gulch and Evelyne Mine.

Several unanswered questions also remain about some of the mining sites discussed. These issues were discussed in the narrative for each individual site in this report. In most cases, the unanswered question must be investigated prior to a final decision on the best reclamation option. In many cases, the answer to the question may simply involve a water sample. However, in some cases, the answer may be more involved to better understand the site hydrology. For easy reference, these questions are consolidated and reviewed below.

Upper Cement Creek - Water quality sampling stations CC-5 and CC-6 are in Upper Cement Creek and bracket the Mogul Mine and the unknown mine sampled at site SO-7 (Figure 3). Between stations CC-5 and CC-6, dissolved copper concentrations increased during low-flow and high-flow. At low-flow, the increase in copper load between these two stations is consistent with the load from the Mogul Mine and there was no drainage from the mine at sampling site SO-7. However, at high-flow, the downstream loading increase is greater than what can be accounted for at the two draining mines. A portion of the increased loading is probably from snowmelt and mine drainage leaching of the waste rock, but the small south-flowing tributary which enters Cement Creek just downstream of sampling site CC-5 may also be a partial source. This tributary should be investigated further.

Ross Basin Upper Site - There are several small waste piles at this site, which contain acid forming materials. Some of these piles are located near small prospect shafts. These shafts should be investigated to determine whether the waste rock can be simply placed back in the mine opening, covered and revegetated.

Ross Basin Lower Site - Sampling site CC-3 was located as a background water quality site for upper Cement Creek from Ross Basin (Figure 3). However, low-flow and high-flow sampling shows that a significant zinc load comes from the area above. There are numerous prospects, a few small mines, and one large mine above this site. The large mine, labelled here as the Ross Basin Lower Site, is approximately 200 yards above the sampling site (shown at waste rock sampling site #31 on Figure 6). A portion of the zinc load is thought to come from this large mine site, particularly during spring snow melt. It is recommended that a water quality monitoring station be added to bracket this area. The monitoring site should be set at the bottom of the cascade from

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Ross Basin. This is immediately above where white precipitate has been observed to form in the channel.

There are several small waste rock piles located near small prospect shafts. These shafts should be investigated to determine whether the waste rock can be simply placed back in the mine opening, covered and revegetated.

Grand Mogul-East Adit - Before any definite reclamation measures are developed at this mine site, the source of the acid rock drainage flowing from the waste rock pile must be determined. This can be done by drilling into the mine workings or driving a well point through the collapsed adit to evaluate whether there is water in the adit. If the mine workings are the source of water, the adit should be reopened, so the drainage can be diverted from the waste rock pile and characterized. If the source of the drainage is a spring, either the waste rock must be moved to a relatively drier site, or the spring flow must be intercepted and diverted away from the waste rock.

Mine North of Mogul - The spring/mine drainage flowing from near the edge of the waste rock pile should be monitored at least one time to determine whether any further investigations are warranted.

Mogul Mine - There is an inclined shaft which may connect to the Mogul adit 850 ft. northeast of the portal. The shaft collar is 201 ft. above the Mogul level on the same vein (Figure 3). It was constructed adjacent to Cement Creek, and includes a diversion dam and pipe intake through its side, which may have been used to deliver water for drilling to the main Mogul adit level, though this connection has not been verified. The shaft is still open, but the pipe intake has been disconnected. If this shaft connects to the Mogul, it could be allowing groundwater from Cement Creek 25 ft. away to enter the mine workings. There is also an open stope present in the area. This shaft and the open stope could be allowing water to directly enter the Mogul Mine workings, and may be significantly contributing to the total portal discharge. These should be investigated to determine their influence on the portal discharge and to assess the feasibility of source control approaches to control the flow. Source control approaches include methods of preventing water from flowing into the mine, such as stream diversion, lining the stream, or shallow fracture grouting.

Mine South of Mogul - This collapsed mine adit drains about 13 gpm from late spring through early summer. The adit should be reopened to determine if there is perennial drainage from the mine.

Red and Bonita Mine - The adit at this mine is collapsed, but still drains approximately 5 gpm of zinc-laden water during high-flow (Figure 3). It should be determined if there is any perennial flow from the mine workings. A well point could be driven through the collapsed portion of the mine, or the adit can be reopened. If the mine drainage is seasonal, reclamation of the barren ferricrete area can serve as the treatment system for this site. If there is perennial drainage, characterization of the drainage will be necessary before a treatment plan can be developed.

Some of the drainage may be entering the groundwater system through the loose, unconsolidated colluvium and scree at the portal or through fractures in the mine tunnel rather than exiting the

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portal as surface flow. The mine workings should be reopened and investigated to determine the presence of additional flow and to assess whether it is necessary to capture and treat that flow.

Samples should be taken from the main channel flowing from the barren ferricrete area below and west of the mine to determine the metals loading from that site.

Prospect Gulch - A south-flowing tributary enters Prospect Gulch from the northwest of the Lark Mine and north pile of the Henrietta Mine. This tributary was sampled upstream at WQCD site *CC-22* and downstream at site PG-10 by DMG (Figure 4). Between these sites, there are no mine-related features other than the two roads which the drainage crosses. Low-flow and high-flow concentrations measured at DMG site PG-10 are higher than measured at WQCD site *CC-22*. In fact, the concentrations measured at PG-10 were higher at high-flow than at low-flow. The WQCD data shows the opposite trend. The most likely explanation is that the roads are the principal cause of the apparent increase. Particularly during snowmelt, tributary water flowing down the roads is churned up by 4-wheel drive vehicles, which may explain the increase in zinc concentrations. However, this area between the two sampling sites should be investigated further.

Galena Queen/ Hercules - The possibility of processing the wastes in the Galena Queen/ Hercules piles to remove the heavy metals should be investigated as a reclamation option (Figures 7 and 31). Although the metal values are probably too low to completely pay for the processing, they may offset the overall cost of reclaiming this area.

Henrietta Mine - The Henrietta 800 level adit should be investigated to determine if there is mine drainage flowing underground from the collapsed portal (Figure 32).

Lark Mine - Some of the mine drainage may be entering the groundwater system through the loose, unconsolidated colluvium and scree at the portal or through fractures in the mine tunnel rather than exiting the portal as surface flow. The mine workings should be reopened and investigated to determine the presence of additional flow and to assess whether it is necessary to capture and treat that flow.

Georgia Gulch - Much of the flow in Georgia Gulch has, subsequent to the completion of monitoring, been observed to flow underground through the alluvial fan. It is recommended that Georgia Gulch be monitored in at least two new areas. The first would be a background sample above the upper-most mine of the Kansas City Group (Figure 5). This site will be difficult to monitor during the spring because of high flow. The most important monitoring site may be in the canyon above the alluvial fan.

Evelyne Mine - This mine adit drains approximately 2-60 gpm of iron-rich water, sampled at site SO-24 on Figure 5. One reclamation option to mitigate this drainage is bulkheading the adit. The surrounding rock appears to have many fractures, but the rock inside the adit may be tighter. The mine workings should be investigated to determine if this is an option.

Gold Hub Mine - A series of springs lies below the waste pile. Water quality samples should be

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taken at the springs below the waste pile to determine the metals loading from this source.

ANALYSIS OF RESULTS

Water quality in the Cement Creek basin is affected by both natural and mining-related metals loading. One important aspect of this investigation was to quantify the relative contribution of surface mine waste and surface mine portal discharge sources from potential mining-related groundwater sources and natural background metals inflows to Cement Creek. A simple model can be used to provide some indication of the potential for water quality improvement if surface wastes and portal discharges were addressed.

To do this, manganese was selected as the parameter to be used to determine the relative percentage of metals that can be attributed to mining-related surface discharge sources. Manganese was chosen because it is found in all the mine drainages in the Cement Creek basin and because it is a 'conservative' metal, meaning that it is not readily precipitated. Therefore, the total manganese load measured in mine drainage at the adits will be approximately equal to the manganese load measured in the creek downstream of these sources if there are no natural manganese sources or inflows of mining-impacted groundwater. For example, at water quality sampling site CC-6 (location on Figure 3), low-flow manganese load was measured at 8.7 lb/day. The manganese load from all the draining mines upstream of this site was totaled at 2.4 lb/day. The total manganese load from mine drainages is about 0.28 times the load measured in the main creek. This is very close to equal and confirms that the manganese is staying in solution.

In contrast, an example of a 'nonconservative' metal is iron, which is also found at all the mine drainages in the basin. In this example, the iron load measured at all the draining mines upstream of site CC-6 totaled 6.4 lb/ day. The iron load measured at site CC-6 was 0.33 lb/day. The amount measured from the upstream sources is about 19 times more than what was measured in the stream at CC-6. This metal is apparently precipitating between the sources and site CC-6, and would not be a good indicator of the mining-related metal loads in this basin.

The relative contributions from mining-related surface discharge sources in the creek were investigated in upper Cement Creek at water quality sampling site CC-9 (location on Figure 3). This area was chosen because it lies upstream of the confluence with the North Fork of Cement Creek. Active mining is still occurring in the North Fork watershed and this creek contributes significant metals loads to the mainstem of Cement Creek. At site CC-9, the low-flow manganese load was measured at 7.5 lb/day, and the load from all the surface mine-discharges upstream of this site was totaled at 2.4 lb/day. The percentage of the manganese load, contributed by mine-discharge sources at the surface, can be estimated by dividing the total manganese input from mine-discharge sources at the surface upstream by the manganese load at site CC-9. In this case, 32% of the manganese load at low-flow can be attributed to mine-discharge sources at the surface. In the same way, the high-flow manganese load at site CC-9 was measured at 81 lb/day and the load from all the upstream mine-discharge sources at the surface totaled 14.5 lb/day. The percentage of the manganese load that can be attributed to mine-discharge sources at the surface at high-flow is estimated at 18%. 000141

Waste rock piles, in general, only affect water quality during snowmelt and runoff events (i.e. high-flow conditions). The data collected to-date indicate that the waste rock piles produce two orders of magnitude more sulfates than the natural outcrops and soils. If the waste rock piles comprise 0.2% (an educated guess) of the total watershed area, this would mean that 20% of the sulfates in runoff comes from the waste rock piles. Extrapolating that further to assume that 20% of the metals come from the waste rock piles, the percentage of metals in the water at site CC-9 at high-flow that are mining-related can be estimated by adding the 20% contribution from waste piles to the 18% from mine drainages. Therefore, about 38% of the metals and sulfates in upper Cement Creek upstream of North Fork is estimated to be contributed by mining-related sources at the surface.

The same method described above can be used to estimate the percentage of metals and sulfates attributable to mining-related sources at the surface for the entire Cement Creek basin. Water quality site CC-31 is the most downstream water quality station monitored by DMG for both low and high-flow above the confluence of Cement Creek and the Animas River. Based on the WQCD data and the lack of mining downstream of this site, data from this site should be representative of the situation at the confluence of Cement Creek with the Animas River. At high-flow, about 24% of the manganese can be attributed to the draining mines upstream of site CC-31. At low-flow, about 29% of the manganese can be attributed to the draining mines upstream. Using the sulfate analogy above for metals contribution from waste piles (20%) and the percentages for metals contribution from draining mines, the percentage contribution from mining-related surface sources is estimated to be about 44% of the metals in Cement Creek during high-flow.

There are two problems with the above estimate of metals contribution from mining-related sources at the surface. The first is that the estimate does not include the impact of the mine drainage from the operating Gold King Mine in the North Fork of Cement Creek. The second is that the water in Cement Creek upstream of Gladstone is being treated by SGC, and a reduction in metals is documented as a result of this system. The first problem will tend to increase the metals load in the creek. The second problem will tend to decrease the metals load in the creek, especially at low-flow.

Another way to estimate the percentage of metals and sulfates attributable to mining-related sources at the surface for the entire Cement Creek basin is to add the manganese load attributable to waste rock piles that can be directly measured by water quality sampling (5% at high-flow, almost negligible at low-flow) to the loads in the surface drainage from the mines (24% at high-flow, 29% at low-flow). These calculations show that about 29% of the load at water quality site CC-31 at low-flow and high-flow can be attributed to mining-related surface sources. To further refine this, if the measured load at site CC-12 from the North Fork is subtracted from the manganese load at site CC-31, the relative contributions from the measured mining-related surface sources is about 33% during low-flow and 30% during high-flow. Detailed modeling of the geochemical and hydrologic conditions in the creek would be necessary to refine these estimates of results of reclaiming the major mining sources of metals to Cement Creek.

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CONCLUSIONS

Based on the analysis of data collected during this investigation, the following conclusions can be made.

1. Upper Cement Creek and Prospect Gulch are the major source areas for zinc and copper.

2. The South Fork of Cement Creek and Cement Creek below Gladstone are principally iron loaders, but also produce considerable zinc.

3. The iron bogs between Gladstone and Georgia Gulch are a major source of iron and contribute a large portion of the natural metal loading to Cement Creek.

4. Table 3 is a brief synopsis of the reclamation recommended at this time at each of the sites discussed in this report. Detailed discussion of these recommended actions is provided in the text.

5. The mine-drainage sources discharging at the surface and waste rock piles in Cement Creek contribute an estimated 29 to 44% of the heavy metals in Cement Creek. The remaining metals load is a combination of natural background inflows and mining-related contaminated groundwater inflows. Groundwater data must be collected before the remaining unknown loading sources can be partitioned into natural versus mining-related groundwater problems.

6. It is estimated that at high-flow, about 44% of the metals in Cement Creek can be attributed to mining-related surface sources, including waste piles and draining mines. If the reclamation activities described in this report for each site were completed, the reduction in loading from the individual sites would vary, but would probably average about 80%. Therefore, if all the reclamation activities described in this report were completed, the overall loading reduction in the Cement Creek basin would be in the range of 35%. Additional reduction of metals, due to geochemical processes in the stream, would further reduce the loading at the mouth of Cement Creek.

7. Reclamation of the mining-related sources at the surface in the Cement Creek watershed is likely to improve water quality visibly upstream of Gladstone. However, downstream of that area, the natural iron springs will continue to make Cement Creek run red.

8. Even if all the mining-related impacts are mitigated, the water quality of Cement Creek will be too poor to support aquatic life.

9. Reclamation of the mining-related sources in Cement Creek is an important step in accomplishing the goal of improving the water quality in the Animas River. However, because of the high percentage of metals loading from natural sources in this drainage, reclamation of other watersheds in the upper Animas River must also be conducted.

Table 3. Brief Synopsis of Reclamation Actions Recommended at This Time

SITE	RECOMMENDED ACTION		
	Mine Drainage Reclamation	Waste Rock Reclamation	No Action at this time
ROSS BASIN SITES			
Ross Basin Upper Site		X	
Ross Basin Lower Site		X	
Grand Mogul - East Adit	X	X	
Grand Mogul Stope		X	
Mine North of Mogul			X
Queen Anne Mine	X	X	
Columbia Mine and Upper Queen Anne Complex		X	
Mogul Mine	X	X	
Mine South of Mogul	X		
CEMENT CREEK - BONITA PEAK AREA			
Adams Mine			X
Red & Bonita Mine	X	X	
Lead Carbonate Mine and Mill		X	
Black Hawk Mine			X
Unknown Mine South of the Black Hawk Mine		X	
SOUTH FORK AREA			
Big Colorado Mine			X
Silver Ledge Mine	X	X	
PROSPECT GULCH - GEORGIA GULCH AREA			
Upper Prospect Gulch Adit		X	
Galena Queen/ Hercules		X	
Henrietta Mine	X	X	
Lark Mine	X		
Joe & Johns Mine	X	X	
Kansas City Mines		X	
LOWER CEMENT CREEK AREA			
Galty Boy Mine			X
Evelyne Mine	X		
Mammoth Tunnel	X		
BLM Adit Near Fairview Gulch (Elk Tunnel)	X		
Anglo Saxon Mine	X	X	
Gold Hub Mine	X	X	
OTHER SITE OF INTEREST			
Corkscrew Pass Mine		X	

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APPENDIX 1

Cement Creek
Low-Flow
10/1/96
Analytical Results

Site #	Description	PH (S.U.)	Temp (deg C)	Spec. Cond. (umhos/cm)	Flow (cfs)	Diss. Al ug/l	Tot. Al ug/l	Diss. As ug/l	Tot. As ug/l	Diss. Ba ug/l	Tot. Ba ug/l	Diss. Be ug/l	Tot. Be ug/l	Diss. Cd ug/l	Tot. Cd ug/l	Diss. Co ug/l	Tot. Co ug/l
A-68	Silverton Co.	8.35	2.70	273.00	55.00	0.00	69.00	0.00	0.00	22.40	24.90	0.00	0.00	1.10	1.50	0.00	0.00
A-72	Silverton Co. G.S. Gage	7.97	2.40	377.00	127.00	0.00	1530.00	0.00	0.00	20.20	22.30	0.00	0.00	1.20	1.50	0.00	0.00
CC-1	Above Queen Anne	7.05	8.30	189.00	0.08	0.00	40.00	0.00	0.00	26.80	28.20	0.00	0.00	0.80	1.20	0.00	0.00
CC-2	CC Below Queen Anne	5.46	5.00	394.00	0.11	3331.00	3224.00	0.00	0.00	31.00	31.50	0.00	0.00	12.30	11.50	0.00	0.00
CC-3	Background Below Ross Basin	4.47	ND	187.00	0.63	0.00	284.00	0.00	0.00	26.20	26.90	0.00	0.00	2.90	3.30	0.00	0.00
CC-4	CC Below SO-3	4.47	5.90	182.00	0.52	451.00	840.00	0.00	0.00	26.60	28.40	0.00	0.00	10.30	9.40	0.00	0.00
CC-5	CC Above Mogul	4.73	ND	210.00	1.42	699.00	818.00	0.00	0.00	28.00	29.40	0.00	0.00	11.50	7.90	0.00	0.00
CC-6	CC Below Mogul	3.83	ND	225.00	1.84	1149.00	1241.00	0.00	0.00	27.40	29.00	0.00	0.00	11.70	11.10	0.00	0.00
CC-6 DUP		3.83	ND	225.00	1.84	1119.00		0.00	0.00	26.90		0.00	0.00	11.50		0.00	0.00
CC-7	CC Above Ferricrete	4.24	ND	250.00	1.42	1128.00	1114.00	0.00	0.00	23.20	27.50	0.00	0.00	11.10	12.20	0.00	0.00
CC-8	Below North Ferricrete	5.01	5.70	359.00	1.45	1139.00	1108.00	0.00	0.00	23.40	26.00	0.00	0.00	10.20	10.00	0.00	0.00
CC-9	Below Lower Ferricrete	4.32	9.20	361.00	1.79	1418.00	1524.00	0.00	0.00	23.30	26.30	0.00	0.00	11.00	11.10	0.00	0.00
CC-12	North Fork Above CC	2.68	7.60	2090.00	0.20	58773.00	62206.00	4.40	5.20	1.60	2.50	5.30	5.80	100.00	112.00	106.00	116.00
CC-13	Below North Fork	4.54	8.50	376.00	1.15	1788.00	1849.00	0.00	0.00	22.60	25.80	0.00	0.00	11.00	13.50	0.00	0.00
CC-15	Minnehaha	4.24	6.20	190.00	0.05	2772.00	3185.00	0.00	0.00	21.60	25.20	0.00		9.60	11.60	9.30	0.00
CC-16	Minnehaha Above SF	6.46	7.00	143.00	0.16	0.00	46.00	0.00	0.00	10.70	12.90	0.00	0.00	0.00	0.50	0.00	6.80
CC-16 DUP		6.46	7.00	143.00	0.16	0.00		0.00	0.00	10.90		0.00		0.00		0.00	
CC-19	MF Below Blackhawk	6.68	5.10	646.00	0.62	108.00	212.00	0.00	0.00	12.30	13.00	0.00	0.00	1.40	1.50	5.70	0.00
CC-20	MF Above SF	6.87	4.60	580.00	0.44	0.00	291.00	0.00	0.00	12.00	13.00	0.00	0.00	0.90	1.00	0.00	0.00
CC-21	SF Above Silver Ledge	6.32	5.80	180.00	0.38	95.00	492.00	0.00	0.00	9.60	10.20	0.00	0.00	0.00	0.00	0.00	0.00
CC-22	SF Below Silver Ledge	5.71	5.60	658.00	1.36	861.00	2153.00	0.00	0.00	7.80	9.90	0.00	0.00	1.70	2.20	0.00	16.00
CC-23	SF Above CC	5.60	9.50	738.00	2.27	895.00	1957.00	0.00	0.00	9.60	11.10	0.00	0.00	2.20	2.60	16.80	13.30
CC-24	CC Below SF	6.11	8.40	1227.00	4.36	384.00	1445.00	0.00	0.00	10.90	11.90	0.00	0.00	2.00	2.80	7.10	5.80
CC-25	Above Prospect Gulch	5.44	9.50	1071.00	6.50	1256.00	2148.00	0.00	0.00	10.90	10.80	0.00	0.00	1.90	2.60	9.70	7.70
CC-25 DUP		5.44	9.50	1071.00	6.50	1300.00		0.00		10.30		0.00		1.80		13.60	
CC-26	Below Prospect Gulch	4.79	6.50	1119.00	7.09	3195.00	3746.00	0.00	1.60	10.00	10.00	0.00	0.00	2.00	2.60	0.00	14.30
CC-28	CC Below Georgia Gulch	3.86	8.20	772.00	9.49	6042.00	6319.00	3.20	7.50	9.50	9.80	1.30	0.00	1.70	2.30	26.00	17.30
CC-28 DUP		3.86	8.20	772.00	9.49	6286.00		2.50		9.50		0.00		1.80		14.30	
CC-29	CC Above Porcupine Gulch	3.71	8.60	805.00	13.72	5812.00	5882.00	1.10	4.50	9.60	10.60	0.00	0.00	1.90	2.50	13.00	17.20
CC-30	Porcupine Gulch Above CC	4.45	11.30	197.00	0.14	1673.00	2114.00	0.00	0.00	24.60	27.00	0.00	0.00	1.90	2.50	8.00	9.90
CC-31	CC Below Porcupine	3.76	11.00	820.00	11.89	5648.00	5538.00	0.00	4.60	17.90	9.90	1.90	0.00	1.90	2.10	7.90	11.80
CC-33	Cement Creek Above SF	7.90	9.00	1567.00	2.88	369.00	861.00	0.00	0.00	11.70	12.80	0.00	0.00	1.40	2.80	0.00	0.00
CC-48	Cement Creek Gage	4.10	6.60	790.00	17.64	5001.00	5183.00	0.00	2.10	10.60	12.40	0.00	0.00	1.80	2.10	16.30	13.10
M-34	Mineral Creek Gage	7.70	4.00	313.00	51.00	0.00	2222.00	0.00	0.00	22.80	24.20	0.00	0.00	0.80	1.10	7.60	7.60
PG-1	Background-Upper Prospect	4.48	7.00	112.00	0.00	0.00	40.00	0.00	0.00	55.40	62.30	0.00	0.00	0.00	0.00	0.00	6.50
PG-2	Background-Upper Prospect	4.46	6.00	194.00	0.01	244.00	638.00	0.00	0.00	37.50	42.90	0.00	0.00	0.00	0.00	0.00	5.90

