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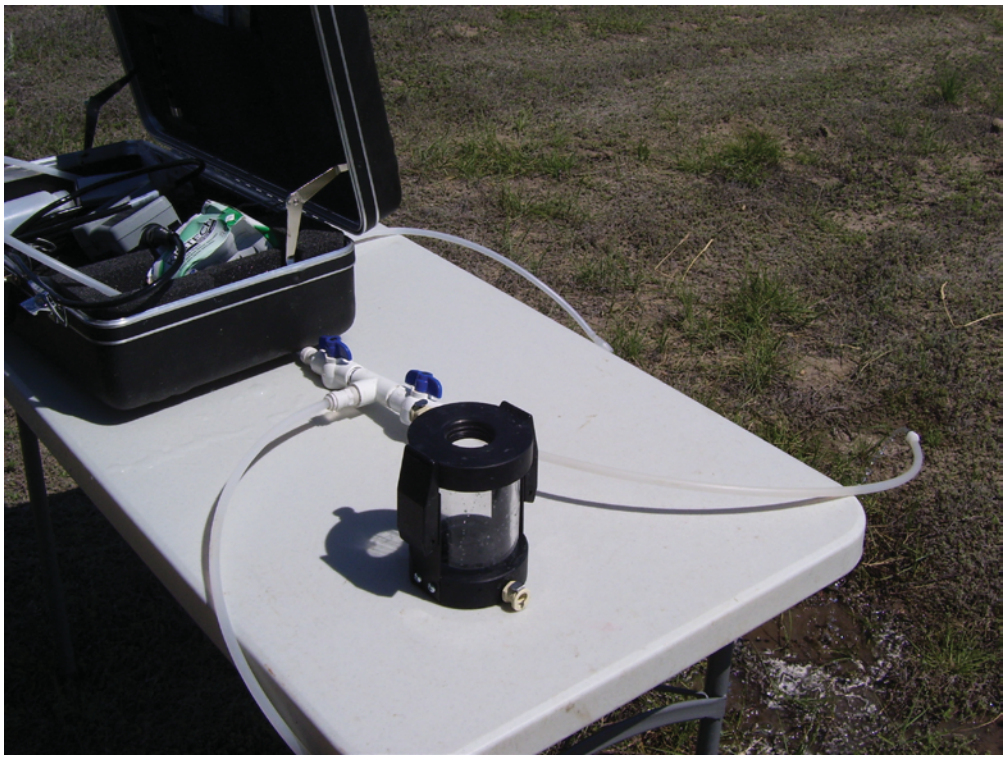
Geochemical Data from Groundwater at the Proposed Dewey Burdock Uranium In-Situ Recovery Mine, Edgemont, South Dakota

By Raymond H. Johnson



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Geochemical Data from Groundwater at the Proposed Dewey Burdock Uranium In-Situ Recovery Mine, Edgemont, South Dakota

By Raymond H. Johnson

Abstract

This report releases groundwater geochemistry data from samples that were collected in June 2011 at the Dewey Burdock proposed uranium in-situ recovery site near Edgemont, South Dakota. The sampling and analytical methods are summarized, and all of the data, including quality assurance/quality control information are provided in data tables.

Introduction

Powertech Uranium Corporation (Powertech) has proposed to mine uranium at the Dewey Burdock site using in-situ recovery methods. The Dewey Burdock site is located in the southwestern region of the Black Hills of South Dakota (fig. 1). The uranium recovery license application by Powertech to the United States Nuclear Regulatory Commission (NRC) is publicly available and contains background information about the site along with technical details and baseline sampling data. The NRC application Web site is: *http://www.nrc.gov/materials/uranium-recovery/license-apps/dewey-burdock.html* (with detailed application documents under the "application documents" link). A brief summary of the site history is provided by Powertech at *http://www.powertechuranium.com/s/DeweyBurdock.asp*.

At the Dewey Burdock site, uranium occurs as roll-front ore bodies in several sandstone units of the Inyan Kara Group of Early Cretaceous Age. The Late Jurassic Morrison Formation underlies the Inyan Kara Group. In the vicinity of the mine site, the Inyan Kara Group is comprised of the Fall River Formation (upper unit) and the Lakota Formation (lower unit). The Lakota Formation is comprised of the Chilson and the Fuson Members, with the Fuson Member occurring between the Fall River and Lakota Formations. Uranium roll-front deposits occur in the Fall River Formation and the Chilson Member of the Lakota Formation. Other geologic units of interest for the study area are the surface alluvial aquifers and the Unkpapa aquifer underlying the Morrison Formation. The well location symbols on the maps in figures 2 through 4 are color coded to indicate the aquifer screened interval for each well.

The U.S. Geological Survey (USGS) collected 28 groundwater samples from monitoring wells (figs. 2 through 4) in and around the Dewey Burdock site during the last two weeks of June 2011. This sampling was completed with funding from the U.S. Environmental Protection Agency (USEPA) Region 8's Regional Applied Research Effort (RARE) Program. USEPA is responsible for evaluating the site through its underground injection control program

(*http://www.epa.gov/region8/water/uic*) and Powertech has submitted a separate permit application to USEPA (see documentation in a link within the above USEPA Web site). While these new samples provide data on major ion and metal concentrations that overlap with Powertech's baseline sampling, the main intent of this sampling is to get isotopic measurements that will be used to better understand the hydrogeologic system.

Sampling Methods

Groundwater samples were collected using either a peristaltic pump (used in shallow wells), a bailer (used when access problems were encountered), installed pump, or using a low-flow, submersible, stainless steel pump. Many of the wells are under artesian pressure and are flowing, with a valve assembly attached at the surface to control the flow (fig. 5). This same valve assembly was present in all wells with installed pumps. For wells with installed pumps or that were flowing, approximately three well bore volumes were purged prior to sampling.

A peristaltic pump was used in shallow 2-inch diameter wells where the water table was less than 27 feet below the top of the well casing. The sample tubing was placed approximately 1 foot above the bottom of the well and groundwater was purged until field parameters stabilized, which usually occurred within a few minutes. New polyethylene sample tubing was used for each well.

The submersible pump was a Geotech SS Geosub model by Geotech Environmental. The stainless pump was placed at approximately 50 feet below the water table and a drop tube assembling was lowered ahead of the pump to the bottom of the well (*http://www.geotechenv.com/pdf/ground_water_sampling_equipment/ss_geosub_wcontroller.pdf*). The tubing and pump were then pulled back so the intake was one foot from the bottom of the well. This allowed for direct sampling within the well screen and within the active groundwater flow zone using micropurge sampling. Groundwater was purged until field parameters stabilized, which usually occurred within a few minutes and was generally a function of meter stabilization (partially because of added pumping pressure) and not a change in groundwater conditions. New polyethylene sample tubing was used for each well.

A bailer was used in well 680 when the installed pump in the well failed after having purged three casing volumes. The well head was opened and the bailer was used to get water within the casing. A bailer was also used for well NBA, a newly installed well with a 2-inch diameter casing where the water table was below the limit of the peristaltic pump. A bailer was used to purge the well of three casing volumes before sampling. Sampling was completed using the peristaltic pump with new sample tubing to get water out of the bailer and through an inline filter.

For all samples, groundwater sampling was completed through a "T-valve" apparatus that split the flow into a flow through cell for field parameter measurement and a separate line for filling sample bottles (fig. 6). The sample line included an inline 0.45 micron filter that was used for all bottles except for tritium (sample NBA was filtered for tritium also, as the sediment load was high). Field parameter measurements of pH, specific conductance, temperature, dissolved oxygen, and oxidation/reduction potential were all done using a YSI 556 multiparameter meter that screwed directly into the flow through cell (see cover photograph), thereby eliminating any contact with the atmosphere.

Nine aliquots of water provided samples for (1) cations/metals, (2) $^{234}U/^{238}U$ activity ratios, (3) anions, (4) dissolved organic carbon, (5) iron pairs (Fe^{3+}/Fe^{2+}), (6) tritium, (7) stable isotopes (^{18}O and deuterium), (8) sulfur isotopes (^{34}S), and (9) carbon isotopes (^{14}C). Details on bottle type,

bottle size, rinsing, filtration, and preservative methods are listed in table 1. Any acids used for preservatives were ultra pure and made specifically for sample preservation. For bottles that were rinsed, rinsing was completed three times prior to filling the bottle.

Table 1. Bottle type and size, rinsing, filtration, and preservation for analytes.

[HDPE, high density polyethylene; mL, milliliter; L, liter; µm, micrometer; HNO_3, nitric acid; HPO_4, phosphoric acid; HCl, hydrochloric acid]

Analytes	Bottle Type	Bottle Size	Rinsing	Filtration	Preservative
Cations and dissolved metals	HDPE	30 mL	New bottle, rinse with sample water	0.45-µm	5 drops HNO_3 or to pH less than 2
$^{234}U/^{238}U$	HDPE	30 mL	New bottles, rinse with sample water	0.45-µm	5 drops HNO_3 or to pH less than 2
Anions	HDPE	30 mL	New bottle, rinse with sample water	0.45-µm	Keep cool
Dissolved organic carbon	Amber glass	125 mL	New bottles, cleaned and burned, do not rinse with sample water	0.45-µm	5 drops HPO_4 or to pH less than 2, keep cool
Dissolved iron species	Amber polyethylene	60 mL	New bottle, rinse with sample water	0.45-µm	5 drops HCl or to pH less than 2, keep cool
Tritium	HDPE	500 mL	New bottles, rinse with sample water	None	None
Water Isotopes: ^{18}O and Deuterium	Borosilicate glass	60 mL	New bottles, rinse with sample water	0.45-µm	None
^{34}S	HDPE	125 mL	New bottles, rinse with sample water	0.45-µm	2 drops of HNO_3 to reduce biotic activity
^{14}C	Amber glass	1 L	New bottles, cleaned and burned, do not rinse with sample water	0.45-µm	Keep cool

Analytical Methods

This section describes the analytical procedures completed on each of the nine water sample aliquots. The cations/metals sample was analyzed at the USEPA (Ada, Oklahoma) and at the USGS laboratories (Denver, Colorado). USEPA analyses were made using inductively coupled plasma – optical emission spectrometry (ICP-OES, Perkin-Elmer Optima 3300DV) using EPA Method 200.7 and inductively coupled plasma – mass spectrometry (ICP-MS, PQExcell, Thermo Elemental) using USEPA Method 6020. USGS analyses were made using ICP-MS at the USGS Mineral Resources Laboratory (Denver, Colorado) following the method described in Lamothe and others (2002).

