Assessment of Nonpoint Source Chemical Loading Potential to Watersheds Containing Uranium Waste Dumps Associated with Uranium Exploration and Mining, Browns Hole, Utah

Prepared in cooperation with the Bureau of Land Management

Scientific Investigations Report 2011–5230

Cover: Photograph looking northeast near site BH-46, San Juan County, Utah. By Kimberly R. Beisner in August 2008.

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Conversion Factors and Abbreviations

SI to Inch/Pound

Multiply	By	To obtain
Length		
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
Area		
square kilometer (km ²)	0.3861	square mile (mi ²)
Volume		
cubic meter (m ³)	35.31	cubic foot (ft ³)
liter (L)	61.02	cubic inch (in ³)
Mass		
gram (g)	0.03527	ounce, avoirdupois (oz)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

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

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{C}=(^{\circ}\text{F}-32)/1.8$$

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).

Abbreviations and Acronyms

(Clarification or additional information given in parentheses)

AML	abandoned mine lands
BG	background
BH	Browns Hole
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund)
GIS	geographic information system
HDPE	high density polyethylene
ID	identification
SED	stream sediment

Organizations

BLM	Bureau of Land Management
NWQL	National Water Quality Laboratory (USGS)
USGS	U.S. Geological Survey
US EPA	U.S. Environmental Protection Agency

Units of measurement

C	Celsius
cm	centimeter (10^{-2} meter)
ft	foot (feet)
ft³/s	cubic feet per second
g	gram
g/m³	grams per cubic meter
g/yr	grams per year
in.	inch
L	liter
m³/y	cubic meters per year
mi	mile
mi²	square mile
mL	milliliter (10^{-3} liter)
mm	millimeter (10^{-3} meter)
mrem	millirem (10^{-3} rem)
mV	millivolt
pCi/g	picocurie(s) per gram (10^{-12} curie)
ppm	parts per million
pCi/L	picocurie(s) per liter
µg/L	microgram(s) per liter (10^{-6} grams per liter)

Chemical Elements

Ag	Silver	Cs	Cesium	Na	Sodium	Sr	Strontium
Al	Aluminum	Cu	Copper	Nb	Niobium	Te	Tellurium
As	Arsenic	Fe	Iron	Ni	Nickel	Th	Thorium
Ba	Barium	Ga	Gallium	P	Phosphorous	Ti	Titanium
Be	Beryllium	Hg	Mercury	Pb	Lead	Tl	Thallium
Bi	Bismuth	In	Indium	Ra	Radium	U	Uranium
Ca	Calcium	K	Potassium	Rb	Rubidium	V	Vanadium
Cd	Cadmium	La	Lanthanum	S	Sulfur	W	Tungsten
Ce	Cerium	Li	Lithium	Sb	Antimony	Y	Yttrium
Co	Cobalt	Mg	Magnesium	Sc	Scandium	Zn	Zinc
Cr	Chromium	Mn	Manganese	Se	Selenium		
		Mo	Molybdenum	Sn	Tin		

Assessment of Nonpoint Source Chemical Loading Potential to Watersheds Containing Uranium Waste Dumps Associated with Uranium Exploration and Mining, Browns Hole, Utah

By Thomas M. Marston, Kimberly R. Beisner, David L. Naftz, and Terry Snyder

Abstract

During August of 2008, 35 solid-phase samples were collected from abandoned uranium waste dumps, undisturbed geologic background sites, and adjacent streambeds in Browns Hole in southeastern Utah. The objectives of this sampling program were (1) to assess impacts on human health due to exposure to radium, uranium, and thorium during recreational activities on and around uranium waste dumps on Bureau of Land Management lands; (2) to compare concentrations of trace elements associated with mine waste dumps to natural background concentrations; (3) to assess the nonpoint source chemical loading potential to ephemeral and perennial watersheds from uranium waste dumps; and (4) to assess contamination from waste dumps to the local perennial stream water in Muleshoe Creek. Uranium waste dump samples were collected using solid-phase sampling protocols. Solid samples were digested and analyzed for major and trace elements. Analytical values for radium and uranium in digested samples were compared to multiple soil screening levels developed from annual dosage calculations in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act's minimum cleanup guidelines for uranium waste sites. Three occupancy durations for sites were considered: 4.6 days per year, 7.0 days per year, and 14.0 days per year. None of the sites exceeded the radium soil screening level of 96 picocuries per gram, corresponding to a 4.6 days per year exposure. Two sites exceeded the radium soil screening level of 66 picocuries per gram, corresponding to a 7.0 days per year exposure. Seven sites exceeded the radium soil screening level of 33 picocuries per gram, corresponding to a 14.0 days per year exposure. A perennial stream that flows next to the toe of a uranium waste dump was sampled, analyzed for major and trace elements, and compared with existing aquatic-life and drinking-water-quality standards. None of the water-quality standards were exceeded in the stream samples.

Introduction

Browns Hole is located in southeastern Utah in San Juan County, 18 mi south of the town of Moab and covers approximately 36 mi² of primarily Bureau of Land Management (BLM) lands (fig. 1) that have altitudes ranging from 5,600 to 6,500 ft above sea level. Exposed rocks range in age from the Permian Cutler Formation to the Jurassic Navajo Sandstone. Most of the land is covered by ephemeral drainages that only contribute runoff during rainfall and snowmelt events.

The lowland canyons are characterized by mild winters, with an average maximum daily temperatures of 42 °F, and hot summers, with average maximum daily temperature of 98°F. Most of the precipitation falls as rain from convective thunderstorms that typically occur between August and October. This arid region receives approximately 6 to 8 in. of precipitation in the lower elevations and approximately 8 to 10 in. of precipitation in the higher elevations (Natural Resources Conservation Service, 1998).

Browns Hole is one of several areas in southern Utah that experienced uranium mining and exploration in the 1950s. Most of the mines and exploration activities extracted material from the Salt Wash Sandstone Member of the Jurassic Morrison Formation, which is overlain by the Cretaceous Burro Canyon Formation and is underlain by the Slickrock Member of the Jurassic Entrada Sandstone (Gloyn and others, 1995). Currently (2010), thousands of abandoned uranium waste dumps exist throughout the state of Utah, with many of the properties located on lands managed by the BLM. Sixty-three uranium mine adits have been inventoried by the BLM throughout the Browns Hole area (Terry Snyder, Bureau of Land Management, written commun., 2008). Of the 63 inventoried adits, 20 adits were selected for sampling on the basis of size and ease of access (table 1). Abandoned uranium waste dumps associated with the previously mentioned adits present unique characteristics that make it difficult to quantify nonpoint source pollution contributions to specific watersheds. These characteristics include (1) locations that are primarily in watersheds with ephemeral streams, (2) radioactive sands and fine particulates that persist for hundreds of thousands of years, (3) intense rainfall and snowmelt events that can mobilize and transport mine waste with associated radioactive

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Figure 1. Location of the abandoned mine lands study area in Browns Hole, Utah.

Table 1. U.S. Geological Survey site identification and associated Bureau of Land Management Tag Numbers for abandoned uranium mines selected for this study, Browns Hole, Utah.

[Abbreviations: Site ID, site identification; BLM, Bureau of Land Management; BH, Browns Hole; HO, horizontal opening; IO, inclined opening]

Site ID	USGS site number	BLM tag number
BH-2	382228109254301	4282307HO001 and HO002
BH-26	382153109241801	4282317IO001
BH-27	382157109241601	4282317IO002
BH-28	382146109244901	4282317HO001 and HO002
BH-30	382146109241801	4282317HO003 and HO004
BH-32	382147109241901	4282317HO005
BH-33	382149109242701	4282317HO006 and HO007
BH-35	382224109253901	4282318HO001
BH-36	382220109253501	4282318HO002
BH-37	382049109230001	4282322HO001
BH-40	382048109225701	4282322HO002 through HO007
BH-46	382009109233101	4282328HO001 through HO003
BH-49	382008109233101	4282328HO004 through HO006
BH-52	381903109232401	4282333HO001 through HO003
BH-54	381907109232501	4282333HO004
BH-58	381945109231901	4282333HO005 through HO008
BH-59	381849109224401	4292303HO001
BH-60	381848109224301	4292303HO002
BH-62	381849109225801	4292303HO003 and HO004
BH-63	381849109230001	4292303HO005

material and trace elements long distances during relatively short time periods, and (4) remote locations that do not allow for cost effective water and suspended-sediment sampling during intermittent rainfall and snowmelt runoff events.

The Browns Hole area is bisected by a perennial stream, Muleshoe Creek, which flows past the toe of an abandoned uranium waste dump (fig. 2). The site is further complicated by the presence of water flowing out of adits and onto the uranium waste dump primarily during the spring season. Muleshoe Creek dries up downstream of the mining area and resurfaces near U.S. Highway 191 to the west.

Sample collection from uranium waste dump sites during August 2008 was completed by the U.S. Geological Survey (USGS) in cooperation with the BLM. The primary objective of this report is to present results of chemical analyses of both solid-phase and stream-water samples collected at abandoned mine sites for assessment of risk to human health from exposure to radioactive elements in waste dump piles. The first objective is similar to a study completed by the U.S. Environmental Protection Agency (2008), which investigated potential human health, geographic, and environmental issues related to abandoned uranium mines in southeastern Utah. The second

objective is to assess the nonpoint source chemical loading potential from uranium waste dump sites to ephemeral and perennial watersheds for use in setting remediation priorities. The third objective is to compare trace-element concentrations associated with waste dump sites to natural background areas. The fourth objective is to assess possible contamination by waste dump sites adjacent to the local perennial stream, Muleshoe Creek.

Methodology

Solid-Phase Sample Collection

Thirty-five samples (20 from uranium waste dump sites, 8 from streambed sites, and 7 from geologic background sites) were collected in August 2008. The general locations of the uranium waste dump, geologic background, and streambed sites that were sampled are shown in figure 2, and more detailed maps of the sampled sites are shown in figures 3–8. Because the uranium waste dumps had steep slopes, sampling generally took place from the safest and most accessible location, which was typically at the top of waste dumps. Geologic background samples were collected in the same geologic layer adjacent to sampled uranium waste dump sites. Streambed samples were collected from ephemeral stream channels downstream from sampled uranium waste dump sites.

A modified version of the solid-phase sampling methods outlined in Smith and others (2000) and Hageman and Briggs (2000) was used to collect samples from the uranium waste dump and undisturbed geologic background sites. Samples consisted of 30 scoops of soil collected using a plastic trowel from the top 5 cm of soil depth. One scoop is approximately equal to 7 in.³. Scoops of soil for each sample were compiled into 2-gallon Ziploc® bags and labeled. Streambed samples, consisting of 10 scoops of sediment from the top 5 cm of depth, were collected along ephemeral stream channels using a plastic trowel.

Samples from the uranium waste dump sites were labeled BH (for “Browns Hole”) and then numbered in sequential order from the time when the samples were collected. Undisturbed geologic background site samples were labeled BH, followed by the number of the closest waste dump site and the letters BG (for “background”). Streambed site samples were labeled BH, followed by the number of the upstream waste dump site and the letters SED (for “sediment”), with sample locations labeled sequentially with distance from the source waste rock pile. BH sample identifications that were assigned to the abandoned uranium mines by the USGS have been paired with the site identifications assigned by the BLM and can be viewed in table 1.

All sampling equipment was thoroughly cleaned in the field between each sampling location. A plastic multi-purpose sprayer was used to thoroughly wash plastic trowels three times with de-ionized water; trowels were then wiped with a clean paper towel and allowed to air dry before use at the next site.

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Figure 2. Index map of uranium waste dump, streambed sediment, undisturbed geologic background, and stream-water sample sites in Browns Hole, Utah.

Figure 3. Map 1a showing sample locations and associated concentrations of total radium in solid-phase material from uranium waste dump, streambed sediment, and geologic background sites.

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Figure 4. Map 1a showing sample locations and associated concentrations of total uranium in solid-phase material from uranium waste dump, streambed sediment, and geologic background sites.

Figure 5. Map 1b showing sample locations and associated concentrations of total radium in solid-phase material from uranium waste dump, streambed sediment, and geologic background sites.

Figure 6. Map 1b showing sample locations and associated concentrations of total uranium in solid-phase material from uranium waste dump, streambed sediment, and geologic background sites.

Figure 7. Map 1c showing sample locations and associated concentrations of total radium in solid-phase material from uranium waste dump, streambed sediment, and geologic background sites.

Figure 8. Map 1c showing sample locations and associated concentrations of total uranium in solid-phase material from uranium waste dump, streambed sediment, and geologic background sites.

