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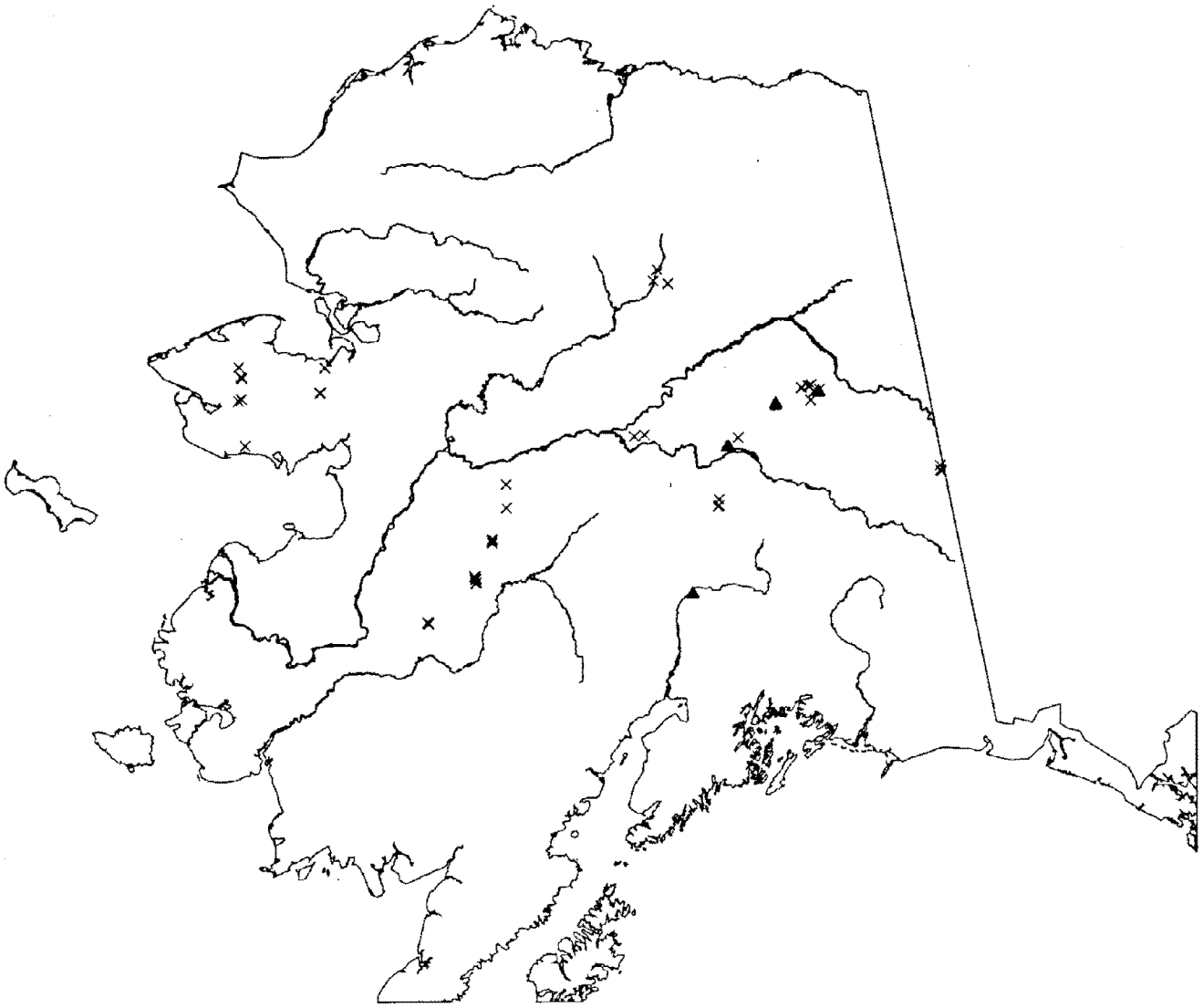
Alaska Placer Mining Metals Study - Year Two



EPA
United States Environmental Protection Agency
Region 10, 1200 Sixth Avenue, Seattle, WA 98101-1128

Alaska Placer Mining Metals Study - Year Two

April, 1999

Prepared by
U.S. Environmental Protection Agency (EPA)
Office of Environmental Assessment
Region 10

Contributors

Project Planning

Cindi Godsey, Carla Fisher, Jim Corpuz
Office of Water

Quality Assurance Project Plan

Laura Castrilli, Bruce Woods
Office of Environmental Assessment

Field Team

Cindi Godsey, Val Haney, Ann Winther, Martha Barber, Rick Albright, Mark Jen
USEPA

Victor Ross
U.S. Army Corps of Engineers

Dean Boening, Mark Silverstein, Jesse (Woody) Campbell, Neil Amick
Lockheed Martin (ESAT)

Laboratory Analysis

USEPA Manchester Environmental Laboratory

Map Compilation

Steve Schumaker
Lockheed Martin (ESAT)

Report Compilation

Joe Goulet, David Frank, Kristen Ryding, Lorraine Edmond
Office of Environmental Assessment

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Abstract

EPA sampled four placer mines in Alaska during the summer of 1998. This was the second phase of a study of the distribution of metals in surface water at placer mines in surface water upstream of the mine site, downstream of the mine discharge, and in the effluent. The first phase of the study evaluated one-time measurements collected in 1997 from 31 mines located in 14 mining districts across Alaska. The second phase of the study, reported in this document, examines temporal variations from eight rounds of measurements collected during 1998 from four placer mines located in three mining districts. During the second phase in 1998, EPA obtained field measurements of temperature, pH, electrical conductivity, dissolved oxygen, turbidity, and settleable solids. In addition, EPA analyzed samples for total suspended solids, total recoverable metals, dissolved metals, and hardness. The metals analyses included aluminum, antimony, arsenic, cadmium, calcium, chromium, copper, lead, magnesium, mercury, nickel, selenium, silver, and zinc. The 1998 data show typically large variations in total recoverable and dissolved metals concentrations through the course of the mining season. Consistent with 1997 results, turbidity was an effective indicator for some, but not all, total recoverable metals found in surface waters. In addition to turbidity, total suspended solids measurements showed similar variations with total recoverable metal content.

I. Introduction

A. Background

The U.S. Environmental Protection Agency (EPA) undertook a two-year study of metals in placer mining areas of Alaska in 1997. This document is a report of data collected during the second year of the study. The report of the first year study is titled Alaska Placer Mining Metals Study (EPA910-R-98-003) and is referenced here as U.S. Environmental Protection Agency (1998).

B. Goal and Objectives

The goals of the study were to measure the concentrations of metals in surface water affected by placer mines, and to determine whether there is a relationship between physical measures (turbidity, settleable solids, total suspended solids) and chemical measures (total recoverable and dissolved metals concentrations) for placer mining effluent in Alaska.

To meet these goals, the study objectives were to determine:

- Levels of the following parameters of concern:

dissolved and total recoverable metals	turbidity
total suspended solids	settleable solids
pH	hardness
temperature	electrical conductivity

during summer at all discharging mines and approximately half of the active, but not discharging, mines during year 1. The parameters of concern were selected on the basis their usefulness in evaluating the distribution of metals in the aquatic environment at placer mines.

- Temporal variability of metals concentrations and other parameters in effluent at a few representative sites during year 2.
- The "natural background" of the parameters of concern for representative placer mining operations in mining districts in Alaska.
- The parameters of concern immediately upstream of the mining operations.
- The parameters of concern downstream from the placer mining operations.
- The relationship between metals and total suspended solids, settleable solids or turbidity in the natural background conditions and discharges.

II. Methods

Appendix A contains the Quality Assurance Project Plan for this work, which includes analytical methods and sampling specifications.

A. Study Design

1. Sample Sites

Four placer mining operations were selected and sampled at weekly intervals. Where a mine was discharging waste water, four samples were taken, one from each of the following:

1) upstream of any obvious disturbance (i.e., "background"),
2) immediately upstream of the discharge,
3) the effluent,
4) downstream of the point of mixing (determined visually). Where the state of Alaska indicated the physical location of the edge of the mixing zone, samples were taken at the edge of the mixing zone.

Where a mine was not discharging, samples were only collected upstream of any obvious disturbance (background) and immediately downstream from the site. The objective for the selection of background was intended to be sites unaffected by mining or other construction disturbance. Considering the mining history of Alaska, it is unrealistic that all of the background sites chosen for this study actually represent a natural background completely unaffected by mining activities. Although an attempt was made to pick background sites upstream from obvious disturbance, the background data may not be representative of true natural conditions.

2. Measurement Parameters

Physical measures consisted of field measurements of temperature, electrical conductivity, turbidity and settleable solids, and laboratory analyses of total suspended solids (TSS). Chemical measures consisted of field measurements of pH and laboratory analyses of total recoverable and dissolved metals, and hardness.

Three of the physical measures including settleable solids, turbidity, and TSS, should be related to suspended particulate material in the water column. Settleable solids are determined by measuring the depth of sediment that settles from a sample of the water column over a one-hour period. Settleable solids represent only the coarsest particulate material in the water column because substantial fine particulates may remain suspended after an hour of settling.

Total suspended solids (TSS) is determined by a gravimetric measurement of filterable material and therefore is a direct measure of the amount of particulates greater than the filter size, 0.45 μm, in a sample of the water column. The finest-size particulates such as colloidal material may pass through the 0.45 μm filter and not be included in a TSS measurement.

Turbidity is determined by a measurement of light scattered by particulate material in a sample of the water column. Light scatter is affected not just by the amount of particulate material, but also by the density, shape, and color of the particulates. Therefore, turbidity can be considered an indirect rather than direct measure of the amount of particulates. Turbidity is especially sensitive to finer grained material.

Each of these physical measures is sensitive to somewhat different characteristics of suspended particulate material. In practice, rough correlation is usually found between total suspended solids and turbidity. Settleable solids, being a measure of only the coarsest fraction of water-borne material, may show less correlation with turbidity and TSS when the predominant part of the suspended material is fine-grained.

One physical measure, electrical conductivity, should be related to the dissolved metal content. Conductivity is determined by measuring the ability of water to conduct electricity. Since conductance is directly related to the charged ion content of water and since most of the dissolved metals in natural surface waters occur as charged ions, electrical conductivity can be then be related to the major dissolved metals.

The chemical measures for metals were total recoverable and dissolved. Total recoverable metals were determined by analysis of unfiltered samples, which would represent metals in the combined dissolved and suspended particulate phases. Dissolved metals were determined by analysis of samples passed through a 0.45 μm filter. Therefore, the difference in metals concentrations between the unfiltered and filtered samples should represent mostly metals in the particulate phase.

The chemical measure, hardness, was determined by the sum of the magnesium and calcium content. Hardness was included in the list of parameters because it is used in calculating chronic water quality criteria for some of the trace metals, cadmium, copper, lead, and nickel.

B. Field Work

During the summer of 1998, EPA collected 120 samples and duplicates from four mine sites located near Talkeetna, Central, and Fairbanks, Alaska (Figure 1). Table 1 lists the mines, their owners and the mine locations. Locations are based on uncorrected GPS readings except for Eldorado Creek which was determined by plotting on a map.

The four mines sampled in 1998 in eastern Alaska were in addition to the 31 mines studied during 1997 in both the Fairbanks and other areas in eastern Alaska, and the McGrath and Nome areas in western Alaska (Figure 1). Criteria for mine selection for both years included: 1) representative distribution from several mining districts, 2) preference for operating and discharging mines, and 3) accessibility. Because of the necessity for repeated measurements, all of the 1998 sites were within driving or helicopter distance from Fairbanks. All mines included in the study were operating, though most were recycling waste water rather than discharging. Dischargers included nine of 31 mines studied in 1997, and three of the four mines in 1998.

The 1998 mines included operations on Eldorado Creek near Talkeetna, Ester Creek near Fairbanks, Faith Creek near Fairbanks, and Ketchem Creek near Central (Figure 1). As with mines studied in 1997, sample sites at each mine were chosen to determine the effects of the mining activity on the respective stream (Figures 2a-d). Each of the mines studied in 1998 had a sample site chosen to be representative of background and another of downstream below mining activities. The three mines with discharges (Eldorado, Faith, and Ketchem Creeks) had additional sample sites for effluent and upstream of the discharge point for effluent. The mine on Ketchem Creek also had an established mixing zone designated by the Alaska Department of Environmental Conservation. Consequently, the downstream sampling point at Ketchem Creek was set to coincide with the edge of the mixing zone. The mine on Faith Creek had a change of in the operation during the course of the sampling whereby water was redirected among the holding ponds (Appendix B). Only the mine operator on Ester Creek continued to recycle waste water during the study, and thus had no effluent sample.

Sample collection occurred between June 23 and September 2. Sampling at the Talkeetna mine began on June 23 and continued through September 1. Sampling at the three mines near Central and Fairbanks began the week of July 13 and continued through the week of August 31.

The sampling plan was followed with some exceptions. Dissolved oxygen was not measured at the Talkeetna mine due to limitations on time available in the field and availability of field equipment. Turbidity was not measured during the first week at Talkeetna due to problems with calibrating the turbidimeter. Two weeks of sampling were lost at Talkeetna, one due to bad weather and another due to helicopter repair. Heavy rainfall in the Fairbanks area caused a washout of part of the Steese Highway during the first week of sampling. Access to the Faith Creek mine was impeded on several occasions due to high water but the sampling crew was able to return later in each week to conduct sampling.

Samples were collected using a "clean hands" technique, labeled in the field, and shipped with a chain of custody form to the Manchester Laboratory using USEPA (1996) procedures. Details of the sampling procedure are described in the Quality Assurance Plan, Appendix A. Appendix B contains the field reports.

C. Laboratory Methods

Laboratory methods are described in the Quality Assurance Plan, Appendix A.

III. Results

A. Distribution of Mines and Relationship to Regional Geology

Alaska has been divided into ten mining regions which are subdivided into 67 mining districts, as defined by the U.S. Geological Survey (Cobb, 1973). Over the two-year period of this project, mines were sampled in 14 of the mining districts (Figure 1), primarily within the Seward Peninsula and Yukon River Regions. Since the report on 1997 data did not consider the distribution of mines with respect to mining district or to regional geology, the following discussion includes both sets of mines sampled during 1997 and 1998.

Summary information relating the placer mining districts to their regional geologic settings can be found in Cobb (1973) and in Nokleberg and others (1996). Appendix C contains selected district descriptions taken from Nokleberg and others (1996). Table 2 derived from these references lists the types of potential source mineralization found in the districts sampled, as well as their associated mineralogy and host rock type.

In most cases, the precise source of the placer gold deposited in these districts remains unknown, but inferences are often made based on the surrounding geology. While some of the summary information applies to the particular drainage containing the sampled mine, more often the descriptions are less specific and apply to the entire district.

The most common type of source mineralization described is polymetallic veins and/or gold-quartz veins related to igneous intrusions, which are included in nearly all the districts.

Massive sulfide deposits are described in the Bonnifield and Circle Districts, and skarn deposits are described in the Fairbanks and Circle Districts.

B. Overview of Data

1. Analytical Results

Table 3 lists the full data set for analyses of both laboratory and field parameters. The results are arranged by mine, sampling round, and type of sample site. Sample types are denoted by background, upstream, effluent, downstream, and mixing zone designations that refer to the respective locations noted on the mine diagrams (Figure 2). Appendix D contains the laboratory reports for 1998 data. Summary statistics of laboratory and field data are listed in Table 4. Statistical functions include the arithmetic mean, geometric mean, and maximum and minimum values derived from the full data set in Table 3. The summary data are grouped in Table 4 by measurement parameter and by sample type for each mine, and for the combination of all four sample types for each mine.

2. Temporal Variability

An objective of the 1998 study was to determine the temporal variability of metals concentrations by repeated sampling through most of a mining season. Figures 3a through 3ab show the variation for field parameters and metals during eight rounds of sampling. The sampling rounds span the period from June 23 to September 2. Inspection of the temporal plots shows that metal concentrations at all mines are variable through time, but in general in a non-synoptic manner except for Round 6.

Comparison with field observations of site conditions indicates that periods of higher precipitation and stream flow generally result in greater variability in concentrations. At Ester Creek, for example, maximum variation in metals concentrations occurred for both background and downstream samples in Round 6 at a time when very wet conditions had increased the stream flow and turbidity (see Figures 3i - turbidity, 3j - aluminum, 3k-n - other metals). The mine on Ester Creek was not discharging at the time of the samples, indicating that increased turbidity and metals concentrations during that round resulted from naturally occurring erosion. The results for the other three mines, which were discharging, also show increases in turbidity and several metals for Round 6. However, additional variability among the mines during the remaining part of the mining season does not appear to coincide with changing background conditions.

Data for the Faith Creek mine provide a specific example of the influence of changing site operations. The operation of holding ponds at Faith Creek changed between the Round 3 and Round 4 sampling, as noted in the field work reports (Appendix B). Figures 3o-3u for Faith Creek show increases in TSS, turbidity, and all of the trace metals during this period. The increases coincide with the redirection of the mine discharge. This example and most of the other trends in temporal variability among the mines studied appear in general to be specific for each site rather than coincident among sites.

3. Estimation of Background

The arithmetic mean concentrations of background measurements for the four mines are listed in Table 4. As shown by the summary in Table 4 and by the temporal plots of individual measurements (Figure 3), the background concentrations represent the lowest values found at each mine for turbidity and for most, but not all, metals. In those few cases where metals in background are at higher concentrations than downstream sites, the difference in mean values is less than a factor of two. The most conspicuous of the high background values occurred for aluminum, copper, mercury, and zinc, with a smaller increase for antimony, lead, and selenium.

Background concentrations for some trace metals differ by over an order of magnitude from mine to mine, indicating that background is quite specific to a particular site. Using aluminum as an example, three of the mines had mean values for dissolved aluminum in the range of 18-60 ug/L whereas, the Ketchem mine had a value of 615 ug/L (Table 4). Additionally, in contrast to the other sites with circumneutral pH values, the Ketchem site had a relatively low mean pH of 6 for the background site. For most dissolved metals, the Ketchem mine had the highest background concentrations. Exceptions occurred for dissolved arsenic and nickel, for which highest background values were found at the Ester Creek mine, and for dissolved selenium found to be highest in at the background site for the Eldorado Creek mine (Table 4).

4. Comparison Upstream and Downstream of Mines

The most common pattern for mean metals concentrations at the four mines is an increase from the background site to the upstream-of-mine site, followed by a further increase to the downstream site (Table 4). For arithmetic mean values of 12 dissolved trace metals at four mines, representing a combination of 48 mean measurements, 77% had higher concentrations at the downstream site than at either the upstream or the background site (Table 4). For mean values of 12 total recoverable trace metals, 87% had higher concentrations at the downstream site. The data show that the relative concentration of upstream versus downstream sampling sites is specific to each mine.

5. Summary of Exceedances of Criteria

Analyte concentrations for both the total recoverable and dissolved samples were compared with Alaska water quality criteria for chronic effects to freshwater aquatic life, with the exception of arsenic (Table 5). For arsenic Alaska has adopted a freshwater criterion for public water supplies, which is used in Table 5 as a benchmark for comparison with measured concentrations (see Office of the Federal Register, 1998).

Exceedances of criteria are depicted on graphs that show variation with time (Figure 3). Criteria on these graphs are shown by dotted lines when the criteria are within the plotting range of the graph. Table 3 also depicts criteria exceedances with outlined values. For metals that used hardness for calculating criteria, the hardness value measured at each sample site was used.

Exceedances were found for the following parameters: arsenic, cadmium, chromium, copper, lead, mercury, silver and zinc. Copper, lead and mercury had the largest number of exceedances. In general, most exceedances occurred in the effluent samples, with a decreasing number of observances found in downstream, upstream and background samples, in that order.

Looking at exceedances by creek, Eldorado Creek had the fewest with only one exceedance of the mercury criterion in a downstream sample. In Ester Creek, four background and one downstream sample exceeded the water quality criteria for the total recoverable mercury.

Faith Creek had exceedances for seven metals. Most exceedances were observed in the effluent samples with the exception of lead, where exceedances were found at all stream sample locations at some time during the study.

Ketchem Creek had exceedances for eight metals and the highest total number of exceedances. Copper, lead and mercury criteria were exceeded at all sampling locations in almost every sample round.

6. Comparison with 1997 Results

In general, metals concentrations found in 1998 measurements are similar to those found in 1997. During both years, mean concentrations varied greatly between individual mines. However when values are averaged together for all mines for each year, the mean yearly values show more similarity. For example, comparison of mean values for each type of sample site (background, upstream, effluent, downstream) in Table 4 of this report with mean values listed in the report of 1997 data (U.S. Environmental Protection Agency, 1998, Table 4) shows that averaged data from both years are within an order of magnitude regardless of sample site.

C. Relationship between Physical and Chemical Measures.

The discussion below follows the approach taken for 1997 data (U.S. Environmental Protection Agency, 1998). A comparison of the physical measures is made with the two types of metals samples, filtered and unfiltered, in order to examine the relationships between physical and chemical measures. As noted under study design, the unfiltered metals samples represent metals in the combined dissolved and particulate phases. The filtered samples represent metals largely in the dissolved phase.

1. Settleable Solids, Total Suspended Solids (TSS), and Turbidity

Three of the mines had detectable values of settleable solids, but mostly only in trace amounts (see values noted by "T" in Table 3). Of those with detectable settleable solids, only one mine (Faith Creek) had at least one value greater than 0.2 ml/L, which is a value used as an effluent limitation criterion. Inspection of Table 3 shows limited correlation between settleable solids, turbidity and TSS wherein the site with the highest value for settleable solids (1.2 ml/L in an effluent sample at Faith Creek) also had one of the highest turbidity values (1050 NTU) and

TSS (876 mg/L). The remaining data show poor correlation between settleable solids and either turbidity or TSS. Many samples with no detectable settleable solids still had turbidity values well over 10 NTU to as high as 2000 NTU, and TSS to over 900 mg/L.

Turbidity measurements are well correlated with TSS data, with a correlation value of r = 0.95 for 106 comparisons (Table 6). Turbidity measurements were made in the field at all sites, whereas TSS was measured in lab samples. Both parameters appear to be useful measures of particulates in the water column for the 1998 data. Because of their sensitivity, both turbidity and TSS rather than settleable solids are used in the discussion below as the particulate measures with which to compare metals concentration.

2. Comparison of Physical Measures with Metal Concentrations

Concentrations of total recoverable metals and dissolved metals were compared with turbidity and other physical measures using the same method as used for 1997 data (U.S. Environmental Protection Agency, 1998). Figures 4a-4n show the comparison of metal concentration of both total recoverable and dissolved fractions with other chemical and physical measures including turbidity. Linear correlation coefficients, r values, were calculated for some of the comparisons and are listed in Table 6. The correlation coefficients indicate that for the combination of all mines, moderate to strong correlation (r values between 0.92 and 0.97) occurs between most total recoverable trace metals and turbidity. These trace metals include aluminum, arsenic, cadmium, chromium, copper, lead, nickel, and zinc. Somewhat lower correlation (r = 0.87) occurs for mercury. Inspection of the data indicates that similar correlations also exist between the same total recoverable trace metals and TSS. In contrast, no correlation occurs between dissolved trace metals and either turbidity or TSS (all r values less than 0.5 in Table 6). The only physical measure that shows correlation with dissolved metals concentration is electrical conductivity, and then only for the major metals, calcium and magnesium.

The degree of correlation between the total recoverable trace metals and turbidity in the 1998 data is influenced to a large extent by results from the two mines with the highest values, on Ketchem Creek and Faith Creek. For copper for example, the correlation (r) with turbidity for the complete data set is 0.95 (Table 6). Consideration of each of the four mines individually yields r values of 0.99 (Ketchem), 0.90 (Faith), 0.78 (Eldorado), and 0.52 (Ester). In another example for lead, overall correlation with turbidity is 0.97 whereas r values for individual mines are 0.99 (Ketchem), 0.88 (Faith), 0.72 (Eldorado), and 0.34 (Ester). The characteristics controlling metal partitioning at Faith Creek and especially Ketchem Creek, therefore, tend to dominate the amount of correlation found in the complete data set. Conversely, poorer correlation values result when the evaluation is restricted to just those mines at Eldorado Creek and Ester Creek which had lower concentrations more in the range of aquatic criteria.

Inspection of the temporal plots (Figure 3) shows that the variation of total recoverable trace metals at individual sites through time are also associated with changes in turbidity as well as total dissolved solids. An example using the data discussed previously for Eldorado Creek shows the highest downstream measurement of total recoverable aluminum, chromium, copper, nickel,

and zinc occurring in Round 6 when turbidity was also at its highest in the downstream sample. Similar temporal patterns of increasing total recoverable concentrations and increasing turbidity are evident at the other sites, especially for this same group of trace metals.

In contrast, no similarity in temporal patterns of dissolved trace metals and turbidity occurs for these sites. The physical measure expected to be influenced by dissolved metals is electrical conductivity as noted above under Study Design (Section II.A.2). The dissolved major metals, calcium and magnesium (and consequently hardness which is derived from calcium and magnesium), show a strong coincidence of temporal trends for all sites. For trace metals, however, very limited similarity in trend through time occurs with electrical conductivity. An isolated example can be shown for dissolved nickel and electrical conductivity at the Eldorado Creek mine (Figures 3a and 3f) whereby an increasing trend in dissolved nickel concentration is evident through time coincidental with increasing conductivity. However, most dissolved trace metals do not track well with conductivity or any of the other physical measures.

IV. Discussion and Conclusions

The 1998 data indicate that all four mine sites had surface water that exceeded chronic aquatic criteria for at least one metal. The highest concentrations, greatest number of elevated metals, and most numerous exceedances occurred at two of the four mines. These exceedances generally occurred at higher concentrations in downstream relative to upstream sample sites, indicating an influence from mining operations. The remaining two mines only had exceedances for one metal, mercury. One of these mines had the highest mercury value in the downstream sample even though the effluent did not exceed criteria. The other mine had its highest values for mercury at the background sample site as well as downstream, suggesting the occurrence of an unrecognized source of mercury further upstream.

Comparison of the results from 1998 mines with those studied in 1997 can be made in general terms, though with the recognition that the two sets of sites are not the same. The individual ore characteristics and depositional environment of the placer deposits would be expected to be important factors controlling relationships between the metals content in either the particulate or dissolved phase and the physical measures. Although the second year's study sites were different from the first, two characteristics show broad commonality. First, except for the mine on Eldorado Creek, the selection of mines for 1998 came from three of the same mining districts examined in 1997 (Section III.A). Second, the mean values for metal concentrations derived from each year's data set are within an order of magnitude (see Section III.B.6) and the overall spread of data cover a similar broad range for each year.

The data show that for several metals, the physical measure of turbidity was a good qualitative indicator of total recoverable concentration for the 1998 samples. The best correlations between the particulate measures and the total recoverable metal concentration occurred for aluminum, arsenic, cadmium, chromium, copper, lead, nickel, and zinc. The correlation for total recoverable mercury was not as strong. The 1998 data are consistent with

1997 data in that good correlation was also found in the first year's study for aluminum, copper, lead, nickel, and zinc (U.S. Environmental Protection Agency, 1998, p. 12). Too few data above detection limits were available for 1997 to draw conclusions for cadmium and mercury. Arsenic showed little correlation with turbidity or any other physical measure in 1997 data; whereas for 1998 data, arsenic shows good correlation with turbidity ($r = 0.94$).

These results are consistent with the occurrence of most trace metals in the placer streams as primarily adsorbed or coprecipitated phases in particulate material. The major metals, calcium and magnesium, show poor correlation with turbidity but high correlation with electrical conductivity, indicating occurrence primarily in the dissolved phase. The metalloid, arsenic, occurs in both the dissolved and particulate phases depending on site and which year's data are considered. The other metalloids, antimony and selenium, appear to be primarily in the dissolved phase though fewer data above detection limits are available for these species to support the evaluation.

V. Limitations of Study

The results of this study would not be expected to necessarily be representative of other placer mining areas not included in the study. For example, a placer mine operating in alluvial sediments that are much more mineralized than those sites included in the study, or that have ore minerals of much higher solubility, would be expected to have higher metals concentrations relative to turbidity than found here. The results for background conditions found in this study do not necessarily represent a natural background because of the potential occurrence of mining or other activities that were not recognized when selecting background sites.

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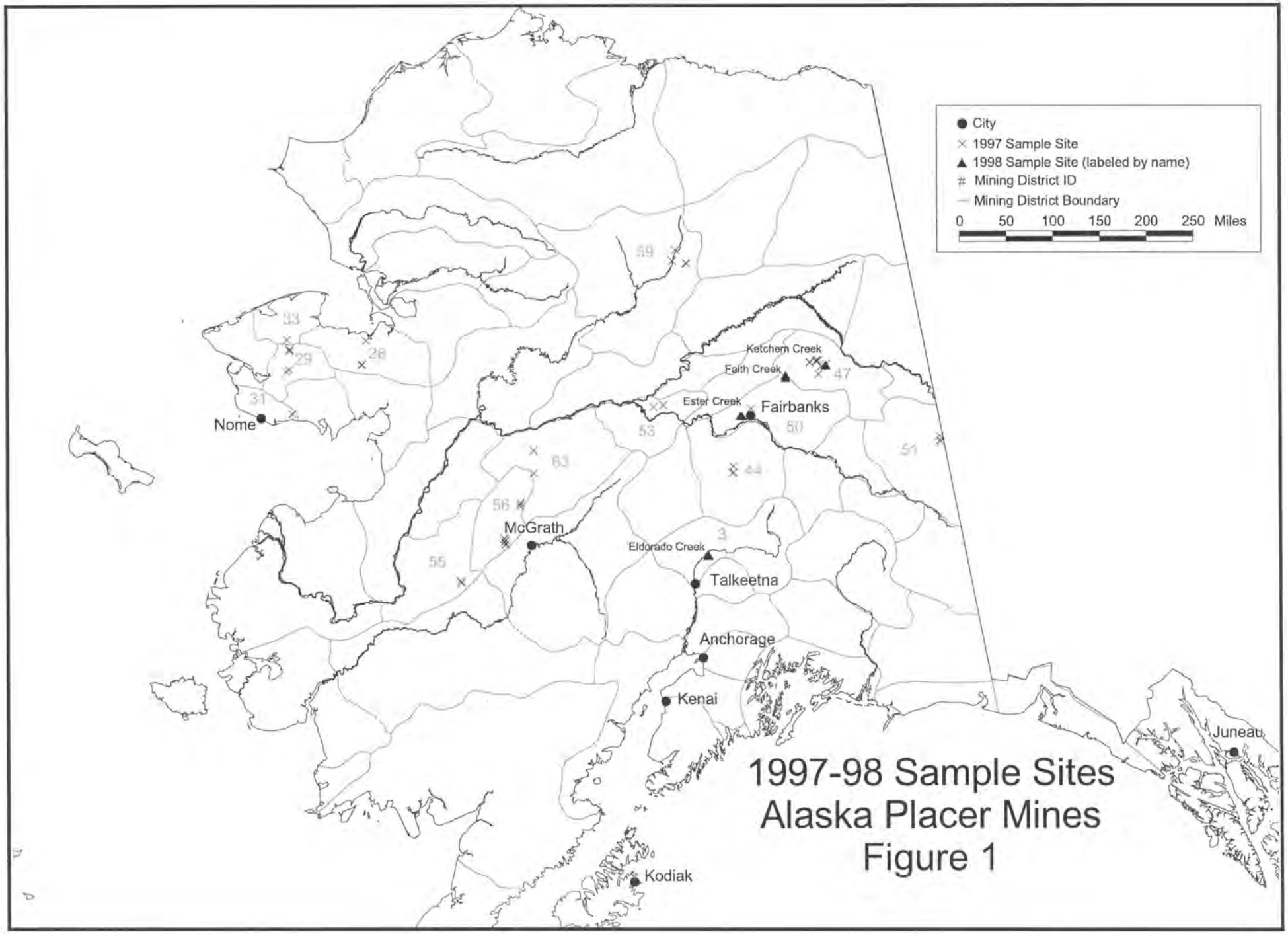
City
1997 Sample Site
1998 Sample Site (labeled by name)
Mining District ID
Mining District Boundary
0 50 100 150 200 250 Miles
Nome
McGrath
Fairbanks
Ketchem Creek
Faith Creek
Ester Creek
Eldorado Creek
Talkeetna
Anchorage
Kenai
Kodiak
Juneau
1997-98 Sample Sites
Alaska Placer Mines
Figure 1

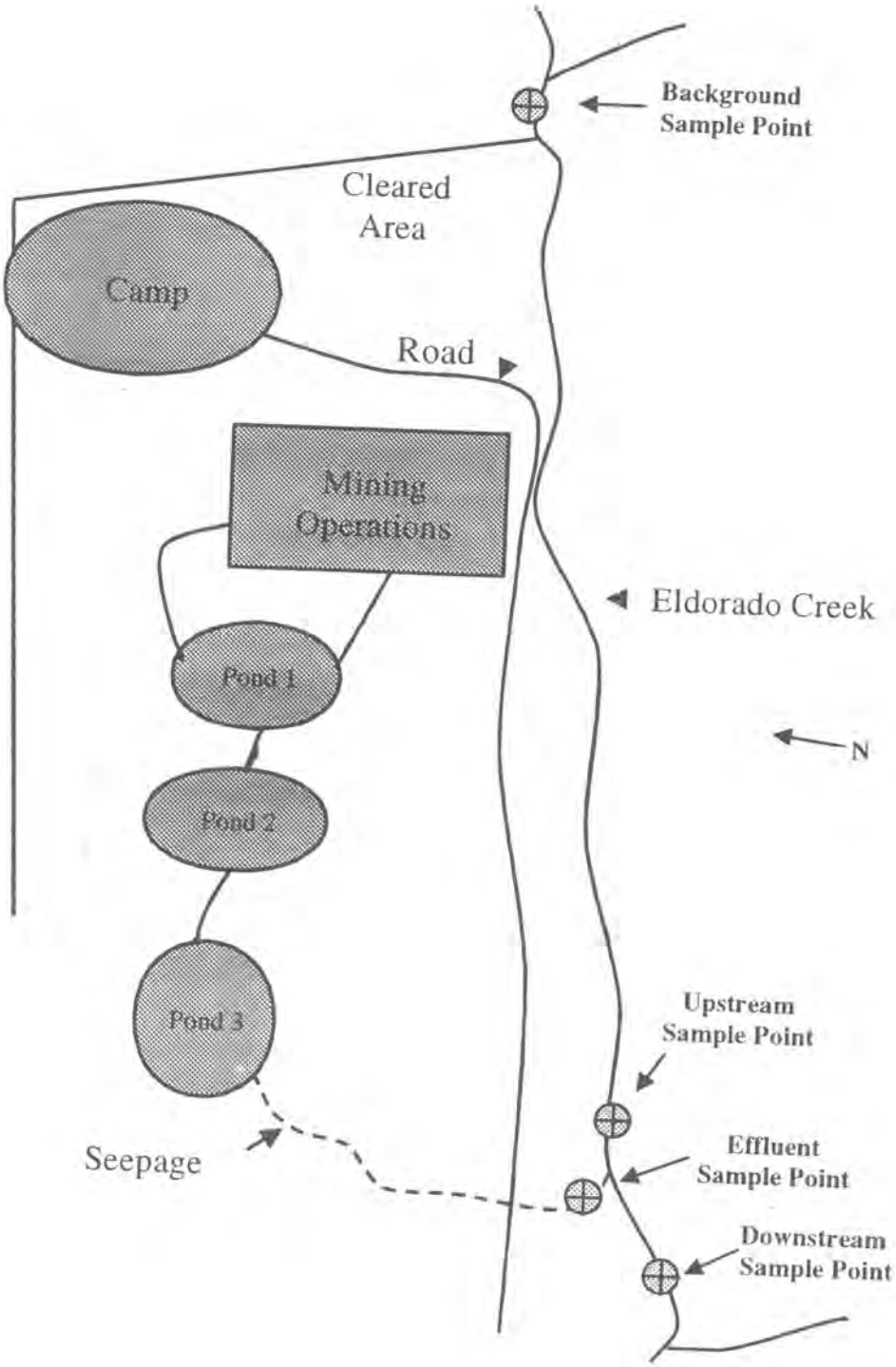

Figure 2a. Eldorado Creek Site Map

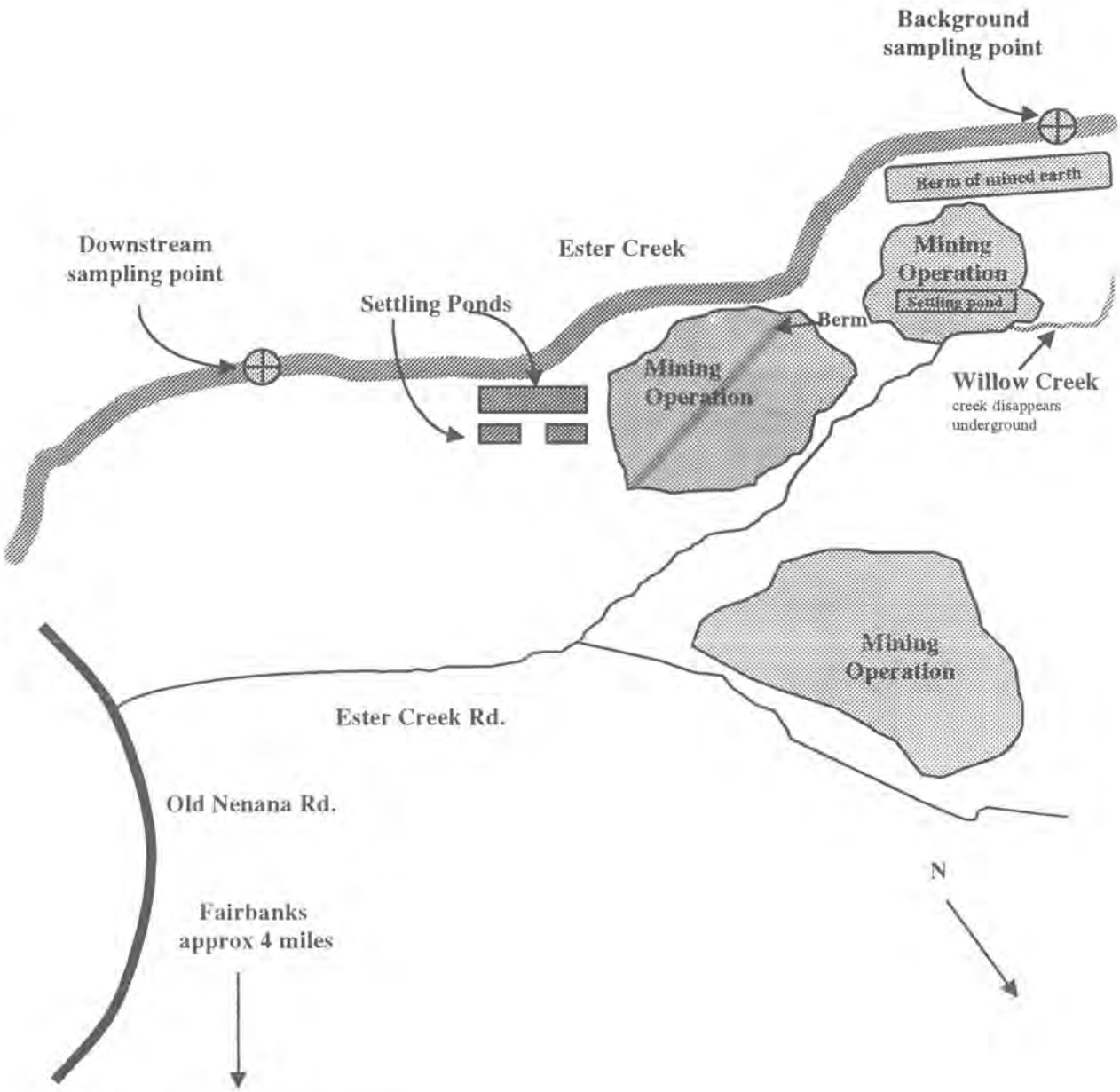

Figure 2b. Ester Creek Site Map

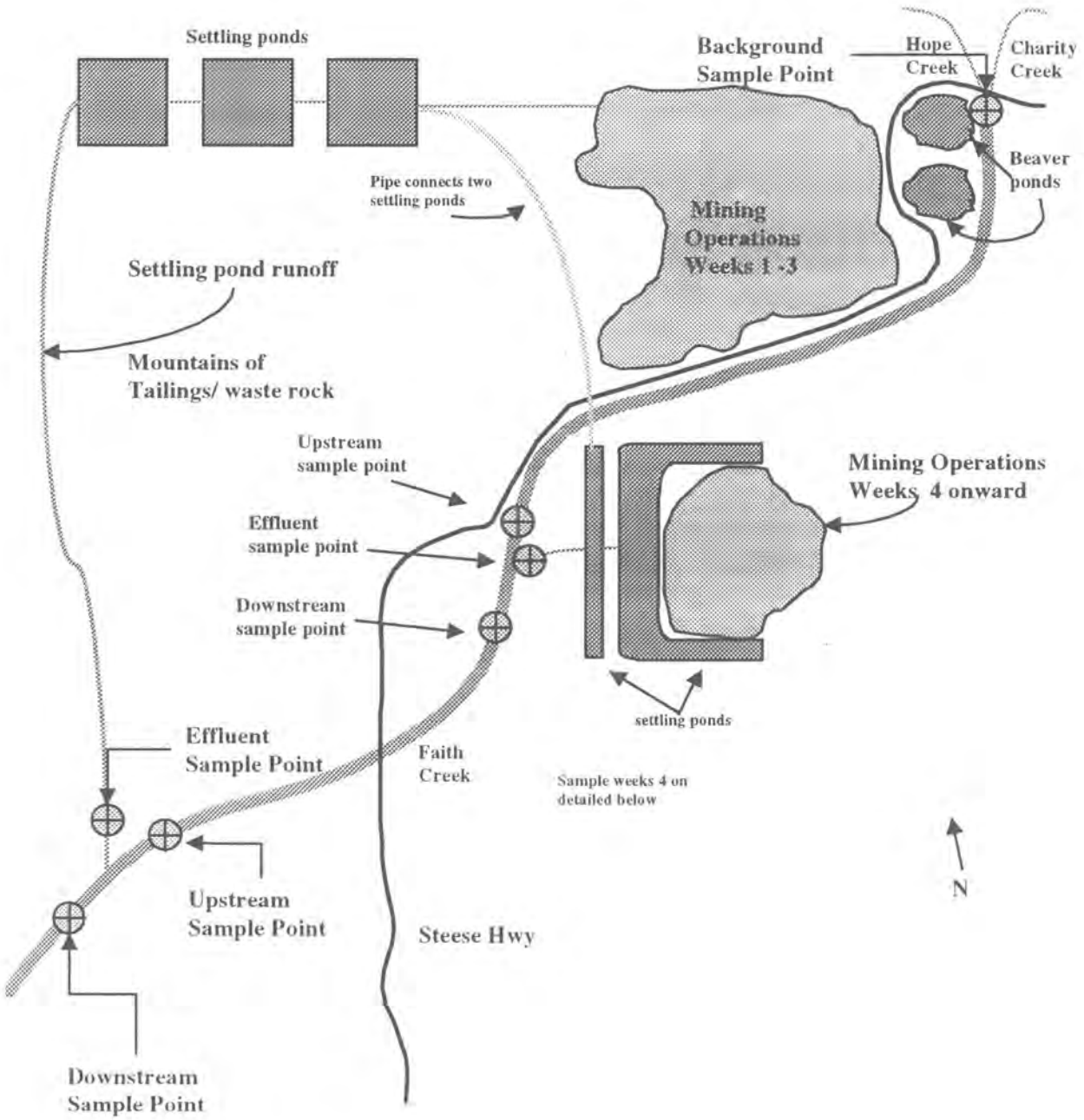

Figure 2c. Faith Creek Site Map

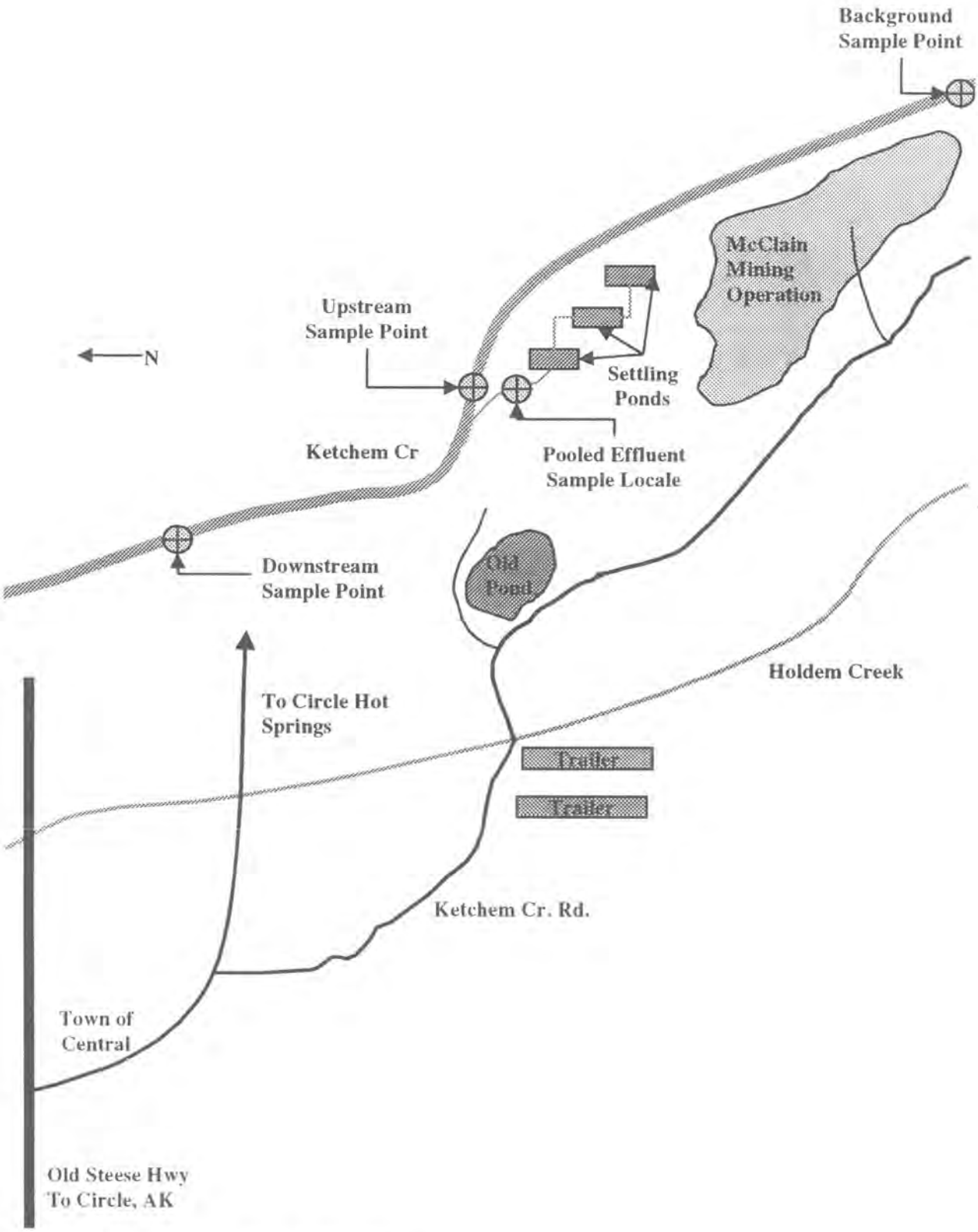

Figure 2d. Ketchem Creek Site Map

Figure 3a - 3 ab. Temporal variability of field parameters and metals. The following time trace graphs are arranged in order by creek and parameter with 7 pages for each creek:

a-g. Eldorado Creek.
h-n. Ester Creek.
o-u. Faith Creek.
v-ab. Ketchem Creek.

Chronic aquatic criteria are shown as horizontal dotted lines on those graphs where the criteria occur within the field of the diagram.