The $^{234}U/^{238}U$ activity ratios were analyzed by Michael Ketterer at the Northern Arizona University in Flagstaff, Arizona using a sector field Thermo X Series II quadrupole ICP-MS unit. Details on the analytical method can be found in file Appendix F.

Dissolved anions were analyzed by the USEPA laboratories (Ada, Oklahoma) using capillary electrophoresis with ultraviolent (UV) detection (USEPA Method 6500). Capillary ion electrophoresis is a free-zone electrophoretic technique optimized for the analysis of anions with molecular weights of less than 200 grams/mole. The anions migrate and are separated according to their mobility in the electrolyte when an electrical field is applied through the open tubular fused silica capillary.

Concentrations of dissolved inorganic carbon were measured by the USEPA laboratories (Ada, Oklahoma) with a Dohrmann DC-80 Carbon Analyzer (USEPA Method 9060A). Iron pairs (Fe^{3+}/Fe^{2+}) were completed by David Fey at the USGS Mineral Resources Laboratory (Denver, Colorado) using the ferrozine method for iron species discussed in Bangthanh To and others (1999). Tritium analyses were completed by Robert Michel at the USGS Isotope Laboratory in Menlo Park, California using liquid scintillation counting with a detection limit of approximately 0.6 tritium units (TU) (similar to USEPA method 906.0). Oxygen- and hydrogen-isotopic ratios of water were analyzed using a high temperature conversion elemental analyzer linked to a continuous flow isotope ratio mass spectrometer (Finnigan Delta plus XP). These analyses followed the methods presented by Lu (2009). Sulfur isotopes (^{34}S) were analyzed by Christopher Eastoe at the University of Arizona following the method of Coleman and Moore (1978). Additional analytical procedures for that laboratory can be found at *http://www.geo.arizona.edu/research/iso_analytical.html*.

Data

All of the resulting data are provided in table 2. Sample identification numbers in table 2 match the well identification numbers used in Powertech permit application documents. Original labeling included “B” and “D” in the sample name for ease of sample identification (found in appendix files) by area, “B” for Burdock and “D” for Dewey, but were not included in the final data table (table 2).

The samples in table 2 have been organized by categories to reflect geologic units that the wells are screened in along with general area locations. These are purely initial categories used by the author for later use in interpretations.

Quality Assurance/Quality Control

For all USEPA solution measurements, quality assurance tests involved duplicate samples, blanks, sample matrix spikes, calibration check standards, and second-source quality control samples. Data for the laboratory quality assurance/quality control (QA/QC) checks are included in the original data that can be found in the appendixes. Uranium isotope data also included internal laboratory checks that can be found in Appendix F. All other laboratories used typical internal reference standards for the appropriate analyses and QA/QC information is available upon request. No internal laboratory QA/QC issues were found.

In addition to the internal laboratory checks, three duplicate samples and five blanks were submitted as part of the QA/QC process. Data from these duplicates and blanks are reported in table 3. No QA/QC issues were found in any of the duplicate samples. Blanks for all of the different sampling conditions are represented (Geosub pump, peristaltic pump, and bailer

sampling). For metals, cations, and anions, a few blanks did show values above the detection limits, but generally these values were well below any sample results. Only one blank had an iron concentration that was high enough compared to the groundwater samples to be of concern. Iron in the bailer blank (B-VS4) was 3.72 µg/L, which is likely because of incomplete cleaning of the bailer. Cleaning the bailer was difficult because of limited access inside the bailer in addition to sample NBA (well sampled prior to blank) having a high silt content. As a result, any measured iron values below 4 µg/L, may not be accurate, especially for samples using a bailer. Sample data were not blank corrected.

Acknowledgments

Funding from the US EPA made this data collection possible. Special thanks go to Richard Wilkin (USEPA, Ada, Oklahoma) for managing the USEPA contract and organizing the sample submittals to the appropriate USEPA laboratories. We are grateful for well access provided by individual land owners and through arrangements made by Powertech. Powertech employees, Wyatt Van Eaton and Mike Beshore provided invaluable assistance in accessing the wells and assisting with equipment logistics. Facilities for equipment storage and a convenient staging area were provided by Mark Hollenbeck. In addition, the groundwater sampling included assistance from Brian Zimmerman, Andrew Mahan, Valois Shea, Tanya Gallegos, and John Horton.

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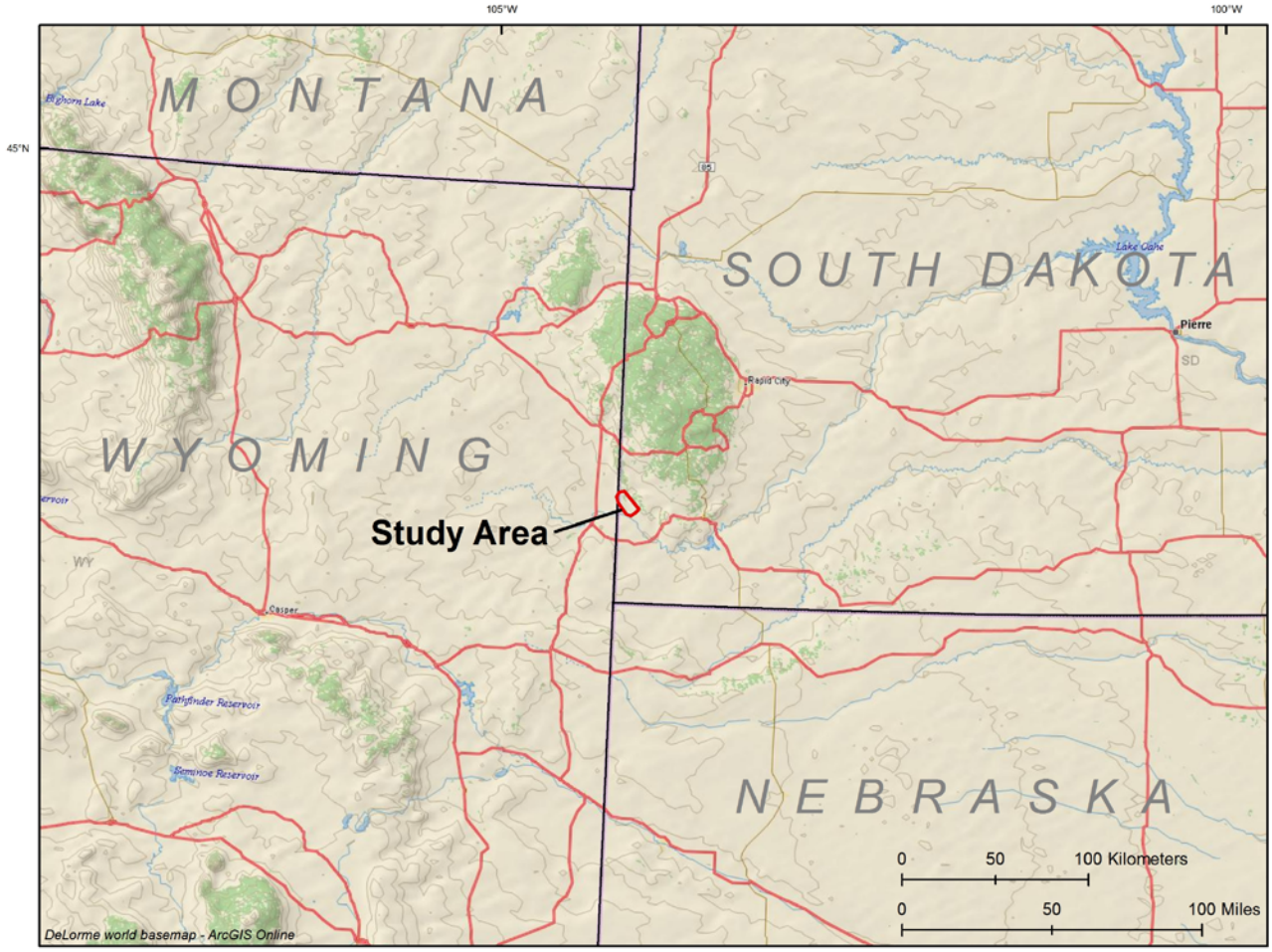

Figure 1. Location of study area.

