GROUNDWATER HYDROGEOLOGY AND GEOCHEMISTRY OF THE UTAH FORGE SITE AND VICINITY

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ABSTRACT

The FORGE deep drill site is located approximately 10 miles northeast of Milford in Beaver County, Utah, on the eastern side of Milford Valley. Shallow groundwater in the study area resides in an unconsolidated basin-fill aquifer that blankets older rock units including the crystalline basement rocks that will host the FORGE EGS reservoir. The unconsolidated basin-fill aquifer supplies groundwater that is currently used for stock watering and fire suppression. The potentiometric surface slopes steeply to the west away from the Opal Mound fault from 5800 to 4900 feet in elevation over approximately 5 miles. Beneath the FORGE deep drill site, the groundwater elevation is approximately 5100 feet and the depth to water is between 200 and 600 feet. Along the valley floor west of the FORGE site, groundwater is within 150 feet of the land surface.

The chemical composition of groundwater across the study area varies according to local conditions. Springs in the Mineral Mountains are supplied by meteoric water, and the water is dilute (TDS <500 mg/L) and dominated by Ca and HCO_3. This type of water is the primary source of recharge to the basin-fill aquifer. Locally important components of groundwater are sourced from subsurface outflow from the Roosevelt Hot Springs hydrothermal system, which is 2 miles to the east of the FORGE deep drill site. This water has a high concentration of TDS (>6000 mg/L) dominated by Na and Cl. In the middle of Milford Valley near Milford, a third groundwater type with high TDS (>4000 mg/L) is dominated by Na and SO_4. Mixing trends reflected in a number of solutes and stable isotopes indicate the groundwater beneath the FORGE deep drill site is sourced primarily by subsurface outflow from the Roosevelt Hot Springs system. This water moves westward as a shallow outflow plume toward the center of the valley. Beneath the FORGE deep drill site, groundwater TDS concentrations are between 4000 and 6000 mg/L. Along the axis of Milford Valley groundwater TDS concentrations are generally less than 3000 mg/L.

To better constrain water yielding characteristics of the basin-fill aquifer near the FORGE site available aquifer test data were analyzed. Two new aquifer tests on supply wells near the FORGE site were completed by the Smithfield Corporation in the fall of 2017. Modeled results from these two tests give transmissivities of 1200 and 1600 ft^2/day. Previous aquifer tests of the basin-fill aquifer completed as part of FORGE Phase 2a and as part of earlier geothermal investigations yielded transmissivities of 240 and 1400 ft^2/day, respectively. Taken together the available aquifer test data show shallow basin fill near the FORGE site has a range of transmissivity between 240 and 1600 ft^2/day, and most shallow basin fill likely has transmissivity near 1000 ft^2/day. This transmissivity is moderate and similar to transmissivities for existing agricultural production wells nearby. Based on the available aquifer test data, the transmissivity in the basin-fill aquifer near the FORGE site is sufficient for future production wells needed to supply long-term needs of the project.

INTRODUCTION

The Frontier Observatory for Research in Geothermal Energy (FORGE) deep drill site is located just west of the Mineral Mountains, approximately 10 miles northeast of Milford in Beaver County, Utah. The project site is located west of the Roosevelt Hot Springs hydrothermal system and east of the valley axis along west-sloping alluvial fans. The FORGE project will require groundwater for various phases of drilling, completion, stimulation, and circulation testing. This paper describes the baseline hydrogeology and the groundwater availability for the FORGE project needs, based on both legacy data and new data collected as part of the FORGE project.

The groundwater system across the FORGE project area was evaluated 30 years ago as part of an initial appraisal of hot dry rock resources (Vautaz and Goff, 1987). Kirby (2012) examined the regional groundwater system including the study area to develop a groundwater budget and to examine the possibility of flow between hydrologic basins along Cove Creek and the Beaver River Valley. Other significant work has focused on the geothermal resources at Roosevelt Hot Springs (Faulder, 1991; see summaries in Moore and Nielson, 1994; Allis et al., 2015, 2016; and Simmons et al., 2016) and agricultural water and groundwater conditions in areas adjoining the study area (Mower and Cordova, 1974; Mower, 1978; Mason, 1998).

HYDROGEOLOGIC SETTING

The study area lies along the eastern margin of the Basin and Range Province in southwestern Utah. This area is characterized by a series of north-south-trending bedrock mountain ranges separated by broad basins filled with alluvium and lake sediments. Heat flow across the area is high relative to adjoining areas (Allis et al., 2015, 2016).

East of the FORGE project area, the Mineral Mountains consist primarily of Tertiary-age granitic intrusive rocks (Figure 1). Along the western margin of the range the Tertiary intrusive rocks intrude Precambrian metamorphic rocks (Nielson et al., 1986; Coleman et al., 1997). Precambrian and lower Paleozoic carbonate and clastic sedimentary rocks crop out at the northern and southern ends of the range (Nielson et al., 1986). Quaternary volcanic rocks occur west of the crest of the Mineral Mountains as well as north of the Mineral Mountains (Rowley et al., 2005). Unconsolidated basin fill covers the remainder of the study area and consists of alluvial, lacustrine, and fluvial deposits.

Figure 1 depicts the general geologic setting of the basin fill and the bedrock in the study area. Igneous and metamorphic rocks exposed in the Minerals Mountains lie beneath basin fill across the study area (e.g., Simmons et al., 2016). The thickness of basin fill increases to the west away from the Mineral Mountains as indicated by the lithologies in the Acord-1 well and other boreholes, and seismic and gravity data. Unconsolidated basin fill along the western flank of the Mineral Mountains consists primarily of sands and gravels that lie directly on fractured Tertiary intrusives (Vautaz and Goff, 1987). Along the valley floor near the Beaver River, unconsolidated basin fill is underlain by a series of consolidated to semi-consolidated Tertiary volcanic rocks and Tertiary basin fill (Hintze and Davis, 2003). The total thickness of these deposits along the valley floor is up to 9000 feet(Saltus and Jachens, 1995; Allis et al., 2016; Hardwick et al., 2016; Simmons et al., 2016). Based on well logs, groundwater in unconsolidated basin fill exists in both unconfined and confined conditions in the study area. Confined conditions exist along the valley floor where thick clay layers occur (Kirby, 2012). Unconfined conditions generally exist across the broad alluvial fans that slope to the west from the Mineral Mountains. The transition from confined to unconfined conditions correlates with the mapped position of the Lake Bonneville highstand shoreline, an elevation of approximately 5200 feet.

Unconsolidated basin fill forms the primary aquifer in the study area. The fill covers the entire study area west of the Mineral Mountains and includes a range of alluvial and lacustrine deposits. Along the west flank of the Mineral Mountains these deposits consist primarily of sand and gravel without significant confining layers (Vautaz and Goff, 1987). Within the basin -fill aquifer, particle size and sand content increases to the east up the alluvial fans. Near the western toe of these fans, the unconsolidated basin-fill aquifer is generally finer grained with significant clay layers (Figure 1).

Farther west along the valley floor, the unconsolidated basin fill includes fine grained lacustrine deposits and thick layers of clay (Mower and Cordova, 1974). Based on well logs the clay layers may be just over 100 feet thick and laterally extensive along the valley axis (Kirby, 2012). The transition between unconfined and confined conditions in the unconsolidated basin fill is likely gradational and controlled by the extent and nature of lacustrine versus alluvial deposits (Mower and Cordova, 1974). The total thickness of the unconsolidated basin-fill aquifer varies from greater than 500 feet west of the Roosevelt Hot Springs hydrothermal system to 100–400 feet thick along the valley floor (Mower and Cordova, 1974; Kirby, 2012). Current groundwater use in the study area is limited to several stock watering wells (labeled NSW, SSW, MB1, and SPW on Figure 2) and a supply well used for fire suppression at a single site (labeled FWW on Figure 2). These wells are all completed within the upper 500 feet of the basin-fill aquifer.

GROUNDWATER LEVELS

Existing groundwater elevation data was compiled and used to construct a contoured potentiometric surface across the study area (Table 1, Figure 2). Most water level data are limited to the area west of the Opal Mound fault. Two upland springs in the Mineral Mountains are shown to indicate the higher groundwater levels that occur in the bedrock of the Mineral Mountains.

Groundwater in the study area moves from areas of recharge along the upper reaches of the Mineral Mountains to areas of regional discharge along the valley floor to the north and south of the study area (Kirby, 2012). Groundwater elevations decrease to the west away from the Mineral Mountains (Table 1, Figure 2). Between the Opal Mound fault and OH-4, the potentiometric surface dips steeply westward and then flattens out towards the center of the valley. The Opal Mound fault represents the boundary of the active geothermal reservoir and is likely a lateral barrier to groundwater movement, with leakage into shallow aquifers occurring at the northern tip of the fault as indicated by chemical trends (discussed below).

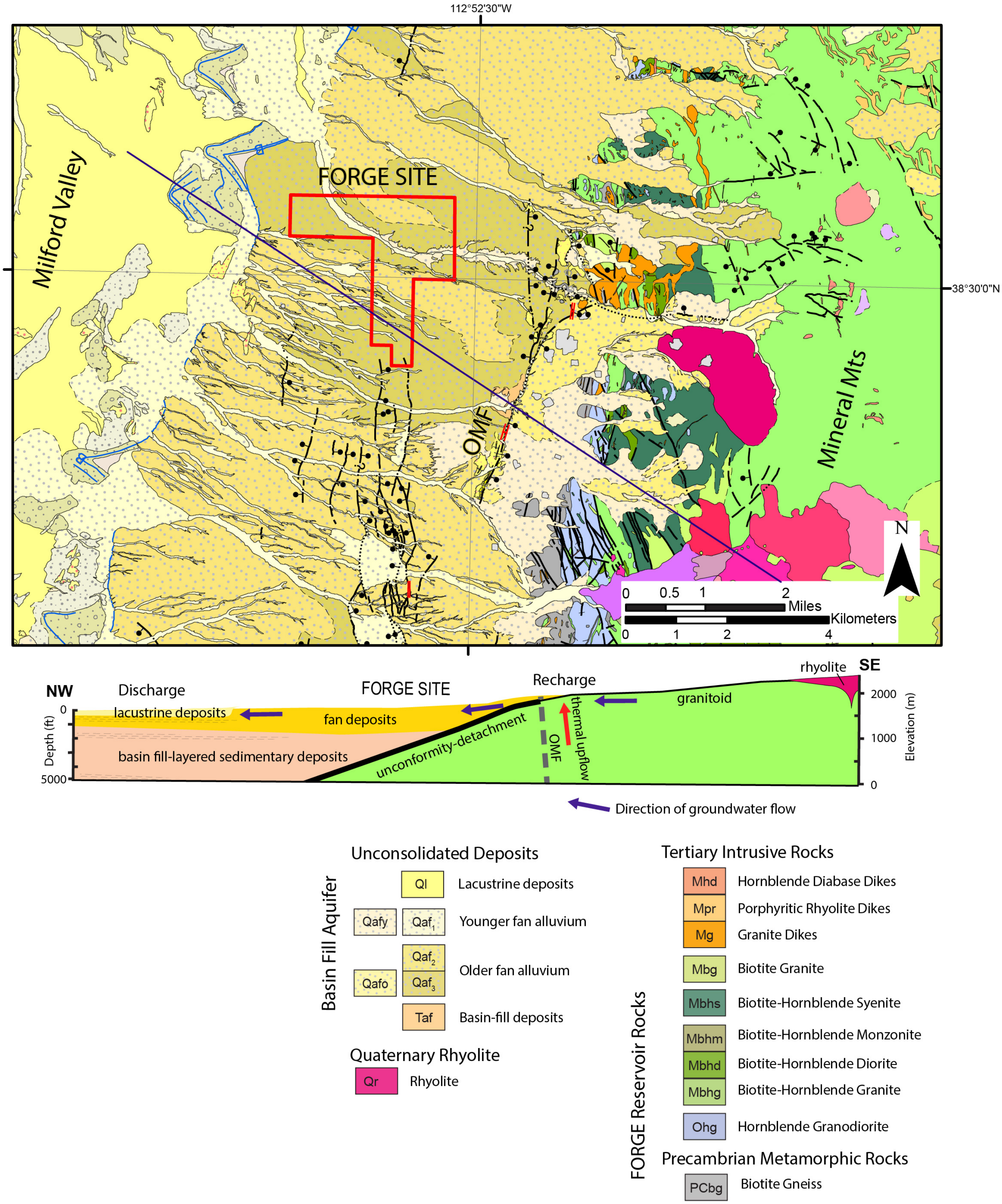

Figure 1. *Simplified geologic map of the FORGE deep well site, Milford, Utah. Geology is modified from Kirby (2019). The cross section shows simplified stratigraphy and structure across the FORGE site. The units labeled alluvium-fan deposits and lacustrine deposits compose the unconsolidated basin-fill aquifer. The zero datum for the depth axis is at 1524 m asl (5000 ft asl). Precambrian gneiss and Tertiary plutonic rocks are undifferentiated in the cross section and simply referred to as granitoid. The Roosevelt Hot Springs hydrothermal system lies east of the Opal Mound fault (OMF). The contact between granitoid and overlying basin fill is interpreted from borehole, seismic, and gravity measurements (Hardwick et al., 2019; Miller et al., 2019).*

