UNITED STATES DEPARTMENT OF THE INTERIOR

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# Analytical results and sample locality map for 10 water samples from springs, domestic wells, and streams near the Baboquivari Peak, Ragged Top, and Table Top Mountain Wilderness Study Areas, Pima and Pinal Counties, Arizona

By

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

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# CONTENTS



## ILLUSTRATIONS



## TABLES

## STUDIES RELATED TO WILDERNESS

### Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine their mineral resource potential. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of analyses of water samples collected as part of geochemical surveys of the Baboquivari Peak, Ragged Top, and Table Top Mountain Wilderness Study Areas, Pima and Pinal Counties, Arizona.

## INTRODUCTION

In 1986 and 1987, the U.S. Geological Survey conducted reconnaissance geochemical surveys of the Baboquivari Peak (AZ-020-203B), Ragged Top (AZ-020-197), and Table Top Mountain (AZ-020-172) Wilderness Study Areas, Pima and Pinal Counties, Arizona. Routine sample media for the reconnaissance survey were minus-30-mesh (0.595-mm) stream-sediment samples and panned-concentrate samples derived from stream sediment. Results of analyses of the stream-sediment and concentrate samples are tabulated by Adrian and others (1987, 1988) for the Baboquivari Peak and Table Top Mountain Wilderness Study Areas and by McHugh and others (1988) for the Ragged Top Wilderness Study Area. A few water samples were also collected. Results from the analysis of water samples are presented in this report.

In addition to aiding in the mineral-resource evaluation of wilderness study areas, the water samples were collected to supplement studies of water geochemistry on and near the Tohono O'Odham (formerly Papago) Indian Reservation that were carried out from 1976 to 1979 (Ficklin and others, 1978, 1980; Nowlan and others, 1979). Included in this report are results for a sample collected in 1979 from a spring in a bench wall of the Sierrita porphyry copper mine; results from this sample have not been released previously and are of special interest because the spring issued from mineralized rock.

The Baboquivari Peak Wilderness Study Areas comprises 2,065 acres (about 3 $mi^2$) in the southcentral part of Pima County, Arizona, and lies about 50 mi southwest of Tucson, Arizona (see fig. 1). Access is provided on the east by state and private roads from Arizona Route 286, and on the west by Tohono O'Odham Indian Reservation roads from Arizona Route 86 (plate 1). The topographic relief is about 3,400 ft, with a maximum elevation of 7,734 ft at the summit of Baboquivari Peak, a dramatic granite monolith that rises 500-1,000 ft above surrounding ridges and peaks. The wilderness study area lies along the east side of the crest of the Baboquivari Mountains in an area of rugged canyons, spectacular walls, and jagged outcrops of bedrock. The vegetation is mostly that of the Upper Sonoran life zone. Arizona white oak and Mexican pinyon are the dominant types of vegetation. Streams are ephemeral but may have running water for several months at a time during winter and early spring. A number of springs and wells exist outside the wilderness study area within one-half mile of the boundary and at least one spring is within the wilderness study area in Sabino Canyon.

The Baboquivari Peak Wilderness Study Area is underlain by granitic, volcanic, and sedimentary rocks of Jurassic age. The Jurassic rocks are cut by numerous Tertiary rhyolite dikes that generally trend northwest and in some

