VIRGINIA CITY AQUIFER TEST

Andrew L. Bobst

Montana Bureau of Mines and Geology

Ground Water Investigations Program

Cover photo by Andrew L. Bobst, 2018

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Montana Bureau of Mines and Geology Open-File Report 726

MBMG
Montana Bureau of Mines and Geology

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1 BACKGROUND

1.1 Purpose of Test

These tests were designed to estimate the aquifer properties of the Tertiary fractured tuff in the area uphill from Virginia City's Spring 1 (figs. 1, 2), and to evaluate if pumping from this aquifer would affect the discharge of Spring 1. Aquifer test data, including aquifer test 633 forms, are available from the Montana Bureau of Mines and Geology (MBMG) Groundwater Information Center (GWIC) online database (http://mbmggwic.mtech.edu) by using the wells' GWIC ID numbers (table 1, appendix A).

1.2 Test Location

The aquifer test site is approximately 625 ft north of Virginia City's Spring 1 (T. 6 S., R.3 W., sec. 23) and within the city limits of Virginia City (figs. 1, 2). This site is used as pasture and is approximately 0.3 mi from the nearest well reported in GWIC.

1.3 Test Type

A step-test and a 72-h constant-rate aquifer test were conducted. The step-test was performed on 5/9/2018, and the 72-h test ran from 5/14/2018 to 5/17/2018. Water-level recovery was monitored until 7/2/2018.

1.4 Hydrogeologic Setting

The general stratigraphy at this site is fractured mafic to intermediate lava flows (basalt, trachybasalt, trachyandesite, and andesite) from 0 to 75 ft, weathered tuff (clay) from 80 to 120 ft, and consolidated tuff from 120 to 610 ft (appendix A).

Four wells were installed in the Tertiary tuff deposits (table 1). Well B1 was screened in the first productive zone from 135 to 155 ft. Well B2 was screened from 570 to 610 ft; based on seismic surveys, this should be near the bottom of the tuff. Wells B3 and B4 were screened from 200 to 240 ft, which was the most productive zone encountered while drilling well B2. Well B3 was the pumping well for the aquifer tests (fig. 2).

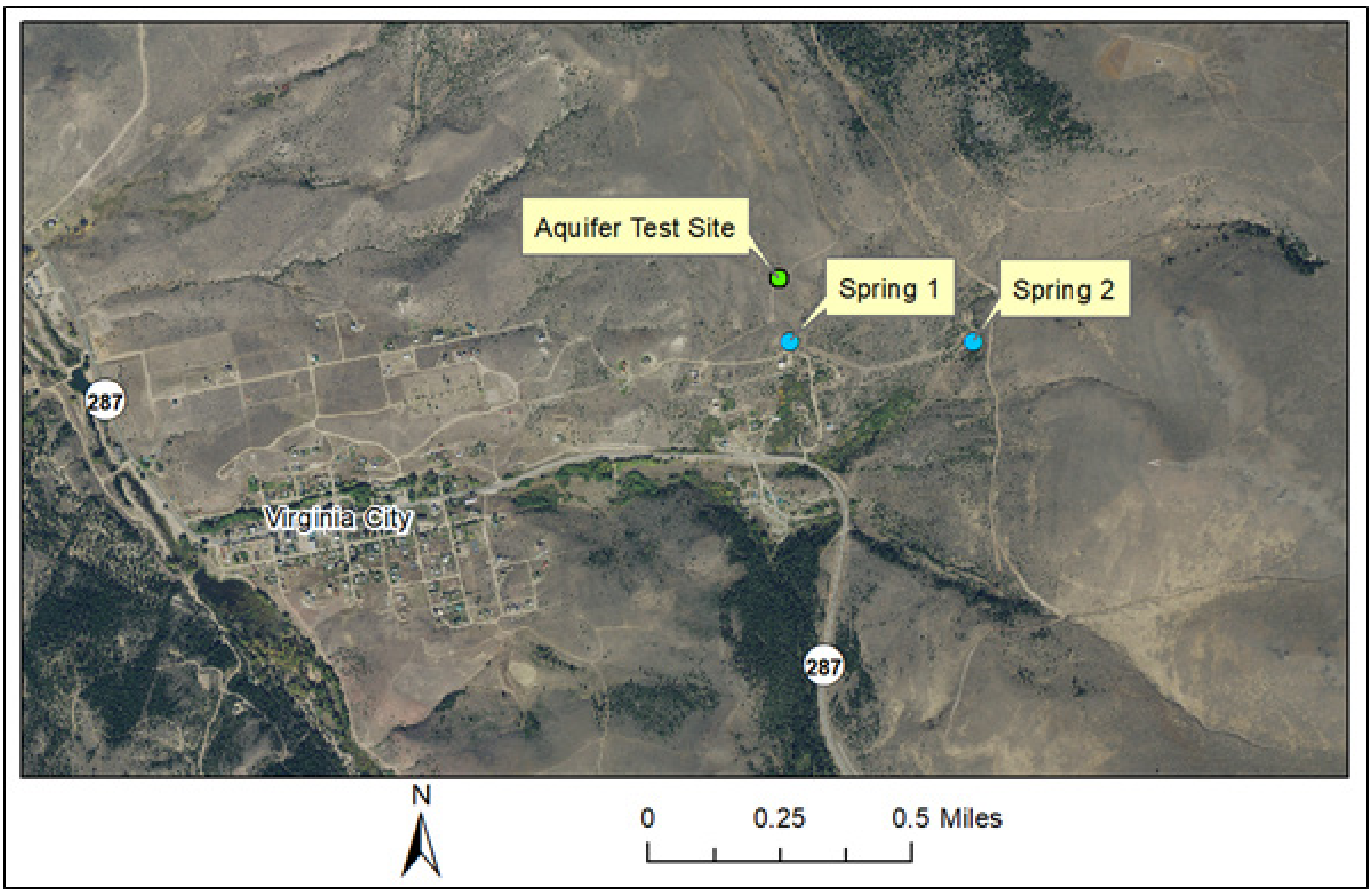


Figure 1. The Virginia City aquifer test site was located above Spring 1 in the hills east of Virginia City, MT.

