AQUIFER TESTS COMPLETED IN THE UPPER GALLATIN RIVER VALLEY, BIG SKY, MONTANA

James Rose

Montana Bureau of Mines and Geology
Ground Water Investigation Program

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Cover photo: Aquifer pumping test near the Gallatin River. Photo by James Rose.

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Montana Bureau of Mines and Geology Open-File Report 750

2022

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OVERVIEW

Two aquifer tests were completed as part of the Upper Gallatin River Corridor (UGRC) project by the Montana Bureau of Mines and Geology (MBMG) Ground Water Investigation Program (GWIP). These tests were conducted in the alluvial gravel aquifer of the Gallatin River Valley in Gallatin County in near Big Sky (fig. 1).

The Gallatin River Valley is an intermontane valley in the Madison Mountain Range of southwestern Montana. The Gallatin River originates in Yellowstone Park to the south of the aquifer test area and flows north through Bozeman, MT and into the Missouri River at Three Forks, MT. At the test sites the valley floor is covered by 20 ft to 60 ft of Quaternary alluvial river gravel on top of Cretaceous shale. Slopes of the valley margins are locally covered by alluvial fan deposits and, in at least one location, a landslide that locally covers the Quaternary river alluvium. The valley floor is about 3,500 ft wide east–west at the aquifer test sites.

The MBMG drilled 10 monitoring wells during July and August 2020, although not all are shown in figure 1. The wells were installed in the alluvial aquifer to determine aquifer thickness and aquifer composition, and to monitor water levels for the GWIP-UGRC project. All of the wells were drilled to fully penetrate the alluvial aquifer. However, wells were not as closely spaced as would be preferred for an aquifer test, because placing wells at greater distances provided needed information about aquifer geometry (extent and thickness). The wells are located on the Montana Fish Wildlife and Parks (FWP) Porcupine Unit of the Gallatin Wildlife Management Area (fig. 1), and were completed and monitored in cooperation with Montana FWP.

The Wildlife Management Area is a 600-acre flat to gently sloping former pastureland converted to a grassland and riparian area within the bottom of the Gallatin River Valley. The management area is bisected by the Gallatin River (fig. 1).

Two of the monitoring wells were selected for performing single well aquifer tests to determine the hydraulic properties of the aquifer. Single well tests were performed because the nearest monitoring wells were more than 300 ft from the pumping wells. In this unconfined aquifer setting, this distance is too great to expect measurable drawdown in the monitoring wells at the pumping rate used for this test. The lack of drawdown was verified during testing.

The two test wells are located on the east and west sides of the Gallatin River (wells 308527 and 308704, respectively; fig. 1). Aquifer tests were conducted in late October through early November 2021, after first frost, to avoid potential interference/influence from a nearby sprinkler irrigation well and phreatophyte evapotranspiration.

For analysis of aquifer tests, several simplifying assumptions are made about site conditions (Theis, 1935):

The aquifer is homogenous and isotropic.

1. The aquifer is of uniform thickness and effectively infinite lateral extent.
2. The pumped well fully penetrates and is open to the entire thickness of the aquifer.
3. The aquifer receives no recharge during the test.
4. Removal of water from aquifer storage is instantaneous.
5. The water table or potentiometric surface has no slope.
6. The pumped well is 100 percent efficient.

As is common to most aquifer tests, the test sites in the Upper Gallatin River Valley reported here did not satisfy all these conditions.

The Quaternary alluvial aquifer is likely heterogeneous, anisotropic, and limited in lateral extent due to alluvial depositional processes, and thus does not satisfy conditions 1 and 2. Modifications to the Theis solution (Theis, 1935) were applied to the aquifer test data that account for partially penetrating wells (condition 3), and recharge boundaries (condition 4). A comparison of well log lithologies in the 10 drilled monitoring wells suggests similar depositional sequences are present at each location.

Aquifer boundaries at each site were evaluated based on drawdown in the pumped wells and derivative plots (Renard and others, 2009).