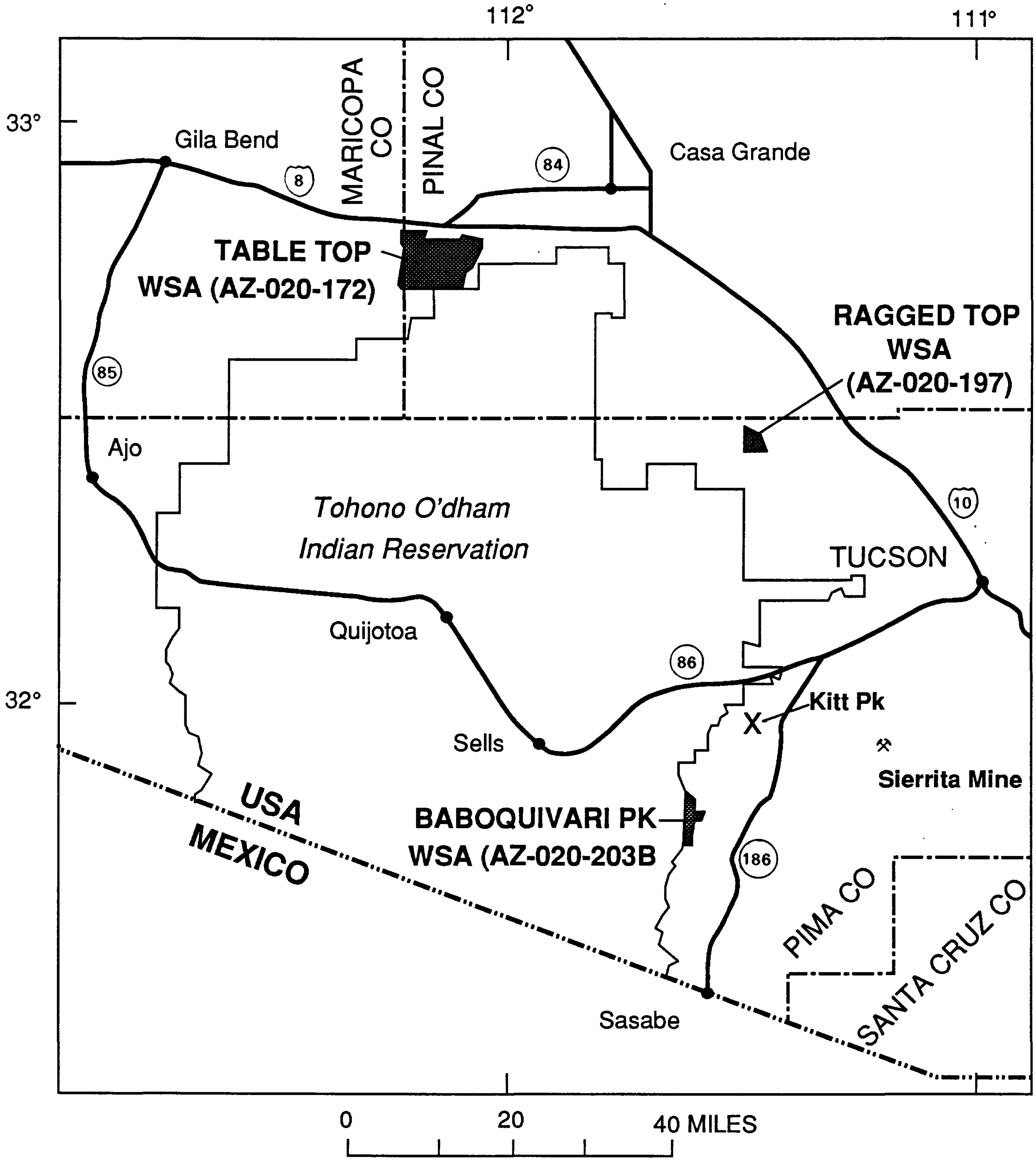


Figure 1. Index map showing location of the Baboquivari Peak, Ragged Top, and Table Top Mountain Wilderness Study Areas, Pima and Pinal Counties, Arizona.

