UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

A HYDROGEOCHEMICAL SURVEY USING GOLD IN WATER, NORTHERN NEVADA

By

J.B. McHugh* and W.R. Miller*

Open-File Report 92-303

*U.S. Geological Survey, Federal Center, Box 25046, MS 973, Denver, CO 80225

1992

CONTENTS

Page

Introduction 1

Sample collection and analytical methods 1

Results and conclusions 2

References cited 2

ILLUSTRATIONS

Figure 1. Sample locality map 4

Figure 2. Sample locality map 5

Figure 3. Sample locality map 6

TABLES

Table 1. Sample sources, northern Nevada 7

Table 3. Analytical methods used for water analyses, northern Nevada 8

APPENDIX

Appendix A. Analytical results for 28 water samples from northern Nevada 9

INTRODUCTION

An extremely sensitive analytical method for determining gold in water was developed by the U.S. Geological Survey (McHugh, 1986). Gold in water could be determined down to 0.001 µg/L (one part per trillion). A limited study was initiated by the USGS to collect water samples throughout the Western U.S. in order to determine range and background of gold concentrations in the natural waters of these areas.

In addition, the 1984 discovery by AMAX of the Sleeper high grade gold deposit in basin sediments in northern Nevada led to considerable interest in exploration in basins. The ground waters of an area were a logical media to test for the geochemical exploration of gold deposits under shallow basin fill. Therefore a supplemental study was initiated to test the use of gold in water as a technique to explore for concealed gold deposits, particularly in basins in Nevada. The use of water as a media for geochemical exploration, particularly for concealed deposits, has increased in recent times. Summary papers on hydrogeochemical exploration include Boyle and others, 1971; Cameron, 1978; Dyck, 1979; Ficklin and others, 1991; Grimes and others, 1991; and Miller, 1979.

Several areas in northern Nevada were selected for the collection of water samples. These areas contain or are near or along trends of known gold deposits and include the Carlin trend, the Bilt Creek Mountains northwest of the Sleeper deposit, and the Shoshone Mountains.

Samples of water were collected from 21 springs, six wells, and one pond fed by a small unbranched stream (table 1).

SAMPLE COLLECTION AND ANALYTICAL METHODS

Twenty-eight water samples were collected in July of 1987 from wells and springs (table 1). At each site, a 60-mL sample was collected and filtered through a 0.45-µm membrane filter into an acid-rinsed polyethylene bottle and then acidified with reagent grade concentrated nitric acid to a pH of less than 2. A 500-mL and 1000-mL untreated sample was also collected in a clean polyethylene bottle.

Temperature of the water and pH were measured at each site. All other analyses were determined at the U.S. Geological Survey laboratory in Denver, Colorado.

Calcium, magnesium, sodium, potassium, lithium, silica, arsenic, copper, molybdenum, silver, zinc, iron, manganese, and aluminum were determined using the filtered-acidified sample. Alkalinity, sulfate, chloride, fluoride, nitrate, uranium, and specific conductance were determined using the untreated sample. Alkalinity measures the total acid-neutralizable constituents in water and is generally due to the presence of carbonate and bicarbonate ions. Gold was determined using the 1000-mL untreated sample. A complete list of analytical methods used and a reference for each are listed in table 2.

RESULTS AND CONCLUSIONS

The analytical results of the 23 constituents that were determined for these samples are shown in appendix A along with the latitude and longitude for each sample location. The charge balances were also calculated for each sample and are shown in the last column of appendix A. Because ionic solutions are electrically neutral, comparing the sums of the charges for cations against anions checks the accuracy of the analyses. Sample locality maps are shown in figures 1 through 3.

The concentration of gold in water ranged from <0.001 µg/L to 0.011 µg/L. The medium value (18 out of 28 samples) is <0.001 µg/L. The medium value indicates that the solubility of gold is very minimal at these sample sites. Two sites (NV09 and NV07) were clearly anomalous in gold with values of 0.011 and 0.009 µg/L, respectively. Site NV09 was from a small pond fed by a small unbranched stream approximately 1 mi from a tailings pile of the Carlin mine (fig. 1). The anomalous value for gold is probably due to leakage of water from the mine tailings area. Site NV07 was collected from Maggie spring along Maggie Creek (fig. 1) contained 0.009 µg/L gold, which is clearly anomalous. The water from the spring is ground water whose source is probably Maggie Creek and to the west of the spring. This area was under intensive exploration by industry at the time of the sampling. The remaining samples in the other areas did not contain clearly anomalous gold, but the argument could be made that any gold above the detection limit of 1 µg/L is anomalous.