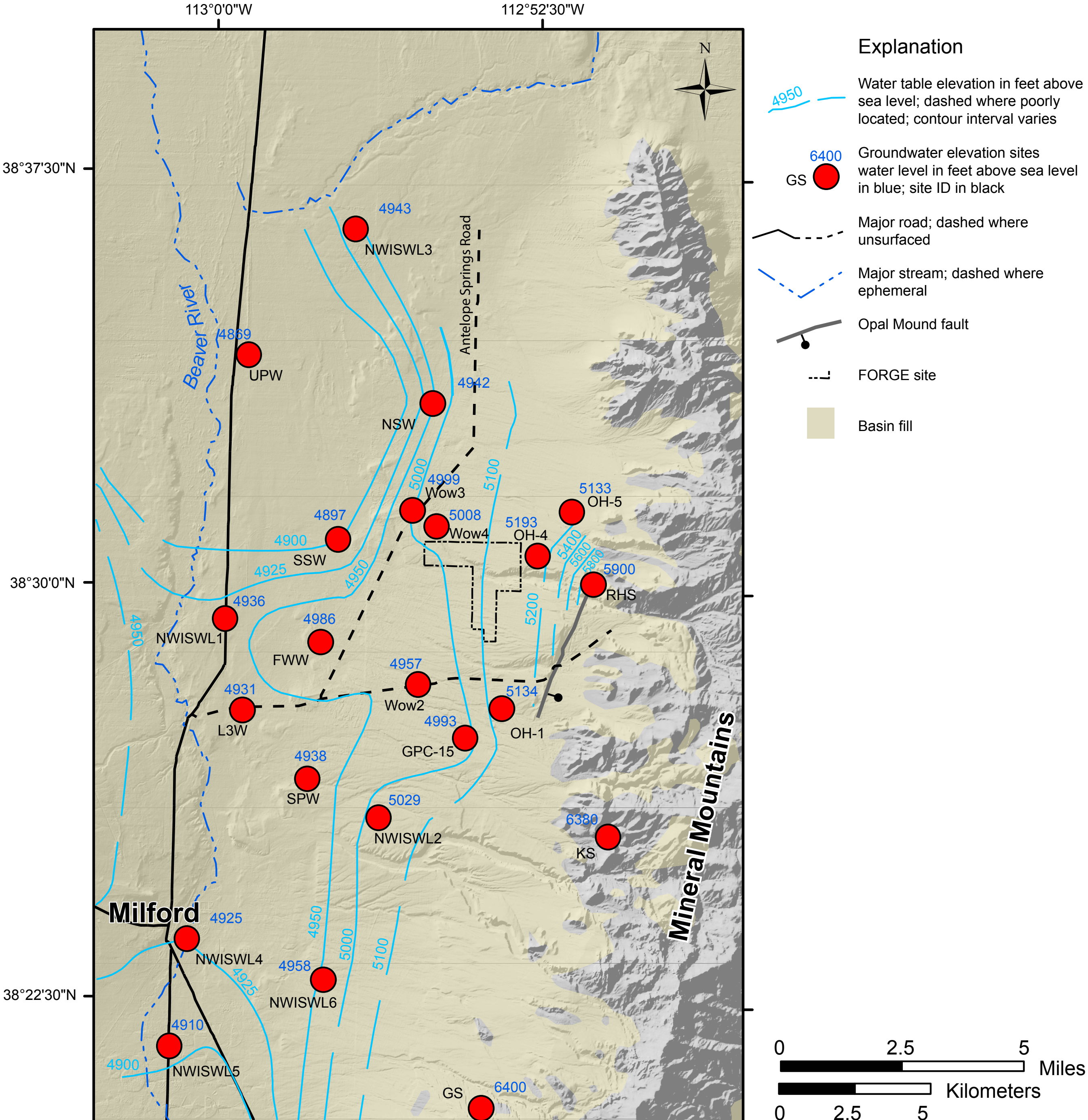

Figure 2. *Groundwater elevation map of the FORGE study area. RHS is the historic Roosevelt Hot Springs site. Site IDs correlate with Table 1.*

Table 1. *Compiled water levels for the FORGE study area.* https://ugspub.nr.utah.gov/publications/misc_pubs/mp-169/mp-169-e.zip

Name	Label[1]	Source[2]	Easting[3]	Northing	Date Measured	Land Elev (ft)	DTW (ft)[4]	Water Elev (ft)
Level 3 comm well	L3W	UGS (unpublished)	326823	4259004	8/13/14	4970.00	39.10	4930.90
First Wind Office well	FWW	UGS (unpublished)	329453	4261265	8/6/14	5035.00	49.10	4985.90
North Stock well	NSW	UGS (unpublished)	333208	4269283	8/13/14	5010.00	67.54	4942.46
UP Read siding well	UPW	UGS (unpublished)	327053	4270920	8/14/14	4882.00	12.59	4869.41
South Stock well	SSW	UGS (unpublished)	330036	4264716	8/14/14	4962.00	64.20	4897.80
Solar Panel Well	SPW	UGS (unpublished)	329007	4256688	8/13/14	5070.00	132.20	4937.80
Kirk Spring	KS	Spring	339092	4254744	--	6380.00	0.00	6380.00
Griffith Spring	GS	Spring	334829	4245644	--	6400.00	0.00	6400.00
Roosevelt Hot Springs	RHS	Spring	338216	4262751	--	5900.00	0.00	5900.00
NWIS383117112551401	Wow3	USGS (2015)	332538	4265699	3/9/15	5120.00	120.44	4999.56
NWIS382814112550101	Wow2	USGS (2015)	332721	4259849	3/9/15	5300.00	343.02	4956.98
NWIS382551112555101	NWISWL2	USGS (2015)	331398	4255382	3/9/15	5360.00	330.46	5029.54
NWIS382924112592901	NWISWL1	USGS (2015)	326254	4262060	3/6/15	4960.00	23.82	4936.18
NWIS383631112564001	NWISWL3	USGS (2015)	330628	4275136	3/9/15	4960.00	16.82	4943.18
NWIS382138113003303	NWISWL5	USGS (2015)	324382	4247736	3/5/15	4974.00	64.17	4909.83
NWIS382336113001402	NWISWL4	USGS (2015)	324961	4251331	3/6/15	4955.00	29.86	4925.14
NWIS382254112570201	NWISWL6	USGS (2015)	329547	4249940	3/6/15	5188.00	229.84	4958.16
Well OH-4	OH-4	Vautaz and Goff (1987)	336732	4264166	5/26/82	5699.00	505.25	5193.57
Well OH1	OH-1	Vautaz and Goff (1987)	335530	4259049	4/19/83	5640.00	505.25	5134.51
Well GPC-15	GPC-15	Glenn and Hulen (1979)	334304	4258057	7/25/78	5538.00	545.00	4993.00
Well Wow4	Wow4	Vautaz and Goff (1987)	333338	4265143	5/26/82	5200.00	192.26	5007.87

All location information is NAD 83 UTM zone 12N. Site ID's correlate with those on Figures 3 and 5.
[1] Labels correlate with those in Figures 3, 4, and 5.
[2] UGS measurements were collected as part of the sedimentary basins project
[3] Location coordinates are NAD 83 UTM Zone 12N.
[4] Depth to water
-- indicates no data.

Along the valley floor, groundwater elevations are generally consistent and the potentiometric surface slopes south toward areas of significant groundwater pumping near Milford or north toward areas of regional discharge (Kirby, 2012). Beneath the FORGE deep drill site groundwater elevations are near 5100 feet above sea level and between 200 and 600 feet below the land surface.

Depth to water constrains the groundwater supply and the design of new water wells. Depth to water was calculated as the difference between the potentiometric surface (Figure 2) and the surface elevation. The depth to groundwater in the unconsolidated aquifer varies sharply across the study area, from less than 20 feet near the Beaver River to over 500 feet west of the Opal Mound fault (Figure 3), decreasing to the west away from the Opal Mound fault. Near the north end of the Opal Mound fault an area of shallow groundwater correlates with historical outflow from the geothermal system. Across the FORGE deep drill site, groundwater lies within 200 feet of the ground surface along the west side and within 600 feet along the east side.

Several wells within the study area have long-term water level data (U.S. Geological Survey, 2017). These data show changes in groundwater elevation through time for the unconsolidated aquifer across the study area (Figure 4). Long-term water level change in the FORGE study area at wells WOW2 and WOW3 is less than 15 feet. Farther from the FORGE project site, NWISWL1, NWISWL2, and NWISWL3 show water level changes less than 10 feet. These data indicate that over the 70-year period in which water level data have been recorded, groundwater recharge and discharge are nearly equal across the FORGE study area. In addition, there has been little fluctuation in groundwater elevation due to current groundwater use in the area. To the south near Milford, site NWISWL5 shows a decline of 50 feet from 1985 to present, which is likely due to agricultural groundwater use.

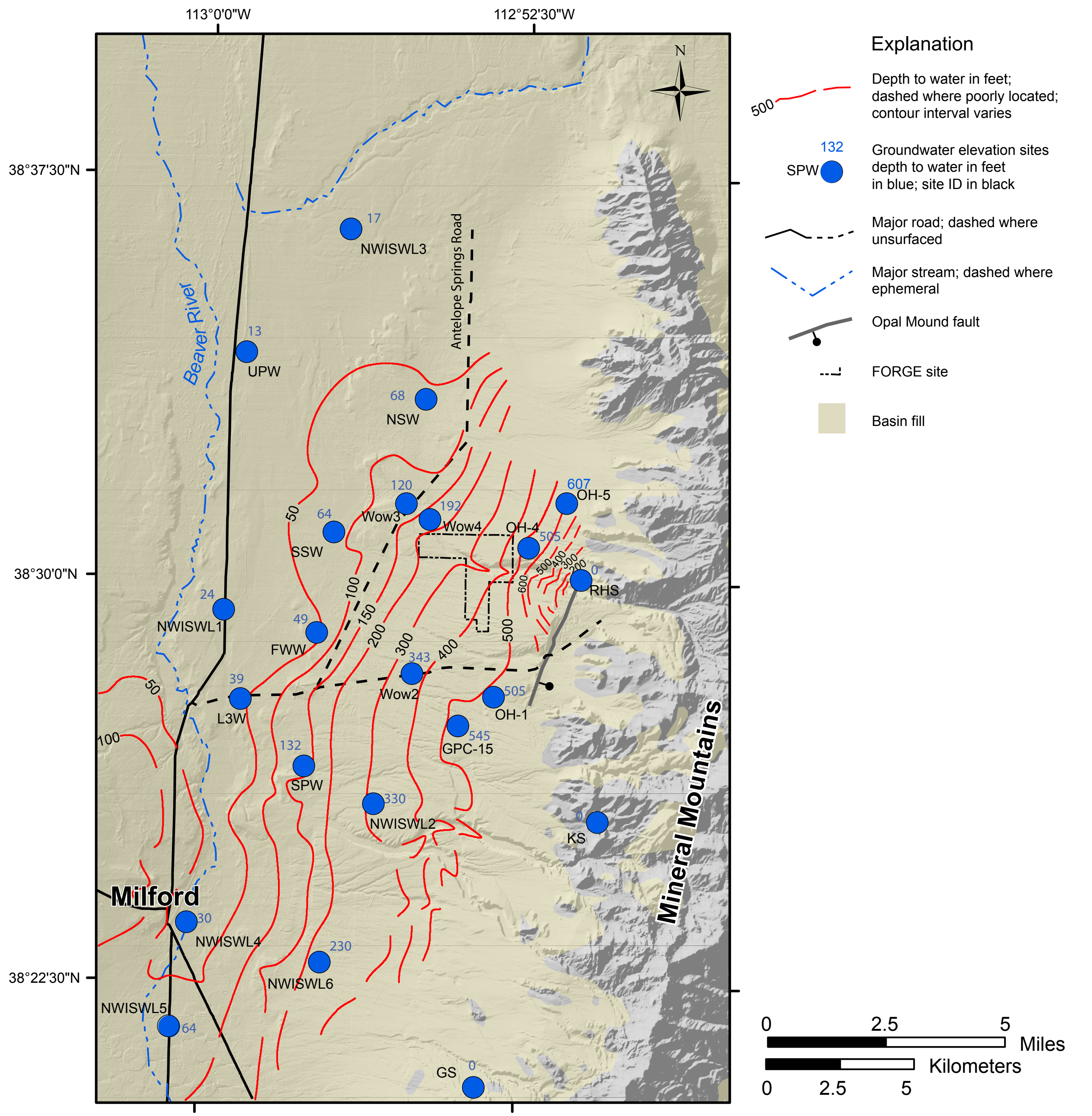

Figure 3. *Depth-to-water map for the FORGE study area. Depth to water calculated as the difference between the potentiometric surface in Figure 2 and a 5-meter digital elevation model.*

