Prepared in cooperation with the Metro Wastewater Reclamation District

Biosolids, Crop, and Groundwater Data for a Biosolids-Application Area near Deer Trail, Colorado, 2009 and 2010

Data Series 664

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By Tracy J.B. Yager, David B. Smith, and James G. Crock

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Conversion Factors, Vertical Datum, and Abbreviations

Multiply	By	To obtain
Length		
centimeter (cm)	0.3937	inch (in.)
foot (ft)	0.3048	meter (m)
inch (in.)	2.54	centimeter (cm)
kilometer (km)	0.6214	mile (mi)
meter (m)	3.281	foot (ft)
micrometer (μm)	0.00003937	inch (in.)
mile (mi)	1.609	kilometer (km)
millimeter (mm)	0.03937	inch (in.)
Area		
acre	0.004047	square kilometer (km ²)
section (640 acres or 1 square mile)	259.0	square hectometer (hm ²)
square foot (ft ²)	0.09290	square meter (m ²)
square mile (mi ²)	2.590	square kilometer (km ²)
Volume		
gallon (gal)	3.785	liter (L)
liter (L)	33.82	ounce, fluid (fl. oz)
ounce, fluid (fl. oz)	0.02957	liter (L)
Mass		
gram (g)	0.03527	ounce, avoirdupois (oz)
pound, avoirdupois (lb)	0.4536	kilogram (kg)
ton, short (2,000 lb)	0.9072	megagram (Mg)
ton, long (2,240 lb)	1.016	megagram (Mg)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
 $^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32$

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (μS/cm at 25°C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (μg/L).

Biosolids, Crop, and Groundwater Data for a Biosolids-Application Area near Deer Trail, Colorado, 2009 and 2010

By Tracy J.B. Yager, David B. Smith, and James G. Crock

Abstract

During 2009 and 2010, the U.S. Geological Survey monitored the chemical composition of biosolids, crops, and groundwater related to biosolids applications near Deer Trail, Colorado, in cooperation with the Metro Wastewater Reclamation District. This monitoring effort was a continuation of the monitoring program begun in 1999 in cooperation with the Metro Wastewater Reclamation District and the North Kiowa Bijou Groundwater Management District. The monitoring program addressed concerns from the public about potential chemical effects from applications of biosolids to farmland in the area near Deer Trail, Colo. This report presents chemical data from 2009 and 2010 for biosolids, crops, and alluvial and bedrock groundwater. The chemical data include the constituents of highest concern to the public (arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, zinc, and plutonium) in addition to many other constituents. The groundwater section also includes data for precipitation, air temperature, and depth to groundwater at various groundwater-monitoring sites.

Introduction

Since 1993, the Metro Wastewater Reclamation District (Metro District) has been applying biosolids generated from municipal sewage treatment in Denver, Colo., to their property near Deer Trail, Colo. (figs. 1 and 2; these figures and all other figures and tables are located in the Data Section at the back of the report). The biosolids are trucked about 75 mi east from Denver to the Metro District property (fig. 2) and are applied to nonirrigated farmland. The first property the Metro District acquired near Deer Trail was about 15 mi² (fig. 3). In 1995, the Metro District traded some of the property and acquired additional property in the same area. The resulting boundaries of the original property became known as the Metro District central property (fig. 2). The new properties consisted of about 14.5 mi², known as the north property, and about 50 mi², known as the south property (fig. 2). In 1999, the three Metro District properties together (known as the METROGRO

Farm) encompassed almost 70 mi² of farmland in Arapahoe and Elbert Counties. The three Metro District properties and surrounding private property are considered the study area for this report (fig. 2).

Description of Study Area

The study area is located on the eastern plains of Colorado about 10 mi east of Deer Trail (fig. 1). The study area is on the eastern margin of the Denver Basin, a bowl-shaped sequence of Cretaceous sedimentary rocks that was formed in an ocean or near-ocean environment. The geology of the study area consists of interbedded shale, siltstone, and sandstone, which may be overlain by clay, windblown silt and sand, or alluvial sand and gravel (Sharps, 1980; Major and others, 1983; Robson and Banta, 1995). The primary water-supply aquifer is the Laramie-Fox Hills aquifer, which is a bedrock aquifer that ranges from 0 to about 200 ft thick in the study area and is the bottom aquifer in the Denver Basin aquifer sequence (Robson and others, 1981; Robson and Banta, 1995; Yager and Arnold, 2003). Multiple alluvial aquifers are present in the study area. These aquifers are associated with the surficial drainage network and contain water of variable quality, are of limited extent, and generally yield little water (Stevens and others, 2003; Yager and Arnold, 2003).

The study area is within the South Platte River drainage basin; all streams in this area drain northward to the South Platte River (fig. 1; U.S. Geological Survey, 1974; Seaber and others, 1987; Yager and Arnold, 2003). Short segments of some of the streams are intermittent, but in general, the streams are ephemeral and flow only after storms. No surface water flows off the Metro District properties except after storms. Most ponds in the area have been created by soil-retention structures. Soils in the area generally are sandy or loamy on flood plains and stream terraces, clayey to loamy on gently sloping to rolling uplands, and sandy and shaley on steeper uplands (Larsen and others, 1966; Larsen and Brown, 1971).

Land use in the study area was historically rangeland or cropland and pasture (U.S. Geological Survey, 1980). Some petroleum exploration was done in the area (Drew and others, 1979), but no oil or gas exploration or production took place on the Metro District properties during 2009 and 2010 (N. Crews, Metro Wastewater Reclamation District, written

commun., April 13, 2011). During 2009 and 2010, land use was rangeland or cropland, cattle and sheep were the primary domesticated animals grazing the area, and wheat was the primary crop. Farmland was not irrigated. Herbicides and other chemicals were applied to the study area during 2009 and 2010 for farming purposes. Pesticides and other fertilizers also may have been applied to the Metro District properties historically, but little information is available about these historical applications. Biosolids were applied as a fertilizer and soil amendment only on the Metro District properties.

Biosolids are applied by the Metro District to their properties near Deer Trail (figs. 2 and 4) according to agronomic loading rates (table 1; Colorado Department of Public Health and Environment, 2003). Land-applied biosolids must meet Colorado regulatory limits (Colorado Department of Public Health and Environment, 2003); otherwise, agronomic loading rates could be exceeded and soils could become overloaded. Soil quality either can be improved by biosolids applications through increased nutrients and organic matter or degraded through accumulation of excessive nutrients, metals, or other chemical constituents. Animal waste (related to wildlife and grazing domestic livestock) and applications of pesticides and fertilizers (organic and inorganic) can affect soil and water quality (Adeyinka and Mustapha, 2005) and therefore can affect crops, dust, groundwater and surface-water quality, and streambed-sediment chemistry.

Monitoring History

The U.S. Geological Survey (USGS) has collected data in the study area since 1993. From 1993 to 1999, the USGS, in cooperation with the Metro District, monitored the quality of shallow groundwater on the original Metro District property (fig. 3). Public concern about applications of biosolids to farmland increased in the late 1990s after the Metro District agreed to accept treated groundwater from the Lowry Landfill Superfund site in Denver. The concern was that water from the Lowry Superfund site might contain radionuclides that would contaminate the Metro District biosolids and the study area. In January 1999, the USGS began an expanded monitoring program for 1999 through 2003, in cooperation with the Metro District and the North Kiowa Bijou Groundwater Management District, to address this and other concerns from stakeholders. A subsequent phase of the expanded monitoring program near Deer Trail continued with selected monitoring from 2005 through 2010. Conclusions from the 1999–2003 phase (Yager and others, 2004d) were used to determine monitoring components, analytes, sites, and frequency for the 2005–2010 phase. The USGS refers to the 1999–2003 monitoring program and subsequent USGS monitoring efforts in the study area as the “expanded monitoring program.”

The expanded monitoring program near Deer Trail is distinct from, but built on, the first USGS monitoring program near Deer Trail on the Metro District central property (fig. 3).

Compared to the previous program (1993–1999), the expanded program includes a larger study area (fig. 2; all three Metro District properties and private-property locations), more monitoring components (biosolids, soil, crops, and streambed sediments were monitored in addition to groundwater), a more comprehensive list of chemical constituents, expanded statistical analyses of data, and an extended monitoring period (1999–2010). In 2005, the monitoring program was further expanded to include analysis of nitrogen isotopes and organic wastewater compounds in biosolids, biosolids leachates, and groundwater. A monitoring component to characterize dust was included for 2006–2007.

The USGS conducts both the original and expanded monitoring programs in cooperation with the Metro District. Both programs were designed, conducted, and interpreted independently by the USGS, and quality-assured USGS data and reports were released to the public and the Metro District at the same time. Selected monitoring results for 1993 through 1999 and a detailed discussion of hydrogeology of the study area are reported by Yager and Arnold (2003). Monitoring results for 1999 were reported by Stevens and others (2003). Monitoring results for 2000 were reported by Yager and others (2004a). Monitoring results for 2001 were reported by Yager and others (2004b). Monitoring results for 2002 through 2003 were reported by Yager and others (2004c). Monitoring results for 2004 through 2006 were reported by Yager and others (2009). Monitoring results for 2007 and 2008 were reported by Yager and others (2011). Interpretive information for the 1999 through 2003 data was reported by Yager and others (2004d). Data and interpretations for the dust-monitoring component were reported by Reheis and others (2009). Additional chemical data were reported by Crock and others (2008a, 2008b, 2009a, 2009b, and 2010). Selected data for 1999 through 2009 also were published in the “USGS Expanded Monitoring Program near Deer Trail” progress reports (<http://co.water.usgs.gov/projects/CO406/pubsprogress.html> accessed August 31, 2011).

The expanded monitoring program near Deer Trail addressed concerns about the effects of biosolids applications and other agricultural activities on the environment and increased scientific insight about Denver Basin hydrology. The objectives of this USGS program were to (1) evaluate the combined effects of biosolids applications, land use, and natural processes on soils, crops, dust, the bedrock aquifer, alluvial aquifers, and streambed sediments by comparing chemical data to (a) regulatory standards, (b) data from a site where biosolids are not applied (a control site), or (c) earlier data from the same site (trends); (2) monitor biosolids for trace elements and radioactivity and compare trace-element concentrations and radioactivity with regulatory standards; and (3) characterize the hydrology of the study area. The monitoring of each component (such as crops or groundwater) was a stand-alone study that did not necessarily encompass the entire study area. More detailed information about the monitoring of each component is included later in this report.

Purpose and Scope

The purpose of this report is to present data from the expanded monitoring program near Deer Trail for January 2009 through December 2010. This report presents data for all monitoring components of the program for which data were collected during 2009 and 2010. The report includes information for biosolids, crops, and alluvial-aquifer and bedrock-aquifer groundwater. The groundwater section includes hydrologic data (precipitation, air temperature, and depth to groundwater) and water-quality data (chemistry and field measurements). Data in this report were collected by the USGS after the water transfer from the Lowry Landfill Superfund site to the Metro District plant, which began in July 2000 and continues today (August 2011).

This report does not include any statistical comparisons of data to regulatory standards or calculation of trends; plans are to include statistical testing of the data in an interpretive report for the 2004–2010 data prepared after 2010. No description, data, or discussion of the soil and streambed-sediment monitoring components are included in this report because no data for these components were collected during 2009 and 2010.

This report is organized by monitoring component because each component is monitored as a separate study. For each monitoring component, the specific objectives, approach, data, and a discussion are included in this report.

Biosolids

Biosolids are solid organic matter recovered from a sewage-treatment process that meets State and Federal regulatory criteria for beneficial use, such as for fertilizer. The regulatory limits for Colorado biosolids are described by Colorado Department of Public Health and Environment (2003) as Table 1 Ceiling Concentration Limits and Table 3 Pollutant Concentration Limits. Table 3 Pollutant Concentration Limits (formerly known as Grade I) are more restrictive than Table 1 Ceiling Concentration Limits (formerly known as Grade II). In this report, “Table 3 biosolids” and “Table 3 Class B biosolids” mean biosolids that meet the criteria in Table 3 of the Colorado biosolids regulation. Land-applied biosolids must meet or exceed Table 1, Class B criteria (Colorado Department of Public Health and Environment, 2003). The Metro District applies Table 3 Class B biosolids from the Denver area (fig. 1) to their properties near Deer Trail (fig. 2). The biosolids-application areas, dates of application, and application rates provided by the Metro District for their properties near Deer Trail are listed in table 1 of this report; application areas (called “Destination Codes” [DC]) are shown in figure 4.

Objectives of Monitoring Biosolids

The biosolids must meet regulatory standards for trace elements. Exceeding these standards could adversely affect the quality of soil on which the biosolids are applied and could alter the Metro District plans for the application of biosolids in Arapahoe and Elbert Counties. The chemical composition of biosolids was monitored to provide an independently determined data set against which the Metro District chemical analyses and the regulatory standards for biosolids can be compared. The data also will constitute a chemical baseline against which any future change in the concentration of constituents analyzed for in this study may be recognized, measured, and compared.

Approach for Monitoring Biosolids

Biosolids samples were collected directly from the Metro District treatment plant in Denver (fig. 1) rather than from individual trucks or fields near Deer Trail to enable the USGS to obtain a more representative sample. Biosolids samples were analyzed for concentrations of arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, sulfur, zinc, and plutonium. The concentrations in the samples were compared to applicable Colorado standards for biosolids (Colorado Department of Public Health and Environment, 2003).

Sampling Methods for Biosolids

In 2009 and 2010, the USGS received biosolids samples monthly from the Metro District. Each monthly sample was a composite bottled over 1–2 days at the Metro District wastewater treatment plant by Metro District personnel. Biosolids samples were collected in acid-washed, rinsed, 1-gal plastic or glass bottles. The USGS received one to two bottles from each centrifuge that was active at the treatment plant at the time the sample was collected; the treatment plant had a maximum of four centrifuges active at any time. The USGS combined the contents of all sample bottles into a plastic tray and dried the resulting composited sample in a fume hood in the laboratory. Samples for trace-element or radioactivity analyses were dried under an infrared heat lamp to decrease drying time. After the biosolids sample was dried, an aliquot was removed and ground in an agate-lined shatterbox to less than 150 μm before chemical analysis. The remaining dried biosolids sample was archived as a single monthly sample and stored at the USGS facilities in Denver.

Analytical Methods for Biosolids

The monthly biosolids samples were processed and usually analyzed in groups for trace elements at the USGS Mineral Resources Program laboratories (MRPL) in Denver. A single, randomly selected biosolids sample was

analyzed each year for radioactivity through a contract with the USGS National Water Quality Laboratory (NWQL) at Eberline Services in California. The methods used to analyze the biosolids for each constituent are listed in table 2.

Quality Assurance for Biosolids

The purpose of the quality-assurance program developed for the biosolids monitoring component was to ensure that the analytical results were within acceptable limits of both precision (the reproducibility of results) and accuracy (the degree of conformity of results for a sample having known concentrations). The precision was determined by analyzing the same biosolids sample multiple times, and accuracy was determined by analyzing a National Institute of Standards and Technology (NIST) standard reference material (SRM). The SRM 2781, a domestic sewage sludge, was prepared by NIST from material collected at the Metro District treatment plant in Denver. The SRM 2781 has been analyzed extensively by many laboratories throughout the world, and the NIST has certified an acceptable range of values for various constituents in the SRM. The constituents include those of interest in this study. Each group of biosolids samples was submitted to the laboratories with a sample of the SRM. If the analytical results for the constituent of interest in the SRM were within the acceptable range, the results for the biosolids samples were accepted. Additional quality-assurance information for the 2009 and 2010 biosolids samples is provided by Crock and others (2008b and 2009a). The analytical quality-assurance practices and procedures of the MRPL are described by Taggart (2002).

Biosolids Data

Data for trace-element concentrations in the 2009 and 2010 biosolids samples are listed in table 3 of this report along with the Colorado standards (Table 1 Ceiling Concentration Limits and Table 3 Pollutant Concentration Limits) for land-applied biosolids. Quality-control data (NIST SRM 2781) associated with the biosolids samples are listed in table 4. Data for plutonium concentrations in the 2009 and 2010 biosolids samples are listed in table 5.

Discussion of Biosolids Data

All trace-element concentrations in the biosolids samples were much less than the Colorado standards established by the Table 1 Ceiling Concentration Limits and Table 3 Pollutant Concentration Limits (Colorado Department of Public Health and Environment, 2003). Although a low bias in concentration data is indicated for some of the elements (table 4), the bias is not large enough to cause the biosolids data to appear less than the regulatory standard when in fact a standard has been exceeded.

No plutonium standards are applicable to the biosolids. The plutonium data for biosolids (table 5) are similar to the plutonium data for soil in the study area (Stevens and others, 2003; Yager and others, 2004b). The radioactivity data are reported in the uncensored form as received from the laboratory rather than censored by either the contract or calculated minimum detectable concentration (MDC). Relative to the censored form (data reported as less than the MDC), the uncensored form provides more information about the uncertainty and the very small concentrations of plutonium. The negative activity concentrations reported in table 5 mean the sample count was less than the laboratory background count for that day. Radioactivity data are produced from instruments that detect radioactive decay (disintegrations) in a sample as counts per minute. The background count was subtracted from the sample count, and the resulting value was converted to activity-concentration units of picocuries per gram.

Crops

As previously mentioned, biosolids can contain elevated concentrations of certain trace elements. The application of biosolids to farmland on which grain crops are grown that eventually will be consumed by animals or humans has led to public concern about the composition of the crops grown on the fields receiving biosolids.