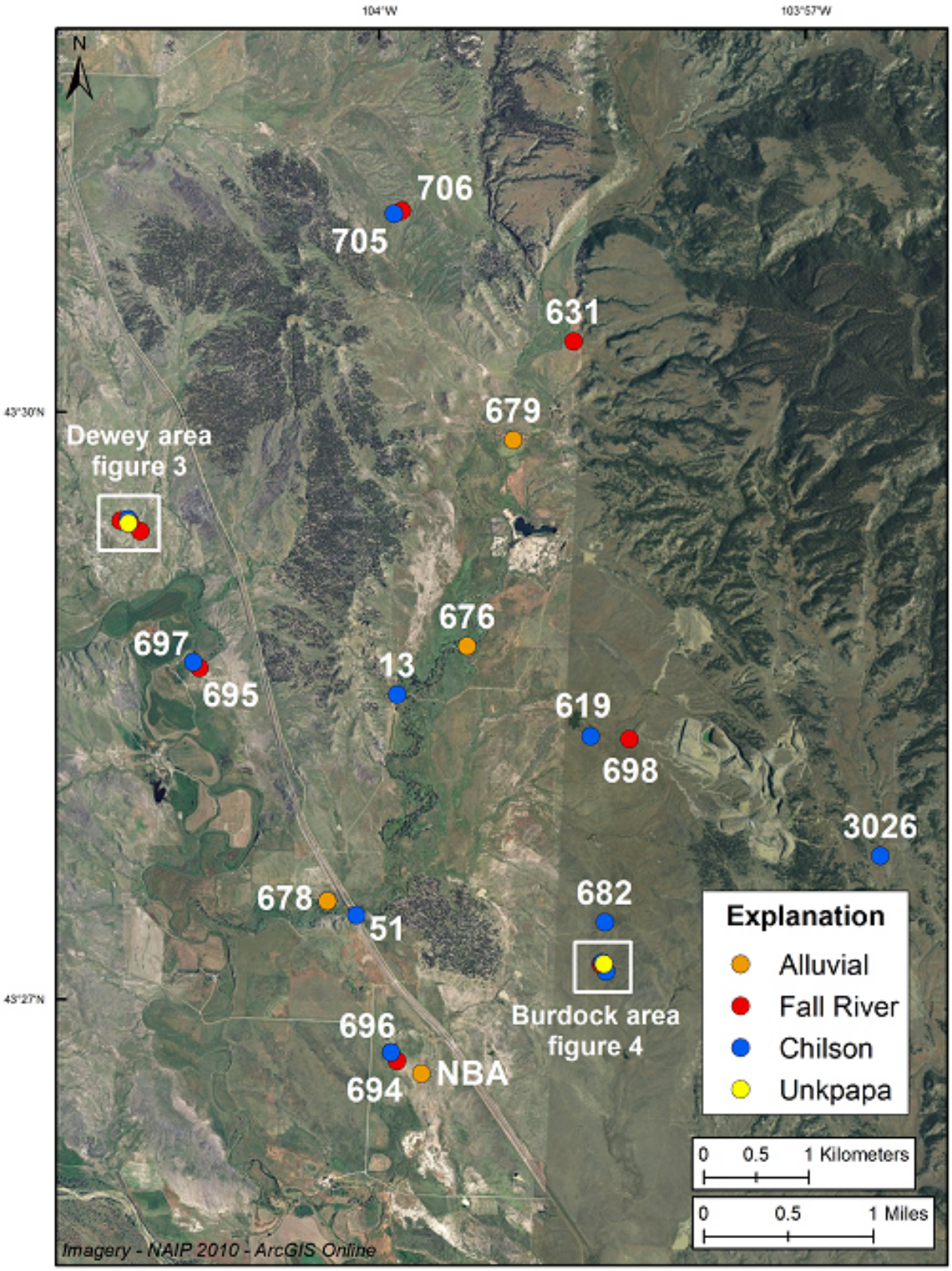

Figure 2. Satellite imagery overlain with monitoring well locations. Labels indicate well identification number. White boxes indicate location of expanded views for figures 3 and 4.

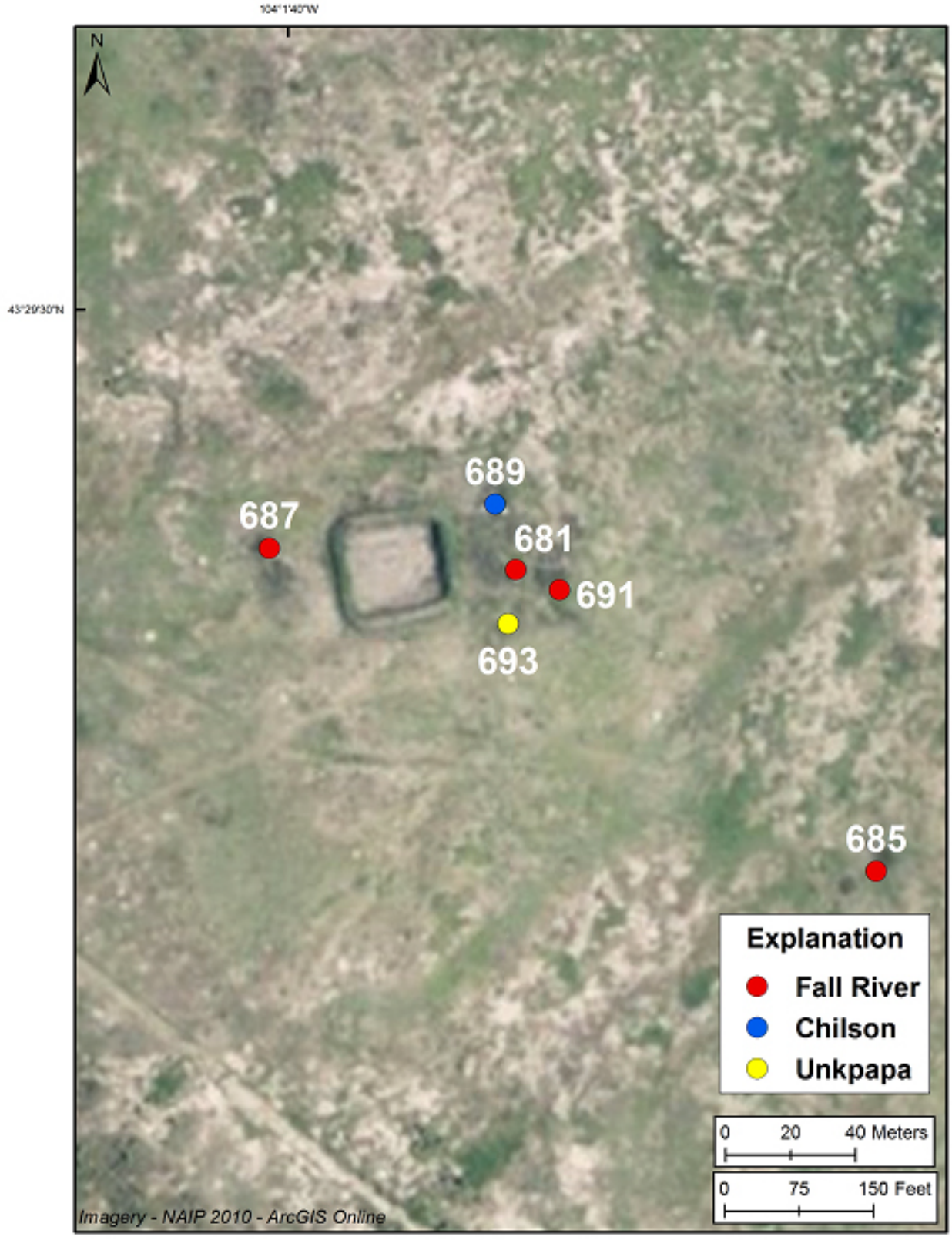

Figure 3. Expanded view of Dewey area. Labels indicate well identification number.

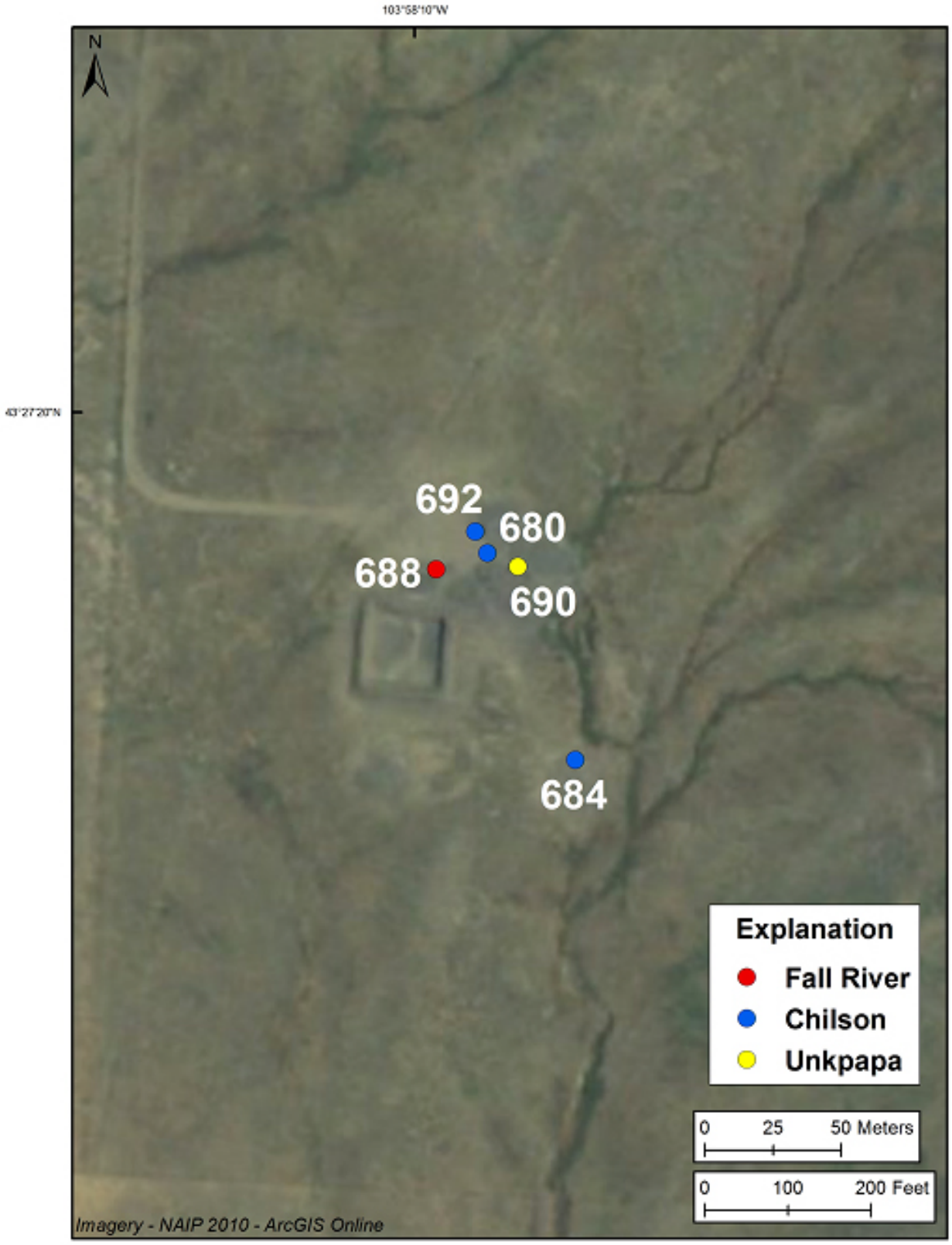

Figure 4. Expanded view of Burdock area. Labels indicate well identification number.