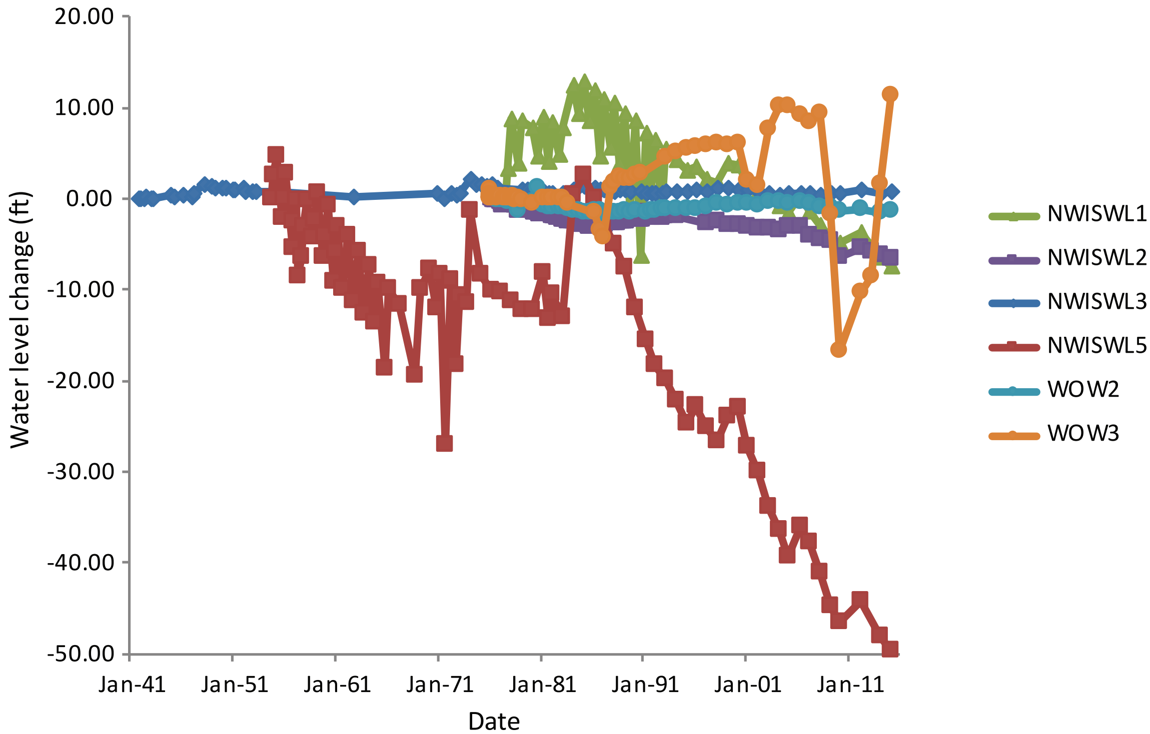

Figure 4. *Long-term water level changes in groundwater wells. Data used to construct the graph are from the USGS NWIS database (U.S. Geological Survey, 2017). Long-term water level changes near the FORGE deep drill site are less than 10 feet. To the south, near Milford, NWISWL5 shows a decline of 50 feet from 1985 to present, which is interpreted to be due to agricultural groundwater use.*

GROUNDWATER GEOCHEMISTRY AND ISOTOPES

Groundwater chemistry provides basic information concerning groundwater quality and fluid flow through the shallow aquifer. To investigate trends in groundwater chemistry, relevant chemical and isotopic data obtained in earlier investigations (e.g., Vuataz and Goff, 1987) were combined with new sampling completed as part of the FORGE project. This section examines existing chemical and isotopic data for groundwater within the FORGE project area to constrain groundwater movement and evolution and the potential for groundwater to supply water to the FORGE project.

The groundwater data comprises chemical analyses from: 1) two samples of the produced geothermal fluids and a sample from Roosevelt Hot Springs, 2) two samples from high-elevation cool springs in the Mineral Mountains, and 3) samples of cooler groundwater from wells and springs across the study area. All water samples were analyzed for the major ions Na, K, Mg, Ca, Cl, SO_4, and HCO_3, and dissolved silica (Table 2). Some samples were analyzed for other constituents including B and the stable isotopes deuterium and oxygen-18. Total dissolved solids (TDS) were calculated as the sum of dissolved constituents for each sample.

Major ion chemistry defines the dominant cation and anion in a sample based on meq/L concentrations (Kehew, 2000). Across the study area chemistry varies from Ca-HCO_3 to Na-Cl; a single sample is classified as Na-SO_4 type (Figure 5). Samples of geothermal fluids from Roosevelt Hot Springs and geothermal production wells 14-2 and 54-3 are Na-Cl waters. Nearly all samples, downgradient and west of these geothermal samples, share the Na-Cl chemistry. Samples from Kirk Springs (KS) and Bailey Springs (BS) in the Mineral Mountains, upgradient of the geothermal samples, are Ca-HCO_3, representing non-thermal water. Other Ca-HCO_3 samples are located north of the project area near Antelope Springs and to the south near Milford. A single Na-SO_4 type sample occurs in an agricultural area east of Milford. Sample NMS also consists of Na-SO_4 type water and was collected from boiling water along NMag Wash that may represent condensed steam and/or steam-heated shallow groundwater.

The groundwater compositions are differentiated using a piper diagram shown in Figure 6. Samples are categorized based on their setting relative to the general sources of groundwater in the area, including Mineral Mountain Cold Springs, Roosevelt Hot Springs upflow, geothermal outflow, and Milford Valley groundwater. Wells 14-2 and 54-3, and Roosevelt Hot Springs (RHS) plot in a corner of the diagram, and these waters are dominated by high Na and Cl, representing undiluted thermal water. Samples of upland springs BS and KS plot well to the left of the other samples with high concentrations of Ca and HCO_3. Many of the compiled samples of Milford Valley groundwater (sites NWIS11, NWIS13, NWIS14, and SPW) plot in the upper half of the piper

Table 2. *Groundwater chemistry for the FORGE study area.* [*https://ugspub.nr.utah.gov/publications/misc_pubs/mp-169/mp-169-e.zip*](https://ugspub.nr.utah.gov/publications/misc_pubs/mp-169/mp-169-e.zip)

Name	Label[1]	Easting[2]	Northing	Source	Hydrogeologic setting	Sample Date	Temp (°C)	pH	Ca(mg/L)	Mg(mg/L)	Na(mg/L)	K(mg/L)	Cl(mg/L)	SO_4(mg/L)	HCO_3(mg/L)	Si(mg/L)	F(mg/L)	Br(mg/L)	B(mg/L)	NO_3(mg/L)	As(ug/L)	TDS(mg/L)	$\delta^{18}O$(‰)	δ^2H (‰)	Water Type	Charge Bal[3]	Cl/B	$\delta^{13}C$ (‰)	pmc[4]	Tritium (TU)
14-2	14-2	339393	4262172	Capuano and Cole (1982)	Roosevelt Hot Springs upflow	9/1/77	268	6.2	9.2	0.6	2150	390	3650	78	126.09	229	5	--	29	--	--	6667	-13.6	-116	Na-Cl	-2.62	125.9	--	--	--
382919113994701	NWIS1	324364	4261972	USGS (2017)	Milford Valley groundwater	6/27/62	13.3	8.2	25	15	203.8	--	240	20	250	22	1.2	--	2	0.158	--	779	--	--	Na-Cl	-0.82	120.0	--	--	--
383016113000101	NWIS2	325399	4263513	USGS (2017)	Milford Valley groundwater	6/21/50	--	7.36	90	92	480.4	--	980	16	304	32	0	--	--	1.6	--	1995	--	--	Na-Cl	-0.04	--	--	--	--
383123113061201	NWIS9	316574	4265946	USGS (2017)	Milford Valley groundwater	9/7/63	17.8	7.8	66	23	80	11	150	57	219	30	0.7	--	0.18	1.6	--	638	--	--	Na-Cl	-0.77	833.3	--	--	--
383138113063301	NWIS8	316076	4266420	USGS (2017)	Milford Valley groundwater	9/7/63	15	7.8	56	14	64	6.7	78	40	240	24	0.4	--	0.14	2.2	--	525	--	--	Ca-HCO_3	-0.96	557.1	--	--	--
383625112534501	NWIS5	335174	4274683	USGS (2017)	Milford Valley groundwater	3/2/71	--	8	58	22	23	5.7	53	41	200	74	2.8	--	0.14	--	--	480	-15.55	-116.8	Ca-HCO_3	0.55	378.6	--	--	--
383912112561201	NWIS7	331410	4280085	USGS (2017)	Milford Valley groundwater	5/9/71	15	7.7	45	14	30	5.2	54	43	161	61	0.3	--	0.1	0.113	--	414	--	--	Ca-HCO_3	-2.51	540.0	--	--	--
382403112592601	NWIS3	326087	4252116	USGS (2017)	Milford Valley groundwater	7/21/78	20.5	7.7	270	230	730	13	300	2300	470	43	0.6	--	1.7	2.3	--	4361	--	--	Na-SO_4	0.14	176.5	--	--	--
382254112570201	NWIS4	329572	4249956	USGS (2017)	Milford Valley groundwater	5/20/71	20.5	8	33	5.7	29	2.2	33	25	130	27	0.6	--	--	0.7	--	286	--	--	Ca-HCO_3	-2.71	--	-10.37	47.31	<0.1
382349113021101	NWIS6	322165	4251615	USGS (2017)	Milford Valley groundwater	5/6/71	20	7.9	64	23	72	4.9	86	130	200	45	1	--	0.23	--	--	626	--	--	Ca-HCO_3	-0.85	373.9	--	--	--
Roosevelt Hot Springs	RHS	338369	4263072	Capuano and Cole (1982)	Roosevelt Hot Springs upflow	9/11/57	55	7.9	22	3.3	2500	488	4240	73	156	310	7.5	3.3	38	2.48	--	7844	--	--	Na-Cl	-2.03	111.6	--	--	--
Wow 2	Wow 2	332746	4259842	Vautaz and Goff (1987)	Geothermal outflow	5/25/82	32.3	7.22	151	33	494	19	1050	3.4	229	46	0.49	0.15	7.53	--	--	2034	--	--	Na-Cl	-2.92	139.4	--	--	--
Wow 3	Wow 3	332637	4265602	Vautaz and Goff (1987)	Geothermal outflow	4/19/83	23.5	8.28	77	15.4	1540	185	2840	3.2	90	2	0.91	2	21.5	--	--	4777	-13.25	-112.7	Na-Cl	-4.29	132.1	--	--	--
Well OH-4	OH-4	336732	4264166	Vautaz and Goff (1987)	Geothermal outflow	5/26/82	48.2	6.89	260	40	1800	240	3440	84.8	104	60	1.64	2.1	30.6	--	--	6063	--	--	Na-Cl	-1.34	112.4	--	--	--
Antelope Springs	AS	337217	4280141	Kirby (2012)	Milford Valley groundwater	6/6/07	15.4	7.5	38.59	10.68	31.01	4.75	51.47	38.72	141.4	41	0.46	0.28	--	0.55	--	359	-15.67	-116.9	Ca-HCO_3	-3.8	--	--	--	--
South Stock Well	SSW	330036	4264716	This study	Geothermal outflow	11/6/17	15.8	7.2	439.1	93	1035	45.4	2365	23	341	102	0	--	17	1.1	21	4373	-13.59	-112.8	Na-Cl	-3.46	129.4	-0.35	3.27	0.1
North Stock Well	NSW	333208	4269283	Allis et al. (2015)	Geothermal outflow	8/13/14	16.8	7.4	302	13.6	882	62.2	1640	22.4	828	78.9	0	--	12.7	0.02	438.35	3842	-13.95	-106.9	Na-Cl	-4.51	129.1	-2.91	1.2	<0.1
Level 3 communications well	L3W	326823	4259004	This study	Milford Valley groundwater	11/8/17	19.1	6.7	95.1	70.8	223	12.9	657	2.5	53	23.5	0	--	1.09	0.03	4	1124	-15.3	-117.6	Na-Cl	2.99	577.1	-4.11	13.3	<0.1
BLM solar panel well	SPW	329005	4256696	Allis et al. (2015)	Milford Valley groundwater	8/14/14	24.2	7.1	117	19.4	164	7.6	411	1.5	173	36.2	0	--	2.09	0.31	1.93	932	-14.68	-109.9	Na-Cl	0.36	196.7	-4.78	14.65	<0.1
First Wind Well	FWW	329453	4261265	Allis et al. (2015)	Geothermal outflow	8/14/14	32.4	7.9	203	103	1100	45.2	1870	172	580	91.9	0	--	11.7	0.02	67.3	4177	-14.57	-115.9	Na-Cl	0.52	159.8	--	--	--
54-3	54-3	338607	4262196	Capuano and Cole (1982)	Roosevelt Hot Springs upflow	--	260	--	8	2	2320	461	3860	73	232	263	6.8	--	29.9	--	--	7256	--	--	Na-Cl	-1.76	129.1	--	--	--
Bailey Spring	BS	342471	4260408	This study	Mineral Mt cold springs	11/6/17	6.6	7.39	59.6	10.3	19.2	2.8	22	9	217	23	1.6	--	0.0014	0.4	1	350	-15.31	-114.4	Ca-HCO_3	0.92	10142.9	-12.89	98.86	4.2
Kirk Spring	KS	339092	4254744	Vautaz and Goff (1987)	Mineral Mt cold springs	5/27/82	6.1	7.6	50	11.7	33	4.6	34.5	21.8	234	23	1.15	--	0.0014	--	--	414	--	--	Ca-HCO_3	-3.02	24642.9	-12.53	91.56	0.7
382924112592901	NWIS14	326335	4262088	USGS (2017)	Milford Valley groundwater	7/21/14	18.4	7.2	63.9	24.9	67.9	2.8	146	109	101	27.1	0.28	0.193	0.183	0.7	0.014	510	--	--	Ca-Cl	1.3	797.8	--	--	--
382456113010501	NWIS12	323625	4254001	USGS (2017)	Milford Valley groundwater	9/17/70	27.1	7.9	20	6.4	74	8.4	17	31	220	70	1.2	--	0.23	0.023	--	336	-16.4	-124	Na-HCO_3	2.4	73.9	--	--	--
382506113041201	NWIS13	319253	4254308	USGS (2017)	Milford Valley groundwater	5/14/71	--	7.6	140	28	66	4.1	160	270	118	37	0.3	--	0.18	13	--	821	--	--	Ca-SO_4	0.8	888.9	--	--	--
382212112585301	NWIS10	326765	4248827	USGS (2017)	Milford Valley groundwater	5/9/71	19	7.9	65	23	50	2.6	59	160	158	26	0.6	--	0.01	2.7	--	476	--	--	Ca-SO_4	-1.4	5900.0	--	--	--
382204113002501	NWIS11	324572	4248566	USGS (2017)	Milford Valley groundwater	5/18/62	14.4	7.6	390	120	200	10	680	780	169	45	0.1	--	0.32	0.41	--	2860	--	--	Ca-SO_4	0	2125.0	--	--	--
Well OH-5	OH-5	337664	4265503	Vautaz and Goff (1987)	Geothermal outflow	5/26/82	82.7	6.56	330	41	620	34	1740	5.16	51	44	1.56	0.18	9.28	--	--	2895	-13.2	-106.8	Na-Cl	-2.4	187.5	--	--	--
Negro Mag Seep	NMS	338251	4262824	This study	Geothermal outflow	11/7/17	85	4.2	8	2.6	26.4	10	2	127	0	--	0.5	--	--	0.1	7	188	-8.69	-85.9	Na-SO_4	-15.19	--	--	--	--
Murphy-Brown Supply Well 1	MB1	328302	4259283	This study	Milford Valley groundwater	11/1/17	22.4	7.09	145.4	77.5	300	17.1	806	9	341	--	0.1	--	--	--	2	1501	-14.96	-115.9	Na-Cl	3.75	--	-6.41	5.22	<0.1