Objectives of Monitoring Crops

Crops are monitored for trace elements to establish independent chemical data sets for the composition of the crops before and after the application of biosolids. The data will enable the USGS to recognize and quantify changes in the chemical composition of crops caused by the application of biosolids to agricultural soils or by other natural or anthropogenic processes.

Approach for Monitoring Crops

In the summer of 2000, the USGS began monitoring crops grown in the same two areas where soils were monitored (figs. 2, 5, and 6). Each of the two soil- and crop-monitoring areas included one field that received biosolids and two fields that did not receive biosolids and are used as “control” fields to determine the natural variability of soil and crop composition for the duration of the study (figs. 5–6). The fields at each area are farmed in a way similar to the rest of the Metro District property and have crops planted and harvested approximately every other year. Soils from each of the six fields were sampled in 1999 before biosolids were applied to the two center fields and were sampled again after each harvest through 2003. Crop samples are collected from every harvest, which is in summer.

The primary crop monitored is winter wheat, although millet and corn also have been grown and sampled. The primary form of the crop that is monitored is mature grain at the time of harvest. Crops grown on fields that receive biosolids applications are monitored along with crops grown on fields that do not receive biosolids applications. The crops from fields that do not receive biosolids applications are used as a reference for comparison. Crop samples were obtained from the monitoring areas in 2000, 2001, 2002, 2004, 2006, 2008, 2009, and 2010. The crop samples were analyzed for arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, and zinc. During 2003, 2005, and 2007, no crops were grown in either the Arapahoe or Elbert County soil- and crop-monitoring areas. Data will be compared after each sampling and at the conclusion of the study to determine how the concentrations of the constituents of interest vary with time.

Site Selection for Monitoring Crops

The two soil- and crop-monitoring areas were selected in 1999 on the basis of Metro District land that was eligible for biosolids application but where biosolids had never been applied. One area was selected on the Metro District's north property in Arapahoe County, and one area was selected on the Metro District's south property in Elbert County (fig. 2). The Arapahoe County area is located in Township 4 South, Range 58 West, Section 22 and lies about 0.25 mi west of Badger Creek (fig. 5). The Elbert County area is located in Township 6 South, Range 57 West, Section 8 and lies immediately west of Beaver Creek (fig. 6). Each of the two soil- and crop-monitoring areas consist of three 20-acre (933-ft by 933-ft) fields separated by 100-ft buffer strips (figs. 5 and 6). When samples could not be obtained from a designated soil- and crop-monitoring area (such as in the case of crop failure), a sample from a nearby biosolids-applied field was analyzed when possible.

Sampling Methods for Crops

During 2009 and 2010, the crop sample was collected by the Metro District from the machine-harvested and threshed grain obtained from each field. The combine was emptied before harvesting grain from any of the soil- and crop-monitoring fields to ensure that the grain sampled was from only the designated field; no grain from the buffer strips (figs. 5 and 6) was included in the wheat-grain sample. The grain harvested from each designated field was collected by hand from the combine hopper about every 100–200 ft of the entire field and composited into a clean bucket. Samples of mature, field-dried wheat grain and corn kernels were provided to the USGS by the Metro District in clean, white, plastic buckets. The USGS received a single, separate, composited crop sample from each of the 20-acre fields harvested (figs. 5 and 6).

Analytical Methods for Crops

The crop samples were processed and analyzed for trace elements at the USGS MRPL in Denver. The crop samples were dried under forced air at room temperature and then cleaned using forced air and sieving. The cleaned crop samples were ground to a flour using a commercial table-top grain mill. A split of each ground sample was ashed in a forced-air muffle furnace at 500° C. The ashed grain samples and the dried, unashed grain samples were analyzed by the protocols described in detail by Yager and others (2004a). The 2009 and 2010 crop samples were analyzed for arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, sulfur, and zinc. The analytical methods are summarized in table 2. The analytical quality-assurance practices and procedures of the MRPL are described by Taggart (2002).

Crop Data

In 2009, wheat grain was sampled from the Elbert County soil- and crop-monitoring area (fig. 6). In 2010, wheat grain was sampled from the Arapahoe County soil- and crop-monitoring area (fig. 5). Chemical data for the Arapahoe County and Elbert County wheat grain are listed in table 6. No data are available for sulfur concentration in the 2009 crop samples or for mercury concentration in the 2010 crop samples.

Discussion of Crop Data

All analyses of crop samples met the quality-assurance criteria described by Taggart (2002). The chemical differences between wheat collected from the 20-acre field to which biosolids have been applied and wheat from the control fields where no biosolids have been applied are minimal. Fluctuations in wheat-grain concentration among the samples are within the normal range of uncertainty associated with the method.

Only one crop cycle took place during the 2009–2010 monitoring period so only one sample was collected from each monitored field. Each sample was a composite from across the entire field, so the single sample represents the entire field. Collecting additional composite samples from the same field could have provided information about concentration variability within a field but would not have increased sample representativeness.

Few comparisons can be made between the grain samples of Elbert County relative to the grain samples of Arapahoe County; only one set of samples was collected from each sampling area. Copper concentration generally was larger in the samples from both biosolids-applied and control fields of Elbert County in 2009 than in the samples from both biosolids-applied and control fields of Arapahoe County in 2010. Molybdenum and selenium concentrations generally were smaller in the samples from both biosolids-applied and control fields of Elbert County in 2009 than in the samples from both biosolids-applied and control fields of Arapahoe County in 2010.

Groundwater

Applications of pesticides, herbicides, or fertilizers (including biosolids) to the land surface can affect the quality of shallow groundwater directly by contaminating recharge water at the surface or during infiltration through contaminated soils or sediments (remobilization). These applications also can affect the quality of shallow groundwater indirectly by contributing to natural processes such as nitrification. Discharge from contaminated alluvial groundwater also could contaminate surface water (ponds or streams) or bedrock water-supply aquifers. For this report, alluvial groundwater is defined as the water contained in subsurface, unconsolidated (uncemented), wind- or water-transported sediments in current or historical stream channels or flood plains. Bedrock groundwater is defined as the water contained in the fractures or pore spaces of the rock (consolidated sediments) that underlies soil or other uncemented materials; the primary bedrock aquifer in the study area is the Laramie-Fox Hills aquifer (Robson and Banta, 1995).

Objectives of Monitoring Groundwater

Groundwater was monitored to characterize the hydrology and water quality of the aquifers; to determine if concentrations of nitrate, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc in the groundwater are significantly greater than regulatory standards; and to determine if concentrations of these constituents are increasing with time in groundwater at or near the Metro District properties.

Approach for Monitoring Groundwater

Alluvial and bedrock groundwater was monitored during 2009 and 2010 at USGS monitoring wells in the study area that were installed either in 1993–2002 during previous phases of monitoring or in 2009. “D”-numbered wells were drilled before 1999 as part of the first monitoring program (except for wells D6A and D25A, which were drilled in 2002); lithologic and well-completion information for these well locations are provided by Yager and Arnold (2003) and Yager and others (2004a). “DTX”-numbered wells were drilled in 1999, 2000, or 2009 (fig. 2); lithologic and well-completion information for these well locations are provided by Stevens and others (2003), Yager and others (2004a), table 7, and table 8. Selected information for all the USGS wells monitored during 2009 and 2010 as part of this program is summarized in table 8.

To characterize hydrology, semi-quantitative meteorologic (precipitation and air temperature) data were collected, depth to groundwater was measured monthly, and groundwater altitude was compared at two recharge-evaluation sites. Each recharge-evaluation site consisted of a nested bedrock-aquifer well paired with an alluvial-aquifer well at the same location. Monitoring multiple wells in the same location

enabled different zones of groundwater to be monitored without having to consider spatial variability and can enable inferences about vertical directions of groundwater flow between zones. In this study, a nested well consists of a single borehole that has two separate piezometers screened at two separate zones; the shallow zone is designated by “A” and the deep zone is designated by “B” after the well name. Therefore, three different aquifer zones are monitored at each of the two recharge-evaluation sites in Muddy Creek downgradient from the Metro District properties in the northwest part of the study area (fig. 2). A fourth aquifer zone (well DTX11) is monitored at the DTX9 recharge site to provide information about a deeper coarse-grained part of the Muddy Creek alluvial aquifer than is monitored by well DTX9.

To provide detailed information about groundwater hydrology in the study area, electronic equipment (commonly referred to as “continuous-recorder equipment”) was used at selected well sites. In 2000, electronic data-logger (EDL) equipment was installed at the DTX9/DTX10 (A,B)/DTX11 site to automatically report hourly measurements of cumulative precipitation and instantaneous depth to groundwater. In 2007, this continuous-recorder equipment was upgraded to a data-collection platform (DCP) to transmit the data by satellite into the USGS database. In November 2008, the continuous-recorder equipment again was upgraded, and data were collected at 15-minute intervals. DCPs have been used to collect hourly data at various other locations in the study area (DTX2, DTX5, and D25). However, the recorders were discontinued at wells DTX2, DTX5, and D25 during 2004 through 2008. During 2009 and 2010, all the study-area DCP data usually were available on the Internet. The data generated from the continuous-recorder equipment is called “continuous data” because the recording equipment runs continuously and records data frequently (hourly or more often).

To characterize water quality of the alluvial aquifers, samples were collected quarterly from five sites and twice from one site (the new well installed in 2009). To characterize water quality of the bedrock aquifer, a sample was collected annually from two sites. Groundwater samples were analyzed for physical properties, dissolved major ions and trace elements, and dissolved and total nutrients. Analyses included dissolved nitrate, arsenic, cadmium, copper, chromium, lead, mercury, molybdenum, nickel, selenium, and zinc (constituents considered the most important by the stakeholders). Selected analytical data are compared to the Colorado standards (Colorado Department of Public Health and Environment, 2004) annually.

All groundwater data are maintained in the USGS National Water Information System (NWIS) data base. All groundwater data collected for this program during 1999 through 2008 and corresponding interpretive information were published in USGS reports (Stevens and others, 2003; Yager and Arnold, 2003; Yager and others, 2004a, 2004b, 2004c, 2004d, 2009, and 2011) and are available on the Internet (<http://co.water.usgs.gov/projects/CO406/pubs.html> accessed August 31, 2011).

Site Selection for Monitoring Groundwater

Site selection for routine groundwater monitoring during 2009 and 2010 generally was the same as that for 2005 and 2006, which is described in detail by Yager and others (2009). Well DTX12, the new well installed in 2009 as a replacement for damaged well D30, was located slightly closer to the METROGRO Farm property boundary than well D30 but generally in the same location and monitored in a similar fashion to well D30. Depth to water usually was measured at all USGS monitoring wells shown in figure 2. Groundwater routinely was sampled at five alluvial property-boundary wells (DTX1, DTX2, D6, D17, and D25) and at the shallowest zones of the bedrock aquifer at two locations (DTX8A and DTX10A) (fig. 2). Recharge interactions were monitored at the two recharge-evaluation sites in the northwest part of the study area, each of which included at least one alluvial-aquifer well and one nested bedrock-aquifer well. Wells DTX7 and DTX8 (A,B) comprise one recharge-evaluation site, and wells DTX9, DTX10 (A,B), and DTX11 comprise the other recharge-evaluation site (fig. 2).

Sites for continuous-recorder equipment were selected to provide detailed data for evaluating complex or changing interactions. During 2009 and 2010, the interactions between various aquifers and groundwater zones and weather variables were of most interest at the location containing wells DTX9, DTX10 (A,B), and DTX11 (fig. 2). This location is the nearest recharge-evaluation site downstream from the Metro District property near Deer Trail and is a location where two distinct zones of alluvial aquifer are present above the bedrock aquifer at an ephemeral stream (Stevens and others, 2003; Yager and others, 2004a). Therefore, continuous-recorder equipment was used at the DTX9/DTX10/DTX11 site to collect detailed data in 2009 and 2010.

Sampling Methods for Groundwater

All data-collection methods used during 2009 and 2010 were the same as the 1999 methods, which are detailed by U.S. Geological Survey (variously dated) and Stevens and others (2003). Monthly depth-to-water measurements were made using a vinyl-coated electric tape. Data from the DCPs automatically were recorded every 15 minutes and were checked against the manually measured monthly data.

Water-quality samples were collected using standard USGS methods (Horowitz and others, 1994; U.S. Geological Survey, variously dated). Water levels and field measurements such as pH and specific conductance were recorded with the collection of each groundwater sample. Blank and replicate samples were analyzed to evaluate bias and variability of the groundwater data. All sampling equipment was used exclusively by the USGS and was used only in the study area to prevent cross contamination from other sites in other study areas. All samples and sampling equipment were thoroughly cleaned between sampling events and retained at all times in the custody of the USGS in secured facilities.

Analytical Methods for Groundwater

Groundwater samples were analyzed by the USGS NWQL in Denver. The methods used to analyze the 2009 and 2010 groundwater samples are listed in table 9, which includes laboratory Minimum Reporting Levels (MRLs) for the constituents of interest. The NWQL MRL for many analytes varied over time because of method optimization but also was raised if the sample needed to be diluted for analysis or if an interference was detected for that analyte.

Quality Assurance for Groundwater

Quality-assurance procedures were implemented during the course of the monitoring program to ensure the quality of the data. Procedures were implemented for depth-to-water measurements, DCP-data collection, groundwater-sampling preparation, field-properties measurements, groundwater sampling, and laboratory analysis. Replicate and blank water-quality samples were collected every sampling trip and analyzed for the same constituents and properties as were the environmental groundwater samples. Additional blank samples occasionally were collected for specific topical quality-assurance purposes and, therefore, were analyzed only for selected constituents and properties. Quality-assurance procedures are detailed in the 1999 data report (Stevens and others, 2003). The analytical quality-assurance practices and procedures of the NWQL are described by Friedman and Erdmann (1982).

Groundwater Data

Monitoring at groundwater sites during 2009 and 2010 produced hydrologic and water-quality data. Hydrologic data included cumulative measurements of precipitation at one site, continuous measurements of air temperature at one site and depth to water at three wells, and monthly measurements of depth to water at all wells. Water-quality data included analytical results from quarterly or annual sampling.

Hydrologic Data

Precipitation and air-temperature data were collected every 15 minutes from the study area during 2009 and 2010. The data for precipitation and air temperature collected during 2009 and 2010 at the DTX9/DTX10/DTX11 site are shown in figure 7.

Monthly depth-to-water data and continuous depth-to-water data were collected from the study area during 2009 and 2010. The monthly depth-to-water data for the USGS monitoring wells are listed as measurements below the measuring point at a specific time (table 10) to show the maximum precision of the measurements. The measuring point for the USGS monitoring wells generally was about 2–3 ft above land surface (table 8), although land surface

fluctuates over time relative to the fixed measuring points and was not remeasured after well installation. Daily data derived from continuous (every 15 minutes) depth-to-water data for the DCP site (DTX9/DTX10/DTX11; fig. 2) are shown in figure 7 as daily maximum depth to water below land surface.

Water-level data can indicate groundwater recharge information. Water-level altitudes for the paired alluvial-aquifer and bedrock-aquifer wells at the northernmost recharge-evaluation site (wells DTX7 and DTX8) are compared for 2009 and 2010 in figure 8. Water-level altitudes for the paired alluvial-aquifer and bedrock-aquifer wells at the other recharge-evaluation site (wells DTX9, DTX10, and DTX11) are compared for 2009 and 2010 in figure 9.

Water-Quality Data

Water-quality data for groundwater samples collected from the study area during 2009 and 2010 are listed in table 11. Data are included for field properties, physical properties, major ions, nutrients, and trace elements for eight USGS monitoring wells in the study area, including the shallowest zone of the bedrock-aquifer wells at the recharge-evaluation sites. Graphs of selected groundwater-quality data for selected wells are provided in figures 10 and 11. Quality-control water-quality data for the blank samples are listed in table 12, and comparison data for groundwater and replicate samples are listed in table 13.

Discussion of Groundwater Data

The precipitation and air-temperature data collected during 2009 and 2010 (fig. 7) are semi-quantitative. These data were checked by manual measurements when possible during monthly site visits. The tipping-bucket rain gage (the part of the continuous-recorder equipment used to measure precipitation) was deployed throughout the year but is known to under-report precipitation during winter months (unpublished data on file at U.S. Geological Survey, Colorado Water Science Center). Precipitation data for all months of 2009 and 2010 are included in figure 7, but the precipitation data for winter months are best used for general indication of magnitude and timing of precipitation in the area. The air-temperature data are accurate to within several degrees year round. The checks indicate that these data for 2009 and 2010 are acceptable for the intended purpose of evaluating the response of groundwater to changes in air temperature and precipitation.

Depth-to-water data (table 10) indicate that water levels fluctuated at all monitoring wells during 2009 and 2010. The magnitude of water-level fluctuation during 2009 through 2010 varied. Water-level data indicate that recharge was larger in spring 2009 than in spring 2010 or summer of either year at wells DTX1, D6, and D13. Water-level data indicate that recharge was larger in summer 2010 than in summer 2009

or spring of either year at wells DTX5 and DTX7. The water level in well DTX4 was below the screened interval during June 2009 through April 2010, but recharge elevated the water level into the screened interval during most of the remainder of 2010 (tables 8 and 10). Although well DTX3 recharged substantially in 2006 for the first time since 2001 (Yager and others, 2004b, 2004c, and 2009), this well remained dry throughout 2009 and 2010 (table 10). Water level fluctuated less in bedrock-aquifer monitoring wells (D11a, D29, DTX8, DTX10) than in alluvial-aquifer monitoring wells.

Hydrologic interactions between alluvial and bedrock aquifers can be inferred using water-level data for the same point in time for wells at the same site (figs. 8 and 9). The direction of the vertical movement of groundwater, or the recharge direction, may be indicated by noting that water moves from areas of high hydraulic head (high water-level altitude) to areas of low hydraulic head (low water-level altitude).