Figure 5. Typical wellhead control valves.

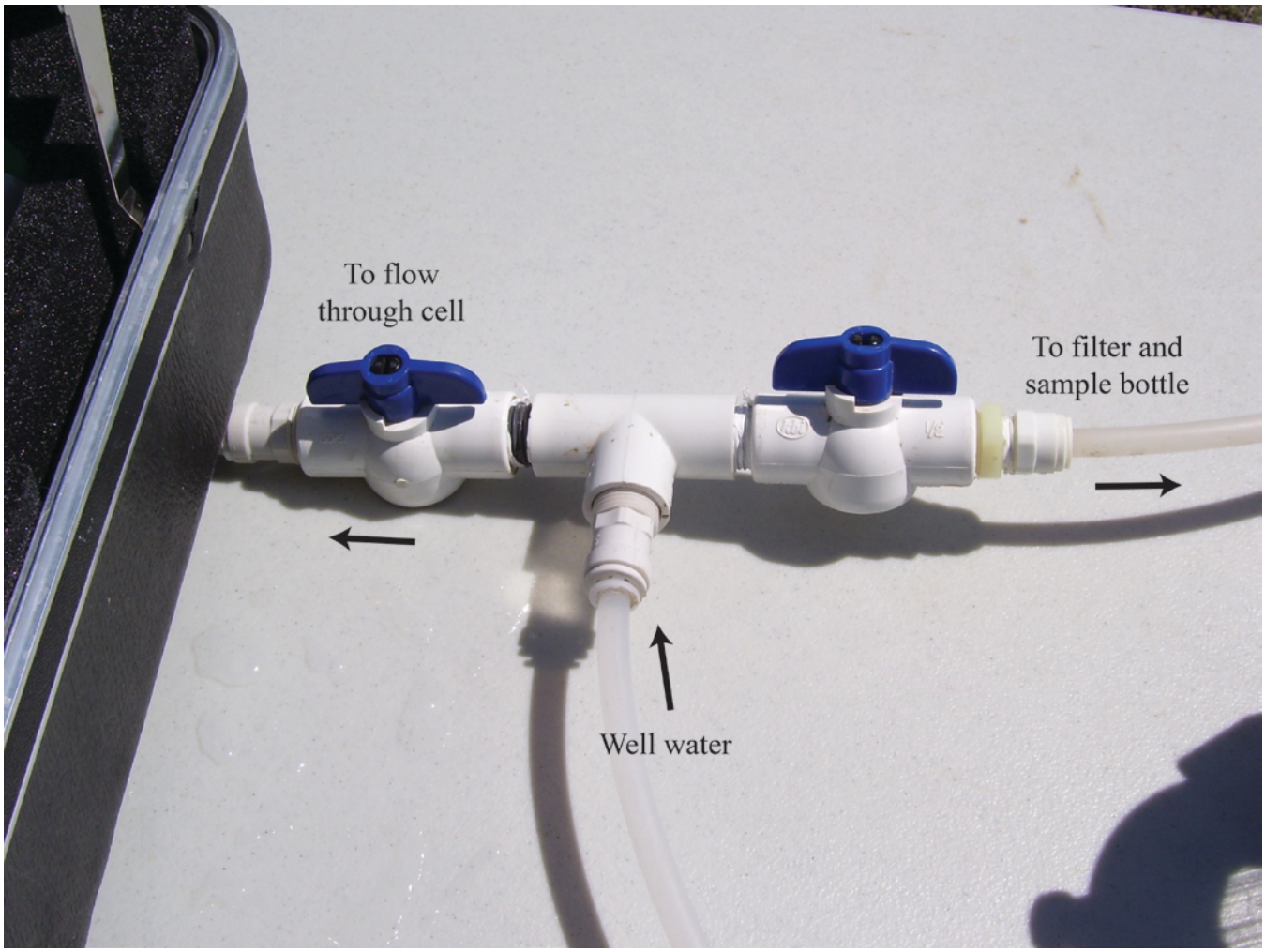

Figure 6. "T-valve" used for sampling.

Table 2. Locations and geochemical data for groundwater samples.

Field sample ID	Latitude	Longitude	Comments	Sampling method	Depth to water feet from top of casing	1000 δ^{18}O$_{VSMOW}$	1 SD 1000 δ^{18}O$_{VSMOW}$	1000 δ^{2}H$_{VSMOW}$	1 SD 1000 δ^{2}H$_{VSMOW}$	USEPA Dissolved organic carbon mg/L	USGS-Menlo Park Tritium TU	USGS-Menlo Park Tritium 1 SD TU	Field parameter pH	Field parameter Oxidation reduction potential (ORP) mV	ORP converted to Eh mV	Eh converted to pe mV	Field parameter Temperature degrees Celsius
Detection limits (MDL)										0.067							
Detection limits (QL)										0.500							
Alluvial																	
676	43.48166	-103.98653	Alluvial	peristaltic pump	-15.64	-12.3	0.09	-98.4	0.26	2.04	0.0	0.6	6.66	134	347	5.9	10.7
678	43.45943	-104.00157	Alluvial	peristaltic pump	-9.20	-12.5	0.04	-101.3	0.60	4.21	9.3	0.7	6.95	148	361	6.1	10.5
NBA	43.44510	-103.98968	Alluvial	bailer	-32.58	-12.3	0.06	-97.8	0.46	1.63	3.0	0.6	7.29	158	369	6.2	12.5
Active flow zone																	
13	43.47728	-103.99446	Chilson	installed pump	not available	-17.8	0.06	-135.9	0.33	0.511	15.3	0.9	7.99	-268	-58.4	-1.0	13.7
51	43.45834	-103.99811	Chilson	flowing	not available	-16.9	0.06	-132.4	0.18	BQL (0.492)	-0.3	0.6	6.83	-93.9	117	2.0	13.1
Burdock area recharge																	
679	43.49938	-103.98217	Alluvial	Geosub pump	-29.86	-13.5	0.07	-104.6	0.10	1.40	8.4	0.6	6.95	206	418	7.1	12.0
631	43.50800	-103.97560	Fall River	installed pump	-27.71	-14.0	0.06	-105.9	0.24	0.866	9.3	0.7	6.50	-8.80	201	3.4	13.5
3026	43.46535	-103.93706	Lower Chilson	installed pump	-140.05	-14.5	0.07	-116.3	0.16	1.70	-0.2	0.6	6.17	17.5	230	3.9	12.3
Burdock oxidized zone																	
619	43.47445	-103.97160	Chilson	installed pump	not available	-14.3	0.06	-113.0	0.06	1.32	-0.2	0.5	6.80	-57.0	153	2.6	14.1
Lower Chilson Burdock																	
682	43.45867	-103.96896	Oxidized side	Geosub pump	-52.75	-13.7	0.01	-108.7	0.51	1.48	1.6	0.6	7.00	-119	90.7	1.5	14.2
680	43.45515	-103.96901	Pump well	bailer	-40.76	-13.7	0.03	-110.5	0.12	3.87	0.3	0.5	7.51	-281	-70.0	-1.2	13.4
684	43.45448	-103.96857	Reduced side	Geosub pump	-27.69	-14.2	0.01	-109.2	0.24	1.46	-0.4	0.6	6.78	-139	71.9	1.2	12.8
Burdock Fall River																	
698	43.47435	-103.96703	Fall River	Geosub pump	-35.00	-14.5	0.02	-116.5	0.21	1.92	0.1	0.5	7.43	-230	-20.9	-0.4	14.5
688	43.45509	-103.96924	Fall River	Geosub pump	-37.63	-15.8	0.09	-126.4	0.08	2.12	-0.2	0.5	7.36	-231	-21.0	-0.4	14.0
Upper Chilson Burdock																	
692	43.45522	-103.96907	Pump area	Geosub pump	-40.93	-14.2	0.02	-111.1	0.42	1.22	0.0	0.5	8.21	-211	-1.3	0.0	14.1
Burdock downgradient																	
694	43.44655	-103.99319	Fall River	flowing	40.76	-17.4	0.06	-137.7	0.29	0.680	0.9	0.5	8.21	-198	13.9	0.2	12.4
696	43.44680	-103.99335	Chilson	flowing	49.29	-15.5	0.02	-122.3	0.44	0.804	0.7	0.6	6.65	-11.3	200	3.4	13.2
Dewey recharge zone																	
706	43.51829	-103.99717	Fall River	installed pump	-116.80	-15.7	0.09	-121.9	0.08	0.511	-0.3	0.6	6.89	-110	100	1.7	14.1
705	43.51819	-103.99733	Chilson	installed pump	-99.37	-16.0	0.05	-127.7	0.01	BQL (0.437)	0.1	0.6	6.88	11.3	222	3.8	13.4
Dewey area Fall River																	
685	43.49021	-104.02540	Oxidized side	flowing	15.91	-16.5	0.04	-128.9	0.09	BQL (0.366)	0.0	0.5	7.30	-27.0	182	3.1	15.2
681	43.49100	-104.02682	Pump well	flowing	17.03	-17.2	0.01	-136.0	0.22	BQL (0.410)	0.0	0.6	7.35	-77.1	132	2.2	14.6
687	43.49103	-104.02776	Reduced side	flowing	20.45	-17.7	0.07	-135.2	0.10	BQL (0.295)	0.1	0.6	7.52	-77.9	131	2.2	14.6
695	43.47919	-104.01837	"Downgradient"	flowing	36.42	-17.5	0.01	-137.8	0.16	BQL (0.383)	0.3	0.6	6.94	-101.4	111	1.9	12.2
Dewey Upper Fall River																	
691	43.49095	-104.02665	Pump area	flowing	17.45	-16.0	0.01	-126.0	0.00	0.640	-0.1	0.5	8.29	-73.0	138	2.3	12.5
Dewey area Chilson																	
689	43.49118	-104.02691	Pump area	flowing	54.30	-14.5	0.00	-117.5	0.21	BQL (0.431)	0.0	0.5	7.30	-47.1	161	2.7	15.9
697	43.47927	-104.01852	"Downgradient"	flowing	72.40	-16.8	0.02	-132.0	0.05	BQL (0.399)	0.1	0.5	7.17	-78.9	131	2.2	13.8
Unkpapa																	
693	43.49085	-104.02684	Dewey	flowing	121.51	-16.1	0.00	-125.9	0.48	BQL (0.294)	0.2	0.5	8.65	-319	-110	-1.9	14.8
690	43.45511	-103.96887	Burdock	flowing	21.36	-15.9	0.03	-126.0	0.47	1.02	0.1	0.6	9.61	-298	-97.0	-1.6	21.7