cases were intruded along pre-existing faults. A reconnaissance geologic map of the Baboquivari Peak 15-minute quadrangle has been released by the U.S. Geological Survey (Haxel and others, 1980). The Baboquivari Peak Wilderness Study Area is within the Baboquivari mining district (Keith, 1974, p. 14-17) which covers the Baboquivari and Quinlan Mountains, an area that reaches about 33 mi from the Mexican border north to Arizona Route 86 (McDonnell, 1986a). Known mineral deposits within the district consist of scattered small occurrences of gold, silver, copper, lead, zinc, molybdenum, tungsten, manganese, fluorine, and beryllium. The deposits are closely associated with fault zones and swarms of intrusive dikes and sills (Keith, 1974). Keith (1969) indicates a copper occurrence in the Baboquivari Peak Wilderness Study Area. A gold-silver occurrence in the wilderness study area was reported by Cruver and others (1982) and by Stipp and others (1967). These are the only reported mineral occurrences within the wilderness study area. Mining took place for many years at the Allison mine (Keith, 1974), which is 3 mi west of the wilderness study area, and in the Jupiter Canyon region (Seaman, 1983), which is 1-2 mi south of the wilderness study area. Production figures for the nearby mining districts are listed by Keith and others (1983). Identified mineral resources are summarized by McDonnell (1986a) and mineral resource potential is discussed by Nowlan and others (in press).

The Ragged Top Wilderness Study Area comprises 4,460 acres (about 7 $mi^2$) in the north central part of Pima County, Arizona, and lies about 35 mi northwest of Tucson, Arizona (see fig. 1). Access is provided by the Silver Bell, Avra Valley, and Red Rock roads (plate 1). Topography of the study area is dominated by the rugged mass of Ragged Top Peak, elevation 3,907 ft, and a shorter subsidiary peak called Wolcott Peak which rise abruptly to a maximum of 1,700 ft above the surrounding bajada. The two peaks, which are collectively known as Ragged Top, are the northeastern peaks of the Silver Bell Mountains. Ragged Top is separated from the main mass of the Silver Bell Mountains by a mile-wide valley. Vegetation is characteristic of the Sonoran Desert. Common species include saguaro and other cacti, paloverde, acacia, ironwood, mesquite, and creosote bush. Springs are rare, but there are several wells nearby.

Geology of the Ragged Top Wilderness Study Area is included in reports by Sawyer (1986, 1987) and Spencer and Sawyer (1988). A major structural feature in the wilderness study area is the Ragged Top fault, a probable strike-slip fault that runs from near the southeast tip of the wilderness study area west-northwest across the wilderness study area. Precambrian granite predominates on the north side of the fault although Middle Proterozoic Apache Group sedimentary rocks crop out east of Ragged Top. Late Cretaceous volcanic rocks predominate south of the Ragged Top fault. The volcanic rocks consist of andesite-to-dacite extrusive flows and rhyolite tuffs. Late Cretaceous sedimentary rocks southwest of Ragged Top contain clasts of Precambrian schist, Paleozoic sedimentary rocks, probable Early Cretaceous sandstone, and Cretaceous volcanic rocks. An Early Cretaceous granodiorite porphyry laccolith underlies part of the southwestern section of the wilderness study area. Ragged Top is an Oligocene rhyolite dome that was extruded along the trace of the Ragged Top fault. Quaternary sediments that are mostly unconsolidated cover the flatter sections of the study area. Sawyer (1986, 1987) and Lipman and Sawyer (1985) present evidence to support the concept that the Late Cretaceous sedimentary rocks, the Late Cretaceous andesite-to-dacite extrusive rocks, and certain of the Late Cretaceous rhyolite tuffs are the results of the formation and later collapse of a caldera during Late Cretaceous time.