The data included in this report indicate that alluvial- and bedrock-aquifer chemistry is variable in space (from site to site) and in time (from one data-collection time to the next at the same site) in the study area (table 11). The distribution of concentrations at each routinely monitored well for selected constituents during 2009 and 2010 is compared to Colorado regulatory standards (Colorado Department of Public Health and Environment, 2004) in figure 10. Time-series graphs (concentration plotted with time) of selected constituents for selected wells are included as figure 11. All concentrations of dissolved nitrite plus nitrate as nitrogen in water samples from well D6 were greater than the Colorado Human Health standard (fig. 10), but concentrations did not increase markedly with time during 2009 and 2010 (fig. 11). All concentrations of dissolved selenium in water samples from well D6 were greater than the Colorado Agricultural and Human Health standards (fig. 10). During 2009 and 2010, concentrations of dissolved arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, and zinc in water samples from the monitoring wells all were less than regulatory standards (table 11 and fig. 10). Most of the concentration data for chromium and all the concentration data for zinc were less than the reporting limit and therefore censored (table 11 and fig. 11).

Blank samples were analyzed to evaluate high bias in the low concentration range, which can indicate contamination of field or laboratory supplies or equipment. Concentrations for the blank water-quality samples (table 12) generally indicate little or no contamination bias in the low concentration range for the 2009 and 2010 environmental samples. The blank samples of type "Q" (table 12) were from the submersible stainless steel pump or from the deionized water used to clean equipment before sampling. None of these data indicate any contamination bias for 2009 or 2010 in samples that came from the submersible pump (samples from wells DTX8 and DTX10). No contamination bias was contributed from the deionized water used for cleaning (table 12). However, the

field blanks from November 2009 and January 2010 showed uncharacteristic high bias in the low-concentration range for chloride and silica; this high bias was still much less than the groundwater concentrations for these elements during those sampling trips so the groundwater-concentration data likely are not much affected by this bias. In general, concentrations for the blank samples were much less than those for the groundwater samples.

The relative percent differences (RPD) between the groundwater samples and the replicate samples were computed to summarize sample variability (table 13). Most of the larger RPDs are due to values or concentrations near the MRL where precision is expected to be poor. In these instances, concentrations may vary little but result in large RPDs. For example, a groundwater sample concentration of 0.04 mg/L and a replicate-sample concentration of 0.03 mg/L results in an RPD of 29 percent, but the difference is considered to be within the precision of the method at that concentration. Variability in the data was highest for analyses of calcium, magnesium, arsenic, barium, nickel, iron, molybdenum, and selenium, although rerun analyses improved RPDs for some of these constituents in table 13. Note that most if not all of this variability likely is from the analyses and is not inherently present in the groundwater or contributed through field processing. The replicate-sample data indicate generally reproducible analytical results.

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Data Section

Figure 1. Location of study area near Deer Trail, Colorado.

Figure 2. Location of U.S. Geological Survey Expanded Monitoring Program sites near Deer Trail, Colorado, 2009 and 2010.

Figure 3. Locations of U.S. Geological Survey monitoring wells during 2009 and 2010 on the original (1993–1995) Metro Wastewater Reclamation District property near Deer Trail, Colorado, now part of the METROGRO Farm central property.

Figure 4. Metro Wastewater Reclamation District biosolids-application areas near Deer Trail, Colorado, 2009 and 2010.

Figure 5. Arapahoe County, Colorado, soil- and crop-sampling area. Modified from Metro Wastewater Reclamation District. (DC, Destination Code, which is used to track biosolids applications.)

Figure 6. Elbert County, Colorado, soil- and crop-sampling area. Modified from Metro Wastewater Reclamation District. (DC, Destination Code, which is used to track biosolids applications.)

Figure 7. Continuous depth-to-water, precipitation, and air-temperature data for wells DTX9, DTX10 (A), and DTX11 (a recharge-evaluation site) near Deer Trail, Colorado, 2009 and 2010.

Figure 8. Water-level comparison for the recharge-evaluation site containing wells DTX7 and DTX8 (A,B) near Deer Trail, Colorado, 2009 and 2010.

Figure 9. Water-level comparison for the recharge-evaluation site containing wells DTX9, DTX10 (A,B), and DTX11 near Deer Trail, Colorado, 2009 and 2010.

Figure 10. Distribution of groundwater constituent data collected near Deer Trail, Colorado, compared to regulatory standards (Colorado Department of Public Health and Environment, 2004) for selected constituents, 2009 and 2010. (MRL, minimum reporting level.)

Figure 10. Distribution of groundwater constituent data collected near Deer Trail, Colorado, compared to regulatory standards (Colorado Department of Public Health and Environment, 2004) for selected constituents, 2009 and 2010. (MRL, minimum reporting level.)—Continued

Figure 10. Distribution of groundwater constituent data collected near Deer Trail, Colorado, compared to regulatory standards (Colorado Department of Public Health and Environment, 2004) for selected constituents, 2009 and 2010. (MRL, minimum reporting level.)—Continued

Figure 11. Groundwater concentrations near Deer Trail, Colorado, for selected dissolved constituents, 2009 and 2010. Values that are censored at less than the reporting limit are not shown but are included in table 11. (MRL, minimum reporting level.)

Table 1. Biosolids applications by Metro Wastewater Reclamation District to the study area near Deer Trail, Colorado, 2009 and 2010.

[All information provided by the Metro Wastewater Reclamation District; DC, destination code; Ac, acre; wT, wet tons; dT, dry tons; CAKE, Table 3 Class B biosolids; Rec, recommended; N, nitrogen; lbs, pounds; %, percent; P, phosphorous; K, potassium; TKN, Total Kjeldahl Nitrogen; PAN, plant available nitrogen; incorporated, biosolids are pushed down into the soil 4 to 8 inches after application by the tines of a rotating implement pulled by a tractor; surface, no incorporation step]

DC (fig. 4)	Total DC area, Ac	Application start date	Application stop date	Area applied, Ac	Application method	Total wT applied	Actual loading rate, wT/Ac	Total dT applied	Actual loading rate, dT CAKE/ Ac
304	320	10/08/09	10/14/09	234.53	Incorporated	1,377.86	5.87	314.90	1.34
305	320	10/14/09	10/17/09	159.38	Incorporated	958.87	6.02	217.66	1.37
306	320	07/08/09	09/23/09	93.69	Incorporated	703.79	7.51	162.22	1.73
306	320	10/30/09	10/31/09	93.11	Incorporated	370.23	3.98	80.72	0.87
307	320	09/23/09	10/06/09	112.18	Incorporated	836.07	7.45	185.62	1.65
307	320	10/21/09	10/21/09	110.61	Incorporated	426.51	3.86	102.36	0.93
314	320	10/06/09	10/30/09	183.12	Incorporated	1,333.43	7.28	296.03	1.62
315	320	07/03/09	07/10/09	231.38	Incorporated	1,421.60	6.14	332.64	1.44
341	320	11/16/09	11/16/09	61.06	Incorporated	244.89	4.01	58.77	0.96
342	320	09/24/09	11/16/09	247.42	Incorporated	986.22	3.99	225.09	0.91
347	320	08/31/09	09/02/09	137.81	Incorporated	570.98	4.14	128.98	0.94
348	320	09/01/09	09/03/09	141.22	Incorporated	578.55	4.10	139.48	0.99
349	320	08/24/09	08/27/09	273.59	Incorporated	1,104.19	4.04	250.71	0.92
350	320	08/27/09	08/31/09	216.58	Incorporated	863.47	3.99	198.80	0.92
353	320	09/03/09	09/05/09	159.65	Incorporated	638.34	4.00	160.90	1.01
354	320	09/05/09	09/10/09	248.04	Incorporated	990.12	3.99	245.06	0.99
359	320	09/17/09	09/21/09	254.59	Incorporated	1,009.70	3.97	242.40	0.95
360	320	09/21/09	09/22/09	83.42	Incorporated	338.69	4.06	77.92	0.93
361	320	09/12/09	09/17/09	214.67	Incorporated	865.12	4.03	215.49	1.00
362	320	09/10/09	09/14/09	171.97	Incorporated	695.39	4.04	167.63	0.97
363	320	09/22/09	10/01/09	99.24	Incorporated	403.70	4.07	84.90	0.86
364	320	10/02/09	10/03/09	139.84	Incorporated	562.91	4.03	118.57	0.85
365	320	09/22/09	10/06/09	143.81	Incorporated	559.92	3.89	121.22	0.84
366	320	10/06/09	10/08/09	140.22	Incorporated	572.89	4.09	121.95	0.87
375	320	11/04/09	11/19/09	188.63	Surface	1,328.25	7.04	300.13	1.59
410	139	12/15/09	12/17/09	61.76	Surface	538.65	8.72	128.00	2.07
450	320	07/28/09	07/31/09	91.18	Surface	689.55	7.56	163.48	1.79
451	320	06/27/09	07/22/09	207.88	Surface	1,568.32	7.54	371.98	1.79
453	320	07/27/09	07/28/09	43.48	Surface	322.50	7.42	74.56	1.71
464	320	07/22/09	07/25/09	105.75	Surface	804.52	7.61	191.24	1.81
466	320	07/25/09	07/27/09	38.12	Surface	298.51	7.83	68.38	1.79
300	320	04/20/10	04/21/10	148.78	Surface	588.37	3.95	136.95	0.92
301	320	04/19/10	04/20/10	160.03	Surface	625.89	3.91	146.34	0.91
302	320	10/17/09	04/12/10	194.61	Incorporated	706.23	3.63	162.28	0.83
303	320	10/19/09	04/13/10	146.19	Incorporated	586.89	4.01	131.20	0.90
308	320	04/13/10	04/15/10	140.92	Surface	570.51	4.05	122.96	0.87
309	320	04/15/10	04/19/10	200.18	Surface	791.69	3.95	174.73	0.87
312	320	08/04/10	08/17/10	306.02	Surface	1,498.61	4.90	318.28	1.04
313	320	08/10/10	08/16/10	247.80	Surface	1,406.91	5.68	306.81	1.24
314	320	08/03/10	08/04/10	75.07	Incorporated	377.38	5.03	83.54	1.11
315	320	08/17/10	08/18/10	55.51	Surface	272.02	4.90	59.62	1.07
318	320	08/07/10	08/11/10	220.73	Surface	1,078.46	4.89	231.85	1.05
333	320	04/23/10	05/13/10	321.12	Surface	1,280.10	3.99	303.51	0.95
334	320	05/13/10	06/23/10	290.10	Surface	1,146.88	3.95	257.28	0.89
344	279	06/11/10	06/30/10	282.17	Surface	1,094.03	3.88	249.09	0.88
351	320	11/03/10	11/08/10	272.02	Surface	1,373.43	5.05	297.92	1.10
352	324	10/21/10	11/03/10	305.39	Surface	3,006.99	9.85	665.62	2.18
374	320	12/08/09	12/09/09	96.24	Surface	623.38	6.48	139.85	1.45
408	360	12/17/09	01/08/10	350.63	Surface	3,061.26	8.73	720.17	2.05
409	360	01/08/10	01/20/10	350.00	Surface	3,030.93	8.66	703.75	2.01
424	320	10/11/10	10/21/10	288.54	Surface	2,855.82	9.90	635.14	2.20
425	320	11/16/10	11/22/10	297.00	Surface	1,427.35	4.81	303.75	1.02
426	320	09/29/10	10/11/10	288.96	Surface	2,867.62	9.92	657.46	2.28
427	320	11/09/10	11/16/10	268.18	Surface	1,335.73	4.98	297.74	1.11
440	320	11/12/10	11/13/10	55.58	Surface	268.36	4.83	59.53	1.07
468	320	04/05/10	04/08/10	236.73	Surface	912.64	3.86	207.31	0.88
469	320	04/08/10	04/10/10	304.44	Surface	1,145.26	3.76	257.02	0.84
478	320	09/27/10	09/29/10	132.58	Surface	651.65	4.92	151.04	1.14
480	320	09/18/10	09/25/10	264.51	Surface	1,357.28	5.13	314.58	1.19
481	320	09/14/10	09/24/10	259.55	Surface	1,425.26	5.49	336.92	1.30

Table 1. Biosolids applications by Metro Wastewater Reclamation District to the study area near Deer Trail, Colorado, 2009 and 2010.

—Continued

[All information provided by the Metro Wastewater Reclamation District; DC, destination code; Ac, acre; wT, wet tons; dT, dry tons; CAKE, Table 3 Class B biosolids; Rec, recommended; N, nitrogen; lbs, pounds; %, percent; P, phosphorous; K, potassium; TKN, Total Kjeldahl Nitrogen; PAN, plant available nitrogen; incorporated, biosolids are pushed down into the soil 4 to 8 inches after application by the tines of a rotating implement pulled by a tractor; surface, no incorporation step]

DC (fig. 4)	Rec N loading rate, lbs/Ac	Rec N-based loading rate, dT/Ac	% of Rec N applied	Actual N loading rate, lbs/Ac	Total P applied, lbs/Ac	Total K applied, lbs/Ac	Crop	Total Rec N/ Crop, lbs/ field	TKN fraction of CAKE	PAN, lbs/dT
304	60	1.82	79	47.53	59.35	3.84	Wheat	14,072	0.065	35.40
305	60	1.82	81	48.34	60.36	3.91	Wheat	9,563	0.065	35.40
306	75	2.17	78	58.52	79.30	5.37	Native grass	7,027	0.062	33.80
306	40	1.21	77	30.69	38.32	2.48	Wheat	3,724	0.065	35.40
307	75	2.18	75	56.59	77.11	4.90	Native grass	8,414	0.063	34.20
307	40	1.21	82	32.76	40.90	2.65	Wheat	4,424	0.065	35.40
314	75	2.27	76	57.23	71.45	4.62	Native grass	13,734	0.065	35.40
315	75	2.17	64	48.30	63.83	5.15	Native grass	17,354	0.061	33.60
341	40	1.13	87	34.65	41.19	2.83	Wheat	2,442	0.066	36.00
342	40	1.16	79	31.66	41.48	2.69	Wheat	9,897	0.064	34.80
347	40	1.19	79	31.63	43.24	2.75	Wheat	5,512	0.062	33.80
348	40	1.16	81	32.59	47.21	2.98	Wheat	5,649	0.061	33.00
349	40	1.19	79	31.52	39.77	2.57	Wheat	10,944	0.063	34.40
350	40	1.19	79	31.58	39.84	2.57	Wheat	8,663	0.063	34.40
353	40	1.16	83	33.26	48.17	3.04	Wheat	6,386	0.061	33.00
354	40	1.16	82	32.60	47.23	2.98	Wheat	9,922	0.061	33.00
359	40	1.16	79	31.42	45.51	2.88	Wheat	10,184	0.061	33.00
360	40	1.16	77	30.82	44.65	2.82	Wheat	3,337	0.061	33.00
361	40	1.16	83	33.13	47.98	3.03	Wheat	8,587	0.061	33.00
362	40	1.16	80	32.17	46.59	2.94	Wheat	6,879	0.061	33.00
363	40	1.16	73	29.26	39.87	2.53	Wheat	3,970	0.063	34.20
364	40	1.21	75	30.02	37.48	2.42	Wheat	5,594	0.065	35.40
365	40	1.16	72	28.83	39.28	2.50	Wheat	5,752	0.063	34.20
366	40	1.21	77	30.79	38.44	2.49	Wheat	5,609	0.065	35.40
375	75	2.12	76	57.28	68.10	4.68	Grass	14,147	0.066	36.00
410	90	2.50	86	77.51	93.26	6.51	Corn	5,558	0.069	37.40
450	75	2.17	80	60.24	79.61	6.42	Wheat	6,839	0.061	33.60
451	75	2.14	82	61.20	87.32	6.12	Wheat	15,591	0.062	34.20
453	75	2.17	77	57.62	76.14	6.14	Wheat	3,261	0.061	33.60
464	75	2.17	81	60.76	80.29	6.47	Wheat	7,931	0.061	33.60
466	75	2.17	80	60.27	79.65	6.42	Wheat	2,859	0.061	33.60
300	40	1.06	87	34.61	44.92	3.35	Wheat	5,951	0.069	37.60
301	40	1.06	86	34.38	44.63	3.33	Wheat	6,401	0.069	37.60
302	40	1.21	77	30.69	37.69	2.69	Wheat	7,784	0.068	36.80
303	40	1.21	83	33.03	40.57	2.89	Wheat	5,848	0.068	36.80
308	40	1.06	82	32.81	42.58	3.18	Wheat	5,637	0.069	37.60
309	40	1.06	82	32.82	42.60	3.18	Wheat	8,007	0.069	37.60
312	50	1.29	79	39.52	49.51	3.87	Wheat	15,301	0.067	38.00
313	50	1.29	94	47.05	58.94	4.61	Wheat	12,390	0.067	38.00
314	50	1.29	85	42.29	52.97	4.14	Wheat	3,754	0.067	38.00
315	50	1.29	82	40.81	51.12	4.00	Wheat	2,776	0.067	38.00
318	50	1.29	80	39.91	50.00	3.91	Wheat	11,037	0.067	38.00
333	40	1.06	88	35.35	45.37	3.35	Wheat	12,845	0.068	37.40
334	40	1.06	84	33.70	41.86	3.03	Wheat	11,604	0.068	38.00
344	40	1.08	86	34.25	41.67	3.00	Wheat	11,287	0.069	38.80
351	50	1.37	83	41.62	54.10	3.20	Wheat	13,601	0.067	38.00
352	100	2.81	81	81.08	103.75	6.54	Corn	30,539	0.067	37.20
374	75	2.08	72	54.06	65.39	4.56	Native grass	7,218	0.069	37.20
408	90	2.50	86	77.23	92.43	6.20	Corn	31,557	0.070	37.60
409	90	2.42	84	76.01	90.08	5.83	Corn	31,500	0.070	37.80
424	100	2.81	80	80.12	100.82	6.78	Corn	28,854	0.066	36.40
425	50	1.37	78	38.86	50.52	2.99	Wheat	14,850	0.067	38.00
426	100	2.63	82	81.91	96.93	6.51	Corn	28,896	0.066	36.00
427	50	1.37	84	42.19	54.85	3.24	Wheat	13,409	0.067	38.00
440	50	1.37	81	40.70	52.91	3.13	Wheat	2,779	0.067	38.00
468	40	1.06	82	32.93	42.74	3.19	Wheat	9,469	0.069	37.60
469	40	1.06	79	31.74	41.20	3.07	Wheat	12,178	0.069	37.60
478	50	1.32	81	40.56	44.89	2.98	Wheat	6,629	0.065	35.60
480	50	1.32	85	42.34	46.86	3.12	Wheat	13,226	0.065	35.60
481	50	1.32	92	46.21	51.14	3.40	Wheat	12,978	0.065	35.60

Table 2. Methods used to analyze biosolids samples collected at the Metro Wastewater Reclamation District and crop samples collected near Deer Trail, Colorado, 2009 and 2010.

