

**INTRODUCTION**

Metals enter Little Cottonwood Creek in Salt Lake County, Utah, in drainage water that discharges from inactive mines in the watershed (fig. 1). As part of a study to evaluate the effects of this mine drainage on water quality, a sodium chloride tracer was injected into Little Cottonwood Creek during September 17-18, 1998. The purpose of the injection was to quantify stream discharge to identify inflows, both those observable and those dispersed in the subsurface; and ultimately, to determine which areas within the watershed contribute the most metals to Little Cottonwood Creek. The purpose of this report is to make these data available to agencies responsible for managing the area's water resources and to supplement interpretive reports for this study.

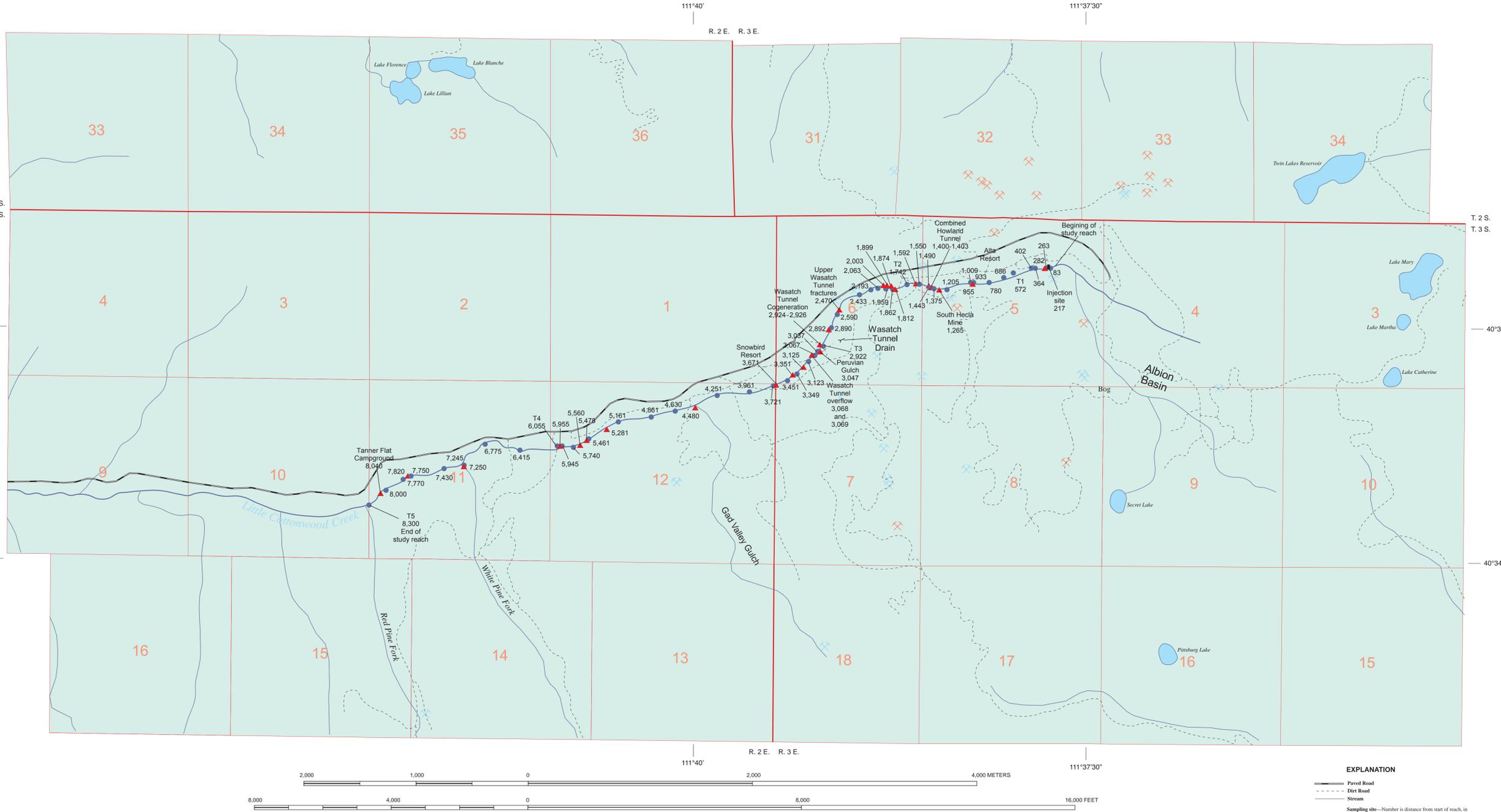


Figure 2. Location of sampling sites in Little Cottonwood Creek, Salt Lake County, Utah, September 1998.

After an initial increase at the beginning of the tracer injection, instream chloride reached a constant but elevated concentration at which it remained throughout the duration of the injection until the injection pumps were turned off. When the chloride concentration was constant, water samples were collected from an 8,300-meter reach that included 45 stream sites and 33 observable inflows (fig. 2). Three samples also were collected near a bog in Albion Basin. All of the samples were collected during a single day in order to provide a snapshot of the water quality in time, with minimal environmental differences. Data presented in table 1 of this report include discharge that was calculated after Brothers and others (1993), water temperature, pH, specific conductance, and results of chemical analyses. Samples were collected at five sites for an extended time so that transport time between sites could be determined from tracer arrivals and departures. Analytical results for samples collected during extended periods are not included in this report.

**METHODS**

Stream samples were collected at equal-width intervals using a DH-81 sampler so that samples were depth integrated (Ward and Harr, 1990). Samples from a single stream site were composited into a half-gallon plastic bottle. Inflow samples were collected as grab samples directly into the half-gallon plastic bottle from as close to the center of flow as possible. The half-gallon bottles were kept in dark plastic bags to shield them from direct sunlight until they were processed at a central location. Processing included subsiding the half-gallon sample into smaller 125-milliliter and 50-milliliter samples for different analyses.

