Historical and 2009 Water Chemistry of Wells, Perennial and Intermittent Streams, and Springs in Northern Arizona

By Donald J. Bills, Fred D Tillman, David W. Anning, Ronald C. Antweiler, and Thomas F. Kraemer

Chapter C of

Hydrological, Geological, and Biological Site Characterization of Breccia Pipe Uranium Deposits in Northern Arizona

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U.S. Department of the Interior
U.S. Geological Survey

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Plate

[In pocket]

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
Fluid ounces (oz)	0.03	milliliters (mL)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
	Concentration	
part per billion (ppb)	1.0	microgram per liter (µg/L)
part per million (ppm)	1.0	milligram per liter (mg/L)
	Radioactivity	
becquerel per liter (Bq/L)	27.027	picocurie per liter (pCi/L)
tritium unit (TU)	1 ^3H per 1,018 hydrogen atoms	--
picocurie per liter (pCi/L)	4 (x/y); where x is photon activity and y is conversion rate	millirems per year (mrem/y)

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

°F=(1.8×°C)+32

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

°C=(°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).

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

Abbreviations Used in This Report

ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
ICP–AES	inductively coupled plasma–atomic emission spectroscopy
ICP–MS	inductively coupled plasma–mass spectrometry
INAA	instrumental neutron-activation analysis
GRCA	Grand Canyon National Park
MCL	maximum contaminant level
MPV	most-probable value
NURE	National Uranium Resource Evaluation Program
NWQL	U.S. Geological Survey National Water Quality Laboratory
PMCL	primary maximum contaminant level
BLM	U.S. Bureau of Land Management
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

Chapter C

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Abstract

This chapter provides an evaluation of selected historical water-chemistry data and recently collected water-chemistry data for wells, springs, and streams in the Grand Canyon region of northern Arizona. Historical data were used to evaluate the effects of legacy mining and recent uranium mining and to provide an historical context for the concentration of dissolved uranium in water in northern Arizona. New data were collected in the three segregation areas, East, North, and South, where recent uranium mining is on standby or is planned. A few springs were sampled along the corridor of the Colorado River in the Marble Canyon reach, which is downgradient from the House Rock area (the East Segregation Area) where mining claims have been filed and very little water-chemistry data exist.

Historical water-quality and water-chemistry data evaluated for 1,014 water samples from 428 sites indicate that about 70 sites exceeded either the primary or secondary maximum contaminant levels (or both) for a few major ions and trace elements such as arsenic, iron, lead, manganese, sulfate, radium, and uranium. These data suggest that water recharged from the surface or from perched water-bearing zones contains dissolved gypsum from overlying rock units or may have been in contact with sulfide-rich ore.

Samples from about 120 springs and 32 streams in the region contained dissolved uranium concentrations greater than 5 µg/L but less than 30 µg/L; those concentrations are probably the result of natural dissolution and erosion of mineralized ore deposits. Samples from 15 springs and 5 wells in the region contained dissolved uranium concentrations greater than the U.S. Environmental Protection Agency maximum contaminant level for drinking water. These springs and wells are close by or in direct contact with mineralized orebodies, and those concentrations are related to natural processes, mining, or to both. In 66 percent of natural water samples in the dataset, uranium concentrations were 5 µg/L or less and may be subjectively classified as low concentrations for this study area on the basis of the subjective evaluation of historical data. Samples of surface water from the Colorado River in the Grand Canyon region typically contained less than 5 µg/L dissolved uranium. However, in the northwest corner of the area a sample of Virgin River water contained a dissolved uranium concentration greater than 80 µg/L.

Groundwater samples were collected from 24 sites in August and September 2009 in the study area; they augment the historical dataset and allowed variations in groundwater chemistry to be evaluated by geographic region and groundwater source. Major-ion composition, specific conductance, and concentrations of uranium, barium, strontium, and molybdenum appear correlated with geographic region and groundwater source. In addition, arsenic concentrations appear correlated with groundwater source, and zinc concentrations appear correlated with geographic region. Relations of uranium and 13 other trace elements to mining activity were few and inconclusive.

Introduction

The U.S. Geological Survey (USGS) evaluated historical and recently collected water-chemistry data in northern Arizona in order to understand better the source and distribution of dissolved uranium in the Grand Canyon region. This chapter describes the region's general hydrogeologic setting, investigative methods, and the resultant chemical analyses of historical and recently collected data. The evaluation describes the presence of natural dissolved uranium and other elements in groundwater and the potential for and extent of any release of postmining waste into the region's groundwater. Data on historical and 2009 concentrations of dissolved uranium provide a context that could then be used to evaluate past and current mining activity. Surface water samples were not collected owing to a lack of precipitation and runoff. The evaluation focuses on the East, North, and South Segregation Areas in the Grand Canyon region that are being considered for withdrawal from future mining (fig. 1).

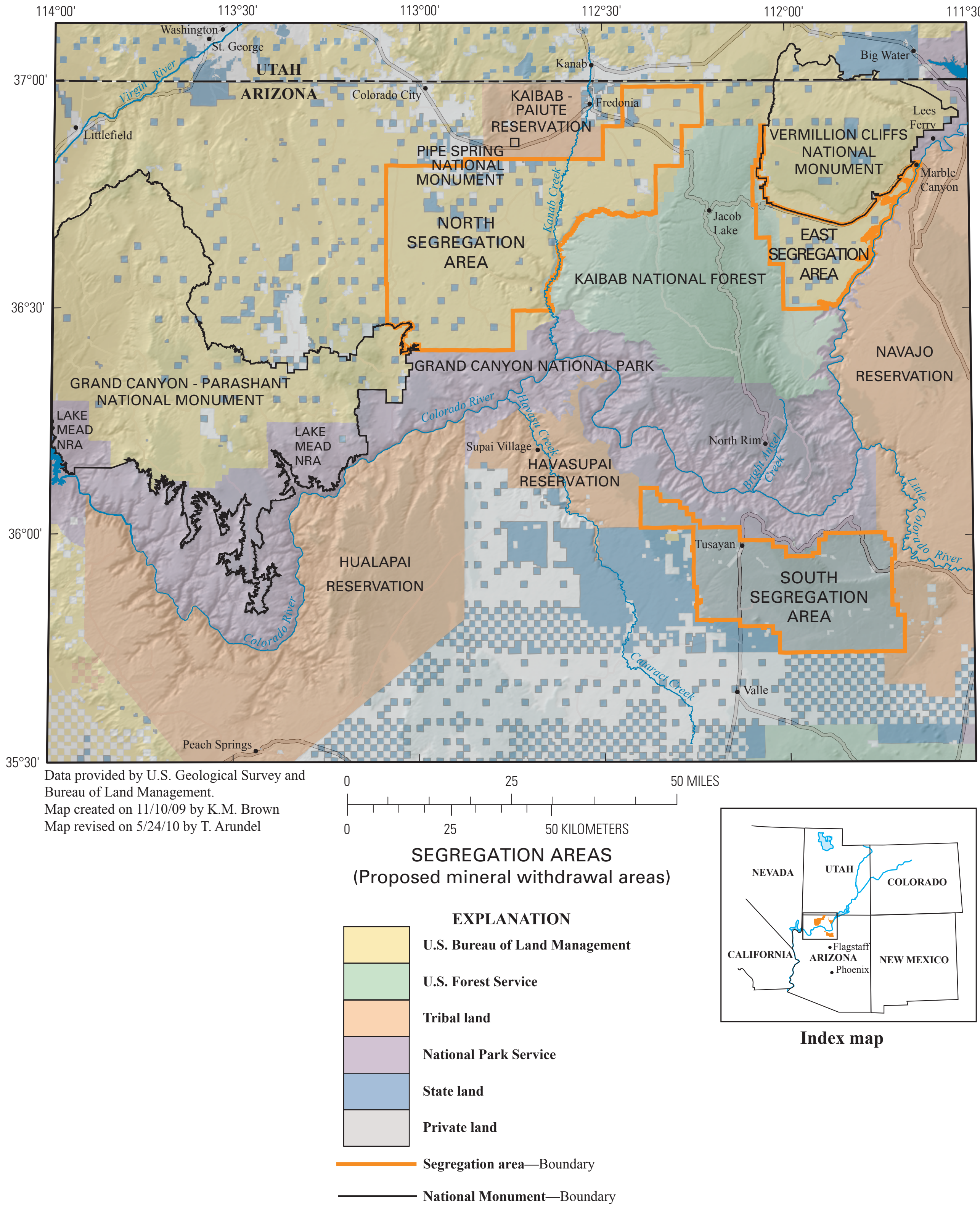

Figure 1. Study area, segregation areas, and land ownership in northern Arizona. NRA, National Recreation Area.

Hydrogeologic Setting

The study area is in the Colorado River Basin in northern Arizona on the southern edge of the Colorado Plateau (fig. 1). The Colorado River and its many tributaries have exposed Paleozoic and Mesozoic sedimentary rocks containing mineralized breccia pipes that are enriched in uranium (Finch and others, 1987; Finch, 2003). Past mine development has, in some cases, accelerated the erosion of these mineral deposits (Billingsley, 1997). Regional groundwater flow systems in this part of the Colorado Plateau are largely contained within Paleozoic rocks. Erosion of the Grand Canyon has produced large regional discharge zones (springs) that drain these aquifers to the Colorado River and its tributaries. Surface water and groundwater are natural pathways for migration of trace elements and radionuclides in the environment. Therefore, the water chemistry of streams and springs can provide insight into the sources and directions of groundwater flow as well as the effects of anthropogenic activities, such as mining within the region.

Surface Water

South of the Colorado River

South of the Colorado River, all tributaries on the Coconino Plateau are ephemeral except for short perennial reaches supported by groundwater discharge (fig. 2). On the south, the largest tributaries that drain to the Colorado River are the Little Colorado River and Havasu Creek. The Little Colorado River basin drains about 27,000 square miles (mi^2) of northeastern Arizona and central New Mexico. Headwater reaches of the Little Colorado River are perennial, supported by groundwater discharge from local and regional aquifers (Hart and others, 2002). The middle reaches of the Little Colorado River are ephemeral and flow only in response to winter and spring runoff and summer thunderstorms. The lower 13 miles (mi) of the Little Colorado River are also perennial and are supported by groundwater discharge from a series of large springs in the Blue Spring area (fig. 2). The Blue Spring area, in the lower Little Colorado River, is the largest single source of spring discharge (220 cubic feet per second [ft^3/s]) in the entire Grand Canyon region and is a primary discharge area for the regional aquifer (Cooley and others, 1969; Hart and others, 2002; and Bills and others, 2007).

Havasu Creek is the second largest tributary south of the Colorado River, draining 3,020 mi^2. Havasu Creek is perennial from Havasu Spring, about 2 mi upstream of Supai, to the mouth of its canyon (fig. 2). The base flow of Havasu Creek, about 70 ft^3/s (Bills and others, 2007), comes entirely from the Redwall-Muav aquifer (Bills and Flynn, 2002; Bills and others, 2007). Upstream from Havasu Spring, Havasu Creek is called Cataract Creek; it is ephemeral for its entire length and flows only in response to substantial winter precipitation and summer thunderstorms. The Havasu and Cataract Creek drainage is subject to periodic, catastrophic floods that transport large sediment loads (Melis and others, 1996). In this drainage, several breccia pipes have been exposed largely by normal erosional processes.

Other tributaries south of the Colorado River are relatively small and mostly ephemeral (fig. 2). The few tributaries that do have perennial flow to their mouths have base flows between about 10 ft^3/s and less than 0.1 ft^3/s (Hualapai Water Resources Department, 1995; Monroe and others, 2005; Bills and others, 2007). The base flow in these drainages is supported by groundwater discharge from the Redwall-Muav aquifer and from water-bearing zones in underlying units. All of the drainages south of the Colorado River are capable of high-volume flash floods and debris flows that can mobilize large amounts of rock and sediment (Melis and others, 1994). These floods can effectively transport trace elements and radionuclides.

North of the Colorado River

Most of the tributaries that drain the north of the Colorado River are ephemeral except for short perennial reaches supported by groundwater discharge (fig. 2). Paria River and Kanab Creek are the only perennial streams that drain large areas. The Paria River, northeast of the study area, has a drainage area of 1,410 mi^2 (fig. 2). Most of the lands drained by the Paria River contain rock units that in turn contain uranium and associated trace elements; these elements augment the trace element or radionuclide content of the both the Paria and Colorado Rivers (Foust and Hope, 1985).

Kanab Creek, the largest tributary north of the Colorado River, drains 2,360 mi^2. The Kanab Creek Basin contains many breccia pipes, many mines and prospects for copper and other ore, and six uranium mines. In addition, it drains all of the North Segregation Area (see plate 1). Kanab Creek is perennial at Fredonia, Ariz. (fig. 2), because of spring flow from the Navajo Sandstone in Utah and from irrigation return flows (Levings and Farrar, 1979a; Cordova, 1981). A few miles south of Fredonia the creek is dry, because flow has been lost by evapotranspiration or infiltration into the streambed. The lower 10 mi of Kanab Creek is perennial (fig. 2); a base flow of about 4.0 ft^3/s discharges from the Redwall-Muav aquifer (Rote and others, 1997). Winter storms and intense summer thunderstorms within in the drainage can produce floods, flash floods, and debris flows that could transport substantial volumes of trace elements and radionuclides in dissolved, suspended, and bed loads. Fine-grained particles that have a high cation-exchange capacity are nearly ideal sites for the mobilization of radionuclides (Ames and Dhanpat, 1978). In 1984, a flash flood in Hack Canyon, a tributary of Kanab Creek, washed away parts of waste rock and ore piles of the Hack Canyon mines (J.K. Otton, U.S. Geological Survey, written commun., 2009). Foust and Hoppe (1985) reported that Kanab Creek contained numerous dissolved trace metals in excess of established standards for both domestic supplies and the support of freshwater aquatic and terrestrial wildlife use that warrant further investigation.

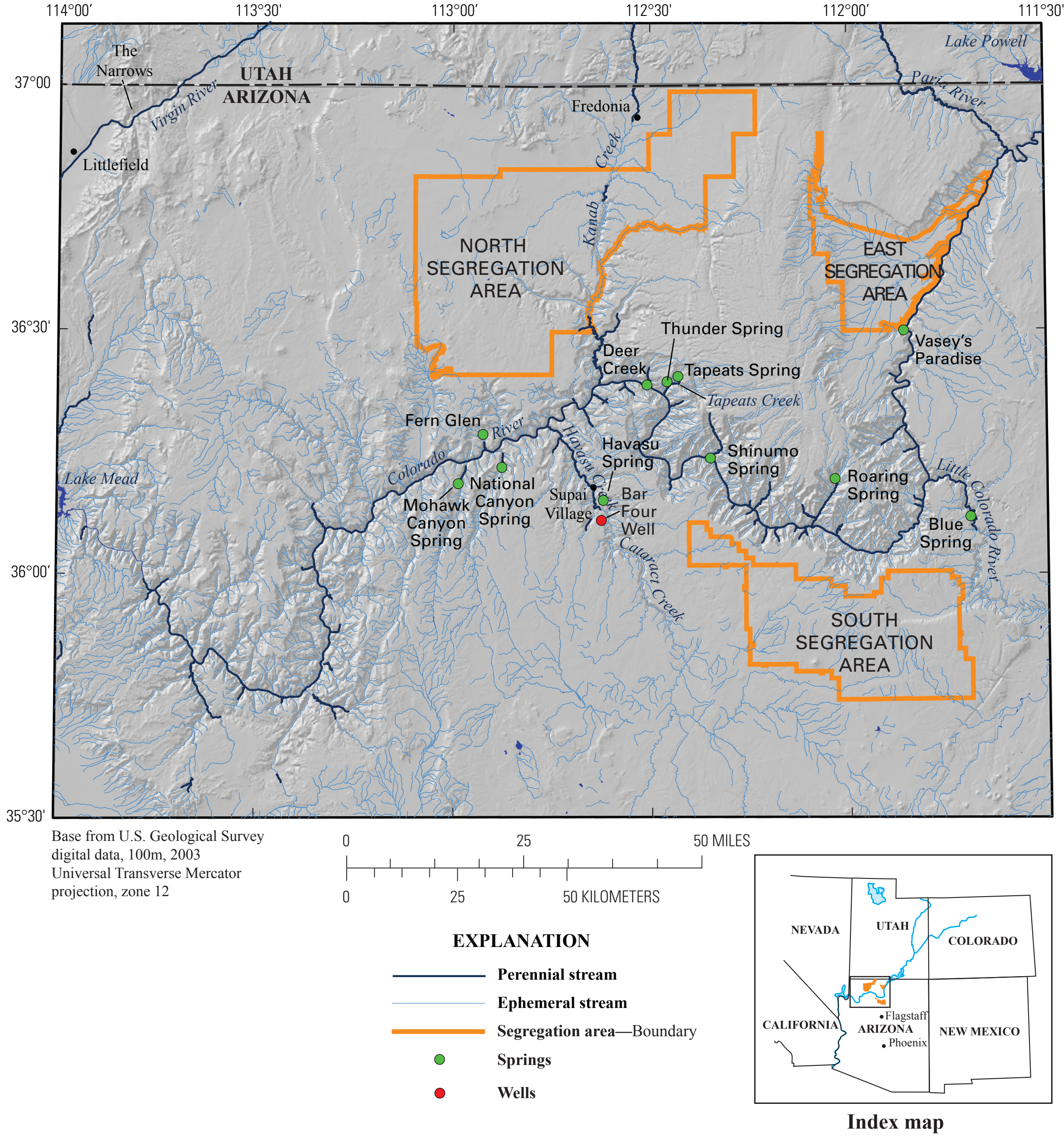

Figure 2. Perennial and ephemeral streams and selected springs in northern Arizona.

Other tributaries north of the Colorado River have relatively small drainage areas but some of the largest base-flow discharge issuing from the Redwall-Muav aquifer, ranging from 75 ft^3/s at Tapeats Creek to less that 1.0 ft^3/s at Fern Glen (fig. 2) (Johnson and Sanderson, 1968; S.E. Rice, Grand Canyon National Park, written commun., 2007; *http://waterdata.usgs.gov/az/nwis/sw/*, accessed September 2009). All drainages north of the Colorado River are capable of substantial flash floods and debris flows that can mobilize large volumes of rock and sediment (Melis and others, 1994) and represent significant transport mechanism for trace elements and radionuclides.

Groundwater

The groundwater flow systems in the study area are divided into smaller perched water-bearing zones and larger regional aquifer systems (fig. 3). The perched water-bearing zones are contained in unconsolidated alluvium, volcanic rocks, and consolidated sedimentary rocks located a thousand feet or more above the main regional aquifer systems. These perched zones generally are small and discontinuous in the subsurface. Groundwater flows downgradient and discharges at springs or migrates deeper into the subsurface (Farrar 1979, 1980; Levings and Farrar, 1979a,b; McGavock and others, 1986; Bills and others, 2007; Arizona

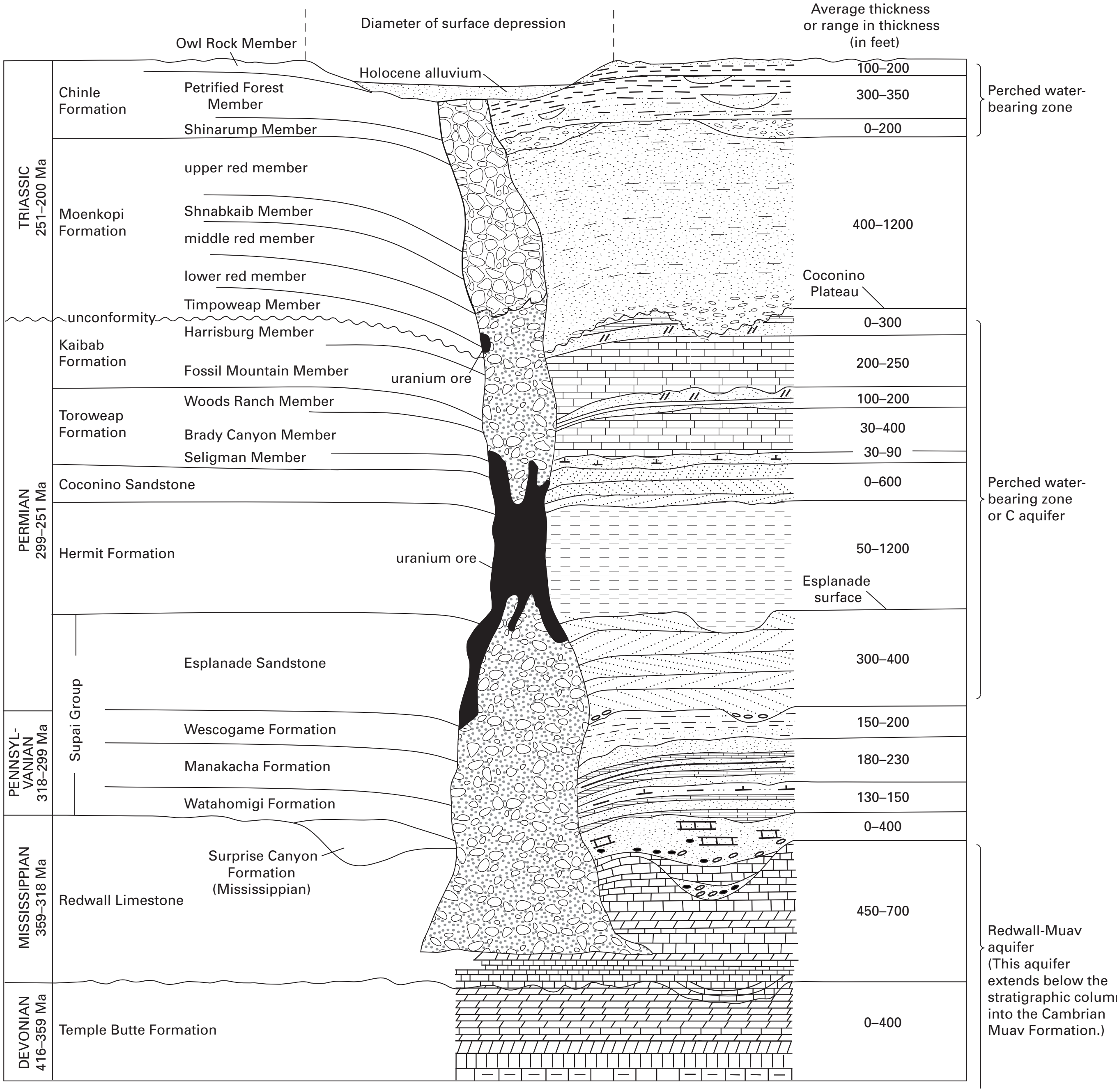

Figure 3. Stratigraphic column showing relation of perched water-bearing zones and aquifers to mineralized breccia deposits in northern Arizona. Modified from Van Gosen and Wenrich, 1989. Ma, million years ago.

Department of Water Resources, 2009). The depth to water ranges from a few feet to more than 300 ft below land surface (Levings and Farrar, 1979; Bills and others, 2007; Arizona Department of Water Resources, 2009). Perched water-bearing zones can be in direct contact with mineralized orebodies in the Chinle Formation, the Coconino Sandstone, or the Supai Group (fig. 3).

The C aquifer and the Redwall-Muav aquifer (fig. 3) are the two primary regional aquifer systems in the study area (Hart and others, 2002; Bills and others, 2007). These aquifer systems are contained in hydraulically connected Paleozoic sedimentary rocks, typically sandstone and limestone. The relatively simple layered nature of the Paleozoic strata throughout the study area obscures the more complex character of the regional aquifers they contain (plate 1, fig. 3). The complexity is due to variations in stratigraphy, lithology and, most important, geologic structure throughout the southern Colorado Plateau (plate 1). The C aquifer is present at the southern edge of the study area and in the Little Colorado River Valley east of the Mesa Butte fault (plate 1) where fractures and faults in the rock provide pathways for migration of groundwater from this aquifer deeper into the subsurface (Bills and others, 2007). The saturated thickness of the C aquifer is about 600 ft along the Little Colorado River valley before it drains completely to underlying rock units just east of the study area (Bills and others, 2007). Groundwater in the C aquifer could be in direct contact with mineralized ore where breccia pipes are present east of the Mesa Butte fault (plate 1, fig. 3). In addition, fractures associated with these collapse features could be pathways that allow dissolved constituents to move deeper into the subsurface. The hydrogeology of the C aquifer is described in detail by McGavock and others (1986), Bills and others (2000), and Bills and others (2007). The C aquifer is not present west of the Mesa Butte fault or north of the Colorado River (Bills and others, 2007; Arizona Department of Water Resources, 2009). In these areas, perched water-bearing zones in the Kaibab Formation, Coconino Sandstone, or sandstones in the Supai Group are underlain by finer grained sediments (fig. 3).

The Devonian Temple Butte Formation, Mississippian Redwall Limestone, and Cambrian Muav Limestone compose the Redwall-Muav aquifer and are the principal water-bearing rock units underlying the entire study area (fig 4). The Redwall-Muav aquifer also underlies the C aquifer south of the Colorado River; there, 1,500 to 2,500 feet of unsaturated rock separate the two (McGavock and others, 1986; Bills and others, 2000; Bills and others, 2007). The Redwall-Muav aquifer is the ultimate drain for groundwater and for dissolved trace elements and radionuclides migrating downward from overlying ore deposits. The aquifer is confined throughout much of its extent (fig. 4) by very fine grained sediments in the overlying Supai Group (fig. 3) and by underlying Proterozoic granites and schists. It is fully to partly saturated south of the Colorado River. In a few places along the South Rim of Grand Canyon, these limestones may be partly saturated to unsaturated where groundwater migrates into lower units of the aquifer (Bills and others, 2007). The Redwall-Muav aquifer extends north of the Colorado River into Utah and Nevada but is poorly defined there because it is deeply buried and subsurface borehole data is lacking (fig. 4). It is a major aquifer system in central and northern Utah also, where it has been better defined (Taylor and others, 1986). Most information about the extent and flow of groundwater in the Redwall-Muav aquifer north of the Colorado River is derived from studies by Cooley (1976) and Huntoon (1977, 2000a,b), from observation of springs in Marble Canyon and the Grand Canyon, and from a few wells drilled to support mining activity in the Kanab Creek drainage. North of the Colorado River, the Redwall-Muav aquifer can be described as an unconfined to confined, karstified carbonate aquifer. Groundwater flow in the aquifer is controlled by five main features: cave systems developed on joint fractures and faults, large regional faults, lithology and regional dip of the rock matrix, incision of the Colorado River and its tributaries through rock units of the aquifer, and the Bright Angel Shale (plate 1, fig. 4) (Cooley, 1976; Goings, 1985; Zukosky, 1995; Huntoon, 1996, 2000a,b; Ross, 2005; Arizona Department of Water Resources, 2009). In Marble Canyon, the Colorado River has not fully penetrated the Redwall or Muav Limestones. As result, there is underflow in the Redwall-Muav aquifer in this area (fig. 4) (Huntoon, 1996). The water-level elevation on the Kaibab Plateau, where limited well data exist, is 2,800 to 3,700 ft above sea level (fig. 4).

Groundwater discharges from the Redwall-Muav aquifer as springs supplying water to the Colorado River and its many tributaries, as downward leakage into the Bright Angel Shale and Tapeats Sandstone, as supply to wells, and as evapotranspiration where the water table in the aquifer is at or near land surface (Johnson and Sanderson, 1968; Cooley, 1976; Levings and Farrar, 1978, 1979a,b; Farrar, 1979; Monroe and others 2005; and Bills and others, 2007). Water in the Early to Middle Cambrian Bright Angel Shale and Tapeats Sandstone is believed to be hydraulically connected with the overlying Redwall-Muav aquifer through faults and fractures in the Bright Angel confining unit or where, in the central part of the study area, the Bright Angel Shale is thin or absent (plate 1) (Bills and others, 2007).

Relation of Hydrologic Flow Components to Breccia Pipes

Fractures, faults, sinkholes, and breccia pipes occur throughout the study area and are pathways for downward migration of surface water and groundwater. Collapse features and breccia pipes in particular can intercept precipitation, runoff, and groundwater in perched water-bearing zones and can direct that water deeper into the subsurface. In areas containing mineralized pipes, this process can dissolve trace elements and radionuclides in the deposits and transport them to groundwater deeper in the subsurface. This process has been occurring naturally for millions of years (Sanford, 1982; Wenrich and Stuphin, 1989; Young, 2008). Uranium mineralization is concentrated in or near the Esplanade Sandstone, Hermit Formation, and Coconino Sandstone (fig. 3) (Van Gosen and Wenrich, 1989). These stratigraphic units typically lie several hundred feet below the plateau surface north and south of the Colorado River. Orebodies range in thickness from a few hundred to more than a thousand feet. Uranium minerals in the Canyon breccia pipe south of the Colorado River extend from the contact between the Coconino Sandstone and Toroweap Formation for more than 1,600 ft vertically down through the breccia pipe to the upper Redwall Limestone (plate 1) (Casadevall, 1989). The depth to perched water in these rock units generally is greater than 1,000 ft below land surface south of the Colorado River and a few hundred to more than 1,000 ft below the surface north of the river (Levings and Farrar, 1979a,b; Farrar, 1980; Bills and others, 2007; Arizona Department of Water Resources, 2009). These water-bearing zones generally are separated by more than 2,000 ft of unsaturated rock above the

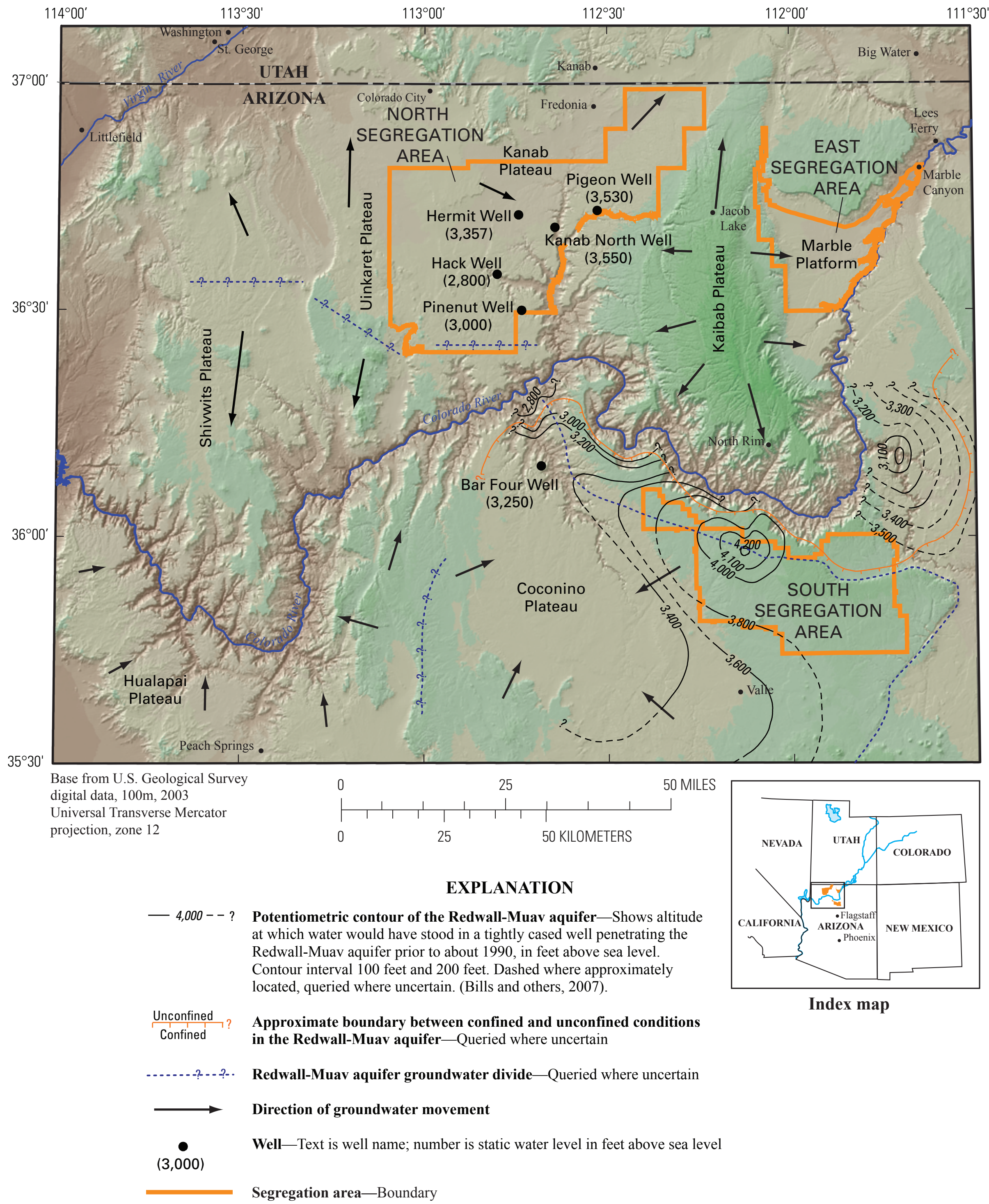

Figure 4. Hydrologic framework of northern Arizona.

regional aquifer in the Redwall and Muav Limestones (fig. 3) (Bills and others, 2007). The Redwall-Muav aquifer is confined throughout much of its extent by very fine grained sediments at the base of the overlying Supai Group, except where it is faulted or fractured or where breccia pipes have developed (plate 1, fig. 3). The depth to water in the Redwall-Muav aquifer both south and north of the Colorado River is 2,500 ft or more below the surface (fig. 4) (Bills and others, 2007) and typically 1,000 ft or more below the bottom of most ore deposits in breccia pipes (fig. 3). The stratigraphically confined nature of the Redwall-Muav aquifer and other features—faults, fractures, and breccia pipes—provide pathways by which dissolved minerals may reach this flow system. Groundwater flow systems south and north of the Colorado River are connected hydraulically with some stream reaches of the many tributaries of the Grand Canyon and possibly to the Virgin River (figs. 2, 4). The interaction of groundwater, surface water, and dissolved minerals in these stream reaches is controlled by the physical properties of the rock units and sediments that make up the stream channels and geologic structure near the spring and base-flow areas.

Short reaches of several streams north of the Colorado River have perennial flow because groundwater discharges where stream channels intersect rock units of the Redwall-Muav aquifer (plate 1, fig. 2). Large regional springs—Vasey's Paradise, Roaring Spring, Shinumo Spring, Tapeats Spring, Thunder Spring, and Deer Creek—are the main regional discharge areas for the Redwall-Muav aquifer north of the Colorado River (fig. 2). The lower 10 mi of Kanab Creek are perennial owing to spring flow from the Redwall-Muav aquifer. Spring flow in the creek is controlled by the channel's deep incision that intersects deep-seated fractures and normal faults in the area (plate 1, fig. 2). The spring-fed base flow of Kanab Creek is small because most of the flow to the east has been intercepted by larger springs, the remaining area of the Kanab Creek Basin receives much less annual recharge, and the springs are close to a potential groundwater divide that may further limit recharge to this area (figs. 2, 4). Potential groundwater divides in the central parts of the Uinkaret and Shivwits Plateaus divert groundwater flow north to the Virgin River and south to the Colorado River (fig. 4). Even though these plateaus are large, the low annual precipitation limits recharge potential in these areas (Flint and others, 2004; Flint and Flint, 2007) (fig. 5). Only a few small seeps and springs discharge to tributaries of the Colorado River at the southern ends of these plateaus because of the proximity of groundwater divides to potential recharge areas and regional dip of rock units to the north (plate 1, fig. 4). Several springs discharge large volumes to the Virgin River to the north; this groundwater flows from limestones exposed from the Narrows to Littlefield that may originate on the Uinkaret and Shivwits Plateaus (fig. 4) (Levings and Farrar, 1979a,b; Billingsley and Workman, 2000).

Methods

Water-chemistry data have been collected by many agencies and by academia for selected springs, streams, wells, and mine sumps that discharge water from the perched water-bearing zones, the C aquifer, and Redwall-Muav aquifer in northern Arizona; these data were evaluated for this study. New water data were collected by the USGS in August and September 2009 and were primarily used to fill gaps in the limited information. The historical and new data were used in three ways: to conceptualize a hydrogeologic framework for the north side of the Colorado River, to evaluate water chemistry in relation to natural uranium concentrations and concentrations that may be influenced by mining, and to determine the distribution of concentrations of dissolved uranium in the study area.

Field Methods

New water samples were collected from 20 springs and 3 wells north of the Colorado River in and adjacent to the North and East Segregation Areas, and from one well south of the Colorado River in the South Segregation Area. Most of the springs are 2,000 ft or more below the canyon rim and required access by foot along several miles of unimproved trails or in stream channels. These remote sites and excessive heat necessitated modification of standard water-sampling protocols described in the USGS National Field Manual for the Collection of Water-Quality Data (Wilde and Radtke, 1998). These protocols ensure the quality of the water samples and limit exposure of field personnel to potentially hazardous conditions. In some cases, the modification required completion of sample processing after returning to base camp or to a motel room rather than processing the sample onsite (table 1). Helicopter access was used at seven of the remote spring sites to limit time between collection and processing of the water sample.

At all spring sites, field personnel completed field notes that provided a complete description of the sample site, sample conditions, sample location (including global positioning system coordinates), and any site conditions that might affect the water sample. Field parameters such as spring discharge, air and water temperature, pH, specific conductance, and dissolved-oxygen concentration were measured onsite by using calibrated instruments and USGS protocols (Wilde and others, 1998). Alkalinity was determined at the processing area by incremental titration (Wilde and Radtke, 1998). Spring discharge was measured by using a pygmy meter and Aquacalc, or a Parshall flume, or it was measured volumetrically as physical conditions required (Rantz and others, 1982). Springs were sampled as close as possible to the point of discharge. At sites where discharge locations were inaccessible, water samples were collected from the flowing channel as close as possible to the discharge point. Water

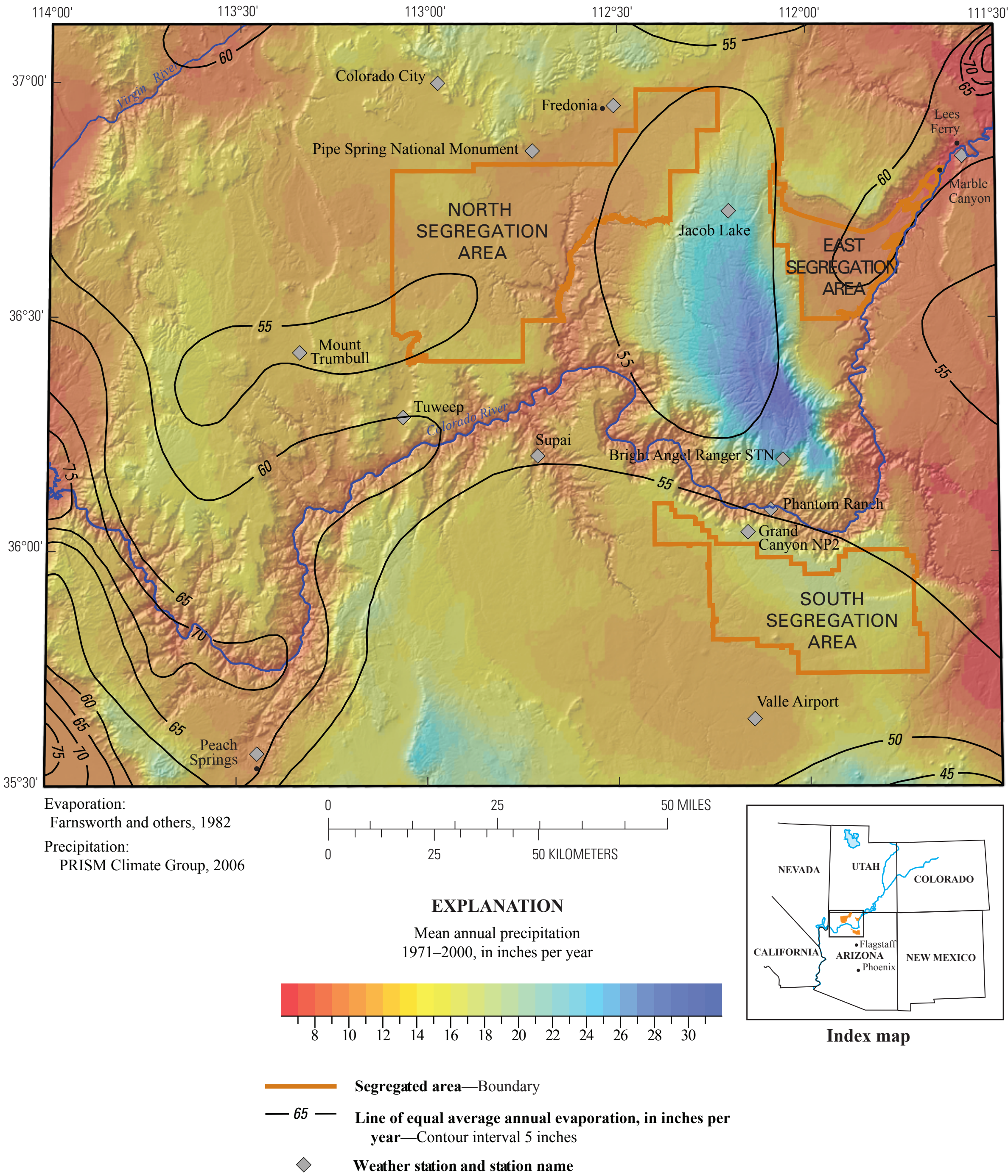

Figure 5. Annual average precipitation and average annual evaporation in northern Arizona.

samples were collected in three cleaned 4 L Nalgene bottles and then transported to the processing area using a sampling protocol modified for backcountry use as described by Monroe and others (2004) and Bills and others (2007).

At the base camp, field processing was completed in a partially enclosed, tent-like structure constructed of tarps that protected the processing area from precipitation, sun, wind, and dust. Samples were processed immediately after they arrived at the processing site. At all times during processing, polypropylene gloves were worn to ensure that samples were not contaminated. New cleaned, Tygon silicon tubing connected to a peristaltic pump was inserted into each of the 4-L bottles in turn; spring water was sucked through the tubing into a glove-box-like chamber where subsamples were collected according to a set protocol (table 1) (Koterba and others, 1995). All sample bottles for individual subsets were precleaned and individually bagged in zip-lock plastic bags.

Table 1. Field protocol used to process spring-water and well-water samples collected in 2009 in northern Arizona.

[µm, micrometer; mL, milliliter; DIC, dissolved inorganic carbon; FA, filtered acidified acid-rinsed polyethylene bottle; FAR, filtered acidified with Ultrex (ultrapure distilled water) nitric-acid-rinsed polyethylene bottle; FCC, filtered chilled brown polyethylene bottle; FU, filtered unacidified plain polyethylene bottle; FUS, filtered plastic-coated glass bottle with polyseal cap; L, liter; N, normal; RU, raw unacidified plain polyethylene bottle; RUR, raw unacidified in an acid-rinsed polyethylene bottle; RUS, raw clear glass with baked polyseal cap; WCA, filtered chilled plain polyethylene bottle acidified with sulfuric acid]

Fill order	Bottle type	Filter	Preservation	Analysis type	# bottles
1	250 mL RU, clear plastic	No	None	Major anions and selected trace elements	2
2	125-mL WCA, clear plastic	No	4.5 N sulfuric acid, chill	Nutrients	2
3	500-mL, RUR, clear plastic	No	None	Tritium	1
4	60-mL RUS, clear glass	No	None	^{18}O and deuterium	1
5	500-mL RU, clear plastic	No	None	^{87}Sr	1
6	250-mL FU, clear plastic	0.45 µm Gelman filter	Chill	Major anions	4
7	250-mL FU, clear plastic	0.45 µm Gelman filter	None	Alkalinity	1
8	125-mL FCC, brown plastic	0.45 µm Gelman filter	Chill	Nutrients	2
9	250-mL FA, clear plastic	0.45 µm Gelman filter	2-mL Ultrex nitric acid	Major ions and trace metals	4
10	45-mL FA plastic vial	0.45 µm Gelman filter	2-mL Ultrex nitric acid	Uranium replicates	1
11	125-mL clear glass	0.45 µm Gelman filter	2-mL Ultrex nitric acid	Mercury	2
12	60-mL FU brown glass with septum cap	0.45 µm Gelman filter	Chill	DIC/^{13}C	1
13	1-L FAR, clear plastic	0.45 µm Gelman filter	4-mL Ultrex nitric acid	Gross alpha and beta radioactivity	1
14	1-L FAR, clear plastic	0.45 µm Gelman filter	4-mL Ultrex nitric acid	Radium 224 isotopes	1
15	1-L FAR, clear plastic	0.45 µm Gelman filter	4-mL Ultrex nitric acid	Uranium and other isotopes	1
16	1-L FUS plastic-coated glass	0.45 µm Gelman filter	Chill	^{14}C and ^{13}C	1

An additional 100 gallons of water was processed through manganese-impregnated acrylic-fiber cartridges at 3 springs and 2 wells in order to produce a quantitative extract of radium that was used for radium isotope analysis (Kramer, 2005). Once the sample was collected, the filters were again sealed in clean zip-lock bags for shipping to a laboratory for analysis; accompanying field notes described the sample site, sample conditions, flow rate, volume of water pumped, and any site conditions that might affect the water sample. One-liter water samples also were collected at these same sites in order to determine total dissolved radium concentrations.

Groundwater samples from wells were collected as close to the well head as possible and after purging a minimum of three casing volumes of water from each well while temperature, pH, and specific conductance were monitored. Alkalinity was determined at the site by incremental titration (Wilde and Radtke, 1998). All samples were collected according to protocols described in the USGS National Field Manual for the Collection of Water-Quality Data (Wilde and Radtke, 1998) and USGS protocols in effect at the time of sample collection. Well discharge was measured volumetrically using methods described by Rantz and others (1982). Field processing was done onsite directly from the stream discharging from the well. At all times during processing, polypropylene gloves were worn to ensure that samples were not contaminated. New pre-cleaned, Tygon silicon tubing was inserted into a glove-box-like chamber where subsamples were collected according to a set protocol (table 1; Koterba and others, 1995). All sample bottles for individual subsets were pre-cleaned and individually bagged in zip-lock plastic bags.

Duplicates were collected for all subsamples except the stable isotopes. Two field blank samples were collected to ensure that equipment did not become contaminated between samples. These blanks consisted of ultrapure deionized water and were treated in all regards as if they were spring samples; they were processed according to protocol (table 1). After processing and preservation, all subsamples from each spring and well were double-sealed in zip-lock plastic bags and placed into a dedicated cooler already chilled with ice until they could be express mailed to the individual laboratories responsible for analysis.

At all steps in the collection, processing, and transportation of the spring and well samples, chain-of-custody procedures were followed (Driscoll, 2007). A chain-of-custody form accompanied each water sample from collection to the processing laboratory. Once the water samples arrived at individual laboratories and were signed for, chain-of-custody became the responsibility of each laboratory and it followed the laboratory's protocol. Chain-of-custody forms were returned to the Flagstaff Water Science Center office, where they are filed with other forms and information for each sample site.

Laboratory Methods

Samples were analyzed for selected constituents at several laboratories to compare results of analytical methods from different laboratories and to reduce analysis error (table 2).

Major ions, nutrients, trace elements, dissolved uranium, and stable isotopes were determined by the USGS National Water Quality Laboratory (NWQL) in Denver, Colo. Details of analytical procedures are described by Fishman and others, 1994; Hoffman and others, 1996; and Garbarino and others, 2006. Chloride and sulfate were determined by ion chromatography by using a modified ion chromatograph (Brinton and others, 1996). Nutrients were determined by using methods described by Wershaw and others (1987). Gross-alpha and gross-beta particle counting, used to provide semiquantitative information on the overall degree of radioactivity in water samples without quantifying individual radionuclides, was completed by use of decay-counting that in turn used a gas-proportional detector (U.S. Environmental Protection Agency, 1976). This method is most often applied for screening purposes. The method has the advantage of being sensitive to activity from a wide range of radionuclides, but it does not inherently provide information about the identity of the radioactive isotopes present. Count rates from the detector are converted to and reported as activities. More details of the methodology can be found in American Public Health Association (1985). Tritium was determined using a liquid-scintillation counting technique (Kendall and Caldwell, 1998) after preconcentration by an electrolytic-enrichment procedure. Results are reported in picocuries per liter (pCi/L) and tritium units (TU) (Fritz and Fontes, 1980; Clark and Fritz, 1997).

A duplicate set of water samples was sent to USGS National Research Program research analytical laboratory in Boulder, Colo. (Taylor Laboratory) and analyzed for concentrations of major ions, trace elements, and mercury (table 3). All analyses of dissolved metals were run in triplicate by two different instruments—inductively coupled plasma−atomic emission spectroscopy (ICP−AES) and inductively coupled plasma−mass spectrometer (ICP−MS). A selected suite of elements (boron, calcium, cobalt, iron, magnesium, manganese, sodium, nickel, potassium, phosphorus, silica, strontium, sulfur, titanium, and zinc) were analyzed by ICP−AES). Trace elements (table 3) were analyzed with a Perkin Elmer Elan Model 6000 ICP−MS using indium, iridium, and rhodium as internal standards to normalize for instrument drift. A general description of the analysis conditions and procedures are reported by Garbarino and Taylor (1979), details of operational conditions are reported in Mitko and Bebek (1999, 2000), and details of specific analytical techniques, procedures, and instrumental settings are described in Garbarino and Taylor (1996) and Taylor (2000). At least 30 percent of the samples analyzed in all batches (by both ICP−AES and ICP−MS) used standard reference waters or other quality-control samples in order to assess accuracy. Samples designated for mercury analyses were further preserved by addition of potassium dichromate in the laboratory (3 to 4 days after collection). Total dissolved mercury concentrations were measured in triplicate using an automated cold-vapor atomic fluorescence spectrometric method using a PS Analytical Millennium System mercury analyzer (Roth, 1994; Roth and others, 2001). All analytical batches included at least 20 percent quality-control and standard-reference samples to assess accuracy.

Water samples were analyzed for carbon-13 at USGS Isotope Fractionation Project Laboratory in Reston, Va. An isotope ratio−mass spectrometric technique was used to analyze $\delta^{13}C$ in water (Clark and Fritz, 1997). Measured $^{13}C/^{12}C$ ratios are reported as $\delta^{13}C$ relative to per mil deviation from values obtained from the Vienna Peedee belemnite standard (Coplen, 1994). The activity of ^{14}C was measured by accelerator mass spectrometry (Beukens, 1992); results are reported as percent modern carbon normalized to the 1950 National Bureau of Standards (National Bureau of Standards, 1984) oxalic acid standard (Stuiver and Polach, 1977; Wigley and Muller, 1981), along with 1-sigma analytical uncertainties.

Isotope compositions of radium and uranium as well as concentrations of radium, uranium, major ions, and trace elements were determined at USGS National Research Program Laboratories in Reston, Va., and Menlo Park, Calif. Uranium concentrations were determined by ICP−MS on a small aliquot (10 mL) in order to determine amounts of sample required for isotope analysis of $^{234}U/^{238}U$ (Kraemer and others, 2002). Uranium was concentrated and purified by using standard ion-chromatographic methods, and the final uranium fraction was eluted into a 30 mL bottle for liquid aspiration into the ICP−MS. This method measures the ^{234}U and ^{235}U peaks and calculates a $^{234}U/^{238}U$ uranium activity ratio on the basis of

Table 2. Laboratories used and analyte and quality-control sample types for spring-water and well-water samples collected in 2009 in northern Arizona.

Laboratory	Analyte	Quality control
USGS National Water Quality Laboratory (NWQL), Denver, Colorado	Major ions, nutrients, trace elements, alpha and beta, dissolved uranium, carbon-13 (^{13}C), carbon-14 (^{14}C), and tritium	Field blanks
USGS National Research Program Laboratory (Taylor Laboratory), Boulder, Colorado	Major ions, trace elements, mercury, rare earth elements, dissolved uranium	Duplicates
USGS National Isotope Fractionation Project Laboratory, Reston, Virginia (RSIL or Coplen Laboratory)	Oxygen-18 and deuterium, dissolved inorganic carbon, and carbon-13	
USGS National Research Program Laboratory, Menlo Park, California (Bullen Laboratory)	Strontium-87 ($^{87}Sr/^{86}Sr$)	
USGS National Research Program Laboratory, Reston, Virginia (Doughten Laboratory and Kraemer Laboratory)	Dissolved uranium, uranium isotopes, dissolved radium, radium isotopes, and major ions and trace elements	Duplicates
Northern Arizona University Isotope and Radiochemistry Laboratory (NAU Laboratory), Flagstaff, Arizona	Dissolved uranium and uranium isotopes	Duplicates

Table 3. Chemical and isotopic analytes and corresponding median detection limits for spring-water and well-water samples collected in 2009 in northern Arizona.

[Elements not footnoted were analyzed by more than one laboratory; µg/L, microgram per liter; mg/L, milligram per liter; mg N/L, milligram nitrogen per liter; mg P/L, milligram phosphorus per liter; ng/L, nanogram per liter; pCi/L, picocurie per liter; pmc, percent modern carbon; TU, tritium unit; δ, delta notation; ‰, per mil; na, not applicable]

Chemical constituent	Symbol	Median detection limit	Unit	Chemical constituent	Symbol	Median detection limit	Unit
Bicarbonate[1]	HCO_3	0.5	mg/L	Lead	Pb	0.008	µg/L
Carbonate[1]	CO_3	0.05	mg/L	Lithium	Li	0.07	µg/L
Calcium	Ca	0.001	mg/L	Lutetium[2]	Lu	0.0002	µg/L
Chloride[1]	Cl	0.02	mg/L	Manganese	Mn	0.06	µg/L
Potassium	K	0.005	mg/L	Mercury	Hg	0.4	ng/L
Magnesium	Mg	0.0005	mg/L	Molybdenum[2]	Mo	0.03	µg/L
Sodium	Na	0.01	mg/L	Neodymium[2]	Nd	0.001	µg/L
Sulfate[1]	SO_4	0.04	mg/L	Nickel	Ni	0.03	µg/L
Silica	SiO_3	0.01	mg/L	Praseodymium[2]	Pr	0.0004	µg/L
Nitrate[1]	NO_3	0.01	mg N/L	Radium[3,4]	Ra	0.003	pCi/L
Nitrite[1]	NO_2	0.001	mg N/L	Rhenium[2]	Re	0.001	µg/L
Ammonium[1]	NH_4	0.03	mg N/L	Rubidium	Rb	0.003	µg/L
Phosphorus	P	8	µg/L	Samarium[2]	Sm	0.002	µg/L
Phosphate[2]	PO_4	0.02	mg P/L	Selenium	Se	0.4	µg/L
Aluminum	Al	0.2	µg/L	Strontium	Sr	0.1	µg/L
Antimony	Sb	0.004	µg/L	Tellurium	Te	0.02	µg/L
Arsenic	As	0.05	µg/L	Terbium[2]	Tb	0.0003	µg/L
Barium	Ba	0.02	µg/L	Thallium	Tl	0.005	µg/L
Beryllium	Be	0.03	µg/L	Thorium	Th	0.0006	µg/L
Bismuth	Bi	0.003	µg/L	Thulium[2]	Tm	0.0003	µg/L
Boron	B	11	µg/L	Tungsten	W	0.001	µg/L
Bromine[3]	Br	0.5	mg/L	Uranium[1–4 and 6]	U	0.001	µg/L
Cadmium	Cd	0.009	µg/L	Vanadium	V	0.1	µg/L
Cerium[2]	Ce	0.0005	µg/L	Ytterbium[2]	Yb	0.0007	µg/L
Cesium	Cs	0.01	µg/L	Yttrium[2]	Y	0.0008	µg/L
Chromium	Cr	0.3	µg/L	Zinc	Zn	0.2	µg/L
Cobalt	Co	0.007	µg/L	Zirconium	Zr	0.003	µg/L
Copper	Cu	0.03	µg/L	Gross beta[1]	na	4	pCi/L
Dysprosium[2]	Dy	0.001	µg/L	Gross alpha[1]	na	3	pCi/L
Erbium[2]	Er	0.0009	µg/L	Oxygen-18[1]	$\delta^{18}O$	na	‰
Europium[2]	Eu	0.0005	µg/L	Deuterium[1]	$\delta^{2}H$	na	‰
Gadolinium[2]	Gd	0.001	µg/L	Strontium-87[4]	$^{87}Sr/^{86}Sr$	na	None
Holmium[2]	Ho	0.0002	µg/L	Carbon-14[5]	^{14}C	na	pmc
Iron	Fe	0.5	µg/L	Carbon-13[5]	$\delta^{13}C$	na	‰
Lanthanum[2]	La	0.0007	µg/L	Tritium[1]	^{3}H	1	TU

[1]USGS National Water Quality Laboratory.

[2]USGS National Research Program Taylor Laboratory.

[3]USGS National Research Program Kraemer Laboratory.

[4]USGS National Research Program Bullen Laboratory.

[5]USGS Isotope Fractionation Project Laboratory.

[6]Northern Arizona University Isotope and Radiochemistry Laboratory reported precision.

the assumption that the natural $^{235}U/^{238}U$ ratio is constant. The error associated with each uranium activity ratio is estimated from complete duplicate or triplicate analyses of the same sample. Acceptable instrument operation was verified by running standards of known uranium activity ratio value before, between, and after sample sets.

Radium isotope compositions were determined by gamma-ray spectroscopy on radium extracted from large-volume water samples preconcentrated in the field on manganese-impregnated acrylic-fiber cartridges (Kraemer, 2005). Manganese dioxide, along with adsorbed cations, is removed by circulating a solution of hydroxylamine hydrochloride through the cartridge. Chemical processing includes dissolution and reprecipitation of Ba(Ra)SO_4, which is collected and placed in a high-purity germanium detector for quantitative analysis of ^{228}Ra and ^{226}Ra by gamma-ray spectrometry. Samples are counted for a sufficient length of time to achieve a 1-sigma counting error of 5 percent or less. Analytical error was estimated from counting statistics only.

Total radium concentrations were determined by adding $Ba(NO_3)_2$ to a known amount of water until $BaSO_4$ precipitated. Usually, dissolved sulfate in the samples was sufficient such that addition of H_2SO_4 was not necessary. The barite precipitate was filtered, dried, and counted in the same manner as in large-volume samples.

A duplicate set of water samples was sent to the Northern Arizona University Isotope and Radiochemistry Laboratory, Flagstaff, Ariz., for analysis of dissolved uranium and uranium isotopes (see appendix 1 for methods). These analyses provide an independent check on USGS analyses of dissolved uranium and uranium isotopes.

Water samples were analyzed for strontium-87 ($^{87}Sr/^{86}Sr$) at USGS National Research Program Laboratory in Menlo Park, California by using thermal ionization mass spectrometry (Bullen and others, 1996; Taylor, 2000). Resulting measurements of $^{87}Sr/^{86}Sr$ were normalized for mass-dependent fractionation to a value of 8.37521 for measured $^{88}Sr/^{86}Sr$ ratios.

Determining Most Probable Value

Appendix 2 contains data reported from each laboratory used in this study. Because multiple values were available for many analytes, it was necessary to establish a final (or most-probable) value (MPV) for each analyte. Calculation of MPVs depended on how many laboratories reported results. If only one laboratory reported an analyte, then that value was used as the MPV. If two laboratories reported results, then the average value was usually taken, although laboratory detection limits were considered. If one laboratory had a much higher detection limit than the other and reported a concentration, whereas the other laboratory reported a “less than detection,” then the value was listed rather than the detection limit. If both laboratories reported values less than the detection limit, then the value from the laboratory with the smaller detection limit was reported. If the two laboratories had similar detection limits and reported values greater than and less than this limit, then the MPV was calculated as the average of the greater value and a value of half the detection limit; if this average was greater than the detection limit, then the average value was used; otherwise the parameter was listed as less than detection. Finally, in the rare cases in which values reported by two laboratories were widely discrepant, neither value was accepted and an “na” was reported as the MPV.

For analytes reported from three or four laboratories—especially for uranium—a more elaborate method was used to determine an MPV. First, one of the laboratories (typically NWQL) was selected as a temporary control, and results of other laboratories were ratioed to its values. These ratios were then plotted against the control concentrations to verify that no concentration dependencies were present. The median value of the sample and control ratios for a given analyte reported by each laboratory is a measure of interlaboratory bias. Median values were compared, and results from the laboratory having the central-most ratio were selected to represent the MPV for a given analyte. Results were screened to remove spurious or systematically biased results. In these cases, the values reported by the remaining laboratories were averaged. When two or more laboratories had equivalent ratios (typically within 2 percent), the values from those laboratories were averaged and reported as the MPV.

Because uranium is the most important element for this report, it is instructive to outline how the MPV was selected for it. Four laboratories reported uranium data: NWQL, USGS National Research Program Laboratory (Doughten Laboratory), Reston Va., the Taylor Laboratory, and the Northern Arizona University Laboratory (appendix 2). NWQL data were selected as a temporary control and all values were ratioed to them. After first determining that ratios of none of the laboratories were concentration dependent, the median ratio for each lab was determined. NWQL had a ratio of 1.000 (by construction); Doughten Laboratory had a median ratio of 1.052; Taylor Laboratory had a median ratio of 1.042; and Northern Arizona University had a median ratio of 1.238. These results clearly demonstrate that Northern Arizona University data are strongly biased relative to the other three laboratories, and its data are therefore rejected. Of the remaining three laboratories, the middle ratio, 1.042, corresponds with the ratio of Taylor Laboratory. Thus, the Taylor average value is used as the MPV for uranium except for cases in which the Taylor Laboratory reported a value more than 10 percent different from values reported by the other two laboratories. This event occurred only once, for the Tom Land Well, in which the average Taylor Laboratory value is 17.6 µg/L, the (bias-adjusted) NWQL value is 20.8 µg/L, and the (bias-adjusted) Doughten Laboratory value is 20.4 µg/L. In this case, the average value of the NWQL and Doughten Laboratory values is used (20.6 µg/L).

Water Chemistry

It is not uncommon to find streams and springs in the region that contain high concentrations of dissolved trace elements and radionuclides owing to natural processes of evaporation, weathering, and erosion. In addition, human activities such as mining may further contribute to the dissolved chemical load. Historical mining activity in northern Arizona has left a legacy of abandoned mines, mine waste, and waste rock. Uranium mining of breccia pipes in northern Arizona through 1969 left waste rock and low-grade ore exposed at the surface, allowing subsequent remobilization of minerals and radionuclides and contamination of both surface water and groundwater systems in the region. Beginning in the mid-1970s, the advent of stricter environmental regulations and improvements in mining practices reduced the potential for environmental contamination. However, secondary permeability in fractured rocks provides pathways for dispersing remobilized radionuclides.

Waters from wells and springs have water chemistries that depend on the chemistry of rock units that contact the water. Therefore, water-chemistry data provide important clues about the origins and flow paths of water in groundwater systems. Major-ion and trace-element data can be used to distinguish groundwater from different sources. Nutrient and selected trace-element data can be used to indicate sources of contamination and secondary groundwater recharge (for example, wastewater). Trace element, isotope, and radiochemistry data can be used to evaluate the presence of and contributions from mineralized orebodies in surface-water drainages. In particular, historical dissolved-uranium data can be used to determine a baseline value for the Grand Canyon region. Dissolved uranium, radium, gross alpha and gross beta particles, and other radionuclides can be used to compare mined and unmined drainages.

Wells and springs that discharge from perched water-bearing zones and aquifers south of the Colorado River contain mostly calcium-magnesium-bicarbonate water (figs. 6, 7). This composition is consistent with groundwater that has spent substantial time in contact with rock units of these groundwater flow systems (Bills and others, 2007). Groundwater discharging from perched water-bearing zones north of the Colorado River is a calcium-magnesium-sulfate water. These springs discharge from either the Coconino Sandstone or sandstones in the Supai Group; these formations are overlain by silty sandstones containing gypsum ($CaSO_4 \cdot 2H_2O$), which dissolves readily in water. Besides creating shallow collapse features that are easily confused with breccia pipes (Billingsley and others, 2006), the dissolved gypsum creates a water type that is easy to recognize.

Groundwater discharging from the Redwall-Muav aquifer south of the Colorado River typically has calcium-magnesium-bicarbonate compositions (Monroe and others, 2004; Bills and others, 2007). Groundwater from the same aquifer has calcium-magnesium-sulfate compositions in the western part of Grand Canyon and sodium-chloride compositions to the southeast in the Little Colorado River Canyon (figs. 6, 7) (Cooley, 1976; Hualapai Water Resources Department, 1995; Hart and others, 2004; Bills and others, 2007). North of the Colorado River, groundwater that discharges from the Redwall-Muav aquifer has different chemical compositions in different areas. Groundwater has a calcium-bicarbonate composition with low total dissolved solids in the Marble Canyon reach and to the west of the Kaibab Plateau, but a calcium-magnesium-sulfate composition with high total dissolved solids on the Kanab Plateau and lower Kanab Creek north of the estimated groundwater divide (figs. 4, 6, 7). Groundwater in the Redwall-Muav aquifer south of the groundwater divide still has a calcium-bicarbonate composition. Higher concentrations of magnesium and sulfate in the Redwall-Muav aquifer on the Kanab Plateau could be evidence of recharge through rocks that contain gypsum or sulfide. The increased sulfate concentrations of springs in the Kanab Creek area in proximity to mined sites and unmined ore deposits could also be evidence (subject to further analysis) of this relation (plate 1, fig. 7). Groundwater discharging from the Redwall-Muav aquifer in the central part of Grand Canyon has low major-ion concentrations that suggest greater contributions from local recharge and shorter contact time with the aquifer rock (Monroe and others, 2004). Similar increases in the proportions of calcium and magnesium also are found among sites near the South Rim of Grand Canyon, suggesting recharge from more distant sources and longer contact time with the rock (Monroe and others, 2004; Bills and others, 2007). The low total-dissolved-solid calcium-bicarbonate water of the Redwall-Muav aquifer north of the Colorado River is typical of groundwater that has had little contact time with the rock as it flowed through large fracture and solution-channel systems that probably originate on the Kaibab Plateau (Huntoon, 2000a,b; Ross, 2005). The higher total-dissolved-solid content of groundwater from the Redwall-Muav aquifer on the Kanab Plateau indicates that groundwater likely has a much longer residence time in this area (figs. 4, 6, 7). The larger concentrations of dissolved magnesium and sulfate in groundwater in this area are consistent with the accumulation of salts derived from water that contains dissolved sulfate from gypsum or sulfide-rich orebodies, that percolated downward from the perched water-bearing zones in sandstones in the Supai Group, the Coconino Sandstone, or the Chinle Formation.

Water discharging from the perched water-bearing zones and the Redwall-Muav aquifer in northern Arizona are generally of good quality for most intended uses. However, a number of sites were found to have constituent concentrations in excess of selected criteria for drinking water, fish, wildlife, and irrigation uses (table 4). In many cases, the elevated concentrations of these elements are from natural sources (Hualapai Water Resources Department, 1995; Monroe and others, 2005; Bills and others, 2007).

At some sites, high trace-element concentrations and radionuclide activity are known to be associated with legacy mines or uranium-ore deposits in breccia pipes that are near the sample site (Wenrich and others, 1994; Hualapai Water Resources Department, 1995; Billingsley, 1997; Monroe and others, 2005; Bills and others, 2007). High concentrations of trace elements at other locations result from dissolution of certain minerals in secondary ore deposits (table 4; arsenic, iron, lead, uranium, zinc). Some high concentrations of other elements probably are related to other recent human-caused and land-management practices (Hualapai Tribe, 1995; Monroe and others, 2005; Bills and others, 2007). Boron concentrations are high in several areas, and although those concentrations may have natural origins, they could also be related to wildfire suppression, mining, or detergents. Water from the springs on the lower Little Colorado River (for example, Blue Spring, fig. 2) generally had higher concentrations of most trace elements than did other springs and streams south of the Colorado River. The differences in water chemistry of these springs and the geologic setting of their points of discharge suggests that either the water that discharges from these systems has resided longer in the flow system, resulting in greater dissolution of minerals, or that the water has traveled along flow paths originating in different source areas (Hart and others, 2002; Bills and others, 2007). Mohawk Canyon Spring, National Canyon Spring, and Bar Four Well also had higher concentrations of many trace elements

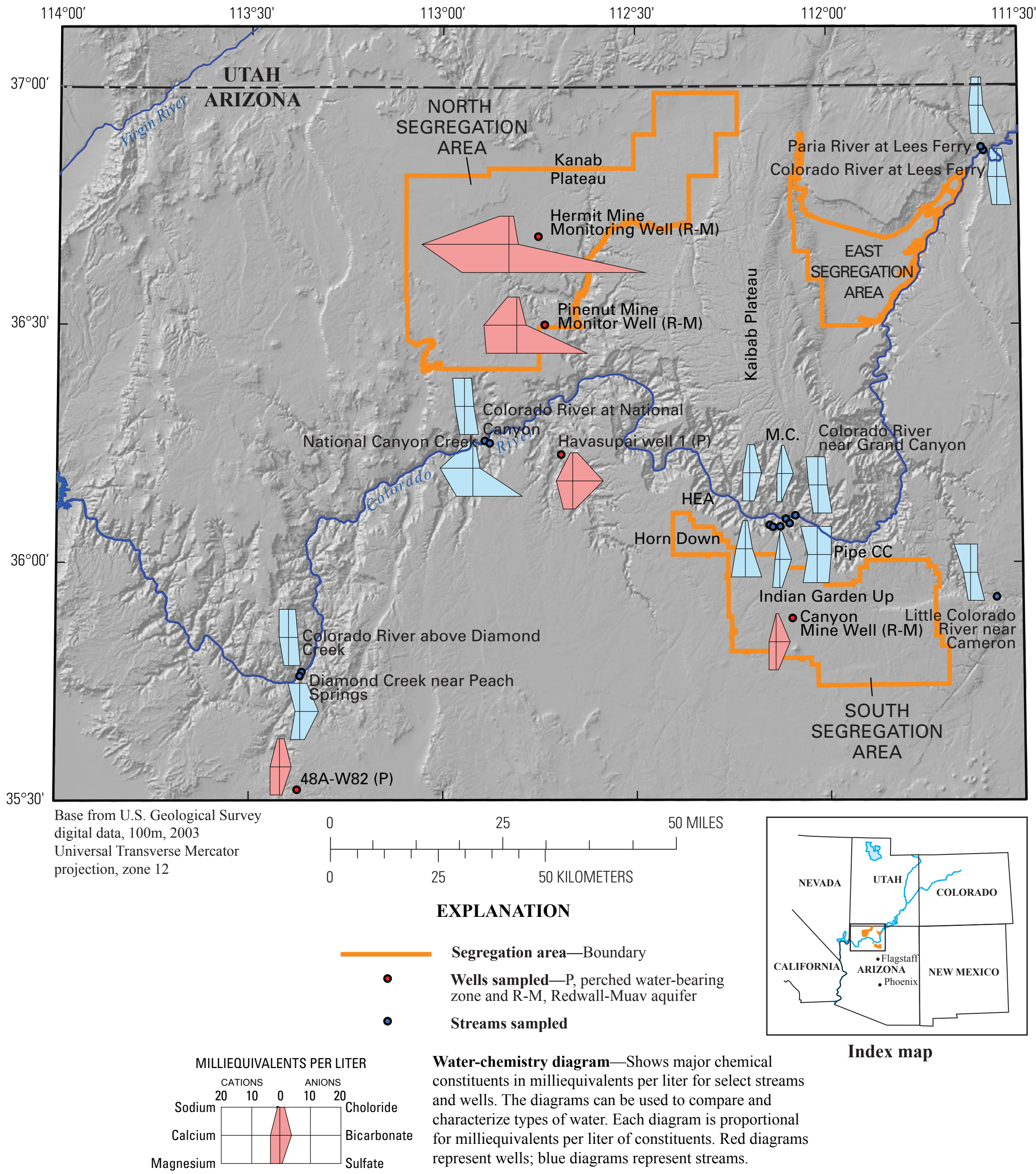

Figure 6. Water chemistry data for selected wells and streams in northern Arizona.

compared with other wells on the Coconino Plateau or springs in Havasu Canyon (figs. 2, 4, 6, 7) (Monroe and others, 2004; Bills and others, 2007). This difference implies that groundwater at Mohawk Canyon Spring, National Canyon Spring, and Bar Four Well have recharge areas and flow paths that differ from those of other groundwater that discharges in areas along the western part of Grand Canyon (fig. 4).

Arsenic and lead are common accessory metals in uranium ore deposits. At 70 sites the average concentrations of arsenic exceeded the primary maximum contaminant level (PMCL) of 10 µg/L, and at 40 sites arsenic concentrations exceeded 100 µg/L (appendix 3; tables 4, 5). Lead concentrations exceeded the PMCL of 15 µg/L at three sites, Havasu Spring, Fern Spring, and Canyon Mine Well (fig. 8) (tables 4, 5) (Bills and others, 2007). High lead concentrations in Kanab Creek and Virgin River water samples that were collected before 1990—under a less-strict sampling protocol—may reflect contamination (tables 4, 5). Recent samples collected from sites on Kanab Creek and from the Canyon Mine Well all have lead concentrations less than 0.3 µg/L (appendix 2).

