Water Levels and Nitrate in Warne Heights, Upper Summit Valley, Silver Bow County, Montana

By Camela A. Carstarphen, John I. LaFave, and Thomas W. Patton

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# Ground-Water Open-File Report 18

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by

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ABSTRACT

Warne Heights, 4 miles south of Butte, Montana, is located in the foothills of the Highland Mountains. This subdivision of 1- to 5-acre lots served by individual wells and septic-waste systems is located on fractured granitic bedrock. The bedrock is exposed at land surface and is the sole-source aquifer for the area. This report discusses data collected over 2.5 years, within and around Warne Heights, to address local concerns about water quantity and quality. Concerns centered on availability of ground water, elevated nitrate concentrations in ground water, and the sources of the nitrate. Water-level data indicate that: (1) ground-water flow directions generally follow topography and (2) the primary source of recharge is from the southeast. During summer months, a cone of depression is generated in the southern section of the subdivision, likely due to a combination of lawn irrigation and lower aquifer permeability-porosity conditions in that section of the subdivision. Nitrate concentrations, ranging from 0.9 to 11.60 mg/L-N, document not only temporal persistence of the nitrate but also its wide distribution. Analytical results from nitrogen and oxygen isotope samples suggest that the source of the nitrate is septic-system effluent. Elevated nitrate levels in an upgradient well and the direction of ground-water flow through Warne Heights suggest that nitrate sources may exist in areas south of Warne Heights. Lab results of 12.90 TU from the tritium sample indicate that the ground water is young. These results highlight the vulnerability of fractured bedrock aquifers to surface conditions despite the depths to water of 70 to 300 ft.

INTRODUCTION

Warne Heights is a 58-acre subdivision located in the Butte area within the southeastern corner of the Summit Valley (fig.1). All residences in the subdivision rely on ground water for their domestic supply and have individual septic tank and drainfield sewage disposal systems. Forty-seven of fifty-seven lots have been developed, most of which are 1 acre in size.

In 1999 the Butte-Silver Bow County Health Department field-tested water from 25 wells in Warne Heights for nitrate concentrations. The measured values ranged from 0.1 to 9.7 mg/L-N (unpublished data). The elevated nitrate concentrations in the ground water and a proposed subdivision adjacent to Warne Heights prompted the formation of a local landowner group. This group was concerned about the potential impact of additional development on ground-water resources: not just from the proposed subdivision, but also from further development within Warne Heights. In the spring of 2000, the landowner group sampled 46 wells in Warne Heights for nitrate and chloride analysis.

Although nitrate concentrations were the focus of concern in Warne Heights, landowners also worried that additional development might decrease ground-water...
availability. In response to this concern, the Montana Bureau of Mines and Geology (MBMG) Ground-Water Characterization Program (GWCP) measured wells in the Warne Heights area as part of a large-scale ground-water resource investigation in Deer Lodge, Powell, Granite, and Silver Bow counties. These wells were added as monitoring sites to obtain needed baseline ground-water level and ground-water quality data for this area of the Summit Valley and evaluate the potential impact of subdivisions on fractured bedrock aquifers.

This monitoring was conducted for 2.5 years, from August of 2000 through December of 2002. Water-level elevations and variations were used to define ground-water flow characteristics and seasonal changes in ground-water storage within Warne Heights. Water-quality samples included: samples for major cations/anions and trace metals, quarterly samples for nitrate concentrations, and samples for nitrogen and oxygen isotopes. This information helped establish an understanding of water quality, both general and specific to nitrate concentrations, including possible identification of nitrate sources. A tritium sample was collected to clarify the relative age of the ground water.

This report presents a description of the data-collection effort and the results of the water-level monitoring and water-quality testing in the Warne Heights area. As with most studies that endeavor to collect baseline data and build a fundamental framework, the data raise more questions and set the stage for more
work. Not only is additional work needed, but
the results suggest that some of the work
should be focused along the upgradient water-
courses south and southeast of the subdivision.

DESCRIPTION OF STUDY AREA

Location
The Summit Valley is an intermontane basin that covers 23 sq mi in southwest Montana and includes the city of Butte at its northern end (fig. 1). Its southern extent is defined by the foothills of the Highland Mountains and it is framed on the east and northeast by the Continental Divide, which runs along the East Ridge. Relatively low-lying hills frame its western extent. Summit Valley is drained by Silver Bow Creek and its tributaries: Blacktail, Little Blacktail, and Basin Creek (fig. 1). Land surface altitudes within the valley vary from 5,450 ft at the confluence of Silver Bow and Blacktail Creeks to between 5,600 and 5,680 ft at Warne Heights near its southern end.

Warne Heights (fig. 2) sits on a north–northwest-facing grassy slope in the southeast corner of Summit Valley, between Blacktail Creek and the confluence of Passmore Gulch and Little Blacktail Creek. It is bounded to the south by a small unnamed drainage and the timbered foothills of the Highland Mountains.

The area is semi-arid and the landscape is open and dominated by grasses, but supports low shrubs in the drainages. Average yearly precipitation measured at the Butte airport is 11.5 inches (National Weather Service, 2003), with 65% of that falling between May 1 and September 30.

Geology
The Summit Valley is framed and underlain by the Boulder Batholith, a large igneous intrusive complex 30 mi wide and 65 mi long (Smedes and others, 1973). Although the composition of the individual plutons which make up this complex vary, the largest and most extensive of the plutons is quartz monzonite. In the Butte area, this heavily fractured quartz monzonite has most often been called the Butte Quartz Monzonite (Botz, 1969; Miller, 1973) and underlies and crops out in Warne Heights and the surrounding area. For the purpose of this report it will be referred to as either “the batholith” or “fractured bedrock.”

The tectonic mechanisms responsible for the Boulder Batholith’s emplacement and subsequent “unroofing” are not absolutely agreed upon. However, the same tectonic activity responsible for bringing the batholith to the surface was also responsible for continued deformation along multiple faults, down-dropping part of the batholith and creating the basin that is the present-day Summit Valley (Smedes and others, 1973). This basin gradually filled with sediment eroded from the surrounding highlands.

The thickness of this accumulated sediment, or basin fill, has been estimated by geophysical means. Botz (1969), using refraction and gravity data, identified a maximum of 800 ft of fill in parts of the valley. However, in parts of the basin the depth to bedrock

Figure 2. Warne Heights sits on a north-northwest grassy slope near timbered foothills of the Highland Mountains.
exceeded the capabilities of the geophysical instrumentation. Basin fill thicknesses have not been verified by drilling; the deepest well reported in the basin fill is 448 ft deep [(Ground-Water Information Center (GWIC)].

Even though depths to the bedrock in the deepest parts of the valley are greater than 450 ft, along the fringe of the valley the bedrock is at or near the land surface. In these areas unconsolidated deposits are thin and are often “in situ” weathered bedrock. Most wells in these locations must penetrate fractured bedrock to produce water.

It is the fractures and weathering in the bedrock that provide sufficient permeability for it to be an aquifer. However, where these fractures extend to the land surface they act as conduits between potential surface sources of contamination and ground water (fig.3). The size and occurrence of these fractures vary. Where they are numerous and intersect, the bedrock will be more permeable, hence ground water is likely to move easily and potentially occur in greater quantity. Generally speaking, the more fractured the bedrock, the better the aquifer. Unfortunately, it is difficult to predict the occurrence and distribution of fractures in the subsurface; well depths and yields from bedrock vary, reflecting the variable distribution of water-bearing fractures. Well variability in Warne Heights is no exception.

In Warne Heights, all of the wells are completed in the fractured bedrock; well depths range from 48 to 540 ft. Well depths in Warne Heights do not necessarily increase with land surface altitude, but most relatively shallow wells are located in the central and northern sections of the development, which are topographically lower. The distribution of well depths may be related to subsurface structural elements; a faint lineament along the land surface running SE–NW (fig.2) could represent a fault. Although this trace has not been investigated, it might explain the differences in the magnitude of seasonal ground-water fluctuation identified between the northern and southern sections of the subdivision, discussed later in the text.

DATA COLLECTION AND RESULTS

Procedures

Water Levels

Water levels were measured in 23 wells between August 2000 and December 2002. Of these 23 wells, 7 were measured monthly (fig. 4), beginning in either August 2000 or February 2001, and 16 were measured twice, in August and December of 2001. Depth and location information for all of the measured wells are listed in appendix A. All water-level data are in appendix B. Well logs for wells visited are in appendix C.

Sampling

Water-quality data were collected from 7 wells (the monthly measurement sites) in or adjacent to Warne Heights (fig. 5). Three of
these wells were sampled for major cations/anions, trace metals, and nitrate. Four wells were each sampled for nitrate, two were sampled again for nitrate along with oxygen and nitrogen isotopes, and one well was sampled for tritium.

Samples for major cations/anions, trace metals, and tritium were collected after pumping for 30 min or after 3 well-volumes had been purged. Samples were preserved according to standard procedures. Nitrate samples were collected after a 5-min discharge from the well and preserved with sulfuric acid. The $\delta^{15}$N and $\delta^{18}$O samples were collected after a 10-min purge and preserved with mercuric chloride. Cation/anion, trace metal, and nitrate analyses were performed by the MBMG Analytical Laboratory. The tritium and nitrogen/oxygen isotope analyses were completed at the University of Waterloo Environmental Isotope Laboratory. The water quality, nitrate, and nitrogen/oxygen isotope results are in appendix D.

All measured wells were privately owned domestic wells. Well locations were determined by a global positioning system using a 1927 datum, and site elevations were determined from USGS 1:24,000 maps (appendix A). Water-level measurements were made with an electronic water-level indicator to the nearest 100th foot from the top of the well casing. Only static (non-pumping) water-level measurements were evaluated. All landowners have received copies of the water-level measurements and results of the sampling and analysis.

**WATER-LEVEL RESULTS AND DISCUSSION**

Water levels are controlled by a balance between recharge to, storage within, and discharge from an aquifer. A graph of multiple water levels taken through time at a single well (hydrograph) is useful in understanding conditions near the well and illustrating seasonal patterns in ground-water levels.