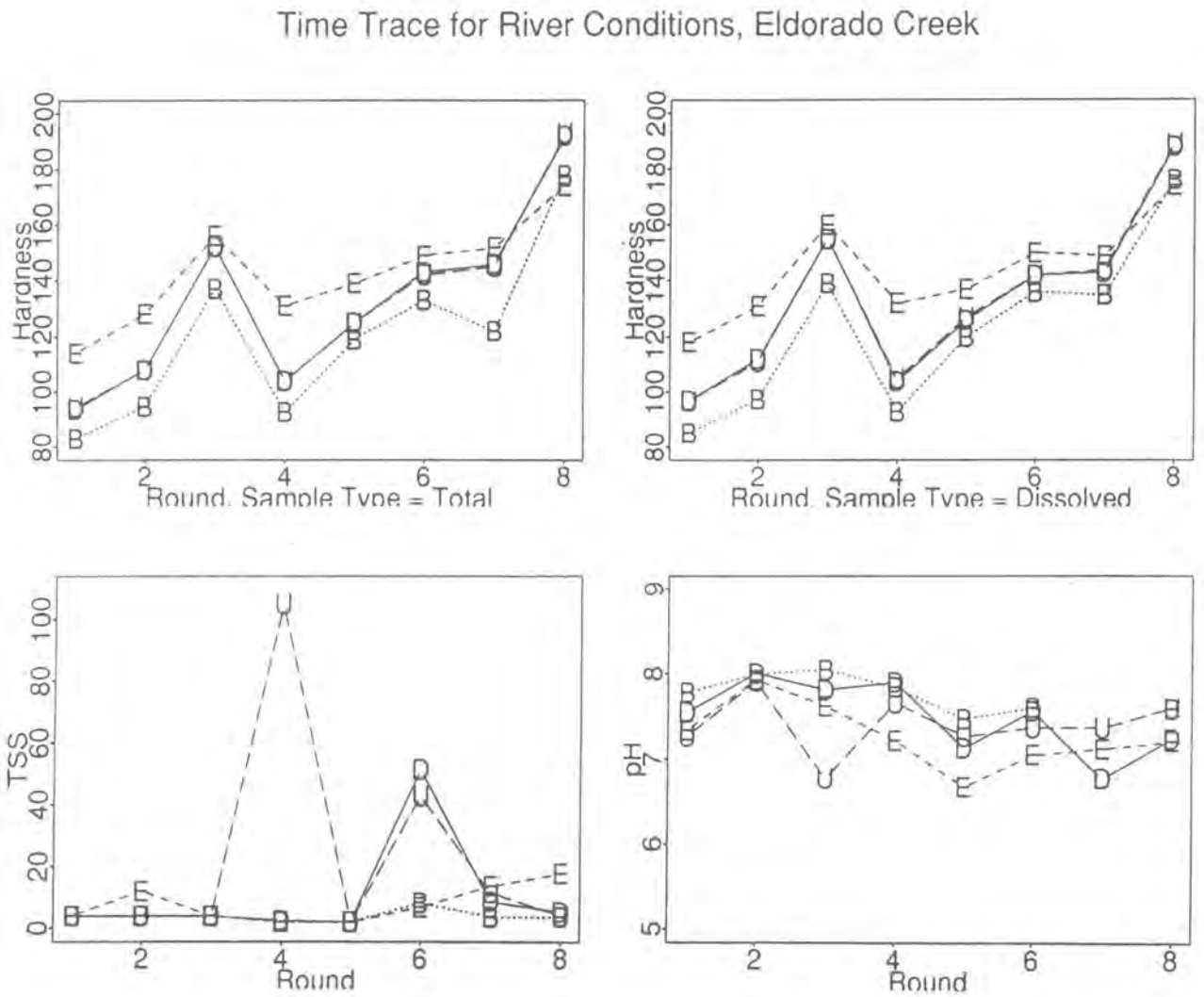

Figure 3a. Temporal variation of field parameters and metals. Hardness, TSS, and pH.

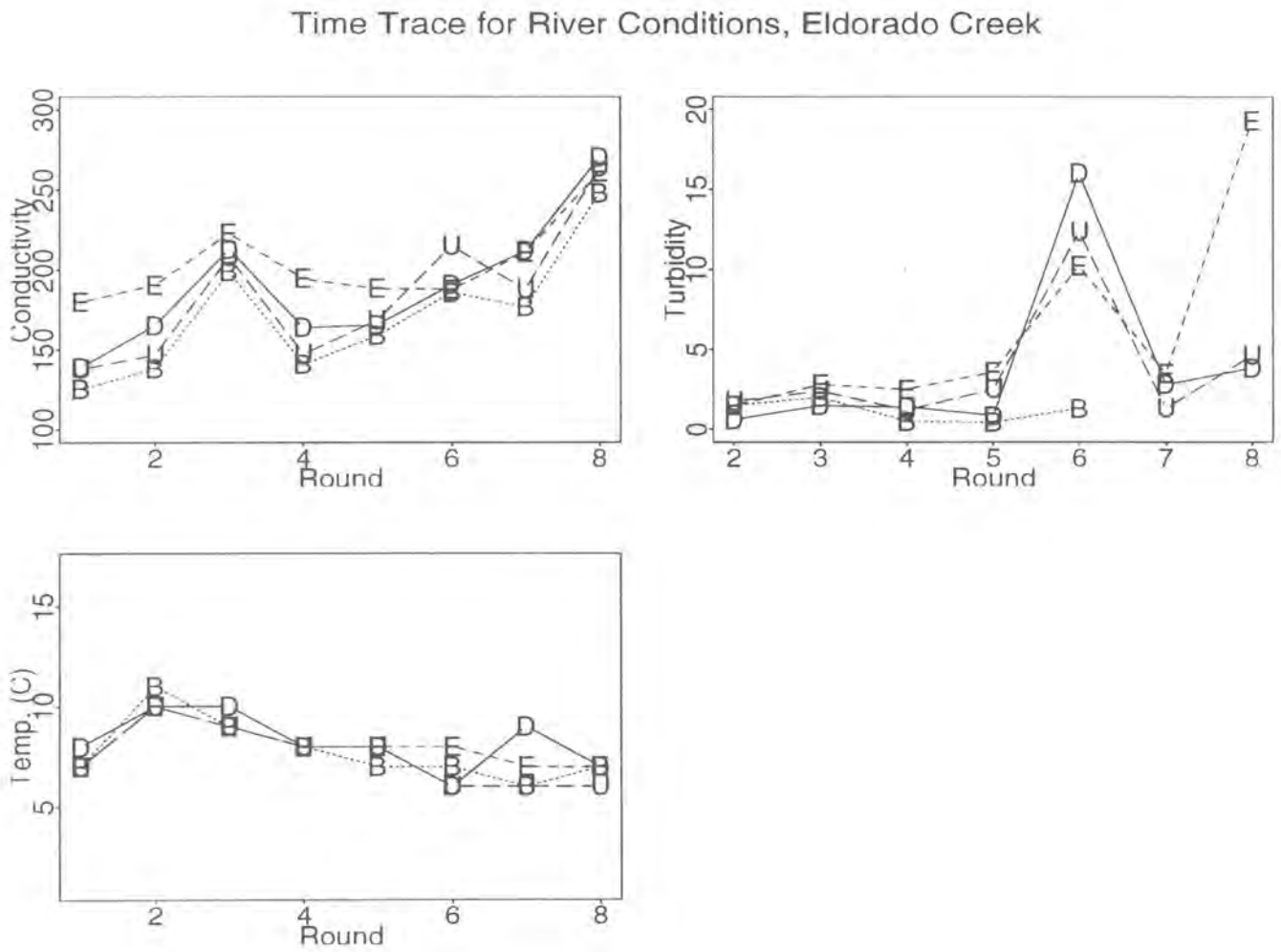

Figure 3b. Temporal variation of field parameters and metals. Conductivity, turbidity, and temperature.

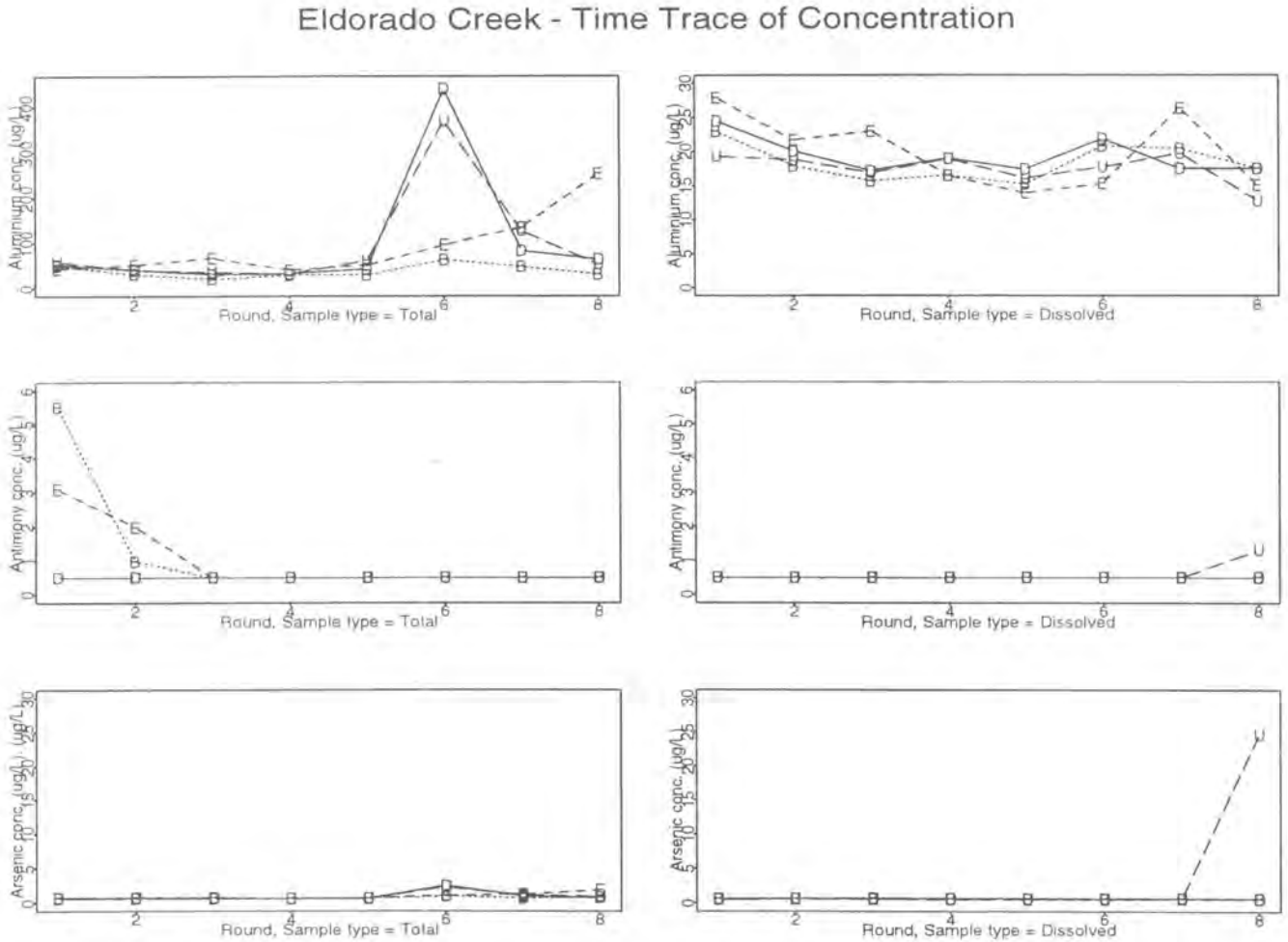

Figure 3c. Temporal variation of field parameters and metals. Aluminum, antimony, and arsenic.

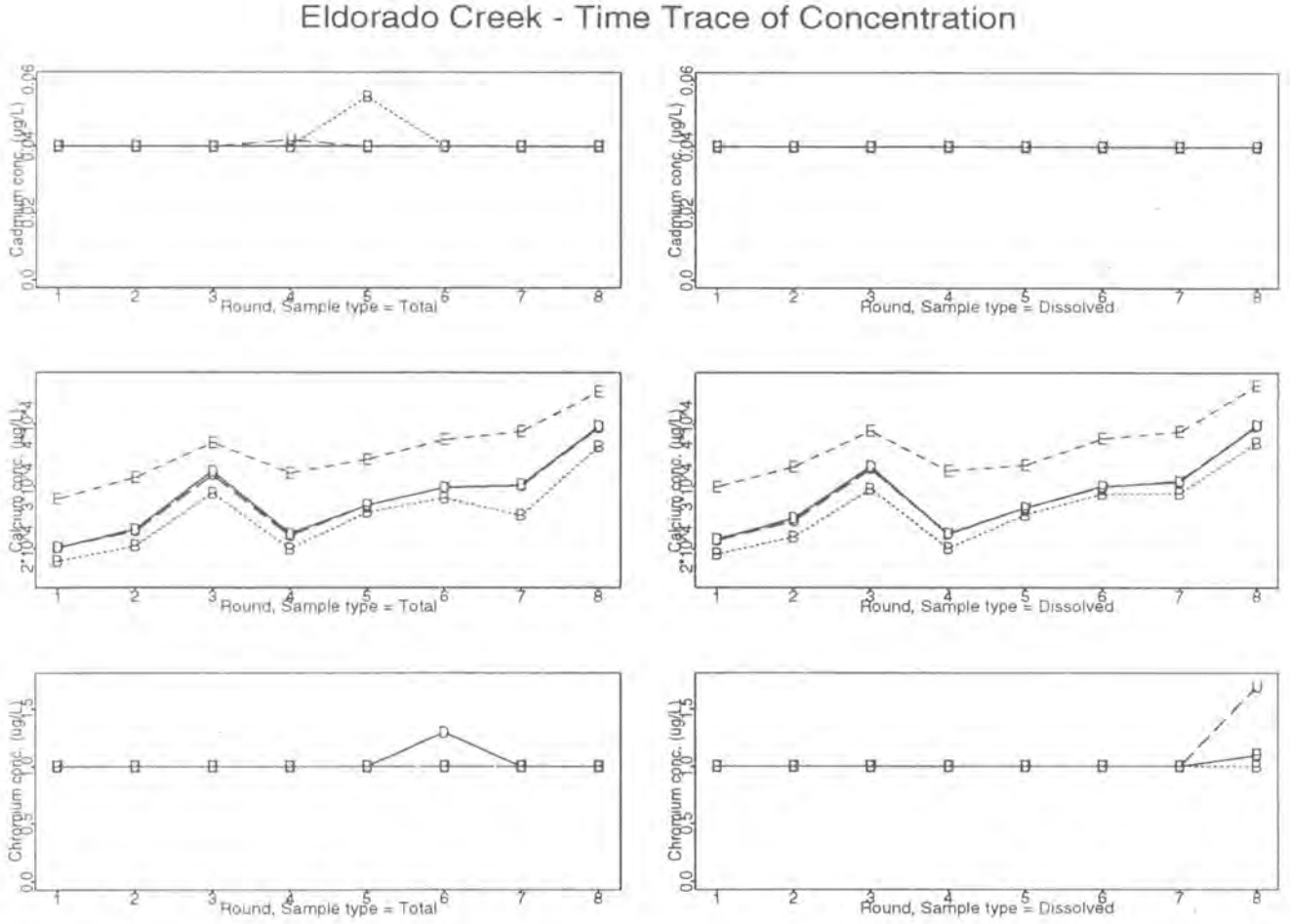

Figure 3d. Temporal variation of field parameters and metals. Cadmium, calcium, and chromium.

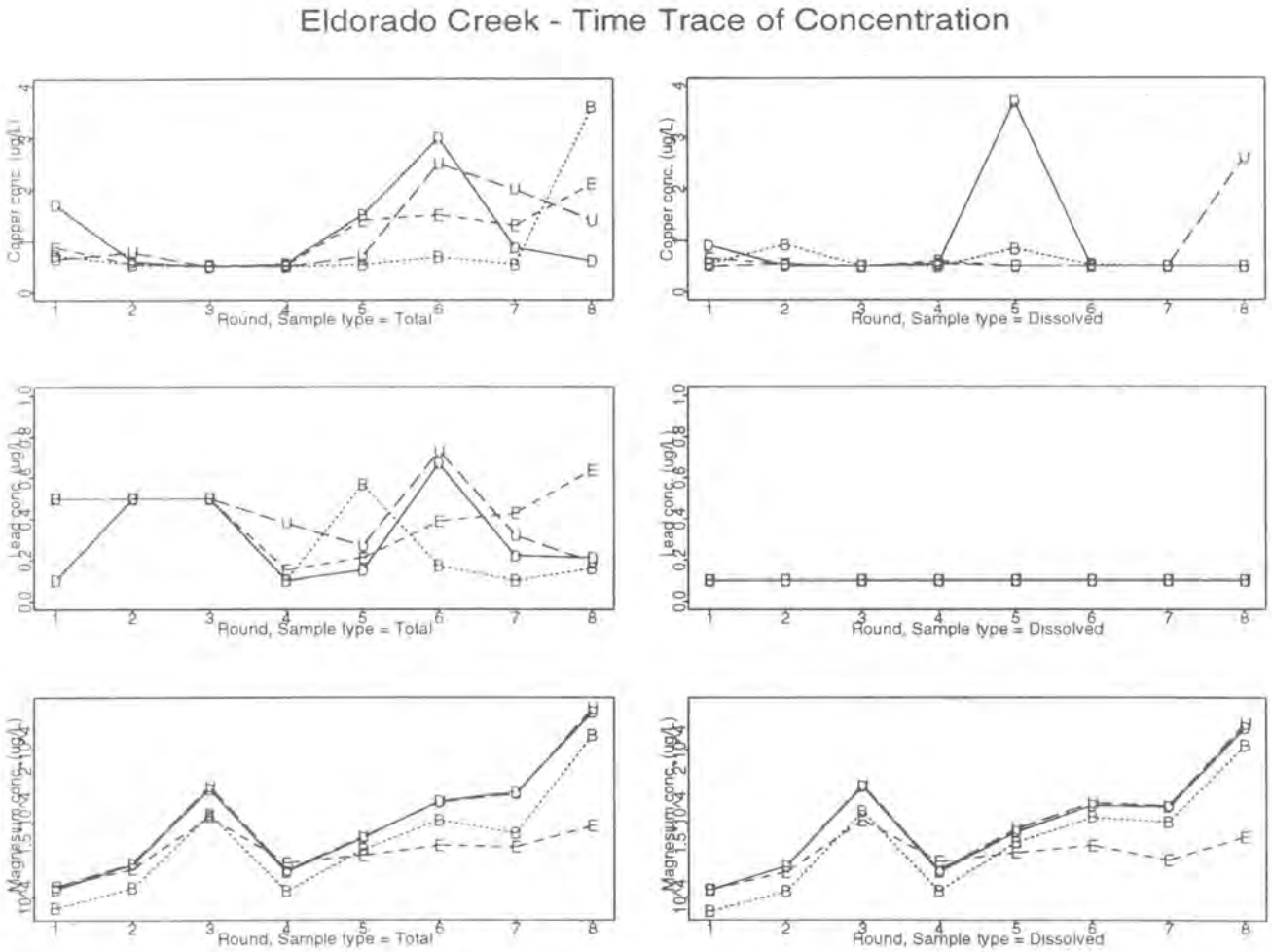

Figure 3e. Temporal variation of field parameters and metals. Copper, lead, and magnesium.

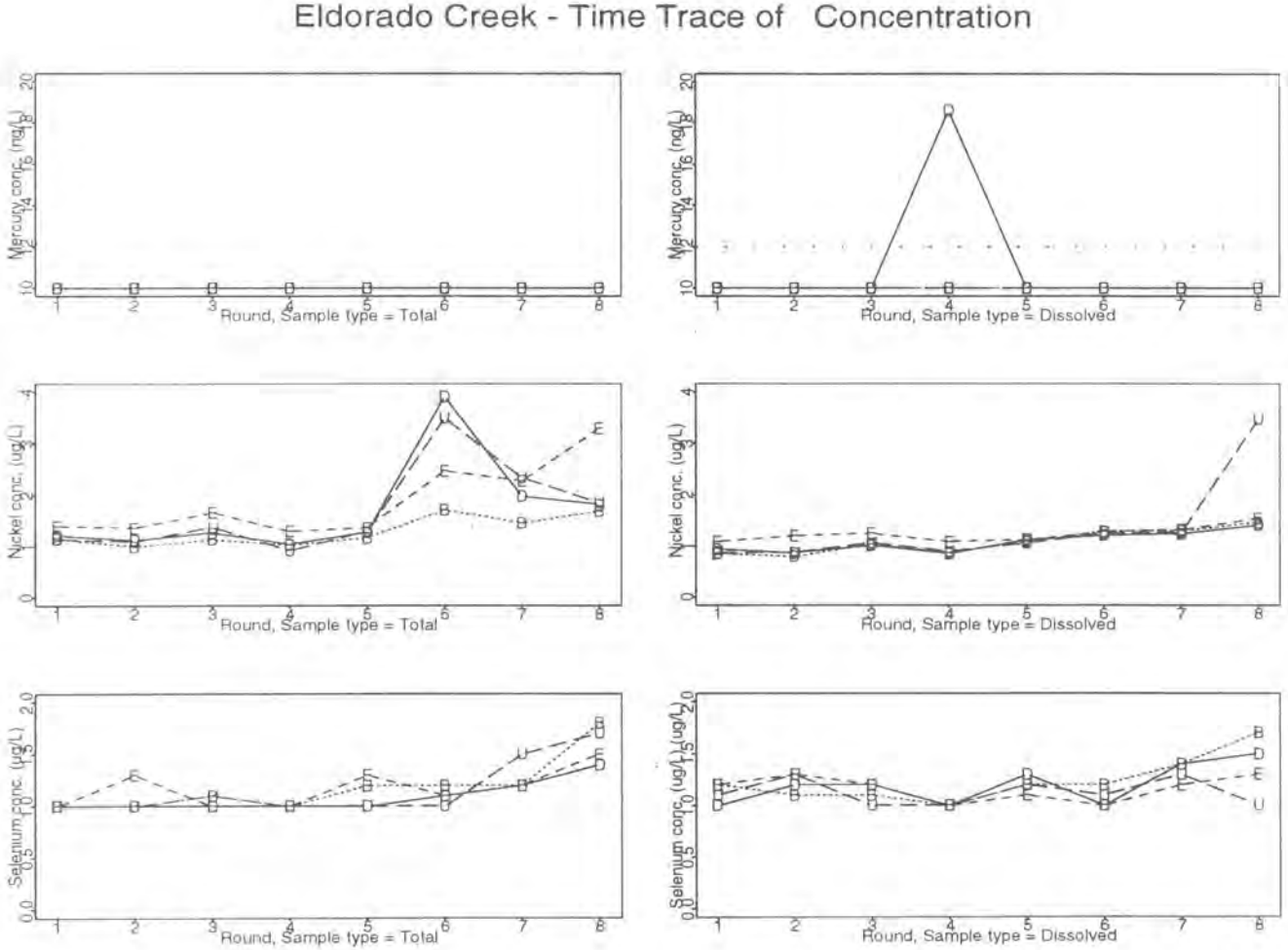

Figure 3f. Temporal variation of field parameters and metals. Mercury, nickel, and selenium.

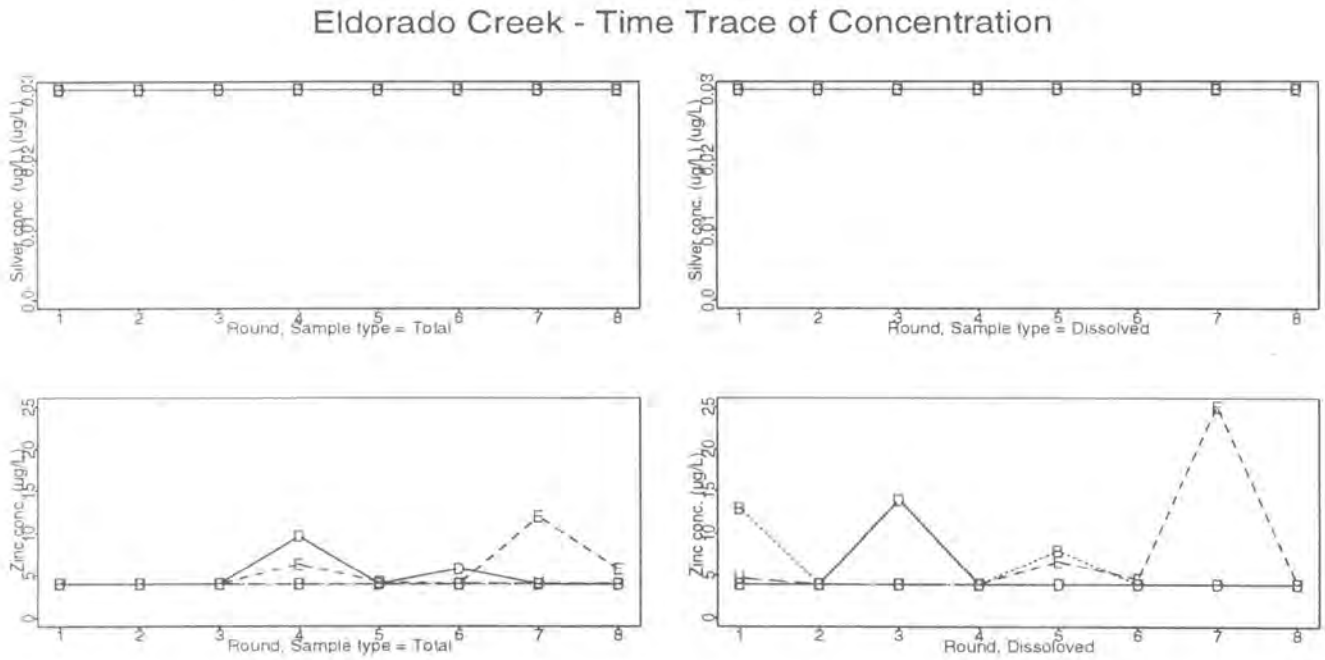

Figure 3g. Temporal variation of field parameters and metals. Silver and zinc.

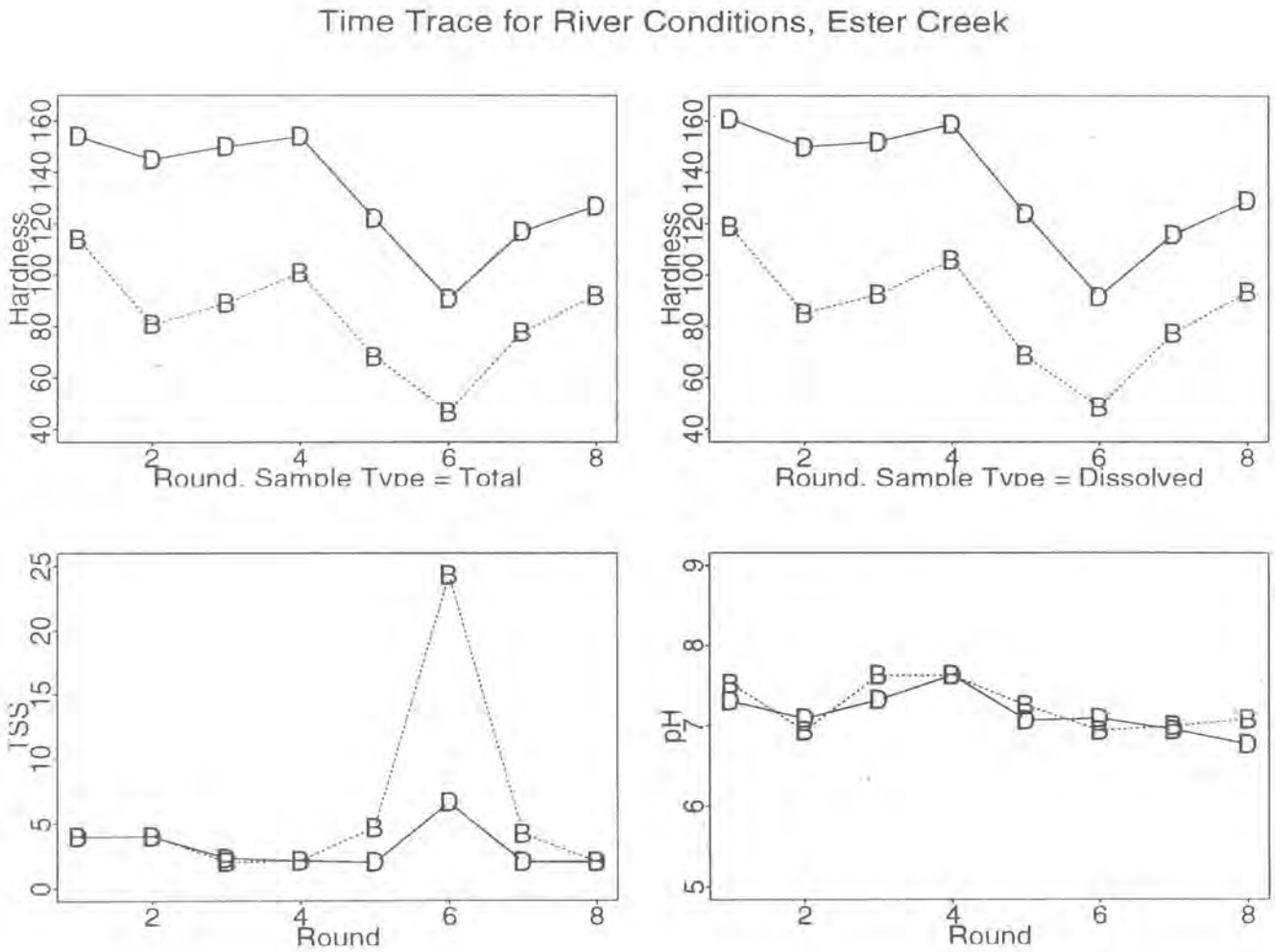

Figure 3h. Temporal variation of field parameters and metals. Hardness, TSS, and pH.

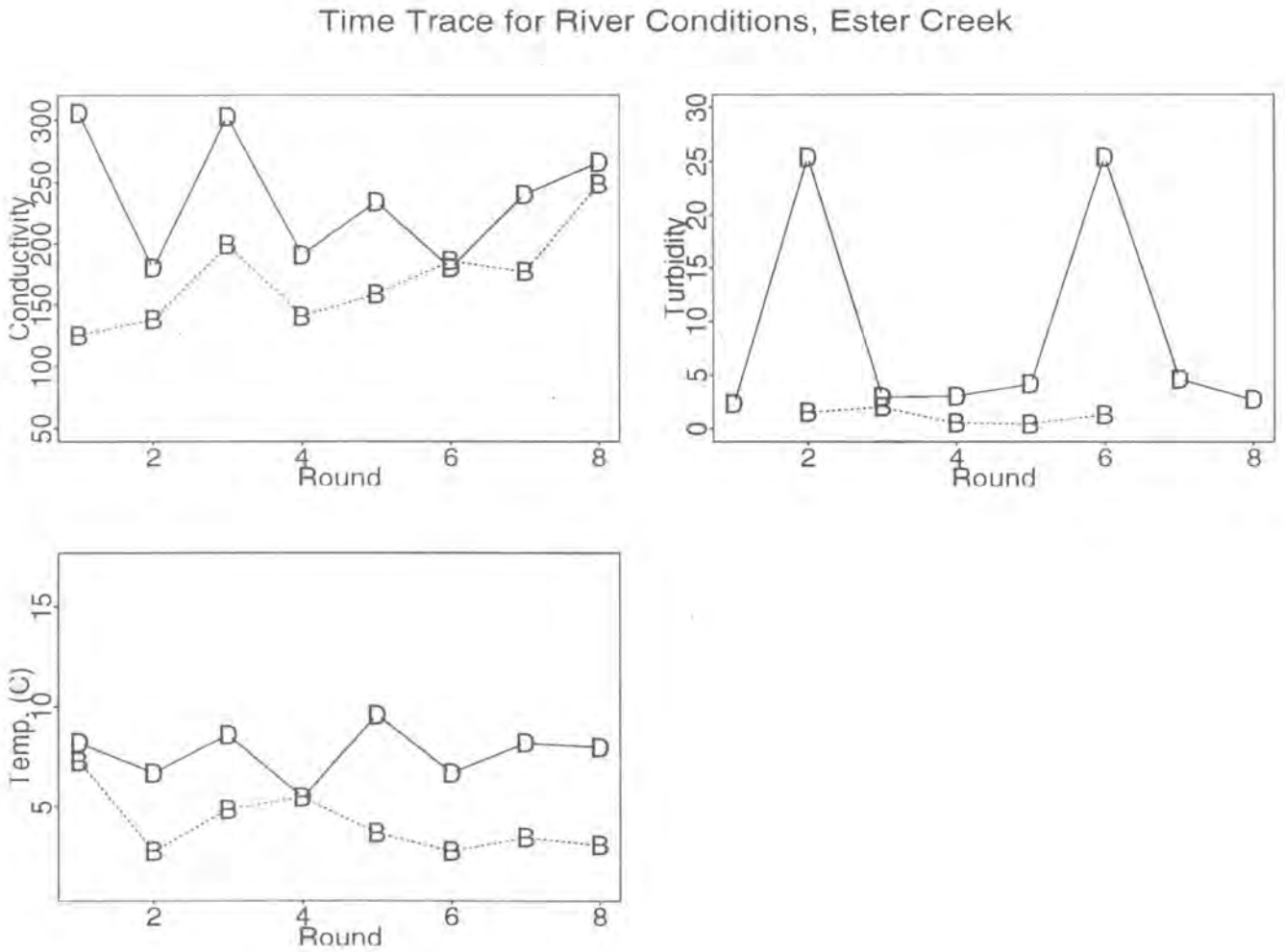

Figure 3i. Temporal variation of field parameters and metals. Conductivity, temperature, and turbidity.

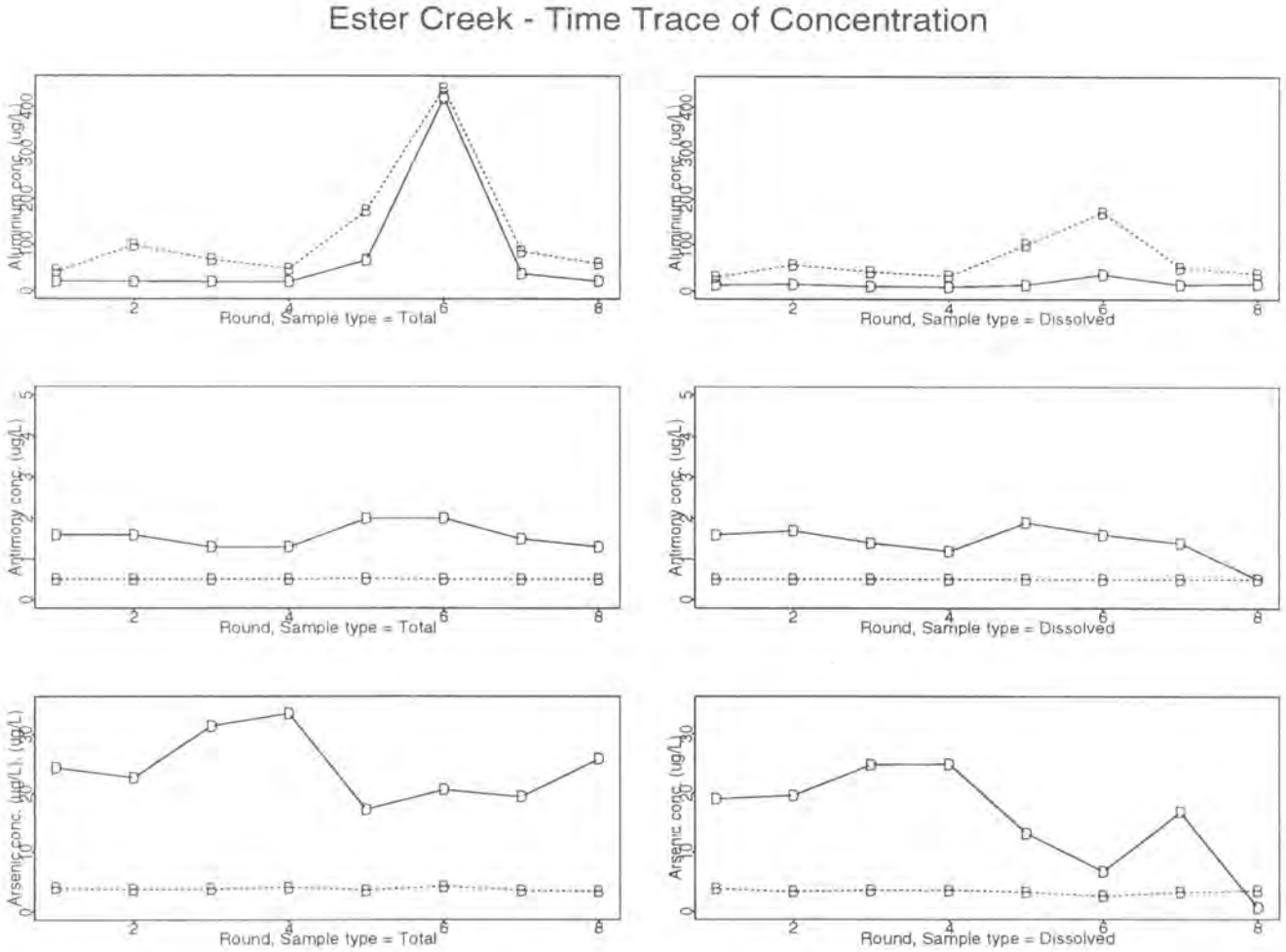

Figure 3j. Temporal variation of field parameters and metals. Aluminum, antimony, and arsenic.

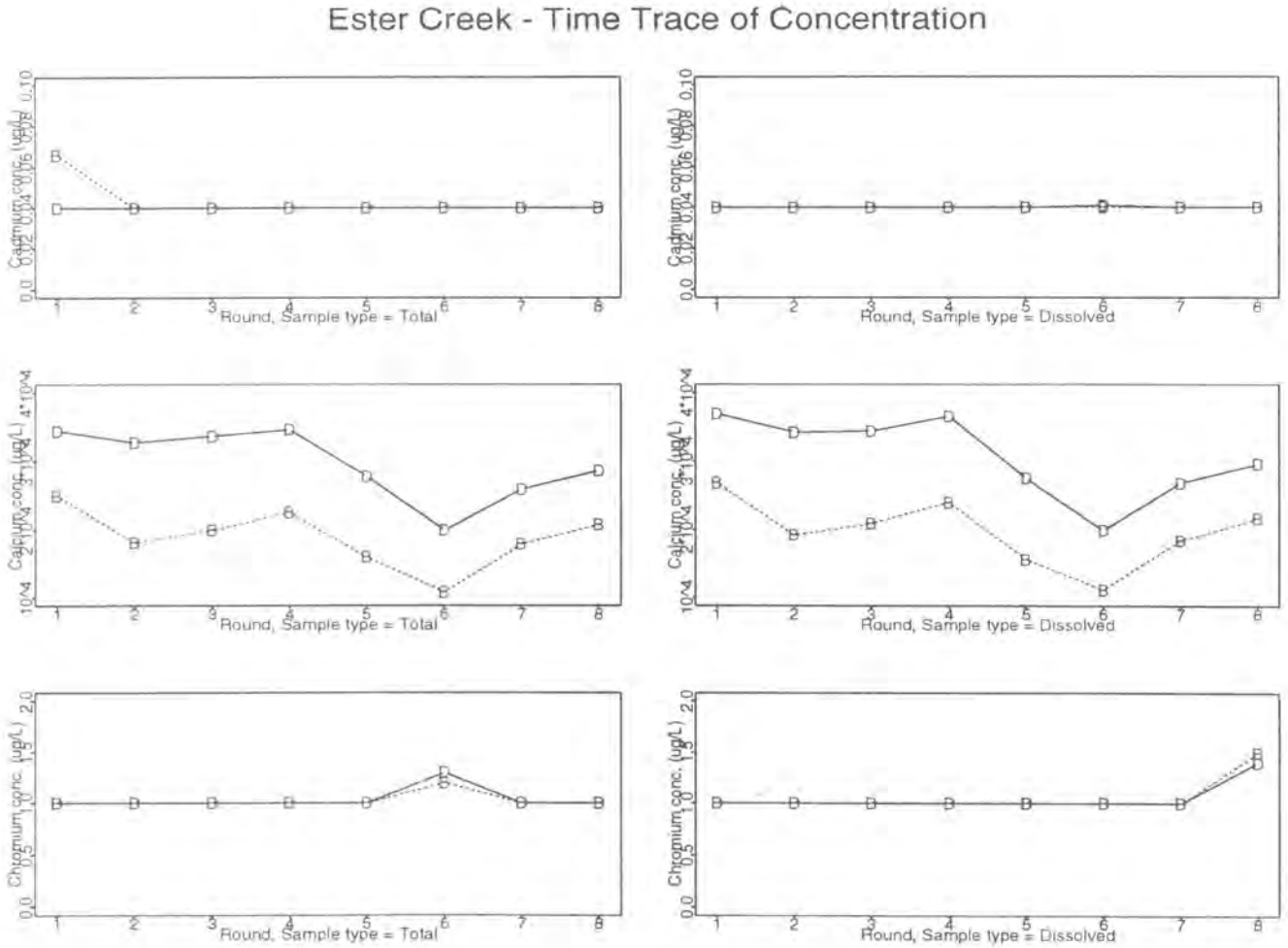

Figure 3k. Temporal variation of field parameters and metals. Cadmium, calcium, and chromium.

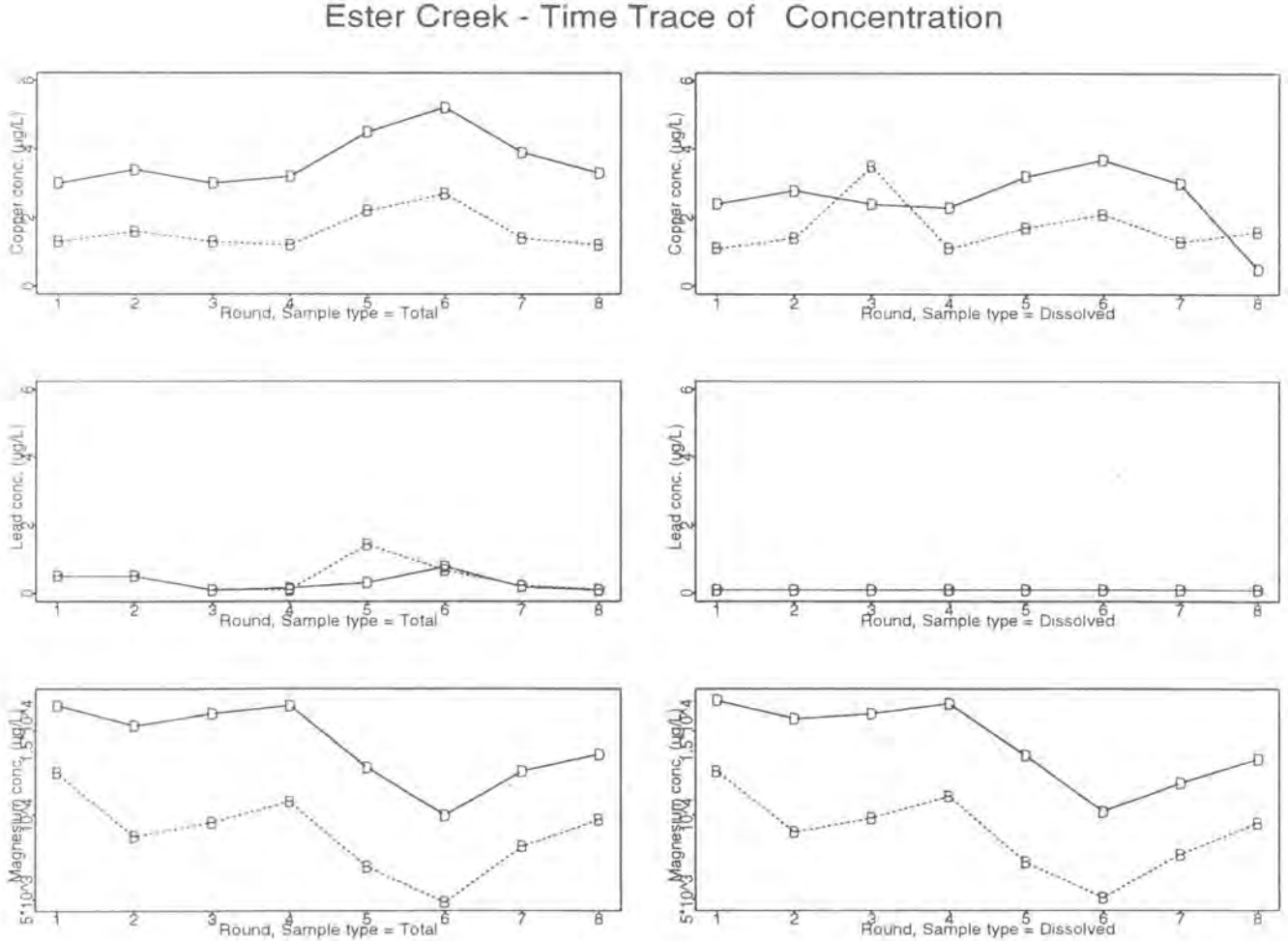

Figure 31. Temporal variation of field parameters and metals. Copper, lead, and magnesium.

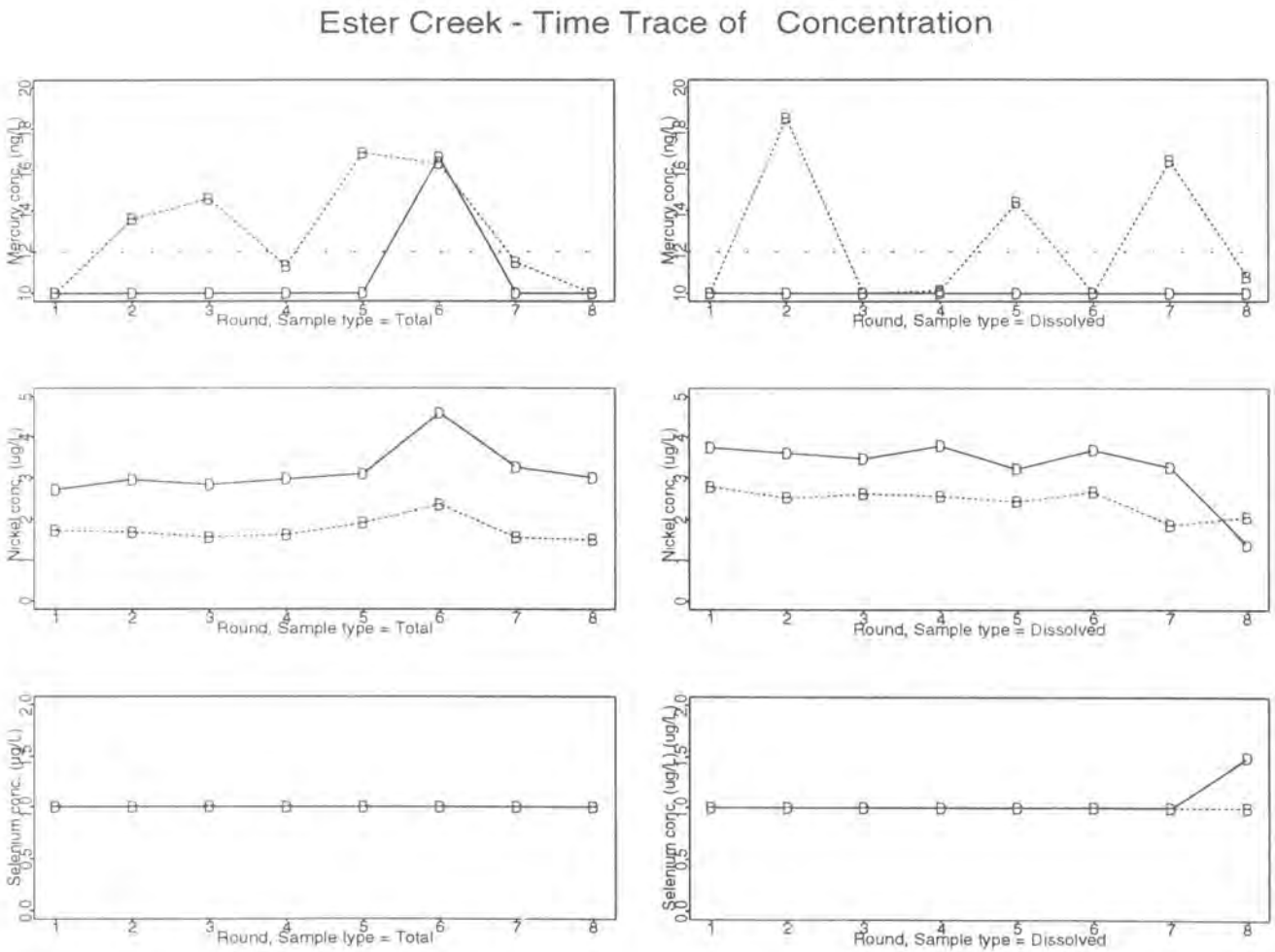

Figure 3m. Temporal variation of field parameters and metals. Mercury, nickel, and selenium.