[DSAC, distillation with semi-automated colorimetry, method 350.1; KSAC, Kjeldahl with semi-automated colorimetry, method 351.2; LSAC, deionized water leaching procedure with semi-automated colorimetry, method 353.2; HG, hydride generation; AAS, atomic absorption spectrophotometry; ICP, inductively coupled plasma; MS, mass spectrometry; AES, atomic emission spectrometry; CV-AFS, continuous flow, cold vapor, atomic fluorescence spectrometry; IR, infrared]

Constituent	Medium	Analytical method	Reference
Nutrients			
Nitrogen, ammonia	Biosolids	DSAC	U.S. Environmental Protection Agency (1993)
Nitrogen, organic plus ammonia, soluble	Biosolids	KSAC	U.S. Environmental Protection Agency (1993)
Nitrogen, nitrate plus nitrite, soluble	Biosolids	LSAC	U.S. Environmental Protection Agency (1993)
Trace elements			
Arsenic	Biosolids and crops	HG-AAS	Taggart (2002)
Cadmium	Biosolids	ICP-MS	Taggart (2002)
Cadmium	Crops	ICP-AES	Taggart (2002)
Copper	Biosolids	ICP-MS	Taggart (2002)
Copper	Crops	ICP-AES	Taggart (2002)
Lead	Biosolids	ICP-MS	Taggart (2002)
Lead	Crops	ICP-AES	Taggart (2002)
Mercury	Biosolids and crops	CV-AFS	Hageman (2007)
Molybdenum	Biosolids	ICP-MS	Taggart (2002)
Molybdenum	Crops	ICP-AES	Taggart (2002)
Nickel	Biosolids	ICP-MS	Taggart (2002)
Nickel	Crops	ICP-AES	Taggart (2002)
Selenium	Biosolids and crops	HG-AAS	Taggart (2002)
Sulfur	Biosolids and crops	Combustion, IR detection	Brown and Curry (2002)
Zinc	Biosolids	ICP-MS	Taggart (2002)
Zinc	Crops	ICP-AES	Taggart (2002)
Radioactivity			
Plutonium-238, Total	Biosolids	Radiological method	Whittaker and Grothaus (1979); Lyon (1980)
Plutonium-239+240, Total	Biosolids	Radiological method	Whittaker and Grothaus (1979); Lyon (1980)

Table 3. Chemical data for biosolids samples collected at the Metro Wastewater Reclamation District, 2009 and 2010.

[“Table 1 Ceiling Concentration Limits” and “Table 3 Pollutant Concentration Limits” from Colorado Department of Public Health and Environment (2003); mg/kg, milligrams per kilogram; N, nitrogen; ppm, parts per million, which is equivalent to mg/kg; %, percent; --, no analysis; <, less than]

Sample date	Ammonia, soluble, mg/kg as N	Nitrate plus nitrite, mg/kg as N	Organic nitrogen plus ammonia, soluble, mg/kg	Arsenic, ppm	Cadmium, ppm	Copper, ppm	Lead, ppm	Mercury, ppm	Molybdenum, ppm	Nickel, ppm	Selenium, ppm	Sulfur, %	Zinc, ppm
January 2009	--	--	--	1.34	1.9	630	37.2	1.05	22.0	16.9	13.4	1.49	731
February 2009	--	--	--	1.17	1.9	634	45.4	1.73	22.0	16.9	14.3	1.67	709
March 2009	--	--	--	1.31	2.0	665	43.2	1.56	21.4	73.8	13.7	1.69	739
April 2009	--	--	--	1.66	1.7	630	41.3	1.86	18.7	15.1	14.7	1.66	734
May 2009	--	--	--	1.63	1.5	647	38.9	1.42	18.6	15.4	15.5	1.67	731
June 2009	--	--	--	1.68	1.7	694	45.2	1.09	16.5	16.2	15.4	1.79	776
July 2009	--	--	--	1.89	2.0	703	43.8	1.43	16.9	17.1	15.4	1.85	848
August 2009	--	--	--	1.89	2.8	698	59.9	1.40	20.2	18.2	15.5	1.99	876
September 2009	--	--	--	1.86	3.1	686	48.2	1.47	21.4	17.6	15.5	2.01	878
October 2009	--	--	--	1.58	3.0	709	41.9	1.62	21.3	16.0	15.4	1.88	859
November 2009	--	--	--	1.42	2.7	638	40.9	1.21	21.6	17.1	15.5	1.76	776
December 2009	--	--	--	1.42	2.2	604	39.9	1.27	19.7	16.5	15.4	1.69	729
January 2010	--	--	--	1.40	1.8	594	31.6	1.05	14.9	17.6	9.7	1.55	712
February 2010	--	--	--	1.36	1.7	590	35.9	1.52	14.7	18.2	9.6	1.61	714
March 2010	--	--	--	1.35	1.9	607	35.7	0.92	13.2	18.1	9.4	1.51	687
April 2010	--	--	--	1.43	1.8	614	35.1	1.26	11.9	18.0	9.8	1.52	669
May 2010	--	--	--	1.44	1.9	684	42.6	1.30	14.6	18.7	11.3	1.63	749
June 2010	--	--	--	1.49	1.8	684	38.3	1.37	13.6	17.8	13.6	1.71	775
July 2010	--	--	--	1.85	1.9	671	43.0	1.18	17.7	18.5	15.4	1.88	810
August 2010	--	--	--	1.67	1.9	714	49.0	1.31	18.6	19.0	14.0	1.89	848
September 2010	--	--	--	1.59	1.7	665	48.3	1.28	21.2	20.2	10.9	1.78	848
October 2010	15,000	<47	71,000	1.69	2.7	933	63.0	1.64	33.8	28.1	11.2	1.92	1090
October 2010 replicate	15,000	<47	51,000	--	--	--	--	--	--	--	--	--	--
November 2010	9,000	<40	71,000	1.60	2.2	711	43.4	1.62	26.5	21.8	9.4	1.76	846
November 2010 replicate	8,000	6	63,000	--	--	--	--	--	--	--	--	--	--
December 2010	15,000	<44	68,000	1.27	2.4	712	46.5	1.23	22.9	19.1	10.4	1.77	821
December 2010 replicate	15,000	<44	70,000	--	--	--	--	--	--	--	--	--	--
Table 1 Ceiling Concentration Limits	None	None	None	75	85	4,300	840	57	75	420	100	None	7,500
Table 3 Pollutant Concentration Limits	None	None	None	41	39	1,500	300	17	None	420	100	None	2,800

Table 4. Quality-control data associated with biosolids samples collected at the Metro Wastewater Reclamation District, 2009 and 2010.

[Data are for NIST 2781, a standard reference material prepared by the National Institute of Standards and Technology from domestic sewage sludge; ppm, parts per million; %, percent; ±, plus or minus the analytical uncertainty; --, no value]

Analysis date	Arsenic, ppm	Cadmium, ppm	Copper, ppm	Lead, ppm	Mercury, ppm	Molybdenum, ppm	Nickel, ppm	Selenium, ppm	Sulfur, %	Zinc, ppm
2009	5.47	12.0	578	176	3.78	42.2	73	15.3	1.59	1,120
2010	7.4	11.7	584	185	3.47	41.8	75	15.9	1.59	1,110
NIST 2781 Recommended or Certified Value										
	7.82±0.28	12.78±0.72	627.4±13.5	202.1±6.5	3.64±0.25	46.7±3.2	80.2±2.3	16.0±1.6	--	1,273±53

Table 5. Plutonium data for biosolids samples collected at the Metro Wastewater Reclamation District, 2009 and 2010.

[pCi/g, picocuries per gram; ±, plus or minus the analytical uncertainty; analytical uncertainty is the 1-sigma total combined standard uncertainty provided by the laboratory]

Sample date	Plutonium 238, pCi/g	Plutonium 238, minimum detectable concentration, pCi/g	Plutonium 239+240, pCi/g	Plutonium 239+240, minimum detectable concentration, pCi/g
June 2009	0.014±0.022	0.10	-0.004±0.007	0.10
January 2010	0.005±0.009	0.10	0.014±0.009	0.10

Table 6. Chemical data for crop samples collected near Deer Trail, Colorado, 2009 and 2010.

[Sampled fields are shown in figure 2, figure 5 (Arapahoe County fields), and figure 6 (Elbert County fields); data are reported as dry weight; ppm, parts per million; %, percent; <, less than; --, no data]

Sample location	Sample type	Harvest year	Arsenic, ppm	Cadmium, ppm	Copper, ppm	Lead, ppm	Mercury, ppm	Molybdenum, ppm	Nickel, ppm	Selenium, ppm	Sulfur, %	Zinc, ppm
Elbert County north field (control)	Wheat grain	2009	<0.02	0.02	2.2	<0.01	<0.03	0.4	0.16	<0.1	--	14.9
Elbert County middle field (biosolids applied)	Wheat grain	2009	.02	.02	3.4	<.01	<.03	.4	.18	<.1	--	12.2
Elbert County south field (control)	Wheat grain	2009	.03	.01	2.3	<.01	<.03	.4	.16	<.1	--	15.9
Arapahoe County north field (control)	Wheat grain	2010	.01	<.001	<.05	<.04	--	1.0	<.3	.78	0.15	11.6
Arapahoe County middle field (biosolids applied)	Wheat grain	2010	.02	<.001	<.05	<.04	--	1.4	<.3	.43	.16	17.6
Arapahoe County south field (control)	Wheat grain	2010	.02	<.001	<.05	<.04	--	1.3	.3	.59	.11	15.9

Table 7. Lithologic description for U.S. Geological Survey monitoring well, DTX12, near Deer Trail, Colorado, 2009.

[Description from geologist's notes taken when well was installed on September 1, 2009; ft, feet]

Depth below land surface, in ft	Source	Description of material
0–5	Core	Medium-brown clayey loam soil; damp with much surface vegetation and many roots.
5–15	Core	Medium-brown and gray clayey silt to silty clay soil; wet.
15–17	Core	Gray and brown silty clay coarsening downward to silt with pebbles of sandstone and shale; wet.
17	Core	Large (0.3 ft × 0.2 ft × 0.2 ft), hard, rounded cobble. Could not drill below this rock using auger drill rig because too hard.

Table 8. Selected information for U.S. Geological Survey monitoring wells near Deer Trail, Colorado, 2009 and 2010.

[Wells shown in bold routinely are sampled for water quality; all wells have 2-inch-diameter casing; latitude and longitude are in the format degrees minutes seconds referenced to North American Datum of 1983; Alt., altitude in feet above North American Vertical Datum of 1988; stickup, the length of well casing above ground (fluctuates because land surface is uneven and changes height over time), and measuring point is at the top of the stickup; bmp, below measuring point; sump, the nonperforated closed casing below the screen; HUC, Hydrologic Unit Code (Seaber and others, 1987); NWIS, U.S. Geological Survey National Water Information System database; ID, identification number; Metro, Metro Wastewater Reclamation District; L, alluvial; R, bedrock]

Well	Latitude	Longitude	Alt. of land surface (feet)	Alt. of stickup (feet)	Property owner	County	Drill date	Measured stickup ¹ (feet)	Total depth (feet bmp)	Screen top (feet bmp)	Screen bottom (feet bmp)	Screen- slot size (inch)	Screen length (feet)	Sump length (feet)	Aquifer type	HUC	NWIS station ID
DTX1	39 43 33	103 52 51	4,909	4,906	Metro	Arapahoe	2/16/1999	2.56	25.50	20.59	22.19	0.010	1.60	3.31	L	10190012	394333103525100
DTX2	39 41 49	103 51 38	4,903	4,900	Metro	Arapahoe	2/16/1999	3.23	20.50	15.59	17.19	0.010	1.60	3.31	L	10190012	394148103513300
DTX3	39 30 24	103 43 28	5,195	5,192	Metro	Elbert	2/12/1999	3.11	18.71	13.80	15.40	0.010	1.60	3.31	L	10190013	393024103432800
DTX4	39 33 58	103 43 42	4,957	4,954	Metro	Elbert	2/10/1999	2.70	16.72	11.81	13.41	0.010	1.60	3.31	L	10190013	393558103434200
DTX5	39 33 58	103 45 48	4,975	4,973	Metro	Elbert	2/10/1999	2.30	20.90	16.09	17.69	0.010	1.60	3.21	L	10190013	393358103454800
DTX6	39 33 58	103 46 48	4,970	4,968	Metro	Elbert	2/9/1999	2.36	39	34	36	0.010	1.60	3.31	L	10190013	393358103464800
DTX7	39 40 54	103 56 46	5,076	5,073	Price	Arapahoe	2/18/1999	2.77	16.10	11.19	12.79	0.010	1.60	3.31	L	10190011	394054103564600
DTX8A⁴	39 40 54	103 56 45	5,076	5,074	Price	Arapahoe	3/2/1999	2.46	77.52	67.56	71.83	0.010	4.27	5.69	R	10190011	394054103564501
DTX8B⁴	39 40 54	103 56 45	5,076	5,074	Price	Arapahoe	3/2/1999	2.49	177.48	167.52	171.79	0.010	4.27	5.69	R	10190011	394054103564502
DTX9³	39 39 02	103 55 40	5,121	5,119	Weisensee	Arapahoe	2/17/1999	2.46	30.15	22.72	24.32	0.010	1.60	5.83	L	10190011	393902103554000
DTX10A^{3,4}	39 39 02	103 55 40	5,122	5,120	Weisensee	Arapahoe	3/4/1999	2.03	61.97	52.01	56.28	0.010	4.27	5.69	R	10190011	393902103554001
DTX10B⁴	39 39 02	103 55 40	5,122	5,120	Weisensee	Arapahoe	3/4/1999	2.11	121.73	111.77	116.04	0.010	4.27	5.69	R	10190011	393902103554002
DTX11³	39 39 02	103 55 40	5,122	5,120	Weisensee	Arapahoe	1/19/2000	2.24	32	28	30	0.020	1.85	2.35	L	10190011	393902103554003
DTX12	39 36 54	103 51 20	5,096	5,093	Metro	Arapahoe	09/01/09	2.73	20.06	16.33	18.52	0.010	2.19	1.54	L	10190013	393953103554002
D6	39 36 33	103 51 22	5,128.78	5,126	Metro	Arapahoe	9/12/1993	2.65	25	15	25	0.010	10	0.3	L	10190013	393633103512300
D6A	39 36 33	103 51 22	5,129	5,126	Metro	Arapahoe	2/6/2002	2.42	32.96	28.42	30.71	0.010	2.29	2.25	L	10190013	393633103512301
D11a	39 33 45	103 54 23	5,377	5,374	Metro	Elbert	10/23/1997	2.46	143.03	112.65	122.65	0.010	10	20.38	R	10190011	393334103543600
D13	39 34 42	103 54 38	5,235.33	5,234	Metro	Arapahoe	4/4/1994	1.81	16	6	16	0.010	10	0.3	L	10190011	393439103543400
D17	39 33 34	103 54 36	5,277.73	5,276	Metro	Elbert	4/5/1994	1.90	21	11	21	0.010	10	0.3	L	10190011	393327103541200
D19	39 33 17	103 54 18	5,304.24	5,303	Metro	Elbert	4/5/1994	1.69	30	20	30	0.010	10	0.3	R	10190011	393311103541800
D25	39 37 02	103 54 42	5,167.13	5,165	Metro	Arapahoe	5/1/1995	2.23	23	13	23	0.010	10	0.3	L	10190011	393702103544100
D25A	39 37 02	103 54 42	5,167	5,165	Metro	Arapahoe	2/5/2002	2.28	24.39	19.85	22.14	0.010	2.29	2.25	L	10190011	393702103544102
D29	39 36 41	103 52 48	5,371	5,369	Metro	Arapahoe	11/4/1997	2.38	183.19	147.81	157.81	0.010	10	25.38	R	10190013	393632103524300

¹Stickup measured at a specific date and time soon after well was installed, but this measurement is relative to land surface, which is not uniform or constant over time.

²DTX6 stickup went from 2.43 to 2.36 feet between mid-October 2002 and early November 2002 when well was vandalized.

³Well had continuous-recorder equipment any time during 2009 and 2010.