Cement Creek
Low-Flow
10/1/96
Analytical Results

Site #	Description	PH (S.U.)	Temp (deg C)	Spec. Cond. (umhos/cm)	Flow (cfs)	Diss. Al ug/l	Tot. Al ug/l	Diss. As ug/l	Tot. As ug/l	Diss. Ba ug/l	Tot. Ba ug/l	Diss. Be ug/l	Tot. Be ug/l	Diss. Cd ug/l	Tot. Cd ug/l	Diss. Co ug/l	Tot. Co ug/l
PG-3	Below Galena Queen	2.73	6.00	1073.00	0.00	6827.00	6955.00	1.60	2.30	32.70	35.60	0.00	0.00	114.00	111.00	14.60	23.30
PG-4	Background-Upper Prospect	5.46	7.00	585.00	0.00	62.00	482.00	0.00	0.00	40.90	44.40	0.00	0.00	1.40	1.50	0.00	7.60
PG-5	Below Mine Drainages	6.00	6.00	490.00	0.01	98.00	93.00	0.00	0.00	40.40	43.70	0.00	0.00	0.00	0.50	0.00	0.00
PG-6	Tributary Below Hercules	3.62	7.00	256.00	0.00	1903.00	1861.00	0.00	0.00	53.70	56.80	0.00	0.00	4.20	4.30	0.00	11.90
PG-7	Tributary Below Draining Mine	3.67	6.00	575.00	0.00	3268.00	3379.00	0.00	0.00	26.80	36.20	0.00	0.00	1.20	1.50	9.40	17.70
PG-8	Below Upper Mines	3.95	5.00	772.00	0.02	1265.00	1279.00	0.00	0.00	38.20	42.30	0.00	0.00	6.90	7.80	0.00	9.60
PG-9	Below Mineralized Canyon	3.61	4.00	414.00	0.05	1617.00	1920.00	0.00	0.00	38.80	45.90	0.00	0.00	7.20	7.90	0.00	10.50
PG-10	Undisturbed Tributary	3.66	9.20	363.00	0.01	7944.00	8028.00	0.00	0.00	50.00	52.90	0.00	0.00	0.00	0.00	18.80	27.40
PG-11	Above Henrietta 7	3.33	3.00	351.00	0.05	2392.00	2371.00	0.00	0.00	37.20	40.80	0.00	0.00	6.50	6.30	7.30	8.60
PG-16	Below Henrietta 7	3.08	7.30	741.00	0.05	6450.00	6289.00	0.00	1.90	27.50	29.80	0.00	0.00	13.90	12.50	17.00	25.90
PG-18	Above Henrietta 11	2.82	2.00	694.00	0.04	6343.00	6034.00	0.00	0.00	27.60	27.90	0.00	0.00	14.60	12.80	18.70	25.20
SO-1	Queen Anne	6.37	ND	301.00	0.05	105.00	614.00	0.00	0.00	13.80	15.30	0.00	0.00	9.10	10.90	0.00	8.50
SO-3	Grand Mogul	3.43	8.70	510.00	0.02	10029.00	10085.00	0.00	0.00	21.40	22.70	0.00	0.00	88.10	86.70	5.10	13.80
SO-5	Mogul	2.89	ND	1098.00	0.02	5002.00	5243.00	8.80	17.30	5.90	8.80	4.40	4.70	156.00	148.00	17.00	27.30
SO-6	Joe & Johns	2.71	10.00	1350.00	0.00	13450.00	13352.00	23.20	26.10	4.70	5.30	0.00	0.00	52.60	48.20	32.50	35.70
SO-12	Black Hawk Mine	7.29	7.40	1200.00	0.20	0.00	106.00	0.00	0.00	8.60	9.40	0.00	0.00	1.80	2.50	5.40	5.00
SO-13	Silver Ledge	6.28	5.90	1050.00	0.89	768.00	1014.00	1.00	2.10	8.40	10.20	1.30	1.60	2.10	2.40	9.60	17.00
SO-14	Yukon Tunnel	7.08	14.00	953.00	1.21	0.00	427.00	1.00	1.10	15.10	17.90	0.00	0.00	0.00	0.00	0.00	11.60
SO-16	Anglo Saxon	6.61	10.00	1692.00	0.09	338.00	356.00	5.00	8.40	12.40	12.10	2.30	2.20	3.00	3.60	48.00	42.20
SO-17	Big Colorado	4.56	6.10	825.00	0.04	6774.00	7346.00	6.80	8.70	2.40	2.40	1.60	1.80	4.80	6.70	58.50	63.00
SO-18	Mammoth Tunnel	4.90	9.00	1464.00	0.07	1725.00	1758.00	9.20	12.10	4.60	4.80	1.20	1.70	1.30	1.80	22.50	32.10
SO-19	Elk Tunnel	7.05	14.00	1501.00	0.38	0.00	0.00	2.80	3.10	10.60	9.70	0.00	0.00	0.00	0.00	0.00	0.00
SO-20	KC #1 Adit	3.02	2.00	1431.00	0.00	10038.00	9976.00	45.70	54.20	1.70	2.40	1.80	2.50	25.40	35.40	41.60	51.70
SO-23	Porcupine Adit	6.58	12.00	1526.00	0.09	126.00	442.00	2.80	5.20	12.40	12.60	1.00	1.40	2.30	2.40	26.60	36.20
SO-24	Evelyne	3.36	3.00	469.00	0.00	11311.00	10960.00	0.00	0.00	1.30	1.90	1.00	1.00	10.00	9.50	21.80	26.80

000148

Cement Creek
Low-Flow
10/1/96
Analytical Results

Site #	Description	Diss. Cr ug/l	Tot. Cr ug/l	Diss. Cu ug/l	Tot. Cu ug/l	Diss. Fe ug/l	Tot. Fe ug/l	Diss. Mn ug/l	Tot. Mn ug/l	Diss. Ni ug/l	Tot. Ni ug/l	Diss. Pb ug/l	Tot. Pb ug/l	Diss. Sb ug/l	Tot. Sb ug/l	Diss. Se ug/l	Tot. Se ug/l
A-68	Silverton Co.	0.00	0.00	0.00	0.00	28.60	98.50	678.00	672.30	0.00	0.00	0.00	1.40	0.00	0.00	0.00	0.00
A-72	Silverton Co. G.S. Gage	0.00	0.00	4.20	18.20	1156.10	2235.80	599.70	618.60	0.00	0.00	0.00	4.30	0.00	0.00	0.00	0.00
CC-1	Above Queen Anne	0.00	0.00	0.00	6.20	0.00	16.70	1.00	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CC-2	CC Below Queen Anne	0.00	0.00	114.20	116.00	0.00	104.00	4492.60	4402.90	14.90	11.90	1.40	2.80	0.00	0.00	0.00	0.00
CC-3	Background Below Ross Basin	0.00	0.00	39.80	74.60	0.00	27.00	121.50	120.40	0.00	0.00	0.00	3.60	0.00	0.00	0.00	0.00
CC-4	CC Below SO-3	0.00	0.00	220.20	223.50	5.60	118.70	517.50	521.40	0.00	0.00	2.30	3.30	0.00	0.00	0.00	0.00
CC-5	CC Above Mogul	0.00	0.00	168.60	166.40	0.00	77.10	704.80	690.40	0.00	0.00	3.80	4.60	0.00	0.00	0.00	0.00
CC-6	CC Below Mogul	0.00	0.00	237.70	244.00	33.90	100.70	874.50	884.40	0.00	0.00	3.60	4.80	0.00	0.00	0.00	0.00
CC-6 DUP		0.00	0.00	231.50		31.90		861.40		0.00	0.00	3.80		0.00	0.00	0.00	0.00
CC-7	CC Above Ferricrete	0.00	0.00	202.90	215.10	50.90	113.30	806.90	832.30	0.00	0.00	5.00	5.60	0.00	0.00	0.00	0.00
CC-8	Below North Ferricrete	0.00	0.00	183.40	192.60	29.80	50.90	760.80	792.30	0.00	0.00	5.40	6.30	0.00	0.00	0.00	0.00
CC-9	Below Lower Ferricrete	0.00	0.00	182.30	196.80	46.70	146.80	774.10	812.60	0.00	0.00	6.20	6.40	0.00	0.00	0.00	0.00
CC-12	North Fork Above CC	14.20	18.00	5959.60	6292.60	80355.00	88912.00	10569.50	11208.30	82.20	80.70	1.70	3.50	0.00	0.00	0.00	0.00
CC-13	Below North Fork	9.40	0.00	210.10	217.60	142.40	218.20	832.60	861.90	11.80	0.00	6.10	7.30	0.00	0.00	0.00	0.00
CC-15	Minnehaha	0.00	0.00	242.60	268.40	857.60	3877.00	681.30	728.30	0.00	0.00	108.30	170.70	0.00	0.00	0.00	0.00
CC-16	Minnehaha Above SF	0.00	0.00	0.00	6.30	8.50	67.00	1.30	3.30	0.00	0.00	0.00	1.80	0.00	0.00	0.00	0.00
CC-16 DUP		0.00	0.00	4.00		10.90		1.90		0.00	0.00	0.00		0.00	0.00	0.00	0.00
CC-19	MF Below Blackhawk	0.00	0.00	11.90	13.70	13.40	789.80	717.20	808.10	0.00	0.00	1.80	2.40	0.00	0.00	0.00	0.00
CC-20	MF Above SF	0.00	0.00	0.00	12.90	50.80	720.60	329.90	399.50	0.00	0.00	0.00	1.70	0.00	0.00	0.00	0.00
CC-21	SF Above Silver Ledge	0.00	0.00	7.40	6.50	25.30	120.90	58.80	59.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CC-22	SF Below Silver Ledge	0.00	0.00	11.50	27.10	5207.00	6637.30	1310.50	1276.10	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00
CC-23	SF Above CC	8.10	0.00	28.50	29.90	2008.00	3216.90	1645.40	1659.70	0.00	0.00	0.00	2.30	0.00	0.00	0.00	0.00
CC-24	CC Below SF	0.00	0.00	9.10	25.20	868.10	2021.40	1641.30	1671.60	0.00	0.00	0.00	8.40	0.00	0.00	0.00	0.00
CC-25	Above Prospect Gulch	0.00	0.00	14.30	19.70	2831.70	4023.50	1597.30	1646.90	0.00	0.00	1.30	14.50	0.00	0.00	0.00	0.00
CC-25 DUP		0.00		18.40		2931.70		1640.20		0.00	0.00	1.10		0.00	0.00	0.00	0.00
CC-26	Below Prospect Gulch	0.00	4.30	10.00	28.90	7100.70	8599.90	1460.60	1458.90	0.00	0.00	6.70	13.30	0.00	0.00	0.00	0.00
CC-28	CC Below Georgia Gulch	0.00	0.00	34.10	14.40	16868.00	18827.00	1723.00	1732.60	19.90	13.40	10.50	14.70	46.90	0.00	0.00	0.00
CC-28 DUP		0.00	0.00	22.80		17316.00		1782.30		16.20		10.50		0.00	0.00	0.00	0.00
CC-29	CC Above Porcupine Gulch	0.00	0.00	28.80	24.40	11624.00	13694.00	1771.10	1756.20	12.50	0.00	13.50	17.10	0.00	0.00	0.00	0.00
CC-30	Porcupine Gulch Above CC	0.00	0.00	43.70	46.80	92.10	457.80	856.60	869.90	0.00	0.00	1.70	4.60	0.00	0.00	0.00	0.00
CC-31	CC Below Porcupine	0.00	0.00	16.90	26.00	10742.00	12569.00	1592.30	1537.50	16.40	0.00	13.10	15.70	0.00	0.00	0.00	0.00
CC-33	Cement Creek Above SF	0.00	0.00	0.00	23.90	39.40	531.60	1390.90	2050.80	0.00	0.00	0.00	11.90	0.00	0.00	0.00	0.00
CC-48	Cement Creek Gage	0.00	0.00	30.60	26.30	5304.70	7992.60	1543.50	1558.90	16.50	0.00	10.30	12.40	0.00	0.00	0.00	0.00
M-34	Mineral Creek Gage	0.00	0.00	7.90	33.60	1979.70	3244.20	306.60	298.70	0.00	0.00	0.00	5.80	0.00	0.00	0.00	0.00
PG-1	Background-Upper Prospect	0.00	0.00	18.70	25.50	19.70	18.70	24.30	28.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PG-2	Background-Upper Prospect	0.00	0.00	0.00	0.00	209.00	1034.10	164.00	172.30	0.00	0.00	0.90	2.50	0.00	0.00	0.00	0.00

Cement Creek
Low-Flow
10/1/96
Analytical Results

Site #	Description	Diss. Cr ug/l	Tot. Cr ug/l	Diss. Cu ug/l	Tot. Cu ug/l	Diss. Fe ug/l	Tot. Fe ug/l	Diss. Mn ug/l	Tot. Mn ug/l	Diss. Ni ug/l	Tot. Ni ug/l	Diss. Pb ug/l	Tot. Pb ug/l	Diss. Sb ug/l	Tot. Sb ug/l	Diss. Se ug/l	Tot. Se ug/l
PG-3	Below Galena Queen	0.00	0.00	3087.80	3116.60	17864.00	18050.00	483.10	494.70	18.30	12.40	1011.50	1027.40	0.00	0.00	0.00	0.00
PG-4	Background-Upper Prospect	0.00	0.00	0.00	55.20	0.00	324.10	137.60	149.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PG-5	Below Mine Drainages	0.00	0.00	0.00	0.00	298.30	369.40	64.60	67.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PG-6	Tributary Below Hercules	0.00	0.00	139.50	140.10	955.60	1056.10	246.90	244.90	0.00	0.00	167.10	155.91	0.00	0.00	0.00	0.00
PG-7	Tributary Below Draining Mine	0.00	0.00	125.00	130.60	633.90	802.10	901.20	939.10	10.10	0.00	16.10	17.00	0.00	0.00	0.00	0.00
PG-8	Below Upper Mines	0.00	0.00	180.00	186.00	455.90	552.60	309.50	322.50	0.00	0.00	88.60	72.77	0.00	0.00	0.00	0.00
PG-9	Below Mineralized Canyon	0.00	0.00	178.60	171.20	250.50	919.80	353.10	345.70	11.50	0.00	57.90	62.60	0.00	0.00	0.00	0.00
PG-10	Undisturbed Tributary	0.00	0.00	21.20	22.80	193.30	235.00	1015.40	1035.60	17.50	20.40	41.50	41.20	0.00	0.00	0.00	0.00
PG-11	Above Henrietta 7	0.00	0.00	163.10	162.70	247.10	270.00	414.00	421.80	12.20	0.00	61.40	63.00	0.00	0.00	0.00	0.00
PG-16	Below Henrietta 7	0.00	0.00	689.90	676.90	2630.80	15458.00	783.70	772.50	12.80	16.30	106.90	98.39	0.00	0.00	0.00	0.00
PG-18	Above Henrietta 11	0.00	0.00	639.30	616.80	10672.00	9842.00	770.20	751.30	17.10	13.90	104.60	103.25	0.00	0.00	0.00	0.00
SO-1	Queen Anne	0.00	0.00	83.60	231.60	121.30	1816.60	1223.30	1190.80	0.00	0.00	1.60	81.60	0.00	0.00	0.00	0.00
SO-3	Grand Mogul	0.00	0.00	2562.50	2613.40	726.80	824.30	7071.40	7284.70	11.80	13.10	38.40	39.40	0.00	0.00	0.00	0.00
SO-5	Mogul	0.00	0.00	6453.40	6422.80	48397.00	51192.00	9730.60	9742.70	20.70	15.10	182.30	206.22	0.00	0.00	0.00	0.00
SO-6	Joe & Johns	0.00	0.00	513.40	507.90	62289.00	61740.00	287.90	287.00	32.90	30.20	550.43	531.14	0.00	0.00	0.00	0.00
SO-12	Black Hawk Mine	0.00	0.00	0.00	11.20	49.70	2206.10	2540.60	2742.30	10.10	0.00	0.00	5.90	0.00	0.00	0.00	0.00
SO-13	Silver Ledge	0.00	4.70	0.00	15.70	12750.00	15638.00	2343.20	2405.20	0.00	0.00	0.00	5.20	0.00	0.00	0.00	0.00
SO-14	Yukon Tunnel	0.00	5.20	0.00	20.30	1105.20	3466.10	1048.30	1121.10	0.00	0.00	0.00	2.20	0.00	0.00	0.00	0.00
SO-16	Anglo Saxon	0.00	0.00	14.10	14.30	30827.00	39290.00	9242.50	9173.90	22.40	12.10	0.00	8.90	0.00	0.00	0.00	0.00
SO-17	Big Colorado	0.00	0.00	15.00	25.90	74949.00	78415.00	2210.00	2323.30	36.90	40.10	0.00	1.70	0.00	0.00	0.00	0.00
SO-18	Mammoth Tunnel	0.00	0.00	12.20	44.20	53470.00	53721.00	4416.80	4511.20	19.50	22.50	0.00	0.80	0.00	0.00	0.00	0.00
SO-19	Elk Tunnel	0.00	0.00	0.00	0.00	3487.10	3701.90	1725.80	1687.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SO-20	KC #1 Adit	0.00	0.00	2102.70	2137.30	57278.00	61240.00	31600.20	32659.10	30.40	34.80	101.20	124.61	0.00	0.00	0.00	0.00
SO-23	Porcupine Adit	0.00	0.00	0.00	29.30	19888.00	23829.00	11164.00	11094.00	12.30	0.00	0.00	4.40	0.00	0.00	0.00	0.00
SO-24	Evelyne	0.00	0.00	55.70	57.40	14643.00	18266.00	847.60	848.70	16.20	13.80	1.40	1.80	0.00	0.00	0.00	0.00

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Cement Creek
Low-Flow
10/1/96
Analytical Results

Site #	Description	Diss. Th ug/l	Tot. Th ug/l	Diss. V ug/l	Tot. V ug/l	Diss. Zn ug/l	Tot. Zn ug/l	Diss. Ca mg/l	Diss. Mg mg/l	Diss. K mg/l	Diss. Na mg/l	HARDNESS	Si mg/l	Cl mg/l	SO4 mg/l
A-68	Silverton Co.	0.00	0.00	0.00	0.00	422.70	431.80	45.97	2.52	0.00	1.93	125.00	3.80	1.53	86.20
A-72	Silverton Co. G.S. Gage	0.00	0.00	0.00	0.00	376.00	416.10	67.65	4.05	0.00	2.53	186.00	4.20	2.01	173.00
CC-1	Above Queen Anne	0.00	0.00	0.00	0.00	225.00	215.20	28.61	2.87	0.00	0.69	83.30	2.00	1.39	68.20
CC-2	CC Below Queen Anne	0.00	0.00	0.00	0.00	2419.00	2260.00	53.87	6.79	0.00	1.13	162.00	4.10	1.28	176.00
CC-3	Background Below Ross Basin	0.00	0.00	0.00	0.00	537.30	517.30	29.33	2.45	0.00	0.85	83.30	1.90	1.26	59.80
CC-4	CC Below SO-3	0.00	0.00	0.00	0.00	2248.40	2136.20	25.37	2.76	0.00	0.91	74.70	1.80	1.22	65.20
CC-5	CC Above Mogul	0.00	0.00	0.00	0.00	2160.40	2007.30	29.21	3.32	0.00	0.83	86.60	2.00	1.20	80.50
CC-6	CC Below Mogul	0.00	0.00	0.00	0.00	2727.70	2614.50	28.80	3.23	0.00	0.90	85.20	2.40	1.21	85.20
CC-6 DUP		0.00	0.00	0.00	0.00	2701.30		28.39	3.22	0.00	0.87	84.10			
CC-7	CC Above Ferricrete	0.00	0.00	0.00	0.00	2447.60	2397.00	35.51	3.12	0.00	1.13	102.00	2.50	1.33	102.00
CC-8	Below North Ferricrete	0.00	0.00	0.00	0.00	2391.60	2372.00	39.99	3.06	0.00	1.18	112.00	3.00	1.20	115.00
CC-9	Below Lower Ferricrete	0.00	0.00	0.00	0.00	2673.20	2618.80	40.51	3.07	1.30	1.68	114.00	3.00	1.21	119.00
CC-12	North Fork Above CC	0.00	0.00	0.00	0.00	19950.00	21932.00	50.79	32.85	0.00	2.95	262.00	21.40	1.20	858.00
CC-13	Below North Fork	0.00	0.00	5.40	0.00	2545.30	2700.30	41.43	3.26	0.00	1.29	117.00	3.50	1.22	125.00
CC-15	Minnehaha	0.00	0.00	0.00	0.00	2328.30	2557.50	19.09	2.45	0.00	1.37	57.80	6.40	1.53	73.30
CC-16	Minnehaha Above SF	0.00	0.00	0.00	0.00	75.50	93.00	22.01	1.64	0.00	0.98	61.70	2.50	1.38	39.00
CC-16 DUP		0.00	0.00	0.00	0.00	78.10		22.15	1.67	0.00	1.22	62.20			
CC-19	MF Below Blackhawk	0.00	0.00	4.80	0.00	298.20	368.70	121.80	6.17	1.50	1.82	330.00	3.80	1.62	303.00
CC-20	MF Above SF	0.00	0.00	0.00	0.00	196.30	236.00	112.10	5.94	0.00	1.82	304.00	3.80	1.31	266.00
CC-21	SF Above Silver Ledge	0.00	0.00	0.00	0.00	47.40	41.00	29.94	1.75	0.00	1.24	82.00	3.40	1.29	66.60
CC-22	SF Below Silver Ledge	0.00	0.00	0.00	3.00	441.00	451.80	124.90	6.12	0.00	2.92	337.00	9.70	1.34	338.00
CC-23	SF Above CC	0.00	0.00	3.60	0.00	690.30	707.10	108.10	5.89	1.40	2.50	294.00	9.90	1.33	289.00
CC-24	CC Below SF	0.00	0.00	0.00	0.00	611.10	659.10	188.10	7.40	1.90	3.13	500.00	6.10	1.37	449.00
CC-25	Above Prospect Gulch	0.00	0.00	0.00	0.00	645.80	706.30	165.90	7.33	0.00	3.13	444.00	8.80	1.39	420.00
CC-25 DUP		0.00	0.00	0.00	0.00	680.80		170.80	7.49	1.30	3.17	457.00			
CC-26	Below Prospect Gulch	0.00	0.00	0.00	0.00	701.90	678.70	150.30	7.52	0.00	3.09	406.00	10.30	1.38	403.00
CC-28	CC Below Georgia Gulch	0.00	0.00	0.00	0.00	833.90	863.50	165.60	8.75	3.30	3.18	450.00	14.90	1.40	465.00
CC-28 DUP		0.00	0.00	0.00	0.00	844.30		169.00	9.00	1.80	3.27	459.00			
CC-29	CC Above Porcupine Gulch	0.00	0.00	0.00	5.10	834.30	881.60	167.00	8.58	2.90	3.38	452.00	15.40	1.46	472.00
CC-30	Porcupine Gulch Above CC	0.00	0.00	3.10	0.00	565.70	590.10	27.67	5.10	0.00	1.69	90.10	8.90	1.35	94.30
CC-31	CC Below Porcupine	0.00	0.00	0.00	0.00	775.50	764.80	163.10	8.35	0.00	3.39	442.00	16.10	1.41	469.00
CC-33	Cement Creek Above SF	0.00	0.00	0.00	0.00	317.80	724.90	264.00	8.49	0.00	3.59	694.00	0.70	1.40	623.00
CC-48	Cement Creek Gage	0.00	0.00	0.00	0.00	653.50	677.40	162.60	8.04	2.90	3.71	439.00	16.70	1.44	469.00
M-34	Mineral Creek Gage	0.00	0.00	0.00	0.00	268.80	286.60	59.56	4.61	1.30	2.63	168.00	4.50	1.55	152.00
PG-1	Background-Upper Prospect	0.00	0.00	0.00	0.00	28.30	21.80	11.79	1.91	0.00	0.93	37.30	1.40	1.16	32.80
PG-2	Background-Upper Prospect	0.00	0.00	0.00	0.00	35.60	44.90	23.63	3.19	0.00	1.04	72.10	2.20	1.27	65.50