[1] Label field correlates with labels shown on figures.
[2] Location coordinates are NAD 83 UTM Zone 12N.
[3] Charge balance of meq/L of anions to cations, taken as percent of total.
[4] Percent Modern Carbon

-- indicates no data.

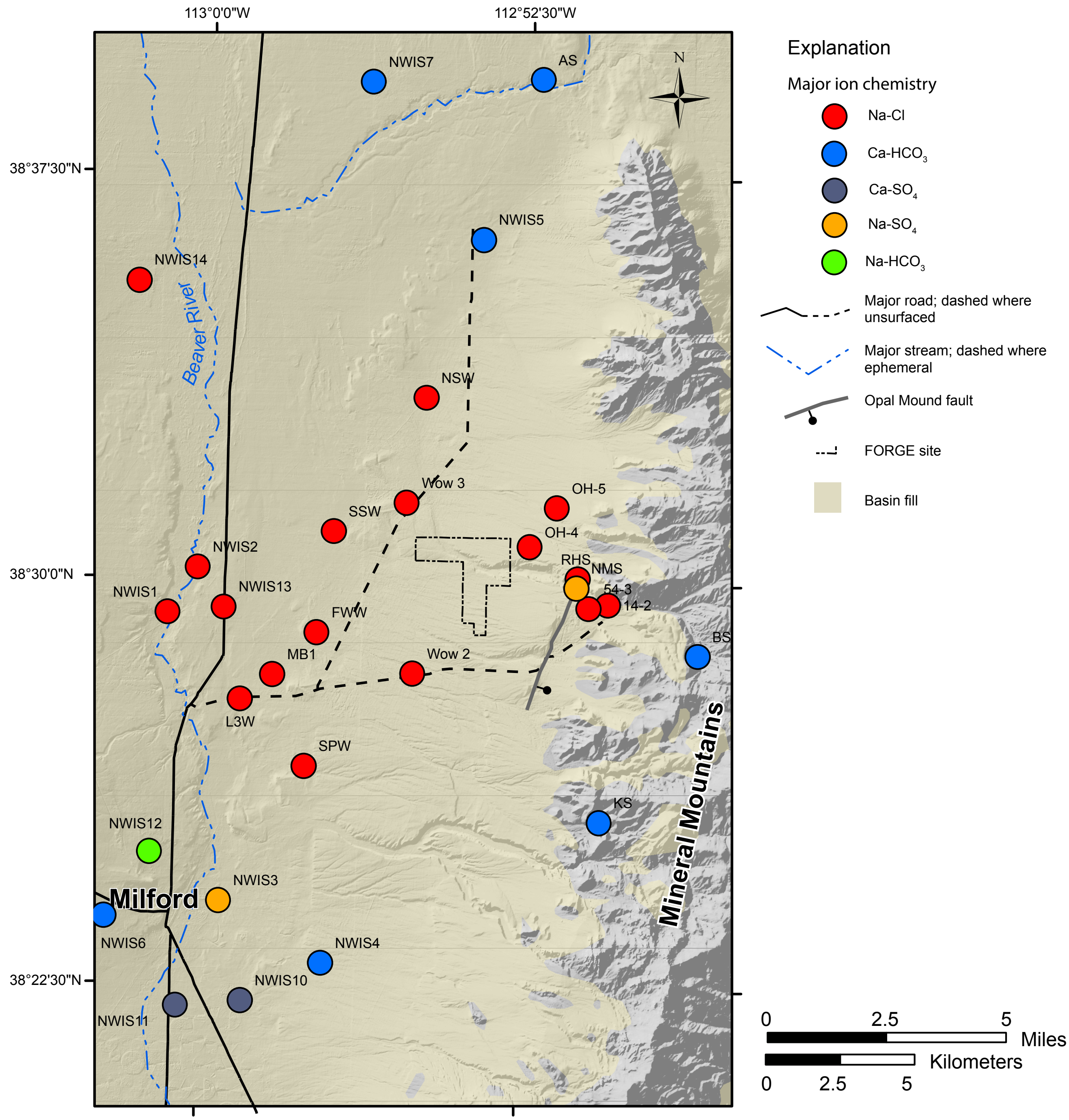

Figure 5. *Major ion chemistry for compiled groundwater samples. Site ID corresponds with those in Table 2. Most water samples near the FORGE site consist of Na-Cl type waters.*

diagram owing to increased concentrations of SO_4 relative to Cl. Samples from locations west of the Opal Mound fault that include geothermal outflow (sites WOW3, NSW, SSW, and FWW) show increasing relative concentrations of Ca, Mg, and SO_4 relative to Na and Cl, which may result from mixing between RHS thermal water, water similar to the upland springs BS and KS, and Milford Valley groundwater in the basin-fill aquifer. Based on the distribution of the different chemical types illustrated by the map (Figure 5) and the piper diagram (Figure 6), the chemistry of outflow samples is likely controlled by dilution of Roosevelt Hot Spring upflow with Milford Valley groundwater as groundwater moves to the west away from Roosevelt Hot Springs.

To better examine possible mixing trends, the ratio of major anions Cl to HCO_3 versus the TDS of each sample is shown in Figure 7. Samples appear to plot in at least two groupings which are not exclusive to a given sample's assumed setting. Samples of thermal water from wells 14-2 and 54-3, and RHS plot in a zone in the upper right part of the figure along with several of the samples of geothermal outflow including OH-4, OH-5, and Wow3. The remainder of the geothermal outflow samples plot in

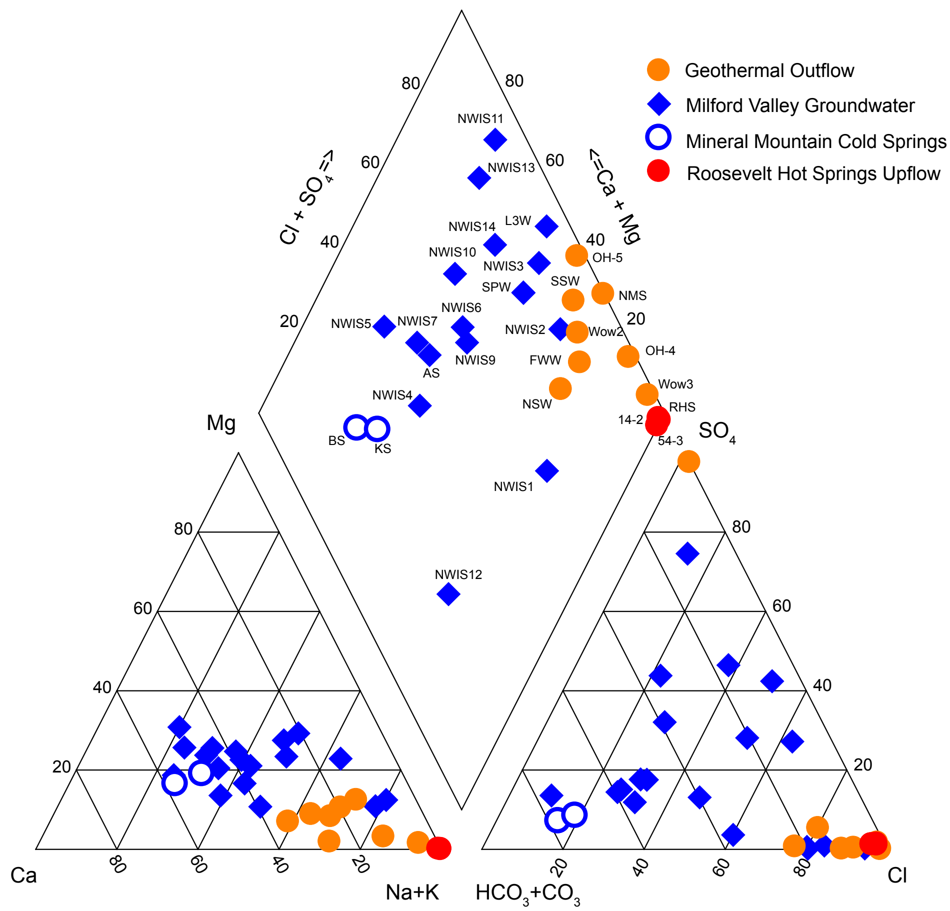

Figure 6. *Piper diagram of compiled groundwater chemistry. Site ID corresponds with those in Table 2.*

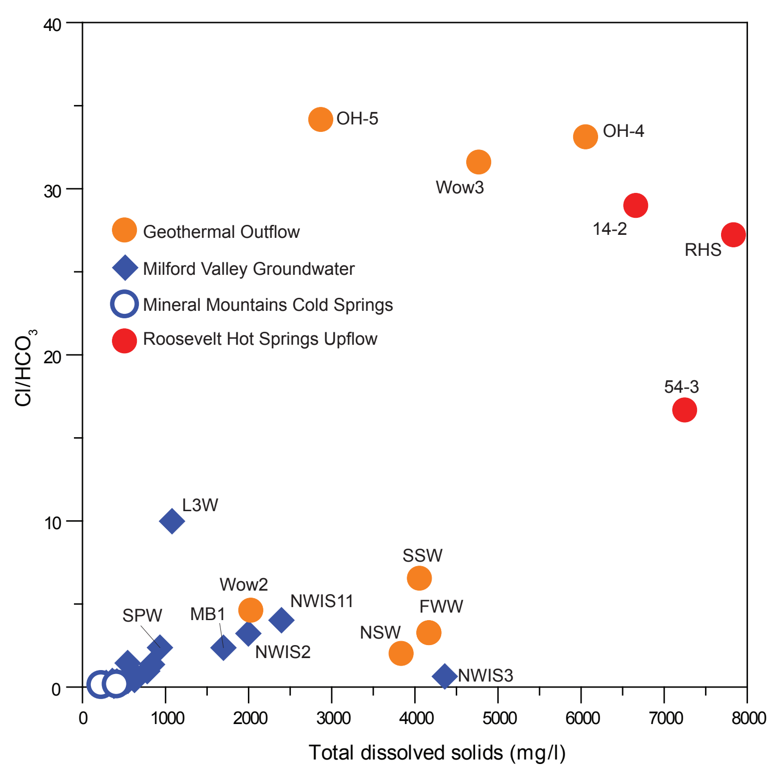

Figure 7. *Graph of the ratio of Cl and HCO_3 anions versus total dissolved solids. Samples do not lie along a simple mixing trend, implying that simple end member mixing does not control all chemical variation.*

the lower half of the diagram. The offset among samples of outflow implies that a simple linear mixing trend between Milford Valley groundwater or upland springs and Roosevelt Hot Springs upflow is insufficient to explain the variation in major ion chemistry in geothermal outflow samples.