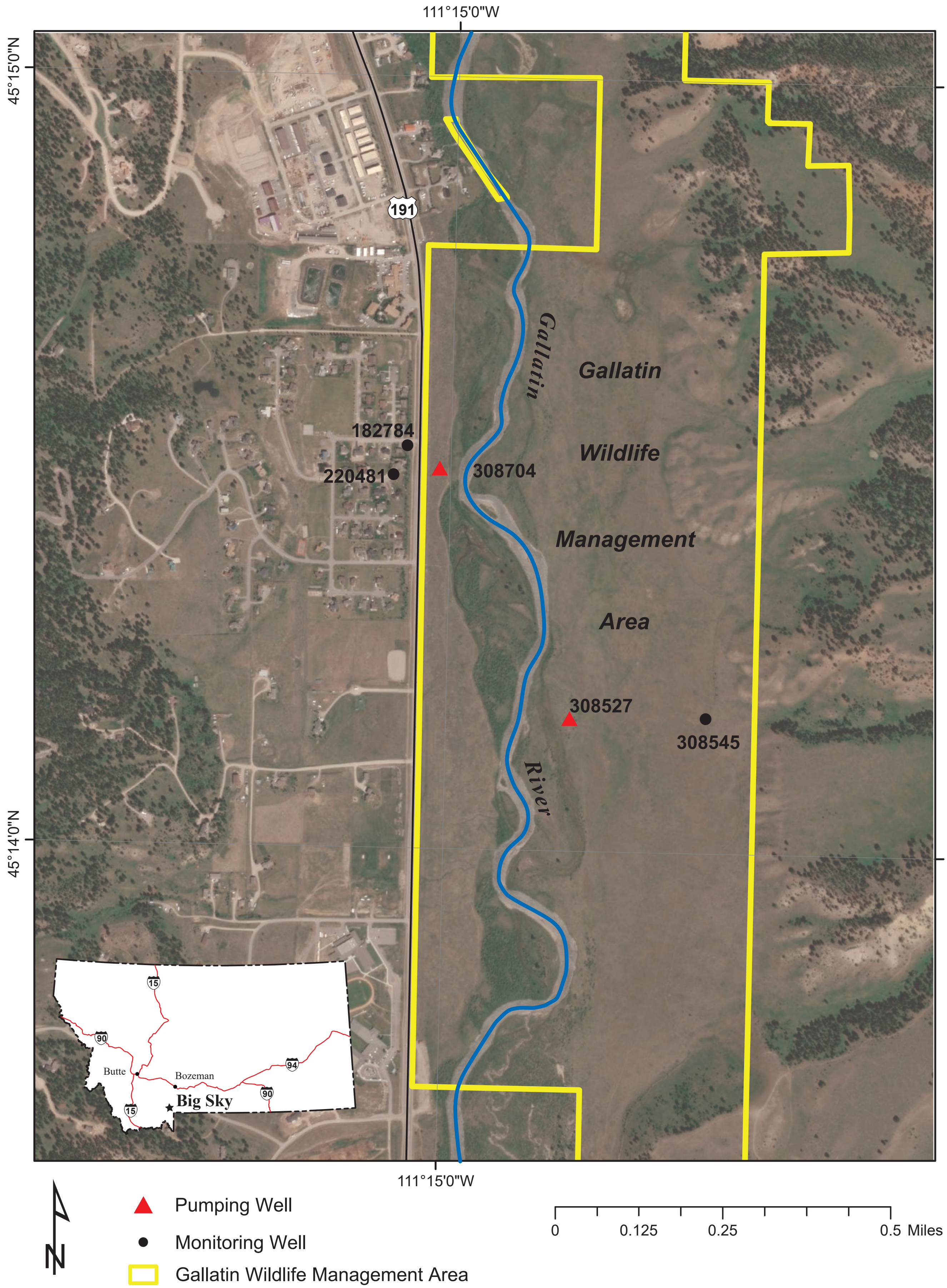

Figure 1. Location map of pumping test wells and monitoring wells along the Gallatin River and near Highway 191 near Big Sky. Inset map shows site location.

Table 1. Well completion details and maximum aquifer pumping test drawdown.

GWIC ID	Well Type; Pumping Well (PW), Monitoring Well (MW)	Diameter (in)	Well Depth (ft)	Screened Interval (ft-bgs)	Distance from PW (ft)	Max Water-Level Change (ft)
308527	PW	4	18	13–18	0	-1.50
308545	MW	4	46	36–46	1,073	-0.01*
308704	PW	4	37	27–37	0	-0.79
182784	MW	6	60	55–60	313	-0.08*
220481	MW	6	20	17–20	365	-0.04*

*Measured water-level declines in observation wells are similar to those measured in the pumping well prior to the aquifer test. The water-level declines are likely unrelated to pumping drawdown (figs. 2, 3).

Both aquifer tests were conducted following MBMG Standard Operating Procedures (SOPs) for constant-rate aquifer tests per MBMG SOP 11.6 (Gotkowitz, 2022). Well information and aquifer test results are summarized in this report. Well identification and construction details are listed in table 1 and appendix A. Well designations (i.e., well 308527) are the same as those used in the Ground Water Information Center (GWIC) database. GWIC is accessible online at http://mbmggwic.mtech.edu/, and includes information on well completions, groundwater levels, water chemistry, aquifer tests, and other data. Aquifer test data are reported on Form 633 and can be accessed in GWIC under the pumping well GWIC ID number.

EAST SITE, WELL 308527

Background

Test Location

Well 308527 is a 4-in-diameter PVC monitoring well in a grass meadow east of the Gallatin River at latitude 45.236162, and longitude -111.246220 (fig. 1).

Test Type

The aquifer test was conducted as a 48-h, single well, constant-rate test. Pumping from well 308527 began on October 27, 2021 at 11:00 am and ended at 11:00 am on October 29, 2021.

Hydrogeologic Setting

The test well is completed in the alluvial gravel of the Gallatin River Valley. Well completion details are shown in table 1 and appendix A1. The primary hydrologic feature at the test site is the Gallatin River, located 320 ft west of the well. The static groundwater elevation at well 308527 at the start of the test was 6058.50 ft MSL (4.03 ft below ground level).

Field Procedures

Data Collection

A data logging pressure transducer was installed in the pumped well prior to testing. Pre-testing, the logger was programmed to record water-level measurements every hour to measure antecedent water levels (fig. 2). During aquifer testing, and post-test water-level recovery, the transducer was programmed to record water levels every 30 s. Manual depth to water measurements were collected using an electronic tape (e-line) during the aquifer test at intervals shown in table 2.

The well was pumped using a portable generator and submersible pump. The pump was operated at its full capacity of 11 gpm. The pumped water was discharged through a hose 150 ft to the west, downslope towards the river. No ponding of water occurred on the land surface. A totalizing flow meter was installed on the pump discharge line to measure the pumping rate. The discharge was manually verified using a 5-gal bucket and stopwatch to measure the fill rate at intervals throughout the test.

Although the aquifer is highly transmissive and the well design is capable of a higher pumping rate, the well was pumped at 11 gpm using equipment available at the time. Calculation of screen entrance velocity using the well's construction parameters estimates the efficient well pumping capacity to be about 30 gpm.