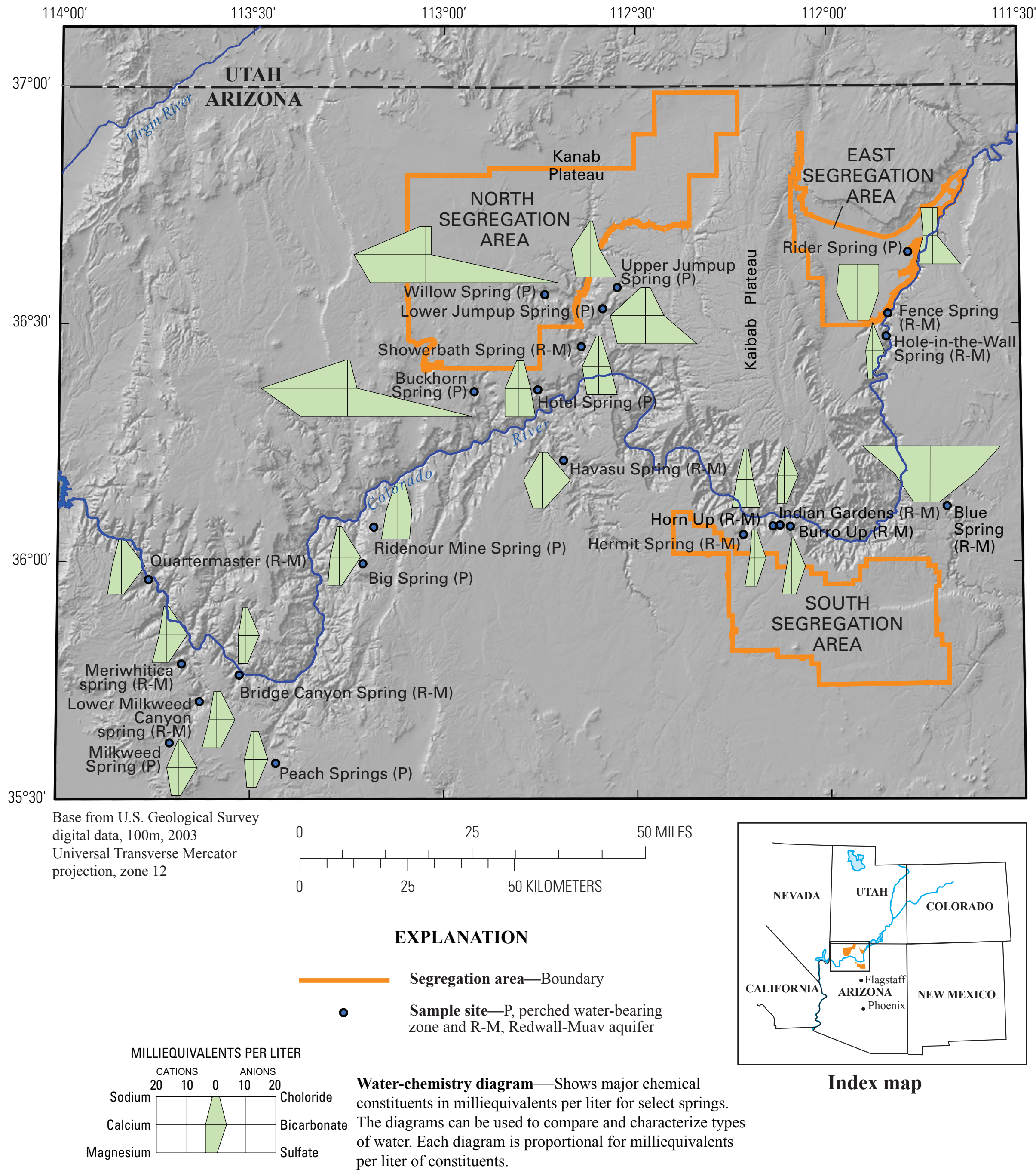

Figure 7. Water chemistry data for selected springs in northern Arizona.

Radioactive constituents were near or above PMCL at a few sites (appendixes 2, 4; tables 4, 6–9). Uranium concentrations in samples from Salt Creek Spring (average, 30.6 µg/L) exceeded U.S. Environmental Protection Agency (USEPA) PMCL of 30 µg/L (fig. 9). One sample from Horn Creek had a concentration only slightly lower than the PMCL (29.2 µg/L). Previous studies have found high gross-alpha-particle activity in samples from Salt Creek Spring and Horn Creek (Monroe and others, 2005; Bills and others, 2007). Salt Creek and Horn Creek are downgradient from the abandoned Orphan Lode Mine site, a breccia pipe that has been mined for copper and uranium (plate 1). The high gross-alpha-particle activity and uranium concentrations at these sites are likely related to the pipe or to mining activity (Fitzgerald, 1996; Monroe and others, 2005; Bills and others, 2007). Samples from Turquoise Creek, Forster Canyon Spring No. 2, Mohawk Canyon Spring, and the Bar Four Well near the village of Supai all had unadjusted gross-alpha-particle activities greater than 14 pCi/L (Monroe and others, 2005; Bills and others, 2007). The unadjusted gross-alpha-particle data from a water sample recently collected from Willow Spring in Hack Canyon is also high (appendix 2). These sites are near or downstream from breccia pipes that are known to concentrate uranium ores on this part of the Coconino and Kanab Plateaus (Wenrich and others 1994; Billingsley and others, 1997; Wenrich and others, 1997).

Table 4. Concentrations of elements from the historical dataset and from spring-water and well-water samples collected in 2009 in northern Arizona that exceed U.S. Environmental Protection Agency primary maximum contaminant levels and secondary maximum contaminant levels for selected constituents.

[See appendixes 1–4 for measured concentration data; PMCL, primary maximum contaminant level (enforceable); SMCL, secondary maximum contaminant level (not enforceable); µg/L, microgram per liter; mg/L, milligram per liter; mrem/yr, millirem per year; pCi/L, picocurie per liter; source of PMCL and SMCL data: *http://www.epa.gov/safewater/contaminants/index.html*, accessed October 2009]

Trace element	Drinking water standard (PMCL unless otherwise stated)	Potential health effect from ingestion of water	Sites that exceed 75 percent of the PMCL or SMCL
Arsenic	10 µg/L	Skin damage; problems with circulatory systems; increased risk of cancer	70 sites greater than 10 µg/L. 40 sites greater than 100 µg/L.
Copper	1,300 µg/L (1,000 µg/L, SMCL)	Short term exposure: gastrointestinal distress Long term exposure: liver or kidney damage	
Adjusted gross alpha radioactivity (72-hour gross alpha radioactivity minus uranium activity)	15 pCi/L	Increased risk of cancer	2 sites with high gross alpha unadjusted.
Gross beta radioactivity	4 mrem/yr (screening level is 50 pCi/L gross beta radioactivity minus potassium-40)	Increased risk of cancer	
Iron	300 µg/L, SMCL	Conjunctivitis, choroiditis, and retinitis if it contacts and remains in the tissues	Pinenut Well (4,650 µg/L). Burnt Canyon Well (680 µg/L).
Lead	15 µg/L	Infants and children: delays in physical and mental development; children could show learning disabilities and slight deficits in attention span	Virgin River (350 to 550 µg/L). Havasu Spring (29 µg/L). Fern Spring (20 µg/L). Canyon Mine Well (20 µg/L). Kanab Creek (15 to 20 µg/L). Havasupai Well 1(12 µg/L).
Manganese	50 µg/L	Hallucinations, forgetfulness, impotence, and nerve damage	Clear Water Spring (980 µg/L). Pinenut Well (334 µg/L). Canyon Mine Well (66 µg/L).
Nitrate (measured as nitrogen)	10 mg/L	Infants below the age of six months who drink water in excess of MCL could become seriously ill and if untreated may die; symptoms include shortness of breath and blue-baby syndrome	Monument Spring (6.8 mg/L). Tom Land Well (6.86 mg/L). Monument Creek No. 1 (4.5 mg/L). Willow Spring (4.36 mg/L).

Table 4. Concentrations of elements from the historical dataset and from spring-water and well-water samples collected in 2009 in northern Arizona that exceed U.S. Environmental Protection Agency primary maximum contaminant levels and secondary maximum contaminant levels for selected constituents.—Continued

[See appendixes 1–4 for measured concentration data; PMCL, primary maximum contaminant level (enforceable); SMCL, secondary maximum contaminant level (not enforceable); µg/L, microgram per liter; mg/L, milligram per liter; mrem/yr, millirem per year; pCi/L, picocurie per liter; source of PMCL and SMCL data: *http://www.epa.gov/safewater/contaminants/index.html*, accessed October 2009]

Trace element	Drinking water standard (PMCL unless otherwise stated)	Potential health effect from ingestion of water	Sites that exceed 75 percent of the PMCL or SMCL
Radium	5 pCi/L	Increased risk of cancer	Pinenut Well, 17.5 pCi/L.
Selenium	50 µg/L	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Willow Spring (52 µg/L). Schmutz Spring (44 µg/L). Tom Land Well (45 µg/L).
Sulfate	250 mg/L	Diarrhea	15 sites greater than 250 µg/L. 6 sites greater than 500 µg/L.
Total dissolved solids	500 mg/L (SMCL)	Hardness, salty taste	70 sites greater than SMCL .
Uranium	30 µg/L	Increased risk of cancer; kidney toxicity	14 sites greater than 15 µg/L. The following sites greater than 30 µg/L: Canyon Mine Well (309 µg/L). GCAE517R (250 µg/L). well 23032 (110 µg/L). 15140 (90 µg/L). well GCBD501R (86 µg/L). GCAA503R (72 µg/L). 23168 (57 µg/L). 23169 (51 µg/L). GCAG510R (47 µg/L). 15139 (46 µg/L). GCAA503R (32 µg/L). Rays Place, left fork (32 µg/L). well GCAD511R (32 µg/L). well GCAD505R (31 µg/L). Salt Creek Spring (31 µg/L). Cedar Spring (31 µg/L). Horn Creek (30 µg/L). GCBB006R (87 µg/L). GCBB004R (89 µg/L).

Table 5. Water samples from springs, streams, wells, and mine sumps in the historical dataset of sites in northern Arizona containing mercury, molybdenum, or lead with at least one measurement above U.S. Environmental Protection Agency maxiumum contaminant level or health advisory level.

[--, data not available; µg/L, microgram per liter; NAD 83, North American Datum of 1983; P, perched water-bearing zone; R-M, Redwall-Muav aquifer. Maximum contaminant level for mercury = 2 µg/L; maximum contaminant level for lead = 15 µg/L; health advisory level for molybdenum = 40 µg/L]

Sample or site identifier	Site description	Source of groundwater	Longitude (NAD 83)	Latitude (NAD 83)	Reported sample date	Reported uranium concentration (µg/L)	Sample type	Source of data
Mercury								
9380000	Colorado River at Lees Ferry, Ariz.	--	–111.588	36.865	5/5/1981	3.8	Stream	USGS, 2009b
353713113421800	Milkweed Spring; B–26–13 20CCB	P; volcanic rocks	–113.706	35.620	5/27/1993	3.8	Spring	USGS, 2009b
360455112111002	Monument Spring	R-M	–112.176	36.064	12/5/2000	2.1	Spring	Monroe and others, 2005
75A–W82	Warm Springs	R-M	–113.082	36.197	1982	2.4	Spring	Wenrich and others, 1994
76A–W82	Lava Falls (by cliff)	R-M	–113.081	36.196	1982	2.4	Spring	Wenrich and others, 1994
Molybdenum								
15139[a]		--	–114.049	36.584	9/23/1977	48.8	Spring	USGS, 2009a
15140[a]		--	–114.058	36.581	9/23/1977	55.0	Spring	USGS, 2009a
15141[a]		--	–114.051	36.525	9/23/1977	45.7	Spring	USGS, 2009a
23004		--	–113.994	35.879	8/24/1977	40.5	Spring	USGS, 2009a
23010		P, gravels	–113.706	35.618	8/30/1977	40.1	Spring	USGS, 2009a
23012		--	–113.801	35.624	8/31/1977	45.3	Spring	USGS, 2009a
23013		--	–113.791	35.645	8/31/1977	43.2	Well	USGS, 2009a
23014		--	–113.767	35.608	9/1/1977	75.0	Well	USGS, 2009a
23016		--	–113.629	35.507	9/1/1977	79.0	Well	USGS, 2009a
23024		P	–113.114	35.783	9/4/1977	61.0	Well	USGS, 2009a
23026		--	–113.900	35.821	9/13/1977	44.0	Well	USGS, 2009a
23032		--	–113.985	35.774	9/15/1977	75.3	Well	USGS, 2009a
23077		P; Coconino Sandstone	–112.524	35.950	10/17/1977	100.6	Spring	USGS, 2009a
23080		P; volcanic rocks	–112.875	35.742	10/19/1977	129.4	Well	USGS, 2009a
23081		P; volcanic rocks	–112.687	35.641	10/19/1977	43.8	Spring	USGS, 2009a
23088		P; Coconino Sandstone	–112.396	35.958	10/27/1977	79.9	Well	USGS, 2009a
23090		P; volcanic rocks	–112.597	35.557	10/28/1977	47.0	Well	USGS, 2009a
23169[a]		--	–113.702	35.492	1/8/1978	46.4	Spring	USGS, 2009a
43536		--	–113.309	35.885	7/18/1978	50.4	Stream	USGS, 2009a
Canyon Mine Well		R-M	–112.095	35.886	12/1/1987	60.0	Well	Errol Montgomery and Assoc., 1993a
GCAD505R	TRSS Carbonate	P; Chinle Formation	–113.177	36.865	5/8/1979	97.0	Well	USGS, 2009a
GCAD509R	TRSS Carbonate	P; Chinle Formation	–113.225	36.866	5/8/1979	54.0	Well	USGS, 2009a
GCAE501R	TRSS Volcanic	P; volcanic rocks	–112.958	36.845	5/12/1979	49.0	Well	USGS, 2009a
GCAE517R	TRSS	P; Chinle Formation	–112.781	36.881	5/17/1979	191.0	Spring	USGS, 2009a

Table 5. Water samples from springs, streams, wells, and mine sumps in the historical dataset of sites in northern Arizona containing mercury, molybdenum, or lead with at least one measurement above U.S. Environmental Protection Agency maxiumum contaminant level or health advisory level.—Continued

[--, data not available; µg/L, microgram per liter; NAD 83, North American Datum of 1983; P, perched water-bearing zone; R-M, Redwall-Muav aquifer. Maximum contaminant level for mercury = 2 µg/L; maximum contaminant level for lead = 15 µg/L; health advisory level for molybdenum = 40 µg/L]

Sample or site identifier	Site description	Source of groundwater	Longitude (NAD 83)	Latitude (NAD 83)	Reported sample date	Reported uranium concentration (µg/L)	Sample type	Source of data
				Lead				
9413600	Virgin River above Hwy. I15 Rest area near Littlefield, Ariz.	--	–113.780	36.954	5/21/1979	400.0	Stream	USGS, 2009b
9413600	Virgin River above Hwy. I15 Rest area near Littlefield, Ariz.	--	–113.780	36.954	6/25/1979	500.0	Stream	USGS, 2009b
9413650	Virgin River below Hwy. I15 Rest area near Littlefield, Ariz.	--	–113.797	36.949	5/22/1979	200.0	Stream	USGS, 2009b
9413650	Virgin River below Hwy. I15 Rest area near Littlefield, Ariz.	--	–113.797	36.949	6/26/1979	500.0	Stream	USGS, 2009b
9413800	Virgin River at mouth of Narrows near Littlefield, Ariz.	--	–113.861	36.921	5/23/1979	500.0	Stream	USGS, 2009b
9413800	Virgin River at mouth of Narrows near Littlefield, Ariz.	--	–113.861	36.921	6/27/1979	600.0	Stream	USGS, 2009b
361303112411200	Havasu Spring; B-33-04 26 unsurveyed	R-M	–112.687	36.217	Aug 23, 1994	20.0	Spring	USGS, 2009b
361524112420400	Fern Spring; B-33-04 11 unsurveyed	R-M	–112.702	36.257	Aug 24, 1994	20.0	Spring	USGS, 2009b
365149112442201	Pipe Spring; B-40-04 17DDB	--	–112.740	36.864	Dec 10, 1996	20.0	Spring	USGS, 2009b
365435112455501	B-41-04 31DBB	--	–112.766	36.910	Mar 20, 1997	20.0	Well	USGS, 2009b
16A–W82	Unnamed well; Tertiary Frazier Well gravels	P; gravels	–113.050	35.810	1982	17.0	Well	Wenrich and others, 1994
37A–W82	Big Spring	P; Coconino Sandstone	–113.207	36.000	1982	32.0	Spring	Wenrich and others, 1994
Canyon Mine Well	Local ID (A–29–03) 202BCD	R-M	–112.095	35.886	5/1/1992	20.0	Well	Errol Montgomery and Assoc., 1993a
Canyon Mine Well	Local ID (A–29–03) 202BCD	R-M	–112.095	35.886	9/10/1987	20.0	Well	Errol Montgomery and Assoc., 1993a
Canyon Mine Well	Local ID (A–29–03) 202BCD	R-M	–112.095	35.886	1/15/1992	30.0	Well	Errol Montgomery and Assoc., 1993a
Canyon Mine Well	Local ID (A–29–03) 202BCD	R-M	–112.095	35.886	5/14/1993	40.0	Well	Errol Montgomery and Assoc., 1993a
Havasu Spring		R-M	–112.686	36.217	5/29/1990	29.0	Spring	Errol Montgomery and Assoc., 1993b
Hermit Mine Monitoring Well		R-M	–112.751	36.689	6/29/1988	150.0	Well	Energy Fuels Nuclear, Inc., 1990b
Hermit Mine Monitoring Well		R-M	–112.751	36.689	12/10/1992	30.0	Well	Energy Fuels Nuclear, Inc., 1990b
Hermit Mine Sump[b]		Breccia	–112.751	36.689	9/21/1989	30.0	Sump	Canonie Environmental Services Corp., 1991

Table 5. Water samples from springs, streams, wells, and mine sumps in the historical dataset of sites in northern Arizona containing mercury, molybdenum, or lead with at least one measurement above U.S. Environmental Protection Agency maxiumum contaminant level or health advisory level.—Continued

[--, data not available; µg/L, microgram per liter; NAD 83, North American Datum of 1983; P, perched water-bearing zone; R-M, Redwall-Muav aquifer. Maximum contaminant level for mercury = 2 µg/L; maximum contaminant level for lead = 15 µg/L; health advisory level for molybdenum = 40 µg/L]

Sample or site identifier	Site description	Source of groundwater	Longitude (NAD 83)	Latitude (NAD 83)	Reported sample date	Reported uranium concentration (µg/L)	Sample type	Source of data
			Lead—Continued					
Hermit Mine Sump[b]		Breccia	–112.751	36.689	12/8/1989	30.0	Sump	Canonie Environmental Services Corp., 1991
Hermit Mine Sump[b]		Breccia	–112.751	36.689	2/6/1990	40.0	Sump	Canonie Environmental Services Corp., 1991
KAN002W		--	–112.510	36.717	March 1982	20.0	Stream	Hopkins and others, 1984b
KAN005W		--	–112.572	36.684	March 1982	15.0	Stream	Hopkins and others, 1984b
KAN006W		--	–112.529	36.709	March 1982	15.0	Stream	Hopkins and others, 1984b
Pinenut Mine Monitor Well	(B-36-04) 21CB; 55-513394	R-M	–112.735	36.504	12/21/1989	20.0	Well	Energy Fuels Nuclear, 1995a
Pinenut Mine Monitor Well	(B-36-04) 21CB; 55-513394	R-M	–112.735	36.504	6/30/1993	20.0	Well	Energy Fuels Nuclear, 1995a
Pinenut Mine Monitor Well	(B-36-04) 21CB; 55-513394	R-M	–112.735	36.504	6/29/1988	30.0	Well	Energy Fuels Nuclear, 1995a
Pinenut Mine Monitor Well	(B-36-04) 21CB; 55-513394	R-M	–112.735	36.504	9/26/1991	80.0	Well	Energy Fuels Nuclear, 1995a
Pinenut Mine Monitor Well	(B-36-04) 21CB; 55-513394	R-M	–112.735	36.504	6/29/1988	110.0	Well	Energy Fuels Nuclear, 1995a
Pinenut Mine Monitor Well	(B-36-04) 21CB; 55-513394	R-M	–112.735	36.504	March 1986	25.0	Well	Energy Fuels Nuclear, 1995a

[a]Site not plotted on figure 8.

[b]Latitude and longitude not reported, given location of Hermit Mine Monitoring Well.

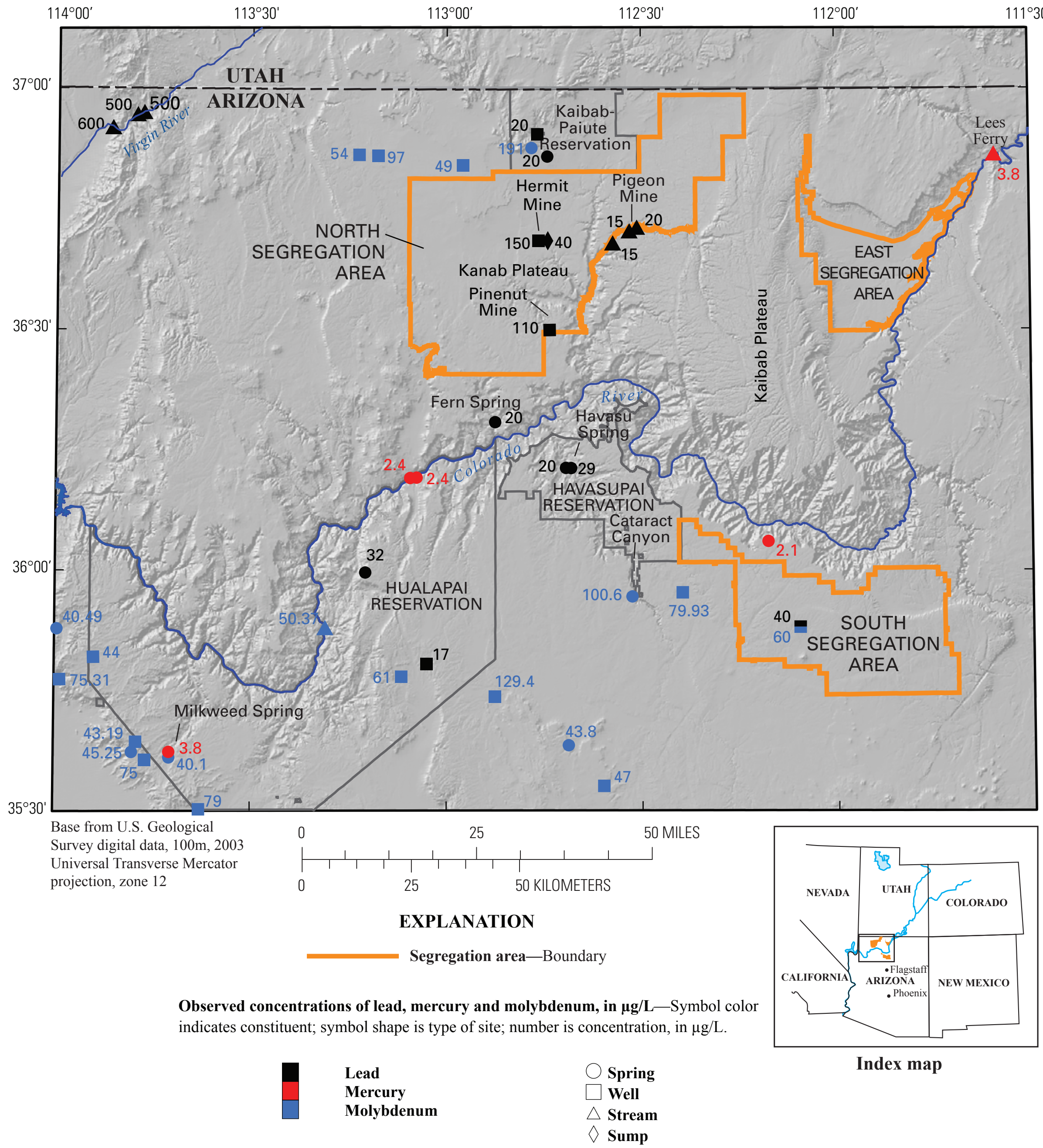

Figure 8. Selected spring, stream, well, and sump sites from the historical dataset for northern Arizona, table 5, at which concentrations of lead and mercury exceed U.S. Environmental Protection Agency maximum contaminant level of 15 and 2 micrograms per liter, respectively, and molybdenum exceeds U.S. Environmental Protection Agency health advisory level of 40 micrograms per liter.

Table 6. Summary information about stream-water samples analyzed for dissolved uranium from the historical dataset compiled for northern Arizona.

[µg/L, microgram per liter; na, not available; rm, river mile; CC, crystalline core below Tonto platform; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USGS, U.S. Geological Survey]

Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Number of samples	First sample date	Last sample date	Dissolved uranium average concentration (µg/L)	Standard deviation of average concentration (µg/L)	Minimum reported concentration (µg/L)	Date of minimum concentration sample	Maximum reported concentration (µg/L)	Date of maximum concentration sample	Source of data
43536		–113.309	35.885	1	7/18/1978	7/18/1978	2.1	na	2.1	7/18/1978	2.1	7/18/1978	USGS, 2009a
43538		–113.426	35.746	1	7/18/1978	7/18/1978	2.2	na	2.2	7/18/1978	2.2	7/18/1978	USGS, 2009a
43540		–113.524	35.772	1	7/18/1978	7/18/1978	5.4	na	5.4	7/18/1978	5.4	7/18/1978	USGS, 2009a
9380000	Colorado River at Lees Ferry	–111.588	36.865	19	1/30/1996	8/11/1998	3.2	0.4	2.9	6/30/1998	4.0	4/1/1996	USGS, 2009b
9382000	Paria River at Lees Ferry	–111.595	36.872	3	6/27/2005	11/29/2005	3.7	0.5	3.3	8/24/2005	4.2	11/29/2005	USGS, 2009b
9403000	Bright Angel Creek near Grand Canyon	–112.096	36.103	1	9/2/1981	9/2/1981	1.0	na	1.0	9/2/1981	1.0	9/2/1981	USGS, 2009b
9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	78	11/21/1996	8/15/2007	3.6	0.5	2.7	10/31/2002	4.9	3/25/2004	USGS, 2009b
9404208	Diamond Creek near Peach Springs	–113.368	35.765	1	5/26/1993	5/26/1993	10.0	na	10.0	5/26/1993	10.0	5/26/1993	USGS, 2009b
354555113222100	Diamond Creek above mouth at rm 225.7	–113.373	35.765	4	11/5/1990	11/6/1990	7.6	0.6	7.0	11/6/1990	8.3	11/6/1990	USGS, 2009b
360128111591501	Cottonwood Creek No. 1; lower Bright Angel (alluvium)	–111.987	36.023	2	5/25/2000	4/9/2001	1.5	0.1	1.5	5/25/2000	1.6	4/9/2001	Monroe and others, 2005
360415112060601	Pipe Creek; lower Bright Angel (alluvium)	–112.099	36.068	3	5/22/2000	4/8/2001	2.5	0.2	2.3	4/8/2001	2.7	5/22/2000	Monroe and others, 2005
360441112073202	Pumphouse Wash gage; middle Bright Angel (alluvium)	–112.126	36.076	1	12/7/2000	12/7/2000	1.8	na	1.8	12/7/2000	1.8	12/7/2000	Monroe and others, 2005
360450112083601	Horn Creek; middle Bright Angel (alluvium)	–112.143	36.079	3	5/22/2000	4/7/2001	15.7	11.7	8.6	5/22/2000	29.2	4/7/2001	Monroe and others, 2005
360455112111001	Monument Creek No. 1; Tapeats (alluvium)	–112.185	36.080	1	5/24/2000	5/24/2000	7.1	na	7.1	5/24/2000	7.1	5/24/2000	Monroe and others, 2005
361518112523900	National Canyon above mouth at rm 166.5 in Hualapai	–112.878	36.255	1	10/8/1993	10/8/1993	4.0	na	4.0	10/8/1993	4.0	10/8/1993	USGS, 2009b
361947112550200	Cottonwood Creek, north rim Grand Canyon	–112.917	36.330	2	5/26/2005	11/30/2005	4.9	0.1	4.8	5/26/2005	5.0	11/30/2005	USGS, 2009b
4A-W82	Diamond Creek (at mouth); Diamond Creek gravels	–113.371	35.766	1	6/1/1982	6/1/1982	6.9	na	6.9	6/1/1982	6.9	6/1/1982	Wenrich and others, 1994
17A-W82	Travertine Falls; Vishnu Schist	–113.426	35.751	1	6/1/1982	6/1/1982	2.9	na	2.9	6/1/1982	2.9	6/1/1982	Wenrich and others, 1994
19A-W82	Lost Travertine Falls Spring; Tapeats Sandstone	–113.498	35.756	1	6/1/1982	6/1/1982	6.3	na	6.3	6/1/1982	6.3	6/1/1982	Wenrich and others, 1994
20A-W82	¼ mile below Bridge Canyon Spring; Vishnu Schist	–113.527	35.769	1	6/1/1982	6/1/1982	4.6	na	4.6	6/1/1982	4.6	6/1/1982	Wenrich and others, 1994
23A-W82	Mouth of Spencer Canyon; Spencer Canyon gravels	–113.568	35.823	1	6/1/1982	6/1/1982	2.0	na	2.0	6/1/1982	2.0	6/1/1982	Wenrich and others, 1994
27A-W82	Base of Columbine Falls—½ mi from spring; Muav Limestone	–113.921	36.092	1	6/1/1982	6/1/1982	1.5	na	1.5	6/1/1982	1.5	6/1/1982	Wenrich and others, 1994

Table 6. Summary information about stream-water samples analyzed for dissolved uranium from the historical dataset compiled for northern Arizona.—Continued

[µg/L, microgram per liter; na, not available; rm, river mile; CC, crystalline core below Tonto platform; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USGS, U.S. Geological Survey]

Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Number of samples	First sample date	Last sample date	Dissolved uranium average concentration (µg/L)	Standard deviation of average concentration (µg/L)	Minimum reported concentration (µg/L)	Date of minimum concentration sample	Maximum reported concentration (µg/L)	Date of maximum concentration sample	Source of data
79A-W82	Hindu Canyon; Muav Limestone	–113.580	35.703	1	6/1/1982	6/1/1982	1.8	na	1.8	6/1/1982	1.8	6/1/1982	Wenrich and others, 1994
Boulder Creek	Tapeats Sandstone	–112.010	36.027	1	6/3/1995	6/3/1995	8.1	na	8.1	6/3/1995	8.1	6/3/1995	Fitzgerald, 1996
Bright Angel Creek near mouth		–112.087	36.101	8	6/18/1991	6/20/1991	0.5	0.0	0.5	6/18/1991	0.6	6/18/1991	Taylor and others, 1996
Burro Down		–112.100	36.077	3	6/4/2002	7/15/2002	4.2	0.3	3.8	7/15/2002	4.4	6/4/2002	Liebe, 2003
Colorado River above Diamond Creek		–113.370	35.770	16	11/5/1990	6/20/1991	5.0	0.5	4.3	11/5/1990	5.8	6/20/1991	Taylor and others, 1996
Colorado River above Havasu Creek		–112.760	36.317	7	11/5/1990	11/6/1990	4.5	0.1	4.4	11/6/1990	4.6	11/6/1990	Taylor and others, 1996
Colorado River above Kanab Creek		–112.615	36.392	16	11/5/1990	6/20/1991	5.0	0.5	4.4	11/6/1990	5.6	6/19/1991	Taylor and others, 1996
Colorado River above Little Colorado River		–111.800	36.202	16	11/5/1990	6/20/1991	4.8	0.5	4.2	11/5/1990	5.5	6/19/1991	Taylor and others, 1996
Colorado River at Grand Canyon		–112.082	36.101	14	11/5/1990	6/20/1991	5.1	0.5	4.3	11/6/1990	5.8	11/6/1990	Taylor and others, 1996
Colorado River at Lees Ferry		–111.588	36.865	16	11/5/1990	6/20/1991	4.9	0.4	4.3	11/5/1990	5.5	6/19/1991	Taylor and others, 1996
Colorado River at National Canyon		–112.888	36.261	14	11/5/1990	6/20/1991	5.0	0.5	4.3	11/6/1990	5.8	6/20/1991	Taylor and others, 1996
Colorado River at Page		–111.588	36.865	100	5/6/1963	5/12/1972	6.5	2.2	2.6	12/27/1971	16.0	5/12/1972	USEPA, 1973
Colorado River below Glen Canyon Dam		–111.506	36.902	16	11/5/1990	6/20/1991	4.9	0.4	4.2	11/5/1990	5.4	6/19/1991	Taylor and others, 1996
Colorado River near Columbine Falls		–113.894	36.082	8	11/5/1990	11/6/1990	4.6	0.1	4.4	11/6/1990	4.7	11/6/1990	Taylor and others, 1996
Colorado River near Travertine Cleft		–113.804	36.040	8	6/18/1991	6/20/1991	5.4	0.3	4.8	6/19/1991	5.6	6/19/1991	Taylor and others, 1996
Diamond Creek near mouth		–113.371	35.769	12	11/5/1990	6/20/1991	7.1	0.8	5.9	11/5/1990	7.8	6/19/1991	Taylor and others, 1996
GCAA006R	Metamorphic	–113.901	36.765	1	5/6/1979	5/6/1979	87.0	na	87.0	5/6/1979	87.0	5/6/1979	USGS, 2009a
GCAA026R	Unconsolidated	–113.909	36.815	1	5/9/1979	5/9/1979	26.2	na	26.2	5/9/1979	26.2	5/9/1979	USGS, 2009a
GCBA014R	Sandstone	–113.767	36.735	1	5/7/1979	5/7/1979	11.3	na	11.3	5/7/1979	11.3	5/7/1979	USGS, 2009a
GCBB004R	Carbonate	–113.738	36.729	1	5/12/1979	5/12/1979	89.0	na	89.0	5/12/1979	89.0	5/12/1979	USGS, 2009a
GCBB014R	Carbonate	–113.664	36.511	1	5/12/1979	5/12/1979	44.2	na	44.2	5/12/1979	44.2	5/12/1979	USGS, 2009a
GCBH032R	Carbonate	–112.136	36.510	1	5/19/1979	5/19/1979	0.1	na	0.1	5/19/1979	0.1	5/19/1979	USGS, 2009a
Havasu Creek near mouth		–112.760	36.314	16	11/5/1990	6/20/1991	3.8	0.1	3.6	11/6/1990	4.0	11/5/1990	Taylor and others, 1996
Horn Down	Contact, Redwall and Muav Limestones	–112.145	36.078	4	6/4/2002	7/29/2002	320.5	29.9	295.0	6/4/2002	362.0	7/29/2002	Liebe, 2003
Indian Garden CC		–112.111	36.093	2	7/15/2002	7/29/2002	1.5	0.1	1.4	7/29/2002	1.6	7/15/2002	Liebe, 2003

Table 6. Summary information about stream-water samples analyzed for dissolved uranium from the historical dataset compiled for northern Arizona.—Continued

[µg/L, microgram per liter; na, not available; rm, river mile; CC, crystalline core below Tonto platform; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USGS, U.S. Geological Survey]

Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Number of samples	First sample date	Last sample date	Dissolved uranium average concentration (µg/L)	Standard deviation of average concentration (µg/L)	Minimum reported concentration (µg/L)	Date of minimum concentration sample	Maximum reported concentration (µg/L)	Date of maximum concentration sample	Source of data
Indian Garden Down	Contact, Redwall and Muav Limestones	–112.126	36.078	4	6/4/2002	7/29/2002	3.1	1.1	2.4	7/15/2002	4.7	7/29/2002	Liebe, 2003
Indian Garden Pump Station		–112.126	36.078	1	4/30/1994	4/30/1994	0.5	na	0.5	4/30/1994	0.5	4/30/1994	Fitzgerald, 1996
Indian Garden Up	Contact, Redwall and Muav Limestones	–112.126	36.078	3	6/4/2002	7/15/2002	2.8	0.4	2.3	7/15/2002	3.1	6/4/2002	Liebe, 2003
KAN001W		–112.563	36.658	1	3/15/1982	3/15/1982	1.5	na	1.5	3/15/1982	1.5	3/15/1982	Hopkins and others, 1984b
KAN002W		–112.510	36.717	1	3/15/1982	3/15/1982	14.0	na	14.0	3/15/1982	14.0	3/15/1982	Hopkins and others, 1984b
KAN003W		–112.509	36.724	1	3/15/1982	3/15/1982	44.0	na	44.0	3/15/1982	44.0	3/15/1982	Hopkins and others, 1984b
KAN004W		–112.464	36.711	1	3/15/1982	3/15/1982	5.2	na	5.2	3/15/1982	5.2	3/15/1982	Hopkins and others, 1984b
KAN005W		–112.572	36.684	1	3/15/1982	3/15/1982	15.0	na	15.0	3/15/1982	15.0	3/15/1982	Hopkins and others, 1984b
KAN006W		–112.529	36.709	1	3/15/1982	3/15/1982	10.0	na	10.0	3/15/1982	10.0	3/15/1982	Hopkins and others, 1984b
Kanab Creek near mouth		–112.618	36.392	16	11/5/1990	6/20/1991	5.2	0.2	4.9	6/18/1991	5.5	11/6/1990	Taylor and others, 1996
Little Colorado River near mouth		–111.800	36.201	15	11/5/1990	6/19/1991	9.2	8.3	4.2	11/5/1990	25.6	11/6/1990	Taylor and others, 1996
Mixing confluence of Garden Creek & unnamed Tonto platform		–112.111	36.094	2	7/15/2002	7/29/2002	2.2	0.4	1.9	7/15/2002	2.4	7/29/2002	Liebe, 2003
Paria River near mouth		–111.593	36.861	15	11/5/1990	6/20/1991	3.5	1.1	2.3	6/18/1991	4.7	11/5/1990	Taylor and others, 1996
Pipe CC		–112.102	36.085	2	7/15/2002	7/29/2002	21.0	2.8	19.0	7/15/2002	23.0	7/29/2002	Liebe, 2003
Pipe Down	Muav Limestone	–112.102	36.072	4	6/4/2002	7/29/2002	3.2	0.4	2.7	7/15/2002	3.6	6/4/2002	Liebe, 2003
Salt Creek	Tapeats Sandstone–Bright Angel Shale	–112.170	36.087	1	3/19/1995	3/19/1995	14.7	na	14.7	3/19/1995	14.7	3/19/1995	Fitzgerald, 1996

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Sample or Site Identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Number of samples	First sample date	Last sample date	Dissolved uranium average concentration (µg/L)	Standard deviation of average concentration (µg/L)	Minimum reported concentration (µg/L)	Date of minimum concentration sample	Maximum reported concentration (µg/L)	Date of maximum concentration sample	Source of data
15139		–114.049	36.584	1	9/23/1977	9/23/1977	45.8	na	45.8	9/23/1977	45.8	9/23/1977	USGS, 2009a
15140		–114.058	36.581	1	9/23/1977	9/23/1977	89.7	na	89.7	9/23/1977	89.7	9/23/1977	USGS, 2009a
15141		–114.051	36.525	1	9/23/1977	9/23/1977	0.4	na	0.4	9/23/1977	0.4	9/23/1977	USGS, 2009a
15145		–114.025	36.551	1	9/23/1977	9/23/1977	0.4	na	0.4	9/23/1977	0.4	9/23/1977	USGS, 2009a
15204		–114.052	35.854	1	11/9/1977	11/9/1977	22.7	na	22.7	11/9/1977	22.7	11/9/1977	USGS, 2009a
15210		–114.009	35.822	1	11/16/1977	11/16/1977	36.9	na	36.9	11/16/1977	36.9	11/16/1977	USGS, 2009a
23002		–113.527	35.941	1	8/16/1977	8/16/1977	0.7	na	0.7	8/16/1977	0.7	8/16/1977	USGS, 2009a
23004		–113.994	35.879	1	8/24/1977	8/24/1977	30.8	na	30.8	8/24/1977	30.8	8/24/1977	USGS, 2009a
23005		–113.971	35.828	1	8/24/1977	8/24/1977	0.9	na	0.9	8/24/1977	0.9	8/24/1977	USGS, 2009a
23010		–113.706	35.618	1	8/30/1977	8/30/1977	1.3	na	1.3	8/30/1977	1.3	8/30/1977	USGS, 2009a
23012		–113.801	35.624	1	8/31/1977	8/31/1977	1.9	na	1.9	8/31/1977	1.9	8/31/1977	USGS, 2009a
23017		–113.403	35.518	1	9/1/1977	9/1/1977	0.9	na	0.9	9/1/1977	0.9	9/1/1977	USGS, 2009a
23019		–113.422	35.559	1	9/2/1977	9/2/1977	3.3	na	3.3	9/2/1977	3.3	9/2/1977	USGS, 2009a
23021		–113.177	35.934	1	9/3/1977	9/3/1977	2.0	na	2.0	9/3/1977	2.0	9/3/1977	USGS, 2009a
23025		–113.676	35.787	1	9/13/1977	9/13/1977	1.0	na	1.0	9/13/1977	1.0	9/13/1977	USGS, 2009a
23027		–113.579	35.714	1	9/14/1977	9/14/1977	0.4	na	0.4	9/14/1977	0.4	9/14/1977	USGS, 2009a
23028		–113.362	35.762	1	9/14/1977	9/14/1977	7.2	na	7.2	9/14/1977	7.2	9/14/1977	USGS, 2009a
23029		–113.440	35.593	1	9/14/1977	9/14/1977	1.1	na	1.1	9/14/1977	1.1	9/14/1977	USGS, 2009a
23030		–113.939	35.969	1	9/15/1977	9/15/1977	1.3	na	1.3	9/15/1977	1.3	9/15/1977	USGS, 2009a
23077		–112.524	35.950	1	10/17/1977	10/17/1977	3.1	na	3.1	10/17/1977	3.1	10/17/1977	USGS, 2009a
23078		–112.585	35.564	1	10/18/1977	10/18/1977	1.5	na	1.5	10/18/1977	1.5	10/18/1977	USGS, 2009a
23081		–112.687	35.641	1	10/19/1977	10/19/1977	1.8	na	1.8	10/19/1977	1.8	10/19/1977	USGS, 2009a
23168		–113.691	35.501	1	1/8/1978	1/8/1978	56.8	na	56.8	1/8/1978	56.8	1/8/1978	USGS, 2009a
23169		–113.702	35.492	1	1/8/1978	1/8/1978	51.0	na	51.0	1/8/1978	51.0	1/8/1978	USGS, 2009a
23172		–113.162	35.822	1	1/8/1978	1/8/1978	1.9	na	1.9	1/8/1978	1.9	1/8/1978	USGS, 2009a
353445113255000	Peach Springs	–113.431	35.579	2	5/27/1993	11/19/1993	2.0	0	2.0	11/19/1993	2.0	11/19/1993	USGS, 2009b
353713113421800	Milkweed Spring	–113.706	35.620	2	5/27/1993	12/10/1993	2.0	0	2.0	12/10/1993	2.0	12/10/1993	USGS, 2009b
354228113374300	Lower Milkweed Canyon	–113.629	35.708	1	5/16/1993	5/16/1993	4.0	na	4.0	5/16/1993	4.0	5/16/1993	USGS, 2009b
354248113153800	Diamond Spring	–113.261	35.713	1	5/19/1993	5/19/1993	1.0	na	1.0	5/19/1993	1.0	5/19/1993	USGS, 2009b
354250113343800	Hindu Spring	–113.578	35.714	1	5/16/1993	5/16/1993	1.0	na	1.0	5/16/1993	1.0	5/16/1993	USGS, 2009b
354311113135200	Diamond Creek	–113.232	35.720	1	5/19/1993	5/19/1993	4.0	na	4.0	5/19/1993	4.0	5/19/1993	USGS, 2009b
354346113520200	Clay (Middle) Spring	–113.868	35.729	2	6/10/1993	11/18/1993	2.0	0	2.0	11/18/1993	2.0	11/18/1993	USGS, 2009b
354406113263400	Travertine Canyon	–113.444	35.735	1	5/15/1993	5/15/1993	2.0	na	2.0	5/15/1993	2.0	5/15/1993	USGS, 2009b
354503113252600	Travertine Canyon above mouth at rm 229	–113.425	35.751	1	5/15/1993	5/15/1993	4.0	na	4.0	5/15/1993	4.0	5/15/1993	USGS, 2009b
354522113264800	Travertine Falls	–113.447	35.756	1	5/15/1993	5/15/1993	11.0	na	11.0	5/15/1993	11.0	5/15/1993	USGS, 2009b
354550113313400	Bridge Canyon	–113.527	35.764	1	5/15/1993	5/15/1993	6.0	na	6.0	5/15/1993	6.0	5/15/1993	USGS, 2009b
354711113403200	Meriwhitica Spring	–113.676	35.786	1	5/16/1993	5/16/1993	2.0	na	2.0	5/16/1993	2.0	5/16/1993	USGS, 2009b
354800113390800		–113.653	35.800	1	5/16/1993	5/16/1993	2.0	na	2.0	5/16/1993	2.0	5/16/1993	USGS, 2009b
354815113192000	222 Mile Canyon	–113.323	35.804	1	10/15/1993	10/15/1993	29.0	na	29.0	10/15/1993	29.0	10/15/1993	USGS, 2009b
354855113183300	Granite Spring Canyon	–113.310	35.815	1	5/19/1993	5/19/1993	1.0	na	1.0	5/19/1993	1.0	5/19/1993	USGS, 2009b
354923114001000	Ray Place Right Fork	–114.004	35.823	2	6/9/1993	12/9/1993	19.5	0.7	19.0	6/9/1993	20.0	12/9/1993	USGS, 2009b
354924114001200	Ray Place Left Fork	–114.004	35.823	1	6/9/1993	6/9/1993	32.0	na	32.0	6/9/1993	32.0	6/9/1993	USGS, 2009b
354942113581500	Hillside Spring	–113.972	35.828	1	6/9/1993	6/9/1993	0.5	na	0.5	6/9/1993	0.5	6/9/1993	USGS, 2009b
354944113592300	Iron Spring	–113.991	35.829	1	6/10/1993	6/10/1993	25.0	na	25.0	6/10/1993	25.0	6/10/1993	USGS, 2009b
355052113591900	Mud Spring	–113.989	35.848	1	6/11/1993	6/11/1993	15.0	na	15.0	6/11/1993	15.0	6/11/1993	USGS, 2009b

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355111113462300	Horse Flat Canyon	–113.774	35.853	1	5/17/1993	5/17/1993	1.0	na	1.0	5/17/1993	1.0	5/17/1993	USGS, 2009b
355124113404000	Clay Tank Canyon	–113.679	35.857	1	5/17/1993	5/17/1993	3.0	na	3.0	5/17/1993	3.0	5/17/1993	USGS, 2009b
355308113182600	Three Springs Canyon above the mouth	–113.308	35.886	1	10/14/1993	10/14/1993	2.0	na	2.0	10/14/1993	2.0	10/14/1993	USGS, 2009b
355502113195900	Pumpkin Spring at rm 213	–113.334	35.917	1	10/13/1993	10/13/1993	17.0	na	17.0	10/13/1993	17.0	10/13/1993	USGS, 2009b
355748113454500	Quartermaster Canyon above the mouth	–113.763	35.963	1	5/17/1993	5/17/1993	2.0	na	2.0	5/17/1993	2.0	5/17/1993	USGS, 2009b
355750113183600	Granite Park Spring	–113.311	35.964	1	10/13/1993	10/13/1993	4.0	na	4.0	10/13/1993	4.0	10/13/1993	USGS, 2009b
355807113561800	New Water Spring	–113.939	35.969	2	6/11/1993	11/17/1993	2.0	0	2.0	11/17/1993	2.0	11/17/1993	USGS, 2009b
355959113122700	Big Spring	–113.208	36.000	1	5/20/1993	5/20/1993	4.0	na	4.0	5/20/1993	4.0	5/20/1993	USGS, 2009b
360020111560401	Red Canyon Spring; upper Bright Angel near Muav contact (bedrock)	–111.934	36.004	1	9/26/2001	9/26/2001	1.7	na	1.7	9/26/2001	1.7	9/26/2001	Monroe and others, 2005
360025111571501	JT Spring (Hance Spring; upper Bright Angel near Muav contact (bedrock)	–111.951	36.002	2	4/8/2001	5/11/2001	3.8	0.4	3.5	4/8/2001	4.1	5/11/2001	Monroe and others, 2005
360059111581700	Miners Spring at train in Hance Canyon	–111.972	36.016	1	11/20/1981	11/20/1981	3.9	na	3.9	11/20/1981	3.9	11/20/1981	USGS, 2009b
360100111582001	Miners Spring; upper Bright Angel near Muav contact (bedrock)	–111.971	36.015	3	5/24/2000	4/7/2001	3.3	0.2	3.1	5/24/2000	3.5	11/28/2000	Monroe and others, 2005
360128111591502	Cottonwood Creek No. 2 (Cottonwood Spring); middle Bright Angel (alluvium)	–111.990	36.017	1	11/29/2000	11/29/2000	1.6	na	1.6	11/29/2000	1.6	11/29/2000	Monroe and others, 2005
360232112004801	Grapevine East Spring; lower Bright Angel (bedrock)	–112.012	36.040	3	5/25/2000	4/9/2001	5.8	3.3	2.1	5/25/2000	8.3	11/29/2000	Monroe and others, 2005
360232112004802	Grapevine Main Spring; upper Bright Angel near Muav contact (bedrock)	–112.003	36.009	2	4/10/2001	4/30/2001	1.1	0.0	1.1	4/10/2001	1.1	4/30/2001	Monroe and others, 2005
360336112131801	Hermit Spring	–112.222	36.060	4	6/20/2005	12/30/2005	4.7	0.4	4.4	12/30/2005	5.3	6/20/2005	USGS, 2009b
360400112025001	Lonetree Spring; upper Bright Angel near Muav contact (bedrock)	–112.047	36.065	2	4/11/2001	5/1/2001	6.0	0.0	6.0	4/11/2001	6.0	5/1/2001	Monroe and others, 2005
360411112141701	Boucher East Spring; upper Tapeats (travertine dome)	–112.237	36.101	3	5/26/2000	4/12/2001	1.9	0.1	1.8	12/4/2000	1.9	5/26/2000	Monroe and others, 2005
360417112130701	Hawaii Spring; middle Bright Angel (bedrock)	–112.218	36.069	3	5/25/2000	4/11/2001	1.9	0.0	1.9	12/4/2000	2.0	4/11/2001	Monroe and others, 2005
360417112130702	Hermit Spring; lower Muav near Bright Angel contact (bedrock)	–112.225	36.061	2	12/4/2000	4/11/2001	2.0	0.1	2.0	12/4/2000	2.1	4/11/2001	Monroe and others, 2005
360435113104700	Ridenour Mine	–113.180	36.076	1	5/20/1993	5/20/1993	8.0	na	8.0	5/20/1993	8.0	5/20/1993	USGS, 2009b
360436112060401	Burro Spring; lower Bright Angel (alluvium)	–112.100	36.075	3	5/22/2000	4/8/2001	2.5	0.1	2.4	4/8/2001	2.7	12/7/2000	Monroe and others, 2005
360437112060210	Burro Spring at Tonto Trail	–112.101	36.077	1	9/1/1981	9/1/1981	2.6	na	2.6	9/1/1981	2.6	9/1/1981	USGS, 2009b

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360439112094101	Salt Creek Spring; upper Bright Angel (bedrock)	–112.161	36.075	3	5/23/2000	4/10/2001	30.2	1.0	29.3	4/10/2001	31.2	12/6/2000	Monroe and others, 2005
360441112073201	Pumphouse Spring; middle Bright Angel (alluvium)	–112.125	36.076	3	5/22/2000	4/7/2001	1.8	0.1	1.7	5/22/2000	1.9	12/7/2000	Monroe and others, 2005
360455112111002	Monument Spring; lower Muav near Bright Angel contact (bedrock)	–112.176	36.064	2	12/5/2000	4/9/2001	7.2	0.1	7.1	12/5/2000	7.3	4/9/2001	Monroe and others, 2005
360957113080200	Beecher Spring	–113.135	36.166	1	10/11/1993	10/11/1993	2.0	na	2.0	10/11/1993	2.0	10/11/1993	USGS, 2009b
361025113071100	Artesian Spring at rm 182	–113.120	36.174	1	10/11/1993	10/11/1993	5.0	na	5.0	10/11/1993	5.0	10/11/1993	USGS, 2009b
361143112270500	Royal Arch Creek at mouth at Elves Chasm	–112.452	36.195	1	11/19/1981	11/19/1981	3.5	na	3.5	11/19/1981	3.5	11/19/1981	USGS, 2009b
361148113045900	Warm Spring	–113.084	36.197	1	10/10/1993	10/10/1993	5.0	na	5.0	10/10/1993	5.0	10/10/1993	USGS, 2009b
361237113025700	Honga above the mouth	–113.050	36.210	1	10/10/1993	10/10/1993	13.0	na	13.0	10/10/1993	13.0	10/10/1993	USGS, 2009b
361303112411200	Havasu Spring	–112.687	36.217	1	8/23/1994	8/23/1994	4.0	na	4.0	8/23/1994	4.0	8/23/1994	USGS, 2009b
361310112580400	Mohawk Canyon	–112.969	36.219	1	10/9/1993	10/9/1993	12.0	na	12.0	10/9/1993	12.0	10/9/1993	USGS, 2009b
361344113032001	Saddle Horse Spring	–113.056	36.229	3	5/24/2005	12/1/2005	0.5	0.0	0.5	9/8/2005	0.6	12/1/2005	USGS, 2009b
361524112420400	Fern Spring	–112.702	36.257	1	8/24/1994	8/24/1994	4.0	na	4.0	8/24/1994	4.0	8/24/1994	USGS, 2009b
361650112052001	Robbers Roost Spring	–112.089	36.281	3	5/27/2005	10/25/2005	0.3	0.2	0.1	5/27/2005	0.5	10/25/2005	USGS, 2009b
362143112551201	Schmutz Spring	–112.920	36.362	5	5/26/2005	8/25/2009	4.7	0.8	4.1	8/25/2009	6.0	5/26/2005	USGS, 2009b
362157112451601	Hotel Spring	–112.754	36.366	3	5/23/2005	8/25/2009	3.2	0.8	2.6	8/25/2009	4.2	11/29/2005	USGS, 2009b
362258112464701	Buckhorn Spring	–112.780	36.383	2	5/23/2005	11/29/2005	10.5	0.2	10.3	5/23/2005	10.6	11/29/2005	USGS, 2009b
362434111533601		–111.893	36.409	1	8/23/2009	8/23/2009	2.8	na	2.8	8/23/2009	2.8	8/23/2009	USGS, 2009b
362702112394701		–112.663	36.451	1	8/26/2009	8/26/2009	7.2	na	7.2	8/26/2009	7.2	8/26/2009	USGS, 2009b
362723112382801	Showerbath Spring	–112.641	36.456	1	8/26/2009	8/26/2009	4.2	na	4.2	8/26/2009	4.2	8/26/2009	USGS, 2009b
362802112374601		–112.629	36.467	2	8/26/2009	8/26/2009	4.9	0.4	4.6	8/26/2009	5.2	8/26/2009	USGS, 2009b
362827111504101		–111.845	36.474	1	8/21/2009	8/21/2009	0.6	na	0.6	8/21/2009	0.6	8/21/2009	USGS, 2009b
362831111504401	Hole-in-the-Wall Spring	–111.846	36.475	1	8/22/2009	8/22/2009	0.6	na	0.6	8/22/2009	0.6	8/22/2009	USGS, 2009b
363115112342601		–112.574	36.521	1	9/1/2009	9/1/2009	7.8	na	7.8	9/1/2009	7.8	9/1/2009	USGS, 2009b
363123111503101	Fence Spring	–111.842	36.523	1	8/20/2009	8/20/2009	1.4	na	1.4	8/20/2009	1.4	8/20/2009	USGS, 2009b
363209112350801	Lower Jumpup Spring	–112.586	36.536	1	8/28/2009	8/28/2009	7.2	na	7.2	8/28/2009	7.2	8/28/2009	USGS, 2009b
363357112440801	Willow	–112.736	36.566	1	8/26/2009	8/26/2009	19.6	na	19.6	8/26/2009	19.6	8/26/2009	USGS, 2009b
363450112325001	Upper Jumpup Spring	–112.547	36.581	1	8/27/2009	8/27/2009	3.7	na	3.7	8/27/2009	3.7	8/27/2009	USGS, 2009b
363907111471701	Rider Spring	–111.788	36.652	1	8/25/2009	8/25/2009	4.5	na	4.5	8/25/2009	4.5	8/25/2009	USGS, 2009b
363922112334501		–112.563	36.656	1	8/27/2009	8/27/2009	2.3	na	2.3	8/27/2009	2.3	8/27/2009	USGS, 2009b
10A–W82	Upper Pine Spring; Kaibab Limestone	–113.114	35.842	1	6/1/1982	6/1/1982	1.6	na	1.6	6/1/1982	1.6	6/1/1982	Wenrich and others, 1994
11A–W82	Unnamed spring ⅓ mi from Pine Tank; Kaibab Limestone	–113.104	35.840	1	6/1/1982	6/1/1982	1.4	na	1.4	6/1/1982	1.4	6/1/1982	Wenrich and others, 1994
12A–W82	Pine Spring; Tertiary Frazier Well (gravels)	–113.099	35.837	1	6/1/1982	6/1/1982	1.8	na	1.8	6/1/1982	1.8	6/1/1982	Wenrich and others, 1994
15A–W82	Pocomate Springs; Coconino Sandstone	–113.162	35.822	1	6/1/1982	6/1/1982	2.0	na	2.0	6/1/1982	2.0	6/1/1982	Wenrich and others, 1994
18A–W82	Travertine Falls Spring; Precambrian granite	–113.448	35.756	1	6/1/1982	6/1/1982	9.5	na	9.5	6/1/1982	9.5	6/1/1982	Wenrich and others, 1994
1A–W82	Red Spring; Muav Limestone	–113.423	35.559	1	6/1/1982	6/1/1982	3.6	na	3.6	6/1/1982	3.6	6/1/1982	Wenrich and others, 1994

Table 7. Summary information about spring-water samples analyzed for dissolved uranium from the historical dataset compiled for northern Arizona.—Continued

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Sample or Site Identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Number of samples	First sample date	Last sample date	Dissolved uranium average concen-tration (µg/L)	Standard deviation of average concen-tration (µg/L)	Minimum reported concen-tration (µg/L)	Date of minimum concen-tration sample	Maximum reported concen-tration (µg/L)	Date of maximum concen-tration sample	Source of data
21A–W82	Seep south of Separation Canyon; Precambrian granite	–113.567	35.808	1	6/1/1982	6/1/1982	18.0	na	18.0	6/1/1982	18.0	6/1/1982	Wenrich and others, 1994
22A–W82	Seep south of Separation Canyon; Precambrian granite	–113.568	35.808	1	6/1/1982	6/1/1982	28.0	na	28.0	6/1/1982	28.0	6/1/1982	Wenrich and others, 1994
24A–W82	Quartermaster Springs NE; Travertine	–113.766	35.959	1	6/1/1982	6/1/1982	1.3	na	1.3	6/1/1982	1.3	6/1/1982	Wenrich and others, 1994
25A–W82	Quartermaster Springs SW; Travertine	–113.767	35.956	1	6/1/1982	6/1/1982	1.4	na	1.4	6/1/1982	1.4	6/1/1982	Wenrich and others, 1994
26A–W82	Rampart Springs; Muav Limestone	–113.110	36.145	1	6/1/1982	6/1/1982	1.6	na	1.6	6/1/1982	1.6	6/1/1982	Wenrich and others, 1994
28A–W82	Diamond Creek Spring (Upper Diamond Spring); Redwall Limestone	–113.232	35.720	1	6/1/1982	6/1/1982	0.2	na	0.2	6/1/1982	0.2	6/1/1982	Wenrich and others, 1994
29A–W82	Hells Hollow Spring; Esplanade Sandstone	–113.110	36.145	1	6/1/1982	6/1/1982	0.9	na	0.9	6/1/1982	0.9	6/1/1982	Wenrich and others, 1994
2A–W82	Peach Springs; Muav Limestone	–113.431	35.578	1	6/1/1982	6/1/1982	1.6	na	1.6	6/1/1982	1.6	6/1/1982	Wenrich and others, 1994
30A&B–W82	Beecher Spring; Hermit-Esplanade contact	–113.179	36.076	2	6/1/1982	6/1/1982	9.0	0.8	8.4	6/1/1982	9.5	6/1/1982	Wenrich and others, 1994
31A&B–W82	Surprise Springs; Redwall Limestone	–113.402	35.519	2	6/1/1982	6/1/1982	1.1	0.1	1.0	6/1/1982	1.2	6/1/1982	Wenrich and others, 1994
32A–W82	Spencer Springs; Muav Limestone & Spencer Canyon (gravels)	–113.651	35.783	1	6/1/1982	6/1/1982	2.8	na	2.8	6/1/1982	2.8	6/1/1982	Wenrich and others, 1994
33A&B–W82	Meriwhitica Springs; Muav Limestone	–113.676	35.786	2	6/1/1982	6/1/1982	1.2	0.0	1.2	6/1/1982	1.2	6/1/1982	Wenrich and others, 1994
34A&B–W82	Hockey Puck Spring; contact of Hermit Shale and Coconino Sandstone	–113.176	35.934	2	6/1/1982	6/1/1982	2.2	0.1	2.1	6/1/1982	2.2	6/1/1982	Wenrich and others, 1994
35A–W82	Red Spring; Coconino Sandstone	–113.024	36.071	1	6/1/1982	6/1/1982	1.7	na	1.7	6/1/1982	1.7	6/1/1982	Wenrich and others, 1994
362837111504201 & CF-3	Redwall Limestone; rm 34.2	–111.846	36.477	2	4/29/1976	8/22/2009	0.6	0.1	0.5	4/29/1976	0.6	8/22/2009	USGS, 2009b and Peterson and others, 1977
362957111512600 & CF1	Vasey's Paradise, rm 31.9; Redwall Limestone	–111.858	36.499	2	4/29/1976	11/20/1981	1.2	0.9	0.5	4/29/1976	1.8	11/20/1981	USGS, 2009b and Peterson and others, 1977
36A–W82	Moss Spring; Coconino Sandstone	–113.028	36.062	1	6/1/1982	6/1/1982	1.1	na	1.1	6/1/1982	1.1	6/1/1982	Wenrich and others, 1994
37A–W82	Big Spring; Coconino Sandstone	–113.207	36.000	1	6/1/1982	6/1/1982	2.6	na	2.6	6/1/1982	2.6	6/1/1982	Wenrich and others, 1994
38A–W82	Unnamed Spring; Music Mountain Formation (conglomerate)	–113.678	35.670	1	6/1/1982	6/1/1982	1.6	na	1.6	6/1/1982	1.6	6/1/1982	Wenrich and others, 1994

Table 7. Summary information about spring-water samples analyzed for dissolved uranium from the historical dataset compiled for northern Arizona.—Continued

[µg/L, microgram per liter; na, not available; rm, river mile; NAD 83, North American Datum of 1983; USGS, U.S. Geological Survey]

Sample or Site Identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Number of samples	First sample date	Last sample date	Dissolved uranium average concentration (µg/L)	Standard deviation of average concentration (µg/L)	Minimum reported concentration (µg/L)	Date of minimum concentration sample	Maximum reported concentration (µg/L)	Date of maximum concentration sample	Source of data
39A&B–W82	Willow Spring; Hualapai volcanic rocks	–113.699	35.651	2	6/1/1982	6/1/1982	1.4	0.1	1.3	6/1/1982	1.5	6/1/1982	Wenrich and others, 1994
3A–W82	Lower Peach Springs; Muav Limestone	–113.440	35.592	1	6/1/1982	6/1/1982	2.6	na	2.6	6/1/1982	2.6	6/1/1982	Wenrich and others, 1994
41A&B–W82	West Water Spring (upper); Hualapai volcanic rocks	–113.727	35.618	2	6/1/1982	6/1/1982	1.0	0.1	0.9	6/1/1982	1.0	6/1/1982	Wenrich and others, 1994
42A–W82	Unnamed spring; Music Mountain (conglomerate)	–113.690	35.637	1	6/1/1982	6/1/1982	1.2	na	1.2	6/1/1982	1.2	6/1/1982	Wenrich and others, 1994
43A–W82	Lower Milkweed Spring; Bright Angel Shale	–113.673	35.653	1	6/1/1982	6/1/1982	2.1	na	2.1	6/1/1982	2.1	6/1/1982	Wenrich and others, 1994
44A–W82	Lower West Water Spring; Music Mountain (conglomerate)	–113.695	35.645	1	6/1/1982	6/1/1982	1.0	na	1.0	6/1/1982	1.0	6/1/1982	Wenrich and others, 1994
47A&B–W82	Horse Trough Spring; Muav Limestone	–113.619	35.550	2	6/1/1982	6/1/1982	1.5	0.1	1.4	6/1/1982	1.6	6/1/1982	Wenrich and others, 1994
49A–W82	Horsehair Spring; Wescogame Formation	–112.916	36.157	1	6/1/1982	6/1/1982	13.0	na	13.0	6/1/1982	13.0	6/1/1982	Wenrich and others, 1994
50A–W82	Mohawk Spring; Muav Limestone	–112.971	36.213	1	6/1/1982	6/1/1982	12.0	na	12.0	6/1/1982	12.0	6/1/1982	Wenrich and others, 1994
51A–W82	National Canyon Spring; Redwall Limestone	–112.879	36.213	1	6/1/1982	6/1/1982	8.0	na	8.0	6/1/1982	8.0	6/1/1982	Wenrich and others, 1994
53A–W82	East Diamond Spring; Muav Limestone	–113.255	35.719	1	6/1/1982	6/1/1982	1.1	na	1.1	6/1/1982	1.1	6/1/1982	Wenrich and others, 1994
54A–W82	Milkweed Spring; Hualapai volcanic rocks	–113.706	35.618	1	6/1/1982	6/1/1982	2.3	na	2.3	6/1/1982	2.3	6/1/1982	Wenrich and others, 1994
55A–W82	Clay Springs; Muav Limestone	–113.868	35.731	1	6/1/1982	6/1/1982	1.7	na	1.7	6/1/1982	1.7	6/1/1982	Wenrich and others, 1994
58A–W82	Diamond Spring; Muav Limestone	–113.261	35.713	1	6/1/1982	6/1/1982	1.2	na	1.2	6/1/1982	1.2	6/1/1982	Wenrich and others, 1994
59A–W82	Reference Point Spring; Precambrian granite	–113.732	35.882	1	6/1/1982	6/1/1982	2.8	na	2.8	6/1/1982	2.8	6/1/1982	Wenrich and others, 1994
5A–W82	Rocky Spring; Bright Angel Shale	–113.364	35.749	1	6/1/1982	6/1/1982	28.0	na	28.0	6/1/1982	28.0	6/1/1982	Wenrich and others, 1994
60A–W82	Wild Horse Spring; Bright Angel Shale	–113.645	35.711	1	6/1/1982	6/1/1982	1.1	na	1.1	6/1/1982	1.1	6/1/1982	Wenrich and others, 1994
61A–W82	Hindu Spring; Muav Limestone	–113.585	35.697	1	6/1/1982	6/1/1982	1.4	na	1.4	6/1/1982	1.4	6/1/1982	Wenrich and others, 1994
62A–W82	Blue Mtn Seep; Bright Angel Shale	–113.293	35.697	1	6/1/1982	6/1/1982	2.1	na	2.1	6/1/1982	2.1	6/1/1982	Wenrich and others, 1994
63A–W82	Lost Creek Spring; contact between Precambrian granite and Tapeats Sandstone	–113.677	35.857	1	6/1/1982	6/1/1982	2.1	na	2.1	6/1/1982	2.1	6/1/1982	Wenrich and others, 1994
64A–W82	Unnamed spring in Milkweed Canyon; Precambrian granite	–113.657	35.681	1	6/1/1982	6/1/1982	3.0	na	3.0	6/1/1982	3.0	6/1/1982	Wenrich and others, 1994
65A–W82	Sheep Spring; Temple Butte Formation	–113.826	35.848	1	6/1/1982	6/1/1982	2.6	na	2.6	6/1/1982	2.6	6/1/1982	Wenrich and others, 1994

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Sample or Site Identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Number of samples	First sample date	Last sample date	Dissolved uranium average concentration (µg/L)	Standard deviation of average concentration (µg/L)	Minimum reported concentration (µg/L)	Date of minimum concentration sample	Maximum reported concentration (µg/L)	Date of maximum concentration sample	Source of data
66A–W82	Unnamed spring in Milkweed Canyon; Bright Angel Shale	–113.640	35.984	1	6/1/1982	6/1/1982	2.0	na	2.0	6/1/1982	2.0	6/1/1982	Wenrich and others, 1994
67A–W82	Robbers Roost Spring; Vishnu Schist	–113.296	35.718	1	6/1/1982	6/1/1982	21.0	na	21.0	6/1/1982	21.0	6/1/1982	Wenrich and others, 1994
68A–W82	Unnamed spring in Milkweed Canyon; Precambrian granite	–113.655	35.680	1	6/1/1982	6/1/1982	3.2	na	3.2	6/1/1982	3.2	6/1/1982	Wenrich and others, 1994
69A–W82	Hindu Seep; Muav Limestone	–113.603	35.704	1	6/1/1982	6/1/1982	1.3	na	1.3	6/1/1982	1.3	6/1/1982	Wenrich and others, 1994
6A–W82	Mesquite Spring; Bright Angel Shale in landslide block adjacent to Hurricane fault	–113.422	35.670	1	6/1/1982	6/1/1982	21.0	na	21.0	6/1/1982	21.0	6/1/1982	Wenrich and others, 1994
70A–W82	Buck and Doe Spring; Bright Angel Shale	–113.647	35.676	1	6/1/1982	6/1/1982	1.0	na	1.0	6/1/1982	1.0	6/1/1982	Wenrich and others, 1994
71A–W82	Tilted Spring; Tapeats Sandstone	–113.628	35.706	1	6/1/1982	6/1/1982	2.8	na	2.8	6/1/1982	2.8	6/1/1982	Wenrich and others, 1994
72A–W82	Metuck Springs; Muav Limestone	–113.383	35.647	1	6/1/1982	6/1/1982	0.8	na	0.8	6/1/1982	0.8	6/1/1982	Wenrich and others, 1994
74A&B–W82	Dewey Mahone Spring; Vishnu Schist	–113.629	35.506	2	6/1/1982	6/1/1982	12.0	0.0	12.0	6/1/1982	12.0	6/1/1982	Wenrich and others, 1994
75A–W82	Warm Springs; Muav Limestone	–113.082	36.197	1	6/1/1982	6/1/1982	5.4	na	5.4	6/1/1982	5.4	6/1/1982	Wenrich and others, 1994
76A–W82	Lava Falls (by cliff); Muav Limestone	–113.081	36.196	1	6/1/1982	6/1/1982	5.2	na	5.2	6/1/1982	5.2	6/1/1982	Wenrich and others, 1994
77A–W82	Pumpkin Spring; Tapeats Sandstone	–113.333	35.917	1	6/1/1982	6/1/1982	12.0	na	12.0	6/1/1982	12.0	6/1/1982	Wenrich and others, 1994
78A&B–W82	Three Springs; Muav Limestone	–113.294	35.886	2	6/1/1982	6/1/1982	1.7	0.1	1.6	6/1/1982	1.8	6/1/1982	Wenrich and others, 1994
7A–W82	Mulberry Spring; Muav Limestone	–113.403	35.612	1	6/1/1982	6/1/1982	3.1	na	3.1	6/1/1982	3.1	6/1/1982	Wenrich and others, 1994
8A–W82	Pocomate Springs; Coconino Sandstone	–113.160	35.824	1	6/1/1982	6/1/1982	1.5	na	1.5	6/1/1982	1.5	6/1/1982	Wenrich and others, 1994
Berts Canyon	Muav Limestone	–111.886	36.398	1	5/11/1998	5/11/1998	1.4	na	1.4	5/11/1998	1.4	5/11/1998	Taylor and others, 2004
Blue Spring		–111.693	36.117	5	5/16/1985	5/28/1987	5.4	1.3	4.0	5/28/1987	7.0	5/16/1985	Errol Montgomery and Assoc., 1993b
Burro Spring	Bright Angel Shale-Muav Limestone	–112.102	36.084	1	4/29/1994	4/29/1994	3.4	na	3.4	4/29/1994	3.4	4/29/1994	Fitzgerald, 1996
Burro Up		–112.100	36.077	4	6/4/2002	7/29/2002	3.5	0.6	2.7	7/15/2002	4.1	6/4/2002	Liebe, 2003
CDDC503R	Shale	–113.413	37.008	1	6/19/1980	6/19/1980	0.0	na	0.0	6/19/1980	0.0	6/19/1980	USGS, 2009a
Cedar Spring	Tapeats Sandstone–Bright Angel Shale	–112.152	36.088	1	3/18/1995	3/18/1995	18.0	na	18.0	3/18/1995	18.0	3/18/1995	Fitzgerald, 1996
CF–10	Muav Limestone; rm 147.9	–112.672	36.346	1	5/7/1976	5/7/1976	6.4	na	6.4	5/7/1976	6.4	5/7/1976	Peterson and others, 1977
CF–11	Muav Limestone; rm 151.5	–112.725	36.346	1	5/7/1976	5/7/1976	8.5	na	8.5	5/7/1976	8.5	5/7/1976	Peterson and others, 1977