The hydrographs of the monitored wells (fig. 6) depict one common seasonal pattern
but with two different magnitudes. The seasonal pattern shows a water-level rise during spring run-off in April/May followed by a decline that starts in early summer, extends through September, and ends in October with the beginning of a recovery. The amount of this seasonal fluctuation in the wells measured is either small (0–5 ft) or large (10–40 ft).

The wells that show the largest seasonal fluctuation are located in the southern section of Warne Heights (figs. 7, 8). These wells suffer summertime declines of more than 10 ft; two wells show more than 20 ft. The extent of this summertime decline is also illustrated by the summer water-table map (fig. 8). This map shows a depression in the water table that is also apparent on the winter map; however, by December the water table in this area recovered by 30 or 40 ft. It is important to note however, that “recovery” was still occurring in April of 2002, when water levels in the center of the depression had recovered an additional 3-10 ft. When and if a full “recovery” occurs within this area of the cone of depression is not documented by the data.

Both the existence of this summer cone of depression and its location raise questions. Because this is a summertime phenomena, it is logical to look at summertime irrigation practices, and associate increased well use with the water-table depression. Why the cone of depression is located in the south-central area is not clear; all the developed lots are landscaped with lawns requiring regular irrigation between May and September and well distribution throughout the subdivision is fairly uniform. Yet there are no other apparent impacts to the water table. Given an even distribution of wells, relatively even distribution of water use from those wells, and relatively uniform aquifer conditions, a water-table depression related to summertime pumping would be
more centrally located within the development.

Instead, the cone of depression is restricted to the south-central area of the development. It could be that this area has less productive or fewer fractures and thus the aquifer is more sensitive to use. Or, there could simply be more pumping demand from wells in the southern section of the subdivision. During field work, many wells were observed to be discharging water for lawn irrigation during the day, when evapotranspiration rates were highest, throughout the subdivision.

The water-table maps (fig. 8) also depict the direction of ground-water flow (downgradient and perpendicular to the contours). Flow generally follows topography, but there is a southeast–northwest ground-water divide that separates two major directions of flow. North of the divide, ground water moves northward, towards the northeastern corner of Warne Heights. South of the divide, ground water moves westward into the cone of depression and towards Blacktail Creek. This divide within Warne Heights might be a local point of recharge; however, the directions of flow indicate that most of the recharge for Warne Heights is from the southeast and south (the upper reach of Passmore Gulch and an adjacent watercourse, respectively).

Extension of the water-level contours to well 180512 (fig. 5) located in the adjacent subdivision suggests that: (1) ground-water flow is generally parallel to the lower reach of Passmore Gulch and (2) neither subdivision is likely to impact the other with respect to ground-water flow.

Figure 8. Water-level altitudes in Warne Heights do not show much change in ground-water flow directions between summer and winter, although in the south-central corner a cone of depression appears in the summer contour map.
SAMPLING RESULTS AND DISCUSSION

General Water Chemistry

Analytical results for the cation/anion and trace metal samples indicate that the ground water at Warne Heights is generally a calcium-sulfate type water (fig. 9), although well 145960 could be classified as a calcium-sulfate-bicarbonate type. This slight difference suggests that as ground water flows through Warne Heights, it appears to become slightly enriched in sulfate and depleted in bicarbonate (comparing the upgradient sample, well 145960, with the two downgradient samples, wells 150276 and 180512). In general, the water is low in total dissolved solids, ranging in concentration from 143 mg/L to 245 mg/L.

Nitrate

Although nitrate is an essential nutrient for plant life, it is potentially harmful when present at excessive concentrations in drinking water. Pregnant women and infants less than 1 year of age are most commonly at risk from nitrate poisoning if they ingest water with elevated nitrate concentrations. Nitrate in water is most commonly reported as nitrogen (N) and not nitrate. The U.S. Environmental Protection Agency (USEPA) nitrate drinking water standard for public water supplies is 10 mg/L as nitrogen (mg/L-N).

Potential sources of nitrate to ground water include: infiltrating precipitation which contains nitrate from the atmosphere, rainwater; individual sewage disposal systems; nitrogen held within the organic matter of soil; and leachate from organic or synthetic fertilizers.

Nitrate, reported as nitrogen, was detected in all samples: concentrations ranged from 0.9 mg/L-N to 11.6 mg/L-N. Results from periodic sampling of wells 180512, 150276, and 145960 show seasonal fluctuations (fig. 10). Although the concentration of nitrate fluctuates, detectable concentrations were persistent throughout the study, with values highest during the winter and lowest in the early fall. Well 150276 demonstrated the most variation, while nitrate concentrations in well 180512 varied least. Well 150276 is located farthest downgradient (figs. 5, 8) and consistently had the highest nitrate concentrations of the wells sampled periodically. The highest nitrate concentration detected during the study was found in well 49551, which was sampled twice (11.6 mg/L-N and 9 mg/L-N). Well 49551 is the deepest
(340 ft) of all the wells sampled. However, the depth of a well is only one factor that can influence its susceptibility to nitrate contamination: grout depth and effectiveness, relative locations of septic tanks and drain fields, and the presence of near-surface fractures in the aquifer can all be important.

Almost all the nitrate concentrations detected at Warne Heights were near or above the health standard. Based on landuse, the two most likely possible sources of nitrate in Warne Heights appear to be septic tanks/drainfields and/or leachate from the application of lawn fertilizer. The sample results show that in fractured rock aquifers, well depth by itself does not protect the water supply from becoming contaminated. Also, the source(s) of the nitrate need not be limited to the Warne Heights subdivision. Given the presence of nitrate in well 145960, and the ground-water flow directions (fig. 8) from the upgradient portion of Passmore Gulch through Warne Heights, possible contribution of nitrate from this area must be considered.

**Nitrogen Isotopes**

Nitrogen and oxygen isotopes ($\delta^{15}$N, $\delta^{18}$O) present in the nitrate (NO$_3$) molecule have proven useful in distinguishing different sources of nitrate in ground water. The ratio of these isotopes to one another help discern septic waste sources from fertilizer, atmospheric, and soil sources (fig. 11). However, using these isotopes to determine nitrate sources requires that general ground-water flow direction and location of recharge for the aquifer be known, as well as the geochemistry of the ground water (Coplen, 1993; Kendall and Aravena, 2000).

Values of $\delta^{15}$N are reported in parts per mil relative to an internationally accepted standard gas concentration of N$_2$ in the atmosphere. $\delta^{18}$O values are reported in parts per mil relative to the internationally accepted standard concentration of $\delta^{18}$O in Standard Mean Ocean Water (SMOW) that has had a correction applied to it using Standard Light Antarctic Precipitation, V-SMOW.

The two wells sampled for $\delta^{15}$N and $\delta^{18}$O in Warne Heights were part of a broader sampling effort in the Summit valley to determine sources of elevated nitrate concentrations noted in some of the MBMG’s long-term monitoring wells. Figure 12 illustrates the locations of nitrogen isotope samples throughout the Summit Valley. The isotope results from the Warne Heights samples are similar to those in the rest of the Summit Valley. Isotope sample results for the Summit Valley are located in appendix D.

These results from the two wells sampled in Warne Heights are consistent with septic waste or manure sources (fig. 11). Given the land use and geologic setting of Warne Heights, these results suggest that septic tank effluent is the source of elevated nitrate in the ground water. Other analytical work could be conducted to confirm septic waste/manure as the source of the nitrate; this would include chloride and phosphate analysis (high concentrations may indicate septic influence) and additional $\delta^{15}$N and $\delta^{18}$O isotope sampling.
Well inventory and sampling upgradient (south and southeast) of the subdivision should also be conducted, because of the implied directions of ground-water flow.

**Tritium**

Tritium ($^3$H) is a naturally occurring radioactive isotope of hydrogen that has a half-life of 12.43 years. It is produced in the upper atmosphere where it is incorporated into water molecules and, therefore, is present in precipitation and water that recharges aquifers. Concentrations of tritium are measured in tritium units (TU), where one TU is equal to one tritium atom in $10^{18}$ atoms of hydrogen. Before the atmospheric testing of nuclear weapons began in 1952, natural concentrations of tritium in precipitation were 4–20 TUs (Clark and Fritz, 1997). Atmospheric testing of nuclear weapons between 1952 and 1963 released large amounts of tritium into the atmosphere, overwhelming the natural production of tritium; in North America, tritium concentrations in precipitation peaked at several thousand TUs in 1963–64. Because of its short half-life, bomb-derived tritium is an ideal marker of recent (post-1952) ground-water recharge. Ground water recharged by precipitation before 1952 will have tritium concentrations reduced because of radioactive decay to less than 1.0 TU, which is at or below the analytical detection limit. Therefore, a ground-water sample with detectable tritium (> 0.8 TU) includes water that must have been recharged since 1952.

The ground-water sample from well 180512 was analyzed for tritium and contained 12.90 +/- TUs. This value is consistent with water that has been recharged recently, within the past 5 years (LaFave, 2002), and suggests local recharge for the fractured bedrock aquifer.

**CONCLUSIONS**

The variability in seasonal water levels reflects variability in storage and recharge. The period of record in all of the wells is too short to determine any long-term trends. The location of the summer cone of depression may be the result of variations in fracture density/porosity-permeability and storage capacity within the aquifer and/or relatively greater ground-water withdrawal from that part of the aquifer. If the cone of depression is a result of lower storage capacity, this part of Warne Heights may have less ground water for current and future users and development. Additional water-quantity evaluations of the Warne Heights subdivision could refine the cause, shape, and duration of the cone of depression.

Ground-water chemistry evolves from a calcium bicarbonate to a calcium sulfate water generally down the flow path. The ground water is characterized by low dissolved solids and relatively high nitrate concentrations. The elevated nitrate concentrations and the presence of tritium indicate that the fractured rock aquifer near Warne Heights is susceptible to surface sources of contamination. $\delta^{15}$N and $\delta^{18}$O results indicate that the probable source
of nitrate in ground water at Warne Heights is septic tank effluent. Ground-water flow paths and the presence of nitrates in well 145960 suggest that the source(s) of nitrate in Warne Heights might include areas upgradient and within the recharge area for the aquifer.