000151

Cement Creek
Low-Flow
10/1/96
Analytical Results

Site #	Description	Diss. Th ug/l	Tot. Th ug/l	Diss. V ug/l	Tot. V ug/l	Diss. Zn ug/l	Tot. Zn ug/l	Diss. Ca mg/l	Diss. Mg mg/l	Diss. K mg/l	Diss. Na mg/l	HARDNESS	Si mg/l	Cl mg/l	SO4 mg/l
PG-3	Below Galena Queen	0.00	0.00	0.00	0.00	29211.00	28243.00	13.06	3.98	0.00	1.15	49.00	7.60	1.28	259.00
PG-4	Background-Upper Prospect	0.00	0.00	0.00	3.30	542.40	985.10	88.86	8.26	0.00	1.48	256.00	3.70	1.28	244.00
PG-5	Below Mine Drainages	0.00	0.00	0.00	0.00	195.80	191.20	69.36	6.23	0.00	1.26	199.00	2.90	1.27	185.00
PG-6	Tributary Below Hercules	0.00	0.00	0.00	0.00	841.60	797.20	13.97	2.41	0.00	0.76	44.80	4.10	1.35	58.70
PG-7	Tributary Below Draining Mine	0.00	0.00	0.00	0.00	239.30	231.30	62.50	10.85	0.00	0.58	201.00	4.10	1.81	220.00
PG-8	Below Upper Mines	0.00	0.00	0.00	0.00	1741.20	1720.80	46.37	5.40	0.00	1.02	138.00	3.10	1.34	145.00
PG-9	Below Mineralized Canyon	0.00	0.00	0.00	0.00	1909.70	1750.90	45.25	5.33	0.00	1.03	135.00	3.00	1.35	143.00
PG-10	Undisturbed Tributary	0.00	0.00	0.00	0.00	187.80	171.40	24.93	6.82	0.00	0.39	90.30	4.60	1.25	153.00
PG-11	Above Henrietta 7	0.00	0.00	0.00	0.00	1684.90	1615.40	41.19	5.30	0.00	0.94	125.00	2.90	1.30	141.00
PG-16	Below Henrietta 7	0.00	0.00	0.00	0.00	3125.30	2913.30	40.58	7.03	0.00	0.95	130.00	4.60		
PG-18	Above Henrietta 11	0.00	0.00	0.00	0.00	3253.60	3020.60	37.57	6.84	0.00	0.93	122.00	6.30	1.36	219.00
SO-1	Queen Anne	0.00	0.00	0.00	0.00	2165.40	2027.80	40.60	2.80	0.00	0.98	113.00	2.30	1.21	97.30
SO-3	Grand Mogul	0.00	0.00	0.00	0.00	16895.00	16485.00	21.09	7.87	0.00	0.96	85.10	7.90	1.91	192.00
SO-5	Mogul	0.00	0.00	0.00	0.00	29435.00	28091.00	83.53	4.20	1.00	3.32	226.00	9.50	1.35	449.00
SO-6	Joe & Johns	0.00	0.00	4.30	0.00	10690.00	10135.00	1.88	1.89	0.00	0.28	12.50	23.10	1.23	331.00
SO-12	Black Hawk Mine	0.00	0.00	0.00	0.00	582.90	717.90	259.20	11.35	1.10	3.32	694.00	4.90	1.33	614.00
SO-13	Silver Ledge	0.00	0.00	0.00	3.20	713.50	704.80	216.80	8.98	0.00	3.71	578.00	6.80	1.26	541.00
SO-14	Yukon Tunnel	0.00	0.00	0.00	0.00	98.60	110.10	223.40	6.51	0.00	5.70	585.00	7.50	3.62	504.00
SO-16	Anglo Saxon	0.00	0.00	0.00	0.00	2924.90	2780.50	319.30	20.19	3.50	9.19	880.00	10.70	1.28	813.00
SO-17	Big Colorado	0.00	0.00	7.00	6.70	1086.90	1066.50	113.40	13.01	2.80	3.93	337.00	19.50	1.30	446.00
SO-18	Mammoth Tunnel	0.00	0.00	0.00	0.00	1008.50	978.60	207.00	17.70	2.40	5.06	590.00	16.00	1.29	577.00
SO-19	Elk Tunnel	0.00	0.00	0.00	0.00	186.40	171.70	331.80	6.43	0.00	7.90	855.00	10.50	1.27	741.00
SO-20	KC #1 Adit	0.00	0.00	0.00	0.00	8347.90	8254.00	119.70	12.85	0.00	0.99	352.00	7.10	1.52	600.00
SO-23	Porcupine Adit	0.00	0.00	0.00	0.00	2117.80	2085.10	291.10	16.52	1.30	8.82	795.00	10.90	1.38	724.00
SO-24	Evelyne	0.00	0.00	0.00	0.00	853.60	802.20	4.90	10.50	0.00	2.32	55.50	21.60	1.76	168.00

000152

Cement Creek
Low-Flow
Metals Loading

Site #	Description	Diss. Load Al g/day	Tot. Load Al g/day	Diss. Load As g/day	Tot. Load As g/day	Diss. Load Ba g/day	Tot. Load Ba g/day	Diss. Load Be g/day	Tot. Load Be g/day	Diss. Load Cd g/day	Tot. Load Cd g/day	Diss. Load Co g/day	Tot. Load Co g/day
A-68	Silverton Co.	0.00	9297.75	0.00	0.00	3018.40	3355.28	0.00	0.00	148.23	202.13	0.00	0.00
A-72	Silverton Co. G.S. Gage	0.00	476059.50	0.00	0.00	6285.23	6938.65	0.00	0.00	373.38	466.73	0.00	0.00
CC-1	Above Queen Anne	0.00	7.84	0.00	0.00	5.25	5.53	0.00	0.00	0.16	0.24	0.00	0.00
CC-2	CC Below Queen Anne	914.03	884.67	0.00	0.00	8.51	8.64	0.00	0.00	3.38	3.16	0.00	0.00
CC-3	Background Below Ross Basin	0.00	439.75	0.00	0.00	40.57	41.65	0.00	0.00	4.49	5.11	0.00	0.00
CC-4	CC Below SO-3	578.99	1078.39	0.00	0.00	34.15	36.46	0.00	0.00	13.22	12.07	0.00	0.00
CC-5	CC Above Mogul	2424.97	2837.81	0.00	0.00	97.14	101.99	0.00	0.00	39.90	27.41	0.00	0.00
CC-6	CC Below Mogul	5176.88	5591.39	0.00	0.00	123.45	130.66	0.00	0.00	52.71	50.01	0.00	0.00
CC-6 DUP		5041.71	0.00	0.00	0.00	121.20	0.00	0.00	0.00	51.81	0.00	0.00	0.00
CC-7	CC Above Ferricrete	3927.08	3878.34	0.00	0.00	80.77	95.74	0.00	0.00	38.64	42.47	0.00	0.00
CC-8	Below North Ferricrete	4037.93	3928.03	0.00	0.00	82.96	92.17	0.00	0.00	36.16	35.45	0.00	0.00
CC-9	Below Lower Ferricrete	6225.59	6690.97	0.00	0.00	102.30	115.47	0.00	0.00	48.29	48.73	0.00	0.00
CC-12	North Fork Above CC	28798.77	30480.94	2.16	2.55	0.78	1.23	2.60	2.84	49.00	54.88	51.94	56.84
CC-13	Below North Fork	5046.45	5218.62	0.00	0.00	63.79	72.82	0.00	0.00	31.05	38.10	0.00	0.00
CC-15	Minnehaha	339.57	390.16	0.00	0.00	2.65	3.09	0.00	0.00	1.18	1.42	1.14	0.00
CC-16	Minnehaha Above SF	0.00	18.03	0.00	0.00	4.19	5.06	0.00	0.00	0.00	0.20	0.00	2.67
CC-16 DUP		0.00	0.00	0.00	0.00	4.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CC-19	MF Below Blackhawk	164.32	322.55	0.00	0.00	18.71	19.78	0.00	0.00	2.13	2.28	8.67	0.00
CC-20	MF Above SF	0.00	313.70	0.00	0.00	12.94	14.01	0.00	0.00	0.97	1.08	0.00	0.00
CC-21	SF Above Silver Ledge	88.45	458.05	0.00	0.00	8.94	9.50	0.00	0.00	0.00	0.00	0.00	0.00
CC-22	SF Below Silver Ledge	2868.85	7173.80	0.00	0.00	25.99	32.99	0.00	0.00	5.66	7.33	0.00	53.31
CC-23	SF Above CC	4977.54	10883.86	0.00	0.00	53.39	61.73	0.00	0.00	12.24	14.46	93.43	73.97
CC-24	CC Below SF	4101.89	15435.49	0.00	0.00	116.43	127.12	0.00	0.00	21.36	29.91	75.84	61.96
CC-25	Above Prospect Gulch	20001.80	34206.90	0.00	0.00	173.58	171.99	0.00	0.00	30.26	41.41	154.47	122.62
CC-25 DUP		20702.50	0.00	0.00	0.00	164.03	0.00	0.00	0.00	28.67	0.00	216.58	0.00
CC-26	Below Prospect Gulch	55530.06	65106.60	0.00	27.81	173.80	173.80	0.00	0.00	34.76	45.19	0.00	248.54
CC-28	CC Below Georgia Gulch	140420.31	146857.98	74.37	174.31	220.79	227.76	30.21	0.00	39.51	53.45	604.26	402.06
CC-28 DUP		146091.04	0.00	58 10	0.00	220.79	0.00	0.00	0.00	41.83	0.00	332.34	0.00
CC-29	CC Above Porcupine Gulch	195407.29	197760.78	36 98	151.30	322.76	356.39	0.00	0.00	63.88	84.05	437.08	578.29
CC-30	Porcupine Gulch Above CC	577.94	730.28	0 00	0.00	8.50	9.33	0.00	0.00	0.66	0.86	2.76	3.42
CC-31	CC Below Porcupine	164584.41	161378.98	0 00	134.05	521.61	288.49	55.37	0.00	55.37	61.19	230.21	343.86
CC-33	Cement Creek Above SF	2603.66	6075.22	0 00	0.00	82.56	90.32	0.00	0.00	9.88	19.76	0.00	0.00
CC-48	Cement Creek Gage	216133.22	223998.89	0 00	90.76	458.11	535.90	0.00	0.00	77.79	90.76	704.45	566.76
M-34	Mineral Creek Gage	0.00	277638.90	0 00	0.00	2848.86	3023.79	0.00	0.00	99.96	137.45	949.62	949.62
PG-1	Background-Upper Prospect	0.00	0.08	0.00	0 00	0.11	0.12	0.00	0.00	0.00	0.00	0.00	0.01
PG-2	Background-Upper Prospect	2.99	7.82	0.00	0 00	0.46	0.53	0.00	0.00	0.00	0.00	0.00	0.07
PG-3	Below Galena Queen	20.07	20.45	0.00	0 01	0.10	0.10	0.00	0.00	0.34	0.33	0.04	0.07
PG-4	Background-Upper Prospect	0.12	0.94	0.00	0 00	0.08	0.09	0.00	0.00	0.00	0.00	0.00	0.01
		1.20	1.14	0.00	0 00	0 49	0.54	0.00	0.00	0.00	0.01	0.00	0.00

Low-Flow

Metals Loading

Site #	Description	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load	Tot. Load
		Al	Al	As	As	Ba	Ba	Be	Be	Cd	Cd	Co	Co
		g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day
PG-6	Tributary Below Hercules	3.73	3.65	0.00	0.00	0.11	0.11	0.00	0.00	0.01	0.01	0.00	0.02
PG-7	Tributary Below Draining Mine	25.62	26.49	0.00	0.00	0.21	0.28	0.00	0.00	0.01	0.01	0.07	0.14
PG-8	Below Upper Mines	75.00	75.83	0.00	0.00	2.26	2.51	0.00	0.00	0.41	0.46	0.00	0.57
PG-9	Below Mineralized Canyon	202.04	239.90	0.00	0.00	4.85	5.74	0.00	0.00	0.90	0.99	0.00	1.31
PG-10	Undisturbed Tributary	97.31	98.34	0.00	0.00	0.61	0.65	0.00	0.00	0.00	0.00	0.23	0.34
PG-11	Above Henrietta 7	263.72	261.40	0.00	0.00	4.10	4.50	0.00	0.00	0.72	0.69	0.80	0.95
PG-16	Below Henrietta 7	790.13	770.40	0.00	0.23	3.37	3.65	0.00	0.00	1.70	1.53	2.08	3.17
PG-18	Above Henrietta 11	637.15	606.12	0.00	0.00	2.77	2.80	0.00	0.00	1.47	1.29	1.88	2.53
SO-1	Queen Anne	13.63	79.73	0.00	0.00	1.79	1.99	0.00	0.00	1.18	1.42	0.00	1.10
SO-3	Grand Mogul	515.99	518.87	0.00	0.00	1.10	1.17	0.00	0.00	4.53	4.46	0.26	0.71
SO-5	Mogul	294.12	308.29	0.52	1.02	0.35	0.52	0.26	0.28	9.17	8.70	1.00	1.61
SO-6	Joe & Johns	3.30	3.27	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
SO-12	Black Hawk Mine	0.00	51.94	0.00	0.00	4.21	4.61	0.00	0.00	0.88	1.23	2.65	2.45
SO-13	Silver Ledge	1674.62	2211.03	2.18	4.58	18.32	22.24	2.83	3.49	4.58	5.23	20.93	37.07
SO-14	Yukon Tunnel	0.00	1268.98	2.97	3.27	44.87	53.20	0.00	0.00	0.00	0.00	0.00	34.47
SO-16	Anglo Saxon	76.19	80.24	1.13	1.89	2.79	2.73	0.52	0.50	0.68	0.81	10.82	9.51
SO-17	Big Colorado	597.47	647.92	0.60	0.77	0.21	0.21	0.14	0.16	0.42	0.59	5.16	5.56
SO-18	Mammoth Tunnel	304.29	310.11	1.62	2.13	0.81	0.85	0.21	0.30	0.23	0.32	3.97	5.66
SO-19	Elk Tunnel	0.00	0.00	2.63	2.92	9.97	9.13	0.00	0.00	0.00	0.00	0.00	0.00
SO-20	KC #1 Adit	14.76	14.66	0.07	0.08	0.00	0.00	0.00	0.00	0.04	0.05	0.06	0.08
SO-23	Porcupine Adit	28.40	99.63	0.63	1.17	2.79	2.84	0.23	0.32	0.52	0.54	6.00	8.16
SO-24	Evelyne	69.28	67.13	0.00	0.00	0.01	0.01	0.01	0.01	0.06	0.06	0.13	0.16

000154

Cement Creek
Low-Flow
Metals Loading

Site #	Description	Diss. Load Cr g/day	Tot. Load Cr g/day	Diss. Load Cu g/day	Tot. Load Cu g/day	Diss. Load Fe g/day	Tot. Load Fe g/day	Diss. Load Mn g/day	Tot. Load Mn g/day	Diss. Load Ni g/day	Tot. Load Ni g/day	Diss. Load Pb g/day	Tot. Load Pb g/day
A-68	Silverton Co.	0.00	0.00	0.00	0.00	3853.85	13272.88	91360.50	90592.43	0.00	0.00	0.00	188.65
A-72	Silverton Co. G.S. Gage	0.00	0.00	1306.83	5662.93	359720.52	695669.17	186596.66	192477.39	0.00	0.00	0.00	1337.95
CC-1	Above Queen Anne	0.00	0.00	0.00	1.22	0.00	3.27	0.20	0.35	0.00	0.00	0.00	0.00
CC-2	CC Below Queen Anne	0.00	0.00	31.34	31.83	0.00	28.54	1232.77	1208.16	4.09	3.27	0.38	0.77
CC-3	Background Below Ross Basin	0.00	0.00	61.63	115.51	0.00	41.81	188.13	186.43	0.00	0.00	0.00	5.57
CC-4	CC Below SO-3	0.00	0.00	282.69	286.93	7.19	152.39	664.37	669.37	0.00	0.00	2.95	4.24
CC-5	CC Above Mogul	0.00	0.00	584.91	577.27	0.00	267.48	2445.09	2395.14	0.00	0.00	13.18	15.96
CC-6	CC Below Mogul	0.00	0.00	1070.97	1099.35	152.74	453.71	3940.10	3984.71	0.00	0.00	16.22	21.63
CC-6 DUP		0.00	0.00	1043.03	0.00	143.73	0.00	3881.08	0.00	0.00	0.00	17.12	0.00
CC-7	CC Above Ferricrete	0.00	0.00	706.39	748.86	177.21	394.45	2809.18	2897.61	0.00	0.00	17.41	19.50
CC-8	Below North Ferricrete	0.00	0.00	650.18	682.80	105.65	180.45	2697.15	2808.82	0.00	0.00	19.14	22.33
CC-9	Below Lower Ferricrete	0.00	0.00	800.37	864.03	205.03	644.51	3398.61	3567.64	0.00	0.00	27.22	28.10
CC-12	North Fork Above CC	6.96	8.82	2920.20	3083.37	39373.95	43566.88	5179.06	5492.07	40.28	39.54	0.83	1.72
CC-13	Below North Fork	26.53	0.00	592.99	614.15	401.91	615.85	2349.93	2432.63	33.30	0.00	17.22	20.60
CC-15	Minnehaha	0.00	0.00	29.72	32.88	105.06	474.93	83.46	89.22	0.00	0.00	13.27	20.91
CC-16	Minnehaha Above SF	0.00	0.00	0.00	2.47	3.33	26.26	0.51	1.29	0.00	0.00	0.00	0.71
CC-16 DUP		0.00	0.00	1.57	0.00	4.27	0.00	0.74	0.00	0.00	0.00	0.00	0.00
CC-19	MF Below Blackhawk	0.00	0.00	18.11	20.84	20.39	1201.64	1091.18	1229.48	0.00	0.00	2.74	3.65
CC-20	MF Above SF	0.00	0.00	0.00	13.91	54.76	776.81	355.63	430.66	0.00	0.00	0.00	1.83
CC-21	SF Above Silver Ledge	0.00	0.00	6.89	6.05	23.55	112.56	54.74	54.93	0.00	0.00	0.00	0.00
CC-22	SF Below Silver Ledge	0.00	0.00	38.32	90.30	17349.72	22115.48	4366.59	4251.97	0.00	0.00	0.00	8.33
CC-23	SF Above CC	45.05	0.00	158.50	166.29	11167.49	17890.79	9150.89	9230.42	0.00	0.00	0.00	12.79
CC-24	CC Below SF	0.00	0.00	97.21	269.19	9273.04	21592.59	17532.37	17856.03	0.00	0.00	0.00	89.73
CC-25	Above Prospect Gulch	0.00	0.00	227.73	313.72	45094.82	64074.24	25437.00	26226.88	0.00	0.00	20.70	230.91
CC-25 DUP		0.00	0.00	293.02	0.00	46687.32	0.00	26120.19	0.00	0.00	0.00	17.52	0.00
CC-26	Below Prospect Gulch	0.00	74.74	173.80	502.29	123412.30	149468.84	25385.67	25356.12	0.00	0.00	116.45	231.16
CC-28	CC Below Georgia Gulch	0.00	0.00	792.51	334.67	392024.13	437552.66	40043.73	40266.84	462.49	311.43	244.03	341.64
CC-28 DUP		0.00	0.00	529.89	0.00	402435.96	0.00	41421.90	0.00	376.50	0.00	244.03	0.00
CC-29	CC Above Porcupine Gulch	0.00	0.00	968.29	820.36	390814.57	460410.77	59546.77	59045.81	420.27	0.00	453.89	574.93
CC-30	Porcupine Gulch Above CC	0.00	0.00	15.10	16.17	31.82	158.15	295.91	300.51	0.00	0.00	0.59	1.59
CC-31	CC Below Porcupine	0.00	0.00	492.47	757.65	313025.10	366264.43	46400.10	44803.21	477.90	0.00	381.74	457.50
CC-33	Cement Creek Above SF	0.00	0.00	0.00	168.64	278.01	3750.97	9814.19	14470.44	0.00	0.00	0.00	83.97
CC-48	Cement Creek Gage	0.00	0.00	1322.47	1136.63	229258.52	345424.19	66706.98	67372.54	713.10	0.00	445.15	535.90
M-34	Mineral Creek Gage	0.00	0.00	987.11	4198.32	247363.52	405362.79	38309.67	37322.57	0.00	0.00	0.00	724.71
PG-1	Background-Upper Prospect	0.00	0.00	0.04	0.05	0.04	0.04	0.05	0.06	0.00	0.00	0.00	0.00
PG-2	Background-Upper Prospect	0.00	0.00	0.00	0.00	2.56	12.67	2.01	2.11	0.00	0.00	0.01	0.03
PG-3	Below Galena Queen	0.00	0.00	9.08	9.16	52.52	53.07	1.42	1.45	0.05	0.04	2.97	3.02
PG-4	Background-Upper Prospect	0.00	0.00	0.00	0.11	0.00	0.64	0.27	0.29	0.00	0.00	0.00	0.00
PG-5	Below Mine Drainages	0.00	0.00	0.00	0.00	3.65	4.53	0.79	0.83	0.00	0.00	0.00	0.00