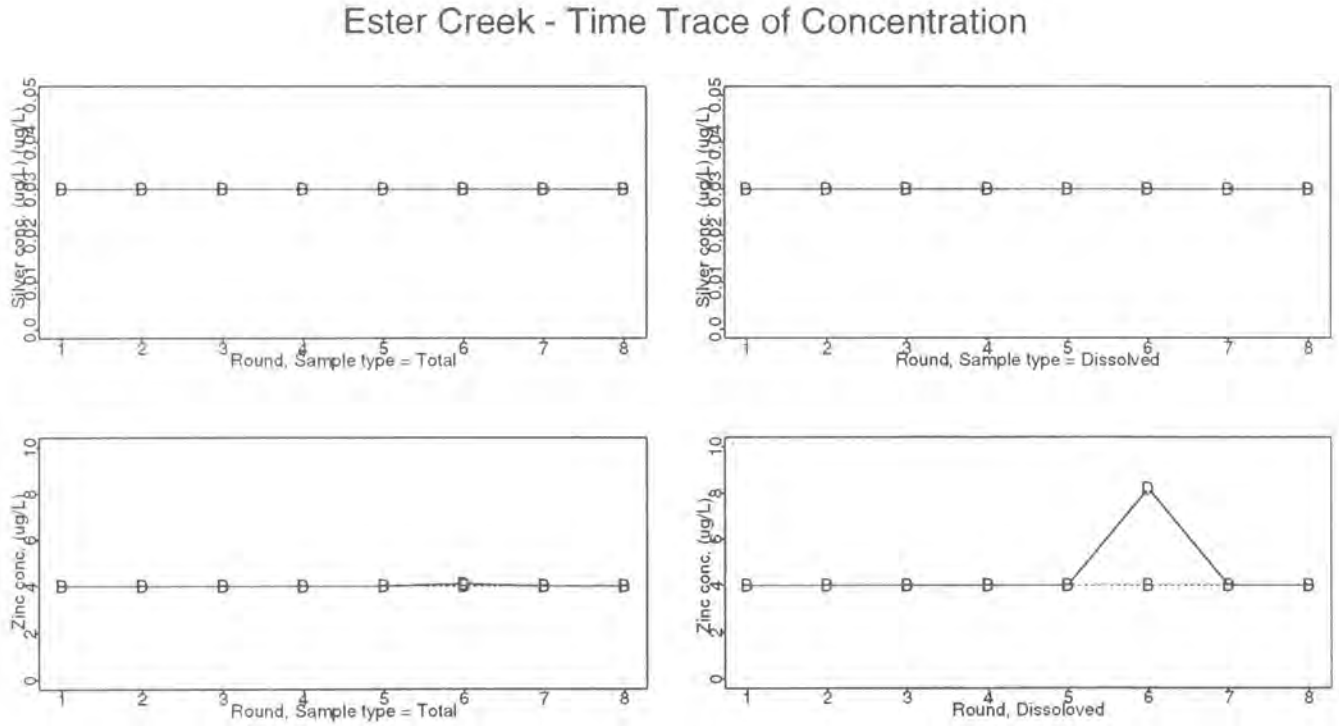

Figure 3n. Temporal variation of field parameters and metals. Silver and zinc.

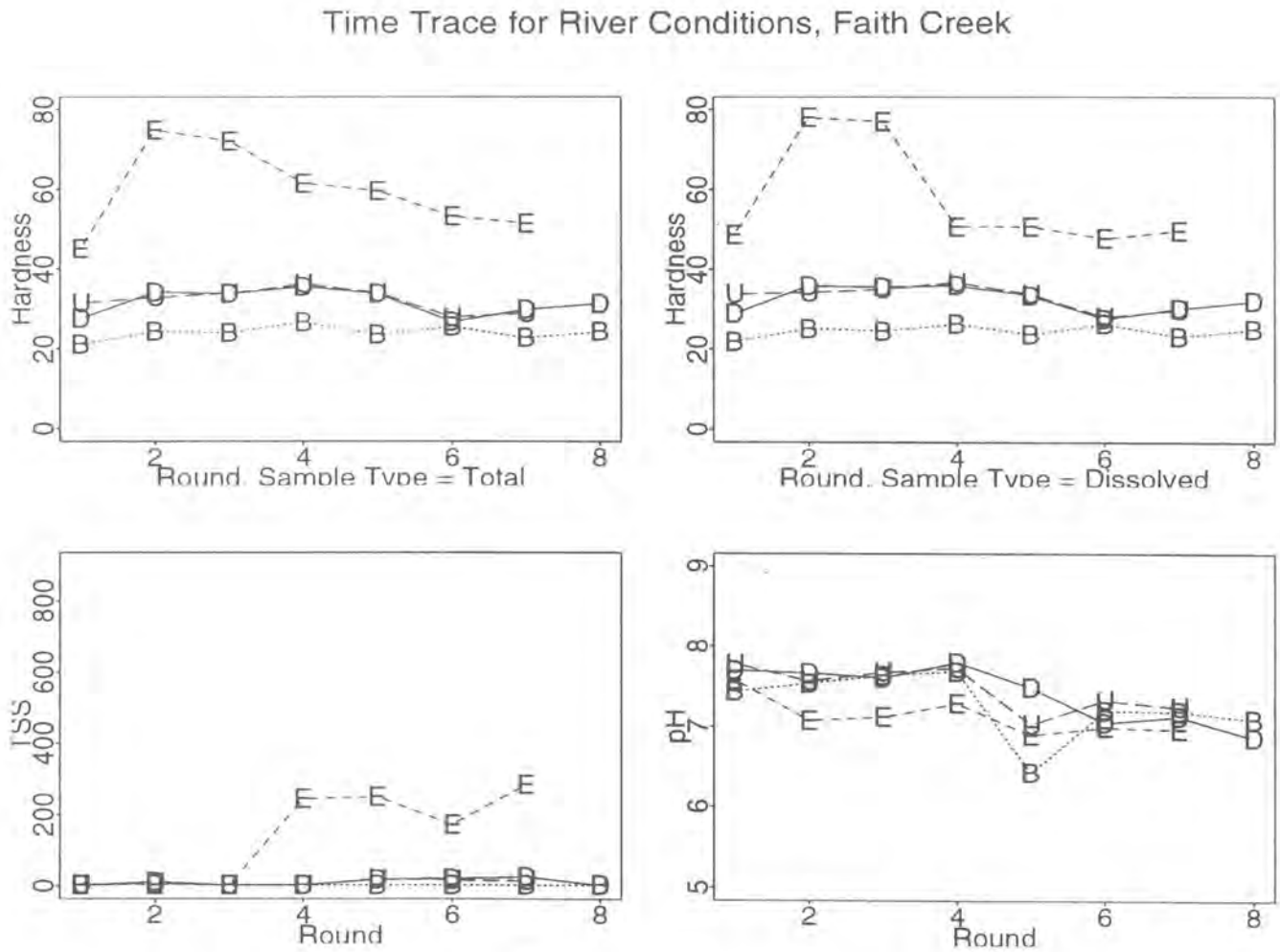

Figure 30. Temporal variation of field parameters and metals. Hardness, TSS, and pH.

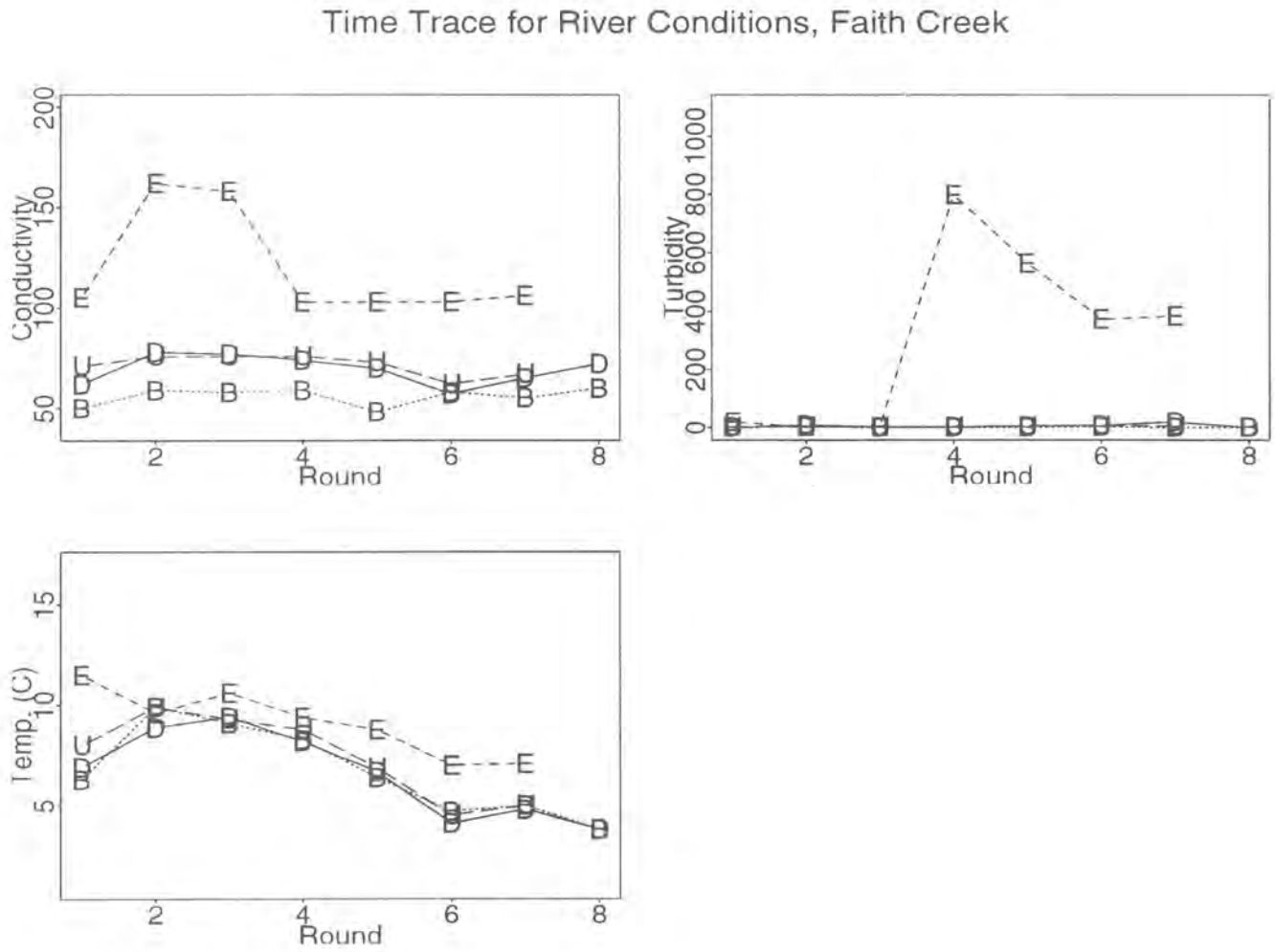

Figure 3p. Temporal variation of field parameters and metals. Conductivity, temperature, and turbidity.

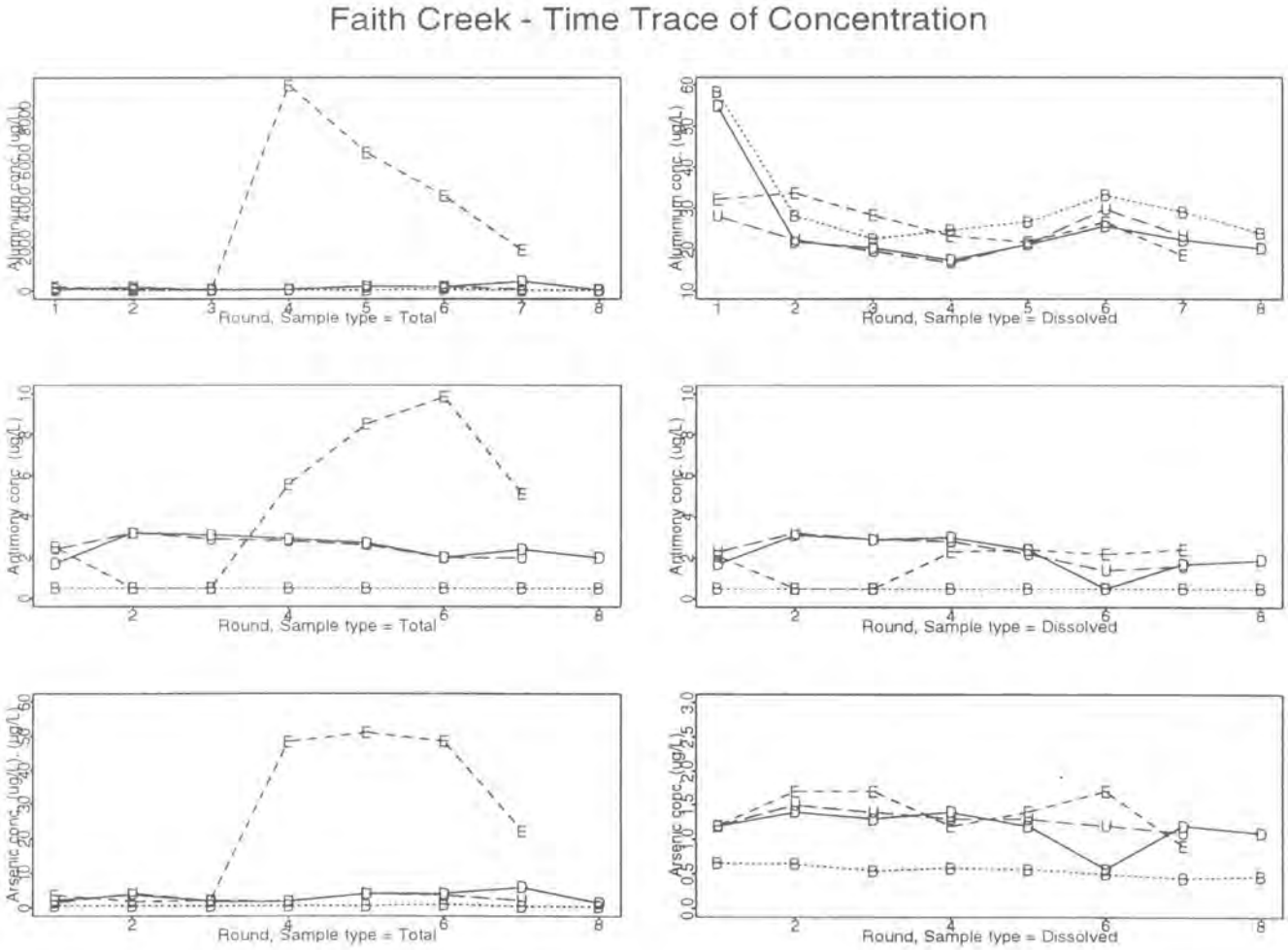

Figure 3q. Temporal variation of field parameters and metals. Aluminum, antimony, and arsenic.

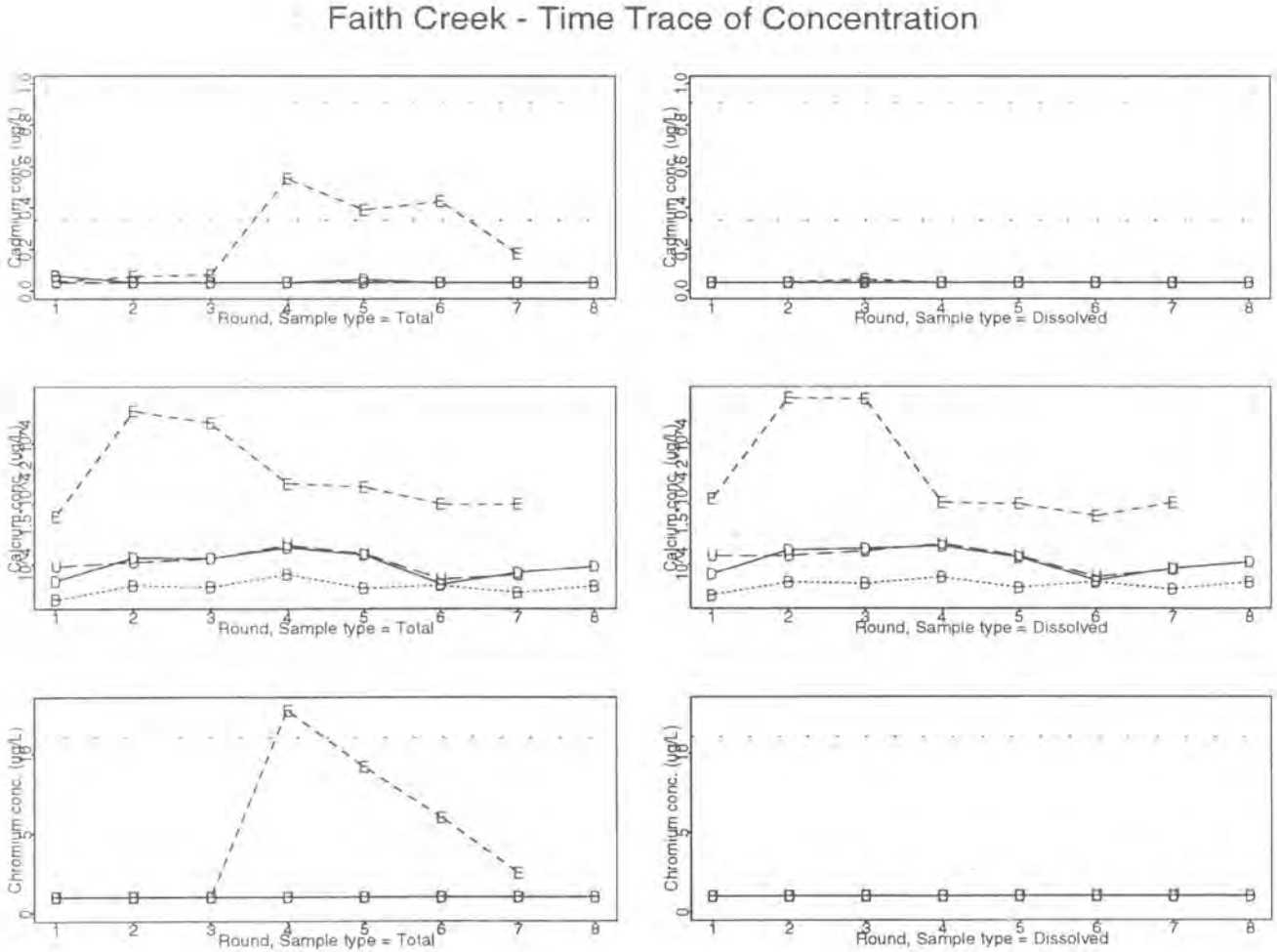

Figure 3r. Temporal variation of field parameters and metals. Cadmium, calcium, and chromium.

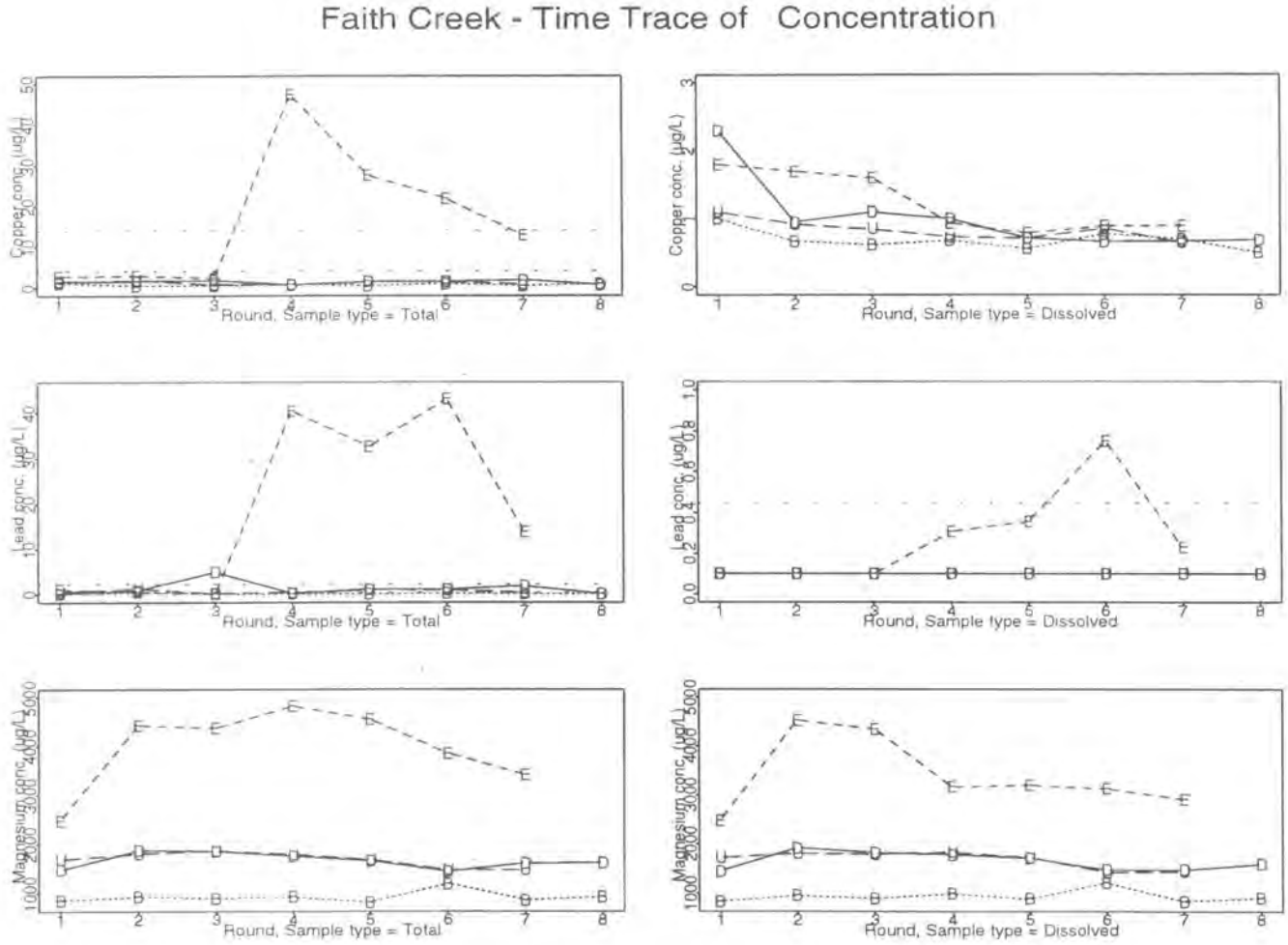

Figure 3s. Temporal variation of field parameters and metals. Copper, lead, and magnesium.

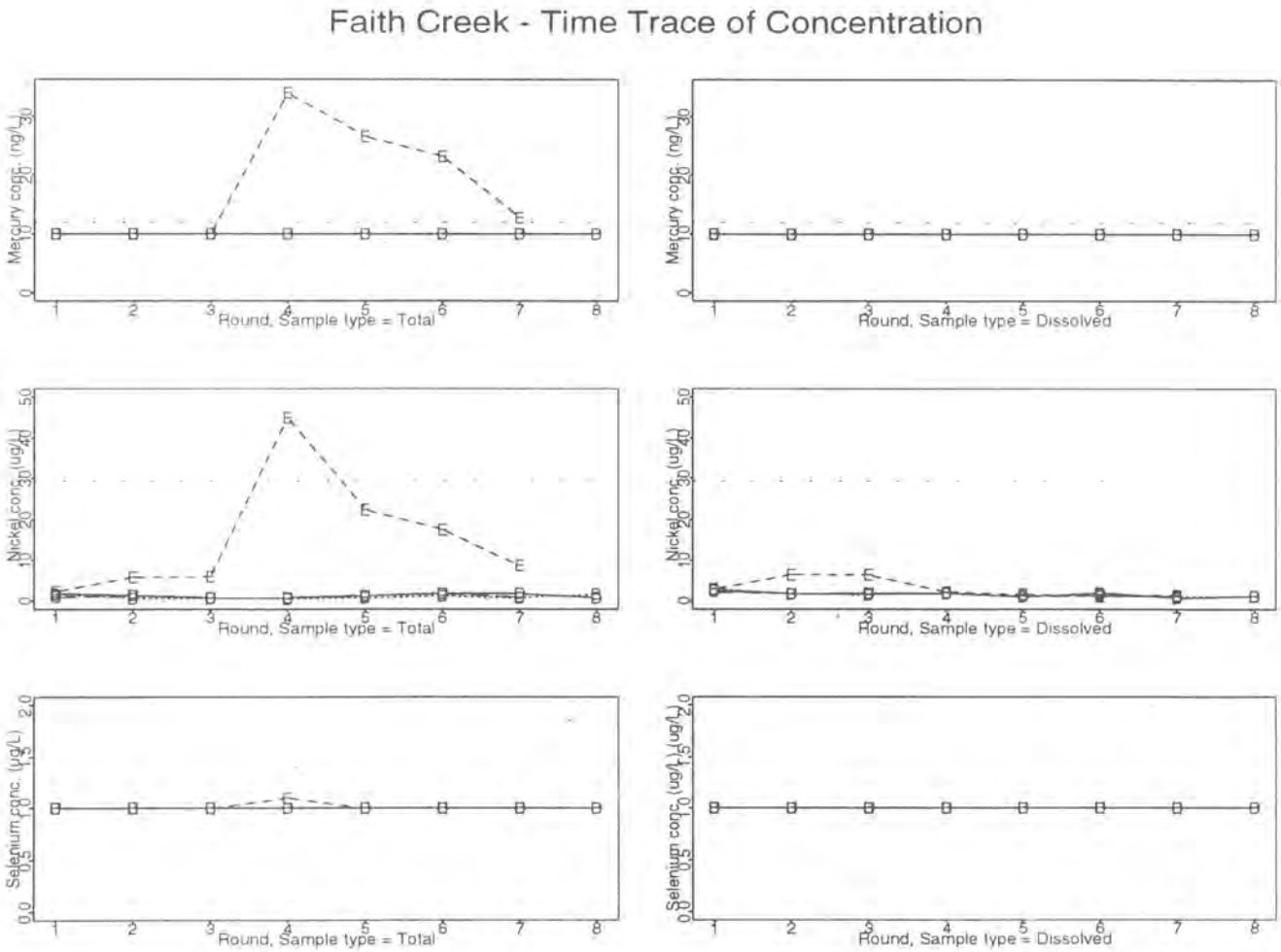

Figure 3t. Temporal variation of field parameters and metals. Mercury, nickel, and selenium.

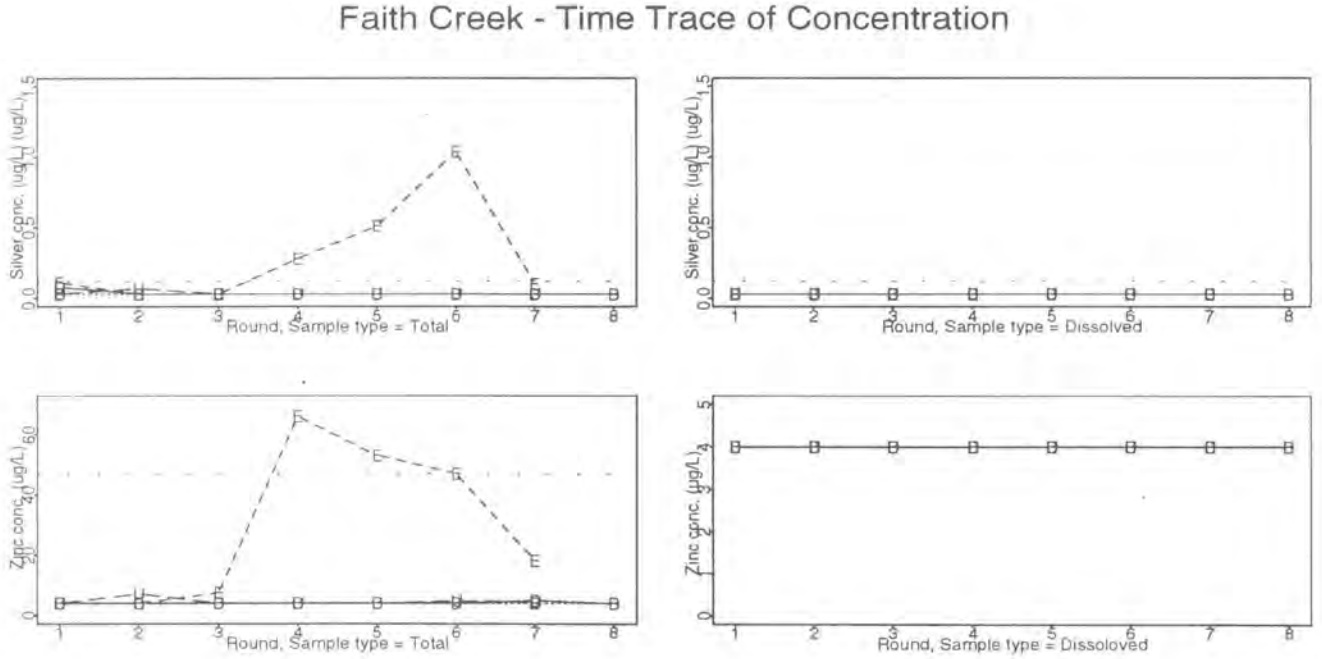

Figure 3u. Temporal variation of field parameters and metals. Silver and zinc.

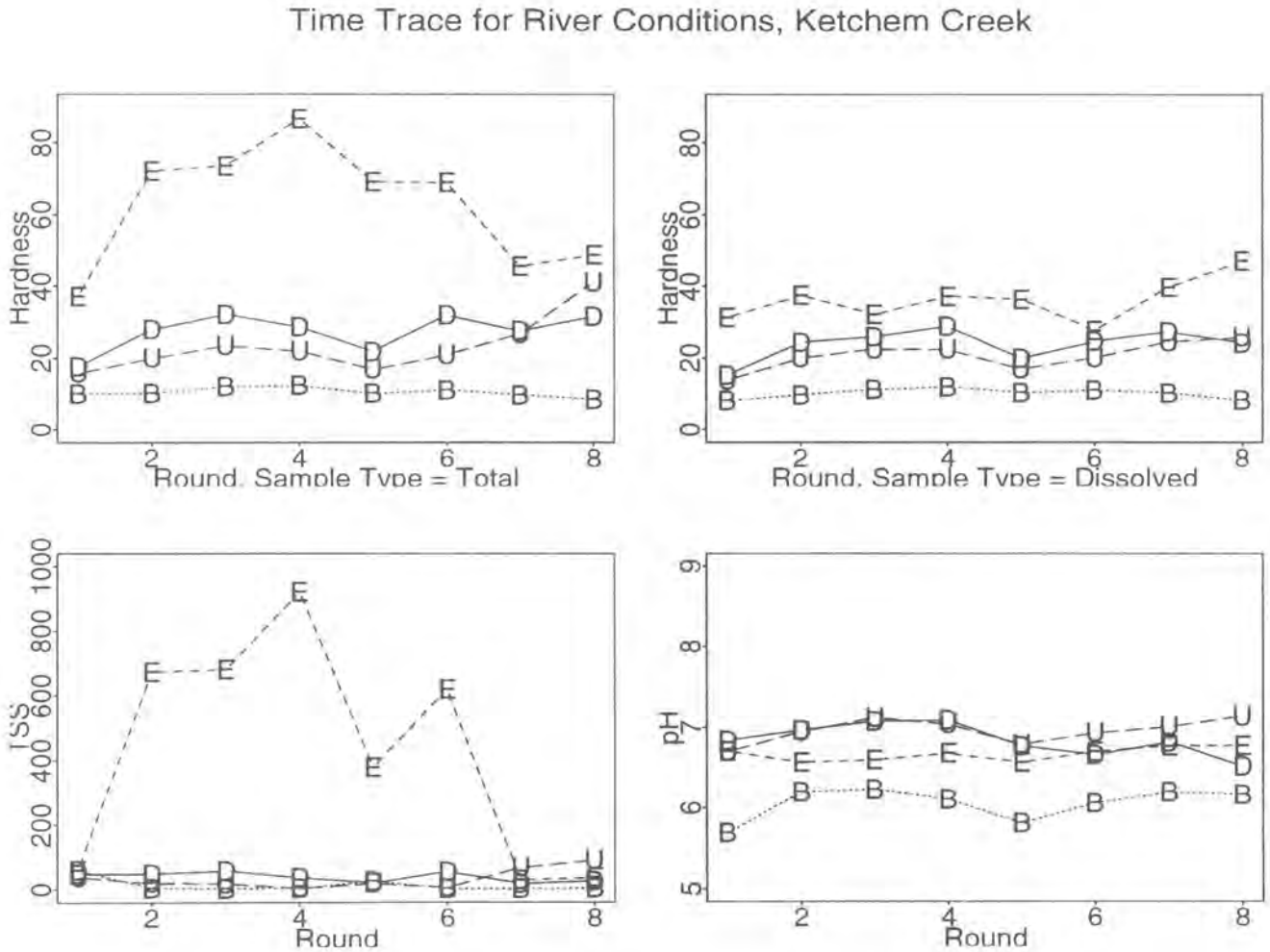

Figure 3v. Temporal variation of field parameters and metals. Hardness, TSS, and pH.

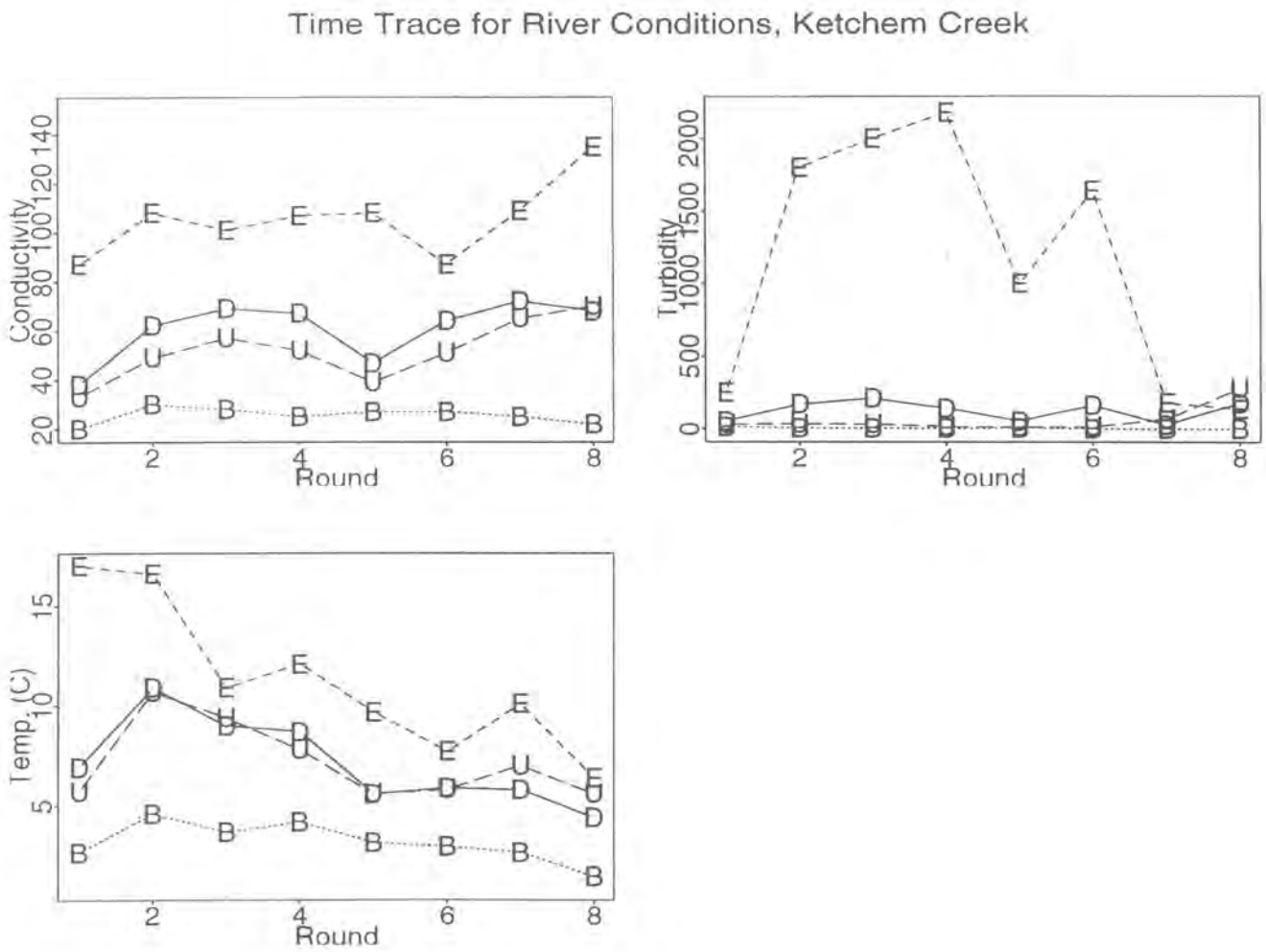

Figure 3w. Temporal variation of field parameters and metals. Conductivity, temperature, and turbidity.

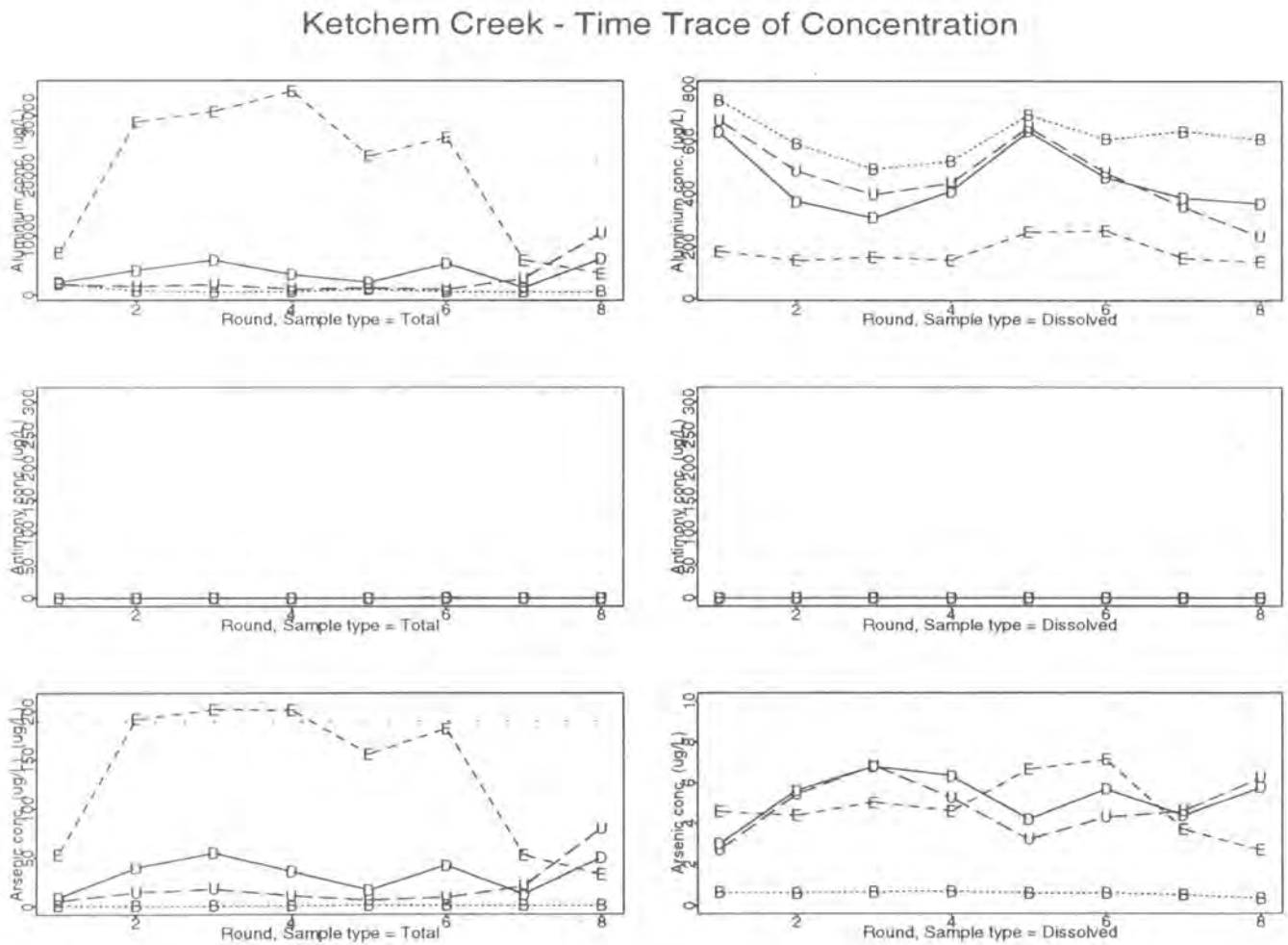

Figure 3x. Temporal variation of field parameters and metals. Aluminum, antimony, and arsenic.

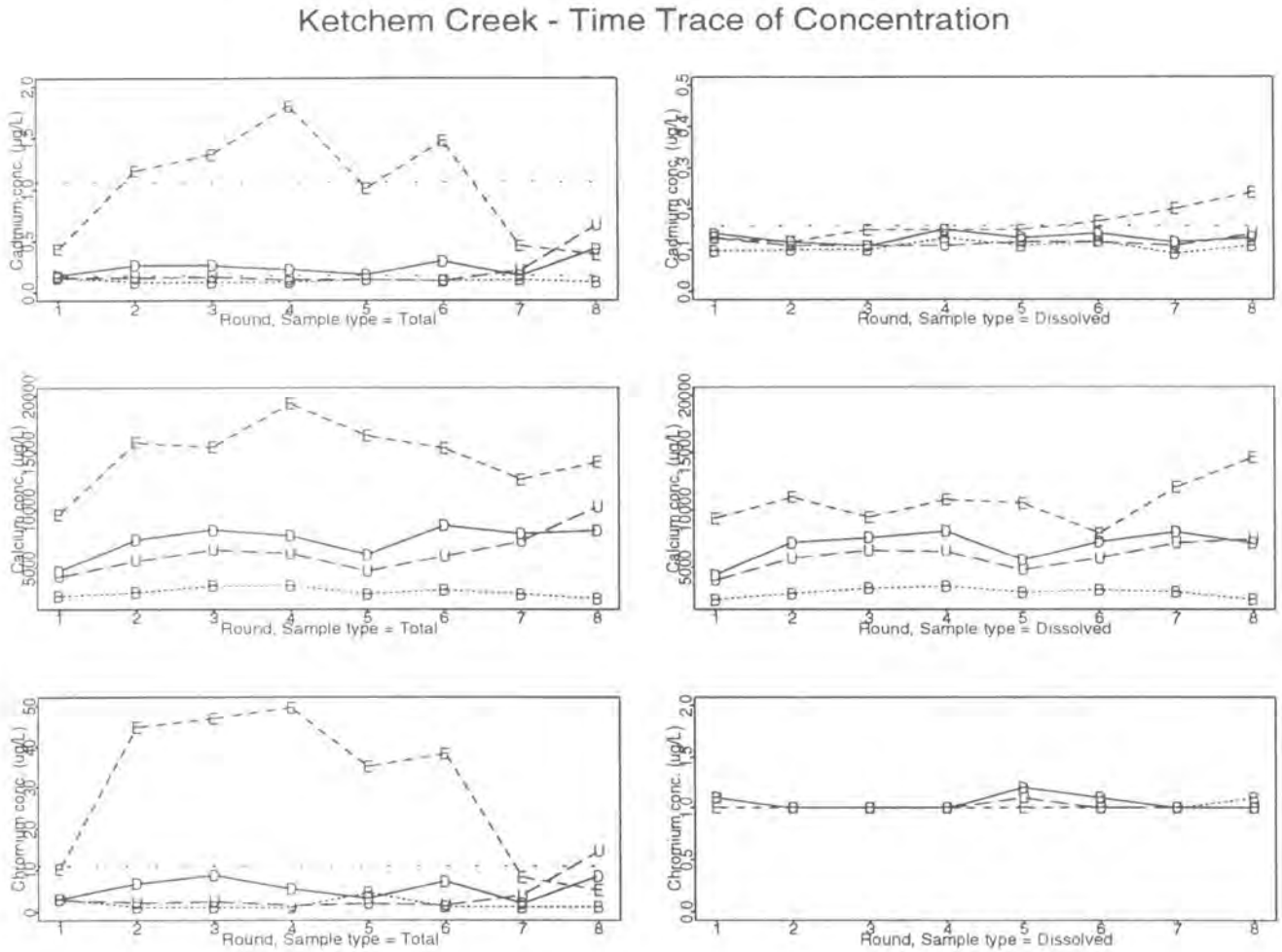

Figure 3y. Temporal variation of field parameters and metals. Cadmium, calcium, and chromium.

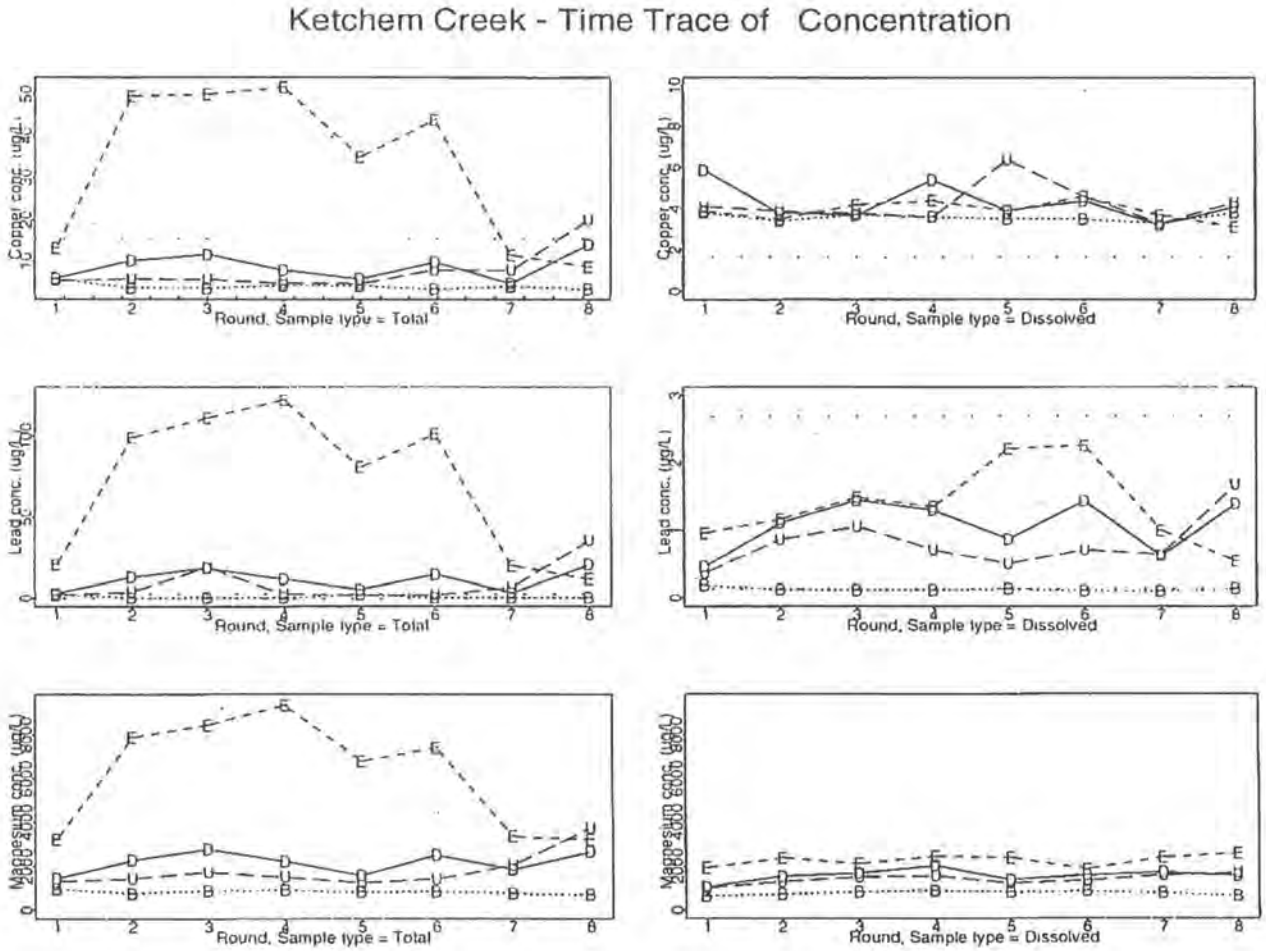

Figure 3z. Temporal variation of field parameters and metals. Copper, lead, and magnesium.