Field sample ID	Field parameter Dissolved oxygen mg/L	Field parameter Specific conductance µS/cm	Field parameter Turbidity NTU	Field parameter Alkalinity mg/L as $CaCO_3$	USEPA-OES Silver (Ag) mg/L	USEPA-OES Aluminum (Al) mg/L	USEPA-OES Arsenic (As) mg/L	USEPA-ICPMS Arsenic (As) µg/L	USEPA-OES Boron (B) mg/L	USEPA-OES Barium (Ba) mg/L	USGS-ICPMS Barium (Ba) µg/L	USEPA-OES Beryllium (Be) mg/L	USEPA-OES Calcium (Ca) mg/L	USGS-ICPMS Calcium (Ca) mg/L	USEPA-OES Cadmium (Cd) mg/L	USEPA-ICPMS Cadmium (Cd) µg/L
Detection limits (MDL)					0.004	0.148	0.006	0.018	0.100	0.001	2.0	0.003	0.086	2.0	0.001	0.008
Detection limits (QL)					0.014	0.494	0.020	0.060	0.333	0.004		0.010	0.287		0.004	0.025
Alluvial																
676	5.8	3,002	1.9	239	ND	ND	ND	2.66	0.470	0.011	12.7	ND	510	498	ND	0.033
678	0.8	6,023	10.2	464	ND	ND	ND	3.43	1.47	0.018	18.7	ND	424	441	ND	0.083
NBA	5.0	5,447	>1100	153	ND	ND	ND	2.77	1.46	0.013	14.8	ND	429	408	ND	0.268
Active flow zone																
13	0.3	1,307	2.2	160	ND	ND	ND	1.35	ND	0.008	8.0	ND	69.4	73.2	ND	ND
51	2.1	1,395	2.1	180	ND	ND	ND	2.09	ND	0.008	9.3	ND	73.7	71.8	ND	ND
Burdock area recharge																
679	11.7	2,745	7.4	138	ND	ND	ND	2.07	0.430	0.009	9.1	ND	462	557	ND	0.045
631	2.3	2,331	2.2	149	ND	ND	ND	2.30	BQL (0.174)	0.023	22.8	ND	317	373	ND	BQL(0.010)
3026	6.3	2,880	2.0	184	BQL (0.006)	ND	ND	14.7	BQL (0.197)	0.012	11.2	ND	396	414	ND	BQL(0.016)
Burdock oxidized zone																
619	0.4	2,427	6.1	128	ND	ND	ND	3.11	ND	0.012	11.7	ND	327	324	ND	0.148
Lower Chilson Burdock																
682	1.4	1,591	27.5	244	ND	ND	ND	4.19	BQL (0.118)	0.015	15.8	ND	335	322	ND	ND
680	0.6	2,335	5.5	195	ND	ND	ND	3.75	BQL (0.114)	0.015	14.5	ND	295	281	ND	ND
684	1.2	2,668	3.1	269	ND	ND	ND	4.72	BQL (0.143)	0.012	12.3	ND	365	358	ND	BQL(0.008)
Burdock Fall River																
698	0.3	2,113	4.7	157	ND	ND	ND	1.75	ND	0.012	12.5	ND	259	248	ND	ND
688	0.3	1,073	2.2	219	ND	ND	ND	1.67	ND	0.018	18.6	ND	46.4	47.1	ND	ND
Upper Chilson Burdock																
692	0.3	760	23.5	115	ND	ND	ND	1.65	ND	0.021	21.2	ND	114	113	ND	ND
Burdock downgradient																
694	0.5	1,434	3.8	179	ND	ND	ND	0.769	ND	0.010	10.7	ND	26.4	24.8	ND	ND
696	0.5	1,418	3.8	203	ND	ND	ND	2.27	ND	0.009	10.3	ND	90.6	82.4	ND	ND
Dewey recharge zone																
706	0.9	1,423	7.8	176	ND	ND	ND	2.06	ND	0.009	9.4	ND	95.5	109	ND	ND
705	0.9	1,630	2.1	191	ND	ND	ND	2.26	ND	0.009	9.0	ND	167	193	ND	ND
Dewey area Fall River																
685	0.4	1,312	6.0	164	ND	ND	ND	3.75	ND	0.013	14.3	ND	56.9	63.6	ND	ND
681	0.5	1,324	0.9	170	ND	ND	ND	2.71	ND	0.009	9.6	ND	58.9	67.2	ND	ND
687	0.5	1,344	1.6	170	ND	ND	ND	2.65	ND	0.011	10.9	ND	68.4	64.5	ND	ND
695	0.3	1,372	0.8	174	ND	ND	ND	1.62	ND	0.009	9.1	ND	48.9	43.9	ND	ND
Dewey Upper Fall River																
691	0.8	1,476	1.8	182	ND	ND	ND	0.175	BQL (0.211)	0.021	22.6	ND	4.96	6.10	ND	ND
Dewey area Chilson																
689	0.4	1,029	26.1	147	ND	ND	ND	1.46	ND	0.012	11.7	ND	42.7	44.9	ND	ND
697	0.5	1,229	0.8	164	ND	ND	ND	1.79	ND	0.011	11.7	ND	50.4	48.1	ND	ND
Unkpapa																
693	0.5	2,018	3.7	58.6	ND	ND	ND	0.728	1.07	0.010	9.8	ND	65.2	69.2	ND	0.049
690	0.3	2,012	1.3	47.5	ND	ND	ND	0.525	0.665	0.009	9.3	ND	36.7	35.1	ND	BQL(0.016)