⁴DTX8 and DTX10 are nested wells that consist of a single borehole that has two separate piezometers screened at two separate zones; the shallow zone is designated by "A", and the deep zone is designated by "B" after the well name.

Table 9. Methods used to analyze groundwater samples collected near Deer Trail, Colorado, 2009 and 2010.

[MRL, minimum reporting level (dilutions for samples having high specific conductance may result in higher MRL's for some samples); $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25°C ; dissolved, from samples filtered at 0.45 microns; mg/L milligrams per liter; ICP, inductively coupled plasma; AES, atomic-emission spectrometry; IC, ion chromatography; $^\circ\text{C}$, degrees Celsius; ASF, automated segmented-flow spectrophotometry; total, from unfiltered samples; $\mu\text{g}/\text{L}$, micrograms per liter; MS, mass spectroscopy; cICP, collision-cell inductively coupled plasma; CVAf, cold-vapor atomic fluorescence spectrometry]

Property or constituent	Units	Analytical method	MRL	Method reference
Major ions and mineral characteristics				
Specific conductance, laboratory	$\mu\text{S}/\text{cm}$	Wheatstone bridge	5	Fishman and Friedman (1989)
pH, laboratory	units	Electrometric electrode	0.1	Fishman and Friedman (1989)
Calcium, dissolved	mg/L	ICP-AES	.02–.044	Fishman (1993)
Magnesium, dissolved	mg/L	ICP-AES	.008–.016	Fishman (1993)
Sodium, dissolved	mg/L	ICP-AES	.06–.12	Fishman (1993)
Potassium, dissolved	mg/L	ICP-AES	.022–.064	American Public Health Association (1998), Fishman and Friedman (1989)
Acid-neutralizing capacity, lab, as calcium carbonate	mg/L	Electrometric titration	4–8	Fishman and Friedman (1989)
Sulfate, dissolved	mg/L	IC	.09–.18	Fishman and Friedman (1989)
Chloride, dissolved	mg/L	IC	.06–.12	Fishman and Friedman (1989)
Fluoride, dissolved	mg/L	ASF, ion-selective electrode	.04–.08	Fishman and Friedman (1989)
Bromide, dissolved	mg/L	Ion chromatography	.01–.02	Fishman and Friedman (1989)
Silica, dissolved	mg/L	ICP-AES	.02–.058	Fishman (1993)
Dissolved solids, residue at 180°C	mg/L	Gravimetric	10–12	Fishman and Friedman (1989)
Nutrients				
Nitrite plus nitrate, dissolved as Nitrogen	mg/L	Colorimetry, ASF, cadmium reduction, diazotization	.02–.04	Fishman (1993)
Nitrogen, ammonia, dissolved as Nitrogen	mg/L	Colorimetry, ASF, salicylate-hypochlorite	.02–.04	Fishman (1993)
Nitrogen, ammonia plus organic, total as Nitrogen	mg/L	Colorimetry, ASF, microkjeldahl digestion	.05–.10	Patton and Truitt (2000)
Nitrogen, ammonia plus organic, dissolved as Nitrogen	mg/L	Colorimetry, ASF, microkjeldahl digestion	.05–.10	Patton and Truitt (2000)
Phosphorus, total as Phosphorus	mg/L	Colorimetry, ASF, microkjeldahl digestion	.02–.04	Patton and Truitt (1992)
Phosphorus, dissolved as Phosphorus	mg/L	Colorimetry, ASF, microkjeldahl digestion	.02–.04	Patton and Truitt (1992)
Trace elements				
Aluminum, dissolved	$\mu\text{g}/\text{L}$	ICP-MS	1.7–4	Garbarino and others (2006)
Antimony, dissolved	$\mu\text{g}/\text{L}$	ICP-MS	.027–.054	Garbarino and others (2006)
Arsenic, dissolved	$\mu\text{g}/\text{L}$	cICP-MS	.022–.06	Garbarino and others (2006)
Barium, dissolved	$\mu\text{g}/\text{L}$	ICP-MS	.07–.4	Garbarino and others (2006)
Beryllium, dissolved	$\mu\text{g}/\text{L}$	ICP-MS	.006–.02	Garbarino and others (2006)
Boron, dissolved	$\mu\text{g}/\text{L}$	ICP-AES	1–2	Struzeski and others (1996)
Cadmium, dissolved	$\mu\text{g}/\text{L}$	ICP-MS	.016–.02	Garbarino and others (2006)
Chromium, dissolved	$\mu\text{g}/\text{L}$	cICP-MS	.06–.12	Garbarino and others (2006)
Cobalt, dissolved	$\mu\text{g}/\text{L}$	cICP-MS	.01–.02	Garbarino and others (2006)
Copper, dissolved	$\mu\text{g}/\text{L}$	cICP-MS	.5–1	Garbarino and others (2006)
Iron, dissolved	$\mu\text{g}/\text{L}$	ICP-AES	3.2–6	Fishman (1993)
Lead, dissolved	$\mu\text{g}/\text{L}$	ICP-MS	.015–.06	Garbarino and others (2006)
Manganese, dissolved	$\mu\text{g}/\text{L}$	ICP-MS	.13–.26	Garbarino and others (2006)
Mercury, dissolved	$\mu\text{g}/\text{L}$	CVAf	.005–.01	Garbarino and Damrau (2001)
Molybdenum, dissolved	$\mu\text{g}/\text{L}$	ICP-MS	.014–.028	Garbarino and others (2006)
Nickel, dissolved	$\mu\text{g}/\text{L}$	cICP-MS	.09–.12	Garbarino and others (2006)
Selenium, dissolved	$\mu\text{g}/\text{L}$	cICP-MS	.03–.06	Garbarino and others (2006)
Silver, dissolved	$\mu\text{g}/\text{L}$	ICP-MS	.005–.01	Garbarino and others (2006)
Strontium, dissolved	$\mu\text{g}/\text{L}$	ICP-AES	.2–.4	Fishman (1993)
Tungsten, dissolved	$\mu\text{g}/\text{L}$	cICP-MS	.01–.02	Garbarino and others (2006)
Zinc, dissolved	$\mu\text{g}/\text{L}$	cICP-MS	1.4–2.8	Garbarino and others (2006)
Radioactivity				
Uranium, natural, dissolved	$\mu\text{g}/\text{L}$	ICP-MS	.004–.008	Garbarino and others (2006)

Table 10. Monthly depth-to-water data for U.S. Geological Survey monitoring wells near Deer Trail, Colorado, 2009 and 2010.—Continued

[W.L. BMP, depth to water level below measuring point, in feet, measured with an electric tape; *, water level is below the screened interval of the well; A, no access to well; --, no data; D, no data because well was not installed until later; uncertainty of the water level measurements is 0.02 foot or less]

Well	January (01/15/2010)		February (02/04/2010)		March (03/30/2010)		April (04/10/2010)		May (05/18/2010)		June (06/15/2010)		July (07/13/2010)		August (08/24/2010)		September (09/07/2010)		October (10/19/2010)		November (11/16/2010)		December (12/14/2010)	
	W.L. BMP	A	W.L. BMP	A	W.L. BMP	A	W.L. BMP	A	W.L. BMP	A	W.L. BMP	A	W.L. BMP	A	W.L. BMP	A	W.L. BMP	A	W.L. BMP	A	W.L. BMP	A	W.L. BMP	A
DTX1	12.51	A			12.43	A	12.32	A	12.22	A	12.23	A	12.38	A	12.35	A	12.37	A	12.48	A	12.50	A	12.56	A
DTX2	8.12	A			7.69	A	7.52	A	7.38	A	7.68	A	8.46	A	9.17	A	9.35	A	9.46	A	9.33	A	9.37	A
DTX3	*	A			*	A	*	A	*	A	*	A	*	A	*	A	*	A	*	A	*	A	*	A
DTX4	*	A			*	A	*	A	13.09	A	A	A	*	A	12.56	A	12.65	A	13.07	A	A	A	13.20	A
DTX5	12.15	A			12.15	A	11.97	A	12.02	A	12.23	A	12.49	A	6.66	A	8.38	A	9.76	A	A	A	A	A
DTX6	20.49	A			20.32	A	19.84	A	20.02	A	20.34	A	20.64	A	19.65	A	19.97	A	20.56	A	A	A	20.91	A
DTX7	7.97	A			7.72	A	7.43	A	7.44	A	7.76	A	8.53	A	6.31	A	9.43	A	9.31	A	9.10	A	8.91	A
DTX8A	8.85	A			8.41	A	8.99	A	8.01	A	8.23	A	9.08	A	10.02	A	10.13	A	9.95	A	9.71	A	9.19	A
DTX8B	4.79	A			4.69	A	4.60	A	4.77	A	4.79	A	4.92	A	5.13	A	5.11	A	5.15	A	5.12	A	5.09	A
DTX9	13.50	A			13.35	A	13.33	A	13.31	A	13.38	A	13.46	A	13.62	A	13.61	A	13.65	A	13.68	A	13.60	A
DTX10A	13.66	A			13.43	A	13.38	A	13.39	A	13.51	A	13.65	A	13.85	A	13.83	A	13.84	A	13.86	A	13.77	A
DTX10B	17.82	A			17.71	A	17.65	A	17.67	A	17.91	A	18.01	A	18.20	A	18.17	A	18.25	A	18.23	A	18.14	A
DTX11	13.84	A			13.69	A	13.67	A	13.65	A	13.72	A	13.79	A	13.94	A	13.95	A	13.99	A	14.01	A	13.94	A
DTX12	6.46	A			5.85	A	5.67	A	5.68	A	6.39	A	7.38	A	7.77	A	7.92	A	7.90	A	7.68	A	7.23	A
D6	9.27	A			8.63	A	7.67	A	7.14	A	7.40	A	7.79	A	8.08	A	8.03	A	8.34	A	8.53	A	8.51	A
D6A	9.14	A			8.46	A	7.56	A	7.02	A	7.24	A	7.55	A	7.91	A	7.86	A	8.20	A	9.05	A	8.37	A
D11a	114.11	A			113.73	A	113.82	A	113.81	A	113.98	A	113.93	A	114.19	A	114.00	A	113.98	A	113.68	A	113.82	A
D13	7.15	A			6.47	A	6.18	A	6.38	A	7.04	A	7.38	A	7.73	A	8.04	A	8.41	A	8.11	A	7.88	A
D17	12.85	A			12.69	A	12.60	A	12.43	A	12.28	A	12.31	A	12.71	A	12.98	A	13.25	A	13.29	A	13.27	A
D25	12.13	A			11.85	A	11.68	A	11.57	A	11.56	A	11.90	A	12.22	A	12.27	A	12.22	A	12.13	A	11.96	A
D25A	12.04	A			11.77	A	11.61	A	11.49	A	11.48	A	11.82	A	12.14	A	12.16	A	12.11	A	12.02	A	11.86	A
D29	153.95	A			153.42	A	153.32	A	153.74	A	153.85	A	153.63	A	154.10	A	153.76	A	153.76	A	153.90	A	153.57	A

Table 11. Water-quality data for groundwater samples collected at U.S. Geological Survey monitoring wells near Deer Trail, Colorado, 2009 and 2010.

[Dissolved constituents obtained from samples filtered at 0.45 microns; total constituents obtained from unfiltered samples; CaCO₃, calcium carbonate; SiO₂, silicon dioxide; E, estimated; <, less than; n, value is less than the minimum reporting level; b, value extrapolated at low end; --, no data available]

Well name	Date	Sample time	Temperature, air, degrees Celsius	Water level, depth below measuring point, feet	Dissolved oxygen, unfiltered, milligrams per liter	pH, unfiltered, field, standard units	Specific conductance, unfiltered, field, microsiemens per centimeter at 25 degrees Celsius	Temperature, degrees Celsius
DTX1	03-04-2009	0930	24.0	14.49	0.6	6.9	4,050	12.1
DTX1	05-21-2009	0915	11.0	14.26	1.0	6.7	4,080	10.8
DTX1	09-09-2009	1000	21.0	12.58	.9	6.8	4,100	12.2
DTX1	11-24-2009	1010	11.0	12.58	<.5	6.9	4,140	12.7
DTX1	01-26-2010	1000	-1.5	12.51	.5	6.9	4,050	11.1
DTX1	04-20-2010	1615	19.8	12.42	.3	6.8	4,180	11.0
DTX1	09-07-2010	1000	23.0	12.37	.3	6.8	4,090	12.0
DTX1	11-16-2010	1000	12.1	12.50	<.5	6.9	4,160	12.3
DTX2	03-04-2009	1100	24.0	9.65	.8	6.9	5,710	11.3
DTX2	05-21-2009	1050	12.0	9.36	.5	6.8	5,700	9.6
DTX2	09-09-2009	1140	29.5	8.43	<.5	6.8	5,990	12.0
DTX2	11-24-2009	1215	9.5	8.13	.4	6.8	5,980	11.4
DTX2	01-26-2010	1200	3.4	8.02	.4	7.1	5,540	9.7
DTX2	04-20-2010	1415	18.8	7.81	<.5	6.9	5,690	9.4
DTX2	09-07-2010	1145	24.5	9.35	.3	6.7	5,020	11.9
DTX2	11-16-2010	1200	15.6	9.33	.3	6.8	5,160	12.1
DTX8A	05-20-2009	1030	29.0	9.00	.3	7.4	1,960	13.8
DTX8A	04-20-2010	1130	11.4	8.53	.3	7.4	1,910	12.1
DTX10A	05-19-2009	1015	30.0	13.89	.3	7.0	3,280	15.0
DTX10A	04-21-2010	1330	15.8	13.49	.2	7.0	3,200	13.3
DTX12	09-29-2009	1010	--	7.91	.5	6.8	5,810	11.4
DTX12	11-25-2009	1210	7.0	6.73	.4	6.8	5,790	10.8
D6	03-03-2009	1130	23.5	9.67	0.5	7.0	17,300	12.4
D6	05-20-2009	1345	34.0	9.28	.4	6.9	17,600	13.1
D6	09-10-2009	1100	32.0	9.28	<.5	6.9	17,400	13.0
D6	11-25-2009	1020	6.0	9.37	.5	7.0	17,300	10.6
D6	01-27-2010	1115	-2	9.17	.5	7.0	17,200	9.7
D6	04-21-2010	1030	12.3	8.36	.4	7.0	17,300	10.5
D6	09-08-2010	1015	27.5	8.03	.4	6.8	17,200	13.1
D6	11-17-2010	1100	-2.0	8.53	.4	7.1	17,200	9.8
D17	03-03-2009	1415	28.0	13.07	.5	7.5	480	12.4
D17	05-19-2009	1300	33.0	12.54	.3	7.5	490	12.6
D17	09-09-2009	1335	28.0	12.99	<.5	7.4	480	13.8
D17	11-24-2009	1415	10.5	12.97	.6	7.5	480	12.9
D17	01-26-2010	1420	7.3	12.82	.7	7.5	476	11.3
D17	04-21-2010	1530	22.0	12.63	.4	7.4	472	11.0
D17	09-07-2010	1400	29.0	12.98	.3	7.4	479	13.7
D17	11-16-2010	1415	12.0	13.29	.3	7.5	471	13.5
D25	03-04-2009	1300	24.5	12.26	.6	6.9	4,610	13.9
D25	05-21-2009	1300	--	12.09	.6	7.0	4,530	10.4
D25	09-10-2009	1320	34.0	12.62	.5	7.0	4,580	14.7
D25	11-25-2009	1400	9.0	12.28	.7	6.9	4,510	11.8
D25	01-27-2010	1415	2.4	12.07	.8	7.0	4,580	10.5
D25	04-22-2010	0945	14.7	11.79	.6	6.9	4,520	10.2
D25	09-08-2010	1230	28.5	12.27	.5	6.8	4,670	14.2
D25	11-17-2010	1345	11.0	12.13	.5	7.1	4,570	12.2

Table 11. Water-quality data for groundwater samples collected at U.S. Geological Survey monitoring wells near Deer Trail, Colorado, 2009 and 2010.—Continued

[Dissolved constituents obtained from samples filtered at 0.45 microns; total constituents obtained from unfiltered samples; CaCO₃, calcium carbonate; SiO₂, silicon dioxide; E, estimated; <, less than; n, value is less than the minimum reporting level; b, value extrapolated at low end; --, no data available]