DATA SOURCES

All data collected are listed in appendices A–D; all data are also available from the GWIC database at the MBMG (http://mbmg-wic.mtech.edu), with the exception of the isotope work.

ACKNOWLEDGMENTS

We thank all property owners who gave permission to use their wells. A special thank you to all the reviewers of this text.

REFERENCES


Appendix A

Location Information
Locating a Well Using Township, Range, and Section and A-B-C-D Tract Information

Tract locations are read from left to right, largest tract to smallest, which is the opposite of legal land descriptions.

Location information: 10N 58E 15 BAAD

Legal land description: SE¼ NE¼ NE¼ NW¼ Sec 15 T10N R58E

For example: to find a well located in 10N 58E 15 BAAD, read the tract designations from left to right, largest tract to smallest tract.
### Location Information for Wells Used in Study

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¹In a well casing that has been perforated, the depth water enters is the depth from ground to the uppermost perforation; in wells with no perforations the depth water enters is the same as the total depth of the well, or where casing ends.
Appendix B

Water-Level Data
## Water-Level Data

**Monthly Sites** (see appendix A for location and total depth information)

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Appendix C

Well Logs
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
LARSON MIKE

Location Information

GWIC Id: 165704
Location (TRS): 02N 07W 22 ACCA
County (MT): SILVER BOW
DNRC Water Right: C111720-00
PWS Id: 
Block: 
Lot: D
Addition: PASSMORE PLACER

Source of Data: LOG
Latitude (dd): 45.9101
Longitude (dd): -112.4531
Geomethod: NAV-GPS
Datum: NAD27
Altitude (feet): 5685.00
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 120.00
Static Water Level (ft): 25.00
Pumping Water Level (ft): 110.00
Yield (gpm): 25.00
Test Type: AIR
Test Duration: 1.00
Drill Stem Setting (ft):
Recovery Water Level (ft): 25.00
Recovery Time (hrs): 1.00
Well Notes:

Hole Diameter Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
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Casing Information¹

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<th>Dia</th>
<th>Wall Thickness</th>
<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
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Annular Seal Information

<table>
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<tr>
<th>From</th>
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<th>Description</th>
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<tbody>
<tr>
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Completion Information¹

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<th># of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
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<tr>
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<td>TORCH CUTS</td>
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Lithology Information

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<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>2.0</td>
<td>TOPSOIL</td>
</tr>
<tr>
<td>2.0</td>
<td>120.0</td>
<td>DECOMPOSED GRANITE</td>
</tr>
</tbody>
</table>

¹ - All diameters reported are inside diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
FISHER WILLIAM T.

Location Information
GWIC Id: 150276
Location (TRS): 02N 07W 22 ABBC
County (MT): SILVER BOW
DNRC Water Right: 97395
PWS Id: 
Block: 
Lot: 1-3
Addition: WARNE HEIGHTS
Source of Data: LOG
Latitude (dd): 45.9146
Longitude (dd): -112.4555
Geomethod: NAV-GPS
Datum: NAD27
Altitude (feet): 5605.00
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data
Total Depth (ft): 160.00
Static Water Level (ft): 30.00
Pumping Water Level (ft): 140.00
Yield (gpm): 14.00
Test Type: AIR
Test Duration: 1.00
Drill Stem Setting (ft): 160.00
Recovery Water Level (ft): 30.00
Recovery Time (hrs): 2.00
Well Notes:
How Drilled: ROTARY
Driller's Name: DYNAMITE
Driller License: WW431
Completion Date (m/d/y): 1/20/1995
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 211BDBT
Well/Water Use: DOMESTIC

Hole Diameter Information
<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
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<td>6.0</td>
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Casing Information¹
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<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Dia</th>
<th>Wall Thickness</th>
<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
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</thead>
<tbody>
<tr>
<td>-2.0</td>
<td>60.0</td>
<td>6.0</td>
<td>0.250</td>
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<td>WELDED</td>
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<td>PVC</td>
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Annular Seal Information
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<th>From</th>
<th>To</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
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<td>BENTONITE</td>
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Completion Information¹
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<th># of Openings</th>
<th>Size of Openings</th>
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<td>SAW SLOTS</td>
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Lithology Information
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<tr>
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<th>To</th>
<th>Description</th>
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<tbody>
<tr>
<td>0.0</td>
<td>2.0</td>
<td>TOPSOIL</td>
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<tr>
<td>2.0</td>
<td>60.0</td>
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<tr>
<td>60.0</td>
<td>160.0</td>
<td>GRANITE</td>
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</tbody>
</table>

¹ - All diameters reported are inside diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
RUCKDASCHEL KENNETH

Location Information

GWIC Id: 49551
Location (TRS): 02N 07W 22 BDCB
County (MT): SILVER BOW
DNRC Water Right: C014404-00
PWS Id:
Block: 12
Lot: 12
Addition: WARNE HEIGHTS
Source of Data: LOG
Latitude (dd): 45.9109
Longitude (dd): -112.4599
Geomethod: NAV-GPS
Datum: NAD27
Altitude (feet): 5640.00
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 340.00
Static Water Level (ft): 40.00
Pumping Water Level (ft):
Yield (gpm): 14.00
Test Type: AIR
Test Duration:
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):
Well Notes:
How Drilled: FORWARD ROTARY/CABLE
Driller's Name: OKEEFE
Driller License: WWD287
Completion Date (m/d/y): 3/22/1977
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 211BDBT
Well/Water Use: DOMESTIC

Hole Diameter Information

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<th>Diameter</th>
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<tbody>
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Annular Seal Information

No Seal Records currently in GWIC.

Casing Information

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<tr>
<th>From</th>
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Completion Information

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Lithology Information

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<td>GRANITE; PICKED UP 6 GPM</td>
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1 - All diameters reported are inside diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
HERZOG JIM

Location Information

GWIC Id: 145960
Location (TRS): 02N 07W 22 ADCC
County (MT): SILVER BOW
DNRC Water Right: C090002-00
PWS Id: 5524
Source of Data: LOG
Latitude (dd): 45.9095
Longitude (dd): -112.4501
Datum: NAD27
Altitude (feet): 5740.00
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 100.00
Static Water Level (ft): 31.00
Pumping Water Level (ft):
Yield (gpm): 10.00
Test Type: AIR
Test Duration: 1.00
Drill Stem Setting (ft): 100.00
Recovery Water Level (ft): 47.00
Recovery Time (hrs): 1.00
Completion Date (m/d/y): 5/11/1994
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 211BDBT
Well/Water Use: DOMESTIC

Hole Diameter Information

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Annular Seal Information

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Completion Information

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Lithology Information

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<th>Description</th>
</tr>
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<tbody>
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<tr>
<td>1.0</td>
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<td>DECOMPOSED GRANITE</td>
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<tr>
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<td>30.0</td>
<td>GRANITE</td>
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<td>WATER</td>
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1 - All diameters reported are inside diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
MONTGOMERY GARY

Location Information

GWIC Id: 168216
Location (TRS): 02N 07W 22 BACB
County (MT): SILVER BOW
DNRC Water Right: C111694-00
PWS Id:
Lot: 6
Block: 
Addition: WARNE HEIGHTS

Source of Data: LOG
Latitude (dd): 45.9140
Longitude (dd): -112.4599
Geomethod: NAV-GPS
Datum: NAD27
Altitude (feet): 5620.00
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 95.00
Static Water Level (ft): 45.00
Pumping Water Level (ft): 85.00
Yield (gpm): 12.00
Test Type: BAILER
Test Duration: 1.00
Drill Stem Setting (ft):
Recovery Water Level (ft): 45.00
Recovery Time (hrs): 0.50
Driller's Name: DYNAMITE
Driller License: WWC431
Completion Date (m/d/y): 4/1/1998
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 211BDBT
Well/Water Use: DOMESTIC

Hole Diameter Information

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<th>To</th>
<th>Diameter</th>
</tr>
</thead>
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Casing Information

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<th>Dia</th>
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<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
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<td>PVC</td>
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Annular Seal Information

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<th>Description</th>
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Completion Information

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Lithology Information

<table>
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<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
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<tr>
<td>2.0</td>
<td>25.0</td>
<td>SANDY CLAY</td>
</tr>
<tr>
<td>25.0</td>
<td>60.0</td>
<td>DECOMPOSED GRANITE</td>
</tr>
<tr>
<td>60.0</td>
<td>95.0</td>
<td>GRANITE</td>
</tr>
</tbody>
</table>

1 - All diameters reported are inside diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
MCLEAN JOE

Location Information
GWIC Id: 165216
Location (TRS): 02N 07W 22 BDAB
County (MT): SILVER BOW
DNRC Water Right: C102871-00
PWS Id: 02N 07W 22 BDAB
Block: 28
Lot: 28
Addition: WARNE HEIGHTS
Source of Data: LOG
Latitude (dd): 45.9117
Longitude (dd): -112.4579
Geomethod: NAV-GPS
Datum: NAD27
Altitude (feet): 5650.00
Certificate of Survey: Type of Site: WELL

Well Construction and Performance Data
Total Depth (ft): 180.00
Static Water Level (ft): 44.00
Yield (gpm): 12.00
Test Type: AIR
Test Duration: 1.00
Drill Stem Setting (ft): 175.00
Recovery Water Level (ft):
Recovery Time (hrs): 0.50
Well Notes:

Hole Diameter Information
<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>180.0</td>
<td>6.0</td>
</tr>
</tbody>
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Annular Seal Information
<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>20.0</td>
<td>BENTONITE/HOLE PLUG</td>
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Casing Information
<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Wall Thickness</th>
<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.5</td>
<td>18.0</td>
<td>6.0</td>
<td>0.250</td>
<td>STEEL</td>
<td>STEEL</td>
</tr>
<tr>
<td>10.0</td>
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<td></td>
<td>PVC</td>
<td>PVC</td>
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Completion Information
<table>
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<tr>
<th>From</th>
<th>To</th>
<th># of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>160.0</td>
<td>180.0</td>
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<td>4.0</td>
<td>TORCH CUTS</td>
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Lithology Information
<table>
<thead>
<tr>
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<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>5.0</td>
<td>TOPSOIL</td>
</tr>
<tr>
<td>5.0</td>
<td>45.0</td>
<td>GRANITE</td>
</tr>
<tr>
<td>45.0</td>
<td>60.0</td>
<td>SILT</td>
</tr>
<tr>
<td>60.0</td>
<td>140.0</td>
<td>FINE SAND</td>
</tr>
<tr>
<td>140.0</td>
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<td>GRANITE</td>
</tr>
</tbody>
</table>