Field sample ID	USEPA-IC Chloride (Cl) mg/L	USEPA-OES Cobalt (Co) mg/L	USEPA-OES Chromium (Cr) mg/L	USEPA-OES Copper (Cu) mg/L	USEPA-IC Fluoride (F) mg/L	USEPA-OES Iron (Fe) mg/L	USGS-Ferrozine Iron (Fe) mg/L	USEPA-ICPMS Iron (Fe) µg/L	USGS-ICPMS Iron (Fe) µg/L	USGS-Ferrozine Percent Ferrous	Field test Iron (Fe) mg/L	USEPA-OES Potassium (K) mg/L	USGS-ICPMS Potassium (K) mg/L	USGS-ICPMS Lithium (Li) µg/L
Detection limits (MDL)	0.136	0.001	0.002	0.006	0.056	0.020	0.010	0.055	500		0.05	0.106	0.30	1.0
Detection limits (QL)	1.00	0.004	0.007	0.020	0.200	0.067		0.182				0.354		
Alluvial														
676	BQL (9.02)	ND	ND	ND	ND	ND	ND	4.00	ND	ND	0.0	11.0	10.7	128
678	55.4	0.006	ND	ND	ND	ND	ND	9.88	ND	ND	0.0	18.2	18.5	520
NBA	43.3	0.005	ND	ND	ND	ND	ND	7.90	ND	ND	0.1	13.7	13.0	927
Active flow zone														
13	10.3	BQL(0.001)	ND	ND	0.499	3.79	3.95	3,830	4,300	92.6	2.0	10.8	11.5	113
51	10.1	BQL(0.001)	ND	ND	0.424	0.395	0.40	434	ND	98.9	0.3	10.3	10.2	129
Burdock area recharge														
679	8.76	ND	ND	ND	ND	ND	ND	3.55	ND	ND	0.0	10.4	11.9	67.0
631	8.43	BQL(0.001)	ND	ND	ND	0.720	0.73	797	548	97.5	0.3	15.4	17.1	75.0
3026	12.9	BQL(0.002)	ND	ND	ND	20.5	22.2	21,800	22,000	97.2	>5	18.7	18.9	116
Burdock oxidized zone														
619	7.72	BQL(0.002)	ND	ND	ND	8.37	8.17	9,080	8,850	39.2	>5	18.2	17.8	124
Lower Chilson Burdock														
682	11.4	BQL(0.001)	ND	BQL (0.007)	ND	1.23	1.35	1,440	1,200	100	1.0	17.6	16.7	169
680	10.5	ND	ND	ND	ND	ND	0.02	11.9	ND	0.0	0.0	22.3	21.1	192
684	9.67	BQL(0.001)	ND	ND	ND	1.57	1.50	1,830	1,670	100	1.5	18.5	17.8	170
Burdock Fall River														
698	7.64	BQL(0.001)	ND	ND	ND	1.49	1.49	1,800	1,510	98.0	1.0	14.9	14.4	112
688	11.6	BQL(0.001)	ND	ND	0.251	ND	0.09	9.42	ND	3.4	0.0	12.3	12.2	97.2
Upper Chilson Burdock														
692	7.56	BQL(0.002)	ND	ND	0.491	0.353	0.37	402	ND	98.3	0.0	14.3	14.1	108
Burdock downgradient														
694	12.7	ND	ND	ND	0.496	0.147	0.16	165	ND	39	0.1	8.73	8.10	118
696	8.62	ND	ND	ND	BQL (0.152)	0.113	0.13	126	ND	35	0.2	12.3	11.4	125
Dewey recharge zone														
706	6.30	ND	ND	ND	0.312	0.202	0.15	222	ND	94.3	0.2	11.1	12.9	72.3
705	9.20	ND	ND	ND	0.248	ND	ND	12.0	ND	ND	0.0	11.2	12.7	61.1
Dewey area Fall River														
685	12.0	ND	ND	ND	0.460	ND	ND	9.26	ND	ND	0.0	8.81	10.3	50.2
681	14.4	ND	ND	ND	0.565	BQL(0.045)	0.05	56.5	ND	100.0	0.0	9.06	10.4	46.0
687	11.6	ND	ND	ND	0.558	0.109	0.11	133	ND	100.0	0.1	10.1	9.90	81.6
695	11.3	ND	ND	ND	0.535	0.128	0.14	154	ND	100.0	0.1	8.07	7.40	83.0
Dewey Upper Fall River														
691	148	ND	ND	ND	0.817	ND	ND	5.10	ND	ND	0.0	4.42	5.20	28.6
Dewey area Chilson														
689	4.90	ND	ND	ND	0.617	BQL(0.051)	0.05	62.2	ND	92.0	0.0	7.16	7.80	63.9
697	8.22	ND	ND	ND	0.650	0.070	0.08	84.5	ND	86.7	0.0	7.99	7.50	117
Unkpapa														
693	34.0	ND	ND	ND	0.844	0.747	0.73	876	756	100.0	0.5	7.30	7.90	174
690	31.1	ND	ND	ND	ND	ND	0.02	18.1	ND	0.0	0.1	8.42	8.00	232

Field sample ID	USEPA-OES Magnesium (Mg) mg/L	USGS-ICPMS Magnesium (Mg) mg/L	USEPA-OES Manganese (Mn) mg/L	USGS-ICPMS Manganese (Mn) µg/L	USEPA-OES Molybdenum (Mo) mg/L	USEPA-OES Sodium (Na) mg/L	USGS-ICPMS Sodium (Na) mg/L	USEPA-OES Nickel (Ni) mg/L	USEPA-ICPMS Nickel (Ni) µg/L	USEPA-OES Lead (Pb) mg/L	USEPA-ICPMS Lead (Pb) µg/L	USEPA-OES Antimony (Sb) mg/L	USEPA-OES Selenium (Se) mg/L	USEPA-ICPMS Selenium (Se) µg/L	USGS-ICPMS Selenium (Se) µg/L
Detection limits (MDL)	0.030	0.1	0.004	2.0	0.005	0.513	0.1	0.025	0.023	0.005	0.027	0.005	0.009	0.060	1.0
Detection limits (QL)	0.100		0.014		0.017	1.710		0.084	0.077	0.017	0.090	0.017	0.030	0.198	
Alluvial															
676	131	131	ND	ND	BQL(0.005)	91.8	84.2	ND	5.62	ND	ND	BQL (0.009)	BQL(0.020)	24.4	28.2
678	453	470	2.70	2710	BQL(0.012)	633	623	ND	10.9	ND	ND	BQL (0.012)	ND	26.6	ND
NBA	217	229	0.859	846	BQL(0.005)	745	722	ND	12.2	ND	ND	ND	BQL(0.017)	22.0	22.4
Active flow zone															
13	26.3	28.6	0.162	169	ND	169	174	ND	0.690	ND	ND	ND	ND	0.585	ND
51	25.6	25.6	0.108	105	ND	188	184	ND	0.749	ND	ND	ND	ND	0.561	ND
Burdock area recharge															
679	101	111	ND	ND	ND	81.7	87.3	ND	5.44	ND	ND	ND	BQL(0.012)	18.0	1.4
631	96.2	106	0.296	319	ND	107	111	ND	3.65	ND	BQL (0.035)	ND	ND	0.555	ND
3026	126	140	1.48	1510	ND	158	160	ND	5.88	ND	ND	BQL (0.005)	ND	0.703	ND
Burdock oxidized zone															
619	118	125	1.83	1850	ND	88.1	86.7	ND	3.83	ND	0.647	ND	ND	0.521	ND
Lower Chilson Burdock															
682	106	110	0.541	519	ND	115	110	ND	4.11	ND	ND	BQL (0.007)	ND	0.838	ND
680	77.9	81.1	0.236	225	ND	143	136	ND	3.27	ND	ND	BQL (0.008)	ND	1.14	ND
684	117	122	0.552	541	ND	118	113	ND	4.17	ND	ND	ND	ND	0.883	ND
Burdock Fall River															
698	92.0	96.9	0.985	973	ND	96.0	94.1	ND	2.74	ND	ND	ND	ND	0.567	ND
688	17.3	18.1	0.068	71.1	ND	182	181	ND	0.585	ND	ND	ND	ND	0.682	ND
Upper Chilson Burdock															
692	41.5	42.8	0.162	158	ND	98.1	98.2	ND	1.37	ND	ND	ND	ND	0.459	ND
Burdock downgradient															
694	9.56	9.80	0.058	54.3	ND	266	252	ND	0.306	ND	ND	ND	ND	0.615	ND
696	33.1	32.5	0.157	142	ND	164	156	ND	0.906	ND	ND	ND	ND	0.512	ND
Dewey recharge zone															
706	34.9	38.9	0.054	57.4	ND	166	178	ND	0.914	ND	ND	BQL (0.007)	ND	0.458	ND
705	48.0	56.7	0.582	627	ND	132	145	ND	1.67	ND	ND	BQL (0.007)	ND	1.14	ND
Dewey area Fall River															
685	20.4	23.0	0.070	75	ND	200	217	ND	0.667	ND	ND	ND	ND	4.71	ND
681	21.9	24.7	0.083	90.3	ND	202	221	ND	0.640	ND	ND	ND	ND	0.795	ND
687	25.6	25.1	0.102	102	BQL(0.005)	193	180	ND	0.763	ND	ND	BQL (0.005)	ND	0.592	ND
695	17.0	16.5	0.081	78.8	BQL(0.005)	231	212	ND	0.418	ND	ND	BQL (0.006)	ND	0.540	ND
Dewey Upper Fall River															
691	3.48	4.00	ND	ND	ND	301	336	ND	0.092	ND	BQL (0.038)	ND	ND	5.77	ND
Dewey area Chilson															
689	14.1	14.8	0.044	46	BQL(0.006)	164	172	ND	0.429	ND	ND	ND	ND	0.357	ND
697	15.8	15.9	0.060	60.2	ND	198	188	ND	0.507	ND	BQL (0.034)	ND	ND	0.466	ND
Unkpapa															
693	26.9	29.7	BQL(0.008)	9.4	0.025	346	351	ND	0.603	ND	ND	BQL (0.008)	ND	2.00	ND
690	31.7	31.4	ND	3.9	BQL(0.006)	346	338	ND	0.345	ND	ND	ND	ND	1.49	ND