Well name	Date	Acid neutralizing capacity, titration, laboratory, milligrams per liter as CaCO ₃	Specific conductance, unfiltered, laboratory, microsiemens per centimeter at 25 degrees Celsius	Dissolved solids dried at 180 degrees Celsius, filtered, milligrams per liter	Dissolved solids, filtered, sum of constituents, milligrams per liter	Hardness, milligrams per liter as CaCO ₃
DTX1	03-04-2009	286	4,040	3,970	E 3,750	2,120
DTX1	05-21-2009	279	4,030	3,940	E 3,670	2,120
DTX1	09-09-2009	279	4,090	4,000	E 3,670	1,990
DTX1	11-24-2009	264	4,070	4,050	E 3,730	2,010
DTX1	01-26-2010	276	4,040	3,980	E 3,520	1,990
DTX1	04-20-2010	279	3,960	3,950	E 3,660	1,960
DTX1	09-07-2010	294	4,040	3,970	3,690	2,010
DTX1	11-16-2010	274	4,040	4,070	3,710	2,020
DTX2	03-04-2009	428	5,670	5,440	E 5,130	2,220
DTX2	05-21-2009	433	5,690	5,490	5,020	2,230
DTX2	09-09-2009	426	5,860	5,730	E 5,330	2,330
DTX2	11-24-2009	401	5,840	5,770	E 5,320	2,420
DTX2	01-26-2010	433	5,750	5,580	E 5,400	2,500
DTX2	04-20-2010	421	5,470	5,120	E 4,900	2,310
DTX2	09-07-2010	437	4,990	4,830	4,460	2,160
DTX2	11-16-2010	428	5,190	5,170	4,750	2,360
DTX8A	05-20-2009	214	1,920	1,410	1,390	520
DTX8A	04-20-2010	210	1,880	1,430	1,400	504
DTX10A	05-19-2009	220	3,260	3,130	E 2,930	1,820
DTX10A	04-21-2010	220	3,140	3,090	E 2,930	1,820
DTX12	09-29-2009	538	5,740	6,120	E 5,803	3,860
DTX12	11-25-2009	569	5,730	6,153	E 5,940	3,860
D6	03-03-2009	655	E 17,600	22,600	E 21,100	11,900
D6	05-20-2009	645	E 17,600	21,800	20,500	11,000
D6	09-10-2009	631	E 17,500	22,200	E 20,800	13,400
D6	11-25-2009	645	E 17,100	22,500	21,300	13,500
D6	01-27-2010	645	E 17,200	22,000	E 21,100	12,800
D6	04-21-2010	627	E 17,100	22,400	E 21,200	12,900
D6	09-08-2010	643	E 17,100	21,300	E 20,500	13,100
D6	11-17-2010	635	E 17,100	22,000	20,700	11,800
D17	03-03-2009	193	487	273	E 286	220
D17	05-19-2009	197	485	300	284	217
D17	09-09-2009	192	482	303	E 283	219
D17	11-24-2009	183	471	292	283	226
D17	01-26-2010	195	480	298	283	213
D17	04-21-2010	189	458	283	275	214
D17	09-07-2010	199	471	289	E 287	222
D17	11-16-2010	193	471	289	283	223
D25	03-04-2009	353	4,500	4,520	E 4,220	2,590
D25	05-21-2009	367	4,500	4,530	4,320	2,840
D25	09-10-2009	377	4,500	4,540	E 4,190	2,540
D25	11-25-2009	340	4,470	4,560	E 4,250	2,600
D25	01-27-2010	373	4,490	4,360	E 4,020	2,520
D25	04-22-2010	362	4,420	4,550	E 4,220	2,570
D25	09-08-2010	382	4,540	4,640	4,320	2,600
D25	11-17-2010	375	4,550	4,530	4,260	2,520

Table 11. Water-quality data for groundwater samples collected at U.S. Geological Survey monitoring wells near Deer Trail, Colorado, 2009 and 2010.—Continued

[Dissolved constituents obtained from samples filtered at 0.45 microns; total constituents obtained from unfiltered samples; CaCO₃, calcium carbonate; SiO₂, silicon dioxide; E, estimated; <, less than; n, value is less than the minimum reporting level; b, value extrapolated at low end; --, no data available]

Well name	Date	Calcium, filtered, milligrams per liter	Magnesium, filtered, milligrams per liter	Potassium, filtered, milligrams per liter	Sodium, filtered, milligrams per liter	Bromide, filtered, milligrams per liter	Chloride, filtered, milligrams per liter	Fluoride, filtered, milligrams per liter	Silica, filtered, milligrams per liter as SiO ₂	Sulfate, filtered, milligrams per liter
DTX1	03-04-2009	506	205	3.95	368	0.84	55.5	0.65	33.4	2,380
DTX1	05-21-2009	505	207	3.81	333	.81	55.2	.60	38.1	2,330
DTX1	09-09-2009	478	191	3.98	330	.91	63.3	.65	35.4	2,380
DTX1	11-24-2009	476	198	3.9	353	.87	62.8	.65	35.4	2,420
DTX1	01-26-2010	475	193	4.04	330	.90	65.5	.65	32.7	2,230
DTX1	04-20-2010	461	196	3.84	346	.99	65.1	.66	32.9	2,370
DTX1	09-07-2010	483	193	3.89	336	.87	63.3	.61	32.8	2,370
DTX1	11-16-2010	491	192	4.08	350	.87	64.0	.68	35.8	2,390
DTX2	03-04-2009	488	242	11.5	760	1.26	120	.64	17.0	3,220
DTX2	05-21-2009	476	251	11.1	693	1.29	123	.60	17.3	3,170
DTX2	09-09-2009	518	251	11.9	742	1.26	140	.64	17.4	3,380
DTX2	11-24-2009	516	272	12.1	799	1.25	147	.64	18.0	3,300
DTX2	01-26-2010	540	279	13.1	783	1.30	148	.64	16.8	3,340
DTX2	04-20-2010	504	253	11.2	726	1.20	140	.60	15.7	2,990
DTX2	09-07-2010	489	227	10.1	531	1.11	112	.58	16.0	2,800
DTX2	11-16-2010	533	248	10.3	608	1.19	133	.62	19.7	2,920
DTX8A	05-20-2009	153	32.4	6.49	232	.29	27.3	.35	13.6	787
DTX8A	04-20-2010	146	32.9	6.64	242	.28	28.3	.38	13.0	795
DTX10A	05-19-2009	453	167	9.09	162	.25	19.5	.92	17.2	1,960
DTX10A	04-21-2010	441	172	9.22	163	.24	19.6	.95	16.7	1,960
DTX12	09-29-2009	569	589	6.87	4.33	.76	66.4	.94	23.2	3,600
DTX12	11-25-2009	570	589	7.04	4.33	.80	62.8	.92	23.7	3,720
D6	03-03-2009	466	2,600	15.7	2,660	4.26	388	1.25	20.7	14,300
D6	05-20-2009	468	2,390	16.9	2,410	4.20	381	1.16	23.2	14,200
D6	09-10-2009	518	2,940	17.8	2,290	4.19	380	1.18	24.1	14,000
D6	11-25-2009	515	2,960	16.9	2,720	4.17	383	1.17	23.5	14,100
D6	01-27-2010	490	2,810	17.2	2,600	4.18	398	1.27	21.6	14,200
D6	04-21-2010	516	2,810	16.2	2,780	3.95	403	1.24	23.3	14,000
D6	09-08-2010	425	2,920	14.3	2,250	3.97	390	1.12	20.4	13,900
D6	11-17-2010	533	2,530	14.4	2,450	3.94	371	1.22	21.3	14,200
D17	03-03-2009	58.1	18.0	1.70	18.6	.06	2.47	1.37	18.2	47.0
D17	05-19-2009	57.6	17.7	1.49	16.4	.06	2.51	1.32	18.3	45.4
D17	09-09-2009	58.1	17.8	1.59	16.6	.07	2.46	1.36	18.5	46.3
D17	11-24-2009	59.6	18.7	1.63	17.8	.06	2.49	1.38	18.4	47.8
D17	01-26-2010	56.1	17.7	1.66	16.5	.07	2.75	1.37	18.0	46.9
D17	04-21-2010	55.6	18.2	1.53	15.4	.06	2.68	1.37	17.4	44.3
D17	09-07-2010	59.2	17.9	1.59	17.3	.07	2.71	1.46	19.0	42.3
D17	11-16-2010	59.6	17.8	1.59	16.9	.07	2.54	1.39	19.9	42.0
D25	03-04-2009	740	180	8.11	283	2.20	134	1.04	24.0	2,630
D25	05-21-2009	805	201	8.32	316	2.04	130	1.02	26.6	2,600
D25	09-10-2009	712	185	7.84	275	2.08	130	1.04	27.0	2,610
D25	11-25-2009	739	182	7.93	305	2.14	138	1.02	26.0	2,640
D25	01-27-2010	721	174	8.01	279	2.23	149	1.06	23.2	2,430
D25	04-22-2010	721	185	7.70	281	2.16	141	1.06	24.0	2,630
D25	09-08-2010	749	176	8.25	333	2.17	138	1.02	26.1	2,640
D25	11-17-2010	722	172	8.21	320	2.10	141	.98	26.7	2,630

Table 11. Water-quality data for groundwater samples collected at U.S. Geological Survey monitoring wells near Deer Trail, Colorado, 2009 and 2010.—Continued

[Dissolved constituents obtained from samples filtered at 0.45 microns; total constituents obtained from unfiltered samples; CaCO₃, calcium carbonate; SiO₂, silicon dioxide; E, estimated; <, less than; n, value is less than the minimum reporting level; b, value extrapolated at low end; --, no data available]

Well name	Date	Ammonia plus organic nitrogen, filtered, milligrams per liter as nitrogen	Ammonia plus organic nitrogen, unfiltered, milligrams per liter as nitrogen	Ammonia, filtered, milligrams per liter as nitrogen	Nitrate plus nitrite, filtered, milligrams per liter as nitrogen	Phosphorus, filtered, milligrams per liter as phosphorus	Phosphorus, unfiltered, milligrams per liter as phosphorus
DTX1	03-04-2009	0.27	0.23	0.043	3.30	0.07	0.07
DTX1	05-21-2009	.23	.22	E .035 n	3.40	.07	.07
DTX1	09-09-2009	.26	.25	.042	3.33	.09	.07
DTX1	11-24-2009	.30	.27	E .032 n	3.86	.07	.07
DTX1	01-26-2010	.27	.30	E .037 n	3.98	.05	.07
DTX1	04-20-2010	.26	.27	E .023 n	4.12	.07	.07
DTX1	09-07-2010	.29	.29	.056	4.50	.07	.07
DTX1	11-16-2010	.28	.27	.073	4.32	.08	.10
DTX2	03-04-2009	1.5	1.3	1.13	.04	<.04	<.04
DTX2	05-21-2009	1.4	1.4	1.12	.06	<.04	<.04
DTX2	09-09-2009	1.7	1.7	1.27	<.04	E .04 n	<.04
DTX2	11-24-2009	1.6	1.6	1.34	<.04	<.04	E .02 n
DTX2	01-26-2010	1.6	1.7	1.24	E .03 n	E .03 n	<.04
DTX2	04-20-2010	1.5	1.5	1.14	.06	<.04	E .03 n
DTX2	09-07-2010	1.4	1.4	1.12	<.04	<.04	<.04
DTX2	11-16-2010	1.5	1.5	1.18	<.02	.03 b,n	.03 b,n
DTX8A	05-20-2009	1.5	1.5	1.49	<.04	<.04	<.04
DTX8A	04-20-2010	1.5	1.5	1.44	<.04	<.04	<.04
DTX10A	05-19-2009	1.4	1.3	1.35	<.04	<.04	<.04
DTX10A	04-21-2010	1.3	1.4	1.32	<.04	<.04	<.04
DTX12	09-29-2009	.59	.67	.159	<.04	E .04 n	E .04 n
DTX12	11-25-2009	.60	.62	.189	<.04	<.04	E .03 n
D6	03-03-2009	1.6	1.5	0.076	46.0	E 0.04 n	E 0.04 n
D6	05-20-2009	1.6	1.5	.084	50.4	E .03 n	.04
D6	09-10-2009	1.5	1.6	.081	52.6	E .03 n	E .03 n
D6	11-25-2009	1.4	1.6	.097	53.2	E .02 n	E .02 n
D6	01-27-2010	1.5	1.6	.078	51.6	E .03 n	.06
D6	04-21-2010	1.5	1.7	.077	53.8	E .04 n	E .04 n
D6	09-08-2010	1.5	1.6	.100	50.4	E .04 n	E .03 n
D6	11-17-2010	1.4	1.5	.133	48.0	.03 b,n	.05
D17	03-03-2009	E .10 n	E .09 n	E .025 n	.93	.08	.08
D17	05-19-2009	E .08 n	E .08 n	<.040	.99	.09	.08
D17	09-09-2009	E .07 n	<.10	<.040	.96	.10	.10
D17	11-24-2009	E .09 n	.13	<.040	.95	.09	.08
D17	01-26-2010	E .05 n	E .06 n	<.040	1.01	.07	.08
D17	04-21-2010	E .06 n	E .09 n	<.040	1.07	.09	.09
D17	09-07-2010	E .07 n	E .05 n	<.040	1.15	.09	.08
D17	11-16-2010	.07 b,n	.08 b,n	<.020	1.17	.11	.10
D25	03-04-2009	.58	.48	.067	E .03 n	.08	.07
D25	05-21-2009	.59	.60	.065	1.15	.08	.08
D25	09-10-2009	.62	.65	.074	1.66	.09	.10
D25	11-25-2009	.53	.58	.081	.23	.06	.08
D25	01-27-2010	.56	.57	.073	.10	.06	.07
D25	04-22-2010	.56	.58	.063	.53	.08	.07
D25	09-08-2010	.58	.55	.080	.44	.08	.08
D25	11-17-2010	.56	.53	.174	.28	.08	.10

Table 11. Water-quality data for groundwater samples collected at U.S. Geological Survey monitoring wells near Deer Trail, Colorado, 2009 and 2010.—Continued

[Dissolved constituents obtained from samples filtered at 0.45 microns; total constituents obtained from unfiltered samples; CaCO₃, calcium carbonate; SiO₂, silicon dioxide; E, estimated; <, less than; n, value is less than the minimum reporting level; b, value extrapolated at low end; --, no data available]

Well name	Date	Aluminum, filtered, micrograms per liter	Antimony, filtered, micrograms per liter	Arsenic, filtered, micrograms per liter	Barium, filtered, micrograms per liter	Beryllium, filtered, micrograms per liter	Boron, filtered, micrograms per liter	Cadmium, filtered, micrograms per liter	Chromium, filtered, micrograms per liter
DTX1	03-04-2009	<8.0	0.13	1.6	9	<0.04	445	0.20	<0.24
DTX1	05-21-2009	<8.0	.13	1.6	9	<.04	478	.14	<.24
DTX1	09-09-2009	<20.0	.22	1.6	10	<.10	461	.12	E .34 n
DTX1	11-24-2009	<6.8	.18	1.8	10	<.02	498	.14	E .16 n
DTX1	01-26-2010	<23.8	<.38	2.3	10	<.08	424	.14	.88
DTX1	04-20-2010	<34.0	E .40 n	1.6	10	<.12	395	<.20	<1.2
DTX1	09-07-2010	<6.8	.16	1.5	9	<.02	417	.14	<.24
DTX1	11-16-2010	<3.4	.18	2.0	10	<.06	464	.16	<.60
DTX2	03-04-2009	<12.0	.17	.71	14	<.06	300	.06	<.36
DTX2	05-21-2009	<12.0	.14	.63	13	<.06	341	.07	<.36
DTX2	09-09-2009	<20.0	<.20	.76	13	<.10	326	E .07 n	<.60
DTX2	11-24-2009	<10.2	E .09 n	.93	14	<.04	339	E .04 n	E .26 n
DTX2	01-26-2010	<10.2	E .08 n	.88	13	<.04	304	E .03 n	.39
DTX2	04-20-2010	<27.2	E .40 n	.58	14	<.10	278	<.16	<.96
DTX2	09-07-2010	<6.8	<.11	.74	12	<.02	322	.04	<.24
DTX2	11-16-2010	<5.1	<.08	1.1	14	<.02	366	.06 n	.48
DTX8A	05-20-2009	<4.0	<.04	.08	10	<.02	275	<.02	<.12
DTX8A	04-20-2010	<10.2	<.16	.17	10	<.04	257	<.06	<.36
DTX10A	05-19-2009	<8.0	<.08	E .07 n	11	<.04	249	<.04	<.24
DTX10A	04-21-2010	<34.0	<.54	E .26 n	11	<.12	238	<.20	<1.2
DTX12	09-29-2009	--	.14	.86	12	<.06	532	.15	E .33 n
DTX12	11-25-2009	<10.2	E .12 n	.76	10	<.04	529	<.06	.45
D6	03-03-2009	E 28.7 n	E 0.19 n	1.5	7	<0.16	839	E 0.14 n	<0.96
D6	05-20-2009	<32.0	<.32	1.2	4	<.16	910	<.16	<.96
D6	09-10-2009	<40.0	<.40	1.4	5	<.20	992	E .15 n	E .98 n
D6	11-25-2009	<23.8	<.38	1.9	6	<.08	977	.19	.87
D6	01-27-2010	<51.0	<.81	1.2	5	<.18	868	<.30	E 1.6 n
D6	04-21-2010	<68.0	<1.08	1.1	5	<.24	808	<.40	<2.4
D6	09-08-2010	<23.8	<.38	1.3	6	<.08	819	E .09 n	<.84
D6	11-17-2010	<11.9	<.19	1.4	5	<.04	1,000	<.11	1.1
D17	03-03-2009	21.1	.07	1.4	58	<.02	53	.03	<.12
D17	05-19-2009	<4.0	.06	1.6	56	<.02	57	.02	<.12
D17	09-09-2009	<4.0	.06	1.7	58	<.02	60	E .02 n	E .10 n
D17	11-24-2009	<3.4	.07	1.5	59	<.01	61	.03	<.12
D17	01-26-2010	<3.4	.08	1.6	58	<.01	57	.03	<.12
D17	04-21-2010	<3.4	.06	1.5	59	<.01	52	.03	<.12
D17	09-07-2010	E 1.8 n	.06	1.4	55	<.01	59	.02	<.12
D17	11-16-2010	<1.7	.07	1.4	59	<.01	61	.03	<.06
D25	03-04-2009	<8.0	.10	1.4	18	<.04	142	.20	<.24
D25	05-21-2009	<8.0	.14	1.5	15	<.04	189	.22	<.24
D25	09-10-2009	<20.0	E .13 n	2.1	15	<.10	215	.25	<.60
D25	11-25-2009	<6.8	E .09 n	2.1	17	<.02	166	.21	.30
D25	01-27-2010	<20.4	<.32	1.8	17	<.07	141	.21	E .64 n
D25	04-22-2010	<34.0	<.54	1.6	13	<.12	146	E .16 n	<1.2
D25	09-08-2010	<6.8	E .08 n	1.4	16	<.02	156	.19	<.24
D25	11-17-2010	3.5 n	.09 n	1.9	18	<.06	158	.20	<.60