1 - All diameters reported are inside diameter of the casing.
# Montana Bureau of Mines and Geology

## Ground-Water Information Center Site Report

### BRANDON-LEGG DEVELOPMENT MW-7

## Location Information

- **GWIC Id:** 180512
- **Source of Data:** LOG
- **Location (TRS):** 02N 07W 22 AACB
- **Latitude (dd):** 45.9139
- **County (MT):** SILVER BOW
- **Longitude (dd):** -112.4517
- **DNRC Water Right:***
- **PWS Id:**
- **Datum:** NAD27
- **Block:**
- **Lot:**
- **Altitude (feet):** 5635.00
- **Certificate of Survey:**
- **Addition:** HOMESTAKE ACRES
- **Type of Site:** WELL

## Well Construction and Performance Data

- **Total Depth (ft):** 100.00
- **How Drilled:** ROTARY
- **Static Water Level (ft):** 28.00
- **Driller’s Name:** OKEEFE
- **Pumping Water Level (ft):**
- **Driller License:** WWC082
- **Yield (gpm):** 12.00
- **Completion Date (m/d/y):** 4/13/2000
- **Test Type:** AIR
- **Is Well Flowing?:***
- **Test Duration:** 1.00
- **Shut-In Pressure:**
- **Drill Stem Setting (ft):** 95.00
- **Recovery Water Level (ft):** 28.00
- **Recovery Time (hrs):** 1.00
- **Geology/Aquifer:** 211BDBT
- **Well/Water Use:** DOMESTIC

## Hole Diameter Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>18.0</td>
<td>8.0</td>
</tr>
<tr>
<td>18.0</td>
<td>100.0</td>
<td>6.0</td>
</tr>
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## Annular Seal Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>0.0</td>
<td>18.0</td>
<td>BENTONITE CHIPS</td>
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## Casing Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Dia</th>
<th>Wall Thickness</th>
<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2.0</td>
<td>18.0</td>
<td>6.0</td>
<td></td>
<td></td>
<td></td>
<td>WELDED STEEL</td>
</tr>
<tr>
<td>0.0</td>
<td>100.0</td>
<td>4.0</td>
<td></td>
<td></td>
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<td>WELDED PVC</td>
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## Completion Information

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<th># of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>80.0</td>
<td>100.0</td>
<td>4.0</td>
<td>54</td>
<td>1/8X6</td>
<td>SAW SLOTS</td>
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## Lithology Information

<table>
<thead>
<tr>
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<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>5.0</td>
<td>BROWN DECOMPOSED GRANITE</td>
</tr>
<tr>
<td>5.0</td>
<td>15.0</td>
<td>REDDISH BROWN DECOMPOSED GRANITE</td>
</tr>
<tr>
<td>15.0</td>
<td>20.0</td>
<td>TAN PARTIALLY DECOMPOSED GRANITE</td>
</tr>
<tr>
<td>20.0</td>
<td>25.0</td>
<td>REDDISH BROWN PARTIALLY DECOMPOSED GRANITE</td>
</tr>
<tr>
<td>25.0</td>
<td>40.0</td>
<td>LIGHT BROWN GRANITIC MATERIAL A FEW MICA FLAKES</td>
</tr>
<tr>
<td>40.0</td>
<td>45.0</td>
<td>LIGHT BROWN TO TAN WEATHERED GRANITIC MATERIAL WITH SOME MICA</td>
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<tr>
<td>45.0</td>
<td>60.0</td>
<td>TAN GRANITIC MATERIAL WITH MICA</td>
</tr>
<tr>
<td>60.0</td>
<td>65.0</td>
<td>WET TAN GRANITIC MATERIAL WITH MICA</td>
</tr>
<tr>
<td>65.0</td>
<td>80.0</td>
<td>TAN GRANITIC MATERIAL WITH MICA</td>
</tr>
<tr>
<td>80.0</td>
<td>100.0</td>
<td>WET TAN GRANITIC MATERIAL WITH MICA</td>
</tr>
</tbody>
</table>

1 - All diameters reported are **inside** diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
PETERS JOHN AND PAULA

Location Information
GWIC Id: 190731
Source of Data: LOG
Location (TRS): 02N 07W 22 BABC
Latitude (dd): 45.9149
County (MT): SILVER BOW
Longitude (dd): -112.4600
DNRC Water Right: C063476-00
Datum: NAD27
PWS Id: 
Altitude (feet): 5590.00
Block: 
Certificate of Survey: 
Lot: 4
Type of Site: WELL

Well Construction and Performance Data
Total Depth (ft): 320.00
How Drilled: FORWARD ROTARY
Static Water Level (ft): 26.00
Driller's Name: BRAZILL
Pumping Water Level (ft): 
Driller License: WWC355
Yield (gpm): 
Completion Date (m/d/y): 5/2/1986
Test Type: AIR
Is Well Flowing?: 
Test Duration:
Special Conditions:
Drill Stem Setting (ft): 
Geology/Aquifer: 211BDBT
Recovery Water Level (ft): 
Well/Water Use: DOMESTIC
Recovery Time (hrs):
Well Notes:

Hole Diameter Information

<table>
<thead>
<tr>
<th>From To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 320.0</td>
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Annular Seal Information
No Seal Records currently in GWIC.

Casing Information

<table>
<thead>
<tr>
<th>From To</th>
<th>Wall Thickness</th>
<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 86.0</td>
<td>6.0</td>
<td></td>
<td></td>
<td>STEEL</td>
</tr>
<tr>
<td>50.0 290.0</td>
<td>4.0</td>
<td></td>
<td></td>
<td>PVC</td>
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Completion Information

<table>
<thead>
<tr>
<th>From To</th>
<th>Dia # of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>50.0 290.0</td>
<td>4.0</td>
<td></td>
<td>SAW SLOTS</td>
</tr>
</tbody>
</table>

Lithology Information

<table>
<thead>
<tr>
<th>From To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 20.0</td>
<td>TOPSOIL &amp; SAND</td>
</tr>
<tr>
<td>20.0 40.0</td>
<td>GRAVEL TOPSOIL &amp; SAND</td>
</tr>
<tr>
<td>40.0 80.0</td>
<td>SAND</td>
</tr>
<tr>
<td>80.0 320.0</td>
<td>ROCK</td>
</tr>
</tbody>
</table>

1 - All diameters reported are inside diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
SICOTTE PATRICIA

Location Information
GWIC Id: 49550
Location (TRS): 02N 07W 22 BBDAC
County (MT): SILVER BOW
DNRC Water Right: C012532-00
PWS Id:
Block: 2
Lot: 2
Addition: WARNE HEIGHTS
Source of Data: LOG
Latitude (dd): 45.9143
Longitude (dd): -112.4609
Geomethod: MAP
Datum: NAD27
Altitude (feet): 5595.00
Certificate of Survey:
Type of Survey: Type of Site: WELL

Well Construction and Performance Data
Total Depth (ft): 54.00
Static Water Level (ft): 23.00
Pumping Water Level (ft):
Yield (gpm): 14.00
Test Type: PUMP
Test Duration:
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):
Well Notes:
How Drilled: CABLE
Driller's Name: OKEEFE
Driller License: WWD287
Completion Date (m/d/y): 10/26/1976
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 211BDBT
Well/Water Use: DOMESTIC

Hole Diameter Information
<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>54.0</td>
<td>6.0</td>
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</tbody>
</table>

Annular Seal Information
No Seal Records currently in GWIC.

Lithology Information
<table>
<thead>
<tr>
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<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>2.0</td>
<td>FILL</td>
</tr>
<tr>
<td>2.0</td>
<td>3.0</td>
<td>TOPSOIL</td>
</tr>
<tr>
<td>3.0</td>
<td>45.0</td>
<td>DECOMPOSED GRANITE SAND AND CLAY</td>
</tr>
<tr>
<td>45.0</td>
<td>53.0</td>
<td>SAND AND GRAVEL WATER</td>
</tr>
<tr>
<td>53.0</td>
<td>54.0</td>
<td>GRANITE</td>
</tr>
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Casing Information
<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Wall Thickness</th>
<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.5</td>
<td>54.0</td>
<td>6.0</td>
<td></td>
<td></td>
<td>WELDED STEEL</td>
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Completion Information
<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th># of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
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<tbody>
<tr>
<td>47.0</td>
<td>52.0</td>
<td>1/8</td>
<td>6.0</td>
<td>SLOTS</td>
</tr>
</tbody>
</table>

1 - All diameters reported are inside diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
KRISKOVICH JOHN

Location Information

GWIC Id: 149205
Location (TRS): 02N 07W 22 BDBB
County (MT): SILVER BOW
DNRC Water Right:
PWS Id:
Block:
Lot:
Addition: WARNE HEIGHTS
Source of Data: LOG
Latitude (dd): 45.9127
Longitude (dd): -112.4604
Geomethod: MAP
Datum: NAD27
Altitude (feet): 5620.00
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 240.00
Static Water Level (ft): 45.00
Pumping Water Level (ft):
  Yield (gpm): 10.00
  Test Type: AIR
  Test Duration: 1.00
  Drill Stem Setting (ft): 240.00
  Recovery Water Level (ft): 45.00
  Recovery Time (hrs): 1.00
  Well Notes:
  How Drilled: ROTARY
  Driller's Name: OKEEFE
  Driller License: WWC462
  Completion Date (m/d/y): 10/21/1993
  Special Conditions:
  Is Well Flowing?:
  Shut-In Pressure:
  Geology/Aquifer: 211BDBT
  Well/Water Use: DOMESTIC

Hole Diameter Information

No Hole Diameter Records currently in GWIC.