Low-Flow
Metals Loading

Site #	Description	Diss. Load Cr g/day	Tot. Load Cr g/day	Diss. Load Cu g/day	Tot. Load Cu g/day	Diss. Load Fe g/day	Tot. Load Fe g/day	Diss. Load Mn g/day	Tot. Load Mn g/day	Diss. Load Ni g/day	Tot. Load Ni g/day	Diss. Load Pb g/day	Tot. Load Pb g/day
PG-6	Tributary Below Hercules	0.00	0.00	0.27	0.27	1.87	2.07	0.48	0.48	0.00	0.00	0.33	0.31
PG-7	Tributary Below Draining Mine	0.00	0.00	0.98	1.02	4.97	6.29	7.07	7.36	0.08	0.00	0.13	0.13
PG-8	Below Upper Mines	0.00	0.00	10.67	11.03	27.03	32.76	18.35	19.12	0.00	0.00	5.25	4.31
PG-9	Below Mineralized Canyon	0.00	0.00	22.32	21.39	31.30	114.93	44.12	43.20	1.44	0.00	7.23	7.82
PG-10	Undisturbed Tributary	0.00	0.00	0.26	0.28	2.37	2.88	12.44	12.69	0.21	0.25	0.51	0.50
PG-11	Above Henrietta 7	0.00	0.00	17.98	17.94	27.24	29.77	45.64	46.50	1.35	0.00	6.77	6.95
PG-16	Below Henrietta 7	0.00	0.00	84.51	82.92	322.27	1893.61	96.00	94.63	1.57	2.00	13.10	12.05
PG-18	Above Henrietta 11	0.00	0.00	64.22	61.96	1072.00	988.63	77.37	75.47	1.72	1.40	10.51	10.37
SO-1	Queen Anne	0.00	0.00	10.86	30.07	15.75	235.89	158.85	154.63	0.00	0.00	0.21	10.60
SO-3	Grand Mogul	0.00	0.00	131.84	134.46	37.39	42.41	363.82	374.80	0.61	0.67	1.98	2.03
SO-5	Mogul	0.00	0.00	379.46	377.66	2845.74	3010.09	572.16	572.87	1.22	0.89	10.72	12.13
SO-6	Joe & Johns	0.00	0.00	0.13	0.12	15.26	15.13	0.07	0.07	0.01	0.01	0.13	0.13
SO-12	Black Hawk Mine	0.00	0.00	0.00	5.49	24.35	1080.99	1244.89	1343.73	4.95	0.00	0.00	2.89
SO-13	Silver Ledge	0.00	10.25	0.00	34.23	27801.38	34098.66	5109.35	5244.54	0.00	0.00	0.00	11.34
SO-14	Yukon Tunnel	0.00	15.45	0.00	60.33	3284.49	10300.73	3115.39	3331.74	0.00	0.00	0.00	6.54
SO-16	Anglo Saxon	0.00	0.00	3.18	3.22	6948.41	8855.97	2083.26	2067.80	5.05	2.73	0.00	2.01
SO-17	Big Colorado	0.00	0.00	1.32	2.28	6610.50	6916.20	194.92	204.92	3.25	3.54	0.00	0.15
SO-18	Mammoth Tunnel	0.00	0.00	2.15	7.80	9432.11	9476.38	779.12	795.78	3.44	3.97	0.00	0.14
SO-19	Elk Tunnel	0.00	0.00	0.00	0.00	3280.66	3482.75	1623.63	1587.79	0.00	0.00	0.00	0.00
SO-20	KC #1 Adit	0.00	0.00	3.09	3.14	84.20	90.02	46.45	48.01	0.04	0.05	0.15	0.18
SO-23	Porcupine Adit	0.00	0.00	0.00	6.60	4482.76	5371.06	2516.37	2500.59	2.77	0.00	0.00	0.99
SO-24	Evelyne	0.00	0.00	0.34	0.35	89.69	111.88	5.19	5.20	0.10	0.08	0.01	0.01

Cement Creek
Low-Flow
Metals Loading

Site #	Description	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load	Tot. Load
		Sb	Sb	Se	Se	Th	Th	V	V	Zn	Zn
		g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day
A-68	Silverton Co.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	56958.83	58185.05
A-72	Silverton Co. G.S. Gage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	116992.40	129469.52
CC-1	Above Queen Anne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.10	42.18
CC-2	CC Below Queen Anne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	663.77	620.14
CC-3	Background Below Ross Basin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	831.96	800.99
CC-4	CC Below SO-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2886.50	2742.45
CC-5	CC Above Mogul	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7494.86	6963.73
CC-6	CC Below Mogul	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12289.79	11779.76
CC-6 DUP		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12170.84	0.00
CC-7	CC Above Ferricrete	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8521.20	8345.04
CC-8	Below North Ferricrete	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8478.58	8409.10
CC-9	Below Lower Ferricrete	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11736.42	11497.58
CC-12	North Fork Above CC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9775.50	10746.68
CC-13	Below North Fork	0.00	0.00	0.00	0.00	0.00	0.00	15.24	0.00	7183.85	7621.33
CC-15	Minnehaha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	285.22	313.29
CC-16	Minnehaha Above SF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.60	36.46
CC-16 DUP		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.62	0.00
CC-19	MF Below Blackhawk	0.00	0.00	0.00	0.00	0.00	0.00	7.30	0.00	453.70	560.96
CC-20	MF Above SF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	211.61	254.41
CC-21	SF Above Silver Ledge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.13	38.17
CC-22	SF Below Silver Ledge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	1469.41	1505.40
CC-23	SF Above CC	0.00	0.00	0.00	0.00	0.00	0.00	20.02	0.00	3839.10	3932.54
CC-24	CC Below SF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6527.77	7040.51
CC-25	Above Prospect Gulch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10284.37	11247.83
CC-25 DUP		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10841.74	0.00
CC-26	Below Prospect Gulch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12199.23	11796.01
CC-28	CC Below Georgia Gulch	1089.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19380.42	20068.34
CC-28 DUP		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19622.12	0.00
CC-29	CC Above Porcupine Gulch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	171.47	28050.29	29640.58
CC-30	Porcupine Gulch Above CC	0.00	0.00	0.00	0.00	0.00	0.00	1.07	0.00	195.42	203.85
CC-31	CC Below Porcupine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22598.30	22286.50
CC-33	Cement Creek Above SF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2242.40	5114.89
CC-48	Cement Creek Gage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28242.96	29275.87
M-34	Mineral Creek Gage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33586.56	35810.67
PG-1	Background-Upper Prospect	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.04
PG-2	Background-Upper Prospect	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.55
PG-3	Below Galena Queen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	85.88	83.03
PG-4	Background-Upper Prospect	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	1.06	1.93
PG-5	Below Mine Drainages	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40	2.34

000157

Low-Flow
Metals Loading

Site #	Description	Diss. Load Sb g/day	Tot. Load Sb g/day	Diss. Load Se g/day	Tot. Load Se g/day	Diss. Load Th g/day	Tot. Load Th g/day	Diss. Load V g/day	Tot. Load V g/day	Diss. Load Zn g/day	Tot. Load Zn g/day
PG-6	Tributary Below Hercules	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.65	1.56
PG-7	Tributary Below Draining Mine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.88	1.81
PG-8	Below Upper Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	103.24	102.03
PG-9	Below Mineralized Canyon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	238.62	218.77
PG-10	Undisturbed Tributary	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.30	2.10
PG-11	Above Henrietta 7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	185.76	178.10
PG-16	Below Henrietta 7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	382.85	356.88
PG-18	Above Henrietta 11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	326.82	303.42
SO-1	Queen Anne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	281.18	263.31
SO-3	Grand Mogul	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	869.25	848.15
SO-5	Mogul	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1730.78	1651.75
SO-6	Joe & Johns	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.62	2.48
SO-12	Black Hawk Mine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	285.62	351.77
SO-13	Silver Ledge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.98	1555.79	1536.82
SO-14	Yukon Tunnel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	293.02	327.20
SO-16	Anglo Saxon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	659.27	626.72
SO-17	Big Colorado	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.59	95.86	94.07
SO-18	Mammoth Tunnel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	177.90	172.63
SO-19	Elk Tunnel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	175.37	161.54
SO-20	KC #1 Adit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.27	12.13
SO-23	Porcupine Adit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	477.35	469.98
SO-24	Evelyne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.23	4.91

000158

APPENDIX 2

Cement Creek
February 25, 1997 Sampling

Site #	Flow	pH	Cond.	Temp.	Tot. As	Diss. As	Tot. Cd	Diss. Cd	Tot. Pb	Diss. Pb	Tot. Se	Diss. Se	Tot. Th	Diss. Th
	cfs	s.u.	umhos/cm	Deg C	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
PG-19	0.2	3.84	779	2	43	44.9	4.3	3.8	4.2	4.4	0	0	1.1	1.1
CC-23	1.151	5.01	890	2	0	0	4.1	3.3	4.6	1.2	0	0	0	0
CC-24	2.58	6.5	1143	3	0	0	4.2	3.1	17.9	0.8	0	0	0	0
CC-25	3.476	4.77	1337	2	0	0	3.1	2.6	25.5	14.9	0	0	0	0
CC-26	4.532	4.41	1270	3	3.8	0	3	2.5	32.8	17.1	0	0	0	0
CC-29	7.405	3.56	1360	6	8.6	1.7	2.5	2	22.6	20.2	0	0	0	0
CC-30	0.03	6.26	1840	5	6	0	2.7	2	8.4	0	0	0	0	0
CC-31	7.589	3.46	1370	2	7.9	2.1	2.5	2.1	19.4	20	0	0	0	0
CC-33	1.49	6.55	1723	3	0	0	3.7	3	17.7	0	0	0	0	0
RB-1					0	0	0	0	0	0	0	0	0	0
CC-24						0		3.5		0.8		0		0
CC-31						1.6		2.2		20.1		0		0

Site #	Tot. Al	Diss. Al	Tot. Sb	Diss. Sb	Tot. Ba	Diss. Ba	Tot. Be	Diss. Be	Tot. Cr	Diss. Cr	Tot. Co	Diss. Co	Tot. Cu	Diss. Cu
	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
PG-19	21210	20770	0	0	7	6	3	1	0	0	38	37	44	35
CC-23	3106	1859	0	0	11	11	3	1	0	0	20	21	49	31
CC-24	1923	969	0	0	10	10	2	0	0	0	10	11	44	15
CC-25	4195	3637	0	0	9	9	3	1	0	0	15	13	37	26
CC-26	5764	5059	0	0	9	8	3	1	0	0	18	12	49	31
CC-29	7501	7500	62	0	10	8	6	1	8	0	29	18	39	22
CC-30	671	0	0	0	13	11	5	0	0	0	34	34	70	0
CC-31	7375	7365	0	0	8	8	4	1	5	0	23	21	37	23
CC-33	940	329	0	0	8	8	3	0	0	0	0	7	45	4
RB-1	0	0	0	0	0	0	3	0	0	0	0	0	11	0
CC-24		921		0		9		0		0		7		11
CC-31		7507		0		8		1		0		17		24

0001160

Cement Creek
February 25, 1997 Sampling

Site #	Tot. As g/day	Diss. As g/day	Tot. Cd g/day	Diss. Cd g/day	Tot. Pb g/day	Diss. Pb g/day	Tot. Se g/day	Diss. Se g/day	Tot. Th g/day	Diss. Th g/day	Tot. Al g/day	Diss. Al g/day	Tot. Sb g/day	Diss. Sb g/day
PG-19	21.0	22.0	2.1	1.9	2.1	2.2	0.0	0.0	0.5	0.5	10382.7	10167.3	0.0	0.0
CC-23	0.0	0.0	11.6	9.3	13.0	3.4	0.0	0.0	0.0	0.0	8750.2	5237.1	0.0	0.0
CC-24	0.0	0.0	26.5	19.6	113.0	5.1	0.0	0.0	0.0	0.0	12143.3	6119.0	0.0	0.0
CC-25	0.0	0.0	26.4	22.1	216.9	126.8	0.0	0.0	0.0	0.0	35690.3	30943.0	0.0	0.0
CC-26	42.2	0.0	33.3	27.7	363.8	189.7	0.0	0.0	0.0	0.0	63937.1	56116.9	0.0	0.0
CC-29	155.9	30.8	45.3	36.2	409.6	366.1	0.0	0.0	0.0	0.0	135951.3	135933.1	1123.7	0.0
CC-30	0.4	0.0	0.2	0.1	0.6	0.0	0.0	0.0	0.0	0.0	49.3	0.0	0.0	0.0
CC-31	146.7	39.0	46.4	39.0	360.4	371.5	0.0	0.0	0.0	0.0	136989.0	136803.2	0.0	0.0
CC-33	0.0	0.0	13.5	10.9	64.6	0.0	0.0	0.0	0.0	0.0	3428.1	1199.8	0.0	0.0
RB-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Site #	Tot. Ba g/day	Diss. Ba g/day	Tot. Be g/day	Diss. Be g/day	Tot. Cr g/day	Diss. Cr g/day	Tot. Co g/day	Diss. Co g/day	Tot. Cu g/day	Diss. Cu g/day	Tot. Fe g/day	Diss. Fe g/day	Tot. Mn g/day	Diss. Mn g/day
PG-19	3.4	2.9	1.5	0.5	0.0	0.0	18.6	18.1	21.5	17.1	27765.5	26713.0	400.4	384.3
CC-23	31.0	31.0	8.5	2.8	0.0	0.0	56.3	59.2	138.0	87.3	16136.8	8119.1	8682.5	8136.0
CC-24	63.1	63.1	12.6	0.0	0.0	0.0	63.1	69.5	277.9	94.7	17043.6	8556.5	15155.5	14511.4
CC-25	76.6	76.6	25.5	8.5	0.0	0.0	127.6	110.6	314.8	221.2	84584.8	67586.2	17798.4	16207.4
CC-26	99.8	88.7	33.3	11.1	0.0	0.0	199.7	133.1	543.5	343.9	161839.4	125677.9	23272.0	20698.6
CC-29	181.2	145.0	108.7	18.1	145.0	0.0	525.6	326.2	706.9	398.7	399462.2	297421.7	38061.3	32533.3
CC-30	1.0	0.8	0.4	0.0	0.0	0.0	2.5	2.5	5.1	0.0	2124.3	564.8	826.8	737.9
CC-31	148.6	148.6	74.3	18.6	92.9	0.0	427.2	390.1	687.3	427.2	344190.6	291252.5	38431.2	36183.7
CC-33	29.2	29.2	10.9	0.0	0.0	0.0	0.0	25.5	164.1	14.6	1714.0	43.8	6936.4	5784.0
RB-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cement Creek

February 25, 1997 Sampling

Site #	Tot. Ni	Diss. Ni	Tot. Va	Diss. Va	Tot.Zn	Diss. Zn	Diss. Ca	Diss. Mg	Diss. K	Diss. Na
	g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day
PG-19	16.2	15.7	12.2	10.8	530.6	528.2	15.6	4.4	1.9	0.7
CC-23	0.0	0.0	0.0	0.0	3298.9	3186.2	490.2	24.8	0.0	9.9
CC-24	0.0	0.0	0.0	0.0	6769.5	6453.7	2046.0	64.4	0.0	29.6
CC-25	110.6	102.1	0.0	0.0	8507.8	7912.3	1863.2	81.6	0.0	33.8
CC-26	133.1	166.4	44.4	0.0	11425.3	18091.8	2251.8	100.6	0.0	41.0
CC-29	0.0	308.1	163.1	0.0	19012.5	16819.5	3751.8	178.7	36.6	74.1
CC-30	0.0	1.2	0.0	0.0	170.1	124.0	21.4	1.2	0.2	0.6
CC-31	0.0	297.2	111.4	0.0	18073.3	17757.5	3900.7	189.5	42.0	74.9
CC-33	0.0	0.0	0.0	0.0	3395.3	2746.1	1633.8	40.1	0.0	19.8
RB-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX 3

Cement Creek
High-Flow
June 25-26, 1997
Analytical Results

Site Id	Description	pH	Cond.	Flow	Diss. As	Tot. As	Diss. Cd	Tot. Cd	Diss. Pb	Tot. Pb	Diss. Se	Tot. Se	Diss. Th	Tot. Th	Diss. Al
		s.u.	umhos/cm	cfs	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
CC-1	Above Queen Anne	5.57	87	1.300	BDL	BDL	BDL	BDL	2.5	3.5	BDL	BDL	BDL	BDL	BDL
CC-2	CC Below Queen Anne	5.43	82	4.610	BDL	BDL	BDL	0.5	1.8	3.8	BDL	BDL	BDL	BDL	BDL
CC-3	Background Below Ross Basin	6.70	90	5.969	BDL	BDL	1.9	2.5	6.5	12.4	BDL	BDL	BDL	BDL	52
CC-4	CC Below SO-3	6.38	120	6.999	BDL	BDL	4.6	5.8	6.5	13.7	BDL	BDL	BDL	BDL	440
CC-5	CC Above Mogul	4.91	124	18.918	BDL	BDL	3.2	4.1	2.7	8.4	BDL	BDL	BDL	BDL	161
CC-6	CC Below Mogul	5.16	192	24.850	BDL	BDL	3.9	4.6	4.9	9.8	BDL	BDL	BDL	BDL	377
CC-7	CC Above Ferricrete	5.27	87	29.983	BDL	BDL	3.5	4.4	4.5	8	BDL	BDL	BDL	BDL	330
CC-8	Below North Ferricrete	4.18	105	40.647	BDL	BDL	2.8	3.4	4.2	6.8	BDL	BDL	BDL	BDL	475
CC-9	Below Lower Ferricrete	4.52	84	34.555	BDL	BDL	2.7	3.3	4	5.7	BDL	BDL	BDL	BDL	466
CC-12	North Fork Above CC	2.71	612	1.225	25.2	9.7	38	4.4	3.7	4.4	BDL	BDL	BDL	BDL	15210
CC-13	Below North Fork	3.30	176	37.072	2	3.2	6	6.4	4.9	6.4	BDL	BDL	BDL	BDL	2215
CC-14	Minnehaha Background	5.59	107	2.607	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
CC-15	Minnehaha Below Lead Carbonate	5.65	109	2.508	BDL	BDL	0.7	0.8	4.4	12.9	BDL	BDL	BDL	BDL	96
CC-16	Minnehaha Above SF	5.64	124	4.438	BDL	BDL	0.5	0.5	1.5	3.9	BDL	BDL	BDL	BDL	65
CC-17	Middle Fork Above Mine Blockage	5.04	70	0.800	BDL	BDL	BDL	BDL	0.8	1.3	BDL	BDL	BDL	BDL	BDL
CC-19	MF Below Blackhawk	5.15	194	2.010	BDL	BDL	2.1	1.3	1.2	1.6	BDL	BDL	BDL	BDL	141
CC-20	MF Above SF	5.49	349	5.610	BDL	BDL	0.8	1.1	BDL	1.4	BDL	BDL	BDL	BDL	48
CC-21	SF Above Silver Ledge	5.59	106	17.896	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	66
CC-22	SF Below Silver Ledge	4.93	220	20.104	BDL	BDL	1.1	1.6	BDL	5.7	BDL	BDL	BDL	BDL	377
CC-23	SF Above CC	4.90	190	31.701	BDL	BDL	1.2	1.2	BDL	3.7	BDL	BDL	BDL	BDL	92
CC-24	CC Below SF	3.62	230	64.460	BDL	BDL	4	3.6	6.9	9.2	BDL	BDL	BDL	BDL	1247
CC-25	CC Above Prospect Gulch	3.76	217	59.440	BDL	BDL	3.6	3.4	12.3	14.1	BDL	BDL	BDL	BDL	1394
CC-26	CC Below Prospect	3.36	230	89.435	BDL	BDL	3.6	3.1	17.3	18.4	BDL	BDL	BDL	BDL	1466
CC-27	Georgia Gulch Above Confluence	5.09	136	7.018	BDL	BDL	1.4	1.2	BDL	1	BDL	BDL	BDL	BDL	BDL
CC-28	CC Below Georgia Gulch	3.54	255	109.379	BDL	1.3	3.2	2.4	17	18.6	BDL	BDL	BDL	BDL	1751
CC-29	CC Above Porcupine Gulch	3.60	200	111.200	BDL	1.4	3.4	3.6	15.2	17.6	BDL	BDL	BDL	BDL	1546
CC-30	Porcupine Gulch Above CC	4.85	440	3.951	BDL	BDL	0.9	0.8	6.6	22.5	BDL	BDL	BDL	BDL	75
CC-31	CC Below Porcupine	3.93	203	116.797	BDL	1.3	3.2	4	15.6	16.5	BDL	BDL	BDL	BDL	1507
CC-32	Below Hurricane Mine Complex	4.05	183	1.043	BDL	BDL	8.1	4.3	5	4.3	BDL	BDL	BDL	BDL	1977
CC-33	CC Below Sunnyside Ponds	2.96	271	33.442	1.8	2.2	7.9	9.5	11.1	12.8	BDL	BDL	BDL	BDL	2217
PG-1	Background-Upper Prospect	6.14	32	0.187	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
PG-2	Background-Upper Prospect	5.52	60	0.403	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	71
PG-3	Below Galena Queen	3.77	90	0.334	1.3	3.3	11	10	62.3	59.3	BDL	BDL	BDL	BDL	300
PG-4	Background-Upper Prospect	5.97	200	0.537	BDL	BDL	1.3	1.3	BDL	BDL	BDL	BDL	BDL	BDL	240
PG-5	Below Mine Drainages	5.66	329	0.485	BDL	BDL	1	0.9	BDL	BDL	BDL	BDL	BDL	BDL	BDL
PG-6	Tributary Below Hercules	4.35	40	0.562	BDL	1.1	1.2	1	15.1	15.1	BDL	BDL	BDL	BDL	316
PG-7	Tributary Below Draining Mine	4.67	308	0.124	BDL	BDL	0.9	0.7	16.1	16.3	BDL	BDL	BDL	BDL	666