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Sample or Site Identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Number of samples	First sample date	Last sample date	Dissolved uranium average concentration (µg/L)	Standard deviation of average concentration (µg/L)	Minimum reported concentration (µg/L)	Date of minimum concentration sample	Maximum reported concentration (µg/L)	Date of maximum concentration sample	Source of data
CF–14	Fern Glen Canyon; Muav Limestone; rm 168	–112.918	36.262	1	5/8/1976	5/8/1976	3.6	na	3.6	5/8/1976	3.6	5/8/1976	Peterson and others, 1977
CF–15	Lava Falls; Muav Limestone; rm 179.3	–113.084	36.194	1	5/9/1976	5/9/1976	3.5	na	3.5	5/9/1976	3.5	5/9/1976	Peterson and others, 1977
CF–16	Pumpkin Spring; Tapeats Sandstone; rm 212.9	–113.334	35.916	1	5/11/1976	5/11/1976	7.1	na	7.1	5/11/1976	7.1	5/11/1976	Peterson and others, 1977
Cottonwood Spring	Bright Angel Shale–Muav Limestone	–111.992	36.025	1	5/12/1995	5/12/1995	2.1	na	2.1	5/12/1995	2.1	5/12/1995	Fitzgerald, 1996
Cottonwood West Spring	Tapeats Sandstone–Bright Angel Shale	–111.992	36.025	1	5/13/1995	5/13/1995	5.7	na	5.7	5/13/1995	5.7	5/13/1995	Fitzgerald, 1996
Cove Canyon	Muav Limestone	–113.015	36.246	1	5/19/1998	5/19/1998	11.0	na	11.0	5/19/1998	11.0	5/19/1998	Taylor and others, 2004
Dripping Spring	Hermit Shale–Coconino Sandstone contact	–112.255	36.077	1	3/17/1995	3/17/1995	2.4	na	2.4	3/17/1995	2.4	3/17/1995	Fitzgerald, 1996
Elves Chasm	Muav Limestone	–112.454	36.189	1	5/15/1998	5/15/1998	3.1	na	3.1	5/15/1998	3.1	5/15/1998	Taylor and others, 2004
Fern Glen	Muav Limestone	–112.918	36.262	1	5/19/1998	5/19/1998	18.0	na	18.0	5/19/1998	18.0	5/19/1998	Taylor and others, 2004
Four Mile Spring (Below Dam)		–111.507	36.875	2	3/2/1995	5/1/1995	1.0	0.1	0.9	5/1/1995	1.0	3/2/1995	Taylor and others, 1997
Frog Marsh Spring (Below Dam)		–111.557	36.846	2	3/2/1995	5/1/1995	0.6	0.0	0.6	5/1/1995	0.6	3/2/1995	Taylor and others, 1997
GCAA501R	Carbonate	–113.891	36.763	1	5/6/1979	5/6/1979	17.7	na	17.7	5/6/1979	17.7	5/6/1979	USGS, 2009a
GCAA502R	Metamorphic	–113.852	36.772	1	5/6/1979	5/6/1979	3.9	na	3.9	5/6/1979	3.9	5/6/1979	USGS, 2009a
GCAA503R	Carbonate	–113.916	36.896	1	5/10/1979	5/10/1979	32.0	na	32.0	5/10/1979	32.0	5/10/1979	USGS, 2009a
GCAA504R	Volcanic rocks—mafic	–113.798	36.770	1	5/6/1979	5/6/1979	0.0	na	0.0	5/6/1979	0.0	5/6/1979	USGS, 2009a
GCAA505R	Volcanic rocks—mafic	–113.790	36.804	1	5/11/1979	5/11/1979	0.2	na	0.2	5/11/1979	0.2	5/11/1979	USGS, 2009a
GCAB501R	Carbonate	–113.670	36.835	1	5/8/1979	5/8/1979	0.1	na	0.1	5/8/1979	0.1	5/8/1979	USGS, 2009a
GCAB502R	Volcanic rocks—mafic	–113.741	36.810	1	5/8/1979	5/8/1979	0.5	na	0.5	5/8/1979	0.5	5/8/1979	USGS, 2009a
GCAB503R	Sandstone	–113.589	36.767	1	5/9/1979	5/9/1979	0.9	na	0.9	5/9/1979	0.9	5/9/1979	USGS, 2009a
GCAB504R	Other	–113.628	36.757	1	5/10/1979	5/10/1979	5.5	na	5.5	5/10/1979	5.5	5/10/1979	USGS, 2009a
GCAB505R	Volcanic rocks—mafic	–113.724	36.776	1	5/10/1979	5/10/1979	1.6	na	1.6	5/10/1979	1.6	5/10/1979	USGS, 2009a
GCAB506R	Sandstone	–113.706	36.763	1	5/10/1979	5/10/1979	6.6	na	6.6	5/10/1979	6.6	5/10/1979	USGS, 2009a
GCAC501R	Sandstone	–113.356	36.946	1	5/6/1979	5/6/1979	22.2	na	22.2	5/6/1979	22.2	5/6/1979	USGS, 2009a
GCAC503R	Other	–113.313	36.895	1	5/10/1979	5/10/1979	7.0	na	7.0	5/10/1979	7.0	5/10/1979	USGS, 2009a
GCAD503R	Sandstone	–113.056	36.948	1	5/7/1979	5/7/1979	1.2	na	1.2	5/7/1979	1.2	5/7/1979	USGS, 2009a
GCAD513R		–113.124	36.931	1	5/10/1979	5/10/1979	16.7	na	16.7	5/10/1979	16.7	5/10/1979	USGS, 2009a
GCAE503R		–112.828	36.933	1	5/13/1979	5/13/1979	0.1	na	0.1	5/13/1979	0.1	5/13/1979	USGS, 2009a
GCAE508R	Sandstone	–112.762	36.909	1	5/14/1979	5/14/1979	0.4	na	0.4	5/14/1979	0.4	5/14/1979	USGS, 2009a
GCAE509R	Sandstone	–112.921	36.990	1	5/14/1979	5/14/1979	0.4	na	0.4	5/14/1979	0.4	5/14/1979	USGS, 2009a
GCAE511R	Carbonate	–112.847	36.782	1	5/15/1979	5/15/1979	1.6	na	1.6	5/15/1979	1.6	5/15/1979	USGS, 2009a
GCAE515R	Sandstone	–112.777	36.956	1	5/16/1979	5/16/1979	0.0	na	0.0	5/16/1979	0.0	5/16/1979	USGS, 2009a
GCAE516R	Sandstone	–112.783	36.995	1	5/16/1979	5/16/1979	0.0	na	0.0	5/16/1979	0.0	5/16/1979	USGS, 2009a
GCAE517R		–112.781	36.881	1	5/17/1979	5/17/1979	249.6	na	249.6	5/17/1979	249.6	5/17/1979	USGS, 2009a
GCAF502R	Clastics—coarse	–112.576	36.962	1	5/14/1979	5/14/1979	8.9	na	8.9	5/14/1979	8.9	5/14/1979	USGS, 2009a
GCAF503R	Sandstone	–112.689	36.984	1	5/16/1979	5/16/1979	1.3	na	1.3	5/16/1979	1.3	5/16/1979	USGS, 2009a
GCAF504R	Sandstone	–112.723	36.921	1	5/17/1979	5/17/1979	25.1	na	25.1	5/17/1979	25.1	5/17/1979	USGS, 2009a
GCAG501R	Shale	–112.324	36.990	1	5/14/1979	5/14/1979	47.3	na	47.3	5/14/1979	47.3	5/14/1979	USGS, 2009a

Table 7. Summary information about spring-water samples analyzed for dissolved uranium from the historical dataset compiled for northern Arizona.—Continued

[µg/L, microgram per liter; na, not available; rm, river mile; NAD 83, North American Datum of 1983; USGS, U.S. Geological Survey]

Sample or Site Identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Number of samples	First sample date	Last sample date	Dissolved uranium average concentration (µg/L)	Standard deviation of average concentration (µg/L)	Minimum reported concentration (µg/L)	Date of minimum concentration sample	Maximum reported concentration (µg/L)	Date of maximum concentration sample	Source of data
GCAH501R	Carbonate	–112.034	36.952	1	5/19/1979	5/19/1979	0.8	na	0.8	5/19/1979	0.8	5/19/1979	USGS, 2009a
GCAH502R	Sandstone	–112.055	36.823	1	5/18/1979	5/18/1979	5.1	na	5.1	5/18/1979	5.1	5/18/1979	USGS, 2009a
GCBA503R	Sandstone	–113.783	36.653	1	5/9/1979	5/9/1979	0.2	na	0.2	5/9/1979	0.2	5/9/1979	USGS, 2009a
GCBA504R		–113.997	36.551	1	5/10/1979	5/10/1979	17.6	na	17.6	5/10/1979	17.6	5/10/1979	USGS, 2009a
GCBB501R	Sandstone	–113.736	36.669	1	5/12/1979	5/12/1979	1.4	na	1.4	5/12/1979	1.4	5/12/1979	USGS, 2009a
GCBB502R	Sandstone	–113.742	36.597	1	5/12/1979	5/12/1979	1.0	na	1.0	5/12/1979	1.0	5/12/1979	USGS, 2009a
GCBB503R	Sandstone	–113.715	36.524	1	5/12/1979	5/12/1979	0.9	na	0.9	5/12/1979	0.9	5/12/1979	USGS, 2009a
GCBE501R	Sandstone	–112.943	36.728	1	5/13/1979	5/13/1979	31.4	na	31.4	5/13/1979	31.4	5/13/1979	USGS, 2009a
GCBG501R	Sandstone	–112.348	36.602	1	5/12/1979	5/12/1979	0.4	na	0.4	5/12/1979	0.4	5/12/1979	USGS, 2009a
GCBG502R	Sandstone	–112.346	36.625	1	5/14/1979	5/14/1979	1.0	na	1.0	5/14/1979	1.0	5/14/1979	USGS, 2009a
GCBG503R	Sandstone	–112.312	36.695	1	5/15/1979	5/15/1979	0.7	na	0.7	5/15/1979	0.7	5/15/1979	USGS, 2009a
GCBG504R	Sandstone	–112.342	36.586	1	5/16/1979	5/16/1979	0.6	na	0.6	5/16/1979	0.6	5/16/1979	USGS, 2009a
GCBH501R	Sandstone	–112.045	36.586	1	5/19/1979	5/19/1979	0.8	na	0.8	5/19/1979	0.8	5/19/1979	USGS, 2009a
GCCA501R	Volcanic rocks—mafic	–113.973	36.325	1	5/16/1979	5/16/1979	2.9	na	2.9	5/16/1979	2.9	5/16/1979	USGS, 2009a
GCCA504R	Clastic rocks—coarse	–113.973	36.378	1	5/16/1979	5/16/1979	13.0	na	13.0	5/16/1979	13.0	5/16/1979	USGS, 2009a
GCCA506R	Volcanic rocks—mafic	–113.957	36.416	1	5/15/1979	5/15/1979	1.7	na	1.7	5/15/1979	1.7	5/15/1979	USGS, 2009a
GCCB501R	Carbonate	–113.664	36.294	1	5/17/1979	5/17/1979	1.8	na	1.8	5/17/1979	1.8	5/17/1979	USGS, 2009a
GCCB502R	Sandstone	–113.687	36.300	1	5/17/1979	5/17/1979	1.9	na	1.9	5/17/1979	1.9	5/17/1979	USGS, 2009a
GCCC501R	Volcanic rocks—mafic	–113.463	36.383	1	5/14/1979	5/14/1979	4.2	na	4.2	5/14/1979	4.2	5/14/1979	USGS, 2009a
GCCC502R	Carbonate	–113.479	36.267	1	5/17/1979	5/17/1979	13.6	na	13.6	5/17/1979	13.6	5/17/1979	USGS, 2009a
GCCC503R	Carbonate	–113.262	36.374	1	5/18/1979	5/18/1979	1.5	na	1.5	5/18/1979	1.5	5/18/1979	USGS, 2009a
GCCD501R	Volcanic rocks—mafic	–113.152	36.392	1	5/15/1979	5/15/1979	0.1	na	0.1	5/15/1979	0.1	5/15/1979	USGS, 2009a
GCCD502R	Volcanic rocks—mafic	–113.191	36.336	1	5/16/1979	5/16/1979	1.1	na	1.1	5/16/1979	1.1	5/16/1979	USGS, 2009a
GCDD501R	Coconino Sandstone	–113.067	36.126	1	5/27/1979	5/27/1979	1.0	na	1.0	5/27/1979	1.0	5/27/1979	USGS, 2009a
Grapevine East Spring	Bright Angel Shale	–112.023	36.049	1	5/13/1995	5/13/1995	3.0	na	3.0	5/13/1995	3.0	5/13/1995	Fitzgerald, 1996
Grapevine Spring	Bright Angel Shale-Muav Limestone	–112.022	36.028	1	5/13/1995	5/13/1995	2.2	na	2.2	5/13/1995	2.2	5/13/1995	Fitzgerald, 1996
Grapevine Hell Spring	Bright Angel Shale	–112.022	36.028	1	5/13/1995	5/13/1995	8.3	na	8.3	5/13/1995	8.3	5/13/1995	Fitzgerald, 1996
GW021W		–113.692	36.465	1	3/15/1981	3/15/1981	1.2	na	1.2	3/15/1981	1.2	3/15/1981	Hopkins and others, 1984a
GW022W		–113.691	36.479	1	3/15/1981	3/15/1981	1.1	na	1.1	3/15/1981	1.1	3/15/1981	Hopkins and others, 1984a
GW023W		–113.754	36.504	1	3/15/1981	3/15/1981	0.2	na	0.2	3/15/1981	0.2	3/15/1981	Hopkins and others, 1984a
GW024W		–113.710	36.499	1	3/15/1981	3/15/1981	1.2	na	1.2	3/15/1981	1.2	3/15/1981	Hopkins and others, 1984a
GW025W		–113.554	36.225	1	3/15/1981	3/15/1981	2.8	na	2.8	3/15/1981	2.8	3/15/1981	Hopkins and others, 1984a
GW026W		–113.559	36.231	1	3/15/1981	3/15/1981	4.8	na	4.8	3/15/1981	4.8	3/15/1981	Hopkins and others, 1984a
GW027W		–113.744	36.178	1	3/15/1981	3/15/1981	2.2	na	2.2	3/15/1981	2.2	3/15/1981	Hopkins and others, 1984a
GW028W		–113.688	36.300	1	3/15/1981	3/15/1981	2.4	na	2.4	3/15/1981	2.4	3/15/1981	Hopkins and others, 1984a

Table 7. Summary information about spring-water samples analyzed for dissolved uranium from the historical dataset compiled for northern Arizona.—Continued

[µg/L, microgram per liter; na, not available; rm, river mile; NAD 83, North American Datum of 1983; USGS, U.S. Geological Survey]

Sample or Site Identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Number of samples	First sample date	Last sample date	Dissolved uranium average concentration (µg/L)	Standard deviation of average concentration (µg/L)	Minimum reported concentration (µg/L)	Date of minimum concentration sample	Maximum reported concentration (µg/L)	Date of maximum concentration sample	Source of data
GW028WA		–113.488	36.145	1	3/15/1981	3/15/1981	0.2	na	0.2	3/15/1981	0.2	3/15/1981	Hopkins and others, 1984a
GW029W		–113.456	36.193	1	3/15/1981	3/15/1981	2.8	na	2.8	3/15/1981	2.8	3/15/1981	Hopkins and others, 1984a
GW030W		–113.441	36.201	1	3/15/1981	3/15/1981	1.9	na	1.9	3/15/1981	1.9	3/15/1981	Hopkins and others, 1984a
GW031W		–113.536	36.224	1	3/15/1981	3/15/1981	0.2	na	0.2	3/15/1981	0.2	3/15/1981	Hopkins and others, 1984a
GW032W		–113.501	36.247	1	3/15/1981	3/15/1981	2.6	na	2.6	3/15/1981	2.6	3/15/1981	Hopkins and others, 1984a
GW033W		–113.701	36.219	1	3/15/1981	3/15/1981	0.2	na	0.2	3/15/1981	0.2	3/15/1981	Hopkins and others, 1984a
GW034W		–113.480	36.267	1	3/15/1981	3/15/1981	5.8	na	5.8	3/15/1981	5.8	3/15/1981	Hopkins and others, 1984a
GW035W		–113.664	36.292	1	3/15/1981	3/15/1981	2.2	na	2.2	3/15/1981	2.2	3/15/1981	Hopkins and others, 1984a
GW036W		–113.739	36.191	1	3/15/1981	3/15/1981	0.4	na	0.4	3/15/1981	0.4	3/15/1981	Hopkins and others, 1984a
GW037W		–113.694	36.311	1	3/15/1981	3/15/1981	2.4	na	2.4	3/15/1981	2.4	3/15/1981	Hopkins and others, 1984a
GW038W		–113.701	36.502	1	3/15/1981	3/15/1981	0.5	na	0.5	3/15/1981	0.5	3/15/1981	Hopkins and others, 1984a
Hance Rapid Spring	Precambrian quartzite/schist	–111.923	36.054	1	5/13/1998	5/13/1998	4.8	na	4.8	5/13/1998	4.8	5/13/1998	Taylor and others, 2004
Havasu Spring		–112.686	36.217	18	5/16/1985	5/29/1990	5.0	2.9	0.5	12/8/1986	12.0	5/30/1989	Errol Montgomery and Assoc., 1993b
Hawaii Spring	Muav Limestone	–112.218	36.075	1	3/18/1995	3/18/1995	4.0	na	4.0	3/18/1995	4.0	3/18/1995	Fitzgerald, 1996
Horn Creek/Spring	Bright Angel Shale–Muav Limestone	–112.152	36.088	3	4/30/1994	6/5/1995	36.1	27.5	18.9	4/30/1994	67.8	3/19/1995	Fitzgerald, 1996
Horn Up	Redwall-Muav Limestones contact	–112.145	36.078	4	6/4/2002	7/29/2002	344.8	38.2	312.0	7/29/2002	400.0	7/15/2002	Liebe, 2003
Horn West	Redwall-Muav Limestones contact	–112.149	36.079	2	7/15/2002	7/29/2002	168.5	47.4	135.0	7/29/2002	202.0	7/15/2002	Liebe, 2003
Indian Gardens		–112.127	36.079	4	5/17/1985	12/18/1985	4.3	1.3	3.0	12/8/1986	6.0	12/18/1985	Errol Montgomery and Assoc., 1993b
Keyhole Spring	Muav Limestone	–112.582	36.380	1	5/11/1998	5/11/1998	1.7	na	1.7	5/11/1998	1.7	5/11/1998	Taylor and others, 2004
Lonetree Spring	Tapeats Sandstone–Bright Angel Shale	–112.054	36.074	1	6/3/1995	6/3/1995	4.9	na	4.9	6/3/1995	4.9	6/3/1995	Fitzgerald, 1996
Marble Canyon Spring 1	Mississippian Leadville Limestone; rm 25.3	–111.794	36.576	1	9/19/1982	9/19/1982	2.2	na	2.2	9/19/1982	2.2	9/19/1982	Office of Nuclear Waste Isolation, 1985
Marble Canyon Spring 2	Mississippian Leadville Limestone; rm 30.5	–111.846	36.519	1	9/19/1982	9/19/1982	2.4	na	2.4	9/19/1982	2.4	9/19/1982	Office of Nuclear Waste Isolation, 1985

Table 7. Summary information about spring-water samples analyzed for dissolved uranium from the historical dataset compiled for northern Arizona.—Continued

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Sample or Site Identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Number of samples	First sample date	Last sample date	Dissolved uranium average concentration (µg/L)	Standard deviation of average concentration (µg/L)	Minimum reported concentration (µg/L)	Date of minimum concentration sample	Maximum reported concentration (µg/L)	Date of maximum concentration sample	Source of data
Marble Canyon Spring 3	Mississippian Leadville Limestone; rm 30.6	–111.846	36.518	1	9/19/1982	9/19/1982	2.3	na	2.3	9/19/1982	2.3	9/19/1982	Office of Nuclear Waste Isolation, 1985
Marble Canyon Spring 4	Mississippian Leadville Limestone; rm 30.8	–111.848	36.515	1	9/19/1982	9/19/1982	2.0	na	2.0	9/19/1982	2.0	9/19/1982	Office of Nuclear Waste Isolation, 1985
Marble Canyon Spring 5	Mississippian Leadville Limestone; rm 30.7	–111.847	36.517	1	9/19/1982	9/19/1982	2.3	na	2.3	9/19/1982	2.3	9/19/1982	Office of Nuclear Waste Isolation, 1985
Marble Canyon Spring 6	Mississippian Leadville Limestone; rm 30.7	–111.846	36.516	1	9/19/1982	9/19/1982	2.5	na	2.5	9/19/1982	2.5	9/19/1982	Office of Nuclear Waste Isolation, 1985
Marble Canyon Spring 7	Mississippian Leadville Limestone; rm 35	–111.841	36.470	1	9/19/1982	9/19/1982	1.4	na	1.4	9/19/1982	1.4	9/19/1982	Office of Nuclear Waste Isolation, 1985
Marble Canyon Spring 9	Mississippian Leadville Limestone; rm 31.2	–111.851	36.510	1	9/19/1982	9/19/1982	1.4	na	1.4	9/19/1982	1.4	9/19/1982	Office of Nuclear Waste Isolation, 1985
MCBA501R	Sandstone	–111.898	36.727	1	5/19/1979	5/19/1979	2.4	na	2.4	5/19/1979	2.4	5/19/1979	USGS, 2009a
Mohawk Canyon	Muav Limestone	–112.967	36.225	1	5/19/1998	5/19/1998	18.0	na	18.0	5/19/1998	18.0	5/19/1998	Taylor and others, 2004
Monument Creek/ Spring	Tapeats Sandstone–Bright Angel Shale	–112.187	36.093	1	3/18/1995	3/18/1995	11.1	na	11.1	3/18/1995	11.1	3/18/1995	Fitzgerald, 1996
Nankoweap Twin Spring	Precambrian quartzite/schist	–111.889	36.282	1	5/12/1998	5/12/1998	1.5	na	1.5	5/12/1998	1.5	5/12/1998	Taylor and others, 2004
Page Spring	Muav Limestone–Bright Angel Shale	–111.977	36.027	2	5/12/1995	9/9/1995	4.0	0.2	3.8	9/9/1995	4.1	5/12/1995	Fitzgerald, 1996
Pinenut Mine Willow Springs		–112.735	36.504	2	12/21/1988	12/28/1989	18.8	0.4	18.5	12/21/1988	19.0	12/28/1989	Energy Fuels Nuclear, Inc., 1990a
Pipe Creek/Spring	Bright Angel Shale–Muav Limestone	–112.108	36.073	2	4/29/1994	6/4/1995	3.3	0.3	3.1	4/29/1994	3.5	6/4/1995	Fitzgerald, 1996
Pipe Up	Muav Limestone	–112.102	36.072	4	6/4/2002	7/29/2002	3.1	0.2	2.8	7/29/2002	3.3	6/4/2002	Liebe, 2003
Power Lines Spring (below dam)		–111.492	36.927	3	10/20/1994	5/1/1995	1.1	0.0	1.1	5/1/1995	1.1	5/1/1995	Taylor and others, 1997
Pumpkin Spring	Tapeats Sandstone	–113.307	35.885	1	5/21/1998	5/21/1998	13.0	na	13.0	5/21/1998	13.0	5/21/1998	Taylor and others, 2004
River Mile 125 Spring	Muav Limestone	–112.523	36.264	1	5/15/1998	5/15/1998	6.3	na	6.3	5/15/1998	6.3	5/15/1998	Taylor and others, 2004
River Mile 147 Seep	Muav Limestone	–112.676	36.343	1	5/17/1998	5/17/1998	9.0	na	9.0	5/17/1998	9.0	5/17/1998	Taylor and others, 2004
River Mile 213 Spring	Bright Angel Shale	–113.336	35.919	1	5/21/1998	5/21/1998	3.4	na	3.4	5/21/1998	3.4	5/21/1998	Taylor and others, 2004
Saddle Canyon	Muav Limestone	–111.904	36.360	1	5/11/1998	5/11/1998	2.6	na	2.6	5/11/1998	2.6	5/11/1998	Taylor and others, 2004
Sam Magee Spring	Bright Angel Shale–Muav Limestone	–112.075	36.087	1	6/3/1995	6/3/1995	3.9	na	3.9	6/3/1995	3.9	6/3/1995	Fitzgerald, 1996
Santa Maria Spring	Esplanade Sandstone	–112.222	36.066	1	3/17/1995	3/17/1995	7.2	na	7.2	3/17/1995	7.2	3/17/1995	Fitzgerald, 1996
Sewage Ponds Spring (below dam)		–111.478	36.912	3	10/20/1994	5/1/1995	2.7	0.1	2.6	10/20/1994	2.8	5/1/1995	Taylor and others, 1997
Slimy Tick Spring	Muav Limestone	–112.754	36.326	1	5/18/1998	5/18/1998	18.0	na	18.0	5/18/1998	18.0	5/18/1998	Taylor and others, 2004
Three Springs	Muav Limestone	–113.308	35.888	1	5/21/1998	5/21/1998	2.2	na	2.2	5/21/1998	2.2	5/21/1998	Taylor and others, 2004
Two Trees Spring	Bright Angel Shale–Muav Limestone	–112.086	36.086	2	4/30/1994	6/5/1995	3.2	0.1	3.1	6/5/1995	3.2	4/30/1994	Fitzgerald, 1996
UCC	Tapeats Sandstone	–112.126	36.088	1	7/29/2002	7/29/2002	1.8	na	1.8	7/29/2002	1.8	7/29/2002	Liebe, 2003

Table 8. Summary information about well-water samples analyzed for dissolved uranium from the historical dataset compiled for northern Arizona.

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Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Number of samples	First sample date	Last sample date	Dissolved uranium average concentration (µg/L)	Standard deviation of average concentration (µg/L)	Minimum reported concentration (µg/L)	Date of minimum concentration sample	Maximum reported concentration (µg/L)	Date of maximum concentration sample	Source of data
23003		–113.851	35.625	1	8/23/1977	8/23/1977	0.8	na	0.8	8/23/1977	0.8	8/23/1977	USGS, 2009a
23007		–113.557	35.496	1	8/25/1977	8/25/1977	1.5	na	1.5	8/25/1977	1.5	8/25/1977	USGS, 2009a
23013		–113.791	35.645	1	8/31/1977	8/31/1977	1.7	na	1.7	8/31/1977	1.7	8/31/1977	USGS, 2009a
23014		–113.767	35.608	1	9/1/1977	9/1/1977	6.5	na	6.5	9/1/1977	6.5	9/1/1977	USGS, 2009a
23016		–113.629	35.507	1	9/1/1977	9/1/1977	10.5	na	10.5	9/1/1977	10.5	9/1/1977	USGS, 2009a
23022		–113.075	35.768	1	9/4/1977	9/4/1977	1.4	na	1.4	9/4/1977	1.4	9/4/1977	USGS, 2009a
23023		–113.037	35.705	1	9/4/1977	9/4/1977	1.5	na	1.5	9/4/1977	1.5	9/4/1977	USGS, 2009a
23024		–113.114	35.783	1	9/4/1977	9/4/1977	2.6	na	2.6	9/4/1977	2.6	9/4/1977	USGS, 2009a
23026		–113.900	35.821	1	9/13/1977	9/13/1977	2.3	na	2.3	9/13/1977	2.3	9/13/1977	USGS, 2009a
23032		–113.985	35.774	1	9/15/1977	9/15/1977	110.4	na	110.4	9/15/1977	110.4	9/15/1977	USGS, 2009a
23079		–112.622	35.624	1	10/18/1977	10/18/1977	1.2	na	1.2	10/18/1977	1.2	10/18/1977	USGS, 2009a
23080		–112.875	35.742	1	10/19/1977	10/19/1977	13.5	na	13.5	10/19/1977	13.5	10/19/1977	USGS, 2009a
23088		–112.396	35.958	1	10/27/1977	10/27/1977	3.1	na	3.1	10/27/1977	3.1	10/27/1977	USGS, 2009a
23089		–112.436	35.806	1	10/28/1977	10/28/1977	1.9	na	1.9	10/28/1977	1.9	10/28/1977	USGS, 2009a
23090		–112.597	35.557	1	10/28/1977	10/28/1977	1.6	na	1.6	10/28/1977	1.6	10/28/1977	USGS, 2009a
23091		–112.621	35.624	1	10/28/1977	10/28/1977	1.4	na	1.4	10/28/1977	1.4	10/28/1977	USGS, 2009a
23173		–113.320	35.515	1	1/8/1978	1/8/1978	7.4	na	7.4	1/8/1978	7.4	1/8/1978	USGS, 2009a
361352112413201		–112.693	36.231	1	8/23/1994	8/23/1994	3.0	na	3.0	8/23/1994	3.0	8/23/1994	USGS, 2009b
13A-W82	Unnamed well; Tertiary Frazier Well gravels	–113.093	35.836	1	6/1/1982	6/1/1982	1.6	na	1.6	6/1/1982	1.6	6/1/1982	Wenrich and others, 1994
14A-W82	Fed by Frazier well; Tertiary Frazier Well gravels	–113.078	35.797	1	6/1/1982	6/1/1982	1.4	na	1.4	6/1/1982	1.4	6/1/1982	Wenrich and others, 1994
16A-W82	Unnamed well; Tertiary Frazier Well gravels	–113.051	35.810	1	6/1/1982	6/1/1982	1.3	na	1.3	6/1/1982	1.3	6/1/1982	Wenrich and others, 1994
45A+B-W82	PMG Well (Truxton); Quaternary & Tertiary gravels	–113.557	35.496	2	6/1/1982	6/1/1982	2.0	0.1	1.9	6/1/1982	2.1	6/1/1982	Wenrich and others, 1994
48A-W82	Shipley Well; Muav Limestone	–113.375	35.526	1	6/1/1982	6/1/1982	1.1	na	1.1	6/1/1982	1.1	6/1/1982	Wenrich and others, 1994
56A+B-W82	Santa Fe No. 5 Well; Muav Limestone	–113.678	35.527	2	6/1/1982	6/1/1982	1.2	0	1.2	6/1/1982	1.2	6/1/1982	Wenrich and others, 1994
57A+B-W82	XI Well; Tertiary Frazier Well gravel	–113.114	35.784	2	6/1/1982	6/1/1982	2.1	0.6	1.7	6/1/1982	2.5	6/1/1982	Wenrich and others, 1994
73A+B-W82	Truxton Well; Quaternary & Tertiary gravels	–113.536	35.496	2	6/1/1982	6/1/1982	1.3	0.1	1.2	6/1/1982	1.3	6/1/1982	Wenrich and others, 1994
Canyon Mine Well		–112.095	35.886	11	12/18/1986	9/19/1990	42.6	89.9	4.1	4/30/1987	309.0	5/30/1989	Errol Montgomery and Assoc., 1993a
CDDD502R		–113.180	37.001	1	6/26/1980	6/26/1980	4.0	na	4.0	6/26/1980	4.0	6/26/1980	USGS, 2009a
CDDE502R	Sandstone	–112.967	37.017	1	7/7/1980	7/7/1980	0.3	na	0.3	7/7/1980	0.3	7/7/1980	USGS, 2009a
CDDF503R		–112.527	37.006	1	7/10/1980	7/10/1980	0.3	na	0.3	7/10/1980	0.3	7/10/1980	USGS, 2009a
CDDG501R		–112.465	37.014	1	6/29/1980	6/29/1980	1.3	na	1.3	6/29/1980	1.3	6/29/1980	USGS, 2009a
GCAA506R	Carbonate	–113.931	36.907	1	5/8/1979	5/8/1979	2.5	na	2.5	5/8/1979	2.5	5/8/1979	USGS, 2009a
GCAA507R	Other	–113.988	36.777	1	5/8/1979	5/8/1979	4.0	na	4.0	5/8/1979	4.0	5/8/1979	USGS, 2009a
GCAA508R	Carbonate	–113.983	36.973	1	5/10/1979	5/10/1979	1.1	na	1.1	5/10/1979	1.1	5/10/1979	USGS, 2009a
GCAC502R	Other	–113.353	36.908	1	5/6/1979	5/6/1979	15.6	na	15.6	5/6/1979	15.6	5/6/1979	USGS, 2009a

Table 8. Summary information about well-water samples analyzed for dissolved uranium from the historical dataset compiled for northern Arizona.—Continued

[µg/L, microgram per liter; na, not available; NAD 83, North American Datum of 1983; USGS, U.S. Geological Survey]

Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Number of samples	First sample date	Last sample date	Dissolved uranium average concentration (µg/L)	Standard deviation of average concentration (µg/L)	Minimum reported concentration (µg/L)	Date of minimum concentration sample	Maximum reported concentration (µg/L)	Date of maximum concentration sample	Source of data
GCAD501R	Sandstone	–113.012	36.946	1	5/6/1979	5/6/1979	14.9	na	14.9	5/6/1979	14.9	5/6/1979	USGS, 2009a
GCAD502R	Sandstone	–113.150	36.960	1	5/6/1979	5/6/1979	0.2	na	0.2	5/6/1979	0.2	5/6/1979	USGS, 2009a
GCAD504R	Sandstone	–113.117	36.876	1	5/8/1979	5/8/1979	3.6	na	3.6	5/8/1979	3.6	5/8/1979	USGS, 2009a
GCAD505R	Carbonate	–113.177	36.865	1	5/8/1979	5/8/1979	31.7	na	31.7	5/8/1979	31.7	5/8/1979	USGS, 2009a
GCAD506R	Sandstone	–113.145	36.890	1	5/8/1979	5/8/1979	6.5	na	6.5	5/8/1979	6.5	5/8/1979	USGS, 2009a
GCAD507R	Volcanic rocks—mafic	–113.184	36.919	1	5/8/1979	5/8/1979	25.7	na	25.7	5/8/1979	25.7	5/8/1979	USGS, 2009a
GCAD508R	Carbonate	–113.249	36.940	1	5/8/1979	5/8/1979	4.6	na	4.6	5/8/1979	4.6	5/8/1979	USGS, 2009a
GCAD509R	Carbonate	–113.225	36.866	1	5/8/1979	5/8/1979	11.9	na	11.9	5/8/1979	11.9	5/8/1979	USGS, 2009a
GCAD510R	Carbonate	–113.173	36.810	1	5/9/1979	5/9/1979	13.2	na	13.2	5/9/1979	13.2	5/9/1979	USGS, 2009a
GCAD511R	Sandstone	–113.125	36.797	1	5/9/1979	5/9/1979	33.2	na	33.2	5/9/1979	33.2	5/9/1979	USGS, 2009a
GCAD512R	Sandstone	–113.136	36.756	1	5/10/1979	5/10/1979	25.7	na	25.7	5/10/1979	25.7	5/10/1979	USGS, 2009a
GCAD514R		–113.195	36.997	1	5/12/1979	5/12/1979	1.0	na	1.0	5/12/1979	1.0	5/12/1979	USGS, 2009a
GCAE501R	Volcanic rocks—mafic	–112.958	36.845	1	5/12/1979	5/12/1979	0.1	na	0.1	5/12/1979	0.1	5/12/1979	USGS, 2009a
GCAE502R		–112.862	36.847	1	5/12/1979	5/12/1979	0.3	na	0.3	5/12/1979	0.3	5/12/1979	USGS, 2009a
GCAE504R		–112.864	36.998	1	5/13/1979	5/13/1979	0.0	na	0.0	5/13/1979	0.0	5/13/1979	USGS, 2009a
GCAE505R	Sandstone	–112.864	36.949	1	5/13/1979	5/13/1979	0.0	na	0.0	5/13/1979	0.0	5/13/1979	USGS, 2009a
GCAE506R		–112.893	36.949	1	5/13/1979	5/13/1979	7.3	na	7.3	5/13/1979	7.3	5/13/1979	USGS, 2009a
GCAE507R	Carbonate	–112.963	36.938	1	5/13/1979	5/13/1979	12.9	na	12.9	5/13/1979	12.9	5/13/1979	USGS, 2009a
GCAE510R		–112.978	36.872	1	5/14/1979	5/14/1979	3.6	na	3.6	5/14/1979	3.6	5/14/1979	USGS, 2009a
GCAE512R	Clastics—coarse	–112.829	36.817	1	5/15/1979	5/15/1979	9.0	na	9.0	5/15/1979	9.0	5/15/1979	USGS, 2009a
GCAE513R	Clastics—coarse	–112.809	36.803	1	5/15/1979	5/15/1979	1.9	na	1.9	5/15/1979	1.9	5/15/1979	USGS, 2009a
GCAE514R		–112.889	36.803	1	5/15/1979	5/15/1979	2.4	na	2.4	5/15/1979	2.4	5/15/1979	USGS, 2009a
GCAF501R	Sandstone	–112.535	36.998	1	5/14/1979	5/14/1979	3.3	na	3.3	5/14/1979	3.3	5/14/1979	USGS, 2009a
GCAF505R	Sandstone	–112.625	36.948	1	5/17/1979	5/17/1979	1.1	na	1.1	5/17/1979	1.1	5/17/1979	USGS, 2009a
GCBA501R	Sandstone	–113.902	36.663	1	5/5/1979	5/5/1979	0.4	na	0.4	5/5/1979	0.4	5/5/1979	USGS, 2009a
GCBA502R	Sandstone	–113.949	36.608	1	5/6/1979	5/6/1979	4.3	na	4.3	5/6/1979	4.3	5/6/1979	USGS, 2009a
GCBD501R		–113.045	36.690	1	5/19/1979	5/19/1979	86.0	na	86.0	5/19/1979	86.0	5/19/1979	USGS, 2009a
GCBD502R		–113.069	36.724	1	5/19/1979	5/19/1979	15.3	na	15.3	5/19/1979	15.3	5/19/1979	USGS, 2009a
GCCA502R	Carbonate	–113.850	36.485	1	5/16/1979	5/16/1979	0.6	na	0.6	5/16/1979	0.6	5/16/1979	USGS, 2009a
GCCA503R	Volcanic rocks—mafic	–113.889	36.423	1	5/16/1979	5/16/1979	2.1	na	2.1	5/16/1979	2.1	5/16/1979	USGS, 2009a
GCCA505R	Volcanic rocks—mafic	–113.953	36.388	1	5/15/1979	5/15/1979	3.9	na	3.9	5/15/1979	3.9	5/15/1979	USGS, 2009a
GCCH501R	Carbonate	–112.247	36.463	1	10/24/1979	10/24/1979	0.0	na	0.0	10/24/1979	0.0	10/24/1979	USGS, 2009a
GCDB501R	Volcanic rocks—mafic	–113.536	36.151	1	5/18/1979	5/18/1979	2.4	na	2.4	5/18/1979	2.4	5/18/1979	USGS, 2009a
GCDB502R	Carbonate	–113.512	36.190	1	5/20/1979	5/20/1979	20.8	na	20.8	5/20/1979	20.8	5/20/1979	USGS, 2009a
GCDE501R		–112.827	36.018	1	5/28/1979	5/28/1979	7.1	na	7.1	5/28/1979	7.1	5/28/1979	USGS, 2009a
GCDG501R		–112.299	36.013	1	5/31/1979	5/31/1979	0.6	na	0.6	5/31/1979	0.6	5/31/1979	USGS, 2009a
Hermit Mine Monitoring Well		–112.751	36.689	26	4/28/1988	11/23/1998	2.6	4.6	0.2	3/3/1994	24.0	12/7/1989	Energy Fuels Nuclear, Inc., 1990b; International Uranium Corp., 1999
MCAA501R	Sandstone	–111.971	36.926	1	5/20/1979	5/20/1979	0.6	na	0.6	5/20/1979	0.6	5/20/1979	USGS, 2009a
Pinenut Mine Monitor Well		–112.735	36.504	26	4/28/1988	10/26/1994	3.8	3.6	0.3	3/11/1994	12.2	9/26/1990	Energy Fuels Nuclear, 1995a

Table 9. Summary information about water samples from mine shafts and sumps analyzed for dissolved uranium from the historical dataset compiled for northern Arizona.

[µg/L, microgram per liter; na, not available; NAD 83, North American Datum of 1983]

Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Number of samples	First sample date	Last sample date	Dissolved uranium average concentration (µg/L)	Standard deviation of average concentration (µg/L)	Minimum reported concentration (µg/L)	Date of minimum concentration sample	Maximum reported concentration (µg/L)	Date of maximum concentration sample	Source of data
Pigeon Mine main sump		–112.531	36.730	1	8/22/1986	8/22/1986	170.0	na	170.0	8/22/1986	170.0	8/22/1986	Dames & Moore, 1987
Hermit Mine shaft		–112.751	36.689	6	8/23/1988	12/8/1989	28.2	7.7	20.7	12/23/1988	42.0	8/23/1988	Energy Fuels Nuclear, Inc., 1995b
Hermit Mine sump		–112.751	36.689	4	6/27/1989	2/6/1990	15,650.0	15575.5	3310.0	6/27/1989	36,600.0	12/8/1989	Canonie Environmental Services Corp., 1991

Historical Uranium Water-Chemistry Data

A dataset of historical water information for the study area was compiled and evaluated with a particular focus on gathering observations of dissolved uranium in water samples. Additional sampling along the Colorado River corridor and in the Kanab Creek drainage was conducted in August and September 2009 to fill in known gaps in data. Information from this combined dataset was evaluated to determine if there are indications that mining affected waters in the study area. The dataset also provides baseline values for comparison during future monitoring activities so that any changes to water quality in the area can be evaluated. Relevant data for locations in and near the study area were compiled from databases, government reports, published scientific literature, graduate theses, and reports and laboratory analyses from environmental consulting firms. Information on a limited number of dissolved metals was included, because they are associated with mineralized breccia pipes in the area. While this dataset is not a verifiably complete set of all data from the study area, it does present a good first-level compilation and evaluation of existing water-quality information for the area and will be amended as new sources of data are located and new samples collected.

Documentation of these data differed in completeness and required some assumptions during compilation and analysis. Differing laboratory methods with differing detection and reporting limits were used for various data sources, making the comparison of data between sources problematic. The limited scope of this study precluded investigation of the quality assurance and quality control methods used either by those collecting and handling the water-quality samples or by the laboratories analyzing the samples, and all data were treated as of equal quality. No statement can be made about the uncertainty associated with the reported data. Field procedures were not documented in some historical studies; therefore, the data compilation used for analyses in this report may combine analytical results from both filtered and unfiltered samples. Additionally, uranium isotope data in two reports (Office of Nuclear Waste Isolation, 1985; Fitzgerald, 1996) were not reported as mass of total uranium but rather in units of activity (pCi). In order to facilitate comparisons with other studies, activities were converted to masses of total uranium by using an activity-to-mass ratio of 0.90 (U.S. Environmental Protection Agency, 2000b). The reader is encouraged to investigate the primary sources of the data used in this report for more information on sample handling, analysis, and reporting (table 10). Uncertainties in sampling locations provided by previous reports may have resulted in this study listing a single site as separate locations. The horizontal datum for sample locations was not always provided. For these cases, the datum was assumed to be NAD27 for all samples collected before 1983 and NAD83 for samples collected in 1983 and afterwards.

Water-quality data were compiled from several sources (table 10) that include dissolved uranium, major ions, and selected metals. Data retrieved from sources listed in table 10 were combined into a single dataset for analyses and presentation. Samples in these datasets were collected from springs, streams, wells, mine shafts, and mine sumps in the area for a variety of purposes, such as water-quality research projects, uranium reconnaissance investigations, surveys for mineralized breccia pipes, and mine permitting documentation. Data from samples collected in the study area were sparse, both spatially and temporally, and time-series data from any site is very limited. The timing and location of water quality information in the area is important, because the potential effects of breccia-pipe uranium mining and other activities may be localized and appear rapidly (for example, a flash flood), or they may be more spatially dispersed during longer timescales (for example, groundwater discharging as springs some distance from mining sites).

Dissolved Uranium

The aqueous geochemistry of uranium is complicated because of the many forms it can assume depending on factors such as pH, redox conditions, and concentrations of other complexing species (Langmuir, 1978). Hexavalent uranium is soluble under oxidizing conditions, forming the highly stable divalent uranyl ion ($[UO_2]^{2+}$) which readily complexes with other anions in solution (particularly carbonate, hydroxyl, and sulfate). Uranium concentrations in oxidized groundwaters commonly range from 0.1 to 10 µg/L (Osmond and Cowart, 1992; Paces and others, 2002). Under reducing conditions, tetravalent uranium remains highly insoluble and concentrations in groundwater are typically much less than 0.1 µg/L. Information on dissolved uranium species is typically unreported in the data sources used in this report. However, the vast majority of uranium concentrations compiled for this study (1,005 of 1,014 analyses; appendix 4) are greater than 0.1 µg/L. Therefore, it is highly likely that groundwater throughout the study area is oxidized and can readily transport uranium in solution.

Dissolved uranium may be transported away from mining locations or ore deposits by water. The investigation of available dissolved uranium analyses produced 1,014 documented water samples with uranium analyses from 428 sites in and near the study area (appendix 4). Of these 1,014 samples, 480 were from 63 stream locations, 385 were from 288 spring locations, 138 were from 74 wells, 6 were from a single mine shaft, and 5 were from 2 mine sumps (the lowest point in a mine shaft into which water drains). Sampling dates ranged from 1963 (stream samples by the USEPA from the Colorado River at Page, Ariz.) to August and September 2009 (spring samples collected by USGS) (fig. 10). Most uranium samples located were collected during the 1990–95 time period, many as part of USGS studies in the area—such as a synoptic water-quality study on the Colorado River in the Grand Canyon in 1990–91 (Taylor and others, 1996). Two USGS studies during the 1975–85 time period also produced a number of documented uranium samples: the National Uranium Resource Evaluation (NURE) Program (Smith, 2006) and a hydrogeochemical survey for mineralized breccia pipes on the Hualapai Reservation (Wenrich and others, 1994).

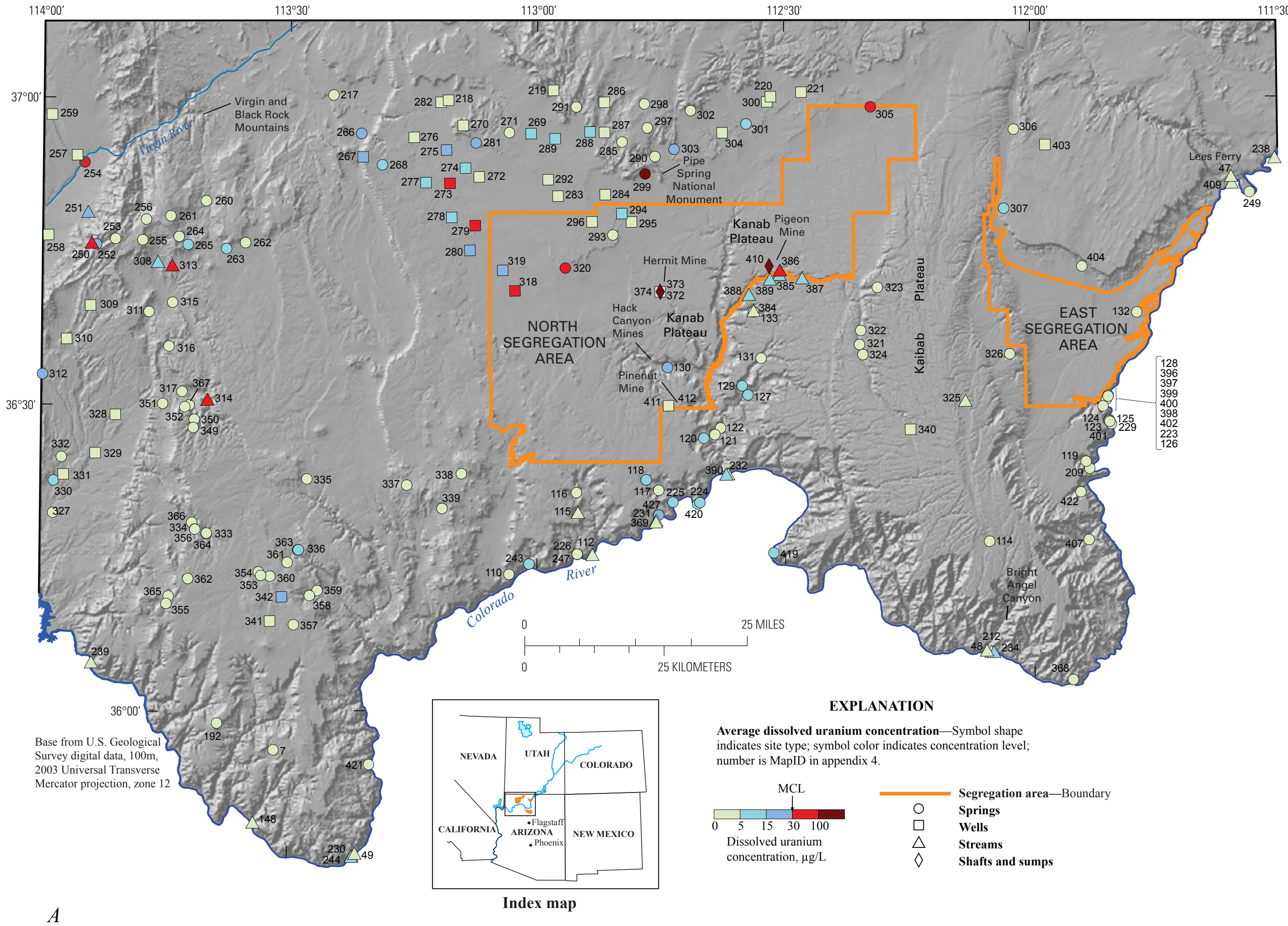

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Figure 9. Average uranium concentration in selected spring, stream, well, mine shaft, and mine sump water samples in the historical dataset for northern Arizona. *A*, Sites located north of the Colorado River. See tables 6–9 and appendix 4 for complete dataset.

In this chapter, if uranium concentrations at a site were reported as less than a reporting limit, then they were assigned a value of one-half the reporting limit for calculation of summary information. This assumption affects observations from 9 wells with reporting limits of 0.002–0.5 µg/L and 3 springs with reporting limits of 0.002–1 µg/L. All uranium observations are listed in appendix 4. Concentrations of dissolved uranium in all water samples in the dataset ranged from less than reporting limits in 12 samples to a high of 36,600 µg/L in the Hermit Mine sump. Figure 11 shows the distribution of uranium concentrations in available natural water samples in the Grand Canyon region of Arizona.

The compilation of uranium data in natural waters (tables 6–8) permits two important observations for the study area. First, it compiles sampling sites whose data may be used to try to determine baseline values. As used in this chapter, baseline refers to a set of observations with which future observations may be compared. Because mining and mineral exploration has occurred in the area for many decades, it is probable that some observations in this dataset are already the result of mining activities and therefore should not be considered background values (that is, natural concentrations in local waters, unaffected by human activities). To determine truly background water values for uranium in the study area, all documented and undocumented mining and exploration activities would need to be fully investigated and then water samples in the dataset classified as likely affected or likely unaffected by these activities. This classification of water samples would require a more-complete understanding of the direction and timing of groundwater flow in the area, particularly north of the Colorado River. Two hypothetical examples may serve to illustrate this point. First, depending on groundwater flow paths, springs emanating at great distances from a mine may have water chemistries that were affected by the mine, whereas springs located near mines may have groundwater that is unaffected by those mines. Second, even if a spring is along the downgradient groundwater flow path of a mine, it may take decades for the water chemistry of a spring to show the effects of mining activities, depending on the rate of groundwater flow. Better information on the complex flow system in the area and geochemical investigations of groundwater may provide insight into the connection between source and observation necessary for determining true background values.

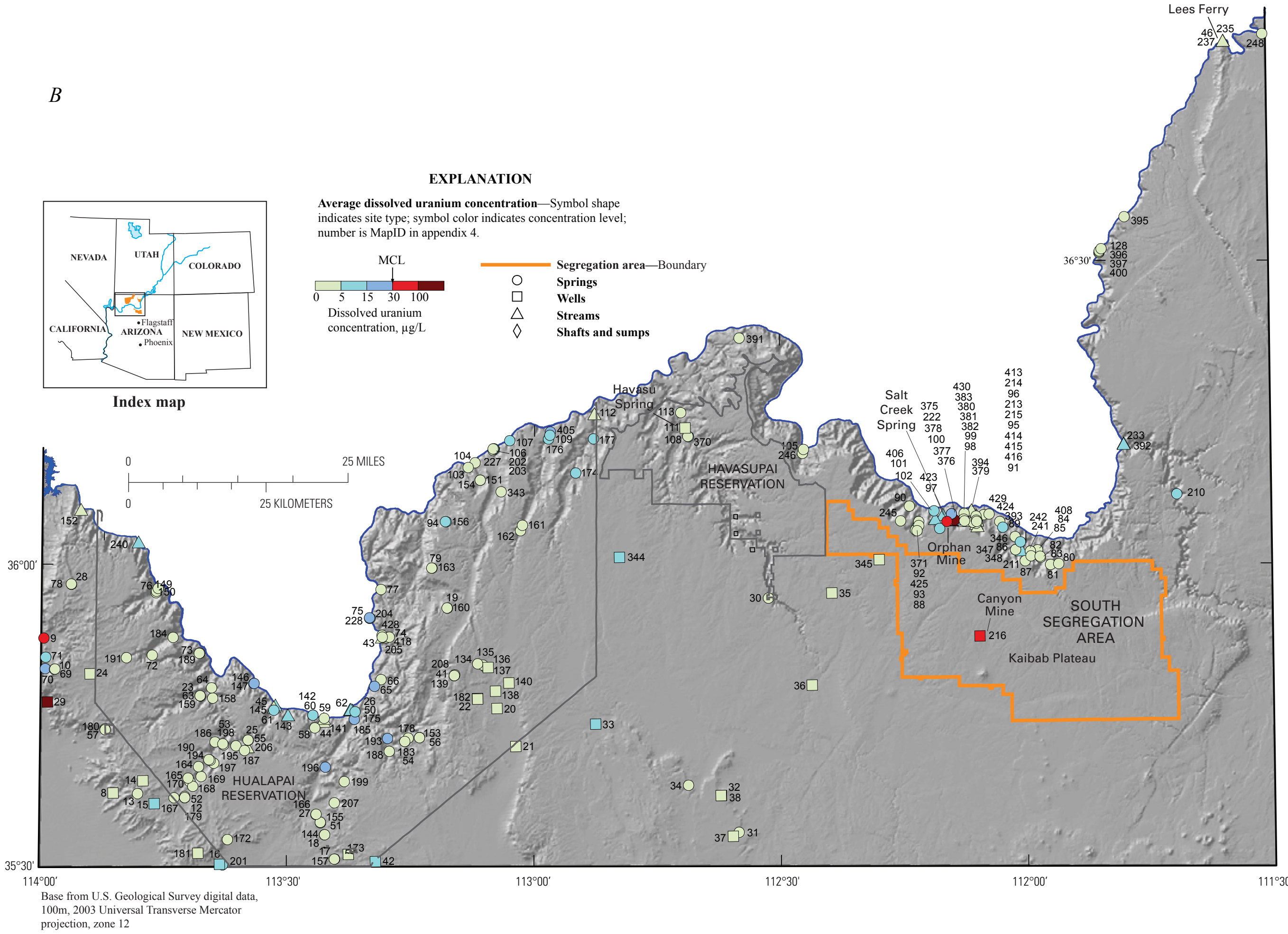


Figure 9—Continued. Average uranium concentration in selected spring, stream, well, mine shaft, and mine sump water samples in the historical dataset for northern Arizona. *B*, Sites located south of the Colorado River. See tables 6–9 and appendix 4 for complete dataset.

The second important utility of the compilation of available uranium observations is that it provides subjective definitions of high, medium, and low uranium concentrations in the study area. Future studies on the effect of uranium mining in the area may have as one hypothesis that uranium concentrations in waters affected by mining will have high values and concentrations in unmined areas will have low values. The majority (66 percent) of natural water sample concentrations in the dataset was 5 µg/L or less (fig. 11), and may be subjectively classified as low concentrations in the study area (although quite high for other aquifers in other parts of the country). Nearly 95 percent of the concentrations in the dataset were 20 µg/L or less (fig. 11), allowing a subjective definition of medium concentration values as 5–20 µg/L. High concentrations may be defined as greater than 20 µg/L; they compose about 5 percent of the observations in the dataset. Some samples with concentrations above this high threshold may be unaffected by anthropogenic activities and, in fact, reflect natural geochemical conditions favorable to elevated dissolved-uranium concentrations.

Quartiles (75th and 25th percentiles) and median uranium concentrations were similar for spring, stream, and well samples in the study area (fig. 12); they have median values of 2.8, 4.6, and 2.4 µg/L, respectively. Maximum uranium observations ranged from 309 to 400 µg/L for these sample types. Shaft and sump water, although based on many fewer observations, produced higher ranges of uranium concentrations; medians were 25 and 4,290 µg/L, respectively (fig. 13).

Nearly 95 percent of all spring samples have uranium concentrations less than the USEPA maximum contaminant level (MCL) of 30 µg/L; most (72 percent) are less than 5 µg/L (figs. 9, 12, table 7). Notable exceptions include the Horn Creek and Horn Spring samples collected in 1994–95 by Fitzgerald (1996) and the Horn Up and Horn West sites sampled by in 2002 Liebe (2003), all within Grand Canyon National Park. Horn Creek and Horn Spring were sampled three times in 1994–95; concentrations ranged from 18.9 to 67.8 µg/L (appendix 4). The Horn Up site was sampled four times in June and July 2002; concentrations ranged from 312 to 400 µg/L (appendix 4). Two samples from the Horn West site, both collected in July 2002, had uranium

Table 10. Sources of data and types of samples used to compile historical dissolved uranium data for northern Arizona used in this study.

Data source	Type of sample
Canonie Environmental Services Corp., 1991, Water Quality Data Evaluation Report, 33 p.	Mine sump
Dames & Moore, 1987, Hermit Mine ground-water conditions Mohave County, Arizona: submitted to Energy Fuels Nuclear, Inc., Denver, Colorado, March 20, 1987.	Mine sump
Energy Fuels Nuclear Inc., 1990a, Hermit Mine groundwater monitoring report mining and post mining phase: Denver, Colorado.	Spring
Energy Fuels Nuclear, Inc., 1990b, Hermit Mine groundwater monitoring report mining phase: submitted to Arizona Department of Environmental Quality, Denver, Colorado, February 12, 1990.	Well
Energy Fuels Nuclear, Inc., 1990c, Letter report to Abigail A. Myers, Arizona Department of Environmental Quality, from William J. Almas re: Hermit Mine Groundwater Protection Permit No. G–0035–08: Denver, Colorado, March 7, 1990.	Well
Energy Fuels Nuclear, Inc., 1995a, Arizona aquifer protection permit application Pinenut Mine: Denver, Colorado.	Well
Energy Fuels Nuclear, Inc., 1995b, Arizona aquifer protection permit closure plan Hack Canyon Mine: Denver, Colorado.	Mine shaft
Errol L. Montgomery and Assoc., 1993a, Aquifer protection permit application Energy Fuels Nuclear, Inc., Canyon Mine, Coconino County, Arizona: December 1993 Final Report.	Well
Errol L. Montgomery and Assoc., 1993b, Data for Canyon Mine Groundwater Monitoring Program Reference N2219 (GRCA–8213): Annual Letter Report to Grand Canyon National Park, 16 tables.	Spring
Fitzgerald, Jim, 1996, Residence time of groundwater issuing from the South Rim Aquifer in the eastern Grand Canyon: Las Vegas, University of Nevada, M.S. thesis, 103 p.	Spring, stream
Hopkins, R.T., Fox, J.P., Campbell, W.L., Antweiler, J.C., 1984a, Analytical results and sample locality map of stream-sediment, panned-concentrate, rock, and water samples from the Andrus Canyon, Grassy Mountain, Last Chance Canyon, Mustang Point, Nevershine Mesa, Pigeon Canyon, and Snap Point Wilderness Study Areas, Mohave County, Arizona: U.S. Geological Survey Open-File Report 84–288, 34 p.	Spring
Hopkins, R.T., Fox, J.P., Campbell, W.L., Antweiler, J.C., 1984b, Analytical results and sample locality map of stream sediment, panned-concentrate, soil, and rock samples from the Kanab Creek (B3060) Roadless Area, Coconino and Mohave counties, Arizona: U.S. Geological Survey Open-File Report 84–291, 18 p.	Stream
International Uranium Corp., 1999, Letter report to Craig Dewalt, Arizona Department of Environmental Quality, from Donn M. Pillmore, January 29, 1999.	Well
Liebe, Dirk, 2003, The use of the $^{234}U/^{238}U$ activity ratio at the characterization of springs and surface streams in Grand Canyon National Park, Arizona: Dresden, Saxony, Germany, Hochschule fur Technik und Wirtschaft Dresden, M.S. thesis, 105 p.	Spring, stream
Monroe, S.A., Antweiler, R.C., Hart, R.J., Taylor, H.E., Truini, Margot, Rihs, J.R., and Felger, T.J., 2005, Chemical characteristics of ground-water discharge along the south rim of Grand Canyon in Grand Canyon National Park, Arizona, 2000–2001: U.S. Geological Survey Scientific Investigations Report 2004–5146, 59 p.	Spring, stream
Office of Nuclear Waste Isolation, 1985, Marble Canyon Spring sampling investigation: Technical Report BMI/ONWI–514, 62 p.	Spring
Peterson, J.E., Buell, S.E., Cadigan, R.A., Felmlee, J.K., and Sprakis, C.S., 1977, Uranium, radium and selected metallic-element analyses of spring water and travertine samples from the Grand Canyon, Arizona: U.S. Geological Survey Open-File Report 77–36, 7 p.	Spring
Taylor, H.E., Peart, D.B., Antweiler, R.C., Brinton, T.I., Campbell, W.L., Garbarino, J.R., Roth, D.A., Hart, R.J., and Averett, R.C., 1996, Data from synoptic water-quality studies on the Colorado River in the Grand canyon, Arizona, November 1990 and June 1991: U.S. Geological Survey Open-File Report 96–614, 175 p.	Stream
Taylor, H.E., Berghoff, K., Andrews, E.D., Antweiler, R.C., Brinton, T.I., Miller, C., Peart, D.B., and Roth, D.A., 1997, Water quality of springs and seeps in Glen Canyon National Recreation Area: National Park Service Technical Report NPS/NRWRD/NRTR–97/128, 26 p.	Springs

Table 10. Sources of data and types of samples used to compile historical dissolved uranium data for northern Arizona used in this study.—Continued

Data source	Type of sample
Taylor, H.E., Spence, J.R., Antweiler, R.C., Berghoff, K., Plowman, T.I., Peart, D.B., and Roth, D.A., 2004, Water quality and quantity of selected springs and seeps along the Colorado River Corridor, Utah and Arizona: Arches National Park, Canyonlands National Park, Glen Canyon National Recreation Area, and Grand Canyon National Park, 1997–98: U.S. Geological Survey Open-File Report 2003–496, 33 p.	Spring
U.S. Environmental Protection Agency Region VIII, 1973, Radium-226, uranium and other radiological data from water quality surveillance stations located in the Colorado River Basin of Colorado, Utah, New Mexico and Arizona—January 1961 through June 1972, 155 p.	Stream
U.S. Geological Survey, 2009a, Mineral Resources On-Line Spatial Data: Geochemistry of water samples in the U.S. from the NURE–HSSR database, accessed November 4, 2009, at *http://tin.er.usgs.gov/nure/water/*.	Spring, stream, well
U.S. Geological Survey, 2009b, National Water Information System (NWISWeb): U.S. Geological Survey database, accessed October 16, 2009 at *http://waterdata.usgs.gov/nwis/*.	Spring, stream, well
Wenrich, K.J.; Boundy, S.Q.; Aumente-Modreski, R.M.; Schwarz, S.P.; Sutphin, H.B.; Been, J.M., 1994, A hydrogeochemical survey for mineralized breccia pipes—Data from springs, wells, and streams on the Hualapai Indian Reservation, northwestern Arizona: U.S. Geological Survey Open-File Report 93–619, 66 p.	Spring, stream, well

concentrations of 135 and 202 µg/L (appendix 4). Other spring samples reported by USGS with elevated uranium concentrations include sample GCAE517R collected by the NURE project in 1979 near Pipe Spring National Monument (250 µg/L), and samples 23168 and 23169 collected by the NURE project in 1978 just south of the Hualapai Reservation (57 and 51 µg/L, respectively; appendix 4, table 7). In all, water collected from 15 of the 288 spring sites had uranium concentrations greater than or equal to 30 µg/L, and nearly all observations were in the NURE (U.S. Geological Survey, 2009a), Fitzgerald (1996), and Liebe (2003) studies.

Uranium concentrations were reported for several stream samples from the Colorado River, mostly from locations near Lees Ferry, Grand Canyon National Park near Bright Angel Canyon, and on the Hualapai Reservation (fig. 9; table 6). A few other samples were located on tributaries to Kanab Creek and near the Virgin River in the northwest portion of the study. The Horn Down site (Liebe, 2003) had the highest stream concentration in the dataset at 362 µg/L. Presumably, this stream is fed by groundwater discharge from the high-concentration Horn Creek Spring and Horn Up and Horn West springs noted earlier. Most other stream samples near the Colorado River near Bright Angel Canyon in the national park were 5 µg/L or less. All stream samples reported for locations on or near the Hualapai Reservation were 10 µg/L or less. Two other stream samples of note are in the northwest portion of the study area near the Virgin and Black Rock Mountains (plate 1; fig. 9A). These two samples, GCAA006R and GCBB004R, both collected by NURE in 1979, had uranium concentrations of 87 and 88 µg/L, respectively (fig. 9*A*) (U.S. Geological Survey, 2009a).

A small number of water samples from wells also had elevated uranium concentrations. The highest is from the Canyon Mine Well on the Kaibab Plateau (appendix 4, figs. 9*B*, 12, 14, table 8). Eleven samples reported from this well had concentrations ranging from 4.1 µg/L in 1987 to 309 µg/L in 1989. Concentrations in 9 of the 11 Canyon Mine Well samples were less than 20 µg/L. Hermit Mine Monitoring Well produced 26 reported observations, all but one less than 7 µg/L; the exception was 24.0 µg/L in December, 1989. Twenty-six reported observations from the Pinenut Mine Monitoring Well were all less than 13 µg/L (appendix 4). Four other wells that were sampled between 1977 and 1979 for the NURE investigation had values above 30 µg/L: samples GCAD505R (32 µg/L), GCAD511R (33 µg/L), and GCBD501R (86 µg/L), all from the Kanab Plateau; and sample 23032 (110 µg/L) from the southwest part of the study area (fig. 9B) (U.S. Geological Survey, 2009a).

Mine shaft and sump samples were located on mining property on the Kanab Plateau and, unsurprisingly, have elevated dissolved-uranium concentrations (appendix 4, table 9). Water samples collected in the Hermit Mine shaft for

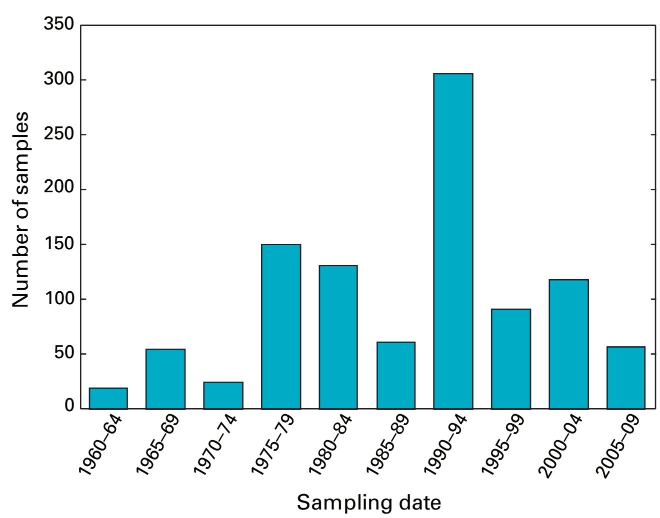


Figure 10. Number of dissolved uranium samples collected during 5-year intervals from 1960 to 2009 in northern Arizona.

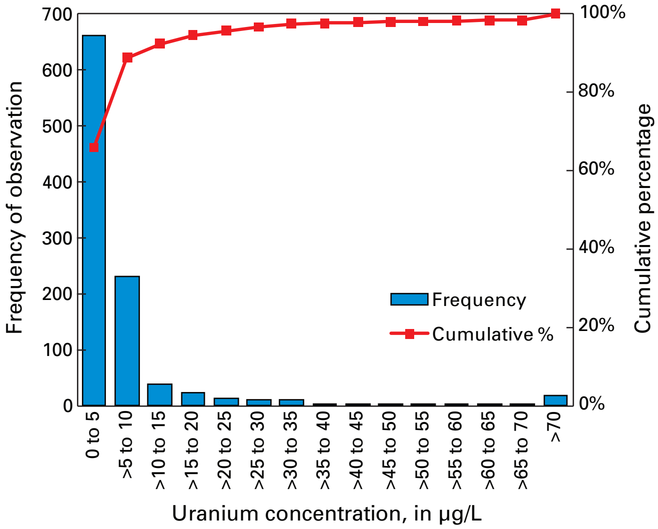


Figure 11. Frequency and cumulative distribution of uranium concentrations in all spring, stream, and well-water analyses from historical dataset for northern Arizona, appendix 4.

the Arizona Department of Environmental Quality in 1988 and 1989 range from 20 to 42 µg/L (Energy Fuels Nuclear, 1995b). Higher uranium concentrations were reported for similar samples from the Hermit and Pigeon Mine sumps. The Pigeon Mine sump had a single reported value of 170 µg/L in 1986, and the Hermit Mine sump concentrations ranged from 3,310 to 36,600 µg/L (the highest reported value of any sample type in this study) in 1989–90 (figs. 9*A*, 13). These high-concentration mine shaft and sump waters may be sources of dissolved uranium for nearby sites if mine water is capable of entering the regional groundwater flow system.

The large number of historical analyses of both spring and well samples allows for comparison of uranium concentrations from areas north and south of the Colorado River (figs. 9, 14). Maximum observations were greater for springs and wells south of the river compared with observations from north of the river. The 90th and 75th percentiles and median observations for spring data were similar for samples from north (17.7, 5.4, and 2.1 µg/L, respectively) and south (18.5, 6.1, and 3 µg/L, respectively) of the river. Well observations had similar 90th percentiles and means for north (14.2 and 2.4 µg/L, respectively) and south (15.5 and 2.3 µg/L, respectively) locations, but south wells had a higher 75th percentile observation at 8.7 µg/L compared with 6.1 µg/L for north wells.

Consistent temporal water sampling is essential for determining trends and observing potential effects on water quality of mining and other activities; however, only very limited temporal data were available for this study. Three wells at Canyon, Hermit, and Pinenut Mines, 6 spring sites, and 3 stream locations had more than two observations that spanned at least one year (fig. 15). Dissolved uranium concentrations in the wells are mostly less than 20 µg/L. Three exceptions are a single observation of 24 µg/L from the Hermit Mine Well in December 1989 and observations of 65 µg/L in December 1987 and 309 µg/L in May 1989 at the Canyon Mine Well (fig. 15). Dissolved uranium concentrations at both the Hermit Mine and Canyon Mine Wells returned to less than 20 µg/L after these peak observations. Two stream sampling sites on the Colorado River near Lees Ferry, Ariz., present dissolved uranium data for different time periods. The "Colorado River at Page" line graph (fig. 15) contains observations from May 1963 through May 1972; early observations (through June 1965) were around 9–10 µg/L and later observations were around 5–6 µg/L, except for a spike of 16 µg/L in May 1972, the last observation in the record (fig. 15). The record for nearby site 09380000 (Colorado River at Lees Ferry; fig. 15) extends from January 1996 through June 1998 and consistently records observations of 3–4 µg/L. The temporal dissolved uranium data from springs are consistently less than 10 µg/L with two exceptions, Horn Creek Spring and Havasu Spring. Horn Creek Spring has values that range from 19 to 67 µg/L (fig. 15). Horn Creek Spring is located in the same drainage and downgradient from the Orphan Mine. Several investigators have linked the elevated dissolved uranium in Horn Creek and Salt Creek with the Orphan breccia pipe or with mining activity in the area (Fitzgerald, 1996; Monroe and others, 2004; Grand Canyon National Park, 2006; Bills and others, 2007). Havasu Spring has dissolved uranium concentrations that are typically 5 µg/L or less; however several samples measured in 1985 and again in 1989–90 may have had values between 7 and 12 µg/L (duplicate data from same-day samples were less than 5 µg/L).

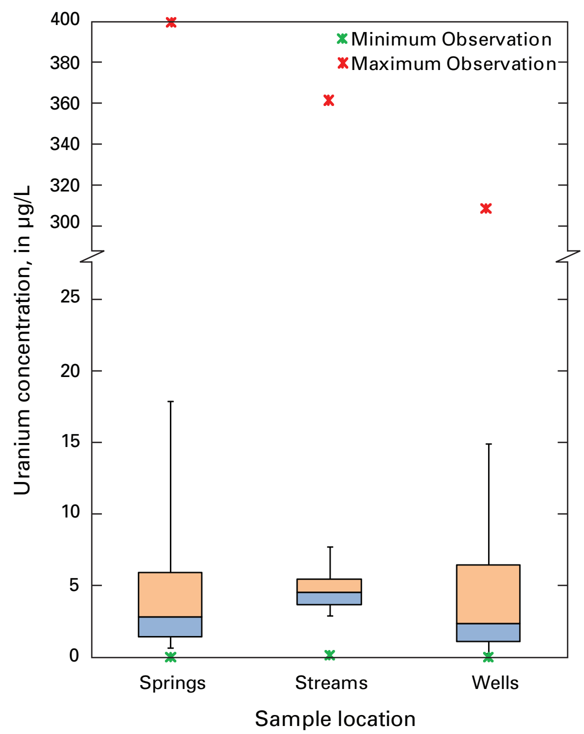


Figure 12. Dissolved uranium concentrations in water samples from springs, streams, wells, and mine shafts from historical dataset for northern Arizona, appendix 4. Upper and lower whiskers represent 90th and 10th percentiles, respectively. Upper, middle, and lower lines on box represent the 75th percentile, median, and 25th percentile, respectively. Note broken concentration axis.

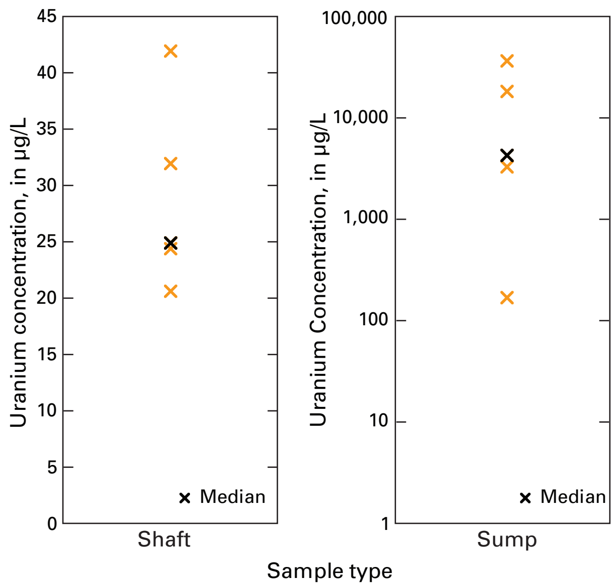


Figure 13. Dissolved uranium concentrations in water samples from mine shafts (left panel) and mine sumps (right panel) in historical dataset for northern Arizona, appendix 4. Note logarithmic scale for concentration axis on mine sump plot.