Solid Sample Digestion

Prior to laboratory submission, the uranium waste dump and streambed samples were sieved through a 2-millimeter (mm) mesh (U.S. Sieve No. 10). The fraction of sample passing through the No. 10 sieve was analyzed by the USGS Geologic Division Laboratory for total extractable concentrations of selected trace elements. Forty-two elements (Ag, Al, As, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cs, Cu, Fe, Ga, In, K, La, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Rb, S, Sb, Sc, Sn, Sr, Te, Th, Ti, Tl, U, V, W, Y, and Zn) were analyzed using inductively coupled plasma-atomic emission spectrometry (ICP-AES) following decomposition of the solid sample using hydrochloric, nitric, perchloric, and hydrofluoric acids at low temperature (Crock and others, 1983). The digested samples are aspirated in the ICP-AES discharge, where the elemental emission signal is measured simultaneously for the forty-two elements. The procedure and analytical performance are presented in Briggs (2002). Selenium was analyzed using hydride generation-atomic absorption spectrophotometry (HG-AAS) following digestion of the solid sample using nitric, hydrochloric, and sulfuric acids (Hageman and others, 2002). Mercury was analyzed using cold vapor-atomic absorption spectrometry (CV-AAS) following digestion of the solid sample using nitric acid and sodium dichromate (Brown and others, 2002). Radium was analyzed by Eberline Services using a gas-flow proportional alpha-particle counting system following digestion of the solid sample and co-precipitation of barium and lead sulfate (U.S. Environmental Protection Agency, 2010).

Water Sample Collection

Water samples were collected in Muleshoe Creek at three locations along the stream reach surrounding the abandoned mining area. Point-grab samples from the center of the stream were collected starting downstream of the mining area and moving upstream to avoid contamination from stream disturbance. Discharge measurements were made at each sample site using a Pygmy meter (Price Pygmy meter no. 227656). Field water-quality parameters, including pH, specific conductance, temperature, dissolved oxygen, and oxidation reduction potential were measured using an In-Situ, Inc. Troll® 9500 (table 2). Water samples were collected following the trace-element protocol defined by U.S. Geological Survey (2006). Samples were sent to the USGS National Water Quality Laboratory (NWQL) for major- and trace-element analyses.

Results

Solid-Phase Trace-Element Concentrations

All uranium waste dump, background, and stream sediment samples were analyzed for total digestible metal concentrations (table 3, located on page 22 in the back of the report). Trace-element concentrations in solid-phase samples collected at mine sites and in ephemeral stream channels downstream of mine sites were compared to trace-element concentrations

Table 2. Field parameters measured in Muleshoe Creek on August 13, 2008, Browns Hole, Utah.

[Abbreviations: DD.dddd, Degrees.decimal degrees; ft, feet; ft³/sec, cubic feet per second; hh:mm, hour:minute; MDT, Mountain Daylight Time; mg/L, milligrams per liter; mmHg, millimeters of mercury; mV, millivolts; Site ID, site identification; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Site ID	Map ID	USGS site number	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Discharge (ft ³ /sec)	pH (standard units)
Muleshoe Creek 1 downstream	Muleshoe-1	382048109230801	10:00	38.34677	109.38558	5,680	0.27	8.3
Muleshoe Creek 2 at mining area	Muleshoe-2	382046109225801	11:15	38.34607	109.38286	5,720	0.27	8.4
Muleshoe Creek 3 upstream	Muleshoe-3	382042109224201	12:45	38.34497	109.37836	5,800	0.42	8.3

Site ID	Map ID	USGS site number	Specific conductance (µS/cm)	Temperature (°C)	Dissolved oxygen (mg/L)	Barometric pressure (mmHg)	Oxidation reduction potential (mV)
Muleshoe Creek 1 downstream	Muleshoe-1	382048109230801	944	14.7	9.38	622	+51
Muleshoe Creek 2 at mining area	Muleshoe-2	382046109225801	946	16.4	9.17	621	+27
Muleshoe Creek 3 upstream	Muleshoe-3	382042109224201	944	19.2	9.32	620	+18

in solid-phase samples collected at undisturbed background sites within the study area (fig. 9). The median value of seven background samples collected from various locations in the Browns Hole study area (fig. 2) determined the background concentration for all trace elements. All sites exceeded background concentrations for arsenic, radium, uranium, and vanadium. Concentrations of arsenic at BH-35 ranged from background levels of 5 parts per million (ppm) up to 195 ppm. Concentrations of radium ranged from background levels of 1.39 pCi/g up to 91 pCi/g at BH-30. Concentrations of uranium ranged from background levels of 6.2 ppm up to 359 ppm at BH-46. Concentrations of vanadium ranged from background levels of 70 ppm up to 2,550 ppm at BH-30. Many

sites also exceeded background concentrations for cadmium, cobalt, chromium, copper, molybdenum, lead, antimony, tungsten, and zinc (fig. 9). Concentrations of cadmium ranged from background levels of 0.1 ppm up to 3.5 ppm at BH-30. Concentrations of cobalt ranged from background levels of 10 ppm to 90 ppm at BH-27. Concentrations of chromium ranged from background levels of 50 ppm up to 390 ppm at BH-33. Concentrations of copper ranged from background levels of 20 ppm up to 110 ppm at BH-27. Concentrations of molybdenum ranged from background levels of 10 ppm up to 90 ppm at BH-27. Concentrations of lead ranged from background levels of 14.6 ppm up to 266 ppm at BH-35. Concentrations of antimony ranged from background levels of 0.69 ppm up

Figure 9. Concentrations of selected trace elements in solid-phase material from 20 uranium mine waste dump sites in Browns Hole, Utah. Dashed line indicates the median value for undisturbed background samples from seven sites.

Figure 9. Concentrations of selected trace elements in solid-phase material from 20 uranium mine waste dump sites in Browns Hole, Utah. Dashed line indicates the median value for undisturbed background samples from seven sites.—Continued

to 3.38 ppm at BH-32. Concentrations of tungsten ranged from background levels of 0.7 ppm up to 1.7 ppm at BH-26. Concentrations of zinc ranged from background levels of 40 ppm up to 550 ppm at BH-30. Only one site, BH-37, exceeded background concentrations for thorium. Overall, the highest concentrations of the selected trace elements occurred at BH-30 and BH-46, which were also the sites that had the highest concentrations of radium and uranium.

Analytical results for sediment samples collected from dry ephemeral stream channels downstream of mine sites BH-36, BH-40, and BH-49 were used to plot transects of radium, uranium, vanadium, and arsenic concentrations at various distances from the mine sites (fig. 10). For all three sites, the concentrations of radium, uranium, vanadium, and arsenic in sediment from downstream were significantly lower than the concentrations found in samples from the mine sites. Downstream samples, BH-36-SED and BH-49-SED1, 2, 3, 4, and 5, all yielded concentrations of radium and uranium that were above background concentrations. Ephemeral stream sediment samples downstream from BH-49 yielded a noticeable decrease in concentrations of radium, uranium, and vanadium with increasing distance from the source material. Similar decreases in concentration with increasing distance from the source material were observed for vanadium and arsenic. One ephemeral stream site located 45 ft downstream of BH-36, BH-36-SED, yielded elevated radium concentrations relative to background. BH-40-SED1 and 2 yielded concentrations that were near background for radium, uranium, vanadium, and arsenic and had no significant decrease in concentrations with increasing distance from the source material.

Stream-Water Trace-Element Concentrations

Trace-element concentrations in the water samples collected in Muleshoe Creek were compared to water-quality standards for aquatic life (U.S. Environmental Protection Agency, 2007b) and drinking water (U.S. Environmental Protection Agency, 2007a; table 4). For constituents without a water-quality standard for aquatic life or drinking water, no comparison was made. At all three sample collection sites (fig. 2), 1,200 ft upstream of BH-40 (Muleshoe-3), at the mining area (Muleshoe-2), and 1,000 ft downstream of BH-40 (Muleshoe-1), no elements exceeded the water-quality standards (tables 5 and 6). Uranium concentration increased slightly from upstream to downstream samples, with a concentration of 4.4 $\mu\text{g/L}$ upstream of BH-40, 5.62 $\mu\text{g/L}$ at BH-40, and 5.96 $\mu\text{g/L}$ downstream of BH-40 (table 6). Arsenic concentration increased slightly from upstream to downstream samples, with a concentration of 1.3 $\mu\text{g/L}$ upstream of BH-40, 1.5 $\mu\text{g/L}$ at BH-40, and 1.8 $\mu\text{g/L}$ downstream of BH-40 (table 6). Concentrations of aluminum, antimony, barium, beryllium, cadmium, chromium, copper, iron, lead, magnesium, manganese, molybdenum, nickel, radium, selenium, silver, sodium, vanadium, and zinc remained relatively stable or decreased from upstream to downstream samples (tables 5 and 6).

Figure 10. Solid-phase sediment transects of BH-36, BH-40, and BH-49 and associated downstream streambed sediment for total radium, uranium, vanadium, and arsenic concentrations.

Table 4. U.S. Environmental Protection Agency drinking water-quality standards¹ and aquatic life water-quality standards².

[Abbreviations: na, not applicable; pCi/L, picocuries per liter; µg/L, micrograms per liter]

Element	Drinking-water-quality standard concentration (µg/L)	Aquatic life water-quality standard concentration (µg/L)
Antimony (Sb)	6	na
Arsenic (As)	10	150
Barium (Ba)	2,000	na
Beryllium (Be)	4	na
Cadmium (Cd)	5	0.25
Chromium (Cr)	100	na
Cobalt (Co)	na	na
Copper (Cu)	1,300	9
Iron (Fe)	300	na
Lead (Pb)	15	2.5
Manganese (Mn)	50	na
Mercury (Hg)	2	0.77
Molybdenum (Mo)	na	na
Nickel (Ni)	na	52
Radium (Ra) (pCi/L)	5	na
Selenium (Se)	50	5
Silver (Ag)	100	na
Thallium (Tl)	2	na
Uranium (U)	30	na
Vanadium (V)	na	na
Zinc (Zn)	5,000	120

¹Drinking-water-quality standards (U.S. Environmental Protection Agency, 2007a).

²Aquatic life water-quality standards (U.S. Environmental Protection Agency, 2007b).

Quality Control

Two standard reference materials obtained from the USGS (Green River Shale (SGR-1B) and Mica Schist (SDC-1)) were submitted blindly with the routine waste rock and stream sediment samples collected in the Browns Hole study area. Analytical results from the standard reference materials were generally within acceptable limits and were within ± 12.4 percent for Green River Shale (SGR-1B) and ± 10.3 percent for Mica Schist (SDC-1) on average (table 3). An onsite field blank for water samples consisting of certified inorganic blank water poured into a sample bottle to replicate the point-grab sampling method yielded results below laboratory reporting levels (tables 5 and 6).

Soil Screening Levels for Radium, Uranium, and Thorium

Three soil screening levels (SSL) for various exposure durations were determined for the combined carcinogenic

effects of radium, uranium, and thorium as radionuclides on the basis of calculations made with RESRAD 6.5, a computer model designed to estimate radiation doses and risks from residual radioactive materials (Yu and others, 1993). Soil screening levels were evaluated for a maximum annual dosage of 15 additional millirem per year (mrem/yr) (U.S. Environmental Protection Agency, 1997a). Several exposure pathways were considered in the model: direct external exposure to contaminated soils, internal exposure to inhaled radionuclides, and internal exposure by ingestion of contaminated soils. RESRAD also considers exposures from ingestion of plants grown in contaminated soils, from ingestion of meat derived from livestock fed with contaminated feed or water, from drinking water directly, and from ingestion of fish from a contaminated body of water. These pathways were not included on the basis of low radionuclide concentrations in background samples and water-quality samples. The waste-rock sites do not support significant plant life and have an average radium concentration of 31 pCi/g, whereas areas adjacent to the piles with significant plant life and potential for livestock forage have an average radium concentration of 1.5 pCi/g. Given that the natural background concentration in the area is less than 5 percent of the average radium concentration found in the waste-rock piles, radionuclide propagation by local plant-life uptake poses a minimal risk to humans. Water-quality samples from Muleshoe Creek yielded concentrations of the radioactive elements uranium, radium, and thorium that were below U.S. Environmental Protection Agency (USEPA) aquatic-life and drinking-water standards, resulting in a minimal risk for consumption of water sources by humans and aquatic life (U.S. Environmental Protection Agency, 2007a, b).