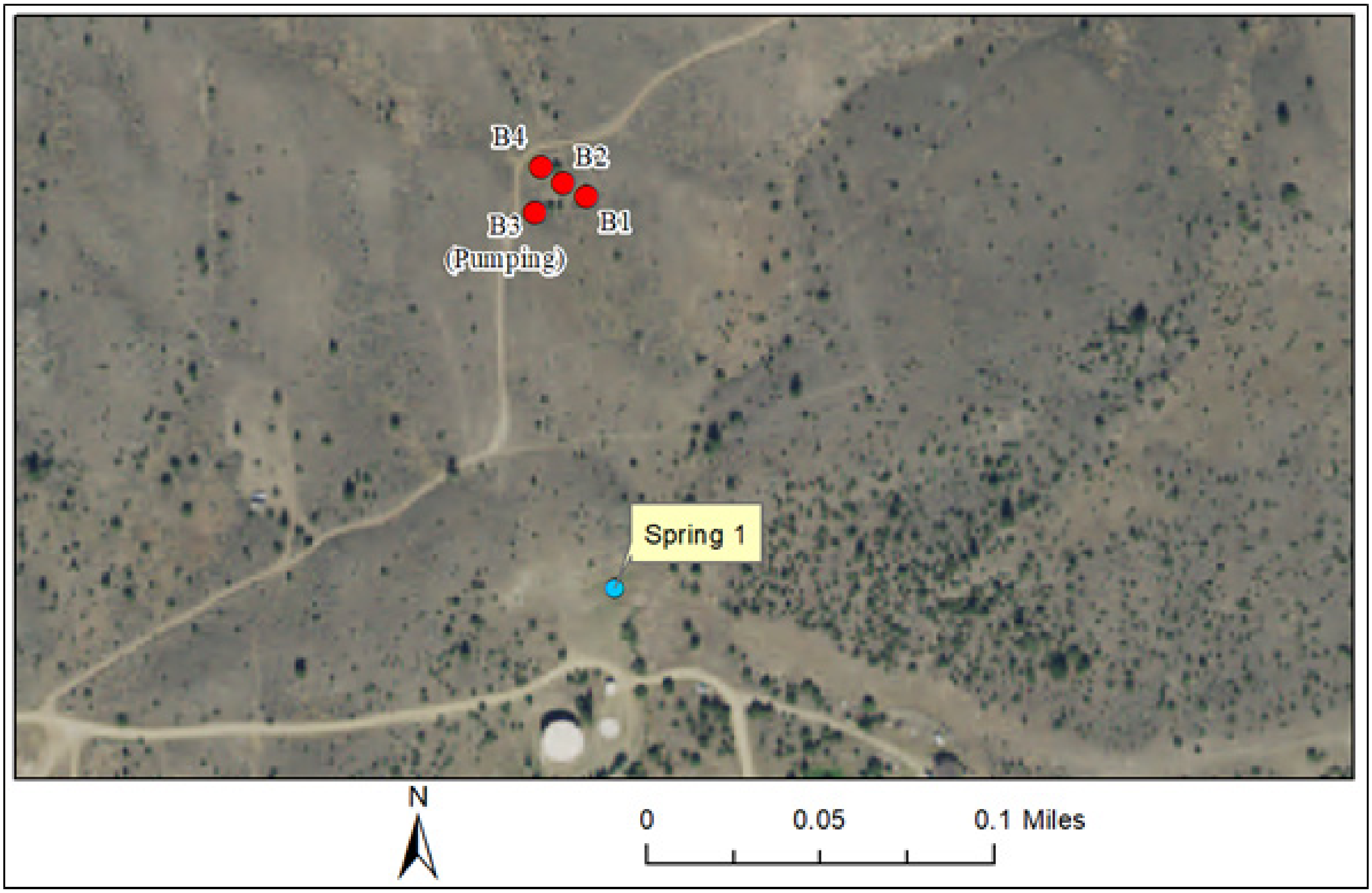


Figure 2. Site layout for the Virginia City aquifer test site.

Static water levels were measured before the start of testing (table 1). Groundwater elevations for wells B1, B3, and B4 were near 6,171 ft-amsl, while the groundwater elevation in B2 was at 6,135 ft-amsl. Since B2 is the deepest well, this indicates a downward gradient at this site (table 1).

This entire area is part of a landslide complex (Mosolf, in preparation). The tuff at the base of the lava flow deposits has a relatively low shear strength, which resulted in a rotational landslide. Large blocks of the overlying lava flows are largely intact, but within the tuff there are many fracture zones and internal shear plains (small-scale, gravity-driven faulting). The fracture zones provide discreet conduits for groundwater flow, while the shear plains likely form flow barriers.

1.5 Hydrologic Features

The wells were drilled uphill from Virginia City's Spring 1 to assess the stratigraphy and allow for testing of the zone feeding Spring 1. At the drill site there was no groundwater at the elevation of the spring, but there is a contact between the lava flows and the underlying weathered tuff at this elevation (6,205 ft-amsl). This suggests that Spring 1 is a contact spring since it issues at the contact between the relatively permeable lava flows and the low-permeability weathered tuff. Daylight Creek is located approximately 0.4 mi south of the site, and the many small springs feeding the stream in that area are likely fed by groundwater flow through the tuff.

Monitoring from August 2017 to July 2018 (fig. 3) showed that groundwater levels drop gradually through the late summer and winter, with a springtime rise beginning in April. Groundwater levels rose by nearly 2 ft in April in all wells. Since the aquifer tests were conducted in May, and recovery from the test was slow, the overall springtime rise was not fully documented because it was impacted by the aquifer tests.

Table 1. Well designations, locations, and completion information, Virginia City aquifer tests.

GWIC ID	Name	Latitude (degrees N)	Longitude (degrees W)	Ground Surface Elevation (ft-amsl)	Measuring Point Elevation (ft-amsl)	Total Depth (ft-bgs)	Distance from B3 (ft)	Bearing from B3 (degrees)	Static Depth to Water 5/14/2018 (ft-bMP)	Pre-Test Groundwater Elevation (ft-amsl)	Comments
294417	B1	45.30055089	111.92710877	6280.23	6282.97	155	82.5	N75E	111.32	6171.65	Shallow observation well
294418	B2	45.30060617	111.92725194	6280.26	6282.21	610	62.1	N45E	146.84	6135.37	Deep observation well
294419	B3	45.30047915	111.92741294	6277.71	6280.23	240	NA	NA	109.28	6170.95	Pumping well
294421	B4	45.30066741	111.92738784	6282.84	6284.89	240	68.9	N08E	113.40	6171.49	Observation well

Note. All locations and elevation determined by survey grade GPS. Horizantal Datum, NAD83. Vertical Datum, NAVD88. ft-amsl, feet above mean sea level; ft-bgs, feet below ground surface; ft-bMP, feet below measuring point.