Based on a limited study and only a small number of samples, there is indication that, the use of gold concentrations in ground water has potential as a technique for geochemical exploration for concealed gold deposits. One of the major limits on the use of water, particularly in arid regions such as Nevada, is its availability for sampling. Nevertheless, with the development of low-level gold analysis water, if available, should be considered as a medium for geochemical exploration.

REFERENCES CITED

Boyle, R.W., Hornbrook, E.H.W., Allen, R.J., Dyck, W., and Smith, A.V., 1971, Hydrogeochemical methods—Application in the Canadian Shield, Canadian Institute Mining Metall. Bulletin 64, p. 60-71.

Cameron, E.M., 1978, Hydrogeochemical methods for base metal exploration in the northern Canadian shield: Journal of Geochemical Exploration, v. 10, p. 219-243.

Dyck, W., 1979, Geochemistry applied to uranium exploration, Canadian Geological Survey Paper 75-26, p. 33-47.

Ficklin, W.H., Meier, A.L., and Grimes, D.J., 1991, Arsenic, antimony, and tungsten distribution in surface waters and ground-water near and away from concealed gold deposits in the Kelly Creek valley, Nevada [abs.], *in* Thorman, C.H., ed., Some Current Research in Eastern Nevada and Western Utah by the U.S. Geological Survey: U.S. Geological Survey Open-File Report 91-386.

Fishman, J.J., and Pyen, G., 1979, Determination of selected anions in water by ion chromatography, U.S. Geological Survey Water Resource Investigations 79-101, 30 p.

Grimes, D.J., McHugh, J.B., and Ficklin, W.H., 1991, Drill hole hydrogeochemistry—A potential exploration tool for conceased disseminated gold deposits in Nevada [abs.], *in* Thorman, C.H., ed., Some Current Research in Eastern Nevada and Western Utah by the U.S. Geological Survey: U.S. Geological Survey Open-File Report 91-386.

Grimes, D.J., Ficklin, W.H., McHugh, J.B., and Meier, A.L., 1991, Geochemical investigation of groundwater associated with disseminated gold deposits along the Getchell Trend, northern Nevada [abs.], *in* Good, E.E., Slack, J.F., and Kotra, R.K., eds., USGS Research on Mineral Resources—1991 Program and Abstracts: U.S. Geological Survey Circular 1062.

McHugh, J.B., 1986, Determining gold in water by anion-exchange batch extraction, Talanta, 33, p. 349-351.

Miller, W.R., 1979, Application of hydrogeochemistry to the search for base metals, Canadian Geological Survey, Economic Geology Report 31, p. 479-487.

Orion Research, Inc., 1978, Analytical methods guide, 9th ed., Cambridge, Mass., 48 p.

Perkin-Elmer Corporation, 1976, Analytical methods for atomic-absorption spectrophotometry, Norwalk, Conn., Perkin-Elmer Corporation, 586 p.

______1977, Analytical methods for atomic-absorption spectrophotometry, using the HGA graphite furnace: Norwalk, Conn., Perkin-Elmer Corporation, 208 p.

Scintrex Corporation, 1978, UA-3 Uranium analysis, Toronto, Canada, 45 p.

Skougstad, M.W., Fishman, M.J., Friedman, L.C., Erdmann, D.E., and Duncan, S.S., eds., 1979, Methods for determination of inorganic substances in water and fluvial sediments—Techniques of Water Resource Investigations of the U.S. Geological Survey, Ch. A1, 26 p.