For this study, the radioactive elements uranium, radium, and thorium were analyzed for total concentrations in soil. Both uranium and thorium were reported in ppm, while radium was reported in pCi/g. Concentrations of both uranium and thorium were converted to activity of uranium-238 and thorium-232 because these are the most abundant isotopes, with 99.27 percent of natural uranium occurring as uranium-238 and 100 percent of natural thorium as thorium-232. Radioactive concentration for total radium was considered equal to the activity of radium-226 because it is the most abundant isotope associated with decay of natural uranium deposits, such as those found at Browns Hole. Natural uranium consists of uranium-234, -235, and -238 in ratios corresponding to natural isotopic abundances, which are less than 0.01, 0.72, and 99.27 percent, respectively. The uranium decay series considered includes the natural uranium species along with the decay chains of uranium-238, uranium-235, and one daughter product of uranium-234, thorium-230 (fig. 11). Radium-226 and its associated short-lived decay chain along with thorium-232 and its decay chain were considered as separate radionuclide series (fig. 11). Given the three exposure pathways considered, radium-226 and its associated decay chain poses the greatest risk to human health as shown by the model's sensitivity to radium-226 concentrations.

Because of the particular uses of the study area, some of the assumptions about the parameters used by RESRAD have

16 Assessment of Nonpoint Source Chemical Loading Potential to Watersheds Containing Uranium Waste Dumps

Table 5. Chemical analysis of filtered water samples collected on August 13, 2008, from Muleshoe Creek, Browns Hole, Utah.

[Abbreviations: DD.dddd, Degrees.decimal degrees; E, estimated; Site ID, site identification; ft, feet; hh:mm, hour:minute; MDT, Mountain Daylight Time; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than laboratory reporting level; NA, not analyzed]

Site ID	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Calcium dissolved (mg/L as Ca)	Chloride dissolved (mg/L as Cl)	Fluoride dissolved (mg/L as F)	Magnesium dissolved (mg/L as Mg)	Potassium dissolved (mg/L as K)	Silica dissolved (mg/L as Si)
Muleshoe Creek 1 down-stream	10:00	38.34677	109.38558	5,680	110	28.2	0.34	33.9	2.21	18.1
Muleshoe Creek 2 at mining area	11:15	38.34607	109.38286	5,720	113	27.7	0.33	33.7	2.24	18
Muleshoe Creek 3 up-stream	12:45	38.34497	109.37836	5,800	114	27.4	0.32	33.2	2.29	18.4
Onsite field blank	13:00	38.34497	109.37836	5,800	NA	<0.12	<0.12	NA	<0.02	NA
Site ID	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Sodium dissolved (mg/L as Na)	Sulfate dissolved (mg/L as SO ₄)	Aluminum dissolved (µg/L as Al)	Antimony dissolved (µg/L as Sb)	Arsenic dissolved (µg/L as As)	Boron dissolved (µg/L as B)
Muleshoe Creek 1 down-stream	10:00	38.34677	109.38558	5,680	54.4	236	E1.1	<0.14	1.4	53
Muleshoe Creek 2 at mining area	11:15	38.34607	109.38286	5,720	54.4	234	1.7	<0.14	1.3	52
Muleshoe Creek 3 up-stream	12:45	38.34497	109.37836	5,800	53.1	227	E0.8	E0.07	1.3	49
Onsite field blank	13:00	38.34497	109.37836	5,800	NA	<0.18	NA	NA	NA	NA
Site ID	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Barium dissolved (µg/L as Ba)	Beryllium dissolved (µg/L as Be)	Cadmium dissolved (µg/L as Cd)	Chromium dissolved (µg/L as Cr)	Cobalt dissolved (µg/L as Co)	Copper dissolved (µg/L as Cu)
Muleshoe Creek 1 down-stream	10:00	38.34677	109.38558	5,680	60	<0.01	<0.04	<0.12	0.16	<1.0
Muleshoe Creek 2 at mining area	11:15	38.34607	109.38286	5,720	60	<0.01	E0.03	E0.07	0.21	1.1
Muleshoe Creek 3 up-stream	12:45	38.34497	109.37836	5,800	61	<0.01	0.23	<0.12	0.19	<1.0
Onsite field blank	13:00	38.34497	109.37836	5,800	NA	NA	NA	NA	NA	NA
Site ID	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Iron dissolved (µg/L as Fe)	Lead dissolved (µg/L as Pb)	Lithium dissolved (µg/L as Li)	Manganese dissolved (µg/L as Mn)	Molybdenum dissolved (µg/L as Mo)	Nickel dissolved (µg/L as Ni)
Muleshoe Creek 1 down-stream	10:00	38.34677	109.38558	5,680	E4	<0.08	30.5	31.7	1.9	0.84
Muleshoe Creek 2 at mining area	11:15	38.34607	109.38286	5,720	<8	<0.08	29.6	31.1	1.9	0.86
Muleshoe Creek 3 up-stream	12:45	38.34497	109.37836	5,800	<8	<0.08	27.9	39.2	1.8	0.75
Onsite field blank	13:00	38.34497	109.37836	5,800	NA	NA	NA	NA	NA	NA
Site ID	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Silver dissolved (µg/L as Ag)	Strontium dissolved (µg/L as Sr)	Thallium dissolved (µg/L as Tl)	Uranium dissolved (µg/L as U)	Vanadium dissolved (µg/L as V)	Zinc dissolved (µg/L as Zn)
Muleshoe Creek 1 down-stream	10:00	38.34677	109.38558	5,680	<0.1	2,120	<0.04	5.18	1.2	E1.1
Muleshoe Creek 2 at mining area	11:15	38.34607	109.38286	5,720	<0.1	2,130	<0.04	4.79	1.2	<1.8
Muleshoe Creek 3 up-stream	12:45	38.34497	109.37836	5,800	<0.1	2,090	<0.04	3.81	1.2	<1.8
Onsite field blank	13:00	38.34497	109.37836	5,800	NA	NA	NA	NA	NA	NA

Table 6. Chemical analysis of unfiltered water samples collected on August 13, 2008, from Muleshoe Creek, Browns Hole, Utah.

[Abbreviations: DD.dddd, Degrees.decimal degrees; ft, feet; hh:mm, hour:minute; MDT, Mountain Daylight Time; mg/L, milligrams per liter; pCi/L, picocuries per liter; Site ID, site identification; µg/L, micrograms per liter; <, less than laboratory reporting level]

Site ID	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Calcium dissolved (mg/L as Ca)	Magnesium dissolved (mg/L as Mg)	Sodium dissolved (mg/L as Na)	Aluminum dissolved (µg/L as Al)	Antimony dissolved (µg/L as Sb)	Arsenic dissolved (µg/L as As)
Muleshoe Creek 1 down-stream	10:00	38.34677	109.38558	5,680	112	34.1	51.3	115	<0.1	1.8
Muleshoe Creek 2 at mining area	11:15	38.34607	109.38286	5,720	112	33.3	50.9	118	<0.1	1.5
Muleshoe Creek 3 up-stream	12:45	38.34497	109.37836	5,800	113	32.4	49.2	159	<0.1	1.3
Onsite field blank	13:00	38.34497	109.37836	5,800	<0.04	<0.004	<0.12	<4	<0.14	<0.6
Site ID	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Barium dissolved (µg/L as Ba)	Beryllium dissolved (µg/L as Be)	Cadmium dissolved (µg/L as Cd)	Chromium dissolved (µg/L as Cr)	Copper dissolved (µg/L as Cu)	Iron dissolved (µg/L as Fe)
Muleshoe Creek 1 down-stream	10:00	38.34677	109.38558	5,680	56.8	<0.40	<0.8	<0.40	5.3	130
Muleshoe Creek 2 at mining area	11:15	38.34607	109.38286	5,720	56.6	<0.40	<0.8	<0.40	<1.2	136
Muleshoe Creek 3 up-stream	12:45	38.34497	109.37836	5,800	58	<0.40	<0.8	<0.40	<1.2	176
Onsite field blank	13:00	38.34497	109.37836	5,800	<0.4	<0.4	<0.8	<0.40	<1.2	<6
Site ID	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Lead dissolved (µg/L as Pb)	Manganese dissolved (µg/L as Mn)	Mercury dissolved (µg/L as Hg)	Molybdenum dissolved (µg/L as Mo)	Nickel dissolved (µg/L as Ni)	Radium dissolved (pCi/L as Ra)
Muleshoe Creek 1 down-stream	10:00	38.34677	109.38558	5,680	0.19	32.5	<0.010	2	0.43	0.1
Muleshoe Creek 2 at mining area	11:15	38.34607	109.38286	5,720	0.08	32.5	<0.010	2	0.46	0.06
Muleshoe Creek 3 up-stream	12:45	38.34497	109.37836	5,800	0.13	45	<0.010	1.8	0.56	0.09
Onsite field blank	13:00	38.34497	109.37836	5,800	<0.06	<0.4	<0.01	<0.08	<0.12	0.06
Site ID	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Selenium dissolved (µg/L as Se)	Silver dissolved (µg/L as Ag)	Uranium dissolved (µg/L as U)	Vanadium dissolved (µg/L as V)	Zinc dissolved (µg/L as Zn)	
Muleshoe Creek 1 down-stream	10:00	38.34677	109.38558	5,680	0.71	<0.02	5.96	2	25.7	
Muleshoe Creek 2 at mining area	11:15	38.34607	109.38286	5,720	0.76	<0.02	5.62	1	<2.0	
Muleshoe Creek 3 up-stream	12:45	38.34497	109.37836	5,800	0.75	<0.02	4.4	1	<2.0	
Onsite field blank	13:00	38.34497	109.37836	5,800	<0.08	<0.02	<0.02	<1.2	<2	

Uranium-235 Series

Thorium-232 Series

Uranium-238 Series

Radium-226 Series

Modified from Argonne National Laboratory, 2005
Note: * indicates the isotope is a significant gamma emitter

Figure 11. Chart of selected natural decay series: uranium, radium, and thorium.

been altered to fit the site conditions. The primary use of the area appears to be for recreational off-road activity by riders of all-terrain vehicles (ATVs), on the basis of visual inspection during sample collection. Two primary use scenarios were considered in determining the amount of annual exposure a visitor experiences. The first scenario considers the duration of activities of an individual that lives in proximity to the site and visits the site periodically during any given year. The total annual visitation by an individual to the site was 4.6 days per year based on calculations made for daily duration of outdoor activities by a young adult (U.S. Environmental Protection Agency, 1997b, table 15.3). The second scenario considers the duration of time spent on the site by an individual who is using the area as a recreation destination and spends 7 to 14 days on the site, the latter equal to the maximum annual recreational occupancy of a site by the BLM. In all scenarios, RESRAD was set up to inspect three exposure pathways appropriate to the usage scenarios that were identified: (a) external gamma exposure, (b) inhalation exposure, and (c) soil ingestion exposure. Soil screening levels were determined with respect to the concentration of radium, with all other uranium decay series radionuclides set to secular equilibrium with radium-226. In the Colorado Plateau region uranium deposits, secular equilibrium between radium and uranium is typically not observed, and in many cases, uranium deposits are depleted in radium with respect to uranium by a process of leaching daughter products from primary uranium minerals by formation of secondary minerals due to changing groundwater conditions and oxidation (Stearn and Stieff, 1959). Modifications to default data used by RESRAD to calculate an annual radiation dosage were made in the "Occupancy and Ingestion: Dietary" sub-sections of modifiable data; in all other sub-sections, default data were used (Yu and others, 1993). In the "Occupancy" sub-section, an inhalation rate of 14,016 m³/yr was used over the default value of 8,400 m³/yr to reflect moderate activities by an individual either riding an ATV or involved in outdoor activities (U.S. Environmental Protection Agency, 1997b, table 5.23.) The mass loading for inhalation was set to 0.0004 g/m³ over the default value 0.0001 g/m³ to reflect the increased dust present on unpaved roads while ATVs are in use (Yu and others, 1993 Chapter 35). The indoor time fraction was set to 0.0 over the default of 0.5, implying that the individual spends the entire time on the site outdoors. The outdoor time fraction was set to the annual exposure duration that was considered appropriate: 0.013 for 4.6 days per year, 0.019 for 7.0 days per year, and 0.038 for 14.0 days per year. Outdoor time fractions are expressed as fractions of a 1-year period. In the "Ingestion: Dietary" sub-section, a soil ingestion rate of 73 grams per year (g/yr) was used over the default value of 36.5 g/yr to represent an average rate for all human age groups, not just adults (U.S. Environmental Protection Agency, 1997b, table 4.23). The resulting SSLs for combined radium, uranium, and thorium for a maximum of 15 additional mrem/yr are 96 pCi/g radium for 4.6 days per year, 66 pCi/g radium for 7.0 days per year, and 33 pCi/g radium for 14.0 days per year.