2 FIELD PROCEDURE

A step-test was conducted to determine the sustainable pumping rate for the constant-rate test. Each of the three steps were 1 h in duration. Time-weighted mean pumping rates were 7.0, 8.5, and 9.6 gpm (fig. 4). Observation wells B1 and B4 showed drawdown from these pumping rates, while the deep well (B2) showed no response (fig. 4). Produced water was discharged 200 ft south of B3 and away from the observation wells. Based on the observed drawdowns, it was determined that approximately 10 gpm would provide adequate drawdown in the observation wells while not causing the pumping well to be drawn down to the pump intake during the 72-h constant-rate test.

During the constant-rate test the time-weighted mean pumping rate was 10.3 gpm (fig. 5). Produced water was again discharged 200 ft south of B3. Prior to the start of the constant-rate test, water levels in the pumping well (B3) had recovered to within 0.01 ft of the static water levels measured before installing the pump.

3 DATA COLLECTION

A vented pressure transducer was installed in each well on 5/8/2018. The transducers were set to record water levels at a 1-min interval from 5/8/2018 to 6/6/2018. From 6/6/2018 to 7/2/2018 non-vented transducers in wells B1 and B4 recorded at 1-h intervals. The readings from the non-vented transducers were corrected for barometric variations by using data from a barometric logger located at Spring 1. Manual readings of water levels were made for all wells using an e-tape prior to placing transducers, and were made periodically during the test, during recovery, and prior to transducer retrieval. These manual measurements were used to calibrate transducer response and provided a backup in case of transducer malfunction.

Pumping rates were monitored using a bucket and stopwatch and a totalizing flow meter (figs. 4, 5). Discharge measurements were made more frequently at the start of the constant-rate test, with the average interval during the first 4 hours being 9 min. The maximum interval between discharge measurements during this test was 270 min (4.5 h).

During the constant-rate test, Spring 1 was also monitored to evaluate if the pumping resulted in

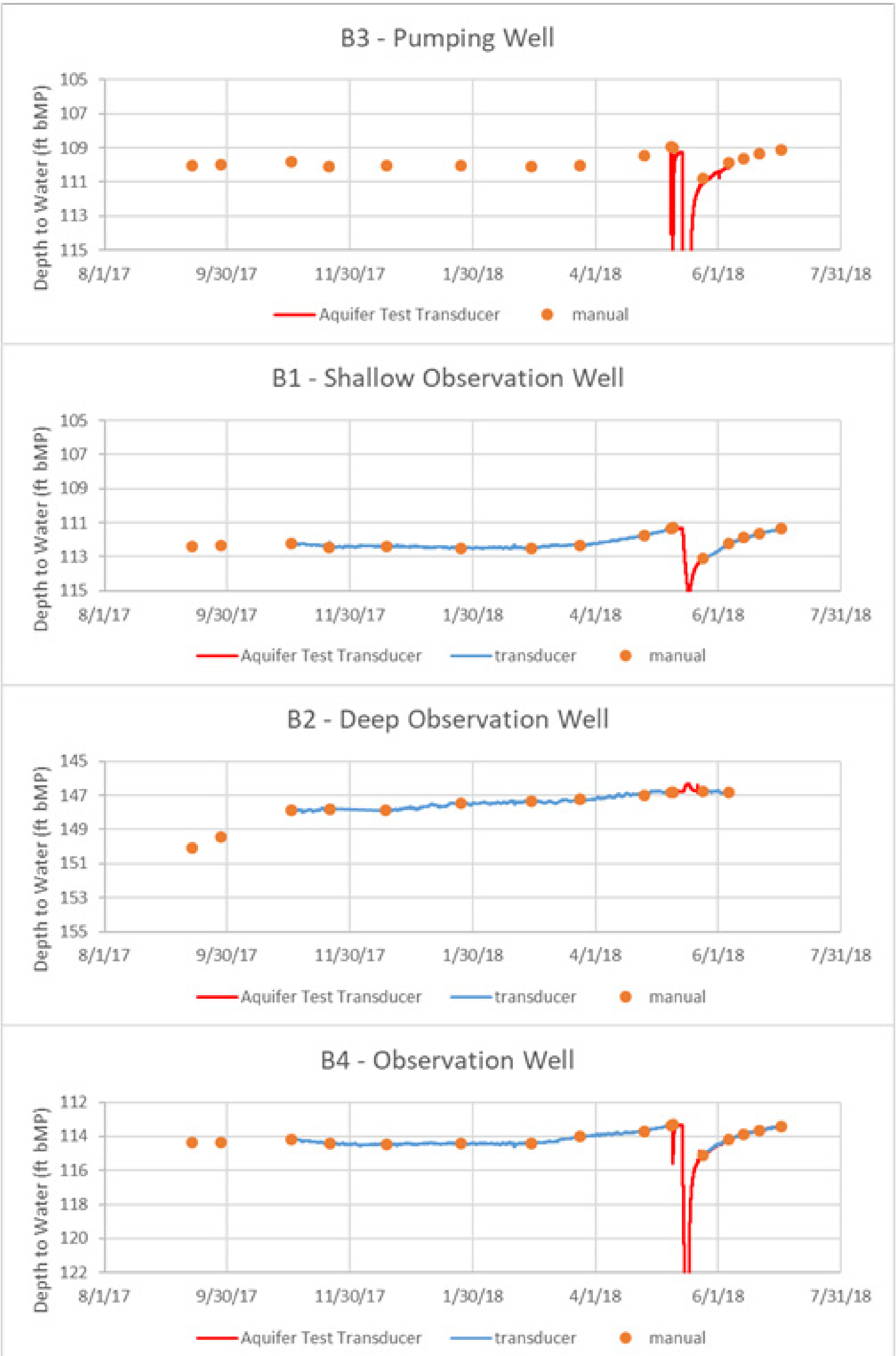


Figure 3. Long-term hydrographs for the aquifer test site.