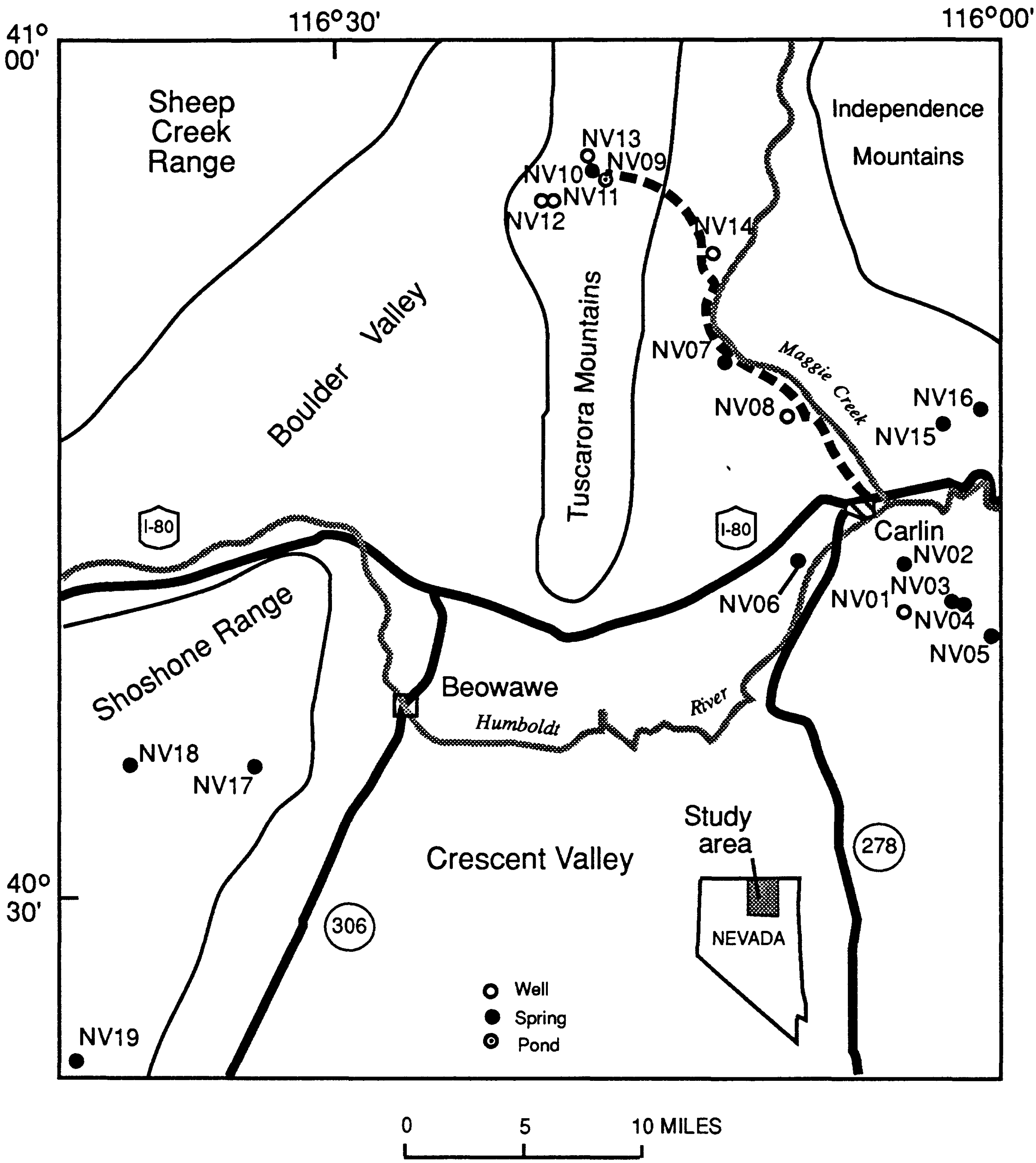

Figure 1. Sample locality map.