Field sample ID	USEPA-IC Sulfate(SO_4) mg/L	USGS-ICPMS Sulfate(SO_4) mg/L	U of A ^{34}S ‰	USEPA-OES Strontium (Sr) mg/L	USGS-ICPMS Strontium (Sr) µg/L	USEPA-OES Titanium (Ti) mg/L	USEPA-OES Thallium (Tl) mg/L	USEPA-ICPMS Uranium (U) µg/L	USGS-ICPMS Uranium (U) µg/L	NAU-ICPMS Uranium (U) µg/L	NAU-ICPMS ^{234}U/^{238}U Activity Ratio	NAU-ICPMS ^{234}U/^{238}U Activity Ratio - 1 SD	USEPA-OES Vanadium (V) mg/L	USEPA-ICPMS Vanadium (V) µg/L	USEPA-OES Zinc (Zn) mg/L	USGS-ICPMS Zinc (Zn) µg/L	USEPA-OES Silicon (Si) mg/L	USGS-ICPMS Silicon (Si) as SiO_2 mg/L	USGS-ICPMS Silicon (Si) mg/L
Detection limits (MDL)	0.103	20		0.001	5.0	0.002	0.005	0.002	10.0	0.010			0.003	0.002	0.015	30	0.130	2.0	0.93
Detection limits (QL)	1.00			0.004		0.007	0.017	0.007					0.010	0.006	0.050		0.434		
Alluvial																			
676	1,830	1,900	7.5	8.49	8,830	ND	0.158	54.5	59.9	53.9	1.36	0.01	ND	0.393	0.086	ND	7.51	13	6.1
678	3,560	4,000	5.2	10.4	11,000	ND	0.114	36.1	38.5	34.4	1.49	0.01	ND	1.91	0.073	ND	8.83	16	7.5
NBA	3,310	3,500	-11.4	4.36	4,780	ND	0.136	5.25	ND	5.28	1.90	0.02	ND	0.488	0.079	ND	5.27	9.7	4.5
Active flow zone																			
13	511	560	-4.1	1.78	1,870	ND	0.021	0.064	ND	0.01	81.4	8.44	ND	0.157	BQL (0.021)	ND	4.19	8.4	3.9
51	551	580	-4.6	2.05	2,140	ND	0.024	0.039	ND	0.03	45.8	5.56	ND	0.093	BQL (0.021)	ND	4.22	8.6	4.0
Burdock area recharge																			
679	1,660	1,800	6.4	7.78	7,990	ND	0.153	13.7	18.4	13.3	1.84	0.02	ND	0.400	0.085	ND	6.95	14	6.5
631	1,340	1,400	4.2	6.41	6,380	ND	0.106	2.34	ND	2.86	6.42	0.03	ND	0.126	0.069	ND	4.22	8.2	3.8
3026	1,810	2,000	-17.8	6.76	7,480	ND	0.121	1.76	ND	2.08	4.13	0.05	ND	0.142	0.079	ND	3.38	6.9	3.2
Burdock oxidized zone																			
619	1,430	1,500	-7.1	4.94	5,150	ND	0.107	1.56	ND	1.60	7.51	0.03	ND	0.060	2.32	2390	4.43	8.6	4.0
Lower Chilson Burdock																			
682	1,350	1,300	-15.8	6.60	6,840	ND	0.103	14.5	16.4	13.7	4.07	0.04	ND	0.582	0.068	ND	4.85	9.4	4.4
680	1,250	1,200	-10.4	7.13	7,500	ND	0.090	6.28	ND	6.34	3.76	0.02	ND	0.638	0.061	ND	3.32	6.4	3.0
684	1,460	1,500	-15.5	7.37	7,710	ND	0.117	22.1	24.1	24.7	4.07	0.02	ND	0.873	0.067	ND	4.90	9.3	4.3
Burdock Fall River																			
698	1,140	1,200	-6.6	3.80	3,940	ND	0.089	53.1	54.1	49.7	1.72	0.01	ND	0.762	0.054	ND	4.86	8.6	4.0
688	413	410	0.1	1.20	1,220	ND	0.021	0.021	ND	0.01	15.5	1.58	ND	0.090	BQL (0.018)	ND	4.20	8.2	3.8
Upper Chilson Burdock																			
692	520	550	-7.3	2.87	3,010	ND	0.044	1.54	ND	1.80	2.95	0.02	ND	ND	BQL (0.030)	ND	5.13	10	4.7
Burdock downgradient																			
694	521	510	-4.0	0.760	784	ND	ND	0.092	ND	0.08	15.9	0.80	ND	0.144	ND	ND	4.65	8.8	4.1
696	566	530	-6.6	2.72	2,890	ND	0.018	0.518	ND	0.54	8.78	0.05	ND	0.106	BQL (0.026)	ND	4.27	8.1	3.8
Dewey recharge zone																			
706	581	610	-7.3	2.86	2,900	ND	0.021	0.087	ND	0.08	18.4	0.38	ND	0.140	BQL (0.030)	ND	4.44	9.4	4.4
705	725	770	-2.9	2.41	2,370	ND	0.044	8.29	12.9	7.91	4.85	0.04	ND	0.558	BQL (0.042)	ND	4.26	8.8	4.1
Dewey area Fall River																			
685	508	520	-3.6	1.19	1,240	ND	0.019	5.61	10.2	5.31	6.10	0.01	ND	3.27	BQL (0.019)	ND	4.28	8.3	3.9
681	506	540	-3.8	1.20	1,240	ND	0.018	9.35	14.2	8.99	5.33	0.03	ND	0.230	BQL (0.018)	ND	4.01	8.4	3.9
687	580	520	-4.3	1.41	1,420	ND	BQL(0.013)	4.22	ND	4.16	6.44	0.04	ND	0.136	BQL (0.039)	34.3	4.14	6.7	3.1
695	568	480	-3.8	0.926	959	ND	BQL(0.007)	2.86	ND	2.82	3.33	0.04	ND	0.109	ND	ND	4.03	7.2	3.4
Dewey Upper Fall River																			
691	291	320	24.1	0.251	258	ND	ND	0.046	ND	0.02	2.67	0.76	ND	0.634	ND	ND	4.21	9.1	4.3
Dewey area Chilson																			
689	395	370	-4.2	0.890	913	ND	BQL(0.009)	2.82	ND	2.91	6.01	0.04	ND	1.43	ND	ND	4.41	8.3	3.9
697	463	440	-4.0	1.12	1,190	ND	BQL(0.011)	0.079	ND	0.08	18.9	0.38	ND	0.092	ND	ND	4.25	7.9	3.7
Unkpapa																			
693	936	940	7.2	1.98	2,040	ND	BQL(0.017)	BQL (0.006)	ND	0.01	4.08	0.24	ND	0.224	ND	ND	3.55	6.4	3.0
690	939	940	-9.4	2.39	2,460	ND	BQL(0.014)	0.011	ND	ND	ND	ND	ND	0.203	ND	ND	1.54	3.1	1.4

Note that temperatures in flowthrough cell can warm if very slow flow - especially for 690
Datum for latitude/longitude measurements is WGS84 from a handheld GPS unit
Listed latitude/longitude measurements were done at each well during sampling and may vary slightly from other documentation of well locations
Sulfur-34 isotopes analytical precision is 0.15 for 1 SD.

Abbreviations
USEPA = United States Environmental Protection Agency
USGS = United States Geological Survey
OES = optical emission spectrometry
ICPMS = inductively coupled plasma - mass spectrometry
VSMOW = Vienna standard mean ocean water
SD = standard deviation
TU = tritium units
MDL = method detection limit
QL = quantitation limit
ND = not detected
BQL = below quantitation limit, but number reported if above method detection limit
NTU = national turbidity units
mg/L - milligrams per liter
µg/L = micrograms per liter
µS/cm = microSiemens per centimeter

Table 3. Geochemical data for duplicates and blanks.

Field sample ID	Sample type	Comments	Sampling method	1000 $\delta^{18}O_{VSMOW}$	1 SD 1000 $\delta^{18}O_{VSMOW}$	1000 $\delta^{2}H_{VSMOW}$	1 SD 1000 $\delta^{2}H_{VSMOW}$	EPA Dissolved organic carbon mg/L	USGS-Menlo Park Tritium TU	USGS-Menlo Park Tritium 1 SD TU	Field Param. pH	Field parameter oxidation reduction potential (ORP) mV	ORP converted to Eh mV	Eh converted to pe mV	Field parameter Temperature degrees Celsius	Field parameter Dissolved oxygen mg/L	Field parameter Specific conductance µS/cm	Field parameter Turbidity NTU	Field parameter Alkalinity mg/L as $CaCO_3$
Detection limits (MDL)								0.067											
Detection limits (QL)								0.500											
684	regular		Geosub pump	-14.2	0.01	-109.2	0.24	1.46	-0.4	0.6	6.78	-139	71.9	1.2	12.8	1.2	2,668	3.14	269
684 DUP	duplicate			-14.1	0.04	-109.1	0.44	1.54	-0.1	0.5	6.86	-107	104	1.8	12.8	1.3	2,679	3.44	267
679	regular		Geosub pump	-13.5	0.07	-104.6	0.10	1.40	8.4	0.6	6.95	206	418	7.1	12.0	11.7	2,745	7.38	138
679 DUP	duplicate			-13.5	0.01	-105.1	0.25	1.51	9.4	0.6	6.96	196	408	6.9	11.5	11.6	2,746		142
695	regular		flowing	-17.5	0.01	-137.8	0.16	BQL (0.383)	0.3	0.6	6.94	-101	111	1.9	12.2	0.25	1,372	0.76	174
695 DUP	duplicate			-17.6	0.08	-138.0	0.10	BQL (0.373)	0.0	0.6	7.35	-124	88.0	1.5	12.1	0.32	1,373	0.54	172
B-VS1	blank	filtered in line	Geosub pump					BQL (0.460)											
B-VS2	blank	no filter	Direct to bottles					BQL (0.198)											
B-VS3	blank	filter and all sample tubing contact	Peristaltic pump					0.750											
B-VS4	blank	used peristaltic pump and filter to sample	Bailer					BQL (0.204)											
D-VS5	blank	filtered in line	Geosub pump					BQL (0.355)											