Selected Dissolved Metals

Other metals are associated with uranium in mineralized breccia pipes including silver, arsenic, barium, cadmium, cobalt, copper, mercury, molybdenum, nickel, lead, antimony, strontium, vanadium, and zinc. However, these metals do not necessarily correlate with dissolved uranium in groundwater, owing to differences in aqueous solubilities and the possible presence of complexing anions (Wenrich and others, 1994). The historical dataset was evaluated for arsenic, molybdenum, mercury, and silver at concentrations exceeding USEPA maximum contaminant levels or lifetime health advisory level in the case of molybdenum (U.S. Environmental Protection Agency, 2004). Available data for silver ≥100 µg/L, mercury ≥2.0 µg/L, molybdenum ≥40 µg/L, and lead ≥15 µg/L indicate that few samples in the study area exceed these concentrations (fig. 8, table 5). Elevated lead concentrations were reported at the Hermit Mine sump and monitoring well (40 and 150 µg/L in 1990 and 1988, respectively) and at the Pinenut Mine monitoring well (110 µg/L in 1988), all on the Kanab Plateau. The highest lead concentrations were reported in Virgin River samples in the northwestern portion of the study area (fig. 8). Two observations of 500 µg/L and a single observation of 600 µg/L were reported from this area in June 1979. Although these water samples were collected using a pre-1990 USGS sampling protocol that may have resulted in contamination of the water sample, similar results are reported for samples collected days later. Five mercury exceedances were found in the dataset; the reported high is 3.8 µg/L in both a stream sample from site 09380000 (Colorado River at Lees Ferry) and a spring sample from site 353713113421800 (Milkweed Spring) (fig. 8, table 5). Water samples with elevated molybdenum concentrations are more widely distributed in the study area. Higher concentrations were reported in spring sample GCAE517R (191 µg/L) on the Kaibab-Paiute Reservation, in well sample 23080 (129.4 µg/L) just southeast of the Hualapai Reservation, in spring sample 23077 (100 µg/L) in Cataract Canyon at the southern end of the Havasupai Reservation, and in well sample GCAD505R (97 µg/L) near the northwest corner of the North Segregation Area (fig. 8, table 5). Although no silver samples were reported above the MCL, a value of 80 µg/L was reported in Havasu Spring (Errol Montgomery and Associates, 1993b).

A number of water samples within the study area contained arsenic concentrations exceeding the EPA MCL of 10 µg/L (fig. 16, appendix 3). Twelve well samples had concentrations above 100 µg/L, all along the south rim of the Grand Canyon. The highest was reported from sample 23014 (301 µg/L); the sample locality is just southwest of the Hualapai Reservation. Twenty-two spring samples had concentrations above 100 µg/L: 16 on the south rim of the Grand Canyon and 6 near the Virgin Mountains north of Lake Mead. Spring sample 77A–W82 (Pumpkin Spring) on the Hualapai Reservation had the highest arsenic concentration of 350 µg/L (fig. 16, appendix 3). Elevated arsenic concentrations were also noted in stream samples from the Hualapai Reservation; the three highest concentrations were in samples 43536 (175 µg/L), 43540 (178 µg/L) and 43538 (310 µg/L) (fig. 16, appendix 3).

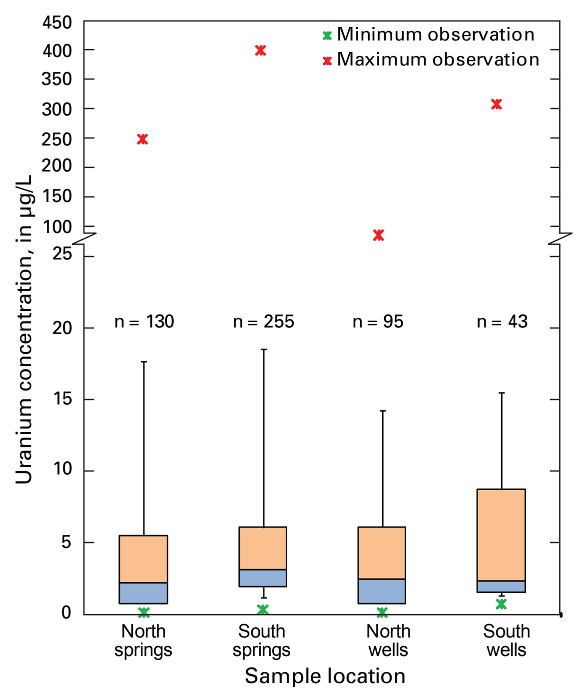


Figure 14. Range of dissolved uranium concentrations in water samples from springs and wells in historical dataset for northern Arizona, appendix 4, in relation to location north and south of Colorado River. Upper and lower whiskers represent 90th and 10th percentiles, respectively. Upper, middle, and lower lines on box represent the 75th percentile, median, and 25th percentile, respectively. Note broken concentration axis.

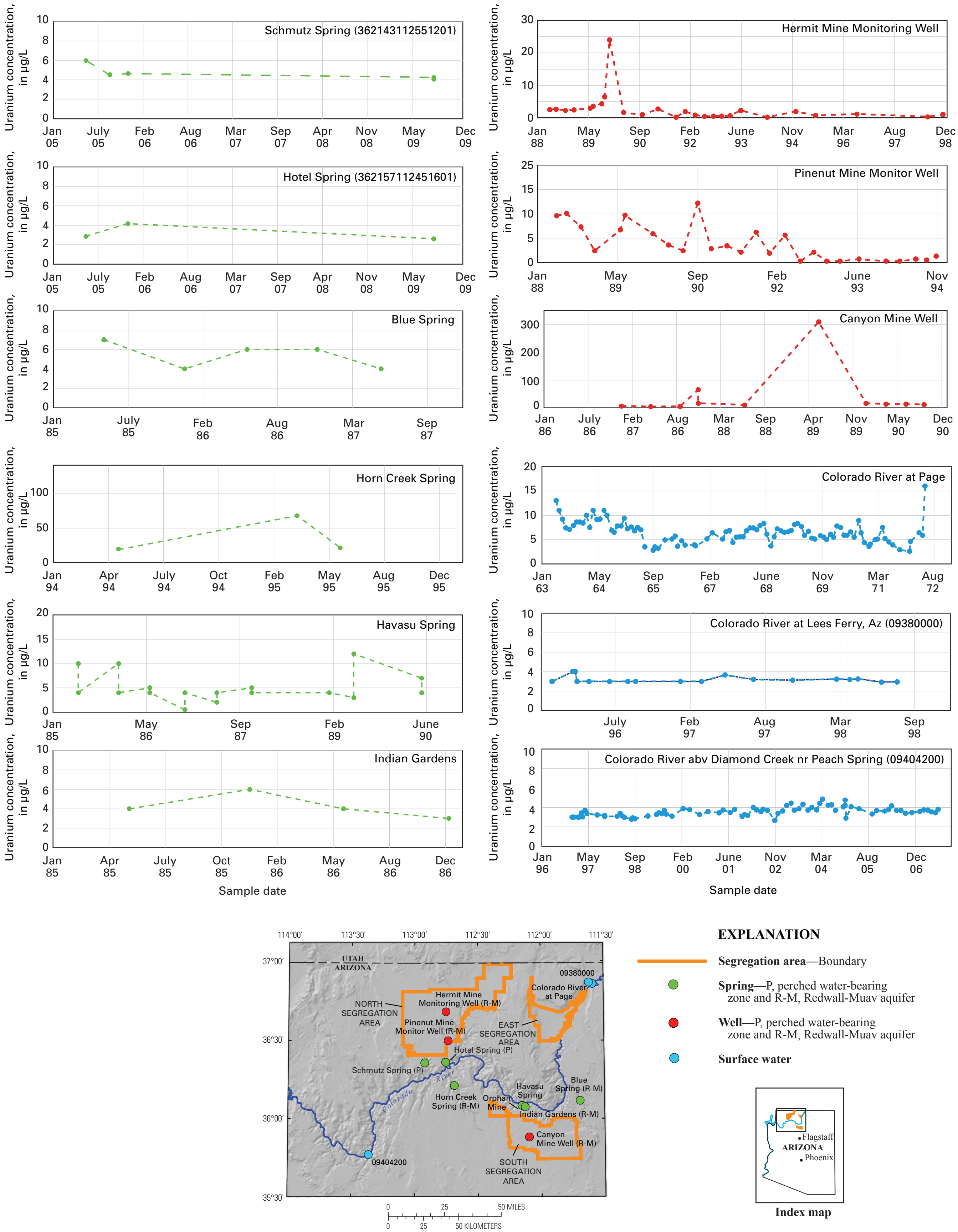


Figure 15. Variation in uranium concentration with time for selected springs, streams, and wells in the historical dataset for northern Arizona, appendix 4.

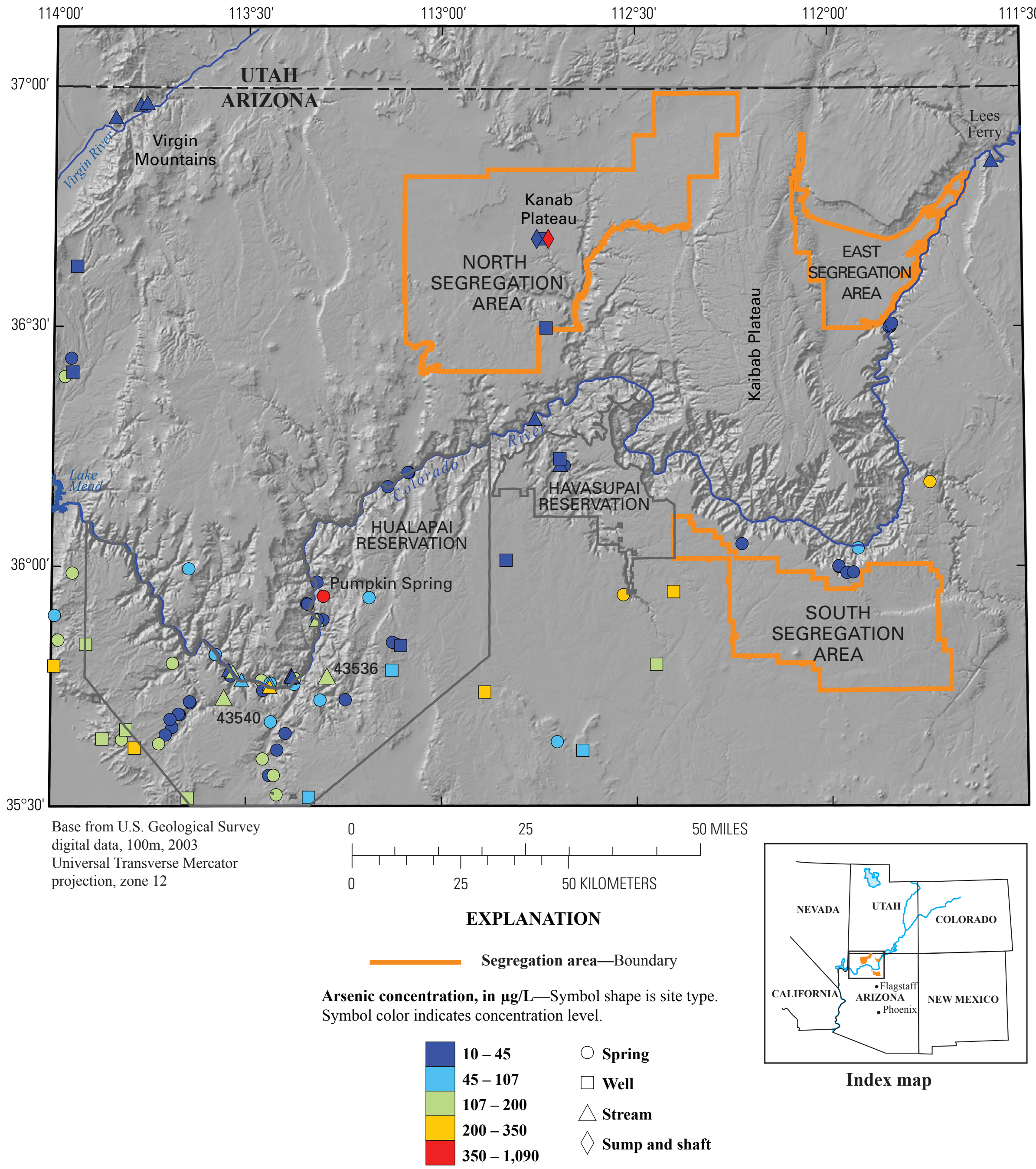


Figure 16. Selected spring, stream, well, and sump sites from the historical dataset, appendix 3, at which concentrations of arsenic exceed U.S. Environmental Protection Agency maximum contaminant level of 10 µg/L. For sites at which more than one sample exceeded 10 µg/L, the maximum value is plotted.

2009 Groundwater Samples

Groundwater samples were collected at 24 sites in the study area during August–September 2009 (fig. 17) to augment the historical dataset and to provide additional information for evaluation of variations in groundwater chemistry by geographic region, groundwater source, and mining condition (fig. 7, appendix 2). Sample collection sites were geographically located in the northern part of the Marble platform, the lower Kanab Creek drainage, and the Havasu drainage (figs. 4, 17). The samples represent groundwater from either the Redwall-Muav aquifer or perched water-bearing zones in the Coconino Sandstone and sandstones of the Supai Group (appendix 2). Sites were also categorized on the basis of mining conditions of the surface drainage basin in which the site is located; the three mining categories were no mines, reclaimed mines, or active mines that are on standby (appendix 2). All sites sampled were in areas that contain uranium orebodies associated with breccia pipes, and for the latter two classes the mines are associated with extracting uranium ore from breccia pipes.

For comparison of groundwater-chemistry data by geographic region and groundwater source, it is necessary to be certain that each site was classified correctly. For sites associated with active or reclaimed mines, however, it not known with certainty that the groundwater sampled at each site actually flowed past and had opportunity to be affected by the mining activity. For this reason it is vital that comparison of groundwater-chemistry data by mining condition be considered strictly an exploratory assessment that needs further sampling and evaluation to determine if there is a relationship.

Table 11 lists the 24 groundwater sites sampled in 2009 and their geographic region, groundwater source, and mining condition (see also fig. 17). To facilitate comparison of the water-chemistry data, the ranks for selected trace-element concentrations reported in appendix 2 are also presented in this table. Only one site was available in the Havasu Creek drainage, the Canyon Mine Well; consequently, comparison of geographic regions is limited to the Marble platform and the Kanab Creek drainage. The three sites in areas with reclaimed mines—Slide, Rock, and Willow Springs (fig. 17)—are potentially downgradient and affected by the reclaimed Pigeon and Hack Mines. Five sites in areas with active mines in the Kanab Creek drainage—Pinenut Well and Hotel, Kanab, Showerbath, and Side Canyon Springs (figs. 9*A*, 17)—are potentially downgradient and affected by the Kanab North Mine, Arizona 1 Mine, and Pinenut Mine.

In addition to major ion and trace elements, the 2009 samples were analyzed for strontium, uranium, radium, carbon, tritium, and oxygen-deuterium isotopes (appendix 2). These isotopic data provide information on groundwater-recharge sources, rock-water interactions affecting groundwater along the flow path, and the length of time during which groundwater flowed from recharge areas to the point of discharge. The work-scope and tight schedule for this report, however, precluded a detailed analysis of and integration of information learned from the isotopes into the analysis of variations in major ions and trace elements. The work-scope and tight schedule also precluded an advanced statistical or geochemical evaluation of the major ion and trace element data.

Major Ions and Trace Elements

Major ions and trace elements dissolved in water are derived from water-rock interactions during recharge and from flow within the aquifer. Aquifer-rock composition differs on local and regional scales and, therefore, water composition also differs spatially. This section presents major ion and trace metal concentration variations by geographic region, groundwater source, and mining condition.

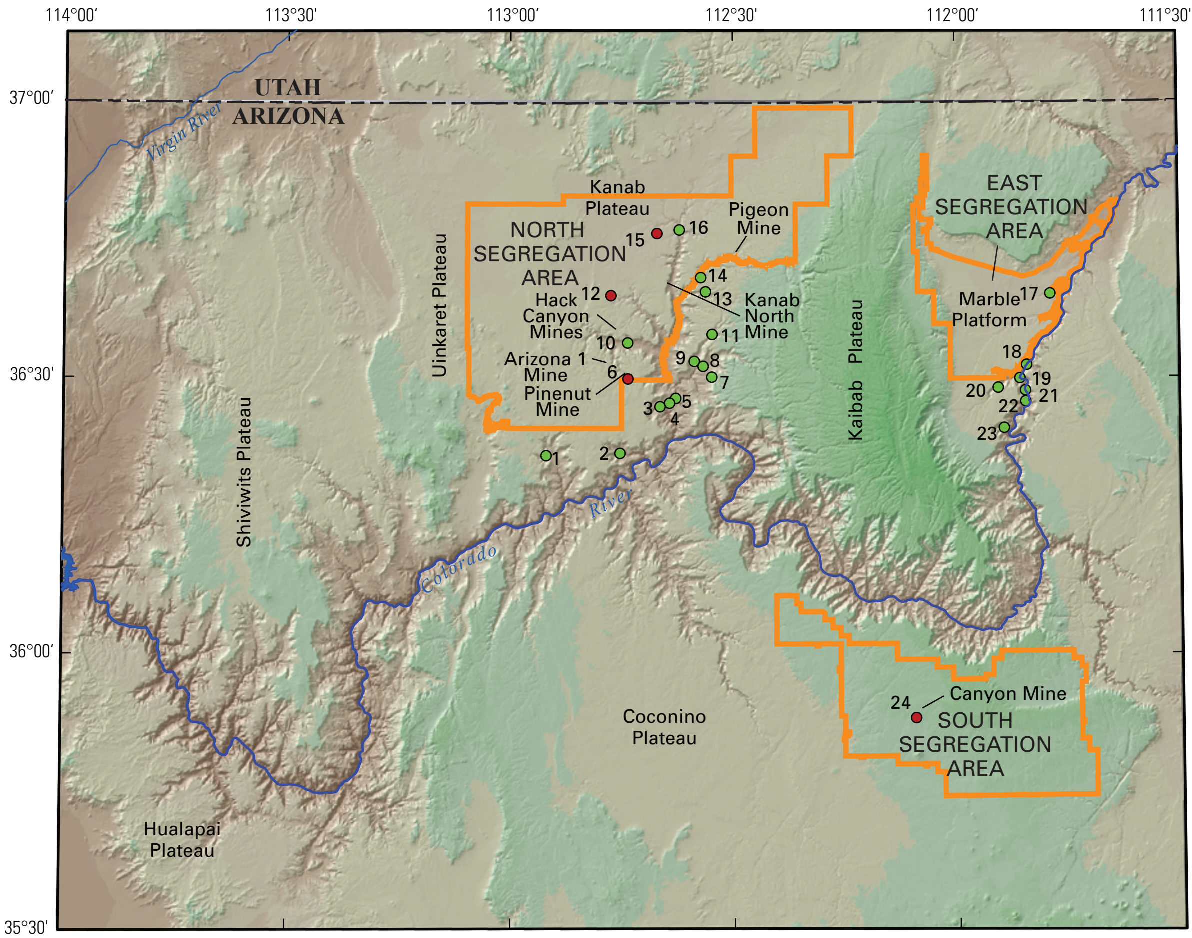
Major Ions

The composition of major ions and their total concentration, as measured by specific conductance, differs by geographic region and by groundwater source. Overall, the major ions composing groundwater at the 24 sites sampled in 2009 (fig. 18) had varying proportions of calcium, magnesium, bicarbonate, and sulfate (fig. 18). High concentrations of sulfate were common; the USEPA secondary maximum contaminant level for sulfate in drinking water (250 mg/L) was exceeded in samples from 15 sites (appendix 2). Specific conductance values ranged from 303 to 3,570 µS/cm (appendix 2).

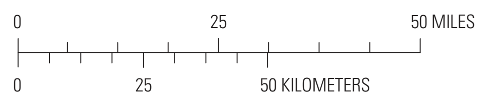
Groundwater from the Marble platform (fig. 18), which is typically of calcium-magnesium-sulfate composition, tended to have the lowest specific conductance (appendix 2; fig. 18; table 11). Fence Spring and Rider Spring (fig. 17), however, have higher specific conductance and larger contributions to the water composition from sodium and chloride than other sites in the Marble platform. Groundwater from the Kanab Creek drainage tends to have a higher specific conductance than groundwater from the Marble platform, and it is enriched in sulfate (appendix 2, fig. 18, table 11).

The specific conductance and contributions of sulfate to water composition are typically greater in perched water-bearing zones than in the Redwall-Muav aquifer (appendix 2; fig. 18). Groundwater with relatively high amounts of sulfate may result from the dissolution of gypsum from the overlying Moenkopi Formation or from dissolution of sulfides in ore deposits (Wenrich and others, 1994; Billingsley and others, 2006).

Characteristics of major ions differ widely in groundwater samples from sites without mining activities, which indicates that this variation is natural. The highest (Burnt Canyon Well, fig. 17) and lowest (Hole in the Wall Spring) specific conductance values (appendix 2) observed in the 2009 samples were from sites without mining activities. Consequently, specific conductance values for sites in basins with active mines or reclaimed mines fall within the range of values observed for sites in basins without mines. For sites within the Kanab Creek drainage, no systematic change in major ion characteristics was noted for different mining conditions (appendix 2, fig. 18, table 11).



Base from U.S. Geological Survey digital data, 100m, 2003
Universal Transverse Mercator projection, zone 12



Index map

EXPLANANTION

Segregation area—Boundary

Spring sampled

Well sampled

1 Schmutz Spring
2 Hotel Spring
3 Side Canyon Spring
4 Showerbath Spring
5 Kanab Spring
6 Pinenut Well
7 27 Mule Spring
8 Mountain Sheep Spring
9 Below Lower Jumpup Spring
10 Willow Spring
11 Upper Jumpup Spring
12 Tom Land Well
13 Slide Spring
14 Rock Spring
15 Burnt Canyon Well
16 Clearwater Spring
17 Rider Spring
18 Fence Spring
19 Vasey's Paradise
20 South Canyon Spring
21 Hanging Spring
22 No Name Spring
23 Buck Farm Spring
24 Canyon Mine Well

Figure 17. Well and spring sites in or near segregation areas of northern Arizona where water samples were collected in 2009.

Table 11. Relative rank of concentrations of selected trace elements from spring-water and well-water samples collected in 2009 in northern Arizona.

[Samples collected in August and September 2009; number indicates rank of data; a rank of 1 indicates highest concentrations; larger values indicate smaller concentrations. --, sample not analyzed for that constituent; H, Havasu Creek drainage; K, Kanab Creek; M, Marble Platform; AM, active mine; NM, not mined; RM, reclaimed mine; DO, dissolved oxygen; P, perched water-bearing zones in Coconino Sandstone and sandstones in the Supai Formation; R, Redwall-Muav aquifer; SC, specific conductance]

Spring or well	Geo-graphic region	Ground-water source	Mining condi-tion	Uranium	Silver	Arsenic	Barium	Cadmium	Cobalt	Copper	Mercury	Molybdenum	Nickel	Lead	Antimony	Strontium	Vanadium	Zinc	DO	pH	SC
Buck Farm Spring	M	R	NM	15	1	19	8	16	--	8	--	16	--	--	2	18	2	19	11	8	17
Fence Spring	M	R	NM	18	1	1	7	5	--	8	--	18	--	--	5	14	6	10	15	22	8
Hanging Spring	M	R	NM	21	1	6	--	16	--	8	--	21	--	--	--	22	8	19	8	4	20
Hole in the Wall Spring	M	R	NM	22	1	7	2	16	--	8	--	21	--	--	--	21	8	19	3	8	22
No Name Spring	M	R	NM	23	1	7	1	16	--	8	--	21	--	--	--	22	8	19	7	7	21
Vasey's Paradise	M	R	NM	24	--	17	3	24	--	8	--	24	--	--	--	24	--	--	1	1	--
South Canyon Spring	M	P	NM	20	--	12	5	8	2	5	--	18	7	3	12	20	7	17	2	3	--
Rider Spring	M	P	NM	10	1	5	20	3		8	--	2	--	--	--	12	15	19	5	2	11
Clearwater Spring	K	P	NM	19	--	15	12	8	2	6	12	14	7	13	19	4	21	12	24	8	5
Upper Jumpup Spring	K	P	NM	12	1	20	15	8	2	8	7	9	7	10	14	13	13	6	15	11	16
Lower Jumpup Spring	K	P	NM	6	14	14	9	8	2	24	10	8	7	9	7	7	4	14	18	21	7
Mountain Sheep Spring	K	P	NM	5	--	16	13	7	2	4	14	17	7	8	11	10	5	13	8	19	9
Schmutz Spring	K	P	NM	11	1	9	18	16	2	8	9	6	7	14	18	8	17	11	12	11	10
Burnt Canyon Well	K	P	NM	13	--	2	22	1	14	3	1	13	4	--	6	2	23	2	22	24	1
Tom Land Well	K	P	NM	1	--	23	23	2	14	2	5	12	1	2	13	5	19	1	20	22	2
Hotel Spring	K	P	AM	16	1	3	6	16	1	7	2	7	5	6	1	17	1	18	3	4	14
Kanab Spring	K	R	AM	8	1	10	10	8	2	8	13	10	7	4	3	16	14	4	8	17	15
Showerbath Spring	K	R	AM	9	1	13	11	8	2	8	11	10	7	11	4	15	12	7	14	19	18
Side Canyon Spring	K	R	AM	7	1	11	14	16	2	8	14	4	7	12	10	9	16	9	17	11	12
Pinenut Well	K	R	AM	17	--	4	15	4	14	8	3	1	2	5	8	6	20	15	22	16	6
Slide Spring	K	P	RM	14	--	21	17	8	2	8	6	15	7	16	16	11	11	5	21	14	13
Rock Spring	K	P	RM	4	--	22	19	8	2	8	14	5	7	15	9	3	18	16	5	--	--
Willow Spring	K	P	RM	2	--	18	20	16	2	23	8	3	6	7	17	1	3	8	13	--	--
Canyon Mine Well	H	R	AM	3	1	24	4	6	14	1	4	20	3	1	15	19	22	3	19	--	--

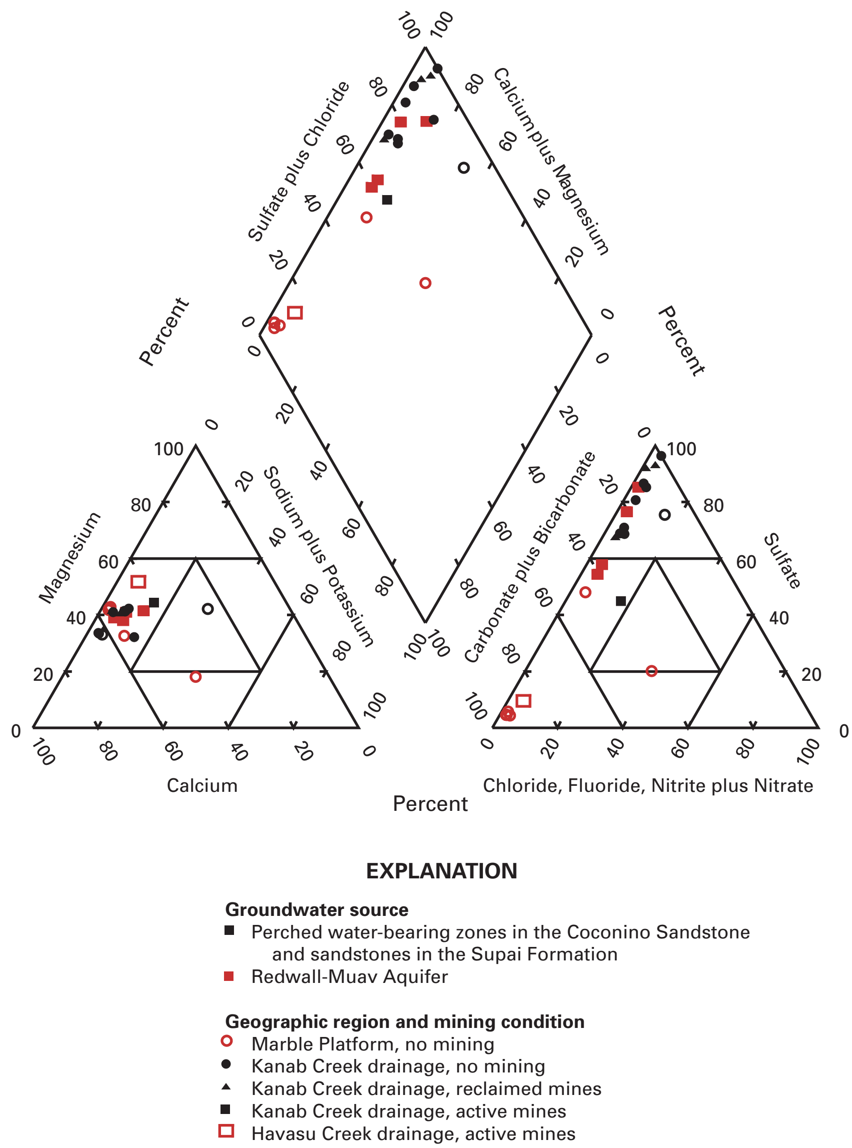


Figure 18. Major ion composition in groundwater samples collected in 2009 from sites in northern Arizona. Vasey's Paradise and South Canyon Springs samples excluded owing to insufficient data.

Trace Elements

Several trace elements differ by geographic region and by groundwater source. Although the 2009 groundwater samples were analyzed for many trace elements, this evaluation focuses on those determined by a previous study (Wenrich and others, 1994) to occur with uranium in mineralized breccia-pipe orebodies: antimony, arsenic, barium, cadmium, cobalt, copper, mercury, molybdenum, lead, nickel, silver, strontium, vanadium, and zinc. Some of these elements may not appear in groundwater as a result of differing solubilities and complexing anions. Relations between some trace elements and geographic region were not examined owing to the elements' low concentrations. Concentrations of cobalt, copper, and silver were less than the minimum reporting limit in nearly all of the wells and springs sampled (appendix 2). Neither nickel nor cadmium was commonly detected, although they were detected at low concentrations in all four wells; however, cadmium was detected at only 3 springs and nickel at only 2 springs (appendix 2, table 11).

Overall concentrations of the examined trace elements were low compared with drinking water standards. Arsenic concentrations at two sites, Fence Spring and Burnt Canyon Well (fig. 17) exceeded the drinking water standard of 10 µg/L (appendix 2). No other trace-element concentrations exceeded primary drinking water standards, including the drinking water standard for uranium of 30 µg/L.

Patterns of trace-element concentrations in groundwater by geographic region were found for uranium, barium, molybdenum, strontium, and zinc. Uranium, molybdenum, strontium, and zinc concentrations were generally higher in groundwater from the Kanab Creek drainage than in groundwater from the Marble platform (appendix 2; table 11). Conversely, barium concentrations were generally higher in groundwater from the Marble platform than in groundwater from the Kanab Creek drainage (appendix 2; table 11). Concentrations of vanadium were not clearly higher or lower in groundwater from either of the two geographic regions. A high minimum reporting limit for lead and tin concentrations at several sites in the Marble platform precluded comparison of those elements in groundwater from the two geographic regions (appendix 2).

Patterns of trace-element concentrations in samples from the two groundwater sources were found for uranium, arsenic, barium, molybdenum, and strontium. Concentrations of uranium, molybdenum, and strontium were generally higher in groundwater from perched water-bearing zones than in groundwater from the Redwall-Muav aquifer (appendix 2; table 11). Conversely, arsenic and barium concentrations are generally higher in the Redwall-Muav aquifer than in the perched water-bearing zones (appendix 2; table 11). No pattern with respect to groundwater source was found for concentrations of lead, mercury, tin, vanadium and zinc.

Only a few patterns were found between of trace-element concentrations in groundwater and the three types of mining activity associated with the sites. Arsenic and barium concentrations appear to be lowest in groundwater associated with reclaimed mines, and molybdenum concentrations appear to be lowest in groundwater from unmined areas (appendix 2; table 11). None of the sites of the three types of mining activity were clearly enriched in dissolved uranium—sites of each type of mining activity produced 2 of the 7 sites with the highest uranium concentrations (table 11). Also, the range in uranium concentrations at sites in areas without mining activities (0.57–20.6 µg/L) was similar to that for sites associated with active or reclaimed mines (2.14–19.5 µg/L; appendix 2). Additionally, neither lead, mercury, strontium, tin, vanadium, nor zinc concentrations appear related to mining conditions. As stated previously for sites associated with active or reclaimed mines, it is assumed but not known with certainty that the groundwater sampled at each site actually flowed past and had opportunity to be affected by the mining activity. The lack of patterns in trace elements observed in this study could have resulted if the groundwater sampled did not flow past the mined areas. Consequently, patterns or lack of patterns in trace-element chemistry with respected to mining conditions noted here must be considered exploratory and inconclusive.

Summary of Evaluation of Groundwater Samples Collected in 2009

Groundwater samples collected in 2009 augmented the historical dataset compiled in this study and provided additional spatial resolution for the geographic distribution of uranium and trace metals in the Grand Canyon area of northern Arizona. Through evaluation of these water-quality data, the following was learned about the effects of geographic locations, groundwater source, and mining activities on major ion and trace metal concentrations:

- Major ion composition, specific conductance, and concentrations of uranium, barium, strontium, and molybdenum appear correlated with geographic region and groundwater source.
- Arsenic concentrations appear correlated with groundwater source, and zinc concentrations appear correlated with geographic region.
- Relations of uranium and 13 other trace elements with mining activity were few and inconclusive.

Certain limitations of this analysis of major ion and trace element data, many of which were due to programmatic resource and timing constraints, should be recognized. These limitations include the following:

- Information contained in the isotopic data was not incorporated into this analysis, and consideration of these data could affect our conclusions.
- Geochemical factors, such as pH, temperature, and redox state, which are known to affect the fate and transport of trace elements, were not accounted for in this analysis.
- Compositional differences in the breccia pipes throughout the study area were not considered in the analysis, nor were the distances between the pipes and the sampling locations.
- The trace constituents examined in this analysis were limited to those determined by previous studies to be relevant to breccia pipe deposits; other elements not considered could be affected by mining activities.
- Most of the groundwater samples represent conditions at the end of a groundwater flow path from areas of recharge to location of discharge (springs). Affected groundwater, if any, may not have flowed yet to the points sampled in this study.
- This study was based on observational data without benefit of an optimal sampling design. Examination of the groundwater-chemistry data showed that groundwater chemistry appears correlated with groundwater source and location. To fully assess the relation

between trace-element concentrations and mining conditions, the study needs to fully control for confounding effects of groundwater source and location on water chemistry. An ideal sampling design would have equal numbers of sites in each of the different permutations of the 3 types of mining conditions, the 2 groundwater sources, and the 3 different geographic regions.

- Groundwater samples were used to assess the relation between water chemistry and mining. The relation between surface-water chemistry and mining was not assessed.

Future Water-Quality Investigations

A more thorough investigation of water chemistry in the Grand Canyon region is required to better understand groundwater flow paths, travel times, and contributions from mining activities, particularly on the north side of the Colorado River. The hydrologic processes that control the distribution and mobilization of natural uranium in this hydrogeologic setting are poorly understood. New investigations of water chemistry can help to provide critical information that will refine our current understanding of the area. Suggested investigations include the following:

1. Collect and analyze additional water-chemistry data from springs and wells in the Redwall-Muav aquifer to determine groundwater flow characteristic north of the Colorado River that affect mobility of radionuclides near ore deposits and mined areas. Such an investigation would require the drilling of new observation wells in this area.

2. Monitoring of water levels in wells developed in the Redwall-Muav aquifer could provide information about the hydraulic connections between mined areas, springs, and seasonal precipitation in the area.

3. Establish a network of surface-water and water-quality-monitoring sites in Kanab Creek Basin (the North Segregation Area). These sites would allow sampling of runoff that can then be analyzed for total radionuclide flux in this area.

4. Collect water and sediment samples from existing USGS streamflow gages tributary to the Colorado River in the Grand Canyon region (Paria River and the Little Colorado River) and from proposed new or reactivated gage sites on Kanab Creek and Havasu Creek. These data could be used to calculate maximum daily loads of uranium and radium. Such samples would provide net flux of radionuclides from the study area and provide an estimate of the storage of this material in Lake Mead.

5. Evaluate 2009 groundwater samples for isotopic composition, and then use those results to evaluate the recharge source area and water-rock interactions along flow paths that may or may not encounter orebodies.

6. Evaluate sediment samples archived by other USGS programs that were collected from tributaries to the Colorado River for their potential to be analyzed for total uranium and radium. Such analyses of archived samples would provide additional insight into historical radionuclide flux in the Grand Canyon region.

Summary and Conclusions

During 2009, the U.S. Geological Survey compiled available historical water-chemistry data for wells, springs, and streams in the Grand Canyon region and collected new samples at 24 sample sites for water-chemistry analysis. These data have three uses: evaluating the effects of legacy mining in the region, providing baseline information for dissolved uranium in groundwater, and comparing subbasin mining activities in the Kanab Creek Basin in northern Arizona. The occurrence and movement of groundwater north of the Colorado River has never been fully described owing to the limited population in this part of northern Arizona and to a lack of data needed to complete an analysis. Geologic and available hydrologic data from wells and springs were used to conceptualize the movement of groundwater in this part of northern Arizona.

Historical water-quality and water-chemistry data evaluated for 1,014 water samples from 428 sites indicate that about 70 sites have exceeded either the primary or secondary maximum contaminant levels for certain major ions and trace elements, such as arsenic, iron, lead, manganese, radium, sulfate, and uranium. These data suggest that water recharged from the surface or from perched water-bearing zones may contain dissolved gypsum from overlying rock units or may have been in contact with sulfide-rich ore. A few springs and wells in the region contain concentrations of dissolved uranium greater than the U.S. Environmental Protection Agency maximum contaminant level of 30 µg/L. These springs and wells are close by or in direct contact with orebodies. Water samples from a few springs produce gross alpha and gross beta particle values greater than the U.S. Environmental Protection Agency recommended maximum contaminant level of 15 pCi/L and 4 mrem/y respectively.

Sixty-six percent of natural water sample concentrations of dissolved uranium in the dataset were 5 µg/L or less, and they may be subjectively be classified as low concentrations for the study area. Dissolved uranium concentrations in about 120 springs and 32 streams in the region in the range 5–30 µg/L result from natural dissolution and erosion of ore deposits. Fifteen springs and 5 wells in the region contain concentrations of dissolved uranium that exceed the U.S. Environmental Protection Agency maximum contaminant level for drinking water and are related to mining processes. Surface water in the Colorado River in the Grand Canyon region contains dissolved uranium concentrations typically less than 5 µg/L. The Virgin River in the northwest corner of the study area, in contrast, contains dissolved-uranium concentrations greater than 80 µg/L from 1979. There is no information since then to determine whether the concentrations persist or not.

Observation of groundwater-chemistry relations between concentration and geographic region (Marble platform, Kanab Creek drainage, and Havasu Creek drainage) and groundwater source (Redwall-Muav aquifer or perched water-bearing zone in the Coconino Sandstone and sandstones of the Supai Group) were made for major-ion composition, specific conductance, and concentrations of uranium, arsenic, barium, molybdenum, strontium, and zinc. Observation of groundwater-chemistry relations between concentration and mining condition (no mining activity, active mines on standby, or reclaimed mine areas) were limited and inconclusive. Surface water was not evaluated in this study.

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Appendix 1. Northern Arizona University Isotope and Radiochemistry Laboratory Methods for Dissolved Uranium and Uranium Isotope Analysis of Spring-Water and Well-Water Samples Collected from Sites in Northern Arizona

A duplicate set of water samples were sent to the Northern Arizona University (NAU) Isotope and Radiochemistry Laboratory, Flagstaff, Ariz., for dissolved uranium and uranium isotopes analysis. The NAU Laboratory used a 20 mL aliquot for analysis pipetted volumetrically into a precleaned 50 mL polypropylene test tube along with trace-metal grade nitric acid (16 M, 2 mL) and a known amount of purified ^{233}U tracer solution. After sample-spike equilibration, uranium was purified using 50 mg of UTEVA resin beads (50–100 µm) added to each sample, agitated for 30 minutes, and retained on an ion-exchange column. Columns were rinsed three times with 1 mL of 2 M HNO_3, followed by elution of uranium using 1.0 mL water, 1.0 mL 0.05 M ammonium oxalate, and 1.0 mL water. Chemical process blanks (n=3) were run through the entire sample preparation process along with duplicates of two samples. Inductively coupled plasma–mass spectrometer (ICP–MS) analyses were conducted using a Thermo X Series II quadrupole ICP–MS equipped with an APEX HF sample introduction system (ESI Scientific, Omaha, Nebr.) operating in peak-jumping mode (10 millisecond dwell at each of ^{232}Th, ^{233}U, ^{234}U, and ^{235}U peaks with 1,500 sweeps per integration). An analysis consisted of three sequential integrations, each requiring 70 seconds. Resulting data represent the average and standard deviations for these three integrations. The sample introduction system was rinsed between samples with an aqueous solution containing 0.005 M ammonium oxalate and 0.1 M HNO_3 while monitoring the $^{235}U^+$ ion beam was monitored until the signal reached levels typical of the blanks. Average blank results were used to correct $^{234}U^+$ and $^{235}U^+$ signals. Corrections to the $^{233}U^+$ signal for contributions of ThH^+ were not necessary because Th is virtually absent in all samples. Mass bias corrections were applied based on external measurements of $^{238}U/^{235}U$ in natural U solutions. Corrected $^{234}U/^{235}U$ atom ratios were converted to $^{234}U/^{238}U$ activity ratios as follows:

$$\text{AR } 234/238 = (^{234}U/^{235}U) \times (1/137.88) / 0.00005472 \quad (1)$$

where

(1/137.88) is the $^{235}U/^{238}U$ atom ratio in nature (constant within 0.1 percent)

and

0.00005472 is the $^{234}U/^{238}U$ atom ratio at secular equilibrium. (Steiger and Jäger, 1977; Cheng and others, 2000). Eight blocks of $^{234}U/^{235}U$ atom ratios were collected at different times during the analysis of a uranium solution prepared from "modern coral." This material has the activity ratio characteristic of modern seawater (see following table).

Uranium Atomic Ratios in Modern Corals

[The expected atomic ratio in modern seawater is 1.148±0.002. AR 234/238, atomic ratio of uranium-234 to uranium-238; SD, standard deviation

Block	AR 234/238	SD
1	1.158	0.001
2	1.154	0.004
3	1.153	0.001
4	1.154	0.003
5	1.150	0.002
6	1.158	0.006
7	1.156	0.009
8	1.155	0.006
Average	1.155	0.003

The expected AR in modern seawater is 1.148±0.002 (Szabo and others, 1994).

The average NAU value of 1.155 for the atomic ratio of uranium-234 to uranium-238 (AR 234/238) is in close agreement with the expected value for modern seawater (1.148±0.002). Given the large differences among AR 234/238 values observed for unknown samples, the slight bias between measured and expected seawater AR 234/238 values is insignificant. Uranium concentrations in the water samples were obtained from the correct $^{233}U/^{235}U$ and standard isotope dilution calculations. Duplicate analyses of two water samples (Showerbath Spring and Rider Spring) are in excellent agreement for both activity ratios and uranium concentrations.

Appendix 2. Water Chemistry Data from Water Samples Collected from Springs and Wells Sampled in Northern Arizona in 2009

Table A. Analysis results from all laboratories.

These terms are used on the following pages in table A:

[H, Havasu Creek drainage;
K, Kanab Creek;
M, Marble Platform;
P, perched water-bearing zones in the Coconino Sandstone and sandstones in the Supai Formation;
R, Redwall-Muav aquifer;
AM, active mines;
NM, not mined;
RM, reclaimed mines;

Bullen, USGS National Research Program Laboratory, Menlo Park, California;
Coplen, USGS National Isotope Fractionation Project Laboratory, Reston, Virginia;

Doughten, USGS National Research Program Laboratory, Reston, Virginia;
Kraemer, USGS National Research Program Laboratory, Reston, Virginia;
Michel, USGS National Research Program Laboratory, Menlo Park, California;
NAU, Northern Arizona University Isotope and Radiochemistry Laboratory, Flagstaff, Arizona;
NWQL, USGS National Water Quality Laboratory, Denver, Colorado;
RSIL, USGS National Isotope Fractionation Project Laboratory, Reston, Virginia;
Taylor, USGS National Research Program Laboratory, Boulder, Colorado;

AASCE, atomic absorption spectrometry–chelation extraction;
AASD, atomic absorption spectrometry direct;
AAS–GF, atomic absorption spectrophotometry–graphite furnace;
AASH, atomic absorption spectrometry hydride;
AES, atomic emission spectroscopy;
AES–DCP, atomic emission spectrometry–direct current plasma;
CCRDSF, colorimetry hydrazine reduction–diazotization segmented flow;
CPBDSF, colorimetry phosphormolydate block digester segmented flow;
CS, colorimetry salicylate-hypochlorite;
CV–AFS, cold vapor–atomic fluorescence spectroscopy;
EISE, electrometry ion-selective electrode;
IC, ion chromatography;
ICP–OES, inductively coupled plasma–optical emission spectroscopy;
ICP–AES, inductively coupled plasma–atomic emission spectroscopy;
ICP–MS, inductively coupled plasma–mass spectrometry;
KDM, Kjeldahl digestion method;

--, not available;
<, less than;
°C, degree Celsius;
‰, per mil;
e, estimated;
field, value determined at the site;
gal/min, gallon per minute;
µg/L, microgram per liter;
µS/cm, microsiemen per centimeter at 25°C;
mg CaCO3/L, milligram calcium carbonate per liter;
mg N/L, milligram nitrogen per liter;
mg P/L, milligram phosphorus per liter;
mg/L, milligram per liter;
mm Hg, millimeter of mercury;
nm, not measured;
ns, no sample;
pC/L, picocurie per liter;
R, results less than sample-specific reporting limit;
SD, standard deviation;
TU, tritium unit;
unf, unfiltered]

Table A. Analysis results from all laboratories.

Spring or well	Geographic region	Groundwater source	Mining condition	*Element Lab Method Units*	Silver NWQL AASGF µg/L	Aluminum NWQL AES–DCP µg/L	Aluminum Doughten ICP–MS µg/L	Aluminum Taylor ICP–MS µg/L	Aluminum-SD Taylor ICP–MS µg/L
Buck Farm Spring	M	R	NM		--	<4	<1	ns	ns
Buck Farm Spring	M	R	NM		<0.008	<4	ns	ns	ns
Fence Spring	M	R	NM		<0.008	<4	2	ns	ns
Hanging Spring	M	R	NM		<0.008	<4	2	ns	ns
Hole in the Wall Spring	M	R	NM		<0.008	<4	1	ns	ns
South Canyon Spring	M	P	NM		--	ns	1	0.62	0.04
South Canyon Spring	M	P	NM		--	ns	ns	0.56	0.03
Unknown Spring	M	R	NM		<0.008	<4	2	ns	ns
Unknown Spring	M	R	NM		<0.008	3.8e	2	ns	ns
Vasey's Paradise	M	R	NM		--	ns	2	ns	ns
Clearwater Spring	K	P	NM		--	<8	<5	0.32	0.02
Clearwater Spring	K	P	NM		--	ns	ns	0.35	0.02
Hotel Spring	K	P	AM		<0.008	3.1e	4	3.2	0.1
Hotel Spring	K	P	AM		--	ns	ns	3.2	0.1
Kanab Spring	K	R	AM		<0.008	<4	<1	0.48	0.02
Kanab Spring	K	R	AM		<0.008	<4	ns	0.45	0.04
Lower Jumpup Spring	K	P	NM		<0.024	<12	1	0.69	0.06
Lower Jumpup Spring	K	P	NM		--	ns	ns	0.65	0.04
Mountain Sheep Spring	K	P	NM		--	<4	1	0.44	0.01
Mountain Sheep Spring	K	P	NM		--	<4	ns	0.41	0.01
Rider Spring	M	P	NM		<0.008	<4	1	ns	ns
Rider Spring	M	P	NM		--	ns	ns	ns	ns
Rock Spring	K	P	RM		--	<8	<5	0.66	0.05
Rock Spring	K	P	RM		--	ns	ns	0.87	0.04
Schmutz Spring	K	P	NM		<0.008	<4	<1	0.50	0.03
Schmutz Spring	K	P	NM		--	<4	ns	0.43	0.00
Showerbath Spring	K	R	AM		<0.008	<4	<1	0.25	0.02
Showerbath Spring	K	R	AM		--	ns	ns	0.31	0.04
Side Canyon Spring	K	R	AM		<0.008	<4	1	0.28	0.02
Side Canyon Spring	K	R	AM		--	ns	ns	0.25	0.01
Slide Spring	K	P	RM		--	<4	<1	0.23	0.02
Slide Spring	K	P	RM		--	ns	ns	0.22	0.04
Upper Jumpup Spring	K	P	NM		<0.008	<4	1	0.21	0.01
Upper Jumpup Spring	K	P	NM		--	ns	ns	0.25	0.01
Willow Spring (Hack Canyon)	K	P	RM		--	<8	<5	0.96	0.09
Willow Spring (Hack Canyon)	K	P	RM		--	ns	ns	0.60	0.01
Burnt Canyon Well	K	P	NM		--	<8	<3	0.2	0.1
Burnt Canyon Well	K	P	NM		--	ns	ns	0.2	0.1
Canyon Mine Well	H	R	AM		<0.008	2.4e	<1	0.2	0.1
Canyon Mine Well	H	R	AM		--	ns	ns	0.3	0.1
Pinenut Well	K	R	AM		--	<4	<3	0.3	0.1
Pinenut Well	K	R	AM		--	ns	ns	0.1	0.0
Tom Land Well	K	P	NM		--	10.8	<3	0.1	0.1
Tom Land Well	K	P	NM		--	ns	ns	0.2	0.0

Table A. Analysis results from all laboratories.—Continued

Spring or well	Arsenic NWQL ICP–MS µg/L	Arsenic Doughten ICP–MS µg/L	Arsenic Taylor ICP–MS µg/L	Arsenic-SD Taylor ICP – MS µg/L	Boron NWQL AES–DCP µg/L	Boron Doughten ICP–MS µg/L	Boron Taylor ICP–MS/AES µg/L	Boron-SD Taylor ICP–MS/AES µg/L
Buck Farm Spring	0.95	1.2	ns	ns	59	60	ns	ns
Buck Farm Spring	0.99	ns	ns	ns	58	ns	ns	ns
Fence Spring	16.4	16.0	ns	ns	483	380	ns	ns
Hanging Spring	2.3	2.3	ns	ns	11	<20	ns	ns
Hole in the Wall Spring	2.2	2.3	ns	ns	11	<20	ns	ns
South Canyon Spring	ns	1.5	1.4	0.1	ns	30	26	2
South Canyon Spring	ns	ns	1.4	0.0	ns	ns	24	2
Unknown Spring	2.2	2.3	ns	ns	12	<20	ns	ns
Unknown Spring	2.2	2.3	ns	ns	12	<20	ns	ns
Vasey's Paradise	ns	1.9	ns	ns	ns	<20	ns	ns
Clearwater Spring	0.93	2.0	1.3	0.0	365	360	350	7
Clearwater Spring	ns	ns	1.4	0.2	ns	ns	353	11
Hotel Spring	6.2	6.9	6.4	0.0	171	190	176	7
Hotel Spring	ns	ns	6.5	0.1	ns	ns	175	3
Kanab Spring	1.8	2.0	1.8	0.0	57	60	58	3
Kanab Spring	1.8	ns	1.8	0.1	59	ns	56	2
Lower Jumpup Spring	1.2	2.1	1.4	0.1	100	130	128	5
Lower Jumpup Spring	ns	ns	1.4	0.1	ns	ns	131	7
Mountain Sheep Spring	0.9	1.9	1.3	0.1	89	120	113	5
Mountain Sheep Spring	0.89	ns	1.3	0.0	72	ns	111	4
Rider Spring	4.8	5.7	ns	ns	559	580	ns	ns
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns
Rock Spring	0.3	2.0	0.41	0.04	174	260	230	1
Rock Spring	ns	ns	0.40	0.09	ns	ns	240	26
Schmutz Spring	1.9	2.8	1.8	0.1	102	100	102	3
Schmutz Spring	1.8	ns	1.9	0.0	89	ns	104	11
Showerbath Spring	1.2	1.7	1.4	0.0	62	70	65	3
Showerbath Spring	ns	ns	1.4	0.1	ns	ns	63	3
Side Canyon Spring	1.7	2.3	1.7	0.1	105	100	100	5
Side Canyon Spring	ns	ns	1.7	0.1	ns	ns	98	7
Slide Spring	0.5	1.6	0.77	0.02	61	70	63	5
Slide Spring	ns	ns	0.77	0.03	ns	ns	59	4
Upper Jumpup Spring	0.92	1.9	1.0	0.1	43	50	40	3
Upper Jumpup Spring	ns	ns	1.1	0.1	ns	ns	41	4
Willow Spring (Hack Canyon)	0.79	3.0	1.2	0.0	345	330	325	7
Willow Spring (Hack Canyon)	ns	ns	1.2	0.1	ns	ns	325	12
Burnt Canyon Well	13.00	12.1	13	0	324	460	481	13
Burnt Canyon Well	ns	ns	13	0	ns	ns	469	15
Canyon Mine Well	0.16	0.4	0.26	0.04	36	40	37	1
Canyon Mine Well	ns	ns	0.26	0.02	ns	ns	34	1
Pinenut Well	5.8	5.5	6.2	0.4	242	320	311	8
Pinenut Well	ns	ns	6.3	0.2	ns	ns	323	4
Tom Land Well	0.21	1.6	0.41	0.03	244	330	310	7
Tom Land Well	ns	ns	0.39	0.06	ns	ns	311	7

Table A. Analysis results from all laboratories.—Continued

Spring or well	Barium NWQL AASD µg/L	Barium Doughten ICP–MS µg/L	Barium Taylor ICP–MS/AES µg/L	Barium-SD Taylor ICP–MS/AES µg/L	Beryllium NWQL ICP–MS µg/L	Beryllium Taylor ICP–MS µg/L	Beryllium-SD Taylor ICP–MS µg/L	Bismuth Taylor ICP–MS µg/L	Bismuth-SD Taylor ICP–MS µg/L
Buck Farm Spring	31	30	ns	ns	<0.02	ns	ns	ns	ns
Buck Farm Spring	31	ns	ns	ns	<0.02	ns	ns	ns	ns
Fence Spring	52	54	ns	ns	0.04	ns	ns	ns	ns
Hanging Spring	181	65	ns	ns	<0.02	ns	ns	ns	ns
Hole in the Wall Spring	178	162	ns	ns	<0.02	ns	ns	ns	ns
South Canyon Spring	ns	72	74	2	ns	<0.02	0.02	<0.006	0.001
South Canyon Spring	ns	ns	73	2	ns	<0.02	0.01	<0.006	0.000
Unknown Spring	180	166	ns	ns	<0.02	ns	ns	ns	ns
Unknown Spring	178	165	ns	ns	<0.02	ns	ns	ns	ns
Vasey's Paradise	ns	134	ns	ns	ns	ns	ns	ns	ns
Clearwater Spring	22	22	21	1	<0.04	<0.02	0.01	<0.006	0.000
Clearwater Spring	ns	ns	21	0	ns	<0.02	0.00	<0.006	0.000
Hotel Spring	57	54	56	2	<0.02	<0.02	0.01	<0.006	0.003
Hotel Spring	ns	ns	57	1	ns	<0.02	0.01	<0.006	0.001
Kanab Spring	25	24	25	0	<0.02	<0.02	0.01	<0.006	0.001
Kanab Spring	26	ns	25	0	<0.02	<0.02	0.02	<0.006	0.002
Lower Jumpup Spring	29	29	28	0	<0.06	<0.02	0.01	<0.006	0.001
Lower Jumpup Spring	ns	ns	28	1	ns	<0.02	0.02	<0.006	0.000
Mountain Sheep Spring	18	19	18	0	<0.02	0.009	0.005	<0.006	0.001
Mountain Sheep Spring	18	ns	18	0	<0.02	0.010	0.006	<0.006	0.002
Rider Spring	8	8	ns	ns	<0.02	ns	ns	ns	ns
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Rock Spring	9	9	8.6	0.2	<0.04	0.007	0.002	<0.006	0.001
Rock Spring	ns	ns	6.5	0.4	ns	<0.006	0.008	<0.006	0.001
Schmutz Spring	7	9	8.5	0.5	<0.02	<0.02	0.02	<0.006	0.001
Schmutz Spring	9	ns	8.4	0.8	<0.02	<0.02	0.01	<0.006	0.001
Showerbath Spring	23	22	23	0	<0.02	<0.02	0.01	<0.006	0.002
Showerbath Spring	ns	ns	22	1	ns	<0.02	0.01	<0.006	0.001
Side Canyon Spring	12	12	12	0	<0.02	<0.02	0.01	<0.006	0.001
Side Canyon Spring	ns	ns	12	0	ns	<0.02	0.01	<0.006	0.001
Slide Spring	10	10	10	0	<0.02	<0.02	0.01	<0.006	0.001
Slide Spring	ns	ns	10	0	ns	0.02	0.01	<0.006	0.001
Upper Jumpup Spring	11	11	11	0	<0.02	<0.02	0.01	<0.006	0.001
Upper Jumpup Spring	ns	ns	11	0	ns	<0.02	0.00	<0.006	0.001
Willow Spring (Hack Canyon)	8	8	7.7	0.2	<0.04	<0.02	0.01	<0.006	0.000
Willow Spring (Hack Canyon)	ns	ns	8.3	0.5	ns	<0.02	0.01	<0.006	0.002
Burnt Canyon Well	7	8	7.7	0.5	0.06	0.04	0.01	<0.007	0.001
Burnt Canyon Well	ns	ns	7.6	0.9	ns	0.04	0.01	<0.007	0.001
Canyon Mine Well	78	89	96	1	<0.02	<0.02	0.00	<0.007	0.001
Canyon Mine Well	ns	ns	93	5	ns	<0.02	0.01	<0.007	0.000
Pinenut Well	11	10	11	1	<0.02	<0.02	0.01	<0.007	0.001
Pinenut Well	ns	ns	11	0	ns	<0.02	0.00	<0.007	0.001
Tom Land Well	7	7	6.6	0.6	0.02e	<0.02	0.01	<0.007	0.001
Tom Land Well	ns	ns	6.8	0.8	ns	<0.02	0.00	<0.007	0.001

Table A. Analysis results from all laboratories.—Continued

Spring or well	Bromine Doughten IC mg/L	Calcium NWQL ICP–MS mg/L	Calcium Doughten ICP–OES mg/L	Calcium Taylor ICP–AES mg/L	Calcium-SD Taylor ICP–AES mg/L	Cadmium NWQL AASGF µg/L	Cadmium Doughten ICP–MS µg/L	Cadmium Taylor ICP–MS µg/L	Cadmium-SD Taylor ICP–MS µg/L
Buck Farm Spring	0.07	95.1	94.4	ns	ns	0.01e	<0.05	ns	ns
Buck Farm Spring	ns	ns	ns	ns	ns	<0.02	ns	ns	ns
Fence Spring	0.50	147	145	ns	ns	0.03	<0.05	ns	ns
Hanging Spring	0.03	44.9	43.5	ns	ns	0.01e	<0.05	ns	ns
Hole in the Wall Spring	0.03	45.5	45.2	ns	ns	<0.02	<0.05	ns	ns
South Canyon Spring	ns	ns	55.7	55	1	ns	<0.05	<0.002	0.002
South Canyon Spring	ns	ns	ns	56	2	ns	ns	<0.002	0.000
Unknown Spring	0.02	44.2	44.3	ns	ns	<0.02	<0.05	ns	ns
Unknown Spring	0.02		44.1	ns	ns	<0.02	<0.05	ns	ns
Vasey's Paradise	ns	ns	43.7	ns	ns	ns	<0.05	ns	ns
Clearwater Spring	0.52	492	472	464	1	0.04	<0.25	<0.002	0.000
Clearwater Spring	ns	ns	ns	469	6	ns	ns	<0.002	0.000
Hotel Spring	0.53	72.6	72.8	72	2	0.02	<0.05	<0.002	0.002
Hotel Spring	ns	ns	ns	72	1	ns	ns	<0.002	0.003
Kanab Spring	0.12	97.6	99.3	102	2	0.01e	<0.05	<0.002	0.000
Kanab Spring	ns	ns	ns	97	3	0.02e	ns	<0.002	0.002
Lower Jumpup Spring	0.46	238	251	254	0	0.04e	<0.05	<0.002	0.003
Lower Jumpup Spring	ns	ns	ns	245	2	ns	ns	<0.002	0.001
Mountain Sheep Spring	0.13	188	189	184	13	0.02e	<0.05	0.004	0.001
Mountain Sheep Spring	ns	ns	ns	184	12	0.02e	ns	0.004	0.000
Rider Spring	0.57	63.9	63.0	ns	ns	0.04	<0.05	ns	ns
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Rock Spring	0.34	447.0	437	404	3	0.06	<0.25	<0.001	0.001
Rock Spring	ns	ns	ns	433	15	ns	ns	<0.001	0.001
Schmutz Spring	0.18	239	241	241	8	0.01e	<0.05	<0.002	0.002
Schmutz Spring	ns	ns	ns	230	10	0.02	ns	<0.002	0.001
Showerbath Spring	0.11	113	115	111	2	0.01e	<0.05	<0.002	0.002
Showerbath Spring	ns	ns	ns	114	3	ns	ns	<0.002	0.000
Side Canyon Spring	0.08	176	181	181	2	0.03	<0.05	<0.002	0.003
Side Canyon Spring	ns	ns	ns	177	8	ns	ns	<0.002	0.000
Slide Spring	0.21	142	149	147	6	<0.02	<0.05	<0.002	0.000
Slide Spring	ns	ns	ns	144	2	ns	ns	0.003	0.004
Upper Jumpup Spring	0.20	132	136	137	2	0.01e	<0.05	<0.002	0.002
Upper Jumpup Spring	ns	ns	ns	138	2	ns	ns	<0.002	0.002
Willow Spring (Hack Canyon)	0.31	498	488	483	32	0.04e	<0.25	<0.002	0.002
Willow Spring (Hack Canyon)	ns	ns	ns	493	6	ns	ns	<0.002	0.001
Burnt Canyon Well	0.41	548	525	568	27	0.16	<0.15	0.11	0.01
Burnt Canyon Well	ns	ns	ns	565	11	ns	ns	0.11	0.00
Canyon Mine Well	0.07	32.9	42.6	43	1	<0.02	<0.05	0.009	0.002
Canyon Mine Well	ns	ns	ns	41	1	ns	ns	0.011	0.001
Pinenut Well	0.10	238	264	245	9	0.05	<0.15	0.011	0.002
Pinenut Well	ns	ns	ns	253	10	ns	ns	0.013	0.005
Tom Land Well	0.38	470	466	454	23	0.10	<0.15	0.047	0.001
Tom Land Well	ns	ns	ns	464	21	ns	ns	0.047	0.001

Table A. Analysis results from all laboratories.—Continued

Spring or well	Cerium Taylor ICP–MS µg/L	Cerium-SD Taylor ICP–MS µg/L	Chlorine NWQL IC mg/L	Chlorine Doughten IC mg/L	Cobalt NWQL ICP–MS µg/L	Cobalt Doughten ICP–MS µg/L	Cobalt Taylor ICP–AES µg/L	Cobalt-SD Taylor ICP–AES µg/L
Buck Farm Spring	ns	ns	12.7	12.9	0.09	0.10	ns	ns
Buck Farm Spring	ns	ns	ns		0.1	ns	ns	ns
Fence Spring	ns	ns	239	243	0.12	0.21	ns	ns
Hanging Spring	ns	ns	2.0	2.03	0.07	0.08	ns	ns
Hole in the Wall Spring	ns	ns	2.0	2.02	0.04	0.05	ns	ns
South Canyon Spring	0.0021	0.0009	ns	ns	ns	0.07	<0.2	0.2
South Canyon Spring	0.0015	0.0005	ns	ns	ns	ns	<0.2	0.2
Unknown Spring	ns	ns	2.0	2.03	0.05	0.05	ns	ns
Unknown Spring	ns	ns		2.06	0.05	<0.05	ns	ns
Vasey's Paradise	ns	ns	ns	ns	ns	0.41	ns	ns
Clearwater Spring	0.0009	0.0005	69.8	70.9	0.6	0.42	<0.2	0.0
Clearwater Spring	0.0008	0.0003	ns	ns	ns	ns	<0.2	0.0
Hotel Spring	0.0079	0.0000	48.9	52.3	0.95	1.46	1.1	0.2
Hotel Spring	0.0081	0.0009	ns	ns	ns	ns	0.9	0.2
Kanab Spring	0.0025	0.0018	16.0	16.2	0.09	0.09	<0.2	0.2
Kanab Spring	0.0020	0.0007	ns	ns	0.16	ns	<0.2	0.2
Lower Jumpup Spring	0.0072	0.0009	41.7	42.4	0.48	0.35	<0.2	0.1
Lower Jumpup Spring	0.0072	0.0012	ns	ns	ns	ns	<0.2	0.2
Mountain Sheep Spring	0.0010	0.0002	41.2	41.1	0.42	0.19	<0.2	0.0
Mountain Sheep Spring	0.0008	0.0001	ns	ns	0.29	ns	<0.2	0.1
Rider Spring	ns	ns	57.4	60.5	0.09	0.15	ns	ns
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns
Rock Spring	0.0012	0.0000	15.2	15.4	0.58	0.43	<0.2	0.3
Rock Spring	0.0010	0.0002	ns	ns	ns	ns	0.2	0.2
Schmutz Spring	0.0009	0.0001	18.4	18.2	0.18	0.24	<0.2	0.1
Schmutz Spring	0.0010	0.0006	ns	ns	0.25	ns	<0.2	0.1
Showerbath Spring	<0.0006	0.0005	16.1	16.3	0.11	0.10	<0.2	0.1
Showerbath Spring	<0.0006	0.0003	ns	ns	ns	ns	<0.2	0.1
Side Canyon Spring	<0.0006	0.0009	10.7	11.3	0.19	0.16	<0.2	0.1
Side Canyon Spring	<0.0006	0.0005	ns	ns	ns	ns	<0.2	0.3
Slide Spring	<0.0006	0.0004	15.3	15.4	0.12	0.14	<0.2	0.1
Slide Spring	<0.0006	0.0003	ns	ns	ns	ns	<0.2	0.2
Upper Jumpup Spring	0.0023	0.0004	16.2	16.4	0.12	0.12	<0.2	0.1
Upper Jumpup Spring	0.0006	0.0003	ns	ns	ns	ns	<0.2	0.1
Willow Spring (Hack Canyon)	0.0088	0.0004	48.5	47.3	0.57	0.48	<0.2	0.1
Willow Spring (Hack Canyon)	0.0076	0.0003	ns	ns	ns	ns	<0.2	0.1
Burnt Canyon Well	0.0035	0.0013	55.7	53.8	0.86	0.72	<0.3	0.3
Burnt Canyon Well	0.0031	0.0007	ns	ns	ns	ns	<0.3	0.1
Canyon Mine Well	0.0004	0.0002	6.45	6.51	1.7	0.16	0.3	0.0
Canyon Mine Well	0.0008	0.0003	ns	ns	ns	ns	<0.3	0.3
Pinenut Well	0.0019	0.0001	18.9	18.8	0.60	0.52	<0.3	0.1
Pinenut Well	0.0017	0.0004	ns	ns	ns	ns	<0.3	0.1
Tom Land Well	0.0024	0.0004	28.5	28.0	0.73	0.51	<0.3	0.1
Tom Land Well	0.0027	0.0008	ns	ns	ns	ns	<0.3	0.3

Table A. Analysis results from all laboratories.—Continued

Spring or well	Chromium NWQL ICP–MS µg/L	Chromium Doughten ICP–MS µg/L	Chromium Taylor ICP–MS/AES µg/L	Chromium-SD Taylor ICP–MS/AES µg/L	Cesium Taylor ICP–MS µg/L	Cesium-SD Taylor ICP–MS µg/L	Copper NWQL ICP–MS µg/L	Copper Doughten ICP–MS µg/L	Copper Taylor ICP–MS/AES µg/L	Copper-SD Taylor ICP–MS/AES µg/L
Buck Farm Spring	0.24	4	ns	ns	ns	ns	<1	0.4	ns	ns
Buck Farm Spring	0.25	ns	ns	ns	ns	ns	<1	ns	ns	ns
Fence Spring	0.97	2	ns	ns	ns	ns	<1	0.6	ns	ns
Hanging Spring	0.97	1	ns	ns	ns	ns	<1	0.2	ns	ns
Hole in the Wall Spring	0.95	2	ns	ns	ns	ns	<1	0.2	ns	ns
South Canyon Spring	ns	1	0.7	0.2	0.14	0.00	ns	0.7	2.0	0.1
South Canyon Spring	ns	ns	0.7	0.2	0.14	0.00	ns	ns	2.0	0.2
Unknown Spring	0.96	1	ns	ns	ns	ns	<1	0.2	ns	ns
Unknown Spring	0.99	1	ns	ns	ns	ns	<1	0.3	ns	ns
Vasey's Paradise	ns	1	ns	ns	ns	ns	ns	<0.1	ns	ns
Clearwater Spring	<0.24	<5	<0.2	0.1	0.012	0.020	<2.0	1.9	<0.04	0.08
Clearwater Spring	ns	ns	<0.2	0.0	<0.006	0.003		ns	<0.04	0.04
Hotel Spring	0.29	3	0.3	0.2	0.054	0.003	0.72e	1.0	0.76	0.03
Hotel Spring	ns	ns	0.3	0.2	0.056	0.002	ns	ns	0.74	0.01
Kanab Spring	0.35	3	0.3	0.0	0.29	0.01	<1	0.4	0.08	0.02
Kanab Spring	0.49	ns	0.3	0.1	0.28	0.01	<1	ns	0.09	0.02
Lower Jumpup Spring	0.29e	4	<0.2	0.1	0.006	0.002	<3	1.1	0.11	0.04
Lower Jumpup Spring	ns	ns	<0.2	0.1	0.007	0.000	ns	ns	0.11	0.03
Mountain Sheep Spring	0.30	4	1.3	0.2	0.071	0.003	0.64e	1.4	4.0	0.1
Mountain Sheep Spring	0.26	ns	1.0	0.1	0.069	0.001	0.96e	ns	3.3	0.0
Rider Spring	3.0	4	ns	ns	ns	ns	<1	0.7	ns	ns
Rider Spring	ns	ns	ns	ns	ns	ns	ms	ns	ns	ns
Rock Spring	0.82	<5	0.7	0.1	0.017	0.003	<2.0	1.8	<0.007	0.010
Rock Spring	ns	ns	0.6	0.2	0.014	0.001	ns	ns	<0.007	0.033
Schmutz Spring	0.45	2	0.3	0.0	0.083	0.004	<1	0.9	0.05	0.03
Schmutz Spring	0.42	ns	<0.2	0.5	0.079	0.008	<1	ns	<0.04	0.04
Showerbath Spring	0.30	3	0.4	0.2	0.23	0.00	<1	0.5	0.07	0.03
Showerbath Spring	ns	ns	0.3	0.0	0.22	0.00	ns	ns	0.05	0.03
Side Canyon Spring	0.25	3	0.3	0.1	0.36	0.01	<1	0.8	0.06	0.02
Side Canyon Spring	ns	ns	0.2	0.2	0.36	0.00	ns	ns	<0.04	0.02
Slide Spring	2.3	5	2.9	0.1	0.091	0.007	<1	0.8	0.22	0.02
Slide Spring	ns	ns	3.0	0.1	0.091	0.006	ns	ns	0.26	0.03
Upper Jumpup Spring	3.0	5	3.1	0.0	0.17	0.00	<1	0.7	0.13	0.00
Upper Jumpup Spring	ns	ns	3.2	0.1	0.17	0.01	ns	ns	0.11	0.01
Willow Spring (Hack Canyon)	1.3	<5	1.1	0.2	0.10	0.01	<2	2.2	0.18	0.04
Willow Spring (Hack Canyon)	ns	ns	1.1	0.2	0.11	0.01	ns	ns	0.18	0.09
Burnt Canyon Well	0.36	4	1.9	0.1	1.0	0.0	<2.0	2.9	<0.6	1.2
Burnt Canyon Well	ns	ns	1.9	0.2	1.0	0.0	ns	ns	<0.6	0.3
Canyon Mine Well	0.23	5	<0.2	0.1	1.4	0.0	2.5	2.8	2.6	0.0
Canyon Mine Well	ns	ns	<0.2	0.1	1.4	0.0	ns	ns	2.7	0.0
Pinenut Well	0.11e	3	1.2	0.0	0.85	0.02	<1	1.5	<0.6	0.1
Pinenut Well	ns	ns	1.2	0.1	0.84	0.00	ns	ns	<0.6	0.4
Tom Land Well	0.66	4	1.4	0.0	0.13	0.00	2.1	3.5	1.3	0.0
Tom Land Well	ns	ns	1.3	0.2	0.14	0.02	ns	ns	1.2	0.0