Cement Creek
High-Flow
June 25-26, 1997
Analytical Results

Site Id	Description	pH s.u.	Cond. umhos/cm	Flow cfs	Diss. As ug/l	Tot. As ug/l	Diss. Cd ug/l	Tot. Cd ug/l	Diss. Pb ug/l	Tot. Pb ug/l	Diss. Se ug/l	Tot. Se ug/l	Diss. Th ug/l	Tot. Th ug/l	Diss. Al ug/l
PG-8	Below Upper Mines	4.93	90	2.850	BDL	BDL	2.3	2.6	5.5	14.1	BDL	BDL	BDL	BDL	64
PG-9	Below Mineralized Canyon	5.81	166	3.079	BDL	BDL	2.1	2.2	5.8	14.7	BDL	BDL	BDL	BDL	72
PG-10	Undisturbed Tributary	3.60	98	1.021	BDL	BDL	2	BDL	5.7	17.3	BDL	BDL	BDL	BDL	52
PG-11	Above Henrietta 7	4.52	90	4.220	BDL	3.1	1.6	1.6	16.3	137	BDL	BDL	BDL	BDL	626
PG-12	Spring	3.93	33	0.106	BDL	133	1	1.6	4	1511	BDL	4.1	BDL	1.6	188
PG-13	Spring	4.35	70	0.002	BDL	BDL	1.9	2.1	7.3	6.7	BDL	BDL	BDL	BDL	1488
PG-14	Tributary Below Lark & Mine Waste	2.74	330	0.095	BDL	16.4	9	10	20.8	165	BDL	BDL	BDL	BDL	1456
PG-15	Below Henrietta 7	3.97	130	5.262	BDL	2.6	2.6	2.7	19.4	20.3	BDL	BDL	BDL	BDL	812
PG-16	Below Tributary PG14	3.04	150	5.360	1	2.9	3.4	3.4	29.5	88.2	BDL	BDL	BDL	BDL	918
PG-17	Below Joe & Johns Tributary	2.54	530	0.014	2.3	3.1	21	21	164	157	BDL	BDL	BDL	BDL	2923
PG-18	Above Henrietta 11	3.47	150	6.600	1.3	*	2.7	*	24.7	*	BDL	*	BDL	*	951
PG-18	Above Henrietta 11	3.47	150	6.600	1.1	*	3.1	*	25.2	*	BDL	*	BDL	*	946
PG-19	Prospect Gulch Above Confluence	3.01	193	9.956	2	2.7	3.4	4.2	47.7	51.9	BDL	BDL	BDL	BDL	1820
PG-20	Tributary Above Hercules	3.81	41	0.381	BDL	BDL	BDL	BDL	2.9	5.7	BDL	BDL	BDL	BDL	161
SO-1	Queen Anne Mine	6.26	144	0.083	BDL	BDL	4	5.2	9.1	44.5	BDL	BDL	BDL	BDL	46
SO-2	Lark Mine	2.71	60	0.012	142	136	242	226	1117	1034	BDL	BDL	BDL	BDL	3532
SO-3	Grand Mogul	3.34	294	1.356	BDL	1.4	20	18	29.3	30.6	BDL	BDL	BDL	BDL	2020
SO-4	Henrietta 7 Mine	2.80	49	0.101	38	36.4	16	14	6.3	6.3	1.2	2	BDL	BDL	2238
SO-5	Mogul	2.61	722	0.060	9.1	7.8	119	98	259	200	BDL	BDL	BDL	BDL	3695
SO-6	Joe & Johns	2.92	80	0.034	111	98.4	63	59	1538	1434	BDL	BDL	BDL	1.3	8439
SO-7	Mine South of Mogul	3.00	706	0.030	12.2	13	28	28	54.3	51.3	BDL	BDL	BDL	BDL	5912
SO-8	Red & Bonita Mine	3.01	879	0.013	BDL	BDL	97	101	110	143	BDL	BDL	BDL	BDL	11270
SO-12	Black Hawk Mine	nd	nd	0.845	BDL	BDL	0.9	1.3	BDL	2.4	BDL	BDL	BDL	BDL	BDL
SO-13	Silver Ledge	6.14	560	2.456	1	2.6	7	6	9.2	36.1	BDL	BDL	BDL	BDL	2877
SO-14	Yukon Tunnel	6.72	997	1.210	BDL	BDL	BDL	BDL	BDL	2.4	BDL	BDL	BDL	BDL	BDL
SO-16	Anglo Saxon	6.63	1510	0.131	5.7	6.7	4.9	4.8	3.8	9.1	BDL	BDL	BDL	BDL	348
SO-17	Big Colorado	5.24	685	0.015	X	7.5	X	3.3	X	1.3	X	BDL	X	BDL	X
SO-18	Mammoth Tunnel	5.76	982	0.065	6.8	10	2.9	1.9	1.5	BDL	BDL	BDL	BDL	BDL	7159
SO-19	Adit Below Georgia Gulch	7.05	1257	0.385	3.6	3.5	BDL	BDL	BDL	0.9	BDL	BDL	BDL	BDL	BDL
SO-20	Kansas City Adit #1	6.44	166	0.022	BDL	7.6	1.4	2.3	10.5	140	BDL	BDL	BDL	BDL	BDL
SO-21	Kansas City Adit #2	6.11	270	0.021	BDL	BDL	9	10	2.2	14.6	BDL	BDL	BDL	BDL	62
SO-23	Porcupine Gulch Adit	6.43	1359	0.120	2.3	4.1	4.2	4.1	BDL	11.4	BDL	BDL	BDL	BDL	475
SO-24	Dry Gulch Adit (Evelyne)	3.31	450	0.130	BDL	1.3	10	12	3.2	2.8	BDL	BDL	BDL	BDL	11290
DG-1	Deer Gulch	7.10	80	nd	BDL	BDL	BDL	BDL	BDL	0.9	BDL	BDL	BDL	BDL	BDL
EP-1	Elk Park	7.30	120	nd	BDL	BDL	0.8	0.8	BDL	8.1	BDL	BDL	BDL	BDL	BDL
KC-1	Kendall Creek	8.10	60	nd	BDL	BDL	BDL	BDL	BDL	0.8	BDL	BDL	BDL	BDL	BDL
UK-1	1st East Trib south of Deer Creek	7.70	20	nd	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	81
SO-18	Duplicate			0.065	6.9		1.5		BDL		BDL		BDL		1780
	* Bottle leaked during transport														

Cement Creek
High-Flow
June 25-26, 1997
Analytical Results

Site Id	Description	Tot. Al ug/l	Diss. Sb ug/l	Tot. Sb ug/l	Diss. Ba ug/l	Tot. Ba ug/l	Diss. Be ug/l	Tot. Be ug/l	Diss. Ca mg/l	Diss. Cr ug/l	Tot. Cr ug/l	Diss. Co ug/l	Tot. Co ug/l	Diss. Cu ug/l	Tot. Cu ug/l
CC-1	Above Queen Anne	43	BDL	BDL	12	13	BDL	BDL	11.7	BDL	5	BDL	BDL	BDL	BDL
CC-2	CC Below Queen Anne	59	BDL	BDL	12	13	BDL	BDL	11.9	BDL	BDL	BDL	BDL	BDL	BDL
CC-3	Background Below Ross Basin	306	BDL	BDL	17	18	BDL	BDL	15	BDL	BDL	BDL	BDL	40	59
CC-4	CC Below SO-3	676	BDL	BDL	16	17	BDL	BDL	13.4	BDL	BDL	BDL	BDL	174	180
CC-5	CC Above Mogul	553	BDL	BDL	16	18	BDL	BDL	14.1	BDL	BDL	BDL	BDL	78	90
CC-6	CC Below Mogul	706	BDL	BDL	16	18	BDL	BDL	13.9	BDL	BDL	BDL	BDL	110	118
CC-7	CC Above Ferricrete	658	BDL	BDL	15	17	BDL	BDL	13.4	BDL	5	BDL	BDL	95	104
CC-8	Below North Ferricrete	670	BDL	BDL	18	20	BDL	BDL	12	BDL	7	BDL	BDL	84	87
CC-9	Below Lower Ferricrete	709	BDL	BDL	18	19	BDL	BDL	11.9	BDL	BDL	BDL	BDL	82	87
CC-12	North Fork Above CC	15660	BDL	BDL	10	12	BDL	1	14.9	BDL	BDL	34	36	2349	2398
CC-13	Below North Fork	2478	BDL	BDL	17	19	BDL	BDL	11.8	BDL	BDL	7	BDL	333	353
CC-14	Minnehaha Background	53	BDL	BDL	16	17	BDL	BDL	15.8	BDL	BDL	BDL	BDL	BDL	BDL
CC-15	Minnehaha Below Lead Carbonate	337	BDL	BDL	16	18	BDL	BDL	15	BDL	BDL	BDL	BDL	15	34
CC-16	Minnehaha Above SF	130	BDL	BDL	14	16	BDL	BDL	17.1	BDL	BDL	BDL	BDL	BDL	9
CC-17	Middle Fork Above Mine Blockage	116	BDL	BDL	8	9	BDL	BDL	9.34	BDL	BDL	BDL	BDL	BDL	5
CC-19	MF Below Blackhawk	522	BDL	BDL	10	10	BDL	BDL	31.4	BDL	BDL	BDL	BDL	37	43
CC-20	MF Above SF	336	BDL	BDL	7	10	BDL	BDL	26.2	BDL	BDL	BDL	BDL	10	23
CC-21	SF Above Silver Ledge	403	BDL	BDL	10	11	BDL	BDL	16.6	BDL	BDL	6	BDL	BDL	4
CC-22	SF Below Silver Ledge	1143	BDL	BDL	10	10	BDL	BDL	34.9	BDL	BDL	6	8	16	28
CC-23	SF Above CC	717	BDL	BDL	10	10	BDL	BDL	29.3	BDL	BDL	8	6	9	22
CC-24	CC Below SF	1566	BDL	BDL	13	16	BDL	1	29.6	BDL	BDL	7	7	175	174
CC-25	CC Above Prospect Gulch	1613	BDL	BDL	14	16	BDL	BDL	28.3	BDL	BDL	BDL	8	155	158
CC-26	CC Below Prospect	1691	BDL	BDL	16	17	BDL	BDL	26	BDL	BDL	BDL	7	169	168
CC-27	Georgia Gulch Above Confluence	298	BDL	BDL	18	20	BDL	BDL	18.7	BDL	BDL	BDL	BDL	25	33
CC-28	CC Below Georgia Gulch	2084	BDL	BDL	15	18	BDL	BDL	30	BDL	4	6	BDL	155	158
CC-29	CC Above Porcupine Gulch	1769	BDL	BDL	16	18	BDL	BDL	29.3	BDL	BDL	9	9	130	132
CC-30	Porcupine Gulch Above CC	754	BDL	BDL	34	38	BDL	BDL	29.7	BDL	BDL	8	7	6	15
CC-31	CC Below Porcupine	1753	BDL	BDL	16	17	BDL	BDL	29.1	BDL	BDL	6	6	128	131
CC-32	Below Hurricane Mine Complex	1949	BDL	BDL	30	30	BDL	BDL	24	BDL	BDL	BDL	BDL	262	253
CC-33	CC Below Sunnyside Ponds	2456	BDL	BDL	16	18	BDL	BDL	19.5	BDL	BDL	BDL	6	326	329
PG-1	Background-Upper Prospect	117	BDL	BDL	18	21	BDL	BDL	3.16	BDL	BDL	BDL	BDL	BDL	5
PG-2	Background-Upper Prospect	257	BDL	BDL	19	20	BDL	BDL	9.65	BDL	BDL	BDL	BDL	BDL	BDL
PG-3	Below Galena Queen	408	BDL	BDL	16	18	BDL	BDL	3.13	BDL	BDL	BDL	BDL	269	264
PG-4	Background-Upper Prospect	BDL	BDL	BDL	32	34	BDL	BDL	36.3	BDL	BDL	BDL	BDL	BDL	4
PG-5	Below Mine Drainages	42	BDL	BDL	29	29	BDL	BDL	31.9	BDL	BDL	BDL	BDL	BDL	BDL
PG-6	Tributary Below Hercules	256	BDL	BDL	32	31	BDL	BDL	3.28	BDL	BDL	BDL	BDL	22	22
PG-7	Tributary Below Draining Mine	652	BDL	BDL	20	21	BDL	2	24.5	BDL	BDL	BDL	6	53	57

Cement Creek
High-Flow
June 25-26, 1997
Analytical Results

Site Id	Description	Tot. Al ug/l	Diss. Sb ug/l	Tot. Sb ug/l	Diss. Ba ug/l	Tot. Ba ug/l	Diss. Be ug/l	Tot. Be ug/l	Diss. Ca mg/l	Diss. Cr ug/l	Tot. Cr ug/l	Diss. Co ug/l	Tot. Co ug/l	Diss. Cu ug/l	Tot. Cu ug/l
PG-8	Below Upper Mines	519	BDL	BDL	24	28	BDL	BDL	14.3	BDL	BDL	BDL	BDL	37	48
PG-9	Below Mineralized Canyon	548	BDL	BDL	22	24	BDL	BDL	13.5	BDL	BDL	BDL	6	35	44
PG-10	Undisturbed Tributary	1842	BDL	BDL	22	BDL	BDL	BDL	13.4	BDL	BDL	BDL	BDL	32	6
PG-11	Above Henrietta 7	971	BDL	BDL	29	34	BDL	BDL	11.1	BDL	BDL	BDL	BDL	28	38
PG-12	Spring	21080	BDL	BDL	74	422	1	BDL	2.45	BDL	13	BDL	BDL	BDL	143
PG-13	Spring	1527	BDL	BDL	84	85	BDL	BDL	2.66	BDL	BDL	BDL	BDL	104	BDL
PG-14	Tributary Below Lark & Mine Waste	7539	BDL	BDL	63	118	BDL	BDL	2.54	BDL	BDL	11	6	372	371
PG-15	Below Henrietta 7	1101	BDL	BDL	28	29	1	BDL	13.7	4	BDL	BDL	BDL	104	100
PG-16	Below Tributary PG14	1424	BDL	BDL	28	32	1	BDL	13.6	BDL	BDL	BDL	BDL	142	142
PG-17	Below Joe & Johns Tributary	2946	BDL	BDL	22	22	1	BDL	2.36	BDL	BDL	9	14	601	588
PG-18	Above Henrietta 11	*	BDL	*	29	*	1	*	12.5	4	*	BDL	*	166	*
PG-18	Above Henrietta 11	*	BDL	*	29	*	1	*	12.5	BDL	*	BDL	*	169	*
PG-19	Prospect Gulch Above Confluence	2011	BDL	BDL	27	28	1	BDL	10.8	BDL	BDL	BDL	7	260	259
PG-20	Tributary Above Hercules	377	BDL	BDL	31	31	1	BDL	3.67	BDL	BDL	BDL	BDL	18	14
SO-1	Queen Anne Mine	149	BDL	BDL	8	9	2	BDL	27	5	BDL	BDL	BDL	61	82
SO-2	Lark Mine	3612	BDL	BDL	17	16	2	BDL	2.86	BDL	4	45	44	12020	11820
SO-3	Grand Mogul	2114	BDL	BDL	15	15	2	BDL	11.3	4	BDL	BDL	BDL	727	725
SO-4	Henrietta 7 Mine	2342	BDL	BDL	14	14	2	BDL	4.79	BDL	BDL	18	21	170	167
SO-5	Mogul	3259	BDL	BDL	4	3	4	2	45.8	BDL	BDL	15	14	5395	4567
SO-6	Joe & Johns	8538	BDL	BDL	17	18	2	BDL	2.04	4	4	25	26	1121	1100
SO-7	Mine South of Mogul	6268	BDL	BDL	3	4	6	4	59.3	BDL	BDL	23	27	1991	2059
SO-8	Red & Bonita Mine	12630	BDL	BDL	5	6	5	4	47.1	BDL	BDL	92	102	1359	1429
SO-12	Black Hawk Mine	139	BDL	BDL	12	14	1	BDL	72.6	BDL	BDL	BDL	BDL	4	6
SO-13	Silver Ledge	3516	BDL	BDL	5	6	4	3	126	BDL	BDL	30	34	114	126
SO-14	Yukon Tunnel	209	BDL	BDL	15	17	1	BDL	215	BDL	4	BDL	BDL	BDL	15
SO-16	Anglo Saxon	598	BDL	BDL	9	11	3	2	280	BDL	BDL	34	45	30	35
SO-17	Big Colorado	8170	BDL	BDL	X	4	X	2	X	X	BDL	X	63	X	77
SO-18	Mammoth Tunnel	2007	BDL	BDL	3	7	3	1	127	4	BDL	54	34	73	38
SO-19	Adit Below Georgia Gulch	50	BDL	BDL	9	10	1	BDL	255	BDL	BDL	BDL	7	BDL	BDL
SO-20	Kansas City Adit #1	427	BDL	BDL	9	12	1	BDL	25.6	4	5	BDL	BDL	29	84
SO-21	Kansas City Adit #2	342	BDL	BDL	6	7	2	BDL	37.8	4	4	6	8	51	66
SO-23	Porcupine Gulch Adit	846	BDL	BDL	11	13	2	2	237	BDL	BDL	30	50	18	65
SO-24	Dry Gulch Adit (Evelyne)	12720	BDL	BDL	1	1	2	1	4.6	BDL	4	25	31	315	324
DG-1	Deer Gulch	51	BDL	BDL	10	11	1	BDL	16.2	BDL	BDL	BDL	BDL	BDL	BDL
EP-1	Elk Park	510	BDL	BDL	19	24	1	BDL	17.8	4	BDL	BDL	BDL	7	14
KC-1	Kendall Creek	153	BDL	BDL	22	25	1	BDL	12	4	6	BDL	BDL	BDL	7
UK-1	1st East Trib south of Deer Creek	199	BDL	BDL	8	10	1	BDL	4.17	BDL	4	BDL	BDL	5	BDL
SO-18	Duplicate		BDL		5		2		200	5		32		27	
	* Bottle leaked during transport														

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Cement Creek
High-Flow
June 25-26, 1997
Analytical Results

	Description	Diss. Fe	Tot. Fe	Diss. Mg	Diss. Mn	Tot. Mn	Diss. Ni	Tot. Ni	Diss. K	Diss. Na	Diss. V	Tot. V	Diss. Zn	Tot. Zn
Site Id		ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	mg/l	mg/l	ug/l	ug/l	ug/l	ug/l
CC-1	Above Queen Anne	10	22	1.17	28	32	13	BDL	BDL	0.42	BDL	BDL	64	63
CC-2	CC Below Queen Anne	BDL	31	1.19	28	33	11	BDL	BDL	0.44	BDL	BDL	62	63
CC-3	Background Below Ross Basin	5	110	1.44	147	153	11	BDL	BDL	0.49	BDL	BDL	403	399
CC-4	CC Below SO-3	123	862	1.55	366	365	12	BDL	BDL	0.49	BDL	BDL	1074	1010
CC-5	CC Above Mogul	26	364	1.65	561	594	12	BDL	BDL	0.5	BDL	BDL	709	711
CC-6	CC Below Mogul	115	490	1.64	562	572	13	BDL	BDL	0.53	BDL	BDL	919	864
CC-7	CC Above Ferricrete	61	447	1.55	511	540	17	39	BDL	0.52	BDL	BDL	813	818
CC-8	Below North Ferricrete	80	377	1.38	438	440	BDL	BDL	BDL	0.51	BDL	4	728	696
CC-9	Below Lower Ferricrete	81	365	1.36	434	439	13	BDL	BDL	0.51	BDL	BDL	724	746
CC-12	North Fork Above CC	66330	37810	7.87	2147	2274	37	25	BDL	0.87	6	5	8010	8157
CC-13	Below North Fork	6770	7912	2.08	611	668	32	BDL	BDL	0.57	BDL	BDL	1559	1620
CC-14	Minnehaha Background	16	38	0.99	5	5	BDL	BDL	BDL	0.99	BDL	4	13	11
CC-15	Minnehaha Below Lead Carbonate	314	761	1.11	53	60	12	BDL	BDL	0.93	BDL	BDL	205	214
CC-16	Minnehaha Above SF	61	233	1.42	26	31	12	BDL	BDL	0.84	BDL	BDL	114	125
CC-17	Middle Fork Above Mine Blockage	8	43	1.18	55	58	BDL	BDL	BDL	0.34	BDL	BDL	47	42
CC-19	MF Below Blackhawk	21	200	2.6	240	272	12	BDL	BDL	0.95	BDL	BDL	282	285
CC-20	MF Above SF	56	252	2.27	136	174	12	BDL	BDL	0.68	BDL	BDL	177	184
CC-21	SF Above Silver Ledge	34	222	1.24	44	47	BDL	BDL	BDL	0.78	BDL	BDL	31	32
CC-22	SF Below Silver Ledge	3068	4480	2.63	435	455	14	BDL	BDL	1.17	BDL	BDL	291	289
CC-23	SF Above CC	1279	2020	2.36	359	374	12	BDL	BDL	1.05	BDL	BDL	265	261
CC-24	CC Below SF	2390	4074	2.46	557	562	12	BDL	BDL	0.89	BDL	4	969	907
CC-25	CC Above Prospect Gulch	1929	3662	2.46	539	544	13	BDL	BDL	0.92	BDL	BDL	870	835
CC-26	CC Below Prospect	2298	3816	2.37	491	494	14	BDL	BDL	0.86	BDL	BDL	890	816
CC-27	Georgia Gulch Above Confluence	5	211	2.5	317	333	44	BDL	BDL	0.7	BDL	BDL	458	453
CC-28	CC Below Georgia Gulch	3308	4931	2.61	520	530	11	BDL	BDL	0.91	BDL	4	837	809
CC-29	CC Above Porcupine Gulch	2352	4312	2.56	469	477	15	BDL	BDL	0.96	BDL	BDL	711	703
CC-30	Porcupine Gulch Above CC	1337	2444	2.7	1424	1428	14	BDL	BDL	1.33	BDL	BDL	356	364
CC-31	CC Below Porcupine	2323	3791	2.54	462	476	12	BDL	BDL	0.93	BDL	BDL	713	699
CC-32	Below Hurricane Mine Complex	174	211	3.29	2062	1967	15	BDL	BDL	0.61	BDL	BDL	1483	1376
CC-33	CC Below Sunnyside Ponds	5661	6594	2.32	739	762	15	BDL	BDL	0.65	BDL	BDL	1624	1592
PG-1	Background-Upper Prospect	68	454	0.55	8	26	BDL	BDL	BDL	0.42	BDL	BDL	BDL	BDL
PG-2	Background-Upper Prospect	25	104	1.36	55	54	14	BDL	BDL	0.49	BDL	BDL	10	9
PG-3	Below Galena Queen	2984	3542	0.6	24	28	11	BDL	BDL	0.47	BDL	BDL	2830	2687
PG-4	Background-Upper Prospect	9	5	3.4	245	247	11	BDL	BDL	0.87	BDL	5	284	256
PG-5	Below Mine Drainages	BDL	22	2.89	168	162	BDL	BDL	BDL	0.78	BDL	BDL	176	190
PG-6	Tributary Below Hercules	360	202	0.63	30	29	13	BDL	BDL	0.25	BDL	BDL	164	153
PG-7	Tributary Below Draining Mine	360	274	4.79	226	218	20	BDL	BDL	0.36	BDL	BDL	86	82