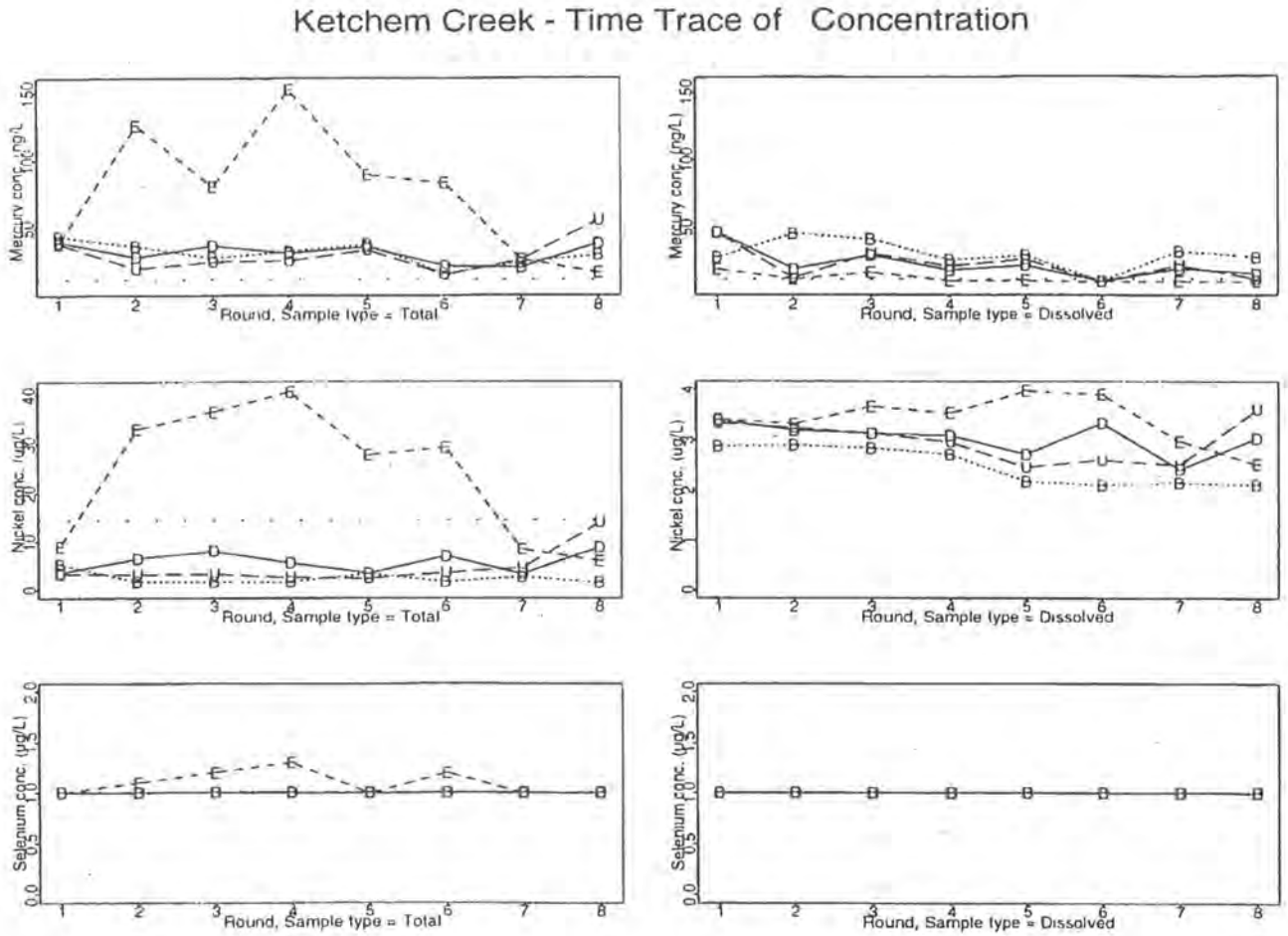

Figure 3aa. Temporal variation of field parameters and metals. Mercury, nickel, and selenium.

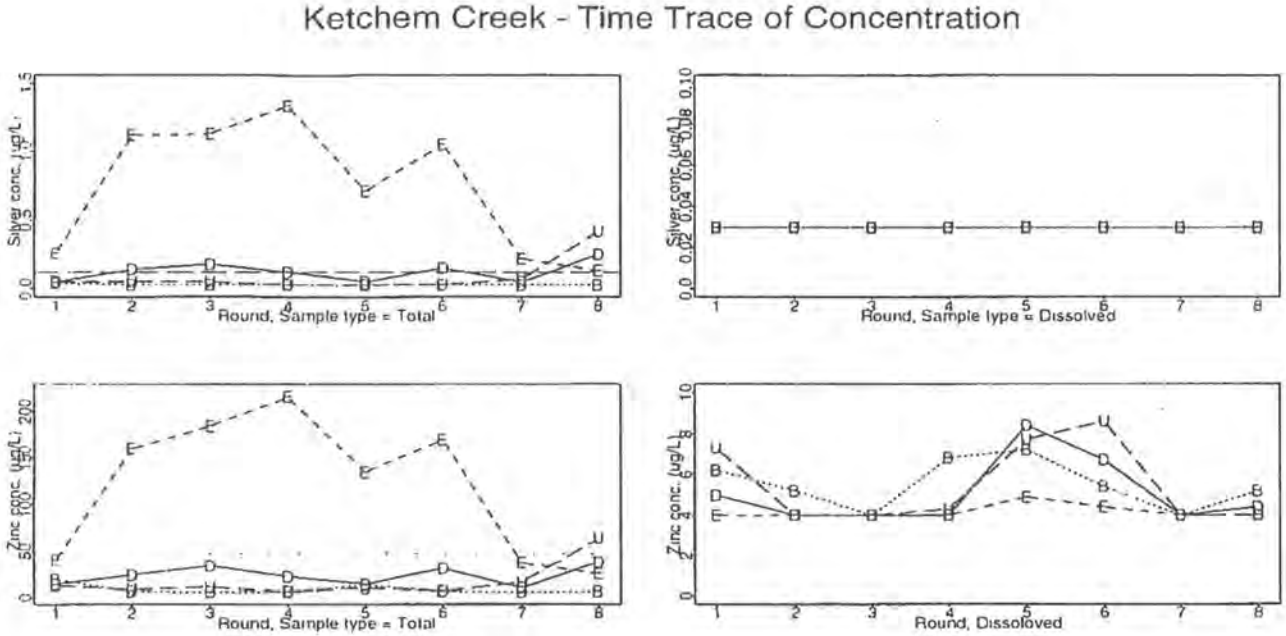

Figure 3ab. Temporal variation of field parameters and metals. Silver and zinc.

Figure 4a - 4n. Comparison of physical and chemical parameters. The following correlation graphs are arranged by metal. Values for total recoverable metals are labeled T; values for dissolved metals are labeled D. Axes are logarithmic.

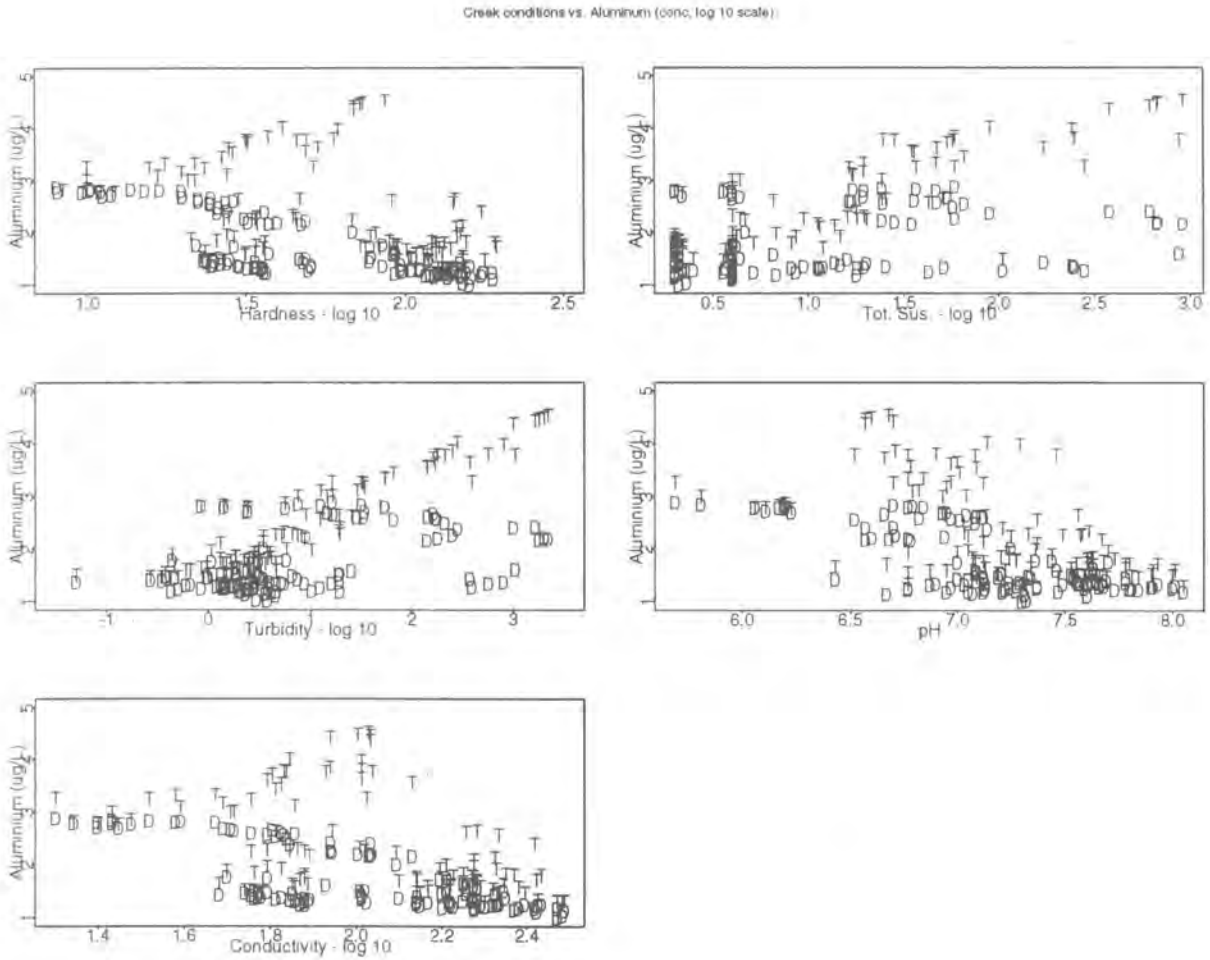

Figure 4a. Comparison of physical and chemical parameters. Aluminum.

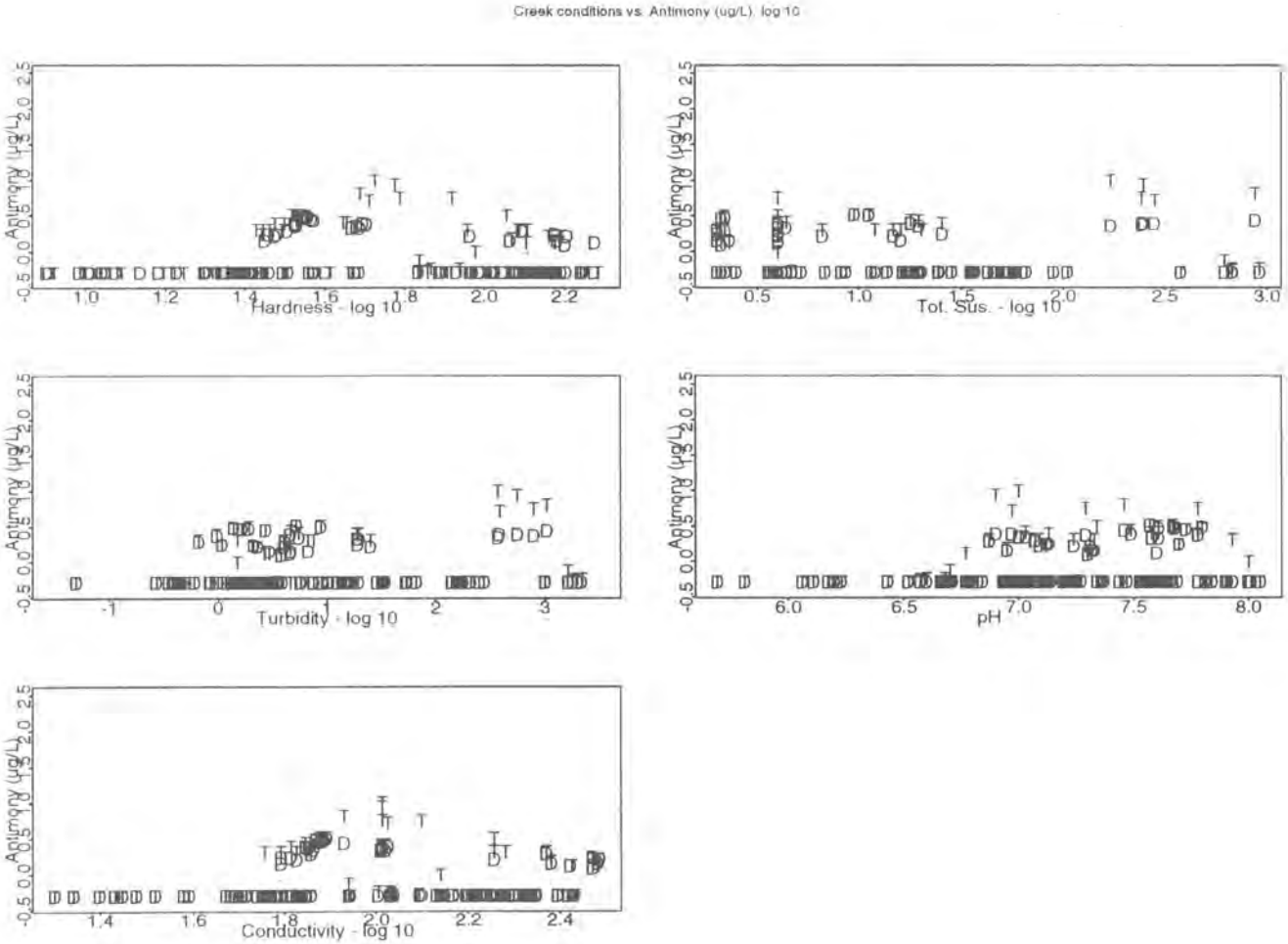

Figure 4b. Comparison of physical and chemical parameters. Antimony.

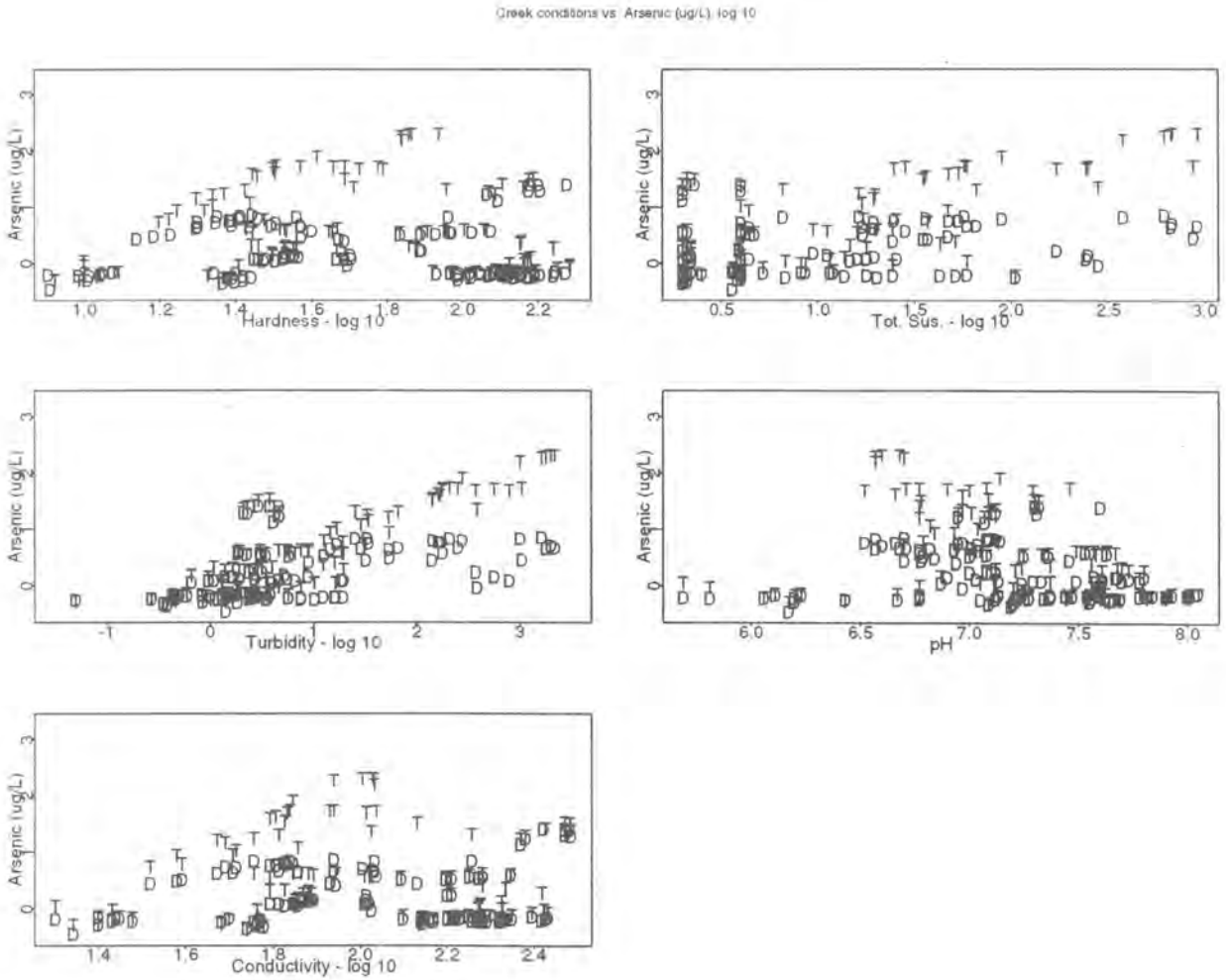

Figure 4c. Comparison of physical and chemical parameters. Arsenic.

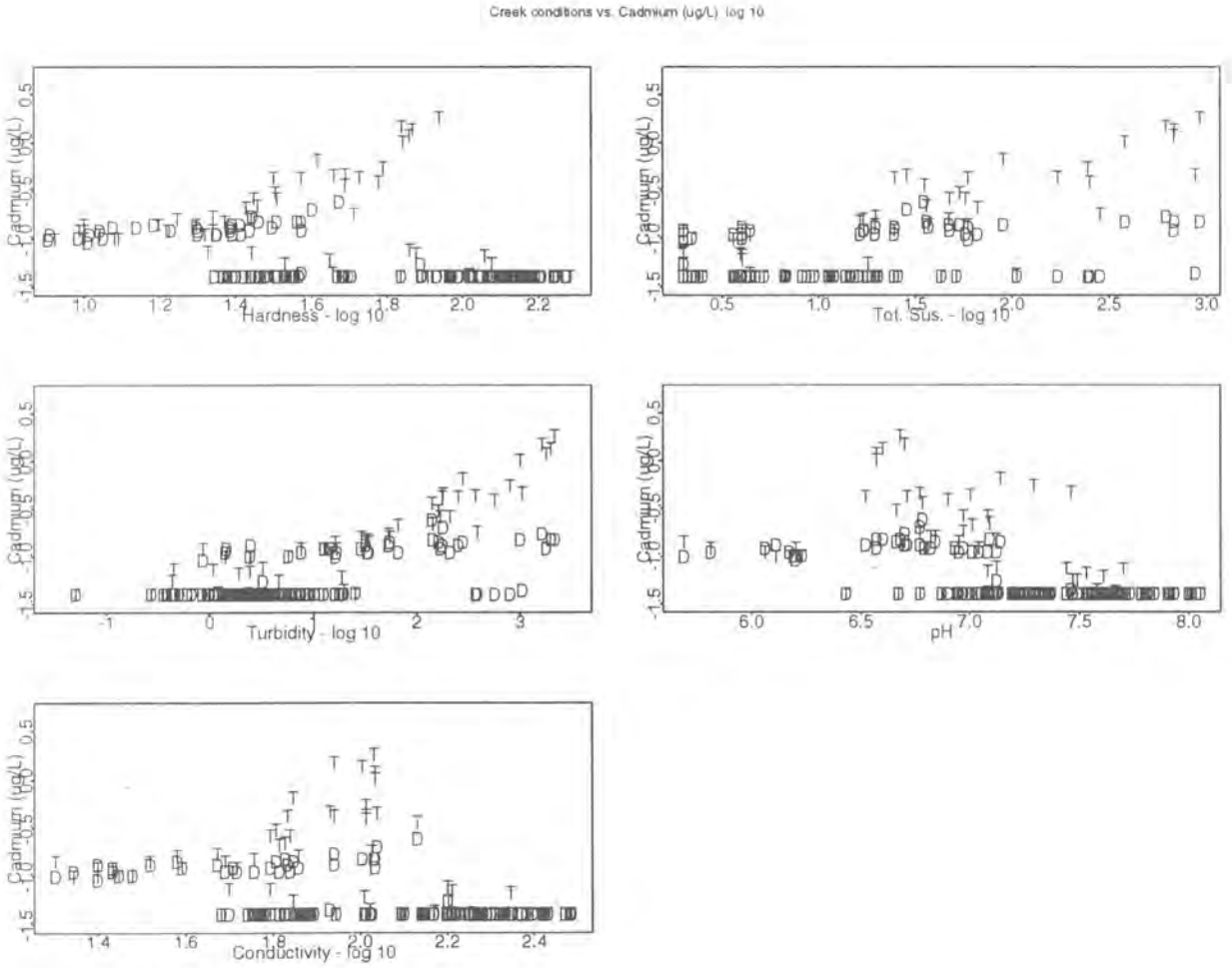

Figure 4d. Comparison of physical and chemical parameters. Cadmium.

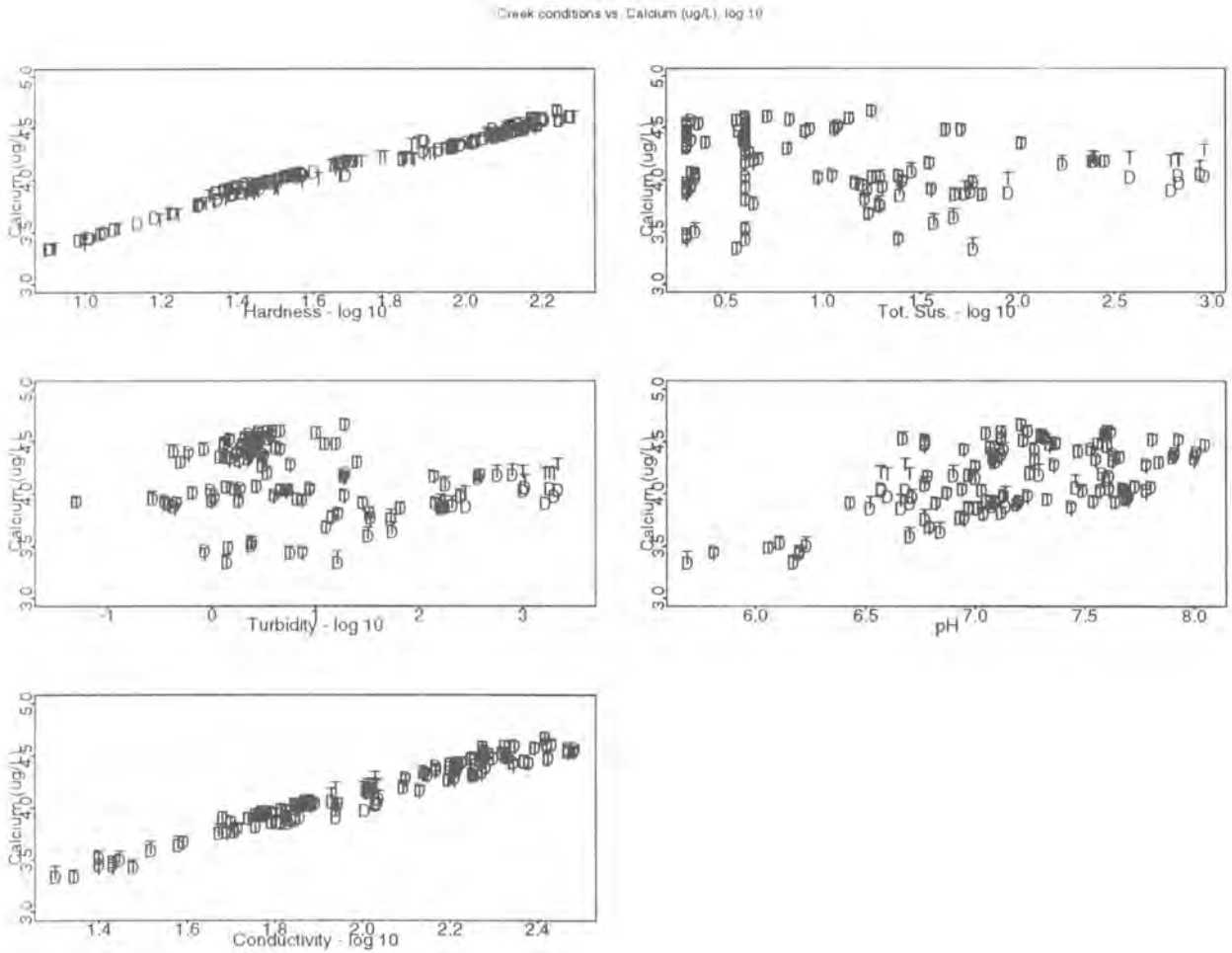

Figure 4e. Comparison of physical and chemical parameters. Calcium.

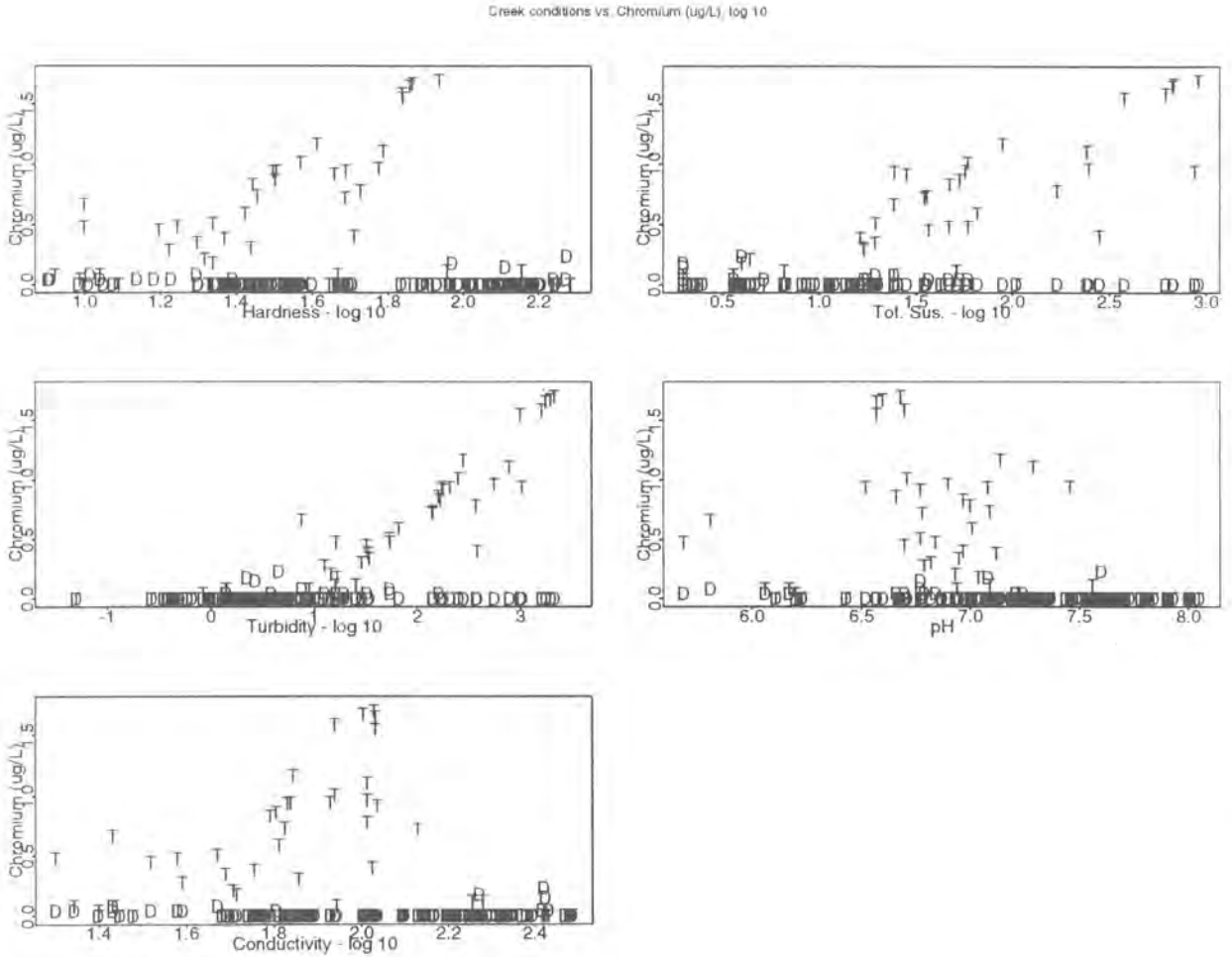

Figure 4f. Comparison of physical and chemical parameters. Chromium.

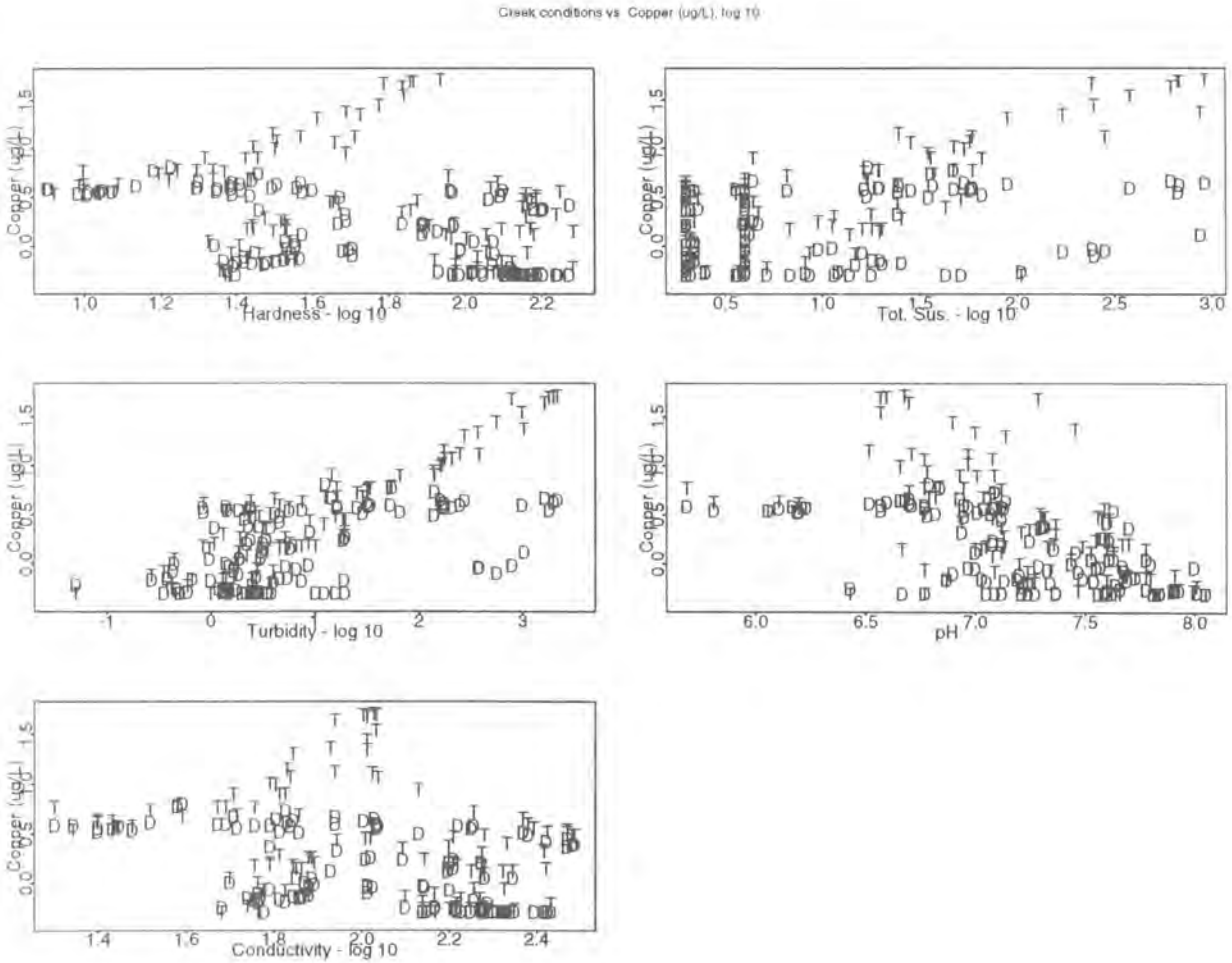

Figure 4g. Comparison of physical and chemical parameters. Copper.

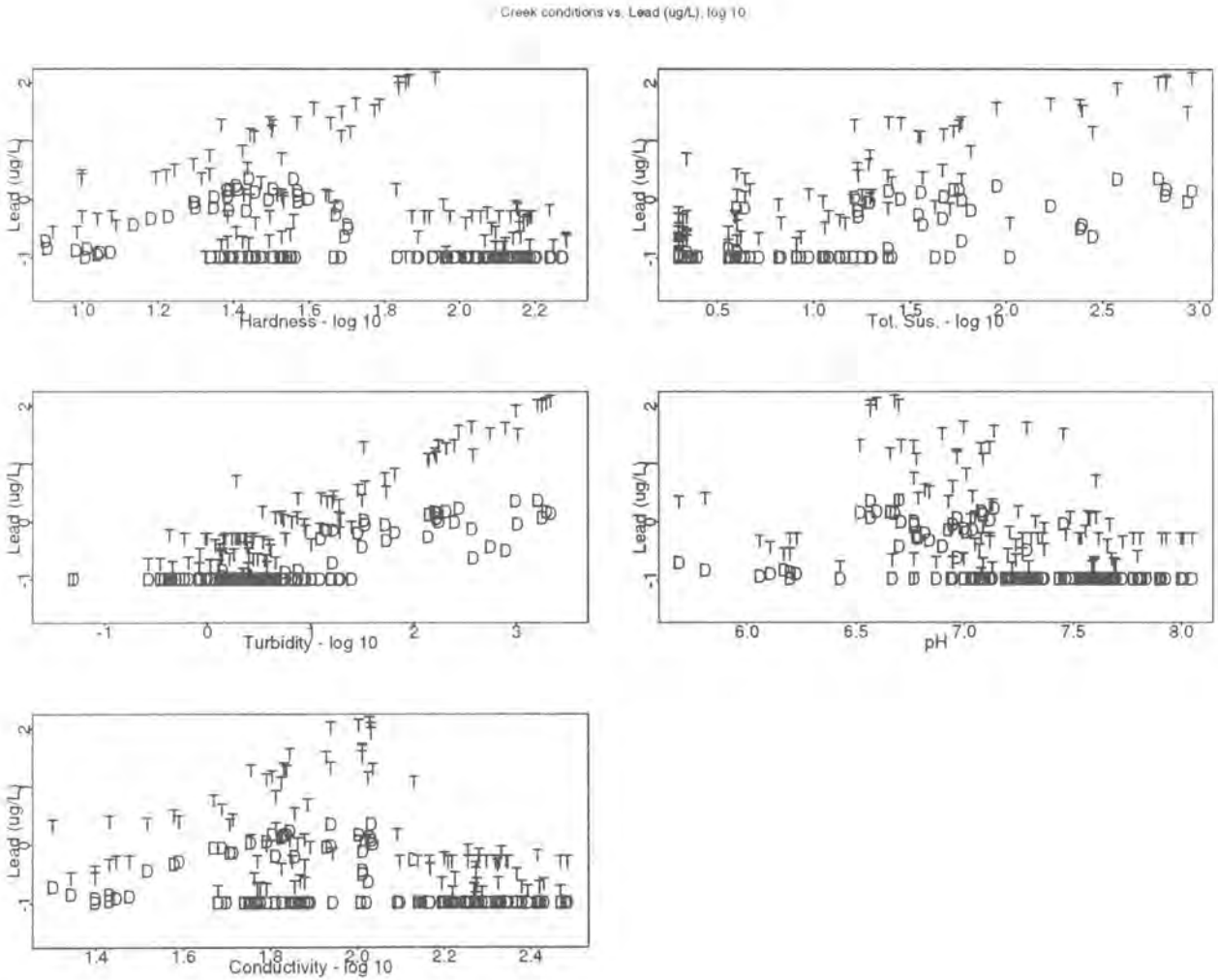

Figure 4h. Comparison of physical and chemical parameters. Lead.

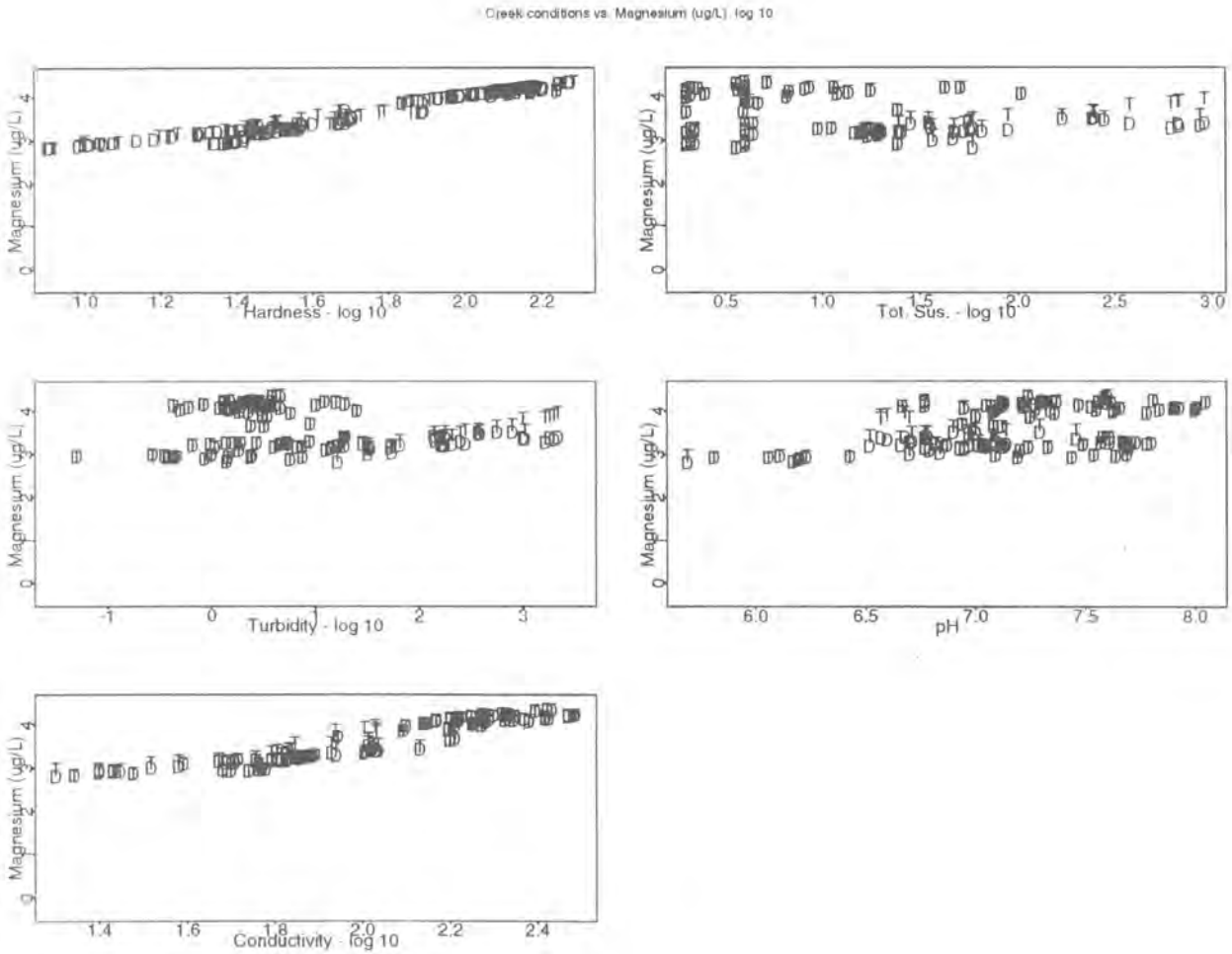

Figure 4i. Comparison of physical and chemical parameters. Magnesium.

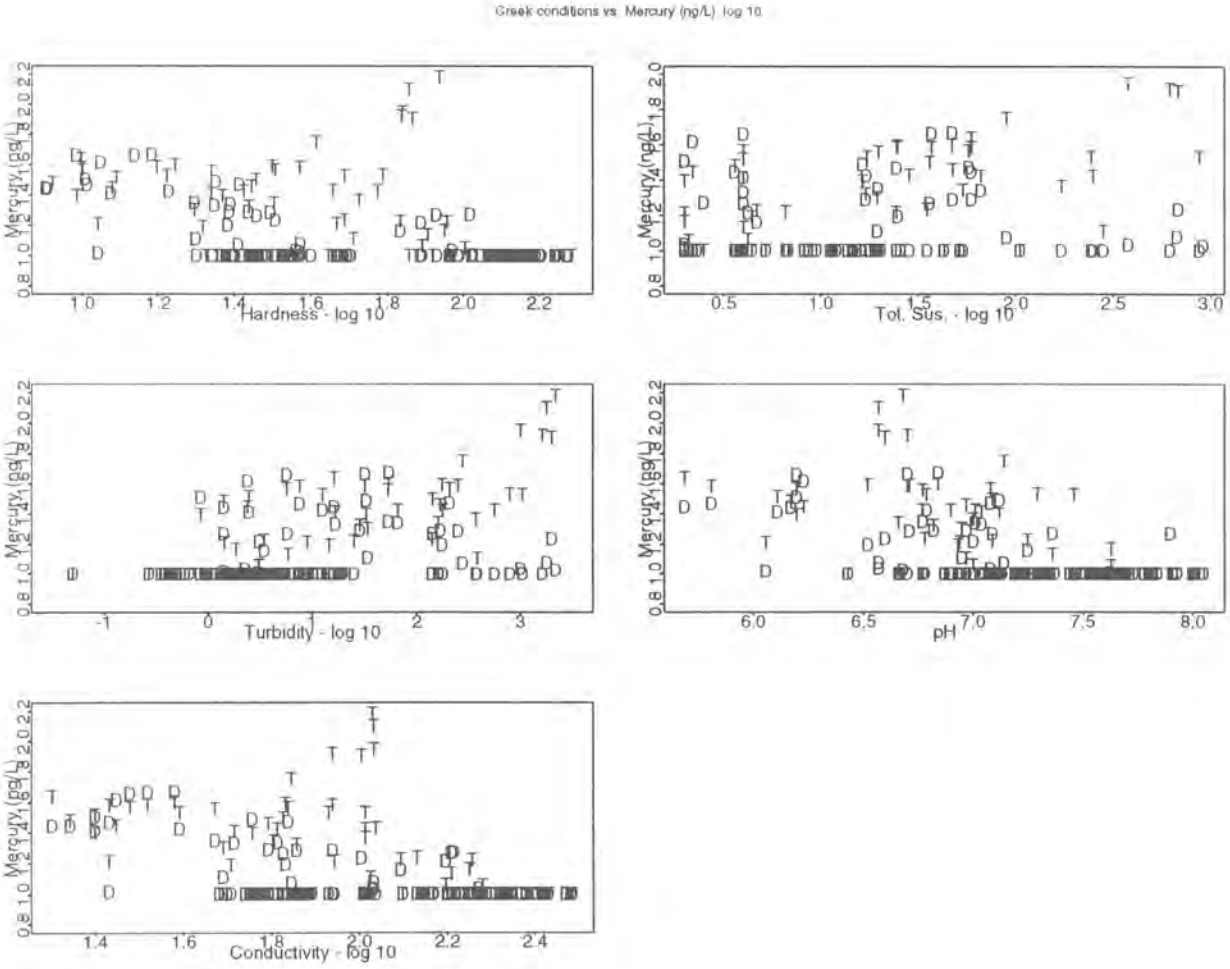

Figure 4j. Comparison of physical and chemical parameters. Mercury.

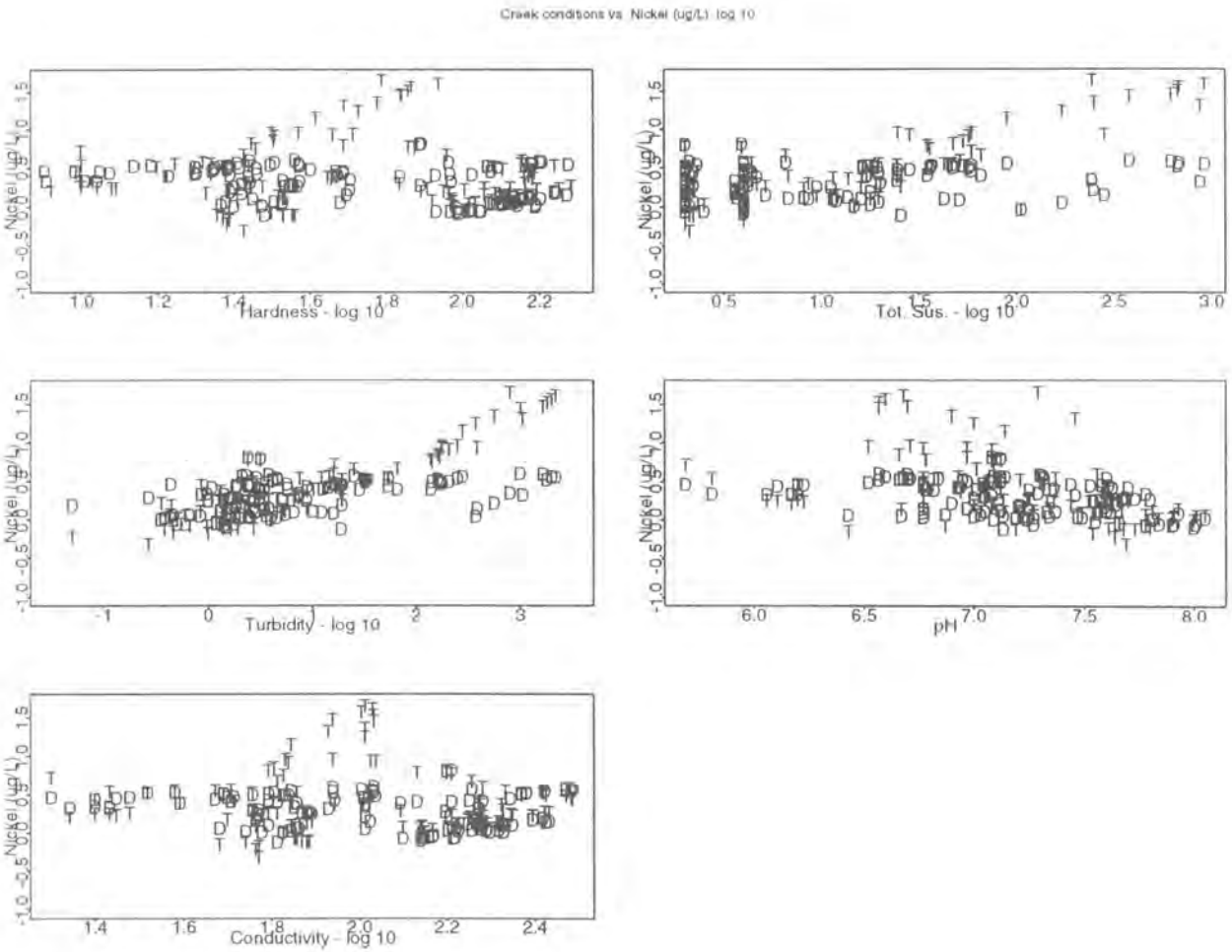

Figure 4k. Comparison of physical and chemical parameters. Nickel.

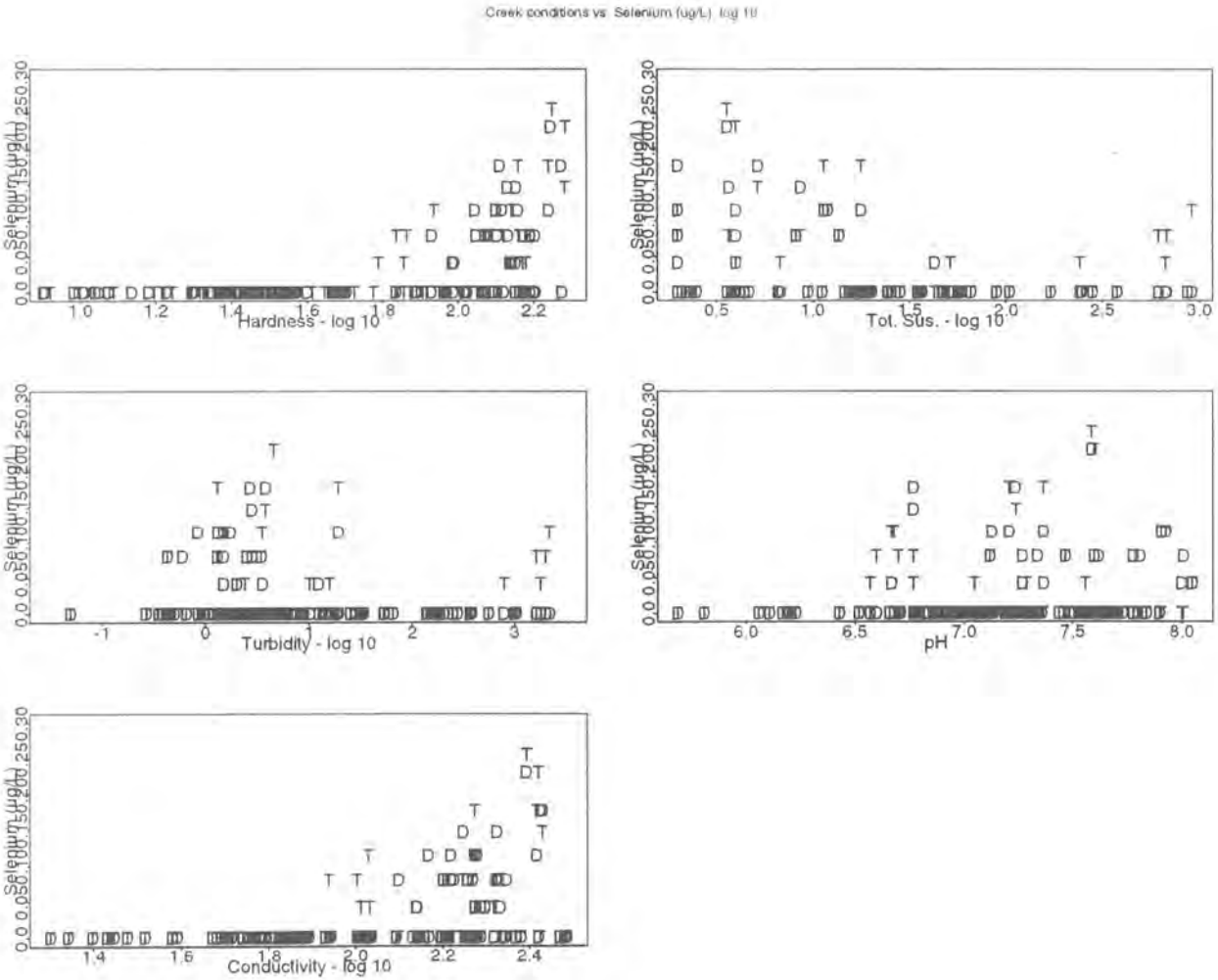

Figure 41. Comparison of physical and chemical parameters. Selenium.