Table A. Analysis results from all laboratories.—Continued

Spring or well	Dysprosium Taylor ICP–MS µg/L	Dysprosium-SD Taylor ICP–MS µg/L	Erbium Taylor ICP–MS µg/L	Erbium-SD Taylor ICP–MS µg/L	Europium Taylor ICP–MS µg/L	Europium-SD Taylor ICP–MS µg/L	Fluorine NWQL EISE mg/L	Fluorine Doughten IC mg/L
Buck Farm Spring	ns	ns	ns	ns	ns	ns	0.18	0.16
Buck Farm Spring	ns	ns	ns	ns	ns	ns	ns	ns
Fence Spring	ns	ns	ns	ns	ns	ns	0.31	0.33
Hanging Spring	ns	ns	ns	ns	ns	ns	0.07e	0.07
Hole in the Wall Spring	ns	ns	ns	ns	ns	ns	0.08e	0.07
South Canyon Spring	0.0008	0.0004	<0.001	0.001	0.002	0.001	ns	ns
South Canyon Spring	0.0004	0.0004	<0.001	0.001	<0.001	0.001	ns	ns
Unknown Spring	ns	ns	ns	ns	ns	ns	0.08e	0.07
Unknown Spring	ns	ns	ns	ns	ns	ns		0.07
Vasey's Paradise	ns	ns	ns	ns	ns	ns	ns	ns
Clearwater Spring	0.0005	0.0004	<0.001	0.000	<0.001	0.000	0.71	0.70
Clearwater Spring	0.0006	0.0002	<0.001	0.001	<0.001	0.001	ns	ns
Hotel Spring	0.0028	0.0001	<0.001	0.001	<0.001	0.001	0.38	0.36
Hotel Spring	0.0032	0.0002	0.001	0.003	<0.001	0.004	ns	ns
Kanab Spring	<0.0004	0.0005	<0.001	0.001	<0.001	0.000	0.28	0.28
Kanab Spring	<0.0004	0.0008	<0.001	0.001	0.002	0.000	ns	ns
Lower Jumpup Spring	0.0011	0.0005	<0.001	0.002	<0.001	0.001	0.56	0.52
Lower Jumpup Spring	0.0014	0.0002	<0.001	0.001	<0.001	0.001	ns	ns
Mountain Sheep Spring	0.0006	0.0005	0.0011	0.0004	<0.001	0.001	0.38	0.78
Mountain Sheep Spring	0.0007	0.0006	0.0006	0.0003	<0.001	0.001	ns	ns
Rider Spring	ns	ns	ns	ns	ns	ns	1.59	1.56
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns
Rock Spring	0.0007	0.0000	0.0006	0.0002	<0.001	0.000	0.84	0.34
Rock Spring	<0.0004	0.0002	<0.0004	0.0003	<0.001	0.001	ns	ns
Schmutz Spring	<0.0004	0.0001	<0.001	0.001	<0.001	0.000	0.47	0.51
Schmutz Spring	<0.0004	0.0003	<0.001	0.002	<0.001	0.001	ns	ns
Showerbath Spring	<0.0004	0.0003	<0.001	0.000	<0.001	0.001	0.30	0.29
Showerbath Spring	<0.0004	0.0002	<0.001	0.001	<0.001	0.001	ns	ns
Side Canyon Spring	<0.0004	0.0005	<0.001	0.001	<0.001	0.001	0.55	0.46
Side Canyon Spring	<0.0004	0.0003	<0.001	0.000	<0.001	0.000	ns	ns
Slide Spring	<0.0004	0.0002	<0.001	0.001	<0.001	0.001	0.38	0.34
Slide Spring	<0.0004	0.0001	<0.001	0.001	<0.001	0.001	ns	ns
Upper Jumpup Spring	<0.0004	0.0001	<0.001	0.002	<0.001	0.001	0.27	0.25
Upper Jumpup Spring	<0.0004	0.0004	<0.001	0.000	<0.001	0.001	ns	ns
Willow Spring (Hack Canyon)	0.0004	0.0007	<0.001	0.001	<0.001	0.001	0.94	1.04
Willow Spring (Hack Canyon)	0.0007	0.0004	<0.001	0.000	<0.001	0.001	ns	ns
Burnt Canyon Well	0.0007	0.0000	0.0014	0.0009	<0.0003	0.0006	1.46	1.38
Burnt Canyon Well	0.0012	0.0004	0.0017	0.0008	<0.0003	0.0009	ns	ns
Canyon Mine Well	<0.0007	0.0004	<0.0005	0.0003	<0.0003	0.0013	0.33	0.29
Canyon Mine Well	<0.0007	0.0003	<0.0005	0.0002	<0.0003	0.0003	ns	ns
Pinenut Well	<0.0007	0.0005	<0.0005	0.0003	<0.0003	0.0006	0.85	0.75
Pinenut Well	<0.0007	0.0002	0.0006	0.0002	<0.0003	0.0002	ns	ns
Tom Land Well	0.0012	0.0009	<0.0005	0.0002	<0.0003	0.0007	1.0	0.90
Tom Land Well	<0.0007	0.0003	0.0006	0.0005	<0.0003	0.0005	ns	ns

Table A. Analysis results from all laboratories.—Continued

Spring or well	Iron NWQL ICP–MS µg/L	Iron Doughten ICP–OES µg/L	Iron Taylor ICP–AES µg/L	Iron-SD Taylor ICP–AES µg/L	Gallium Taylor ICP–MS µg/L	Gallium-SD Taylor ICP–MS µg/L	Gadolinium Taylor ICP–MS µg/L	Gadolinium-SD Taylor ICP–MS µg/L	Mercury Taylor CV–AFS ng/L	Mercury-SD Taylor CV–AFS ng/L
Buck Farm Spring	<4	<20	ns	ns	ns	ns	ns	ns	na	na
Buck Farm Spring	--	ns	ns	ns	ns	ns	ns	ns	na	na
Fence Spring	<4	<20	ns	ns	ns	ns	ns	ns	na	na
Hanging Spring	<4	<20	ns	ns	ns	ns	ns	ns	na	na
Hole in the Wall Spring	<4	<20	ns	ns	ns	ns	ns	ns	na	na
South Canyon Spring	ns	<20	4	2	0.0032	0.0001	0.0009	0.0003	na	na
South Canyon Spring	ns	ms	3	1	0.0033	0.0012	0.0010	0.0005	na	na
Unknown Spring	<4	<20	ns	ns	ns	ns	ns	ns	na	na
Unknown Spring	--	<20	ns	ns	ns	ns	ns	ns	na	na
Vasey's Paradise	ns	<20	ns	ns	ns	ns	ns	ns	na	na
Clearwater Spring	28	<100	31	0	0.020	0.002	<0.0004	0.0003	0.2	0.1
Clearwater Spring	ns	ns	35	2	0.022	0.001	<0.0004	0.0002	na	na
Hotel Spring	5	<20	7	3	0.0044	0.0010	0.0044	0.0001	2.0	0.1
Hotel Spring	ns	ns	4	1	0.0046	0.0009	0.0040	0.0000	na	na
Kanab Spring	<4	<20	<2	1	0.0019	0.0003	0.0007	0.0002	0.2	0.1
Kanab Spring	--	ns	<2	1	0.0017	0.0009	<0.0004	0.0005	na	na
Lower Jumpup Spring	5	<20	4	1	0.0042	0.0021	0.0013	0.0005	0.3	0.1
Lower Jumpup Spring	ns	ns	4	0	0.0036	0.0012	0.0016	0.0006	na	na
Mountain Sheep Spring	4e	<20	3	4	0.0028	0.0010	0.0005	0.0001	<0.2	0.0
Mountain Sheep Spring	--	ns	<3	2	0.0032	0.0006	0.0008	0.0004	na	na
Rider Spring	12	<20	ns	ns	ns	ns	ns	ns	na	na
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns	na	na
Rock Spring	<8	<100	4	3	0.0023	0.0012	<0.0004	0.0002	<0.2	0.1
Rock Spring	ns	ns	20	4	0.0013	0.0007	<0.0004	0.0003	na	na
Schmutz Spring	<4	<20	<2	0	0.0016	0.0002	<0.0004	0.0005	0.3	0.1
Schmutz Spring	--	ns	<2	1	0.0025	0.0007	<0.0004	0.0005	na	na
Showerbath Spring	2e	<20	<2	1	0.0019	0.0006	<0.0004	0.0001	0.2	0.0
Showerbath Spring	ns	ns	<2	2	0.0035	0.0008	<0.0004	0.0005	na	na
Side Canyon Spring	<4	70	<2	3	0.0012	0.0004	<0.0004	0.0004	<0.2	0.1
Side Canyon Spring	ns	ns	<2	1	0.0014	0.0007	<0.0004	0.0003	na	na
Slide Spring	<4	<20	<2	0	0.0020	0.0007	<0.0004	0.0001	0.4	0.1
Slide Spring	ns	ns	<2	1	0.0013	0.0010	0.0005	0.0005	na	na
Upper Jumpup Spring	<4	<20	<2	1	0.0017	0.0003	<0.0004	0.0002	0.4	0.2
Upper Jumpup Spring	ns	ns	<2	1	0.0021	0.0009	<0.0004	0.0003	na	na
Willow Spring (Hack Canyon)	<12	<100	27	4	0.0029	0.0003	0.0012	0.0004	0.3	0.1
Willow Spring (Hack Canyon)	ns	ns	7	1	0.0036	0.0006	0.0010	0.0007	na	na
Burnt Canyon Well	761	680	790	129	0.003	0.001	0.0011	0.0001	2.3	0.2
Burnt Canyon Well	ns	ns	590	16	0.003	0.003	0.0020	0.0005	na	na
Canyon Mine Well	2e	<20	<10	6	0.006	0.001	0.0007	0.0005	1.6	0.4
Canyon Mine Well	ns	ns	<10	4	0.005	0.001	0.0006	0.0000	na	na
Pinenut Well	4,170	4,650	4,860	209	0.019	0.000	0.0004	0.0000	1.7	0.2
Pinenut Well	ns	ns	4,830	76	0.015	0.001	0.0004	0.0001	na	na
Tom Land Well	779	776	721	19	0.003	0.002	0.0008	0.0000	1.4	0.2
Tom Land Well	ns	ns	703	27	0.005	0.000	0.0010	0.0001	na	na

Table A. Analysis results from all laboratories.—Continued

Spring or well	Holmium Taylor ICP–MS µg/L	Holmium-SD Taylor ICP–MS µg/L	Potassium NWQL ICP–MS mg/L	Potassium Doughten ICP–OES mg/L	Potassium Taylor ICP–MS/AES mg/L	Potassium-SD Taylor ICP–MS/AES mg/L	Kjeldahl-nitrogen, unf NWQL KDM mg N/L	Lanthanum Taylor ICP–MS µg/L	Lanthanum-SD Taylor ICP–MS µg/L
Buck Farm Spring	ns	ns	7.32	7.0	ns	ns	<0.1	ns	ns
Buck Farm Spring	ns	ns	--	ns	ns	ns	ns	ns	ns
Fence Spring	ns	ns	15.9	15.3	ns	ns	<0.1	ns	ns
Hanging Spring	ns	ns	0.82	0.8	ns	ns	<0.1	ns	ns
Hole in the Wall Spring	ns	ns	0.86	0.8	ns	ns	<0.1	ns	ns
South Canyon Spring	0.0003	0.0002	ns	1.5	1.6	0.1	ns	0.0027	0.0002
South Canyon Spring	<0.0003	0.0001	ns	ns	1.6	0.1	ns	0.0027	0.0004
Unknown Spring	ns	ns	0.75	0.8	ns	ns	<0.1	ns	ns
Unknown Spring	ns	ns	--	0.8	ns	ns	ns	ns	ns
Vasey's Paradise	ns	ns	ns	0.7	ns	ns	ns	ns	ns
Clearwater Spring	0.0008	0.0002	12.8	11.4	11	1	0.5	0.0007	0.0000
Clearwater Spring	0.0015	0.0001	ns	ns	11	0	ns	0.0007	0.0005
Hotel Spring	0.0008	0.0004	7.26	7.1	7.0	0.2	0.5	0.0085	0.0012
Hotel Spring	0.0008	0.0003	ns	ns	7.0	0.0	ns	0.0088	0.0016
Kanab Spring	<0.0003	0.0002	4.03	3.8	3.9	0.1	<0.1	0.0017	0.0007
Kanab Spring	<0.0003	0.0003	--	ns	3.8	0.1	ns	0.0015	0.0002
Lower Jumpup Spring	0.0005	0.0003	8.32	8.1	8.1	0.0	0.09e	0.0052	0.0002
Lower Jumpup Spring	0.0005	0.0002	ns	ns	7.8	0.3	ns	0.0051	0.0004
Mountain Sheep Spring	0.0002	0.0000	8.09	7.6	7.7	0.1	<0.1	0.0021	0.0001
Mountain Sheep Spring	0.0002	0.0001	--	ns	7.6	0.1	ns	0.0017	0.0004
Rider Spring	ns	ns	5.79	5.4	ns	ns	<0.1	ns	ns
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Rock Spring	0.0001	0.0000	5.64	5.4	4.8	0.2	<0.1	0.0008	0.0001
Rock Spring	<0.0001	0.0001	ns	ns	5.0	0.0	ns	0.0005	0.0002
Schmutz Spring	<0.0003	0.0003	3.05	2.9	2.7	0.0	<0.1	0.0006	0.0003
Schmutz Spring	<0.0003	0.0002	--	ns	2.6	0.1	ns	0.0005	0.0005
Showerbath Spring	<0.0003	0.0002	4.58	4.2	4.1	0.2	0.05e	0.0008	0.0002
Showerbath Spring	<0.0003	0.0002	ns	ns	4.0	0.4	ns	0.0006	0.0001
Side Canyon Spring	<0.0003	0.0001	5.41	5.2	4.8	0.2	<0.1	0.0008	0.0001
Side Canyon Spring	<0.0003	0.0003	ns	ns	5.1	0.2	ns	0.0004	0.0001
Slide Spring	<0.0003	0.0002	2.06	2.1	1.9	0.1	<0.1	0.0002	0.0002
Slide Spring	<0.0003	0.0002	ns	ns	2.0	0.0	ns	0.0006	0.0004
Upper Jumpup Spring	0.0003	0.0002	1.78	1.8	1.6	0.2	<0.1	0.0008	0.0003
Upper Jumpup Spring	<0.0003	0.0003	ns	ns	1.6	0.1	ns	0.0004	0.0001
Willow Spring (Hack Canyon)	<0.0003	0.0001	12.7	12.0	11	1	0.2	0.0060	0.0001
Willow Spring (Hack Canyon)	0.0004	0.0002	ns	ns	12	1	ns	0.0053	0.0009
Burnt Canyon Well	0.0006	0.0004	15.5	14.8	15	0	0.08e	0.0025	0.0002
Burnt Canyon Well	0.0009	0.0001	ns	ns	16	1	ns	0.0032	0.0006
Canyon Mine Well	<0.0003	0.0001	1.74	2.2	2.3	0.1	<0.1	0.0012	0.0004
Canyon Mine Well	<0.0003	0.0001	ns	ns	2.3	0.1	ns	0.0012	0.0002
Pinenut Well	<0.0003	0.0002	24.70	23.4	25	1	0.06e	0.0013	0.0003
Pinenut Well	<0.0003	0.0003	ns	ns	26	2	ns	0.0013	0.0005
Tom Land Well	<0.0003	0.0003	7.16	6.7	7.1	0.1	0.1	0.0023	0.0001
Tom Land Well	<0.0003	0.0002	ns	ns	7.3	0.2	ns	0.0018	0.0002

Table A. Analysis results from all laboratories.—Continued

Spring or well	Lithium NWQL AASD µg/L	Lithium Doughten ICP–MS µg/L	Lithium Taylor ICP–MS µg/L	Lithium-SD Taylor ICP–MS µg/L	Lutetium Taylor ICP–MS µg/L	Lutetium-SD Taylor ICP–MS µg/L	Magnesium NWQL ICP–MS mg/L	Magnesium Doughten ICP–OES mg/L	Magnesium Taylor ICP–AES mg/L	Magnesium-SD Taylor ICP–AES mg/L
Buck Farm Spring	24.4	24	ns	ns	ns	ns	33.9	33.3	ns	ns
Buck Farm Spring	22.7	ns	ns	ns	ns	ns	ns	ns	ns	ns
Fence Spring	355	378	ns	ns	ns	ns	39.4	38.6	ns	ns
Hanging Spring	1.7	2	ns	ns	ns	ns	21.0	19.8	ns	ns
Hole in the Wall Spring	1.6	2	ns	ns	ns	ns	21.2	20.0	ns	ns
South Canyon Spring	ns	3	4.0	0.1	0.0001	0.0001	ns	18.6	17	1
South Canyon Spring	ns	ns	4.0	0.2	0.0002	0.0001	ns	ns	18	1
Unknown Spring	1.7	2	ns	ns	ns	ns	20.7	20.1	ns	ns
Unknown Spring	1.7	2	ns	ns	ns	ns	ns	20.3	ns	ns
Vasey's Paradise	ns	1	ns	ns	ns	ns	ns	20.8	ns	ns
Clearwater Spring	92.1	100	82	1	0.0001	0.0001	182.0	177	170	3
Clearwater Spring	ns	ns	84	4	<0.0001	0.0000	ns	ns	172	0
Hotel Spring	18.9	18	18	0	0.0003	0.0001	49.7	47.4	49	1
Hotel Spring	ns	ns	19	1	0.0004	0.0001	ns	ns	47	2
Kanab Spring	18.4	18	20	1	<0.0001	0.0001	48.8	48.4	51	1
Kanab Spring	19.4	ns	20	1	<0.0001	0.0001	ns	ns	48	3
Lower Jumpup Spring	45.3	54	53	2	0.0002	0.0001	121	124	117	3
Lower Jumpup Spring	ns	ns	51	0	0.0002	0.0000	ns	ns	120	2
Mountain Sheep Spring	33.9	40	39	1	0.0003	0.0002	98.2	97.2	98	6
Mountain Sheep Spring	32.1	ns	39	2	<0.0001	0.0001	ns	ns	95	3
Rider Spring	70.5	70	ns	ns	ns	ns	65.6	62.5	ns	ns
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Rock Spring	59.3	74	63	0	<0.0001	0.0001	158.0	153	150	5
Rock Spring	ns	ns	66	2	<0.0001	0.0001	ns	ns	150	2
Schmutz Spring	21.9	24	23	1	0.0002	0.0002	77.4	83.3	78	0
Schmutz Spring	21.6	ns	26	4	<0.0001	0.0000	ns	ns	76	1
Showerbath Spring	17.8	20	21	0	<0.0001	0.0001	53.0	49.8	49	3
Showerbath Spring	ns	ns	21	0	<0.0001	0.0001	ns	ns	48	3
Side Canyon Spring	29.5	31	31	0	<0.0001	0.0001	78.7	76.8	75	2
Side Canyon Spring	ns	ns	31	1	<0.0001	0.0001	ns	ns	79	2
Slide Spring	9.7	13	13	0	<0.0001	0.0000	68.8	65.9	65	2
Slide Spring	ns	ns	13	0	<0.0001	0.0000	ns	ns	65	1
Upper Jumpup Spring	7.5	8	8.7	0.3	<0.0001	0.0001	63.3	61.6	59	2
Upper Jumpup Spring	ns	ns	8.8	0.1	0.0002	0.0001	ns	ns	59	2
Willow Spring (Hack Canyon)	87.9	89	75	0	0.0002	0.0001	227	234	222	1
Willow Spring (Hack Canyon)	ns	ns	75	1	0.0002	0.0001	ns	ns	225	10
Burnt Canyon Well	348.0	344	342	3	0.0002	0.0001	269.0	263	273	21
Burnt Canyon Well	ns	ns	368	45	0.0002	0.0000	ns	ns	279	5
Canyon Mine Well	6.1	6	8.0	0.2	<0.0002	0.0001	22.9	30.2	30	0
Canyon Mine Well	ns	ns	7.8	0.3	<0.0002	0.0000	ns	ns	30	1
Pinenut Well	196	154	166	2	<0.0002	0.0000	135	143	138	9
Pinenut Well	ns	ns	168	5	<0.0002	0.0001	ns	ns	143	7
Tom Land Well	51.7	54	58	1	<0.0002	0.0001	149	150	155	3
Tom Land Well	ns	ns	58	0	0.0002	0.0001	ns	ns	159	1

Table A. Analysis results from all laboratories.—Continued

Spring/well	Manganese NWQL AASGF µg/L	Manganese Doughten ICP–MS µg/L	Manganese Taylor ICP–MS/AES µg/L	Manganese-SD Taylor ICP–MS/AES µg/L	Molybdenum NWQL AASCE µg/L	Molybdenum Doughten ICP–MS µg/L	Molybdenum Taylor ICP–MS µg/L	Molybdenum-SD Taylor ICP–MS µg/L
Buck Farm Spring	<0.2	<1	ns	ns	2.7	2.6	ns	ns
Buck Farm Spring	0.1e	ns	ns	ns	2.7	ns	ns	ns
Fence Spring	<0.2	<1	ns	ns	1.1	1.1	ns	ns
Hanging Spring	0.1e	<1	ns	ns	0.2	0.3	ns	ns
Hole in the Wall Spring	ns	<1	ns	ns	0.2	0.3	ns	ns
South Canyon Spring	--	<1	0.26	0.01	ns	1.1	1.0	0.0
South Canyon Spring	ns	ns	0.08	0.01	ns	ns	1.1	0.0
Unknown Spring	0.1e	<1	ns	ns	0.2	0.3	ns	ns
Unknown Spring	<0.2	<1	ns	ns	0.2	0.3	ns	ns
Vasey's Paradise	ns	<1	ns	ns	ns	0.2	ns	ns
Clearwater Spring	1,060	980	1,040	50	3.6	4.0	2.6	0.0
Clearwater Spring	ns	ns	1,050	50	ns	ns	2.7	0.1
Hotel Spring	1.6	3	1.8	0.1	8.1	8.1	7.8	0.2
Hotel Spring	ns	ns	1.8	0.1	ns	ns	7.7	0.0
Kanab Spring	0.3	<1	0.29	0.02	4.5	4.5	4.3	0.0
Kanab Spring	0.3	ns	0.28	0.02	4.8	ns	4.3	0.0
Lower Jumpup Spring	7.1	8	7.5	0.4	6.1	6.9	6.5	0.0
Lower Jumpup Spring	ns	ns	7.5	0.4	ns	ns	6.3	0.2
Mountain Sheep Spring	0.2	<1	0.019	0.001	2.4	2.4	2.1	0.1
Mountain Sheep Spring	<0.2	ns	<0.009	0.008	2.1	ns	2.1	0.0
Rider Spring	0.1e	<1	ns	ns	17.1	17.3	ns	ns
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns
Rock Spring	0.2e	<5	0.038	0.005	9.0	10.0	8.7	0.3
Rock Spring	ns	ns	0.036	0.003	ns	ns	8.7	0.0
Schmutz Spring	0.6	<1	0.64	0.06	8.5	8.6	7.8	0.0
Schmutz Spring	0.8	ns	0.64	0.03	8.4	ns	7.8	0.0
Showerbath Spring	<0.2	<1	<0.02	0.01	4.1	4.5	4.2	0.0
Showerbath Spring	ns	ns	<0.02	0.00	ns	ns	4.2	0.0
Side Canyon Spring	<0.2	<1	<0.02	0.00	11.2	11.5	11	0
Side Canyon Spring	ns	ns	<0.02	0.00	ns	ns	10	0
Slide Spring	<0.2	<1	<0.02	0.01	2.2	2.8	2.4	0.0
Slide Spring	ns	ns	<0.02	0.01	ns	ns	2.5	0.0
Upper Jumpup Spring	<0.2	<1	<0.02	0.00	4.2	4.7	4.3	0.0
Upper Jumpup Spring	ns	ns	<0.02	0.01	ns	ns	4.3	0.1
Willow Spring (Hack Canyon)	0.6	<5	0.26	0.03	13.9	14.0	12	0
Willow Spring (Hack Canyon)	ns	ns	0.25	0.01	ns	ns	13	0
Burnt Canyon Well	4	5	4.4	0.1	3.1	3.0	2.9	0.1
Burnt Canyon Well	ns	ns	4.6	0.3	ns	ns	3.0	0.0
Canyon Mine Well	58.4	66	71	1	0.9	1.0	1.1	0.0
Canyon Mine Well	sn	ns	71	1	ns	ms	1.1	0.0
Pinenut Well	317	334	364	2	24.6	21.2	22	0
Pinenut Well	ns	ns	371	2	ns	ms	22	0
Tom Land Well	11.4	11	12	0	5.1	4.4	4.4	0.0
Tom Land Well	ns	ns	12	0	ns	ns	4.4	0.0

Table A. Analysis results from all laboratories.—Continued

Spring or well	Sodium NWQL ICP–MS mg/L	Sodium Doughten ICP–OES mg/L	Sodium Taylor ICP–AES mg/L	Sodium-SD Taylor ICP–AES mg/L	Neodymium Taylor ICP–MS µg/L	Neodymium-SD Taylor ICP–MS µg/L	Ammonium (NH4) NWQL CS mg N/L
Buck Farm Spring	19.1	19.0	ns	ns	ns	ns	<0.02
Buck Farm Spring	ns	ns	ns	ns	ns	ns	ns
Fence Spring	156	161	ns	ns	ns	ns	<0.02
Hanging Spring	1.74	1.65	ns	ns	ns	ns	<0.02
Hole in the Wall Spring	1.80	1.66	ns	ns	ns	ns	<0.02
South Canyon Spring	ns	4.35	3.7	0.5	0.0050	0.0004	ns
South Canyon Spring	ns	ns	3.7	0.4	0.0035	0.0000	ns
Unknown Spring	1.75	1.69	ns	ns	ns	ns	<0.02
Unknown Spring	ns	1.70	ns	ns	ns	ns	ns
Vasey's Paradise	ns	1.81	ns	ns	ns	ns	ns
Clearwater Spring	153.0	142	148	1	0.0018	0.0005	0.42
Clearwater Spring	ns	ns	157	5	0.0011	0.0003	ns
Hotel Spring	25.7	26.6	27	1	0.014	0.000	0.017e
Hotel Spring	ns	ns	27	1	0.015	0.000	ns
Kanab Spring	15.7	15.7	16	0	0.0015	0.0008	<0.02
Kanab Spring	ns	ns	16	0	0.0010	0.0007	ns
Lower Jumpup Spring	37.0	38.6	38	0	0.0043	0.0007	<0.02
Lower Jumpup Spring	ns	ns	38	1	0.0041	0.0008	ns
Mountain Sheep Spring	31.4	32.0	32	2	0.0026	0.0008	<0.02
Mountain Sheep Spring	ns	ns	34	0	0.0021	0.0003	ns
Rider Spring	91.7	88.8	ns	ns	ns	ns	<0.02
Rider Spring	ns	ns	ns	ns	ns	ns	ns
Rock Spring	33.9	32.7	35	1	0.0007	0.0005	<0.02
Rock Spring	ns	ns	35	1	<0.0005	0.0006	ns
Schmutz Spring	13.0	12.7	12	1	0.0006	0.0004	<0.02
Schmutz Spring	ns	ns	12	0	0.0013	0.0005	ns
Showerbath Spring	18.8	18.6	18	1	0.0009	0.0003	<0.02
Showerbath Spring	ns	ns	18	0	<0.0005	0.0008	ns
Side Canyon Spring	17.1	17.6	17	1	<0.0005	0.0007	<0.02
Side Canyon Spring	ns	ns	18	1	0.0006	0.0004	ns
Slide Spring	10.1	10.7	9.3	0.8	<0.0005	0.0001	<0.02
Slide Spring	ns	ns	9.0	1.0	<0.0005	0.0001	ns
Upper Jumpup Spring	10.6	10.9	9.6	0.6	0.0006	0.0005	<0.02
Upper Jumpup Spring	ns	ns	9.9	1.1	0.0012	0.0006	ns
Willow Spring (Hack Canyon)	64.2	62.5	65	3	0.0049	0.0021	0.05
Willow Spring (Hack Canyon)	ns	ns	68	3	0.0035	0.0005	ns
Burnt Canyon Well	79.8	79.0	83	5	0.0036	0.0005	0.053e
Burnt Canyon Well	ns	ns	85	0	0.0018	0.0004	ns
Canyon Mine Well	4.23	5.7	6.2	0.0	<0.0009	0.0002	<0.02
Canyon Mine Well	ns	ns	6.1	0.2	0.0029	0.0004	ns
Pinenut Well	67.7	70.1	73	0	<0.0009	0.0005	0.05
Pinenut Well	ns	ns	77	4	<0.0009	0.0005	ns
Tom Land Well	26.9	26.8	27	1	0.0029	0.0013	0.02
Tom Land Well	ns	ns	28	1	0.0016	0.0003	ns

Table A. Analysis results from all laboratories.—Continued

Spring or well	Nickel NWQL ICP–MS µg/L	Nickel Doughten ICP–MS µg/L	Nickel Taylor ICP–AES µg/L	Nickel-SD Taylor ICP–AES µg/L	Nitrate NWQL CCRDSF mg N/L	Nitrate Doughten IC mg N/L	Nitrate + nitrite NWQL CCRDSF mg N/L	Phosphorus NWQL CPBDSF mg P/L	Phosphorus Taylor ICP–MS/AES mg P/L	Phosphorus-SD Taylor ICP–MS/AES mg P/L	Phosphorus, unf NWQL CPBDSF mg P/L
Buck Farm Spring	0.42	0.2	ns	ns	<0.002	0.20	0.17	<0.04	ns	ns	<0.04
Buck Farm Spring	0.45	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Fence Spring	1.1	1.1	ns	ns	<0.002	0.19	0.17	<0.04	ns	ns	0.02e
Hanging Spring	0.20	<0.1	ns	ns	<0.002	0.20	0.19	<0.04	ns	ns	0.03e
Hole in the Wall Spring	0.19	<0.1	ns	ns	<0.002	0.20	0.19	<0.04	ns	ns	<0.04
South Canyon Spring	ns	0.1	<0.3	0.1	ns	<0.05	ns	ns	<0.005	0.003	ns
South Canyon Spring	ns	ns	<0.3	0.3	ns	ns	ns	ns	0.010	0.008	ns
Unknown Spring	0.19	<0.1	ns	ns	<0.002	0.20	0.18	<0.04	ns	ns	0.02e
Unknown Spring	0.20	<0.1	ns	ns	ns	0.21	ns	ns	ns	ns	ns
Vasey’s Paradise	ns	<0.1	ns	ns	ns	0.00	ns	ns	ns	ns	ns
Clearwater Spring	2.9	7.1	<0.3	0.2	<0.002	<0.05	<0.04	<0.04	<0.005	0.005	0.09
Clearwater Spring	ns	ns	<0.3	0.0	ns	ns	ns	ns	<0.005	0.007	ns
Hotel Spring	0.88	0.8	0.6	0.1	0.018	0.75	0.74	<0.04	<0.005	0.009	<0.04
Hotel Spring	ns	ns	0.3	0.1	ns	ns	ns	ns	<0.005	0.001	ns
Kanab Spring	0.68	0.5	<0.3	0.3	<0.002	0.30	0.28	<0.04	<0.005	0.008	<0.04
Kanab Spring	1.2	ns	<0.3	0.2	ns	ns	ns	ns	<0.005	0.011	ns
Lower Jumpup Spring	2.7	1.6	<0.3	0.3	<0.002	<0.05	<0.04	<0.04	<0.005	0.010	<0.04
Lower Jumpup Spring	ns	ns	<0.3	0.2	ns	ns	ns	ns	<0.005	0.006	ns
Mountain Sheep Spring	2.5	1.2	<0.3	0.6	<0.002	0.49	0.48	<0.04	<0.008	0.008	0.03e
Mountain Sheep Spring	2.0	ns	<0.3	0.2	ns	ns	ns	ns	<0.008	0.008	ns
Rider Spring	0.40	8.2	ns	ns	<0.002	2.16	2.12	<0.04	ns	ns	<0.04
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Rock Spring	3.3	1.8	<0.3	0.7	<0.002	<0.05	<0.04	<0.04	<0.008	0.002	<0.04
Rock Spring	ns	ns	<0.3	0.4	ns	ns	ns	ns	<0.008	0.011	ns
Schmutz Spring	0.98	0.6	<0.3	0.3	<0.002	0.78	0.75	<0.04	<0.005	0.006	<0.04
Schmutz Spring	1.4	ns	<0.3	0.3	ns	ns	ns	ns	<0.005	0.001	ns
Showerbath Spring	0.70	0.4	<0.3	0.1	<0.002	0.25	0.23	<0.04	<0.005	0.006	<0.04
Showerbath Spring	ns	ns	<0.3	0.1	ns	ns	ns	ns	<0.005	0.008	ns
Side Canyon Spring	1.4	0.7	<0.3	0.4	<0.002	1.85	1.78	<0.04	<0.005	0.008	<0.04
Side Canyon Spring	ns	ns	<0.3	0.2	ns	ns	ns	ns	<0.005	0.005	ns
Slide Spring	1.1	0.8	<0.3	0.3	<0.002	1.31	1.29	<0.04	<0.005	0.001	<0.04
Slide Spring	ns	ns	<0.3	0.0	ns	ns	ns	ns	<0.005	0.004	ns
Upper Jumpup Spring	1.1	0.7	<0.3	0.2	<0.002	1.43	1.43	<0.04	<0.005	0.005	<0.04
Upper Jumpup Spring	ns	ns	<0.3	0.3	ns	ns	ns	ns	<0.005	0.004	ns
Willow Spring (Hack Canyon)	2.7	3.7	<0.3	0.2	<0.002	4.38	4.36	<0.04	<0.005	0.005	<0.04
Willow Spring (Hack Canyon)	ns	ns	0.5	0.2	ns	ns	ns	ns	<0.005	0.006	ns
Burnt Canyon Well	7.6	9.6	5.2	0.4	<0.002	<0.05	<0.04	<0.04	<0.007	0.001	<0.04
Burnt Canyon Well	ns	ns	5.5	0.1	ns	ns	ns	ns	<0.007	0.001	ns
Canyon Mine Well	7.8	8.6	8.3	0.1	<0.002	0.15	0.12	<0.04	<0.007	0.003	<0.04
Canyon Mine Well	sn	ns	8.1	0.4	ns	ns	ns	ns	<0.007	0.002	ns
Pinenut Well	10.7	14.3	8.8	0.0	<0.002	0.00	<0.04	<0.04	<0.007	0.000	<0.04
Pinenut Well	ns	ns	9.6	0.2	ns	ns	ns	ns	<0.007	0.004	ns
Tom Land Well	30.7	29.3	29	0	<0.006	6.80	6.96	<0.04	<0.007	0.001	<0.04
Tom Land Well	ns	ns	29	0	ns	ns	ns	ns	<0.007	0.001	ns

Table A. Analysis results from all laboratories.—Continued

Spring or well	Lead NWQL AASGF µg/L	Lead Doughten ICP–MS µg/L	Lead Taylor ICP–AES µg/L	Lead-SD Taylor ICP–AES µg/L	Phosphate PO_4 NWQL not provided mg P/L	Praseodymium Taylor ICP–MS µg/L	Praseodymium-SD Taylor ICP–MS µg/L	Rubidium Doughten ICP–MS µg/L	Rubidium Taylor ICP–MS µg/L	Rubidium-SD Taylor ICP–MS µg/L
Buck Farm Spring	<0.06	<0.05	ns	ns	0.005e	ns	ns	4.2	ns	ns
Buck Farm Spring	<0.06	ns	ns	ns	ns	ns	ns	ns	ns	ns
Fence Spring	<0.06	<0.05	ns	ns	0.017	ns	ns	44.4	ns	ns
Hanging Spring	<0.06	<0.05	ns	ns	0.018	ns	ns	1.3	ns	ns
Hole in the Wall Spring	<0.06	<0.05	ns	ns	0.018	ns	ns	1.3	ns	ns
South Canyon Spring	ns	0.34	0.068	0.004	ns	0.0009	0.0001	1.5	1.6	0.0
South Canyon Spring	ns	ns	0.064	0.003	ns	0.0004	0.0000	ns	1.6	0.0
Unknown Spring	<0.06	<0.05	ns	ns	0.018	ns	ns	1.3	ns	ns
Unknown Spring	<0.06	<0.05	ns	ns	ns	ns	ns	1.3	ns	ns
Vasey's Paradise	ns	<0.05	ns	ns	ns	ns	ns	1.2	ns	ns
Clearwater Spring	<0.12	<0.25	0.007	0.001	0.006e	<0.0002	0.0002	1.4	1.4	0.1
Clearwater Spring	ns	ns	0.007	0.001	ns	<0.0002	0.0002	ns	1.4	0.0
Hotel Spring	<0.06	<0.05	0.033	0.009	0.005e	0.0029	0.0001	3.9	4.1	0.1
Hotel Spring	ns	ns	0.025	0.003	ns	0.0027	0.0003	ns	4.1	0.1
Kanab Spring	0.04e	<0.05	0.043	0.003	0.007e	<0.0002	0.0001	3.4	3.6	0.0
Kanab Spring	0.04e	ns	0.042	0.004	ns	0.0002	0.0002	ns	3.4	0.0
Lower Jumpup Spring	<0.18	<0.05	0.008	0.001	0.012	0.0007	0.0003	2.1	2.2	0.1
Lower Jumpup Spring	ns	ns	0.012	0.003	ns	0.0008	0.0003	ns	2.2	0.0
Mountain Sheep Spring	<0.06	<0.05	0.012	0.002	0.011	0.0005	0.0001	4.3	4.4	0.0
Mountain Sheep Spring	<0.06	ns	0.010	0.000	ns	0.0005	0.0001	ns	4.3	0.0
Rider Spring	<0.06	<0.05	ns	ns	<0.008	ns	ns	8.0	ns	ns
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Rock Spring	<0.12	<0.25	0.006	0.000	0.006e	<0.0002	0.0002	4.3	4.0	0.0
Rock Spring	ns	ns	0.004	0.002	ns	<0.0002	0.0001	ns	3.9	0.0
Schmutz Spring	<0.06	<0.05	0.007	0.005	0.005e	<0.0002	0.0001	3.1	3.1	0.1
Schmutz Spring	<0.06	ns	0.007	0.005	ns	0.0002	0.0002	ns	3.1	0.1
Showerbath Spring	<0.06	<0.05	0.007	0.002	0.005e	<0.0002	0.0001	3.1	3.2	0.1
Showerbath Spring	ns	ns	0.008	0.005	ns	<0.0002	0.0001	ns	3.2	0.0
Side Canyon Spring	<0.06	<0.05	0.009	0.006	0.005e	<0.0002	0.0003	6.1	6.1	0.0
Side Canyon Spring	ns	ns	0.006	0.001	ns	<0.0002	0.0001	ns	6.1	0.0
Slide Spring	<0.06	<0.05	0.004	0.003	0.005e	<0.0002	0.0000	2.0	2.0	0.0
Slide Spring	ns	ns	0.005	0.001	ns	<0.0002	0.0000	ns	2.0	0.0
Upper Jumpup Spring	<0.06	<0.05	0.010	0.005	0.006e	0.0005	0.0001	1.9	2.0	0.0
Upper Jumpup Spring	ns	ns	0.009	0.002	ns	<0.0002	0.0001	ns	2.0	0.0
Willow Spring (Hack Canyon)	<0.12	<0.25	0.021	0.011	0.007e	0.0010	0.0001	8.3	8.0	0.3
Willow Spring (Hack Canyon)	ns	ns	0.020	0.005	ns	0.0008	0.0002	ns	8.0	0.4
Burnt Canyon Well	0.76	<0.15	0.75	0.01	0.008e	0.0004	0.0001	21.9	23	0
Burnt Canyon Well	ns	ns	0.75	0.00	ns	0.0003	0.0000	ns	23	0
Canyon Mine Well	0.24	0.29	0.26	0.01	0.006e	<0.0001	0.0001	7.9	8.4	0.0
Canyon Mine Well	ns	ns	0.28	0.01	ns	<0.0001	0.0001	ns	8.4	0.1
Pinenut Well	<0.06	<0.15	0.050	0.003	<0.024	<0.0001	0.0001	20.7	22	0
Pinenut Well	ns	ns	0.013	0.003	ns	0.0002	0.0001	ns	22	0
Tom Land Well	0.13	<0.15	0.094	0.008	0.006e	0.0004	0.0000	7.9	8.2	0.2
Tom Land Well	ns	ns	0.094	0.001	ns	0.0003	0.0001	ns	8.4	0.1

Table A. Analysis results from all laboratories.—Continued

Spring or well	Rhenium Taylor ICP–MS µg/L	Rhenium-SD Taylor ICP–MS µg/L	Sulfur Taylor ICP–AES mg/L	Sulfur-SD Taylor ICP–AES mg/L	Antimony NWQL AASH µg/L	Antimony Doughten ICP–MS µg/L	Antimony Taylor ICP–MS µg/L	Antimony-SD Taylor ICP–MS µg/L	Scandium Taylor ICP–AES µg/L	Scandium-SD Taylor ICP–AES µg/L
Buck Farm Spring	ns	ns	ns	ns	0.12	<0.1	ns	ns	ns	ns
Buck Farm Spring	ns	ns	ns	ns	0.12	ns	ns	ns	ns	ns
Fence Spring	ns	ns	ns	ns	0.06	<0.1	ns	ns	ns	ns
Hanging Spring	ns	ns	ns	ns	0.03e	<0.1	ns	ns	ns	ns
Hole in the Wall Spring	ns	ns	ns	ns	0.03e	<0.1	ns	ns	ns	ns
South Canyon Spring	0.045	0.005	18	0	ns	<0.1	0.030	0.002	<0.4	0.0
South Canyon Spring	0.039	0.005	18	0	ns	ns	0.020	0.003	<0.4	0.1
Unknown Spring	ns	ns	ns	ns	0.03e	<0.1	ns	ns	ns	ns
Unknown Spring	ns	ns	ns	ns	0.03e	<0.1	ns	ns	ns	ns
Vasey's Paradise	ns	ns	ns	ns	ns	<0.1	ns	ns	ns	ns
Clearwater Spring	0.34	0.00	690	5	0.93	<0.5	0.008	0.002	<0.4	0.2
Clearwater Spring	0.33	0.00	689	41	ns	ns	0.006	0.001	<0.4	0.1
Hotel Spring	0.048	0.002	73	4	0.12	<0.1	0.13	0.01	<0.4	0.6
Hotel Spring	0.048	0.005	72	4	ns	ns	0.13	0.00	<0.4	0.6
Kanab Spring	0.12	0.00	100	7	0.07	<0.1	0.072	0.000	<0.4	0.1
Kanab Spring	0.12	0.01	96	6	0.09	ns	0.073	0.003	<0.4	0.1
Lower Jumpup Spring	0.31	0.00	313	7	<0.12	<0.1	0.043	0.006	<0.4	0.5
Lower Jumpup Spring	0.31	0.01	310	5	ns	ns	0.045	0.004	<0.4	0.3
Mountain Sheep Spring	0.20	0.00	220	25	0.04	<0.1	0.026	0.003	<0.4	0.1
Mountain Sheep Spring	0.20	0.00	216	16	0.03e	ns	0.024	0.002	<0.4	0.1
Rider Spring	ns	ns	ns	ns	0.04e	<0.1	ns	ns	ns	ns
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Rock Spring	0.47	0.00	534	14	0.06e	<0.5	0.030	0.003	<0.4	0.1
Rock Spring	0.32	0.03	557	7	ns	ns	0.029	0.001	<0.4	0.1
Schmutz Spring	0.82	0.03	302	21	0.04e	<0.1	0.013	0.003	<0.4	0.5
Schmutz Spring	0.80	0.02	293	3	0.04e	ns	0.007	0.008	<0.4	0.6
Showerbath Spring	0.12	0.00	113	6	0.06	<0.1	0.066	0.004	<0.4	0.2
Showerbath Spring	0.11	0.00	117	5	ns	ns	0.069	0.004	<0.4	0.5
Side Canyon Spring	0.18	0.00	229	3	0.03e	<0.1	0.028	0.001	<0.4	0.5
Side Canyon Spring	0.18	0.00	222	14	ns	ns	0.031	0.003	<0.4	0.4
Slide Spring	0.24	0.00	165	6	0.04e	<0.1	0.015	0.002	<0.4	0.4
Slide Spring	0.25	0.00	162	3	ns	ns	0.015	0.002	<0.4	0.4
Upper Jumpup Spring	0.22	0.00	159	3	0.04e	<0.1	0.016	0.004	<0.4	0.3
Upper Jumpup Spring	0.22	0.01	162	4	ns	ns	0.019	0.004	<0.4	0.4
Willow Spring (Hack Canyon)	1.3	0.0	768	75	<0.08	<0.5	0.015	0.003	<0.4	0.3
Willow Spring (Hack Canyon)	1.3	0.0	761	63	ns	ns	0.014	0.002	<0.4	0.9
Burnt Canyon Well	0.21	0.00	867	67	0.09	<0.3	0.062	0.002	<0.5	0.5
Burnt Canyon Well	0.21	0.00	874	29	ns	ns	0.056	0.000	<0.5	1.7
Canyon Mine Well	0.015	0.000	7.6	0.5	0.05	<0.1	0.013	0.002	<0.5	2.0
Canyon Mine Well	0.016	0.000	7.6	0.6	ns	ns	0.019	0.002	<0.5	2.0
Pinenut Well	0.096	0.001	424	29	0.05	<0.3	0.034	0.001	<0.5	0.8
Pinenut Well	0.10	0.00	442	25	ns	ns	0.034	0.001	<0.5	0.6
Tom Land Well	0.62	0.00	543	31	0.05e	<0.3	0.024	0.004	<0.5	0.1
Tom Land Well	0.60	0.00	548	28	ns	ns	0.026	0.002	<0.5	0.0

Table A. Analysis results from all laboratories.—Continued

Spring or well	Selenium NWQL ICP–MS µg/L	Selenium Doughten ICP–MS µg/L	Selenium Taylor ICP–MS µg/L	Selenium-SD Taylor ICP–MS µg/L	Silica NWQL ICP–MS mg/L	Silica Doughten ICP–OES mg/L	Silica Taylor ICP–AES mg/L	Silica-SD Taylor ICP–AES mg/L	Samarium Taylor ICP–MS µg/L	Samarium-SD Taylor ICP–MS µg/L
Buck Farm Spring	3.5	4	ns	ns	--	11.8	ns	ns	ns	ns
Buck Farm Spring	3.7	ns	ns	ns	ns	ns	ns	ns	ns	ns
Fence Spring	1.2	3	ns	ns	9.8	9.93	ns	ns	ns	ns
Hanging Spring	0.78	<1	ns	ns	8.0	7.98	ns	ns	ns	ns
Hole in the Wall Spring	0.73	<1	ns	ns	8.0	8.17	ns	ns	ns	ns
South Canyon Spring	ns	3	3.3	0.1	ns	7.81	6.9	0.1	0.0011	0.0002
South Canyon Spring	ns	ns	3.3	0.2	ns	ns	7.0	0.2	0.0012	0.0005
Unknown Spring	0.72	<1	ns	ns	8.0	8.02	ns	ns	ns	ns
Unknown Spring	0.75	<1	ns	ns	ns	7.94	ns	ns	ns	ns
Vasey's Paradise	ns	<1	ns	ns	ns	7.5	ns	ns	ns	ns
Clearwater Spring	0.13	<5	2.6	0.8	--	14.5	14	0	<0.0009	0.0007
Clearwater Spring	ns	ns	3.1	0.2	ns	ms	14	0	<0.0009	0.0010
Hotel Spring	6.8	8	8.9	1.6	10.6	10.5	11	0	0.0034	0.0004
Hotel Spring	ns	ns	9.5	1.6	ns	ms	11	0	0.0037	0.0004
Kanab Spring	5.1	5	5.1	0.3	10.6	10.3	11	0	<0.0009	0.0003
Kanab Spring	5.7	ns	5.0	0.2	ns	ms	10	0	<0.0009	0.0007
Lower Jumpup Spring	1.1	3	3.6	1.0	18.9	19.6	18	0	0.0010	0.0011
Lower Jumpup Spring	ns	ns	3.2	0.8	ns	ms	18	0	0.0015	0.0002
Mountain Sheep Spring	19.1	16	16	1	12.0	12.4	12	1	0.0014	0.0003
Mountain Sheep Spring	15.8	ns	16	0	ns	ms	13	0	<0.0009	0.0014
Rider Spring	20.0	18	ns	ns	8.2	8.00	ns	ns	ns	ns
Rider Spring	ns	ns	ns	ns	ns	ms	ns	ns	ns	ns
Rock Spring	11.2	13	12	0	--	12.2	13	0	<0.0009	0.0002
Rock Spring	ns	ns	12	0	ns	ns	13	0	<0.0009	0.0005
Schmutz Spring	43.7	33	31	1	11.8	11.9	12	0	<0.0009	0.0002
Schmutz Spring	41.6	ns	32	1	ns	ns	11	0	<0.0009	0.0002
Showerbath Spring	4.2	4	4.6	0.1	10.5	10.7	9.8	0.5	<0.0009	0.0004
Showerbath Spring	ns	ns	4.7	0.1	ns	ns	9.9	0.0	<0.0009	0.0006
Side Canyon Spring	16.9	13	13	0	11.3	11.1	10	1	<0.0009	0.0005
Side Canyon Spring	ns	ns	13	1	ns	ns	11	1	<0.0009	0.0009
Slide Spring	19.5	21	21	1	10.7	10.5	9.8	0.6	<0.0009	0.0004
Slide Spring	ns	ns	21	0	ns	ns	10.0	0.1	<0.0009	0.0002
Upper Jumpup Spring	18.9	18	19	0	10.7	10.7	9.8	0.5	<0.0009	0.0000
Upper Jumpup Spring	ns	ns	19	1	ns	ns	9.6	0.2	<0.0009	0.0001
Willow Spring (Hack Canyon)	52.2	50	51	4	12.4	11.9	11	0	0.0010	0.0006
Willow Spring (Hack Canyon)	ns	sn	51	3	ns	ns	12	0	<0.0009	0.0006
Burnt Canyon Well	0.62	<3	2.8	0.7	--	8.2	9.2	0.3	0.0020	0.0007
Burnt Canyon Well	ns	ns	2.7	0.5	ns	ns	9.2	0.3	0.0028	0.0004
Canyon Mine Well	4.2	5	4.8	0.3	--	9.6	9.4	0.1	0.0018	0.0007
Canyon Mine Well	ns	ns	4.7	0.4	ns	ns	9.4	0.2	0.0021	0.0006
Pinenut Well	0.15	<3	0.8	0.3	9.4	9.2	9.9	0.8	0.0009	0.0004
Pinenut Well	ns	ns	1.0	0.6	ns	ns	10.6	0.2	<0.0008	0.0004
Tom Land Well	44.7	47	50	5	9.2	8.8	9.3	0.3	0.0011	0.0003
Tom Land Well	ns	ns	50	5	ns	ns	9.6	0.3	0.0016	0.0014

Table A. Analysis results from all laboratories.—Continued

Spring or well	Tin Taylor ICP–MS µg/L	Tin-SD Taylor ICP–MS µg/L	Sulfate SO_4 NWQL IC mg/L	Sulfate SO_4 Doughten IC mg/L	Strontium NWQL AASD µg/L	Strontium Doughten ICP–OES mg/L	Strontium Taylor ICP–MS/AES µg/L	Strontium Bullen ICP–MS µg/L	$^{87}Sr/^{86}Sr$ Bullen	Strontium-SD Taylor ICP–MS/AES µg/L
Buck Farm Spring	ns	ns	194	189	590	609	ns	1,150	0.70946	ns
Buck Farm Spring	ns	ns	ns	ns	591		ns	ns	ns	ns
Fence Spring	ns	ns	170	169	1,060	1,090	ns	1,545	0.71417	ns
Hanging Spring	ns	ns	8.21	8.39	75	74	ns	103	0.71071	ns
Hole in the Wall Spring	ns	ns	8.27	8.37	71	76	ns	122	0.71053	ns
South Canyon Spring	<0.008	0.005	ns	ns	--	248	245	--	--	12
South Canyon Spring	<0.008	0.002	ns	ns	--		247	--	--	15
Unknown Spring	ns	ns	8.25	8.35	73	74	ns	140	0.71043	ns
Unknown Spring	ns	ns	ns	8.34	72	74	ns	ns	ns	ns
Vasey's Paradise	ns	ns	ns	ns	--	68	ns	118	0.71077	ns
Clearwater Spring	<0.008	0.002	1,870	1,810		5,750	5,830	10,650	0.70821	40
Clearwater Spring	<0.008	0.002	ns	ns			5,830	ns	ns	210
Hotel Spring	<0.008	0.002	194	186	624	692	681	1,360	0.70828	14
Hotel Spring	<0.008	0.009	ns	ns			681	ns	ns	10
Kanab Spring	<0.008	0.008	261	252	802	857	870	1,475	0.70849	11
Kanab Spring	<0.008	0.004	ns	ns	850		855	ns	ns	4
Lower Jumpup Spring	<0.008	0.003	834	816	2,680	2,660	2,650	4,375	0.70817	50
Lower Jumpup Spring	<0.008	0.003	ns	ns			2,670	ns	ns	100
Mountain Sheep Spring	<0.008	0.001	662	623	1,970	1,840	1,830	3,075	0.7083	0
Mountain Sheep Spring	<0.008	0.002	ns	ns	1,720		1,770	ns	ns	80
Rider Spring	ns	ns	449	451	1,280	1,300	ns	2,140	0.70943	ns
Rider Spring	ns	ns	ns	ns			ns	ns	ns	ns
Rock Spring	<0.008	0.002	1,660.0	1,580		6,060	6,130	11,360	0.70785	40
Rock Spring	<0.008	0.006	ns	ns			5,880	ns	ns	40
Schmutz Spring	<0.008	0.007	826	782	1,850	2,290	2,340	4,490	0.70762	60
Schmutz Spring	<0.008	0.002	ns	ns	2,030		2,200	ns	ns	80
Showerbath Spring	<0.008	0.005	292	298	941	987	997	1,630	0.70846	4
Showerbath Spring	<0.008	0.000	ns	ns			1,010	ns	ns	30
Side Canyon Spring	<0.008	0.002	596	594	2,030	2,000	2,020	3,660	0.70868	50
Side Canyon Spring	<0.008	0.007	ns	ns			2,050	ns	ns	20
Slide Spring	<0.008	0.004	428	430	1,570	1,770	1,640	3,875	0.70778	50
Slide Spring	<0.008	0.007	ns	ns			1,610	ns	ns	50
Upper Jumpup Spring	0.011	0.002	401	403	1,140	1,180	1,160	1,940	0.7079	70
Upper Jumpup Spring	<0.008	0.002	ns	ns			1,160	ns	ns	50
Willow Spring (Hack Canyon)	0.011	0.000	2,100	2,050	6,500	7,720	7,360	13,160	0.70789	170
Willow Spring (Hack Canyon)	<0.008	0.005	ns	ns			7,270	ns	ns	130
Burnt Canyon Well	<0.01	0.01	2,150	2,040		6,330	6,300	11,800	0.70947	261
Burnt Canyon Well	<0.01	0.00	ns	ns			6,420	ns	ns	140
Canyon Mine Well	<0.01	0.00	19.6	18.6	214	275	272	480	0.70971	7
Canyon Mine Well	<0.01	0.00	ns	ns			262	ns	ns	24
Pinenut Well	<0.01	0.00	1,150	1,100	3,520	3,170	3,210	5,780	0.70972	77
Pinenut Well	<0.01	0.00	ns	ns			3,230	ns	ns	185
Tom Land Well	<0.01	0.01	1,440	1,380	4,490	4,540	4,460	7,175	0.70856	37
Tom Land Well	<0.01	0.00	ns	ns			4,530	ns	ns	165

Table A. Analysis results from all laboratories.—Continued

Spring or well	Terbium Taylor ICP–MS µg/L	Terbium-SD Taylor ICP–MS µg/L	Tellurium Taylor ICP–MS µg/L	Tellurium-SD Taylor ICP–MS µg/L	Thorium Taylor ICP–MS µg/L	Thorium-SD Taylor ICP–MS µg/L	Titanium Taylor ICP–AES µg/L	Titanium-SD Taylor ICP–AES µg/L	Thallium NWQL AASGF µg/L	Thallium Taylor ICP–MS µg/L
Buck Farm Spring	ns	ns	ns	ns	ns	ns	ns	ns	0.02e	ns
Buck Farm Spring	ns	ns	ns	ns	ns	ns	ns	ns	<0.04	ns
Fence Spring	ns	ns	ns	ns	ns	ns	ns	ns	0.05	ns
Hanging Spring	ns	ns	ns	ns	ns	ns	ns	ns	<0.04	ns
Hole in the Wall Spring	ns	ns	ns	ns	ns	ns	ns	ns	<0.04	ns
South Canyon Spring	0.0002	0.0001	<0.008	0.003	<0.001	0.000	<0.2	0.1	ns	0.006
South Canyon Spring	0.0003	0.0001	<0.008	0.005	<0.001	0.001	<0.2	0.1	ns	0.006
Unknown Spring	ns	ns	ns	ns	ns	ns	ns	ns	<0.04	ns
Unknown Spring	ns	ns	ns	ns	ns	ns	ns	ns	<0.04	ns
Vasey's Paradise	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Clearwater Spring	0.0010	0.0001	0.022	0.001	0.006	0.004	<0.2	0.1	<0.08	<0.005
Clearwater Spring	0.0008	0.0001	0.014	0.000	0.009	0.004	<0.2	0.2	ns	<0.005
Hotel Spring	0.0006	0.0002	<0.008	0.004	0.006	0.003	<0.2	0.1	0.03e	0.027
Hotel Spring	0.0003	0.0000	<0.008	0.009	0.005	0.001	<0.2	0.1	ns	0.022
Kanab Spring	<0.0002	0.0002	<0.008	0.003	0.002	0.002	<0.2	0.1	0.12	0.12
Kanab Spring	<0.0002	0.0002	<0.008	0.006	0.002	0.002	<0.2	0.1	0.14	0.12
Lower Jumpup Spring	0.0003	0.0001	<0.008	0.002	0.008	0.003	<0.2	0.0	<0.12	0.012
Lower Jumpup Spring	<0.0002	0.0001	0.022	0.006	0.005	0.000	<0.2	0.1	ns	0.012
Mountain Sheep Spring	<0.0002	0.0001	0.008	0.005	0.002	0.001	<0.2	0.2	<0.04	0.012
Mountain Sheep Spring	<0.0002	0.0000	0.011	0.003	0.003	0.001	<0.2	0.0	<0.04	0.013
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns	<0.04	ns
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Rock Spring	0.0004	0.0002	0.009	0.005	0.007	0.003	<0.2	0.2	0.04e	0.020
Rock Spring	<0.0002	0.0001	0.016	0.003	0.005	0.003	<0.2	0.3	ns	0.014
Schmutz Spring	<0.0002	0.0001	<0.008	0.008	0.008	0.000	<0.2	0.2	0.07	0.079
Schmutz Spring	<0.0002	0.0001	<0.008	0.004	0.007	0.003	<0.2	0.2	0.09	0.082
Showerbath Spring	0.0003	0.0001	0.009	0.008	0.005	0.005	<0.2	0.2	0.07	0.064
Showerbath Spring	<0.0002	0.0002	<0.008	0.003	0.006	0.006	<0.2	0.1	ns	0.065
Side Canyon Spring	<0.0002	0.0003	<0.008	0.005	0.005	0.004	<0.2	0.1	0.17	0.16
Side Canyon Spring	<0.0002	0.0000	<0.008	0.003	0.005	0.002	<0.2	0.1	ns	0.17
Slide Spring	<0.0002	0.0002	0.011	0.007	0.004	0.002	<0.2	0.2	0.07	0.081
Slide Spring	<0.0002	0.0001	<0.008	0.004	0.001	0.000	<0.2	0.1	ns	0.079
Upper Jumpup Spring	<0.0002	0.0002	<0.008	0.006	0.002	0.001	<0.2	0.1	0.10	0.095
Upper Jumpup Spring	<0.0002	0.0001	<0.008	0.004	0.004	0.003	<0.2	0.0	ns	0.092
Willow Spring (Hack Canyon)	0.0006	0.0003	0.013	0.010	0.023	0.018	<0.2	0.1	0.06e	0.059
Willow Spring (Hack Canyon)	0.0006	0.0003	0.021	0.003	0.011	0.003	<0.2	0.1	ns	0.058
Burnt Canyon Well	0.0014	0.0001	0.059	0.013	0.016	0.006	<0.1	0.2	0.13	0.12
Burnt Canyon Well	0.0013	0.0001	0.052	0.018	0.014	0.005	<0.1	0.2	ns	0.12
Canyon Mine Well	<0.0002	0.0001	0.010	0.006	<0.003	0.001	<0.1	0.1	0.02e	0.025
Canyon Mine Well	<0.0002	0.0000	<0.008	0.001	<0.003	0.002	<0.1	0.0	ns	0.024
Pinenut Well	0.0008	0.0001	0.030	0.006	0.036	0.001	<0.1	0.2	<0.04	0.015
Pinenut Well	0.0009	0.0001	0.029	0.005	0.031	0.003	<0.1	0.2	ns	0.016
Tom Land Well	0.0004	0.0001	0.036	0.009	0.012	0.001	<0.1	0.1	0.35	0.30
Tom Land Well	0.0003	0.0002	0.040	0.008	0.013	0.010	<0.1	0.2	ns	0.31

Table A. Analysis results from all laboratories.—Continued

Spring or well	Thallium-SD Taylor ICP–MS µg/L	Thulium Taylor ICP–MS µg/L	Thulium-SD Taylor ICP–MS µg/L	Uranium NWQL IC–MS µg/L	Uranium Doughten ICP–MS µg/L	Uranium Taylor ICP–MS µg/L	Uranium-SD Taylor ICP–MS µg/L	Uranium-NAU Appendix 1 µg/L	Uranium-SD Appendix 1 µg/L
Buck Farm Spring	ns	ns	ns	2.77	2.80	ns	ns	3.25	0.01
Buck Farm Spring	ns	ns	ns	2.81	ns	ns	ns	ns	ns
Fence Spring	ns	ns	ns	1.44	1.50	ns	ns	1.70	0.01
Hanging Spring	ns	ns	ns	0.61	0.61	ns	ns	0.70	0.01
Hole in the Wall Spring	ns	ns	ns	0.58	0.62	ns	ns	0.68	0.01
South Canyon Spring	0.002	0.0001	0.0001	ns	0.90	0.83	0.02	0.93	0.01
South Canyon Spring	0.001	<0.0001	0.0001	ns	ns	0.82	0.02	ns	ns
Unknown Spring	ns	ns	ns	0.58	0.61	ns	ns	0.68	0.01
Unknown Spring	ns	ns	ns	0.57	0.61	ns	ns	ns	ns
Vasey’s Paradise	ns	ns	ns	ns	0.59	ns	ns	ns	ns
Clearwater Spring	0.007	0.0001	0.0000	1.28	1.20	1.12	0.05	1.35	0.01
Clearwater Spring	0.003	0.0002	0.0001	ns	ns	1.11	0.04	ns	ns
Hotel Spring	0.001	0.0004	0.0001	2.60	2.69	2.7	0.1	3.18	0.02
Hotel Spring	0.001	0.0004	0.0001	ns	ns	2.7	0.0	ns	ns
Kanab Spring	0.00	<0.0001	0.0000	4.62	4.96	4.9	0.1	5.71	0.01
Kanab Spring	0.00	<0.0001	0.0001	5.17	ns	4.8	0.0	ns	ns
Lower Jumpup Spring	0.002	0.0002	0.0001	7.16	7.87	7.7	0.0	8.98	0.02
Lower Jumpup Spring	0.001	0.0002	0.0001	ns	ns	7.5	0.0	ns	ns
Mountain Sheep Spring	0.001	0.0001	0.0000	8.83	8.76	8.4	0.1	10.2	0.0
Mountain Sheep Spring	0.001	0.0001	0.0000	7.76	ns	8.3	0.1	ns	ns
Rider Spring	ns	ns	ns	4.50	4.70	ns	ns	5.56	0.01
Rider Spring	ns	ns	ns	ns	ns	ns	ns	5.66	0.01
Rock Spring	0.001	<0.0001	0.0001	14.30	16.0	14.1	1.2	19.5	0.0
Rock Spring	0.002	<0.0001	0.0001	ns	ns	11.3	0.4	ns	ns
Schmutz Spring	0.002	<0.0001	0.0001	4.25	4.41	4.4	0.0	5.42	0.01
Schmutz Spring	0.002	<0.0001	0.0001	4.06	ns	4.8	0.4	ns	ns
Showerbath Spring	0.000	0.0001	0.0001	4.19	4.91	4.8	0.1	5.71	0.01
Showerbath Spring	0.001	<0.0001	0.0001	ns	ns	4.7	0.2	5.76	0.01
Side Canyon Spring	0.00	<0.0001	0.0001	7.24	7.43	7.5	0.1	9.03	0.01
Side Canyon Spring	0.00	0.0002	0.0001	ns	ns	7.4	0.1	ns	ns
Slide Spring	0.001	<0.0001	0.0001	2.28	2.90	2.8	0.0	3.34	0.01
Slide Spring	0.004	<0.0001	0.0001	ns	ns	2.9	0.1	ns	ns
Upper Jumpup Spring	0.002	<0.0001	0.0001	3.72	4.02	3.9	0.0	4.70	0.01
Upper Jumpup Spring	0.002	<0.0001	0.0001	ns	ns	4.0	0.1	ns	ns
Willow Spring (Hack Canyon)	0.000	<0.0001	0.0000	19.6	20.0	19.3	0.6	23.9	0.0
Willow Spring (Hack Canyon)	0.003	0.0003	0.0002	ns	ns	19.6	0.8	ns	ns
Burnt Canyon Well	0.00	0.0003	0.0001	2.77	3.20	3.0	0.1	3.70	0.01
Burnt Canyon Well	0.01	0.0002	0.0001	ns	ns	3.0	0.1	ns	ns
Canyon Mine Well	0.001	<0.0001	0.0000	12.1	15.3	14.6	0.0	16.9	0.0
Canyon Mine Well	0.000	<0.0001	0.0001	ns	ns	14.2	0.7	ns	ns
Pinenut Well	0.001	<0.0001	0.0000	2.28	2.40	2.1	0.0	2.71	0.01
Pinenut Well	0.001	<0.0001	0.0001	ns	ns	2.1	0.1	ns	ns
Tom Land Well	0.01	<0.0001	0.0000	19.8	21.1	17.4	1.2	23.9	0.1
Tom Land Well	0.00	0.0001	0.0001	ns	ns	17.8	0.6	ns	ns

Table A. Analysis results from all laboratories.—Continued

Spring or well	Vanadium NWQL ICP–MS µg/L	Vanadium Doughten ICP–MS µg/L	Vanadium Taylor ICP–MS/AES µg/L	Vanadium-SD Taylor ICP–MS/AES µg/L	Tungsten NWQL ICP–MS µg/L	Tungsten Taylor ICP–MS µg/L	Tungsten-SD Taylor ICP–MS µg/L	Yttrium Taylor ICP–MS µg/L	Yttrium-SD Taylor ICP–MS µg/L
Buck Farm Spring	2.6	3.9	ns	ns	0.01e	ns	ns	ns	ns
Buck Farm Spring	2.6	ns	ns	ns	<0.02	ns	ns	ns	ns
Fence Spring	1.6	1.5	ns	ns	<0.02	ns	ns	ns	ns
Hanging Spring	1.1	1.2	ns	ns	<0.02	ns	ns	ns	ns
Hole in the Wall Spring	1.1	1.6	ns	ns	<0.02	ns	ns	ns	ns
South Canyon Spring	ns	1.5	1.3	0.0	ns	0.004	0.001	0.0090	0.0012
South Canyon Spring	ns	ns	1.4	0.1	ns	0.005	0.001	0.0086	0.0004
Unknown Spring	1.1	1.2	ns	ns	<0.02	ns	ns	ns	ns
Unknown Spring	1.1	1.3	ns	ns	<0.02	ns	ns	ns	ns
Vasey’s Paradise	ns	1.2	ns	ns	ns	ns	ns	ns	ns
Clearwater Spring	0.32e	0.8	<0.09	0.11	0.09	0.048	0.000	0.039	0.001
Clearwater Spring	ns	ns	<0.09	0.06	ns	0.051	0.000	0.035	0.003
Hotel Spring	9.6	11.7	11	0	0.02	0.014	0.001	0.035	0.002
Hotel Spring	ns	ns	10	0	ns	0.014	0.000	0.033	0.000
Kanab Spring	0.68	1.6	0.54	0.04	0.03	0.018	0.001	0.0099	0.0014
Kanab Spring	0.78	ns	0.70	0.06	0.03	0.021	0.001	0.0099	0.0012
Lower Jumpup Spring	1.8	2.8	1.6	0.0	<0.06	0.005	0.002	0.031	0.003
Lower Jumpup Spring	ns	ns	1.6	0.1	ns	0.007	0.001	0.029	0.001
Mountain Sheep Spring	1.7	2.9	1.4	0.0	<0.02	0.002	0.000	0.021	0.003
Mountain Sheep Spring	1.6	ns	1.7	0.2	<0.02	0.002	0.001	0.022	0.002
Rider Spring	0.65	0.9	ns	ns	<0.02	ns	ns	ns	ns
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Rock Spring	0.76	1.0	0.5	0.3	0.02e	<0.001	0.001	0.037	0.004
Rock Spring	ns	ns	0.5	0.3	ns	0.004	0.002	0.037	0.003
Schmutz Spring	0.46	0.9	0.48	0.07	<0.02	<0.002	0.002	0.016	0.005
Schmutz Spring	0.50	sn	0.53	0.12	<0.02	<0.002	0.002	0.018	0.001
Showerbath Spring	0.95	1.2	1.0	0.1	0.01e	0.014	0.004	0.010	0.002
Showerbath Spring	ns	ns	0.91	0.14	ns	0.012	0.001	0.010	0.001
Side Canyon Spring	0.61	1.2	0.55	0.16	0.02e	0.012	0.001	0.015	0.002
Side Canyon Spring	ns	ns	0.55	0.07	ns	0.014	0.002	0.014	0.003
Slide Spring	0.90	1.9	1.2	0.0	<0.02	<0.002	0.001	0.012	0.003
Slide Spring	ns	ns	1.0	0.0	ns	<0.002	0.001	0.012	0.003
Upper Jumpup Spring	0.83	1.4	0.86	0.13	<0.02	<0.002	0.002	0.0100	0.0007
Upper Jumpup Spring	ns	ns	0.83	0.00	ns	<0.002	0.000	0.010	0.002
Willow Spring (Hack Canyon)	2.1	2.3	1.8	0.1	<0.04	0.002	0.001	0.052	0.004
Willow Spring (Hack Canyon)	ns	ns	1.8	0.0	ns	0.002	0.001	0.046	0.010
Burnt Canyon Well	0.30e	1.3	0.4	0.1	<0.04	<0.001	0.001	0.035	0.001
Burnt Canyon Well	ns	ns	<0.3	0.2	ns	<0.001	0.001	0.035	0.004
Canyon Mine Well	<0.16	1.4	<0.3	0.3	0.02	0.018	0.002	0.0034	0.0001
Canyon Mine Well	ns	ns	<0.3	0.1	ns	0.018	0.001	0.0028	0.0003
Pinenut Well	0.18	0.9	<0.3	0.3	0.06	0.037	0.002	0.016	0.003
Pinenut Well	ns	ns	<0.3	0.1	ns	0.038	0.000	0.016	0.003
Tom Land Well	0.37	1.4	0.5	0.1	<0.04	0.002	0.001	0.026	0.005
Tom Land Well	ns	ns	0.4	0.1	ns	0.002	0.000	0.025	0.005

Table A. Analysis results from all laboratories.—Continued

Spring or well	Ytterbium Taylor ICP–MS µg/L	Ytterbium-SD Taylor ICP–MS µg/L	Zinc NWQL ICP–MS µg/L	Zinc Doughten ICP–MS µg/L	Zinc Taylor ICP–MS/AES µg/L	Zinc-SD Taylor ICP–MS/AES µg/L	Zirconium Taylor ICP–MS µg/L	Zirconium-SD Taylor ICP–MS µg/L
Buck Farm Spring	ns	ns	<2	1	ns	ns	ns	ns
Buck Farm Spring	ns	ns	<2	ns	ns	ns	ns	ns
Fence Spring	ns	ns	5.7	7	ns	ns	ns	ns
Hanging Spring	ns	ns	<2	4	ns	ns	ns	ns
Hole in the Wall Spring	ns	ns	<2	4	ns	ns	ns	ns
South Canyon Spring	<0.0007	0.0004	ns	3	1	0	0.014	0.013
South Canyon Spring	<0.0007	0.0000	ns	ns	1	0	0.008	0.009
Unknown Spring	ns	ns	<2	4	ns	ns	ns	ns
Unknown Spring	ns	ns	1.1e	4	ns	ns	ns	ns
Vasey's Paradise	ns	ns	ns	4	ns	ns	ns	ns
Clearwater Spring	<0.0007	0.0002	3.9e	<5	3	0	0.22	0.13
Clearwater Spring	<0.0007	0.0006	ns	ns	3	1	0.22	0.01
Hotel Spring	0.0019	0.0011	1.1e	2	<1	1	0.16	0.12
Hotel Spring	0.0023	0.0003	ns	ns	<1	1	0.32	0.27
Kanab Spring	<0.0007	0.0002	20.5	17	17	1	0.031	0.011
Kanab Spring	<0.0007	0.0005	19.1	ns	17	0	0.037	0.017
Lower Jumpup Spring	0.0008	0.0003	<6	4	3	1	0.088	0.022
Lower Jumpup Spring	0.0009	0.0000	ns	ns	3	0	0.082	0.013
Mountain Sheep Spring	0.0006	0.0003	14.8	6	4	0	0.051	0.002
Mountain Sheep Spring	0.0006	0.0000	2.7	ns	3	0	0.049	0.009
Rider Spring	ns	ns	1.5e	2	ns	ns	ns	ns
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns
Rock Spring	<0.0005	0.0003	<4.0	<5	1	0	0.10	0.00
Rock Spring	<0.0005	0.0003	ns	ns	1	1	0.084	0.005
Schmutz Spring	<0.0007	0.0000	3.7	5	4	1	0.22	0.20
Schmutz Spring	<0.0007	0.0004	4.1	ns	4	1	0.16	0.09
Showerbath Spring	<0.0007	0.0003	12.3	8	9	0	0.12	0.12
Showerbath Spring	<0.0007	0.0004	ns	ns	9	0	0.031	0.034
Side Canyon Spring	<0.0007	0.0009	6.6	8	7	0	0.038	0.002
Side Canyon Spring	<0.0007	0.0003	ns	ns	7	1	0.054	0.026
Slide Spring	<0.0007	0.0006	13.6	16	15	1	0.041	0.012
Slide Spring	<0.0007	0.0001	ns	ns	15	0	0.049	0.017
Upper Jumpup Spring	0.0009	0.0005	14.2	14	13	2	0.026	0.019
Upper Jumpup Spring	<0.0007	0.0003	ns	ns	13	2	0.020	0.010
Willow Spring (Hack Canyon)	0.0010	0.0005	9.2	9	11	0	0.33	0.24
Willow Spring (Hack Canyon)	<0.0007	0.0004	ns	ns	11	0	0.23	0.04
Burnt Canyon Well	0.0008	0.0003	82	68	95	4	0.38	0.12
Burnt Canyon Well	0.0009	0.0002	ns	ns	92	4	0.51	0.02
Canyon Mine Well	<0.0004	0.0003	24.4	24	25	3	0.04	0.03
Canyon Mine Well	<0.0004	0.0000	ns	ns	25	1	0.04	0.06
Pinenut Well	0.0005	0.0003	2.1	4	3	2	0.16	0.05
Pinenut Well	<0.0004	0.0001	ns	ns	2	2	0.25	0.15
Tom Land Well	<0.0004	0.0002	245	208	264	16	0.96	1.03
Tom Land Well	<0.0004	0.0001	ns	ns	265	18	0.22	0.13