Results

Hydrographs

Figure 2 shows the pumping well hydrograph for 1 week prior to pumping, the duration of pumping, and the recovery (post-pumping) period. Water levels

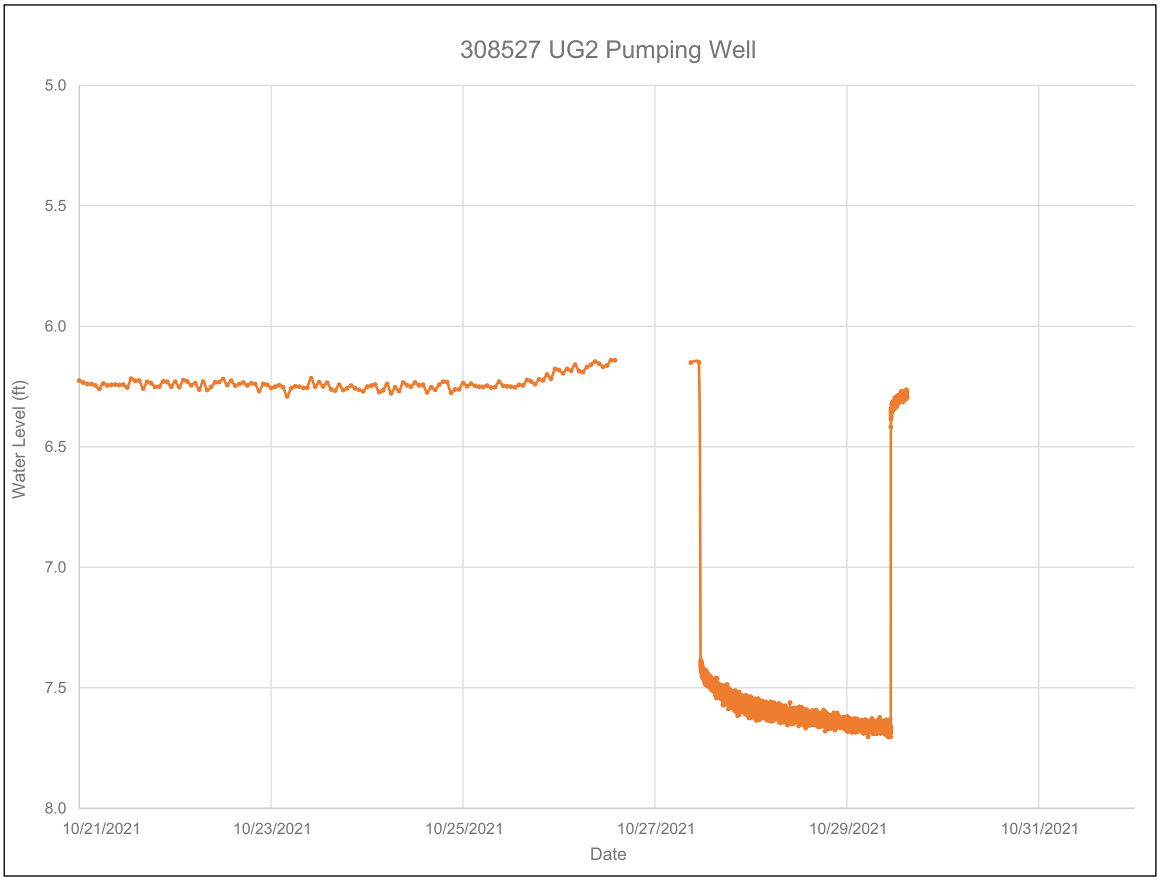

Figure 2. Hydrograph for pumping well UG2 (308527) prior to, during, and after pumping test.

measured for 1 week prior to the aquifer test show a flat trend. Recovering water levels returned to near pre-test levels. The natural background water level oscillated 0.1 ft or less.

The maximum drawdown for the pumping well during the aquifer test was 1.50 ft. Water levels in the closest alluvial well (308545, 1,073 ft east of the pumping well; fig. 1) were monitored during the test, but as expected, showed no drawdown response. Water levels measured in the observation well during the pumping test declined 0.01 ft. This is more likely the result of natural water-level fluctuations within the aquifer than effects from pumping from the test well (fig. 2).

At the end of the aquifer test, water-level recovery was monitored at intervals of 30 s with the pressure transducer, and manual measurements were taken at intervals in table 2, for 4 h, until the pumping well water level recovered to 98% (95% recommended in SOP) of the pre-pumping level (fig. 2).

Aquifer Properties

A Cooper–Jacob (1946) analysis was performed on late-time data from the pumping well to estimate transmissivity in an unconfined aquifer using a single well (appendix B1). The aquifer saturated thickness at the pumping well was 14 ft. The hydraulic conductivity is 384 ft/d, calculated from the estimated transmis-

Table 2. Manual water-level measurement intervals during aquifer pumping test.

Elapsed Test Time (Starts at 0 min)	Measurement Interval	Where Measurement Is Collected
0–5 min	As frequent as practical	Pumping well and other monitoring wells as feasible
5–60 min	5 min	
1–2 h	10 min	
2–4 h	15 min	
4–8 h	30 min	
8–16 h	1 h	
>16 h	4 h	

sivity of 5,293 ft^2/d using a saturated aquifer thickness of 14 ft. Derivative analysis of the drawdown data showed no evidence of hydrologic boundaries (appendix B2) when pumping at 11 gpm.

The derivative plots form straight lines showing no deflection that might indicate a boundary condition.

Estimating the aquifer storage coefficient requires measuring drawdown at a monitoring well within the cone of depression of the pumping well. This was not possible for this single-well aquifer test. Storage coefficients of unconfined aquifers typically range from 0.1 to 0.3 (Lohman, 1979).

WEST SITE, WELL 308704

Background

Test Location

Pumping well 308704 is a 4-in-diameter PVC monitoring well in flat sagebrush and grassland between Highway 191 and the west bank of the Gallatin River at latitude 45.2415072, latitude -111.250349 (fig. 1).

The nearest wells completed in the alluvial aquifer are an inactive irrigation well, 182784, located 313 ft northwest of the pumping well, and a monitoring well, 220481, located 365 ft southwest of the pumping well (fig. 1, table 1). No nearby wells were actively pumping during the test period.