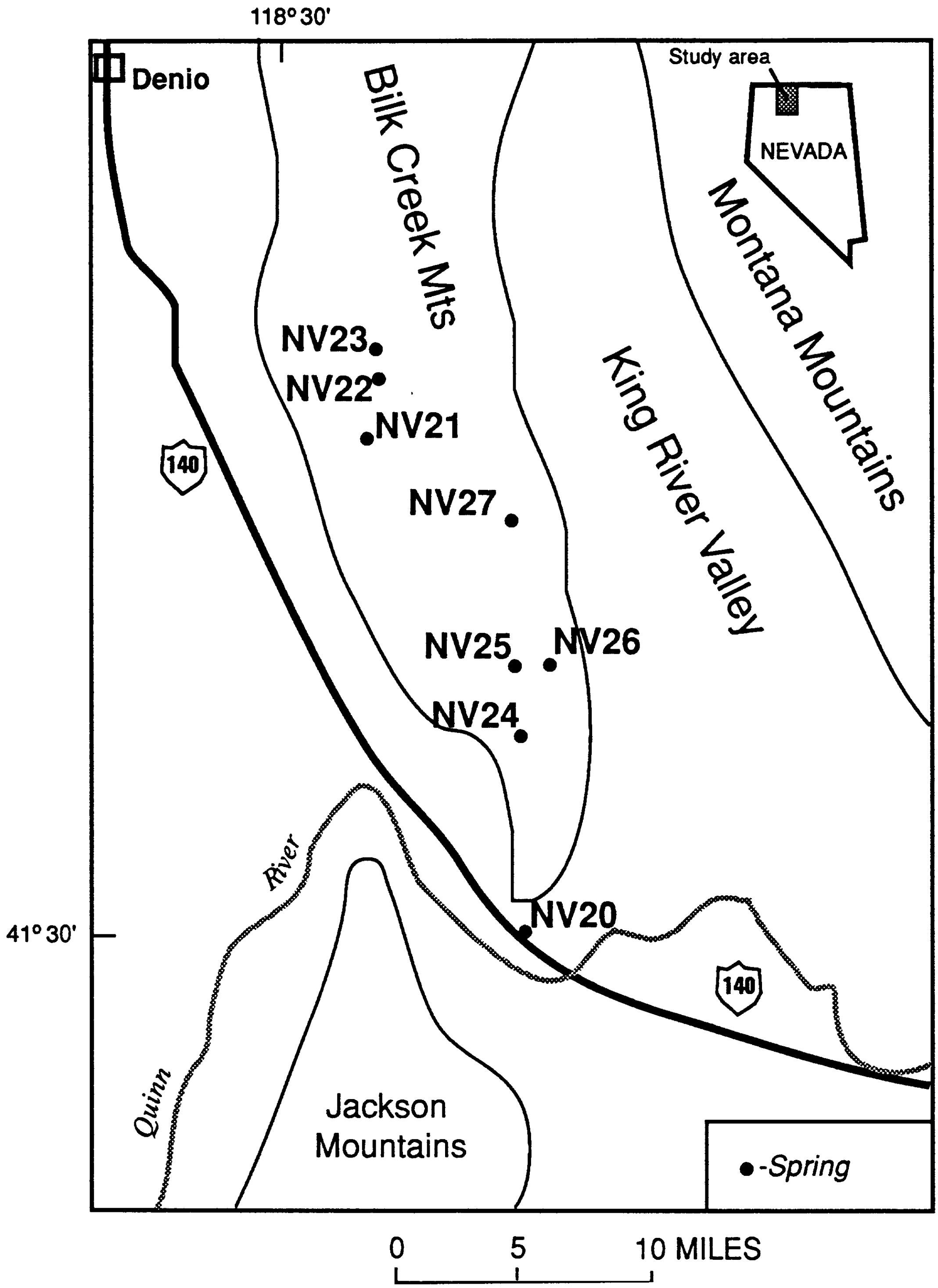

Figure 2. Sample locality map.