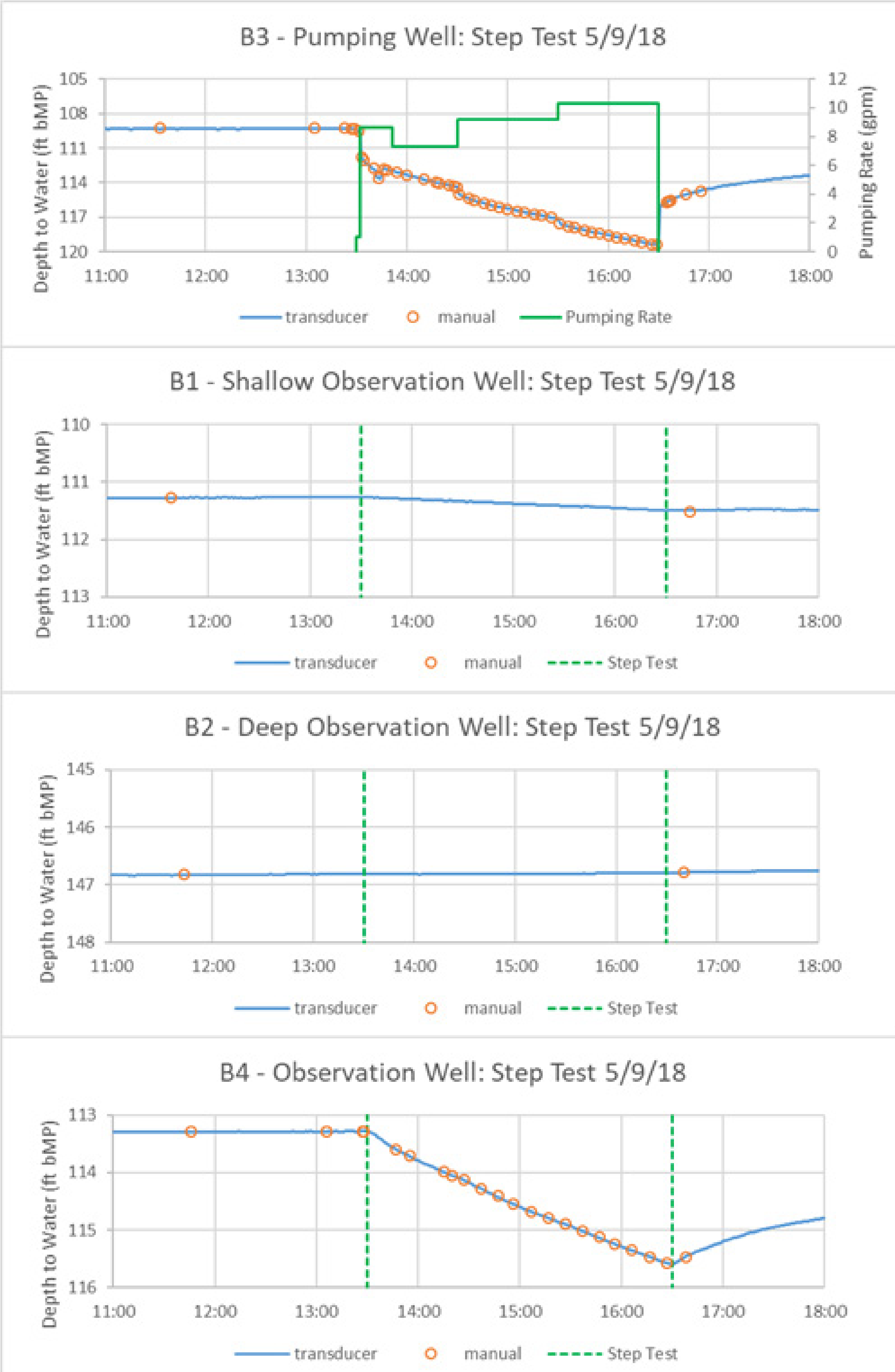


Figure 4. Hydrographs showing the response to pumping at the aquifer site during the step test on 5/9/2018.