In addition to major ion chemistry, many of the groundwater samples include B analyses that can be examined to better understand fluid flow in the groundwater system. High B concentrations are typical of many geothermal systems and comparisons of these concentrations to the relatively nonreactive Cl provides an additional perspective on groundwater mixing in the FORGE area. A plot of the ratio of Cl to B versus TDS for the sample set is shown in Figure 8. Samples of Roosevelt Hot Springs upflow have a characteristic Cl/B value of ~100 and most Milford Valley groundwater samples range from 200 to 700. Geothermal outflow samples are generally between 150 and 200 Cl/B and appear to lie along a trend of decreasing TDS and relatively consistent Cl/B. This implies that, at least with respect to Cl and B, simple dilution of Roosevelt Hot Springs upflow by groundwater with comparable Cl/B may explain observed variation in constituents. However, concentrations of the other major solutes may vary due to additional water-rock interactions and/or mixing of other sources that are not characterized by this sample set.

A map of TDS concentrations shows a plume of high-TDS thermal water emanating from the north end of the Opal Mound fault and Roosevelt Hot Springs (Figure 9). This plume broadly defines the area of thermal outflow in which TDS concentrations decrease to the west, north, and south as the plume disperses in the unconsolidated basin-fill aquifer across the FORGE deep drill site. Additional areas of high TDS (greater than 3000 mg/L) occur across Milford Valley to the northwest of the FORGE area and to the south near Milford. The extent and scale of the plume implies long-term subsurface outflow of geothermal fluids from the Roosevelt Hot Springs area.

The TDS thresholds for primary and secondary drinking water standards are 500 and 1000 mg/L, respectively. Groundwater beneath the FORGE site ranges from 4000 to >6000 mg/L, and it is unsuitable for use as drinking water supply. Potential supply wells located along the Antelope Springs Road east of the FWW well could encounter groundwater with TDS ranging from 2000 mg/L to just over 4000 mg/L.

The abundances of stable isotopes deuterium and oxygen (expressed as δ^2H and δ^{18}O, respectively) in water provide information about both the source of the groundwater and the degree of high-temperature water-rock interaction (Clark and Fritz, 1997). These isotopes also provide an independent constraint on the interpretation of mixing trends. Deuterium and oxygen-18 isotope data exist for 11 samples (Table 2). Samples AS, NWIS5, SPW, BS, and NSW plot along and near the meteoric water lines and represent the compositions of local rainfall and snowmelt (Figure 10). Two samples of thermal water (14-2 and RHS) are shifted to the right from the meteoric water line by nearly 2 per mil δ^{18}O. These samples show evidence of isotope exchange produced by high-temperature water-rock interaction (Bowman and Rohrs, 1981). Samples L3W, FWW, SSW and WOW3 plot in between the thermal waters and the meteoric water line, reflecting mixing as the thermal (high-TDS) plume disperses westward through the shallow aquifer.

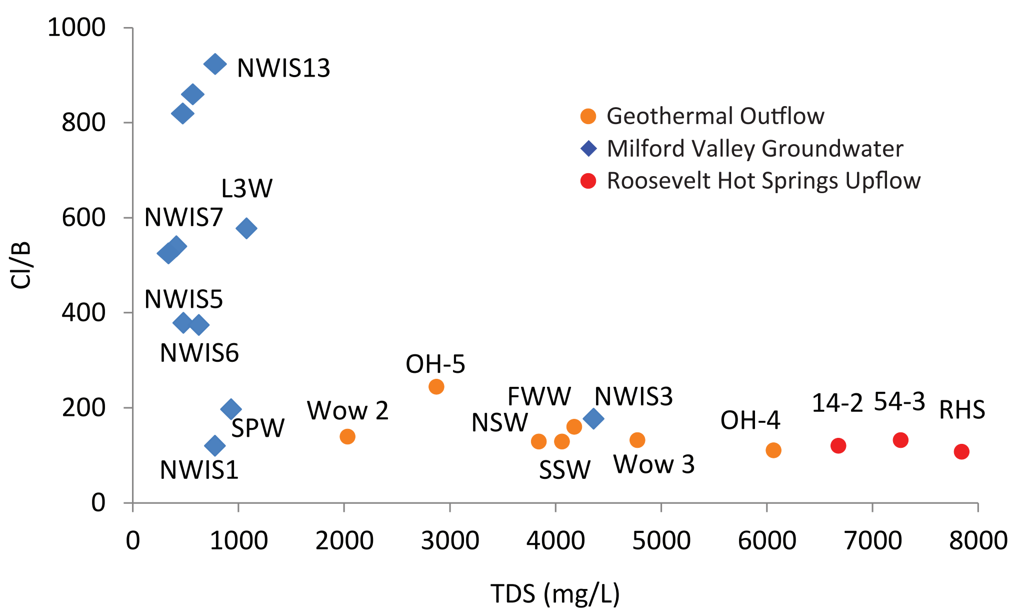

Figure 8. *Graph of Cl/B versus TDS. Most groundwater samples surrounding the FORGE deep drill site have uniform Cl/B values of ~150 with decreasing TDS resulting from mixing and dilution.*

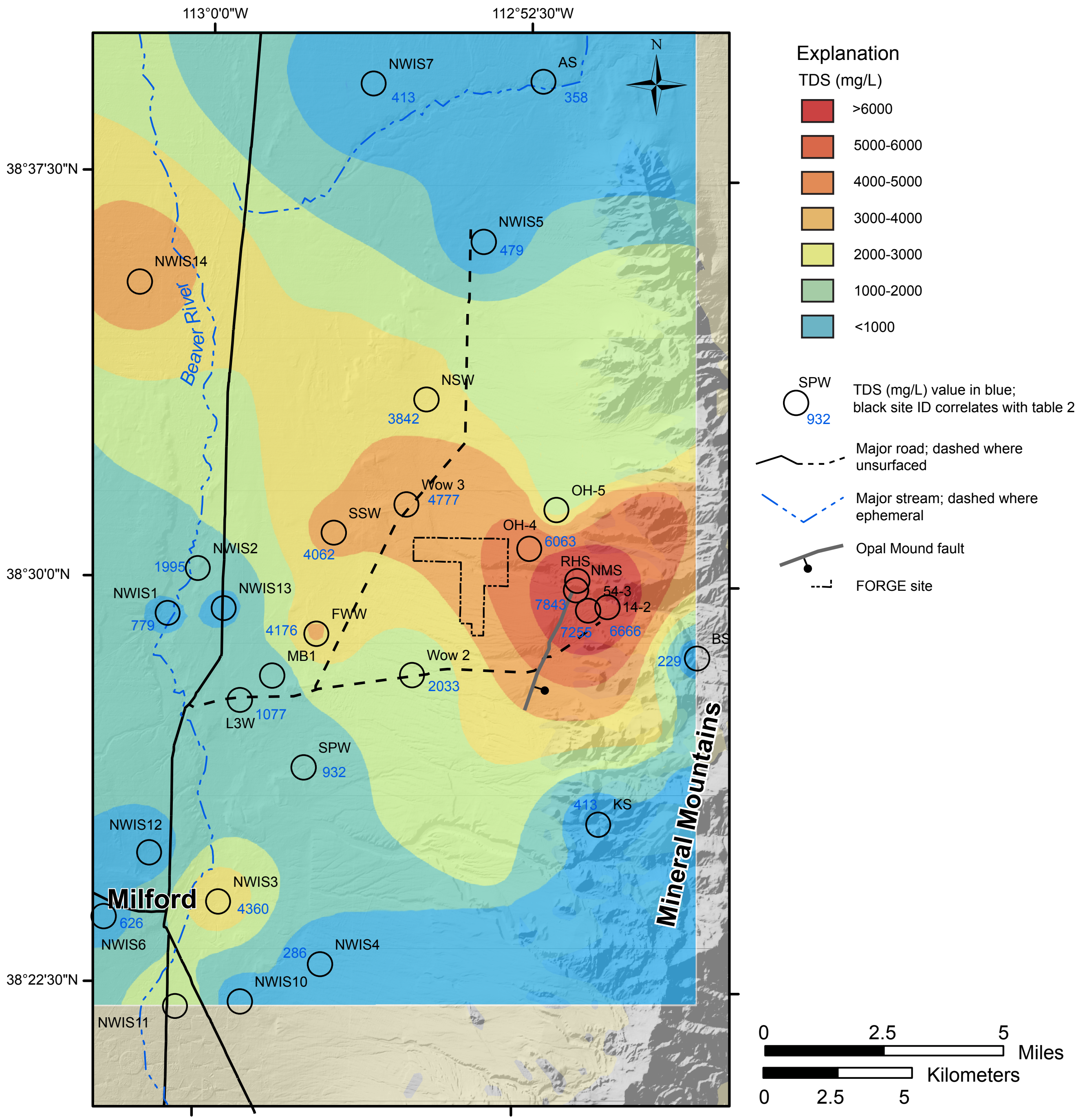

Figure 9. *Map of TDS concentrations. A high-TDS plume extends to the west from Roosevelt Hot Springs (RHS) and the north end of the Opal Mound fault.*

As part of the FORGE Phase 2b project, eight groundwater sites were sampled for the radiogenic and stable isotopes of carbon and tritium to constrain groundwater age adjoining the FORGE site (Table 2). Sample sites included the upland springs in the Mineral Mountains (sites KS and BS), geothermal outflow sites (NSW and SSW), and Milford Valley groundwater sites (MB1, L3W, SPW, and NWIS4) (Figure 11). Samples were collected in clean and rinsed HDPE bottles, carefully filled to minimize atmospheric contamination. Samples of carbon isotopes were analyzed via AMS methods at the University of Georgia CAIS laboratory. Samples of tritium were analyzed via scintillation counting at the Brigham Young University hydrogeology laboratory.