Test Type

The test was a 70-h single-well constant-rate test that started at 1:45 pm on November 2, 2021 and continued to November 5 at 11:00 am. The well was pumped at an average rate of 11.3 gpm for the duration of the test. Although this is a relatively low rate to test a highly conductive aquifer, the project objectives were met with this test.

Hydrogeologic Setting

The test well is completed in the alluvial gravel of the Gallatin River Valley. Well completion details are shown in appendix A2. Logs from nearby wells confirm similar lithologies. The primary hydrologic feature at the study site is the Gallatin River. Pumping well 308704 is located 200 ft west of the river (fig. 1). The groundwater elevation in the well at the test start was measured at 6044.22 ft MSL (13.04 ft below ground level).

Field Procedures

Data Collection

Water levels were monitored in pumping well 308704 using a pressure transducer with a data logger. For 1 week prior to the test, the logger was programmed to record water-level measurements every hour (fig. 3). The recording interval was shortened to every 30 s for the aquifer test and recovery period. Manual water measurements were collected during the aquifer test to verify transducer readings, at intervals shown in table 2.

The constant-rate pumping test was started at 1:45 pm on November 2, 2021 and continued for 70 h, to November 5 at 11:00 am. A totalizing flow meter was installed on the pump discharge line to track the total amount of water pumped during the test. The total discharge over time was used to determine the average pumping rate in gpm. The discharge was manually verified using a 5-gal bucket and stopwatch. The time-weighted average using the totalizer values was 11.3 gpm. Calculation of screen entrance velocity using the well's construction parameters estimated an efficient well pumping capacity of about 60 gpm. The pumped water was discharged through a hose 150 ft to the east, downslope, towards the river. No ponding of water occurred on the land surface.

For data analysis, the potential drawdown in the observation wells was calculated using estimated transmissivity and well properties to calculate u, determining a well function $W(u)$, and applying the Theis equation (Driscoll, 1986).

Results

Hydrographs

Groundwater levels were monitored for 1 week prior to the aquifer test to determine any trends in the water levels (fig. 3). The monitoring showed a decline of 0.17 ft over 7 d (about 0.02 ft/d). No corrections to the pumping water levels were made. Maximum drawdown during the aquifer test was 0.79 ft over the 70-h period. The water level recovered to pre-test levels within 1 min of the end of pumping.

Water levels in the closest alluvial wells (irrigation well 182784 and well 220481; fig. 1, table 1) were monitored during the test. Theis equation calculations (Driscoll, 1986) showed a potential drawdown of 0.03

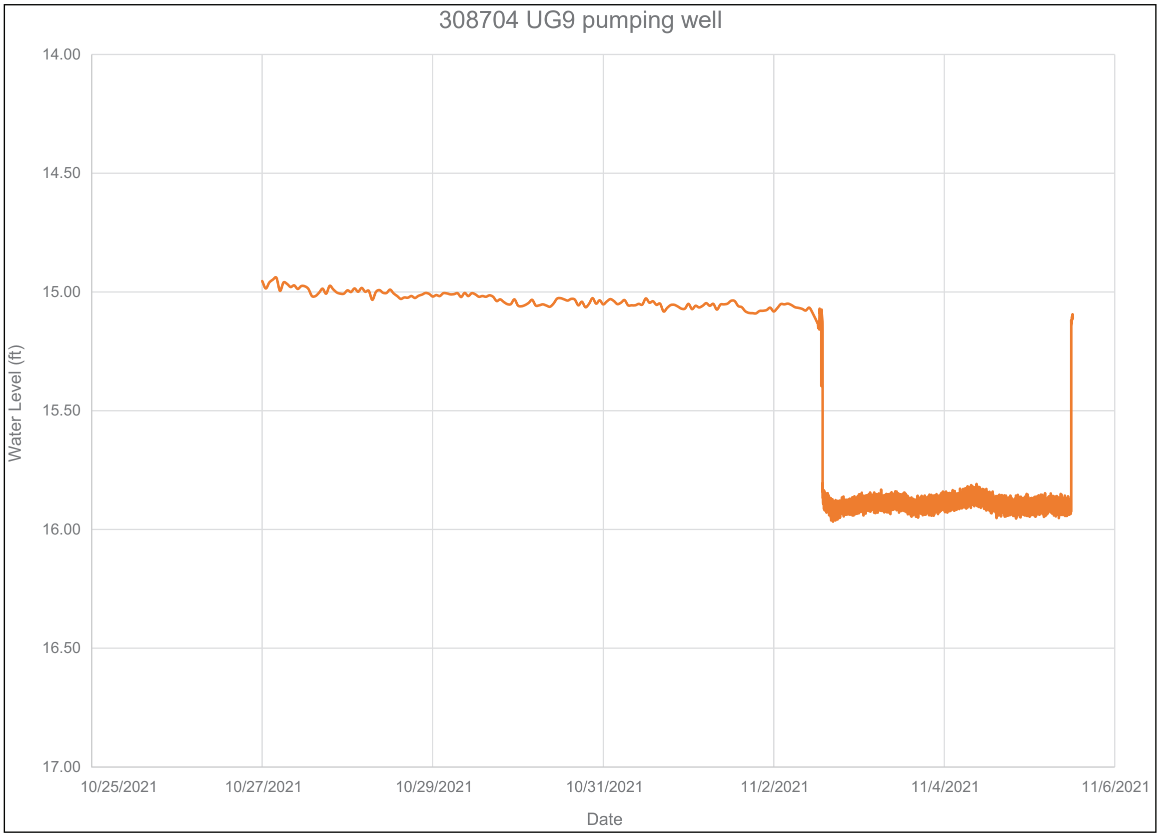

Figure 3. Hydrograph for pumping well UG9 (308704) prior to, during, and after pumping test.

ft is possible at the observation wells at 313 ft and 365 ft from the pumping well at a pumping rate of 11 gpm (table 1). Actual drawdowns of 0.04 ft and 0.08 ft were measured. The predicted and measured drawdowns are within the range of natural water-level fluctuations in the pumping well prior to the test (fig. 3); therefore, we did not use water-level change in the monitoring wells to estimate hydraulic properties of the aquifer.