Table 11. Water-quality data for groundwater samples collected at U.S. Geological Survey monitoring wells near Deer Trail, Colorado, 2009 and 2010.—Continued

[Dissolved constituents obtained from samples filtered at 0.45 microns; total constituents obtained from unfiltered samples; CaCO₃, calcium carbonate; SiO₂, silicon dioxide; E, estimated; <, less than; n, value is less than the minimum reporting level; b, value extrapolated at low end; --, no data available]

Well name	Date	Cobalt, filtered, micrograms per liter	Copper, filtered, micrograms per liter	Iron, filtered, micrograms per liter	Lead, filtered, micrograms per liter	Manganese, filtered, micrograms per liter	Mercury, filtered, micrograms per liter	Molybdenum, filtered, micrograms per liter	Nickel, filtered, micrograms per liter
DTX1	03-04-2009	0.67	<2.0	E 9 n	<0.12	136	<0.010	2.8	15.5
DTX1	05-21-2009	.56	<2.0	<12	<.12	77.1	<.010	2.4	12.6
DTX1	09-09-2009	1.1	<5.0	<12	<.30	E 21.0	<.010	1.7	9.8
DTX1	11-24-2009	1.3	E 1.1 n	<18	<.06	40	<.010	1.8	14.1
DTX1	01-26-2010	1.6	<7.0	<18	<.21	28.5	<.010	1.7	14.7
DTX1	04-20-2010	.24	<10.0	<12	<.30	21.7	<.010	1.6	5.6
DTX1	09-07-2010	.19	<2.0	<12	<.06	41.4	<.010	1.5	4.0
DTX1	11-16-2010	<.20	<5.0	<10	<.03	36.7	<.005	1.7	4.1
DTX2	03-04-2009	5.2	<3.0	457	<.18	4,940	<.010	1.7	6.9
DTX2	05-21-2009	4.7	<3.0	357	<.18	4,960	<.010	1.7	4.4
DTX2	09-09-2009	5.4	<5.0	506	<.30	5,260	<.010	1.8	10.0
DTX2	11-24-2009	7.1	<3.0	593	<.09	5,870	<.010	1.9	16.1
DTX2	01-26-2010	7.1	<3.0	540	<.09	5,400	<.010	1.7	16.5
DTX2	04-20-2010	7.2	<8.0	333	<.24	5,960	<.010	1.9	11.3
DTX2	09-07-2010	6.0	<2.0	550	<.06	5,660	<.010	1.6	5.7
DTX2	11-16-2010	6.0	<1.5	668	<.04	5,630	<.005	2	5.6
DTX8A	05-20-2009	.12	<1.0	781	<.06	93.3	<.010	.5	1.9
DTX8A	04-20-2010	.31	<3.0	804	<.09	91.3	<.010	.5	1.5
DTX10A	05-19-2009	.60	<2.0	4,160	<.12	276	<.010	1.2	3.2
DTX10A	04-21-2010	1.2	<10.0	4,310	<.30	257	<.010	1.1	8.1
DTX12	09-29-2009	3.3	<3	123	<.18	1,080	<.010	1.9	11.9
DTX12	11-25-2009	3.7	E 1.6 n	115	<.09	1,290	<.010	1.8	20.8
D6	03-03-2009	9.0	<8.0	<40	<0.48	4,620	<0.010	5.1	14.4
D6	05-20-2009	6.7	<8.0	<40	<.48	3,840	<.010	3.2	14.1
D6	09-10-2009	7.2	<10.0	E 24 n	<.60	3,540	<.010	3.6	13.4
D6	11-25-2009	9.3	<7.0	<60	<.21	4,650	<.010	3.9	21.8
D6	01-27-2010	7.1	<15.0	<60	<.45	3,730	<.010	3.0	17.4
D6	04-21-2010	6.9	<20.0	E 3 n	<.60	3,740	<.010	3.0	17.0
D6	09-08-2010	7.2	<7.0	E 11 n	<.21	4,000	<.010	3.4	9.3
D6	11-17-2010	7.1	<3.5	12	<.10	3,830	<.005	3.7	10.0
D17	03-03-2009	.14	<1.0	<4	<.06	190	<.010	5.6	.73
D17	05-19-2009	.09	<1.0	<4	<.06	216	<.010	5.6	.51
D17	09-09-2009	.19	<1.0	<4	<.06	337	<.010	5.7	1.1
D17	11-24-2009	.24	<1.0	<6	<.03	332	<.010	5.4	1.6
D17	01-26-2010	.34	<1.0	<6	<.03	191	<.010	5.5	1.6
D17	04-21-2010	.11	<1.0	<6	<.03	199	<.010	5.4	.68
D17	09-07-2010	.10	<1.0	<6	<.03	341	<.010	5.8	.62
D17	11-16-2010	.08	<.50	<3	<.01	353	<.005	5.7	.50
D25	03-04-2009	2.7	<2.0	<12	<.12	2,700	<.010	6.3	6.7
D25	05-21-2009	1.8	<2.0	<12	<.12	2,640	<.010	6.8	3.4
D25	09-10-2009	3.1	<5.0	E 6 n	<.30	2,760	<.010	7.8	16.2
D25	11-25-2009	4.4	E 1.2 n	<18	<.06	3,410	<.010	7.4	19.3
D25	01-27-2010	3.9	<6.0	<18	<.18	2,520	<.010	5.8	17.0
D25	04-22-2010	3.9	<10.0	<18	<.30	2,550	<.010	6.0	16.7
D25	09-08-2010	2.7	<2.0	<18	<.06	3,410	<.010	7.2	4.2
D25	11-17-2010	2.6	<5.0	<10	<.03	3,040	<.005	6.8	4.1

Table 11. Water-quality data for groundwater samples collected at U.S. Geological Survey monitoring wells near Deer Trail, Colorado, 2009 and 2010.—Continued

[Dissolved constituents obtained from samples filtered at 0.45 microns; total constituents obtained from unfiltered samples; CaCO₃, calcium carbonate; SiO₂, silicon dioxide; E, estimated; <, less than; n, value is less than the minimum reporting level; b, value extrapolated at low end; --, no data available]

Well name	Date	Selenium, filtered, micrograms per liter	Silver, filtered, micrograms per liter	Strontium, filtered, micrograms per liter	Tungsten, filtered, micrograms per liter	Uranium, filtered, micrograms per liter	Zinc, filtered, micrograms per liter
DTX1	03-04-2009	13.6	E 0.01 n	6,030	<0.04	41.0	E 2.1 n
DTX1	05-21-2009	12.4	<.02	5,860	<.04	43.1	<4.0
DTX1	09-09-2009	20.1	E .03 n	5,590	<.10	39.8	<10.0
DTX1	11-24-2009	12.6	<.02	5,680	<.04	45.6	<5.6
DTX1	01-26-2010	12.2	E .05 n	5,820	<.14	41.5	<19.6
DTX1	04-20-2010	8.9	<.10	5,440	<.20	43.0	<28.0
DTX1	09-07-2010	10.8	<.02	5,380	<.04	54.4	<5.6
DTX1	11-16-2010	9.2	<.01	5,600	<.02	51.2	<14.0
DTX2	03-04-2009	E .15 n	<.02	5,620	<.06	30.8	<6.0
DTX2	05-21-2009	.36	<.02	5,370	<.06	29.9	<6.0
DTX2	09-09-2009	.33	.04	5,540	<.10	26.0	<10.0
DTX2	11-24-2009	.53	<.03	5,750	<.06	29.0	<8.4
DTX2	01-26-2010	.30	E .02 n	6,210	<.06	29.0	<8.4
DTX2	04-20-2010	E .19 n	<.08	4,960	E .13 n	30.3	<22.4
DTX2	09-07-2010	.15	<.02	5,280	<.04	32.0	<5.6
DTX2	11-16-2010	.27	<.01	5,770	<.03	31.4	<4.2
DTX8A	05-20-2009	.06	<.01	2,530	E .01 n	.15	<2.0
DTX8A	04-20-2010	<.12	.04	2,500	<.06	.12	<8.4
DTX10A	05-19-2009	.15	<.02	5,630	<.04	.14	<4.0
DTX10A	04-21-2010	<.40	<.10	5,390	<.20	.11	<28.0
DTX12	09-29-2009	.41	.16	8,000	E .04 n	36.0	<6.0
DTX12	11-25-2009	.47	E .02 n	7,940	<.06	40.1	<8.4
D6	03-03-2009	104	E 0.05 n	18,900	<0.16	227	<16.0
D6	05-20-2009	79.3	<.06	18,100	<.16	181	<16.0
D6	09-10-2009	85.9	E .05 n	20,000	<.20	168	<20.0
D6	11-25-2009	119	<.07	20,300	<.14	200	<19.6
D6	01-27-2010	80.6	E .10 n	20,800	<.30	160	<42.0
D6	04-21-2010	73.5	E .12 n	19,600	<.40	165	<56.0
D6	09-08-2010	84.8	<.07	16,400	<.14	190	<19.6
D6	11-17-2010	67.7	.04 n	17,400	<.07	174	<9.8
D17	03-03-2009	8.4	.02	313	<.02	4.16	<2.0
D17	05-19-2009	8.8	<.01	304	<.02	4.16	<2.0
D17	09-09-2009	9.1	<.01	304	<.02	4.04	<2.0
D17	11-24-2009	8.9	<.01	309	<.02	3.87	<2.8
D17	01-26-2010	8.9	<.01	312	<.02	4.20	<2.8
D17	04-21-2010	9.0	<.01	292	E .01 n	4.20	<2.8
D17	09-07-2010	8.2	<.01	304	<.02	3.97	<2.8
D17	11-16-2010	8.1	<.01	299	<.01	3.59	<1.4
D25	03-04-2009	.44	<.02	3,480	<.04	29.2	<4.0
D25	05-21-2009	1.4	<.02	3,820	<.04	31.5	<4.0
D25	09-10-2009	1.8	<.04	3,370	<.10	29.4	<10.0
D25	11-25-2009	.75	<.02	3,460	E .02 n	29.7	<5.6
D25	01-27-2010	.65	E .05 n	3,460	<.12	27.3	<16.8
D25	04-22-2010	1.1	<.10	3,420	<.20	27.9	<28.0
D25	09-08-2010	.58	<.02	3,470	<.04	33.6	<5.6
D25	11-17-2010	.65	<.01	3,360	<.02	31.5	<14.0

Table 12. Quality-control data for blank samples associated with groundwater samples collected near Deer Trail, Colorado, 2009 and 2010.

[Site name refers to site where sample was processed or, for equipment blank, site where equipment was last used; dissolved constituents obtained from samples filtered at 0.45 microns; total constituents obtained from unfiltered samples; CaCO₃, calcium carbonate; SiO₂, silicon dioxide; F, field blank; <, less than; E, value estimated by laboratory; n, value is less than the minimum reporting level; Q, equipment blank; d, diluted sample; method high range exceeded; b, value extrapolated at low end; w, high variability; questionable precision and accuracy; M, presence of material verified but not quantified]

Blank type	Sample date	Sample start time (hhmm)	Site name	Specific conductance, water, unfiltered, laboratory, microsiemens per centimeter at 25 degrees Celsius	pH, water, unfiltered, laboratory, standard units	Calcium, water, filtered, milligrams per liter	Magnesium, water, filtered, milligrams per liter	Potassium, water, filtered, milligrams per liter	Sodium, water, filtered, milligrams per liter	Acid neutralizing capacity, water, unfiltered, fixed endpoint (pH 4.5) titration, laboratory, milligrams per liter as CaCO ₃
F	03-03-2009	1300	D17	<5	8.0	<0.02	<0.012	<0.06	<0.12	<8
F	05-19-2009	1145	D17	<5	8.4	<0.02	<0.12	<0.06	<12	<8
Q	05-20-2009	1815	DTX8A	<5	8.2	.02	<0.12	<0.06	<12	<8
F	09-10-2009	1215	D25	<5	8.3	<0.02	<0.12	<0.06	<12	<8
F	11-24-2009	1345	D17	<5	8.4	<.04	<0.16	<.06	<.10	<8
F	01-26-2010	1315	D17	<5	8.2	<.04	<0.16	<.06	<.10	<8
F	04-22-2010	0830	D25	<5	8.2	<.04	<0.16	<.06	<.10	<8
Q	04-22-2010	1330	DTX10A	<5	8.3	<.04	<0.16	<.06	<.10	<8
F	09-07-2010	0830	DTX1	<5	E 8.5 w	<.04	<0.16	<.06	<.10	<8
Q ⁱ	09-09-2010	1145	DTX1	<5	E 7.7 w	<.04	<0.16	<.06	<.10	<8
F	11-17-2010	1245	D25	<5	E 7.1 w	<.02	<.008	<.02	<.06	<.4

Blank type	Sample date	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	Dissolved solids dried at 180 degrees Celsius, water, filtered, milligrams per liter	Aluminum, water, filtered, micrograms per liter	Antimony, water, filtered, micrograms per liter	Arsenic, water, filtered, micrograms per liter	Barium, water, filtered, micrograms per liter	Beryllium, water, filtered, micrograms per liter	Boron, water, filtered, micrograms per liter	Bromide, water, filtered, milligrams per liter
F	03-03-2009	<0.04	<10	<4.0	<0.04	<0.06	<0.4	<0.02	E 1.1 n	<0.02
F	05-19-2009	<0.4	<10	<4.0	<0.4	<0.6	<.4	<.02	E 1.5 n	<.02
Q	05-20-2009	<0.4	<10	<4.0	<0.4	<0.6	<.4	<.02	<.0	<.02
F	09-10-2009	<0.4	<10	<4.0	<0.4	<0.6	<.4	<.02	<.0	<.02
F	11-24-2009	<0.4	<10	<3.4	<.05	<.04	<.14	<.01	<.0	<.02
F	01-26-2010	<0.4	<10	<10.2 d	<.16 d	<.13 d	<.42 d	<.04 d	<.0	<.02
F	04-22-2010	<0.4	<10	<3.4	<.05	<.04	<.14	<.01	<.0	<.02
Q	04-22-2010	<0.4	<10	<3.4	<.05	<.04	<.14	<.01	<.0	<.02
F	09-07-2010	<0.4	<10	<3.4	<.05	<.04	<.14	<.01	<.0	<.02
Q ⁱ	09-09-2010	<0.4	<10	<3.4	<.05	<.04	<.14	<.01	<.0	<.02
F	11-17-2010	<.02	<12	<1.7	<.03	<.02	<.07	<.01	<.10	<.01

Blank type	Sample date	Nickel, water, filtered, micro-grams per liter	Selenium, water, filtered, micrograms per liter	Silver, water, filtered, micrograms per liter	Strontium, water, filtered, micrograms per liter	Tungsten, water, filtered, micrograms per liter	Zinc, water, filtered, micrograms per liter	Uranium, water, filtered, micrograms per liter
F	03-03-2009	<0.12	<0.06	<0.01	<.4	<.02	<.0	<.01
F	05-19-2009	<.12	<.06	<.01	<.4	<.02	<.0	<.01
Q	05-20-2009	E .08 n	<.06	<.01	<.4	<.02	E 1.0 n	<.01
F	09-10-2009	<.12	<.06	<.01	<.4	<.02	<.0	<.01
F	11-24-2009	<.12	<.04	<.01	<.4	<.02	<.8	<.01
F	01-26-2010	<.36 d	<.12 d	<.03 d	<.4	<.06 d	<.4 d	<.02 d
F	04-22-2010	<.12	<.04	<.01	<.4	<.02	<.8	<.01
Q	04-22-2010	E .09 n	<.04	<.01	<.4	<.02	<.8	<.01
F	09-07-2010	<.12	<.04	<.01	<.4	<.02	<.8	<.01
Q ⁱ	09-09-2010	<.12	<.04	<.01	<.4	0.05	<.8	<.01
F	11-17-2010	<.09	<.03	<.01	<.2	<.01	<.4	<.004

Table 12. Quality-control data for blank samples associated with groundwater samples collected near Deer Trail, Colorado, 2009 and 2010.—Continued

[Site name refers to site where sample was processed or, for equipment blank, site where equipment was last used; dissolved constituents obtained from samples filtered at 0.45 microns; total constituents obtained from unfiltered samples; CaCO₃, calcium carbonate; SiO₂, silicon dioxide; F, field blank; <, less than; E, value estimated by laboratory; n, value is less than the minimum reporting level; Q, equipment blank; d, diluted sample; method high range exceeded; b, value extrapolated at low end; w, high variability; questionable precision and accuracy; M, presence of material verified but not quantified]