Pmc is the percent modern carbon relative to an atmospheric standard for carbon-14. Due to significant fractionation and isotopic dilution that is common to the recharge process, values typical of recently recharged water can range from 50 to 100. Low values of pmc, less than 50, indicate at least a component of the pmc concentration has been reduced via radioactive decay. Lower values tend to indicate older waters that have significant age and or may have experienced significant water-rock interaction and carbon

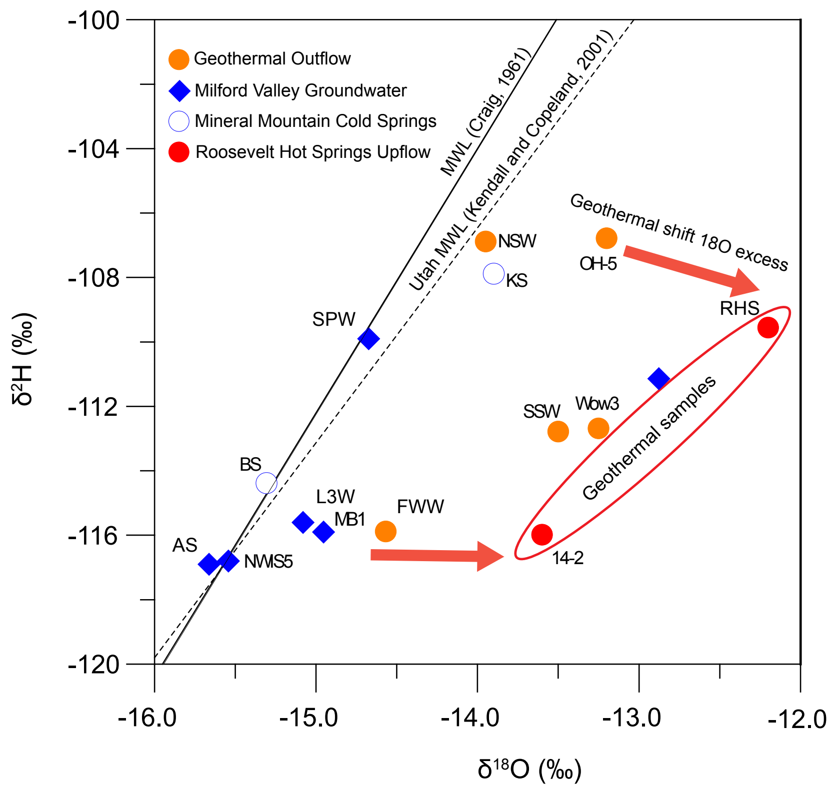

***Figure 10.**Plot of stable isotope compositions (per mil) of groundwater. The meteoric water line (MWL) is defined by Craig (1961) and the Utah meteoric water line is defined by Kendall and Copeland (2001). Thermal water (14-2 and RHS) shows a significant positive shift in $\delta^{18}O$ relative to local meteoric water due to isotope exchange during high-temperature water-rock interaction.*

isotopic fractionation and exchange between the dissolved carbon and mineral carbonate (Clark and Fritz, 1997). Typical Basin and Range groundwater systems show pmc that decreases away from areas of recharge. In the case of the FORGE area, recharge of the basin-fill aquifer likely occurs along the upper reaches of the west-sloping alluvial fans. Following this conceptualization, pmc should decrease (and groundwater age increase) as groundwater flows down-gradient away from the Mineral Mountains towards the valley axis. Samples of the upland springs and sites NWIS4 and SPW follow this general pattern of decreasing sample elevation and distance from upland recharge yielding lower pmc and older water. Samples to the north show a different pattern in which the pmc and groundwater age for samples NSW, SSW, MB1, and L3W have approximately similar positions on the west-sloping fans and which appear to vary with proximity to the plume of geothermal outflow (Figures 11 and 12). The lowest pmc occurs at sites NSW and SSW which are closest to the outflow plume. Pmc increases south of SSW to L3W, away from the outflow plume. This distribution implies that the pmc concentration of these sites is controlled not by radioactive decay and water-rock interaction and instead is controlled by mixing of the geothermal plume with Milford Valley groundwater. This distribution also implies that geothermal outflow is low pmc or carbon-14 free. Groundwater ages derived from these pmc values would not represent ages of recharge and are therefore not calculated. Further sampling of the Roosevelt Hot Springs upflow is necessary to confirm the pmc content of the outflow plume.

Tritium is a radioactive isotope of hydrogen with a half-life of 12.7 years, and is generated naturally in the upper atmosphere. Precipitation, and recently recharged groundwater, typically contain concentrations between 2 and 8 TU or tritium units. Groundwater having tritium concentrations greater than 0.5 TU generally indicates recent recharge at a given site (Clark and Fritz, 1997). Of the eight samples collected, only the upland springs KS and BS have tritium greater than 0.5 TU. All other sites have low or undetectable tritium concentrations with no evidence of recent recharge at these sites. These low values correlate with the low pmc values and further support limited active recharge of groundwater near the FORGE site.

AQUIFER TESTS

Available aquifer tests constrain the water yielding characteristics of the basin-fill aquifer. Data from two single-well aquifer tests near the Utah FORGE project site were provided by the Smithfield Corporation. These aquifer tests were completed in the fall of 2017 as part of a business expansion project by the Smithfield Corporation. The results of the new aquifer tests

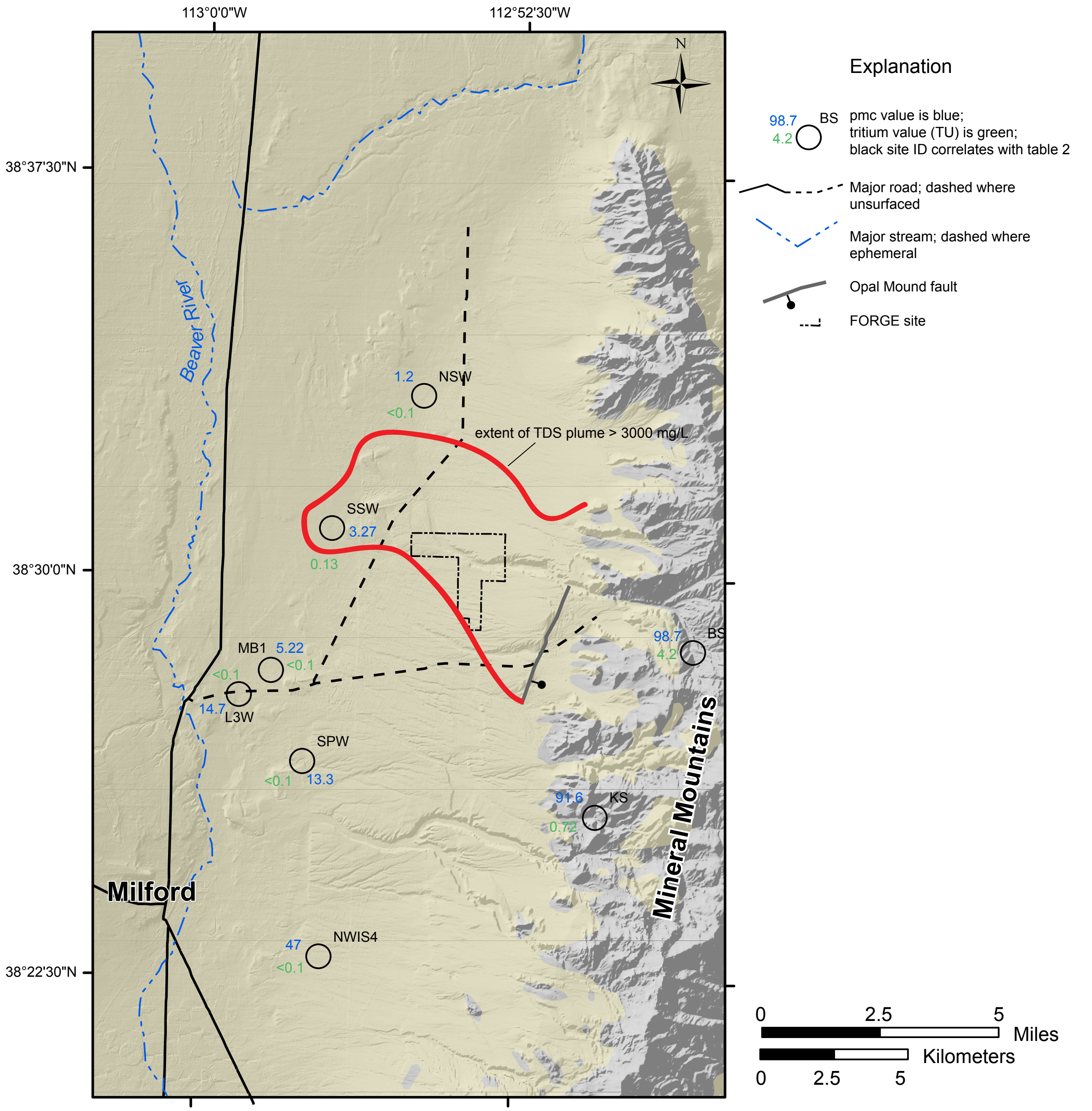

Figure 11. *Map of carbon isotope and tritium samples. Isotopic compositions typical of recharge are shown at sites KS and BS. Samples near the high-TDS plume have low pmc and tritium values.*

are summarized below. These data augment an existing aquifer test completed for the FORGE project Phase 2a and an older aquifer test presented by Vautaz and Goff (1987).

The first aquifer test was conducted on an 8-inch diameter supply well drilled in the summer of 2017 by the Smithfield corporation for agricultural supply. The well (labeled MBW-1) is located approximately 4 miles southwest of the Utah FORGE site. The MBW-1 well is completed in unconsolidated basin fill and has a total depth of 401 feet (Figure 13). Based on driller's logs, the well is screened in gravel, sand, and clay between 322 and 353 feet. The total aquifer thickness is 20 feet. This aquifer section is confined by clay between 72 and 103 feet. Static water level was 60 feet below land surface prior to pumping. Total drawdown after pumping was 3.2 feet.

The MBW-1 well was pumped at a constant rate of 50 gpm for a total of 18 hours. Drawdown was measured during the pumping period and a 4-hour recovery period (Table 3). These data were input into the modeling software AQTESOLVE

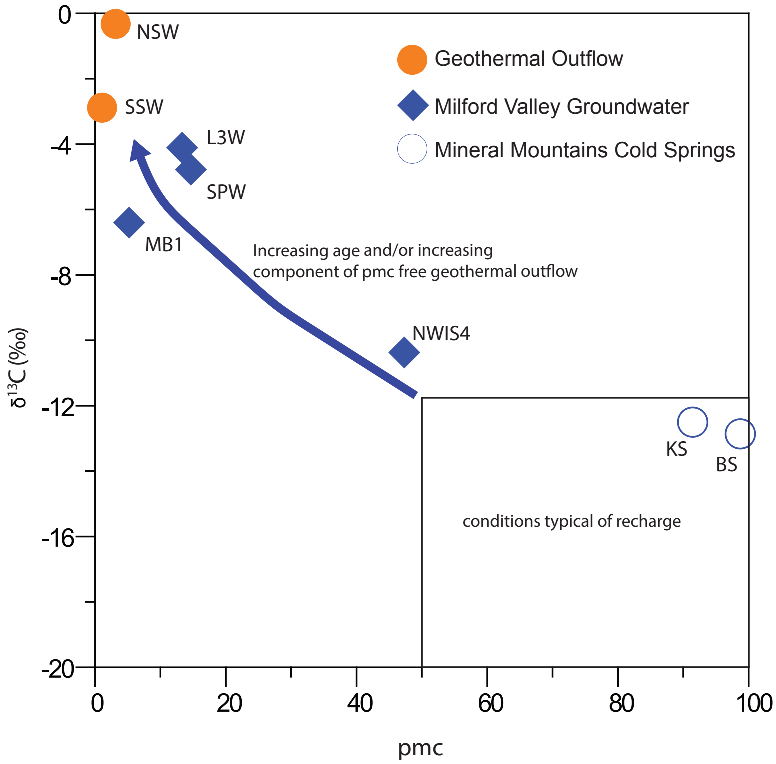

Figure 12. *Graph of pmc versus carbon-13. Graph shows carbon isotopic conditions typical of recharge in the lower right corner. Increasing amounts of water-rock interaction, time since recharge, and or increasing fractions of pmc free geothermal outflow yield a trend of increasing ^{13}C and decreasing pmc towards the upper left corner.*