Annular Seal Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
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<td>BENTONITE</td>
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</tbody>
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Completion Information

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<th>From</th>
<th>To</th>
<th># of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>180.0</td>
<td>240.0</td>
<td>4.0</td>
<td></td>
<td>SAW SLOTS</td>
</tr>
</tbody>
</table>

Casing Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Wall Thickness</th>
<th>Pressure Rating</th>
<th>Joint Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.5</td>
<td>60.0</td>
<td>6.0</td>
<td>0.250</td>
<td>STEEL</td>
</tr>
<tr>
<td>10.0</td>
<td>240.0</td>
<td>4.0</td>
<td></td>
<td>PVC</td>
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Lithology Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>2.0</td>
<td>TOPSOIL</td>
</tr>
<tr>
<td>2.0</td>
<td>60.0</td>
<td>SAND</td>
</tr>
<tr>
<td>60.0</td>
<td>100.0</td>
<td>SANDY CLAY</td>
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<tr>
<td>100.0</td>
<td>180.0</td>
<td>GRANITE</td>
</tr>
<tr>
<td>180.0</td>
<td>240.0</td>
<td>DECOMPOSED GRANITE</td>
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</table>

1 - All diameters reported are inside diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
HALL JOHN AND DIANNE

Location Information

GWIC Id: 49543
Location (TRS): 02N 07W 22 BABD
County (MT): SILVER BOW
DNRC Water Right: C017003-00
PWS Id:
Block: 0
Lot: 21
Addition: WARNE HEIGHTS

Source of Data: LOG
Latitude (dd): 45.9150
Longitude (dd): -112.4589
Geomethod: MAP
Datum: NAD27
Altitude (feet): 5605.00
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 76.00
Static Water Level (ft): 20.00
Pumping Water Level (ft):
Yield (gpm): 5.00
Test Type: BAILER
Test Duration:
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):
Well Notes:

How Drilled: CABLE
Driller's Name: OKEEFE
Driller License: WWC287
Completion Date (m/d/y): 10/7/1977
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 211BDBT
Well/Water Use: DOMESTIC

Hole Diameter Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
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Annular Seal Information

No Seal Records currently in GWIC.

Casing Information¹

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Dia</th>
<th>Thickness</th>
<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
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<td>17 LB</td>
<td>STEEL</td>
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Completion Information¹

<table>
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<tr>
<th>From</th>
<th>To</th>
<th># of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>71.0</td>
<td>76.0</td>
<td>1/8</td>
<td>6.0</td>
<td>TORCH CUTS</td>
</tr>
</tbody>
</table>

Lithology Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
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<tr>
<td>40.0</td>
<td>75.0</td>
<td>SAND &amp; DECOMPOSED ROCK</td>
</tr>
<tr>
<td>75.0</td>
<td>76.0</td>
<td>ROCK</td>
</tr>
</tbody>
</table>

¹ - All diameters reported are inside diameter of the casing
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
EDWARDS JIM AND LISA

Location Information

GWIC Id: 177407
Source of Data: LOG
Location (TRS): 02N 07W 22 BDAA
Latitude (dd): 45.9124
County (MT): SILVER BOW
Longitude (dd): -112.4563
DNRC Water Right: C106553-00
Datum: NAD27
PWS Id: Geomethod: MAP
Block: Altitude (feet): 5670.00
Lot: 45 Certificate of Survey:
Addition: WARNE HEIGHTS Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 160.00 How Drilled: ROTARY
Static Water Level (ft): 70.00 Driller's Name: PARSONS
Pumping Water Level (ft):
Yield (gpm): 12.00 Driller License: WWC596
Test Type: AIR Completion Date (m/d/y): 8/7/1999
Test Duration: 1.00 Is Well Flowing?:
Drill Stem Setting (ft): Shut-In Pressure:
Recovery Water Level (ft): Geology/Aquifer: 211BDBT
Recovery Time (hrs): Well/Water Use: DOMESTIC
Well Notes:

Hole Diameter Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
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</tr>
<tr>
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<td>160.0</td>
<td>6.0</td>
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Casing Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Dia</th>
<th>Wall Thickness</th>
<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2.0</td>
<td>18.0</td>
<td>6.0</td>
<td>0.250</td>
<td>WELDED STEEL</td>
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<td>WELDED STEEL</td>
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Annular Seal Information

<table>
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<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.0</td>
<td>18.0</td>
<td>BENTONITE</td>
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<tr>
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<td>60.0</td>
<td>V TYPE PACKER</td>
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Completion Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th># of Openings</th>
<th>Size of Openings</th>
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<tbody>
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<td>4.0</td>
<td>0.025</td>
<td>PVC</td>
</tr>
<tr>
<td>120.0</td>
<td>150.0</td>
<td>4.0</td>
<td>0.025</td>
<td>PVC</td>
</tr>
</tbody>
</table>

Lithology Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.0</td>
<td>TOPSOIL</td>
</tr>
<tr>
<td>1.0</td>
<td>140.0</td>
<td>SANDY CLAYS - SAND LENSES</td>
</tr>
<tr>
<td>140.0</td>
<td>160.0</td>
<td>GRANITE</td>
</tr>
</tbody>
</table>

1 - All diameters reported are inside diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
RUSSELL TIM P

Location Information

GWIC Id: 131146
GWIC Id: 131146
Location (TRS): 02N 07W 22 BDAB
Location (TRS): 02N 07W 22 BDAB
County (MT): SILVER BOW
County (MT): SILVER BOW
DNRC Water Right:
DNRC Water Right:
PWS Id:
PWS Id:
Block: 26
Block: 26
Lot: 26
Lot: 26
Addition: WARNE HEIGHTS
Addition: WARNE HEIGHTS
Source of Data: LOG
Source of Data: LOG
Latitude (dd): 45.9126
Latitude (dd): 45.9126
Longitude (dd): -112.4580
Longitude (dd): -112.4580
Datum: NAD27
Datum: NAD27
Altitude (feet): 5650.00
Altitude (feet): 5650.00
Certificate of Survey:
Certificate of Survey:
Type of Site: WELL
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 220.00
Total Depth (ft): 220.00
Static Water Level (ft): 45.00
Static Water Level (ft): 45.00
Pumping Water Level (ft): 180.00
Pumping Water Level (ft): 180.00
Yield (gpm): 12.00
Yield (gpm): 12.00
Test Type: AIR
Test Type: AIR
Test Duration: 2.00
Test Duration: 2.00
Drill Stem Setting (ft): 210.00
Drill Stem Setting (ft): 210.00
Recovery Water Level (ft): 45.00
Recovery Water Level (ft): 45.00
Recovery Time (hrs): 2.00
Recovery Time (hrs): 2.00
Well Notes:
Well Notes:

Hole Diameter Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>220.0</td>
<td>6.0</td>
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</table>

Annular Seal Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>18.0</td>
<td>BENTONITE</td>
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Completion Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Dia</th>
<th># of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>200.0</td>
<td>220.0</td>
<td>4.0</td>
<td>1/8X4</td>
<td>SAW SLOTS</td>
<td></td>
</tr>
</tbody>
</table>

Lithology Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.0</td>
<td>TOPSOIL</td>
</tr>
<tr>
<td>1.0</td>
<td>35.0</td>
<td>SANDY SOIL</td>
</tr>
<tr>
<td>35.0</td>
<td>220.0</td>
<td>ROCK</td>
</tr>
</tbody>
</table>

1. All diameters reported are inside diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
WRIGHT PATRICIA AND DICK

Location Information

GWIC Id: 49534
Location (TRS): 02N 07W 22 ACCB
County (MT): SILVER BOW
DNRC Water Right: 
PWS Id: 
Block: 
Lot: 
Addition: 

Source of Data: LOG
Latitude (dd): 45.9103
Longitude (dd): -112.4548
Geomethod: MAP
Datum: NAD27
Altitude (feet): 5690.00
Certificate of Survey: 
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 260.00
Static Water Level (ft): 70.00
Pumping Water Level (ft): 240.00
Yield (gpm): 20.00
Test Type: AIR
Test Duration: 1.00
Drill Stem Setting (ft): 
Recovery Water Level (ft): 
Recovery Time (hrs): 
Well Notes: 

How Drilled: AIR ROTARY
Driller's Name: LINDSAY
Driller License: WWC253
Completion Date (m/d/y): 4/30/1980
Special Conditions: 
Is Well Flowing?:
Shut-In Pressure: 
Geology/Aquifer: 211BDBT
Well/Water Use: DOMESTIC

Hole Diameter Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>260.0</td>
<td>6.0</td>
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</table>

Casing Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Dia</th>
<th>Wall Thickness</th>
<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>22.0</td>
<td>6.0</td>
<td></td>
<td></td>
<td>17 LB</td>
<td>STEEL</td>
</tr>
<tr>
<td>6.0</td>
<td>260.0</td>
<td>4.0</td>
<td></td>
<td></td>
<td>PVC</td>
<td></td>
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Annular Seal Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
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<td>20.0</td>
<td>MUD</td>
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Completion Information

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<thead>
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<th>From</th>
<th>To</th>
<th>Dia Openings</th>
<th># of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>180.0</td>
<td>260.0</td>
<td>4.0</td>
<td>1/4X4</td>
<td>SLOTS</td>
<td></td>
</tr>
</tbody>
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Lithology Information

<table>
<thead>
<tr>
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<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>3.0</td>
<td>TOPSOIL</td>
</tr>
<tr>
<td>3.0</td>
<td>18.0</td>
<td>DECOMPOSED RHYOLITE</td>
</tr>
<tr>
<td>18.0</td>
<td>260.0</td>
<td>RHYOLITE BEDROCK</td>
</tr>
</tbody>
</table>

1 - All diameters reported are inside diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
PAFFHAUSEN MARK & TAMMY

Location Information

GWIC Id: 167964
Location (TRS): 02N 07W 22 BDDB
County (MT): SILVER BOW
DNRC Water Right: C104341-00
PWS Id:
Block:
Lot: 30
Addition: WARNE HEIGHTS

Source of Data: LOG
Latitude (dd): 45.9105
Longitude (dd): -112.4583
Geomethod: MAP
Datum: NAD27
Altitude (feet): 5650.00
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 360.00
Static Water Level (ft): 35.00
Pumping Water Level (ft): 350.00
Yield (gpm): 8.00
Test Type: AIR
Test Duration: 1.00
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):
Well Notes:

How Drilled: ROTARY
Driller’s Name: OKEEFE
Driller License: WWD090
Completion Date (m/d/y): 6/3/1998
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 211BDBT
Well/Water Use: DOMESTIC

Hole Diameter Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>297.0</td>
<td>6.0</td>
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</tbody>
</table>

Casing Information 1

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Wall Dia Thickness</th>
<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2.0</td>
<td>24.0</td>
<td>6.0</td>
<td>0.256</td>
<td>WELDED</td>
<td>A53B STEEL</td>
</tr>
<tr>
<td>6.0</td>
<td>360.0</td>
<td>5.0</td>
<td></td>
<td>WELDED</td>
<td>PLASTIC</td>
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</table>

Annular Seal Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>18.0</td>
<td>BENTONITE</td>
</tr>
</tbody>
</table>

Completion Information 1

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th># of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>320.0</td>
<td>360.0</td>
<td>1/4</td>
<td>5.0</td>
<td>TORCH CUTS</td>
</tr>
</tbody>
</table>

Lithology Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>2.0</td>
<td>TOPSOIL</td>
</tr>
<tr>
<td>2.0</td>
<td>60.0</td>
<td>DECOMPOSED</td>
</tr>
<tr>
<td>60.0</td>
<td>80.0</td>
<td>CLAY</td>
</tr>
<tr>
<td>80.0</td>
<td>420.0</td>
<td>DECOMPOSED GRAVEL, SEEPAGE AT 230 FT.</td>
</tr>
</tbody>
</table>

1 - All diameters reported are inside diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
KRUEGER KURT

Location Information

<table>
<thead>
<tr>
<th>GWIC Id: 49541</th>
<th>Source of Data: LOG</th>
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</thead>
<tbody>
<tr>
<td>Location (TRS): 02N 07W 22 BAACC</td>
<td>Latitude (dd): 45.9152</td>
</tr>
<tr>
<td>County (MT): SILVER BOW</td>
<td>Longitude (dd): -112.4575</td>
</tr>
<tr>
<td>DNRC Water Right: C065167-00</td>
<td>Geomethod: MAP</td>
</tr>
<tr>
<td>PWS Id:</td>
<td>Datum: NAD27</td>
</tr>
<tr>
<td>Block:</td>
<td>Altitude (feet): 5600.00</td>
</tr>
<tr>
<td>Lot: 39</td>
<td>Certificate of Survey:</td>
</tr>
<tr>
<td>Addition: WARNE HEIGHTS</td>
<td>Type of Site: WELL</td>
</tr>
</tbody>
</table>

Well Construction and Performance Data

<table>
<thead>
<tr>
<th>Total Depth (ft): 54.00</th>
<th>How Drilled: CABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static Water Level (ft): 21.00</td>
<td>Driller's Name: OKEEFE</td>
</tr>
<tr>
<td>Pumping Water Level (ft):</td>
<td>Driller License: WWC459</td>
</tr>
<tr>
<td>Yield (gpm): 12.00</td>
<td>Completion Date (m/d/y): 12/12/1986</td>
</tr>
<tr>
<td>Test Type: PUMP</td>
<td>Special Conditions:</td>
</tr>
<tr>
<td>Test Duration:</td>
<td>Is Well Flowing?:</td>
</tr>
<tr>
<td>Drill Stem Setting (ft):</td>
<td>Shut-In Pressure:</td>
</tr>
<tr>
<td>Recovery Water Level (ft):</td>
<td>Geology/Aquifer: 211BDBT</td>
</tr>
<tr>
<td>Recovery Time (hrs):</td>
<td>Well/Water Use: DOMESTIC</td>
</tr>
<tr>
<td>Well Notes:</td>
<td></td>
</tr>
</tbody>
</table>

Hole Diameter Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>54.0</td>
<td>6.0</td>
</tr>
</tbody>
</table>

Annular Seal Information

No Seal Records currently in GWIC.

Lithology Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.0</td>
<td>TOPSOIL</td>
</tr>
<tr>
<td>1.0</td>
<td>30.0</td>
<td>CLAY</td>
</tr>
<tr>
<td>30.0</td>
<td>40.0</td>
<td>DECOMPOSED GRANITE</td>
</tr>
<tr>
<td>40.0</td>
<td>53.0</td>
<td>BROKEN GRANITE</td>
</tr>
<tr>
<td>53.0</td>
<td>54.0</td>
<td>HARD GRANITE</td>
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Casing Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Wall Thickness</th>
<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2.0</td>
<td>54.0</td>
<td>6.0</td>
<td>0.250</td>
<td>STEEL</td>
<td></td>
</tr>
</tbody>
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Completion Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th># of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.0</td>
<td>52.0</td>
<td>6.0</td>
<td>TORCH CUTS</td>
<td></td>
</tr>
</tbody>
</table>

1 - All diameters reported are inside diameter of the casing
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
MCGINNIS DAVID AND MARY

Location Information

GWIC Id: 161873
Location (TRS): 02N 07W 22 BADA
County (MT): SILVER BOW
DNRC Water Right: C100189-00
PWS Id: 
Block: 
Lot: 
Addition: WARNE HEIGHTS
Source of Data: LOG
Latitude (dd): 45.9146
Longitude (dd): -112.4575
Geomethod: MAP
Datum: NAD27
Altitude (feet): 5610.00
Certificate of Survey: 
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 120.00
Static Water Level (ft): 25.00
Pumping Water Level (ft):
Yield (gpm): 11.00
Test Type: AIR
Test Duration: 1.50
Drill Stem Setting (ft): 118.00
Recovery Water Level (ft):
Recovery Time (hrs): 0.50
Well Notes: 
How Drilled: AIR ROTARY
Driller's Name: OKEEFE
Driller License: WWC462
Completion Date (m/d/y): 8/9/1996
Is Well Flowing?:
Geology/Aquifer: 211BDBT
Well/Water Use: DOMESTIC

Hole Diameter Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
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<td>6.0</td>
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</tbody>
</table>

Casing Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Wall Thickness</th>
<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.5</td>
<td>18.0</td>
<td>6.0</td>
<td>0.250</td>
<td></td>
<td>STEEL</td>
</tr>
<tr>
<td>15.0</td>
<td>120.0</td>
<td>4.0</td>
<td></td>
<td></td>
<td>PVC</td>
</tr>
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Annular Seal Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>20.0</td>
<td>BENTONITE/HOLE PLUG</td>
</tr>
</tbody>
</table>

Completion Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th># of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.0</td>
<td>120.0</td>
<td>4.0</td>
<td></td>
<td>SAW SLOTS</td>
</tr>
</tbody>
</table>

Lithology Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>17.0</td>
<td>SAND</td>
</tr>
<tr>
<td>17.0</td>
<td>25.0</td>
<td>SAND AND DECOMPOSED GRANITE</td>
</tr>
<tr>
<td>25.0</td>
<td>120.0</td>
<td>DECOMPOSED GRANITE</td>
</tr>
</tbody>
</table>

1 - All diameters reported are inside diameter of the casing.
Location Information
GWIC Id: 153743
Location (TRS): 02N 07W 22 BADB
County (MT): SILVER BOW
DNRC Water Right:
PWS Id:
Block:
Lot: 37
Addition: WARNE HEIGHTS
Source of Data: LOG
Latitude (dd): 45.9139
Longitude (dd): -112.4575
Datum: NAD27
Altitude (feet): 5630.00
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data
Total Depth (ft): 521.00
Static Water Level (ft): 33.00
Pumping Water Level (ft): 480.00
Yield (gpm): 16.00
Test Type: AIR
Test Duration: 1.00
Drill Stem Setting (ft): 521.00
Recovery Water Level (ft): 33.00
Recovery Time (hrs): 6.00
Completion Date (m/d/y): 7/11/1995
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 211BDBT
Well/Water Use: DOMESTIC

Hole Diameter Information
<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>521.0</td>
<td>6.0</td>
</tr>
</tbody>
</table>

Casing Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Dia Thickness</th>
<th>Pressure Rating</th>
<th>Joint Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.5</td>
<td>170.0</td>
<td>6.0</td>
<td>0.250</td>
<td>WELDED STEEL</td>
</tr>
<tr>
<td>21.8</td>
<td>521.0</td>
<td>4.0</td>
<td>160.00</td>
<td>PVC</td>
</tr>
</tbody>
</table>

Annular Seal Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>40.0</td>
<td>BENTONITE</td>
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Completion Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th># of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>480.0</td>
<td>520.0</td>
<td>1/8X6</td>
<td>SAW SLOTS</td>
<td></td>
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Lithology Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>2.0</td>
<td>TOPSOIL</td>
</tr>
<tr>
<td>2.0</td>
<td>18.0</td>
<td>SAND</td>
</tr>
<tr>
<td>18.0</td>
<td>95.0</td>
<td>SANDSTONE</td>
</tr>
<tr>
<td>95.0</td>
<td>150.0</td>
<td>DECOMPOSED GRANITE (FAULT AREA)</td>
</tr>
<tr>
<td>150.0</td>
<td>180.0</td>
<td>LAYERS OF HARD &amp; SOFT DECOMPOSED GRANITE (4 GPM)</td>
</tr>
<tr>
<td>180.0</td>
<td>220.0</td>
<td>GRANITE (GRAY)</td>
</tr>
<tr>
<td>220.0</td>
<td>480.0</td>
<td>BROWN &amp; GRAY (GRANITE) 6.5 GPM WATER</td>
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<tr>
<td>480.0</td>
<td>521.0</td>
<td>BROKEN LAYERS GRANITE 16 GPM (WATER)</td>
</tr>
</tbody>
</table>

1 - All diameters reported are inside diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
HONER JEFF

Location Information

GWIC Id: 134963
Location (TRS): 02N 07W 22 ABCC
County (MT): SILVER BOW
DNRC Water Right: C085628-00
PWS Id: Block: Lot: 54
Adding: WARNE HEIGHTS
Source of Data: LOG
Latitude (dd): 45.9134
Longitude (dd): -112.4558
Datum: NAD27
Altitude (feet): 5640.00
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 110.00
Static Water Level (ft): 38.00
Pumping Water Level (ft):
Yield (gpm): 20.00
Test Type: AIR
Test Duration: 1.00
Drill Stem Setting (ft): 105.00
Recovery Water Level (ft): 38.00
Recovery Time (hrs): 1.00