No samples from the uranium waste dumps exceeded the 4.6 days per year SSL for radium, although BH-30 approached

this value with a concentration of 91 pCi/g. Two sites, BH-30 and BH-46, exceeded the 7.0 days per year SSL for radium, with concentrations of 91 pCi/g and 79 pCi/g, respectively. Seven sites, BH-26, BH-30, BH-33, BH-46, BH-49, BH-52, and BH-54, exceeded the 14.0 days per year SSL for radium, with concentrations of 49 pCi/g, 91 pCi/g, 58 pCi/g, 79 pCi/g, 50 pCi/g, 36 pCi/g, and 39 pCi/g, respectively (fig. 12). Sediment samples from ephemeral streams downstream from BH-36 and BH-49 showed radium concentrations elevated above local background concentrations for the sites closer to waste piles, but no streambed sites exceeded the SSLs (table 3).

Vulnerability of Waste Dumps to Large-Scale Flood Events

Periodic rainfall events may fill ephemeral drainages with water and transport some of the waste dump material off site. As a result of the episodic nature of streamflow in the Browns Hole area, no permanent gaging stations are currently recording flow. A set of multiple-linear regression equations have been developed for the state of Utah to estimate peak flows in ungaged drainages. All uranium waste dump sites in Browns Hole are located within Region 6, for which regression equations for 2-, 100-, and 500-year recurrence interval peak flows are given below (Kenney and others, 2007):

$$PK_2 + 4,150DRNAREA^{0.553} (ELEV/1,000)^{-2.45} \quad (1)$$

$$PK_{100} = 115,000DRNAREA^{0.391} (ELEV/1,000)^{-2.58} \quad (2)$$

$$PK_{100} = 258,000DRNAREA^{0.344} (ELEV/1,000)^{-2.65} \quad (3)$$

where

- PK is the peak flow, and the number following PK represents the recurrence interval in years;
- DRNAREA is the drainage area in square miles; and
- ELEV is the mean basin elevation in feet.

The parameters and equations for drainage areas in many states, including Utah, were made into an interactive website, StreamStats (Ries III and others, 2004). All Browns Hole sample site locations were input into the StreamStats website to determine the drainage basin characteristics contributing to runoff at the uranium waste dump sites (table 7). Of the sites in Browns Hole, only two waste dumps had significant associated drainage basin areas, BH-27 and BH-36. Drainage basin areas for BH-27 and BH-36 were 0.13 and 0.12 mi², respectively. Also, two stream sediment sites leading away from waste dump BH-40 were associated with the large 16.2 mi² drainage basin area of Muleshoe Creek.

Valid ranges for area and mean basin elevation in equations 1–3 are 0.87–532 mi² and 4,300–9,380 ft, respectively. Many drainage area values were less than the minimum value of 0.87 mi², but all mean basin elevation values fell within the valid range (table 7). Peak flows estimated from values outside

Figure 12. Concentration of radium from 20 waste dump samples collected from Browns Hole, Utah. Colored dashed lines indicate various soil screening levels (SSL) for three exposure durations.

of valid regression equation ranges are extrapolations with unknown errors. The errors given for values within the valid range for PK2, PK100, and PK500 are 110, 61, and 66 percent average standard error of prediction, respectively (Kenney and others, 2007).

Uranium waste dumps with significant drainage basins, BH-27, BH-36, and portions of areas associated with BH-40, have a higher potential to be affected by flood events than other sites in the study area. BH-27 is located in a flow path within a drainage that can produce streamflow discharges of 16.4, 500, and 1,090 ft³/s for peak flow recurrence intervals of 2, 100, and 500 years, respectively. BH-36 is located in a flow path within a drainage that can produce streamflow discharges of 15.6, 481, and 1,050 ft³/s for peak flow recurrence intervals of 2, 100, and 500 years, respectively. BH-40 is located in proximity to Muleshoe Creek which has a large drainage basin upstream of BH-40 equal to 16.2 mi². BH-40-SED1 and 2 are included in the flow path of Muleshoe Creek when at flood stage, which equates to 158, 2,160, and 3,700 ft³/s for peak flow recurrence intervals of 2, 100, and 500 years, respectively.

Summary

Annual exposure times in the Browns Hole study area for 4.6, 7.0, and 14.0 days result in 0, 2, and 7 sites, respectively, that exceeded the soil screening level (SSL) for combined radium, uranium, and thorium via external exposure, inhalation, and soil ingestion. The following sites exceeded one or more of the SSLs: BH-26, BH-30, BH-33, BH-46, BH-49, BH-52, and BH-54.

One site, BH-30 had an elevated radium concentration (91 pCi/g) that approaches the highest SSL for 4.6 days per year. Increased concentrations of radium, uranium, vanadium, and arsenic relative to background in downstream ephemeral streams suggest that transport of abandoned mine dump material is occurring. At two sites, BH-27 and BH-36, which lie directly adjacent to flow paths of stream channels, sediment from waste-rock piles has a high potential to become mobilized and transported significant distances by peak flow events that have recurrence intervals of 2, 100, and 500 years. Although results from StreamStats suggest that the large waste dump associated with BH-40 has a small drainage basin, it lies in proximity to the perennial stream, Muleshoe Creek. Given the magnitude of potential discharge of Muleshoe Creek associated with peak flow events on 2-, 100-, and 500-year recurrence intervals, material from BH-40 also has a high potential to become mobilized and transported by peak flow events.

Table 7. Drainage area characteristics associated with uranium waste dump samples, Browns Hole, Utah.

[Abbreviations: DD.dddd, Degrees.decimal degrees; ft, feet; ft³/sec, cubic feet per second; in, inches; mi², square miles; N/A, not available; Site ID, site identification]

Site ID	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Mean annual precipitation (in.)	Average basin slope (percent)	Area (mi ²)	Mean basin elevation (ft)	Area covered by herbaceous upland (percent)	Peak flow recurrence interval (PK)		
									2 year (ft ³ /sec)	100 year (ft ³ /sec)	500 year (ft ³ /sec)
BH-2	38.37452	109.42864	4,980	12	28.7	0.003	5,880	0	2.24	125	326
BH-2-BG	38.37368	109.42822	4,900	12	26.7	0.002	5,920	0	N/A	N/A	N/A
BH-26	38.36463	109.40498	5,000	11.7	12	0.000	5,820	0	N/A	N/A	N/A
BH-27	38.36576	109.40456	4,980	11.8	16.8	0.130	6,040	0.24	16.4	500	1,090
BH-28	38.36290	109.41353	5,010	11.7	24.1	0.000	5,850	0	0.58	48.5	142
BH-28-BG	38.36309	109.41368	5,010	11.7	25.9	0.000	5,910	0	0.77	58.4	166
BH-30	38.36269	109.40494	4,960	11.7	16.5	0.000	5,800	0	N/A	N/A	N/A
BH-32	38.36293	109.40537	4,960	11.7	17.9	0.000	5,810	0	0.59	49.6	145
BH-33	38.36352	109.40744	4,970	11.7	16.5	0.075	5,980	2.07	12.2	410	917
BH-35	38.37325	109.42760	5,040	12	29.4	0.001	5,870	0	0.81	61.3	174
BH-36	38.37217	109.42636	5,000	12	21.2	0.120	6,060	1.24	15.6	481	1,050
BH-36-BG	38.37207	109.42595	5,000	12	26.4	0.001	5,890	0	0.91	66.4	186
BH-36-SED	38.37192	109.42654	4,920	12	21.2	0.120	6,060	1.24	15.6	481	1,050
BH-37	38.34688	109.38331	5,760	12	23.3	0.000	5,880	0	N/A	N/A	N/A
BH-37-BG	38.34674	109.38286	5,760	12	21.1	0.001	5,860	20	N/A	N/A	N/A
BH-40	38.34657	109.38243	5,760	12	19.4	0.001	5,850	20	N/A	N/A	N/A
BH-40-BG	38.34653	109.38105	5,760	12	26.2	0.001	5,840	0	1.07	75	208
BH-40-SED1	38.34639	109.38210	5,740	15.7	15.5	16.2	7,120	1.9	158	2,160	3,700
BH-40-SED2	38.34613	109.38262	5,720	15.7	15.5	16.2	7,110	1.9	158	2,170	3,720
BH-46	38.33582	109.39196	5,960	11.9	13.3	0.058	6,130	0	10.1	352	795
BH-46-BG	38.33517	109.39233	5,960	11.9	12.1	0.340	6,370	0.55	24.5	635	1,320
BH-49	38.33555	109.39192	5,960	11.9	13.2	0.057	6,140	0	9.94	346	783
BH-49-SED1	38.33554	109.39213	5,910	11.9	13.2	0.057	6,120	0	10.1	351	793
BH-49-SED2	38.33555	109.39218	5,900	11.9	13.2	0.057	6,120	0	10.1	351	793
BH-49-SED3	38.33566	109.39223	5,900	11.9	13.3	0.058	6,130	0	10.1	352	795
BH-49-SED4	38.33578	109.39228	5,900	11.9	13.2	0.058	6,130	0	10.2	352	795
BH-49-SED5	38.33590	109.39230	5,900	11.9	13.2	0.063	6,110	0	10.7	367	825
BH-52	38.31755	109.38996	6,360	11.9	27.7	0.002	6,430	0	1.38	82.4	218
BH-52-BG	38.31804	109.38981	6,360	12	30.7	0.002	6,520	0	1.37	81.1	213
BH-54	38.31853	109.39029	6,360	11.8	27.8	0.001	6,440	0	0.91	61.4	168
BH-58	38.32920	109.38863	6,240	12	16.4	0.006	6,330	13	2.65	133	333
BH-59	38.31348	109.37901	6,380	12	29.9	0.003	6,530	0	N/A	N/A	N/A
BH-60	38.31347	109.37876	6,380	12	20.9	0.002	6,540	0	N/A	N/A	N/A
BH-62	38.31353	109.38284	6,480	12	34.5	0.002	6,690	0	N/A	N/A	N/A
BH-63	38.31358	109.38323	6,480	12	33.4	0.001	6,510	0	N/A	N/A	N/A

Table 3. Chemical analysis of total extractable-from-sediment samples for major-ion and trace-element concentrations from uranium waste dump, undisturbed geologic background, and dry ephemeral streambed samples, Browns Hole, Utah.

[Abbreviations: BH, Browns Hole; BG, background sample; DD.dddd, Degrees, decimal degrees; ft, feet; hh:mm, hour:minute; MDT, Mountain Daylight Time; mm/dd/yyyy, month/day/year; pCi/g, picocuries per gram; ppm, parts per million; SDC, mica schist geochemical reference material; SED, ephemeral stream sediment sample; Site ID, site identification; USGS, U.S. Geological Survey; SGR, Green River Shale geochemical reference material; STD, expected standard value; SUB, submitted standard value; %, percent; <, less than; —, no data]