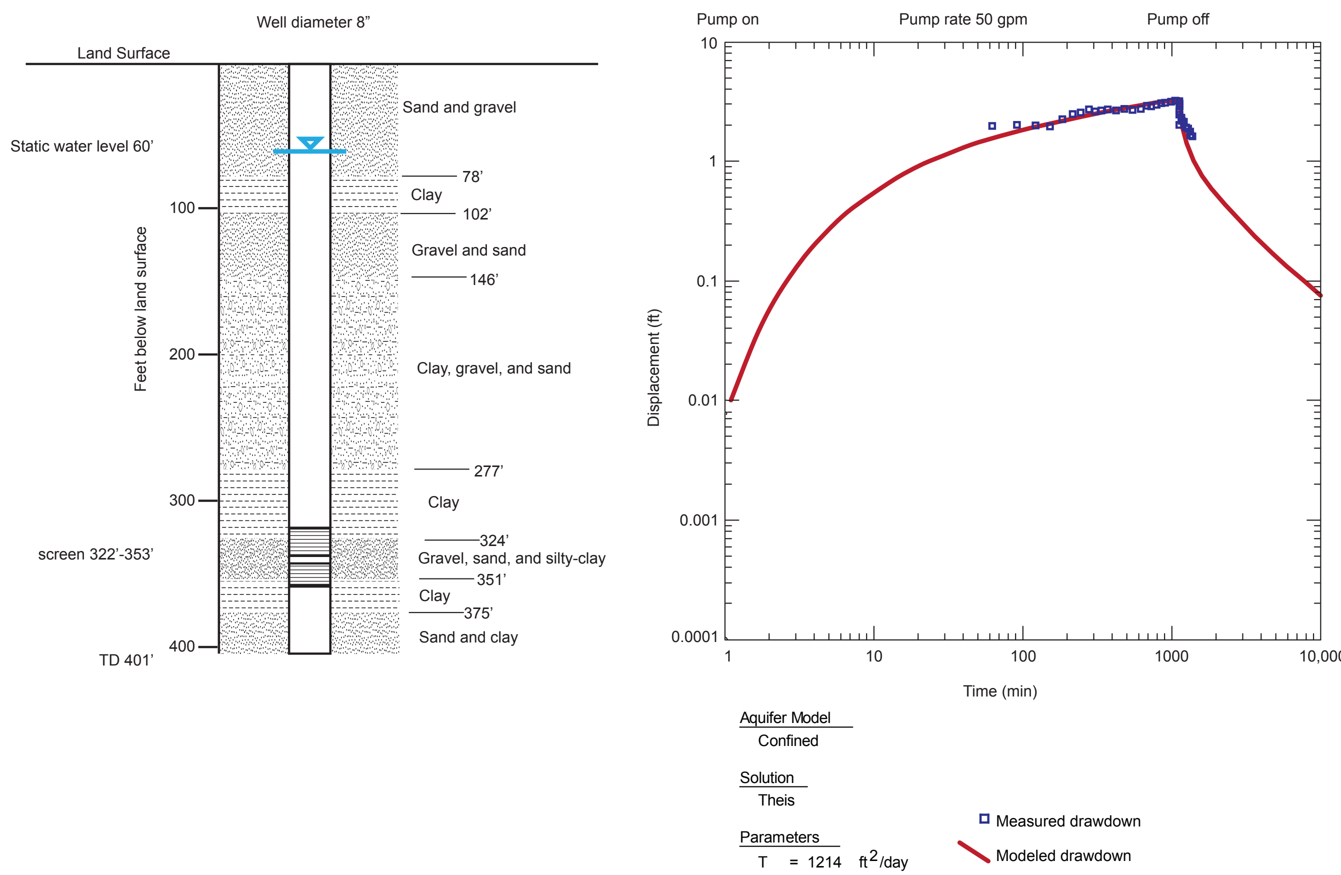

Figure 13. *Well log and aquifer test solution for well MBW-1.*

Table 3. *Aquifer test drawdown data used to model transmissivity.* https://ugspub.nr.utah.gov/publications/misc_pubs/mp-169/mp-169-e.zip

Well MBW1 (hand measurements)				Well MBW2 (hand measurements)				Well FWW (hand measurements)			
Time (min)	Change in WL (ft)	Pump Rate (gpm)	Notes	Time (min)	Change in WL(ft)	Pump Rate (gpm)	Notes	Time (min)	DTW (ft)	Discharge (gpm)	Notes
0	0	50	Pump on	0	0	300	Pump on	0	49.42	100	Pump on
30	-2	50		60	-13.6	300		1	68.74		
60	-2	50		120	-15.6	300		4	71.09		
90	-2	50		180	-18.1	300		10	73.79		
120	-2	50		240	-18.7	300		22	77.81	100	
150	-2	50		320	-19.8	300		27	78.96		
180	-2.25	50		380	-20.2	300		33	80.23		
210	-2.5	50		440	-20.7	300		43	82.14		
240	-2.6	50		500	-19.8	300		61	84.86	94.9	
270	-2.7	50		560	-20	300		77	86.67	93.4	
300	-2.7	50		620	-21.7	300		81		100	
330	-2.7	50		680	-21.9	300		96	91.25		
360	-2.7	50		740	-22	300		116	93.55		
420	-2.7	50		800	-22.1	300	Pump off	136	95.45		
480	-2.7	50		801	-17.3			166	98.09	93.3	
540	-2.7	50		802	-15.8			196	100.24	94.8	
600	-2.8	50		803	-15.75			226	102.14	93.8	
660	-2.9	50		804	-14.8			271	104.7	93.6	
720	-2.9	50		805	-14.1			316	106.98		
780	-3	50		806	-13.8			331		89.2	
840	-3.1	50		807	-13.65			713	117.81	80.8	
900	-3.1	50		808	-13.5			775	118.87	80.9	
960	-3.1	50		809	-12.9			829	119.81	79.5	
980	-3.1	50		810	-12.6			943	121.56	76	
1040	-3.1	50		812	-12			1006	122.49	74.4	
1100	-3.2	50	Pump off	814	-11.8			1066	123.15	72.6	
1101	-3.2			816	-11.4			1126	123.88	75.3	
1102	-3.1			818	-11			1186	124.52	76.1	
1103	-3			820	-10.8			1246	125.16	74.1	
1104	-3			825	-9.8			1306	125.77	73.5	
1105	-3			830	-9.4			1366	126.15	71.8	
1106	-2.9			835	-8.9			1381	126.27	71.1	
1107	-2.8			840	-8.5			1396	126.52	72.6	
1108	-2.75			850	-8.1			1411	126.66	73.3	
1109	-2.17			860	-7.7			1426	126.88	73.3	
1110	-2.6			870	-7.1			1441	127.11	74.7	
1115	-2.5			880	-6.5			1443		0	Pump off
1120	-2.03			890	-6.5			1444	116.81		
1125	-2.25			900	-6			1445	114.9		
1130	-2.25			920	-5.9			1448	113.02		
1135	-2.2			940	-5.8			1454	110.65		
1140	-2.2			960	-5.4			1459	109.1		
1150	-2.2			980	-4.9			1464	107.82		
1160	-2.15			1010	-4.6			1471	106.32		
1170	-2.1			1040	-4.3			1486	103.96		
1180	-2.05							1501	101.91		
1190	-2							1516	100.39		
1200	-1.95							1546	97.78		
1220	-1.9							1578	95.49		
1240	-1.85							1607	93.84		
1260	-1.8							1653	91.41		
1280	-1.75							2208	77.1		
1310	-1.7							2541	72.51		
1340	-1.6							2613	71.55		
								2630	71.55		

(Duffield, 2007) and used as fit points for a modeled drawdown curve. The resulting modeled drawdown was based on a single-well solution for a confined Theis aquifer having a thickness of 20 feet. Because no monitoring wells are nearby, no storativity value could be calculated. Instead, storativity is assumed to be 0.01 based on values typical of similar confined unconsolidated aquifers (Domenico and Schwartz, 1997). Calculated transmissivity based on the selected drawdown model is 1200 ft^2/day.

The second aquifer test was conducted on an existing 16-inch diameter supply well. The well (labeled MBW-2) is located approximately 8 miles north of the Utah FORGE site. Based on well logs, this well was originally drilled to a total depth of 401 feet in 1983 (Figure 14). The lithology in the well consists of a confining clay layer between 53 and 250 feet and limestone from 250 to 401 feet. The limestone is part of the Tertiary basin fill and may be correlative with the Pliocene Cove Creek limestone that is exposed 10 miles northeast of the well site. The well is screened between 101 and 401 feet and the assumed aquifer thickness is 151 feet. Static water level was 98 feet below land surface prior to pumping. Total drawdown after pumping was 22.1 feet.

The MBW-2 well was pumped at a constant rate of 300 gpm for a total of 13 hours. Drawdown was measured during the pumping period and a 4-hour recovery period. Drawdown data were modeled using AQTESOLVE software (Duffield, 2007) assuming a single-well confined Theis solution. Because there are no nearby monitoring wells, a storativity value was not calculated. Instead storativity is assumed to be 0.01 based on values typical of similar aquifers (Domenico and Schwartz, 1997). The resulting transmissivity is 1600 ft^2/day.

An aquifer test was conducted as part of FORGE project Phase 2a on the First Wind supply well (labeled FWW) located 3 miles west of the FORGE project site. The drawdown test was conducted on a 9-inch diameter supply well at the First Wind maintenance facility located approximately 1 mile west of the proposed FORGE project office site. The FWW well is completed in a confined part of the unconsolidated basin-fill aquifer with a total depth of 651 feet (Figure 15). Based on driller's logs, the well is completed in sands and gravels and has a screened interval between 567 and 651 feet and a total aquifer thickness of 440 feet. Clay between 115 and 210 feet makes up the confining layer.