Aquifer Properties

A Cooper–Jacob (1946) analysis was performed on late-time data from the pumping well to estimate transmissivity (appendix B3). The saturated aquifer thickness at the pumping well was 21 ft, and a hydraulic conductivity of 363 ft/d was calculated from the estimated transmissivity of 7,517 ft^2/d using the saturated thickness of 21 ft (table 1). Derivative analysis of the drawdown data shows a straight-line plot without deviation, indicating no boundary conditions were encountered (appendix B4).

We were unable to estimate a storage coefficient because there was not a monitoring well within the cone of depression. Storage coefficients of unconfined aquifers typically range from 0.1 to 0.3 (Lohman, 1979).

SUMMARY

Both single-well aquifer test wells are completed in an unconfined aquifer. Hydraulic conductivity of 385 ft/d and 359 ft/d (wells 308545 and 308704, respectively) are comparable to those reported by Driscoll (1986) for sand and gravel. Transmissivity for wells 308545 and 308704 were 5,293 and 7,517 ft^2/d, respectively. Although the derivative analysis of the pumping drawdown data gives no indication of a boundary condition encounter (Todd Myse, oral commun., 2022), this was somewhat expected, given the relatively low pumping rates used for these tests and the distance between the pumping wells and the river. Thus, we have not evaluated a surface water/groundwater connection, and because these were both single-well aquifer tests, storativity was not estimated. The primary purposes of these tests were estimating hydraulic conductivity and transmissivity of the unconfined aquifer.

REFERENCES

Cooper, H.H., and Jacob, C.E., 1946, A generalized graphical method for evaluation formation constants and summarizing well field history, American Geophysical Union Transactions, v. 27, p. 526–534.

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Gotkowitz, Madeline B., ed., 2022, Standard procedures and guidelines for field activities: Montana Bureau of Mines and Geology 746, 96 p.

Lohman, S.W., 1979, Ground-water hydraulics: USGS Professional Paper 708, 70 p.

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

Theis, C.V., 1935, The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage, American Geophysical Union Transactions, vol. 16, pgs. 519-524.

APPENDIX A: WELL LOGS

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
View scanned update/correction (12/10/2020 9:29:00 AM)

Site Name: UG FWP AREA * UG-2
GWIC Id: 308527

Section 1: Well Owner(s)

1) MONTANA FISH WILDLIFE AND PARKS UG2 (MAIL)
N/A
N/A N/A N/A [07/27/2020]

Section 2: Location

Township	Range	Section	Quarter Sections
07S	04E	9	SE¼ SW¼ SW¼

County	Geocode
GALLATIN	

Latitude	Longitude	Geomethod	Datum
45.23616211	-111.2462205	SUR-GPS	WGS84

Ground Surface Altitude	Ground Surface Method	Datum	Date
6062.53	SUR-GPS	NAVD88	10/30/2020

Measuring Point Altitude	MP Method	Datum	Date Applies
6064.65	SUR-GPS	NAVD88	7/27/2020

Addition	Block	Lot

Section 3: Proposed Use of Water

There are no uses assigned to this well.

Section 4: Type of Work

Drilling Method: Unassigned

Section 5: Well Completion Date

Date well completed: Unknown

Section 6: Well Construction Details

There are no borehole dimensions assigned to this well.

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
0	13	4			THREADED	PVC-SCHED 40

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
13	18	4		0.020	SCREEN-CONTINUOUS-PVC

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
0	9	BENTONITE CHIPS	

Section 7: Well Test Data

There are no well test data details assigned to this well.

Section 9: Well Log

Geologic Source

110ALVM - ALLUVIUM (QUATERNARY)

From	To	Description
0	2	BLACK SOIL, SILT/CLAY WITH GRAVELS
2	4	GRAVEL WITH BLACK SOIL.
4	5	BROWN CLAY WITH GRAVEL
5	8	COBBLY, YELLOW/TAN LIMESTONE FRAGMENTS, BLACK SHALE PEBBLES IN GRAVEL WITH SAND. INCREASING SAND WITH DEPTH.
8	10	BLACK PEBBLES AND GRAVEL WITH SAND, SOME SHALE PEBBLES. COBBLE FRAGMENTS
10	11	MOSTLY LIMESTONE PEBBLES WITH SAND AND SOME CLAY.
11	18	WATER. LIGHT BROWN SOUPY SILTY WATER, SOME PEBBLES IN GRAVEL AND FINE-GRAINED SAND, GRAVELS AND PEBBLES ARE GRANITIC, SCHIST, LS
18	18	GRAY CLAY ON SHALE

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.

There is no certification data for this well.

Figure A1. Well log for well 308527.

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 View scanned update/correction (12/10/2020 9:35:22 AM)

Site Name: MONTANA FISH WILDLIFE AND PARKS MBMG UG-9 * UG-9
GWIC Id: 308704

Section 1: Well Owner(s)

1) GREEN, DAVE (MAIL)
N/A
N/A N/A N/A [07/31/2020]

Section 2: Location

Township	Range	Section	Quarter Sections
07S	04E	9	SE¼ SW¼ NW¼

County	Geocode
GALLATIN	

Latitude	Longitude	Geomethod	Datum
45.2415072	-111.2503491	SUR-GPS	WGS84

Ground Surface Altitude	Ground Surface Method	Datum	Date
6057.26	SUR-GPS	NAVD88	10/30/2020

Measuring Point Altitude	MP Method	Datum	Date Applies
6059.33	SUR-GPS	NAVD88	7/31/2020

Addition	Block	Lot

Section 3: Proposed Use of Water

There are no uses assigned to this well.