Site ID	USGS site number	Date (mm/dd/yyyy)	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Aluminum total (% as Al)	Calcium total (% as Ca)	Iron total (% as Fe)	Magnesium total (% as Mg)	Phosphorus total (% as P)	Potassium total (% as K)	Sodium total (% as Na)
BH-2	382228109254301	08/06/2008	13:50	38.37452	109.42864	4,980	2.9	2.92	0.58	0.47	0.03	1.66	0.08
BH-2-BG	382225109254201	08/12/2008	12:30	38.37368	109.42822	4,900	6.55	4.41	3.19	1.59	0.06	3.28	0.23
BH-26	382153109241801	08/05/2008	13:30	38.36463	109.40498	5,000	3.98	1.15	1.27	0.69	0.03	2.09	0.05
BH-27	382157109241601	08/05/2008	14:00	38.36576	109.40456	4,980	3.39	1.3	0.85	0.52	0.04	1.92	0.07
BH-28	382146109244901	08/05/2008	15:00	38.3629	109.41353	5,010	2.01	1.22	0.43	0.34	0.03	1.07	0.04
BH-28-BG	382147109244901	08/05/2008	15:20	38.36309	109.41368	5,010	3.83	4.64	1.56	0.79	0.03	2.05	0.17
BH-30	382146109241801	08/05/2008	12:30	38.36269	109.40494	4,960	2.21	1.47	0.77	0.57	0.03	1.11	0.04
BH-32	382147109241901	08/05/2008	12:45	38.36293	109.40537	4,960	1.23	1.03	0.38	0.32	<0.01	0.61	0.02
BH-33	382149109242701	08/05/2008	12:00	38.36352	109.40744	4,970	5.18	4.39	1.54	0.9	0.05	2.66	0.07
BH-35	382224109253901	08/06/2008	13:30	38.37325	109.4276	5,040	2.4	2.57	0.97	0.29	0.02	1.12	0.04
BH-36	382220109253501	08/06/2008	12:50	38.37217	109.42636	5,000	3.5	4.25	1.01	0.71	0.04	1.7	0.1
BH-36-BG	382220109253301	08/12/2008	12:50	38.37207	109.42595	5,000	5.59	6.43	1.89	1.39	0.07	2.63	0.29
BH-36-SED	382219109253601	08/12/2008	13:05	38.37192	109.42654	4,920	2.48	3.05	1.01	0.51	0.02	1.28	0.1
BH-37	382049109230001	08/05/2008	09:40	38.34688	109.38331	5,760	4.5	3.99	1.54	1.06	0.04	2.31	0.2
BH-37-BG	382048109225801	08/05/2008	09:45	38.34674	109.38286	5,760	5.74	6.12	2.88	1.46	0.06	2.93	0.23
BH-40	382048109225701	08/05/2008	10:15	38.34657	109.38243	5,760	3.18	2.97	0.96	0.75	0.03	1.57	0.21
BH-40-BG	382048109225201	08/12/2008	11:10	38.34653	109.38105	5,760	4.73	4.9	2.10	1.19	0.05	2.45	0.29
BH-40-SED1	382047109225601	08/12/2008	10:40	38.34639	109.3821	5,740	2.49	3.19	0.89	0.58	0.02	1.32	0.31
BH-40-SED2	382046109225701	08/12/2008	11:00	38.34613	109.38262	5,720	2.66	2.7	1.01	0.52	0.03	1.17	0.52
BH-46	382009109233101	08/05/2008	08:45	38.33582	109.39196	5,960	2.7	2.57	0.90	0.6	0.03	1.35	0.12
BH-46-BG	382006109233201	08/12/2008	09:10	38.33517	109.39233	5,960	4.39	6.05	1.84	1.05	0.05	2.23	0.15
BH-49	382008109233101	08/05/2008	09:00	38.33555	109.39192	5,960	3.36	2.48	1.05	0.72	0.04	1.68	0.14
BH-49-SED1	382008109233201	08/12/2008	09:20	38.33554	109.39213	5,910	1.93	2.12	0.76	0.38	0.02	0.81	0.08
BH-49-SED2	382008109233202	08/12/2008	09:30	38.33555	109.39218	5,900	2.13	2.07	0.80	0.41	0.02	0.96	0.1
BH-49-SED3	382008109233203	08/12/2008	09:40	38.33566	109.39223	5,900	2.34	1.98	0.84	0.44	0.01	1.04	0.12
BH-49-SED4	382009109233201	08/12/2008	9:50	38.33578	109.39228	5,900	3.05	2.55	1.11	0.58	0.03	1.38	0.3
BH-49-SED5	382009109233202	08/12/2008	10:00	38.3359	109.3923	5,900	2.01	2.11	0.75	0.4	0.02	0.96	0.12
BH-52	381903109232401	08/06/2008	15:30	38.31755	109.38996	6,360	2.75	2.53	0.72	0.57	0.03	1.4	0.1
BH-52-BG	381905109232301	08/06/2008	15:40	38.31804	109.38981	6,360	5.23	9.83	2.98	1.35	0.06	2.64	0.14
BH-54	381907109232501	08/06/2008	15:50	38.31853	109.39029	6,360	3.12	2.02	0.56	0.57	0.02	1.65	0.15

Table 3. Chemical analysis of total extractable-from-sediment samples for major-ion and trace-element concentrations from uranium waste dump, undisturbed geologic background, and dry ephemeral streambed samples, Browns Hole, Utah.—Continued

[Abbreviations: BH, Browns Hole; BG, background sample; DD.dddd, Degrees decimal degrees; ft, feet; hh:mm, hour-minute; MDT, Mountain Daylight Time; mm/dd/yyyy, month/day/year; pCi/g, picocuries per gram; ppm, parts per million; SDC, mica schist geochemical reference material; SED, ephemeral stream sediment sample; Site ID, site identification; USGS, U.S. Geological Survey, SGR, Green River Shale geochemical reference material; STD, expected standard value; SUB, submitted standard value; %, percent; <, less than; —, no data]

Site ID	USGS site number	Date (mm/dd/yyyy)	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Sulfur total (% as S)	Titanium total (% as Ti)	Antimony total (ppm as Sb)	Arsenic total (ppm as As)	Barium total (ppm as Ba)	Beryllium total (ppm as Be)	Bismuth total (ppm as Bi)
BH-2	382228109254301	08/06/2008	13:50	38.37452	109.42864	4,980	0.03	0.12	0.98	23	440	1	0.08
BH-2-BG	382225109254201	08/12/2008	12:30	38.37368	109.42822	4,900	0.09	0.3	0.8	6	210	2.7	0.25
BH-26	382153109241801	08/05/2008	13:30	38.36463	109.40498	5,000	0.01	0.2	3.06	78	440	1.8	0.14
BH-27	382157109241601	08/05/2008	14:00	38.36576	109.40456	4,980	0.15	0.18	1.76	33	530	1.7	0.1
BH-28	382146109244901	08/05/2008	15:00	38.3629	109.41353	5,010	0.02	0.09	1.51	12	630	0.7	0.09
BH-28-BG	382147109244901	08/05/2008	15:20	38.36309	109.41368	5,010	0.03	0.18	0.7	6	730	1.3	0.12
BH-30	382146109241801	08/05/2008	12:30	38.36269	109.40494	4,960	0.03	0.11	2.85	44	910	0.9	0.07
BH-32	382147109241901	08/05/2008	12:45	38.36293	109.40537	4,960	0.02	0.06	3.38	29	680	0.4	<0.04
BH-33	382149109242701	08/05/2008	12:00	38.36352	109.40744	4,970	0.15	0.23	0.51	14	890	1.5	0.13
BH-35	382224109253901	08/06/2008	13:30	38.37325	109.4276	5,040	0.02	0.12	10.2	195	410	1.1	0.07
BH-36	382220109253501	08/06/2008	12:50	38.37217	109.42636	5,000	0.03	0.15	0.92	35	630	1.4	0.11
BH-36-BG	382220109253301	08/12/2008	12:50	38.37207	109.42595	5,000	0.19	0.22	0.47	3	330	2.4	0.18
BH-36-SED	382219109253601	08/12/2008	13:05	38.37192	109.42654	4,920	0.03	0.12	0.43	6	700	0.9	0.09
BH-37	382049109230001	08/05/2008	09:40	38.34688	109.38331	5,760	0.03	0.2	3.19	45	510	2.7	0.18
BH-37-BG	382048109225801	08/05/2008	09:45	38.34674	109.38286	5,760	0.1	0.25	0.69	5	430	2	0.19
BH-40	382048109225701	08/05/2008	10:15	38.34657	109.38243	5,760	0.11	0.13	0.66	21	520	1	0.09
BH-40-BG	382048109225201	08/12/2008	11:10	38.34653	109.38105	5,760	0.03	0.22	0.54	4	320	2.1	0.16
BH-40-SED1	382047109225601	08/12/2008	10:40	38.34639	109.3821	5,740	0.03	0.11	0.33	5	420	0.9	0.08
BH-40-SED2	382046109225701	08/12/2008	11:00	38.34613	109.38262	5,720	0.02	0.13	0.38	5	490	1	0.1
BH-46	382009109233101	08/05/2008	08:45	38.33582	109.39196	5,960	0.07	0.14	1.29	68	370	1.1	0.08
BH-46-BG	382006109233201	08/12/2008	09:10	38.33517	109.39233	5,960	0.03	0.2	0.43	3	820	1.6	0.15
BH-49	382008109233101	08/05/2008	09:00	38.33555	109.39192	5,960	0.13	0.16	1.03	65	310	1.3	0.1
BH-49-SED1	382008109233201	08/12/2008	09:20	38.33554	109.39213	5,910	0.06	0.09	0.36	7	1,450	0.7	0.07
BH-49-SED2	382008109233202	08/12/2008	09:30	38.33555	109.39218	5,900	0.04	0.1	0.39	5	1,140	0.9	0.08
BH-49-SED3	382008109233203	08/12/2008	09:40	38.33566	109.39223	5,900	0.05	0.11	0.42	5	1,100	0.9	0.1
BH-49-SED4	382009109233201	08/12/2008	9:50	38.33578	109.39228	5,900	0.03	0.15	0.44	6	740	0.9	0.1
BH-49-SED5	382009109233202	08/12/2008	10:00	38.3359	109.3923	5,900	0.02	0.1	0.31	4	870	0.6	0.06
BH-52	381903109232401	08/06/2008	15:30	38.31755	109.38996	6,360	0.03	0.13	0.99	27	860	1.1	0.08
BH-52-BG	381905109232301	08/06/2008	15:40	38.31804	109.38981	6,360	0.04	0.25	0.76	6	250	2.2	0.18
BH-54	381907109232501	08/06/2008	15:50	38.31853	109.39029	6,360	0.02	0.14	2.32	43	560	0.9	0.08

Table 3. Chemical analysis of total extractable-from-sediment samples for major-ion and trace-element concentrations from uranium waste dump, undisturbed geologic background, and dry ephemeral streambed samples, Browns Hole, Utah.—Continued

[Abbreviations: BH, Browns Hole; BG, background sample; DD, dddd, Degrees, decimal degrees; ft, feet; hh:mm, hour:minute; MDT, Mountain Daylight Time; mm/dd/yyyy, month/day/year; pCi/g, picocuries per gram; ppm, parts per million; SDC, mica schist geochemical reference material; SED, ephemeral stream sediment sample; Site ID, site identification; USGS, U.S. Geological Survey; SGR, Green River Shale geochemical reference material; STD, expected standard value; SUB, submitted standard value; %, percent; <, less than; —, no data]

Site ID	USGS site number	Date (mm/dd/yyyy)	Time (MDT) (hh:mm)	Latitude (DD, dddd)	Longitude (DD, dddd)	Elevation (ft)	Sulfur total (% as S)	Titanium total (% as Ti)	Antimony total (ppm as Sb)	Arsenic total (ppm as As)	Barium total (ppm as Ba)	Beryllium total (ppm as Be)	Bismuth total (ppm as Bi)
BH-58	381945109231901	08/04/2008	15:30	38.3292	109.38863	6,240	0.01	0.09	0.96	26	480	0.6	0.06
BH-59	381849109224401	08/06/2008	09:00	38.31348	109.37901	6,380	0.01	0.12	0.95	58	360	0.8	0.07
BH-60	381848109224301	08/06/2008	09:15	38.31347	109.37876	6,380	<0.01	0.1	0.93	53	260	0.7	0.06
BH-62	381849109225801	08/06/2008	09:50	38.31353	109.38284	6,480	0.02	0.09	0.71	26	540	0.4	0.05
BH-63	381849109230001	08/06/2008	10:00	38.31358	109.38323	6,480	0.01	0.11	0.91	29	280	0.8	0.06
SGR-1B (STD)	—	—	—	—	—	—	—	—	0.54	0.22	630	3.0	—
SGR-1B (SUB)	—	—	—	—	—	—	—	—	0.52	<1.0	681	3.7	—
SDC-1 (STD)	—	—	—	—	—	—	—	—	3.4	67	290	—	—
SDC-1 (SUB)	—	—	—	—	—	—	—	—	2.7	64	294	—	—

Table 3. Chemical analysis of total extractable-from-sediment samples for major-ion and trace-element concentrations from uranium waste dump, undisturbed geologic background, and dry ephemeral streambed samples, Browns Hole, Utah.—Continued

[Abbreviations: BH, Browns Hole; BG, background sample; DD.dddd, Degrees decimal degrees; ft, feet; hh:mm, hour:minute; MDT, Mountain Daylight Time; mm/dd/yyyy, month/day/year; pCi/g, picocuries per gram; ppm, parts per million; SDC, mica schist geochemical reference material; SED, ephemeral stream sediment sample; Site ID, site identification; USGS, U.S. Geological Survey; SGR, Green River Shale geochemical reference material; STD, expected standard value; SUB, submitted standard value; %, percent; <, less than; —, no data]