Field sample ID	USEPA-OES Silver (Ag) mg/L	USEPA-OES Aluminum (Al) mg/L	USEPA-OES Arsenic (As) mg/L	USEPA-ICPMS Arsenic (As) µg/L	USEPA-OES Boron (B) mg/L	USEPA-OES Barium (Ba) mg/L	USGS-ICPMS Barium (Ba) µg/L	USEPA-OES Beryllium (Be) mg/L	USEPA-OES Calcium (Ca) mg/L	USGS-ICPMS Calcium (Ca) mg/L	USEPA-OES Cadmium (Cd) mg/L	USEPA-ICPMS Cadmium (Cd) µg/L	USEPA-IC Chloride (Cl) mg/L	USEPA-OES Cobalt (Co) mg/L	USEPA-OES Chromium (Cr) mg/L	USEPA-OES Copper (Cu) mg/L	USEPA-IC Flouride (F) mg/L
Detection limits (MDL)	0.004	0.148	0.006	0.018	0.100	0.001	2.0	0.003	0.086	2.0	0.001	0.008	0.136	0.001	0.002	0.006	0.056
Detection limits (QL)	0.014	0.494	0.020	0.060	0.333	0.004		0.010	0.287		0.004	0.025	1.00	0.004	0.007	0.020	0.200
684	ND	ND	ND	47.2	BQL(0.143)	0.012	12.3	ND	365	358	ND	BQL(0.008)	9.67	BQL (0.001)	ND	ND	ND
684 DUP	ND	ND	ND	45.3	BQL(0.148)	0.012	13.2	ND	362	365	ND	ND	9.20	ND	ND	ND	ND
679	ND	ND	ND	20.7	0.430	0.009	9.1	ND	462	557	ND	0.045	8.76	ND	ND	ND	ND
679 DUP	ND	ND	ND	19.2	0.435	0.009	8.6	ND	480	552	ND	0.027	8.04	ND	ND	ND	ND
695	ND	ND	ND	16.2	ND	0.009	9.1	ND	48.9	43.9	ND	ND	11.3	ND	ND	ND	0.535
695 DUP	ND	ND	ND	16.2	ND	0.009	10.1	ND	49.4	47.2	ND	ND	11.7	ND	ND	ND	0.522
B-VS1	ND	ND	ND	BQL (0.021)	ND	ND	ND	ND	0.381	ND	ND	ND	ND	ND	ND	ND	ND
B-VS2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
B-VS3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
B-VS4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
D-VS5	ND	ND	ND	ND	ND	ND	ND	ND	BQL(0.088)	ND	ND	ND	ND	ND	ND	ND	ND

Field sample ID	USEPA-OES Iron (Fe) mg/L	USGS-Ferrozine Iron (Fe) mg/L	USEPA-ICPMS Iron (Fe) µg/L	USGS-ICPMS Iron (Fe) µg/L	USGS-Ferrozine Percent Ferrous	Field test Iron (Fe) mg/L	USEPA-OES Potassium (K) mg/L	USGS-ICPMS Potassium (K) mg/L	USGS-ICPMS Lithium (Li) µg/L	USEPA-OES Magnesium (Mg) mg/L	USGS-ICPMS Magnesium (Mg) mg/L	USEPA-OES Manganese (Mn) mg/L	USGS-ICPMS Manganese (Mn) µg/L	USEPA-OES Molybdenum (Mo) mg/L	USEPA-OES Sodium (Na) mg/L	USGS-ICPMS Sodium (Na) mg/L
Detection limits (MDL)	0.020	0.010	0.055	50.0		0.05	0.106	0.3	1.0	0.030	0.1	0.004	2.0	0.005	0.513	0.1
Detection limits (QL)	0.067		0.182				0.354			0.100		0.014		0.017	1.710	
684	1.57	1.50	1,830	1670	100	1.5	18.5	17.8	169.8	117	122	0.552	541	ND	118	113
684 DUP	1.58	1.50	1,810	1630	98.6	0.3	18.4	18.0	160.8	118	126	0.545	536	ND	117	116
679	ND	0.0	3.55	ND	ND	0	10.4	11.9	67.0	101	111	ND	<2	ND	81.7	87.3
679 DUP	ND	0.0	3.86	ND	ND	0	10.5	12.2	58.3	101	117	ND	<2	BQL(0.013)	84.1	88.7
695	0.128	0.14	154	ND	100	0.05	8.07	7.4	83.0	17.0	16.5	0.081	78.8	BQL(0.005)	231	212
695 DUP	0.132	0.13	143	ND	100	0.1	8.11	8.2	90.5	17.1	17.4	0.082	82.6	0.023	232	224
B-VS1	ND		0.839				ND	ND	ND	BQL(0.033)	ND	ND	ND	ND	ND	ND
B-VS2	ND		ND				ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
B-VS3	ND		0.229				ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
B-VS4	ND		3.72				ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
D-VS5	ND		0.290				ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Field sample ID	USEPA-OES Nickel (Ni) mg/L	USEPA-ICPMS Nickel (Ni) µg/L	USEPA-OES Lead (Pb) mg/L	USEPA-ICPMS Lead (Pb) µg/L	USEPA-OES Antimony (Sb) mg/L	USEPA-OES Selenium (Se) mg/L	USEPA-ICPMS Selenium (Se) µg/L	USGS-ICPMS Selenium (Se) µg/L	USEPA-IC Sulfate (SO_4) mg/L	USGS-ICPMS Sulfate (SO_4) mg/L	U of A ^{34}S ‰	USEPA-OES Strontium (Sr) mg/L	USGS-ICPMS Strontium (Sr) µg/L
Detection limits (MDL)	0.025	0.023	0.005	0.027	0.005	0.009	0.060	1.0	0.103	20		0.001	5.0
Detection limits (QL)	0.084	0.077	0.017	0.090	0.017	0.030	0.198		1.00			0.004	
684	ND	4.17	ND	ND	ND	ND	0.883	< 10	1460	1500	-15.5	7.37	7710
684 DUP	ND	4.20	ND	ND	BQL (0.007)	ND	0.676	< 10	1440	1500	-15.5	7.37	7760
679	ND	5.44	ND	ND	ND	BQL(0.012)	18.0	14	1660	1800	6.4	7.78	7990
679 DUP	ND	4.98	ND	ND	BQL (0.013)	BQL(0.011)	17.9	12.6	1680	1800	6.4	7.74	8020
695	ND	0.418	ND	ND	BQL (0.006)	ND	0.540	< 10	568	480	-3.8	0.926	959
695 DUP	ND	0.427	ND	ND	0.029	ND	0.729	< 10	537	530	-3.9	0.935	980
B-VS1	ND	0.129	ND	ND	ND	ND	ND	ND	ND	ND		BQL (0.004)	ND
B-VS2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND
B-VS3	ND	ND	ND	ND	ND	ND	ND	ND	BQL (0.253)	ND		BQL (0.001)	ND
B-VS4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND
D-VS5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND

Field sample ID	USEPA-OES Titanium (Ti) mg/L	USEPA-OES Thallium (Tl) mg/L	USEPA-ICPMS Uranium (U) µg/L	USGS-ICPMS Uranium (U) µg/L	NAU-ICPMS Uranium (U) µg/L	NAU-ICPMS $^{234}U/^{238}U$ Activity Ratio	NAU-ICPMS $^{234}U/^{238}U$ Activity Ratio - 1 SD	USEPA-OES Vanadium (V) mg/L	USEPA-ICPMS Vanadium (V) µg/L	USEPA-OES Zinc (Zn) mg/L	USGS-ICPMS Zinc (Zn) µg/L	USEPA-OES Silicon (Si) mg/L	USGS-ICPMS Silicon (Si) as SiO_2 mg/L	USGS-ICPMS Silicon (Si) mg/L
Detection limits (MDL)	0.002	0.005	0.002	10.0	0.010			0.003	0.002	0.015	30	0.130	2.0	0.93
Detection limits (QL)	0.007	0.017	0.007					0.010	0.006	0.050		0.434		
684	ND	0.117	22.1	24.1	24.65	4.07	0.02	ND	0.873	0.067	ND	4.90	9.3	4.3
684 DUP	ND	0.109	22.6	24.3	20.37	4.07	0.02	ND	0.870	0.071	ND	4.79	9.6	4.5
679	ND	0.153	13.7	18.4	13.25	1.84	0.02	ND	0.400	0.085	ND	6.95	14	6.5
679 DUP	ND	0.160	14.1	18.0	13.30	1.82	0.01	BQL(0.005)	0.388	BQL(0.047)	ND	6.98	13	6.1
695	ND	BQL(0.007)	2.86	ND	2.82	3.33	0.04	ND	0.109	ND	ND	4.03	7.2	3.4
695 DUP	ND	BQL(0.009)	2.92	ND	2.87	3.30	0.01	ND	0.089	ND	ND	4.11	7.5	3.5
B-VS1	ND	BQL(0.005)	BQL(0.007)	ND				ND	ND	ND	ND	ND	ND	
B-VS2	ND	BQL(0.007)	ND	ND				ND	ND	ND	ND	0.473	ND	
B-VS3	ND	BQL(0.006)	BQL(0.002)	ND				ND	ND	ND	ND	ND	ND	
B-VS4	ND	BQL(0.007)	ND	ND				ND	ND	ND	ND	ND	ND	
D-VS5	ND	BQL(0.006)	ND	ND				ND	ND	ND	ND	ND	ND	

All blanks used laboratory deionized water.
For DOC blanks, all samples except B-VS4 used low organic carbon blank water, for B-VS4, laboratory deionized water was used.
Blank samples used new tubing for each sample, except for B-VS3 which used new peristaltic pump tubing, but sampled water after going though a reused sampling "T" connection.
Sulfur-34 isotopes analytical precision is 0.15 for 1 SD.

Abbreviations

USEPA = United States Environmental Protection Agency
USGS = United States Geological Survey
OES = optical emission spectrometry
ICPMS = inductively coupled plasma - mass spectrometry
VSMOW = Vienna standard mean ocean water
SD = standard deviation
TU = tritium units
MDL = method detection limit
QL = quantitation limit
ND = not detected
BQL = below quantitation limit, but number reported if above method detection limit
NTU = national tubidity units
mg/L - milligrams per liter
µg/L = micrograms per liter
µS/cm = microSiemens per centimeter