Blank type	Sample date	Chloride, water, filtered, milligrams per liter	Fluoride, water, filtered, milligrams per liter	Silica, water, filtered, milligrams per liter as SiO ₂	Sulfate, water, filtered, milligrams per liter	Ammonia plus organic nitrogen, water, filtered, milligrams per liter as nitrogen	Ammonia plus organic nitrogen, water, unfiltered, milligrams per liter as nitrogen	Ammonia, water, filtered, milligrams per liter as nitrogen	Nitrate plus nitrite, water, filtered, milligrams per liter as nitrogen	Phosphorus, water, filtered, milligrams per liter as phosphorus
F	03-03-2009	<0.12	<0.08	E 0.01 n	<0.18	<0.10	<0.10	<0.040	<0.04	<0.04
F	05-19-2009	<0.12	<0.08	<0.02	<0.18	<0.10	<0.10	<0.040	<0.04	<0.04
Q	05-20-2009	<0.12	<0.08	0.02	<0.18	<0.10	<0.10	<0.040	<0.04	<0.04
F	09-10-2009	<0.12	<0.08	E .01 n	<0.18	E .06 n	<0.10	<0.040	<0.04	<0.04
F	11-24-2009	.62	<0.08	.24	<0.18	<0.10	<0.10	<0.040	<0.04	<0.04
F	01-26-2010	.12	<0.08	.27	<0.18	<0.10	<0.10	<0.040	<0.04	<0.04
F	04-22-2010	<0.12	<0.08	<0.06	<0.18	<0.10	<0.10	<0.040	<0.04	<0.04
Q	04-22-2010	<0.12	<0.08	<0.06	<0.18	<0.10	<0.10	<0.040	<0.04	E .02 n
F	09-07-2010	<0.12	<0.08	<0.06	<0.18	<0.10	<0.10	<0.040	<0.04	<0.04
Q ¹	09-09-2010	<0.12	<0.08	<0.06	<0.18	<0.10	<0.10	<0.040	<0.04	<0.04
F	11-17-2010	<0.06	<0.04	<0.03	<0.09	.07 bn	<0.05	<0.020	<0.02	<0.02

Blank type	Sample date	Cadmium, water, filtered, micrograms per liter	Chromium, water, filtered, micrograms per liter	Cobalt, water, filtered, micrograms per liter	Copper, water, filtered, micrograms per liter	Iron, water, filtered, micrograms per liter	Lead, water, filtered, micrograms per liter	Manganese, water, filtered, micrograms per liter	Mercury, water, filtered, micrograms per liter	Molybdenum, water, filtered, micrograms per liter
F	03-03-2009	<0.02	<0.12	<0.02	<1.0	<4	<0.06	<0.2	<0.010	<0.02
F	05-19-2009	<0.02	<0.12	<0.02	<1.0	<4	<0.06	<2	<0.010	<0.02
Q	05-20-2009	<0.02	<0.12	<0.02	<1.0	<4	<0.06	<2	<0.010	<0.02
F	09-10-2009	<0.02	<0.12	<0.02	<1.0	<4	<0.06	<2	<0.010	<0.02
F	11-24-2009	<0.02	E .07 n	<0.01	<1.0	<6	<0.03	<3	<0.010	M n
F	01-26-2010	<0.06 d	<0.36 d	<0.03 d	<3.0 d	<6	<0.09 d	<8 d	<0.010	<1 d
F	04-22-2010	<0.02	<0.12	<0.01	<1.0	<6	<0.03	<3	<0.010	<0.028
Q	04-22-2010	<0.02	<0.12	<0.01	<1.0	<6	<0.03	<3	<0.010	<0.028
F	09-07-2010	<0.02	<0.12	<0.01	<1.0	<6	<0.03	<3	<0.010	<0.028
Q ¹	09-09-2010	<0.02	<0.12	<0.01	E .59 n	<6	E .02 n	<3	<0.010	<0.028
F	11-17-2010	<0.02	<0.06	<0.02	<50	<3	<0.01	<1	<0.005	<0.014

¹Solution was deionized water produced by the U.S. Geological Survey and used to clean equipment in preparation for sampling.

Table 13. Comparison of water-quality data for groundwater and replicate samples collected near Deer Trail, Colorado, 2009 and 2010.

[RPD, relative percent difference, which is defined as $[(\text{sample value} - \text{replicate value})/(\text{sample value} + \text{replicate value})/2] \times 100$; $\mu\text{S}/\text{cm}$, microsiemens per centimeter; $^{\circ}\text{C}$, degrees Celsius; dissolved, from samples filtered at 0.45 microns; mg/L , milligrams per liter; N, nitrogen; total, from unfiltered samples; E, value estimated by laboratory; n, value less than the minimum reporting level; <, less than; ND, not determined because data were less than the minimum reporting level; $\mu\text{g}/\text{L}$, micrograms per liter]

Property or constituents	Site name and sample date									
	D6			D6			D6			D6
	Sample	Replicate	RPD	Sample	Replicate	RPD	Sample	Replicate	RPD	
pH, laboratory (standard units)	7.2	7.2	0	7.3	7.2	1	7.2	7.2	0	7.3
Specific conductance, lab ($\mu\text{S}/\text{cm}$ at 25°C)	E 17,600	E 17,800	-1	E 17,600	E 17,600	0	E 17,500	E 17,500	0	E 17,100
Calcium, dissolved (mg/L)	466	476	-2	468	524	-11	518	506	2	515
Magnesium, dissolved (mg/L)	2,600	2,770	-6	2,390	2,390	0	2,940	2,820	4	2,960
Potassium, dissolved (mg/L)	15.7	16.1	-3	16.9	15.5	9	17.8	16.7	6	16.9
Sodium, dissolved (mg/L)	2,660	2,650	0	2,410	2,670	-10	2,290	2,570	-12	2,720
Acid neutralizing capacity, titration to pH 4.5, lab (mg/L as CaCO_3)	651	650	0	612	610	0	648	648	0	641
Bromide, dissolved (mg/L)	4.26	4.26	0	4.20	4.17	1	4.19	4.23	-1	4.17
Chloride, dissolved (mg/L)	388	389	-0	381	381	0	380	380	0	383
Fluoride, dissolved (mg/L)	1.25	1.25	0	1.16	1.16	0	1.18	1.17	1	1.17
Silica, dissolved (mg/L)	20.7	21.0	-1	23.2	22.3	4	24.1	23.5	3	23.5
Sulfate, dissolved (mg/L)	14,300	14,200	1	14,200	14,100	1	14,000	14,100	-1	14,100
Solids, residue on evaporation at 180°C , dissolved (mg/L)	22,600	22,300	1	21,800	22,000	-1	22,200	22,300	-0	22,400
Nitrogen, ammonia plus organic, dissolved (mg/L as N)	1.6	1.5	6	1.6	1.6	0	1.5	1.5	0	1.4
Nitrogen, ammonia plus organic, total (mg/L as N)	1.5	1.5	0	1.5	1.6	-6	1.6	1.6	0	1.6
Nitrogen, ammonia, dissolved (mg/L as N)	0.076	0.073	4	0.084	0.077	9	0.081	0.087	-7	0.097
Nitrite plus nitrate, dissolved (mg/L as N)	46.0	47.1	-2	50.4	51.2	-2	52.6	52.2	1	53.2
Phosphorus, dissolved (mg/L)	E,n 0.04	E,n 0.03	29	E,n 0.03	E,n 0.03	0	E,n 0.03	0.04	-29	E,n 0.02
Phosphorus, total (mg/L)	E,n 0.04	E,n 0.03	29	0.03	E,n 0.04	-29	E,n 0.03	E,n 0.03	0	E,n 0.02
Aluminum, dissolved ($\mu\text{g}/\text{L}$)	E,n 28.7	<32.0	ND	<32.0	<32.0	ND	<40.0	<40.0	ND	<23.8
Antimony, dissolved ($\mu\text{g}/\text{L}$)	E,n 0.19	<0.32	ND	<0.32	<0.32	ND	<40.0	<40.0	ND	<0.38
Arsenic, dissolved ($\mu\text{g}/\text{L}$)	1.5	2.6	-54	1.2	1.2	0	1.4	1.4	0	1.9
Barium, dissolved ($\mu\text{g}/\text{L}$)	7	6	15	4	4	0	5	5	0	6
Beryllium, dissolved ($\mu\text{g}/\text{L}$)	<0.16	<0.16	ND	<0.16	<0.16	ND	<0.20	<0.20	ND	<0.08
Boron, dissolved ($\mu\text{g}/\text{L}$)	839	870	-4	910	880	3	992	944	5	977
Cadmium, dissolved ($\mu\text{g}/\text{L}$)	E,n 0.14	0.23	-49	<0.16	<0.16	ND	E,n 0.15	E,n 0.17	-13	0.19
Chromium, dissolved ($\mu\text{g}/\text{L}$)	<0.96	E,n 0.59	ND	<0.96	<0.96	ND	E,n 0.98	E,n 1.1	-12	0.87
Cobalt, dissolved ($\mu\text{g}/\text{L}$)	9.0	9.1	-1	6.7	7.4	-10	7.2	7.3	-1	9.3
Copper, dissolved ($\mu\text{g}/\text{L}$)	<8.0	<8.0	ND	<8.0	<8.0	ND	<10.0	<10.0	ND	<7.0
Iron, dissolved ($\mu\text{g}/\text{L}$)	<40	<40	ND	<40	<40	ND	E,n 24	E,n 25	-4	<60
Lead, dissolved ($\mu\text{g}/\text{L}$)	<0.48	<0.48	ND	<0.48	<0.48	ND	<0.60	<0.60	ND	<0.21
Manganese, dissolved ($\mu\text{g}/\text{L}$)	4,620	4,560	1	3,840	3,950	-3	3,540	3,570	-1	4,650
Mercury, dissolved ($\mu\text{g}/\text{L}$)	<0.010	<0.010	ND	<0.010	<0.010	ND	<0.010	<0.010	ND	<0.010
Molybdenum, dissolved ($\mu\text{g}/\text{L}$)	5.1	4.7	8	3.2	3.2	0	3.6	3.4	6	3.9
Nickel, dissolved ($\mu\text{g}/\text{L}$)	14.4	14.6	-1	14.1	14.4	-2	13.4	14.0	-4	21.8
Selenium, dissolved ($\mu\text{g}/\text{L}$)	104	104	0	79.3	79.5	-0	85.9	85.6	0	119
Silver, dissolved ($\mu\text{g}/\text{L}$)	E,n 0.05	E,n 0.05	0	<0.06	<0.06	ND	E,n 0.05	E,n 0.06	-18	<0.07
Strontium, dissolved ($\mu\text{g}/\text{L}$)	18,900	19,500	-3	18,100	20,000	-10	20,000	19,700	2	20,300
Tungsten, dissolved ($\mu\text{g}/\text{L}$)	<0.16	<0.16	ND	<0.16	<0.16	ND	<0.20	<0.20	ND	<0.14
Zinc, dissolved ($\mu\text{g}/\text{L}$)	<16.0	<16.0	ND	<16.0	<16.0	ND	<20.0	<20.0	ND	<19.6
Uranium, natural, dissolved ($\mu\text{g}/\text{L}$)	227	228	-0	181	190	-5	168	169	-1	200

Table 13. Comparison of water-quality data for groundwater and replicate samples collected near Deer Trail, Colorado, 2009 and 2010.—Continued

[RPD, relative percent difference, which is defined as $[(\text{sample value} - \text{replicate value})/(\text{sample value} + \text{replicate value})/2]] \times 100$; $\mu\text{S}/\text{cm}$, microsiemens per centimeter; $^{\circ}\text{C}$, degrees Celsius; dissolved, from samples filtered at 0.45 microns; mg/L, milligrams per liter; N, nitrogen; total, from unfiltered samples; E, value estimated by laboratory; n, value less than the minimum reporting level; <, less than; ND, not determined because data were less than the minimum reporting level; $\mu\text{g}/\text{L}$, micrograms per liter]

Property or constituents	Site name and sample date											
	D6 01/21/10			D6 04/21/10			D6 9/8/2010			D6 11/17/2010		
	Sample	Replicate	RPD	Sample	Replicate	RPD	Sample	Replicate	RPD	Sample	Replicate	RPD
pH, laboratory (standard units)	7.2	7.2	0	7.3	7.3	0	7.4	7.4	0	7.2	7.2	0
Specific conductance, lab (µS/cm at 25°C)	E 17,200	E 17,100	1	E 17,100	E 17,230	-1	E 17,100	E 17,110	-0	E 17,100	E 17,150	-0
Calcium, dissolved (mg/L)	490	504	-3	516	510	1	425	419	1	533	468	13
Magnesium, dissolved (mg/L)	2,810	2,330	19	2,810	2,820	-0	2,920	2,340	22	2,530	2,640	-4
Potassium, dissolved (mg/L)	17.2	17.4	-1	16.2	17.1	-5	14.3	13.5	6	14.4	14.8	-3
Sodium, dissolved (mg/L)	2,600	2,580	1	2,780	2,740	1	2,250	2,120	6	2,450	2,320	5
Acid neutralizing capacity, titration to pH 4.5, lab (mg/L as CaCO ₃)	640	644	-1	641.8	642	-0	634.5	641	-1	643.5	642	0
Bromide, dissolved (mg/L)	4.18	4.19	-0	3.95	4.02	-2	3.97	3.94	1	3.94	3.95	-0
Chloride, dissolved (mg/L)	398	396	1	403	402	0	390	394	-1	371	382	-3
Fluoride, dissolved (mg/L)	1.27	1.27	0	1.24	1.19	4	1.12	1.13	-1	1.22	1.22	0
Silica, dissolved (mg/L)	21.6	22.2	-3	23.3	24.6	-5	20.4	20.1	1	21.3	21.9	-3
Sulfate, dissolved (mg/L)	14,200	14,100	1	14,000	14,000	0	13,900	13,900	0	14,200	14,100	1
Solids, residue on evaporation at 180°C, dissolved (mg/L)	22,000	21,300	3	22,400	22,000	2	21,300	21,900	-3	22,000	22,000	0
Nitrogen, ammonia plus organic, dissolved (mg/L as N)	1.5	1.6	-6	1.5	1.4	7	1.5	1.6	-6	1.4	1.6	-13
Nitrogen, ammonia plus organic, total (mg/L as N)	1.6	1.5	6	1.7	1.6	6	1.6	1.6	0	1.5	1.6	-6
Nitrogen, ammonia, dissolved (mg/L as N)	0.078	0.074	5	<0.077	<0.077	ND	0.100	0.103	-3	0.133	0.121	9
Nitrite plus nitrate, dissolved (mg/L as N)	51.6	51.1	1	53.8	53.7	0	50.4	50.3	0	48.0	48.0	0
Phosphorus, dissolved (mg/L)	E,n 0.03	<0.04	ND	E,n 0.04	E,n 0.03	29	E,n 0.04	E,n 0.03	29	b,n 0.03	0.04	-29
Phosphorus, total (mg/L)	0.06	E,n 0.02	100	E,n 0.04	E,n 0.04	0	E,n 0.03	E,n 0.04	-29	0.05	0.05	0
Aluminum, dissolved (µg/L)	<51.0	<51.0	ND	<68.0	<68.0	ND	<23.8	<23.8	ND	<11.9	<11.9	ND
Antimony, dissolved (µg/L)	<0.81	<0.81	ND	<1.08	<1.08	ND	<0.38	<0.38	ND	<0.19	<0.19	ND
Arsenic, dissolved (µg/L)	1.2	1.0	18	1.1	1.3	-17	1.3	1.4	-7	1.4	1.5	-7
Barium, dissolved (µg/L)	5	6	-18	5	5	0	6	5	18	5	5	0
Beryllium, dissolved (µg/L)	<0.18	<0.18	ND	<0.24	<0.24	ND	<0.08	<0.08	ND	<0.04	<0.04	ND
Boron, dissolved (µg/L)	868	892	-3	808	868	-7	819	824	-1	1,000	898	11
Cadmium, dissolved (µg/L)	<0.30	<0.30	ND	<0.40	<0.40	ND	E,n 0.09	E,n 0.09	0	<0.11	<0.11	ND
Chromium, dissolved (µg/L)	E,n 1.6	E,n 1.7	-6	<2.4	<2.4	ND	<0.84	<0.84	ND	1.1	1.2	-9
Cobalt, dissolved (µg/L)	7.1	7.7	-8	6.9	6.6	4	7.2	7.8	-8	7.1	7.3	-3
Copper, dissolved (µg/L)	<15.0	<15.0	ND	<20.0	<20.0	ND	<7.0	<7.0	ND	<3.5	<3.5	ND
Iron, dissolved (µg/L)	<60	<60	ND	E,n 3	E,n 6	-67	E,n 11	<60	ND	12	37	-102
Lead, dissolved (µg/L)	<0.45	<0.45	ND	<0.60	<0.60	ND	<0.21	<0.21	ND	<0.10	<0.10	ND
Manganese, dissolved (µg/L)	3,730	3,950	-6	3,740	3,470	7	4,000	4,200	-5	3,830	3,780	1
Mercury, dissolved (µg/L)	<0.010	<0.010	ND	<0.010	<0.010	ND	<0.010	<0.010	ND	<0.005	<0.005	ND
Molybdenum, dissolved (µg/L)	3.0	3.6	-18	3.0	3.2	-6	3.4	3.6	-6	3.7	3.9	-5
Nickel, dissolved (µg/L)	17.4	19.0	-9	17.0	17.1	-1	9.3	10.0	-7	10.0	9.5	5
Selenium, dissolved (µg/L)	80.6	87.3	-8	73.5	76.9	-4	84.8	93.0	-9	67.7	65.9	3
Silver, dissolved (µg/L)	E,n 0.10	E,n 0.10	0	E,n 0.12	<0.20	ND	<0.07	<0.07	ND	0.04	<0.04	ND
Strontium, dissolved (µg/L)	20,800	21,400	-3	19,600	19,300	2	16,400	15,800	4	17,400	17,000	2
Tungsten, dissolved (µg/L)	<0.30	<0.30	ND	<0.40	<0.40	ND	<0.14	<0.14	ND	<0.07	<0.07	ND
Zinc, dissolved (µg/L)	<42.0	<42.0	ND	<56.0	<56.0	ND	<19.6	<19.6	ND	<9.8	<9.8	ND
Uranium, natural, dissolved (µg/L)	160	171	-7	165	159	4	190	200	-5	174	172	1

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