Site ID	USGS site number	Date (mm/dd/yyyy)	Time (MDT) (hh-mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Cadmium total (ppm as Cd)	Cerium total (ppm as Ce)	Cesium total (ppm as Cs)	Chromium total (ppm as Cr)	Cobalt total (ppm as Co)	Copper total (ppm as Cu)	Gallium total (ppm as Ga)
BH-2	382228109254301	08/06/2008	13:50	38.37452	109.42864	4,980	0.3	19.5	<5	60	<10	30	6.5
BH-2-BG	382225109254201	08/12/2008	12:30	38.37368	109.42822	4,900	<0.1	51.8	13	70	20	20	15.9
BH-26	382153109241801	08/05/2008	13:30	38.36463	109.40498	5,000	1.8	32.8	5	40	30	40	11.1
BH-27	382157109241601	08/05/2008	14:00	38.36576	109.40456	4,980	<0.1	25.0	<5	270	90	110	8.7
BH-28	382146109244901	08/05/2008	15:00	38.3629	109.41353	5,010	0.1	16.1	<5	90	<10	50	4.9
BH-28-BG	382147109244901	08/05/2008	15:20	38.36309	109.41368	5,010	0.2	29.4	<5	40	10	20	9.6
BH-30	382146109241801	08/05/2008	12:30	38.36269	109.40494	4,960	3.5	18.8	<5	50	10	20	5.6
BH-32	382147109241901	08/05/2008	12:45	38.36293	109.40537	4,960	0.3	13.3	<5	60	<10	50	3.2
BH-33	382149109242701	08/05/2008	12:00	38.36352	109.40744	4,970	<0.1	31.5	5	390	20	70	9.9
BH-35	382224109253901	08/06/2008	13:30	38.37325	109.4276	5,040	2.9	20.6	<5	30	30	80	6.7
BH-36	382220109253501	08/06/2008	12:50	38.37217	109.42636	5,000	0.3	30.0	<5	60	10	40	8.3
BH-36-BG	382220109253301	08/12/2008	12:50	38.37207	109.42595	5,000	0.1	41.2	8	40	10	10	12.8
BH-36-SED	382219109253601	08/12/2008	13:05	38.37192	109.42654	4,920	0.2	22.2	<5	50	<10	<10	5.7
BH-37	382049109230001	08/05/2008	09:40	38.34688	109.38331	5,760	1.4	38.1	7	110	10	10	13.0
BH-37-BG	382048109225801	08/05/2008	09:45	38.34674	109.38286	5,760	0.1	44.0	8	50	<10	20	12.7
BH-40	382048109225701	08/05/2008	10:15	38.34657	109.38243	5,760	0.2	22.2	<5	40	<10	20	6.9
BH-40-BG	382048109225201	08/12/2008	11:10	38.34653	109.38105	5,760	<0.1	37.3	7	50	<10	10	11.3
BH-40-SED1	382047109225601	08/12/2008	10:40	38.34639	109.3821	5,740	<0.1	20.4	<5	20	<10	<10	5.7
BH-40-SED2	382046109225701	08/12/2008	11:00	38.34613	109.38262	5,720	<0.1	24.4	<5	50	10	<10	6.1
BH-46	382009109233101	08/05/2008	08:45	38.33582	109.39196	5,960	1.7	22.2	<5	30	10	<10	6.6
BH-46-BG	382006109233201	08/12/2008	09:10	38.33517	109.39233	5,960	0.1	37.6	6	50	10	20	10.2
BH-49	382008109233101	08/05/2008	09:00	38.33555	109.39192	5,960	1.5	30.5	<5	40	20	10	9.1
BH-49-SED1	382008109233201	08/12/2008	09:20	38.33554	109.39213	5,910	0.1	22.5	<5	20	<10	<10	4.4
BH-49-SED2	382008109233202	08/12/2008	09:30	38.33555	109.39218	5,900	0.1	22.8	<5	30	<10	<10	5.0
BH-49-SED3	382008109233203	08/12/2008	09:40	38.33566	109.39223	5,900	0.1	28.4	<5	20	<10	<10	6.0
BH-49-SED4	382009109233201	08/12/2008	9:50	38.33578	109.39228	5,900	0.1	30.9	<5	30	<10	<10	6.2
BH-49-SED5	382009109233202	08/12/2008	10:00	38.3359	109.3923	5,900	<0.1	18.7	<5	50	10	<10	3.9
BH-52	381903109232401	08/06/2008	15:30	38.31755	109.38996	6,360	0.9	22.2	<5	120	10	20	6.4
BH-52-BG	381905109232301	08/06/2008	15:40	38.31804	109.38981	6,360	0.2	44.9	8	80	<10	<10	12.8
BH-54	381907109232501	08/06/2008	15:50	38.31853	109.39029	6,360	1	23.4	<5	250	10	80	7.3

Table 3. Chemical analysis of total extractable-from-sediment samples for major-ion and trace-element concentrations from uranium waste dump, undisturbed geologic background, and dry ephemeral streambed samples, Browns Hole, Utah.—Continued

[Abbreviations: BH, Browns Hole; BG, background sample; DD, dddd, Degrees, decimal degrees; ft, feet; hh:mm, hour:minute; MDT, Mountain Daylight Time; mm/dd/yyyy, month/day/year; pCi/g, picocuries per gram; ppm, parts per million; SDC, mica schist geochemical reference material; SED, ephemeral stream sediment sample; Site ID, site identification; USGS, U.S. Geological Survey; SGR, Green River Shale geochemical reference material; STD, expected standard value; SUB, submitted standard value; %, percent; <, less than; —, no data]

Site ID	USGS site number	Date (mm/dd/yyyy)	Time (MDT) (hh:mm)	Latitude (DD, dddd)	Longitude (DD, dddd)	Elevation (ft)	Cadmium total (ppm as Cd)	Cerium total (ppm as Ce)	Cesium total (ppm as Cs)	Chromium total (ppm as Cr)	Cobalt total (ppm as Co)	Copper total (ppm as Cu)	Gallium total (ppm as Ga)
BH-58	381945109231901	08/04/2008	15:30	38.3292	109.38863	6,240	0.8	18.4	<5	40	10	<10	4.7
BH-59	381849109224401	08/06/2008	09:00	38.31348	109.37901	6,380	0.5	19.2	<5	40	<10	<10	5.9
BH-60	381848109224301	08/06/2008	09:15	38.31347	109.37876	6,380	0.5	16.2	<5	10	<10	<10	4.9
BH-62	381849109225801	08/06/2008	09:50	38.31353	109.38284	6,480	<0.1	14.9	<5	20	10	<10	3.9
BH-63	381849109230001	08/06/2008	10:00	38.31358	109.38323	6,480	0.2	18.5	<5	30	10	<10	5.7
SGR-1B (STD)	—	—	—	—	—	—	—	93.0	<5	64	18	30	21.0
SGR-1B (SUB)	—	—	—	—	—	—	—	90.8	<5	60	18	26	24.3
SDC-1 (STD)	—	—	—	—	—	—	0.9	36.0	5.0	30	12	66	—
SDC-1 (SUB)	—	—	—	—	—	—	1.1	35.5	5.2	28	12	61	—

Table 3. Chemical analysis of total extractable-from-sediment samples for major-ion and trace-element concentrations from uranium waste dump, undisturbed geologic background, and dry ephemeral streambed samples, Browns Hole, Utah.—Continued

[Abbreviations: BH, Browns Hole; BG, background sample; DD, dddd, Degrees, decimal degrees; ft, feet; hh:mm, hour:minute; MDT, Mountain Daylight Time; mm/dd/yyyy, month/day/year; pCi/g, picocuries per gram; ppm, parts per million; SDC, mica schist geochemical reference material; SED, ephemeral stream sediment sample; Site ID, site identification; USGS, U.S. Geological Survey; SGR, Green River Shale geochemical reference material; STD, expected standard value; SUB, submitted standard value; %, percent; <, less than; —, no data]

Site ID	USGS site number	Date (mm/dd/yyyy)	Time (MDT) (hh:mm)	Latitude (DD, dddd)	Longitude (DD, dddd)	Elevation (ft)	Indium total (ppm as In)	Lanthanum total (ppm as La)	Lithium total (ppm as Li)	Lead total (ppm as Pb)	Manganese total (ppm as Mn)	Mercury total (ppm as Hg)	Molybdenum total (ppm as Mo)
BH-2	382228109254301	08/06/2008	13:50	38.37452	109.42864	4,980	<0.02	10.6	20	53.8	190	0.04	<10
BH-2-BG	382225109254201	08/12/2008	12:30	38.37368	109.42822	4,900	0.05	26.9	40	20.8	240	0.02	<10
BH-26	382153109241801	08/05/2008	13:30	38.36463	109.40498	5,000	0.03	17.4	20	133	170	0.07	20
BH-27	382157109241601	08/05/2008	14:00	38.36576	109.40456	4,980	0.02	13.4	80	45.1	180	0.02	90
BH-28	382146109244901	08/05/2008	15:00	38.3629	109.41353	5,010	<0.02	8.9	10	98.1	290	0.04	10
BH-28-BG	382147109244901	08/05/2008	15:20	38.36309	109.41368	5,010	0.02	13.4	20	19.7	530	0.01	<10
BH-30	382146109241801	08/05/2008	12:30	38.36269	109.40494	4,960	<0.02	9.1	10	243	180	0.13	40
BH-32	382147109241901	08/05/2008	12:45	38.36293	109.40537	4,960	<0.02	6.9	<10	91.9	110	0.06	10
BH-33	382149109242701	08/05/2008	12:00	38.36352	109.40744	4,970	0.03	16.6	20	12.1	390	0.22	20
BH-35	382224109253901	08/06/2008	13:30	38.37325	109.4276	5,040	<0.02	10.6	20	266	310	0.06	<10
BH-36	382220109253501	08/06/2008	12:50	38.37217	109.42636	5,000	0.02	16.0	30	30.0	350	0.02	<10
BH-36-BG	382220109253301	08/12/2008	12:50	38.37207	109.42595	5,000	0.04	21.3	30	15.6	460	<0.01	<10
BH-36-SED	382219109253601	08/12/2008	13:05	38.37192	109.42654	4,920	<0.02	12.0	20	13.5	280	<0.01	10
BH-37	382049109230001	08/05/2008	09:40	38.34688	109.38331	5,760	0.04	19.6	20	203	300	<0.01	<10
BH-37-BG	382048109225801	08/05/2008	09:45	38.34674	109.38286	5,760	0.04	23.0	30	14.4	420	<0.01	<10
BH-40	382048109225701	08/05/2008	10:15	38.34657	109.38243	5,760	<0.02	11.9	20	25.8	240	0.02	<10
BH-40-BG	382048109225201	08/12/2008	11:10	38.34653	109.38105	5,760	0.04	19.4	20	11.3	330	<0.01	<10
BH-40-SED1	382047109225601	08/12/2008	10:40	38.34639	109.3821	5,740	<0.02	10.9	10	10.7	250	<0.01	<10
BH-40-SED2	382046109225701	08/12/2008	11:00	38.34613	109.38262	5,720	<0.02	12.9	<10	12.1	260	0.01	<10
BH-46	382009109233101	08/05/2008	08:45	38.33582	109.39196	5,960	<0.02	11.9	30	41.1	220	0.09	50
BH-46-BG	382006109233201	08/12/2008	09:10	38.33517	109.39233	5,960	0.03	19.7	30	13.6	420	<0.01	<10
BH-49	382008109233101	08/05/2008	09:00	38.33555	109.39192	5,960	0.02	14.5	30	37.7	190	0.06	60
BH-49-SED1	382008109233201	08/12/2008	09:20	38.33554	109.39213	5,910	<0.02	12.0	20	10.7	210	<0.01	<10
BH-49-SED2	382008109233202	08/12/2008	09:30	38.33555	109.39218	5,900	<0.02	11.9	20	10.6	220	<0.01	<10
BH-49-SED3	382008109233203	08/12/2008	09:40	38.33566	109.39223	5,900	<0.02	14.8	20	12.9	210	0.01	<10
BH-49-SED4	382009109233201	08/12/2008	9:50	38.33578	109.39228	5,900	0.02	15.7	20	15.2	260	0.02	<10
BH-49-SED5	382009109233202	08/12/2008	10:00	38.3359	109.3923	5,900	<0.02	9.8	20	10.0	190	<0.01	<10
BH-52	381903109232401	08/06/2008	15:30	38.31755	109.38996	6,360	<0.02	12.0	20	55.0	190	0.08	10
BH-52-BG	381905109232301	08/06/2008	15:40	38.31804	109.38981	6,360	0.05	24.2	30	14.6	540	<0.01	10
BH-54	381907109232501	08/06/2008	15:50	38.31853	109.39029	6,360	<0.02	12.9	20	82.7	150	0.07	20

Table 3. Chemical analysis of total extractable-from-sediment samples for major-ion and trace-element concentrations from uranium waste dump, undisturbed geologic background, and dry ephemeral streambed samples, Browns Hole, Utah.—Continued