Section 4: Type of Work

Drilling Method: Unassigned

Section 5: Well Completion Date

Date well completed: Unknown

Section 6: Well Construction Details

There are no borehole dimensions assigned to this well.

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
0	27.3	4			THREADED	PVC-SCHED 40

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
27.3	37.3	4		0.020	SCREEN-CONTINUOUS-PVC

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
0	20	BENTONITE CHIPS	

Section 7: Well Test Data

There are no well test data details assigned to this well.

Section 9: Well Log

Geologic Source

110ALVM - ALLUVIUM (QUATERNARY)

From	To	Description
0	2.5	TAN CLAYEY SILT TOPSOIL. DRY WITH FINE-GRAINED SAND (GRIT)
2.5	9	CLAYEY-SILT WITH ROUNDED GRAVELS DRY.
9	14	SANDY-WILT WITH ROUNDED PRBBLES AND GRAVEL. VERY DRY.
14	24	WATER. SAND AND GRAVEL WITH ROUNDED PEBBLES. TAN SILTY WATER.
24	27	COARSE GRAVEL AND PEBBLES WITH SAND. TAN SILTY WATER.
27	31	ROUNDED PEBBLES WITH GRAVEL AND SAND, BLACK SCHIST PEBBLES. TAN, SILTY WATER
31	33	MOSTLY SAND WITH ROUNDED GRAVEL AND PEBBLES. SILTY WATER.
33	35	GRAY VISOULS CLAYEY EATER WITH ROUNDED GRAVEL, SATURATED SILT-CLAY, OILY SHEEN ON WATER.
35	35	GRAY PLASTIC CLAY FRAGMENTS

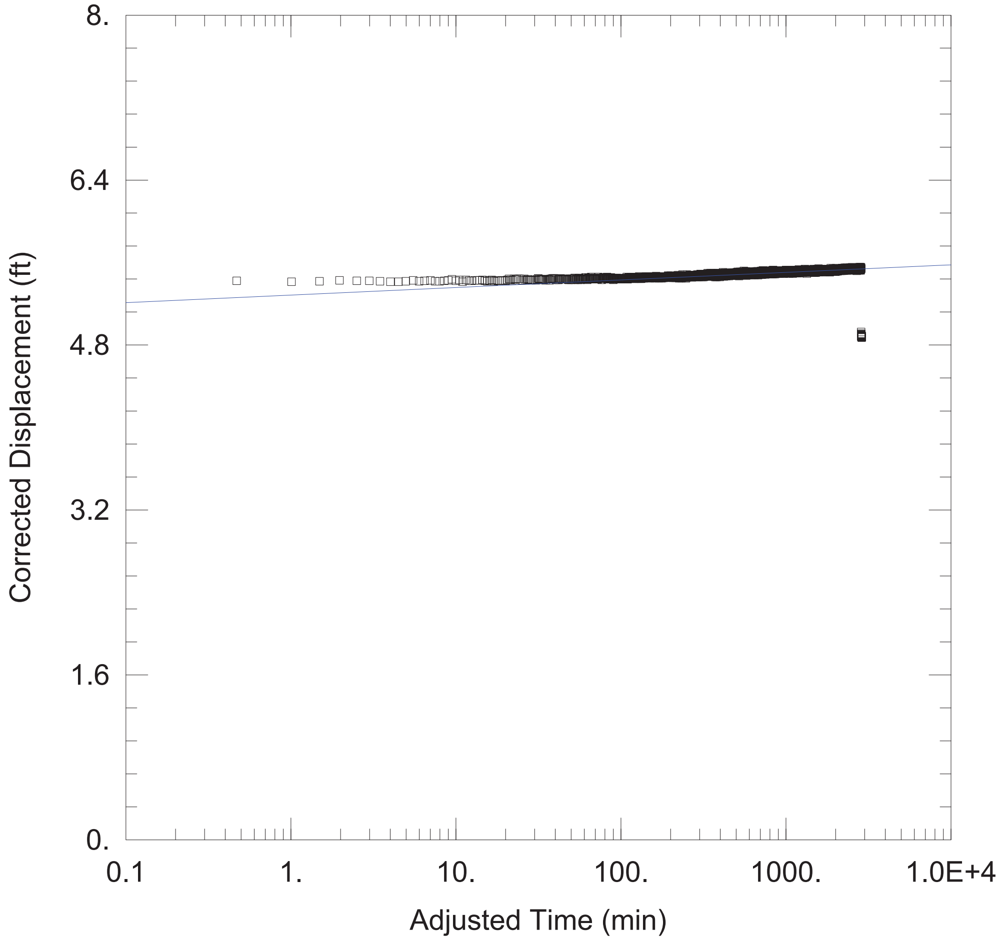
Driller Certification

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.

There is no certification data for this well.

Figure A2. Well log for well 308704.