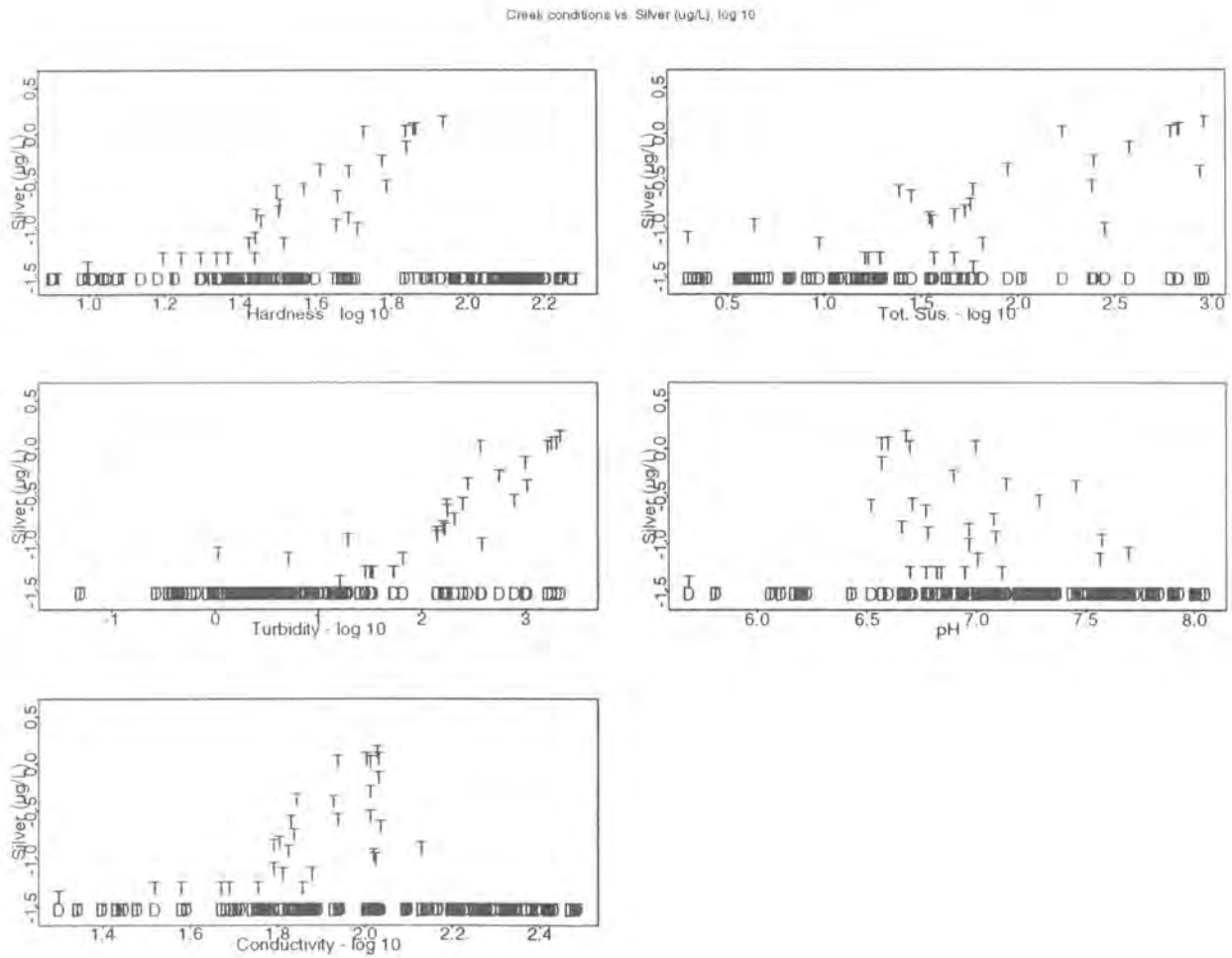

Figure 4m. Comparison of physical and chemical parameters. Silver.

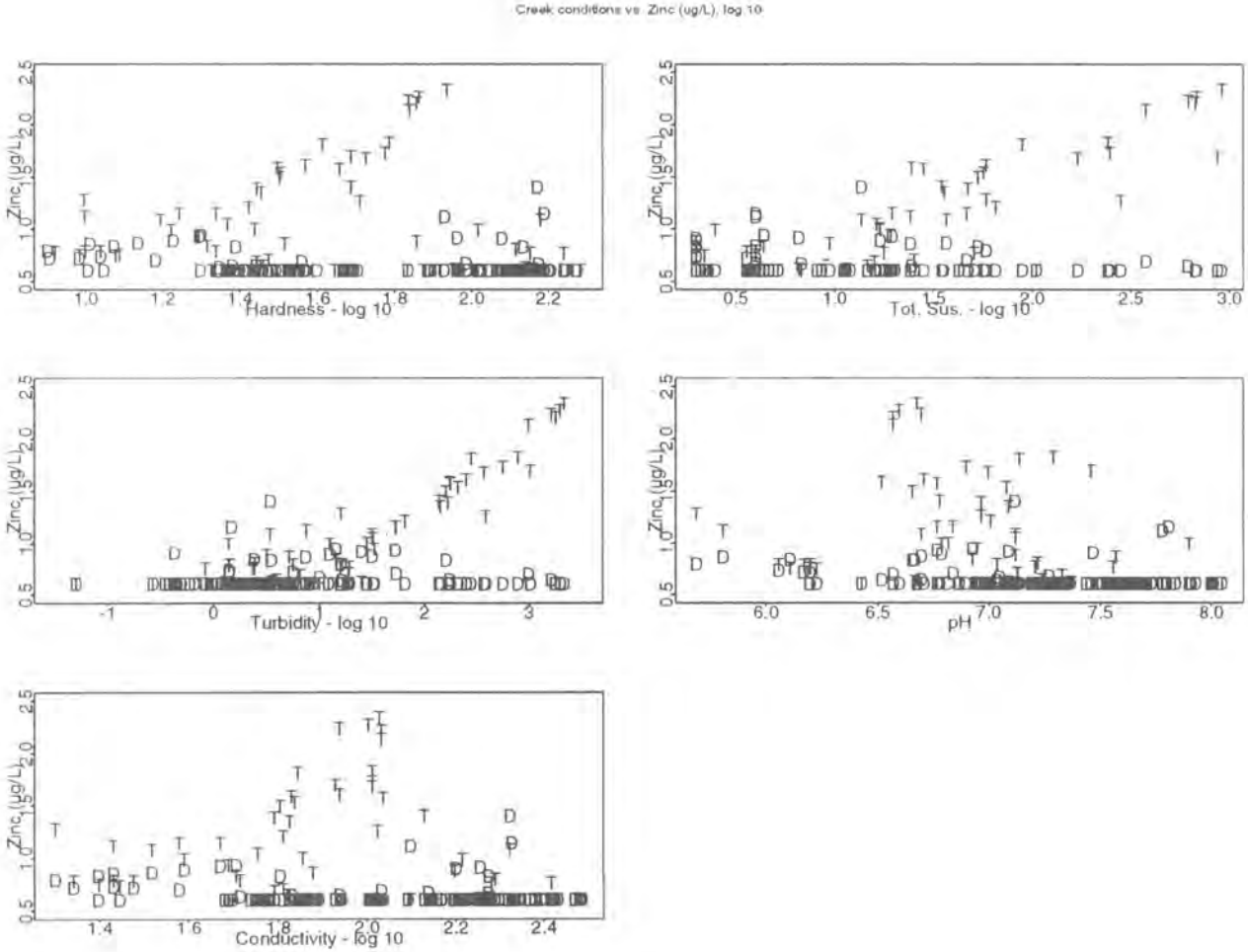

Figure 4n. Comparison of physical and chemical parameters. Zinc.

List of Tables

1. Placer mine sites. 64
2. Source of placer gold deposits. 65-67
3. List of analytical data 68-75
4. Summary statistics of data by mine and sampling location. 76-89
5. Alaska water quality criteria. 90
6. Linear correlation coefficients for comparison of measurement parameters. 91

Table 1. Placer Mine Sites. Sample locations at three of the mines are based on uncorrected GPS readings; the general location of the mine at Eldorado Creek was determined by map.

Mine Owner Receiving Water	Site	Location
Tod Bauer **Eldorado Creek**	Mine	62° 45' 35"N 149° 36' 10"W
Largen Claims **Ester Creek**	Background	64° 50' 55.32"N 148° 05' 05"W
	Downstream	64° 50' 36.38"N 148° 01' 37.59"W
Sam Koppenberg **Faith Creek**	Downstream	65° 21' 21.33"N 146° 17' 13"W
	Upstream	65° 21' 38"N 146° 17' 03"W
	Effluent	65° 21' 38"N 146° 17' 03"W
	Background	65° 23' 43"N 146° 17' 03"W
John McClain **Ketchem Creek**	Downstream	65° 28' 48"N 144° 44' 43"W
	Upstream	65° 28' 47.55"N 144° 44' 36.25"W
	Effluent	65° 28' 44.38"N 144° 44' 39.93"W
	Background	65° 28' 16.81"N 144° 44' 48.90"W

Table 2. Source of Placer Gold according to summaries of Nokleberg, 1996 (1) and Cobb, 1973 (2)
(Mining District designations are from Cobb)

1997 Sampling

Receiving Water	Mining District and No.	Gold Source, Host Rock[1] [2]	Source Mineralization Type[3]	Assoc. Minerals[4]	Host[5]
1. Goldstream Creek	Fairbanks District-50	Gold skarns and/or polymetallic veins associated with Cretaceous plutons (1, 2)	S, V	Q, P, C	I, M
2. Quartz Creek	Hot Springs District-53	Possibly related to granitic intrusions (1)	—	—	I?
3. American Creek	Hot Springs District-53	Quartz-carbonate veins assoc. with shear zone, possibly rel. to granitic intrusions (1)	V	Q, C	I?
4. Totatlanika River	Bonnifield District-44	Gold-bearing quartz or polymetallic veins and massive sulfides in metamorphic rocks, recycled through Tertiary gravels (1, 2)	V, M	Q, P	M
5. Homestake Creek	Bonnifield District-44	(see Totatlanika River, above)	V, M	Q, P	M
6. Platt Creek	Bonnifield District-44	(see Totatlanika River, above)	V, M	Q, P	M
7. Harrison Creek	Circle District-47	Gold-bearing quartz veins, polymetallic veins, skarns, porphyry lode deposits and volcanogenic massive sulfide deposits in metamorphic rocks, recycled through Tertiary conglomerates (1,2)	V, S, M	Q, P, C	M
8. Ketchem Creek	Circle District-47	(See Harrison Creek, above)	V, S, M	Q, P, C	M
9. Switch Creek	Circle District-47	(See Harrison Creek, above)	V, S, M	Q, P, C	M
10. Crooked Creek	Circle District-47	(See Harrison Creek, above)	V, S, M	Q, P, C	M

[1] From Nokleberg, 1996

[2] From Cobb, 1973

[3] V= vein, S= skarn, M=massive sulfide— = unknown

(Note: description of mineralization type, associated mineralogy, and host rock may apply to this particular deposit or drainage, but many are less specific and apply to entire district)

[4] Q= quartz, C= carbonate, P= polymetallic, — = unknown

[5] I= igneous, S= sedimentary, M= metamorphic, — = unknown

Receiving Water	Mining District	Gold Source, Host Rock	Mineralization type	Assoc. Minerals	Host
11. Bonanza Creek	Circle District-47	(See Harrison Creek, above)	V, S, M	Q, P, C	M
12. Trib to Cherry Ck.	Fortymile District–51	Gold-quartz and polymetallic veins in metamorphic rocks near contacts with Cretaceous or early Tertiary plutons (1, 2)	V	Q, P	I
13. Turk Creek	Fortymile District[6]-51	(See trib to Cherry Creek, above)	V	Q, P	I
14. Canyon Creek	Fortymile District-51	(See trib to Cherry Creek, above)	V	Q, P	I
15. Emma Creek	Koyukuk District-59	Source of gold unknown (1, 2)	—	—	—
16. Hammond River	Koyukuk District-59	Gold-quartz and quartz-stibnite veins	V	Q, P	M
17. Boulder Creek[7]	Koyukuk District-59	(See Emma Creek, above)	—	—	—
18. Colorado Creek	Innoko District-56	Quartz-stibnite cinnabar vein (2) or granite porphyry and monzonite (1)	V?	Q,P?	I
19. Little Creek	Iditarod District-55	Vein deposits in monzonitic intrusives and from other mineralized contact zones (1,2)	V	Q,P	I
20. Ganes Creek	Innoko District-56	Mineralized basalt and rhyolite dikes in swarms intruding Cretaceous slate (1,2)	V?	P, Q?	I
21. Timber Creek	Ruby District-63	Polymetallic vein and skarn deposits assoc. with granitic intrusives (1)	V	P, C	I
22. Swift Creek	Ruby District-63	(See Timber Creek, above)	V	P, C	I
23. Prince Creek	Iditarod District-55	Vein deposits in monzonitic intrusives and from other min. contact zones (1,2)	V	Q,P	I
24. Solomon River	Nome District-31	Gold-bearing quartz vein deposits in metamorphic rocks (1)	V	Q	M
25. Coffee Creek	Kougarok District-29	Low-sulfide, gold-bearing quartz veins in metamorphic rocks and from tin lode deposits assoc. with granitic plutons (1)	V	Q, P	M, I
26. Kougarok River	Kougarok District-29	(See Coffee Creek, above)	V	Q, P	M, I
27. Dick Creek	Serpentine District-33	Source of gold unknown, (2)	—	—	—
28. Mud Creek	Fairhaven District-28	Polymetallic vein lode deposits assoc. with Cretaceous granitic plutons or alternatively from gold-bearing quartz veins in met. rocks (1)	Q?	Q?	I?, M?

[6] Not listed in Cobb, but GPS location puts it in Fortymile District

[7] Not listed in Cobb, but GPS location puts it in Koyukuk District

Receiving Water	Mining District	Gold Source, Host Rock	Source Mineralization Type	Assoc. Minerals	Host
29. Gold Run	Fairhaven District-28	(See Mud Creek, above)	Q?	Q?	I?, M?
1998 Sampling					
30. Eldorado Creek	Valdez Creek District-3	Polymetallic veins associated with Cretaceous plutons intruding metasedimentary rocks (1)	V	Q, P	I, M
31. Ketchem Creek	Circle District-47	(See Harrison Creek, above)	V, S, M	Q, P, C	M
32. Faith Creek	Fairbanks District-50	Polymetallic veins associated with Cretaceous plutons (2)	V	Q, P,	I
33. Ester Creek	Fairbanks District-50	(see Faith Creek, above)	V	Q, P,	I

massive sulfide–any mass of unusually abundant metallic sulfide minerals (in contrast to more localized vein deposits).
polymetallic–deposits that contain economically important quantities of three or more metals.
porphyry-an igneous rock with a texture of larger crystals set in a finer-grained matrix.
skarn– a rock of complex mineralogy formed where igneous rocks intrude carbonate rocks.

Table 3 List of Analytical data. Shading indicates detection limit values. Outlines indicate exceedances of aquatic criteria for Alaska.

Stream	Type	Hardne mg/L	TSS mg/L	Alumin µg/L	Antimo µg/L	Arseni µg/L	Cadmiu µg/L	Calciu µg/L	Chroi µg/L	Coppe µg/L	Lead µg/L	Magnesi µg/L	Mercur ng/L	Nickel µg/L	Seleni µg/L	Silve µg/L	Zinc µg/L	pH	DO mg/L	Cond µS	Turbid NTU	Set. So ml/L	Temp degC
Eldorado Creek - Round 1																							
Downstream	tot rec	93.7	4	52.1	0.5	0.7	0.04	20200	1	1.7	0.1	10500	10	1.22	1	0.03	4	7.55		139		T	8
Downstream	diss	96.9	4	24.5	0.5	0.53	0.04	21500	1	0.9	0.1	10500	10	0.94	1	0.03	4	7.55		139		T	8
Effluent	tot rec	114	4	42.6	3.1	0.62	0.04	28000	1	0.87	0.5	10700	10	1.4	1	0.03	4	7.34		180		T	7
Effluent	diss	118	4	27.9	0.5	0.6	0.04	30000	1	0.65	0.1	10500	10	1.09	1.2	0.03	4	7.34		180		T	7
Upstream	tot rec	94.5	4	58.5	0.5	0.62	0.04	20200	1	0.64	0.5	10700	10	1.14	1	0.03	4	7.27		138		T	7
Upstream	diss	96.7	4	19.3	0.5	0.6	0.04	21400	1	0.5	0.1	10500	10	0.86	1.1	0.03	4.7	7.27		138		T	7
Background	tot rec	83.1	4	49.8	5.5	0.73	0.04	18000	1	0.72	0.5	9260	10	1.16	1	0.03	4	7.78		125.5		T	7
Background	diss	85.2	4	23	0.5	0.65	0.04	19200	1	0.55	0.1	9040	10	0.85	1.2	0.03	13	7.78		125.5		T	7
Eldorado Creek - Round 2																							
Downstream	tot rec	108	4	40	0.5	0.71	0.04	23200	1	0.6	0.5	12200	10	1.13	1	0.03	4	8.01		165.2	0.6	T	10
Downstream	diss	112	4	20.1	0.5	0.65	0.04	24900	1	0.51	0.1	12100	10	0.87	1.2	0.03	4	8.01		165.2	0.6	T	10
Effluent	tot rec	128	12	51.2	2	0.75	0.04	31500	1	0.55	0.5	11900	10	1.37	1.3	0.03	4	7.93		190.7	1.5	T	10
Effluent	diss	131	12	21.7	0.5	0.68	0.04	33200	1	0.54	0.1	11700	10	1.2	1.3	0.03	4	7.93		190.7	1.5	T	10
Upstream	tot rec	108	4	39.5	0.5	0.66	0.04	22900	1	0.77	0.5	12300	10	1.1	1	0.03	4	7.91		146.8	1.75	T	10
Upstream	diss	111	4	18.8	0.5	0.66	0.04	24500	1	0.54	0.1	12100	10	0.88	1.3	0.03	4	7.91		146.8	1.75	T	10
Background	tot rec	94.8	4	30.8	0.97	0.68	0.04	20500	1	0.54	0.5	10600	10	1	1	0.03	4	8		138.2	1.5	T	11
Background	diss	97.5	4	17.9	0.5	0.66	0.04	21900	1	0.92	0.1	10400	10	0.8	1.1	0.03	4	8		138.2	1.5	T	11
Upstream	tot rec	149		371	0.5	2.2	0.04	37900	1	2.6	0.79	13300	10	3.93	1.1	0.03	4.1						
Eldorado Creek - Round 3																							
Downstream	tot rec	152	4	30.3	0.5	0.61	0.04	32500	1	0.5	0.5	17300	10	1.27	1	0.03	4	7.81		213	1.5	T	10
Downstream	diss	155	4	17.2	0.5	0.66	0.04	33300	1	0.5	0.1	17500	10	1.01	1.2	0.03	14	7.81		213	1.5	T	10
Effluent	tot rec	156	4	67.1	0.5	0.75	0.04	37100	1	0.52	0.5	15400	10	1.66	1	0.03	4	7.62		223	2.8	T	9
Effluent	diss	160	4	23	0.5	0.63	0.04	39000	1	0.5	0.1	15200	10	1.25	1.2	0.03	4	7.62		223	2.8	T	9
Upstream	tot rec	152	4	35	0.5	0.66	0.04	31900	1	0.5	0.5	17500	10	1.38	1.1	0.03	4	6.77		208	2.4	T	9
Upstream	diss	155	4	16.9	0.5	0.59	0.04	32900	1	0.5	0.1	17600	10	1.07	1	0.03	4	6.77		208	2.4	T	9
Background	tot rec	137	4	20.1	0.5	0.72	0.04	29000	1	0.5	0.5	15600	10	1.14	1.1	0.03	4	8.05		199	2	T	9
Background	diss	139	4	15.7	0.5	0.74	0.04	29700	1	0.5	0.1	15800	10	1.03	1.1	0.03	4	8.05		199	2	T	9
Effluent D*	tot rec	154	4	44.2	0.5	0.66	0.04	37000	1	0.53	0.5	14900	10	1.54	1	0.03	4						
Effluent D*	diss	160	4	22.5	0.5	0.6	0.04	39200	1	0.5	0.1	15000	10	1.26	1.1	0.03	4						
Eldorado Creek - Round 4																							
Downstream	tot rec	104	2.5	32.7	0.5	0.63	0.04	22500	1	0.55	0.1	11700	10	1.05	1	0.03	9.7	7.9		164	1.4	T	8
Downstream	diss	104	2.5	19	0.5	0.65	0.04	22400	1	0.53	0.1	11700	18.6	0.85	1	0.03	4	7.9		164	1.4	T	8
Effluent	tot rec	131	2	39.9	0.5	0.6	0.04	32200	1	0.52	0.15	12300	10	1.3	1	0.03	6.3	7.22		194.6	2.5	T	8
Effluent	diss	132	2	16.5	0.5	0.59	0.04	32600	1	0.6	0.1	12400	10	1.09	1	0.03	4	7.22		194.6	2.5	T	8
Upstream	tot rec	104	105	31.4	0.5	0.6	0.042	22100	1	0.5	0.38	11800	10	0.92	1	0.03	4	7.66		147.3	1.2	T	8
Upstream	diss	105	105	18.9	0.5	0.57	0.04	22500	1	0.55	0.1	11800	10	0.9	1	0.03	4	7.66		147.3	1.2	T	8
Background	tot rec	92.8	2	28.8	0.5	0.65	0.04	20000	1	0.5	0.1	10400	10	1.03	1	0.03	4	7.84		140.8	<0.5	T	8

Table 3 List of Analytical data. Shading indicates detection limit values. Outlines indicate exceedances of aquatic criteria for Alaska.

Stream	Type	Hardne mg/L	TSS mg/L	Alumin µg/L	Antimo µg/L	Arseni µg/L	Cadmiu µg/L	Calciu µg/L	Chroi µg/L	Coppe µg/L	Lead µg/L	Magnesi µg/L	Mercur ng/L	Nickel µg/L	Seleni µg/L	Silve µg/L	Zinc µg/L	pH	DO mg/L	Cond µS	Turbid NTU	Set. So ml/L	Temp degC
Background	diss	93	2	16.5	0.5	0.66	0.04	20100	1	0.5	0.1	10400	10	0.87	1	0.03	4	7.84		140.8	<0.5	T	8
Eldorado Creek - Round 5																							
Downstream	tot rec	125	2	42.1	0.5	0.65	0.04	27000	1	1.5	0.15	14000	10	1.28	1	0.03	4	7.13		165.6	0.84	T	8
Downstream	diss	126	2	17.4	0.5	0.68	0.04	26600	1	3.7	0.1	14400	10	1.13	1.3	0.03	4	7.13		165.6	0.84	T	8
Effluent	tot rec	139	2	50.5	0.5	0.71	0.04	34400	1	1.4	0.21	12800	10	1.37	1.3	0.03	4.2	6.67		188.5	3.6	T	8
Effluent	diss	137	2	13.9	0.5	0.57	0.04	33500	1	0.5	0.1	13000	10	1.12	1.1	0.03	6.7	6.67		188.5	3.6	T	8
Upstream	tot rec	125	2	61	0.5	0.69	0.04	27000	1	0.69	0.27	14100	10	1.3	1	0.03	4	7.27		168.5	2.52	T	8
Upstream	diss	127	2	16.1	0.5	0.63	0.04	26600	1	0.5	0.1	14600	10	1.06	1.2	0.03	4	7.27		168.5	2.52	T	8
Background	tot rec	119	2	29.1	0.5	0.69	0.055	25900	1	0.54	0.57	13200	10	1.17	1.2	0.03	4	7.47		159	0.43		7
Background	diss	120	2	15.2	0.5	0.65	0.04	25500	1	0.83	0.1	13700	10	1.08	1.2	0.03	8	7.47		159	0.43		7
Eldorado Creek - Round 6																							
Downstream	tot rec	143	51.4	440	0.5	2.5	0.04	29900	1.3	3	0.67	16500	10	3.91	1.1	0.03	5.8	7.56		190.9	16	0.1	6
Downstream	diss	142	51.4	21.9	0.5	0.61	0.04	30100	1	0.5	0.1	16200	10	1.21	1	0.03	4	7.56		190.9	16	0.1	6
Effluent	tot rec	149	6.8	95	0.5	1.1	0.04	37600	1	1.5	0.39	13500	10	2.47	1.1	0.03	4	7.05		188	10.25	T	8
Effluent	diss	150	6.8	15.3	0.5	0.57	0.04	37800	1	0.5	0.1	13500	10	1.28	1	0.03	4	7.05		188	10.25	T	8
Upstream	tot rec	142	42.8	369	0.5	2.3	0.04	29900	1	2.5	0.73	16400	10	3.5	1	0.03	4	7.37		215	12.4	T	6
Upstream	diss	142	42.8	17.7	0.5	0.62	0.04	30000	1	0.5	0.1	16400	10	1.25	1.1	0.03	4	7.37		215	12.4	T	6
Background	tot rec	133	8.2	62.9	0.5	1	0.04	28200	1	0.68	0.17	15200	10	1.71	1.2	0.03	4	7.6		186	1.3	T	7
Background	diss	136	8.2	20.8	0.5	0.69	0.04	28900	1	0.53	0.1	15400	10	1.29	1.2	0.03	4	7.6		186	1.3	T	7
Eldorado Creek - Round 7																							
Downstream	tot rec	146	8.6	83.3	0.5	1	0.04	30300	1	0.86	0.22	17100	10	1.98	1.2	0.03	4	6.77		212	2.8	T	9
Downstream	diss	143	8.6	17.5	0.5	0.68	0.04	30800	1	0.5	0.1	16100	10	1.24	1.4	0.03	4	6.77		212	2.8	T	9
Effluent	tot rec	152	13.7	135	0.5	1.3	0.04	38900	1	1.3	0.43	13400	10	2.28	1.2	0.03	12	7.12		211	3.5	T	7
Effluent	diss	149	13.7	26.4	0.5	0.59	0.04	38900	1	0.5	0.1	12500	10	1.32	1.2	0.03	25	7.12		211	3.5	T	7
Upstream	tot rec	145	11.5	127	0.5	1.2	0.04	30100	1	2	0.32	17000	10	2.33	1.5	0.03	4.1	7.37		188	1.32	T	6
Upstream	diss	144	11.5	19.7	0.5	0.68	0.04	31000	1	0.51	0.1	16200	10	1.27	1.3	0.03	4	7.37		188	1.32	T	6
Background	tot rec	122	3.7	47.5	0.5	0.76	0.04	25400	1	0.54	0.1	14300	10	1.46	1.2	0.03	4			177		T	6
Background	diss	135	3.7	20.4	0.5	0.69	0.04	29000	1	0.5	0.1	15100	10	1.3	1.4	0.03	4			177		T	6
Eldorado Creek - Round 8																							
Effluent D*	tot rec	172	20.5	506	0.5	1.7	0.04	44700	1.2	1.8	0.55	14600	10	2.98	1.2	0.03	4.8						
Effluent D*	diss	171	20.5	15.7	0.5	0.66	0.04	45500	1.4	0.5	0.1	13900	10	1.56	1.4	0.03	4						
Downstream	tot rec	192	5.2	63.6	0.5	0.84	0.04	39700	1	0.61	0.21	22600	10	1.82	1.4	0.03	4	7.24		270	3.83	T	7
Downstream	diss	188	5.2	17.5	0.5	0.67	0.04	39800	1.1	0.5	0.1	21500	10	1.41	1.5	0.03	4	7.24		270	3.83	T	7
Effluent	tot rec	174	17.8	253	0.5	1.9	0.04	45200	1	2.1	0.64	14800	10	3.3	1.5	0.03	5.8	7.21		261	19.3	0*	7
Effluent	diss	174	17.8	15	0.5	0.61	0.04	46300	1.1	0.5	0.1	14100	10	1.55	1.3	0.03	4	7.21		261	19.3	0*	7
Upstream	tot rec	193	4	53	0.5	0.95	0.04	39500	1	1.4	0.19	22800	10	1.85	1.7	0.03	4	7.6		264	4.6	T	6
Upstream	diss	189	4	12.8	1.3	24.7	0.04	39900	1.7	2.6	0.1	21800	10	3.48	1	0.03	4	7.6		264	4.6	T	6
Background	tot rec	178	3.6	30.1	0.5	0.83	0.04	36500	1	3.6	0.16	21000	10	1.69	1.8	0.03	4	7.59		248		T	7

Table 3 List of Analytical data. Shading indicates detection limit values. Outlines indicate exceedances of aquatic criteria for Alaska.

Stream	Type	Hardne mg/L	TSS mg/L	Alumin µg/L	Antimo µg/L	Arseni µg/L	Cadmiu µg/L	Calciu µg/L	Chroi µg/L	Coppe µg/L	Lead µg/L	Magnesi µg/L	Mercur ng/L	Nickel µg/L	Seleni µg/L	Silve µg/L	Zinc µg/L	pH	DO mg/L	Cond µS	Turbid NTU	Set. So ml/L	Temp degC
Background	diss	176	3.6	17.5	0.5	0.71	0.04	37100	1	0.5	0.1	20300	10	1.47	1.7	0.03	4	7.59		248		T	7
Ester Creek - Round 1																							
Downstream	tot rec	154	4	20.7	1.6	24.3	0.04	34400	1	3	0.5	16500	10	2.72	1	0.03	4	7.31	6.5	306	2.3	0	8.2
Downstream	diss	161	4	13.6	1.6	19	0.04	36900	1	2.4	0.1	16800	10	3.75	1	0.03	4	7.31	6.5	306	2.3	0	8.2
Background	tot rec	114	4	43.3	0.5	4	0.066	25000	1	1.3	0.5	12500	10	1.73	1	0.03	4	7.53	10.39	221	1.9	0	7.3
Background	diss	119	4	31.3	0.5	3.8	0.04	26800	1	1.1	0.1	12600	10	2.8	1	0.03	4	7.53	10.39	221	1.9	0	7.3
Ester Creek - Round 2																							
Downstream	tot rec	145	4	20.8	1.6	22.7	0.04	32700	1	3.4	0.5	15300	10	2.97	1	0.03	4	7.12	9.85	295	2.1	0	8.9
Downstream	diss	150	4	14.9	1.7	19.6	0.04	34200	1	2.8	0.1	15700	10	3.62	1	0.03	4	7.12	9.85	295	2.1	0	8.9
Background	tot rec	80.9	4	99.9	0.5	3.7	0.04	18000	1	1.6	0.5	8730	13.6	1.69	1	0.03	4	7.36	13.04	162	5.8	0	5.8
Background	diss	85	4	57.7	0.5	3.3	0.04	19200	1	1.4	0.1	8990	18.5	2.53	1	0.03	4	7.36	13.04	162	5.8	0	5.8
Ester Creek - Round 3																							
Downstream	tot rec	150	2.3	19.7	1.3	31.4	0.04	33600	1	3	0.1	16000	10	2.84	1	0.03	4	7.32	7.65	303	2.95	0	8.6
Downstream	diss	152	2.3	10.6	1.4	24.8	0.04	34400	1	2.4	0.1	16000	10	3.48	1	0.03	4	7.32	7.65	303	2.95	0	8.6
Background	tot rec	89.1	2	68.6	0.5	3.8	0.04	19900	1	1.3	0.1	9570	14.6	1.57	1	0.03	4	7.63	11.34	178	1.85	0	4.9
Background	diss	92.6	2	42.6	0.5	3.6	0.04	20900	1	3.5	0.1	9820	10	2.63	1	0.03	4	7.63	11.34	178	1.85	0	4.9
Ester Creek - Round 4																							
Downstream	tot rec	154	2.1	20.2	1.3	33.5	0.04	34600	1	3.2	0.16	16500	10	2.98	1	0.03	4	7.3	6.91	2.95	3.81	0	9
Downstream	diss	159	2.1	10	1.2	24.9	0.04	36500	1	2.3	0.1	16600	10	3.8	1	0.03	4	7.3	6.91	2.95	3.81	0	9
Background	tot rec	101	2.1	48.6	0.5	4.1	0.04	22500	1	1.2	0.1	10800	11.3	1.63	1	0.03	4	7.63	10.4	191	3.04	0	5.5
Background	diss	106	2.1	33.9	0.5	3.6	0.04	24000	1	1.1	0.1	11100	10.13	2.58	1	0.03	4	7.63	10.4	191	3.04	0	5.5
Ester Creek - Round 5																							
Downstream	tot rec	122	2	66.6	2	17.2	0.04	27800	1	4.5	0.31	12800	10	3.1	1	0.03	4	7.07	7.72	234	4.14	0	9.6
Downstream	diss	124	2	14.1	1.9	13.2	0.04	27500	1	3.2	0.1	13500	10	3.23	1	0.03	4	7.07	7.72	234	4.14	0	9.6
Background	tot rec	68.2	4.7	175	0.52	3.6	0.04	15900	1	2.2	1.44	6920	16.8	1.91	1	0.03	4	7.25	11.4	124	3.44	0	3.7
Background	diss	68.5	4.7	101	0.5	3.2	0.04	15600	1	1.7	0.1	7170	14.4	2.44	1	0.03	4	7.25	11.4	124	3.44	0	3.7
Ester Creek - Round 6																							
Downstream	tot rec	90.8	6.6	418	2	20.6	0.04	19900	1.3	5.22	0.79	9980	16.6	4.59	1	0.03	4.1	7.09	12.95	180	25.4	0	6.7
Downstream	diss	91.7	6.6	37.5	1.6	6.71	0.041	19900	1	3.7	0.1	10200	10	3.69	1	0.03	8.2	7.09	12.95	180	25.4	0	6.7
Background	tot rec	46.7	24.3	440	0.5	4.2	0.04	10800	1.2	2.7	0.68	4800	16.3	2.36	1	0.03	4	6.94	15.54	88	8.96	0	2.8
Background	diss	48.6	24.3	171	0.5	2.5	0.04	11100	1	2.1	0.1	5080	10	2.68	1	0.03	4	6.94	15.54	88	8.96	0	2.8
Ester Creek - Round 7																							
Downstream	tot rec	117	2	38.1	1.5	19.4	0.04	25900	1	3.9	0.19	12600	10	3.26	1	0.03	4	6.95	10.23	240	4.63	0	8.2
Downstream	diss	116	2	15.1	1.4	16.8	0.04	26800	1	3	0.1	11900	10	3.27	1	0.03	4	6.95	10.23	240	4.63	0	8.2

Table 3 List of Analytical data. Shading indicates detection limit values. Outlines indicate exceedances of aquatic criteria for Alaska.

Stream	Type	Hardne mg/L	TSS mg/L	Alumin µg/L	Antimo µg/L	Arseni µg/L	Cadmiu µg/L	Calciu µg/L	Chro µg/L	Coppe µg/L	Lead µg/L	Magnesi µg/L	Mercur ng/L	Nickel µg/L	Seleni µg/L	Silve µg/L	Zinc µg/L	pH	DO mg/L	Cond µS	Turbid NTU	Set. So ml/L	Temp degC
Background	tot rec	77.9	4.2	85.9	0.5	3.6	0.04	17800	1	1.4	0.22	8120	11.5	1.56	1	0.03	4	7	15.03	157	3.11	0	3.5
Background	diss	77.4	4.2	53	0.5	3.2	0.04	18400	1	1.3	0.1	7650	16.4	1.88	1	0.03	4	7	15.03	157	3.11	0	3.5
Backgroun D*	tot rec	77.2	2.8	103	0.5	3.5	0.052	17600	1	1.5	0.12	8070	12.4	1.73	1	0.03	4	7.41	17.92	156	2.85	0	3.5
Backgroun D*	diss	77.7	2.8	58.9	0.5	2.9	0.04	17700	1	1.4	0.16	8140	14	2.13	1	0.03	4	7.41	17.92	156	2.85	0	3.5
Ester Creek - Round 8																							
Downstream	tot rec	127	2	21.7	1.3	25.8	0.04	28600	1	3.3	0.1	13600	10	3.02	1	0.03	4	6.77	8.28	266	2.7	0	8
Downstream	diss	129	2	16.9	0.5	0.63	0.04	29600	1.4	0.5	0.1	13300	10	1.38	1.5	0.03	4	6.77	8.28	266	2.7	0	8
Downstrea D*	tot rec	127	2.6	20.7	1.3	26.4	0.04	28400	1	4	0.1	13600	10	3.16	1	0.03	4	6.79	8.1	266	2.38	0	8.1
Downstrea D*	diss	128	2.6	12.5	1.2	24.1	0.04	29400	1.7	2.5	0.1	13300	10	3.16	1	0.03	4	6.79	8.1	266	2.38	0	8.1
Background	tot rec	92	2	59.6	0.5	3.4	0.04	20800	1	1.2	0.12	9730	10	1.52	1	0.03	4	7.08	13.18	187	2.26	0	3.1
Background	diss	93.4	2	38.2	0.5	3.4	0.04	21700	1.5	1.6	0.1	9520	10.8	2.07	1	0.03	4	7.08	13.18	187	2.26	0	3.1
Faith Creek - Round 1																							
Downstream	tot rec	27.6	2	90.6	1.7	2.1	0.072	8610	1	1.6	0.17	1480	10	1.77	1	0.08	4	7.7	8.18	62	1.08	0	6.9
Downstream	diss	28.9	2	55	1.7	1.2	0.04	9190	1	2.3	0.1	1450	10	2.62	1	0.03	4	7.7	8.18	62	1.08	0	6.9
MIXING	tot rec	44.3	4	219	2.5	3.7	0.06	13700	1	2.8	1.14	2440	10	2.36	1	0.03	4	7.61	10.85	102	18.8	0	11.3
MIXING	diss	46.5	4	31.5	2.1	1.2	0.04	14700	1	1.7	0.1	2370	10	2.81	1	0.03	4	7.61	10.85	102	18.8	0	11.3
Effluent	tot rec	45.2	4.4	189	2.5	3.6	0.044	14000	1	2.8	1.09	2480	10	2.26	1	0.11	4	7.58	10.99	105	19.7	0	11.5
Effluent	diss	48.7	4.4	32.2	2.1	1.2	0.04	15400	1	1.8	0.1	2480	10	2.85	1	0.03	4	7.58	10.99	105	19.7	0	11.5
Background	tot rec	21.2	2	76.6	0.5	0.62	0.073	7100	1	1.1	0.1	853	10	1.5	1	0.03	4	7.44	13.14	50	0.44	0	6.3
Background	diss	22	2	58.2	0.5	0.66	0.04	7450	1	1	0.1	830	10	2.88	1	0.03	4	7.44	13.14	50	0.44	0	6.3
Upmixing	tot rec	31.5	4	42.9	2.4	1.4	0.04	9820	1	1.4	0.5	1690	10	0.83	1	0.03	4	7.78	11.8	71	0.97	0	8
Upmixing	diss	33.8	4	28.2	2.3	1.2	0.04	10700	1	1.1	0.1	1720	10	2.16	1	0.03	4	7.78	11.8	71	0.97	0	8
Upmixing D*	tot rec	31.9	4	49.2	2.3	1.5	0.04	9930	1	2.1	0.5	1720	10	0.86	1	0.03	4	7.65	11.95	71	1.4	0	8.1
Upmixing D*	diss	33.5	4	27.3	2.4	1.3	0.04	10600	1	1.2	0.1	1700	10	1.99	1	0.03	4	7.65	11.95	71	1.4	0	8.1
Faith Creek - Round 2																							
Downstream	tot rec	34.2	11.2	149	3.2	3.8	0.04	10600	1	1.6	0.89	1870	10	1.37	1	0.03	4	7.67	13.85	78	8.8	0	8.9
Downstream	diss	35.9	11.2	21.9	3.1	1.4	0.04	11200	1	0.95	0.1	1920	10	1.78	1	0.03	4	7.67	13.85	78	8.8	0	8.9
Effluent	tot rec	74.9	3.9	50	0.5	1.8	0.069	22700	1	2.9	0.5	4420	10	5.84	1	0.03	4	7.08	11.66	162	2.4	0	9.6
Effluent	diss	78.1	3.9	33.7	0.5	1.7	0.041	23800	1	1.7	0.1	4530	10	6.5	1	0.03	4	7.08	11.66	162	2.4	0	9.6
Upmixing	tot rec	32.9	9.5	181	3.2	4.1	0.04	10200	1	1.8	1.19	1800	10	1.35	1	0.07	7.2	7.57	13.95	76	5.2	0	9.9
Upmixing	diss	34.2	9.5	22.4	3.2	1.5	0.04	10700	1	0.92	0.1	1810	10	1.78	1	0.03	4	7.57	13.95	76	5.2	0	9.9
Background	tot rec	24.4	4	31.5	0.5	0.57	0.04	8240	1	0.5	0.5	926	10	0.66	1	0.03	4	7.54	12.67	59	1	0	9.9
Background	diss	25.2	4	28.2	0.5	0.65	0.04	8520	1	0.67	0.1	948	10	1.76	1	0.03	4	7.54	12.67	59	1	0	9.9
Faith Creek - Round 3																							
Downstream	tot rec	33.8	2.2	42.6	3.1	1.8	0.04	10500	1	1.8	4.88	1850	10	0.77	1	0.03	4	7.61	11.02	77	1.91	0	9.4
Downstream	diss	35.7	2.2	20.4	2.9	1.3	0.04	11300	1	1.1	0.1	1820	10	1.89	1	0.03	4	7.61	11.02	77	1.91	0	9.4

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Stream		Type	Hardne mg/L	TSS mg/L	Alumin µg/L	Antimo µg/L	Arseni µg/L	Cadmiu µg/L	Calciu µg/L	Chro µg/L	Coppe µg/L	Lead µg/L	Magnesi µg/L	Mercur ng/L	Nickel µg/L	Seleni µg/L	Silve µg/L	Zinc µg/L	pH	DO mg/L	Cond µS	Turbid NTU	Set. So ml/L	Temp degC
Effluent		tot rec	72.2	2	56.8	0.5	2	0.076	21700	1	2.3	0.1	4370	10	5.93	1	0.03	7.5	7.12	8.98	158	3.2	0	10.6
Effluent		diss	77.1	2	28.4	0.5	1.7	0.054	23700	1	1.6	0.1	4350	10	6.33	1	0.03	4	7.12	8.98	158	3.2	0	10.6
Effluent	D*	tot rec	72.8	2	49.3	0.92	1.9	0.073	21900	1	2.2	0.3	4410	10	5.92	1	0.03	4	7.35		159	3.03	0	10.4
Effluent	D*	diss	77.8	2	28.5	0.5	1.8	0.059	23900	1	1.9	0.1	4410	10	6.72	1	0.03	4	7.35		159	3.03	0	10.4
Upmixing		tot rec	33.9	2.2	58	2.9	2	0.04	10500	1	0.76	0.22	1860	10	0.75	1	0.03	4	7.68	10.81	76	1.65	0	9.3
Upmixing		diss	35.1	2.2	19.6	2.9	1.4	0.04	11100	1	0.85	0.1	1790	10	1.85	1	0.03	4	7.68	10.81	76	1.65	0	9.3
Background		tot rec	24	2	31	0.5	0.53	0.04	8130	1	0.5	0.1	891	10	0.6	1	0.03	4	7.64	11.2	58	0.05	0	9.1
Background		diss	24.6	2	22.6	0.5	0.55	0.04	8380	1	0.62	0.1	893	10	1.56	1	0.03	4	7.64	11.2	58	0.05	0	9.1
Faith Creek - Round 4																								
Downstream		tot rec	35.7	2.2	52.3	2.9	1.8	0.04	11400	1	0.7	0.24	1750	10	0.77	1	0.03	4	7.8	10.8	74	1.39	0	8.2
Downstream		diss	36	2.2	17.4	3	1.4	0.04	11500	1	1	0.1	1780	10	1.83	1	0.03	4	7.8	10.8	74	1.39	0	8.2
Upmixing		tot rec	36.3	2.1	65.7	2.8	1.9	0.04	11600	1	0.73	0.43	1790	10	0.76	1	0.03	4	7.73	10.34	76	2.73	0	8.8
Upmixing		diss	36.8	2.1	16.7	2.8	1.3	0.04	11700	1	0.73	0.1	1830	10	1.85	1	0.03	4	7.73	10.34	76	2.73	0	8.8
Effluent		tot rec	61.5	243	9520	5.57	48.3	0.54	16700	12.7	47.4	40.5	4820	34	45	1.1	0.28	66	7.29	8.13	103	798	0	9.4
Effluent		diss	50.8	243	23.3	2.3	1.2	0.04	15100	1	0.94	0.31	3170	10	2.2	1	0.03	4	7.29	8.13	103	798	0	9.4
Background		tot rec	26.7	2.1	29.1	0.5	0.58	0.04	9190	1	0.76	0.18	920	10	0.48	1	0.03	4	7.69	10.81	59	0.27	0	8.3
Background		diss	26.3	2.1	24.7	0.5	0.59	0.04	8910	1	0.68	0.1	987	10	1.95	1	0.03	4	7.69	10.81	59	0.27	0	8.3
Faith Creek - Round 5																								
Downstream		tot rec	33.8	17.9	186	2.7	4.1	0.055	10800	1	1.5	1.17	1660	10	1.24	1	0.03	4	7.49	11.33	70	4.61	0	6.7
Downstream		diss	33.5	17.9	21.2	2.4	1.2	0.04	10600	1	0.71	0.1	1710	10	1.06	1	0.03	4	7.49	11.33	70	4.61	0	6.7
Effluent		tot rec	59.7	249	6380	8.51	51	0.39	16400	9.16	27.6	32.7	4550	26.6	22.4	1	0.51	53	6.9	7.5	103	564	0	8.8
Effluent		diss	50.6	249	21.8	2.4	1.4	0.04	15000	1	0.79	0.36	3200	10	1.64	1	0.03	4	6.9	7.5	103	564	0	8.8
Upmixing		tot rec	34.1	19.6	205	2.6	4.1	0.04	10900	1	1.4	1.03	1680	10	1.28	1	0.03	4	7.03	10.88	73	5.5	0	6.9
Upmixing		diss	33.8	19.6	21.3	2.2	1.3	0.04	10700	1	0.71	0.1	1720	10	1.15	1	0.03	4	7.03	10.88	73	5.5	0	6.9
Background		tot rec	23.5	2	44.6	0.5	0.54	0.04	8060	1	0.5	0.16	820	10	0.7	1	0.03	4	6.43	11.05	48	0.46	0	6.4
Background		diss	23.8	2	26.7	0.5	0.57	0.04	8070	1	0.56	0.1	883	10	1.14	1	0.03	4	6.43	11.05	48	0.46	0	6.4
Faith Creek - Round 6																								
Downstream		tot rec	26.8	20.2	180	2	4.1	0.04	8360	1	1.5	1.17	1440	10	1.88	1	0.03	4	7.05	11.89	57	7.5	0	4.1
Downstream		diss	27.6	20.2	25.7	0.5	0.57	0.04	8620	1	0.66	0.1	1470	10	2	1	0.03	4	7.05	11.89	57	7.5	0	4.1
Effluent		tot rec	53.3	171	4390	9.84	48.5	0.43	15000	6	21.9	43.2	3850	23.2	17.5	1	1.04	47	7	8.62	103	372	0	7
Effluent		diss	47.8	171	26.7	2.2	1.7	0.04	14000	1	0.89	0.75	3130	10	1.11	1	0.03	4	7	8.62	103	372	0	7
Upmixing		tot rec	27.9	16	197	2	3.6	0.04	8750	1	1.5	0.95	1470	10	1.75	1	0.03	4.8	7.33	12.2	62	6.67	0	4.5
Upmixing		diss	28.1	16	29.9	1.4	1.2	0.04	8930	1	0.86	0.1	1420	10	1.25	1	0.03	4	7.33	12.2	62	6.67	0	4.5
Background		tot rec	25.6	2.1	70.6	0.5	0.93	0.04	8280	1	1	0.26	1190	10	1.2	1	0.03	4	7.2	12.17	58	1.83	0	4.7
Background		diss	26.3	2.1	33.2	0.5	0.5	0.04	8520	1	0.77	0.1	1210	10	1.46	1	0.03	4	7.2	12.17	58	1.83	0	4.7

Table 3 List of Analytical data. Shading indicates detection limit values. Outlines indicate exceedances of aquatic criteria for Alaska.