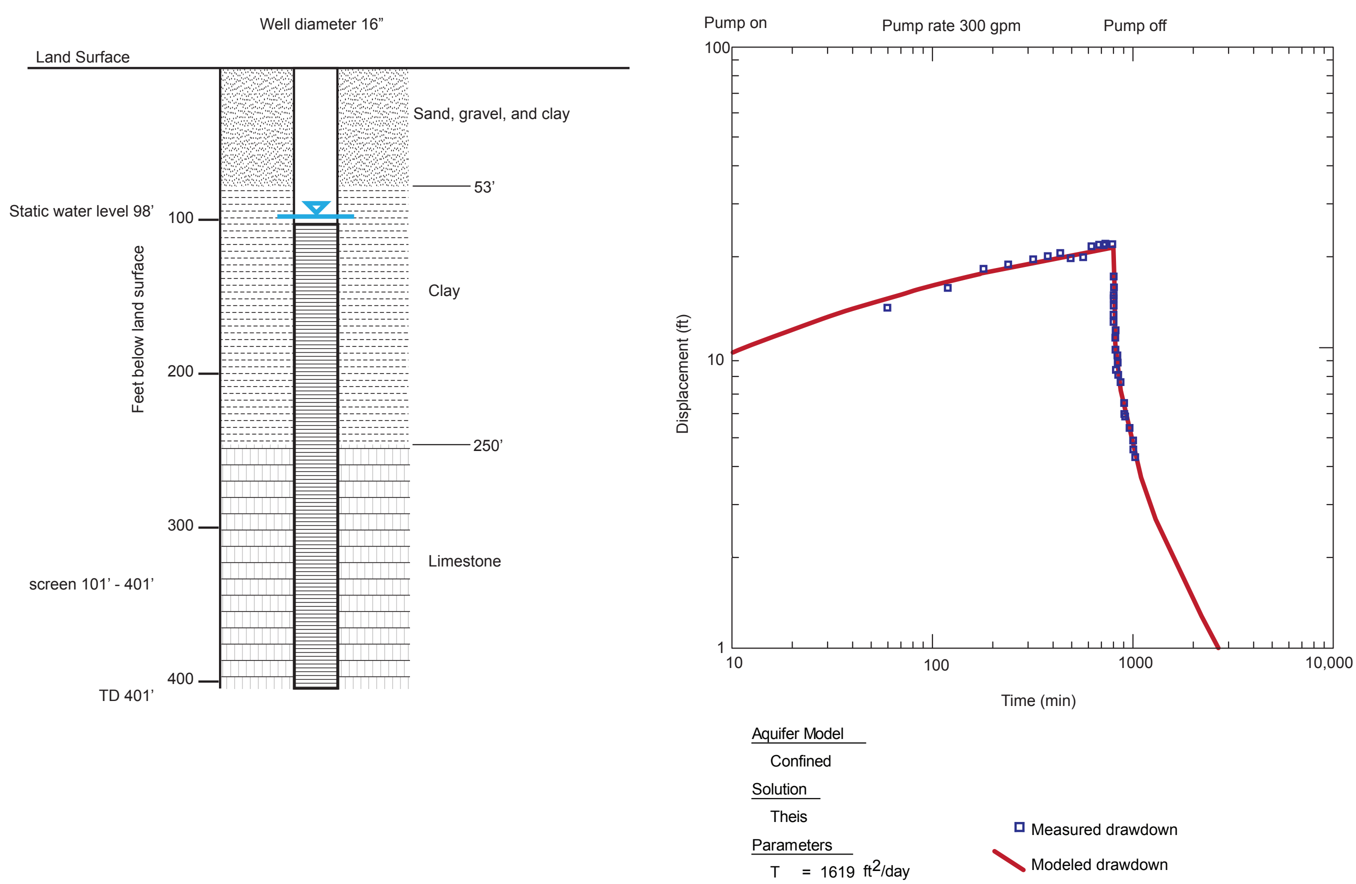

Figure 14. *Well log and aquifer test solution for well MBW-2.*

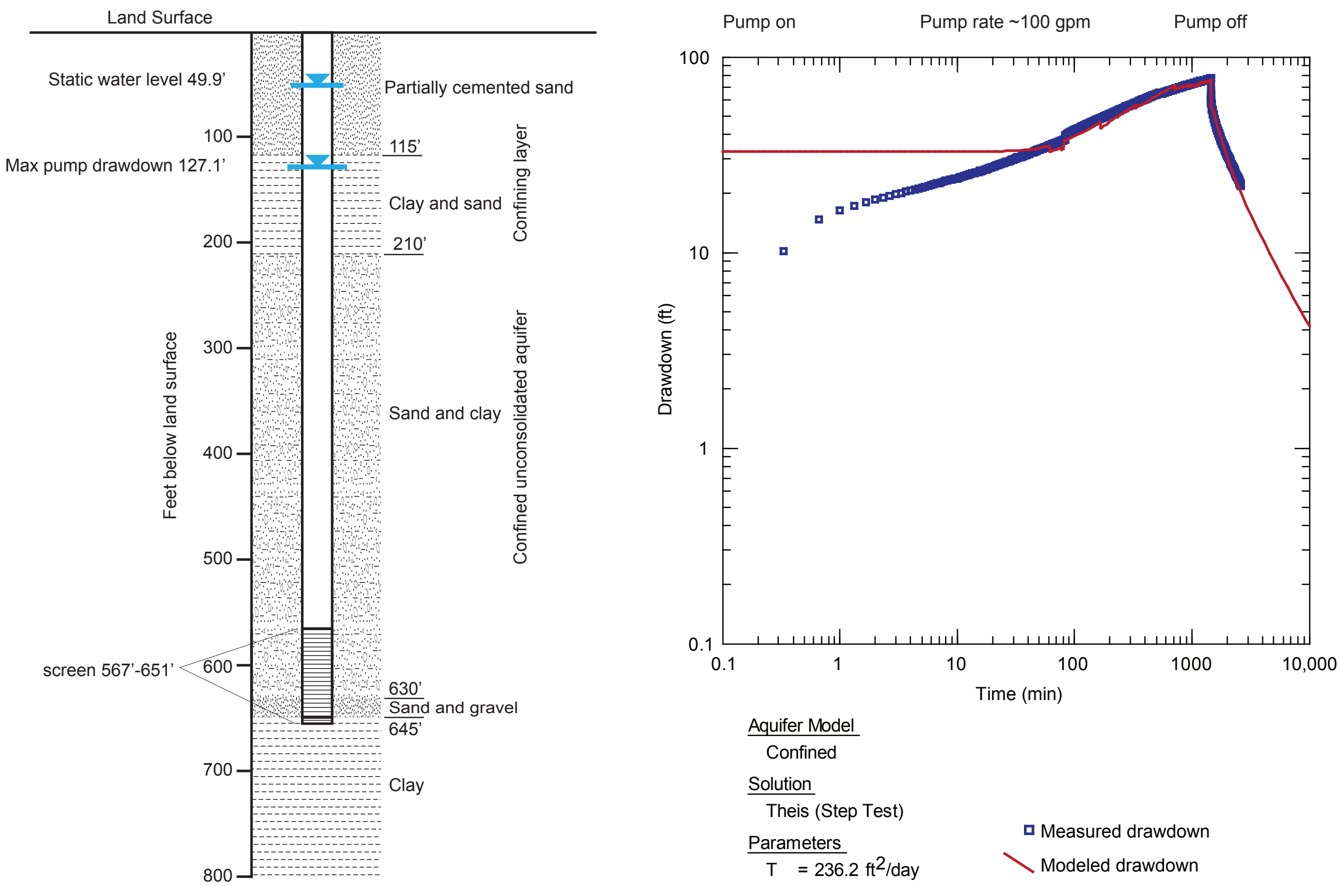

Figure 15. *Well log and aquifer test solution for well FWW.*

The well was pumped at a rate of approximately 100 gpm for 24 hours, and the flow rate and total volume pumped were measured with a clamp-on flow meter. Drawdown was measured in a sounding tube placed in the pumping well, by hand and with a downhole pressure transducer during pumping and for a recovery period following pumping. Table 3 contains the pump and drawdown data used to estimate transmissivity. Just prior to the test, the static water level was 49.1 feet below the wellhead. The water level after 24 hours of pumping was 127.1 feet and total drawdown during the test was 77.9 feet.

Transducer drawdown data and flow rate data were input into the modeling software AQTESOLVE (Duffield, 2007) and used to calculate a transmissivity of ~ 240 ft^2/ day for the FWW. Due to the changes in pump rate over time, the confined nature of the aquifer, and the partial well penetration, a Theis step solution was chosen for curve matching. Because there are no nearby monitoring wells, a storativity value was not calculated. Instead storativity is assumed to be 0.001 based on values typical of similar unconsolidated aquifers (Domenico and Schwartz, 1997). Modeled drawdown and recovery data fit well with observed data (Figure 3), and the estimated transmissivity at the FWW site appears accurate.

As part of a previous investigation of groundwater resources, a single-well aquifer test was performed on an existing supply well (labeled NSW) located approximately 3 miles north of the FORGE project site (Vautaz and Goff, 1987) (Figure 16). The aquifer test was conducted on an 8-inch-diameter supply well completed in unconsolidated basin fill with a total depth of 246 feet. The well is screened between 115 and 246 feet below land surface. No lithologic log is available for this well, and Vautaz and Goff (1987) assumed the lithology is equivalent to a well several miles to the south that was completed in unconfined interbedded sand, gravel, and clay. Estimates of aquifer thickness are not available. Static water level was 70 feet below land surface prior to pumping. Total drawdown after pumping was 24 feet.

The NSW well was pumped at five pumping steps with rates varying from 55 to 220 gpm over a total pumping period of 56 hours. Drawdown was measured during the pumping period and these data were analyzed via six separate solutions for drawdown in an unconfined aquifer. Results were broadly consistent across the solutions analyzed and transmissivity was calculated at ~1400 ft^2/day (Vautaz and Goff, 1987). Due to a lack of detailed well lithologic information for this test the transmissivity value has a much greater uncertainty than the other presented transmissivity values.

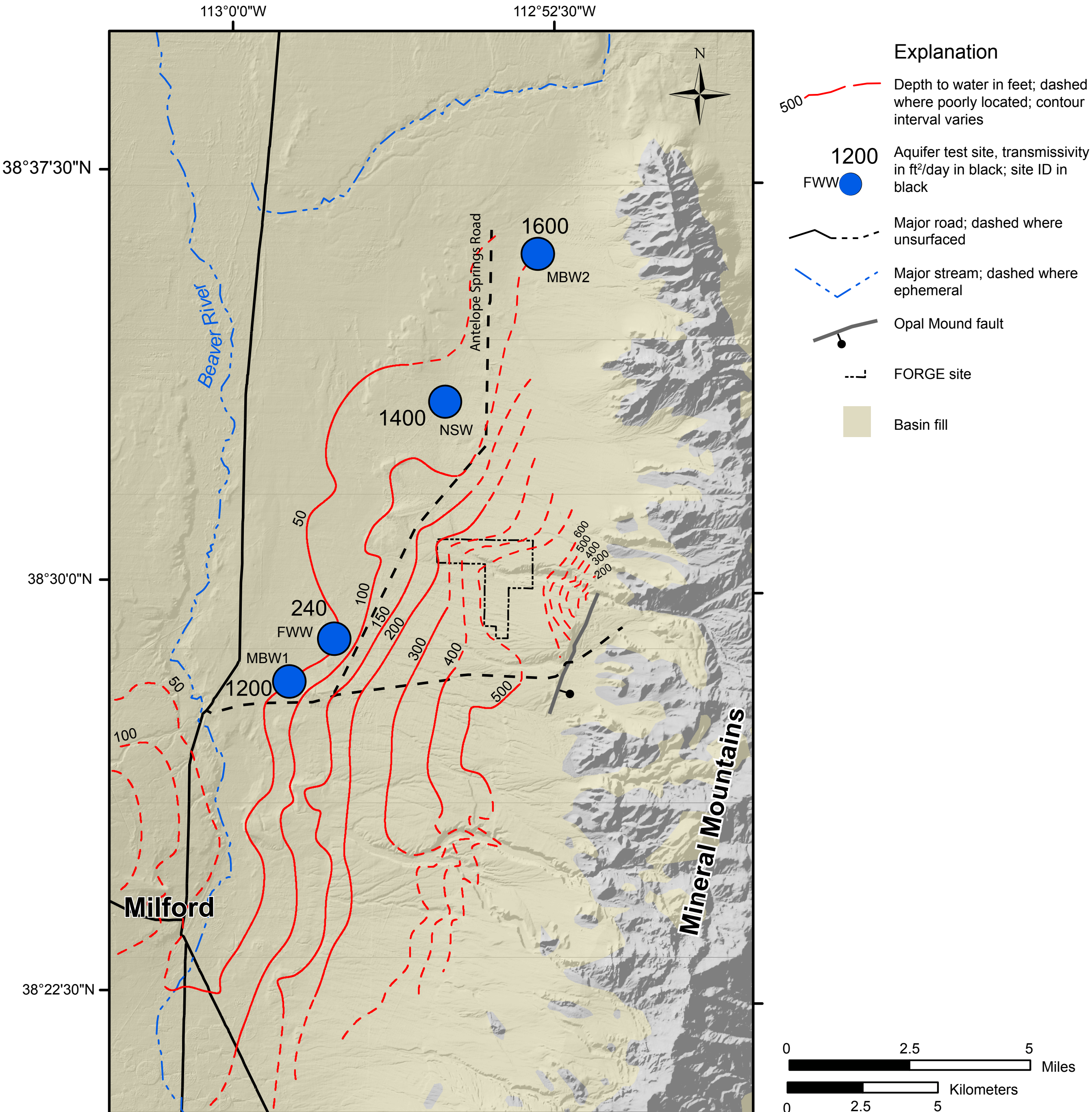

Figure 16. *Summary of aquifer test data for the basin fill aquifer. Transmissivity of the basin-fill near the FORGE site ranges from 240 to 1600 ft²/day.*

CONCLUSIONS

The groundwater in and around the FORGE deep drill site resides in a shallow unconsolidated basin-fill aquifer that overlies impermeable crystalline basement rock. The water in this aquifer is not potable and is not used for human consumption. Groundwater is currently used in the study area for stock watering at several wells and fire suppression.

Based on compiled water levels for groundwater in the unconsolidated basin-fill aquifer, the potentiometric surface slopes to the west away from the Opal Mound fault. Groundwater depth beneath the FORGE deep drill site is between 200 and 500 feet and at about 5100 feet in elevation. Depth to water in the unconsolidated basin fill, in areas surrounding the FORGE deep drill site, ranges from tens of feet along the valley floor to greater than 500 feet west of the Opal Mound fault. Potential supply wells are located about 2.5 miles southwest from this site, where the depth to groundwater is approximately 150 feet.

The groundwater in the study area represents a mix of geochemically distinct waters that include: 1) Roosevelt Hot Springs upflow, 2) Milford Valley groundwater, and 3) cold upland meteoric groundwater (Mower and Cordova, 1974; Vautaz and Goff, 1987; Kirby, 2012). The thermal water is dominated by Na and Cl, with TDS concentrations greater than 6000 mg/L, Cl/B ~100, and enriched $\delta^{18}O$ values. Most groundwater in the vicinity of the FORGE deep drill site represents a mixture of thermal and basinal waters. Non-thermal groundwaters have TDS concentrations less than 1000 mg/L, Cl/B >200, and stable isotope compositions that plot along the meteoric water line. Comparison of solutes other than Cl implies processes other than or in addition to dilution are required to produce the observed concentrations. The other major solutes may vary due to additional water-rock interactions and or mixing of other sources that are not characterized by this sample set. Groundwater in the geothermal outflow plume shows no evidence of recent recharge; consequently, geothermal upflow may have been recharged in the late Pleistocene.

Groundwater in the study area spans a wide range of chemical compositions from dilute (TDS <500 mg/L) to saline (TDS >6000 mg/L). The springs in the Mineral Mountains discharge dilute Ca-HCO_3 water, whereas at Roosevelt Hot Springs the groundwater is made of Na-Cl thermal water. This thermal water fills the shallow aquifer and disperses westward as it migrates downhill. Increasing dilution with Milford Valley groundwater is reflected in decreasing TDS from east to west. Groundwater TDS concentrations around the FORGE deep drill site range from 2000 to >6000 mg/L TDS, exceeding both the primary and secondary drinking water standards.

In aggregate the available aquifer test data indicate the shallow basin-fill aquifer near the FORGE site has a range of transmissivity between 240 and 1600 ft^2/day, and most shallow basin fill likely has transmissivity near 1000 ft^2/day (Figure 4). This transmissivity is moderate and similar to transmissivities for the basin fill to the south near Milford (Mower and Cordova, 1974) and to the north along the Cove Creek drainage (Kirby, 2012). Supply wells in both of these areas commonly yield several hundred gallons per minute of continuous supply and it is likely that production wells for the Utah FORGE site will have similar yields. Actual water-yielding characteristics for new production wells will be site specific. However, based on the new and existing aquifer test data presented above the transmissivity in the basin-fill aquifer near the FORGE site is sufficient for future production wells needed to supply long-term needs of the project.

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