The southwest part of the Ragged Top Wilderness Study Area lies within the Silver Bell mining district (Richard and Courtright, 1966; Graybeal, 1982). The first recorded mining activity in the district was in 1865 about 2 miles south-southwest of the wilderness study area; silver and copper were recovered from skarn. Exploitation of porphyry copper deposits at the El Tiro and Oxide pits began in 1954 and continued until 1985. The El Tiro pit is about 2 miles southwest of the wilderness study area and the Oxide pit is about 3 miles south. A third, unexploited, porphyry copper deposit, the North Silver Bell deposit, lies about 1 mile from the southwest corner of the wilderness study area. Production from the El Tiro and Oxide deposits from 1954 to 1977 totaled 75,655,000 tons averaging 0.80 percent copper, 0.07 oz/ton silver, and 0.022 percent molybdenum sulfide (Graybeal, 1982). Copper has been the predominant commodity produced in the Silver Bell district, but two mines about 2 miles southwest of the wilderness study area produced about 150,000 tons of ore averaging 16 percent zinc, 1.3 percent copper, 0.6 oz/ton silver, and minor lead and gold (Keith, 1974). Total production of base and precious metals in the Silver Bell district from 1885 to 1981 amounted to 90,351,000 tons (Keith and others, 1983). Identified mineral resources of the wilderness study area are summarized by Kreidler (1987).

The Table Top Mountain Wilderness Study Area comprises 34,400 acres (about 60 $mi^2$) in the southwest corner of Pinal County and the southeast corner of Maricopa County, Arizona, and lies about 20 mi southwest of Casa Grande, Arizona (see fig. 1). Access to the wilderness study area is provided on the north by roads leading from the Hidden Valley interchange on Interstate 8 (plate 1), on the west by roads leading from the Vekol interchange on Interstate 8, and on the south and east by county roads (plate 1). The topographic relief in the wilderness study area is about 2,700 ft, with a maximum elevation of 4,373 ft at the summit of Table Top. The topography of most of the wilderness study area consists of deep, wide canyons and steeply rising, flat-topped mountains with ridges radiating from the mountains. Included within the wilderness study area are gently sloping bajadas that nearly surround the mountain range. On the west side, the bajada extends from the northern boundary to the southern boundary and is 1-2 miles wide from the base of the mountains to the western boundary of the wilderness study area. Vegetation over most of the area is typical of the Lower Sonoran life zone. Paloverde and saguaro, cholla, and prickly pear cacti are ubiquitous. Mesquite, ironwood, and acacia grow along the ephemeral streams. An undisturbed 40-acre desert grassland, unique for the vicinity, exists at the summit of Table Top. Natural springs are rare, and there are a few wells nearby.

Bedrock of the mountainous portions of the Table Top Mountain Wilderness Study Area is mainly Precambrian granite and schist (Dockter and Keith, 1978; Peterson and others, 1987). Some of the mountains and hills are capped by Tertiary basalts. Quaternary sediments in varying stages of consolidation blanket the bajadas. No mineral production is recorded from within the Table Top Mountain Wilderness Study Area (McDonnell, 1986b). Visible chrysocolla is found in quartz veins and fault zones in Precambrian schist in the west-central part of the wilderness study area (McDonnell, 1986b). Mineral resource potential of the wilderness study area is discussed by Peterson and others (1988).

The Sierrita porphyry copper mine is an open-pit operation located about 20 mi southwest of Tucson on the eastern bajada of the Sierrita Mountains at an elevation of about 4,000 ft. At the time of sample collection, the mine was owned and operated by the Duval Corporation. The sample was collected from a spring that was issuing from the wall of a bench that was undergoing active mining. The sample was collected during a field trip to the mine sponsored by the Society of Economic Geologists in April 1979. The spring is probably no longer in existence. Geology of the deposit is described by West and Aiken (1982). Mesozoic and Tertiary igneous rocks make up most of the bedrock at the Sierrita deposit. The sampled spring was issuing from Upper Cretaceous biotite-quartz diorite that was mineralized with molybdenite, chalcopyrite, and gypsum.

## SAMPLING TECHNIQUES

Samples were collected from 6 springs, 2 wells, and 2 streams (plate 1). Locations and other information are listed in table 1. The wells were sampled with a polyethylene bottle suspended on a cord and lowered into the well. Fifty ml of water from each source were filtered through a 0.45-micron membrane filter into an acid-rinsed polyethylene bottle and were then acidified to approximately pH 2 with ultrapure, concentrated nitric acid. In addition, a new 250-ml bottle was filled with untreated water.