Stream	Type	Hardne mg/L	TSS mg/L	Alumin µg/L	Antimo µg/L	Arseni µg/L	Cadmiu µg/L	Calciu µg/L	Chro µg/L	Coppe µg/L	Lead µg/L	Magnesi µg/L	Mercur ng/L	Nickel µg/L	Seleni µg/L	Silve µg/L	Zinc µg/L	pH	DO mg/L	Cond µS	Turbid NTU	Set. So ml/L	Temp degC
Faith Creek - Round 7																							
Downstream	tot rec	29.9	25.5	435	2.4	5.93	0.04	9320	1	1.9	1.87	1610	10	1.8	1	0.03	5	7.13	14.11	65	19.1	0	4.8
Downstream	diss	30.2	25.5	22.3	1.7	1.2	0.04	9660	1	0.67	0.1	1470	10	0.76	1	0.03	4	7.13	14.11	65	19.1	0	4.8
Discharge	tot rec	48.9	876	6060	6.35	53.6	0.46	13400	8.73	23.3	31.5	3740	33.8	20.5	1	0.4	49	7.46	12.6	85	1050	1.2	7
Discharge	diss	37.4	876	40.1	2.7	2.8	0.044	11400	1	1.3	0.9	2180	10	2.08	1	0.03	4	7.46	12.6	85	1050	1.2	7
Upmixing	tot rec	28.9	14.7	83.6	2	2.1	0.04	9130	1	0.83	0.38	1470	10	0.96	1	0.03	4.4	7.24	14.75	67	4.01	0	5
Upmixing	diss	29.8	14.7	23.4	1.6	1.1	0.04	9550	1	0.64	0.1	1440	10	1.02	1	0.03	4	7.24	14.75	67	4.01	0	5
Background	tot rec	22.7	2	33.7	0.5	0.43	0.04	7670	1	0.57	0.1	861	10	0.76	1	0.03	4	7.19	14.17	55	0.38	0	5
Background	diss	23.2	2	29.2	0.5	0.44	0.04	7930	1	0.7	0.1	833	10	1.04	1	0.03	4	7.19	14.17	55	0.38	0	5
Effluent	tot rec	51.5	283	1870	5.11	22.4	0.18	15000	2.5	12.9	14	3420	12.8	8.6	1	0.1	18	6.97	8.72	106	384	0.2	7.1
Effluent	diss	49.6	283	18.6	2.4	0.91	0.04	15100	1	0.9	0.23	2900	10	1.41	1	0.03	4	6.97	8.72	106	384	0.2	7.1
Faith Creek - Round 8																							
Downstream	tot rec	31.3	2.2	38.1	2	1.5	0.04	9840	1	0.67	0.19	1630	10	0.83	1	0.03	4	6.87	14.89	72	0.66	0	3.8
Downstream	diss	32	2.2	20.3	1.9	1.1	0.04	10200	1	0.69	0.1	1590	10	1.15	1	0.03	4	6.87	14.89	72	0.66	0	3.8
Background	tot rec	24.3	2.1	29	0.5	0.48	0.04	8210	1	0.84	0.18	923	10	1.65	1	0.03	4	7.09	13.91	60	0.35	0	3.8
Background	diss	25	2.1	24	0.5	0.47	0.04	8530	1	0.5	0.1	901	10	1.01	1	0.03	4	7.09	13.91	60	0.35	0	3.8
Downstream	tot rec	36.6		936	3.9	15.7	0.12	11200	1.3	5.61	5.99	2100	10.2	4.37	1	0.04	7.7						
Ketchem Creek - Round 1																							
Downstream	tot rec	17.6	46.8	2150	0.5	8.64	0.16	4660	3	6.01	3.14	1450	39.7	3.51	1	0.05	14	6.84	8.7	38	54.4	0.1	6.9
Downstream	diss	15.2	46.8	635	0.5	3	0.14	4320	1.1	5.87	0.46	1060	46.6	3.4	1	0.03	5	6.84	8.7	38	54.4	0.1	6.9
Upmixing	tot rec	15.7	36.8	1830	0.5	5.42	0.14	4160	2.8	5.43	2.29	1300	38.4	3.24	1	0.05	12	6.7	9.11	33	31.9	0.1	5.7
Upmixing	diss	13.7	36.8	680	0.5	2.7	0.13	3860	1.1	4.1	0.36	990	46.1	3.34	1	0.03	7.3	6.7	9.11	33	31.9	0.1	5.7
Effluent	tot rec	37.2	58.7	7110	0.5	52.5	0.42	9610	10.2	13.1	20.5	3200	38.3	9.03	1	0.26	40	6.71	8	87	251	0	17
Effluent	diss	31.2	58.7	181	0.5	4.6	0.13	9300	1	3.9	0.96	1940	19.3	3.41	1	0.03	4	6.71	8	87	251	0	17
Background	tot rec	9.96	58.8	1870	0.5	1.1	0.14	2430	3	5.86	2.14	945	43.4	5.19	1	0.04	19	5.69	13.03	20	16.4	0.1	2.7
Background	diss	8	58.8	758	0.5	0.63	0.098	2150	1.1	3.8	0.19	640	28	2.87	1	0.03	6.2	5.69	13.03	20	16.4	0.1	2.7
Ketchem Creek - Round 2																							
Downstream	tot rec	27.9	47.5	4170	0.5	39.1	0.26	7420	6.74	10.2	12.9	2270	28.8	6.5	1	0.14	24	6.97	10.3	62	170	0	10.9
Downstream	diss	24.3	47.5	373	0.5	5.65	0.12	7190	1	3.8	1.11	1540	19.5	3.19	1	0.03	4	6.97	10.3	62	170	0	10.9
Upmixing	tot rec	19.8	19.4	1500	0.5	14.2	0.14	5540	2.2	5.85	3.95	1440	20	3.16	1	0.05	8.6	6.95	13.6	49	34	0	10.7
Upmixing	diss	19.9	19.4	487	0.5	5.44	0.11	5810	1	3.9	0.87	1300	12.9	3.24	1	0.03	4	6.95	13.6	49	34	0	10.7
Effluent	tot rec	72.2	673	28900	0.53	192	1.18	15900	44.7	49.5	98.9	7890	126	33	1.1	1.12	160	6.57	10.15	108	1800	0	16.6
Effluent	diss	37.4	673	147	0.5	4.4	0.12	11100	1	3.5	1.17	2360	11.9	3.32	1	0.03	4	6.57	10.15	108	1800	0	16.6
Effluent D*	tot rec	70.3	624	27300	0.58	179	1.11	15800	41.9	44.5	93.8	7500	108	31.6	1.1	1.05	151	6.57	9.75	111	1600	0	16.9
Effluent D*	diss	37.8	624	132	0.5	4.1	0.13	11200	1	3.5	1.03	2380	17.3	3.33	1	0.03	4	6.57	9.75	111	1600	0	16.9
Background	tot rec	10.02	4	724	0.5	0.67	0.1	2760	1	3.7	0.5	760	36.7	1.79	1	0.03	6.1	6.2	12.6	30	5.7	0	4.6
Background	diss	9.64	4	589	0.5	0.6	0.1	2670	1	3.4	0.13	723	45.7	2.89	1	0.03	5.2	6.2	12.6	30	5.7	0	4.6

Table 3 List of Analytical data. Shading indicates detection limit values. Outlines indicate exceedances of aquatic criteria for Alaska.

Stream	Type	Hardne mg/L	TSS mg/L	Alumin µg/L	Antimo µg/L	Arseni µg/L	Cadmiu µg/L	Calciu µg/L	Chro µg/L	Coppe µg/L	Lead µg/L	Magnesi µg/L	Mercur ng/L	Nickel µg/L	Seleni µg/L	Silve µg/L	Zinc µg/L	pH	DO mg/L	Cond µS	Turbid NTU	Set. So ml/L	Temp degC
Ketchem Creek - Round 3																							
Downstream	tot rec	32.1	57	5910	0.5	54.3	0.26	8290	8.68	11.7	18.3	2770	36.7	8.11	1	0.18	34	7.08	12.95	69	210	0	9
Downstream	diss	25.9	57	309	0.5	6.8	0.11	7610	1	3.7	1.45	1670	29.6	3.13	1	0.03	4	7.08	12.95	69	210	0	9
Effluent	tot rec	73.5	680	30700	0.56	202	1.34	15500	46.8	49.9	111	8450	80.4	36.6	1.2	1.13	184	6.6	10.34	101	2000	0	10.9
Effluent	diss	32.1	680	159	0.5	5.04	0.15	9370	1	4.2	1.49	2120	17.1	3.66	1	0.03	4	6.6	10.34	101	2000	0	10.9
Upmixing	tot rec	23.4	16.4	1770	0.5	17.4	0.15	6530	2.4	5.72	18.7	1730	24.9	3.29	1	0.05	11	7.12	12.98	57	33	0	9.4
Upmixing	diss	22.4	16.4	397	0.5	6.83	0.11	6500	1	3.8	1.06	1500	30.8	3.13	1	0.03	4	7.12	12.98	57	33	0	9.4
Background	tot rec	12	2.2	588	0.5	0.71	0.1	3360	1	3.6	0.5	882	28	1.71	1	0.03	5.5	6.23	13.61	28	2.4	0	3.7
Background	diss	11.2	2.2	494	0.5	0.66	0.1	3150	1	3.7	0.12	816	41.4	2.84	1	0.03	4	6.23	13.61	28	2.4	0	3.7
Ketchem Creek - Round 4																							
Downstream	tot rec	28.6	36.1	3480	0.5	35.3	0.22	7770	5.39	7.94	11.6	2240	31.6	5.57	1	0.12	22	7.09	10.69	67	142	0	8.7
Downstream	diss	28.8	36.1	410	0.5	6.34	0.15	8190	1	5.4	1.3	2020	18.4	3.09	1	0.03	4	7.09	10.69	67	142	0	8.7
Downstrea D*	tot rec	29.2	50.8	3780	0.5	34.5	0.23	7900	5.46	8.1	12.2	2300	31.1	5.85	1	0.14	24	7.07	10.67	64	138	0	8.3
Downstrea D*	diss	25	50.8	419	0.5	6.46	0.13	7340	1	3.8	1.55	1630	21.4	3.28	1	0.03	4.9	7.07	10.67	64	138	0	8.3
Upmixing	tot rec	21.8	4	1030	0.5	10.6	0.12	6220	1.5	4.8	2.63	1520	25.7	2.61	1	0.03	6.1	7.04	10.98	52	16.7	0	7.8
Upmixing	diss	22.3	4	441	0.5	5.26	0.11	6390	1	3.6	0.71	1550	21.4	2.96	1	0.03	4.3	7.04	10.98	52	16.7	0	7.8
Effluent	tot rec	86.7	922	34100	0.56	201	1.81	19300	49.4	51.6	122	9360	152	40.6	1.3	1.33	215	6.68	8.2	107	2180	0	12.1
Effluent	diss	37.2	922	149	0.5	4.6	0.15	10900	1	4.4	1.35	2430	10.6	3.53	1	0.03	4	6.68	8.2	107	2180	0	12.1
Background	tot rec	12.3	4	626	0.5	0.71	0.099	3410	1	4.3	0.34	915	32.8	1.74	1	0.03	5.6	6.11	11.88	25	2.46	0	4.2
Background	diss	11.9	4	524	0.5	0.69	0.13	3320	1	3.6	0.12	879	25.8	2.71	1	0.03	6.8	6.11	11.88	25	2.46	0	4.2
Ketchem Creek - Round 5																							
Downstream	tot rec	21.8	19.6	2180	0.5	16.2	0.17	6120	3.2	5.91	5.54	1590	36.1	3.52	1	0.05	14	6.77	11.43	47	53.5	0	5.6
Downstream	diss	19.8	19.6	637	0.5	4.2	0.13	5660	1.2	3.9	0.87	1370	22.3	2.71	1	0.03	8.4	6.77	11.43	47	53.5	0	5.6
Upmixing	tot rec	16.7	17.1	1260	0.5	6.12	0.12	4630	1.9	4.7	2.51	1260	33.8	2.46	1	0.03	9.7	6.79	11.53	39	12.7	0	5.6
Upmixing	diss	16.9	17.1	653	0.5	3.2	0.12	4770	1.1	6.38	0.5	1210	26.6	2.46	1	0.03	7.7	6.79	11.53	39	12.7	0	5.6
Effluent	tot rec	69.2	379	23200	0.5	156	1.01	16500	35.1	34.9	80.7	6790	89.2	27.8	1	0.71	135	6.57	8.74	108	1000	0	9.7
Effluent	diss	36.3	379	255	0.5	6.66	0.15	10600	1	3.9	2.21	2390	10.8	3.97	1	0.03	4.9	6.57	8.74	108	1000	0	9.7
Background	tot rec	9.99	24.4	1020	0.5	0.93	0.12	2630	4.6	4.2	2.51	830	38.2	3.41	1	0.03	13	5.81	12.05	27	7.57	0	3.2
Background	diss	10.3	24.4	701	0.5	0.6	0.11	2790	1.2	3.5	0.14	815	29.4	2.18	1	0.03	7.2	5.81	12.05	27	7.57	0	3.2
Ketchem Creek - Round 6																							
Downstream	tot rec	31.9	53.5	5290	0.5	41.2	0.3	8660	7.28	9.81	14.6	2500	22	7.02	1	0.15	31	6.66	13.89	64	162	0	5.9
Downstream	diss	24.6	53.5	463	0.5	5.68	0.14	7240	1.1	4.4	1.44	1590	10	3.33	1	0.03	6.7	6.66	13.89	64	162	0	5.9
Downstrea D*	tot rec	32.4	62.3	5150	0.5	41.9	0.32	8820	7.09	10.4	16.7	2530	24.2	6.86	1	0.17	32	6.76	13.96	64	195	0	6.1
Downstrea D*	diss	24.8	62.3	451	0.5	5.66	0.13	7280	1	3.7	1.33	1600	10	2.61	1	0.03	6.2	6.76	13.96	64	195	0	6.1
Effluent	tot rec	68.9	620	26300	0.73	182	1.47	15400	38.3	43.8	101	7400	83.1	29.3	1.2	1.05	169	6.7	11.25	87	1642	0	7.7
Effluent	diss	27.7	620	261	0.5	7.13	0.17	8000	1	4.6	2.26	1870	10	3.9	1	0.03	4.4	6.7	11.25	87	1642	0	7.7

Table 3 List of Analytical data. Shading indicates detection limit values. Outlines indicate exceedances of aquatic criteria for Alaska.

Stream	Type	Hardne mg/L	TSS mg/L	Alumin µg/L	Antimo µg/L	Arseni µg/L	Cadmiu µg/L	Calciu µg/L	Chro µg/L	Coppe µg/L	Lead µg/L	Magnesi µg/L	Mercur ng/L	Nickel µg/L	Seleni µg/L	Silve µg/L	Zinc µg/L	pH	DO mg/L	Cond µS	Turbid NTU	Set. So ml/L	Temp degC
Upmixing	tot rec	20.8	4.4	1020	0.5	8.73	0.11	5970	1.6	7.95	2.19	1420	15.5	3.65	1	0.03	6.8	6.93	14.32	51	14.5	0	5.8
Upmixing	diss	20	4.4	481	0.5	4.31	0.12	5810	1	4.6	0.71	1330	10	2.6	1	0.03	8.6	6.93	14.32	51	14.5	0	5.8
Background	tot rec	11	2	632	0.5	0.63	0.11	3010	1.2	3.4	0.45	847	16.2	1.76	1	0.03	6.1	6.06	15.47	27	1.44	0	3
Background	diss	11	2	608	0.5	0.6	0.12	3010	1.1	3.5	0.11	849	10.4	2.11	1	0.03	5.4	6.06	15.47	27	1.44	0	3
Ketchem Creek - Round 7																							
Downstream	tot rec	27.5	16.9	1310	0.5	11.8	0.16	7960	2	4.8	3.39	1850	21	3.35	1	0.048	9.9	6.82	15.1	72	28.8	0	5.8
Downstream	diss	27.3	16.9	385	0.5	4.4	0.12	8090	1	3.2	0.62	1730	19.4	2.42	1	0.03	4	6.82	15.1	72	28.8	0	5.8
Effluent	tot rec	45.5	28.4	5950	0.5	51.8	0.45	12700	8.23	11.5	19.8	3340	26.8	8.44	1	0.22	37	6.77	10.52	109	179	0	10.1
Effluent	diss	39.8	28.4	157	0.5	3.7	0.2	12000	1	3.7	1	2400	10	2.97	1	0.03	4	6.77	10.52	109	179	0	10.1
Upmixing	tot rec	26.6	66	2810	0.5	20.2	0.21	7280	3.9	7.79	6.57	2050	26.6	4.6	1	0.07	16	7.01	13.3	65	65.9	0	7
Upmixing	diss	24.5	66	351	0.5	4.6	0.11	7170	1	3.3	0.64	1590	21.8	2.5	1	0.03	4	7.01	13.3	65	65.9	0	7
Background	tot rec	9.71	2	619	0.5	0.51	0.12	2630	1.1	4.1	0.27	762	24.8	2.75	1	0.03	5.6	6.2	17.5	25	0.85	0	2.7
Background	diss	10.2	2	639	0.5	0.51	0.091	2820	1	3.3	0.1	776	32.2	2.15	1	0.03	4	6.2	17.5	25	0.85	0	2.7
Ketchem Creek - Round 8																							
Downstream	tot rec	31.5	24.6	6130	0.5	49.2	0.42	8240	8.62	14	20.4	2650	38.9	8.89	1	0.25	38	6.52	14.16	68	177	0	4.4
Downstream	diss	24.2	24.6	364	0.5	5.77	0.13	7120	1	4.1	1.4	1560	15.7	3.03	1	0.03	4.4	6.52	14.16	68	177	0	4.4
Effluent	tot rec	48.7	35.1	3660	0.5	32.1	0.36	14200	5.22	8.74	11.7	3210	17.2	6.03	1	0.13	25	6.78	9.85	135	139	0	6.4
Effluent	diss	47.1	35.1	143	0.5	2.7	0.24	14600	1	3.1	0.54	2580	10	2.51	1	0.03	4	6.78	9.85	135	139	0	6.4
Upmixing	tot rec	41.1	89.5	10400	0.5	79.4	0.65	10300	14.6	20	35.6	3740	56.2	14	1	0.42	64	7.14	13.97	70	278	0	5.6
Upmixing	diss	25.7	89.5	239	0.5	6.25	0.14	7490	1	4.3	1.68	1690	11.8	3.6	1	0.03	4	7.14	13.97	70	278	0	5.6
Background	tot rec	8.37	3.6	673	0.5	0.51	0.099	2230	1.2	3.4	0.27	680	30.4	1.57	1	0.03	6	6.17	5.72	22	1.41	0	1.5
Background	diss	8.1	3.6	608	0.5	0.35	0.11	2170	1.1	3.8	0.14	652	27.8	2.11	1	0.03	5.2	6.17	5.72	22	1.41	0	1.5

Table 4. Summary statistics of data by mine and by sampling site.

		Faith Creek		Ketchem Creek		Eldorado Creek		Ester Creek	
		Total	Dissol.	Total	Dissol.	Total	Dissol	Total	Dissol.
Aluminum (ug/L)									
Overall	Arithmetic Mean	972	15.4	6840	427	81.0	18.8	103	41.3
	Geometric Mean	148	26.0	2960	379	57.2	18.5	58.9	29.1
	Max.	9520	58.2	34100	758	440	27.9	440	171
	Min.	29	16.7	588	143	20.1	12.8	29	10
	Std. Dev.	2280	9.36	9920	189	96.0	3.49	134	41.9
Background	Arithmetic Mean	43.3	30.9	844	615	37.4	18.4	116	59.9
	Geometric Mean	39.9	29.5	776	617	35.5	18.2	79.4	45.7
	Max.	76.6	58.2	1870	758	62.9	23.0	440	171
	Min.	29	22.6	588	494	20.1	15.2	20.2	10.0
	Std. Dev.	19.4	5.77	437	86.3	14.4	2.75	129	48.5
Upstream	Arithmetic Mean	119	23.1	2700	466	96.8	17.5		
	Geometric Mean	100	22.9	1910	447	66.1	17.4	N/A	N/A
	Max.	205	29.9	10400	680	369	19.7		
	Min.	42.9	16.7	1020	239	31.4	12.8		
	Std. Dev.	71.8	4.64	3160	147	114	6.64		
Effluent	Arithmetic Mean	321	26.4	12000	182	91.8	20.0		
	Geometric Mean	832	25.7	15100	178	74.1	19.5	N/A	N/A
	Max.	9520	33.7	34100	261	253	27.9		
	Min.	50	18.6	3660	143	39.9	13.9		
	Std. Dev.	3700	5.52	12400	48.6	72.6	5.50		
Downstream	Arithmetic Mean	147	25.5	3830	447	98.0	19.4	86.5	17.5
	Geometric Mean	107	24.0	3400	433	61.7	19.1	40.7	16.2
	Max.	435	55	6130	637	440	24.5	418	37.5
	Min.	38.1	17.4	1310	309	30.3	17.2	19.7	10.6
	Std. Dev.	131	12.1	1850	124	139	2.64	147	9.01
Antimony (ug/L)									
Overall	Arithmetic Mean	2.6	1.71	0.51	0.50	0.80	0.53	1.04	0.96
	Geometric Mean	1.76	1.36	0.51	0.50	0.61	0.52	0.88	0.82
	Max.	0.73	3.2	9.84	0.50	5.5	1.3	2	1.9
	Min.	0.5	0.5	0.5	0.50	0.5	0.5	0.5	0.5
	Std. Dev.	2.30	0.98	0.04	0	1.01	0.14	0.59	0.55
Backgroud	Arithmetic Mean	0.50	0.50	0.50	0.50	1.18	0.50	0.59	0.58
	Geometric Mean	0.50	0.50	0.50	0.50	0.74	0.50	0.56	0.55
	Max.	0.50	0.50	0.50	0.50	5.50	0.50	1.30	1.20
	Min.	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	Std. Dev.	0	0	0	0	1.75	0	0.27	0.23

Table 4 (cont.) Summary statistics of data by mine and by sampling site.

		Faith Creek		Ketchem Creek		Eldorado Creek		Ester Creek	
		Total	Dissol.	Total	Dissol.	Total	Dissol	Total	Dissol.
Upstream	Arithmetic Mean	2.00	2.34	0.50	0.50	0.50	0.60	N/A	N/A
	Geometric Mean	2.51	2.23	0.50	0.50	0.50	0.56		
	Max.	3.20	3.20	0.50	0.50	0.50	1.30		
	Min.	2.00	1.40	0.50	0.50	0.50	0.50		
	Std. Dev.	0.45	0.67	0	0	0	0.28		
Effluent	Arithmetic Mean	4.65	1.77	0.55	0.50	1.01	0.50	N/A	N/A
	Geometric Mean	2.82	1.48	0.54	0.50	0.74	0.50		
	Max.	9.84	2.40	0.73	0.50	3.10	0.50		
	Min.	0.50	0.50	0.50	0.50	0.50	0.50		
	Std. Dev.	3.70	0.88	0.08	0	0.99	0		
Downstream	Arithmetic Mean	2.50	2.15	0.50	0.50	0.50	0.50	1.61	1.44
	Geometric Mean	2.45	1.91	0.50	0.50	0.50	0.50	1.58	1.35
	Max.	3.20	3.10	0.50	0.50	0.50	0.50	2.00	1.90
	Min.	1.70	0.50	0.50	0.50	0.50	0.50	1.30	0.50
	Std. Dev.	0.56	0.88	0	0	0	0	0.29	0.45
Arsenic (ug/L)									
Overall	Arithmetic Mean	8.87	1.14	46.7	3.87	0.91	1.39	14.08	9.52
	Geometric Mean	2.8	1.04	12.9	3.81	0.84	0.71	9.50	6.03
	Max.	53.6	2.8	202	7.13	2.5	24.7	33.5	24.9
	Min.	0.43	0.44	0.51	0.35	0.6	0.53	3.4	0.63
	Std. Dev.	16.4	0.49	64.8	2.25	0.47	4.25	11.3	8.65
Background	Arithmetic Mean	0.59	0.55	0.72	0.58	0.76	0.68	7.10	5.72
	Geometric Mean	1.74	0.55	0.69	0.56	0.76	0.68	4.79	4.17
	Max.	0.93	0.66	1.10	0.69	1.00	0.74	33.5	24.9
	Min.	0.43	0.44	0.51	0.35	0.65	0.65	3.40	2.50
	Std. Dev.	0.15	0.08	0.20	0.11	0.11	0.03	9.90	7.20
Upstream	Arithmetic Mean	2.74	1.29	20.3	4.82	0.96	3.63	N/A	N/A
	Geometric Mean	2.51	1.28	13.8	4.68	0.85	0.98		
	Max.	4.10	1.50	79.4	6.83	2.30	24.7		
	Min.	1.40	1.10	5.42	2.70	0.60	0.57		
	Std. Dev.	1.15	0.13	24.5	1.42	0.58	0.28		
Effluent	Arithmetic Mean	25.4	1.40	134	4.85	0.97	0.61	N/A	N/A
	Geometric Mean	11.2	1.38	110	4.68	0.89	0.60		
	Max.	51.0	1.70	202	7.13	1.90	0.68		
	Min.	1.80	0.91	32.1	2.70	0.60	0.57		
	Std. Dev.	23.5	0.31	74.7	1.45	0.45	0.04		

Table 4 (cont.) Summary statistics of data by mine and by sampling site.

		Faith Creek		Ketchem Creek		Eldorado Creek		Ester Creek	
		Total	Dissol.	Total	Dissol.	Total	Dissol	Total	Dissol.
Downstream	Arithmetic Mean	3.14	1.17	32.0	5.23	0.96	0.64	23.1	14.4
	Geometric Mean	2.82	1.15	26.3	5.08	0.85	0.65	22.9	9.77
	Max.	5.93	1.40	54.5	6.80	2.50	0.68	31.4	24.8
	Min.	1.50	0.57	8.6	3.00	0.61	0.53	17.2	0.63
	Std. Dev.	1.58	0.26	17.5	1.26	0.64	0.05	4.70	8.29
Cadmium (ug/L)									
Overall	Arithmetic Mean	0.10	0.04	0.39	0.13	0.04	0.04	0.04	0.04
	Geometric Mean	0.06	0.04	0.25	0.13	0.04	0.04	0.04	0.04
	Max.	0.54	0.05	1.81	0.24	0.06	0.04	0.07	0.04
	Min.	0.04	0.04	0.1	0.09	0.04	0.04	0.04	0.04
	Std. Dev.	0.14	0	0.46	0.03	<0.01	0	0.01	0
Background	Arithmetic Mean	0.04	0.04	0.11	0.11	0.04	0.04	0.04	0.04
	Geometric Mean	0.04	0.04	0.69	0.11	0.04	0.04	0.04	0.04
	Max.	0.07	0.04	0.14	0.13	0.06	0.04	0.07	0.04
	Min.	0.04	0.04	0.10	0.09	0.04	0.04	0.04	0.04
	Std. Dev.	0.01	0	0.15	0.01	<0.01	0	0.01	0
Upstrream	Arithmetic Mean	0.04	0.04	0.21	0.12	0.04	0.04		
	Geometric Mean	0.04	0.04	13.8	0.12	0.04	0.04	N/A	N/A
	Max.	0.04	0.04	0.65	0.14	0.04	0.04		
	Min.	0.04	0.04	0.11	0.11	0.04	0.04		
	Std. Dev.	0	0	0.18	0.01	0	0		
Effluent	Arithmetic Mean	0.25	0.04	1.01	0.16	0.04	0.04		
	Geometric Mean	0.17	0.04	110	0.16	0.04	0.04	N/A	N/A
	Max.	0.54	0.05	1.81	0.24	0.04	0.04		
	Min.	0.04	0.04	0.36	0.12	0.04	0.04		
	Std. Dev.	0.20	<0.01	0.54	0.04	0	0		
Downstream	Arithmetic Mean	0.05	0.04	0.24	0.13	0.04	0.04	0.04	0.04
	Geometric mean	0.04	0.04	26.3	0.13	0.04	0.04	0.04	0.04
	Max.	0.07	0.04	0.42	0.15	0.04	0.04	0.04	0.04
	Min.	0.04	0.04	0.16	0.11	0.04	0.04	0.04	0.04
	Std. Dev.	0.01	0	0.09	0.01	0	0	0	<0.01
Calcium (ug/L)									
Overall	Arithmetic Mean	11400	11600	7850	6600	29300	30000	24300	25200
	Geometric Mean	10900	11100	6520	5820	28500	29300	23200	24000
	Max.	22700	23800	19300	14600	45200	46300	34600	36900
	Min.	7100	7450	2230	2150	18000	19200	10800	11100
	Std. Dev.	3860	3960	4810	3160	6890	6780	7250	7720

Table 4 (cont.) Summary statistics of data by mine and by sampling site.

		Faith Creek		Ketchem Creek		Eldorado Creek		Ester Creek	
		Total	Dissol.	Total	Dissol.	Total	Dissol	Total	Dissol.
Background	Arithmetic Mean	8110	8290	2810	2760	25400	26400	20600	21600
	Geometric Mean	8130	8320	2750	2730	25100	25700	19500	20400
	Max.	9190	8910	3410	3320	36500	37100	34600	36500
	Min.	7100	7450	2230	2150	18000	19200	10800	11100
	Std. Dev.	590	453	42.3	424	6000	5990	6640	72200
Upstream	Arithmetic Mean	10100	10500	6330	5980	28000	28600		
	Geometric Mean	10000	10500	6170	5860	25100	28200	N/A	N/A
	Max.	11600	11700	10300	7490	39500	39900		
	Min.	8750	8930	4160	3860	20200	21400		
	Std. Dev.	991	939	1890	1200	6300	6140		
Effluent	Arithmetic Mean	17400	17400	14900	10700	35600	36400		
	Geometric Mean	17000	17000	14800	10600	35500	36300	N/A	N/A
	Max.	22700	23800	19300	14600	45200	46300		
	Min.	14000	14000	9610	8000	28000	30000		
	Std. Dev.	3440	4330	2850	2000	5300	5170		
Downstream	Arithmetic Mean	9930	10300	7390	6930	28200	28700	29000	29900
	Geometric Mean	9770	10200	7240	6800	27500	28200	28800	29500
	Max.	11400	11500	8660	8190	39700	39800	34400	36900
	Min.	8360	8620	4660	4320	20200	21500	19900	19900
	Std. Dev.	1090	1060	1350	1310	6340	6110	5130	5820
Chromium (ug/L)									
Overall	Arithmetic Mean	2.07	1.00	10.3	1.03	1.01	1.03	1.03	1.06
	Geometric Mean	1.35	1.00	4.63	1.03	1.01	1.02	1.03	1.05
	Max.	12.7	1.00	49.4	1.20	1.30	1.70	1.30	1.50
	Min.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Std. Dev.	2.86	0	14.8	0.06	0.05	0.13	0.09	0.16
Backgroud	Arithmetic Mean	1.00	1.00	1.76	1.06	1.00	1.00	1.02	1.06
	Geometric Mean	1.00	1.00	1.48	1.06	1.00	1.00	1.02	1.05
	Max.	1.00	1.00	4.60	1.20	1.00	1.00	1.20	1.50
	Min.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Std. Dev.	0	0	1.33	0.07	0	0	0.07	0.17
Upstream	Arithmetic Mean	1.00	1.00	3.86	1.03	1.00	1.09		
	Geometric Mean	1.00	1.00	2.82	1.02	1.00	1.07	N/A	N/A
	Max.	1.00	1.00	14.6	1.10	1.00	1.70		
	Min.	1.00	1.00	1.50	1.00	1.00	1.00		
	Std. Dev.	0	0	4.41	0.05	0	0.25		

Table 4 (cont.) Summary statistics of data by mine and by sampling site.

		Faith Creek		Ketchem Creek		Eldorado Creek		Ester Creek	
		Total	Dissol.	Total	Dissol.	Total	Dissol	Total	Dissol.
Effluent	Arithmetic Mean	4.77	1.00	29.7	1.0	1.00	1.01	N/A	N/A
	Geometric Mean	2.88	1.00	22.3	1.0	1.00	1.02		
	Max.	12.7	1.00	49.4	1.0	1.00	1.10		
	Min.	1.00	1.00	5.22	1.0	1.00	1.00		
	Std. Dev.	4.68	0	18.7	0	0	0.04		
Downstream	Arithmetic Mean	1.00	1.00	5.61	1.05	1.04	1.01	1.04	1.06
	Geometric Mean	1.00	1.00	5.01	1.05	1.02	1.02	1.05	1.05
	Max.	1.00	1.00	8.68	1.20	1.30	1.10	1.30	1.40
	Min.	1.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00
	Std. Dev.	0	0	2.63	0.08	0.11	0.04	0.11	0.15
Copper (ug/L)									
Overall	Arithmetic Mean	5.29	0. 97	13.4	4.01	1.08	0.72	2.65	2.13
	Geometric Mean	1.87	0.90	8.84	3.95	0.89	0.61	2.37	1.90
	Max.	47.4	2.3	51.6	6.38	3.6	3.7	5.22	3.7
	Min.	0.5	0.5	3.4	3.1	0.5	0.5	1.2	0.5
	Std. Dev.	10.4	0.42	14.9	0.73	0.80	0.66	1.26	0.94
Background	Arithmetic Mean	0.72	0.69	4.07	3.58	0.95	0.60	1.79	1.79
	Geometric Mean	0.69	0.68	3.98	3.57	0.72	0.59	1.66	1.66
	Max.	1.10	1.00	5.86	3.80	3.60	0.92	3.20	3.50
	Min.	0.50	0.50	3.40	3.30	0.50	0.50	1.20	1.10
	Std. Dev.	0.24	0.15	0.80	0.18	1.07	0.17	0.74	0.76
Upstream	Arithmetic Mean	1.20	0.83	7.78	4.25	1.13	0.78	N/A	N/A
	Geometric Mean	1.15	1.70	6.92	4.17	0.93	0.64		
	Max.	1.80	1.10	20.0	6.38	2.50	2.60		
	Min.	0.73	0.64	4.70	3.30	0.50	0.50		
	Std. Dev.	0.42	0.15	5.09	0.95	0.76	0.74		
Effluent	Arithmetic Mean	16.8	1.23	32.9	3.91	1.10	0.54	N/A	N/A
	Geometric Mean	9.55	1.17	26.9	3.89	0.95	0.54		
	Max.	47.4	1.80	51.6	4.60	2.10	0.65		
	Min.	2.30	0.79	8.74	3.10	0.52	0.50		
	Std. Dev.	16.8	0.44	18.8	0.49	0.58	0.06		
Downstream	Arithmetic Mean	1.41	1.01	8.80	4.30	1.17	0.96	3.76	2.57
	Geometric Mean	1.32	0.91	8.32	4.22	0.95	0.70	3.72	2.24
	Max.	1.90	2.30	14.0	5.87	3.00	3.70	5.22	3.70
	Min.	0.67	0.66	4.80	3.20	0.50	0.50	3.00	0.50
	Std. Dev.	0.47	0.55	3.19	0.90	0.87	1.12	0.84	1.02
Lead (ug/L)									

Table 4 (cont.) Summary statistics of data by mine and by sampling site.

		Faith Creek		Ketchem Creek		Eldorado Creek		Ester Creek	
		Total	Dissol.	Total	Dissol.	Total	Dissol	Total	Dissol.
Overall	Arithmetic Mean	5.67	0.16	23.0	0.85	0.37	0.10	0.39	0.10
	Geometric Mean	0.82	0.13	6.19	0.59	0.31	0.10	0.28	0.10
	Max.	43.2	0.9	122	2.26	0.73	0.10	1.44	0.10
	Min.	0.1	0.10	0.27	0.10	0.1	0.10	0.1	0.10
	Std. Dev.	12.4	1.08	36.2	0.61	0.19	0	0.36	0
Background	Arithmetic Mean	0.20	0.10	0.87	0.13	0.33	0.10	0.42	0.10
	Geometric Mean	0.17	0.10	0.59	0.13	0.26	0.10	0.28	0.10
	Max.	0.50	0.10	2.51	0.19	0.57	0.10	1.44	0.10
	Min.	0.10	0.10	0.27	0.10	0.10	0.10	0.10	0.10
	Std. Dev.	0.13	0	0.91	0.03	0.21	0	0.44	0
Upstrream	Arithmetic Mean	0.67	0.10	9.31	0.82	0.42	0.10	N/A	N/A
	Geometric Mean	1.15	0.10	5.24	0.74	0.39	0.10		
	Max.	1.19	0.10	35.6	1.68	0.73	0.10		
	Min.	0.22	0.10	2.19	0.36	0.19	0.10		
	Std. Dev.	0.38	0	12.0	0.41	0.17	0		
Effluent	Arithmetic Mean	18.9	0.28	70.7	1.37	0.42	0.10	N/A	N/A
	Geometric Mean	4.57	0.21	51.3	1.25	0.38	0.10		
	Max.	43.2	0.75	122.0	2.26	0.64	0.10		
	Min.	1.00	0.10	11.7	0.54	0.15	0.10		
	Std. Dev.	19.5	0.23	45.8	0.60	0.16	0		
Downstream	Arithmetic Mean	1.32	0.10	11.2	1.08	0.31	0.10	0.36	0.10
	Geometric mean	0.74	0.10	9.12	1.01	0.24	0.10	0.28	0.10
	Max.	4.88	0.10	20.4	1.45	0.67	0.10	0.76	0.10
	Min.	0.17	0.10	3.14	0.46	0.10	0.10	0.10	0.10
	Std. Dev.	1.56	0	6.63	0.39	0.22	0	0.26	0
Magnesium (ug/L)									
Overall	Arithmetic Mean	2080	1900	2750	1500	14300	14200	11500	11600
	Geometric Mean	1790	1700	2020	1380	14000	13800	11000	11100
	Max.	4820	4530	9360	2580	22800	21800	16500	16800
	Min.	820	830	680	640	9260	9040	4800	5080
	Std. Dev.	1220	950	2460	581	3430	3240	3540	3560
Background	Arithmetic Mean	923	935	828	769	13700	13800	9740	9840
	Geometric Mean	1000	1000	832	764	13200	13200	9330	9330
	Max.	1190	1210	945	879	21000	20300	16500	16600
	Min.	820	830	680	640	9260	9040	4800	5080
	Std. Dev.	114	123	89.0	88.9	3780	3710	3360	3360

Table 4 (cont.) Summary statistics of data by mine and by sampling site.

		Faith Creek		Ketchem Creek		Eldorado Creek		Ester Creek	
		Total	Dissol.	Total	Dissol.	Total	Dissol	Total	Dissol.
Upstream	Arithmetic Mean	1680	1680	1810	1400	15300	15100	N/A	N/A
	Geometric Mean	1590	2510	1700	1380	14800	14800		
	Max.	1860	1830	3740	1690	22800	21800		
	Min.	1470	1420	1260	990	10700	10500		
	Std. Dev.	157	173	822	230	3950	3690		
Effluent	Arithmetic Mean	3990	3390	6210	2260	13100	12900	N/A	N/A
	Geometric Mean	3980	3160	5620	2250	12900	12900		
	Max.	4820	4530	9360	2580	15400	15200		
	Min.	2480	2480	3200	1870	10700	10500		
	Std. Dev.	812	757	2560	254	1530	1450		
Downstream	Arithmetic Mean	1660	1650	2165	1570	15200	15000	13800	13900
	Geometric Mean	1590	1590	2089	1540	14800	14800	13800	13800
	Max.	1870	1920	2770	2020	22600	21500	16500	16800
	Min.	1440	1450	1450	1060	10500	10500	4800	10200
	Std. Dev.	157	182	489	278	3950	3600	2300	2390
Mercury (ng/L)									
Overall	Arithmetic Mean	12.5	10	42.5	22.0	10	10.3	11.9	11.3
	Geometric Mean	11.5	10	35.6	19.4	10	10.2	11.7	11.0
	Max.	34	10	152	46.6	10	18.6	16.8	18.5
	Min.	10	10	15.5	10.0	10	10	10	10
	Std. Dev.	6.72	0	31.3	11.4	0	1.52	2.69	2.68
Backgroud	Arithmetic Mean	10.0	10.0	31.3	30.1	10.0	10.0	12.7	12.3
	Geometric Mean	10.0	10.0	30.2	28.0	10.0	10.0	12.3	12.0
	Max.	10.0	10.0	43.4	45.7	10.0	10.0	16.8	18.5
	Min.	10.0	10.0	16.2	10.4	10.0	10.0	10.0	10.0
	Std. Dev.	0	0	8.51	10.6	0	0	2.73	3.31
Upstream	Arithmetic Mean	10.0	10.0	30.1	22.7	10.0	10.0	N/A	N/A
	Geometric Mean	10.0	10.0	20.2	20.1	10.0	10.0		
	Max.	10.0	10.0	56.2	46.1	10.0	10.0		
	Min.	10.0	10.0	15.5	10.0	10.0	10.0		
	Std. Dev.	0	0	12.8	12.0	0	0		
Effluent	Arithmetic Mean	18.1	10.0	76.6	12.5	10.0	10.0	N/A	N/A
	Geometric Mean	15.9	10.0	61.7	12.1	10.0	10.0		
	Max.	34.0	10.0	152	19.3	10.0	10.0		
	Min.	10.0	10.0	17.2	10.0	10.0	10.0		
	Std. Dev.	9.8	0	47.5	3.64	0	0		

Table 4 (cont.) Summary statistics of data by mine and by sampling site.

		Faith Creek		Ketchem Creek		Eldorado Creek		Ester Creek	
		Total	Dissol.	Total	Dissol.	Total	Dissol	Total	Dissol.
Downstream	Arithmetic Mean	10.0	10.0	31.9	22.7	10.0	11.1	10.9	10.0
	Geometric Mean	10.0	10.0	30.9	20.7	10.0	10.8	10.7	10.0
	Max.	10.0	10.0	39.7	46.6	10.0	18.6	16.6	10.0
	Min.	10.0	10.0	21.0	10.0	10.0	10.0	10.0	10.0
	Std. Dev.	0	0	7.34	11.1	0	3.13	2.49	0
Nickel (ug/L)									
Overall	Arithmetic Mean	4.88	2.00	9.19	2.98	1.65	1.19	2.47	2.86
	Geometric Mean	1.92	1.75	5.51	2.93	1.53	1.14	2.33	2.77
	Max.	45	6.5	40.6	3.97	3.91	3.48	4.59	3.8
	Min.	0.48	0.76	1.57	2.11	0.92	0.8	1.52	1.38
	Std. Dev.	9.30	1.29	11.1	0.51	0.75	0.46	0.87	0.72
Background	Arithmetic Mean	0.9	1.6	2.49	2.48	1.30	1.09	1.88	2.60
	Geometric Mean	0.85	1.58	0.36	2.46	1.25	1.07	1.82	2.57
	Max.	1.7	2.9	5.19	2.89	1.71	1.47	2.98	3.80
	Min.	0.5	1.0	1.57	2.11	1.00	0.80	1.52	1.88
	Std. Dev.	0.4	0.6	1.27	0.37	0.29	0.25	0.63	0.54
Upstream	Arithmetic Mean	1.1	1.6	4.63	2.98	1.69	1.35	N/A	N/A
	Geometric Mean	1.05	1.58	3.89	2.95	1.55	1.20		
	Max.	1.8	2.2	14.0	3.60	3.50	3.48		
	Min.	0.8	1.0	2.46	2.46	0.92	0.86		
	Std. Dev.	0.4	0.4	3.84	0.42	0.86	0.88		
Effluent	Arithmetic Mean	15.4	3.1	23.9	3.41	1.89	1.24	N/A	N/A
	Geometric Mean	10.2	2.51	19.1	3.38	1.78	1.23		
	Max.	45.0	6.5	40.6	3.97	3.30	1.55		
	Min.	2.3	1.1	6.03	2.51	1.30	1.09		
	Std. Dev.	1.5	2.3	13.9	0.48	0.72	0.15		
Downstream	Arithmetic Mean	1.3	1.6	5.81	3.04	1.71	1.08	3.21	3.20
	Geometric Mean	1.23	1.58	5.37	3.02	1.55	1.07	3.16	3.09
	Max.	1.88	2.6	8.89	3.40	3.91	1.41	4.59	3.75
	Min.	0.8	0.8	3.35	2.42	1.05	0.85	2.72	1.38
	Std. Dev.	0.5	0.6	2.18	0.33	0.95	0.20	0.49	0.83
Selenium (ug/L)									
Overall	Arithmetic Mean	1.00	1	1.03	1	1.15	1.18	1	1.03
	Geometric Mean	1.00	1	1.02	1	1.14	1.17	1	1.03
	Max.	1.1	1	1.3	1	1.8	1.7	1	1.5
	Min.	1	1	1	1	1	1	1	1
	Std. Dev.	0.02	0	0.07	0	0.22	0.17	0	0.13

Table 4 (cont.) Summary statistics of data by mine and by sampling site.

		Faith Creek		Ketchem Creek		Eldorado Creek		Ester Creek	
		Total	Dissol.	Total	Dissol.	Total	Dissol	Total	Dissol.
Background	Arithmetic Mean	1.0	1.0	1.0	1.0	1.19	1.24	1.0	1.0
	Geometric Mean	1.0	1.0	1.0	1.0	1.17	1.23	1.0	1.0
	Max.	1.0	1.0	1.0	1.0	1.80	1.70	1.0	1.0
	Min.	1.0	1.0	1.0	1.0	1.00	1.00	1.0	1.0
	Std. Dev.	0	0	0	0	0.26	0.22	0	0
Upstrream	Arithmetic Mean	1.0	1.0	1.0	1.0	1.16	1.13	N/A	N/A
	Geometric Mean	1.0	1.0	1.0	1.0	1.15	1.12		
	Max.	1.0	1.0	1.0	1.0	1.70	1.30		
	Min.	1.0	1.0	1.0	1.0	1.00	1.00		
	Std. Dev.	0	0	0	0	0.28	0.13		
Effluent	Arithmetic Mean	1.0	1.0	1.0	1.0	1.18	1.16	N/A	N/A
	Geometric Mean	1.0	1.0	1.0	1.0	1.17	1.15		
	Max.	1.0	1.0	1.0	1.0	1.50	1.30		
	Min.	1.0	1.0	1.30	1.0	1.00	1.00		
	Std. Dev.	0	0	0.12	0	0.18	0.19		
Downstream	Mean	1.0	1.0	1.0	1.0	1.09	1.20	1.0	1.10
	Geometric mean	1.0	1.0	1.0	1.0	1.07	1.17	1.0	1.07
	Max.	1.0	1.0	1.0	1.0	1.40	1.50	1.0	1.50
	Min.	1.0	1.0	1.0	1.0	1.00	1.00	1.0	1.0
	Std. Dev.	0	0	0	0	0.15	0.19	0	0.19
Silver (ug/L)									
Overall	Arithmetic Mean	0.10	0.03	0.025	0.03	0.03	0.03	0.03	0.03
	Geometric Mean	0.05	0.03	0.10	0.03	0.03	0.03	0.03	0.03
	Max.	1.04	0.03	1.33	0.03	0.03	0.03	0.03	0.03
	Min.	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
	Std. Dev.	0.20	0	0.38	0	0	0	0	0
Background	Arithmetic Mean	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
	Geometric Mean	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
	Max.	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.03
	Min.	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
	Std. Dev.	0	0	<0.01	0	0	0	0	0
Upstream	Arithmetic Mean	0.04	0.03	0.09	0.03	0.03	0.03	N/A	N/A
	Geometric Mean	0.03	0.03	0.06	0.03	0.03	0.03		
	Max.	0.07	0.03	0.42	0.03	0.03	0.03		
	Min.	0.03	0.03	0.03	0.03	0.03	0.03		
	Std. Dev.	0.02	0	0.13	0	0	0		

Table 4 (cont.) Summary statistics of data by mine and by sampling site.