APPENDIX B: AQUIFER TEST ANALYSES RESULTS



WELL TEST ANALYSIS

Data Set: M:\GWIP\Projects 2019-2020\Upper Gallatin\Aquifer tests\UG2_aquifer_test_logger_data.aqt
Date: 05/16/22 Time: 13:52:09

PROJECT INFORMATION

Test Well: 308527

AQUIFER DATA

Saturated Thickness: 13.85 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
308527	0	0

Observation Wells

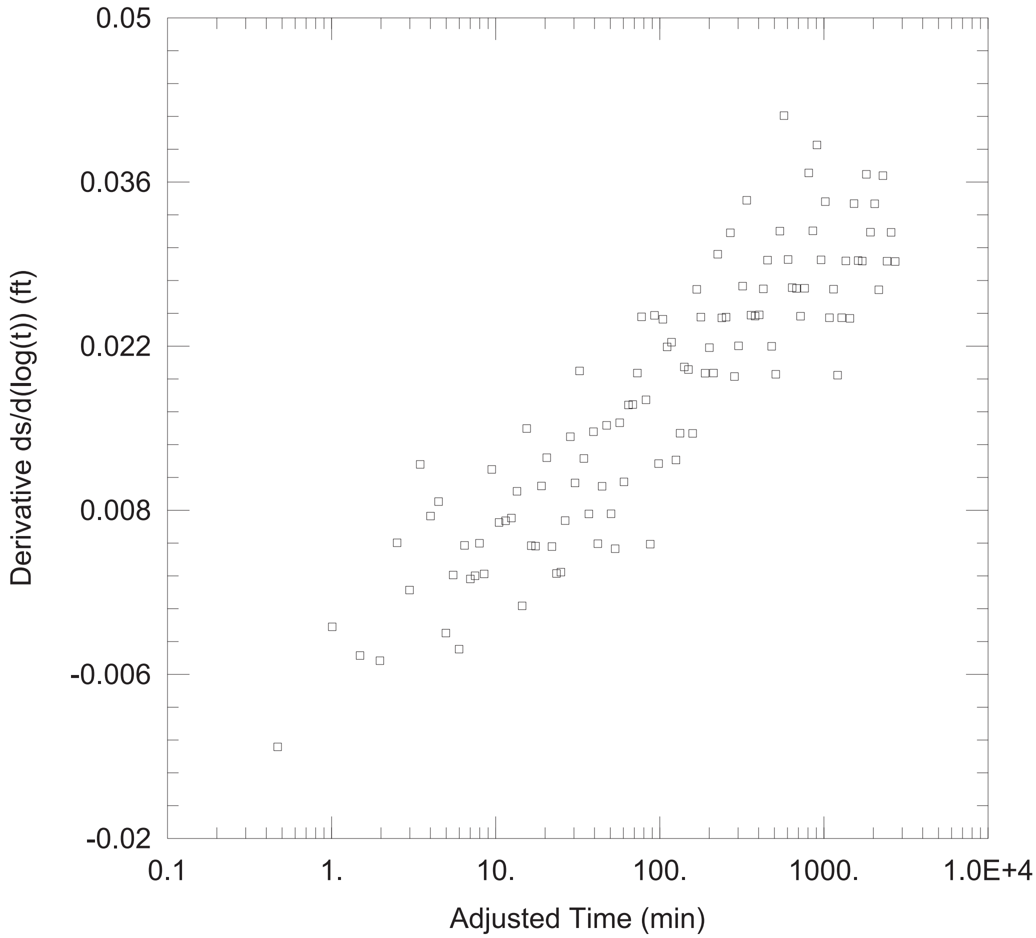
Well Name	X (ft)	Y (ft)
□ 308527	0	0

SOLUTION

Aquifer Model: Unconfined Solution Method: Cooper-Jacob

T = 5292.5 ft^2/day S = 2.457E-70

Figure B1. Cooper–Jacob analysis for pumping well UG2 (308527). Showing line match with late-time pumping drawdown data.



WELL TEST ANALYSIS

Data Set: M:\...\UG2_aquifer_test_logger_data_filtered_tm.aqt
Date: 05/19/22 Time: 09:10:59

PROJECT INFORMATION

Test Well: 308527

AQUIFER DATA

Saturated Thickness: 13.85 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
308527	0	0