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Cement Creek
High-Flow
June 25-26, 1997
Analytical Results

Site Id	Description	Diss. Fe ug/l	Tot. Fe ug/l	Diss. Mg mg/l	Diss. Mn ug/l	Tot. Mn ug/l	Diss. Ni ug/l	Tot. Ni ug/l	Diss. K mg/l	Diss. Na mg/l	Diss. V ug/l	Tot. V ug/l	Diss. Zn ug/l	Tot. Zn ug/l
PG-8	Below Upper Mines	83	597	1.77	92	94	12	BDL	BDL	0.45	BDL	BDL	501	470
PG-9	Below Mineralized Canyon	111	654	1.81	93	95	13	BDL	BDL	0.4	BDL	BDL	419	400
PG-10	Undisturbed Tributary	114	495	1.78	91	220	BDL	BDL	BDL	0.4	BDL	BDL	427	37
PG-11	Above Henrietta 7	189	653	1.84	138	135	14	BDL	BDL	0.34	BDL	BDL	298	315
PG-12	Spring	24	58990	0.4	27	1511	BDL	BDL	BDL	0.26	BDL	47	250	367
PG-13	Spring	258	102	0.7	72	355	BDL	BDL	BDL	0.37	BDL	BDL	431	402
PG-14	Tributary Below Lark & Mine Waste	7507	20120	0.9	76	165	22	BDL	BDL	0.32	BDL	11	2268	2058
PG-15	Below Henrietta 7	2364	2724	2.02	152	148	BDL	BDL	BDL	0.37	BDL	BDL	532	463
PG-16	Below Tributary PG14	3813	3909	1.97	156	156	BDL	BDL	BDL	0.36	BDL	BDL	655	585
PG-17	Below Joe & Johns Tributary	12720	10490	2.43	388	374	BDL	BDL	BDL	0.33	BDL	BDL	4949	4431
PG-18	Above Henrietta 11	3561	*	1.89	150	*	BDL	*	BDL	0.36	BDL	*	789	*
PG-18	Above Henrietta 11	3578	*	1.88	150	*	BDL	*	BDL	0.36	BDL	*	784	*
PG-19	Prospect Gulch Above Confluence	4767	4710	1.92	177	174	BDL	BDL	BDL	0.42	BDL	5	810	732
PG-20	Tributary Above Hercules	228	454	0.61	28	27	BDL	BDL	BDL	0.22	BDL	BDL	18	12
SO-1	Queen Anne Mine	75	446	1.79	397	400	BDL	BDL	BDL	0.63	BDL	BDL	885	815
SO-2	Lark Mine	71800	64060	1.22	164	157	27	33	BDL	0.21	BDL	4	55110	49940
SO-3	Grand Mogul	4451	4114	2.15	1357	1315	BDL	BDL	BDL	0.45	BDL	BDL	3737	3405
SO-4	Henrietta 7 Mine	48880	43600	1.23	106	102	BDL	BDL	BDL	0.26	BDL	5	3136	2833
SO-5	Mogul	44750	39240	2.96	7195	200	BDL	BDL	BDL	1.55	BDL	BDL	25200	21250
SO-6	Joe & Johns	57540	51110	1.11	130	124	BDL	13	BDL	0.3	10	11	12080	10890
SO-7	Mine South of Mogul	48770	48300	5.42	1892	1941	BDL	18	BDL	1.91	BDL	BDL	5316	5113
SO-8	Red & Bonita Mine	38770	41450	16.7	26120	27730	18	36	BDL	3.06	BDL	BDL	18200	18490
SO-12	Black Hawk Mine	80	470	4.06	426	437	BDL	BDL	BDL	1.2	BDL	BDL	286	276
SO-13	Silver Ledge	22970	30050	9.08	2424	1557	BDL	19	BDL	2.73	BDL	BDL	1641	1646
SO-14	Yukon Tunnel	273	1488	6.28	711	788	BDL	BDL	BDL	5.67	BDL	BDL	119	116
SO-16	Anglo Saxon	32190	34240	18.8	8825	9198	BDL	19	2.3	9.02	BDL	BDL	3203	3227
SO-17	Big Colorado	X	86650	X	X	2271	X	36	X	X	X	7	X	1009
SO-18	Mammoth Tunnel	85010	56490	13.7	2192	4546	24	19	3.45	4.02	7	BDL	1026	1049
SO-19	Adit Below Georgia Gulch	3634	4161	5.57	1674	1838	BDL	BDL	BDL	6.9	BDL	BDL	285	266
SO-20	Kansas City Adit #1	79	1655	1.8	216	365	BDL	BDL	BDL	0.76	BDL	5	358	548
SO-21	Kansas City Adit #2	1742	2802	2.51	1452	1578	BDL	BDL	BDL	0.78	BDL	BDL	1020	1037
SO-23	Porcupine Gulch Adit	20870	27740	15.5	14870	15390	BDL	32	BDL	7.98	BDL	BDL	3088	3062
SO-24	Dry Gulch Adit (Evelyne)	26240	29780	10.2	820	876	BDL	16	BDL	2.37	BDL	5	1053	1059
DG-1	Deer Gulch	BDL	26	1.24	1	2	BDL	BDL	BDL	0.89	BDL	BDL	6	4
EP-1	Elk Park	58	659	2.05	114	186	BDL	BDL	BDL	1.03	BDL	BDL	194	223
KC-1	Kendall Creek	8	72	1.02	3	6	BDL	BDL	BDL	0.69	BDL	BDL	12	11
UK-1	1st East Trib south of Deer Creek	38	78	0.71	BDL	2	BDL	BDL	BDL	0.41	BDL	4	10	9
SO-18	Duplicate	54680		17.9	4431		BDL		3.41	5.29	4		1076	
	* Bottle leaked during transport													

Cement Creek
High-Flow
June 25-26, 1997
Analytical Results

	Description	Hardness	Silica	Chloride	Sulfate
Site id		mg CaCO3/l	mg/l	mg/l	mg/l
CC-1	Above Queen Anne	34	2.71	BDL	25.4
CC-2	CC Below Queen Anne	34.6	2.73	BDL	25.5
CC-3	Background Below Ross Basin	43.4	3.27	BDL	33.9
CC-4	CC Below SO-3	39.8	4.17	BDL	43.3
CC-5	CC Above Mogul	42	4.11	BDL	44.7
CC-6	CC Below Mogul	41.5	4.89	BDL	51.4
CC-7	CC Above Ferricrete	39.8	4.89	BDL	51.3
CC-8	Below North Ferricrete	35.6	5.78	BDL	43.6
CC-9	Below Lower Ferricrete	35.3	6.13	BDL	50
CC-12	North Fork Above CC	69.6	X	X	X
CC-13	Below North Fork	38	7.36	BDL	111
CC-14	Minnehaha Background	43.5	6.39	BDL	21.5
CC-15	Minnehaha Below Lead Carbonate	42	6.83	BDL	25.9
CC-16	Minnehaha Above SF	48.5	5.78	BDL	27.8
CC-17	Middle Fork Above Mine Blockage	28.2	3.13	BDL	24.1
CC-19	MF Below Blackhawk	89.1	5.59	BDL	90.7
CC-20	MF Above SF	74.8	5.55	BDL	67.2
CC-21	SF Above Silver Ledge	46.6	6.6	BDL	37.2
CC-22	SF Below Silver Ledge	98	12	BDL	112
CC-23	SF Above CC	82.9	9.42	BDL	85.3
CC-24	CC Below SF	84	8.72	BDL	125
CC-25	CC Above Prospect Gulch	80.8	9.75	BDL	128
CC-26	CC Below Prospect	74.7	9.81	BDL	124
CC-27	Georgia Gulch Above Confluence	57	6.76	BDL	73.5
CC-28	CC Below Georgia Gulch	85.7	11.2	BDL	142
CC-29	CC Above Porcupine Gulch	83.7	10.7	BDL	128
CC-30	Porcupine Gulch Above CC	85.3	8.41	BDL	94
CC-31	CC Below Porcupine	83.1	10.8	BDL	130
CC-32	Below Hurrican Mine Complex	73.5	6.31	BDL	117
CC-33	CC Below Sunnyside Ponds	58.2	7.73	BDL	128
PG-1	Background-Upper Prospect	10.2	1.87	BDL	4
PG-2	Background-Upper Prospect	29.7	3	BDL	22.8
PG-3	Below Galena Queen	10.3	2.22	BDL	45.2
PG-4	Background-Upper Prospect	105	5.06	BDL	94.8
PG-5	Below Mine Drainages	91.6	4.44	BDL	79.5
PG-6	Tributary Below Hercules	10.8	4.91	BDL	14.2
PG-7	Tributary Below Draining Mine	80.9	3.76	BDL	99.9

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Cement Creek
High-Flow
June 25-26, 1997
Analytical Results

Site Id	Description	Hardness mg CaCO3/l	Silica mg/l	Chloride mg/l	Sulfate mg/l
PG-8	Below Upper Mines	43	3.84	BDL	46.8
PG-9	Below Mineralized Canyon	41.2	3.68	BDL	45.6
PG-10	Undisturbed Tributary	40.8	5.7	BDL	61.1
PG-11	Above Henrietta 7	35.3	4.14	BDL	61.9
PG-12	Spring	7.8	10.2	BDL	8.4
PG-13	Spring	9.5	11.3	BDL	44.5
PG-14	Tributary Below Lark & Mine Waste	10	12.2	BDL	123
PG-15	Below Henrietta 7	42.5	4.14	BDL	74.2
PG-16	Below Tributary PG14	42.1	4.73	BDL	91.7
PG-17	Below Joe & Johns Tributary	15.9	16.9	BDL	169
PG-18	Above Henrietta 11	39	5.24	BDL	92.6
PG-18	Above Henrietta 11	39			
PG-19	Prospect Gulch Above Confluence	34.9	8.62	BDL	101
PG-20	Tributary Above Hercules	11.7	4.95	BDL	35.4
SO-1	Queen Anne Mine	74.8	3.65	BDL	66.7
SO-2	Lark Mine	12.2	35.1	0.56	478
SO-3	Grand Mogul	37.1	6.89	BDL	117
SO-4	Henrietta 7 Mine	17	4.42	BDL	212
SO-5	Mogul	127	16.4	0.52	453
SO-6	Joe & Johns	9.7	45.5	BDL	368
SO-7	Mine South of Mogul	170	31.6	BDL	438
SO-8	Red & Bonita Mine	186	39.3	BDL	555
SO-12	Black Hawk Mine	198	6.62	BDL	194
SO-13	Silver Ledge	352	30.3	BDL	553
SO-14	Yukon Tunnel	563	19	BDL	577
SO-16	Anglo Saxon	777	28.9	BDL	914
SO-17	Big Colorado	X	49.9	BDL	793
SO-18	Mammoth Tunnel	374	48	BDL	957
SO-19	Adit Below Georgia Gulch	660	28.3	BDL	733
SO-20	Kansas City Adit #1	71.3	4.4	BDL	60.5
SO-21	Kansas City Adit #2	105	7.17	BDL	103
SO-23	Porcupine Gulch Adit	656	27.9	BDL	771
SO-24	Dry Gulch Adit (Evelyne)	53.5	50.5	BDL	236
DG-1	Deer Gulch	45.6	4.03	BDL	19.8
EP-1	Elk Park	52.9	6.27	BDL	35.5
KC-1	Kendall Creek	34.2	3.27	BDL	5.4
UK-1	1st East Trib south of Deer Creek	13.3	3.02	BDL	3.1
SO-18	Duplicate	573			
	* Bottle leaked during transport				

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Cement Creek
High-Flow
June 25-26, 1997
Analytical Results

0000172

Cement Creek
High-Flow
Metals Loading

Site Id	Description	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load
		As	As	Cd	Cd	Pb	Pb	Al	Al	Ba	Ba	Be
		g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day
CC-1	Above Queen Anne	0.00	0.00	0.00	0.00	7.96	11.15	0.00	136.96	38.22	41.41	0.00
CC-2	CC Below Queen Anne	0.00	0.00	0.00	5.65	20.33	42.92	0.00	666.38	135.53	146.83	0.00
CC-3	Background Below Ross Basin	0.00	0.00	27.79	36.56	95.06	181.34	760.45	4474.96	248.61	263.23	0.00
CC-4	CC Below SO-3	0.00	0.00	78.88	99.46	111.46	234.92	7544.92	11591.74	274.36	291.51	0.00
CC-5	CC Above Mogul	0.00	0.00	148.32	190.03	125.14	389.33	7462.21	25631.05	741.59	834.28	0.00
CC-6	CC Below Mogul	0.00	0.00	237.44	280.06	298.32	596.65	22952.70	42983.05	974.12	1095.89	0.00
CC-7	CC Above Ferricrete	0.00	0.00	257.10	323.22	330.56	587.67	24241.26	48335.59	1101.88	1248.79	0.00
CC-8	Below North Ferricrete	0.00	0.00	278.84	338.59	418.26	677.18	47302.95	66722.05	1792.53	1991.70	0.00
CC-9	Below Lower Ferricrete	0.00	0.00	228.58	279.38	338.64	482.56	39451.44	60023.76	1523.88	1608.54	0.00
CC-12	North Fork Above CC	75.63	29.11	114.05	13.21	11.10	13.21	45649.01	46999.58	30.01	36.02	0.00
CC-13	Below North Fork	181.65	290.64	544.96	581.29	445.05	581.29	201180.48	225067.82	1544.05	1725.70	0.00
CC-14	Minnehaha Background	0.00	0.00	0.00	0.00	0.00	0.00	0.00	338.52	102.19	108.58	0.00
CC-15	Minnehaha Below Lead Carbonate	0.00	0.00	4.30	4.92	27.04	79.27	589.88	2070.73	98.31	110.60	0.00
CC-16	Minnehaha Above SF	0.00	0.00	5.44	5.44	16.31	42.41	706.75	1413.50	152.22	173.97	0.00
CC-17	Middle Fork Above Mine Blockage	0.00	0.00	0.00	0.00	1.57	2.55	0.00	227.36	15.68	17.64	0.00
CC-19	MF Below Blackhawk	0.00	0.00	10.34	6.40	5.91	7.88	694.35	2570.59	49.25	49.25	0.00
CC-20	MF Above SF	0.00	0.00	11.00	15.12	0.00	19.24	659.74	4618.15	96.21	137.45	0.00
CC-21	SF Above Silver Ledge	0.00	0.00	0.00	0.00	0.00	0.00	2893.78	17669.62	438.45	482.30	0.00
CC-22	SF Below Silver Ledge	0.00	0.00	54.18	78.81	0.00	280.75	18569.06	56298.24	492.55	492.55	0.00
CC-23	SF Above CC	0.00	0.00	93.20	93.20	0.00	287.37	7145.41	55687.56	776.67	776.67	0.00
CC-24	CC Below SF	0.00	0.00	631.71	568.54	1089.70	1452.93	196934.97	247313.68	2053.05	2526.83	0.00
CC-25	CC Above Prospect Gulch	0.00	0.00	524.26	495.14	1791.22	2053.35	203005.43	234897.96	2038.79	2330.05	0.00
CC-26	CC Below Prospect	0.00	0.00	788.82	679.26	3790.70	4031.73	321223.69	370524.73	3505.85	3724.97	0.00
CC-27	Georgia Gulch Above Confluence	0.00	0.00	24.07	20.63	0.00	17.19	0.00	5123.84	309.49	343.88	0.00
CC-28	CC Below Georgia Gulch	0.00	348.37	857.53	643.15	4555.64	4984.40	469230.44	558467.30	4019.68	4823.61	0.00
CC-29	CC Above Porcupine Gulch	0.00	381.42	926.30	980.78	4141.09	4794.94	421192.24	481946.36	4359.04	4903.92	0.00
CC-30	Porcupine Gulch Above CC	0.00	0.00	8.71	7.74	63.89	217.80	726.00	7298.68	329.12	367.84	0.00
CC-31	CC Below Porcupine	0.00	372.00	915.69	1144.61	4463.98	4721.52	431232.04	501625.60	4578.44	4864.60	0.00
CC-32	Below Hurricane Mine Complex	0.00	0.00	20.70	10.99	12.78	10.99	5051.93	4980.38	76.66	76.66	0.00
CC-33	CC Below Sunnyside Ponds	147.48	180.25	647.27	778.36	909.46	1048.74	181645.24	201227.20	1310.93	1474.79	0.00
PG-1	Background-Upper Prospect	0.00	0.00	0.00	0.00	0.00	0.00	0.00	53.60	8.25	9.62	0.00
PG-2	Background-Upper Prospect	0.00	0.00	0.00	0.00	0.00	0.00	70.10	253.75	18.76	19.75	0.00
PG-3	Below Galena Queen	1.06	2.70	9.00	8.18	50.98	48.53	245.49	333.87	13.09	14.73	0.00
PG-4	Background-Upper Prospect	0.00	0.00	1.71	1.71	0.00	0.00	276.29	0.00	42.10	44.73	0.00
PG-5	Below Mine Drainages	0.00	0.00	1.19	1.07	0.00	0.00	0.00	49.91	34.46	34.46	0.00
PG-6	Tributary Below Hercules	0.00	1.51	1.65	1.38	20.79	20.79	435.10	352.49	44.06	42.68	0.00
PG-7	Tributary Below Draining Mine	0.00	0.00	0.27	0.21	4.89	4.95	202.33	198.08	6.08	6.38	0.00
PG-8	Below Upper Mines	0.00	0.00	16.06	18.15	38.40	98.45	446.88	3623.92	167.58	195.51	0.00

000174

[illegible]

Cement Creek

High-Flow

Metals Loading

Site Id	Description	Diss. Load As g/day	Tot. Load As g/day	Diss. Load Cd g/day	Tot. Load Cd g/day	Diss. Load Pb g/day	Tot. Load Pb g/day	Diss. Load Al g/day	Tot. Load Al g/day	Diss. Load Ba g/day	Tot. Load Ba g/day	Diss. Load Be g/day
PG-10	Undisturbed Tributary	0.00	0.00	5.00	0.00	14.26	43.28	130.08	4607.67	55.03	0.00	0.00
PG-11	Above Henrietta 7	0.00	32.05	16.54	16.54	168.53	1416.44	6472.21	10039.17	299.83	351.53	0.00
PG-12	Spring	0.00	34.54	0.26	0.42	1.04	392.41	48.82	5474.48	19.22	109.59	0.26
PG-13	Spring	0.00	0.00	0.01	0.01	0.04	0.03	7.29	7.48	0.41	0.42	0.00
PG-14	Tributary Below Lark & Mine Waste	0.00	3.82	2.09	2.33	4.84	38.40	338.88	1754.70	14.66	27.46	0.00
PG-15	Below Henrietta 7	0.00	33.52	33.52	34.81	250.10	261.71	10468.22	14193.98	360.97	373.87	12.89
PG-16	Below Tributary PG14	13.13	38.08	44.65	44.65	387.39	1158.24	12055.18	18699.97	367.70	420.22	13.13
PG-17	Below Joe & Johns Tributary	0.08	0.11	0.72	0.72	5.63	5.39	100.26	101.05	0.75	0.75	0.03
PG-18	Above Henrietta 11	21.02	0.00	43.66	0.00	399.40	0.00	15377.67	0.00	468.93	0.00	16.17
PG-18	Above Henrietta 11	17.79	0.00	50.13	0.00	407.48	0.00	15296.82	0.00	468.93	0.00	16.17
PG-19	Prospect Gulch Above Confluence	48.78	65.86	82.93	102.45	1163.51	1265.96	44393.80	49052.71	658.59	682.98	24.39
PG-20	Tributary Above Hercules	0.00	0.00	0.00	0.00	2.71	5.32	150.29	351.91	28.94	28.94	0.93
SO-1	Queen Anne	0.00	0.00	0.81	1.06	1.85	9.05	9.35	30.30	1.63	1.83	0.41
SO-2	Lark Mine	4.17	4.00	7.11	6.64	32.84	30.40	103.84	106.19	0.50	0.47	0.06
SO-3	Grand Mogul	0.00	4.65	66.44	59.80	97.34	101.66	6710.84	7023.13	49.83	49.83	6.64
SO-4	Henrietta 7 Mine	9.40	9.01	3.96	3.46	1.56	1.56	553.79	579.53	3.46	3.46	0.49
SO-5	Mogul	1.34	1.15	17.49	14.41	38.07	29.40	543.17	479.07	0.59	0.44	0.59
SO-6	Joe & Johns	9.25	8.20	5.25	4.91	128.12	119.45	702.97	711.22	1.42	1.50	0.17
SO-7	Mine South of Mogul	0.90	0.96	2.06	2.06	3.99	3.77	434.53	460.70	0.22	0.29	0.44
SO-8	Red & Bonita Mine	0.00	0.00	3.09	3.22	3.50	4.55	358.95	402.27	0.16	0.19	0.16
SO-12	Black Hawk Mine	0.00	0.00	1.86	2.69	0.00	4.97	0.00	287.76	24.84	28.98	2.07
SO-13	Silver Ledge	6.02	15.64	42.12	36.10	55.36	217.22	17311.48	21156.48	30.09	36.10	24.07
SO-14	Yukon Tunnel	0.00	0.00	0.00	0.00	0.00	7.11	0.00	619.58	44.47	50.40	2.96
SO-16	Anglo Saxon	1.83	2.15	1.57	1.54	1.22	2.92	111.69	191.93	2.89	3.53	0.96
SO-17	Big Colorado	*	0.28	*	0.12	*	0.05	*	300.25	*	0.15	*
SO-18	Mammoth Tunnel	1.08	1.59	0.46	0.30	0.24	0.00	1140.07	319.61	0.48	1.11	0.48
SO-19	Adit Below Georgia Gulch	3.40	3.30	0.00	0.00	0.00	0.85	0.00	47.16	8.49	9.43	0.94
SO-20	Kansas City Adit #1	0.00	0.41	0.08	0.12	0.57	7.55	0.00	23.02	0.49	0.65	0.05
SO-21	Kansas City Adit #2	0.00	0.00	0.46	0.51	0.11	0.75	3.19	17.60	0.31	0.36	0.10
SO-23	Porcupine Gulch Adit	0.68	1.21	1.23	1.21	0.00	3.35	139.65	248.72	3.23	3.82	0.59
SO-24	Dry Gulch Adit (Evelyne)	0.00	0.41	3.19	3.82	1.02	0.89	3595.87	4051.32	0.32	0.32	0.64
	* Bottle Leaked in Transport											