Table A. Analysis results from all laboratories.—Continued

Spring or well	Alkalinity NWQL titration mg $CaCO_3$/L	Acid neutralizing capacity NWQL mg $CaCO_3$/L	Specific conductance field meter µS/cm	Specific conductance NWQL meter µS/cm	HCO_3 NWQL titration mg/L	HCO_3 Doughten titration mg/L	HCO_3 field titration mg/L	Discharge field meter or volumetric gal/min	Barometric presssure field meter mm Hg
Buck Farm Spring	198	206	708	784	239	265	239	0.59	690
Buck Farm Spring	ns	--	ns	ns	ns	ns	ns	nm	ns
Fence Spring	360	342	1,000	1,740	439	470	439	732	686
Hanging Spring	177	186	348	362	214	229	214	nm	690
Hole in the Wall Spring	173	186	303	364	210	230	210	8.8	686
South Canyon Spring	130	--	438	ns	156	ns	156	nm	652
South Canyon Spring	ns	--	ns	ns	ns	ns	ns	nm	ns
Unknown Spring	173	186	330	362	210	228	210	0.68	689
Unknown Spring	ns		330	ns	ns	228	ns	nm	ns
Vasey's Paradise	ns	--	300	ns	ns	ns	ns	260	nm
Clearwater Spring	224	222	2,250	3,230	273	274	273	1.4	nm
Clearwater Spring	ns	ns	ns	ns	ns	ns	ns	nm	nm
Hotel Spring	169	173	915	852	204	212	204	<0.001e	754
Hotel Spring	ns	ns	ns	ns	ns	ns	ns	nm	nm
Kanab Spring	199	200	864	869	241	244	241	274	nm
Kanab Spring	ns	ns	ns	ns	ns	ns	ns	nm	nm
Lower Jumpup Spring	294	290	1,960	1,930	357	371	357	57.6	nm
Lower Jumpup Spring	ns	ns	ns	ns	ns	ns	ns	nm	nm
Mountain Sheep Spring	245	256	1,643	1,600	298	311	298	41	673
Mountain Sheep Spring	ns	ns	ns	ns	ns	ns	ns	nm	ns
Rider Spring	59	57	1,380	1,200	71	69	71	0.02	665
Rider Spring	ns		ns	ns	ns	ns	ns	nm	ns
Rock Spring	128	129	2,460	2,620	154	159	154	0.11	674
Rock Spring	ns	ns	ns	ns	ns	ns	ns	nm	ns
Schmutz Spring	100	102	1,602	1,530	121	126	121	0	nm
Schmutz Spring	ns	ns	ns	ns	ns	ns	ns	nm	nm
Showerbath Spring	198	187	700	962	241	246	241	202	nm
Showerbath Spring	ns	ns	ns	ns	ms	ns	ns	nm	nm
Side Canyon Spring	164	170	1,316	1,370	200	208	200	1	nm
Side Canyon Spring	ns	ns	ns	ns	ns	ns	ns	nm	nm
Slide Spring	190	187	1,199	1,150	232	230	232	89.8	nm
Slide Spring	ns	ns	ns	ns	ns	ns	ns	nm	nm
Upper Jumpup Spring	160	153	709	1,060	195	192	195	1.3	nm
Upper Jumpup Spring	ns	ns	ns	ns	ns	ns	ns	nm	nm
Willow Spring (Hack Canyon)	85	89	2,460	3,220	102	108	102	nm	nm
Willow Spring (Hack Canyon)	ns	ns	ns	ns	ns	ns	ns	nm	nm
Burnt Canyon Well	292	307	3,570	3,520	355	370	355	50	765
Burnt Canyon Well	ns	ns	ns	ns	ns	ns	ns	nm	ns
Canyon Mine Well	214	218	437	451	260	265	260	70	770
Canyon Mine Well	ns	ns	ns	ns	ns	ns	ns	nm	ns
Pinenut Well	171	184	2,170	2,160	208	225	208	13.6	767
Pinenut Well	ns	ns	ns	ns	ns	ns	ns	nm	ns
Tom Land Well	284	293	2,666	2,670	346	354	346	8.2	761
Tom Land Well	ns	ns	ns	ns	ns	ns	ns	nm	ns

Table A. Analysis results from all laboratories.—Continued

Spring or well	Dissolved oxygen, unf field meter mg/L	pH field meter standard units	pH NWQL meter standard units	Air temperature field manual °C	Water temperature field manual °C	Gross alpha radioactivity, 30-day NWQL pCi/L	Gross alpha radioactivity, 30-day- SD NWQL pCi/L	Gross alpha radioactivity, 30-day- sample specific reporting limit NWQL pCi/L
Buck Farm Spring	6.8	7.5	7.8	34.7	27.3	3.9	1.1	1.2
Buck Farm Spring	nm	nm	--	nm	nm	ns	ns	ns
Fence Spring	5.0	6.8	7.3	31.0	21.5	0.1R	1.5	2.3
Hanging Spring	7.3	7.9	7.9	34.0	20.9	0.1R	0.55	0.81
Hole in the Wall Spring	7.8	7.5	7.8	nm	22.4	2.2	0.64	0.63
South Canyon Spring	8.0	8.0	--	nm	15.5	ns	ns	ns
South Canyon Spring	nm	nm	--	nm	nm	ns	ns	ns
Unknown Spring	7.6	7.6	7.7	30.0	18.8	3.5	1.1	1.3
Unknown Spring	nm	nm	--	nm	nm	ns	ns	ns
Vasey's Paradise	9.1	8.6	--	25.9	18.6	2.1	0.59	0.53
Clearwater Spring	0.2	7.5	7.5	28.2	17.1	–1.0R	4.7	7.5
Clearwater Spring	nm	nm	ns	nm	nm	ns	ns	ns
Hotel Spring	7.8e	7.9	8.1	33.0	27.8	4.4	0.96	0.76
Hotel Spring	nm	nm	ns	nm	nm	ns	ns	ns
Kanab Spring	7.3	7.1	7.6	24.5	21.8	6.7	1.6	1.5
Kanab Spring	nm	nm	ns	nm	nm	ns	ns	ns
Lower Jumpup Spring	4.1	6.9	7.4	30.3	21.1	16.0	4.0	2.9
Lower Jumpup Spring	nm	nm	ns	nm	nm	ns	ns	ns
Mountain Sheep Spring	7.3	7.0	7.2	25.8	18.3	14.5	2.6	1.6
Mountain Sheep Spring	nm	nm	ns	nm	nm	ns	ns	ns
Rider Spring	7.7	8.3	8.0	25.5	18.9	5.0	1.5	1.7
Rider Spring	nm	nm	ns	nm	nm	ns	ns	ns
Rock Spring	7.7	7.9	8.1	22.3	18.2	24.5	5.0	3.8
Rock Spring	nm	nm	ns	nm	nm	ns	ns	ns
Schmutz Spring	6.7	7.4	7.8	23.5	19.8	5.0	1.6	1.5
Schmutz Spring	nm	nm	ns	nm	nm	ns	ns	ns
Showerbath Spring	6.3	7.0	7.5	35.5	21.1	6.4	1.5	1.3
Showerbath Spring	nm	nm	ns	nm	nm	ns	ns	ns
Side Canyon Spring	4.2	7.4	7.4	28.7	23.3	9.0	3.0	3.9
Side Canyon Spring	nm	nm	ns	nm	nm	ns	ns	ns
Slide Spring	2.6	7.3	7.6	20.9	15.6	8.0	2.0	2.0
Slide Spring	nm	nm	ns	nm	nm	ns	ns	ns
Upper Jumpup Spring	5.0	7.4	7.8	29.3	13.4	11.2	1.9	1.1
Upper Jumpup Spring	nm	nm	ns	nm	nm	ns	ns	ns
Willow Spring (Hack Canyon)	6.4	7.3	7.8	31.0	18.6	12.0	5.0	6.0
Willow Spring (Hack Canyon)	nm	nm	ns	nm	nm	ns	ns	ns
Burnt Canyon Well	0.6	6.6	6.9	nm	16.3	48	8.2	4.7
Burnt Canyon Well	nm	nm	ns	nm	nm	ns	ns	ns
Canyon Mine Well	3.9	7.1	7.4	nm	26.7	12.4	1.6	0.43
Canyon Mine Well	nm	nm	sn	nm	nm	ns	ns	ns
Pinenut Well	0.6	7.2	7.2	nm	26.6	142	16	3.2
Pinenut Well	nm	nm	ns	nm	nm	ns	ns	ns
Tom Land Well	3.8	6.8	6.9	23.0	17.9	52.0	9.2	8.5
Tom Land Well	nm	--	ns	nm	nm	ns	ns	ns

Table A. Analysis results from all laboratories.—Continued

Spring or well	Gross alpha radioactivity, 72-hour NWQL pCi/L	Gross alpha radioactivity, 72-hour-SD NWQL pCi/L	Gross alpha radioactivity, 72-hour-sample specific reporting limit NWQL pCi/L	Gross beta radioactivity, 30-day NWQL pCi/L	Gross beta radioactivity, 30-day-SD NWQL pCi/L	Gross beta radioactivity, 30-day, sample specific reporting limit NWQL pCi/L	Gross beta radioactivity, 72-hour NWQL pCi/L	Gross beta radioactivity, 72-hour-SD NWQL pCi/L	Gross beta radioactivity, 72-hour, sample specific reporting limit NWQL pCi/L
Buck Farm Spring	4.3	1.7	2.3	3.9	0.92	1.2	8.1	0.87	1.0
Buck Farm Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Fence Spring	0.6R	1.6	2.4	15.4	1.3	1.2	16.7	1.4	1.2
Hanging Spring	1.8	0.53	0.57	1.1	0.44	0.68	0.4R	0.38	0.61
Hole in the Wall Spring	2.4	0.60	0.53	0.3R	0.60	0.98	0.3R	0.45	0.71
South Canyon Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
South Canyon Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Unknown Spring	1.9	0.54	0.52	2.3	0.48	0.68	0.50R	0.40	0.63
Unknown Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Vasey's Paradise	1.2	0.51	0.60	1.2	0.49	0.76	0.80R	0.60	0.96
Clearwater Spring	–3.0R	3.0	5.2	12.0	2.2	3.1	12.2	1.6	2.1
Clearwater Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Hotel Spring	3.3	0.92	0.89	7.9	0.82	0.95	6.0	0.77	0.94
Hotel Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Kanab Spring	4.1	1.2	1.2	6.1	0.51	0.48	6.1	0.52	0.50
Kanab Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Lower Jumpup Spring	7.0	4.2	6.0	9.9	0.97	1.00	10.2	0.94	0.96
Lower Jumpup Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Mountain Sheep Spring	10.6	2.3	2.0	11.4	0.90	0.75	8.8	0.77	0.79
Mountain Sheep Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Rider Spring	4.7	1.4	1.4	6.3	0.53	0.49	6.6	0.66	0.80
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Rock Spring	16.6	4.6	4.9	11.7	1.2	1.4	7.8	1.1	1.5
Rock Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Schmutz Spring	4.3	1.6	1.6	3.8	0.53	0.68	4.6	0.61	0.80
Schmutz Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Showerbath Spring	5.4	1.4	1.3	5.6	0.53	0.55	4.8	0.48	0.53
Showerbath Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Side Canyon Spring	7.5	1.9	1.7	6.8	0.71	0.87	6.6	0.62	0.67
Side Canyon Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Slide Spring	8.5	1.8	1.3	3.4	0.47	0.60	2.0	0.56	0.73
Slide Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Upper Jumpup Spring	10.3	1.9	1.2	0.7	0.45	0.62	2.1	0.46	0.66
Upper Jumpup Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Willow Spring (Hack Canyon)	18	5	5	15.5	1.7	1.9	15.8	1.6	1.8
Willow Spring (Hack Canyon)	ns	ns	ns	ns	ns	ns	ns	ns	ns
Burnt Canyon Well	22.0	5.4	4.8	31.0	2.5	2.2	18.0	2.1	2.7
Burnt Canyon Well	ns	ns	ns	ns	ns	ns	ns	ns	ns
Canyon Mine Well	13.0	2.0	1.0	6.3	0.52	0.48	3.0	0.50	0.62
Canyon Mine Well	ns	ns	ns	ns	ns	ns	ns	ns	ns
Pinenut Well	39.0	7.2	7.2	55.0	3.3	1.0	31.0	2.0	1.0
Pinenut Well	ns	ns	ns	ns	ns	ns	ns	ns	ns
Tom Land Well	28.0	5.1	3.4	19.4	1.7	1.7	9.7	1.5	2.2
Tom Land Well	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table A. Analysis results from all laboratories.—Continued

Spring or well	$\delta^{13}C$ RSIL ‰	$\delta^{18}O$ Coplen ‰	$\delta^{2}H$ Coplen ‰	Tritium Michel TU	Trit-SD Michel TU	$^{234}U/^{238}U$ activity ratio NAU	$^{234}U/^{238}U$ activity ratio-SD NAU	$^{234}U/^{238}U$ activity ratio Kraemer/Bullen	$^{234}U/^{238}U$ error, 1 sigma Kraemer/Bullen
Buck Farm Spring	–11.20	–12.22	–91.38	1.33	0.18	1.837	0.009	ns	ns
Buck Farm Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Fence Spring	–4.74	–13.83	–101.27	0.80	0.50	2.623	0.021	ns	ns
Hanging Spring	–11.40	–13.78	–98.52	1.76	0.19	4.054	0.018	3.924	0.014
Hole in the Wall Spring	–10.85	–13.74	–99.07	1.61	0.20	4.124	0.094	3.911	0.006
South Canyon Spring	ns	–11.57	–83.06	ns	ns	3.365	0.016	3.272	0.017
South Canyon Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Unknown Spring	–10.97	–13.78	–99.48	1.93	0.20	4.071	0.020	3.936	0.022
Unknown Spring	ns	sn	ns	ns	ns	ns	ns	3.921	0.013
Vasey’s Paradise	ns	ns	ns	ns	ns	ns	ns	4.339	0.005
Clearwater Spring	–7.91	–11.35	–86.10	2.03	0.28	1.523	0.048	1.505	0.008
Clearwater Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Hotel Spring	–9.35	–7.71	–65.45	2.30	0.30	1.935	0.022	1.951	0.021
Hotel Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Kanab Spring	–8.89	–12.40	–91.56	0.69	0.29	1.966	0.007	1.980	0.018
Kanab Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Lower Jumpup Spring	–12.44	–11.93	–89.77	0.13	0.28	2.634	0.024	2.594	0.010
Lower Jumpup Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Mountain Sheep Spring	–11.79	–12.08	–90.64	0.91	0.27	2.851	0.009	2.816	0.011
Mountain Sheep Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Rider Spring	–0.60	–15.61	–124.55	0.20	0.30	2.632	0.018	2.627	0.010
Rider Spring	ns	ns	ns	ns	ns	2.618	0.008	ns	ns
Rock Spring	–5.02	–11.87	–90.91	0.42	0.29	2.459	0.007	2.434	0.007
Rock Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Schmutz Spring	–6.02	–11.17	–81.20	0.50	0.30	1.883	0.005	1.858	0.008
Schmutz Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Showerbath Spring	–10.21	–12.20	–90.41	1.60	0.30	1.881	0.003	1.890	0.002
Showerbath Spring	ns	ns	ns	ns	ns	1.906	0.005	ns	ns
Side Canyon Spring	–7.15	–12.50	–91.41	0.43	0.28	1.856	0.010	1.857	0.014
Side Canyon Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Slide Spring	–7.22	–11.67	–88.69	0.00	0.28	5.626	0.023	5.590	0.005
Slide Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Upper Jumpup Spring	–6.18	–12.23	–90.34	–0.29	0.28	4.671	0.019	4.584	0.010
Upper Jumpup Spring	ns	ns	ns	ns	ns	ns	ns	ns	ns
Willow Spring (Hack Canyon)	–5.18	–10.58	–76.11	2.00	0.30	1.658	0.005	1.646	0.005
Willow Spring (Hack Canyon)	ns	ns	ns	ns	ns	ns	ns	ns	ns
Burnt Canyon Well	–4.04	–13.48	–105.09	5.20	0.3	2.674	0.021	2.657	0.013
Burnt Canyon Well	sn	ns	ns	ns	ns	ns	ns	2.666	0.011
Canyon Mine Well	–8.69	–12.08	–89.16	7.20	0.4	2.017	0.008	2.026	0.013
Canyon Mine Well	sn	ns	ns	ns	ns	ns	ns	2.024	0.004
Pinenut Well	–4.63	–14.38	–110.70	--	--	2.285	0.014	2.260	0.008
Pinenut Well	ns	ns	ms	ns	ns	ns	ns	2.264	0.012
Tom Land Well	–4.42	–7.22	–55.85	0.17	0.25	1.749	0.010	1.777	0.001
Tom Land Well	ns	ns	ns	ns	ns	ns	ns	1.763	0.013

Table A. Analysis results from all laboratories.—Continued

Spring or well	Large volume ^{226}Ra Doughten pCi/L	Large volume error, 1 sigma Doughten pCi/L	Large volume ^{228}Ra Doughten pCi/L	Large volume error, 1 sigma Doughten pCi/L	Large volume ^{228}Ra/^{226}Ra activity ratio Doughten	Large volume error, 1 sigma Doughten	Small volume ^{226}Ra Doughten pCi/L	Small volume ^{228}Ra Doughten pCi/L
Buck Farm Spring	ns	ns	ns	ns	ns	ns	ns	ns
Buck Farm Spring	ns	ns	ns	ns	ns	ns	ns	ns
Fence Spring	ns	ns	ns	ns	ns	ns	ns	ns
Hanging Spring	ns	ns	ns	ns	ns	ns	<4	<4
Hole in the Wall Spring	ns	ns	ns	ns	ns	ns	ns	ns
South Canyon Spring	ns	ns	ns	ns	ns	ns	ns	ns
South Canyon Spring	ns	ns	ns	ns	ns	ns	ns	ns
Unknown Spring	ns	ns	ns	ns	ns	ns	ns	ns
Unknown Spring	ns	ns	ns	ns	ns	ns	ns	ns
Vasey's Paradise	ns	ns	ns	ns	ns	ns	ns	ns
Clearwater Spring	0.730	0.007	0.239	0.010	0.327	0.010	<4	<4
Clearwater Spring	ns	ns	ns	ns	ns	ns	ns	ns
Hotel Spring	ns	ns	ns	ns	ns	ns	<4	<4
Hotel Spring	ns	ns	ns	ns	ns	ns	ns	ns
Kanab Spring	0.245	0.003	0.016	0.002	0.071	0.009	--	--
Kanab Spring	ns	ns	ns	ns	ns	ns	ns	ns
Lower Jumpup Spring	ns	ns	ns	ns	ns	ns	<4	<4
Lower Jumpup Spring	ns	ns	ns	ns	ns	ns	ns	ns
Mountain Sheep Spring	ns	ns	ns	ns	ns	ns	<4	<4
Mountain Sheep Spring	ns	ns	ns	ns	ns	ns	ns	ns
Rider Spring	ns	ns	ns	ns	ns	ns	<4	<4
Rider Spring	ns	ns	ns	ns	ns	ns	ns	ns
Rock Spring	ns	ns	ns	ns	ns	ns	<4	<4
Rock Spring	ns	ns	ns	ns	ns	ns	ns	ns
Schmutz Spring	ns	ns	ns	ns	ns	ns	<4	<4
Schmutz Spring	ns	ns	ns	ns	ns	ns	ns	ns
Showerbath Spring	ns	ns	ns	ns	ns	ns	<4	<4
Showerbath Spring	ns	ns	ns	ns	ns	ns	ns	ns
Side Canyon Spring	ns	ns	ns	ns	ns	ns	<4	<4
Side Canyon Spring	ns	ns	ns	ns	ns	ns	ns	ns
Slide Spring	ns	ns	ns	ns	ns	ns	ns	ns
Slide Spring	ns	ns	ns	ns	ns	ns	ns	ns
Upper Jumpup Spring	0.230	0.003	0.122	0.002	0.545	0.012	<4	<4
Upper Jumpup Spring	ns	ns	ns	ns	ns	ns	ns	ns
Willow Spring (Hack Canyon)	ns	ns	ns	ns	ns	ns	<4	<4
Willow Spring (Hack Canyon)	ns	ns	ns	ns	ns	ns	ns	ns
Burnt Canyon Well	ns	ns	ns	ns	ns	ns	ns	ns
Burnt Canyon Well	ns	ns	ns	ns	ns	ns	ns	ns
Canyon Mine Well	1.30	0.01	0.081	0.002	0.065	0.003	--	--
Canyon Mine Well	ns	ns	ns	ns	ns	ns	ns	ns
Pinenut Well	17.51	0.08	0.716	0.045	0.041	0.002	--	--
Pinenut Well	ns	ns	ns	ns	ns	ns	ns	ns
Tom Land Well	3.01	0.02	0.266	0.009	0.089	0.003	--	--
Tom Land Well	ns	ns	ns	ns	ns	ns	ns	ns

Table B. Most Probable Value for all elements analyzed.

[*Column heads containing an asterisk present results of analyses by the laboratory noted; values in all other columns derived by comparing results of analyses by many laboratories.

Bullen, USGS National Research Program Laboratory, Menlo Park, California; Doughten, USGS National Research Program Laboratory, Reston, Virginia; Michel, USGS National Research Program Laboratory, Menlo Park, California; NAU, Northern Arizona University Isotope and Radiochemistry Laboratory, Flagstaff, Arizona; NWQL, USGS National Water Quality Laboratory, Denver, Colorado; RSIL, USGS National Isotope Fractionation Project Laboratory, Reston, Virginia; Taylor, USGS National Research Program Laboratory, Boulder, Colorado; MPV, most probable value for all elements analyzed; Site ID, site identification;

δ, delta notation; <, less than; °C, degrees Celsius; ‰, per mil; fil, filtered; unf, unfiltered; gal/min, gallon per minute; µg/L, microgram per liter; µS/cm, microseimen per centimeter at 25°C; mg/L, milligram per liter; milligram per liter; mg $CaCO_3$/L, milligram calcium carbonate per liter; mg N/L, milligram nitrogen per liter; mg P/L, milligram phosphorus per liter; pC/L, picocurie per liter; TU, tritium unit; pmc, percent modern carbon; na, not available; R, results less than sample specific reporting limit; --, not available]

Spring or well data source units	Site ID on figure 17*	Sample date	Discharge field gal/min	Dissolved oxygen field mg/L	pH field standard units	Specific conductance field µS/cm	Water temperature field °C	Calcium MPV* mg/L	Magnesium MPV* mg/L	Sodium MPV* mg/L
East Segregation/House Rock Springs										
Marble Canyon reach of the Colorado River corridor, no uranium mines, breccia pipes present										
Buck Farm Spring	23	8/23/2009	0.59	6.8	7.5	708	27.3	95	34	19
Fence Spring	18	8/20/2009	732	5	6.8	1,740	21.5	146	39	159
Hanging Spring	21	8/22/2009	na	7.3	7.9	348	20.9	44	20	1.7
Hole in the Wall Spring	7	8/22/2009	8.8	7.8	7.5	303	na	45	21	1.7
Unknown Spring	22	8/21/2009	0.68	7.6	7.6	330	18.8	44	20	1.7
Vasey's Paradise	19	8/21/2009	260	9.1	8.6	na	18.6	44	21	1.8
House Rock area, no uranium mines, breccia pipes present										
South Canyon Spring	20	8/26/2009	na	8	8	na	15.5	56	18	4.0
Rider Spring	17	8/25/2009	0.02	7.7	8.3	1,380	18.9	63	64	90
North Segregation/East Kanab Basin Springs										
East Kanab, unmined area, breccia pipes present										
Clearwater Spring	16	8/28/2009	1.4	0.2	7.5	2,250	17.1	472	174	147
Upper Jumpup Spring	11	8/27/2009	1.3	5	7.4	709	13.4	136	62	11
Lower Jumpup Spring	9	8/28/2009	57.6	4.1	6.9	1,930	21.1	247	121	38
Mountain Sheep Spring	8	9/1/2009	na	7.3	7	1,643	18.3	188	97	32
Schmutz Spring	1	8/25/2009	na	6.7	7.4	1,602	19.8	239	77	13
Burnt Canyon Well	15	9/16/2009	50	0.6	6.6	3,570	16.3	549	270	81
Tom Land Well	12	9/14/2009	8.2	3.8	6.8	2,666	17.9	467	150	27
West Kanab, active mine area, on standby (Kanab North, Arizona One , and Pinenut Mines) and reclaimed (Hermit, Hack Canyon Mines)										
Hotel Spring	2	8/25/2009	na	7.8	7.9	915	27.8	73	48	27
Kanab Spring	5	8/26/2009	274	7.3	7.1	864	21.8	99	49	16
Shower Bath Spring	4	8/26/2009	202	6.3	7	700	21.1	114	50	19
Side Canyon Spring	3	8/26/2009	1	4.2	7.4	1,316	23.3	179	77	17
Pinenut Well	6	9/15/2009	13.6	0.6	7.2	2,170	26.6	251	141	70
Reclaimed mine area (Pigeon Mine on east and Hack and Hermit Mines on west)										
Slide Spring	13	8/27/2009	89.8	2.6	7.3	1,199	15.6	146	66	10
Rock Spring	14	9/2/2009	0.11	7.7	7.9	2,460	18.2	438	151	34
Willow Spring	10	8/26/2009	na	6.4	7.3	2,460	18.6	493	227	64
South Segregation Groundwater Well										
Active mine, on standby										
Canyon Mine Well	24	9/18/2009	70	3.9	7.1	437	26.7	43	30	5.7

Table B. Most Probable Value for all elements analyzed.—Continued

[*Column heads containing an asterisk present results of analyses by the laboratory noted; values in all other columns derived by comparing results of analyses by many laboratories.

Bullen, USGS National Research Program Laboratory, Menlo Park, California; Doughten, USGS National Research Program Laboratory, Reston, Virginia; Michel, USGS National Research Program Laboratory, Menlo Park, California; NAU, Northern Arizona University Isotope and Radiochemistry Laboratory, Flagstaff, Arizona; NWQL, USGS National Water Quality Laboratory, Denver, Colorado; RSIL, USGS National Isotope Fractionation Project Laboratory, Reston, Virginia; Taylor, USGS National Research Program Laboratory, Boulder, Colorado; MPV, most probable value for all elements analyzed; Site ID, site identification;

δ, delta notation; <, less than; °C, degrees Celsius; ‰, per mil; fil, filtered; unf, unfiltered; gal/min, gallon per minute; µg/L, microgram per liter; µS/cm, microseimen per centimeter at 25°C; mg/L, milligram per liter; milligram per liter; mg $CaCO_3$/L, milligram calcium carbonate per liter; mg N/L, milligram nitrogen per liter; mg P/L, milligram phosphorus per liter; pC/L, picocurie per liter; TU, tritium unit; pmc, percent modern carbon; na, not available; R, results less than sample specific reporting limit; --, not available]

Spring or well data source units	Potassium MPV* mg/L	Acid neutralizing capacity NWQL mg $CaCO_3$/L	Bicarbonate field mg/L	Sulfate MPV* mg/L	Chlorine MPV* mg/L	Fluorine MPV* mg/L	Silica MPV* mg/L	Uranium MPV* µg/L
East Segregation/House Rock Springs								
Marble Canyon reach of the Colorado River corridor, no uranium mines, breccia pipes present								
Buck Farm Spring	7.0	206	239	192	12.8	0.17	11.9	2.82
Fence Spring	15.3	342	439	170	241	0.32	9.9	1.48
Hanging Spring	0.8	186	214	8.3	2.0	0.07	8.0	0.62
Hole in the Wall Spring	0.8	186	210	8.3	2.0	0.08	8.1	0.60
Unknown Spring	0.8	186	210	8.3	2.0	0.08	8.0	0.60
Vasey's Paradise	0.7	na	na	na	na	na	7.5	0.57
House Rock area, no uranium mines, breccia pipes present								
South Canyon Spring	1.5	na	156	na	na	na	7.8	0.82
Rider Spring	5.4	57	71	450	59.0	1.58	8.1	4.64
North Segregation/East Kanab Basin Springs								
East Kanab, unmined area, breccia pipes present								
Clearwater Spring	11.4	na	273	1,810	70.9	0.70	14.5	1.11
Upper Jumpup Spring	1.8	153	195	402	16.3	0.26	10.7	3.94
Lower Jumpup Spring	8.1	290	357	825	42.1	0.54	19.2	7.60
Mountain Sheep Spring	7.6	256	298	643	41.2	0.58	12.2	8.37
Schmutz Spring	2.9	102	121	804	18.3	0.49	11.8	4.59
Burnt Canyon Well	14.8	na	<0.02	2,040	53.8	1.38	8.2	3.02
Tom Land Well	6.7	293	346	1,410	28.3	0.95	9.0	20.6
West Kanab, active mine area, on standby (Kanab North, Arizona One , and Pinenut Mines) and reclaimed (Hermit, Hack Canyon Mines)								
Hotel Spring	7.1	173	204	190	50.6	0.37	10.6	2.70
Kanab Spring	3.8	200	241	257	16.1	0.28	10.5	4.83
Shower Bath Spring	4.2	187	241	295	16.2	0.30	10.6	4.74
Side Canyon Spring	5.2	170	200	595	11.0	0.51	11.2	7.44
Pinenut Well	23.4	184	208	1,125	18.9	0.80	9.3	2.14
Reclaimed mine area (Pigeon Mine on east and Hack and Hermit Mines on west)								
Slide Spring	2.1	187	232	429	15.4	0.36	10.6	2.83
Rock Spring	5.4	na	154	1,580	15.4	0.34	12.2	12.7
Willow Spring	12.0	89	102	2,075	47.9	0.99	12.2	19.5
South Segregation Groundwater Well								
Active mine, on standby								
Canyon Mine Well	2.2	218	260	19.1	6.5	0.31	9.5	14.4

Table B. Most Probable Value for all elements analyzed.—Continued

[*Column heads containing an asterisk present results of analyses by the laboratory noted; values in all other columns derived by comparing results of analyses by many laboratories.

Bullen, USGS National Research Program Laboratory, Menlo Park, California; Doughten, USGS National Research Program Laboratory, Reston, Virginia; Michel, USGS National Research Program Laboratory, Menlo Park, California; NAU, Northern Arizona University Isotope and Radiochemistry Laboratory, Flagstaff, Arizona; NWQL, USGS National Water Quality Laboratory, Denver, Colorado; RSIL, USGS National Isotope Fractionation Project Laboratory, Reston, Virginia; Taylor, USGS National Research Program Laboratory, Boulder, Colorado; MPV, most probable value for all elements analyzed; Site ID, site identification;

δ, delta notation; <, less than; °C, degrees Celsius; ‰, per mil; fil, filtered; unf, unfiltered; gal/min, gallon per minute; µg/L, microgram per liter; µS/cm, microseimen per centimeter at 25°C; mg/L, milligram per liter; milligram per liter; mg $CaCO_3$/L, milligram calcium carbonate per liter; mg N/L, milligram nitrogen per liter; mg P/L, milligram phosphorus per liter; pC/L, picocurie per liter; TU, tritium unit; pmc, percent modern carbon; na, not available; R, results less than sample specific reporting limit; --, not available]

Spring or well data source	Site ID on figure 17*	Silver NWQL µg/L	Aluminum MPV* µg/L	Arsenic MPV* µg/L	Boron MPV* µg/L	Barium MPV* µg/L	Beryllium MPV* µg/L	Bromine Doughten mg/L	Cadmium MPV* µg/L
East Segregation/House Rock Springs									
Marble Canyon reach of the Colorado River corridor, no uranium mines, breccia pipes present									
Buck Farm Spring	23	<0.008	<1	1.2	59	31	<0.02	0.07	<0.02
Fence Spring	18	<0.008	2	16.6	372	52	0.04	0.50	0.03
Hanging Spring	21	<0.008	2	2.5	11	na	<0.02	0.03	<0.02
Hole in the Wall Spring	7	<0.008	1	2.4	11	172	<0.02	0.03	<0.02
Unknown Spring	22	<0.008	2	2.4	12	175	<0.02	0.02	<0.02
Vasey's Paradise	19	na	2	1.3	<20	138	na	na	<0.05
House Rock area, no uranium mines, breccia pipes present									
South Canyon Spring	20	na	0.6	1.44	25	73	<0.02	na	<0.01
Rider Spring	17	<0.008	1	5.0	568	8	<0.02	0.57	0.04
North Segregation/East Kanab Basin Springs									
East Kanab, unmined area, breccia pipes present									
Clearwater Spring	16	na	0.3	1.35	352	22	<0.02	0.52	<0.01
Upper Jumpup Spring	11	<0.008	0.2	1.06	42	11	<0.02	0.20	<0.01
Lower Jumpup Spring	9	<0.024	0.7	1.42	128	29	<0.02	0.46	<0.01
Mountain Sheep Spring	8	na	0.4	1.30	115	18	0.009	0.13	0.01
Schmutz Spring	1	<0.008	0.5	1.82	100	9	<0.02	0.18	<0.02
Burnt Canyon Well	15	na	0.2	12.8	463	7.9	0.04	0.41	0.11
Tom Land Well	12	na	0.1	0.40	317	7	<0.02	0.38	0.07
West Kanab, active mine area, on standby (Kanab North, Arizona One , and Pinenut Mines) and reclaimed (Hermit, Hack Canyon Mines)									
Hotel Spring	2	<0.008	3.2	6.46	181	57	<0.02	0.53	<0.02
Kanab Spring	5	<0.008	0.5	1.77	58	26	<0.02	0.12	<0.01
Shower Bath Spring	4	<0.008	0.3	1.42	63	23	<0.02	0.11	<0.01
Side Canyon Spring	3	<0.008	0.3	1.69	98	12	<0.02	0.08	<0.02
Pinenut Well	6	na	0.2	6.22	315	11	<0.02	0.10	0.03
Reclaimed mine area (Pigeon Mine on east and Hack and Hermit Mines on west)									
Slide Spring	13	na	0.2	0.77	61	10	<0.02	0.21	<0.01
Rock Spring	14	na	0.8	0.40	245	9	<0.008	0.34	<0.01
Willow Spring	10	na	0.8	1.19	324	8	<0.02	0.31	<0.02
South Segregation Groundwater Well									
Active mine, on standby									
Canyon Mine Well	24	<0.008	0.2	0.26	36	92	<0.02	0.07	0.01

Table B. Most Probable Value for all elements analyzed.—Continued

[*Column heads containing an asterisk present results of analyses by the laboratory noted; values in all other columns derived by comparing results of analyses by many laboratories.

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Spring or well data source	Cerium Taylor µg/L	Cobalt MPV* µg/L	Chromium MPV* µg/L	Cesium Taylor µg/L	Copper MPV* µg/L	Dysprosium Taylor µg/L	Erbium Taylor µg/L	Europium Taylor µg/L
East Segregation/House Rock Springs								
Marble Canyon reach of the Colorado River corridor, no uranium mines, breccia pipes present								
Buck Farm Spring	na	na	0.2	na	<1	na	na	na
Fence Spring	na	na	1.0	na	<1	na	na	na
Hanging Spring	na	na	1.0	na	<1	na	na	na
Hole in the Wall Spring	na	na	1.0	na	<1	na	na	na
Unknown Spring	na	na	1.0	na	<1	na	na	na
Vasey's Paradise	na	na	na	na	<1	na	na	na
House Rock area, no uranium mines, breccia pipes present								
South Canyon Spring	0.0018	<0.2	0.7	0.14	1.4	0.0006	<0.001	0.001
Rider Spring	na	na	3	na	<1	na	na	na
North Segregation/East Kanab Basin Springs								
East Kanab, unmined area, breccia pipes present								
Clearwater Spring	0.0009	<0.2	<0.2	0.008	1	0.0005	<0.001	<0.001
Upper Jumpup Spring	0.0014	<0.2	3.1	0.17	<1	<0.0004	<0.001	<0.001
Lower Jumpup Spring	0.0072	<0.2	<0.2	0.007	<3	0.0012	<0.001	<0.001
Mountain Sheep Spring	0.0009	<0.2	0.7	0.070	1.4	0.0006	0.0009	<0.001
Schmutz Spring	0.0009	<0.2	0.3	0.081	<1	<0.0004	<0.001	<0.001
Burnt Canyon Well	0.0033	<0.3	1.9	1.0	2	0.0009	0.0016	<0.0003
Tom Land Well	0.0026	<0.3	1.0	0.14	2.1	0.0008	<0.0005	<0.0003
West Kanab, active mine area, on standby (Kanab North, Arizona One , and Pinenut Mines) and reclaimed (Hermit, Hack Canyon Mines)								
Hotel Spring	0.0080	1.0	0.3	0.055	0.8	0.0030	<0.001	<0.001
Kanab Spring	0.0023	<0.2	0.4	0.28	<1	<0.0004	<0.001	0.001
Shower Bath Spring	<0.0006	<0.2	0.3	0.23	<1	<0.0004	<0.001	<0.001
Side Canyon Spring	<0.0006	<0.2	0.2	0.36	<1	<0.0004	<0.001	<0.001
Pinenut Well	0.0018	<0.3	0.7	0.84	<1	<0.0007	<0.0005	<0.0003
Reclaimed mine area (Pigeon Mine on east and Hack and Hermit Mines on west)								
Slide Spring	<0.0006	<0.2	2.6	0.091	<1	<0.0004	<0.001	<0.001
Rock Spring	0.0011	<0.2	0.7	0.015	<1	0.0004	<0.0004	<0.001
Willow Spring	0.0082	<0.2	1.2	0.11	<2	0.0006	<0.001	<0.001
South Segregation Groundwater Well								
Active mine, on standby								
Canyon Mine Well	0.0006	<0.3	<0.2	1.4	2.6	<0.0007	<0.0005	<0.0003

Table B. Most Probable Value for all elements analyzed.—Continued

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Spring or well data source	Site ID on figure 17*	Iron MPV* µg/L	Gallium Taylor µg/L	Gadolinium Taylor µg/L	Mercury Taylor ng/L	Holmium Taylor µg/L	Lanthanum Taylor µg/L	Lithium MPV* µg/L	Lutetium Taylor µg/L
East Segregation/House Rock Springs									
Marble Canyon reach of the Colorado River corridor, no uranium mines, breccia pipes present									
Buck Farm Spring	23	<4	na	na	na	na	na	24	na
Fence Spring	18	<4	na	na	na	na	na	378	na
Hanging Spring	21	<4	na	na	na	na	na	2	na
Hole in the Wall Spring	7	<4	na	na	na	na	na	2	na
Unknown Spring	22	<4	na	na	na	na	na	2	na
Vasey's Paradise	19	<20	na	na	na	na	na	1	na
House Rock area, no uranium mines, breccia pipes present									
South Canyon Spring	20	3	0.0032	0.0009	na	<0.0003	0.0027	3	0.0002
Rider Spring	17	12	na	na	na	na	na	70	na
North Segregation/East Kanab Basin Springs									
East Kanab, unmined area, breccia pipes present									
Clearwater Spring	16	33	0.021	<0.0004	0.2	0.0011	0.0007	100	<0.0001
Upper Jumpup Spring	11	<2	0.0019	<0.0004	0.4	<0.0003	0.0006	8	0.0001
Lower Jumpup Spring	9	5	0.0039	0.0014	0.3	0.0005	0.0051	54	0.0002
Mountain Sheep Spring	8	3	0.0030	0.0007	<0.2	0.0002	0.0019	40	0.0002
Schmutz Spring	1	<2	0.0020	<0.0004	0.3	<0.0003	0.0006	24	0.0001
Burnt Canyon Well	15	680	0.003	0.0016	2.3	0.0008	0.0029	344	0.0002
Tom Land Well	12	776	0.004	0.0009	1.4	<0.0003	0.0021	54	<0.0002
West Kanab, active mine area, on standby (Kanab North, Arizona One , and Pinenut Mines) and reclaimed (Hermit, Hack Canyon Mines)									
Hotel Spring	2	5	0.0045	0.0042	2.0	0.0008	0.0087	18	0.0003
Kanab Spring	5	<2	0.0018	0.0004	0.2	<0.0003	0.0016	18	<0.0001
Shower Bath Spring	4	<2	0.0027	<0.0004	0.2	<0.0003	0.0007	20	<0.0001
Side Canyon Spring	3	<2	0.0013	<0.0004	<0.2	<0.0003	0.0006	31	<0.0001
Pinenut Well	6	4,650	0.017	0.0004	1.7	<0.0003	0.0013	163	<0.0002
Reclaimed mine area (Pigeon Mine on east and Hack and Hermit Mines on west)									
Slide Spring	13	<2	0.0016	<0.0004	0.4	<0.0003	0.0004	13	<0.0001
Rock Spring	14	12	0.0018	<0.0004	<0.2	<0.0001	0.0006	74	<0.0001
Willow Spring	10	12	0.0032	0.0011	0.3	<0.0003	0.0057	89	0.0002
South Segregation Groundwater Well									
Active mine, on standby									
Canyon Mine Well	24	2	0.006	0.0007	1.6	<0.0003	0.0012	6	<0.0002

Table B. Most Probable Value for all elements analyzed.—Continued

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Spring or well data source	Manganese MPV* µg/L	Molybdenum MPV* µg/L	Neodymium Taylor µg/L	Nickel MPV* µg/L	Lead MPV* µg/L	Praseodymium Taylor µg/L	Rubidium MPV* µg/L	Rhenium Taylor µg/L
East Segregation/House Rock Springs								
Marble Canyon reach of the Colorado River corridor, no uranium mines, breccia pipes present								
Buck Farm Spring	<0.2	2.6	na	na	<0.05	na	4.2	na
Fence Spring	<0.2	1.1	na	na	<0.05	na	44.4	na
Hanging Spring	<0.2	0.3	na	na	<0.05	na	1.3	na
Hole in the Wall Spring	<0.2	0.3	na	na	<0.05	na	1.3	na
Unknown Spring	<0.2	0.3	na	na	<0.05	na	1.3	na
Vasey's Paradise	<1	0.2	na	na	<0.05	na	1.2	na
House Rock area, no uranium mines, breccia pipes present								
South Canyon Spring	0.17	1.1	0.0042	<0.3	0.066	0.0006	1.5	0.042
Rider Spring	<0.2	17	na	na	<0.05	na	8.0	na
North Segregation/East Kanab Basin Springs								
East Kanab, unmined area, breccia pipes present								
Clearwater Spring	980	2.8	0.0015	<0.3	0.007	<0.0002	1.4	0.33
Upper Jumpup Spring	<0.02	4.7	0.0009	<0.3	0.009	0.0003	1.9	0.22
Lower Jumpup Spring	7.5	6.9	0.0042	<0.3	0.010	0.0007	2.1	0.31
Mountain Sheep Spring	<0.02	2.4	0.0023	<0.3	0.011	0.0005	4.3	0.20
Schmutz Spring	0.67	8.6	0.0009	<0.3	0.007	<0.0002	3.1	0.81
Burnt Canyon Well	4.7	3.0	0.0027	5.3	na	0.0003	22.3	0.21
Tom Land Well	11.4	4.4	0.0023	29	0.094	0.0004	8.1	0.61
West Kanab, active mine area, on standby (Kanab North, Arizona One , and Pinenut Mines) and reclaimed (Hermit, Hack Canyon Mines)								
Hotel Spring	1.8	8.1	0.015	0.5	0.029	0.0028	4.0	0.048
Kanab Spring	0.29	4.5	0.0013	<0.3	0.043	<0.0002	3.4	0.12
Shower Bath Spring	<0.02	4.5	0.0006	<0.3	0.008	<0.0002	3.1	0.11
Side Canyon Spring	<0.02	12	<0.0005	<0.3	0.008	<0.0002	6.1	0.18
Pinenut Well	334	24	<0.0009	9.2	0.031	0.0001	21.3	0.098
Reclaimed mine area (Pigeon Mine on east and Hack and Hermit Mines on west)								
Slide Spring	<0.02	2.8	<0.0005	<0.3	0.004	<0.0002	2.0	0.25
Rock Spring	0.04	10	<0.0005	<0.3	0.005	<0.0002	4.1	0.39
Willow Spring	0.43	14	0.0042	0.1	0.020	0.0009	8.1	1.3
South Segregation Groundwater Well								
Active mine, on standby								
Canyon Mine Well	66	1.0	0.0017	8.2	0.27	<0.0001	8.2	0.015

Table B. Most Probable Value for all elements analyzed.—Continued

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Spring or well data source	Site ID on figure 17*	Sulfur Taylor mg/L	Antimony MPV* µg/L	Scandium Taylor µg/L	Selenium MPV* µg/L	Samarium Taylor µg/L	Tin Taylor µg/L	Strontium MPV* µg/L
East Segregation/House Rock Springs								
Marble Canyon reach of the Colorado River corridor, no uranium mines, breccia pipes present								
Buck Farm Spring	23	na	0.12	na	3.3	na	na	609
Fence Spring	18	na	0.06	na	1.3	na	na	1,090
Hanging Spring	21	na	<0.04	na	0.9	na	na	74
Hole in the Wall Spring	7	na	<0.04	na	0.8	na	na	76
Unknown Spring	22	na	<0.04	na	0.8	na	na	74
Vasey's Paradise	19	na	<0.1	na	<1	na	na	68
House Rock area, no uranium mines, breccia pipes present								
South Canyon Spring	20	18	0.025	<0.4	3.3	0.0011	<0.008	247
Rider Spring	17	na	<0.04	na	18	na	na	1,300
North Segregation/East Kanab Basin Springs								
East Kanab, unmined area, breccia pipes present								
Clearwater Spring	16	689	0.007	<0.4	2.8	<0.0009	<0.008	5,790
Upper Jumpup Spring	11	160	0.017	<0.4	19	<0.0009	<0.008	1,170
Lower Jumpup Spring	9	312	0.044	<0.4	3.4	0.0012	<0.008	2,660
Mountain Sheep Spring	8	218	0.025	<0.4	16	0.0009	<0.008	1,830
Schmutz Spring	1	297	0.010	<0.4	32	<0.0009	<0.008	2,290
Burnt Canyon Well	15	871	0.059	<0.5	2.8	0.0024	<0.01	6,330
Tom Land Well	12	545	0.025	<0.5	49	0.0014	<0.01	4,530
West Kanab, active mine area, on standby (Kanab North, Arizona One , and Pinenut Mines) and reclaimed (Hermit, Hack Canyon Mines)								
Hotel Spring	2	72	0.13	<0.4	9.2	0.0035	<0.008	686
Kanab Spring	5	98	0.073	<0.4	5.0	<0.0009	<0.008	857
Shower Bath Spring	4	115	0.068	<0.4	4.7	<0.0009	<0.008	997
Side Canyon Spring	3	226	0.029	<0.4	13	<0.0009	<0.008	2,020
Pinenut Well	6	433	0.034	<0.5	0.9	<0.0008	<0.01	3,210
Reclaimed mine area (Pigeon Mine on east and Hack and Hermit Mines on west)								
Slide Spring	13	163	0.015	<0.4	21	<0.0009	<0.008	1,640
Rock Spring	14	545	0.030	<0.4	13	<0.0009	<0.008	6,060
Willow Spring	10	765	0.014	<0.4	50	<0.0009	<0.008	7,518
South Segregation Groundwater Well								
Active mine, on standby								
Canyon Mine Well	24	7.6	0.016	<0.5	4.7	0.0019	<0.01	272

Table B. Most Probable Value for all elements analyzed.—Continued

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Bullen, USGS National Research Program Laboratory, Menlo Park, California; Doughten, USGS National Research Program Laboratory, Reston, Virginia; Michel, USGS National Research Program Laboratory, Menlo Park, California; NAU, Northern Arizona University Isotope and Radiochemistry Laboratory, Flagstaff, Arizona; NWQL, USGS National Water Quality Laboratory, Denver, Colorado; RSIL, USGS National Isotope Fractionation Project Laboratory, Reston, Virginia; Taylor, USGS National Research Program Laboratory, Boulder, Colorado; MPV, most probable value for all elements analyzed; Site ID, site identification;

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Spring or well data source	Terbium Taylor µg/L	Tellurium Taylor µg/L	Thorium Taylor µg/L	Titanium Taylor µg/L	Thallium MPV* µg/L	Thulium Taylor µg/L	Vanadium MPV* µg/L	Tungsten MPV* µg/L	Ytterbium Taylor µg/L
East Segregation/House Rock Springs									
Marble Canyon reach of the Colorado River corridor, no uranium mines, breccia pipes present									
Buck Farm Spring	na	na	na	na	<0.04	na	2.6	<0.01	na
Fence Spring	na	na	na	na	0.05	na	1.6	<0.01	na
Hanging Spring	na	na	na	na	<0.04	na	1.1	<0.01	na
Hole in the Wall Spring	na	na	na	na	<0.04	na	1.1	<0.01	na
Unknown Spring	na	na	na	na	<0.04	na	1.1	<0.01	na
Vasey's Paradise	na	na	na	na	na	na	na	na	na
House Rock area, no uranium mines, breccia pipes present									
South Canyon Spring	0.0003	<0.008	<0.001	<0.2	0.006	<0.0001	1.4	0.004	0.0088
Rider Spring	na	na	na	na	<0.04	na	0.7	<0.01	na
North Segregation/East Kanab Basin Springs									
East Kanab, unmined area, breccia pipes present									
Clearwater Spring	0.0009	0.018	0.008	<0.2	<0.005	0.0001	<0.1	0.050	0.037
Upper Jumpup Spring	<0.0002	<0.008	0.003	<0.2	0.097	<0.0001	0.8	<0.002	0.0101
Lower Jumpup Spring	0.0002	0.013	0.006	<0.2	0.012	0.0002	1.7	0.006	0.030
Mountain Sheep Spring	<0.0002	0.009	0.002	<0.2	0.012	0.0001	1.6	0.002	0.022
Schmutz Spring	<0.0002	<0.008	0.007	<0.2	0.080	<0.0001	0.5	<0.002	0.017
Burnt Canyon Well	0.0013	0.055	0.015	<0.1	0.12	0.0003	<0.3	<0.001	0.035
Tom Land Well	0.0004	0.038	0.012	<0.1	0.33	<0.0001	0.4	0.002	0.025
West Kanab, active mine area, on standby (Kanab North, Arizona One , and Pinenut Mines) and reclaimed (Hermit, Hack Canyon Mines)									
Hotel Spring	0.0004	<0.008	0.006	<0.2	0.025	0.0004	9.9	0.014	0.034
Kanab Spring	<0.0002	<0.008	0.002	<0.2	0.12	<0.0001	0.7	0.020	0.0099
Shower Bath Spring	<0.0002	–0.008	0.005	<0.2	0.066	<0.0001	1.0	0.013	0.010
Side Canyon Spring	<0.0002	<0.008	0.005	<0.2	0.17	0.0001	0.6	0.013	0.015
Pinenut Well	0.0008	0.029	0.033	<0.1	0.016	<0.0001	0.2	0.037	0.016
Reclaimed mine area (Pigeon Mine on east and Hack and Hermit Mines on west)									
Slide Spring	<0.0002	<0.008	0.003	<0.2	0.075	<0.0001	1.0	<0.002	0.012
Rock Spring	0.0002	0.012	0.006	<0.2	0.017	<0.0001	0.5	0.002	0.037
Willow Spring	0.0006	0.017	0.017	<0.2	0.059	0.0002	2.0	0.002	0.049
South Segregation Groundwater Well									
Active mine, on standby									
Canyon Mine Well	<0.0002	<0.008	<0.003	<0.1	0.025	<0.0001	<0.2	0.018	0.0031

Table B. Most Probable Value for all elements analyzed.—Continued

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Bullen, USGS National Research Program Laboratory, Menlo Park, California; Doughten, USGS National Research Program Laboratory, Reston, Virginia; Michel, USGS National Research Program Laboratory, Menlo Park, California; NAU, Northern Arizona University Isotope and Radiochemistry Laboratory, Flagstaff, Arizona; NWQL, USGS National Water Quality Laboratory, Denver, Colorado; RSIL, USGS National Isotope Fractionation Project Laboratory, Reston, Virginia; Taylor, USGS National Research Program Laboratory, Boulder, Colorado; MPV, most probable value for all elements analyzed; Site ID, site identification;

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Spring or well data source	Site ID on figure 17*	Ytterbium Taylor µg/L	Zinc MPV* µg/L	Zirconium Taylor µg/L	Phosphorus, unf NWQL mg P/L
East Segregation/House Rock Springs					
Marble Canyon reach of the Colorado River corridor, no uranium mines, breccia pipes present					
Buck Farm Spring	23	na	<2	na	<0.04
Fence Spring	18	na	6	na	<0.04
Hanging Spring	21	na	<2	na	<0.04
Hole in the Wall Spring	7	na	<2	na	<0.04
Unknown Spring	22	na	<2	na	<0.04
Vasey's Paradise	19	na	na	na	na
House Rock area, no uranium mines, breccia pipes present					
South Canyon Spring	20	<0.0007	1	0.011	na
Rider Spring	17	na	<2	na	<0.04
North Segregation/East Kanab Basin Springs					
East Kanab, unmined area, breccia pipes present					
Clearwater Spring	16	<0.0007	3	0.22	0.09
Upper Jumpup Spring	11	<0.0007	14	0.023	<0.04
Lower Jumpup Spring	9	0.0008	3	0.085	<0.04
Mountain Sheep Spring	8	0.0006	3	0.050	<0.04
Schmutz Spring	1	<0.0007	4	0.19	<0.04
Burnt Canyon Well	15	0.0009	93	0.45	<0.04
Tom Land Well	12	<0.0004	255	0.59	<0.04
West Kanab, active mine area, on standby (Kanab North, Arizona One , and Pinenut Mines) and reclaimed (Hermit, Hack Canyon Mines)					
Hotel Spring	2	0.0021	<1	0.24	<0.04
Kanab Spring	5	<0.0007	19	0.034	<0.04
Shower Bath Spring	4	<0.0007	10	0.08	<0.04
Side Canyon Spring	3	<0.0007	7	0.046	<0.04
Pinenut Well	6	<0.0004	2	0.21	<0.04
Reclaimed mine area (Pigeon Mine on east and Hack and Hermit Mines on west)					
Slide Spring	13	<0.0007	15	0.045	<0.04
Rock Spring	14	<0.0005	1	0.09	<0.04
Willow Spring	10	<0.0007	10	0.28	<0.04
South Segregation Groundwater Well					
Active mine, on standby					
Canyon Mine Well	24	<0.0004	25	0.04	<0.04

Table B. Most Probable Value for all elements analyzed.—Continued

[*Column heads containing an asterisk present results of analyses by the laboratory noted; values in all other columns derived by comparing results of analyses by many laboratories.

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Spring or well data source	Phosphorus, fil MPV* mg/L	Phosphate NWQL mg P/L	Nitrate Doughten mg N/L	Nitrite NWQL mg N/L	Kjeldahl-nitrogen, unf NWQL mg N/L	Ammonium NWQL mg N/L
East Segregation/House Rock Springs						
Marble Canyon reach of the Colorado River corridor, no uranium mines, breccia pipes present						
Buck Farm Spring	<0.04	<0.02	0.20	<0.002	<0.1	<0.02
Fence Spring	<0.04	<0.02	0.19	<0.002	<0.1	<0.02
Hanging Spring	<0.04	<0.02	0.20	<0.002	<0.1	<0.02
Hole in the Wall Spring	<0.04	<0.02	0.20	<0.002	<0.1	<0.02
Unknown Spring	<0.04	<0.02	0.20	<0.002	<0.1	<0.02
Vasey's Paradise	na	na	0.00	na	na	na
House Rock area, no uranium mines, breccia pipes present						
South Canyon Spring	0.006	na	0.00	na	na	na
Rider Spring	<0.04	<0.01	2.16	<0.002	<0.1	<0.02
North Segregation/East Kanab Basin Springs						
East Kanab, unmined area, breccia pipes present						
Clearwater Spring	<0.005	<0.02	<0.05	<0.002	0.5	0.42
Upper Jumpup Spring	<0.005	<0.02	1.43	<0.002	<0.1	<0.02
Lower Jumpup Spring	<0.005	0.01	<0.05	<0.002	<0.1	<0.02
Mountain Sheep Spring	<0.008	0.01	0.49	<0.002	<0.1	<0.02
Schmutz Spring	<0.005	<0.02	0.78	<0.002	<0.1	<0.02
Burnt Canyon Well	<0.007	<0.04	<0.04	<0.002	<0.1	<0.02
Tom Land Well	<0.007	<0.02	6.80	<0.006	0.1	0.02
West Kanab, active mine area, on standby (Kanab North, Arizona One , and Pinenut Mines) and reclaimed (Hermit, Hack Canyon Mines)						
Hotel Spring	<0.005	<0.02	0.75	0.018	0.5	<0.02
Kanab Spring	<0.005	<0.02	0.30	<0.002	<0.1	<0.02
Shower Bath Spring	<0.005	<0.02	0.25	<0.002	<0.1	<0.02
Side Canyon Spring	<0.005	<0.02	1.85	<0.002	<0.1	<0.02
Pinenut Well	<0.007	<0.02	<0.04	<0.002	<0.1	0.05
Reclaimed mine area (Pigeon Mine on east and Hack and Hermit Mines on west)						
Slide Spring	<0.005	<0.02	1.31	<0.002	<0.1	<0.02
Rock Spring	<0.008	<0.02	<0.05	<0.002	<0.1	<0.02
Willow Spring	<0.005	<0.02	4.38	<0.002	0.2	0.05
South Segregation Groundwater Well						
Active mine, on standby						
Canyon Mine Well	<0.007	<0.02	0.15	<0.002	<0.1	<0.02

Table B. Most Probable Value for all elements analyzed.—Continued

[*Column heads containing an asterisk present results of analyses by the laboratory noted; values in all other columns derived by comparing results of analyses by many laboratories.

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Spring or well data source	Site ID on figure 17*	Gross alpha radioactivity, 72-hour NWQL pC/L	Gross alpha radioactivity, 30-day NWQL pC/L	Gross beta radioactivity, 72-hour NWQL pC/L	Gross beta radioactivity, 30-day NWQL pC/L
East Segregation/House Rock Springs					
Marble Canyon reach of the Colorado River corridor, no uranium mines, breccia pipes present					
Buck Farm Spring	23	4.3	3.9	8.1	3.9
Fence Spring	18	R.6	R.1	16.7	15.4
Hanging Spring	21	1.8	R.1	0.4R	1.1
Hole in the Wall Spring	7	2.4	2.2	0.3R	0.3R
Unknown Spring	22	1.9	3.5	0.5R	2.3
Vasey's Paradise	19	1.2	2.1	0.8R	1.2
House Rock area, no uranium mines, breccia pipes present					
South Canyon Spring	20	na	na	na	na
Rider Spring	17	4.7	5	6.6	6.3
North Segregation/East Kanab Basin Springs					
East Kanab, unmined area, breccia pipes present					
Clearwater Spring	16	–3.0R	–1.0R	12.2	12
Upper Jumpup Spring	11	10.3	11.2	2.1	0.7
Lower Jumpup Spring	9	7	16	10.2	9.9
Mountain Sheep Spring	8	na	na	na	na
Schmutz Spring	1	4.3	5	4.6	3.8
Burnt Canyon Well	15	na	na	na	na
Tom Land Well	12	na	na	na	na
West Kanab, active mine area, on standby (Kanab North, Arizona One , and Pinenut Mines) and reclaimed (Hermit, Hack Canyon Mines)					
Hotel Spring	2	3.3	4.4	6	7.9
Kanab Spring	5	4.1	6.7	6.1	6.1
Shower Bath Spring	4	5.4	6.4	4.8	5.6
Side Canyon Spring	3	7.5	9	6.6	6.8
Pinenut Well	6	na	na	na	na
Reclaimed mine area (Pigeon Mine on east and Hack and Hermit Mines on west)					
Slide Spring	13	8.5	8	2	3.4
Rock Spring	14	na	na	na	na
Willow Spring	10	18	12	15.8	15.5
South Segregation Groundwater Well					
Active mine, on standby					
Canyon Mine Well	24	na	na	na	na

Table B. Most Probable Value for all elements analyzed.—Continued

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Spring or well data source	$^{234}U/^{238}U$ activity ratio NAU	$^{234}U/^{238}U$ activity ratio Kraemer/Bullen	Strontium Bullen µg/L	$^{87}Sr/^{86}Sr$ Bullen	Tritium Michel TU	^{14}C NWQL pmc	$\delta^{13}C$ RSIL ‰	$\delta^{18}O$ RSIL ‰	$\delta^{2}H$ RSIL ‰
East Segregation/House Rock Springs									
Marble Canyon reach of the Colorado River corridor, no uranium mines, breccia pipes present									
Buck Farm Spring	1.837	ns	1,150	0.70946	1.33	--	–11.2	–12.22	–91.38
Fence Spring	2.623	ns	1,545	0.71417	0.8	--	–4.74	–13.83	–101.27
Hanging Spring	4.054	3.924	103	0.71071	1.76	--	–11.4	–13.78	–98.52
Hole in the Wall Spring	4.124	3.911	122	0.71053	1.61	--	–10.85	–13.74	–99.07
Unknown Spring	4.071	3.936	140	0.71043	1.93	--	–10.97	–13.78	–99.48
Vasey's Paradise	na	4.339	118	0.71077	na	--	na	na	na
House Rock area, no uranium mines, breccia pipes present									
South Canyon Spring	3.365	3.272	--	--	na	--	na	–11.57	–83.06
Rider Spring	2.625	2.627	2,140	0.7943	0.2	--	–0.6	–15.61	–124.55
North Segregation/East Kanab Basin Springs									
East Kanab, unmined area, breccia pipes present									
Clearwater Spring	1.523	1.505	10,650	0.70821	2.03	--	–7.91	–11.35	–86.1
Upper Jumpup Spring	4.671	4.584	1,940	0.7079	<0.29	--	–6.18	–12.23	–90.34
Lower Jumpup Spring	2.634	2.594	4,375	0.70817	0.13	--	–12.44	–11.93	–89.77
Mountain Sheep Spring	2.851	2.816	3,075	0.7083	0.91	--	–11.79	–12.08	–90.64
Schmutz Spring	1.883	1.858	4,490	0.70762	0.5	--	–6.02	–11.17	–81.2
Burnt Canyon Well	2.674	2.657	11,800	0.70947	na	--	–4.04	–13.48	–105.09
Tom Land Well	1.749	1.777	7,175	0.70856	na	--	–4.42	–7.22	–55.85
West Kanab, active mine area, on standby (Kanab North, Arizona One , and Pinenut Mines) and reclaimed (Hermit, Hack Canyon Mines)									
Hotel Spring	1.935	1.951	1,360	0.70828	2.3	--	–9.35	–7.71	–65.45
Kanab Spring	1.966	1.98	1,475	0.70849	0.69	--	–8.89	–12.4	–91.56
Shower Bath Spring	1.893	1.89	1,630	0.70846	1.6	--	–10.21	–12.2	–90.41
Side Canyon Spring	1.856	1.857	3,660	0.70868	0.43	--	–7.15	–12.5	–91.41
Pinenut Well	2.285	2.26	5,780	0.70972	na	--	–4.63	–14.38	–110.7
Reclaimed mine area (Pigeon Mine on east and Hack and Hermit Mines on west)									
Slide Spring	5.626	5.59	3,875	0.70778	0.00	--	–7.22	–11.67	–88.69
Rock Spring	2.459	2.434	11,360	0.70785	0.42	--	–5.02	–11.87	–90.91
Willow Spring	1.658	1.646	13,160	0.70789	2.0	--	–5.18	–10.58	–76.11
South Segregation Groundwater Well									
Active mine, on standby									
Canyon Mine Well	2.017	2.026	480	0.70971	na	--	–8.69	–12.08	–89.16

Appendix 3. Selected dissolved arsenic samples at or above USEPA maximum contaminant level (MCL) of 10 μg/L from all sample types for historical dataset compiled for northern Arizona.

[--, data not available; μg/L, microgram per liter; NAD 83, North American Datum of 1983; P, perched water-bearing zone; R-M, Redwall-Muav aquifer; rm, river mile; USGS, U.S. Geological Survey]

Sample or site identifier	Site description	Source of groundwater	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Arsenic concentration (μg/L)	Comments
15139[a]		--	–114.049	36.584	09/23/1977	USGS, 2009a	Spring	119.8	
15140[a]		--	–114.058	36.581	09/23/1977	USGS, 2009a	Spring	128	
15141[a]		--	–114.051	36.525	09/23/1977	USGS, 2009a	Spring	123.5	
15204[a]		--	–114.052	35.854	11/09/1977	USGS, 2009a	Spring	78.44	
15210[a]		--	–114.009	35.822	11/16/1977	USGS, 2009a	Spring	115.7	
23003		--	–113.851	35.625	08/23/1977	USGS, 2009a	Well	116.5	
23004		--	–113.994	35.879	08/24/1977	USGS, 2009a	Spring	92.78	
23005		--	–113.971	35.828	08/24/1977	USGS, 2009a	Spring	119.4	
23007[a]		--	–113.557	35.496	08/25/1977	USGS, 2009a	Well	119.3	
23010		--	–113.706	35.618	08/30/1977	USGS, 2009a	Spring	113.8	
23012		--	–113.801	35.624	08/31/1977	USGS, 2009a	Spring	190.5	
23013		--	–113.791	35.645	08/31/1977	USGS, 2009a	Well	178.4	
23014		Granite	–113.767	35.608	09/01/1977	USGS, 2009a	Well	301.5	
23016		--	–113.629	35.507	09/01/1977	USGS, 2009a	Well	189.9	No date reported, assigned date of nearby well sampled on 9/1/77.
23017		--	–113.403	35.518	09/01/1977	USGS, 2009a	Spring	168.7	
23019		--	–113.422	35.559	09/02/1977	USGS, 2009a	Spring	142.9	
23021		--	–113.177	35.934	09/03/1977	USGS, 2009a	Spring	90.36	
23024		--	–113.114	35.783	09/04/1977	USGS, 2009a	Well	100.5	
23025		--	–113.676	35.787	09/13/1977	USGS, 2009a	Spring	144.1	
23026		--	–113.900	35.821	09/13/1977	USGS, 2009a	Well	133.7	
23028		--	–113.362	35.762	09/14/1977	USGS, 2009a	Spring	111	
23029		--	–113.440	35.593	09/14/1977	USGS, 2009a	Spring	145	
23030		--	–113.939	35.969	09/15/1977	USGS, 2009a	Spring	159.9	
23032		--	–113.985	35.774	09/15/1977	USGS, 2009a	Well	207.9	
23077		--	–112.524	35.950	10/17/1977	USGS, 2009a	Spring	241.6	
23079		--	–112.622	35.624	10/18/1977	USGS, 2009a	Well	95.93	
23080		--	–112.875	35.742	10/19/1977	USGS, 2009a	Well	248.1	
23081		--	–112.687	35.641	10/19/1977	USGS, 2009a	Spring	105.6	
23088		--	–112.396	35.958	10/27/1977	USGS, 2009a	Well	237.3	
23089		--	–112.436	35.806	10/28/1977	USGS, 2009a	Well	125.2	
23169[a]		--	–113.702	35.492	01/08/1978	USGS, 2009a	Spring	113.4	
23173		--	–113.320	35.515	01/08/1978	USGS, 2009a	Well	107	No date reported, assigned date of nearby well sampled on 1/8/78.
43536		Granite	–113.309	35.885	07/18/1978	USGS, 2009a	Stream	175.2	
43538		Granite	–113.426	35.746	07/18/1978	USGS, 2009a	Stream	310	
43540		R-M	–113.524	35.772	07/18/1978	USGS, 2009a	Stream	178.4	
9380000	Colorado River at Lees Ferry, Ariz.	--	–111.588	36.865	05/28/1974	USGS, 2009b	Stream	19	
9404208	Diamond Creek near Peach Springs, Ariz.	--	–113.368	35.765	05/26/1993	USGS, 2009b	Stream	15	
9413600	Virgin River. above Hwy. I15 rest area near Littlefield, Ariz.	--	–113.780	36.954	12/14/1977	USGS, 2009b	Stream	11	
9413600	Virgin River. above Hwy. I15 rest area near Littlefield, Ariz.	--	–113.780	36.954	01/23/1979	USGS, 2009b	Stream	10	

Appendix 3. Selected dissolved arsenic samples at or above USEPA maximum contaminant level (MCL) of 10 µg/L from all sample types for historical dataset compiled for northern Arizona.—Continued

[--, data not available; µg/L, microgram per liter; NAD 83, North American Datum of 1983; P, perched water-bearing zone; R-M, Redwall-Muav aquifer; rm, river mile; USGS, U.S. Geological Survey]

Sample or site identifier	Site description	Source of groundwater	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Arsenic concentration (µg/L)	Comments
9413600	Virgin River above Hwy. I15 rest area near Littlefield, Ariz.	--	–113.780	36.954	10/29/1979	USGS, 2009b	Stream	12	
9413650	Virgin River below Hwy. I15 rest area near Littlefield, Ariz.	--	–113.797	36.949	12/13/1977	USGS, 2009b	Stream	11	
9413650	Virgin River below Hwy. I15 rest area near Littlefield, Ariz.	--	–113.797	36.949	01/25/1978	USGS, 2009b	Stream	10	
9413650	Virgin River below Hwy. I15 rest area near Littlefield, Ariz.	--	–113.797	36.949	10/30/1979	USGS, 2009b	Stream	12	
9413800	Virgin River at mouth of Narrows near Littlefield, Ariz.	--	–113.861	36.921	10/31/1979	USGS, 2009b	Stream	10	
354228113374300	Lower Milkweed Canyon Spring; B-27-13 24cdb	Granite	–113.629	35.708	05/16/1993	USGS, 2009b	Spring	20	
354406113263400	Travertine Canyon Spring; B-27-11 10 unsurveyed	R-M	–113.444	35.735	05/15/1993	USGS, 2009b	Spring	38	
354503113252600	Travertine Canyon above mouth at rm 229	R-M	–113.425	35.751	05/15/1993	USGS, 2009b	Spring	100	
354522113264800	Travertine Falls Spring; B-27-11 03 unsurveyed	R-M	–113.447	35.756	05/15/1993	USGS, 2009b	Spring	200	
354550113313400	Bridge Canyon Spring; B-28-12 35 unsurveyed	R-M	–113.527	35.764	05/15/1993	USGS, 2009b	Spring	35	
355308113182600	Three Springs Canyon above Mouth Spring; B-29-10 25 unsurveyed	R-M	–113.308	35.886	10/14/1993	USGS, 2009b	Spring	10	
355502113195900	Pumpkin at rm 213 Spring; B-29-10 14 unsurveyed	Granite	–113.334	35.917	10/13/1993	USGS, 2009b	Spring	15	
355750113183600	Granite Park Spring; B-30-10 25 unsurveyed	Granite	–113.311	35.964	10/13/1993	USGS, 2009b	Spring	16	
360020111560401	Red Canyon Spring	R-M	–111.934	36.004	09/26/2001	Monroe and others, 2005	Spring	17	
360025111571501	Hance Spring	R-M	–111.951	36.002	05/11/2001	Monroe and others, 2005	Spring	14	
360059111581700	Vt9 Miners Spring at trail in Hance Canyon	R-M	–111.972	36.016	11/20/1981	USGS, 2009b	Spring	20	
360100111582001	Miners Spring	R-M	–111.971	36.015	05/24/2000	Monroe and others, 2005	Spring	17	
360100111582001	Miners Spring	R-M	–111.971	36.015	11/28/2000	Monroe and others, 2005	Spring	19	
360100111582001	Miners Spring	R-M	–111.971	36.015	04/07/2001	Monroe and others, 2005	Spring	19	
360336112131801	A-31-02 19 unsurveyed	R-M	–112.222	36.060	06/20/2005	USGS, 2009b	Spring	13.7	
360336112131801	A-31-02 19 unsurveyed	R-M	–112.222	36.060	09/29/2005	USGS, 2009b	Spring	12.6	
360336112131801	A-31-02 19 unsurveyed	R-M	–112.222	36.060	12/30/2005	USGS, 2009b	Spring	12.1	
360336112131801	A-31-02 19 unsurveyed	R-M	–112.222	36.060	12/30/2005	USGS, 2009b	Spring	12.1	
360957113080200	Beecher Spring; B-32-08 22 unsurveyed	R-M	–113.135	36.166	10/11/1993	USGS, 2009b	Spring	10	
361148113045900	Warm Spring; B-33-08 31 unsurveyed	R-M	–113.084	36.197	10/10/1993	USGS, 2009b	Spring	14	
361303112411200	Havasu Spring; B-33-04 26 unsurveyed	R-M	–112.687	36.217	08/23/1994	USGS, 2009b	Spring	17	
361308112413001	Sample Point #25 Havasu Creek near Supai, Ariz.	--	–112.692	36.219	03/28/1982	USGS, 2009b	Stream	19	
361352112413201	B-33-04 22 unsurveyed	P	–112.693	36.231	08/23/1994	USGS, 2009b	Well	12	
363123111503101	A-36-05 14	--	–111.842	36.523	08/20/2009	USGS, 2009b	Spring	16.4	
364610114043501[a]	222 S13 E71 28Ccc 1	R-M	–114.074	36.767	02/07/1991	USGS, 2009b	Well	18	
364830114041901[a]	222 S13 E71 16Bbc 1	R-M	–114.073	36.808	07/21/1994	USGS, 2009b	Well	21	
1A-W82	Red Spring; Muav Limestone	R-M	–113.423	35.559	06/01/1982	Wenrich and others, 1994	Spring	24	Date reported as 1982.
4A-W82	Diamond Creek (at mouth); Diamond Creek Gravels	--	–113.371	35.766	06/01/1982	Wenrich and others, 1994	Stream	17	Date reported as 1982.
5A-W82	Rocky Spring; Bright Angel Shale	R-M	–113.364	35.749	06/01/1982	Wenrich and others, 1994	Spring	62	Date reported as 1982.
6A-W82	Mesquite Spring; Bright Angel Shale in landslide block adjacent to Hurricane fault	P	–113.422	35.670	06/01/1982	Wenrich and others, 1994	Spring	73	Date reported as 1982.
7A-W82	Mulberry Spring; Muav Limestone	R-M	–113.403	35.612	06/01/1982	Wenrich and others, 1994	Spring	11	Date reported as 1982.
10A-W82	Upper Pine Spring; Kaibab Limestone	R-M	–113.114	35.842	06/01/1982	Wenrich and others, 1994	Spring	20	Date reported as 1982.