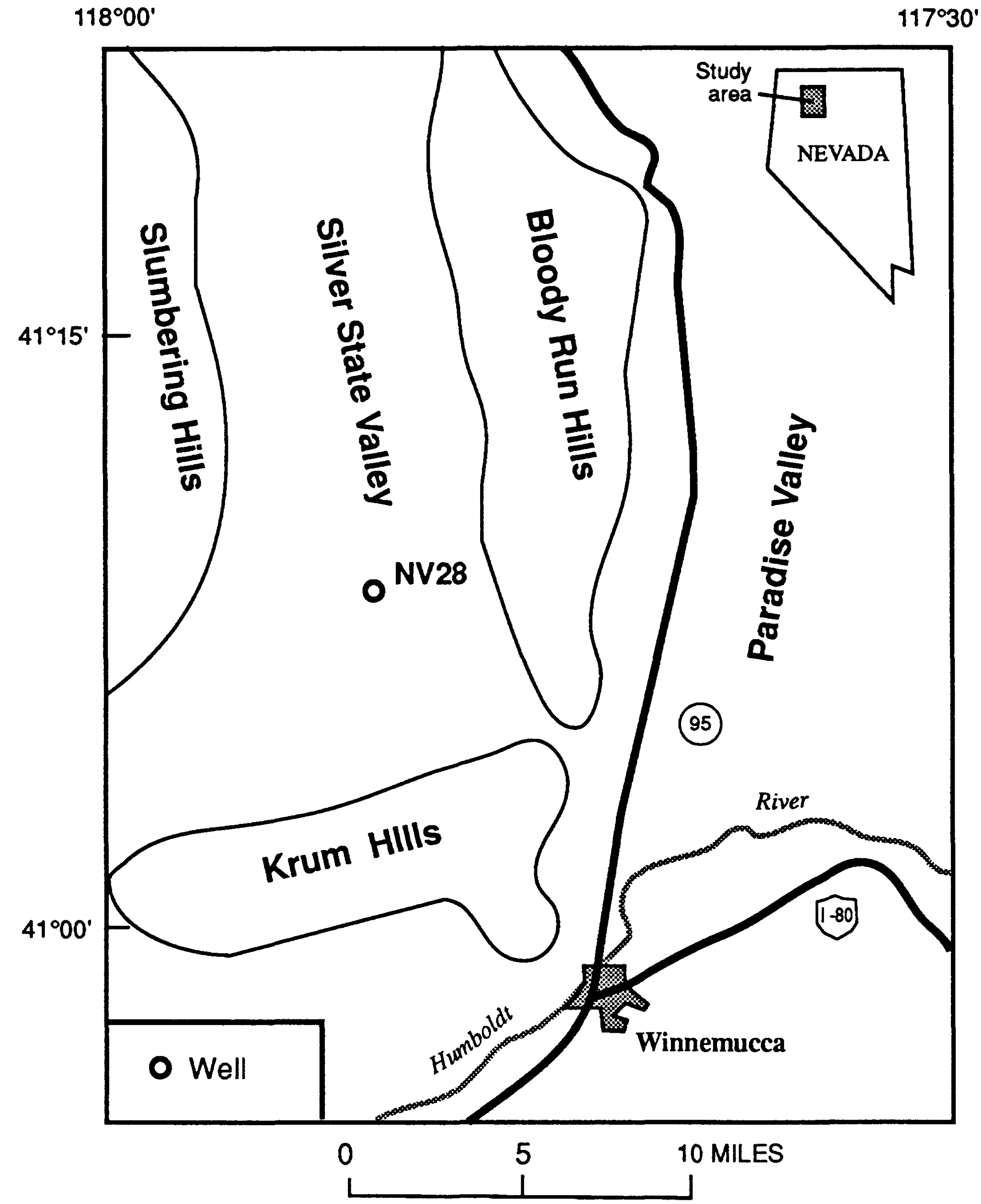

Figure 3. Sample locality map.

Table 1. Sample sources, northern Nevada

Sample no.	Source
NV01	Well
NV02	Rye Patch Spring
NV03	Spring
NV04	Spring
NV05	Spring
NV06	Warm Spring
NV07	Spring
NV08	Well
NV09	Pond
NV10	Spring
NV11	Well
NV12	Well
NV13	Spring
NV14	Well
NV15	Hot Spring
NV16	Lower Dry Susie Spring
NV17	Spring "Beowawe Geyser"
NV18	Spring
NV19	Mud Spring
NV20	Spring
NV21	Texas Spring
NV22	Ecthart Spring
NV23	Spring
NV24	Mustang Spring
NV25	Road Spring
NV26	Cherry Hill Spring
NV27	Mud Spring
NV28	Well

Table 2. Analytical methods used for water analyses, northern Nevada

Constituents	Methods	Reference
Alkalinity	Gran's plot potentiometric titration	Orion Research, Inc. (1978)
Sulfate, chloride, fluoride, and nitrate	Ion chromatography	Fishman and Pyen (1979)
Specific conductance	Conductivity bridge	Skougstad and others (1979)
Calcium, magnesium, silica, potassium, lithium, sodium, aluminum, iron, and manganese	Flame atomic-absorption spectrophotometry	Perkin-Elmer, Corp. (1976)
Arsenic, silver, copper molybdenum, and zinc	Flameless atomic-absorption spectrophotometry	Perkin-Elmer, Corp. (1977)
Uranium	Laser-excited fluorescence	Scintrex Corp. (1978)
Gold	Anion-exchange-flameless atomic-absorption spectrophotometry	McHugh (1986)