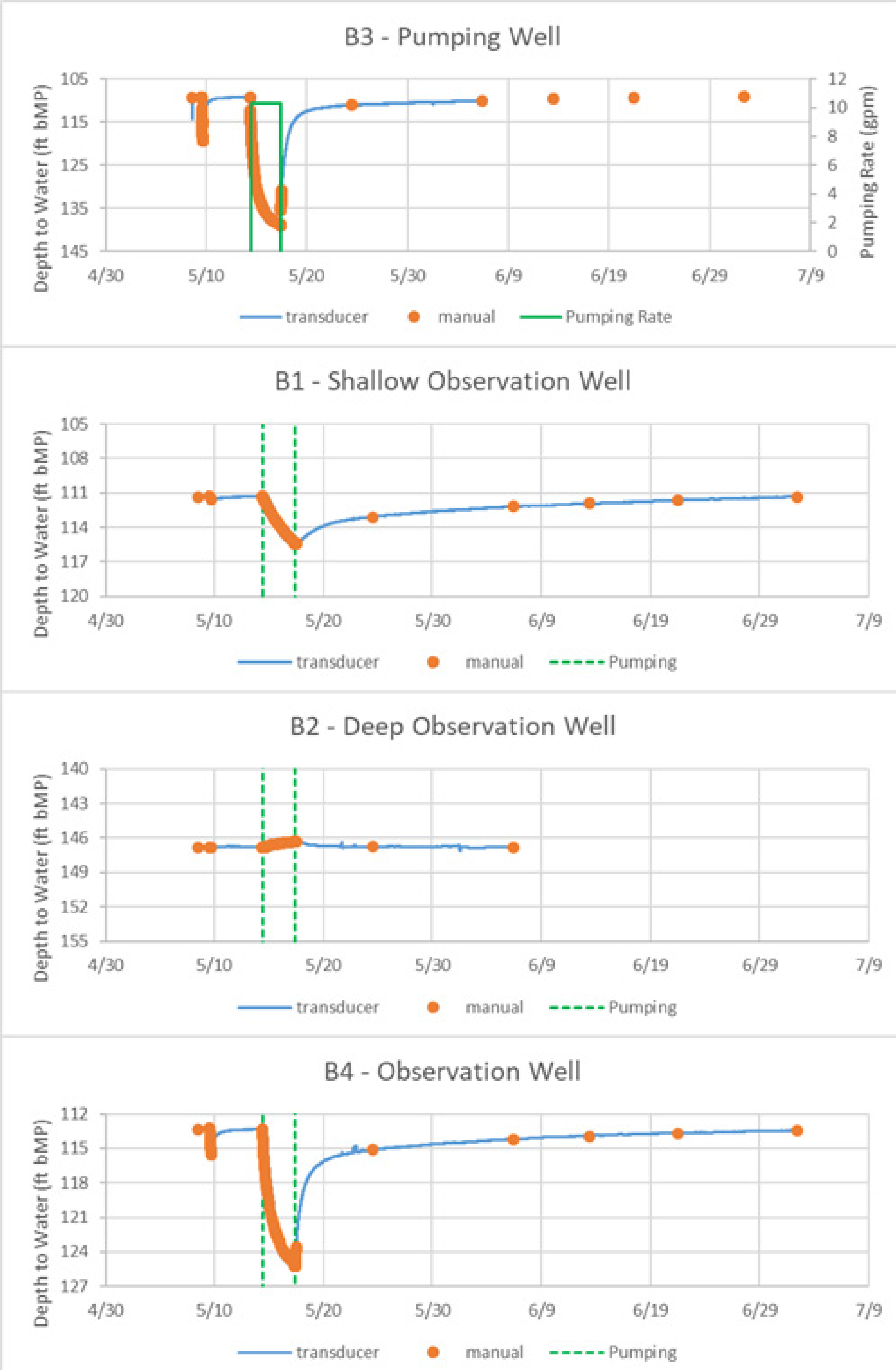


Figure 5. Hydrographs showing the response to pumping at the aquifer site in May 2018.

any noticeable change in spring discharge. Spring discharge monitoring began 1 h prior to the start of the aquifer test and continued for 4 h after pumping began (fig. 6). Spring flow measurements were made based on a totalizing flow meter between the spring box and the municipal storage tank. The duration of spring discharge measurements was limited because the flow meter could only be used while the tank was filling.

4 RESULTS

While groundwater levels rose during April 2018, they appeared to be stable during the tests and through recovery (figs. 3–5). Final groundwater elevations recorded on 7/2/2018 were within 0.14 ft of pre-test conditions (5/8/2018). As such, no correction was made for antecedent trends. While it is possible that static water levels continued to go up and then back down, correction for this type of antecedent trend is not possible without supporting data, and those data are not available due to the aquifer tests.

4.1 Water-Level Response

The maximum recorded drawdown in the pumping well (well B3) was 29.66 ft. Drawdown in well B3 showed a rapid initial decline followed by declining water levels that began to stabilize after about 24 h. After pumping ceased, well B3 exhibited a very slow recovery, requiring 246 h (10 days) to reach 95% recovery, and measurable recovery occurring for at least 46 days (fig. 5).

Well B4, which was completed in the same zone as the pumping well, at a depth of 200–240 ft, had a maximum drawdown of 11.83 ft. Recovery was also slow in well B4, requiring 25 days to reach 95% recovery (fig. 5).

Well B1, which was completed in a shallow zone of the tuff (at 135–155 ft), had a maximum drawdown of 4.08 ft. Recovery was also slow in well B1, requiring 39 days to reach 95% recovery (fig. 5).

Well B2, which was completed in a deeper zone of the tuff (570–610 ft), showed a slight rise during the test (fig. 5).

4.2 Aquifer Properties

AQTESOLV was used to analyze the drawdown and recovery data from the aquifer test. Evaluation of the hydrogeologic setting, lithologic descriptions from

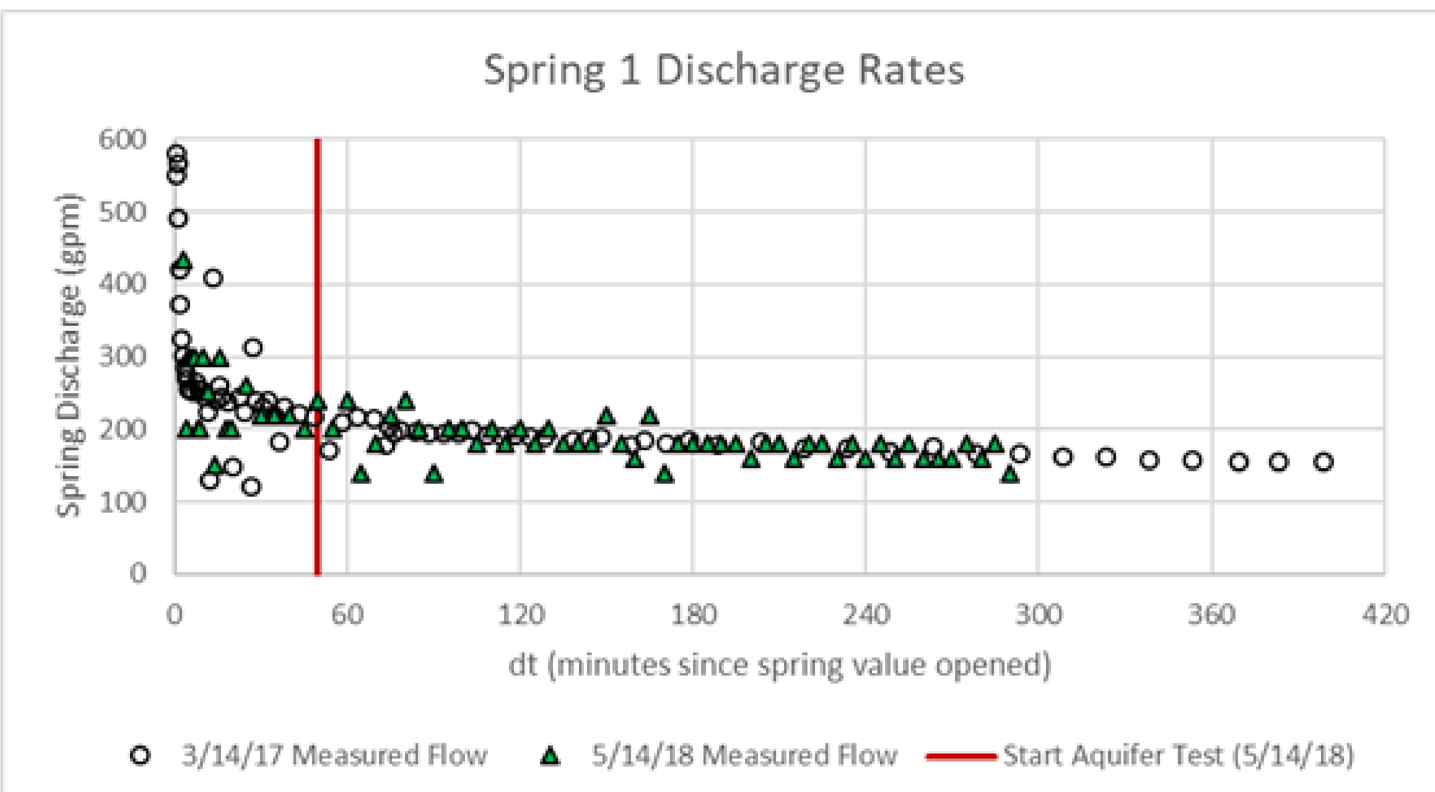


Figure 6. Discharge rates from Spring 1 were not noticeably altered by the aquifer test based on a comparison to spring flow rates during a non-aquifer test period (3/14/2017).