[Abbreviations: BH, Browns Hole; BG, background sample; DD.dddd, Degrees, decimal degrees; ft, feet; hh:mm, hour:minute; MDT, Mountain Daylight Time; mm/dd/yyyy, month/day/year; pCi/g, picocuries per gram; ppm, parts per million; SDC, mica schist geochemical reference material; SED, ephemeral stream sediment sample; Site ID, site identification; USGS, U.S. Geological Survey; SGR, Green River Shale geochemical reference material; STD, expected standard value; SUB, submitted standard value; %, percent; <, less than; —, no data]

Site ID	USGS site number	Date (mm/dd/yyyy)	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Indium total (ppm as In)	Lanthanum total (ppm as La)	Lithium total (ppm as Li)	Lead total (ppm as Pb)	Manganese total (ppm as Mn)	Mercury total (ppm as Hg)	Molybdenum total (ppm as Mo)
BH-58	381945109231901	08/04/2008	15:30	38.3292	109.38863	6,240	<0.02	9.1	20	12.5	140	0.06	<10
BH-59	381849109224401	08/06/2008	09:00	38.31348	109.37901	6,380	<0.02	10.2	20	15.2	160	0.02	30
BH-60	381848109224301	08/06/2008	09:15	38.31347	109.37876	6,380	<0.02	9.1	20	12.8	170	0.05	20
BH-62	381849109225801	08/06/2008	09:50	38.31353	109.38284	6,480	<0.02	8.1	20	30.9	170	0.05	20
BH-63	381849109230001	08/06/2008	10:00	38.31358	109.38323	6,480	<0.02	10.2	20	28.2	280	0.17	20
SGR-1B (STD)	—	—	—	—	—	—	—	42.0	34	25.0	880	—	—
SGR-1B (SUB)	—	—	—	—	—	—	—	42.1	33	21.2	839	—	—
SDC-1 (STD)	—	—	—	—	—	—	12	20.0	147	—	267	—	35
SDC-1 (SUB)	—	—	—	—	—	—	9	19.2	128	—	233	—	35

Table 3. Chemical analysis of total extractable-from-sediment samples for major-ion and trace-element concentrations from uranium waste dump, undisturbed geologic background, and dry ephemeral streambed samples, Browns Hole, Utah.—Continued

[Abbreviations: BH, Browns Hole; BG, background sample; DD.dddd, Degrees decimal degrees; ft, feet; hh:mm, hour-minute; MDT, Mountain Daylight Time; mm/dd/yyyy, month/day/year; pCi/g, picocuries per gram; ppm, parts per million; SDC, mica schist geochemical reference material; SED, ephemeral stream sediment sample; Site ID, site identification; USGS, U.S. Geological Survey; SGR, Green River Shale geochemical reference material; STD, expected standard value; SUB, submitted standard value; %, percent; <, less than; —, no data]

Site ID	USGS site number	Date (mm/dd/yyyy)	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Nickel total (ppm as Ni)	Niobium total (ppm as Nb)	Radium total (pCi/g as Ra)	Rubidium total (ppm as Rb)	Scandium total (ppm as Sc)	Selenium total (ppm as Se)	Silver total (ppm as Ag)
BH-2	382228109254301	08/06/2008	13:50	38.37452	109.42864	4,980	40	2.9	19.6	64.2	<5	14.3	<1
BH-2-BG	382225109254201	08/12/2008	12:30	38.37368	109.42822	4,900	10	3.4	0.92	135	11	0.3	<1
BH-26	382153109241801	08/05/2008	13:30	38.36463	109.40498	5,000	<10	4.9	49	97.7	6	24.3	2
BH-27	382157109241601	08/05/2008	14:00	38.36576	109.40456	4,980	70	3.9	15.7	81.3	125	6.1	<1
BH-28	382146109244901	08/05/2008	15:00	38.3629	109.41353	5,010	<10	2.1	7.8	46.8	5	4.9	<1
BH-28-BG	382147109244901	08/05/2008	15:20	38.36309	109.41368	5,010	<10	5	2.34	112	8	1.6	<1
BH-30	382146109241801	08/05/2008	12:30	38.36269	109.40494	4,960	<10	2.1	91	44.3	<5	4.3	3
BH-32	382147109241901	08/05/2008	12:45	38.36293	109.40537	4,960	<10	1.2	23.1	24.2	<5	2.3	1
BH-33	382149109242701	08/05/2008	12:00	38.36352	109.40744	4,970	<10	5.2	58	93.6	7	8.9	<1
BH-35	382224109253901	08/06/2008	13:30	38.37325	109.4276	5,040	<10	2.8	17.4	48	<5	8.8	3
BH-36	382220109253501	08/06/2008	12:50	38.37217	109.42636	5,000	<10	5.2	7.9	75	<5	4.7	<1
BH-36-BG	382220109253301	08/12/2008	12:50	38.37207	109.42595	5,000	<10	9.4	0.86	113	7	0.3	<1
BH-36-SED	382219109253601	08/12/2008	13:05	38.37192	109.42654	4,920	<10	3.4	3.4	56.2	<5	0.5	<1
BH-37	382049109230001	08/05/2008	09:40	38.34688	109.38331	5,760	<10	6.9	6.9	114	7	0.4	2
BH-37-BG	382048109225801	08/05/2008	09:45	38.34674	109.38286	5,760	<10	1.9	1.42	115	9	0.4	<1
BH-40	382048109225701	08/05/2008	10:15	38.34657	109.38243	5,760	<10	3.9	24.2	61.5	<5	11.2	<1
BH-40-BG	382048109225201	08/12/2008	11:10	38.34653	109.38105	5,760	<10	5.8	1.39	113	8	0.2	<1
BH-40-SED1	382047109225601	08/12/2008	10:40	38.34639	109.3821	5,740	<10	2.8	1.62	53.4	<5	0.4	<1
BH-40-SED2	382046109225701	08/12/2008	11:00	38.34613	109.38262	5,720	<10	2.9	1.66	49	<5	0.6	<1
BH-46	382009109233101	08/05/2008	08:45	38.33582	109.39196	5,960	<10	3.4	79	55.4	<5	17.8	<1
BH-46-BG	382006109233201	08/12/2008	09:10	38.33517	109.39233	5,960	<10	4.8	1.04	96	7	0.4	<1
BH-49	382008109233101	08/05/2008	09:00	38.33555	109.39192	5,960	<10	4.4	50	91.1	5	19.8	<1
BH-49-SED1	382008109233201	08/12/2008	09:20	38.33554	109.39213	5,910	<10	2.9	3.3	36.6	<5	1	<1
BH-49-SED2	382008109233202	08/12/2008	09:30	38.33555	109.39218	5,900	<10	3.1	3.4	42.2	<5	1.4	<1
BH-49-SED3	382008109233203	08/12/2008	09:40	38.33566	109.39223	5,900	<10	3.8	2.8	50.5	<5	1.1	<1
BH-49-SED4	382009109233201	08/12/2008	9:50	38.33578	109.39228	5,900	<10	4.3	2.08	57.9	<5	0.9	<1
BH-49-SED5	382009109233202	08/12/2008	10:00	38.3359	109.3923	5,900	<10	2.5	1.55	37.2	<5	0.5	<1
BH-52	381903109232401	08/06/2008	15:30	38.31755	109.38996	6,360	<10	3.3	36	56.5	<5	6	<1
BH-52-BG	381905109232301	08/06/2008	15:40	38.31804	109.38981	6,360	<10	2.2	2.7	121	10	<0.2	<1
BH-54	381907109232501	08/06/2008	15:50	38.31853	109.39029	6,360	<10	3.5	39	64.1	<5	2.4	<1

Table 3. Chemical analysis of total extractable-from-sediment samples for major-ion and trace-element concentrations from uranium waste dump, undisturbed geologic background, and dry ephemeral streambed samples, Browns Hole, Utah.—Continued

[**Abbreviations:** BH, Browns Hole; BG, background sample; DD.dddd, Degrees, decimal degrees; ft, feet; hh:mm, hour:minute; MDT, Mountain Daylight Time; mm/dd/yyyy, month/day/year; pCi/g, picocuries per gram; ppm, parts per million; SDC, mica schist geochemical reference material; SED, ephemeral stream sediment sample; Site ID, site identification; USGS, U.S. Geological Survey; SGR, Green River Shale geochemical reference material; STD, expected standard value; SUB, submitted standard value; %, percent; <, less than; —, no data]

Site ID	USGS site number	Date (mm/dd/yyyy)	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Nickel total (ppm as Ni)	Niobium total (ppm as Nb)	Radium total (pCi/g as Ra)	Rubidium total (ppm as Rb)	Scandium total (ppm as Sc)	Selenium total (ppm as Se)	Silver total (ppm as Ag)
BH-58	381945109231901	08/04/2008	15:30	38.3292	109.38863	6,240	<10	2.1	23.6	42.2	<5	4	<1
BH-59	381849109224401	08/06/2008	09:00	38.31348	109.37901	6,380	<10	2.8	25.2	57.6	<5	3.8	<1
BH-60	381848109224301	08/06/2008	09:15	38.31347	109.37876	6,380	<10	2.6	32	48.3	<5	8.3	<1
BH-62	381849109225801	08/06/2008	09:50	38.31353	109.38284	6,480	<10	2.1	6.4	33.3	<5	1.1	<1
BH-63	381849109230001	08/06/2008	10:00	38.31358	109.38323	6,480	<10	3.2	7.6	46.6	<5	2.1	<1
SGR-1B (STD)	—	—	—	—	—	—	38.0	21.0	—	127	17	—	—
SGR-1B (SUB)	—	—	—	—	—	—	29.6	15.7	—	126	16	—	—
SDC-1 (STD)	—	—	—	—	—	—	—	5.2	—	38	5	3.5	—
SDC-1 (SUB)	—	—	—	—	—	—	—	4.9	—	40	5	2.5	—

Table 3. Chemical analysis of total extractable-from-sediment samples for major-ion and trace-element concentrations from uranium waste dump, undisturbed geologic background, and dry ephemeral streambed samples, Browns Hole, Utah.—Continued

[Abbreviations: BH, Browns Hole; BG, background sample; DD.dddd, Degrees decimal degrees; ft, feet; hh:mm, hour-minute; MDT, Mountain Daylight Time; mm/dd/yyyy, month/day/year; pCi/g, picocuries per gram; ppm, parts per million; SDC, mica schist geochemical reference material; SED, ephemeral stream sediment sample; Site ID, site identification; USGS, U.S. Geological Survey; SGR, Green River Shale geochemical reference material; STD, expected standard value; SUB, submitted standard value; %, percent; <, less than; —, no data]