Well Notes:

Hole Diameter Information

<table>
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<th>From</th>
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<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
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<td>110.0</td>
<td>6.0</td>
</tr>
</tbody>
</table>

Annular Seal Information

<table>
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<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>28.0</td>
<td>BENTONITE CUMBLES</td>
</tr>
</tbody>
</table>

Lithology Information

<table>
<thead>
<tr>
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<th>To</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
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<td>2.0</td>
<td>TOPSOIL</td>
</tr>
<tr>
<td>2.0</td>
<td>28.0</td>
<td>SAND &amp; GRAVEL</td>
</tr>
<tr>
<td>28.0</td>
<td>64.0</td>
<td>GRANITE</td>
</tr>
<tr>
<td>64.0</td>
<td>105.0</td>
<td>SAND AND GRAVEL LAYERS</td>
</tr>
<tr>
<td>105.0</td>
<td>110.0</td>
<td>GRANITE</td>
</tr>
</tbody>
</table>

Completion Information

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<tr>
<th>From</th>
<th>To</th>
<th># of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>50.0</td>
<td>110.0</td>
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<td>4.0</td>
<td>SAW SLOTS</td>
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</table>

Casing Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Wall Thickness</th>
<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.5</td>
<td>18.0</td>
<td>6.0</td>
<td>0.250</td>
<td>STEEL</td>
<td>PVC</td>
</tr>
<tr>
<td>10.0</td>
<td>110.0</td>
<td>4.0</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

1 - All diameters reported are inside diameter of the casing.
**Montana Bureau of Mines and Geology**

**Ground-Water Information Center Site Report**

**WALTER JEFF & KATHY**

### Location Information

- **GWIC Id:** 154868
- **Source of Data:** LOG
- **Location (TRS):** 02N 07W 22 BDDBB
- **Latitude (dd):** 45.9110
- **County (MT):** SILVER BOW
- **Longitude (dd):** -112.4576
- **DNRC Water Right:** C096192-00
- **Geomethod:** MAP
- **Datum:** NAD27
- **Altitude (feet):** 5670.00
- **Certificate of Survey:**
- **Addition:** WARNE HEIGHTS
- **Type of Site:** WELL

### Well Construction and Performance Data

- **Total Depth (ft):** 390.00
- **Static Water Level (ft):** 67.00
- **Pumping Water Level (ft):**
  - **Yield (gpm):** 7.00
  - **Test Type:** AIR
  - **Test Duration:** 1.50
  - **Drill Stem Setting (ft):** 380.00
  - **Recovery Water Level (ft):** 67.00
  - **Recovery Time (hrs):** 1.00
- **Completion Date (m/d/y):** 7/18/1995
- **Driller's Name:** OKEEFE
- **Driller License:** WWC462
- **Completion Date (m/d/y):** 7/18/1995
- **Geology/Aquifer:** 211BDBT
- **Well/Water Use:** DOMESTIC

### Hole Diameter Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>440.0</td>
<td>6.0</td>
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</tbody>
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### Casing Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Dia Wall Thickness</th>
<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.5</td>
<td>20.0</td>
<td>6.0</td>
<td>0.250</td>
<td>STEEL</td>
<td></td>
</tr>
<tr>
<td>0.0</td>
<td>390.0</td>
<td>4.0</td>
<td></td>
<td>PVC</td>
<td></td>
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### Annular Seal Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>20.0</td>
<td>BENTONITE/HOLE PLUG</td>
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### Completion Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th># of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>350.0</td>
<td>390.0</td>
<td>4.0</td>
<td></td>
<td>SAW SLOTS</td>
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</tbody>
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### Lithology Information

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<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>0.0</td>
<td>3.0</td>
<td>TOPSOIL</td>
</tr>
<tr>
<td>3.0</td>
<td>7.0</td>
<td>DECOMPOSED GRANITE</td>
</tr>
<tr>
<td>7.0</td>
<td>90.0</td>
<td>BROKEN ROCK</td>
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<tr>
<td>90.0</td>
<td>220.0</td>
<td>HARD GRANITE</td>
</tr>
<tr>
<td>220.0</td>
<td>350.0</td>
<td>BROKEN ROCK &amp; WATER</td>
</tr>
<tr>
<td>350.0</td>
<td>440.0</td>
<td>HARD GRANITE</td>
</tr>
</tbody>
</table>

1 - All diameters reported are inside diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
BENEDICT BRUCE

Location Information
GWIC Id: 190733
Location (TRS): 02N 07W 22 ABCC
County (MT): SILVER BOW
DNRC Water Right: C083451-00
PWS Id: 
Block: 
Lot: 55
Addition: WARNE HEIGHTS
Source of Data: LOG
Latitude (dd): 45.9139
Longitude (dd): -112.4558
Geomethod: MAP
Datum: NAD27
Altitude (feet): 5630.00
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data
Total Depth (ft): 140.00
Static Water Level (ft): 
Pumping Water Level (ft):
Yield (gpm):
Test Type: AIR
Test Duration: 1.50
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):
Well Notes:
How Drilled: AIR ROTARY
Driller’s Name: OKEEFE
Driller License: WWC462
Completion Date (m/d/y): 9/8/1992
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 211BDBT
Well/Water Use: DOMESTIC

Hole Diameter Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>140.0</td>
<td>6.0</td>
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Annular Seal Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
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<td>BENTONITE CRUMBLES</td>
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Lithology Information

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>80.0</td>
<td>100.0</td>
<td>GRANITE</td>
</tr>
<tr>
<td>100.0</td>
<td>140.0</td>
<td>BROWN SAND GRAVEL WATER</td>
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Casing Information¹

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<tr>
<th>From</th>
<th>To</th>
<th>Wall Diameter</th>
<th>Pressure Rating</th>
<th>Joint Type</th>
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</thead>
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<tr>
<td>0.0</td>
<td>80.0</td>
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<tr>
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<td>PVC</td>
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</tbody>
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Completion Information¹

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th># of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>80.0</td>
<td>140.0</td>
<td></td>
<td>4.0</td>
<td>SAW SLOTS</td>
</tr>
</tbody>
</table>

¹ - All diameters reported are inside diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
RUSSELL MARK

Location Information
GWIC Id: 49553
Location (TRS): 02N 07W 22 ACBB
County (MT): SILVER BOW
DNRC Water Right: C019213-00
PWS Id:
Block: 53
Lot: 53
Addition: WARNE HEIGHTS
Source of Data: LOG
Latitude (dd): 45.9128
Longitude (dd): -112.4556
Geomethod: NAV-GPS
Datum: NAD27
Altitude (feet): 5660.00
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data
Total Depth (ft): 85.00
Static Water Level (ft): 50.00
Pumping Water Level (ft): 70.00
Yield (gpm): 15.00
Test Type: AIR
Test Duration: 2.00
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):
Completion Date (m/d/y): 1/16/1975
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 211BDBT
Well/Water Use: DOMESTIC

Hole Diameter Information
<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
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<td>6.0</td>
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</tbody>
</table>

Casing Information¹

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Dia</th>
<th>Wall Thickness</th>
<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>40.0</td>
<td>6.0</td>
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<td>WELDED</td>
<td>STEEL</td>
<td></td>
</tr>
<tr>
<td>15.0</td>
<td>85.0</td>
<td>4.0</td>
<td>SOLVENT</td>
<td>PVC</td>
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</table>

Annular Seal Information
No Seal Records currently in GWIC.

Completion Information¹

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<th>From</th>
<th>To</th>
<th>Dia</th>
<th># of Openings</th>
<th>Size of Openings</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>65.0</td>
<td>85.0</td>
<td>4.0</td>
<td>SLOTS</td>
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Lithology Information

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</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>40.0</td>
<td>SOFT SANDY MATERIAL</td>
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<tr>
<td>40.0</td>
<td>60.0</td>
<td>HARDER GRANITE</td>
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<tr>
<td>60.0</td>
<td>85.0</td>
<td>HARD GRANITE &amp; SEAMS WITH WATER</td>
</tr>
</tbody>
</table>

¹ - All diameters reported are inside diameter of the casing.
Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
KETO JIM

Location Information
GWIC Id: 123052
Location (TRS): 02N 07W 22 ACBC
County (MT): SILVER BOW
DNRC Water Right: C078346-00
PWS Id:
Lot: 51
Addition: WARNE HEIGHTS
Source of Data: LOG
Latitude (dd): 45.9118
Longitude (dd): -112.4558
Datum: NAD27
Altitude (feet): 5680.00
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data
Total Depth (ft): 375.00
Static Water Level (ft): 30.00
Pumping Water Level (ft): 270.00
Yield (gpm): 10.00
Test Type: AIR
Test Duration: 2.00
Drill Stem Setting (ft): 370.00
Recovery Water Level (ft): 30.00
Recovery Time (hrs): 4.00
Completion Date (m/d/y): 6/5/1991
Special Conditions:
Driller License: WWC431
Geology/Aquifer: 211BDBT
Well/Water Use: DOMESTIC

Hole Diameter Information
<table>
<thead>
<tr>
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<th>Diameter</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

Casing Information
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<tr>
<th>From</th>
<th>To</th>
<th>Dia</th>
<th>Wall Thickness</th>
<th>Pressure Rating</th>
<th>Joint</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2.0</td>
<td>20.0</td>
<td>6.0</td>
<td>0.250</td>
<td></td>
<td>WELDED</td>
<td>17 LB STEEL</td>
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<td>160.00</td>
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<td>PVC</td>
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Completion Information
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<th>To</th>
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<th>Size of Openings</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
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<td>375.0</td>
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<td>1/8X6</td>
<td>SAW SLOTS</td>
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Annular Seal Information
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<tr>
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<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>20.0</td>
<td>BENTONITE</td>
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</tbody>
</table>