well cuttings, and aquifer test derivative plots from B1 and B4 (figs. B1, B2 in appendix B) suggest the presence of a no-flow and constant-head boundaries (Renard and others, 2009). This is consistent with the shear planes in the landslide deposits creating no-flow boundaries and discrete fracture zones providing recharge boundaries. An initial model was developed for the test using a dual porosity model with no boundaries (Moench, 1984, 1988). No-flow and constant-head boundaries were added to the initial model to improve the fit, and the distance to these boundaries was adjusted to provide a good fit with observations in wells B1 and B4. The best fit was attained by implementing the no-flow boundary 25 ft from the pumping well, and the constant-head boundary 100 ft from the pumping well (perpendicular to the no-flow boundary). This model used a vertical anisotropy factor of 1. This model indicated that the fractures had a K value of 0.1 ft/d and the matrix had a K value of 2.53×10^{-4} ft/d. This model indicated a very low fracture storativity (modeled as 1×10^{-10}) and a matrix storativity of 2.35×10^{-4} (appendix B, figs. B1, B2).

4.3 Spring Flow Response

Since spring flow rates decline following the valve to the storage tank being opened, the flow rates collected during the aquifer test were compared to those collected when an aquifer test was not occurring on 3/14/2017. There was not a noticeable difference between the discharge rates over time curves developed for these different dates (fig. 6), consistent with Spring 1 being a contact spring, emitting from the contact between lava flow deposits and the underlying tuff. However, since the pumping rate was only about 10 gpm, any effects to spring flow would be difficult to discern given a spring discharge rate of about 200 gpm.

5 SUMMARY

At this test site the tuff was not saturated at the elevation of Spring 1. A geologic contact between the lava flow deposits and the underlying tuff at that elevation suggests that the contact provides a contrast in permeability, causing infiltrated water to flow to Spring 1. Since the tuff underlying this contact is not saturated, the spring will not be affected by pumping from the deeper saturated tuff. Observation wells B1 and B4 responded directly to pumping from B3. Their response was modeled using a vertical anisotropy factor of 1, indicating that these zones (135 to 240 ft-bgs) are directly connected, likely due to fractures cross cutting layering. Water levels in B2 (screened from 570 to 610 ft-bgs) did not respond to pumping, indicating that there is a vertical barrier to flow between these zones, and overall fracture zones within the tuff are not well connected. A dual porosity model provided the best fit to the test results, indicating that at this scale the aquifer does not function as an ideal porous media. The most productive zone in the tuff could sustain a pumping rate of about 20 gpm for several days; however, the recovery from pumping was very slow, indicating that such rates would not be sustainable long-term.

6 REFERENCES

Moench, A.F., 1984, Double-porosity models for a fissured groundwater reservoir with fracture skin: Water Resources Research, v. 20, no. 7, p. 831–846.

Moench, A.F., 1988, The response of partially penetrating wells to pumpage from double-porosity aquifers: Proceedings of the International Conference on Fluid Flow in Fractured Rocks, Atlanta, GA, May 16–18, 1988.

Mosolf, J., submitted to the USGS June 2018, in preparation for MBMG publication, Geologic map of the Virginia City 7.5’ quadrangle, Madison County, Montana.

Renard, P., Glenz, D., and Mejias, M., 2009, Understanding diagnostic plots for well-test interpretation: Hydrogeology Journal, v. 17, p. 589–600.

APPENDIX A—WELL LOGS

MONTANA WELL LOG REPORT	Other Options
This well log reports the activities of a licensed Montana well driller, serves as the official record of work done within the borehole and casing, and describes the amount of water encountered. This report is compiled electronically from the contents of the Ground Water Information Center (GWIC) database for this site. Acquiring water rights is the well owner's responsibility and is NOT accomplished by the filing of this report.	Return to menu Plot this site in State Library Digital Atlas Plot this site in Google Maps View hydrograph for this site View field visits for this site View water quality for this site

Site Name: MBMG BOWLING 1
GWIC Id: 294417

Section 1: Well Owner(s)

1) MBMG BOWLING 1 (WELL)
N/A
VIRGINIA CITY MT N/A [07/10/2017]

Section 2: Location

Township	Range	Section	Quarter Sections
06S	03W	23	SW¼ NW¼ SE¼ NE¼

County	Geocode
MADISON	

Latitude	Longitude	Geomethod	Datum
45.30055089	-111.92710877	SUR-GPS	NAD83

Ground Surface Altitude	Ground Surface Method	Datum	Date
6280.23	SUR-GPS	NAVD88	9/27/2017

Measuring Point Altitude	MP Method	Datum	Date Applies
6282.97	SUR-GPS	NAVD88	9/1/2017

Addition	Block	Lot

Section 3: Proposed Use of Water

MONITORING (1)

Section 4: Type of Work

Drilling Method: ROTARY
Status: NEW WELL

Section 5: Well Completion Date

Date well completed: Monday, July 10, 2017

Section 6: Well Construction Details

Borehole dimensions

From	To	Diameter
0	128	10
128	155	8

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
-2	25	8	0.25		WELDED	A53B STEEL
-1	155	4			SPLINE	PVC-SCHED 160

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
135	155	4			SCREEN-CONTINUOUS-PVC

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
14	130	GROUTE	
130	155	SAND	

Section 7: Well Test Data

Total Depth: 155
Static Water Level: 110
Water Temperature:

** During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

Section 8: Remarks

Section 9: Well Log

Geologic Source

120VLCC - VOLCANICS (TERTIARY)

From	To	Description
0	2	TOPSOIL
2	10	CLAY
10	80	BASALT BEDROCK
80	120	STICKY CLAY
120	155	VOLCANIC TUFF

Driller Certification

All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name:	RYAN LINDSAY
Company:	LINDSAY DRILLING CO INC
License No:	WWC-607
Date Completed:	7/10/2017

MONTANA WELL LOG REPORT

This well log reports the activities of a licensed Montana well driller, serves as the official record of work done within the borehole and casing, and describes the amount of water encountered. This report is compiled electronically from the contents of the Ground Water Information Center (GWIC) database for this site. Acquiring water rights is the well owner's responsibility and is NOT accomplished by the filing of this report.