Appendix 3. Selected dissolved arsenic samples at or above USEPA maximum contaminant level (MCL) of 10 µg/L from all sample types for historical dataset compiled for northern Arizona.—Continued

[--, data not available; µg/L, microgram per liter; NAD 83, North American Datum of 1983; P, perched water-bearing zone; R-M, Redwall-Muav aquifer; rm, river mile; USGS, U.S. Geological Survey]

Sample or site identifier	Site description	Source of ground-water	Longi-tude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Arsenic concen-tration (µg/L)	Comments
12A-W82	Pine Spring; Tertiary Frazier Well gravels	P	–113.099	35.837	06/01/1982	Wenrich and others, 1994	Spring	10	Date reported as 1982.
13A-W82	Unnamed well; Tertiary Frazier Well gravels	P	–113.093	35.836	06/01/1982	Wenrich and others, 1994	Well	10	Date reported as 1982.
17A-W82	Travertine Falls; Vishnu Schist	Shist	–113.426	35.751	06/01/1982	Wenrich and others, 1994	Stream	59	Date reported as 1982.
18A-W82	Travertine Falls Spring; Precambrian granite	Granite	–113.448	35.756	06/01/1982	Wenrich and others, 1994	Spring	120	Date reported as 1982.
19A-W82	Lost Travertine Falls Spring; Tapeats Sandstone	R-M	–113.498	35.756	06/01/1982	Wenrich and others, 1994	Stream	48	Date reported as 1982.
20A-W82	¼ mile below Brldge Canyon Spring; Vishnu Schist	Granite	–113.527	35.769	06/01/1982	Wenrich and others, 1994	Stream	32	Date reported as 1982.
21A-W82	Seep south of Separation Canyon; Precambrian granite	Granite	–113.567	35.808	06/01/1982	Wenrich and others, 1994	Spring	60	Date reported as 1982.
22A-W82	Seep south of Separation Canyon; Precambrian granite	Granite	–113.568	35.808	06/01/1982	Wenrich and others, 1994	Spring	61	Date reported as 1982.
28A-W82	Diamond Creek Spring (Upper Diamond Spring); Redwall Limestone	R-M	–113.232	35.720	06/01/1982	Wenrich and others, 1994	Spring	10	Date reported as 1982.
38A-W82	Unnamed Spring; Music Mountain conglomerate	P	–113.678	35.670	06/01/1982	Wenrich and others, 1994	Spring	11	Date reported as 1982.
42A-W82	Unnamed Spring; Music Mountain conglomerate	P	–113.690	35.637	06/01/1982	Wenrich and others, 1994	Spring	20	Date reported as 1982.
43A-W82	Lower Milkweed Spring; Bright Angel Shale	R-M	–113.673	35.653	06/01/1982	Wenrich and others, 1994	Spring	11	Date reported as 1982.
64A-W82	Unnamed Spring in Milkweed Canyon; Precambrian granite	Granite	–113.657	35.681	06/01/1982	Wenrich and others, 1994	Spring	14	Date reported as 1982.
66A-W82	Unnamed Spring in Milkweed Canyon; Bright Angel Shale	R-M	–113.640	35.984	06/01/1982	Wenrich and others, 1994	Spring	55	Date reported as 1982.
67A-W82	Robbers Roost Spring; Vishnu Schist	Shist	–113.296	35.718	06/01/1982	Wenrich and others, 1994	Spring	58	Date reported as 1982.
68A-W82	Unnamed Spring in Milkweed Canyon; Precambrian granite	Granite	–113.655	35.680	06/01/1982	Wenrich and others, 1994	Spring	13	Date reported as 1982.
71A-W82	Tilted Spring; Tapeats Sandstone	R-M	–113.628	35.706	06/01/1982	Wenrich and others, 1994	Spring	24	Date reported as 1982.
72A-W82	Metuck Springs; Muav Limestone	R-M	–113.383	35.647	06/01/1982	Wenrich and others, 1994	Spring	16	Date reported as 1982.
75A-W82	Warm Springs; Muav Limestone	R-M	–113.082	36.197	06/01/1982	Wenrich and others, 1994	Spring	14	Date reported as 1982.
76A-W82	Lava Falls (by cliff); Muav Limestone	R-M	–113.081	36.196	06/01/1982	Wenrich and others, 1994	Spring	14	Date reported as 1982.
77A-W82	Pumpkin Spring; Tapeats Sandstone	R-M	–113.333	35.917	06/01/1982	Wenrich and others, 1994	Spring	350	Date reported as 1982.
78A+B-W82	Three Springs; Muav Limestone	R-M	–113.294	35.886	06/01/1982	Wenrich and others, 1994	Spring	16	Date reported as 1982.
78A+B-W82			–113.294	35.886	06/01/1982	Wenrich and others, 1994	Spring	15	Date reported as 1982.
Diamond Creek near mouth		--	–113.371	35.769	11/05/1990	Taylor and others, 1996	Stream	13.9	
Diamond Creek near mouth		--	–113.371	35.769	11/06/1990	Taylor and others, 1996	Stream	14.7	
Diamond Creek near mouth		--	–113.371	35.769	11/06/1990	Taylor and others, 1996	Stream	14.3	
Diamond Creek near mouth		--	–113.371	35.769	11/06/1990	Taylor and others, 1996	Stream	13.8	
Diamond Creek near mouth		--	–113.371	35.769	06/18/1991	Taylor and others, 1996	Stream	14.7	
Diamond Creek near mouth		--	–113.371	35.769	06/18/1991	Taylor and others, 1996	Stream	14.3	
Diamond Creek near mouth		--	–113.371	35.769	06/18/1991	Taylor and others, 1996	Stream	14.2	
Diamond Creek near mouth		--	–113.371	35.769	06/19/1991	Taylor and others, 1996	Stream	15.1	
Diamond Creek near mouth		--	–113.371	35.769	06/19/1991	Taylor and others, 1996	Stream	14.8	
Diamond Creek near mouth		--	–113.371	35.769	06/19/1991	Taylor and others, 1996	Stream	14.3	
Diamond Creek near mouth		--	–113.371	35.769	06/19/1991	Taylor and others, 1996	Stream	14.1	
Diamond Creek near mouth		--	–113.371	35.769	06/20/1991	Taylor and others, 1996	Stream	13.6	
GCBA502R	Unknown sandstone	P	–113.949	36.608	05/06/1979	USGS, 2009a	Well	11	
GCCA504R	Quaternary clastic rocks—Coarse	P	–113.973	36.378	05/16/1979	USGS, 2009a	Spring	156	
GCCA505R	Quaternary volcanic rocks—Mafic	P	–113.953	36.388	05/15/1979	USGS, 2009a	Well	29	

Appendix 3. Selected dissolved arsenic samples at or above USEPA maximum contaminant level (MCL) of 10 µg/L from all sample types for historical dataset compiled for northern Arizona.—Continued

[--, data not available; µg/L, microgram per liter; NAD 83, North American Datum of 1983; P, perched water-bearing zone; R-M, Redwall-Muav aquifer; rm, river mile; USGS, U.S. Geological Survey]

Sample or site identifier	Site description	Source of ground-water	Longi-tude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Arsenic concen-tration (µg/L)	Comments
GCCA506R	Quaternary volcanic rocks—Mafic	P	–113.957	36.416	05/15/1979	USGS, 2009a	Spring	20	
GCDE501R	Quaternary	P	–112.827	36.018	05/28/1979	USGS, 2009a	Well	15	
Hance Rapid Spring		R-M	–111.923	36.054	05/13/1998	Taylor and others, 2004	Spring	54	Reported location UTM (416872,3990117).
Havasu Creek near mouth		--	–112.760	36.314	11/05/1990	Taylor and others, 1996	Stream	12	
Havasu Creek near mouth		--	–112.760	36.314	11/05/1990	Taylor and others, 1996	Stream	11.9	
Havasu Creek near mouth		--	–112.760	36.314	11/05/1990	Taylor and others, 1996	Stream	11.8	
Havasu Creek near mouth		--	–112.760	36.314	11/05/1990	Taylor and others, 1996	Stream	11.8	
Havasu Creek near mouth		--	–112.760	36.314	11/06/1990	Taylor and others, 1996	Stream	12	
Havasu Creek near mouth		--	–112.760	36.314	11/06/1990	Taylor and others, 1996	Stream	11.6	
Havasu Creek near mouth		--	–112.760	36.314	11/06/1990	Taylor and others, 1996	Stream	11.4	
Havasu Creek near mouth		--	–112.760	36.314	11/06/1990	Taylor and others, 1996	Stream	11.2	
Havasu Creek near mouth		--	–112.760	36.314	06/18/1991	Taylor and others, 1996	Stream	11.3	
Havasu Creek near mouth		--	–112.760	36.314	06/18/1991	Taylor and others, 1996	Stream	10.9	
Havasu Creek near mouth		--	–112.760	36.314	06/18/1991	Taylor and others, 1996	Stream	10.8	
Havasu Creek near mouth		--	–112.760	36.314	06/19/1991	Taylor and others, 1996	Stream	11.4	
Havasu Creek near mouth		--	–112.760	36.314	06/19/1991	Taylor and others, 1996	Stream	11.3	
Havasu Creek near mouth		--	–112.760	36.314	06/19/1991	Taylor and others, 1996	Stream	11.2	
Havasu Creek near mouth		--	–112.760	36.314	06/19/1991	Taylor and others, 1996	Stream	10.9	
Havasu Creek near mouth		--	–112.760	36.314	06/20/1991	Taylor and others, 1996	Stream	11.2	
Havasu Spring		R-M	–112.686	36.217	05/16/1985	Errol Montgomery and Assoc., 1993b	Spring	10	
Havasu Spring		R-M	–112.686	36.217	12/18/1985	Errol Montgomery and Assoc., 1993b	Spring	10	
Havasu Spring		R-M	–112.686	36.217	06/03/1986	Errol Montgomery and Assoc., 1993b	Spring	10	
Havasu Spring		R-M	–112.686	36.217	06/03/1986	Errol Montgomery and Assoc., 1993b	Spring	10	
Havasu Spring		R-M	–112.686	36.217	12/08/1986	Errol Montgomery and Assoc., 1993b	Spring	20	
Havasu Spring		R-M	–112.686	36.217	12/08/1986	Errol Montgomery and Assoc., 1993b	Spring	10	
Havasu Spring		R-M	–112.686	36.217	12/08/1986	Errol Montgomery and Assoc., 1993b	Spring	10	
Havasu Spring		R-M	–112.686	36.217	05/28/1987	Errol Montgomery and Assoc., 1993b	Spring	20	
Havasu Spring		R-M	–112.686	36.217	05/28/1987	Errol Montgomery and Assoc., 1993b	Spring	10	
Havasu Spring		R-M	–112.686	36.217	05/28/1987	Errol Montgomery and Assoc., 1993b	Spring	10	
Havasu Spring		R-M	–112.686	36.217	12/01/1987	Errol Montgomery and Assoc., 1993b	Spring	10	
Havasu Spring		R-M	–112.686	36.217	01/18/1989	Errol Montgomery and Assoc., 1993b	Spring	10	

Appendix 3. Selected dissolved arsenic samples at or above USEPA maximum contaminant level (MCL) of 10 µg/L from all sample types for historical dataset compiled for northern Arizona.—Continued

[--, data not available; µg/L, microgram per liter; NAD 83, North American Datum of 1983; P, perched water-bearing zone; R-M, Redwall-Muav aquifer; rm, river mile; USGS, U.S. Geological Survey]

Sample or site identifier	Site description	Source of ground-water	Longi-tude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Arsenic concen-tration (µg/L)	Comments
Havasu Spring		R-M	–112.686	36.217	01/18/1989	Errol Montgomery and Assoc., 1993b	Spring	10	
Havasu Spring		R-M	–112.686	36.217	05/30/1989	Errol Montgomery and Assoc., 1993b	Spring	15	
Havasu Spring		R-M	–112.686	36.217	05/29/1990	Errol Montgomery and Assoc., 1993b	Spring	14	
Havasu Spring		R-M	–112.686	36.217	05/29/1990	Errol Montgomery and Assoc., 1993b	Spring	13	
Havasu Spring		R-M	–112.686	36.217	05/29/1990	Errol Montgomery and Assoc., 1993b	Spring	10	
Havasu Spring		R-M	–112.686	36.217	11/16/1992	Errol Montgomery and Assoc., 1993b	Spring	14.6	
Havasu Spring		R-M	–112.686	36.217	11/16/1992	Errol Montgomery and Assoc., 1993b	Spring	10	
Hermit Mine Monitoring Well		R-M	–112.751	36.689	04/28/1988	Energy Fuels Nuclear, Inc., 1990b	Well	13	
Hermit Mine Monitoring Well		R-M	–112.751	36.689	06/29/1988	Energy Fuels Nuclear, Inc., 1990b	Well	15	
Hermit Mine Monitoring Well		R-M	–112.751	36.689	09/29/1988	Energy Fuels Nuclear, Inc., 1990b	Well	20	
Hermit Mine Monitoring Well		R-M	–112.751	36.689	10/19/1989	Energy Fuels Nuclear, Inc., 1990c	Well	22	
Hermit Mine Shaft		Breccia	–112.751	36.689	08/23/1988	Energy Fuels Nuclear, Inc., 1995b	Shaft	45	No location reported, given lat/long of well Hermit Mine Monitor Well.
Hermit Mine Shaft		Breccia	–112.751	36.689	12/23/1988	Energy Fuels Nuclear, Inc., 1995b	Shaft	45	No location reported, given lat/long of well Hermit Mine Monitor Well.
Hermit Mine Sump		Breccia	–112.751	36.689	12/08/1989	Canonie Environmental Services Corp., 1991	Sump	205	No location reported, given lat/long of well Hermit Mine Monitor Well.
Hermit Mine Sump		Breccia	–112.751	36.689	06/27/1989	Canonie Environmental Services Corp., 1991	Sump	1,090	No location reported, given lat/long of well Hermit Mine Monitor Well.
Hermit Mine Sump		Breccia	–112.751	36.689	09/21/1989	Canonie Environmental Services Corp., 1991	Sump	530	No location reported, given lat/long of well Hermit Mine Monitor Well.
Hermit Mine Sump		Breccia	–112.751	36.689	02/06/1990	Canonie Environmental Services Corp., 1991	SUMP	266	No location reported, given lat/long of well Hermit Mine Monitor Well.
Marble Canyon Spring 2		R-M	–111.846	36.519	09/19/1982	Office of Nuclear Waste Isolation, 1985	SPRING	18	Location reported as "river mile 30.5"; date reported as Sept 19 to Oct 3, 1982.

Appendix 3. Selected dissolved arsenic samples at or above USEPA maximum contaminant level (MCL) of 10 µg/L from all sample types for historical dataset compiled for northern Arizona.—Continued

[--, data not available; µg/L, microgram per liter; NAD 83, North American Datum of 1983; P, perched water-bearing zone; R-M, Redwall-Muav aquifer; rm, river mile; USGS, U.S. Geological Survey]

Sample or site identifier	Site description	Source of groundwater	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Arsenic concentration (µg/L)	Comments
Marble Canyon Spring 3		R-M	–111.846	36.518	09/19/1982	Office of Nuclear Waste Isolation, 1985	SPRING	21	Location reported as "river mile 30.6"; date reported as Sept 19 to Oct 3, 1982.
Marble Canyon Spring 4		R-M	–111.848	36.515	09/19/1982	Office of Nuclear Waste Isolation, 1985	SPRING	15	Location reported as "river mile 30.8"; date reported as Sept 19 to Oct 3, 1982.
Marble Canyon Spring 5		R-M	–111.847	36.517	09/19/1982	Office of Nuclear Waste Isolation, 1985	SPRING	13	Location reported as "river mile 30.7"; date reported as Sept 19 to Oct 3, 1982.
Marble Canyon Spring 6		R-M	–111.846	36.516	09/19/1982	Office of Nuclear Waste Isolation, 1985	SPRING	20	Location reported as "river mile 30.7"; date reported as Sept 19 to Oct 3, 1982.
Marble Canyon Spring 8		R-M	–111.739	36.193	09/19/1982	Office of Nuclear Waste Isolation, 1985	SPRING	220	Location reported as "river mile 4.5"; date reported as Sept 19 to Oct 3, 1982.
Pinenut Mine Monitor Well		R-M	–112.735	36.504	06/29/1988	Energy Fuels Nuclear, 1995a	WELL	15	No location reported, used location for well 55-513394.
Pinenut Mine Monitor Well		R-M	–112.735	36.504	09/27/1988	Energy Fuels Nuclear, 1995a	WELL	34	No location reported, used location for well 55-513394.
Pinenut Mine Monitor Well		R-M	–112.735	36.504	12/20/1990	Energy Fuels Nuclear, 1995a	WELL	11	No location reported, used location for well 55-513394.
Pinenut Mine Monitor Well		R-M	–112.735	36.504	10/26/1994	Energy Fuels Nuclear, 1995a	WELL	11	No location reported, used location for well 55-513394.
Pinenut Mine Monitor Well		R-M	–112.735	36.504	03/25/1992	Energy Fuels Nuclear, 1995a	WELL	15	No location reported, used location for well 55-513394.
Power Lines Spring (below dam)[a]		Navajo Sandstone	–111.492	36.927	10/20/1994	Taylor and others, 1997	SPRING	12	
Power Lines Spring (below dam)[a]		Navajo Sandstone	–111.492	36.927	03/02/1995	Taylor and others, 1997	SPRING	12	
Power Lines Spring (below dam)[a]		Navajo Sandstone	–111.492	36.927	05/01/1995	Taylor and others, 1997	SPRING	13	
River Mile 213 Spring		R-M	–113.336	35.919	05/21/1998	Taylor and others, 2004	SPRING	24	Reported location UTM (289236,3977233).

[a]Site not plotted on figure 16.

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
1	15139[a]		–114.049	36.584	09/23/1977	USGS, 2009a	Spring	45.8	
2	15140[a]		–114.058	36.581	09/23/1977	USGS, 2009a	Spring	89.7	
3	15141[a]		–114.051	36.525	09/23/1977	USGS, 2009a	Spring	0.4	
4	15145[a]		–114.025	36.551	09/23/1977	USGS, 2009a	Spring	0.4	
5	15204[a]		–114.052	35.854	11/09/1977	USGS, 2009a	Spring	22.7	
6	15210[a]		–114.009	35.822	11/16/1977	USGS, 2009a	Spring	36.9	
7	23002		–113.527	35.941	08/16/1977	USGS, 2009a	Spring	0.7	
8	23003		–113.851	35.625	08/23/1977	USGS, 2009a	Well	0.8	
9	23004		–113.994	35.879	08/24/1977	USGS, 2009a	Spring	30.8	
10	23005		–113.971	35.828	08/24/1977	USGS, 2009a	Spring	0.9	
11	23007[a]		–113.557	35.496	08/25/1977	USGS, 2009a	Well	1.5	
12	23010		–113.706	35.618	08/30/1977	USGS, 2009a	Spring	1.3	
13	23012		–113.801	35.624	08/31/1977	USGS, 2009a	Spring	1.9	
14	23013		–113.791	35.645	08/31/1977	USGS, 2009a	Well	1.7	
15	23014		–113.767	35.608	09/01/1977	USGS, 2009a	Well	6.5	
16	23016		–113.629	35.507	09/01/1977	USGS, 2009a	Well	10.5	No date reported, assigned date of nearby well sampled on 9/1/77.
17	23017		–113.403	35.518	09/01/1977	USGS, 2009a	Spring	0.9	
18	23019		–113.422	35.559	09/02/1977	USGS, 2009a	Spring	3.3	
19	23021		–113.177	35.934	09/03/1977	USGS, 2009a	Spring	2.0	
20	23022		–113.075	35.768	09/04/1977	USGS, 2009a	Well	1.4	
21	23023		–113.037	35.705	09/04/1977	USGS, 2009a	Well	1.5	
22	23024		–113.114	35.783	09/04/1977	USGS, 2009a	Well	2.6	
23	23025		–113.676	35.787	09/13/1977	USGS, 2009a	Spring	1.0	
24	23026		–113.900	35.821	09/13/1977	USGS, 2009a	Well	2.3	
25	23027		–113.579	35.714	09/14/1977	USGS, 2009a	Spring	0.4	
26	23028		–113.362	35.762	09/14/1977	USGS, 2009a	Spring	7.2	
27	23029		–113.440	35.593	09/14/1977	USGS, 2009a	Spring	1.1	
28	23030		–113.939	35.969	09/15/1977	USGS, 2009a	Spring	1.3	
29	23032		–113.985	35.774	09/15/1977	USGS, 2009a	Well	110.4	
30	23077		–112.524	35.950	10/17/1977	USGS, 2009a	Spring	3.1	
31	23078		–112.585	35.564	10/18/1977	USGS, 2009a	Spring	1.5	
32	23079		–112.622	35.624	10/18/1977	USGS, 2009a	Well	1.2	
33	23080		–112.875	35.742	10/19/1977	USGS, 2009a	Well	13.5	
34	23081		–112.687	35.641	10/19/1977	USGS, 2009a	Spring	1.8	
35	23088		–112.396	35.958	10/27/1977	USGS, 2009a	Well	3.1	
36	23089		–112.436	35.806	10/28/1977	USGS, 2009a	Well	1.9	
37	23090		–112.597	35.557	10/28/1977	USGS, 2009a	Well	1.6	
38	23091		–112.621	35.624	10/28/1977	USGS, 2009a	Well	1.4	
39	23168[a]		–113.691	35.501	01/08/1978	USGS, 2009a	Spring	56.8	
40	23169[a]		–113.702	35.492	01/08/1978	USGS, 2009a	Spring	51.0	
41	23172		–113.162	35.822	01/08/1978	USGS, 2009a	Spring	1.9	No date reported, assigned date of nearby well sampled on 1/8/78.
42	23173		–113.320	35.515	01/08/1978	USGS, 2009a	Well	7.4	No date reported, assigned date of nearby well sampled on 1/8/78.
43	43536		–113.309	35.885	07/18/1978	USGS, 2009a	Stream	2.1	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
44	43538		–113.426	35.746	07/18/1978	USGS, 2009a	Stream	2.2	
45	43540		–113.524	35.772	07/18/1978	USGS, 2009a	Stream	5.4	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	01/30/1996	USGS, 2009b	Stream	3.0	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	03/25/1996	USGS, 2009b	Stream	4.0	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	03/27/1996	USGS, 2009b	Stream	4.0	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	04/01/1996	USGS, 2009b	Stream	4.0	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	04/06/1996	USGS, 2009b	Stream	3.0	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	05/08/1996	USGS, 2009b	Stream	3.0	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	07/02/1996	USGS, 2009b	Stream	3.0	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	08/20/1996	USGS, 2009b	Stream	3.0	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	09/10/1996	USGS, 2009b	Stream	3.0	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	01/08/1997	USGS, 2009b	Stream	3.0	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	03/05/1997	USGS, 2009b	Stream	3.0	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	05/07/1997	USGS, 2009b	Stream	3.7	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	07/22/1997	USGS, 2009b	Stream	3.2	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	11/04/1997	USGS, 2009b	Stream	3.1	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	03/02/1998	USGS, 2009b	Stream	3.2	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	04/06/1998	USGS, 2009b	Stream	3.2	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	04/28/1998	USGS, 2009b	Stream	3.3	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	06/30/1998	USGS, 2009b	Stream	2.9	
46	9380000	Colorado River at Lees Ferry, Ariz.	–111.588	36.865	08/11/1998	USGS, 2009b	Stream	3.0	
47	9382000	Paria River at Lees Ferry, Ariz.	–111.595	36.872	06/27/2005	USGS, 2009b	Stream	3.6	
47	9382000	Paria River at Lees Ferry, Ariz.	–111.595	36.872	08/24/2005	USGS, 2009b	Stream	3.3	
47	9382000	Paria River at Lees Ferry, Ariz.	–111.595	36.872	11/29/2005	USGS, 2009b	Stream	4.2	
48	9403000	Bright Angel Creek near Grand Canyon, Ariz.	–112.096	36.103	09/02/1981	USGS, 2009b	Stream	1.0	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	11/21/1996	USGS, 2009b	Stream	3.0	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	12/11/1996	USGS, 2009b	Stream	3.0	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	01/22/1997	USGS, 2009b	Stream	3.0	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	02/05/1997	USGS, 2009b	Stream	3.0	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	02/26/1997	USGS, 2009b	Stream	3.4	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	03/12/1997	USGS, 2009b	Stream	3.0	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	04/08/1997	USGS, 2009b	Stream	3.7	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	04/29/1997	USGS, 2009b	Stream	3.4	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	08/17/1997	USGS, 2009b	Stream	3.2	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	11/04/1997	USGS, 2009b	Stream	3.2	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	11/05/1997	USGS, 2009b	Stream	3.1	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	03/17/1998	USGS, 2009b	Stream	3.1	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	04/19/1998	USGS, 2009b	Stream	3.4	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	05/07/1998	USGS, 2009b	Stream	3.1	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	06/03/1998	USGS, 2009b	Stream	3.0	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	08/18/1998	USGS, 2009b	Stream	2.8	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	09/01/1998	USGS, 2009b	Stream	2.9	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	09/23/1998	USGS, 2009b	Stream	2.8	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	02/09/1999	USGS, 2009b	Stream	3.1	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	05/13/1999	USGS, 2009b	Stream	3.3	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	06/08/1999	USGS, 2009b	Stream	3.5	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	07/08/1999	USGS, 2009b	Stream	3.4	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	08/05/1999	USGS, 2009b	Stream	3.7	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	08/24/1999	USGS, 2009b	Stream	3.3	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	10/26/1999	USGS, 2009b	Stream	3.1	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	02/23/2000	USGS, 2009b	Stream	3.9	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	05/03/2000	USGS, 2009b	Stream	3.8	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	08/16/2000	USGS, 2009b	Stream	3.3	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	11/14/2000	USGS, 2009b	Stream	3.6	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	03/13/2001	USGS, 2009b	Stream	3.5	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	04/25/2001	USGS, 2009b	Stream	3.7	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	07/10/2001	USGS, 2009b	Stream	3.5	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	08/28/2001	USGS, 2009b	Stream	3.8	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	11/15/2001	USGS, 2009b	Stream	3.1	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	12/13/2001	USGS, 2009b	Stream	3.3	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	01/15/2002	USGS, 2009b	Stream	3.2	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	03/14/2002	USGS, 2009b	Stream	4.0	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	04/17/2002	USGS, 2009b	Stream	3.8	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	06/04/2002	USGS, 2009b	Stream	3.6	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	06/26/2002	USGS, 2009b	Stream	3.8	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	08/14/2002	USGS, 2009b	Stream	3.7	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	10/31/2002	USGS, 2009b	Stream	2.7	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	12/05/2002	USGS, 2009b	Stream	3.4	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	01/23/2003	USGS, 2009b	Stream	3.6	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	03/06/2003	USGS, 2009b	Stream	4.2	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	04/23/2003	USGS, 2009b	Stream	4.5	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	05/28/2003	USGS, 2009b	Stream	3.7	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	07/16/2003	USGS, 2009b	Stream	3.9	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	08/28/2003	USGS, 2009b	Stream	4.3	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	10/22/2003	USGS, 2009b	Stream	3.7	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	12/02/2003	USGS, 2009b	Stream	4.0	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	01/22/2004	USGS, 2009b	Stream	3.8	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	02/25/2004	USGS, 2009b	Stream	4.4	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	03/25/2004	USGS, 2009b	Stream	4.9	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	05/25/2004	USGS, 2009b	Stream	4.2	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	06/29/2004	USGS, 2009b	Stream	4.3	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	08/10/2004	USGS, 2009b	Stream	3.7	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	11/03/2004	USGS, 2009b	Stream	4.1	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	11/22/2004	USGS, 2009b	Stream	4.2	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	11/23/2004	USGS, 2009b	Stream	4.8	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	12/01/2004	USGS, 2009b	Stream	2.9	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	01/26/2005	USGS, 2009b	Stream	4.1	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	04/21/2005	USGS, 2009b	Stream	3.9	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	09/07/2005	USGS, 2009b	Stream	3.3	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	10/25/2005	USGS, 2009b	Stream	3.7	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	01/19/2006	USGS, 2009b	Stream	3.6	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	03/02/2006	USGS, 2009b	Stream	3.8	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	04/05/2006	USGS, 2009b	Stream	4.2	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	05/25/2006	USGS, 2009b	Stream	3.7	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	07/13/2006	USGS, 2009b	Stream	3.7	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	08/31/2006	USGS, 2009b	Stream	3.4	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	11/07/2006	USGS, 2009b	Stream	3.5	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	02/01/2007	USGS, 2009b	Stream	3.6	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	03/15/2007	USGS, 2009b	Stream	3.8	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	04/26/2007	USGS, 2009b	Stream	3.7	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	06/06/2007	USGS, 2009b	Stream	3.5	
49	9404200	Colorado River Above Diamond Creek near Peach Springs	–113.364	35.774	07/18/2007	USGS, 2009b	Stream	3.5	
49	9404200	Colorado River above Diamond Creek near Peach Springs	–113.364	35.774	08/15/2007	USGS, 2009b	Stream	3.8	
50	9404208	Diamond Creek near Peach Springs, Ariz.	–113.368	35.765	05/26/1993	USGS, 2009b	Stream	10.0	
51	353445113255000	Peach Springs	–113.431	35.579	05/27/1993	USGS, 2009b	Spring	2.0	
51	353445113255000	Peach Springs	–113.431	35.579	11/19/1993	USGS, 2009b	Spring	2.0	
52	353713113421800	Milkweed Spring	–113.706	35.620	05/27/1993	USGS, 2009b	Spring	2.0	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
52	353713113421800	Milkweed Spring	–113.706	35.620	12/10/1993	USGS, 2009b	Spring	2.0	
53	354228113374300	Lower Milkweed Canyon	–113.629	35.708	05/16/1993	USGS, 2009b	Spring	4.0	
54	354248113153800	Diamond Spring	–113.261	35.713	05/19/1993	USGS, 2009b	Spring	1.0	
55	354250113343800	Hindu Spring	–113.578	35.714	05/16/1993	USGS, 2009b	Spring	1.0	
56	354311113135200	Diamond Creek	–113.232	35.720	05/19/1993	USGS, 2009b	Spring	4.0	
57	354346113520200	Clay (Middle) Spring	–113.868	35.729	06/10/1993	USGS, 2009b	Spring	2.0	
57	354346113520200	Clay (Middle) Spring	–113.868	35.729	11/18/1993	USGS, 2009b	Spring	2.0	
58	354406113263400	Travertine Canyon	–113.444	35.735	05/15/1993	USGS, 2009b	Spring	2.0	
59	354503113252600	Travertine Canyon above mouth at rm 229	–113.425	35.751	05/15/1993	USGS, 2009b	Spring	4.0	
60	354522113264800	Travertine Falls	–113.447	35.756	05/15/1993	USGS, 2009b	Spring	11.0	
61	354550113313400	Bridge Canyon	–113.527	35.764	05/15/1993	USGS, 2009b	Spring	6.0	
62	354555113222100	Diamond Creek above mouth at rm 225.7	–113.373	35.765	11/05/1990	USGS, 2009b	Stream	7.2	
62	354555113222100	Diamond Creek above mouth at rm 225.7	–113.373	35.765	11/06/1990	USGS, 2009b	Stream	8.3	
62	354555113222100	Diamond Creek above mouth at rm 225.7	–113.373	35.765	11/06/1990	USGS, 2009b	Stream	8.0	
62	354555113222100	Diamond Creek above mouth at rm 225.7	–113.373	35.765	11/06/1990	USGS, 2009b	Stream	7.0	
63	354711113403200	Meriwhitica Spring	–113.676	35.786	05/16/1993	USGS, 2009b	Spring	2.0	
64	354800113390800		–113.653	35.800	05/16/1993	USGS, 2009b	Spring	2.0	
65	354815113192000	222 Mile Canyon	–113.323	35.804	10/15/1993	USGS, 2009b	Spring	29.0	
66	354855113183300	Granite Spring Canyon	–113.310	35.815	05/19/1993	USGS, 2009b	Spring	1.0	
67	354923114001000[a]	Ray Place Right Fork	–114.004	35.823	06/09/1993	USGS, 2009b	Spring	19.0	
67	354923114001000[a]	Ray Place Right Fork	–114.004	35.823	12/09/1993	USGS, 2009b	Spring	20.0	
68	354924114001200[a]	Ray Place Left Fork	–114.004	35.823	06/09/1993	USGS, 2009b	Spring	32.0	
69	354942113581500	Hillside Spring	–113.972	35.828	06/09/1993	USGS, 2009b	Spring	<1	Uranium value of 0.5 used for summary table statistics.
70	354944113592300	Iron Spring	–113.991	35.829	06/10/1993	USGS, 2009b	Spring	25.0	
71	355052113591900	Mud Spring	–113.989	35.848	06/11/1993	USGS, 2009b	Spring	15.0	
72	355111113462300	Horse Flat Canyon	–113.774	35.853	05/17/1993	USGS, 2009b	Spring	1.0	
73	355124113404000	Clay Tank Canyon	–113.679	35.857	05/17/1993	USGS, 2009b	Spring	3.0	
74	355308113182600	Three Springs Canyon above the mouth	–113.308	35.886	10/14/1993	USGS, 2009b	Spring	2.0	
75	355502113195900	Pumpkin Spring at rm 213	–113.334	35.917	10/13/1993	USGS, 2009b	Spring	17.0	
76	355748113454500	Quartermaster Canyon above the mouth	–113.763	35.963	05/17/1993	USGS, 2009b	Stream	2.0	
77	355750113183600	Granite Park Spring	–113.311	35.964	10/13/1993	USGS, 2009b	Spring	4.0	
78	355807113561800	New Water Spring	–113.939	35.969	06/11/1993	USGS, 2009b	Spring	2.0	
78	355807113561800	New Water Spring	–113.939	35.969	11/17/1993	USGS, 2009b	Spring	2.0	
79	355959113122700	Big Spring	–113.208	36.000	05/20/1993	USGS, 2009b	Spring	4.0	
80	360020111560401	Red Canyon Spring; upper Bright Angel near Muav contact (bedrock)	–111.934	36.004	09/26/2001	Moore and others, 2005	Spring	1.7	
81	360025111571501	JT Spring (Hance Spring; upper Bright Angel near Muav contact (bedrock))	–111.951	36.002	04/08/2001	Moore and others, 2005	Spring	3.5	
81	360025111571501	JT Spring (Hance Spring; upper Bright Angel near Muav contact (bedrock))	–111.951	36.002	05/11/2001	Moore and others, 2005	Spring	4.1	
82	360059111581700	Miners Spring at train in Hance Canyon	–111.972	36.016	11/20/1981	USGS, 2009b	Spring	3.9	
83	360100111582001	Miners Spring; upper Bright Angel near Muav contact (bedrock)	–111.971	36.015	05/24/2000	Moore and others, 2005	Spring	3.1	
83	360100111582001	Miners Spring; upper Bright Angel near Muav contact (bedrock)	–111.971	36.015	11/28/2000	Moore and others, 2005	Spring	3.5	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

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Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
83	360100111582001	Miners Spring; upper Bright Angel near Muav contact (bedrock)	–111.971	36.015	04/07/2001	Moore and others, 2005	Spring	3.3	
84	360128111591501	Cottonwood Creek No. 1; lower Bright Angel alluvium	–111.987	36.023	05/25/2000	Moore and others, 2005	Stream	1.5	
84	360128111591501	Cottonwood Creek No. 1; lower Bright Angel alluvium	–111.987	36.023	04/09/2001	Moore and others, 2005	Stream	1.6	
85	360128111591502	Cottonwood Creek No. 2 (Cottonwood Spring); mid Bright Angel (alluvium)	–111.990	36.017	11/29/2000	Moore and others, 2005	Spring	1.6	
86	360232112004801	Grapevine East Spring; lower Bright Angel (bedrock)	–112.012	36.040	05/25/2000	Moore and others, 2005	Spring	2.1	
86	360232112004801	Grapevine East Spring; lower Bright Angel (bedrock)	–112.012	36.040	11/29/2000	Moore and others, 2005	Spring	8.3	
86	360232112004801	Grapevine East Spring; lower Bright Angel (bedrock)	–112.012	36.040	04/09/2001	Moore and others, 2005	Spring	7.1	
87	360232112004802	Grapevine Main Spring; upper Bright Angel near Muav contact (bedrock)	–112.003	36.009	04/10/2001	Moore and others, 2005	Spring	1.1	
87	360232112004802	Grapevine Main Spring; upper Bright Angel near Muav contact (bedrock)	–112.003	36.009	04/30/2001	Moore and others, 2005	Spring	1.1	
88	360336112131801	Hermit Spring	–112.222	36.060	06/20/2005	USGS, 2009b	Spring	5.3	
88	360336112131801	Hermit Spring	–112.222	36.060	09/29/2005	USGS, 2009b	Spring	4.7	
88	360336112131801	Hermit Spring	–112.222	36.060	12/30/2005	USGS, 2009b	Spring	4.4	
88	360336112131801	Hermit Spring	–112.222	36.060	12/30/2005	USGS, 2009b	Spring	4.4	
89	360400112025001	Lonetree Spring; upper Bright Angel near Muav contact (bedrock)	–112.047	36.065	04/11/2001	Moore and others, 2005	Spring	6.0	
89	360400112025001	Lonetree Spring; upper Bright Angel near Muav contact (bedrock)	–112.047	36.065	05/01/2001	Moore and others, 2005	Spring	6.0	
90	360411112141701	Boucher East Spring; upper Tapeats (travertine dome)	–112.237	36.101	05/26/2000	Moore and others, 2005	Spring	1.9	
90	360411112141701	Boucher East Spring; upper Tapeats (travertine dome)	–112.237	36.101	12/04/2000	Moore and others, 2005	Spring	1.8	
90	360411112141701	Boucher East Spring; upper Tapeats (travertine dome)	–112.237	36.101	04/12/2001	Moore and others, 2005	Spring	1.9	
91	360415112060601	Pipe Creek; lower Bright Angel (alluvium)	–112.099	36.068	05/22/2000	Moore and others, 2005	Stream	2.7	
91	360415112060601	Pipe Creek; lower Bright Angel (alluvium)	–112.099	36.068	12/07/2000	Moore and others, 2005	Stream	2.4	
91	360415112060601	Pipe Creek; lower Bright Angel (alluvium)	–112.099	36.068	04/08/2001	Moore and others, 2005	Stream	2.3	
92	360417112130701	Hawaii Spring; mid Bright Angel (bedrock)	–112.218	36.069	05/25/2000	Moore and others, 2005	Spring	1.9	
92	360417112130701	Hawaii Spring; mid Bright Angel (bedrock)	–112.218	36.069	12/04/2000	Moore and others, 2005	Spring	1.9	
92	360417112130701	Hawaii Spring; mid Bright Angel (bedrock)	–112.218	36.069	04/11/2001	Moore and others, 2005	Spring	2.0	
93	360417112130702	Hermit Spring; lower Muav near Bright Angel contact (bedrock)	–112.225	36.061	12/04/2000	Moore and others, 2005	Spring	2.0	
93	360417112130702	Hermit Spring; lower Muav near Bright Angel contact (bedrock)	–112.225	36.061	04/11/2001	Moore and others, 2005	Spring	2.1	
94	360435113104700	Ridenour Mine	–113.180	36.076	05/20/1993	USGS, 2009b	Spring	8.0	
95	360436112060401	Burro Spring; lower Bright Angel (alluvium)	–112.100	36.075	05/22/2000	Moore and others, 2005	Spring	2.5	
95	360436112060401	Burro Spring; lower Bright Angel (alluvium)	–112.100	36.075	12/07/2000	Moore and others, 2005	Spring	2.7	
95	360436112060401	Burro Spring; lower Bright Angel (alluvium)	–112.100	36.075	04/08/2001	Moore and others, 2005	Spring	2.4	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

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Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
96	360437112060210	Burro Spring at Tonto Trail	–112.101	36.077	09/01/1981	USGS, 2009b	Spring	2.6	
97	360439112094101	Salt Creek Spring; upper Bright Angel (bedrock)	–112.161	36.075	05/23/2000	Moore and others, 2005	Spring	30.1	
97	360439112094101	Salt Creek Spring; upper Bright Angel (bedrock)	–112.161	36.075	12/06/2000	Moore and others, 2005	Spring	31.2	
97	360439112094101	Salt Creek Spring; upper Bright Angel (bedrock)	–112.161	36.075	04/10/2001	Moore and others, 2005	Spring	29.3	
98	360441112073201	Pumphouse Spring; mid Bright Angel (alluvium)	–112.125	36.076	05/22/2000	Moore and others, 2005	Spring	1.7	
98	360441112073201	Pumphouse Spring; mid Bright Angel (alluvium)	–112.125	36.076	12/07/2000	Moore and others, 2005	Spring	1.9	
98	360441112073201	Pumphouse Spring; mid Bright Angel (alluvium)	–112.125	36.076	04/07/2001	Moore and others, 2005	Spring	1.8	
99	360441112073202	Pumphouse Wash gage; mid Bright Angel (alluvium)	–112.126	36.076	12/07/2000	Moore and others, 2005	Stream	1.8	
100	360450112083601	Horn Creek; mid Bright Angel (alluvium)	–112.143	36.079	05/22/2000	Moore and others, 2005	Stream	8.6	
100	360450112083601	Horn Creek; mid Bright Angel (alluvium)	–112.143	36.079	12/06/2000	Moore and others, 2005	Stream	9.3	
100	360450112083601	Horn Creek; mid Bright Angel (alluvium)	–112.143	36.079	04/07/2001	Moore and others, 2005	Stream	29.2	
101	360455112111001	Monument Creek No. 1; Tapeats (alluvium)	–112.185	36.080	05/24/2000	Moore and others, 2005	Stream	7.1	
102	360455112111002	Monument Spring; lower Muav near Bright Angel contact (bedrock)	–112.176	36.064	12/05/2000	Moore and others, 2005	Spring	7.1	
102	360455112111002	Monument Spring; lower Muav near Bright Angel contact (bedrock)	–112.176	36.064	04/09/2001	Moore and others, 2005	Spring	7.3	
103	360957113080200	Beecher Spring	–113.135	36.166	10/11/1993	USGS, 2009b	Spring	2.0	
104	361025113071100	Artesian Spring at rm 182	–113.120	36.174	10/11/1993	USGS, 2009b	Spring	5.0	
105	361143112270500	Royal Arch Creek at mouth of Elves Chasm	–112.452	36.195	11/19/1981	USGS, 2009b	Spring	3.5	
106	361148113045900	Warm Spring	–113.084	36.197	10/10/1993	USGS, 2009b	Spring	5.0	
107	361237113025700	Honga above the Mouth	–113.050	36.210	10/10/1993	USGS, 2009b	Spring	13.0	
108	361303112411200	Havasu Spring	–112.687	36.217	08/23/1994	USGS, 2009b	Spring	4.0	
109	361310112580400	Mohawk Canyon	–112.969	36.219	10/09/1993	USGS, 2009b	Spring	12.0	
110	361344113032001	Saddle Horse Spring	–113.056	36.229	05/24/2005	USGS, 2009b	Spring	0.6	
110	361344113032001	Saddle Horse Spring	–113.056	36.229	09/08/2005	USGS, 2009b	Spring	0.5	
110	361344113032001	Saddle Horse Spring	–113.056	36.229	12/01/2005	USGS, 2009b	Spring	0.6	
111	361352112413201	B-33-04 22 unsurveyed	–112.693	36.231	08/23/1994	USGS, 2009b	Well	3.0	
112	361518112523900	National Canyon above mouth at rm 166.5 in Hualapai	–112.878	36.255	10/08/1993	USGS, 2009b	Stream	4.0	
113	361524112420400	Fern Spring	–112.702	36.257	08/24/1994	USGS, 2009b	Spring	4.0	
114	361650112052001	Robbers Roost Spring	–112.089	36.281	05/27/2005	USGS, 2009b	Spring	0.1	
114	361650112052001	Robbers Roost Spring	–112.089	36.281	09/07/2005	USGS, 2009b	Spring	0.4	
114	361650112052001	Robbers Roost Spring	–112.089	36.281	10/25/2005	USGS, 2009b	Spring	0.5	
115	361947112550200	Cottonwood Creek North Rim Grand Canyon	–112.917	36.330	05/26/2005	USGS, 2009b	Stream	4.8	
115	361947112550200	Cottonwood Creek North Rim Grand Canyon	–112.917	36.330	11/30/2005	USGS, 2009b	Stream	5.0	
116	362143112551201	Schmutz Spring	–112.920	36.362	05/26/2005	USGS, 2009b	Spring	6.0	
116	362143112551201	Schmutz Spring	–112.920	36.362	09/09/2005	USGS, 2009b	Spring	4.5	
116	362143112551201	Schmutz Spring	–112.920	36.362	11/30/2005	USGS, 2009b	Spring	4.6	
116	362143112551201	Schmutz Spring	–112.920	36.362	08/25/2009	USGS, 2009b	Spring	4.3	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

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116	362143112551201	Schmutz Spring	–112.920	36.362	08/25/2009	USGS, 2009b	Spring	4.1	
117	362157112451601	Hotel Spring	–112.754	36.366	05/23/2005	USGS, 2009b	Spring	2.9	
117	362157112451601	Hotel Spring	–112.754	36.366	11/29/2005	USGS, 2009b	Spring	4.2	
117	362157112451601	Hotel Spring	–112.754	36.366	08/25/2009	USGS, 2009b	Spring	2.6	
118	362258112464701	Buckhorn Spring	–112.780	36.383	05/23/2005	USGS, 2009b	Spring	10.3	
118	362258112464701	Buckhorn Spring	–112.780	36.383	11/29/2005	USGS, 2009b	Spring	10.6	
119	362434111533601		–111.893	36.409	08/23/2009	USGS, 2009b	Spring	2.8	
120	362702112394701		–112.663	36.451	08/26/2009	USGS, 2009b	Spring	7.2	
121	362723112382801	Showerbath Spring	–112.641	36.456	08/26/2009	USGS, 2009b	Spring	4.2	
122	362802112374601		–112.629	36.467	08/26/2009	USGS, 2009b	Spring	4.6	
122	362802112374601		–112.629	36.467	08/26/2009	USGS, 2009b	Spring	5.2	
123	362827111504101		–111.845	36.474	08/21/2009	USGS, 2009b	Spring	0.6	
124	362831111504401	Hole-in-the-Wall Spring	–111.846	36.475	08/22/2009	USGS, 2009b	Spring	0.6	
125	362837111504201	Redwall Limestone; rm 34.2	–111.846	36.477	08/22/2009	USGS, 2009b	Spring	0.6	
126	362957111512600	Vasey's Paradise, rm 31.9; Redwall Limestone	–111.858	36.499	11/20/1981	USGS, 2009b	Spring	1.8	
127	363115112342601		–112.574	36.521	09/01/2009	USGS, 2009b	Spring	7.8	
128	363123111503101	Fence Spring	–111.842	36.523	08/20/2009	USGS, 2009b	Spring	1.4	
129	363209112350801	Lower Jumpup Spring	–112.586	36.536	08/28/2009	USGS, 2009b	Spring	7.2	
130	363357112440801	Willow Spring	–112.736	36.566	08/26/2009	USGS, 2009b	Spring	19.6	
131	363450112325001	Upper Jumpup Spring	–112.547	36.581	08/27/2009	USGS, 2009b	Spring	3.7	
132	363907111471701	Rider Spring	–111.788	36.652	08/25/2009	USGS, 2009b	Spring	4.5	
133	363922112334501		–112.563	36.656	08/27/2009	USGS, 2009b	Spring	2.3	
134	10A-W82	Upper Pine Spring; Kaibab Limestone	–113.114	35.842	06/01/1982	Wenrich and others, 1994	Spring	1.6	Date reported as 1982.
135	11A-W82	Unnamed spring ⅓ mi from Pine Tank; Kaibab Limestone	–113.104	35.840	06/01/1982	Wenrich and others, 1994	Spring	1.4	Date reported as 1982.
136	12A-W82	Pine Spring; Tertiary Frazier Well gravels	–113.099	35.837	06/01/1982	Wenrich and others, 1994	Spring	1.8	Date reported as 1982.
137	13A-W82	Unnamed well; Tertiary Frazier Well gravels	–113.093	35.836	06/01/1982	Wenrich and others, 1994	Well	1.6	Date reported as 1982.
138	14A-W82	Fed by Frazier well; Tertiary Frazier Well gravels	–113.078	35.797	06/01/1982	Wenrich and others, 1994	Well	1.4	Date reported as 1982.
139	15A-W82	Pocomate Springs; Coconino Sandstone	–113.162	35.822	06/01/1982	Wenrich and others, 1994	Spring	2.0	Date reported as 1982.
140	16A-W82	Unnamed well; Tertiary Frazier Well gravels	–113.051	35.810	06/01/1982	Wenrich and others, 1994	Well	1.3	Date reported as 1982.
141	17A-W82	Travertine Falls; Vishnu Schist	–113.426	35.751	06/01/1982	Wenrich and others, 1994	Stream	2.9	Date reported as 1982.
142	18A-W82	Travertine Falls Spring; Precambrian granite	–113.448	35.756	06/01/1982	Wenrich and others, 1994	Spring	9.5	Date reported as 1982.
143	19A-W82	Lost Travertine Falls Spring; Tapeats Sandstone	–113.498	35.756	06/01/1982	Wenrich and others, 1994	Stream	6.3	Date reported as 1982.
144	1A-W82	Red Spring; Muav Limestone	–113.423	35.559	06/01/1982	Wenrich and others, 1994	Spring	3.6	Date reported as 1982.
145	20A-W82	¼ mile below Bridge Canyon Spring; Vishnu Schist	–113.527	35.769	06/01/1982	Wenrich and others, 1994	Stream	4.6	Date reported as 1982.
146	21A-W82	Seep south of Separation Canyon; Precambrian granite	–113.567	35.808	06/01/1982	Wenrich and others, 1994	Spring	18.0	Date reported as 1982.
147	22A-W82	Seep south of Separation Canyon; Precambrian granite	–113.568	35.808	06/01/1982	Wenrich and others, 1994	Spring	28.0	Date reported as 1982.
148	23A-W82	Mouth of Spencer Canyon; Spencer Canyon gravels	–113.568	35.823	06/01/1982	Wenrich and others, 1994	Stream	2.0	Date reported as 1982.
149	24A-W82	Quartermaster Springs-NE; Travertine	–113.766	35.959	06/01/1982	Wenrich and others, 1994	Spring	1.3	Date reported as 1982.

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150	25A-W82	Quartermaster Springs-SW; Travertine	–113.767	35.956	06/01/1982	Wenrich and others, 1994	Spring	1.4	Date reported as 1982.
151	26A-W82	Rampart Springs; Muav Limestone	–113.110	36.145	06/01/1982	Wenrich and others, 1994	Spring	1.6	Date reported as 1982.
152	27A-W82	Base of Columbine Falls—½ mi from spring; Muav Limestone	–113.921	36.092	06/01/1982	Wenrich and others, 1994	Stream	1.5	Date reported as 1982.
153	28A-W82	Diamond Creek Spring (Upper Diamond Spring); Redwall Limestone	–113.232	35.720	06/01/1982	Wenrich and others, 1994	Spring	0.2	Date reported as 1982.
154	29A-W82	Hells Hollow Spring; Esplanade Sandstone	–113.110	36.145	06/01/1982	Wenrich and others, 1994	Spring	0.9	Date reported as 1982.
155	2A-W82	Peach Springs; Muav Limestone	–113.431	35.578	06/01/1982	Wenrich and others, 1994	Spring	1.6	Date reported as 1982.
156	30A+B-W82	Beecher Spring; Hermit/Esplanade contact	–113.179	36.076	06/01/1982	Wenrich and others, 1994	Spring	9.5	Date reported as 1982.
156	30A+B-W82	Beecher Spring; Hermit/Esplanade contact	–113.179	36.076	06/01/1982	Wenrich and others, 1994	Spring	8.4	Date reported as 1982.
157	31A+B-W82	Surprise Springs; Redwall Limestone	–113.402	35.519	06/01/1982	Wenrich and others, 1994	Spring	1.0	Date reported as 1982.
157	31A+B-W82	Surprise Springs; Redwall Limestone	–113.402	35.519	06/01/1982	Wenrich and others, 1994	Spring	1.2	Date reported as 1982.
158	32A-W82	Spencer Springs; Muav Limestone and Spencer Canyon gravels	–113.651	35.783	06/01/1982	Wenrich and others, 1994	Spring	2.8	Date reported as 1982.
159	33A+B-W82	Meriwhitica Springs; Muav Limestone	–113.676	35.786	06/01/1982	Wenrich and others, 1994	Spring	1.2	Date reported as 1982.
159	33A+B-W82	Meriwhitica Springs; Muav Limestone	–113.676	35.786	06/01/1982	Wenrich and others, 1994	Spring	1.2	Date reported as 1982.
160	34A+B-W82	Hockey Puck Spring; contact of Hermit Shale and Coconino Sandstone	–113.176	35.934	06/01/1982	Wenrich and others, 1994	Spring	2.2	Date reported as 1982.
160	34A+B-W82	Hockey Puck Spring; contact of Hermit Shale and Coconino Sandstone	–113.176	35.934	06/01/1982	Wenrich and others, 1994	Spring	2.1	Date reported as 1982.
161	35A-W82	Red Spring; Coconino Sandstone	–113.024	36.071	06/01/1982	Wenrich and others, 1994	Spring	1.7	Date reported as 1982.
162	36A-W82	Moss Spring; Coconino Sandstone	–113.028	36.062	06/01/1982	Wenrich and others, 1994	Spring	1.1	Date reported as 1982.
163	37A-W82	Big Spring; Coconino Sandstone	–113.207	36.000	06/01/1982	Wenrich and others, 1994	Spring	2.6	Date reported as 1982.
164	38A-W82	Unnamed Spring; Music Mountain conglomerate	–113.678	35.670	06/01/1982	Wenrich and others, 1994	Spring	1.6	Date reported as 1982.
165	39A+B-W82	Willow Spring; Hualapai volcanic rocks	–113.699	35.651	06/01/1982	Wenrich and others, 1994	Spring	1.5	Date reported as 1982.
165	39A+B-W82	Willow Spring; Hualapai volcanic rocks	–113.699	35.651	06/01/1982	Wenrich and others, 1994	Spring	1.3	Date reported as 1982.
166	3A-W82	Lower Peach Springs; Muav Limestone	–113.440	35.592	06/01/1982	Wenrich and others, 1994	Spring	2.6	Date reported as 1982.
167	41A+B-W82	West Water Spring (upper); Hualapai volcanic rocks	–113.727	35.618	06/01/1982	Wenrich and others, 1994	Spring	1.0	Date reported as 1982.
167	41A+B-W82	West Water Spring (upper); Hualapai volcanic rocks	–113.727	35.618	06/01/1982	Wenrich and others, 1994	Spring	0.9	Date reported as 1982.
168	42A-W82	Unnamed spring; Music Mountain conglomerate	–113.690	35.637	06/01/1982	Wenrich and others, 1994	Spring	1.2	Date reported as 1982.
169	43A-W82	Lower Milkweed Spring; Bright Angel Shale	–113.673	35.653	06/01/1982	Wenrich and others, 1994	Spring	2.1	Date reported as 1982.
170	44A-W82	Lower West Water Spring; Music Mountain conglomerate	–113.695	35.645	06/01/1982	Wenrich and others, 1994	Spring	1.0	Date reported as 1982.
171	45A+B-W82a	PMG Well (Truxton); Quaternary and Tertiary gravels	–113.557	35.496	06/01/1982	Wenrich and others, 1994	Well	1.9	Date reported as 1982.
171	45A+B-W82a	PMG Well (Truxton); Quaternary and Tertiary gravels	–113.557	35.496	06/01/1982	Wenrich and others, 1994	Well	2.1	Date reported as 1982.
172	47A+B-W82	Horse Trough Spring; Muav Limestone	–113.619	35.550	06/01/1982	Wenrich and others, 1994	Spring	1.6	Date reported as 1982.
172	47A+B-W82	Horse Trough Spring; Muav Limestone	–113.619	35.550	06/01/1982	Wenrich and others, 1994	Spring	1.4	Date reported as 1982.
173	48A-W82	Shipley Well; Muav Limestone	–113.375	35.526	06/01/1982	Wenrich and others, 1994	Well	1.1	Date reported as 1982.
174	49A-W82	Horsehair Spring; Wescogame Formation	–112.916	36.157	06/01/1982	Wenrich and others, 1994	Spring	13.0	Date reported as 1982.
175	4A-W82	Diamond Creek (at mouth); Diamond Creek gravels	–113.371	35.766	06/01/1982	Wenrich and others, 1994	Stream	6.9	Date reported as 1982.

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
176	50A-W82	Mohawk Spring; Muav Limestone	–112.971	36.213	06/01/1982	Wenrich and others, 1994	Spring	12.0	Date reported as 1982.
177	51A-W82	National Canyon Spring; Redwall Limestone	–112.879	36.213	06/01/1982	Wenrich and others, 1994	Spring	8.0	Date reported as 1982.
178	53A-W82	East Diamond Spring; Muav Limestone	–113.255	35.719	06/01/1982	Wenrich and others, 1994	Spring	1.1	Date reported as 1982.
179	54A-W82	Milkweed Spring; Hualapai volcanic rocks	–113.706	35.618	06/01/1982	Wenrich and others, 1994	Spring	2.3	Date reported as 1982.
180	55A-W82	Clay Springs; Muav Limestone	–113.868	35.731	06/01/1982	Wenrich and others, 1994	Spring	1.7	Date reported as 1982.
181	56A+B-W82	Santa Fe #5 Well; Muav Limestone	–113.678	35.527	06/01/1982	Wenrich and others, 1994	Well	1.2	Date reported as 1982.
181	56A+B-W82	Santa Fe #5 Well; Muav Limestone	–113.678	35.527	06/01/1982	Wenrich and others, 1994	Well	1.2	Date reported as 1982.
182	57A+B-W82	XI Well; Tertiary Frazier Well gravel	–113.114	35.784	06/01/1982	Wenrich and others, 1994	Well	2.5	Date reported as 1982.
182	57A+B-W82	XI Well; Tertiary Frazier Well gravel	–113.114	35.784	06/01/1982	Wenrich and others, 1994	Well	1.7	Date reported as 1982.
183	58A-W82	Diamond Spring; Muav Limestone	–113.261	35.713	06/01/1982	Wenrich and others, 1994	Spring	1.2	Date reported as 1982.
184	59A-W82	Reference Point Spring; Precambrian granite	–113.732	35.882	06/01/1982	Wenrich and others, 1994	Spring	2.8	Date reported as 1982.
185	5A-W82	Rocky Spring; Bright Angel Shale	–113.364	35.749	06/01/1982	Wenrich and others, 1994	Spring	28.0	Date reported as 1982.
186	60A-W82	Wild Horse Spring; Bright Angel Shale	–113.645	35.711	06/01/1982	Wenrich and others, 1994	Spring	1.1	Date reported as 1982.
187	61A-W82	Hindu Spring; Muav Limestone	–113.585	35.697	06/01/1982	Wenrich and others, 1994	Spring	1.4	Date reported as 1982.
188	62A-W82	Blue Mtn Seep; Bright Angel Shale	–113.293	35.697	06/01/1982	Wenrich and others, 1994	Spring	2.1	Date reported as 1982.
189	63A-W82	Lost Creek Spring; Contact between Precambrian granite and Tapeats Sandstone	–113.677	35.857	06/01/1982	Wenrich and others, 1994	Spring	2.1	Date reported as 1982.
190	64A-W82	Unnamed spring in Milkweed Canyon; Precambrian granite	–113.657	35.681	06/01/1982	Wenrich and others, 1994	Spring	3.0	Date reported as 1982.
191	65A-W82	Sheep Spring; Temple Butte Formation	–113.826	35.848	06/01/1982	Wenrich and others, 1994	Spring	2.6	Date reported as 1982.
192	66A-W82	Unnamed spring in Milkweed Canyon; Bright Angel Shale	–113.640	35.984	06/01/1982	Wenrich and others, 1994	Spring	2.0	Date reported as 1982.
193	67A-W82	Robbers Roost Spring; Vishnu Schist	–113.296	35.718	06/01/1982	Wenrich and others, 1994	Spring	21.0	Date reported as 1982.
194	68A-W82	Unnamed spring in Milkweed Canyon; Precambrian granite	–113.655	35.680	06/01/1982	Wenrich and others, 1994	Spring	3.2	Date reported as 1982.
195	69A-W82	Hindu Seep; Muav Limestone	–113.603	35.704	06/01/1982	Wenrich and others, 1994	Spring	1.3	Date reported as 1982.
196	6A-W82	Mesquite Spring; Bright Angel Shale in landslide block adjacent to Hurricane fault	–113.422	35.670	06/01/1982	Wenrich and others, 1994	Spring	21.0	Date reported as 1982.
197	70A-W82	Buck and Doe Spring; Bright Angel Shale	–113.647	35.676	06/01/1982	Wenrich and others, 1994	Spring	1.0	Date reported as 1982.
198	71A-W82	Tilted Spring; Tapeats Sandstone	–113.628	35.706	06/01/1982	Wenrich and others, 1994	Spring	2.8	Date reported as 1982.
199	72A-W82	Metuck Springs; Muav Limestone	–113.383	35.647	06/01/1982	Wenrich and others, 1994	Spring	0.8	Date reported as 1982.
200	73A+B-W82[a]	Truxton Well; Quaternary & Tertiary gravels	–113.536	35.496	06/01/1982	Wenrich and others, 1994	Well	1.3	Date reported as 1982.
200	73A+B-W82[a]	Truxton Well; Quaternary & Tertiary gravels	–113.536	35.496	06/01/1982	Wenrich and others, 1994	Well	1.2	Date reported as 1982.
201	74A+B-W82	Dewey Mahone Spring; Vishnu Schist	–113.629	35.506	06/01/1982	Wenrich and others, 1994	Spring	12.0	Date reported as 1982.
201	74A+B-W82	Dewey Mahone Spring; Vishnu Schist	–113.629	35.506	06/01/1982	Wenrich and others, 1994	Spring	12.0	Date reported as 1982.
202	75A-W82	Warm Springs; Muav Limestone	–113.082	36.197	06/01/1982	Wenrich and others, 1994	Spring	5.4	Date reported as 1982.
203	76A-W82	Lava Falls (by cliff); Muav Limestone	–113.081	36.196	06/01/1982	Wenrich and others, 1994	Spring	5.2	Date reported as 1982.
204	77A-W82	Pumpkin Spring; Tapeats Sandstone	–113.333	35.917	06/01/1982	Wenrich and others, 1994	Spring	12.0	Date reported as 1982.
205	78A+B-W82	Three Springs; Muav Limestone	–113.294	35.886	06/01/1982	Wenrich and others, 1994	Spring	1.8	Date reported as 1982.
205	78A+B-W82	Three Springs; Muav Limestone	–113.294	35.886	06/01/1982	Wenrich and others, 1994	Spring	1.6	Date reported as 1982.
206	79A-W82	Hindu Canyon; Muav Limestone	–113.580	35.703	06/01/1982	Wenrich and others, 1994	Stream	1.8	Date reported as 1982.
207	7A-W82	Mulberry Spring; Muav Limestone	–113.403	35.612	06/01/1982	Wenrich and others, 1994	Spring	3.1	Date reported as 1982.
208	8A-W82	Pocomate Springs; Coconino Sandstone	–113.160	35.824	06/01/1982	Wenrich and others, 1994	Spring	1.5	Date reported as 1982.
209	Berts Canyon	Muav Limestone	–111.886	36.398	05/11/1998	Taylor and others, 2004	Spring	1.4	Reported location UTM (420561,4028259).
210	Blue Spring	Redwall-Muav aquifer	–111.693	36.117	05/16/1985	Errol Montgomery and Assoc., 1993b	Spring	7.0	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
210	Blue Spring	Redwall-Muav aquifer	–111.693	36.117	12/18/1985	Errol Montgomery and Assoc., 1993b	Spring	4.0	
210	Blue Spring	Redwall-Muav aquifer	–111.693	36.117	06/03/1986	Errol Montgomery and Assoc., 1993b	Spring	6.0	
210	Blue Spring	Redwall-Muav aquifer	–111.693	36.117	12/08/1986	Errol Montgomery and Assoc., 1993b	Spring	6.0	
210	Blue Spring	Redwall-Muav aquifer	–111.693	36.117	05/28/1987	Errol Montgomery and Assoc., 1993b	Spring	4.0	
211	Boulder Creek	Tapeats Sandstone	–112.010	36.027	06/03/1995	Fitzgerald, 1996	Stream	8.1	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
212	Bright Angel Creek near mouth		–112.087	36.101	06/18/1991	Taylor and others, 1996	Stream	0.6	Reported location river kilometer 141.5.
212	Bright Angel Creek near mouth		–112.087	36.101	06/18/1991	Taylor and others, 1996	Stream	0.6	Reported location river kilometer 141.5.
212	Bright Angel Creek near mouth		–112.087	36.101	06/18/1991	Taylor and others, 1996	Stream	0.5	Reported location river kilometer 141.5.
212	Bright Angel Creek near mouth		–112.087	36.101	06/19/1991	Taylor and others, 1996	Stream	0.6	Reported location river kilometer 141.5.
212	Bright Angel Creek near mouth		–112.087	36.101	06/19/1991	Taylor and others, 1996	Stream	0.6	Reported location river kilometer 141.5.
212	Bright Angel Creek near mouth		–112.087	36.101	06/19/1991	Taylor and others, 1996	Stream	0.6	Reported location river kilometer 141.5.
212	Bright Angel Creek near mouth		–112.087	36.101	06/19/1991	Taylor and others, 1996	Stream	0.5	Reported location river kilometer 141.5.
212	Bright Angel Creek near mouth		–112.087	36.101	06/20/1991	Taylor and others, 1996	Stream	0.5	Reported location river kilometer 141.5.
213	Burro Down		–112.100	36.077	06/04/2002	Liebe, 2003	Stream	4.4	Reported sample date June 4–6, 2002.
213	Burro Down		–112.100	36.077	06/24/2002	Liebe, 2003	Stream	4.3	Reported sample date June 24–26, 2002.
213	Burro Down		–112.100	36.077	07/15/2002	Liebe, 2003	Stream	3.8	Reported sample date July 15–18, 2002.
214	Burro Spring	Bright Angel Shale–Muav Limestone	–112.102	36.084	04/29/1994	Fitzgerald, 1996	Spring	3.4	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
215	Burro Up		–112.100	36.077	06/04/2002	Liebe, 2003	Spring	4.1	Reported sample date June 4–6, 2002.
215	Burro Up		–112.100	36.077	06/24/2002	Liebe, 2003	Spring	3.5	Reported sample date June 24–26, 2002.
215	Burro Up		–112.100	36.077	07/15/2002	Liebe, 2003	Spring	2.7	Reported sample date July 15–18, 2002.
215	Burro Up		–112.100	36.077	07/29/2002	Liebe, 2003	Spring	3.6	Reported sample date July 29–August 1, 2002.
216	Canyon Mine Well	Redwall-Muav aquifer	–112.095	35.886	12/18/1986	Errol Montgomery and Assoc., 1993a	Well	6.0	
216	Canyon Mine Well	Redwall-Muav aquifer	–112.095	35.886	04/30/1987	Errol Montgomery and Assoc., 1993a	Well	4.1	
216	Canyon Mine Well	Redwall-Muav aquifer	–112.095	35.886	09/10/1987	Errol Montgomery and Assoc., 1993a	Well	5.0	
216	Canyon Mine Well	Redwall-Muav aquifer	–112.095	35.886	12/01/1987	Errol Montgomery and Assoc., 1993a	Well	65.0	
216	Canyon Mine Well	Redwall-Muav aquifer	–112.095	35.886	12/01/1987	Errol Montgomery and Assoc., 1993a	Well	16.0	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
216	Canyon Mine Well	Redwall-Muav aquifer	–112.095	35.886	06/28/1988	Errol Montgomery and Assoc., 1993a	Well	10.0	
216	Canyon Mine Well	Redwall-Muav aquifer	–112.095	35.886	05/30/1989	Errol Montgomery and Assoc., 1993a	Well	309.0	
216	Canyon Mine Well	Redwall-Muav aquifer	–112.095	35.886	12/30/1989	Errol Montgomery and Assoc., 1993a	Well	16.0	
216	Canyon Mine Well	Redwall-Muav aquifer	–112.095	35.886	03/30/1990	Errol Montgomery and Assoc., 1993a	Well	13.0	
216	Canyon Mine Well	Redwall-Muav aquifer	–112.095	35.886	06/29/1990	Errol Montgomery and Assoc., 1993a	Well	13.0	
216	Canyon Mine Well	Redwall-Muav aquifer	–112.095	35.886	09/19/1990	Errol Montgomery and Assoc., 1993a	Well	11.5	
217	CDDC503R	Shale	–113.413	37.008	06/19/1980	USGS, 2009a	Spring	<0.002	Uranium value of 0.001 used for summary table statistics.
218	CDDD502R	--	–113.180	37.001	06/26/1980	USGS, 2009a	Well	4.0	
219	CDDE502R	Sandstone	–112.967	37.017	07/07/1980	USGS, 2009a	Well	0.3	
220	CDDF503R	--	–112.527	37.006	07/10/1980	USGS, 2009a	Well	0.3	
221	CDDG501R	--	–112.465	37.014	06/29/1980	USGS, 2009a	Well	1.3	
222	Cedar Spring	Tapeats Sandstone–Bright Angel Shale	–112.152	36.088	03/18/1995	Fitzgerald, 1996	Spring	18.0	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
223	CF-1	Vasey's Paradise, rm 31.9; Redwall Limestone	–111.858	36.499	04/29/1976	Peterson and others, 1977	Spring	0.5	
224	CF-10	Muav Limestone; rm 147.9	–112.672	36.346	05/07/1976	Peterson and others, 1977	Spring	6.4	
225	CF-11	Muav Limestone; rm 151.5	–112.725	36.346	05/07/1976	Peterson and others, 1977	Spring	8.5	
226	CF-14	Fern Glen Canyon; Muav Limestone; rm 168	–112.918	36.262	05/08/1976	Peterson and others, 1977	Spring	3.6	
227	CF-15	Lava Falls; Muav Limestone; rm 179.3	–113.084	36.194	05/09/1976	Peterson and others, 1977	Spring	3.5	
228	CF-16	Pumpkin Spring; Tapeats Sandstone; rm 212.9	–113.334	35.916	05/11/1976	Peterson and others, 1977	Spring	7.1	
229	CF-3	Redwall Limestone; rm 34.2	–111.846	36.477	04/29/1976	Peterson and others, 1977	Spring	0.5	
230	Colorado River above Diamond Creek		–113.370	35.770	11/05/1990	Taylor and others, 1996	Stream	4.3	Reported location river kilometer 363.1.
230	Colorado River above Diamond Creek		–113.370	35.770	11/05/1990	Taylor and others, 1996	Stream	4.4	Reported location river kilometer 363.1.
230	Colorado River above Diamond Creek		–113.370	35.770	11/05/1990	Taylor and others, 1996	Stream	4.4	Reported location river kilometer 363.1.
230	Colorado River above Diamond Creek		–113.370	35.770	11/05/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 363.1.
230	Colorado River above Diamond Creek		–113.370	35.770	11/06/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 363.1.
230	Colorado River above Diamond Creek		–113.370	35.770	11/06/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 363.1.
230	Colorado River above Diamond Creek		–113.370	35.770	11/06/1990	Taylor and others, 1996	Stream	4.4	Reported location river kilometer 363.1.
230	Colorado River above Diamond Creek		–113.370	35.770	11/06/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 363.1.
230	Colorado River above Diamond Creek		–113.370	35.770	06/18/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 363.1.

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
230	Colorado River above Diamond Creek		–113.370	35.770	06/18/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 363.1.
230	Colorado River above Diamond Creek		–113.370	35.770	06/18/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 363.1.
230	Colorado River above Diamond Creek		–113.370	35.770	06/19/1991	Taylor and others, 1996	Stream	5.5	Reported location river kilometer 363.1.
230	Colorado River above Diamond Creek		–113.370	35.770	06/19/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 363.1.
230	Colorado River above Diamond Creek		–113.370	35.770	06/19/1991	Taylor and others, 1996	Stream	5.5	Reported location river kilometer 363.1.
230	Colorado River above Diamond Creek		–113.370	35.770	06/19/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 363.1.
230	Colorado River above Diamond Creek		–113.370	35.770	06/20/1991	Taylor and others, 1996	Stream	5.8	Reported location river kilometer 363.1.
231	Colorado River above Havasu Creek		–112.760	36.317	11/05/1990	Taylor and others, 1996	Stream	4.4	Reported location river kilometer 252.1.
231	Colorado River above Havasu Creek		–112.760	36.317	11/05/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 252.1.
231	Colorado River above Havasu Creek		–112.760	36.317	11/05/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 252.1.
231	Colorado River above Havasu Creek		–112.760	36.317	11/06/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 252.1.
231	Colorado River above Havasu Creek		–112.760	36.317	11/06/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 252.1.
231	Colorado River above Havasu Creek		–112.760	36.317	11/06/1990	Taylor and others, 1996	Stream	4.4	Reported location river kilometer 252.1.
231	Colorado River above Havasu Creek		–112.760	36.317	11/06/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 252.1.
232	Colorado River above Kanab Creek		–112.615	36.392	11/05/1990	Taylor and others, 1996	Stream	4.7	Reported location river kilometer 230.5.
232	Colorado River above Kanab Creek		–112.615	36.392	11/05/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 230.5.
232	Colorado River above Kanab Creek		–112.615	36.392	11/05/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 230.5.
232	Colorado River above Kanab Creek		–112.615	36.392	11/05/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 230.5.
232	Colorado River above Kanab Creek		–112.615	36.392	11/06/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 230.5.
232	Colorado River above Kanab Creek		–112.615	36.392	11/06/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 230.5.
232	Colorado River above Kanab Creek		–112.615	36.392	11/06/1990	Taylor and others, 1996	Stream	4.4	Reported location river kilometer 230.5.
232	Colorado River above Kanab Creek		–112.615	36.392	11/06/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 230.5.
232	Colorado River above Kanab Creek		–112.615	36.392	06/18/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 230.5.