Lithology Information
<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>2.0</td>
<td>TOP SOIL</td>
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<tr>
<td>2.0</td>
<td>42.0</td>
<td>COARSE SAND</td>
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<tr>
<td>42.0</td>
<td>96.0</td>
<td>DECOMPOSED GRANITE</td>
</tr>
<tr>
<td>96.0</td>
<td>360.0</td>
<td>HARD GRANITE</td>
</tr>
<tr>
<td>360.0</td>
<td>375.0</td>
<td>BROKEN GRANITE - WATER</td>
</tr>
</tbody>
</table>

1 - All diameters reported are inside diameter of the casing.
Appendix D

Water Quality
Full Water-Quality Results

Sample Id / Site Id: 2001Q0497 / 180512
Sample Date: 08/28/2000
Location (TRS): 02N 07W 22 AACB
Latitude/Longitude: 45° 54' 50" N 112° 27' 06" W
Location (TRS): 02N 07W 22 AACB
Latitude: 5635.00
County/State: SILVER BOW / MT
State: SILVER BOW / MT
Field Number: 180512
Lab Date: 01/02/2001
Lab/Analyst: MBMG / JMC
Project Code(s): GWCP05
USGS 7.5' Quad: HOMESTAKE
Project Code(s): GWCP05
Drainage Basin: PA
Total Depth (ft): 100.00
Depth Water Enters: 80.0 ft BGS
Lab/Analyst: MBMG / JMC
Sample Method/Handling: NOT REPORTED / 4220
Procedure Type: DISSOLVED
PWS Id: SILVER BOW / MT
Field Method/Handling: NOT REPORTED / 4220
Procedure Type: DISSOLVED
PWS Id: SILVER BOW / MT

<table>
<thead>
<tr>
<th>Cations mg/L / meq/L</th>
<th>Anions mg/L / meq/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium (Ca) 23.00 1.15</td>
<td>Bicarbonate (HCO₃⁻) 41.20 0.68</td>
</tr>
<tr>
<td>Magnesium (Mg) 5.96 0.49</td>
<td>Carbonate (CO₃²⁻) 0.00 0.00</td>
</tr>
<tr>
<td>Sodium (Na) 8.74 0.38</td>
<td>Chloride (Cl⁻) 2.97 0.08</td>
</tr>
<tr>
<td>Potassium (K) 2.02 0.05</td>
<td>Sulfate (SO₄²⁻) 58.90 1.23</td>
</tr>
<tr>
<td>Iron (Fe) &lt;.005 0.00</td>
<td>Nitrate (as N) 1.38 P 0.10</td>
</tr>
<tr>
<td>Manganese (Mn) &lt;.001 0.00</td>
<td>Fluoride (F⁻) 0.09 0.00</td>
</tr>
<tr>
<td>Silica (SiO₂) 19.80 Ortho-Phosphate (OPO₄³⁻) &lt;.05 0.00</td>
<td></td>
</tr>
<tr>
<td><strong>Total Cations 2.07</strong></td>
<td><strong>Total Anions 2.09</strong></td>
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Trace Element Results (µg/L)

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<th>Value</th>
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<tr>
<td>Antimony (Sb)</td>
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</tr>
<tr>
<td>Arsenic (As)</td>
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<tr>
<td>Barium (Ba)</td>
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<tr>
<td>Beryllium (Be)</td>
<td>&lt;2</td>
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<td>Boron (B)</td>
<td>&lt;30</td>
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<tr>
<td>Cadmium (Cd)</td>
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<td>Chromium (Cr)</td>
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<td>Cobalt (Co)</td>
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<td>Copper (Cu)</td>
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<td>Lead (Pb)</td>
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<tr>
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<tr>
<td>Zirconium (Zr)</td>
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Field Chemistry and Other Analytical Results

**Total Dissolved Solids: 143.16**
**Field Alkalinity as CaCO₃: 172.00**
**Langlier Saturation Index: -0.98**

**Sum of Diss. Constituents: 164.06**
**Alkalinity as CaCO₃: 33.79**
**Ammonia (mg/L): NR**

Field Conductivity (µmhos): 198.00
Field Nitrate (mg/L): 0.00
T.P. Hydrocarbons (µg/L): NR

Lab Conductivity (µmhos): 233.00
Nitrite (mg/L as N): NR
Field Dissolved O2 (mg/L): NR

Field pH: 7.50
Water Temp (°C): 8.80
PCP (µL): NR

Lab pH: 7.63
Air Temp (°C): NR
Phosphate, TD (mg/L as P): 0.06

Field Hardness as CaCO₃: NR
Ryznar Stability Index: 9.59
Field Chloride (mg/L): NR

Hardness as CaCO₃: 81.96
Sodium Adsorption Ratio: 0.42
Field Redox (mV): 96.50

Sample Condition: CLEAR
Field
Sample Id / Site Id: 2001Q0499 / 145960
Location (TRS): 02N 07W 22 ADCC
Latitude/Longitude: 45° 54’ 34” N 112° 27’ 00” W
Datum: NAD27
Altitude: 5740,00
County/State: SILVER BOW / MT
Sample Date: 08/25/2000
Agency/Sampler: MBMG / CAC
Field Number: 145960
Lab Date: 01/02/2001
Lab/Analyst: MBMG / JMC
Sample Method/Handling: PUMPED / 4220
Procedure Type: DISSOLVED
PWS Id: NR
USGS 7.5’ Quad: HOMESTAKE
Project Code(s): GWCP05
Drainage Basin: PA

**Trace Element Results (µg/L)**

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<th>Element</th>
<th>µg/L</th>
<th>Meq/L</th>
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<tr>
<td>Arsenic (As)</td>
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<td>Barium (Ba)</td>
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<tr>
<td>Cadmium (Cd)</td>
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<tr>
<td>Chromium (Cr)</td>
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<tr>
<td>Cobalt (Co)</td>
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<tr>
<td>Copper (Cu)</td>
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<td>Sulfate (SO₄)</td>
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<td>1.51</td>
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<tr>
<td>Tin (Sn)</td>
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<tr>
<td>Titanium (Ti)</td>
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<td>Uranium (U)</td>
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<td>Vanadium (V)</td>
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<td>Zinc (Zn)</td>
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<td>Zirconium (Zr)</td>
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**Field Chemistry and Other Analytical Results**

**Total Dissolved Solids: 245.51 Field Alkalinity as CaCO₃: 82.00 Langlier Saturation Index: -0.24

<table>
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<th>Parameter</th>
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<tr>
<td>T.P. Hydrocarbons (µg/L)</td>
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<tr>
<td>Lab Conductivity (µmhos)</td>
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<td>Nitrite (mg/L as N)</td>
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<td>Field Dissolved O₃ (mg/L)</td>
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<td>Air Temp (°C)</td>
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<td>Field Chloride (mg/L)</td>
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<td>Sodium Adsorption Ratio</td>
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<td>Field Redox (mV): 305.50</td>
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### Sample Information
- **Sample Id / Site Id:** 2001Q0498 / 150276
- **Sample Date:** 08/25/2000
- **Location (TRS):** 02N 07W 22 ABBC
- **Latitude/Longitude:** 45° 54' 53" N 112° 27' 20" W
- **Datum:** NAD27
- **Altitude:** 5605.00
- **County/State:** SILVER BOW / MT
- **Field Number:** 150276
- **Sample Method/Handling:** NOT REPORTED / 4220
- **Procedure Type:** DISSOLVED
- **PWS Id:** NR
- **Total Depth (ft):** 160.00
- **Depth Water Enters:** 140.0 ft BGS
- **Field Conductivity (µmhos):** 345.00
- **Lab Conductivity (µmhos):** 407.00
- **Field Hardness as CaCO3:** NR
- **Laboratory Hardness as CaCO3:** 155.14
- **Field Redox (mV):** 309.90

### Cations and Anions (mg/L meq/L)

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<th>Cations</th>
<th>Anions</th>
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<td>Magnesium (Mg)</td>
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<td>Silica (SiO2)</td>
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### Total Cations 3.85

### Total Anions 3.87

### Trace Element Results (µg/L)

<table>
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<th>Element</th>
<th>Value</th>
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<tr>
<td>Aluminum (Al)</td>
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<td>Lithium (Li)</td>
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<td>Vanadium (V)</td>
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<td>Zinc (Zn)</td>
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<tr>
<td>Zirconium (Zr)</td>
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</table>

### Field Chemistry and Other Analytical Results

- **Total Dissolved Solids:** 238.23
- **Field Alkalinity as CaCO3:** 160.00
- **Langlier Saturation Index:** -0.41
- **Sum of Diss. Constituents:** 284.50
- **Alkalinity as CaCO3:** 74.80
- **Ammonia (mg/L):** NR
- **Field Conductivity (µmhos):** 345.00
- **Field Nitrate (mg/L):** NR
- **T.P. Hydrocarbons (µg/L):** NR
- **Lab Conductivity (µmhos):** 407.00
- **Nitrite (mg/L as N):** NR
- **Field Dissolved O2 (mg/L):** NR
- **Field pH:** 6.90
- **Water Temp (°C):** 9.20
- **PCP (µg/L):** NR
- **Lab pH:** 7.61
- **Air Temp (°C):** NR
- **Phosphate, TD (mg/L as P):** 0.07
- **Field Hardness as CaCO3:** NR
- **Ryznar Stability Index:** 8.42
- **Field Chloride (mg/L):** NR
- **Hardness as CaCO3:** 155.14
- **Sodium Adsorption Ratio:** 0.55
- **Field Redox (mV):** 309.90
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Note. Nitrate values are reported as nitrogen in milligrams per liter of concentration (mg/L-N).
### Isotope Sampling Results

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<th>Aquifer Material/Geologic Unit</th>
<th>( \delta^{15}N ) (‰)</th>
<th>( \delta^{18}O ) (‰)</th>
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*Note.* \( \delta^{15}N \) and \( \delta^{18}O \) isotope values are reported in parts per mil (‰). \( \delta^{15}N \) values are relative to the internally accepted standard gas concentration of nitrogen in the atmosphere. \( \delta^{18}O \) values are relative to the internationally accepted standard concentration of \( \delta^{18}O \) in Standard Mean Ocean Water (SMOW) corrected to the Standard Light Antarctic Precipitation (V-SMOW).