000175

Cement Creek
High-Flow
Metals Loading

Site Id	Description	Tot. Load	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load
		Be	Cr	Cr	Co	Co	Cu	Cu	Fe	Fe	Mn
		g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day
CC-1	Above Queen Anne	0.00	0.00	15.93	0.00	0.00	0.00	0.00	31.85	70.07	89.18
CC-2	CC Below Queen Anne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	350.13	316.25
CC-3	Background Below Ross Basin	0.00	0.00	0.00	0.00	0.00	584.96	862.82	73.12	1608.65	2149.74
CC-4	CC Below SO-3	0.00	0.00	0.00	0.00	0.00	2983.67	3086.56	2109.15	14781.19	6276.00
CC-5	CC Above Mogul	0.00	0.00	0.00	0.00	0.00	3615.23	4171.42	1205.08	16871.07	26001.85
CC-6	CC Below Mogul	0.00	0.00	0.00	0.00	0.00	6697.08	7184.14	7001.49	29832.43	34215.97
CC-7	CC Above Ferricrete	0.00	0.00	367.29	0.00	0.00	6978.54	7639.67	4480.96	32835.88	37537.22
CC-8	Below North Ferricrete	0.00	0.00	697.10	0.00	0.00	8365.15	8663.91	7966.81	37543.60	43618.30
CC-9	Below Lower Ferricrete	0.00	0.00	0.00	0.00	0.00	6942.10	7365.40	6857.44	30900.81	36742.33
CC-12	North Fork Above CC	3.00	0.00	0.00	102.04	108.05	7049.94	7197.00	199072.91	113477.26	6443.68
CC-13	Below North Fork	0.00	0.00	0.00	635.78	0.00	30245.19	32061.72	614894.73	718618.48	55494.93
CC-14	Minnehaha Background	0.00	0.00	0.00	0.00	0.00	0.00	0.00	102.19	242.71	31.94
CC-15	Minnehaha Below Lead Carbonate	0.00	0.00	0.00	0.00	0.00	92.17	208.92	1929.40	4676.04	325.66
CC-16	Minnehaha Above SF	0.00	0.00	0.00	0.00	0.00	0.00	97.86	663.26	2533.43	282.70
CC-17	Middle Fork Above Mine Blockage	0.00	0.00	0.00	0.00	0.00	0.00	9.80	15.68	84.28	107.80
CC-19	MF Below Blackhawk	0.00	0.00	0.00	0.00	0.00	182.21	211.75	103.41	984.90	1181.88
CC-20	MF Above SF	0.00	0.00	0.00	0.00	0.00	137.45	316.12	769.69	3463.61	1869.25
CC-21	SF Above Silver Ledge	0.00	0.00	0.00	263.07	0.00	0.00	175.38	1490.74	9733.63	1929.19
CC-22	SF Below Silver Ledge	0.00	0.00	0.00	295.53	394.04	788.08	1379.13	151113.73	220661.50	21425.84
CC-23	SF Above CC	0.00	0.00	0.00	621.34	466.00	699.01	1708.68	99336.67	156888.25	27882.61
CC-24	CC Below SF	157.93	0.00	0.00	1105.49	1105.49	27637.23	27479.30	377445.53	643394.60	87965.34
CC-25	CC Above Prospect Gulch	0.00	0.00	0.00	0.00	1165.02	22572.34	23009.22	280916.41	533289.74	78493.49
CC-26	CC Below Prospect	0.00	0.00	0.00	0.00	1533.81	37030.56	36811.45	503527.99	836145.70	107585.83
CC-27	Georgia Gulch Above Confluence	0.00	0.00	0.00	0.00	0.00	429.85	567.41	85.97	3627.96	5450.53
CC-28	CC Below Georgia Gulch	0.00	0.00	1071.91	1607.87	0.00	41536.68	42340.61	886473.04	1321402.23	139348.85
CC-29	CC Above Porcupine Gulch	0.00	0.00	0.00	2451.96	2451.96	35417.20	35962.08	640778.88	1174761.28	127774.36
CC-30	Porcupine Gulch Above CC	0.00	0.00	0.00	77.44	67.76	58.08	145.20	12942.09	23657.80	13784.25
CC-31	CC Below Porcupine	0.00	0.00	0.00	1716.92	1716.92	36627.54	37486.00	664732.61	1084804.70	132202.52
CC-32	Below Hurricane Mine Complex	0.00	0.00	0.00	0.00	0.00	669.50	646.50	444.63	539.18	5269.13
CC-33	CC Below Sunnyside Ponds	0.00	0.00	0.00	0.00	491.60	26710.13	26955.92	463822.15	540265.54	60548.41
PG-1	Background-Upper Prospect	0.00	0.00	0.00	0.00	0.00	0.00	2.29	31.15	208.00	3.67
PG-2	Background-Upper Prospect	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.68	102.68	54.30
PG-3	Below Galena Queen	0.00	0.00	0.00	0.00	0.00	220.12	216.03	2441.81	2898.42	19.64
PG-4	Background-Upper Prospect	0.00	0.00	0.00	0.00	0.00	0.00	5.26	11.84	6.58	322.33
PG-5	Below Mine Drainages	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.14	199.63
PG-6	Tributary Below Hercules	0.00	0.00	0.00	0.00	0.00	30.29	30.29	495.68	278.13	41.31
PG-7	Tributary Below Draining Mine	0.61	0.00	0.00	0.00	1.82	16.10	17.32	109.37	83.24	68.66
PG-8	Below Upper Mines	0.00	0.00	0.00	0.00	0.00	258.35	335.16	579.55	4168.55	642.39

000176

High-Flow
Metals Loading

Site Id	Description	Tot. Load	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load	Tot. Load	Diss. Load
		Be	Cr	Cr	Co	Co	Cu	Cu	Fe	Fe	Mn
		g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day	g/day
PG-10	Undisturbed Tributary	0.00	0.00	0.00	0.00	0.00	80.05	15.01	285.17	1238.22	227.63
PG-11	Above Henrietta 7	0.00	0.00	0.00	0.00	0.00	289.49	392.88	1954.07	6751.37	1426.78
PG-12	Spring	0.00	0.00	3.38	0.00	0.00	0.00	37.14	6.23	15319.70	7.01
PG-13	Spring	0.00	0.00	0.00	0.00	0.00	0.51	0.00	1.26	0.50	0.35
PG-14	Tributary Below Lark & Mine Waste	0.00	0.00	0.00	2.56	1.40	86.58	86.35	1747.25	4682.93	17.69
PG-15	Below Henrietta 7	0.00	51.57	0.00	0.00	0.00	1340.76	1289.19	30476.45	35117.54	1959.57
PG-16	Below Tributary PG14	0.00	0.00	0.00	0.00	0.00	1864.74	1864.74	50072.32	51332.99	2048.59
PG-17	Below Joe & Johns Tributary	0.00	0.00	0.00	0.31	0.48	20.61	20.17	436.30	359.81	13.31
PG-18	Above Henrietta 11	0.00	64.68	0.00	0.00	0.00	2684.22	0.00	57581.37	0.00	2425.50
PG-18	Above Henrietta 11	0.00	0.00	0.00	0.00	0.00	2732.73	0.00	57856.26	0.00	2425.50
PG-19	Prospect Gulch Above Confluence	0.00	0.00	0.00	0.00	170.75	6341.97	6317.58	116277.62	114887.26	4317.42
PG-20	Tributary Above Hercules	0.00	0.00	0.00	0.00	0.00	16.80	13.07	212.83	423.79	26.14
SO-1	Queen Anne	0.00	1.02	0.00	0.00	0.00	12.40	16.67	15.25	90.69	80.73
SO-2	Lark Mine	0.00	0.00	0.12	1.32	1.29	353.39	347.51	2110.92	1883.36	4.82
SO-3	Grand Mogul	0.00	13.29	0.00	0.00	0.00	2415.24	2408.60	14787.11	13667.53	4508.23
SO-4	Henrietta 7 Mine	0.00	0.00	0.00	4.45	5.20	42.07	41.32	12095.36	10788.82	26.23
SO-5	Mogul	0.29	0.00	0.00	2.21	2.06	793.07	671.35	6578.25	5768.28	1057.67
SO-6	Joe & Johns	0.00	0.33	0.33	2.08	2.17	93.38	91.63	4793.08	4257.46	10.83
SO-7	Mine South of Mogul	0.29	0.00	0.00	1.69	1.98	146.34	151.34	3584.60	3550.05	139.06
SO-8	Red & Bonita Mine	0.13	0.00	0.00	2.93	3.25	43.28	45.51	1234.82	1320.18	831.92
SO-12	Black Hawk Mine	0.00	0.00	0.00	0.00	0.00	8.28	12.42	165.62	973.02	881.93
SO-13	Silver Ledge	18.05	0.00	0.00	180.52	204.58	685.96	758.17	138215.08	180816.86	14585.69
SO-14	Yukon Tunnel	0.00	0.00	11.86	0.00	0.00	0.00	44.47	809.31	4411.18	2107.76
SO-16	Anglo Saxon	0.64	0.00	0.00	10.91	14.44	9.63	11.23	10331.38	10989.33	2832.38
SO-17	Big Colorado	0.07	*	0.00	*	2.32	*	2.83	*	3184.39	*
SO-18	Mammoth Tunnel	0.16	0.64	0.00	8.60	5.41	11.63	6.05	13537.84	8996.03	349.08
SO-19	Adit Below Georgia Gulch	0.00	0.00	0.00	0.00	6.60	0.00	0.00	3427.77	3924.86	1579.00
SO-20	Kansas City Adit #1	0.00	0.22	0.27	0.00	0.00	1.56	4.53	4.26	89.20	11.64
SO-21	Kansas City Adit #2	0.00	0.21	0.21	0.31	0.41	2.62	3.40	89.63	144.16	74.71
SO-23	Porcupine Gulch Adit	0.59	0.00	0.00	8.82	14.70	5.29	19.11	6135.78	8155.56	4371.78
SO-24	Dry Gulch Adit (Evelyne)	0.32	0.00	1.27	7.96	9.87	100.33	103.19	8357.44	9484.93	261.17
	* Bottle Leaked in Transport										

000177

Cement Creek
High-Flow
Metals Loading

Site Id	Description	Tot. Load Mn g/day	Diss. Load Ni g/day	Tot. Load Ni g/day	Diss. Load V g/day	Tot. Load V g/day	Diss. Load Zn g/day	Tot. Load Zn g/day			
CC-1	Above Queen Anne	101.92	41.41	0.00	0.00	0.00	203.84	200.66			
CC-2	CC Below Queen Anne	372.72	124.24	0.00	0.00	0.00	700.26	711.55			
CC-3	Background Below Ross Basin	2237.48	160.86	0.00	0.00	0.00	5893.49	5835.00			
CC-4	CC Below SO-3	6258.86	205.77	0.00	0.00	0.00	18416.47	17319.03			
CC-5	CC Above Mogul	27531.37	556.19	0.00	0.00	0.00	32861.51	32954.21			
CC-6	CC Below Mogul	34824.79	791.47	0.00	0.00	0.00	55951.02	52602.48			
CC-7	CC Above Ferricrete	39667.51	1248.79	2864.88	0.00	0.00	59721.64	60088.93			
CC-8	Below North Ferricrete	43817.47	0.00	0.00	0.00	398.34	72497.99	69311.26			
CC-9	Below Lower Ferricrete	37165.63	1100.58	0.00	0.00	0.00	61293.66	63156.17			
CC-12	North Fork Above CC	6824.84	111.05	75.03	18.01	15.01	24040.01	24481.20			
CC-13	Below North Fork	60672.04	2906.44	0.00	0.00	0.00	141598.36	147138.77			
CC-14	Minnehaha Background	31.94	0.00	0.00	0.00	25.55	83.03	70.26			
CC-15	Minnehaha Below Lead Carbonate	368.68	73.74	0.00	0.00	0.00	1259.64	1314.94			
CC-16	Minnehaha Above SF	337.07	130.48	0.00	0.00	0.00	1239.53	1359.14			
CC-17	Middle Fork Above Mine Blockage	113.68	0.00	0.00	0.00	0.00	92.12	82.32			
CC-19	MF Below Blackhawk	1339.46	59.09	0.00	0.00	0.00	1388.71	1403.48			
CC-20	MF Above SF	2391.54	164.93	0.00	0.00	0.00	2432.78	2528.99			
CC-21	SF Above Silver Ledge	2060.72	0.00	0.00	0.00	0.00	1359.20	1403.05			
CC-22	SF Below Silver Ledge	22410.93	689.57	0.00	0.00	0.00	14333.15	14234.64			
CC-23	SF Above CC	29047.63	932.01	0.00	0.00	0.00	20581.87	20271.20			
CC-24	CC Below SF	88754.97	1895.12	0.00	0.00	631.71	153031.26	143239.79			
CC-25	CC Above Prospect Gulch	79221.63	1893.16	0.00	0.00	0.00	126696.36	121599.38			
CC-26	CC Below Prospect	108243.18	3067.62	0.00	0.00	0.00	195013.02	178798.45			
CC-27	Georgia Gulch Above Confluence	5725.64	756.54	0.00	0.00	0.00	7874.90	7788.93			
CC-28	CC Below Georgia Gulch	142028.63	2947.76	0.00	0.00	1071.91	224298.05	216794.65			
CC-29	CC Above Porcupine Gulch	129953.88	4086.60	0.00	0.00	0.00	193704.84	191525.32			
CC-30	Porcupine Gulch Above CC	13822.97	135.52	0.00	0.00	0.00	3446.06	3523.50			
CC-31	CC Below Porcupine	136208.66	3433.83	0.00	0.00	0.00	204026.84	200020.70			
CC-32	Below Hurricane Mine Complex	5026.37	38.33	0.00	0.00	0.00	3789.58	3516.16			
CC-33	CC Below Sunnyside Ponds	62432.87	1228.99	0.00	0.00	0.00	133059.03	130437.18			
PG-1	Background-Upper Prospect	11.91	0.00	0.00	0.00	0.00	0.00	0.00			
PG-2	Background-Upper Prospect	53.32	13.82	0.00	0.00	0.00	9.87	8.89			
PG-3	Below Galena Queen	22.91	9.00	0.00	0.00	0.00	2315.79	2198.77			
PG-4	Background-Upper Prospect	324.97	14.47	0.00	0.00	6.58	373.64	336.81			
PG-5	Below Mine Drainages	192.50	0.00	0.00	0.00	0.00	209.13	225.77			
PG-6	Tributary Below Hercules	39.93	17.90	0.00	0.00	0.00	225.81	210.67			
PG-7	Tributary Below Draining Mine	66.23	6.08	0.00	0.00	0.00	26.13	24.91			
PG-8	Below Upper Mines	656.36	83.79	0.00	0.00	0.00	3498.23	3281.78			
PG-9	Below Mineralized Canyon	716.64	98.07	0.00	0.00	0.00	3160.75	3017.42			

Site Id	Description	Tot. Load Mn g/day	Diss. Load Ni g/day	Tot. Load Ni g/day	Diss. Load V g/day	Tot. Load V g/day	Diss. Load Zn g/day	Tot. Load Zn g/day			
PG-10	Undisturbed Tributary	550.32	0.00	0.00	0.00	0.00	1068.12	92.55			
PG-11	Above Henrietta 7	1395.77	144.75	0.00	0.00	0.00	3081.02	3256.79			
PG-12	Spring	392.41	0.00	0.00	0.00	12.21	64.93	95.31			
PG-13	Spring	1.74	0.00	0.00	0.00	0.00	2.11	1.97			
PG-14	Tributary Below Lark & Mine Waste	38.40	5.12	0.00	0.00	2.56	527.88	479.00			
PG-15	Below Henrietta 7	1908.00	0.00	0.00	0.00	0.00	6858.49	5968.95			
PG-16	Below Tributary PG14	2048.59	0.00	0.00	0.00	0.00	8601.46	7682.22			
PG-17	Below Joe & Johns Tributary	12.83	0.00	0.00	0.00	0.00	169.75	151.98			
PG-18	Above Henrietta 11	0.00	0.00	0.00	0.00	0.00	12758.13	0.00			
PG-18	Above Henrietta 11	0.00	0.00	0.00	0.00	0.00	12677.28	0.00			
PG-19	Prospect Gulch Above Confluence	4244.24	0.00	0.00	0.00	121.96	19757.68	17855.09			
PG-20	Tributary Above Hercules	25.20	0.00	0.00	0.00	0.00	16.80	11.20			
SO-1	Queen Anne	81.34	0.00	0.00	0.00	0.00	179.96	165.73			
SO-2	Lark Mine	4.62	0.79	0.97	0.00	0.12	1620.23	1468.24			
SO-3	Grand Mogul	4368.69	0.00	0.00	0.00	0.00	12415.06	11312.09			
SO-4	Henrietta 7 Mine	25.24	0.00	0.00	0.00	1.24	776.00	701.03			
SO-5	Mogul	29.40	0.00	0.00	0.00	0.00	3704.40	3123.75			
SO-6	Joe & Johns	10.33	0.00	1.08	0.83	0.92	1006.26	907.14			
SO-7	Mine South of Mogul	142.66	0.00	1.32	0.00	0.00	390.73	375.81			
SO-8	Red & Bonita Mine	883.20	0.57	1.15	0.00	0.00	579.67	588.91			
SO-12	Black Hawk Mine	904.70	0.00	0.00	0.00	0.00	592.09	571.39			
SO-13	Silver Ledge	9368.78	0.00	114.33	0.00	0.00	9874.23	9904.31			
SO-14	Yukon Tunnel	2336.03	0.00	0.00	0.00	0.00	352.78	343.88			
SO-16	Anglo Saxon	2952.10	0.00	6.10	0.00	0.00	1028.00	1035.71			
SO-17	Big Colorado	83.46	*	1.32	*	0.26	*	37.08			
SO-18	Mammoth Tunnel	723.95	3.82	3.03	1.11	0.00	163.39	167.05			
SO-19	Adit Below Georgia Gulch	1733.69	0.00	0.00	0.00	0.00	268.83	250.90			
SO-20	Kansas City Adit #1	19.67	0.00	0.00	0.00	0.27	19.30	29.54			
SO-21	Kansas City Adit #2	81.19	0.00	0.00	0.00	0.00	52.48	53.35			
SO-23	Porcupine Gulch Adit	4524.66	0.00	9.41	0.00	0.00	907.87	900.23			
SO-24	Dry Gulch Adit (Evelyne)	279.01	0.00	5.10	0.00	1.59	335.38	337.29			
	* Bottle Leaked In Transport										

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APPENDIX 4

Cement Creek
Waste Rock Sampling
Analytical Results

Site #	Site Name	pH	Spec. Cond	Total Acidity	Sulfate	Hach SO4	Ag	Al	As	B	Ba	Be	Ca	Cd
		s.u.	umhos	mg/l	mg/l	mg/l	ppb	ppb	ppb	ppb	ppb	ppb	ppm	ppb
1	Lark Mine - Duplicate Extract	nd	nd	nd	920	nd	14.20	4010	404.0	199.0	10.50	bdl	1.74	186.0
1	Lark Mine	2.41	3540	842	935	154	18.60	3990	378.0	191.0	11.20	0.05	1.70	185.0
2	Henrietta 7 Mine North Pile - Dup. Extract	nd	nd	nd	71	nd	bdl	960	2.9	9.6	23.30	0.34	2.83	7.3
2	Henrietta 7 Mine North Pile	3.21	264	70	76	75	0.13	1030	4.5	bdl	24.70	0.35	3.06	7.8
3	Henrietta 7 Mine South Pile - Dup. Extract	nd	nd	nd	836	nd	bdl	11600	bdl	220.0	24.70	0.61	8.87	97.7
3	Henrietta 7 Mine South Pile	2.42	3230	836	923	385	bdl	12500	bdl	219.0	26.20	0.64	9.61	104.0
4	Lower Joe & Johns Mine - Dup. Extract	nd	nd	nd	593	nd	24.90	10900	bdl	118.0	16.20	0.17	2.10	49.4
4	Lower Joe & Johns Mine	2.73	2260	588	614	379	24.30	10800	bdl	111.0	17.00	0.21	2.17	48.8
5	Forested Soil - Prospect Gulch	5.90	90	18	7	11	bdl	150	4.2	bdl	61.30	bdl	2.02	bdl
6	Upper Prospect Gulch Mine	2.15	5840	1426	1908	1270	bdl	18500	2580.0	475.0	24.50	0.33	6.72	33.7
6	Upper Prospect Gulch Mine - Dup. Extract	nd	nd	nd	1947	nd	bdl	18400	2500.0	470.0	20.80	0.33	5.97	34.1
7	Hercules Mine	2.18	8140	1604	5033	1889	bdl	19100	5520.0	958.0	1.23	0.23	3.92	3580.0
7	Hercules Mine - Duplicate Extract	nd	nd	nd	3925	nd	bdl	20500	5690.0	949.0	0.81	0.27	4.13	3850.0
8	Galena Queen - Duplicate Extract	nd	nd	nd	4853	nd	bdl	19400	10600.0	1020.0	1.68	0.29	4.01	4650.0
8	Galena Queen Mine	2.10	8940	1676	5153	3688	bdl	20900	11400.0	1100.0	0.85	0.25	3.56	5000.0
9	Unvegetated Soil - Red Mountain	5.09	110	16	4	30	bdl	3060	6.9	13.3	545.00	0.13	4.80	0.5
10	Henrietta 3 Mine	2.15	6200	1116	2960	1933	bdl	37200	bdl	943.0	25.50	2.43	29.80	127.0
11	Upper Corkscrew Mine	1.69	1380	7610	7160	7045	bdl	43300	17800.0	2370.0	24.00	bdl	4.29	135.0
12	Barren Ferricrete	3.42	260	30	31	20	bdl	430	13.6	0.8	31.60	0.22	3.00	2.2
13	Red & Bonita Mine	2.51	2080	620	581	574	bdl	14000	bdl	96.3	21.30	0.54	6.63	84.5
14	Upper Joe & Johns Mine	2.30	3060	890	1085	483	39.10	10900	11.3	133.0	6.26	0.23	3.97	630.0
15	Adams Mine	3.44	280	60	49	60	bdl	1030	10.0	3.6	1.55	0.68	3.36	5.8
16	Mine South of Black Hawk	2.50	2750	880	1061	1045	bdl	15300	bdl	244.0	8.65	1.26	8.97	34.9
17	Lead Carbonate Mine	2.40	3030	1440	1210	760	bdl	28700	bdl	306.0	19.60	1.83	29.60	188.0
18	Gold King Mine	3.10	1070	290	315	356	bdl	9910	bdl	84.9	65.30	6.82	37.10	35.6
19	Black Hawk Mine	3.20	2450	690	1348	1034	0.58	60200	bdl	77.6	36.60	23.60	183.00	350.0
20	Silver Ledge Mine	2.77	1480	290	276	277	bdl	11100	bdl	80.2	24.60	0.70	4.61	9.5
21	Big Colorado Mine	3.16	430	30	62	20	0.49	1490	bdl	30.2	9.47	0.42	3.88	3.6
22	Queene Anne Mine	2.76	1410	560	274	264	bdl	4900	bdl	64.1	17.30	0.89	11.20	55.0
23	Mine south of Mogul	2.83	1100	200	236	202	bdl	9310	bdl	54.2	5.25	0.41	6.20	10.7
24	Mine north of Mogul	2.64	1520	200	348	216	bdl	5000	bdl	92.3	23.90	0.28	6.18	42.1
25	Grand Mogul - West	2.68	1690	360	536	452	bdl	13600	bdl	77.3	26.00	1.20	12.10	60.1
26	Grand Mogul - East	2.45	2660	890	1052	500	bdl	13000	bdl	258.0	11.90	0.98	9.90	557.0
27	Mogul Mine	1.20	1940	590	581	549	bdl	6500	bdl	155.0	11.20	0.33	3.78	147.0
28	Anglo Saxon - Dup. Extract	nd	nd	nd	2373	nd	bdl	33800	bdl	656.0	22.00	1.51	91.50	112.0
28	Anglo Saxon Mine	2.66	3310	1840	2004	1007	bdl	32000	bdl	622.0	17.30	1.40	81.40	107.0