Appendix A. Analytical results for 28 water samples from northern Nevada

Sample	LATITUDE	LONGTUDE	CA(MG/L)	MG(MG/L)	NA(MG/L)	K(MG/L)	LI(MG/L)	SIO2(MG/	ALK(MG/L
NV01	40 39 16	116 4 43	33.0	9.6	16	2.9	.010	21	68
NV02	40 40 50	116 4 32	68.0	42.0	48	4.3	.031	20	330
NV03	40 39 25	116 2 17	28.0	9.8	23	3.3	.012	22	148
NV04	40 39 21	116 1 44	19.0	4.5	16	.2	.008	9	74
NV05	40 38 52	116 0 48	50.0	9.2	16	1.8	.008	12	177
NV06	40 41 4	116 9 12	32.0	9.4	26	8.5	.026	65	169
NV07	40 48 18	116 12 10	11.0	17.0	61	18.0	.285	25	196
NV08	40 46 8	116 9 45	30.0	8.8	20	9.8	.021	67	109
NV09	40 54 55	116 18 25	94.0	57.0	180	9.7	.014	13	53
NV10	40 55 14	116 18 58	15.0	6.6	16	3.7	.004	32	101
NV11	40 54 58	116 21 3	20.0	18.0	14	2.8	.022	16	145
NV12	40 54 56	116 21 38	20.0	18.0	14	2.9	.024	16	151
NV13	40 55 48	116 19 27	26.0	13.0	19	9.5	.016	35	151
NV14	40 52 14	116 13 37	41.0	19.0	75	5.2	.010	35	196
NV15	40 45 51	116 2 33	13.0	6.8	290	25.0	.380	43	787
NV16	40 46 28	116 0 50	27.0	6.2	14	4.5	.013	47	137
NV17	40 34 0	116 35 17	2.2	.2	210	15.0	.970	250	303
NV18	40 34 0	116 41 4	48.0	22.0	42	3.7	.018	50	199
NV19	40 23 0	116 44 1	49.0	17.0	69	3.4	.011	36	289
NV20	41 27 24	118 19 4	22.0	3.8	450	9.0	.410	46	842
NV21	41 46 23	118 25 44	16.0	13.0	15	5.1	.004	54	131
NV22	41 48 41	118 24 44	14.0	7.5	11	1.2	<.004	38	90
NV23	41 49 41	118 25 40	10.0	4.0	10	1.9	.005	36	68
NV24	41 36 26	118 19 2	61.0	18.0	79	7.0	.032	46	191
NV25	41 38 55	118 19 15	29.0	19.0	65	5.5	.022	40	109
NV26	41 38 55	118 17 23	75.0	32.0	91	4.2	.009	40	116
NV27	41 43 47	118 19 45	30.0	12.0	43	3.4	.016	47	182
NV28	41 8 20	117 51 33	16.0	4.7	170	6.9	.055	57	269