		Faith Creek		Ketchem Creek		Eldorado Creek		Ester Creek	
		Total	Dissol.	Total	Dissol.	Total	Dissol	Total	Dissol.
Effluent	Arithmetic Mean	0.30	0.03	0.74	0.03	0.03	0.03	N/A	N/A
	Geometric Mean	0.15	0.03	0.56	0.03	0.03	0.03		
	Max.	1.04	0.03	1.33	0.03	0.03	0.03		
	Min.	0.03	0.03	0.13	0.03	0.03	0.03		
	Std. Dev.	0.37	0	0.48	0	0	0		
Downstream	Arithmetic Mean	0.04	0.03	0.12	0.03	0.03	0.03	0.03	0.03
	Geometric Mean	0.03	0.03	0.10	0.03	0.03	0.03	0.03	0.03
	Max.	0.08	0.03	0.25	0.03	0.03	0.03	0.03	0.03
	Min.	0.03	0.03	0.05	0.03	0.03	0.03	0.03	0.03
	Std. Dev.	0.02	0	0.07	0	0	0	0	0
Zinc (ug/L)									
Overall	Arithmetic Mean	10.9	4	42.3	5.05	4.62	5.50	4.01	4.26
	Geometric Mean	6.11	4	20.5	4.88	4.42	4.79	4.01	4.18
	Max.	66	4	215	8.6	12	25	4.1	8.2
	Min.	4	4	5.5	4.0	4	4	4	4
	Std. Dev.	16.9	0	59.5	1.47	1.76	4.31	0.03	1.05
Backgroud	Arithmetic Mean	4.0	4.0	8.36	5.50	4.0	5.63	4.00	4.00
	Geometric Mean	4.0	4.0	7.41	5.37	3.98	5.01	4.00	4.00
	Max.	4.0	4.0	19.0	7.20	4.0	13.0	4.00	4.00
	Min.	4.0	4.0	5.5	4.0	4.0	4.00	4.00	4.00
	Std. Dev.	0	0	4.98	1.18	0	3.29	0	0
Upstream	Arithmetic Mean	4.6	4	16.8	5.49	4.01	4.09	N/A	N/A
	Geometric Mean	5.01	4	12.0	5.20	3.99	4.07		
	Max.	7.20	4	64.0	8.60	4.10	4.70		
	Min.	4.0	4	6.10	4.0	4.0	4.00		
	Std. Dev.	1.2	0	19.3	2.00	0.04	0.24		
Effluent	Arithmetic Mean	28.5	4.0	120.6	4.16	5.54	7.39	N/A	N/A
	Geometric Mean	15.9	4.0	93.3	4.15	5.13	5.59		
	Max.	66.0	4.0	215	4.90	12.0	25		
	Min.	4.0	4.0	25.0	4.0	4.0	4		
	Std. Dev.	2.6	0	75.3	0.33	2.77	7.83		
Downstream	Arithmetic Mean	4.1	4.0	23.4	5.06	4.94	5.25	4.01	4.60
	Geometric Mean	3.98	4.0	21.4	4.87	4.68	4.68	3.98	4.47
	Max.	5.0	4.0	38.0	8.40	9.70	14.0	4.10	8.20
	Min.	4.0	4.0	9.9	4.0	4.0	4.00	4.00	4.00
	Std. Dev.	0.4	0	10.3	1.64	2.02	3.53	0.04	1.59
Hardness									

Table 4 (cont.) Summary statistics of data by mine and by sampling site.

		Faith Creek		Ketchem Creek		Eldorado Creek		Ester Creek	
		Total	Dissol.	Total	Dissol.	Total	Dissol	Total	Dissol.
Overall	Arithmetic Mean	37.0	36.7	30.9	22.6	132	133	108	111
	Geometric Mean	34.7	34.7	24.7	20.3	129	131	103	106
	Max.	74.9	78.1	86.7	47.1	193	189	154	161
	Min.	21.2	22	8.37	8	83.1	85.2	46.7	48.6
	Std. Dev.	14.4	13.7	21.8	10.3	28.7	27.3	32.6	33.8
Background	Arithmetic Mean	24.1	24.6	10.4	10.0	120	123	91.5	94.4
	Geometric Mean	1.38	1.38	1.01	1.0	2.07	2.08	1.94	1.95
	Max.	26.7	26.3	12.3	11.9	178	176	156	159
	Min.	21.2	22	8.37	8	83.1	85.2	46.7	48.6
	Std. Dev.	1.68	1.49	1.29	1.41	30.6	30.2	30.3	31.8
Upstream	Arithmetic Mean	32.2	33.1	23.2	20.7	133	134		
	Geometric Mean	1.51	1.51	1.35	1.31	2.11	2.12	N/A	N/A
	Max.	36.3	36.8	41.1	25.7	193	189		
	Min.	27.9	28.1	15.7	13.7	94.5	96.7		
	Std. Dev.	2.99	3.05	8.02	3.95	32.1	30.3		
Effluent	Arithmetic Mean	59.8	57.5	62.7	36.1	143	144		
	Geometric Mean	1.77	1.77	1.78	1.55	2.15	2.16	N/A	N/A
	Max.	74.9	78.1	86.7	47.1	174	174		
	Min.	45.2	47.8	37.2	27.7	114	118		
	Std. Dev.	10.9	13.8	16.9	5.95	18.8	18.0		
Downstream	Arithmetic Mean	31.6	32.5	27.4	23.8	133	133	129	132
	Geometric Mean	1.50	1.50	1.43	1.37	2.11	2.12	2.11	2.11
	Max.	35.7	36	32.1	28.8	192	188	156	161
	Min.	26.8	27.6	17.6	15.2	93.7	96.9	90.8	91.7
	Std. Dev.	3.28	3.33	5.19	4.35	32.0	30.1	22.3	24.2

Total Suspended Solids					
Overall	Arithmetic Mean	62.7	127	11.0	4.52
	Geometric Mean	8.40	29.9	5.56	3.36
	Max.	876	922	105	24.3
	Min.	2	2	2	2
	Std. Dev.	167	240	20.2	5.36
Background	Arithmetic Mean	2.29	12.6	3.93	5.49
	Geometric Mean	2.22	5.40	3.60	3.72
	Max.	4	58.8	8.2	24.3
	Min.	2	2	2	2
	Std. Dev.	0.69	20.1	1.92	51.0

Table 4 (cont.) Summary statistics of data by mine and by sampling site.

Upstream	Arithmetic Mean	9.72	31.7	22.2	
	Geometric Mean	6.98	19.5	8.47	
	Max.	19.6	89.5	105	N/A
	Min.	2.1	4	2	
	Std. Dev.	7.18	30.8	36.3	
Effluent	Arithmetic Mean	137	425	7.79	
	Geometric Mean	37.2	222	5.80	
	Max.	283	922	17.8	N/A
	Min.	2	28.4	2	
	Std. Dev.	129	350	5.97	
Downstream	Arithmetic Mean	10.4	37.8	10.2	3.72
	Geometric Mean	6.21	34.5	5.40	2.95
	Max.	25.5	57	51.4	6.6
	Min.	2	16.9	2	2
	Std. Dev.	9.66	15.8	16.8	2.99
Turbidity					
Overall	Arithmetic Mean	103	335	3.94	6.51
	Geometric Mean	4.76	52.9	2.34	4.31
	Max.	1050	2180	19.3	25.4
	Min.	0.05	0.85	0.43	1.85
	Std. Dev.			4.91	
Background	Arithmetic Mean	0.60	4.78	1.15	4.06
	Geometric Mean	0.40	3.04	0.97	3.41
	Max.	1.83	16.4	2	8.96
	Min.	0.05	11	0.43	1.85
	Std. Dev.	0.57	30.9	0.67	2.83
Upstream	Arithmetic Mean	3.82	60.8	3.74	
	Geometric Mean	3.19	34.5	2.67	
	Max.	6.67	278	12.4	NA
	Min.	0.97	33	1.2	
	Std. Dev.	2.12	22.7	3.99	
Effluent	Arithmetic Mean	306	1150	6.21	
	Geometric Mean	71.6	724	4.28	
	Max.	798	2180	19.3	NA
	Min.	2.4	30	1.5	
	Std. Dev.	312	13.5	6.45	
Downstream	Arithmetic Mean	5.63	125	3.85	9.65
	Geometric Mean	3.20	102	2.10	5.82
	Max.	19.1	210	16	25.4
	Min.	0.66	36	0.6	2.3
	Std. Dev.	6.25	21.5	5.48	10.8
pH					

Table 4 (cont.) Summary statistics of data by mine and by sampling site.

Overall	Arithmetic Mean	7.34	6.63	7.47	7.20
	Geometric Mean	7.33	6.62	7.46	7.20
	Max.	7.8	7.14	8.05	7.63
	Min.	6.43	5.69	6.67	6.77
	Std. Dev.	0.33	0.39	0.38	0.28
Background	Arithmetic Mean	7.28	6.06	7.76	7.29
	Geometric Mean	7.27	6.06	7.76	7.29
	Max.	7.69	6.23	8.05	7.63
	Min.	6.43	5.69	7.47	6.94
	Std. Dev.	0.41	0.20	0.22	0.31
Upstream	Arithmetic Mean	7.48	6.96	7.40[a]	
	Geometric Mean	7.47	6.96	7.40	
	Max.	7.78	7.14	7.91	NA
	Min.	7.03	6.7	6.77	
	Std. Dev.	0.28	0.15	0.34	
Effluent	Arithmetic Mean	7.13	6.67	7.27	
	Geometric Mean	7.13	6.67	7.26	
	Max.	7.58	6.78	7.93	NA
	Min.	6.9	6.57	6.67	
	Std. Dev.	0.23	0.08	0.38	
Downstream	Arithmetic Mean	7.42	6.84	7.50	7.09
	Geometric Mean	7.89	6.84	7.49	7.08
	Max.	7.8	7.09	8.01	7.32
	Min.	6.87	6.52	6.77	6.77
	Std. Dev.	0.35	0.20	0.42	0.19
Temperature					
Overall	Arithmetic Mean	7.5	7.2	7.9	5.9
	Geometric Mean	7.2	6.3	7.8	5.5
	Max.	11.5	17	11	9.6
	Min.	3.8	1.5	6	2.8
	Std. Dev.	2.2	3.7	1.4	2.2
Background	Arithmetic Mean	6.69	3.2	7.75	4.34
	Geometric Mean	6.36	3.05	7.62	4.12
	Max.	9.9	4.6	11	7.3
	Min.	3.8	1.5	6	2.8
	Std. Dev.	2.21	0.97	1.58	1.55
Upstream	Arithmetic Mean	7.49	7.2	7.5	
	Geometric Mean	7.20	6.99	7.37	
	Max.	9.9	10.7	10	NA
	Min.	4.5	5.6	6	
	Std. Dev.	2.10	1.96	1.51	

Table 4 (cont.) Summary statistics of data by mine and by sampling site.

Effluent	Arithmetic Mean	9.14	11.3	8	
	Geometric Mean	9.01	10.8	7.94	
	Max.	11.5	17	10	NA
	Min.	7	6.4	7	
	Std. Dev.	1.68	3.82	1.07	
Downstream	Arithmetic Mean	6.6	7.15	8.25	8
	Geometric Mean	6.26	6.87	8.14	7.94
	Max.	9.4	10.9	10	9.6
	Min.	3.8	4.4	6	6.7
	Std. Dev.	2.18	2.18	1.39	1.03
Conductivity					
Overall	Arithmetic Mean	79.1	60.9	188	196
	Geometric Mean	75.5	53.1	184	185
	Max.	162	135	270	306
	Min.	48	20	126	88
	Std. Dev.	27.0	30.9	38.0	64.0
Background	Arithmetic Mean	55.9	25.5	172	158
	Geometric Mean	55.7	25.3	168	151
	Max.	60	30	248	221
	Min.	48	20	126	88
	Std. Dev.	4.52	3.25	40.0	47.9
Upstream	Arithmetic Mean	71.6	52	185	
	Geometric Mean	71.4	50.7	180	
	Max.	76	70	264	NA
	Min.	62	33	138	
	Std. Dev.	5.38	12.3	43.2	
Effluent	Arithmetic Mean	120	105	205	
	Geometric Mean	118	104	203	
	Max.	162	135	261	NA
	Min.	103	87	180	
	Std. Dev.	27.4	15.1	26.7	
Downstream	Arithmetic Mean	69.4	60.9	190	244
	Geometric Mean	69.0	59.7	186	239
	Max.	78	72	270	306
	Min.	57	38	139	180
	Std. Dev.	7.44	12.0	41.2	51.8

Table 5. Alaska Water Quality Criteria. Values used for comparison with measurements are for chronic effects to aquatic life except where noted.

Aluminum	No criterion used for comparison.
Antimony	Lowest Observed Effect Concentration (LOEC): 610 µg/L
Arsenic	Alaska criterion for public water supplies: 50 µg/L
Cadmium	exp(0.7852*ln(hardness) - 3.490) study range 0.16 - 1.90 µg/L
Calcium	No criterion used for comparison.
Chromium (+6)	11.0 µg/L
Copper	exp(0.8545*ln(hardness) - 1.465) study range 1.37 - 32.90 µg/L
Lead	exp(1.266*ln(hardness) - 4.661) study range 0.13 - 7.40 µg/L
Magnesium	No criterion used for comparison.
Mercury	12 ng/L (0.012 µg/L)
Nickel	exp(0.76*ln(hardness) + 1.06) study range 14.02 - 157.5 µg/L
Selenium	5 µg/L
Silver	0.12 µg/L
Zinc	47.0 µg/L

Table 6. Linear correlation coefficients for comparison of measurement parameters.

Metal	Correlation Coefficients (r)		
	Total vs. Dissolved	Total vs. Turbidity	Dissolved vs. Turbidity
Aluminum	0.14 n = 112	0.9634 n = 112	0.0314 n = 112
Antimony	0.48 n = 29	0.08 n = 38	0.25 n = 31
Arsenic	0.24 n = 112	0.946, n= 112	0.079, n = 112
Cadmium	0.39 n = 36	0.95 n = 53	0.24 n = 40
Calcium	0.99 n = 112	-0.05, n = 112	-0.182, n = 112
Chromium	-0.24 n = 17	0.96 n = 40	-0.15 n = 29
Copper	0.36 n = 95	0.95 n = 40	0.28, n=95
Lead	0.59 n = 38	0.97 n = 83	0.49 n = 40
Magnesium	0.98 n = 112	-0.02 n = 106	-0.21 n = 106
Mercury	-0.23 n = 34	0.87 n = 47	0.36 n = 36
Nickel	0.33 n = 106	0.92 n = 98	0.25 n = 106
Selenium	0.68 n = 23	0.04 n = 24	-0.12 n = 22
Silver	--	--	--
Zinc	-0.22 n = 70	0.97 n =54	-0.24 n = 23
Hardness	0.98 n = 112	-0.04 n = 106	-0.20 n = 106

Turbidity vs. TSS: r = 0.95, n = 106

Appendices

A. Quality Assurance Project Plan
B. Field Reports
C. Description of placer mining districts, from Nokleberg and others (1996).
D. Laboratory Report of Data

Appendix A
Quality Assurance Project Plan

United States Environmental Protection Agency

Region 10, 1200 Sixth Avenue, Seattle WA 98101

FINAL

QUALITY ASSURANCE PROJECT PLAN FOR THE ALASKA PLACER MINING SURVEY

June 1997

Project Code: TEC-311G

Account Code: 9798B10PFEX

Week of Sampling	Sample Numbers Assigned
August 18, 1997	97344550-4699, 97344300-4474
August 25, 1997	97354700-4999

Approvals:

Project Officer: _____ Date: _____

QA Officer: _____ Date: 8/97

Organization Manager: _____ Date: _____

Prepared By The

Region 10 Quality Assurance & Data Unit
Office of Environmental Assessment
U.S. Environmental Protection Agency

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Apendix A Alaska Placer Mining Survey
Apendix B Analytical Statement of Work

1.0 *Project Organization and Responsibility*

The following is a list of key project personnel and their responsibilities:

Organization Manager:	Bob Robichaud
Project Officer:	Phillip North
Study Design:	Phillip North, Carla Fisher, Data Assessment Personnel and Patricia Cirone
QAPP Preparation:	Laura Castrilli
QAPP Review:	Donald Matheny
Field Sampling:	Jim Corpuz, Joseph Goulet and USGS and/or Alaska Department of Environmental Conservation personnel
Laboratory Arrangements:	Laura Castrilli
Laboratory Operation:	Gerald Muth, ESAT Deputy Project Officer Jim Ross, Metals Chemist, Washington Department of Ecology (WDOE)
Data Validation:	Manchester Laboratory (TSS data), Quality Assurance and Data Unit (QADU - metals data)
Data Assessment/Analysis:	Joseph Goulet and David Frank
Report Preparation:	Joe Goulet and Carla Fisher

2 *Project Description*

Objective and Scope:

See the June 10, 1997, Placer Mining Survey document, attached - Appendix A, for a description of the project and it's objectives. This Quality Assurance Project Plan is for the collection and analysis of field samples during 1997 in support of the Placer Mining Survey. An addendum to this plan will be prepared next year for the 1998 sampling season.

1997 Schedule of Sampling Tasks and Milestones:

Activity	Estimated beginning and ending dates					
	6/15 - 6/29/97	8/18 - 8/31/97	8/25 - 10/17/97*	09/22 - 10/27/97*	10/27/97- 01/31/ 98	1/31/98
QA Plan Review	x					
Summer of 1997 Field Sampling		x				

1997 Schedule of Sampling Tasks and Milestones:						
Activity	Estimated beginning and ending dates					
	6/15 - 6/29/97	8/18 - 8/31/97	8/25 - 10/17/97*	09/22 - 10/27/97*	10/27/97- 01/31/ 98	1/31/98
Lab Analysis			x			
Data Validation				x		
Data Analysis					x	
Report Preparation						x

* Depending on the actual number of samples shipped, there will be between six and seven total metals data packages and six and seven dissolved metals data packages. Starting Monday, September 22, a minimum of two packages are to be delivered to the EPA QADU each Monday. The last data packages are to be received by Monday, October 20. The schedule of at least two data packages per week (more some weeks so that all packages are received by October 20) needs to be maintained so that data validation can start in time for the data assessment/analysis to be completed in time. TSS analyses will be validated by the EPA Manchester laboratory. All validated TSS data must be delivered to Joe Goulet by October 27, 1997.

All field reports will be completed within one month of sample collection. Laboratory results and interpretation (if necessary) will be appended.

3 QA Objectives

3.1 Data Usage:

The data from the Summer of 1997 (broad sampling of all active sites and half of the inactive sites) will be used to see if a relationship between metals and other general parameters such as TSS and/or settleable solids and/or hardness can be established for the placer mining operations in Alaska. If a relationship can be established, an extensive second round of sampling will occur in the summer of 1998. The data from the extensive round of sampling will be used to determine temporal trends in the relationship between metals and other general parameters.

3.2 Monitoring network/sample collection design and rationale:

The sampling team will take chemical and physical measurements in August 1997, at approximately 75 active mines in the Anchorage, Fairbanks, and Nome mining areas.. Remote mines on the Trinity Islands, Shumagan Islands and the lower Yukon River will not be included in this survey. Where a mine is discharging waste water, four samples will be taken, one from each of the following:

1) upstream of any disturbance (i.e., "natural background"),

2) immediately upstream of the discharge[1],

3) the effluent,

4) downstream of the point of mixing (determined visually). If the state of Alaska indicates the physical location of the edge of the mixing zone, EPA shall take samples at the edge of the mixing zone. However, if the state indicates a dilution factor, EPA shall sample the effluent and calculate the concentration after dilution (without taking a downstream sample).

Where a mine is not discharging, samples will be collected upstream of any disturbance and immediately upstream from the site.

EPA anticipates visiting approximately 40 to 50 mines that will have discharges. There are likely to be another 50 that do not have a discharge. Samples will be collected at all mines that have a discharge and approximately half those that don't, for a total of up to 250 sample locations (corresponding to 500 metals samples when total and dissolved metals are counted).

Turbidity, temperature, pH, electrical conductivity, and settleable solids will be measured in the field. All dissolved and total recoverable mercury and total suspended solids analyses will be done by the EPA Region 10 Manchester Lab. A private or State lab will be procured by EPA to do the remaining total and dissolved metals analyses.

Containers collected from a given sampling point will be assigned a common EPA lab number which will be marked on the container cap and on the side of the container. Each sampling point will receive a separate EPA lab number. Field duplicates and blanks will all be assigned separate unique EPA lab numbers. In addition, dissolved (filtered) metals aliquots will be assigned a separate unique EPA lab number as most labs cannot use the

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[1]If there are no disturbances upstream from the discharge, only one upstream sample (the "natural background" sample) will be taken.

same sample number to report two sets of similar data (in this case total vs. dissolved metals).

The analytical parameter name or abbreviation will be marked on the cap and on the side of the container. Abbreviations may include: TM for total metals; DM for dissolved metals; Turb for turbidity; and Set Sol. for settleable solids.

Turbidity and settleable solids analysis will be performed in the field with a portable turbidity meter (LaMotte Model 2008) and an Imhoff Cone, respectively.

3.3 Sample Types:

Table 1: Analytical Methods, Containers, Preservation, Holding Time and Detection Limits

Media	Type	Analyte	Container	Method	Detection Limit (μg/L)*	Preservation	Holding Time
Metals**							
Water	Grab	Aluminum	1 Quart Cubitainer[a]	EPA 200.7 and/or 200.8	85.0	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Antimony	a	EPA 200.7 and/or 200.8	140.0	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Arsenic	a	EPA 200.7 and/or 200.8	0.15	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Cadmium	a	EPA 200.7 and/or 200.8	0.35	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Calcium	a	EPA 200.7	1000.0	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Chromium	a	EPA 200.7	50.0	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Copper	a	EPA 200.7 and/or 200.8	3.5	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Lead	a	EPA 200.7 and/or 200.8	0.5	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Magnesium	a	EPA 200.7	1000.0	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Mercury	a	EPA 245.1	0.01	HNO_3 to pH<2, Ice[b]	28 days
Water	Grab	Nickel	a	EPA 200.7 and/or 200.8	10.0	HNO_3 to pH<2, Ice[b]	180 days

Table 1: Analytical Methods, Containers, Preservation, Holding Time and Detection Limits

Media	Type	Analyte	Container	Method	Detection Limit (µg/L)*	Preservation	Holding Time
Water	Grab	Selenium	a	EPA 200.7 and/or 200.8	5.0	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Silver	a	EPA 200.7 and/or 200.8	0.35	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Zinc	a	EPA 200.7 and/or 200.8	30.0	HNO_3 to pH<2, Ice[b]	180 days
Conventional Parameters							
Water	Grab	Hardness	a	c	10,000	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	pH	Field Measurement	EPA 150.1	1 unit	none	immediate
Water	Grab	Temperature	Field Measurement	EPA 170.1	0°C	none	immediate
Water	Grab	Dissolved Oxygen	Field Measurement	EPA 360.1	50.0	none	immediate
Water	Grab	Set. Solids	Field Measurement	160.5	0.2 ml/l/hr	ice if not immediately analyzed	48 hours
Water	Grab	Conductivity	Field Measurement	EPA 120.1	1 µS	ice if not immediately analyzed	28 days
Water	Grab	Total Suspended Solids	1 quart Cubitainer	EPA 160.2	4,000-5,000	ice	7 days
Water	Grab	Turbidity	Field Measurement	EPA 180.1	<1 NTU	ice	48 hours

Table 1: Analytical Methods, Containers, Preservation, Holding Time and Detection Limits							
Media	**Type**	**Analyte**	**Container**	**Method**	**Detection Limit (μg/L)***	**Preservation**	**Holding Time**

a - All total metals will be collected in the same 1 quart cubitainer. For dissolved metals, a field filtration procedure developed by Andy Hess at the EPA Manchester laboratory (consisting of a disposable filter/two pieces of connective tubing and a 'tap' cap) will be used for dissolved metals sample collection. See the section on sampling for further discussion of the sample containers.

b - All water samples for metals analysis should be acidified, in the field when the sample is collected, with nitric acid to a pH less than 2. Further, samples should be acidified for at least 16 hours prior to analysis. Icing of the metals samples is not required by CFR Part 136, Table 1B. However, if preservative cannot be immediately added to the samples, the samplers will be icing the samples if they are to be preserved later in the day. Footnote 2 to Table 1B allows for preserving with ice 24 hour automatic composite samples when it is impossible to immediately preserve each aliquot. The metals samples will be iced during shipment in the event TSS aliquots are shipped in the same cooler. Dissolved metals samples will be filtered through a 0.45 um filter prior to acidification to a pH less than 2 with nitric acid. See the section on sampling for a contingency discussion.

c - hardness will be measured as the sum of the calcium and magnesium as measured by Method 200.7 (See notes in Table 1B, 40 CFR Part 136).

* Metals detection limits (except for calcium and magnesium) have been set to the lowest level aquatic life criteria based on a sample hardness of 25 mg/L.

** In the event of equipment failure or unavailability, 200 series Graphite Furnace Atomic Absorption Spectroscopy procedures may be substituted for ICP-MS method 200.8.

4 *Data Quality Objectives*

Table 2: Quantitative Objectives for Precision and Accuracy			
Analyte Group	**Samples/Matrix***	**RPD**	**% Recovery**
Metals	262-264 total Water, 262-264 dissolved Water	± 20	75-125%
Conventionals	256 Water (no blanks)	± 20	75-125%

4.1 Precision and Accuracy:

Precision: Precision will be evaluated by the relative percent difference (RPD) between matrix spike/matrix spike duplicate samples or between laboratory duplicate samples (or between field duplicate analyses for field measurements). The precision required for the analyses involved with this project are in Table 1. The dispersion of these samples will represent the various sampling areas identified in this plan (i.e., upstream, downstream and effluent). In addition, the initial assessment of the field duplicates will be tied to those areas (especially where divergent analyte concentration ranges are realized between sub-groups of sample duplicates).

Accuracy: Accuracy will be evaluated by the use percent recovery (%R) of the target analyte in spiked samples and/or laboratory control samples, where applicable. The accuracy requirements are presented in Table 1.

4.2 Data Representativeness:

The samples will be grab samples. They do not represent temporal trends in the metals concentrations around placer mining operations. This is an instantaneous representation of water quality conditions around placer mining operations at the time of sampling.

4.3 Data Comparability:

Data will be reported according to established EPA Regional Laboratory protocols and to the requirements specified in the contract laboratory statement of work (SOW) for metals analysis (Appendix B).. Samples will be analyzed according to approved analytical procedures. This set of data may be compared to other data. There should not be a comparability problem for TSS as the EPA regional lab has analyzed a lot of the past samples. For the contract lab metals analyses, comparison to past data may not be possible. However, future metals analyses will be conducted following the same SOW (unless problems occur that require alteration of the SOW). This set of data will be compared to the summer of 1998 sampling. Therefore, equivalent methods must be used for both studies.

4.4 Data Completeness:

All samples collected are to be analyzed with appropriate supportive documentation. Field problems sometimes result in not all planned samples being collected. Laboratory problems sometimes result in loss of samples or loss of data due to qualification. The overall completeness goal for the summer of 1997 sampling is 80%. That is, a loss of 20% of the planned data should not fatally impact the data usability for the 1997 sampling. For each mining operation, the field completeness goal for sample collection is 100% (that

is, effluent should not be collected/submitted if an adequate background sample cannot be obtained).

5 *Sampling Procedures*

5.1 Total Metals Sampling Procedures:

To the extent possible, the samplers will attempt to follow sampling procedures in Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels. Project specific QA procedures are specified in this QAPP. The limited budget may preclude the use of some sampling precautions outlined in this method. However, the collection of field and equipment blanks should document whether or not the sample collection methods have biased the sample results.

Each mining operation potentially will have up to four samples collected around it. The sampling will start at the sampling point the farthest down stream and will proceed in order up to the farthest up-stream sample point so that silt stirred up by wading into the stream will not end up in the sample containers and positively bias the data.

Cubitainers should be held by hand when collecting samples. Samples should be taken from a well mixed location by pointing the neck of the cubitainer upstream and downwards - submerging the neck below the surface of the water. The bottom of the container should be pushed down under the water as the container fills. If sampling requires the sampler to enter the stream, the sampler should be downstream of the sample location. Should it be necessary to use a clean unused cubitainer as a 'scoop' to obtain sufficient sample, it should be thoroughly rinsed with stream water and used only for sample taking purposes at one location. To prevent sample cross-contamination due to 'dirty hands', disposable talc free gloves will be used at each sample collection point prior to collection of metals samples. In accordance with Method 1669, containers (collection chambers for filtration apparatus) will be pre-rinsed at least once with the sample and then submerged and filled with sample. For un-filtered samples, the container cap will be affixed while the container is still submerged (unless it is necessary to use successive scoops of water from shallow streams to obtain sufficient volume).

5.2 Dissolved metals sampling procedures:

Prior to field work, the EPA samplers will make arrangements to visit the EPA laboratory in Manchester, WA and will practice the filtration method that will be used in the field. They will also practice the clean hands/dirty hands sampling technique.

5.2.1 Filtration method:

A field filtration method developed at the EPA Manchester Laboratory is the filtration method that will be used. This filtration procedure is simple to implement but has not been fully tested for water quality criteria analyses. An initial analysis of the filter cartridge and tubing has shown that metals (mercury was not analyzed) were not present at levels above the required detection limits. Two clean cubitainers are connected by two disposable short pieces of tubing with a disposable 0.45 μm accordion folded filter cartridge in between the pieces of tubing. The filter cartridge in this apparatus is unlikely to clog if there is some particulate in the samples as there is more surface area to the filter. The first container is filled with unfiltered sample, a 'tap' cap is affixed to the filled container and then connected via tubing to the filter cartridge (which is connected by another piece of tubing to the receiving container) and then the water is forced through the filter by squeezing the cubitainer. The filter cartridge, tubing, tap cap and first collection container are all disposed of after collection is completed at one location. No sample contact equipment is re-used at other sample locations.

The tubing will be pre-cut and if possible attached to the filter, then will be individually double bagged in zip lock bags and will be shipped to the samplers in the field (or will be taken as excess baggage by the samplers into the field).

Potential problem/resolution: it is slightly possible that the filter will clog up on very turbid samples. It is anticipated that only effluent samples will be turbid and most likely only a sub-set of the effluent samples will be turbid. The cost per filtration apparatus is around $15. It will not be economically possible to use multiple apparatus on samples. If this occurs, a clean cubitainer will be used to collect an un-filtered, un-preserved (but iced) sample aliquot that will then be shipped to the lab for lab filtration and preservation.

It is understood that lab filtration and preservation will result in data that is not quite dissolved metals data. The results will be of unknown bias. This is because some dissolved metals may adsorb to the walls of the container and will not be put through the filtration process (low bias). However, some metals adhering to the particulates in the sample may through bacterial action go into solution, possible high bias in the dissolved metals data.

5.3 General sampling procedures:

All metals samples will be double bagged - the inner bag and container are only to be touched by a clean hands sampler. All metals samples will be chemically preserved in a

controlled manner. The two sampling teams will decide together, based on logistics, how this will be achieved.

During preservation, the container should be kept within the bags - 'dirty hands' holding open the outer bag while 'clean hands' touches the inner bag and container and preserves the sample. 'Clean hands' will then re-cap each preserved sample and re-seal the inner bag after which 'dirty hands' re-seals the outer bag and places the sample in a cooler for shipment.

Sampling for analytes other than metals: the clean sampling techniques described above are only necessary for the trace metals analyses. It is not necessary to double bag and handle the TSS aliquots in this manner. The field crew may at their option take the same precautions but should they find the precautions too onerous, they may opt to use normal sampling procedures or chose not to take corrective action (re-gloving and/or re-sampling) should the clean hands sampler accidentally 'contaminate' his gloves by touching his clothes or a 'dirty' outer bag.

Example scenario: at collection point one using normal sampling procedures, take field measurements and the TSS sample. Then re-glove and follow clean sampling techniques for metals collection. Proceed to the next sampling point, take field measurements and TSS samples. Then re-glove and follow clean sampling techniques for metals collection.

All TSS and total metals sample containers will be supplied through the EPA Region 10 Lab. These will consist of quart/liter Cubitainers purchased as pre-cleaned containers. The bottle supplier will be required to supply analytical data showing that the supply of cubitainers, has been analyzed and shown to have no metals contamination above the required detection limits before supplying the containers. Exception, the selenium detection limit by the potential vendor (ESS) is 6 ug/L (1 ug/L above the required detection limit). The EPA Region 10 Lab will provide each sampling team with four individually double-bagged plastic rods (total of eight rods). The rods will be of suitable diameter and length for the samplers to use them as a cubitainer expanding device (cubitainers are supplied flattened and are difficult to open just with hands). The rods should have smooth ends so that the cubitainers or sampler's hands will not be punctured. Eight rods are needed in the event one or more is dropped and contaminated.

Each field crew will be responsible for double bagging individual un-used cubitainers for use in the field for metals sample collection. Each evening, a sufficient supply of double bagged containers needs to be placed in a 'clean' cooler for use the next day. During initial bagging, both samplers will don clean gloves but only one person ('clean' hands) will handle the containers, plastic rods and inner bags while the other person ('dirty' hands) handles the outer bags and opening the outer containers of the large supply of containers. When the cubitainer is placed in the inner bag, clean hands should then remove a plastic rod from it's inner bag and use it to expand the cubitainer.

Blank water will be suppled by the EPA or Alaska Department of Environmental Conservation laboratory in pre-cleaned 1 gallon cubitainers. Before the water is used, a blank sample from each batch of blank water will be composited from the 1 gallon cubitainers and submitted blind to the contract laboratory to determine if analyte levels are below the detection limits required for this project. Also, the composite blank water will be used to rinse the plastic rods to document whether any contamination was introduced to the samples by using the rods to expand the cubitainers. The rod rinse water will be preserved and submitted blind to the lab for analysis.

A total of six transfer (total) blank and six equipment (filtered) blanks will be obtained and sent blind to the lab. These blanks are expected to reflect the range of different field conditions encountered during sampling. All transfer and filtration blanks are to be collected and preserved using procedures as close to actual sampling as possible. However, it will be unfeasible to exactly imitate stream sampling with blank water. Following the method 1669 blank collection procedure (submersing the container in standing blank water) is not representative of stream sampling. Therefore, a transfer blank will be collected. The six transfer blanks does not include the one blank water sample and one plastic rod rinse blank sample that will also be collected, preserved and submitted for analysis (discussed in the previous paragraph).

Like the samples, the blank container must first be rinsed with blank water. The clean hands sampler will hold the transfer blank bottle while the second sampler (taking care not to handle the blank water supply around the opening) pours blank water into the blank container. So long as the blank water supply is never contaminated by handling around the opening, it can be used for all blanks.

If a second cubitainer has to be used as a scoop during sample collection (or is used as part of the filtration step), the blank water will be used to rinse one clean cubitainer (representing the scoop or supply reservoir for the filter), the blank scoop (connected to the filter apparatus for equipment blans) will be used to rinse and then fill a second cubitainer (representing the field or filtration blank). If two methods for collection (intermediate collection device versus direct container collection) are used, the samplers will collect a total of 8 total and 8 filtered blanks (proportioning the blanks according to the approximate frequency of method use).

Each sampling team will be responsible for collecting half of the blanks. Additional blanks may need to be added if field procedures are materially altered, field conditions warrant more blanks (e.g. windy/dusty/and/or rainy conditions) or if the blank water supply is changed (i.e. they run out and have to request more blank water).

Depending upon the relative concentrations of contaminants observed, the data for each type of blank may be pooled for the purpose of discerning relative degrees of

contamination (e.g., between sample teams, as sampling progresses, etc.) and/or all blank results may be pooled to provide an overall contamination estimate for the entire sample set.

Six TSS, six total metals, and six dissolved metals field duplicate samples will be collected and submitted blind to the lab. With the first shipment and at an overall frequency of one per forty field samples, a laboratory QC sample will be designated. For dissolved metals, this means an extra sample will need to be collected if the special filtration apparatus is used as the sample container on the filtration apparatus is only 500 mL. No extra volume for lab QC should be required for TSS or total metals. Field analyses will be conducted in duplicate at six sample locations. Each field team will be responsible for collection of half of the field QC samples.
The dispersion of the duplicate samples will represent the various sampling areas identified in this plan (i.e., upstream, downstream and effluent). In addition, the initial assessment of the field duplicates will be tied to those areas (especially where divergent analyte concentration ranges are realized between sub-groups of sample duplicates).

6 *Sample Custody Procedures*

The samples will be in the custody of EPA personnel at all times. EPA Region 10 chain of custody forms and procedures will be used. Each cooler of samples shipped to the laboratory must stand alone on the custody documentation (i.e. only samples in the cooler are to be on the custody form).

Minimally, every sample taken in the field will be labeled and accompanied by a chain of custody form when shipped to the laboratory for analysis. EPA Region 10 laboratory Analysis required forms for metals analyses will be completed (TSS can be hand-written/requested on this form). These forms and/or labels will contain:

- Sample identification number
- Date and Time of sample collection
- Sample location identification number and/or description
- Sample matrix type
- Signatures of samplers, sample handlers, and recorders
- Type of analyses required
- Number of containers representing the sample
- Method of Shipment
- Signatures and dates indicating the transfer of sample custody

7 *Calibration Procedures and Preventive Maintenance:*

For all chemical analyses, calibration procedures, frequency and preventive maintenance shall be performed in accordance with the analytical methods cited and/or instrument

manufacturer's recommendations. Additional quality control parameters for water chemistry are given in Tables 1 and 2. The turbidity meter will be calibrated before each measurement in the field.

8 *Analytical Methods:*

Where possible, monitoring/analysis shall be conducted in accordance with 40CFR part 136.3 approved NPDES analytical procedures found in the following references:

- Standard Methods, 18th Edition, 1992
- EPA Methods for the Analysis of Water and Waste Water, EPA EMSL-Cincinnati, EPA-600/4-79-020, Revised March 1983 and 1979 where applicable.
- Appendix C of part 136 (method 200.7)
- Region 10 Alternate Test Procedure for method 200.8 (revision 5.4 found in Methods for the Determination of Metals in Environmental Samples, Supplement I, EPA, EMSL-Cincinnati, EPA/600/R-94/111, May 1994.

See Table 1 in the section on Sample Types for a list of specific method numbers. For analyses to be conducted by the contract lab, see the attached statement of work (Appendix B) and any pre-award alterations approved prior to award by EPA.

For analyses conducted by EPA and/or ESAT, standard reporting formats/deliverables/ approved method modifications routinely employed by the EPA Manchester laboratory are acceptable so long as the DQO's specified in this QAPP are met. EPA Manchester laboratory work assignment managers and/or the Deputy Project Officer will be responsible for overseeing the ESAT contract costs/supplying technical direction to the ESAT contractor in accordance with this QAPP. Just prior to field work, it was anticipated that only EPA will support the TSS analyses to be conducted at the Manchester Laboratory.

9 *Documentation, Data Reduction, and Reporting*

9.1 **Documentation:**

A field data form will be developed and copied onto 'write in the rain' paper. Field data such as descriptive location information, global positioning satellite data, site observations etc. will be recorded on field data forms for each mine location. The field data form will also assist the samplers in completing the chain of custody and analysis required form documentation. The EPA field sample data sheet/chain of custody form and analysis required forms will be used to document the sampling activities. Optionally, dictation to a

tape recorder and photos may be used to further document the sampling activities. There is not a need for precise location description, however the samplers will be locating the sample sites with GPS units.

9.2 Data Reduction and Reporting:

The contract and EPA Regional labs will be responsible for entry into the laboratory data management system. Electronic deliverables are requested for this project. The EPA QA office will be responsible for metals data validation. The EPA Manchester laboratory will be responsible for TSS data validation. The validation of the data will be based on the criteria outlined in the *National Functional Guidelines for Inorganic Data Review (02/94)* and criteria outlined in this QAPP .

9.3 Data Assessment/Analysis:

Validated laboratory data will be provided to the Project Officer, Joe Goulet and David Frank. Joe Goulet and David Frank are primarily responsible for analysis and interpretation of the data.

10 *Performance/System Audits*

Routine performance audits results for the Regional Lab are on record with the Regional QA Officer. No system audit is planned for this investigation.

11 *Corrective Action*

Corrective action procedures that might be implemented from QA results or detection of unacceptable data will be developed when and where required by the field operations personnel.

Sample Alteration Forms will be completed (by field, QA and/or lab personnel) in the event it is necessary to document a change in field and/or laboratory analysis procedures.

Blank Corrective Action and Sample Alteration Forms are attached.

Sample Alteration Form

Project Name and Number: _____

Material to be Sampled: _____

_____

Measurement Parameter: _____

_____

Standard Procedure for Field Collection & Laboratory Analysis (cite reference): _____

_____

_____

_____

Reason for Change in Field Procedure or Analysis Variation:

_____

_____

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_____

_____

Variation from Field or Analytical Procedure:

_____

_____

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_____

Special Equipment, Materials or Personnel Required:

_____

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Initiators Name: _____ Date: _____

Project Officer: _____ Date: _____

QA Officer: _____ Date: _____

Corrective Action Form

Project Name and Number: _____

Sample Dates Involved: _____

Measurement Parameter: _____

_____

Acceptable Data Range: _____

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Problem Areas Requiring Corrective Action:

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Measures Required to Correct Problem:

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Means of Detecting Problems and Verifying Correction:

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Initiators Name: _____ Date: _____

Project Officer: _____ Date: _____

QA Officer: _____ Date: _____

QAPP ADDENDUM - June 30, 1998 Revision 1.0

NOTE: this revision replaces the QAPP addendum for this project that was dated June 19, 1998. This revision changes the digestion procedure for metals and adds a second attachment.

Title of parent QAPP: ALASKA PLACER MINING SURVEY

Author/revision date of parent QAPP: EPA/QADU (Laura Castrilli) Revision 1, August 12, 1997 (date on cover page is June 1997)

Sampling dates: June 23; June 30; July 7; July 17; July 22; July 27 or 28; August 5; August 11; August 19; August 25; and Sept 1 (1998).

Shipping dates: same (or next) day of sampling.

Analyses required: This addendum is for samples to be collected each week specified above by Cindy Godsey. See attachment 1 for DQOs and individual analytes excerpted from the parent QAPP. For this part of the summer of 1998 sampling, four un-filtered samples will be collected each week of sampling and submitted for total recoverable metals, and conventional parameter analyses. Also, each un-filtered metals sample collected will have a corresponding filtered sample that will be collected and submitted for dissolved metals analyses (plus calculated hardness).

Clarification note for total recoverable metals analyses: the digestion procedure for total recoverable metals analyses is required. This procedure is the same as the total metals digestion procedure (for aqueous samples to be analyzed by ICP) that is in the CLP ILM04.0 statement of work for inorganic analyses. **Change:** the second acid (HCL) may be omitted from the total recoverable metals digestion procedure. This change and it's acceptance are discussed in attachment 2 (recent GroupWise memos).

The summary of fixed lab analyses for all anticipated weeks of sampling by Cindy Godsey is:

Parameter or group of compounds	#/MATRIX		
	S	W	Other
total recoverable metals		44	
dissolved metals		44	
Hardness (calculated)		88	
TSS		44	

New sampling locations (if any): Tod Bauer Placer Mine on Eldorado Creek near Talkeetna, Alaska (only location for Cindi's part of the project).

Data due date: Data should be analyzed in batches throughout the project period with the last data analysis due by September 18.

Data validation due date: Data validation can occur throughout the project period with the final validation due by October 6.

Organization responsible for data validation: Quality Assurance & Data Unit

(Laura Castrilli) for metals, Manchester Laboratory for conventionals. QADU can review the conventionals if necessary.

Initiator's Name:	Laura Castrilli	**Date:**	June 30, 1998
Project Officer:	Cindi Godsey	**Date:**	June 30, 1998
QA Officer:	Bruce Woods	**Date:**	June 30, 1998
RSCC:	Melody Walker	**Date:**	June 30, 1998

(NO CHANGES WERE MADE TO ATTACHMENT 1 SINCE THE JUNE 19, 1998 VERSION)

Table 1: Analytical Methods, Containers, Preservation, Holding Time and Detection Limits

Media	Type	Analyte	Container	Method	Detection Limit (μg/L)*	Preservation	Holding Time
Metals**							
Water	Grab	Aluminum	1 Quart Cubitainer[a]	EPA 200.7 and/or 200.8	85.0	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Antimony	a	EPA 200.7 and/or 200.8	140.0	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Arsenic	a	EPA 200.7 and/or 200.8	0.15	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Cadmium	a	EPA 200.7 and/or 200.8	0.35	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Calcium	a	EPA 200.7	1000.0	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Chromium	a	EPA 200.7	50.0	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Copper	a	EPA 200.7 and/or 200.8	3.5	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Lead	a	EPA 200.7 and/or 200.8	0.5	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Magnesium	a	EPA 200.7	1000.0	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Mercury	a	EPA 245.1	0.01	HNO_3 to pH<2, Ice[b]	28 days
Water	Grab	Nickel	a	EPA 200.7 and/or 200.8	10.0	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Selenium	a	EPA 200.7 and/or 200.8	5.0	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Silver	a	EPA 200.7 and/or 200.8	0.35	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	Zinc	a	EPA 200.7 and/or 200.8	30.0	HNO_3 to pH<2, Ice[b]	180 days
Conventional Parameters							
Water	Grab	Hardness	a	c	10,000	HNO_3 to pH<2, Ice[b]	180 days
Water	Grab	pH	Field Measurement	EPA 150.1	1 unit	none	immediate
Water	Grab	Temperature	Field Measurement	EPA 170.1	0°C	none	immediate
Water	Grab	Dissolved Oxygen	Field Measurement	EPA 360.1	50.0	none	immediate
Water	Grab	Set. Solids	Field Measurement	160.5	0.2 ml/l/hr	ice if not immediately analyzed	48 hours
Water	Grab	Conductivity	Field Measurement	EPA 120.1	1 μS	ice if not immediately analyzed	28 days
Water	Grab	Total Suspended Solids	1 quart Cubitainer	EPA 160.2	4,000-5,000	ice	7 days
Water	Grab	Turbidity	Field Measurement	EPA 180.1	<1 NTU	ice	48 hours

Table 1: Analytical Methods, Containers, Preservation, Holding Time and Detection Limits

Media	Type	Analyte	Container	Method	Detection Limit (µg/L)*	Preservation	Holding Time

a - All total metals will be collected in the same 1 quart cubitainer. For dissolved metals, a field filtration procedure developed by Andy Hess at the EPA Manchester laboratory (consisting of a disposable filter/two pieces of connective tubing and a 'tap' cap) will be used for dissolved metals sample collection. See the section on sampling for further discussion of the sample containers.

b - All water samples for metals analysis should be acidified, in the field when the sample is collected, with nitric acid to a pH less than 2. Further, samples should be acidified for at least 16 hours prior to analysis. Icing of the metals samples is not required by CFR Part 136, Table 1B. However, if preservative cannot be immediately added to the samples, the samplers will be icing the samples if they are to be preserved later in the day. Footnote 2 to Table 1B allows for preserving with ice 24 hour automatic composite samples when it is impossible to immediately preserve each aliquot. The metals samples will be iced during shipment in the event TSS aliquots are shipped in the same cooler. Dissolved metals samples will be filtered through a 0.45 um filter prior to acidification to a pH less than 2 with nitric acid. See the section on sampling for a contingency discussion.

c - hardness will be measured as the sum of the calcium and magnesium as measured by Method 200.7 (See notes in Table 1B, 40 CFR Part 136).

* Metals detection limits (except for calcium and magnesium) have been set to the lowest level aquatic life criteria based on a sample hardness of 25 mg/L.

** In the event of equipment failure or unavailability, 200 series Graphite Furnace Atomic Absorption Spectroscopy procedures may be substituted for ICP-MS method 200.8.

1.0 *Project Organization and Responsibility*

The following is a list of key project personnel and their responsibilities:

Organization Manager:	Bob Robichaud
Project Officer:	Cindi Godsey
Study Design:	Phillip North, Carla Fisher, Data Assessment Personnel and Patricia Cirone
Addendum Preparation:	Cindi Godsey and Laura Castrilli
Addendum Review:	Bruce Woods
Field Sampling:	Cindi Godsey and other federal or state personnel
Laboratory Arrangements:	Laura Castrilli for Melody Walker
Laboratory Operation:	Gerald Dodo, ESAT Deputy Project Officer
Data Validation:	Manchester Laboratory (TSS data), Quality Assurance and Data Unit (QADU - metals data)
Data Assessment/Analysis:	Joseph Goulet and David Frank
Report Preparation:	Joe Goulet and Cindi Godsey

1. *Project Description*

Objective and Scope:

This Quality Assurance Project Plan addendum is for the collection and analysis of field samples during 1998 in support of the Placer Mining Survey. This addendum supports the work that will be done in the field out of Anchorage. A second addendum will be prepared for ESAT sampling conducted out of Fairbanks.

1998 Schedule of Sampling Tasks and Milestones:						
Activity	Estimated beginning and ending dates					
	6/19/98	6/23 - 9/1/98	7/20 - 9/18/98*	7/27 - 10/6/98*	9/1- 11/30/98	1/31/99
Addendum Review	x					
Summer of 1998 Field Sampling		x				
Lab Analysis			x			
Data Validation				x		
Data Analysis					x	
Final Report Due						x

2. *QA Objectives*

a. Data Usage:

The data from the Summer of 1998 sampling will be used to determine temporal trends in the relationship between metals and other general parameters. Sampling at one site will be done for 10 or 11 weeks between the week of June 22 and August 31. The last samples should be shipped no later than September 2.

From: LAURA CASTRILLI
To: R10AOO.AOO.GODSEY-CINDI
Date: 6/24/98 2:58pm
Subject: Alaska Placer digestion 'issue'

I've talked to the metals 'gurus' at the lab (Katie and Isa) and in my unit (Don). After these discussions, I've come to the conclusion that for water samples, the difference between total (hard digestion) and total recoverable (soft digestion) is negligible unless a colorimetric method is used to analyze the digestate. Since we are not using colorimetric methods, it should not matter whether one or the other digestion procedure is used (i.e. the resulting data will be within the 20% relative percent difference analytical precision of the method). An exception (not expected to occur that often) would be if there is visible precipitate in the digestate, then obviously the digestion is incomplete.