## ANALYTICAL TECHNIQUES

Water temperature and pH were usually measured at the sample site. All other analyses were done in U.S. Geological Survey laboratories in Denver, Colorado. Alkalinity, sulfate, chloride, fluoride, nitrate, uranium, and specific conductance were determined using the untreated sample. Alkalinity is a term used to indicate the total acid-neutralizable constituents in water. Generally the alkalinity is due to carbonate and bicarbonate ions. Calcium, magnesium, sodium, potassium, strontium, lithium, silica (usually), iron, manganese, aluminum, arsenic, barium, bismuth, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, rubidium, silver, and zinc were determined using the acidified-filtered sample. A complete list of analytical techniques used and a reference for each are listed in table 2. Analysts were J. B. McHugh, W. H. Ficklin, D. J. Preston, and A. R. Stanley.

## RESULTS

Sample localities for the 10 samples are shown on plate 1. The analytical results are shown in table 3. The latitude and longitude for each sample locality are also shown in table 3.

The results of the charge balance shown in table 3 for the samples show good accuracy for the analyses. Ionic solutions are electrically neutral. By comparing the sums of the charges for cations against anions, accuracy of analyses can be checked. All of the samples are within 9 percent of electrical neutrality.

## DATA STORAGE SYSTEM

Upon completion of the analytical work, the results were entered into a U.S. Geological Survey computer data base called RASS. This data base contains both descriptive geological information and analytical data. Any or all of this information may be retrieved and converted to a binary form (STATPAC, VanTrump and Miesch, 1977) for computerized statistical analysis or publication.

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TABLE 1.--Locations, names, collection dates, and other information for 10 spring-, well-, and stream-water samples from near the Baboquivari Peak, Ragged Top, and Table Top Mountain Wilderness Study Areas, Pima and Pinal Counties, Arizona

| Sample | Location | | | | | Name or description | Date of sample collection | Remarks |
|---|---|---|---|---|---|---|---|---|
| | Township | Range | Section | Quarter Section | Quadrangle | | | |
| W2227A | 18 S | 12 E | 7 | SE | Twin Buttes[a] | Spring in Sierrita porphyry copper mine | 4-5-79 | Bedrock is biotite quartz diorite mineralized with molybdenite, chalcopyrite, and gypsum. |
| W2269A | 8 S | 3 E | 5 | SW | Indian Butte[b] | Spring | 3-7-86 | No metal observed in contact with spring. |
| W2270A | 8 S | 3 E | 18 | NE | Vekol Mts., NE[b] | Spring | 3-9-86 | Aluminum can in spring. |
| W2352A | 18 S | 7 E | 36 | SE | Baboquivari Peak[b] | Spring | 3-16-87 | No metal. |
| W2353A | 19 S | 8 E | 6 | NW | Baboquivari Peak[b] | Stream | 3-16-87 | No metal. |
| W2354A | 11 S | 8 E | 22 | NE | Vaca Hills[a] | Well | 3-17-87 | No metal observed in well. Water level 6 ft below ground level. |
| W2355A | 11 S | 8 E | 34 | SW | Vaca Hills[a] | Tin House Well | 3-17-87 | Galvanized pipe in well. Water level 20 ft below ground level. |
| W2356A | 19 S | 7 E | 24 | SE | Baboquivari Peak[b] | Broken Trough Spring | 3-24-87 | Sampled open metal storage tank; tank not galvanized. |
| W2357A | 19 S | 7 E | 24 | SW | Baboquivari Peak[b] | Max Seep | 3-24-87 | No metal. |
| W2358A | 19 S | 7 E | 25 | NW | Baboquivari Peak[b] | Stream | 3-24-87 | No metal. |