Appendix A. Analytical results for 28 water samples from northern Nevada

Sample	SO4(MG/L	CL(MG/L)	F(MG/L)	NO3(MG/L	ZN(UG/L)	CU(UG/L)	MO(UG/L)	AG(UG/L)	AU(UG/L)
NV01	106.0	15.0	.40	<.10	3,800	1.0	66.0	.02	.003
NV02	177.0	36.0	.57	<.10	12	<1.0	20.0	<.02	<.001
NV03	44.0	14.0	.20	.10	5	1.0	3.4	<.02	.001
NV04	27.0	15.0	.11	.29	160	1.3	1.8	<.02	<.001
NV05	68.0	16.0	.16	<.10	10	<1.0	2.6	<.02	<.001
NV06	43.0	19.0	.24	.72	9	<1.0	4.2	<.02	<.001
NV07	76.0	21.0	.81	.28	6	3.8	4.2	.03	.009
NV08	30.0	13.0	.15	.29	8	2.1	2.2	<.02	<.001
NV09	410.0	290.0	.96	4.00	12	6.2	4.7	.08	.011
NV10	12.0	4.6	.11	.20	8	2.4	1.8	<.02	.001
NV11	38.0	11.0	.19	<.10	5	<1.0	13.0	.09	<.001
NV12	37.0	11.0	.20	<.10	3	<1.0	12.0	<.02	<.001
NV13	56.0	8.3	.20	.75	4	1.0	7.8	<.02	.001
NV14	120.0	62.0	.33	.70	5	1.1	2.5	.02	<.001
NV15	29.0	9.6	2.80	.36	4	<1.0	<1.0	.02	<.001
NV16	16.0	14.0	.18	.86	4	4.4	1.0	<.02	<.001
NV17	200.0	53.0	10.00	.63	8	1.5	14.0	.04	.001
NV18	76.0	73.0	.31	2.80	8	<1.0	1.8	<.02	<.001
NV19	56.0	47.0	.44	<.10	4	<1.0	4.2	<.02	<.001
NV20	186.0	54.0	7.10	.60	4	3.5	<1.0	.12	.002
NV21	15.0	12.0	.15	.33	4	1.2	<1.0	<.02	<.001
NV22	6.6	7.3	<.10	.59	12	<1.0	<1.0	<.02	<.001
NV23	2.7	2.4	<.10	<.10	3	1.0	<1.0	<.02	<.001
NV24	89.0	135.0	<.10	.60	9	<1.0	2.0	<.02	<.001
NV25	88.0	105.0	.34	<.10	7	14.0	<1.0	.03	.001
NV26	84.0	197.0	.47	.73	8	13.0	1.7	<.02	<.001
NV27	31.0	39.0	.22	.23	3	3.2	<1.0	.02	<.001
NV28	72.0	56.0	.64	7.40	54	7.8	8.4	.06	.001

Appendix A. Analytical results for 28 water samples from northern Nevada

Sample	AS(UG/L)	U(UG/L)	FE(MG/L)	MN(MG/L)	AL(MG/L)	SP.COND.	PH	TEMP. C	CHAR BAL
NV01	32.0	<.10	7.70	.27	<.1	380	5.99	14	-7.9
NV02	3.3	1.60	.01	<.01	<.1	830	7.15	13	-5.5
NV03	2.0	.52	.01	<.01	<.1	350	8.80	23	-6.4
NV04	<1.0	<.10	.01	<.01	<.1	245	6.64	18	-4.3
NV05	<1.0	.90	<.01	<.01	<.1	420	7.33	19	-8.8
NV06	10.0	5.20	<.01	<.01	<.1	390	7.04	22	-6.3
NV07	36.0	1.30	<.01	<.01	<.1	480	8.06	30	-3.5
NV08	9.2	3.80	.01	<.01	<.1	300	7.23	17	9.1
NV09	120.0	2.00	.02	.02	<.1	1,700	9.14	21	-.6
NV10	62.0	<.10	.20	.66	<.1	230	6.07	20	1.1
NV11	72.0	.96	<.01	<.01	<.1	340	6.77	24	-4.7
NV12	73.0	.98	<.01	<.01	<.1	340	7.02	22	-5.7
NV13	230.0	5.00	.02	.14	<.1	370	7.00	24	-6.2
NV14	21.0	8.00	.02	<.01	<.1	720	6.44	12	-3.2
NV15	2.5	<.10	.04	<.01	<.1	1,140	7.40	20	1.8
NV16	5.6	1.80	<.01	<.01	<.1	290	7.22	18	-7.3
NV17	22.0	.12	<.01	<.01	.3	840	9.42	100	-7.4
NV18	3.7	1.70	<.01	<.01	<.1	640	6.72	15	-6.2
NV19	23.0	26.00	.08	.03	<.1	640	7.24	18	-2.1
NV20	70.0	<.10	.06	.07	<.1	1,600	7.08	33	4.0
NV21	1.2	1.40	<.01	<.01	<.1	290	6.64	15	-2.7
NV22	<1.0	.46	<.01	<.01	<.1	205	6.49	10	.1
NV23	1.0	<.10	.07	.05	<.1	130	6.40	20	2.9
NV24	18.0	6.20	.02	<.01	<.1	830	7.26	18	-3.8
NV25	5.4	3.00	.01	<.01	<.1	630	8.08	20	-4.8
NV26	4.2	3.20	.01	<.01	<.1	890	7.00	15	6.2
NV27	8.3	1.60	.05	.13	<.1	450	6.76	20	-3.2
NV28	21.0	4.00	.03	<.01	<.1	750	7.31	18	6.8