Site ID	USGS site number	Date (mm/dd/yyyy)	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Strontium total (ppm as Sr)	Tellurium total (ppm as Te)	Thallium total (ppm as Tl)	Thorium total (ppm as Th)	Thorium (pCi/g as Th-232)	Tin total (ppm as Sn)	Tungsten total (ppm as W)
BH-2	382228109254301	08/06/2008	13:50	38.37452	109.42864	4,980	90	<0.1	1.2	3.8	0.4	0.7	0.4
BH-2-BG	382225109254201	08/12/2008	12:30	38.37368	109.42822	4,900	270	<0.1	1	11	1.2	1.7	0.9
BH-26	382153109241801	08/05/2008	13:30	38.36463	109.40498	5,000	80	<0.1	3.2	7	0.8	1.1	1.7
BH-27	382157109241601	08/05/2008	14:00	38.36576	109.40456	4,980	190	<0.1	0.8	5.2	0.6	0.9	1.4
BH-28	382146109244901	08/05/2008	15:00	38.3629	109.41353	5,010	50	<0.1	0.4	3.2	0.4	0.6	0.8
BH-28-BG	382147109244901	08/05/2008	15:20	38.36309	109.41368	5,010	140	<0.1	0.6	5	0.6	0.9	0.6
BH-30	382146109241801	08/05/2008	12:30	38.36269	109.40494	4,960	90	<0.1	1.4	3.2	0.4	0.5	1.5
BH-32	382147109241901	08/05/2008	12:45	38.36293	109.40537	4,960	30	<0.1	0.5	1.8	0.2	0.3	0.8
BH-33	382149109242701	08/05/2008	12:00	38.36352	109.40744	4,970	140	<0.1	0.8	6.7	0.7	1.1	0.6
BH-35	382224109253901	08/06/2008	13:30	38.37325	109.4276	5,040	70	<0.1	1.6	3.6	0.4	0.7	1.2
BH-36	382220109253501	08/06/2008	12:50	38.37217	109.42636	5,000	140	<0.1	0.8	5.9	0.6	1.1	0.8
BH-36-BG	382220109253301	08/12/2008	12:50	38.37207	109.42595	5,000	210	<0.1	0.7	9.5	1.0	1.3	0.6
BH-36-SED	382219109253601	08/12/2008	13:05	38.37192	109.42654	4,920	110	<0.1	0.5	4	0.4	0.6	0.5
BH-37	382049109230001	08/05/2008	09:40	38.34688	109.38331	5,760	180	<0.1	2.3	8.6	0.9	1.5	1.1
BH-37-BG	382048109225801	08/05/2008	09:45	38.34674	109.38286	5,760	200	<0.1	0.8	8.8	1.0	1.5	0.8
BH-40	382048109225701	08/05/2008	10:15	38.34657	109.38243	5,760	110	<0.1	0.9	4.4	0.5	0.7	0.6
BH-40-BG	382048109225201	08/12/2008	11:10	38.34653	109.38105	5,760	210	<0.1	0.7	7.2	0.8	1.2	0.7
BH-40-SED1	382047109225601	08/12/2008	10:40	38.34639	109.3821	5,740	120	<0.1	0.4	3.5	0.4	0.6	0.4
BH-40-SED2	382046109225701	08/12/2008	11:00	38.34613	109.38262	5,720	160	<0.1	0.4	3.9	0.4	2.1	0.4
BH-46	382009109233101	08/05/2008	08:45	38.33582	109.39196	5,960	100	<0.1	3.2	4.3	0.5	0.7	0.9
BH-46-BG	382006109233201	08/12/2008	09:10	38.33517	109.39233	5,960	170	<0.1	0.6	7	0.8	1.1	0.6
BH-49	382008109233101	08/05/2008	09:00	38.33555	109.39192	5,960	100	<0.1	2.1	5.2	0.6	1	0.8
BH-49-SED1	382008109233201	08/12/2008	09:20	38.33554	109.39213	5,910	130	<0.1	0.3	3.3	0.4	0.5	0.4
BH-49-SED2	382008109233202	08/12/2008	09:30	38.33555	109.39218	5,900	110	<0.1	0.3	3.7	0.4	0.6	0.4
BH-49-SED3	382008109233203	08/12/2008	09:40	38.33566	109.39223	5,900	120	<0.1	0.4	4.4	0.5	0.9	0.4
BH-49-SED4	382009109233201	08/12/2008	9:50	38.33578	109.39228	5,900	150	<0.1	0.4	5.1	0.6	0.8	0.5
BH-49-SED5	382009109233202	08/12/2008	10:00	38.3359	109.3923	5,900	90	<0.1	0.3	3.2	0.4	0.5	0.3
BH-52	381903109232401	08/06/2008	15:30	38.31755	109.38996	6,360	110	<0.1	0.7	4.4	0.5	0.8	0.5
BH-52-BG	381905109232301	08/06/2008	15:40	38.31804	109.38981	6,360	250	<0.1	0.7	8.5	0.9	1.5	0.7
BH-54	381907109232501	08/06/2008	15:50	38.31853	109.39029	6,360	120	<0.1	0.8	4.5	0.5	0.7	0.5

Table 3. Chemical analysis of total extractable-from-sediment samples for major-ion and trace-element concentrations from uranium waste dump, undisturbed geologic background, and dry ephemeral streambed samples, Browns Hole, Utah.—Continued

[**Abbreviations:** BH, Browns Hole; BG, background sample; DD.dddd, Degrees, decimal degrees; ft, feet; hh:mm, hour:minute; MDT, Mountain Daylight Time; mm/dd/yyyy, month/day/year; pCi/g, picocuries per gram; ppm, parts per million; SDC, mica schist geochemical reference material; SED, ephemeral stream sediment sample; Site ID, site identification; USGS, U.S. Geological Survey; SGR, Green River Shale geochemical reference material; STD, expected standard value; SUB, submitted standard value; %, percent; <, less than; —, no data]

Site ID	USGS site number	Date (mm/dd/yyyy)	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Strontium total (ppm as Sr)	Tellurium total (ppm as Te)	Thallium total (ppm as Tl)	Thorium total (ppm as Th)	Thorium (pCi/g as Th-232)	Tin total (ppm as Sn)	Tungsten total (ppm as W)
BH-58	381945109231901	08/04/2008	15:30	38.3292	109.38863	6,240	50	<0.1	0.8	3.1	0.3	0.5	0.7
BH-59	381849109224401	08/06/2008	09:00	38.31348	109.37901	6,380	80	<0.1	1.2	4	0.4	0.9	0.7
BH-60	381848109224301	08/06/2008	09:15	38.31347	109.37876	6,380	80	<0.1	1.1	3.1	0.3	0.7	0.5
BH-62	381849109225801	08/06/2008	09:50	38.31353	109.38284	6,480	80	<0.1	0.7	2.6	0.3	0.6	0.3
BH-63	381849109230001	08/06/2008	10:00	38.31358	109.38323	6,480	110	<0.1	0.8	3.4	0.4	1.3	0.6
SGR-1B (STD)	—	—	—	—	—	—	180	—	0.7	12	—	3.0	0.8
SGR-1B (SUB)	—	—	—	—	—	—	170	—	0.5	11	—	2.9	0.6
SDC-1 (STD)	—	—	—	—	—	—	—	420	4.8	—	—	1.9	2.6
SDC-1 (SUB)	—	—	—	—	—	—	—	377	4.3	—	—	0.7	1.9

Table 3. Chemical analysis of total extractable-from-sediment samples for major-ion and trace-element concentrations from uranium waste dump, undisturbed geologic background, and dry ephemeral streambed samples, Browns Hole, Utah.—Continued

[Abbreviations: BH, Browns Hole; BG, background sample; DD, dddd, Degrees, decimal degrees; ft, feet; h:mm, hour:minute; MDT, Mountain Daylight Time; mm/dd/yyyy, month/day/year; pCi/g, picocuries per gram; ppm, parts per million; SDC, mica schist geochemical reference material; SED, ephemeral stream sediment sample; Site ID, site identification; USGS, U.S. Geological Survey; SGR, Green River Shale geochemical reference material; STD, expected standard value; SUB, submitted standard value; %, percent; <, less than; —, no data]

Site ID	USGS site number	Date (mm/dd/yyyy)	Time (MDT) (hh:mm)	Latitude (DD, dddd)	Longitude (DD, dddd)	Elevation (ft)	Uranium total (ppm as U)	Uranium (pCi/g as U-238)	Vanadium total (ppm as V)	Yttrium total (ppm as Y)	Zinc total (ppm as Zn)
BH-2	382228109254301	08/06/2008	13:50	38.37452	109.42864	4,980	98.9	33.2	570	7.8	60
BH-2-BG	382225109254201	08/12/2008	12:30	38.37368	109.42822	4,900	4	1.3	100	15.8	60
BH-26	382153109241801	08/05/2008	13:30	38.36463	109.40498	5,000	267	89.6	1,470	17	230
BH-27	382157109241601	08/05/2008	14:00	38.36576	109.40456	4,980	51.4	17.2	600	9.4	100
BH-28	382146109244901	08/05/2008	15:00	38.3629	109.41353	5,010	30.2	10.1	850	6.7	40
BH-28-BG	382147109244901	08/05/2008	15:20	38.36309	109.41368	5,010	6.2	2.1	100	10.5	40
BH-30	382146109241801	08/05/2008	12:30	38.36269	109.40494	4,960	355	119.1	2,550	11.2	550
BH-32	382147109241901	08/05/2008	12:45	38.36293	109.40537	4,960	101	33.9	1,210	7.7	60
BH-33	382149109242701	08/05/2008	12:00	38.36352	109.40744	4,970	22.3	7.5	1,270	11.4	250
BH-35	382224109253901	08/06/2008	13:30	38.37325	109.4276	5,040	101	33.9	1,440	12.7	310
BH-36	382220109253501	08/06/2008	12:50	38.37217	109.42636	5,000	49.1	16.5	430	10.1	60
BH-36-BG	382220109253301	08/12/2008	12:50	38.37207	109.42595	5,000	6.4	2.1	40	14.2	40
BH-36-SED	382219109253601	08/12/2008	13:05	38.37192	109.42654	4,920	18	6.0	100	8.1	20
BH-37	382049109230001	08/05/2008	09:40	38.34688	109.38331	5,760	238	79.9	100	14.9	30
BH-37-BG	382048109225801	08/05/2008	09:45	38.34674	109.38286	5,760	6.2	2.1	80	14.9	50
BH-40	382048109225701	08/05/2008	10:15	38.34657	109.38243	5,760	81.9	27.5	630	8.2	40
BH-40-BG	382048109225201	08/12/2008	11:10	38.34653	109.38105	5,760	6.2	2.1	70	13.5	30
BH-40-SED1	382047109225601	08/12/2008	10:40	38.34639	109.3821	5,740	4.6	1.5	50	7.1	<10
BH-40-SED2	382046109225701	08/12/2008	11:00	38.34613	109.38262	5,720	4.5	1.5	60	7.9	20
BH-46	382009109233101	08/05/2008	08:45	38.33582	109.39196	5,960	359	120.5	1,760	10	140
BH-46-BG	382006109233201	08/12/2008	09:10	38.33517	109.39233	5,960	4	1.3	50	13	40
BH-49	382008109233101	08/05/2008	09:00	38.33555	109.39192	5,960	268	89.9	940	11.7	80
BH-49-SED1	382008109233201	08/12/2008	09:20	38.33554	109.39213	5,910	15.9	5.3	70	6.9	20
BH-49-SED2	382008109233202	08/12/2008	09:30	38.33555	109.39218	5,900	11.8	4.0	70	6.9	20
BH-49-SED3	382008109233203	08/12/2008	09:40	38.33566	109.39223	5,900	17.4	5.8	60	8.8	20
BH-49-SED4	382009109233201	08/12/2008	9:50	38.33578	109.39228	5,900	8.8	3.0	60	9.8	20
BH-49-SED5	382009109233202	08/12/2008	10:00	38.3359	109.3923	5,900	7.1	2.4	40	6	20
BH-52	381903109232401	08/06/2008	15:30	38.31755	109.38996	6,360	207	69.5	1,370	8.7	60
BH-52-BG	381905109232301	08/06/2008	15:40	38.31804	109.38981	6,360	3.6	1.2	70	16.9	50
BH-54	381907109232501	08/06/2008	15:50	38.31853	109.39029	6,360	265	88.9	1,170	9.1	50

Table 3. Chemical analysis of total extractable-from-sediment samples for major-ion and trace-element concentrations from uranium waste dump, undisturbed geologic background, and dry ephemeral streambed samples, Browns Hole, Utah.—Continued

[Abbreviations: BH, Browns Hole; BG, background sample; DD.dddd, Degrees decimal degrees; ft, feet; hh:mm, hour-minute; MDT, Mountain Daylight Time; mm/dd/yyyy, month/day/year; pCi/g, picocuries per gram; ppm, parts per million; SDC, mica schist geochemical reference material; SED, ephemeral stream sediment sample; Site ID, site identification; USGS, U.S. Geological Survey; SGR, Green River Shale geochemical reference material; STD, expected standard value; SUB, submitted standard value; %, percent; <, less than; —, no data]

Site ID	USGS site number	Date (mm/dd/yyyy)	Time (MDT) (hh:mm)	Latitude (DD.dddd)	Longitude (DD.dddd)	Elevation (ft)	Uranium total (ppm as U)	Uranium (pCi/g as U-238)	Vanadium total (ppm as V)	Yttrium total (ppm as Y)	Zinc total (ppm as Zn)
BH-58	381945109231901	08/04/2008	15:30	38.3292	109.38863	6,240	112	37.6	1,240	9.2	100
BH-59	381849109224401	08/06/2008	09:00	38.31348	109.37901	6,380	115	38.6	540	7.9	60
BH-60	381848109224301	08/06/2008	09:15	38.31347	109.37876	6,380	151	50.7	930	6.8	50
BH-62	381849109225801	08/06/2008	09:50	38.31353	109.38284	6,480	23.4	7.9	1,160	6.6	20
BH-63	381849109230001	08/06/2008	10:00	38.31358	109.38323	6,480	22.7	7.6	1,290	8.1	20
SGR-1B (STD)	—	—	—	—	—	—	3.1	—	102	—	103
SGR-1B (SUB)	—	—	—	—	—	—	2.7	—	113	—	102
SDC-1 (STD)	—	—	—	—	—	—	5.4	—	130	13.0	74
SDC-1 (SUB)	—	—	—	—	—	—	5.4	—	146	9.1	72

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