[a]Scale 1:62,500
[b]Scale 1:24,000

TABLE 2.--Analytical methods used for water analyses, Baboquivari Peak, Ragged Top, and Table Top Mountain Wilderness Study Areas, Pima and Pinal Counties, Arizona

| Samples* | Constituents | Method | Reference |
|---|---|---|---|
| All | Alkalinity | Gran's plot potentiometric titration | Orion Research, Inc. 1978. |
| All | Sulfate, chloride, fluoride, and nitrate | Ion chromatography | Fishman and Pyen, 1979. |
| All | Uranium | Laser-excited fluorescence | Scintrex Corp., 1979. |
| All | Specific conductance | Conductivity bridge | Skougstad and others, 1979, p. 545. |
| All | Calcium, magnesium, sodium, potassium, strontium and lithium | Flame atomic-absorption spectrophotometry | Perkin-Elmer Corp., 1976. |
| W2227A | Silica | Molybdate blue | Brown and others, 1970, p. 138-140. |
| All except W2227A | Silica | Flame atomic-absorption spectrophotometry | Perkin-Elmer Corp., 1976. |
| W2227A | Zinc | Flameless atomic-absorption spectrophotometry | Perkin-Elmer Corp., 1977. |
| All except W2227A | Zinc | Flame atomic-absorption spectrophotometry | Perkin-Elmer Corp., 1976. |
| W2227A W2269A W2270A | Iron and manganese | Flameless atomic-absorption spectrophotometry | Perkin-Elmer Corp., 1977. |
| W2352A to W2358A | Iron and manganese | Flame atomic-absorption spectrophotometry | Perkin-Elmer Corp., 1976. |
| All | Aluminum, silver, arsenic, barium, bismuth, cadmium, cobalt, chromium, copper, molybdenum, nickel, lead, and rubidium | Flameless atomic-absorption spectrophotometry | Perkin-Elmer Corp., 1977. |

*Some samples were not analyzed for certain constituents. See Table 3.

TABLE 3.--Results of analyses of water samples from the Baboquivari Peak, Ragged Top, and Table Top Mountain Wilderness Study Areas, Pima and Pinal Counties, Arizona

[<, less than value shown: ---, not analyzed. Alk, alkalinity; Cond, specific conductance; Temp, temperature in degrees Celsius; Chg bal, charge balance in percent]

| Sample | Latitude | Longitude | Ca mg/L | Mg mg/L | Na mg/L | K mg/L | Sr mg/L | $SiO_2$ mg/L | Alk mg/L | $SO_4$ mg/L | Cl mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W2227A | 31 52 17 | 111 8 59 | 595 | 55.3 | 284.0 | 5.30 | --- | 8 | 49.3 | 1,830 | 114.0 |
| W2269A | 32 45 33 | 112 4 41 | 39 | 32.0 | 225.0 | 6.10 | .9 | 34 | 556.0 | 55 | 127.0 |
| W2270A | 32 44 16 | 112 5 3 | 27 | 4.4 | 4.9 | 1.40 | .2 | 8 | 111.0 | 2 | 1.7 |
| W2352A | 31 48 51 | 111 34 23 | 35 | 6.0 | 21.0 | .68 | --- | 17 | 135.0 | 54 | 7.3 |
| W2353A | 31 48 33 | 111 34 5 | 64 | 7.1 | 12.0 | .37 | --- | 19 | 239.0 | 30 | 5.0 |
| W2354A | 32 27 42 | 111 30 43 | 170 | 39.0 | 270.0 | 4.70 | --- | 21 | 207.0 | 899 | 133.0 |
| W2355A | 32 25 42 | 111 31 2 | 380 | 52.0 | 170.0 | 10.00 | --- | 56 | 321.0 | 1,190 | 205.0 |
| W2356A | 31 45 38 | 111 34 53 | 50 | 6.8 | 22.0 | .60 | --- | 22 | 219.0 | 41 | 12.0 |
| W2357A | 31 45 24 | 111 35 6 | 39 | 6.2 | 20.0 | .91 | --- | 19 | 203.0 | 11 | 8.3 |
| W2358A | 31 45 2 | 111 34 58 | 58 | 11.0 | 25.0 | .51 | --- | 24 | 270.0 | 41 | 14.0 |