Other Options

Return to menu
Plot this site in State Library Digital Atlas
Plot this site in Google Maps
View hydrograph for this site
View field visits for this site
View water quality for this site

Site Name: MBMG BOWLING 2
GWIC Id: 294418

Section 1: Well Owner(s)

1) MBMG BOWLING 2 (WELL)
N/A
VIRGINIA CITY MT N/A [07/18/2017]

Section 2: Location

Township	Range	Section	Quarter Sections
06S	03W	23	SW¼ NW¼ SE¼ NE¼

County	Geocode
MADISON	

Latitude	Longitude	Geomethod	Datum
45.30060617	-111.92725194	SUR-GPS	NAD83

Ground Surface Altitude	Ground Surface Method	Datum	Date
6280.26	SUR-GPS	NAVD88	9/27/2017

Measuring Point Altitude	MP Method	Datum	Date Applies
6282.21	SUR-GPS	NAVD88	9/1/2017

Addition	Block	Lot

Section 3: Proposed Use of Water

MONITORING (1)

Section 4: Type of Work

Drilling Method: ROTARY
Status: NEW WELL

Section 5: Well Completion Date

Date well completed: Tuesday, July 18, 2017

Section 6: Well Construction Details

Borehole dimensions

From	To	Diameter
0	118	10
118	610	8

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
-2	25	10			WELDED	A53B STEEL
-1	610	4			SPLINE	PVC-SCHED 160

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
570	610	4			SCREEN-CONTINUOUS-PVC

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
14	565	GROUT	
565	610	SAND	

Section 7: Well Test Data

Total Depth: 610
Static Water Level: 110
Water Temperature:

** During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

Section 8: Remarks

Section 9: Well Log

Geologic Source

120VLCC - VOLCANICS (TERTIARY)

From	To	Description
0	2	TOPSOIL
2	15	CLAY
15	75	BASALT BEDROCK
75	110	STICKY CLAY
110	610	VOLCANIC TUFF

Driller Certification

All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name: RYAN LINDSAY
Company: LINDSAY DRILLING CO INC
License No: WWC-607
Date Completed: 7/18/2017

MONTANA WELL LOG REPORT

This well log reports the activities of a licensed Montana well driller, serves as the official record of work done within the borehole and casing, and describes the amount of water encountered. This report is compiled electronically from the contents of the Ground Water Information Center (GWIC) database for this site. Acquiring water rights is the well owner's responsibility and is NOT accomplished by the filing of this report.

Other Options

Return to menu
Plot this site in State Library Digital Atlas
Plot this site in Google Maps
View hydrograph for this site
View field visits for this site

Site Name: MBMG BOWLING 3
GWIC Id: 294419

Section 1: Well Owner(s)
1) MBMG BOWLING 3 (WELL)
N/A
VIRGINIA CITY MT N/A [08/04/2017]

Section 2: Location

Township	Range	Section	Quarter Sections
06S	03W	23	SW¼ NW¼ SE¼ NE¼

County	Geocode
MADISON	

Latitude	Longitude	Geomethod	Datum
45.30047915	-111.92741294	SUR-GPS	NAD83

Ground Surface Altitude	Ground Surface Method	Datum	Date
6277.71	SUR-GPS	NAVD88	9/27/2017

Measuring Point Altitude	MP Method	Datum	Date Applies
6280.23	SUR-GPS	NAVD88	9/1/2017

Addition	Block	Lot

Section 3: Proposed Use of Water
MONITORING (1)

Section 4: Type of Work
Drilling Method: ROTARY
Status: NEW WELL

Section 5: Well Completion Date
Date well completed: Friday, August 04, 2017

Section 6: Well Construction Details

Borehole dimensions

From	To	Diameter
0	80	10
80	240	8

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
-2	25	10			WELDED	A53B STEEL
-1	240	4			SPLINE	PVC-SCHED 160

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
200	240	4			SCREEN-CONTINUOUS-PVC

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
14	195	GROUT	
195	240	SAND	

Section 7: Well Test Data

Total Depth: 240
Static Water Level: 110
Water Temperature:

** During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

Section 8: Remarks

Section 9: Well Log
Geologic Source
Unassigned

From	To	Description
0	2	TOPSOIL
2	10	CLAY
10	60	BASALT BEDROCK
60	240	VOLCANIC TUFF

Driller Certification
All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name: RYAN LINDSAY
Company: LINDSAY DRILLING CO INC
License No: WWC-607
Date Completed: 8/4/2017

MONTANA WELL LOG REPORT

This well log reports the activities of a licensed Montana well driller, serves as the official record of work done within the borehole and casing, and describes the amount of water encountered. This report is compiled electronically from the contents of the Ground Water Information Center (GWIC) database for this site. Acquiring water rights is the well owner's responsibility and is NOT accomplished by the filing of this report.

Other Options

Return to menu
Plot this site in State Library Digital Atlas
Plot this site in Google Maps
View hydrograph for this site
View field visits for this site
View water quality for this site

Site Name: MBMG BOWLING 4
GWIC Id: 294421

Section 1: Well Owner(s)

1) MBMG BOWLING 4 (WELL)
N/A
VIRGINIA CITY MT N/A [08/10/2017]

Section 2: Location

Township	Range	Section	Quarter Sections
06S	03W	23	SW¼ NW¼ SE¼ NE¼

County	Geocode
MADISON	

Latitude	Longitude	Geomethod	Datum
45.30066741	-111.92738784	SUR-GPS	NAD83

Ground Surface Altitude	Ground Surface Method	Datum	Date
6282.84	SUR-GPS	NAVD88	9/27/2017

Measuring Point Altitude	MP Method	Datum	Date Applies
6284.89	SUR-GPS	NAVD88	9/1/2017

Addition	Block	Lot

Section 3: Proposed Use of Water

MONITORING (1)

Section 4: Type of Work

Drilling Method: ROTARY
Status: NEW WELL

Section 5: Well Completion Date

Date well completed: Thursday, August 10, 2017

Section 6: Well Construction Details

Borehole dimensions

From	To	Diameter
0	80	10
80	240	8

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
-2	25	8			WELDED	A53B STEEL
-1	240	4			SPLINE	PVC-SCHED 160

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
200	240	4			SCREEN-CONTINUOUS-PVC