Unfiltered samples were analyzed for total-recoverable metals and filtered samples were analyzed for dissolved metals. All samples collected for analysis of dissolved metals were filtered by using a tangential-flow filtering system. Samples collected from stream sites and inflows where acid mine drainage was known or suspected to occur (from visual observations) were filtered by using 10,000 Dalton nominal molecular weight (10K) filters. All other inflow sites were filtered by using 0.45-micrometer filters. Colloidal metal concentrations were calculated as the difference in unfiltered and filtered concentrations. The 10K filters were used to more accurately distinguish dissolved metals from colloidal metals, or particulates that pass through 0.45-micrometer filters. All samples collected for metal analysis were acidified with concentrated ultra pure nitric acid by using 1 milliliter per 125 milliliters of sample. Anions were determined from samples that were filtered by using a 0.45-micrometer filter but were not acidified. Samples were analyzed for metals by inductively coupled plasma-atomic emission spectrometry (ICP-AES) and for anions by ion chromatography by using guidelines described in Brinton and others (1996).

**QUALITY ASSURANCE**

One replicate was collected from transport site 4 (table 1) to evaluate sample variability. The sample was collected as a successive replicate immediately after collecting the first T4 sample. There is a substantial difference in concentrations between replicates for colloidal silica, colloidal iron, and colloidal zinc. All other concentrations are comparable with only slight variations between replicates.

One field blank was collected to help evaluate the likelihood of sample contamination from equipment. The equipment under evaluation included the half-gallon plastic sample bottle, the tangential-flow filtering system, and the 125-milliliter plain polyethylene sample bottle. The blank was collected by pouring reagent-grade water directly into a half-gallon plastic bottle. A raw sample was collected by transferring water directly into a 125-milliliter plain-polyethylene bottle. Two more samples were collected from the half-gallon sample bottle. Each was filtered through the tangential-flow filtering system by using a 0.45-micrometer filter for one and a 10K filter for the other. All of the field blanks were analyzed only for dissolved constituents. All concentrations were less than or at detection limits, except zinc. Substantial zinc concentrations were detected only in field blanks that were filtered.

One acid blank was collected to specifically evaluate the potential for contamination from the nitric acid added to samples collected for metal analysis and the acid dispenser. In the laboratory, reagent-grade water was poured directly into a 125-milliliter plain-polyethylene bottle and acidified with 1 milliliter of ultra pure nitric acid. All metals analyzed were less than detection limits.

Concentrations in table 1 are reported with respect to analytical detection limits. No attempt was made to determine reporting limits. In general, at lower concentrations, analytical accuracy decreases and analytical variability increases. Concentrations, particularly near detection limits, therefore, should be interpreted carefully.

Laboratory quality-assurance practices included daily calibration of instrumentation and inclusion of standard reference samples so that analytical accuracy and variability could be estimated according to guidelines described by Kimball and others (1999). Analytical accuracy was evaluated by using standard reference samples prepared by an independent laboratory that certifies the concentrations of the standards to within 0.5 percent. These standards were included in anion and metal analyses every 5 to 10 samples. The certified concentrations of these standard reference samples were used to correct the environmental data and thus compensate for analytical drift and (or) bias. Other standard reference samples included a sample collected from Little Cottonwood Creek, a sample collected from the Animas River, Colorado, and U.S. Geological Survey, Branch of Quality Assurance standard reference samples (Farrar, 1999). Metal and anion concentrations of these standard reference samples were used to check the accuracy and variability of corrected data.

Mean, a measure of general analytical accuracy, and standard deviation, a measure of analytical variability, were determined for each of the chemical constituents analyzed for each of the standard reference samples. Because standard deviation is dependent on concentration, the coefficient of variation also was calculated so that the variability at different concentrations could be more easily compared. Because it is important to distinguish analytical variability from environmental differences, a least-squares regression of standard deviation on mean of standard reference data was used as outlined by Friedmann and Erdmann (1982). By using the slope and y-intercept of this line, a standard deviation can be estimated for a concentration and applied as an error bar representing possible analytical variability for that sample. Laboratory quality-assurance data associated with the analysis of Little Cottonwood Creek samples are summarized in table 2. Mean and standard deviation are reported to 3 significant figures unless results are less than 0.01. If the value is less than 0.01, it is reported to 4 decimal places so that standard deviation is not reported incorrectly as zero.

**ACKNOWLEDGMENTS**

A tracer injection is labor intensive, especially when samples are being collected and processed. The injection in Little Cottonwood Creek was no exception and would not have been possible without the cooperation and assistance of personnel from the U.S. Forest Service, the State of Utah, Salt Lake County, the town of Alta, and Snowbird ski resort. The U.S. Geological Survey acknowledges and thanks all the individuals who contributed their time and energy in making this a successful cooperative effort.

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**CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS**

Multiply	By	To obtain
liter	0.26417	gallon
meter	3.2808	foot
micrometer	0.000032808	foot
milliliter	0.00026417	gallon

Water temperature is reported in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$^{\circ}\text{F} = 1.8 (^{\circ}\text{C}) + 32.$$

**Sea level:** In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Chemical concentration is reported in milligrams per liter (mg/L). Milligrams per liter is a unit expressing the mass of solute per unit volume (liter) of water. For concentrations less than 7,000 milligrams per liter, the numerical value is about the same as for concentrations in parts per million. Specific conductance is reported in microsiemens per centimeter (µS/cm) at 25 degrees Celsius.

**Selected hydrologic data for Little Cottonwood Creek, Salt Lake County, Utah, September 1998**

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