| Sample | F mg/L | $NO_3$ mg/L | Al ug/L | Fe ug/L | Mn ug/L | Ag ug/L | As ug/L | Ba ug/L | Bi ug/L | Cd ug/L | Co ug/L |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W2227A | 2.98 | 170.0 | --- | 7.3 | 100 | --- | 6.3 | --- | --- | --- | --- |
| W2269A | 2.90 | 1.0 | 58 | 13.0 | 10 | .03 | 2.7 | 53 | <1 | .3 | 1.0 |
| W2270A | .80 | .2 | 21 | 38.0 | 200 | <.02 | 1.8 | 41 | <1 | .5 | 1.5 |
| W2352A | .31 | .1 | --- | <10.0 | <10 | --- | <1.0 | --- | --- | --- | <1.0 |
| W2353A | .20 | <.1 | --- | <10.0 | <10 | --- | <1.0 | --- | --- | --- | 1.0 |
| W2354A | 1.10 | <.1 | --- | <10.0 | 350 | --- | 3.0 | --- | --- | --- | 2.6 |
| W2355A | 1.60 | 2.5 | --- | <10.0 | 20 | --- | 4.0 | --- | --- | --- | 2.5 |
| W2356A | .20 | <.1 | --- | <10.0 | <10 | --- | <1.0 | --- | --- | --- | 1.2 |
| W2357A | .14 | <.1 | --- | <10.0 | <10 | --- | 1.0 | --- | --- | --- | 1.0 |
| W2358A | .32 | <.1 | --- | <10.0 | <10 | --- | 1.0 | --- | --- | --- | 1.8 |

| Sample | Cr ug/L | Cu ug/L | Li ug/l | Mo ug/L | Ni ug/L | Pb ug/L | Rb ug/L | U ug/L | Zn ug/L | Cond uS | pH | Temp | Chg bal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W2227A | --- | 68.0 | 100 | 480.0 | --- | --- | --- | --- | 65 | 3,400 | 7.96 | --- | 1.9 |
| W2269A | 1 | 3.0 | 290 | 10.0 | <1 | 1.6 | .4 | 105.00 | 170 | 1,240 | 8.40 | 17.0 | 1.9 |
| W2270A | 1 | 2.5 | 16 | 3.7 | <1 | .5 | <.1 | 5.90 | 19 | 200 | 7.80 | 17.0 | .3 |
| W2352A | --- | 1.7 | --- | 2.0 | <1 | --- | --- | .54 | 50 | 330 | 7.70 | 12.0 | -5.7 |
| W2353A | --- | 1.3 | --- | 2.1 | <1 | --- | --- | 1.90 | 25 | 400 | 8.30 | 10.0 | -4.2 |
| W2354A | --- | 2.0 | --- | 2.6 | 1 | --- | --- | 2.20 | 94 | 1,850 | 7.30 | 20.0 | -4.7 |
| W2355A | --- | 4.4 | --- | 7.5 | 1 | --- | --- | 22.00 | 270 | 2,300 | 7.70 | 18.0 | -7.4 |
| W2356A | --- | <1.0 | --- | 1.5 | <1 | --- | --- | 2.00 | 30 | 420 | 8.20 | 11.5 | -8.6 |
| W2357A | --- | 1.0 | --- | 1.0 | <1 | --- | --- | 4.20 | 16 | 350 | 7.90 | 10.0 | -6.2 |
| W2358A | --- | <1.0 | --- | 1.5 | <1 | --- | --- | 7.20 | 20 | 500 | 7.30 | 13.5 | -7.3 |