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
14	190	GROUT	
190	240	SAND	

Section 7: Well Test Data

Total Depth: 240
Static Water Level: 110
Water Temperature:

** During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

Section 8: Remarks

Section 9: Well Log

Geologic Source

120VLCC - VOLCANICS (TERTIARY)

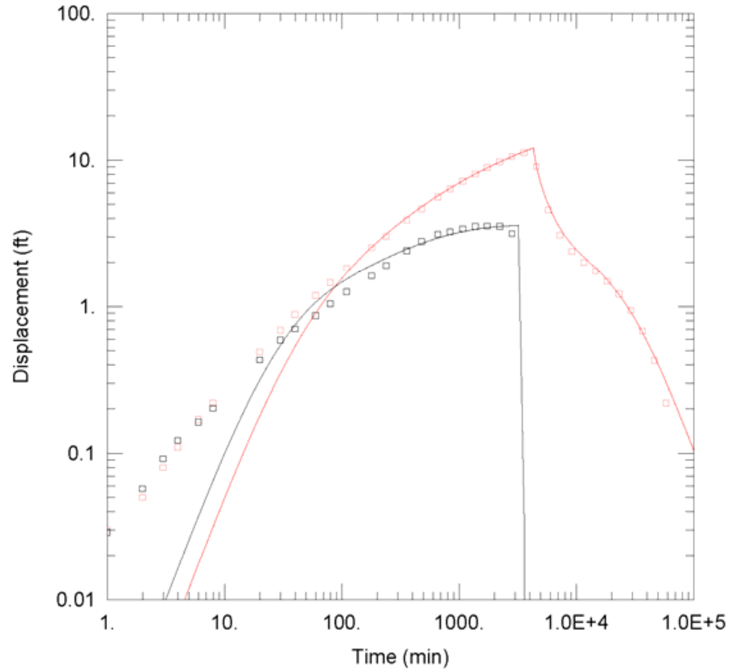
From	To	Description
0	2	TOPSOIL
2	10	CLAY
10	60	BASALT BEDROCK
60	240	VOLCANIC TUFF

Driller Certification

All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name: RYAN LINDSAY
Company: LINDSAY DRILLING CO INC
License No: WWC-607
Date Completed: 8/10/2017

APPENDIX B—AQTESOLV ANALYSIS



VIRGINIA CITY SPECIFIED RATE AQUIFER TEST

Data Set: M:\...\B4-B1_Deriv_mon2.aqt
Date: 12/06/19 Time: 09:41:46

PROJECT INFORMATION

Company: MBMG
Client: BWIPVC
Project: Virginia City
Location: Bowling
Test Well: Bowling #3
Test Date: 5/9/18

AQUIFER DATA

Saturated Thickness: 150. ft Slab Block Thickness: 1. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
Bowling #3	0	0

Observation Wells

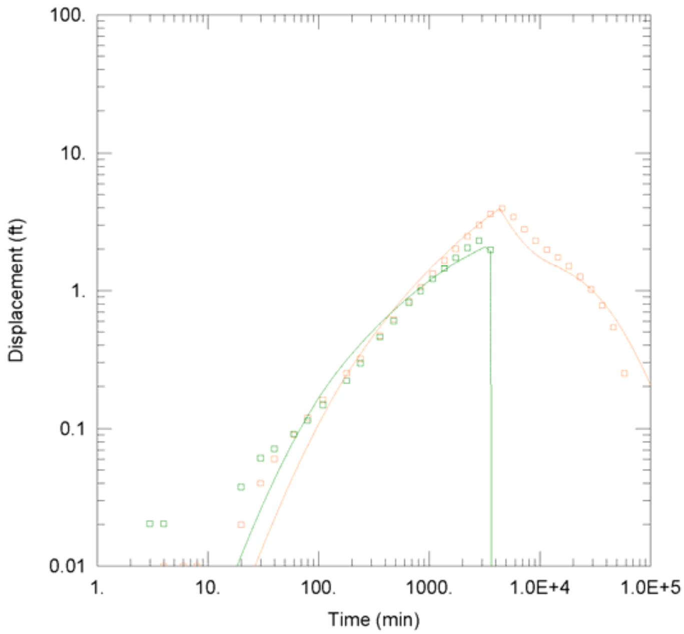
Well Name	X (ft)	Y (ft)
Bowling #4	7.2	68.6

SOLUTION

Aquifer Model: Fractured
Solution Method: Moench w/slab blocks

K = 0.1 ft/day
K' = 0.000253 ft/day
Sw = -2.07
r(w) = 0.333 ft
Ss = 1.0E-10 ft^{-1}
Ss' = 0.000235 ft^{-1}
Sf = 0.0219
r(c) = 0.167 ft

Aquifer test analysis (using Aqtesolv) for the constant-rate test for observation well B4 with a no-flow boundary on one side 25 ft from the pumping well, and a constant-head boundary 100 ft away and perpendicular to the no-flow boundary. Displacement values (drawdown) are in red, derivatives are in black. This well is completed in the same zone as the pumping well (B3).



VIRGINIA CITY SPECIFIED RATE AQUIFER TEST

Data Set: M:\...\B4-B1_Deriv_mon2.aqt
Date: 12/06/19 Time: 09:43:00

PROJECT INFORMATION

Company: MBMG
Client: BWIPVC
Project: Virginia City
Location: Bowling
Test Well: Bowling #3
Test Date: 5/9/18

AQUIFER DATA

Saturated Thickness: 150. ft Slab Block Thickness: 1. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
Bowling #3	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
Bowling #1	78.4	25.3

SOLUTION

Aquifer Model: Fractured Solution Method: Moench w/slab blocks

K = 0.1 ft/day
K' = 0.000253 ft/day
Sw = -2.07
r(w) = 0.333 ft
Ss = 1.0E-10 ft^{-1}
Ss' = 0.000235 ft^{-1}
Sf = 0.0219
r(c) = 0.167 ft

Aquifer test analysis (using Aqtesolv) for the constant-rate test for observation well B1 with a no-flow boundary on one side 25 ft from the pumping well, and a constant head boundary 100 ft away and perpendicular to the no-flow boundary. Displacement values (drawdown) are in orange; derivatives are in green. This well is completed from 135 to 155 ft-bgs while the pumping well is completed from 200 to 240 ft-bgs, so the screened intervals are separated by approximately 45 ft vertically. The model for this well was able to provide a good match with observations while using a vertical to horizontal anisotropy value (K_z/K_h) of 1, indicating that these zones are vertically interconnected.