Observation Wells

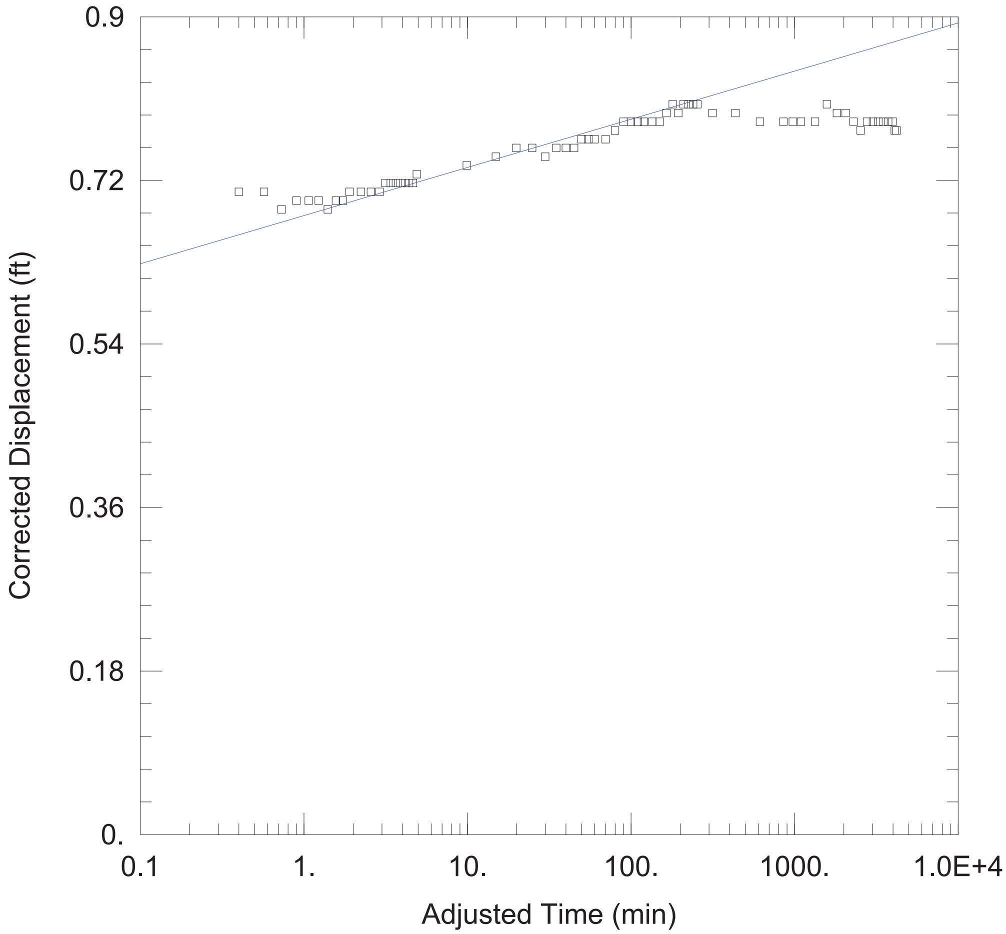
Well Name	X (ft)	Y (ft)
□ 308527	0	0

SOLUTION

Aquifer Model: Unconfined Solution Method: Cooper-Jacob

T = 6904.3 ft^2/day S = 3.537E-93

Figure B2. Derivative plot of drawdown for pumping well UG2 (308527). The derivative plot indicates boundary conditions were not encountered.



WELL TEST ANALYSIS

Data Set: M:\...\UG9 logger data_PW_only - Copy.aqt
Date: 05/16/22 Time: 13:41:53

PROJECT INFORMATION

Test Well: 308704

AQUIFER DATA

Saturated Thickness: 20.7 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
308704	0	0

Observation Wells

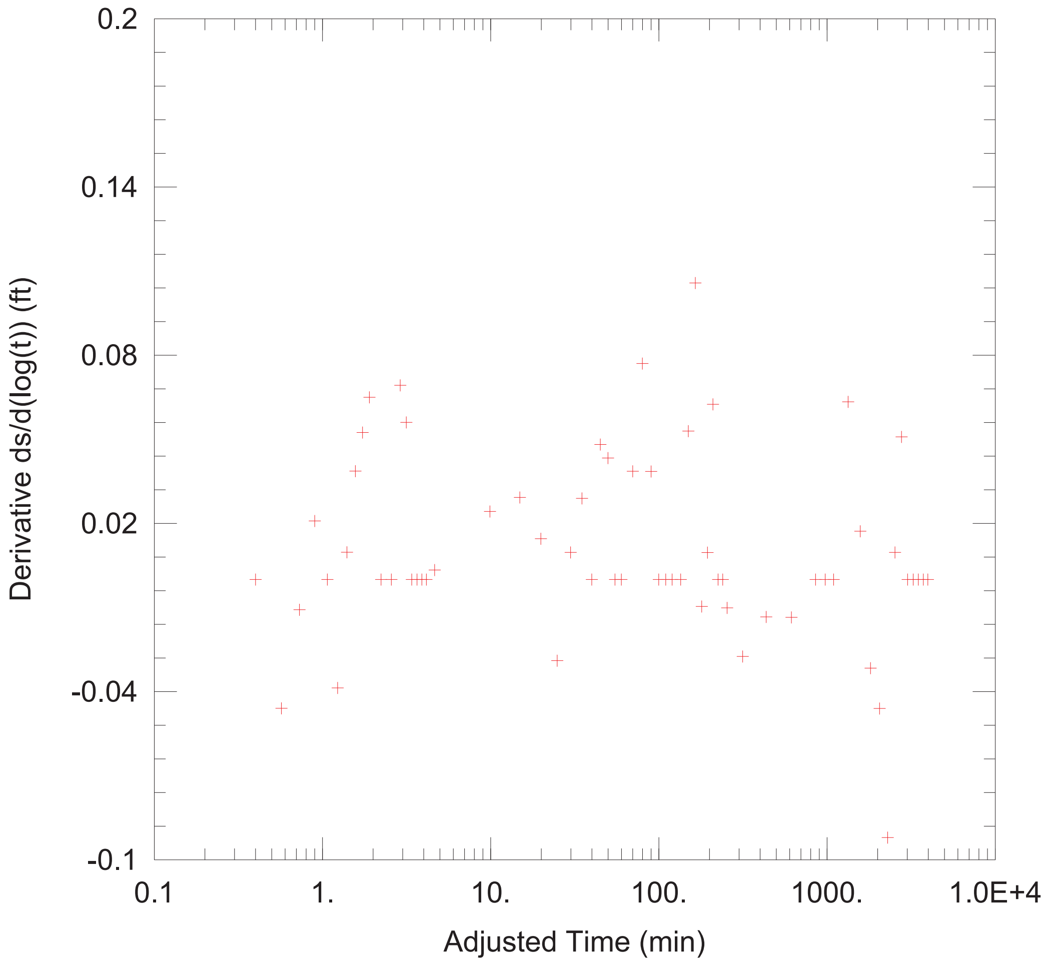
Well Name	X (ft)	Y (ft)
□ 308704	0	0

SOLUTION

Aquifer Model: Unconfined Solution Method: Cooper-Jacob

T = 7517.6 ft^2/day S = 5.987E-11

Figure B3. Cooper–Jacob analysis for pumping well UG9 (308704). Showing line match with late-time pumping drawdown data.



WELL TEST ANALYSIS

Data Set: M:\...\UG9 logger data_filtered_tm.aqt
Date: 05/19/22 Time: 09:11:54

PROJECT INFORMATION

Test Well: 308704

AQUIFER DATA

Saturated Thickness: 20.7 ft Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
308704	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ 308704	0	0

SOLUTION

Aquifer Model: Unconfined Solution Method: Cooper-Jacob

T = 6743.7 ft^2/day S = 2.008E-14

Figure B4. Derivative plot of drawdown for pumping well UG9 (308704). The derivative plot indicates boundary conditions were not encountered.