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
232	Colorado River above Kanab Creek		–112.615	36.392	06/18/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 230.5.
232	Colorado River above Kanab Creek		–112.615	36.392	06/18/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 230.5.
232	Colorado River above Kanab Creek		–112.615	36.392	06/19/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 230.5.
232	Colorado River above Kanab Creek		–112.615	36.392	06/19/1991	Taylor and others, 1996	Stream	5.5	Reported location river kilometer 230.5.
232	Colorado River above Kanab Creek		–112.615	36.392	06/19/1991	Taylor and others, 1996	Stream	5.6	Reported location river kilometer 230.5.
232	Colorado River above Kanab Creek		–112.615	36.392	06/19/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 230.5.
232	Colorado River above Kanab Creek		–112.615	36.392	06/20/1991	Taylor and others, 1996	Stream	5.5	Reported location river kilometer 230.5.
233	Colorado River above Little Colorado River		–111.800	36.202	11/05/1990	Taylor and others, 1996	Stream	4.7	Reported location river kilometer 98.3.
233	Colorado River above Little Colorado River		–111.800	36.202	11/05/1990	Taylor and others, 1996	Stream	4.2	Reported location river kilometer 98.3.
233	Colorado River above Little Colorado River		–111.800	36.202	11/05/1990	Taylor and others, 1996	Stream	4.4	Reported location river kilometer 98.3.
233	Colorado River above Little Colorado River		–111.800	36.202	11/05/1990	Taylor and others, 1996	Stream	4.3	Reported location river kilometer 98.3.
233	Colorado River above Little Colorado River		–111.800	36.202	11/06/1990	Taylor and others, 1996	Stream	4.2	Reported location river kilometer 98.3.
233	Colorado River above Little Colorado River		–111.800	36.202	11/06/1990	Taylor and others, 1996	Stream	4.3	Reported location river kilometer 98.3.
233	Colorado River above Little Colorado River		–111.800	36.202	11/06/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 98.3.
233	Colorado River above Little Colorado River		–111.800	36.202	11/06/1990	Taylor and others, 1996	Stream	4.4	Reported location river kilometer 98.3.
233	Colorado River above Little Colorado River		–111.800	36.202	06/18/1991	Taylor and others, 1996	Stream	5.2	Reported location river kilometer 98.3.
233	Colorado River above Little Colorado River		–111.800	36.202	06/18/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 98.3.
233	Colorado River above Little Colorado River		–111.800	36.202	06/18/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 98.3.
233	Colorado River above Little Colorado River		–111.800	36.202	06/19/1991	Taylor and others, 1996	Stream	5.2	Reported location river kilometer 98.3.
233	Colorado River above Little Colorado River		–111.800	36.202	06/19/1991	Taylor and others, 1996	Stream	5.5	Reported location river kilometer 98.3.
233	Colorado River above Little Colorado River		–111.800	36.202	06/19/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 98.3.
233	Colorado River above Little Colorado River		–111.800	36.202	06/19/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 98.3.
233	Colorado River above Little Colorado River		–111.800	36.202	06/20/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 98.3.

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
234	Colorado River at Grand Canyon		–112.082	36.101	11/05/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 141.
234	Colorado River at Grand Canyon		–112.082	36.101	11/05/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 141.
234	Colorado River at Grand Canyon		–112.082	36.101	11/05/1990	Taylor and others, 1996	Stream	4.7	Reported location river kilometer 141.
234	Colorado River at Grand Canyon		–112.082	36.101	11/06/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 141.
234	Colorado River at Grand Canyon		–112.082	36.101	11/06/1990	Taylor and others, 1996	Stream	4.3	Reported location river kilometer 141.
234	Colorado River at Grand Canyon		–112.082	36.101	11/06/1990	Taylor and others, 1996	Stream	5.8	Reported location river kilometer 141.
234	Colorado River at Grand Canyon		–112.082	36.101	06/18/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 141.
234	Colorado River at Grand Canyon		–112.082	36.101	06/18/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 141.
234	Colorado River at Grand Canyon		–112.082	36.101	06/18/1991	Taylor and others, 1996	Stream	5.2	Reported location river kilometer 141.
234	Colorado River at Grand Canyon		–112.082	36.101	06/19/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 141.
234	Colorado River at Grand Canyon		–112.082	36.101	06/19/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 141.
234	Colorado River at Grand Canyon		–112.082	36.101	06/19/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 141.
234	Colorado River at Grand Canyon		–112.082	36.101	06/19/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 141.
234	Colorado River at Grand Canyon		–112.082	36.101	06/20/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 141.
235	Colorado River at Lees Ferry		–111.588	36.865	11/05/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 0.
235	Colorado River at Lees Ferry		–111.588	36.865	11/05/1990	Taylor and others, 1996	Stream	4.4	Reported location river kilometer 0.
235	Colorado River at Lees Ferry		–111.588	36.865	11/05/1990	Taylor and others, 1996	Stream	4.3	Reported location river kilometer 0.
235	Colorado River at Lees Ferry		–111.588	36.865	11/05/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 0.
235	Colorado River at Lees Ferry		–111.588	36.865	11/06/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 0.
235	Colorado River at Lees Ferry		–111.588	36.865	11/06/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 0.
235	Colorado River at Lees Ferry		–111.588	36.865	11/06/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 0.
235	Colorado River at Lees Ferry		–111.588	36.865	11/06/1990	Taylor and others, 1996	Stream	4.7	Reported location river kilometer 0.
235	Colorado River at Lees Ferry		–111.588	36.865	06/18/1991	Taylor and others, 1996	Stream	5.2	Reported location river kilometer 0.

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
235	Colorado River at Lees Ferry		–111.588	36.865	06/18/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 0.
235	Colorado River at Lees Ferry		–111.588	36.865	06/18/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 0.
235	Colorado River at Lees Ferry		–111.588	36.865	06/19/1991	Taylor and others, 1996	Stream	5.5	Reported location river kilometer 0.
235	Colorado River at Lees Ferry		–111.588	36.865	06/19/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 0.
235	Colorado River at Lees Ferry		–111.588	36.865	06/19/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 0.
235	Colorado River at Lees Ferry		–111.588	36.865	06/19/1991	Taylor and others, 1996	Stream	5.2	Reported location river kilometer 0.
235	Colorado River at Lees Ferry		–111.588	36.865	06/20/1991	Taylor and others, 1996	Stream	5.2	Reported location river kilometer 0.
236	Colorado River at National Canyon		–112.888	36.261	11/05/1990	Taylor and others, 1996	Stream	4.7	Reported location river kilometer 268.1.
236	Colorado River at National Canyon		–112.888	36.261	11/05/1990	Taylor and others, 1996	Stream	4.4	Reported location river kilometer 268.1.
236	Colorado River at National Canyon		–112.888	36.261	11/05/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 268.1.
236	Colorado River at National Canyon		–112.888	36.261	11/06/1990	Taylor and others, 1996	Stream	4.4	Reported location river kilometer 268.1.
236	Colorado River at National Canyon		–112.888	36.261	11/06/1990	Taylor and others, 1996	Stream	4.3	Reported location river kilometer 268.1.
236	Colorado River at National Canyon		–112.888	36.261	11/06/1990	Taylor and others, 1996	Stream	4.3	Reported location river kilometer 268.1.
236	Colorado River at National Canyon		–112.888	36.261	06/18/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 268.1.
236	Colorado River at National Canyon		–112.888	36.261	06/18/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 268.1.
236	Colorado River at National Canyon		–112.888	36.261	06/18/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 268.1.
236	Colorado River at National Canyon		–112.888	36.261	06/19/1991	Taylor and others, 1996	Stream	5.5	Reported location river kilometer 268.1.
236	Colorado River at National Canyon		–112.888	36.261	06/19/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 268.1.
236	Colorado River at National Canyon		–112.888	36.261	06/19/1991	Taylor and others, 1996	Stream	5.5	Reported location river kilometer 268.1.
236	Colorado River at National Canyon		–112.888	36.261	06/19/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 268.1.
236	Colorado River at National Canyon		–112.888	36.261	06/20/1991	Taylor and others, 1996	Stream	5.8	Reported location river kilometer 268.1.
237	Colorado River at Page		–111.588	36.865	05/06/1963	USEPA, 1973	Stream	13.0	
237	Colorado River at Page		–111.588	36.865	06/01/1963	USEPA, 1973	Stream	11.0	
237	Colorado River at Page		–111.588	36.865	07/01/1963	USEPA, 1973	Stream	9.2	
237	Colorado River at Page		–111.588	36.865	08/01/1963	USEPA, 1973	Stream	7.4	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
237	Colorado River at Page		–111.588	36.865	09/01/1963	USEPA, 1973	Stream	7.1	
237	Colorado River at Page		–111.588	36.865	10/07/1963	USEPA, 1973	Stream	7.9	
237	Colorado River at Page		–111.588	36.865	11/04/1963	USEPA, 1973	Stream	8.6	
237	Colorado River at Page		–111.588	36.865	12/02/1963	USEPA, 1973	Stream	8.6	
237	Colorado River at Page		–111.588	36.865	01/01/1964	USEPA, 1973	Stream	8.4	
237	Colorado River at Page		–111.588	36.865	02/03/1964	USEPA, 1973	Stream	10.0	
237	Colorado River at Page		–111.588	36.865	03/02/1964	USEPA, 1973	Stream	7.5	
237	Colorado River at Page		–111.588	36.865	04/01/1964	USEPA, 1973	Stream	11.0	
237	Colorado River at Page		–111.588	36.865	05/04/1964	USEPA, 1973	Stream	9.1	
237	Colorado River at Page		–111.588	36.865	06/01/1964	USEPA, 1973	Stream	9.2	
237	Colorado River at Page		–111.588	36.865	07/06/1964	USEPA, 1973	Stream	11.0	
237	Colorado River at Page		–111.588	36.865	08/03/1964	USEPA, 1973	Stream	10.0	
237	Colorado River at Page		–111.588	36.865	09/14/1964	USEPA, 1973	Stream	6.9	
237	Colorado River at Page		–111.588	36.865	10/05/1964	USEPA, 1973	Stream	6.5	
237	Colorado River at Page		–111.588	36.865	11/02/1964	USEPA, 1973	Stream	7.8	
237	Colorado River at Page		–111.588	36.865	12/07/1964	USEPA, 1973	Stream	7.8	
237	Colorado River at Page		–111.588	36.865	01/04/1965	USEPA, 1973	Stream	9.4	
237	Colorado River at Page		–111.588	36.865	02/01/1965	USEPA, 1973	Stream	7.2	
237	Colorado River at Page		–111.588	36.865	03/08/1965	USEPA, 1973	Stream	7.6	
237	Colorado River at Page		–111.588	36.865	04/05/1965	USEPA, 1973	Stream	6.8	
237	Colorado River at Page		–111.588	36.865	05/03/1965	USEPA, 1973	Stream	7.5	
237	Colorado River at Page		–111.588	36.865	06/01/1965	USEPA, 1973	Stream	7.0	
237	Colorado River at Page		–111.588	36.865	07/05/1965	USEPA, 1973	Stream	3.6	
237	Colorado River at Page		–111.588	36.865	08/02/1965	USEPA, 1973	Stream	3.1	
237	Colorado River at Page		–111.588	36.865	09/20/1965	USEPA, 1973	Stream	2.8	
237	Colorado River at Page		–111.588	36.865	10/04/1965	USEPA, 1973	Stream	3.5	
237	Colorado River at Page		–111.588	36.865	11/01/1965	USEPA, 1973	Stream	3.2	
237	Colorado River at Page		–111.588	36.865	12/06/1965	USEPA, 1973	Stream	4.1	
237	Colorado River at Page		–111.588	36.865	01/03/1966	USEPA, 1973	Stream	4.9	
237	Colorado River at Page		–111.588	36.865	02/07/1966	USEPA, 1973	Stream	5.1	
237	Colorado River at Page		–111.588	36.865	03/07/1966	USEPA, 1973	Stream	5.2	
237	Colorado River at Page		–111.588	36.865	04/04/1966	USEPA, 1973	Stream	5.8	
237	Colorado River at Page		–111.588	36.865	05/02/1966	USEPA, 1973	Stream	3.7	
237	Colorado River at Page		–111.588	36.865	06/01/1966	USEPA, 1973	Stream	4.8	
237	Colorado River at Page		–111.588	36.865	07/01/1966	USEPA, 1973	Stream	3.9	
237	Colorado River at Page		–111.588	36.865	09/26/1966	USEPA, 1973	Stream	3.9	
237	Colorado River at Page		–111.588	36.865	10/06/1966	USEPA, 1973	Stream	3.7	
237	Colorado River at Page		–111.588	36.865	12/02/1966	USEPA, 1973	Stream	4.5	
237	Colorado River at Page		–111.588	36.865	01/13/1967	USEPA, 1973	Stream	5.2	
237	Colorado River at Page		–111.588	36.865	03/01/1967	USEPA, 1973	Stream	6.4	
237	Colorado River at Page		–111.588	36.865	06/01/1967	USEPA, 1973	Stream	5.1	
237	Colorado River at Page		–111.588	36.865	07/01/1967	USEPA, 1973	Stream	6.6	
237	Colorado River at Page		–111.588	36.865	08/01/1967	USEPA, 1973	Stream	6.9	
237	Colorado River at Page		–111.588	36.865	09/01/1967	USEPA, 1973	Stream	4.4	
237	Colorado River at Page		–111.588	36.865	10/01/1967	USEPA, 1973	Stream	5.5	
237	Colorado River at Page		–111.588	36.865	11/01/1967	USEPA, 1973	Stream	5.6	
237	Colorado River at Page		–111.588	36.865	12/01/1967	USEPA, 1973	Stream	5.6	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
237	Colorado River at Page		–111.588	36.865	01/01/1968	USEPA, 1973	Stream	6.8	
237	Colorado River at Page		–111.588	36.865	02/01/1968	USEPA, 1973	Stream	7.4	
237	Colorado River at Page		–111.588	36.865	03/01/1968	USEPA, 1973	Stream	7.4	
237	Colorado River at Page		–111.588	36.865	04/01/1968	USEPA, 1973	Stream	7.0	
237	Colorado River at Page		–111.588	36.865	04/29/1968	USEPA, 1973	Stream	7.9	
237	Colorado River at Page		–111.588	36.865	06/03/1968	USEPA, 1973	Stream	8.3	
237	Colorado River at Page		–111.588	36.865	07/01/1968	USEPA, 1973	Stream	6.1	
237	Colorado River at Page		–111.588	36.865	08/05/1968	USEPA, 1973	Stream	3.7	
237	Colorado River at Page		–111.588	36.865	09/03/1968	USEPA, 1973	Stream	5.6	
237	Colorado River at Page		–111.588	36.865	09/30/1968	USEPA, 1973	Stream	7.2	
237	Colorado River at Page		–111.588	36.865	11/04/1968	USEPA, 1973	Stream	6.8	
237	Colorado River at Page		–111.588	36.865	12/03/1968	USEPA, 1973	Stream	6.5	
237	Colorado River at Page		–111.588	36.865	01/06/1969	USEPA, 1973	Stream	6.6	
237	Colorado River at Page		–111.588	36.865	02/03/1969	USEPA, 1973	Stream	6.9	
237	Colorado River at Page		–111.588	36.865	03/03/1969	USEPA, 1973	Stream	8.1	
237	Colorado River at Page		–111.588	36.865	04/01/1969	USEPA, 1973	Stream	8.3	
237	Colorado River at Page		–111.588	36.865	05/05/1969	USEPA, 1973	Stream	7.7	
237	Colorado River at Page		–111.588	36.865	06/02/1969	USEPA, 1973	Stream	5.9	
237	Colorado River at Page		–111.588	36.865	07/07/1969	USEPA, 1973	Stream	6.7	
237	Colorado River at Page		–111.588	36.865	08/04/1969	USEPA, 1973	Stream	5.3	
237	Colorado River at Page		–111.588	36.865	09/01/1969	USEPA, 1973	Stream	5.1	
237	Colorado River at Page		–111.588	36.865	10/21/1969	USEPA, 1973	Stream	5.8	
237	Colorado River at Page		–111.588	36.865	11/20/1969	USEPA, 1973	Stream	5.5	
237	Colorado River at Page		–111.588	36.865	12/15/1969	USEPA, 1973	Stream	5.0	
237	Colorado River at Page		–111.588	36.865	01/20/1970	USEPA, 1973	Stream	6.1	
237	Colorado River at Page		–111.588	36.865	02/15/1970	USEPA, 1973	Stream	5.5	
237	Colorado River at Page		–111.588	36.865	03/18/1970	USEPA, 1973	Stream	7.8	
237	Colorado River at Page		–111.588	36.865	04/20/1970	USEPA, 1973	Stream	7.5	
237	Colorado River at Page		–111.588	36.865	05/19/1970	USEPA, 1973	Stream	5.9	
237	Colorado River at Page		–111.588	36.865	06/16/1970	USEPA, 1973	Stream	5.9	
237	Colorado River at Page		–111.588	36.865	07/17/1970	USEPA, 1973	Stream	6.6	
237	Colorado River at Page		–111.588	36.865	08/18/1970	USEPA, 1973	Stream	5.5	
237	Colorado River at Page		–111.588	36.865	09/29/1970	USEPA, 1973	Stream	8.9	
237	Colorado River at Page		–111.588	36.865	10/19/1970	USEPA, 1973	Stream	6.4	
237	Colorado River at Page		–111.588	36.865	11/16/1970	USEPA, 1973	Stream	4.4	
237	Colorado River at Page		–111.588	36.865	12/29/1970	USEPA, 1973	Stream	3.6	
237	Colorado River at Page		–111.588	36.865	01/11/1971	USEPA, 1973	Stream	4.1	
237	Colorado River at Page		–111.588	36.865	02/22/1971	USEPA, 1973	Stream	5.0	
237	Colorado River at Page		–111.588	36.865	03/15/1971	USEPA, 1973	Stream	5.1	
237	Colorado River at Page		–111.588	36.865	04/28/1971	USEPA, 1973	Stream	7.5	
237	Colorado River at Page		–111.588	36.865	05/21/1971	USEPA, 1973	Stream	5.2	
237	Colorado River at Page		–111.588	36.865	06/25/1971	USEPA, 1973	Stream	4.5	
237	Colorado River at Page		–111.588	36.865	07/30/1971	USEPA, 1973	Stream	3.9	
237	Colorado River at Page		–111.588	36.865	09/30/1971	USEPA, 1973	Stream	2.9	
237	Colorado River at Page		–111.588	36.865	12/27/1971	USEPA, 1973	Stream	2.6	
237	Colorado River at Page		–111.588	36.865	01/04/1972	USEPA, 1973	Stream	4.6	
237	Colorado River at Page		–111.588	36.865	03/20/1972	USEPA, 1973	Stream	6.4	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
237	Colorado River at Page		–111.588	36.865	04/20/1972	USEPA, 1973	Stream	5.9	
237	Colorado River at Page		–111.588	36.865	05/12/1972	USEPA, 1973	Stream	16.0	
238	Colorado River below Glen Canyon Dam		–111.506	36.902	11/05/1990	Taylor and others, 1996	Stream	4.4	Reported location river kilometer –20.
238	Colorado River below Glen Canyon Dam		–111.506	36.902	11/05/1990	Taylor and others, 1996	Stream	4.2	Reported location river kilometer –20.
238	Colorado River below Glen Canyon Dam		–111.506	36.902	11/05/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer –20.
238	Colorado River below Glen Canyon Dam		–111.506	36.902	11/05/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer –20.
238	Colorado River below Glen Canyon Dam		–111.506	36.902	11/06/1990	Taylor and others, 1996	Stream	4.7	Reported location river kilometer –20.
238	Colorado River below Glen Canyon Dam		–111.506	36.902	11/06/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer –20.
238	Colorado River below Glen Canyon Dam		–111.506	36.902	11/06/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer –20.
238	Colorado River below Glen Canyon Dam		–111.506	36.902	11/06/1990	Taylor and others, 1996	Stream	4.4	Reported location river kilometer –20.
238	Colorado River below Glen Canyon Dam		–111.506	36.902	06/18/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer –20.
238	Colorado River below Glen Canyon Dam		–111.506	36.902	06/18/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer –20.
238	Colorado River below Glen Canyon Dam		–111.506	36.902	06/18/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer –20.
238	Colorado River below Glen Canyon Dam		–111.506	36.902	06/19/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer –20.
238	Colorado River below Glen Canyon Dam		–111.506	36.902	06/19/1991	Taylor and others, 1996	Stream	5.0	Reported location river kilometer –20.
238	Colorado River below Glen Canyon Dam		–111.506	36.902	06/19/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer –20.
238	Colorado River below Glen Canyon Dam		–111.506	36.902	06/19/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer –20.
238	Colorado River below Glen Canyon Dam		–111.506	36.902	06/20/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer –20.
239	Colorado River near Columbine Falls		–113.894	36.082	11/05/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 439.2.
239	Colorado River near Columbine Falls		–113.894	36.082	11/05/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 439.2.
239	Colorado River near Columbine Falls		–113.894	36.082	11/05/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 439.2.
239	Colorado River near Columbine Falls		–113.894	36.082	11/05/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 439.2.
239	Colorado River near Columbine Falls		–113.894	36.082	11/06/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 439.2.
239	Colorado River near Columbine Falls		–113.894	36.082	11/06/1990	Taylor and others, 1996	Stream	4.4	Reported location river kilometer 439.2.

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
239	Colorado River near Columbine Falls		–113.894	36.082	11/06/1990	Taylor and others, 1996	Stream	4.7	Reported location river kilometer 439.2.
239	Colorado River near Columbine Falls		–113.894	36.082	11/06/1990	Taylor and others, 1996	Stream	4.7	Reported location river kilometer 439.2.
240	Colorado River near Travertine Cleft		–113.804	36.040	06/18/1991	Taylor and others, 1996	Stream	5.5	Reported location river kilometer 428.8.
240	Colorado River near Travertine Cleft		–113.804	36.040	06/18/1991	Taylor and others, 1996	Stream	5.6	Reported location river kilometer 428.8.
240	Colorado River near Travertine Cleft		–113.804	36.040	06/18/1991	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 428.8.
240	Colorado River near Travertine Cleft		–113.804	36.040	06/19/1991	Taylor and others, 1996	Stream	5.6	Reported location river kilometer 428.8.
240	Colorado River near Travertine Cleft		–113.804	36.040	06/19/1991	Taylor and others, 1996	Stream	4.8	Reported location river kilometer 428.8.
240	Colorado River near Travertine Cleft		–113.804	36.040	06/19/1991	Taylor and others, 1996	Stream	5.6	Reported location river kilometer 428.8.
240	Colorado River near Travertine Cleft		–113.804	36.040	06/19/1991	Taylor and others, 1996	Stream	5.5	Reported location river kilometer 428.8.
240	Colorado River near Travertine Cleft		–113.804	36.040	06/20/1991	Taylor and others, 1996	Stream	5.5	Reported location river kilometer 428.8.
241	Cottonwood Spring	Bright Angel Shale–Muav Limestone	–111.992	36.025	05/12/1995	Fitzgerald, 1996	Spring	2.1	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
242	Cottonwood West Spring	Tapeats Sandstone–Bright Angel Shale	–111.992	36.025	05/13/1995	Fitzgerald, 1996	Spring	5.7	No location reported, assigned location of Cottonwood Spring; uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
243	Cove Canyon	Muav Limestone	–113.015	36.246	05/19/1998	Taylor and others, 2004	Spring	11.0	Reported location UTM (318924,4012881).
244	Diamond Creek near mouth		–113.371	35.769	11/05/1990	Taylor and others, 1996	Stream	5.9	Reported location river kilometer 363.3.
244	Diamond Creek near mouth		–113.371	35.769	11/06/1990	Taylor and others, 1996	Stream	6.0	Reported location river kilometer 363.3.
244	Diamond Creek near mouth		–113.371	35.769	11/06/1990	Taylor and others, 1996	Stream	6.3	Reported location river kilometer 363.3.
244	Diamond Creek near mouth		–113.371	35.769	11/06/1990	Taylor and others, 1996	Stream	6.2	Reported location river kilometer 363.3.
244	Diamond Creek near mouth		–113.371	35.769	06/18/1991	Taylor and others, 1996	Stream	7.5	Reported location river kilometer 363.3.
244	Diamond Creek near mouth		–113.371	35.769	06/18/1991	Taylor and others, 1996	Stream	7.7	Reported location river kilometer 363.3.
244	Diamond Creek near mouth		–113.371	35.769	06/18/1991	Taylor and others, 1996	Stream	7.4	Reported location river kilometer 363.3.
244	Diamond Creek near mouth		–113.371	35.769	06/19/1991	Taylor and others, 1996	Stream	7.5	Reported location river kilometer 363.3.
244	Diamond Creek near mouth		–113.371	35.769	06/19/1991	Taylor and others, 1996	Stream	7.6	Reported location river kilometer 363.3.

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
244	Diamond Creek near mouth		–113.371	35.769	06/19/1991	Taylor and others, 1996	Stream	7.8	Reported location river kilometer 363.3.
244	Diamond Creek near mouth		–113.371	35.769	06/19/1991	Taylor and others, 1996	Stream	7.7	Reported location river kilometer 363.3.
244	Diamond Creek near mouth		–113.371	35.769	06/20/1991	Taylor and others, 1996	Stream	7.5	Reported location river kilometer 363.3.
245	Dripping Spring	Hermit Shale–Coconino Sandstone contact	–112.255	36.077	03/17/1995	Fitzgerald, 1996	Spring	2.4	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
246	Elves Chasm	Muav Limestone	–112.454	36.189	05/15/1998	Taylor and others, 2004	Spring	3.1	Reported location UTM (369234,4005685).
247	Fern Glen	Muav Limestone	–112.918	36.262	05/19/1998	Taylor and others, 2004	Spring	18.0	Reported location UTM (327710,4014470).
248	Four Mile Spring (Below Dam)		–111.507	36.875	03/02/1995	Taylor and others, 1997	Spring	1.0	
248	Four Mile Spring (Below Dam)		–111.507	36.875	05/01/1995	Taylor and others, 1997	Spring	0.9	
249	Frog Marsh Spring (Below Dam)		–111.557	36.846	03/02/1995	Taylor and others, 1997	Spring	0.6	
249	Frog Marsh Spring (Below Dam)		–111.557	36.846	05/01/1995	Taylor and others, 1997	Spring	0.6	
250	GCAA006R	Metamorphic	–113.901	36.765	05/06/1979	USGS, 2009a	Stream	87.0	
251	GCAA026R	--	–113.909	36.815	05/09/1979	USGS, 2009a	Stream	26.2	
252	GCAA501R	Carbonate	–113.891	36.763	05/06/1979	USGS, 2009a	Spring	17.7	
253	GCAA502R	Metamorphic	–113.852	36.772	05/06/1979	USGS, 2009a	Spring	3.9	
254	GCAA503R	Carbonate	–113.916	36.896	05/10/1979	USGS, 2009a	Spring	32.0	
255	GCAA504R	Volcanic rocks—Mafic	–113.798	36.770	05/06/1979	USGS, 2009a	Spring	0.0	
256	GCAA505R	Volcanic rocks—Mafic	–113.790	36.804	05/11/1979	USGS, 2009a	Spring	0.2	
257	GCAA506R	Carbonate	–113.931	36.907	05/08/1979	USGS, 2009a	Well	2.5	
258	GCAA507R	--	–113.988	36.777	05/08/1979	USGS, 2009a	Well	4.0	
259	GCAA508R	Carbonate	–113.983	36.973	05/10/1979	USGS, 2009a	Well	1.1	
260	GCAB501R	Carbonate	–113.670	36.835	05/08/1979	USGS, 2009a	Spring	0.1	
261	GCAB502R	Volcanic rocks—Mafic	–113.741	36.810	05/08/1979	USGS, 2009a	Spring	0.5	
262	GCAB503R	Sandstone	–113.589	36.767	05/09/1979	USGS, 2009a	Spring	0.9	
263	GCAB504R	--	–113.628	36.757	05/10/1979	USGS, 2009a	Spring	5.5	
264	GCAB505R	Volcanic rocks—Mafic	–113.724	36.776	05/10/1979	USGS, 2009a	Spring	1.6	
265	GCAB506R	Sandstone	–113.706	36.763	05/10/1979	USGS, 2009a	Spring	6.6	
266	GCAC501R	Sandstone	–113.356	36.946	05/06/1979	USGS, 2009a	Spring	22.2	
267	GCAC502R	--	–113.353	36.908	05/06/1979	USGS, 2009a	Well	15.6	
268	GCAC503R	--	–113.313	36.895	05/10/1979	USGS, 2009a	Spring	7.0	
269	GCAD501R	Sandstone	–113.012	36.946	05/06/1979	USGS, 2009a	Well	14.9	
270	GCAD502R	Sandstone	–113.150	36.960	05/06/1979	USGS, 2009a	Well	0.2	
271	GCAD503R	Sandstone	–113.056	36.948	05/07/1979	USGS, 2009a	Spring	1.2	
272	GCAD504R	Sandstone	–113.117	36.876	05/08/1979	USGS, 2009a	Well	3.6	
273	GCAD505R	Carbonate	–113.177	36.865	05/08/1979	USGS, 2009a	Well	31.7	
274	GCAD506R	Sandstone	–113.145	36.890	05/08/1979	USGS, 2009a	Well	6.5	
275	GCAD507R	Volcanic rocks—Mafic	–113.184	36.919	05/08/1979	USGS, 2009a	Well	25.7	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
276	GCAD508R	Carbonate	–113.249	36.940	05/08/1979	USGS, 2009a	Well	4.6	
277	GCAD509R	Carbonate	–113.225	36.866	05/08/1979	USGS, 2009a	Well	11.9	
278	GCAD510R	Carbonate	–113.173	36.810	05/09/1979	USGS, 2009a	Well	13.2	
279	GCAD511R	Sandstone	–113.125	36.797	05/09/1979	USGS, 2009a	Well	33.2	
280	GCAD512R	Sandstone	–113.136	36.756	05/10/1979	USGS, 2009a	Well	25.7	
281	GCAD513R		–113.124	36.931	05/10/1979	USGS, 2009a	Spring	16.7	
282	GCAD514R	--	–113.195	36.997	05/12/1979	USGS, 2009a	Well	1.0	
283	GCAE501R	Volcanic rocks—Mafic	–112.958	36.845	05/12/1979	USGS, 2009a	Well	0.1	
284	GCAE502R	--	–112.862	36.847	05/12/1979	USGS, 2009a	Well	0.3	
285	GCAE503R		–112.828	36.933	05/13/1979	USGS, 2009a	Spring	0.1	
286	GCAE504R	--	–112.864	36.998	05/13/1979	USGS, 2009a	Well	<0.002	Uranium value of 0.001 used for summary table statistics.
287	GCAE505R	Sandstone	–112.864	36.949	05/13/1979	USGS, 2009a	Well	<0.002	Uranium value of 0.001 used for summary table statistics.
288	GCAE506R	--	–112.893	36.949	05/13/1979	USGS, 2009a	Well	7.3	
289	GCAE507R	Carbonate	–112.963	36.938	05/13/1979	USGS, 2009a	Well	12.9	
290	GCAE508R	Sandstone	–112.762	36.909	05/14/1979	USGS, 2009a	Spring	0.4	
291	GCAE509R	Sandstone	–112.921	36.990	05/14/1979	USGS, 2009a	Spring	0.4	
292	GCAE510R	--	–112.978	36.872	05/14/1979	USGS, 2009a	Well	3.6	
293	GCAE511R	Carbonate	–112.847	36.782	05/15/1979	USGS, 2009a	Spring	1.6	
294	GCAE512R	Clastic rocks—Coarse	–112.829	36.817	05/15/1979	USGS, 2009a	Well	9.0	
295	GCAE513R	Clastic rocks—Coarse	–112.809	36.803	05/15/1979	USGS, 2009a	Well	1.9	
296	GCAE514R	--	–112.889	36.803	05/15/1979	USGS, 2009a	Well	2.4	
297	GCAE515R	Sandstone	–112.777	36.956	05/16/1979	USGS, 2009a	Spring	0.0	
298	GCAE516R	Sandstone	–112.783	36.995	05/16/1979	USGS, 2009a	Spring	0.0	
299	GCAE517R		–112.781	36.881	05/17/1979	USGS, 2009a	Spring	249.6	
300	GCAF501R	Sandstone	–112.535	36.998	05/14/1979	USGS, 2009a	Well	3.3	
301	GCAF502R	Clastic rocks—Coarse	–112.576	36.962	05/14/1979	USGS, 2009a	Spring	8.9	
302	GCAF503R	Sandstone	–112.689	36.984	05/16/1979	USGS, 2009a	Spring	1.3	
303	GCAF504R	Sandstone	–112.723	36.921	05/17/1979	USGS, 2009a	Spring	25.1	
304	GCAF505R	Sandstone	–112.625	36.948	05/17/1979	USGS, 2009a	Well	1.1	
305	GCAG501R	Shale	–112.324	36.990	05/14/1979	USGS, 2009a	Spring	47.3	
306	GCAH501R	Carbonate	–112.034	36.952	05/19/1979	USGS, 2009a	Spring	0.8	
307	GCAH502R	Sandstone	–112.055	36.823	05/18/1979	USGS, 2009a	Spring	5.1	
308	GCBA014R	Sandstone	–113.767	36.735	05/07/1979	USGS, 2009a	Stream	11.3	
309	GCBA501R	Sandstone	–113.902	36.663	05/05/1979	USGS, 2009a	Well	0.4	
310	GCBA502R	Sandstone	–113.949	36.608	05/06/1979	USGS, 2009a	Well	4.3	
311	GCBA503R	Sandstone	–113.783	36.653	05/09/1979	USGS, 2009a	Spring	0.2	
312	GCBA504R	--	–113.997	36.551	05/10/1979	USGS, 2009a	Spring	17.6	
313	GCBB004R	Carbonate	–113.738	36.729	05/12/1979	USGS, 2009a	Stream	89.0	
314	GCBB014R	Carbonate	–113.664	36.511	05/12/1979	USGS, 2009a	Stream	44.2	
315	GCBB501R	Sandstone	–113.736	36.669	05/12/1979	USGS, 2009a	Spring	1.4	
316	GCBB502R	Sandstone	–113.742	36.597	05/12/1979	USGS, 2009a	Spring	1.0	
317	GCBB503R	Sandstone	–113.715	36.524	05/12/1979	USGS, 2009a	Spring	0.9	
318	GCBD501R	--	–113.045	36.690	05/19/1979	USGS, 2009a	Well	86.0	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

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Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
319	GCBD502R	--	–113.069	36.724	05/19/1979	USGS, 2009a	Well	15.3	
320	GCBE501R	Sandstone	–112.943	36.728	05/13/1979	USGS, 2009a	Spring	31.4	
321	GCBG501R	Sandstone	–112.348	36.602	05/12/1979	USGS, 2009a	Spring	0.4	
322	GCBG502R	Sandstone	–112.346	36.625	05/14/1979	USGS, 2009a	Spring	1.0	
323	GCBG503R	Sandstone	–112.312	36.695	05/15/1979	USGS, 2009a	Spring	0.7	
324	GCBG504R	Sandstone	–112.342	36.586	05/16/1979	USGS, 2009a	Spring	0.6	
325	GCBH032R	Carbonate	–112.136	36.510	05/19/1979	USGS, 2009a	Stream	0.1	
326	GCBH501R	Sandstone	–112.045	36.586	05/19/1979	USGS, 2009a	Spring	0.8	
327	GCCA501R	Volcanic rocks—Mafic	–113.973	36.325	05/16/1979	USGS, 2009a	Spring	2.9	
328	GCCA502R	Carbonate	–113.850	36.485	05/16/1979	USGS, 2009a	Well	0.6	
329	GCCA503R	Volcanic rocks—Mafic	–113.889	36.423	05/16/1979	USGS, 2009a	Well	2.1	
330	GCCA504R	Clastic rocks—Coarse	–113.973	36.378	05/16/1979	USGS, 2009a	Spring	13.0	
331	GCCA505R	Volcanic rocks—Mafic	–113.953	36.388	05/15/1979	USGS, 2009a	Well	3.9	
332	GCCA506R	Volcanic rocks—Mafic	–113.957	36.416	05/15/1979	USGS, 2009a	Spring	1.7	
333	GCCB501R	Carbonate	–113.664	36.294	05/17/1979	USGS, 2009a	Spring	1.8	
334	GCCB502R	Sandstone	–113.687	36.300	05/17/1979	USGS, 2009a	Spring	1.9	
335	GCCC501R	Volcanic rocks—Mafic	–113.463	36.383	05/14/1979	USGS, 2009a	Spring	4.2	
336	GCCC502R	Carbonate	–113.479	36.267	05/17/1979	USGS, 2009a	Spring	13.6	
337	GCCC503R	Carbonate	–113.262	36.374	05/18/1979	USGS, 2009a	Spring	1.5	
338	GCCD501R	Volcanic rocks—Mafic	–113.152	36.392	05/15/1979	USGS, 2009a	Spring	0.1	
339	GCCD502R	Volcanic rocks—Mafic	–113.191	36.336	05/16/1979	USGS, 2009a	Spring	1.1	
340	GCCH501R	Carbonate	–112.247	36.463	10/24/1979	USGS, 2009a	Well	0.0	
341	GCDB501R	Volcanic rocks—Mafic	–113.536	36.151	05/18/1979	USGS, 2009a	Well	2.4	
342	GCDB502R	Carbonate	–113.512	36.190	05/20/1979	USGS, 2009a	Well	20.8	
343	GCDD501R	Sandstone	–113.067	36.126	05/27/1979	USGS, 2009a	Spring	1.0	
344	GCDE501R	--	–112.827	36.018	05/28/1979	USGS, 2009a	Well	7.1	
345	GCDG501R	--	–112.299	36.013	05/31/1979	USGS, 2009a	Well	0.6	
346	Grapevine East Spring	Bright Angel Shale	–112.023	36.049	05/13/1995	Fitzgerald, 1996	Spring	3.0	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
347	Grapevine Spring	Bright Angel Shale–Muav Limestone	–112.022	36.028	05/13/1995	Fitzgerald, 1996	Spring	2.2	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
348	Grapevine–Hell Spring	Bright Angel Shale	–112.022	36.028	05/13/1995	Fitzgerald, 1996	Spring	8.3	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
349	GW021W		–113.692	36.465	03/15/1981	Hopkins and others, 1984a	Spring	1.2	Date reported as March 1981 and March 1982.
350	GW022W		–113.691	36.479	03/15/1981	Hopkins and others, 1984a	Spring	1.1	Date reported as March 1981 and March 1982.
351	GW023W		–113.754	36.504	03/15/1981	Hopkins and others, 1984a	Spring	0.2	Date reported as March 1981 and March 1982.
352	GW024W		–113.710	36.499	03/15/1981	Hopkins and others, 1984a	Spring	1.2	Date reported as March 1981 and March 1982.
353	GW025W		–113.554	36.225	03/15/1981	Hopkins and others, 1984a	Spring	2.8	Date reported as March 1981 and March 1982.
354	GW026W		–113.559	36.231	03/15/1981	Hopkins and others, 1984a	Spring	4.8	Date reported as March 1981 and March 1982.

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

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Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
355	GW027W		–113.744	36.178	03/15/1981	Hopkins and others, 1984a	Spring	2.2	Date reported as March 1981 and March 1982.
356	GW028W		–113.688	36.300	03/15/1981	Hopkins and others, 1984a	Spring	2.4	Date reported as March 1981 and March 1982.
357	GW028WA		–113.488	36.145	03/15/1981	Hopkins and others, 1984a	Spring	0.2	Date reported as March 1981 and March 1982.
358	GW029W		–113.456	36.193	03/15/1981	Hopkins and others, 1984a	Spring	2.8	Date reported as March 1981 and March 1982.
359	GW030W		–113.441	36.201	03/15/1981	Hopkins and others, 1984a	Spring	1.9	Date reported as March 1981 and March 1982.
360	GW031W		–113.536	36.224	03/15/1981	Hopkins and others, 1984a	Spring	0.2	Date reported as March 1981 and March 1982.
361	GW032W		–113.501	36.247	03/15/1981	Hopkins and others, 1984a	Spring	2.6	Date reported as March 1981 and March 1982.
362	GW033W		–113.701	36.219	03/15/1981	Hopkins and others, 1984a	Spring	0.2	Date reported as March 1981 and March 1982.
363	GW034W		–113.480	36.267	03/15/1981	Hopkins and others, 1984a	Spring	5.8	Date reported as March 1981 and March 1982.
364	GW035W		–113.664	36.292	03/15/1981	Hopkins and others, 1984a	Spring	2.2	Date reported as March 1981 and March 1982.
365	GW036W		–113.739	36.191	03/15/1981	Hopkins and others, 1984a	Spring	0.4	Date reported as March 1981 and March 1982.
366	GW037W		–113.694	36.311	03/15/1981	Hopkins and others, 1984a	Spring	2.4	Date reported as March 1981 and March 1982.
367	GW038W		–113.701	36.502	03/15/1981	Hopkins and others, 1984a	Spring	0.5	Date reported as March 1981 and March 1982.
368	Hance Rapid Spring	Precambrian quartzite/schist	–111.923	36.054	05/13/1998	Taylor and others, 2004	Spring	4.8	Reported location UTM (416872,3990117).
369	Havasu Creek near mouth		–112.760	36.314	11/05/1990	Taylor and others, 1996	Stream	4.0	Reported location river kilometer 252.3.
369	Havasu Creek near mouth		–112.760	36.314	11/05/1990	Taylor and others, 1996	Stream	3.8	Reported location river kilometer 252.3.
369	Havasu Creek near mouth		–112.760	36.314	11/05/1990	Taylor and others, 1996	Stream	3.6	Reported location river kilometer 252.3.
369	Havasu Creek near mouth		–112.760	36.314	11/05/1990	Taylor and others, 1996	Stream	3.8	Reported location river kilometer 252.3.
369	Havasu Creek near mouth		–112.760	36.314	11/06/1990	Taylor and others, 1996	Stream	3.6	Reported location river kilometer 252.3.
369	Havasu Creek near mouth		–112.760	36.314	11/06/1990	Taylor and others, 1996	Stream	3.7	Reported location river kilometer 252.3.
369	Havasu Creek near mouth		–112.760	36.314	11/06/1990	Taylor and others, 1996	Stream	3.6	Reported location river kilometer 252.3.
369	Havasu Creek near mouth		–112.760	36.314	11/06/1990	Taylor and others, 1996	Stream	3.8	Reported location river kilometer 252.3.

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
369	Havasu Creek near mouth		–112.760	36.314	06/18/1991	Taylor and others, 1996	Stream	3.9	Reported location river kilometer 252.3.
369	Havasu Creek near mouth		–112.760	36.314	06/18/1991	Taylor and others, 1996	Stream	3.7	Reported location river kilometer 252.3.
369	Havasu Creek near mouth		–112.760	36.314	06/18/1991	Taylor and others, 1996	Stream	3.7	Reported location river kilometer 252.3.
369	Havasu Creek near mouth		–112.760	36.314	06/19/1991	Taylor and others, 1996	Stream	3.8	Reported location river kilometer 252.3.
369	Havasu Creek near mouth		–112.760	36.314	06/19/1991	Taylor and others, 1996	Stream	3.8	Reported location river kilometer 252.3.
369	Havasu Creek near mouth		–112.760	36.314	06/19/1991	Taylor and others, 1996	Stream	3.8	Reported location river kilometer 252.3.
369	Havasu Creek near mouth		–112.760	36.314	06/19/1991	Taylor and others, 1996	Stream	3.7	Reported location river kilometer 252.3.
369	Havasu Creek near mouth		–112.760	36.314	06/20/1991	Taylor and others, 1996	Stream	3.8	Reported location river kilometer 252.3.
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	05/16/1985	Errol Montgomery and Assoc., 1993b	Spring	10.0	
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	05/16/1985	Errol Montgomery and Assoc., 1993b	Spring	4.0	
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	12/18/1985	Errol Montgomery and Assoc., 1993b	Spring	10.0	
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	12/18/1985	Errol Montgomery and Assoc., 1993b	Spring	4.0	
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	06/03/1986	Errol Montgomery and Assoc., 1993b	Spring	5.0	
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	06/03/1986	Errol Montgomery and Assoc., 1993b	Spring	4.0	
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	12/08/1986	Errol Montgomery and Assoc., 1993b	Spring	4.0	
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	12/08/1986	Errol Montgomery and Assoc., 1993b	Spring	<1	Uranium value of 0.5 used for summary table statistics.
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	05/28/1987	Errol Montgomery and Assoc., 1993b	Spring	2.0	
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	05/28/1987	Errol Montgomery and Assoc., 1993b	Spring	4.0	
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	12/01/1987	Errol Montgomery and Assoc., 1993b	Spring	5.0	
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	12/01/1987	Errol Montgomery and Assoc., 1993b	Spring	4.0	
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	01/18/1989	Errol Montgomery and Assoc., 1993b	Spring	4.0	
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	01/18/1989	Errol Montgomery and Assoc., 1993b	Spring	4.0	
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	05/30/1989	Errol Montgomery and Assoc., 1993b	Spring	3.0	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	05/30/1989	Errol Montgomery and Assoc., 1993b	Spring	12.0	
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	05/29/1990	Errol Montgomery and Assoc., 1993b	Spring	7.0	
370	Havasu Spring	Redwall-Muav aquifer	–112.686	36.217	05/29/1990	Errol Montgomery and Assoc., 1993b	Spring	4.0	
371	Hawaii Spring	Muav Limestone	–112.218	36.075	03/18/1995	Fitzgerald, 1996	Spring	4.0	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	04/28/1988	Energy Fuels Nuclear, Inc., 1990b	Well	2.5	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	06/29/1988	Energy Fuels Nuclear, Inc., 1990b	Well	2.6	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	09/29/1988	Energy Fuels Nuclear, Inc., 1990b	Well	2.2	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	12/23/1988	Energy Fuels Nuclear, Inc., 1990b	Well	2.4	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	05/31/1989	Energy Fuels Nuclear, Inc., 1990b	Well	2.9	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	06/29/1989	Energy Fuels Nuclear, Inc., 1990c	Well	3.5	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	09/21/1989	Energy Fuels Nuclear, Inc., 1990c	Well	4.3	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	10/19/1989	Energy Fuels Nuclear, Inc., 1990c	Well	6.4	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	12/07/1989	Energy Fuels Nuclear, Inc., 1990c	Well	24.0	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	04/24/1990	International Uranium Corp., 1999	Well	1.6	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	10/24/1990	International Uranium Corp., 1999	Well	0.9	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	03/28/1991	International Uranium Corp., 1999	Well	2.7	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	09/20/1991	International Uranium Corp., 1999	Well	<0.3	Uranium value of 0.15 used for summary table statistics.
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	12/19/1991	International Uranium Corp., 1999	Well	1.9	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	03/26/1992	International Uranium Corp., 1999	Well	0.8	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	06/26/1992	International Uranium Corp., 1999	Well	0.4	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	09/22/1992	International Uranium Corp., 1999	Well	0.5	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	12/10/1992	International Uranium Corp., 1999	Well	0.5	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	03/03/1993	International Uranium Corp., 1999	Well	0.6	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	06/16/1993	International Uranium Corp., 1999	Well	2.2	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	03/03/1994	International Uranium Corp., 1999	Well	<0.3	Uranium value of 0.15 used for summary table statistics.
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	12/09/1994	International Uranium Corp., 1999	Well	1.9	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	06/21/1995	International Uranium Corp., 1999	Well	0.7	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	07/31/1996	International Uranium Corp., 1999	Well	1.1	
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	06/25/1998	International Uranium Corp., 1999	Well	<0.5	Uranium value of 0.25 used for summary table statistics.
372	Hermit Mine Monitoring Well	Redwall Limestone aquifer	–112.751	36.689	11/23/1998	International Uranium Corp., 1999	Well	1.0	
373	Hermit Mine Shaft		–112.751	36.689	08/23/1988	Energy Fuels Nuclear, 1995b	Shaft	42.0	No location reported, given lat/long of well Hermit Mine Monitor Well.
373	Hermit Mine Shaft		–112.751	36.689	12/23/1988	Energy Fuels Nuclear, 1995b	Shaft	20.7	No location reported, given lat/long of well Hermit Mine Monitor Well.
373	Hermit Mine Shaft		–112.751	36.689	05/31/1989	Energy Fuels Nuclear, 1995b	Shaft	24.5	No location reported, given lat/long of well Hermit Mine Monitor Well.
373	Hermit Mine Shaft		–112.751	36.689	06/27/1989	Energy Fuels Nuclear, 1995b	Shaft	25.0	No location reported, given lat/long of well Hermit Mine Monitor Well.
373	Hermit Mine Shaft		–112.751	36.689	09/21/1989	Energy Fuels Nuclear, 1995b	Shaft	25.0	No location reported, given lat/long of well Hermit Mine Monitor Well.
373	Hermit Mine Shaft		–112.751	36.689	12/08/1989	Energy Fuels Nuclear, 1995b	Shaft	32.0	No location reported, given lat/long of well Hermit Mine Monitor Well.
374	Hermit Mine Sump		–112.751	36.689	06/27/1989	Canonie Environmental Services Corp., 1991	Sump	3,310.0	No location reported, given lat/long of well Hermit Mine Monitor Well.
374	Hermit Mine Sump		–112.751	36.689	09/21/1989	Canonie Environmental Services Corp., 1991	Sump	18,400.0	No location reported, given lat/long of well Hermit Mine Monitor Well.
374	Hermit Mine Sump		–112.751	36.689	12/08/1989	Canonie Environmental Services Corp., 1991	Sump	36,600.0	No location reported, given lat/long of well Hermit Mine Monitor Well.
374	Hermit Mine Sump		–112.751	36.689	02/06/1990	Canonie Environmental Services Corp., 1991	Sump	4,290.0	No location reported, given lat/long of well Hermit Mine Monitor Well.
375	Horn Creek/Spring	Bright Angel Shale–Muav Limestone	–112.152	36.088	04/30/1994	Fitzgerald, 1996	Spring	18.9	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
375	Horn Creek/Spring	Bright Angel Shale–Muav Limestone	–112.152	36.088	03/19/1995	Fitzgerald, 1996	Spring	67.8	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
375	Horn Creek/Spring	Bright Angel Shale–Muav Limestone	–112.152	36.088	06/05/1995	Fitzgerald, 1996	Spring	21.5	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
376	Horn Down	Contact, Redwall-Muav Limestones	–112.145	36.078	06/04/2002	Liebe, 2003	Stream	295.0	Reported sample date June 4–6, 2002.
376	Horn Down	Contact, Redwall-Muav Limestones	–112.145	36.078	06/24/2002	Liebe, 2003	Stream	303.0	Reported sample date June 24–26, 2002.
376	Horn Down	Contact, Redwall-Muav Limestones	–112.145	36.078	07/15/2002	Liebe, 2003	Stream	322.0	Reported sample date July 15–18, 2002.
376	Horn Down	Contact, Redwall-Muav Limestones	–112.145	36.078	07/29/2002	Liebe, 2003	Stream	362.0	Reported sample date July 29–August 1, 2002.

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
377	Horn Up	Contact, Redwall-Muav Limestones	–112.145	36.078	06/04/2002	Liebe, 2003	Spring	333.0	Reported sample date June 4–6, 2002.
377	Horn Up	Contact, Redwall-Muav Limestones	–112.145	36.078	06/24/2002	Liebe, 2003	Spring	334.0	Reported sample date June 24–26, 2002.
377	Horn Up	Contact, Redwall-Muav Limestones	–112.145	36.078	07/15/2002	Liebe, 2003	Spring	400.0	Reported sample date July 15–18, 2002.
377	Horn Up	Contact, Redwall-Muav Limestones	–112.145	36.078	07/29/2002	Liebe, 2003	Spring	312.0	Reported sample date July 29–August 1, 2002.
378	Horn West	Contact, Redwall-Muav Limestones	–112.149	36.079	07/15/2002	Liebe, 2003	Spring	202.0	Reported sample date July 15–18, 2002.
378	Horn West	Contact, Redwall-Muav Limestones	–112.149	36.079	07/29/2002	Liebe, 2003	Spring	135.0	Reported sample date July 29–August 1, 2002.
379	Indian Garden CC		–112.111	36.093	07/15/2002	Liebe, 2003	Stream	1.6	Reported sample date July 15–18, 2002.
379	Indian Garden CC		–112.111	36.093	07/29/2002	Liebe, 2003	Stream	1.4	Reported sample date July 29–August 1, 2002.
380	Indian Garden Down	Contact, Redwall-Muav Limestones	–112.126	36.078	06/04/2002	Liebe, 2003	Stream	2.6	Reported sample date June 4–6, 2002.
380	Indian Garden Down	Contact, Redwall-Muav Limestones	–112.126	36.078	06/24/2002	Liebe, 2003	Stream	2.6	Reported sample date June 24–26, 2002.
380	Indian Garden Down	Contact, Redwall-Muav Limestones	–112.126	36.078	07/15/2002	Liebe, 2003	Stream	2.4	Reported sample date July 15–18, 2002.
380	Indian Garden Down	Contact, Redwall-Muav Limestones	–112.126	36.078	07/29/2002	Liebe, 2003	Stream	4.7	Reported sample date July 29–August 1, 2002.
381	Indian Garden Pump Station		–112.126	36.078	04/30/1994	Fitzgerald, 1996	Stream	0.5	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
382	Indian Garden Up	Contact, Redwall-Muav Limestones	–112.126	36.078	06/04/2002	Liebe, 2003	Stream	3.1	Reported sample date June 4–6, 2002.
382	Indian Garden Up	Contact, Redwall-Muav Limestones	–112.126	36.078	06/24/2002	Liebe, 2003	Stream	2.9	Reported sample date June 24–26, 2002.
382	Indian Garden Up	Contact, Redwall-Muav Limestones	–112.126	36.078	07/15/2002	Liebe, 2003	Stream	2.3	Reported sample date July 15–18, 2002.
383	Indian Gardens	Redwall-Muav aquifer	–112.127	36.079	05/17/1985	Errol Montgomery and Assoc., 1993b	Spring	4.0	
383	Indian Gardens	Redwall-Muav aquifer	–112.127	36.079	12/18/1985	Errol Montgomery and Assoc., 1993b	Spring	6.0	
383	Indian Gardens	Redwall-Muav aquifer	–112.127	36.079	06/03/1986	Errol Montgomery and Assoc., 1993b	Spring	4.0	
383	Indian Gardens	Redwall-Muav aquifer	–112.127	36.079	12/08/1986	Errol Montgomery and Assoc., 1993b	Spring	3.0	
384	KAN001W		–112.563	36.658	03/15/1982	Hopkins and others, 1984b	Stream	1.5	Date reported as March 1982.
385	KAN002W		–112.510	36.717	03/15/1982	Hopkins and others, 1984b	Stream	14.0	Date reported as March 1982.
386	KAN003W		–112.509	36.724	03/15/1982	Hopkins and others, 1984b	Stream	44.0	Date reported as March 1982.
387	KAN004W		–112.464	36.711	03/15/1982	Hopkins and others, 1984b	Stream	5.2	Date reported as March 1982.
388	KAN005W		–112.572	36.684	03/15/1982	Hopkins and others, 1984b	Stream	15.0	Date reported as March 1982.
389	KAN006W		–112.529	36.709	03/15/1982	Hopkins and others, 1984b	Stream	10.0	Date reported as March 1982.
390	Kanab Creek near mouth		–112.618	36.392	11/05/1990	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 230.7.
390	Kanab Creek near mouth		–112.618	36.392	11/05/1990	Taylor and others, 1996	Stream	5.4	Reported location river kilometer 230.7.
390	Kanab Creek near mouth		–112.618	36.392	11/05/1990	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 230.7.
390	Kanab Creek near mouth		–112.618	36.392	11/05/1990	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 230.7.
390	Kanab Creek near mouth		–112.618	36.392	11/06/1990	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 230.7.
390	Kanab Creek near mouth		–112.618	36.392	11/06/1990	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 230.7.
390	Kanab Creek near mouth		–112.618	36.392	11/06/1990	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 230.7.
390	Kanab Creek near mouth		–112.618	36.392	11/06/1990	Taylor and others, 1996	Stream	5.5	Reported location river kilometer 230.7.
390	Kanab Creek near mouth		–112.618	36.392	06/18/1991	Taylor and others, 1996	Stream	5.0	Reported location river kilometer 230.7.
390	Kanab Creek near mouth		–112.618	36.392	06/18/1991	Taylor and others, 1996	Stream	5.1	Reported location river kilometer 230.7.
390	Kanab Creek near mouth		–112.618	36.392	06/18/1991	Taylor and others, 1996	Stream	4.9	Reported location river kilometer 230.7.
390	Kanab Creek near mouth		–112.618	36.392	06/19/1991	Taylor and others, 1996	Stream	5.0	Reported location river kilometer 230.7.

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
390	Kanab Creek near mouth		–112.618	36.392	06/19/1991	Taylor and others, 1996	Stream	5.3	Reported location river kilometer 230.7.
390	Kanab Creek near mouth		–112.618	36.392	06/19/1991	Taylor and others, 1996	Stream	5.1	Reported location river kilometer 230.7.
390	Kanab Creek near mouth		–112.618	36.392	06/19/1991	Taylor and others, 1996	Stream	5.0	Reported location river kilometer 230.7.
390	Kanab Creek near mouth		–112.618	36.392	06/20/1991	Taylor and others, 1996	Stream	5.0	Reported location river kilometer 230.7.
391	Keyhole Spring	Muav Limestone	–112.582	36.380	05/11/1998	Taylor and others, 2004	Spring	1.7	Reported location utm (358063,4027010).
392	Little Colorado River near mouth		–111.800	36.201	11/05/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 98.5.
392	Little Colorado River near mouth		–111.800	36.201	11/05/1990	Taylor and others, 1996	Stream	4.2	Reported location river kilometer 98.5.
392	Little Colorado River near mouth		–111.800	36.201	11/05/1990	Taylor and others, 1996	Stream	4.2	Reported location river kilometer 98.5.
392	Little Colorado River near mouth		–111.800	36.201	11/05/1990	Taylor and others, 1996	Stream	5.2	Reported location river kilometer 98.5.
392	Little Colorado River near mouth		–111.800	36.201	11/06/1990	Taylor and others, 1996	Stream	25.6	Reported location river kilometer 98.5.
392	Little Colorado River near mouth		–111.800	36.201	11/06/1990	Taylor and others, 1996	Stream	24.3	Reported location river kilometer 98.5.
392	Little Colorado River near mouth		–111.800	36.201	11/06/1990	Taylor and others, 1996	Stream	20.2	Reported location river kilometer 98.5.
392	Little Colorado River near mouth		–111.800	36.201	11/06/1990	Taylor and others, 1996	Stream	18.7	Reported location river kilometer 98.5.
392	Little Colorado River near mouth		–111.800	36.201	06/18/1991	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 98.5.
392	Little Colorado River near mouth		–111.800	36.201	06/18/1991	Taylor and others, 1996	Stream	4.3	Reported location river kilometer 98.5.
392	Little Colorado River near mouth		–111.800	36.201	06/18/1991	Taylor and others, 1996	Stream	4.4	Reported location river kilometer 98.5.
392	Little Colorado River near mouth		–111.800	36.201	06/19/1991	Taylor and others, 1996	Stream	4.3	Reported location river kilometer 98.5.
392	Little Colorado River near mouth		–111.800	36.201	06/19/1991	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 98.5.
392	Little Colorado River near mouth		–111.800	36.201	06/19/1991	Taylor and others, 1996	Stream	4.2	Reported location river kilometer 98.5.
392	Little Colorado River near mouth		–111.800	36.201	06/19/1991	Taylor and others, 1996	Stream	4.3	Reported location river kilometer 98.5.
393	Lonetree Spring	Tapeats Sandstone–Bright Angel Shale	–112.054	36.074	06/03/1995	Fitzgerald, 1996	Spring	4.9	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
394	M.C.		–112.111	36.094	07/15/2002	Liebe, 2003	Stream	1.9	Reported sample date July 15–18, 2002.
394	M.C.		–112.111	36.094	07/29/2002	Liebe, 2003	Stream	2.4	Reported sample date July 29–August 1, 2002.
395	Marble Canyon Spring 1	Mississippian Leadville Limestone; rm 25.3	–111.794	36.576	09/19/1982	Office of Nuclear Waste Isolation, 1985	Spring	2.2	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90); location reported as “river mile 25.3”; date reported as Sept 19 to Oct 3, 1982.
396	Marble Canyon Spring 2	Mississippian Leadville Limestone; rm 30.5	–111.846	36.519	09/19/1982	Office of Nuclear Waste Isolation, 1985	Spring	2.4	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90); location reported as “river mile 30.5”; date reported as Sept 19 to Oct 3, 1982.

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
397	Marble Canyon Spring 3	Mississippian Leadville Limestone; rm 30.6	–111.846	36.518	09/19/1982	Office of Nuclear Waste Isolation, 1985	Spring	2.3	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90); location reported as “river mile 30.6”; date reported as Sept 19 to Oct 3, 1982.
398	Marble Canyon Spring 4	Mississippian Leadville Limestone; rm 30.8	–111.848	36.515	09/19/1982	Office of Nuclear Waste Isolation, 1985	Spring	2.0	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90); location reported as “river mile 30.8”; date reported as Sept 19 to Oct 3, 1982.
399	Marble Canyon Spring 5	Mississippian Leadville Limestone; rm 30.7	–111.847	36.517	09/19/1982	Office of Nuclear Waste Isolation, 1985	Spring	2.3	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90); location reported as “river mile 30.7”; date reported as Sept 19 to Oct 3, 1982.
400	Marble Canyon Spring 6	Mississippian Leadville Limestone; rm 30.7	–111.846	36.516	09/19/1982	Office of Nuclear Waste Isolation, 1985	Spring	2.5	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90); location reported as “river mile30.7”; date reported as Sept 19 to Oct 3, 1982.
401	Marble Canyon Spring 7	Mississippian Leadville Limestone; rm 35	–111.841	36.470	09/19/1982	Office of Nuclear Waste Isolation, 1985	Spring	1.4	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90); location reported as “river mile 35”; date reported as Sept 19 to Oct 3, 1982.
402	Marble Canyon Spring 9	Mississippian Leadville Limestone; rm 31.2	–111.851	36.510	09/19/1982	Office of Nuclear Waste Isolation, 1985	Spring	1.4	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90); location reported as “river mile 31.2”; date reported as Sept 19 to Oct 3, 1982.
403	MCAA501R	Sandstone	–111.971	36.926	05/20/1979	USGS, 2009a	Well	0.6	
404	MCBA501R	Sandstone	–111.898	36.727	05/19/1979	USGS, 2009a	Spring	2.4	
405	Mohawk Canyon	Muav Limestone	–112.967	36.225	05/19/1998	Taylor and others, 2004	Spring	18.0	Reported location UTM (323183,4010459).
406	Monument Creek/Spring	Tapeats Sandstone–Bright Angel Shale	–112.187	36.093	03/18/1995	Fitzgerald, 1996	Spring	11.1	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
407	Nankoweap Twin Spring	Precambrian quartzite/schist	–111.889	36.282	05/12/1998	Taylor and others, 2004	Spring	1.5	Reported location UTM (420166,4015360)
408	Page Spring	Muav Limestone–Bright Angel Shale	–111.977	36.027	05/12/1995	Fitzgerald, 1996	Spring	4.1	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
408	Page Spring	Muav Limestone–Bright Angel Shale	–111.977	36.027	09/09/1995	Fitzgerald, 1996	Spring	3.8	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
409	Paria River near mouth		–111.593	36.861	11/05/1990	Taylor and others, 1996	Stream	4.2	Reported location river kilometer 0.7.
409	Paria River near mouth		–111.593	36.861	11/05/1990	Taylor and others, 1996	Stream	4.1	Reported location river kilometer 0.7.
409	Paria River near mouth		–111.593	36.861	11/05/1990	Taylor and others, 1996	Stream	4.5	Reported location river kilometer 0.7.
409	Paria River near mouth		–111.593	36.861	11/05/1990	Taylor and others, 1996	Stream	4.7	Reported location river kilometer 0.7.
409	Paria River near mouth		–111.593	36.861	11/06/1990	Taylor and others, 1996	Stream	4.7	Reported location river kilometer 0.7.
409	Paria River near mouth		–111.593	36.861	11/06/1990	Taylor and others, 1996	Stream	4.3	Reported location river kilometer 0.7.
409	Paria River near mouth		–111.593	36.861	11/06/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 0.7.
409	Paria River near mouth		–111.593	36.861	11/06/1990	Taylor and others, 1996	Stream	4.6	Reported location river kilometer 0.7.

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
409	Paria River near mouth		–111.593	36.861	06/18/1991	Taylor and others, 1996	Stream	2.4	Reported location river kilometer 0.7.
409	Paria River near mouth		–111.593	36.861	06/18/1991	Taylor and others, 1996	Stream	2.3	Reported location river kilometer 0.7.
409	Paria River near mouth		–111.593	36.861	06/18/1991	Taylor and others, 1996	Stream	2.4	Reported location river kilometer 0.7.
409	Paria River near mouth		–111.593	36.861	06/19/1991	Taylor and others, 1996	Stream	2.4	Reported location river kilometer 0.7.
409	Paria River near mouth		–111.593	36.861	06/19/1991	Taylor and others, 1996	Stream	2.4	Reported location river kilometer 0.7.
409	Paria River near mouth		–111.593	36.861	06/19/1991	Taylor and others, 1996	Stream	2.5	Reported location river kilometer 0.7.
409	Paria River near mouth		–111.593	36.861	06/20/1991	Taylor and others, 1996	Stream	2.4	Reported location river kilometer 0.7.
410	Pigeon Mine Main Sump		–112.531	36.730	8/22/1986	Dames & Moore, 1987	Sump	170.0	No location reported, assigned location of Pigeon #4 well.
411	Pinenut Mine Monitor Well		–112.735	36.504	04/28/1988	Energy Fuels Nuclear, Inc., 1995a	Well	9.6	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	06/29/1988	Energy Fuels Nuclear, Inc., 1995a	Well	10.1	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	09/27/1988	Energy Fuels Nuclear, Inc., 1995a	Well	7.3	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	12/22/1988	Energy Fuels Nuclear, Inc., 1995a	Well	2.4	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	05/31/1989	Energy Fuels Nuclear, Inc., 1995a	Well	6.7	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	06/29/1989	Energy Fuels Nuclear, Inc., 1995a	Well	9.7	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	12/21/1989	Energy Fuels Nuclear, Inc., 1995a	Well	5.9	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	03/28/1990	Energy Fuels Nuclear, Inc., 1995a	Well	3.6	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	06/27/1990	Energy Fuels Nuclear, Inc., 1995a	Well	2.4	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	09/26/1990	Energy Fuels Nuclear, Inc., 1995a	Well	12.2	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	12/20/1990	Energy Fuels Nuclear, 1995a	Well	2.8	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	03/28/1991	Energy Fuels Nuclear, Inc., 1995a	Well	3.4	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	06/24/1991	Energy Fuels Nuclear, Inc., 1995a	Well	2.1	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	09/26/1991	Energy Fuels Nuclear, Inc., 1995a	Well	6.2	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	12/19/1991	Energy Fuels Nuclear, Inc., 1995a	Well	1.9	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	03/25/1992	Energy Fuels Nuclear, Inc., 1995a	Well	5.6	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	06/28/1992	Energy Fuels Nuclear, Inc., 1995a	Well	<0.5	No location reported, used location for well 55-513394; uranium value of 0.25 used for summary table statistics.
411	Pinenut Mine Monitor Well		–112.735	36.504	09/21/1992	Energy Fuels Nuclear, Inc., 1995a	Well	2.1	No location reported, used location for well 55-513394.

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

[µg/L, microgram per liter; rm, river mile; CC, crystalline core below Tonto platform; Map ID, Map ID used on figure 9; M.C., mixing at confluence of Garden Creek and unnamed spring; NAD 83, North American Datum of 1983; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, not available]

Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
411	Pinenut Mine Monitor Well		–112.735	36.504	12/10/1992	Energy Fuels Nuclear, Inc., 1995a	Well	<0.5	No location reported, used location for well 55-513394; uranium value of 0.25 used for summary table statistics.
411	Pinenut Mine Monitor Well		–112.735	36.504	03/03/1993	Energy Fuels Nuclear, Inc., 1995a	Well	<0.5	No location reported, used location for well 55-513394; uranium value of 0.25 used for summary table statistics.
411	Pinenut Mine Monitor Well		–112.735	36.504	06/30/1993	Energy Fuels Nuclear, Inc., 1995a	Well	0.7	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	12/16/1993	Energy Fuels Nuclear, Inc., 1995a	Well	<0.5	No location reported, used location for well 55-513394; uranium value of 0.25 used for summary table statistics.
411	Pinenut Mine Monitor Well		–112.735	36.504	03/11/1994	Energy Fuels Nuclear, Inc., 1995a	Well	0.3	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	06/19/1994	Energy Fuels Nuclear, Inc., 1995a	Well	0.7	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	08/26/1994	Energy Fuels Nuclear, Inc., 1995a	Well	0.5	No location reported, used location for well 55-513394.
411	Pinenut Mine Monitor Well		–112.735	36.504	10/26/1994	Energy Fuels Nuclear, Inc., 1995a	Well	1.3	No location reported, used location for well 55-513394.
412	Pinenut Mine Willow Springs		–112.735	36.504	12/21/1988	Energy Fuels Nuclear, Inc., 1990a	Spring	18.5	No location reported, given location of Pinenut Mine Well.
412	Pinenut Mine Willow Springs		–112.735	36.504	12/28/1989	Energy Fuels Nuclear, Inc., 1990a	Spring	19.0	No location reported, given location of Pinenut Mine Well.
413	Pipe CC		–112.102	36.085	07/15/2002	Liebe, 2003	Stream	19.0	Reported sample date July 15–18, 2002.
413	Pipe CC		–112.102	36.085	07/29/2002	Liebe, 2003	Stream	23.0	Reported sample date July 29–August 1, 2002.
414	Pipe Creek/Spring	Bright Angel Shale–Muav Limestone	–112.108	36.073	04/29/1994	Fitzgerald, 1996	Spring	3.1	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
414	Pipe Creek/Spring	Bright Angel Shale–Muav Limestone	–112.108	36.073	06/04/1995	Fitzgerald, 1996	Spring	3.5	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
415	Pipe Down	Muav Limestone	–112.102	36.072	06/04/2002	Liebe, 2003	Stream	3.6	Reported sample date June 4–6, 2002.
415	Pipe Down	Muav Limestone	–112.102	36.072	06/24/2002	Liebe, 2003	Stream	3.0	Reported sample date June 24–26, 2002.
415	Pipe Down	Muav Limestone	–112.102	36.072	07/15/2002	Liebe, 2003	Stream	2.7	Reported sample date July 15–18, 2002.
415	Pipe Down	Muav Limestone	–112.102	36.072	07/29/2002	Liebe, 2003	Stream	3.4	Reported sample date July 29–August 1, 2002.
416	Pipe Up	Muav Limestone	–112.102	36.072	06/04/2002	Liebe, 2003	Spring	3.3	Reported sample date June 4–6, 2002.
416	Pipe Up	Muav Limestone	–112.102	36.072	06/24/2002	Liebe, 2003	Spring	3.1	Reported sample date June 24–26, 2002.
416	Pipe Up	Muav Limestone	–112.102	36.072	07/15/2002	Liebe, 2003	Spring	3.2	Reported sample date July 15–18, 2002.
416	Pipe Up	Muav Limestone	–112.102	36.072	07/29/2002	Liebe, 2003	Spring	2.8	Reported sample date July 29–August 1, 2002.
417	Power Lines Spring (Below Dam)[a]		–111.492	36.927	10/20/1994	Taylor and others, 1997	Spring	1.1	
417	Power Lines Spring (Below Dam)[a]		–111.492	36.927	03/02/1995	Taylor and others, 1997	Spring	1.1	
417	Power Lines Spring (Below Dam)[a]		–111.492	36.927	05/01/1995	Taylor and others, 1997	Spring	1.1	

Appendix 4. Compilation of dissolved uranium data from springs, wells, surface water, and mine sumps and shafts in northern Arizona.—Continued

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Map ID	Sample or site identifier	Site description	Longitude (NAD 83)	Latitude (NAD 83)	Sample date	Data source	Sample source	Uranium (µg/L)	Comments
418	Pumpkin Spring	Tapeats Sandstone	–113.307	35.885	05/21/1998	Taylor and others, 2004	Spring	13.0	Reported location UTM (291744,3973467).
419	River Mile 125 Spring	Muav Limestone	–112.523	36.264	05/15/1998	Taylor and others, 2004	Spring	6.3	Reported location UTM (363175,4014068).
420	River Mile 147 Seep	Muav Limestone	–112.676	36.343	05/17/1998	Taylor and others, 2004	Spring	9.0	Reported location UTM (349600,4023102).
421	River Mile 213 Spring	Bright Angel Shale	–113.336	35.919	05/21/1998	Taylor and others, 2004	Spring	3.4	Reported location UTM (289236,3977233).
422	Saddle Canyon	Muav Limestone	–111.904	36.360	05/11/1998	Taylor and others, 2004	Spring	2.6	Reported location UTM (418855,4024029).
423	Salt Creek	Tapeats Sandstone–Bright Angel Shale	–112.170	36.087	03/19/1995	Fitzgerald, 1996	Stream	14.7	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
424	Sam Magee Spring	Bright Angel Shale–Muav Limestone	–112.075	36.087	06/03/1995	Fitzgerald, 1996	Spring	3.9	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
425	Santa Maria Spring	Esplanade Sandstone	–112.222	36.066	03/17/1995	Fitzgerald, 1996	Spring	7.2	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
426	Sewage Ponds Spring (Below Dam)[a]		–111.478	36.912	10/20/1994	Taylor and others, 1997	Spring	2.6	
426	Sewage Ponds Spring (Below Dam)[a]		–111.478	36.912	03/02/1995	Taylor and others, 1997	Spring	2.8	
426	Sewage Ponds Spring (Below Dam)[a]		–111.478	36.912	05/01/1995	Taylor and others, 1997	Spring	2.8	
427	Slimy Tick Spring	Muav Limestone	–112.754	36.326	05/18/1998	Taylor and others, 2004	Spring	18.0	Reported location UTM (342552,4021289).
428	Three Springs	Muav Limestone	–113.308	35.888	05/21/1998	Taylor and others, 2004	Spring	2.2	Reported location UTM (291641,3973840).
429	Two Trees Spring	Bright Angel Shale-Muav Limestone	–112.086	36.086	04/30/1994	Fitzgerald, 1996	Spring	3.2	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
429	Two Trees Spring	Bright Angel Shale-Muav Limestone	–112.086	36.086	06/05/1995	Fitzgerald, 1996	Spring	3.1	Uranium calculated as ((U-238 (pCi/L) + U-234 (pCi/L)) /0.90).
430	UCC	Tapeats Sandstone	–112.126	36.088	07/29/2002	Liebe, 2003	Spring	1.8	Reported sample date July 29–August 1, 2002.

[a]Site not plotted on figure 9.