Isa was under the impression the digestion procedure used in the statement of work (basically we allowed for the use of nitric acid only on the soft digestion technique specified in the ICP-MS method) was followed for the first set - she will be checking on this with Katie. Even if the hard digestion was used, it shouldn't have made a significant difference in the data generated as a colorimetric method wasn't used.

For this year's samples, if the HCL is required for the soft digestion, then be advised that:

1) the HCL's purpose is mainly to keep the silver and antimony in solution - if this isn't happening, then the silver and antimony recoveries on the matrix spike and/or blank spike sample analyses will tell us.

2) If HCL use is mandated, then the higher arsenic detection limit on ICP-AES (40 ug/L) will have to suffice as the HCL interferes with the ICP-MS analysis. The current plan calls for a detection limit of 0.15 ug/L.

Please let me know as soon as possible if the soft digestion without the second acid - HCL (basically the total recoverable metals digestion without HCL) will be acceptable. If that is the case, I'll need to revise the addendum we did last week. **CC:** R0LAB.ADAMS-KATIE, MATHENY-DON, R0LAB.CHAMBERLAIN-...

From: CINDI GODSEY
To: R10SEA1.R0HELENS(CASTRILLI-LAURA)
Date: 6/29/98 7:17pm
Subject: Alaska Placer digestion 'issue' -Reply

Laura,

It sounds like it will work so please do whatever revisions you deem necessary. Thanks for looking into this issue for me.

QAPP ADDENDUM - July 9, 1998 Revision 1.0

NOTE: this addendum is related to the QAPP addendum for this project that was dated June 30, 1998. This addendum covers the samples that will be collected by the ESAT team. Attachment 1 is similar to the June 30, 1998 addendum but has been updated to cover the ESAT work. Attachment 2 is the same as the Attachment 2 for the June 30, 1998 addendum.

Title of parent QAPP: ALASKA PLACER MINING SURVEY

Author/revision date of parent QAPP: EPA/OADU (Laura Castrilli) Revision 1, August 12, 1997 (date on cover page is June 1997)

Sampling dates: July 10; weeks of July 13, July 20, July 27, August 3, August 10, August 17, August 24, and August 31 (1998).

Shipping dates: same (or next) day of sampling.

Analyses required: This addendum is for samples to be collected each week specified above by ESAT. See attachment 1 for DQOs and individual analytes excerpted from the parent QAPP. For this part of the summer of 1998 sampling, 20 un-filtered samples will be collected each week of sampling and submitted for total recoverable metals, and conventional parameter analyses. Also, each un-filtered metals sample collected will have a corresponding filtered sample that will be collected and submitted for dissolved metals analyses (plus calculated hardness).

Clarification note for total recoverable metals analyses: the digestion procedure for total recoverable metals analyses is required. This procedure is the same as the total metals digestion procedure (for aqueous samples to be analyzed by ICP) that is in the CLP ILM04.0 statement of work for inorganic analyses. **Change:** the second acid (HCL) may be omitted from the total recoverable metals digestion procedure. This change and it's acceptance are discussed in attachment 2 (recent GroupWise memos).

The summary of fixed lab analyses for all anticipated weeks of sampling by ESAT is:

Parameter or group of compounds	**#/MATRIX**		
	S	**W**	**Other**
total recoverable metals		160	
dissolved metals		160	
Hardness (calculated)		320	

TSS		160	

New sampling locations (if any): Five sampling locations will be determined that are located in areas near Fairbanks, AK.

Data due date: Data should be analyzed in batches throughout the project period with the last data analysis due by September 18.

Data validation due date: Data validation can occur throughout the project period with the final validation due by October 6.

Organization responsible for data validation: Quality Assurance & Data Unit
(Laura Castrilli) for metals, Manchester Laboratory for conventionals. QADU can review the conventionals if necessary.

Initiator's Name: Gerald Dodo **Date:** July 9, 1998

Project Officer: Cindi Godsey **Date:** July 9, 1998

QA Officer: Bruce Woods **Date:** July , 1998

RSCC: Melody Walker **Date:** July , 1998

Table 1: Analytical Methods, Containers, Preservation, Holding Time and Detection Limits							
Media	**Type**	**Analyte**	**Container**	**Method**	**Detection Limit (µg/L)***	**Preservation**	**Holding Time**
Metals**							
Water	Grab	Aluminum	1 Quart Cubitainera	EPA 200.7 and/or 200.8	85.0	HNO3 to pH<2, Iceb	180 days
Water	Grab	Antimony	a	EPA 200.7 and/or 200.8	140.0	HNO3 to pH<2, Iceb	180 days
Water	Grab	Arsenic	a	EPA 200.7 and/or 200.8	0.15	HNO3 to pH<2, Iceb	180 days
Water	Grab	Cadmium	a	EPA 200.7 and/or 200.8	0.35	HNO3 to pH<2, Iceb	180 days
Water	Grab	Calcium	a	EPA 200.7	1000.0	HNO3 to pH<2, Iceb	180 days
Water	Grab	Chromium	a	EPA 200.7	50.0	HNO3 to pH<2, Iceb	180 days
Water	Grab	Copper	a	EPA 200.7 and/or 200.8	3.5	HNO3 to pH<2, Iceb	180 days
Water	Grab	Lead	a	EPA 200.7 and/or 200.8	0.5	HNO3 to pH<2, Iceb	180 days
Water	Grab	Magnesium	a	EPA 200.7	1000.0	HNO3 to pH<2, Iceb	180 days
Water	Grab	Mercury	a	EPA 245.1	0.01	HNO3 to pH<2, Iceb	28 days
Water	Grab	Nickel	a	EPA 200.7 and/or 200.8	10.0	HNO3 to pH<2, Iceb	180 days
Water	Grab	Selenium	a	EPA 200.7 and/or 200.8	5.0	HNO3 to pH<2, Iceb	180 days
Water	Grab	Silver	a	EPA 200.7 and/or 200.8	0.35	HNO3 to pH<2, Iceb	180 days
Water	Grab	Zinc	a	EPA 200.7 and/or 200.8	30.0	HNO3 to pH<2, Iceb	180 days
Conventional Parameters							
Water	Grab	Hardness	a	c	10,000	HNO3 to pH<2, Iceb	180 days
Water	Grab	pH	Field Measurement	EPA 150.1	1 unit	none	immediate
Water	Grab	Temperature	Field Measurement	EPA 170.1	0°C	none	immediate
Water	Grab	Dissolved Oxygen	Field Measurement	EPA 360.1	50.0	none	immediate
Water	Grab	Set. Solids	Field Measurement	160.5	0.2 ml/l/hr	ice if not immediately analyzed	48 hours
Water	Grab	Conductivity	Field Measurement	EPA 120.1	1 µS	ice if not immediately analyzed	28 days
Water	Grab	Total Suspended Solids	1 quart Cubitainer	EPA 160.2	4,000-5,000	ice	7 days
Water	Grab	Turbidity	Field Measurement	EPA 180.1	<1 NTU	ice	48 hours

a - All total metals will be collected in the same 1 quart cubitainer. For dissolved metals, a field filtration procedure developed by Andy Hess at the EPA Manchester laboratory (consisting of a disposable filter/two pieces of connective tubing and a 'tap' cap) will be used for dissolved metals sample collection. See the section on sampling for further discussion of the sample containers.

b - All water samples for metals analysis should be acidified, in the field when the sample is collected, with nitric acid to a pH less than 2. Further, samples should be acidified for at least 16 hours prior to analysis. Icing of the metals samples is not required by CFR Part 136, Table 1B. However, if preservative cannot be immediately added to the samples, the samplers will be icing the samples if they are to be preserved later in the day. Footnote 2 to Table 1B allows for preserving with ice 24 hour automatic composite samples when it is impossible to immediately preserve each aliquot. The metals samples will be iced during shipment in the event TSS aliquots are shipped in the same cooler. Dissolved metals samples will be filtered through a 0.45 um filter prior to acidification to a pH less than 2 with nitric acid. See the section on sampling for a contingency discussion.

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Addendum Preparation: Cindi Godsey and Gerald Dodo
Addendum Review: Bruce Woods
Field Sampling: ESAT
Laboratory Arrangements: Laura Castrilli for Melody Walker
Laboratory Operation: Gerald Dodo, ESAT Regional Project Officer
Isa Chamberlain, ESAT Work Assignment Manager
Data Validation: Manchester Laboratory (TSS data), Quality Assurance and Data Unit (QADU - metals data)
Data Assessment/Analysis: Joseph Goulet and David Frank
Report Preparation: Joe Goulet and Cindi Godsey

1. *Project Description*

Objective and Scope:

This Quality Assurance Project Plan addendum is for the collection and analysis of field samples during 1998 in support of the Placer Mining Survey. This addendum supports the work that will be done in the field out of Fairbanks, AK.

1998 Schedule of Sampling Tasks and Milestones:						
Activity	Estimated beginning and ending dates					
	7/07/98	7/10 - 9/4/98	7/13 - 9/18/98*	7/27 -10/6/98*	9/1-11/30 /98	1/31/99
Addendum Review	x					
Summer of 1998 Field Sampling		x				
Lab Analysis			x			
Data Validation				x		
Data Analysis					x	
Final Report Due						x

2. *QA Objectives*

a. **Data Usage:**

The data from the Summer of 1998 sampling will be used to determine temporal trends in the relationship between metals and other general parameters. Sampling at five sites will be done for eight weeks between the week of July 13 and August 31. The last samples should be shipped no later than September 4.

From: LAURA CASTRILLI
To: R10AOO.AOO.GODSEY-CINDI
Date: 6/24/98 2:58pm
Subject: Alaska Placer digestion 'issue'

I've talked to the metals 'gurus' at the lab (Katie and Isa) and in my unit (Don). After these discussions, I've come to the conclusion that for water samples, the difference between total (hard digestion) and total recoverable (soft digestion) is negligible unless a colorimetric method is used to analyze the digestate. Since we are not using colorimetric methods, it should not matter whether one or the other digestion procedure is used (i.e. the resulting data will be within the 20% relative percent difference analytical precision of the method). An exception (not expected to occur that often) would be if there is visible precipitate in the digestate, then obviously the digestion is incomplete.

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Date: 6/29/98 7:17pm
Subject: Alaska Placer digestion 'issue' -Reply

Laura,

It sounds like it will work so please do whatever revisions you deem necessary. Thanks for looking into this issue for me.

Appendix B
Field Reports

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue
Seattle, Washington 98101

October 27, 1998

Reply To
Attn Of: AOO/A

MEMORANDUM

SUBJECT: Alaska Placer Mining Survey Sampling Report

FROM: Cindi Godsey
Project Coordinator

TO: Robert R. Robichaud
Manager, NPDES Permits Unit

Alaska Placer Mining Survey
Sampling Trip Report

During the summer of 1998, EPA collected a total of 120 samples from four different mine sites located near Talkeetna and Fairbanks, Alaska. These four sites were:

Tod Bauer	Eldorado Creek (near Talkeetna)
John McClain	Ketchum Creek (near Central)
Sam Koppenberg	Faith Creek (near Fairbanks)
Largen Claims	Ester Creek (near Fairbanks)
	(This site did not discharge during the course of the study.)

Sample collection for the Alaska Placer Mining Survey occurred between June 23 and September 2, see Attachment 1 for the Sampling Calendar. Sampling at the Talkeetna mine, conducted by Cindi Godsey (EPA) with other EPA and Federal government staff, began on June 23 and continued through September 1. Sampling near Fairbanks was conducted by Lockheed Martin contractors (ESAT) and began the week of July 13 and continued through the week of August 31.

The sampling plan was followed with some exceptions. Dissolved oxygen was not measured at the Talkeetna mine due to limitations on time available in the field and

availability of field equipment. Turbidity was not measured during the first week due to problems with calibrating the turbidimeter.

A total of 4 mines were sampled resulting in 120 samples including duplicates. Attachment 2 contains the results of the field measurements for each week of sampling. The only site which was granted a mixing zone was the mine on Ketchem Creek. The downstream sampling point was set to coincide with the edge of the designated Alaska Department of Environmental Conservation mixing zone.

Bad weather resulted in the loss of a week of sampling in Talkeetna. A week was also lost when the helicopter was being repaired. Heavy rainfall in the Fairbanks area caused a washout of part of the Steese Highway during the first week of sampling. Access to the Faith Creek mine was impeded on several occasions due to high water but the sampling crew was able to return later in each week to conduct sampling.

EPA plans on completing a final written report analyzing the data by January 31, 1999.

ID	pH	DO mg/L	Cond umhos	Turbidity NTU	Set. Solids ml/L	degC	Temp (creek)	Location Point	Dup	Round
98290339	7.53	10.39	221	1.9	0	7.3	Ester	Background		1
98290335	7.31	6.50	306	2.3	0	8.2	Ester	Downstream		1
98300377	7.36	13.04	162	5.8	0	5.8	Ester	Background		2
98300373	7.12	9.85	295	2.1	0	8.9	Ester	Downstream		2
98310443	7.63	11.34	178	1.85	0	4.9	Ester	Background		3
98310439	7.32	7.65	303	2.95	0	8.6	Ester	Downstream		3
98320477	7.63	10.40	191	3.04	0	5.5	Ester	Background		4
98320473	7.30	6.91	295	3.81	0	9.0	Ester	Downstream		4
98330323	7.25	11.40	124	3.44	0	3.7	Ester	Background		5
98330319	7.07	7.72	234	4.14	0	9.6	Ester	Downstream		5
98340377	6.94	15.54	88	8.96	0	2.8	Ester	Background		6
98340373	7.09	12.95	180	25.4	0	6.7	Ester	Downstream		6
98350423	7.00	15.03	157	3.11	0	3.5	Ester	Background		7
98350427	7.41	17.92	156	2.85	0	3.5	Ester	Background	D	7
98350419	6.95	10.23	240	4.63	0	8.2	Ester	Downstream		7
98360485	7.08	13.18	187	2.26	0	3.1	Ester	Background		8
98360477	6.77	8.28	266	2.7	0	8.0	Ester	Downstream		8
98360481	6.79	8.10	266	2.38	0	8.1	Ester	Downstream	D	8
98290315	7.44	13.14	50	0.44	0	6.3	Faith	Background		1
98290303	7.70	8.18	62	1.08	0	6.9	Faith	Downstream		1
98290311	7.58	10.99	105	19.7	0	11.5	Faith	Effluent		1
98290307	7.61	10.85	102	18.8	0	11.3	Faith	MIXING		1
98290347	7.78	11.80	71	0.97	0	8.0	Faith	Upmixing		1
98290351	7.65	11.95	71	1.4	0	8.1	Faith	Upmixing	D	1
98300393	7.54	12.67	59	1	0	9.9	Faith	Background		2
98300381	7.67	13.85	78	8.8	0	8.9	Faith	Downstream		2
98300385	7.08	11.66	162	2.4	0	9.6	Faith	Effluent		2
98300389	7.57	13.95	76	5.2	0	9.9	Faith	Upmixing		2
98310435	7.64	11.20	58	0.05	0	9.1	Faith	Background		3
98310419	7.61	11.02	77	1.91	0	9.4	Faith	Downstream		3
98310423	7.12	8.98	158	3.2	0	10.6	Faith	Effluent		3
98310427	7.35		159	3.03	0	10.4	Faith	Effluent	D	3
98310444	7.71	10.88	79	53	0	9.0	Faith	GRAB		3
98310431	7.68	10.81	76	1.65	0	9.3	Faith	Upmixing		3
98320493	7.69	10.81	59	0.27	0	8.3	Faith	Background		4
98320481	7.80	10.80	74	1.39	0	8.2	Faith	Downstream		4
98320489	7.29	8.13	103	798	0	9.4	Faith	Effluent		4
98320485	7.73	10.34	76	2.73	0	8.8	Faith	Upmixing		4
98330339	6.43	11.05	48	0.46	0	6.4	Faith	Background		5
98330327	7.49	11.33	70	4.61	0	6.7	Faith	Downstream		5
98330331	6.90	7.50	103	564	0	8.8	Faith	Effluent		5
98330335	7.03	10.88	73	5.5	0	6.9	Faith	Upmixing		5
98340393	7.20	12.17	58	1.83	0	4.7	Faith	Background		6
98340381	7.05	11.89	57	7.5	0	4.1	Faith	Downstream		6
98340385	7.00	8.62	103	372	0	7.0	Faith	Effluent		6
98340389	7.33	12.20	62	6.67	0	4.5	Faith	Upmixing		6
98350443	7.19	14.17	55	0.38	0	5.0	Faith	Background		7
98350435	7.46	12.60	85	1050	1.2	7.0	Faith	Discharge		7
98350431	7.13	14.11	65	19.1	0	4.8	Faith	Downstream		7
98350447	6.97	8.72	106	384	0.2	7.1	Faith	Effluent		7
98350439	7.24	14.75	67	4.01	0	5.0	Faith	Upmixing		7
98360457	7.09	13.91	60	0.35	0	3.8	Faith	Background		8
98360453	6.87	14.89	72	0.66	0	3.8	Faith	Downstream		8
98290331	5.69	13.03	20	16.4	0.1	2.7	Ketchem	Background		1
98290319	6.84	8.70	38	54.4	0.1	6.9	Ketchem	Downstream		1
98290327	6.71	8.00	87	251	0	17.0	Ketchem	Effluent		1
98290323	6.70	9.11	33	31.9	0.1	5.7	Ketchem	Upmixing		1
98300369	6.20	12.60	30	5.7	0	4.6	Ketchem	Background		2
98300353	6.97	10.30	62	170	0	10.9	Ketchem	Downstream		2
98300361	6.57	10.15	108	1800	0	16.6	Ketchem	Effluent		2
98300365	6.57	9.75	111	1600	0	16.9	Ketchem	Effluent	D	2
98300357	6.95	13.60	49	34	0	10.7	Ketchem	Upmixing		2
98310415	6.23	13.61	28	2.4	0	3.7	Ketchem	Background		3
98310403	7.08	12.95	69	210	0	9.0	Ketchem	Downstream		3
98310407	6.60	10.34	101	2000	0	10.9	Ketchem	Effluent		3
98310411	7.12	12.98	57	33	0	9.4	Ketchem	Upmixing		3
98320469	6.11	11.88	25	2.46	0	4.2	Ketchem	Background		4

ID	pH	DO mg/L	Cond umhos	Turbidity NTU	Set. Solids ml/L	degC	Temp (creek)	Location	Point	Dup	Round
98320453	7.09	10.69	67	142	0	8.7	Ketchem	Downstream			4
98320457	7.07	10.67	64	138	0	8.3	Ketchem	Downstream		D	4
98320465	6.68	8.20	107	2180	0	12.1	Ketchem	Effluent			4
98320461	7.04	10.98	52	16.7	0	7.8	Ketchem	Upmixing			4
98330315	5.81	12.05	27	7.57	0	3.2	Ketchem	Background			5
98330303	6.77	11.43	47	53.5	0	5.6	Ketchem	Downstream			5
98330311	6.57	8.74	108	1000	0	9.7	Ketchem	Effluent			5
98330307	6.79	11.53	39	12.7	0	5.6	Ketchem	Upmixing			5
98340369	6.06	15.47	27	1.44	0	3.0	Ketchem	Background			6
98340353	6.66	13.89	64	162	0	5.9	Ketchem	Downstream			6
98340357	6.76	13.96	64	195	0	6.1	Ketchem	Downstream		D	6
98340361	6.70	11.25	87	1642	0	7.7	Ketchem	Effluent			6
98340365	6.93	14.32	51	14.5	0	5.8	Ketchem	Upmixing			6
98350415	6.20	17.50	25	0.85	0	2.7	Ketchem	Background			7
98350403	6.82	15.10	72	28.8	0	5.8	Ketchem	Downstream			7
98350407	6.77	10.52	109	179	0	10.1	Ketchem	Effluent			7
98350411	7.01	13.30	65	65.9	0	7.0	Ketchem	Upmixing			7
98360473	6.17	5.72	22	1.41	0	1.5	Ketchem	Background			8
98360461	6.52	14.16	68	177	0	4.4	Ketchem	Downstream			8
98360465	6.78	9.85	135	139	0	6.4	Ketchem	Effluent			8
98360469	7.14	13.97	70	278	0	5.6	Ketchem	Upmixing			8
98264950	7.55		139		T	8	Eldorado	Downstream			1
98264952	7.34		180		T	7	Eldorado	Effluent			1
98264954	7.27		138		T	7	Eldorado	Upstream			1
98264956	7.78		125.5		T	7	Eldorado	Background			1
98274958	8.01		165.2	0.6	T	10	Eldorado	Downstream			2
98274960	7.93		190.7	1.5	T	10	Eldorado	Effluent			2
98274962	7.91		146.8	1.75	T	10	Eldorado	Upstream			2
98274964	8		138.2	1.5	T	11	Eldorado	Background			2
98294966	7.81		213	1.5	T	10	Eldorado	Downstream			3
98294968	7.62		223	2.8	T	9	Eldorado	Effluent			3
98294974							Eldorado	Effluent		D*	3
98294970	6.77		208	2.4	T	9	Eldorado	Upstream			3
98294972	8.05		199	2	T	9	Eldorado	Background			3
98314976	7.9		164	1.4	T	8	Eldorado	Downstream			4
98314978	7.22		194.6	2.5	T	8	Eldorado	Effluent			4
98314980	7.66		147.3	1.2	T	8	Eldorado	Upstream			4
98314982	7.84		140.8	<0.5	T	8	Eldorado	Background			4
98334984	7.13		165.6	0.84	T	8	Eldorado	Downstream			5
98334986	6.67		188.5	3.6	T	8	Eldorado	Effluent			5
98334988	7.27		168.5	2.52	T	8	Eldorado	Upstream			5
98334990	7.47		159	0.43		7	Eldorado	Background			5
98344950	7.56		190.9	16	0.1	6	Eldorado	Downstream			6
98344952	7.05		188	10.25	T	8	Eldorado	Effluent			6
98344954	7.37		215	12.4	T	6	Eldorado	Upstream			6
98344956	7.6		186	1.3	T	7	Eldorado	Background			6
98354960	6.77		212	2.8	T	9	Eldorado	Downstream			7
98354962	7.12		211	3.5	T	7	Eldorado	Effluent			7
98354964	7.37		188	1.32	T	6	Eldorado	Upstream			7
98354966			177		T	6	Eldorado	Background			7
98364970	7.24		270	3.83	T	7	Eldorado	Downstream			8
98364972	7.21		261	19.3	0*	7	Eldorado	Effluent			8
98364968							Eldorado	Effluent		D*	8
98364974	7.6		264	4.6	T	6	Eldorado	Upstream			8
98364976	7.59		248		T	7	Eldorado	Background			8

T = Trace

D* = Duplicate sent to lab for analysis

0* = actually no measure of settleable solids
Fairbanks team only differentiated between measurable and not thus designating anything less than 0.1 as 0

Summary of 1998 ESAT field work for the Alaska Placer Mines Project

The ESAT sampling team met with Cindi Godsey (US EPA-AOO) and Jim Corpuz (US EPA-Seattle) to discuss site reconnaissance, during the week of July 5-10. ESAT and C. Godsey conducted field reconnaissance of each mining site by helicopter. The ESAT sampling team was directed to begin sampling each of three sites on a weekly basis. ESAT was directed by EPA to take one field duplicate sample per week (beginning with the effluent, and/or based on a rain event) and not to take field blanks throughout the study. Moreover, if any designated mixing zones were observed (where effluent and creek water mix), the downstream sample was to be taken at end of the zone. If there was no designated mixing zone, ESAT was instructed to estimate the location of the downstream sample. If there is no effluent discharge into the creek, the sampling team was directed to take a downstream and background sample, as well as a sample at the point where the discharge would "normally" enter the creek

Alaska Placer Mining Study
July 13-19, 1998
Sampling Week #1

General Issues:

Vendor/supplier shipped nitric acid sample vials with no nitric acid in them. ESAT logistics staff immediately notified the supplier and nitric acid was expedited to Fairbanks immediately. The ESAT sampling team leased a cellular phone with voice mail to ensure all outside communications were received.

Faith Creek:

To get to the downstream sampling locale, ESAT was required to either walk across Faith Creek, or drive the vehicle through the creek (no bridge was available). Since it is estimated that two people crossing on foot is as disturbing as one vehicle, and for safety reasons, the truck was used to cross the creek

The downstream sample was to be secured below the rapids (as per overflight reconnaissance). This location was sampled ~750 feet downstream of the effluent discharge point.
ESAT erroneously sampled the mixing zone, not immediately upstream of the mixing zone (referred to as upstream sample) on July 13. However, ESAT returned to Faith Creek on July 17 to locate the proper upstream location and took both a sample and a field duplicate All field instruments requiring initial and/or weekly calibrations were calibrated at the site on July 13.

It was noted that the effluent discharge stream forked and entered the creek at two locations ~50 ft apart. ESAT chose the lower of the two forks to sample. It was at this site that the sampling team realized that the nitric acid (HNO_3) was missing from the sample vials. ESAT

kept the samples on ice until Jim Corpuz (USEPA) provided ESAT with surplus acid that evening. The samples were preserved prior to shipping to the laboratory.

The turbidity meter provided to us on the evening of July 16 by Alaska Department of Environmental Conservation (ADEC) (via J. Corpuz) was used on the field duplicate upstream sample pair collected on July 17. The meter had not been calibrated, but was accurate when reading the 1.0 and 10.0 NTU standards. To ensure data confidence, additional 1-quart cubitainer samples were collected and shipped to the laboratory for turbidity measurements. Active mining operations were underway during this sampling visit

Ketchem Creek:

There was no HNO_3 available to preserve the filtered and unfiltered metals fractions, so extra ice was purchased and placed in double Ziploc bags to ensure the samples were kept at 4 °C until received at the laboratory (the cubitainers, as well as the custody forms, indicated that acid preservation was required. The sampling day was routine.

Ester Creek:

There was neither an effluent discharge coming from the last settling pond nor clear evidence that the second to last settling pond was feeding the last pond (C. Godsey suggested this be sampled if no effluent was discharging). Thus, only two sampling points were sampled this day; background and downstream. Although maintenance operations were being performed, no actual mining activities were being conducted during this visit.

The turbidity meter malfunctioned, so no field turbidity measurements were taken. Spare cubitainers were filled and labeled for turbidity analysis in the laboratory. ESAT received HNO_3, and resumed the process of preserving all filtered and unfiltered metals fractions in the field.

Alaska Placer Mining Study
July 20-26, 1998
Sampling Week #2

General Issues:

None.

Ketchem Creek:

Spoke to John McClain (Jr.), who brought up the following issues: (1) he said it was not a good day to sample, as they had just hit some dark, iron-like deposit and groundwater, causing the water to turn murky; (2) he was concerned that the discharge at Ketchem Creek, with its relatively low flow, would be compared to mining activities and effluent discharges at Faith

Creek, where the volume of the water is much greater; (3) he stated that mining activities were currently going on above his mine, but ESAT did not observe this. The sampling team said that his concerns would be documented, but that the samples were being collected as directed by the EPA and would continue unless otherwise instructed or if factors such as reductions or increases in effluent or creek flows required these changes

The small diversion of Ketchem Creek water which was flowing into the effluent stream had dried up. Although the effluent sample could now feasiblely be taken closer to where the effluent discharges into Ketchem Creek, the original sampling point was not changed, as per instructions from Cindi Godsey (USEPA Project Manager).

The effluent samples were extremely difficult to filter due to clogging of the filter with suspended solids. The effluent sample also had to be diluted 1:1 with distilled water in order to get a turbidity measurement within the 1100 NTU range. Otherwise, field sampling and analysis operations were routine. Weekly field duplicate samples were taken from the effluent sample locale.

Ester Creek:

The rain gauge read 1.3 inches. No effluent water was discharging from the last settling pond, although effluent water was present. The next-to-last settling pond was dry and, therefore, no effluent was flowing from the pipe into the last settling pond. As a result, only the downstream and background samples were collected. The mine was not active when the creek was sampled, but began operating as ESAT left the site.

Faith Creek:

The downstream sampling site appeared to be visibly more turbid and water appeared to be higher up on the bank than the previous week. Effluent discharge flow was greatly reduced from the previous sampling week. The effluent volume in the settling pond had lowered significantly and the discharge that had been flowing from a breach in the berm/earthen dam on the downstream side of the pond had stopped. The effluent stream was relatively clear and the flow appeared to be coming from water percolating from and collecting in a catchment below the settling pond, as well as from contributions of runoff from the steep slopes and marshy areas around it. The water level of the creek at the background site has lowered significantly (e.g., during the previous week, the sampling team could not cross the creek wearing rubber boots, but were able to this week). The mine was operating.

Alaska Placer Mining Study
July 27 - August 02, 1998
Sampling Week #3

General Issues:

None.

Ketchem Creek:

At the downstream sample location, the creek volume was much less than in previous visits. As a result, ESAT moved the sample location downstream ~2 ft and in the center of the creek channel in order to obtain a sample more representative of the Ketchem Creek flow. Additionally, the effluent stream was more shallow and flowing slower. Again, the effluent samples were difficult to filter and had to be diluted 1:1 in order to get a turbidity measurement within the 1100 NTU range of the turbidimeter. The mine was operating at the time the samples were collected

Faith Creek:

The effluent stream flow was greatly reduced from the previous week. Although ESAT was able to collect a sample, this sample may have been water seeping from the ground around the marshy (wetland) area surrounding this sample point. The weekly field duplicate sample was taken from this locale. The mine was not operating on the day of sampling.

The dissolved oxygen (DO) meter malfunctioned. An attempt was made at using the backup Hach kit, but the results were unsatisfactory. Cubitainers were collected in the event this analysis could be performed at a later date, but this was later deemed as inappropriate. The Orion technical service staff was contacted and the malfunction was corrected. The sampling team returned to Faith Creek on July 31 and collected DO (and pH and conductivity) measurements at all four sampling locations.

While at the site on July 31, the sampling team observed a "slug" of murky, turbid water in Faith Creek. This occurred at 10:00 am and lasted approximately 45 minutes. This event took place after the downstream measurements were taken, so the sampling team returned to the downstream location; noticed that, although the creek bottom had been clearly visible prior to this event, even the boulders near the surface of the water were now obfuscated. ESAT proceeded to remeasure pH, DO, conductivity, turbidity, and collected a grab sample for total metals analysis, in the event the EPA was interested in analyzing the sample. The event was over (i.e., the creek was once again clear) before the sampling team reached the next sampling site.

Ester Creek:

No effluent water discharge was observed. Only the downstream and background samples were collected. No mining operations were noted during our site visit.

General Issues:

The LaMotte turbidimeter was malfunctioning; so the Hach Turbidimeter (borrowed from ADEC) was used. ESAT decided to perform all turbidity measurements off site upon return to our lodging location, as the increasing rain events could compromise the data in the field.

Ketchem Creek:

Weekly duplicate sample collected from downstream location. Effluent samples continued to be difficult to filter. Spoke with John McClain Sr. (miner). He requested and was provided with Cindi Godsey's telephone number. He disagreed with the logic of the sampling points selected. He said that the effluent being sampled wasn't from his operation. ESAT informed him that we were directed by US EPA to sample these locations. The mine was operating at the time the samples were collected

Faith Creek:

C. Godsey was informed on August 4 about the issues regarding the effluent stream's lack of flow and the slug of effluent observed on July 31. She directed the sampling team to send the metals sample collected during the effluent event to the laboratory for analysis. When informed of the possibility that the effluent was now discharging from a settling pond ~1.5 miles farther upstream from the current effluent sampling site, she directed the team to recon the site and change the effluent, upstream, and downstream points if there is discharge from that pond; if not, to continue sampling at the current points (see Faith Creek map).

ESAT performed the requested site reconnaissance. The settling pond adjacent to the cabins exhibited a trickle of effluent discharging into Faith Creek which was clear in appearance. Mining operations had relocated downstream and across the creek from its previous location. A final settling pond was identified, which had effluent discharging into Faith Creek from a seep below the berm/dam of the final settling pond. Thus, ESAT relocated the downstream, upstream, and effluent sampling locales (the background sampling point remained the same). The mine was active on the day of sampling.

Ester Creek:

As with the previous weeks, no effluent water was discharging from the last settling pond. Only the downstream and background samples were collected. Mining operations were not active during the ESAT site visit. ESAT continued to experience calibration problems with the field turbidimeter. In response, the Hach turbidimeter was used and quart cubitainers were collected and sent to the laboratory for turbidity measurements.

Sampling Week #5

Ketchem Creek:

The mine was operating when sampling was performed.

Ester Creek:

Site was very soggy and wet. More than 1.3" of rain fell in the last week, however no effluent discharge was observed. Background and downstream samples were collected. Mining operations were active, including earth moving equipment and sluice box processing.

Faith Creek:

The weather is turning much colder, and rain events have been more frequent this week. 1.1 inches of rain fell at the background location. ESAT ordered a new pH triode as a backup unit.

Alaska Placer Mining Study
August 18-23, 1998
Sampling Week #6

Ketchem Creek:

The Steese Highway is getting fairly rough with many chuckholes and lots of washboarding. A duplicate sample was taken at the downstream sample point.. The weather was cold, wet and raining. The mine was in full operation. The ground is saturated with many seep points some of which were rather turbid. None of these smaller flows were sampled. Several hundred meters upstream of the background site someone had cleared about 1 acre with a tracked excavator. It did not appear to affect the background sample as there was no continuous flow from the cleared site to the background sample site.

Ester Creek:

The site was very wet and soggy, and ambient temperatures were near freezing. Stream flows had noticeably increased, and were more turbid. Both downstream and background samples were secured. No effluent discharge was observed.

Faith Creek:

ESAT could not get to the sampling locations with vehicle. Faith Creek was too high and swift to attempt a fording. ESAT hiked up the south side of Faith creek to get to the sampling sites. The water at the downstream site was too deep and swift to safely get to the actual

sampling site. Another site in approximately the same area was selected. No stream depth was taken at this site. The effluent and upstream samples were taken in the same locations as in Week 5. Due to the walking distance upstream to the background site, ESAT decided to sample above any current mining or road building activities, but at a point well downstream of the established background sampling location. No rainfall measurement was taken this week.

Alaska Placer Mining Study
August 24-26, 1998
Sampling Week #7

Ketchem Creek:

The entire mining operation has been moved several hundred yards upstream. The creek had been rerouted between the background sample location and the upstream sample locale. Greater turbidity was noted in the upstream samples.

Ester Creek:

The mine was not in operation today. Secured the weekly duplicate sample at the background location.

Faith Creek:

ESAT was able to safely cross the stream with the field vehicle. It was noted that the stream channel had changed due to recent flooding conditions. While sampling the effluent sample from the normal location a plume of turbidity was observed in the main channel. The source of the turbid water was located and sampled. This necessitated the moving of the upstream sample about 150 feet upstream so that it was above the source of the turbid water. Road maintenance activities were found to be the source of the "effluent" plume. ESAT collected an effluent sample from the maintenance activity area, labeled "discharge."

Alaska Placer Mining Study
August 31-September 2, 1998
Sampling Week #8

Faith Creek:

The stream levels were down from Week 7. Only 0.25" rain fell since the last sampling event. The mine was not operating. No effluent was observed, so we did not take an effluent or an upstream sample.

Ketchem Creek:

Mr. McClain (miner) informed ESAT that they were doing reclamation work today. The stream was even more turbid than the effluent. The move to the upstream site appears to be complete. Three new settling ponds had been constructed and no effluent was visible from any of them. Most of the muddy water is flowing into the upper settling pond, however, some is escaping into the creek.

Ester Creek:

The stream levels were down. Only 0.32" rain since last sampling event. Secured weekly duplicate sample at downstream site. No mining operations were observed.

Appendix C
Description of Placer Mining Districts, from Nokleberg and Others (1996)

Appendix C. Description of placer mining districts, from Nokleberg and others (1996).

No. 3-- Valdez Creek District
Major commodities: Placer Au, Au, Cu, Pb

Summary Description:
Valdez Creek placers exhibit a complex Pleistocene history. Gold produced from modern stream gravels and from channels is ancestral to Valdez Creek and is buried by up to 60 m of till and glacio-fluial deposits. Main pay channels considered to be Sangamon (mid Pleistocene) in age. District mined by open pit and sluice methods. Heavy minerals are gold, magnetite, pyrite, zircon, sphene, sillimanite, kyanite, galena, realgar, orpiment, hessite (a silver telluride). Gold in district probably derived from polymetallic vein deposits associated with Cretaceous granitic rocks. Extensive recent mining; currently the largest placer mine in Alaska. Other smaller placer mines in district include White, Black, and Timberline Creeks, and Lucky Gulch. Local bedrock is Late Jurassic or older metasedimentary rocks, Mesozoic graywacke, and Cretaceous and early Tertiary granitic plutons.

References Chapin, 1918; Capps, 1919; Tuck, 1938; Smith, 1970; Cobb, 1973; Bressler and others (1985); Fechner and Herzog, 1990; Reger and Bundtzen, 1990; Bundtzen and others, 1996.

No. 27-- Council District (Includes Solomon) Note: Cobb places the Solomon area in the adjacent Nome District
Major commodities: Au, W, Hg, Cu

Summary Description:
District contains beach, modern stream, and rare bench gold placers. Heavy minerals dominated by arsenopyrite, magnetite, and scheelite. Mined mainly by dredging and sluicing. Gold in district probably derived from Au-bearing quartz vein deposits in metamorphic rocks of the Nome Group, such as the Big Hurrah Gold-Tungsten deposit. Local bedrock is schist, marble, dolomite, and thin quartz veins.

References: Collier and others, 1908; Smith, 1910; Smith and Eakin, 1911; Cobb, 1973; Bundtzen and others, 1996.

No. 28-- Fairhaven District (Includes Candle and Inmachuk)
Major commodities: Au, Pb, W, Pt, Ag

Summary Description:
District contains rich placer gold deposits on Candle Creek and Inmachuk River. Major streams extensively dredged; substantial resources remain unmined in buried drainages in northern part of district. Buried gold-rich channel gravel occur in vicinity of Mud Creek. Most production on Candle Creek was from left limit bench (paleo-Candle Creek) about 600 m wide and 6 km long. Placers at Kiwalik Flat occur at mouth of Paleo-Candle Creek and were partially reworked by marine conditions. Auriferous bench deposits occur 30 m above Inmachuk River and are overlain by a 5.7 Ma basalt flow. Heavy minerals are galena, magnetite, scheelite, sphalerite, and trace platinum metals. Gold probably derived from polymetallic vein lode deposits associated with Cretaceous granitic plutons or alternatively from Au-bearing quartz veins in metamorphic rocks, or alternatively from Au-bearing quartz veins in metamorphic rocks. Local bedrock consists of schist, marble, granitic plutons, and Tertiary basalt.

References: Henshaw, 1909; Cobb, 1973, T.K.Bundtzen, written commun., 1991; Bundtzen and others, 1996.

No 29– Kougarok District
Major commodities: Placer Au-Sn, Au, Sn, W

Summary Description:
District contains large gold resources that occur in Quaternary(?) glacial outwash gravels of the Tertiary and Quaternary(?) Kougarok Gravels. Buried Tertiary gravels and conglomerates may be gold source. Most mining by dredging. Heavy minerals are gold, pyrite, magnetite, hematite, cassiterite, scheelite, cinnabar, and lead sulfides. Richest areas in Iron and Taylor Creeks and near Coffee Dome. Placer gold derived mainly from low-sulfide Au-bearing quartz veins in metamorphic rocks and from Sn lode deposits associated with Cretaceous granitic plutons. Local bedrock is schist, slate, marble, and granitic rocks.

References: Collier and others, 1908; Cobb, 1973; Eakins, 1981; Bundtzen and others, 1996.

No 33– Sepentine District
Nokleberg et al does not include a description of the Serpentine District.

No. 44– Bonnifield District

Major commodities: Au, Ag, Hg, Pt, Sn, W

Summary Description:
Placer gold occurs in sreams and a few benches. Thick glaciofluvial deposits and loess cover much of district. Heavy minerals include various sulfides, scheelite, cassiterite, and cinnabar; PGE are found in Daniels Creek. Gold in district probably derived from Cretaceous or early Tertiary Au-bearing quartz or polymetallic vein lodes and middle or older Kuroko massive sulfide deposits in Yukon-Tanana terrane, with probable recycling through Tertiary gravels. Local bedrock is Paleozoic or older metasedimentary and metavolcanic rocks of the Yukon-Tanana terrane, and Cretaceous granitic plutons.

References: Capps, 1912; Cobb, 1973; Gilbert and Bundtzen, 1979; Bundtzen and others, 1996.

No. 47-- Circle District
Major commodities: Placer Au, Au, Ag, Sn, Sb, W, Pb, REE, Mo, Hg

Summary Description:
Gold occurs in alluvial and colluvial deposits (2 to 5 m thick), frequently overlain by 1 to 2 m of muck. Non-glaciated, broad upland of nearly accordant ridge crests. Large gold resource may occur in lower reaches of Crooked and Birch Creeks, and in the topographic trough south of Crazy Mountains. Larger deposits are at Mammoth Creek, Deadwood Creek, Eagle Creek, and Coal Creek. Gold in district probably derived from Cretaceous or early Tertiary Au-bearing quartz vein, polymetallic vein, skarn, porphyry lode, and volcanogenic massive sulfide deposits in region in mid Paleozoic or older metamorphic rocks of Yukon-Tanana terrane, with recycling through Tertiary conglomerates. Alluvial diamonds found in placer concentrates during the 1980's. Local bedrock consists of middle Paleozoic or older metasedimentary rocks of Yukon-Tanana terrane, and Cretaceous granitic plutons.

References: Prindle, 1913; Mertie, 1938; Heiner and Wolff, 1968; Cobb, 1973; Yeend, 1982, 1987, 1991; Menzie and others,
1983; Lasley, 1985; Bundtzen and others, 1996.

No. 50-- Fairbanks District
Major commodities: Placer Au, Au, Sb, W, Sn, Ag , Bi

Summary Description:
Placer deposits occur in streams that radially drain three mineralized areas in Fairbanks District, Ester Dome, Cleary-Pedro Dome, and Gilmore Dome. Nearly all placers consist of buried streams that were ancestral to Cleary, Goldstream, Fairbanks, Engineer, Dome, Eldorado, Treasure, Little Eldorado, Ester, Cripple, Gilmore, and Smallwood drainage basins. Largest placer deposits in Cleary, Fairbanks, Goldstream and Cripple Creek drainages. Deposits are buried by thick sections of frozen loess and mud. Recent stratigraphic and radiometric age studies suggest that most bench deposits in district are Pliocene. Over 30 heavy minerals are identified and include stibnite, scheelite, bismuthinite, native bismuth, and galena. Stibnite and scheelite have been commercially recovered from placers. Placer gold derived from: (1) several hundred mineralized veins in Ester Dome and in the Cleary Hill-Pedro Dome area; (2) Au skarns in the Gilmore Dome area; and (3) polymetallic veins associated with Cretaceous plutons at Melba Creek, and Pedro, Gilmore, and Ester Domes.

References: Smith, 1913a; Prindle and Katz, 1913; Mertie, 1918; Heiner and Wolff, 1968; Cobb, 1973; Light and others, 1987; Metz, 1987, 1991; Metz and Hamil, 1986; T.K.Bundtzen, written commun., 1991; Bundtzen and others, 1996.

No. 51-- Fortymile District
Major commodities: Placer Au, Au, REE, Pb, Sn, W, Hg

Summary Description:
District mostly contains stream and bench placer deposits. Most of area not glaciated. Loess mantles much of area. A 1.71 kg nugget was recovered from Jack Wade Creek deposit. Gold fineness ranges widely between drainages. Highest fineness is in Walker Fork and lowest fineness is in South Fork of Fortymile River. Lode source probably polymetallic quartz-pyrite veins. Mining by hydraulic, drift, dredge, and open cut methods. Gold derived from a combination of Au quartz and polymetallic veins that occur in metamorphic rocks near contacts with Cretaceous or early Tertiary felsic plutons that intrude middle Paleozoic or older metamorphic rocks of Yukon-Tanana terrane. Local bedrock consists of mainly metasedimentary rocks, Cretaceous granitic plutons, ultramafic and mafic plutonic rocks, and Tertiary sedimentary rocks.

References: Mertie, 1938, Cobb, 1973; Bundtzen and others, 1996.

No. 53-- Hot Springs District

Major commodities: Placer Au-Sn-Nb, Au, Sn, Cr, REE, Cu, Pb, Ag, Ni, Hg, W, Bi, Nb

Summary Description:
Nearly all placer deposits in district consist of buried bench gravels that occur on old terraces or buried stream deposits derived from older bench gravels. Thick deposits of frozen silt conceal placer deposits and make exploration difficult. Area not glaciated. Principal deposits explored were those on Sullivan Bench. Gold fineness ranges from 740 to 875. At American Creek, gold occurs in lower 1.1 m of gravels and upper 1 m of bedrock. Gold in quartz-carbonate veins associated with east-west-trending shear zone. Gold in district possibly related to granitic plutons in area. Ni-bearing columbite and aeschynite occurs in tailings of drift placer mines near Tofty. Local bedrock consists of Cretaceous sedimentary rocks and Tertiary granitic plutons.

References: Mertie, 1934; Wayland, 1961; Heiner and Wolff, 1968; Cobb, 1973; Southworth, 1984; Warner, 1985; Warner and Southworth, 1985; Warner and others, 1986; Bundtzen and others, 1996.

No. 55-- Iditarod District
Major commodities: Au, Hg, Sb, Sn, W, Cr, REE, Ag

Summary Description:
District contains gold placer deposits that occur in modern stream gravels, residual concentrations, and benches. All mining occurs within 14 km of Flat. Heavy minerals are chromite, scheelite, cassiterite, arsenopyrite, ilmenorutile, and heavy concentrations of cinnabar. Gold fineness ranges from 830 to 905 and averages 870. Extensive dredging. Nonglaciated highlands are mantled by residual material, colluvium, and silt; lowlands are covered by thick alluvium. Placer deposits on Flat, Chicken, Prince, Happy, Slate, and Willow Creeks are radially distributed around Chicken Mountain. Gold derived from polymetallic vein lode deposits in Late Cretaceous monzonitic stocks such as the Golden Horn and Chicken Mountain deposits, and from other mineralized contact zones in sedimentary and volcanic rocks of the Cretaceous Kuskokwim Group. Local bedrock of Early Proterozoic schist and metagranite, Mesozoic clastic and volcanic rocks, and Cretaceous granitic plutons.

References: Cobb, 1973; Bundtzen and others, 1985, 1988, 1992a; Miller and Bundtzen, 1993; Bundtzen and others, 1996.

No. 56-- Innoko District
Major commodities: Au, Ag, Hg, Pt, Sn, W

Summary Description:
Bulk of gold from Innoko district placers occurs on bedrock benches on easterly or northerly hill slopes. Minor platinum and about 1% of gold content recovered from Boob Creek. Some dredging. Major heavy minerals are chromite, scheelite, and arsenopyrite. Most of district not glaciated. Gold derived from mineralized rhyolite and basalt dike swarms and small monzonite plutons intruding the Kuskokwim Group in the Yankee Creek, Ophir Creek, and Spruce Creek areas. Largest dike swarm located along Ganes-Yankee Creek fault zone which parallels Iditarod Nixon Fault. Placer gold in Colorado, Cripple, and Bear Creeks derived from both granite porphyry and monzonite. Local bedrock also includes Cretaceous metasedimentary and metavolcanic rocks, chert, basalt, and felsic dikes.

References: Harrington, 1919; Mertie, 1936; Cobb, 1973; Bundtzen and Laird, 1980; Bundtzen and others, 1985, 1987, 1996.

No. 59-- Wiseman District (also known as Koyukuk district)
Major commodities: Au, Bi, Cu, W, Pb

Summary Description:
Glaciation in parts of district has caused disarrangements of drainage, resulting in complex placer deposits. Gold-rich gravels occur in modern streams, bench, and buried stream deposits on bedrock. Large nuggets include 4.29 kg nugget on Hammond River and 1.28 kg on Nolan Creek. Large nuggets more common than elsewhere in Alaska. Heavy minerals are gold, stibnite, native silver, native copper, native bismuth, scheelite, pyrite, chalcopyrite, cinnabar, rutile, cassiterite, monazite, andalusite, and kyanite. Larger deposits at Hammond River and Nolan Creek.

References: Maddren, 1913; I.M.Reed, written commun., 1938; Brosge and Reiser, 1960; Cobb, 1973; Dillon, 1982; Bundtzen and others, 1996.

No. 63-- Ruby District
Major commodities: Placer Au, Au, Sn, Bi, REE, Pb, W, Pt

Summary Description:
District displays a complex geomorphic history. Vein quartz, chert, and other resistant rocks are common in placers. Several cycles of erosion and deposition are interpreted. Placer deposits are generally buried and are mined with shafts and drifts. Region not glaciated. Heavy minerals are gold, cassiterite, platinum, scheelite, allanite, and native bismuth. Largest deposit on Long Creek produced nearly half of the district gold through 1993. Bedrock consists of quartz veins in schist in or near granite. District also contains minor placer Sn deposits. Gold in district probably derived from polymetallic vein and skarn deposits associated with Cretaceous hypabyssal granitic plutons. Local bedrock consists of limestone, schist, volcanic rocks, and granitic plutons.

References: Eakin, 1918; Mertie and Harrington, 1924; Cass, 1959; Chapman and others, 1963; Cobb, 1973; Bundtzen and
others, 1996.