Cement Creek
Waste Rock Sampling
Analytical Results

Site #	Site Name	pH	Spec. Cond	Total Acidity	Sulfate	Hach SO4	Ag	Al	As	B	Ba	Be	Ca	Cd
		s.u.	umhos	mg/l	mg/l	mg/l	ppb	ppb	ppb	ppb	ppb	ppb	ppm	ppb
29	Gold Hub - Duplicate Extract	nd	nd	nd	115	nd	1.47	2660	bdl	9.7	36.40	4.00	12.60	9.0
29	Gold Hub Mine	3.40	450	20	97	89	1.30	2390	bdl	13.3	34.60	3.53	11.80	8.2
30	Ross Basin - Upper Mine	2.88	1100	260	386	232	30.10	16000	bdl	24.3	2.51	2.45	10.60	145.0
30	Ross Basin - Upper Mine Dup. Extract	nd	nd	nd	416	nd	30.30	16000	bdl	20.1	2.92	2.43	10.60	144.0
31	Ross Basin - Lower Mine Dup. Extract	nd	nd	nd	1103	nd	bdl	8980	bdl	296.0	13.80	0.42	6.81	274.0
31	Ross Basin - Lower Mine	2.71	2550	1020	1165	576	bdl	8690	bdl	286.0	14.50	0.41	7.10	267.0
32	Mammoth Tunnel - Duplicate Extract	nd	nd	nd	80	nd	0.55	880	bdl	13.1	10.10	0.63	10.40	3.0
32	Mammoth Tunnel	3.66	300	5	86	70	0.82	900	bdl	8.2	10.30	0.63	10.70	3.0
33	Elk Tunnel - Dup. Extract	nd	nd	nd	22	nd	0.75	130	bdl	6.3	8.23	0.12	1.57	0.2
33	Elk Tunnel	3.57	140	3	26	10	0.52	160	bdl	4.8	9.29	0.13	0.93	bdl
34	Columbia Queen Anne Complex - Duplicate	nd	nd	nd	1615	nd	16.10	14000	69.8	391.0	19.50	1.54	6.34	38.4
34	Columbia Queen Anne Complex	2.28	3680	1390	1441	883	13.10	13900	83.2	395.0	22.90	1.50	6.32	37.0
35	Upper Porcupine Gulch Mine	2.59	2420	760	857	545	bdl	39600	bdl	86.7	19.10	1.94	16.30	145.0
36	Lower Porcupine Gulch Mine - Top of Pile	2.59	3050	1380	1219	642	bdl	28400	bdl	321.0	20.90	1.00	14.90	69.7
37	Kansas City Mine #2	2.19	9190	4800	5992	3685	bdl	51100	733.0	1490.0	1.66	3.14	295.00	2300.0
38	Kansas City Mine #1	2.55	3470	1440	1926	1194	bdl	25000	690.0	532.0	9.61	4.44	51.10	370.0
39	Evelyne	3.22	430	90	64	bdl	bdl	940	12.0	bdl	1.67	0.21	3.99	2.0
40	Galty Boy Mine	3.19	520	110	76	13	bdl	2620	12.0	bdl	12.10	0.18	2.27	21.0
41	Kansas City Mine #3	2.86	3860	480	1872	742	5.68	36700	bdl	31.0	211.00	1.72	460.00	7.5
43	Ohio Gulch Natural	2.89	382	60	87	9	bdl	2700	0.9	26.0	77.00	0.88	7.30	2.7
44	Porcupine Adit -outslope only	2.80	1390	640	659	752	bdl	39000	bdl	59.0	11.00	16.00	36.00	62.0
45	Porcupine Gulch Natural	2.47	2770	2735	2517	2700	bdl	110000	bdl	720.0	1.20	1.20	45.00	53.0
49	Elk Tunnel - Dup. Sample	3.16	168	30	25	3	bdl	310	5.3	24.0	6.00	0.24	1.40	1.3
50	Corkscrew Duplicate Sample	1.91	7580	7700	5872	8708	bdl	93000	17000.0	1700.0	64.00	0.18	4.60	120.0

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Cement Creek
Waste Rock Sampling
Analytical Results

Site #	Site Name	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Ni	Pb	S	Sb	Se	Si
		ppb	ppb	ppb	ppb	ppm	ppb	ppm	ppm	ppb	ppb	ppb	ppm	ppb	ppb	ppb
1	Lark Mine - Duplicate Extract	66.7	bdl	8900.0	202000	0.88	bdl	0.71	0.07	bdl	89.90	3370.0	307.0	bdl	bdl	615
1	Lark Mine	66.0	bdl	8920.0	199000	0.69	bdl	0.70	0.07	bdl	91.80	3490.0	312.0	bdl	bdl	613
2	Henrietta 7 Mine North Pile - Dup. Extract	8.1	bdl	185.0	3300	0.38	3.57	1.19	0.15	0.07	7.04	582.0	23.6	bdl	bdl	754
2	Henrietta 7 Mine North Pile	8.7	bdl	198.0	3470	0.46	bdl	1.29	0.16	0.45	7.42	617.0	25.4	bdl	bdl	809
3	Henrietta 7 Mine South Pile - Dup. Extract	50.3	bdl	2850.0	194000	0.63	bdl	3.21	0.59	bdl	69.50	2270.0	279.0	bdl	bdl	1070
3	Henrietta 7 Mine South Pile	53.6	bdl	3070.0	209000	0.64	bdl	3.47	0.63	bdl	76.80	2490.0	308.0	bdl	bdl	1170
4	Lower Joe & Johns Mine - Dup. Extract	59.0	bdl	3300.0	121000	0.36	bdl	2.17	0.16	bdl	67.80	3470.0	198.0	bdl	bdl	749
4	Lower Joe & Johns Mine	59.3	bdl	3340.0	122000	0.46	bdl	2.19	0.15	bdl	66.40	3430.0	205.0	bdl	bdl	747
5	Forested Soil - Prospect Gulch	bdl	bdl	3.4	150	1.88	bdl	0.51	0.03	1.45	bdl	bdl	2.4	bdl	10.50	1740
6	Upper Prospect Gulch Mine	125.0	bdl	25800.0	458000	5.44	12.50	3.52	0.33	bdl	166.00	2580.0	637.0	bdl	bdl	1210
6	Upper Prospect Gulch Mine - Dup. Extract	123.0	bdl	24300.0	431000	4.78	11.20	3.12	0.32	bdl	166.00	2480.0	650.0	bdl	bdl	1180
7	Hercules Mine	213.0	bdl	19600.0	785000	2.80	26.40	1.53	1.04	bdl	343.00	2900.0	1680.0	bdl	bdl	489
7	Hercules Mine - Duplicate Extract	229.0	bdl	20900.0	861000	3.62	11.50	1.55	1.12	bdl	358.00	2860.0	1310.0	bdl	bdl	594
8	Galena Queen - Duplicate Extract	275.0	bdl	105000.0	876000	1.32	20.40	1.19	1.96	bdl	427.00	2770.0	1620.0	bdl	bdl	844
8	Galena Queen Mine	295.0	bdl	113000.0	936000	1.02	21.70	1.06	2.11	bdl	461.00	2810.0	1720.0	bdl	bdl	847
9	Unvegetated Soil - Red Mountain	2.1	0.90	11.3	3130	4.14	bdl	1.34	0.31	0.76	4.02	42.3	1.2	bdl	2.88	4570
10	Henrietta 3 Mine	224.0	bdl	18300.0	853000	5.15	44.70	13.60	2.84	bdl	271.00	2230.0	988.0	bdl	bdl	1100
11	Upper Corkscrew Mine	275.0	bdl	36000.0	1920000	5.28	24.00	1.72	bdl	bdl	674.00	855.0	2390.0	bdl	bdl	242
12	Barren Ferricrete	7.0	0.15	39.7	1270	0.80	bdl	0.77	0.69	bdl	2.92	bdl	10.2	bdl	bdl	2410
13	Red & Bonita Mine	23.8	bdl	9930.0	107000	0.67	bdl	3.96	0.91	bdl	30.60	3420.0	194.0	bdl	bdl	1690
14	Upper Joe & Johns Mine	52.5	bdl	12000.0	113000	0.81	16.30	1.85	0.17	bdl	69.20	3160.0	362.0	bdl	bdl	747
15	Adams Mine	4.7	bdl	290.0	1250	0.48	11.20	1.38	0.42	1.95	3.59	bdl	16.4	bdl	bdl	1130
16	Mine South of Black Hawk	54.0	bdl	1080.0	206000	0.21	34.40	6.75	1.93	bdl	73.90	78.2	354.0	bdl	bdl	1150
17	Lead Carbonate Mine	77.5	bdl	6550.0	293000	0.30	56.80	14.80	5.58	bdl	110.00	1620.0	404.0	bdl	bdl	668
18	Gold King Mine	34.7	bdl	1000.0	33600	0.36	46.00	8.59	5.72	bdl	28.80	77.9	105.0	bdl	bdl	1060
19	Black Hawk Mine	226.0	bdl	4780.0	91200	10.30	118.00	38.80	55.60	bdl	179.00	4070.0	450.0	bdl	bdl	2560
20	Silver Ledge Mine	22.9	bdl	372.0	44000	0.49	bdl	2.76	0.38	bdl	22.80	490.0	92.0	bdl	bdl	832
21	Big Colorado Mine	7.8	bdl	225.0	1770	0.56	29.90	1.89	0.17	0.22	7.70	bdl	20.6	bdl	bdl	1140
22	Queene Anne Mine	17.6	bdl	1990.0	37300	bdl	25.30	1.59	2.13	bdl	19.50	135.0	91.4	bdl	bdl	453
23	Mine south of Mogul	12.3	bdl	896.0	27400	0.21	31.80	6.59	1.80	bdl	14.40	bdl	78.8	bdl	bdl	806
24	Mine north of Mogul	11.7	bdl	1530.0	64800	0.42	7.30	1.18	0.31	bdl	20.60	342.0	116.0	bdl	bdl	317
25	Grand Mogul - West	16.0	bdl	5560.0	59900	3.13	31.90	6.63	4.46	bdl	20.70	1760.0	179.0	bdl	bdl	749
26	Grand Mogul - East	26.0	bdl	8120.0	207000	0.33	30.20	3.27	4.57	bdl	63.70	2570.0	351.0	bdl	bdl	408
27	Mogul Mine	11.7	bdl	4060.0	120000	0.33	27.40	2.31	0.97	bdl	30.40	3180.0	194.0	bdl	bdl	405
28	Anglo Saxon - Dup. Extract	167.0	bdl	5680.0	546000	0.19	102.00	23.00	5.78	bdl	209.00	505.0	792.0	bdl	bdl	985
28	Anglo Saxon Mine	158.0	bdl	5350.0	524000	0.25	54.80	21.40	5.44	bdl	196.00	545.0	669.0	bdl	bdl	808

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Cement Creek
Waste Rock Sampling
Analytical Results

Site #	Site Name	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Ni	Pb	S	Sb	Se	Si
		ppb	ppb	ppb	ppb	ppm	ppb	ppm	ppm	ppb	ppb	ppb	ppm	ppb	ppb	ppb
29	Gold Hub - Duplicate Extract	29.2	bdl	126.0	540	0.76	35.60	4.90	3.81	0.39	16.50	7.3	38.3	5.84	5.73	3580
29	Gold Hub Mine	27.7	bdl	120.0	510	0.82	44.40	4.59	3.56	bdl	13.20	4.9	32.5	5.02	bdl	2910
30	Ross Basin - Upper Mine	39.1	bdl	3360.0	10200	1.56	29.50	5.21	38.50	bdl	34.90	6700.0	129.0	bdl	bdl	1300
30	Ross Basin - Upper Mine Dup. Extract	39.0	bdl	3360.0	10100	1.50	39.40	5.16	38.00	bdl	34.60	6650.0	139.0	bdl	bdl	1310
31	Ross Basin - Lower Mine Dup. Extract	39.1	bdl	18500.0	238000	0.43	23.00	1.44	0.68	bdl	74.00	2120.0	368.0	bdl	bdl	437
31	Ross Basin - Lower Mine	38.2	bdl	17900.0	235000	0.40	22.20	1.57	0.65	bdl	68.40	2130.0	389.0	bdl	bdl	450
32	Mammoth Tunnel - Duplicate Extract	6.1	bdl	51.1	310	4.98	14.70	3.20	0.51	0.53	6.48	bdl	26.8	0.52	0.81	1070
32	Mammoth Tunnel	5.6	bdl	56.1	300	5.15	26.10	3.17	0.51	bdl	4.68	bdl	28.7	2.05	5.45	1070
33	Elk Tunnel - Dup. Extract	1.1	bdl	8.7	290	0.32	6.31	0.49	0.08	bdl	2.73	bdl	7.4	5.21	bdl	666
33	Elk Tunnel	2.1	bdl	10.7	330	0.28	8.35	0.32	0.09	bdl	1.56	bdl	8.7	0.39	7.75	721
34	Columbia Queen Anne Complex - Duplicate	1.3	bdl	15400.0	323000	1.87	12.40	1.15	0.39	bdl	141.00	2210.0	539.0	bdl	bdl	491
34	Columbia Queen Anne Complex	99.0	bdl	15100.0	318000	1.95	14.00	1.19	0.37	bdl	137.00	2130.0	481.0	bdl	bdl	435
35	Upper Porcupine Gulch Mine	71.7	bdl	2760.0	105000	0.03	102.00	24.90	7.14	bdl	53.20	1210.0	286.0	bdl	bdl	2460
36	Lower Porcupine Gulch Mine - Top of Pile	38.4	bdl	3700.0	308000	0.22	32.00	6.35	1.62	bdl	76.80	2770.0	407.0	bdl	bdl	2920
37	Kansas City Mine #2	327.0	bdl	12400.0	1280000	0.88	61.00	23.00	5.60	bdl	422.00	3160.0	2000.0	bdl	bdl	896
38	Kansas City Mine #1	168.0	bdl	5670.0	495000	bdl	25.50	10.60	52.00	bdl	174.00	1500.0	643.0	bdl	bdl	1070
39	Evelyne	5.0	0.03	25.1	410	1.00	7.38	1.87	0.25	bdl	4.58	bdl	21.4	bdl	3.88	1880
40	Galty Boy Mine	6.9	bdl	416.0	1430	bdl	0.86	1.30	0.15	0.15	6.20	19.0	25.5	bdl	bdl	1400
41	Kansas City Mine #3	57.8	bdl	276.0	52600	3.45	53.60	20.80	6.11	bdl	43.20	bdl	625.0	bdl	bdl	2930
43	Ohio Gulch Natural	20.0	2.40	86.0	2200	1.70	bdl	3.00	0.35	bdl	15.00	20.0	29.0	bdl	9.60	1100
44	Porcupine Adit -outslope only	960.0	bdl	8200.0	58000	0.06	bdl	5.80	93.00	bdl	46.00	2800.0	220.0	bdl	57.00	2400
45	Porcupine Gulch Natural	300.0	bdl	1500.0	780000	bdl	35.00	15.00	2.00	bdl	250.00	20.0	840.0	bdl	630.00	970
49	Elk Tunnel - Dup. Sample	2.0	bdl	20.0	230	0.39	0.42	0.62	0.21	0.42	4.90	bdl	8.3	1.00	4.90	600
50	Corkscrew Duplicate Sample	240.0	bdl	32000.0	1750000	12.00	7.90	3.10	0.08	bdl	610.00	700.0	1960.0	bdl	1300.00	bdl

Cement Creek
Waste Rock Sampling
Analytical Results

Site #	Site Name	Sr	Ti	V	Zn	Na
		ppb	ppb	ppb	ppb	ppm
1	Lark Mine - Duplicate Extract	12.1	4.55	bdl	37900	0.70
1	Lark Mine	12.0	4.63	bdl	37800	0.77
2	Henrietta 7 Mine North Pile - Dup. Extract	20.5	bdl	bdl	1670	0.17
2	Henrietta 7 Mine North Pile	21.6	bdl	bdl	1730	0.49
3	Henrietta 7 Mine South Pile - Dup. Extract	273.0	1.39	bdl	18700	bdl
3	Henrietta 7 Mine South Pile	297.0	1.43	bdl	19700	0.52
4	Lower Joe & Johns Mine - Dup. Extract	18.6	bdl	10.00	9150	0.42
4	Lower Joe & Johns Mine	19.1	bdl	9.81	9240	0.31
5	Forested Soil - Prospect Gulch	4.9	bdl	0.31	70	1.11
6	Upper Prospect Gulch Mine	70.4	4.38	bdl	2080	bdl
6	Upper Prospect Gulch Mine - Dup. Extract	69.4	3.73	bdl	2050	bdl
7	Hercules Mine	13.5	5.96	bdl	551000	29.60
7	Hercules Mine - Duplicate Extract	13.0	5.42	2.31	618000	5.32
8	Galena Queen - Duplicate Extract	16.9	11.90	15.60	782000	24.50
8	Galena Queen Mine	17.0	12.90	16.90	833000	28.70
9	Unvegetated Soil - Red Mountain	20.9	2.02	5.37	60	0.27
10	Henrietta 3 Mine	288.0	16.40	15.10	19400	bdl
11	Upper Corkscrew Mine	30.3	47.60	bdl	2040	bdl
12	Barren Ferricrete	15.1	bdl	bdl	720	0.90
13	Red & Bonita Mine	55.6	121.00	bdl	17100	0.84
14	Upper Joe & Johns Mine	21.7	3.44	0.92	136000	5.68
15	Adams Mine	23.3	bdl	bdl	1460	0.96
16	Mine South of Black Hawk	154.0	26.20	bdl	4620	0.33
17	Lead Carbonate Mine	239.0	38.10	12.80	42800	0.80
18	Gold King Mine	163.0	bdl	bdl	5960	0.85
19	Black Hawk Mine	223.0	bdl	bdl	79800	2.43
20	Silver Ledge Mine	55.9	17.30	bdl	1260	0.78
21	Big Colorado Mine	96.9	bdl	bdl	230	0.71
22	Queene Anne Mine	21.1	bdl	bdl	10400	0.92
23	Mine south of Mogul	43.2	6.08	bdl	1850	0.67
24	Mine north of Mogul	102.0	3.39	bdl	9240	0.68
25	Grand Mogul - West	92.6	2.56	bdl	12700	0.90
26	Grand Mogul - East	164.0	41.70	bdl	107000	5.48
27	Mogul Mine	40.5	32.90	bdl	33300	1.35
28	Anglo Saxon - Dup. Extract	177.0	274.00	16.30	18700	0.04
28	Anglo Saxon Mine	155.0	278.00	16.10	17600	0.12

Cement Creek
Waste Rock Sampling
Analytical Results

Site #	Site Name	Sr	Ti	V	Zn	Na
		ppb	ppb	ppb	ppb	ppm
29	Gold Hub - Duplicate Extract	217.0	bdl	bdl	1260	0.37
29	Gold Hub Mine	200.0	bdl	0.21	1170	0.45
30	Ross Basin - Upper Mine	23.4	0.60	bdl	3340	2.13
30	Ross Basin - Upper Mine Dup. Extract	23.5	0.35	bdl	33000	2.07
31	Ross Basin - Lower Mine Dup. Extract	23.7	10.90	bdl	50000	2.59
31	Ross Basin - Lower Mine	23.0	11.40	bdl	49100	1.70
32	Mammoth Tunnel - Duplicate Extract	102.0	bdl	bdl	410	0.96
32	Mammoth Tunnel	104.0	bdl	bdl	410	0.92
33	Elk Tunnel - Dup. Extract	12.4	bdl	bdl	40	0.44
33	Elk Tunnel	13.3	bdl	0.01	50	0.24
34	Columbia Queen Anne Complex - Duplicate	227.0	5.67	5.44	2170	bdl
34	Columbia Queen Anne Complex	215.0	6.40	4.82	2110	0.01
35	Upper Porcupine Gulch Mine	55.2	2.84	bdl	31100	1.19
36	Lower Porcupine Gulch Mine - Top of Pile	488.0	94.30	bdl	11700	0.24
37	Kansas City Mine #2	148.0	6.47	80.40	377000	8.28
38	Kansas City Mine #1	319.0	bdl	bdl	86200	2.13
39	Evelyne	11.9	bdl	bdl	460	2.42
40	Galty Boy Mine	40.4	bdl	bdl	5190	0.30
41	Kansas City Mine #3	997.0	23.40	bdl	800	1.01
43	Ohio Gulch Natural	180.0	bdl	bdl	410	1.10
44	Porcupine Adit -outslope only	170.0	2.80	bdl	16000	0.30
45	Porcupine Gulch Natural	29.0	3200.00	44.00	1000	0.13
49	Elk Tunnel - Dup. Sample	17.0	bdl	bdl	100	0.69
50	Corkscrew Duplicate Sample	39.0	180.00	bdl	2200	1.30

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