Ground-Water Open-File Report 18

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

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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 south-eastern 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 The measured values ranged from 0.1 to 9.7 mg/L-N (unpublished data).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

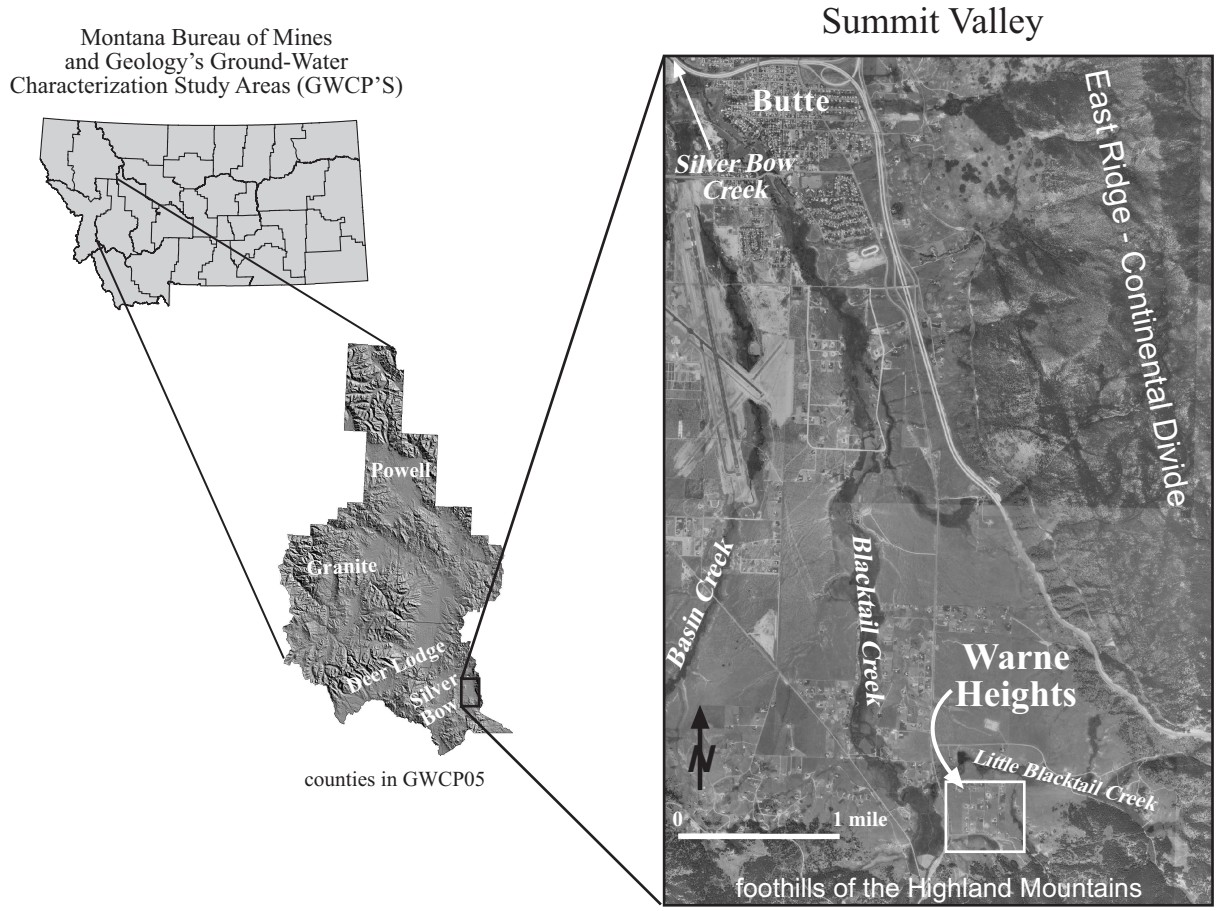

Figure 1. Summit Valley extends from the town of Butte south to the foothills of the Highland Mountains and is part of the MBMG's Upper Clark Fork River Ground-Water Characterization area. Warne Heights is located in the southeastern corner of the valley.

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 watercourses 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.

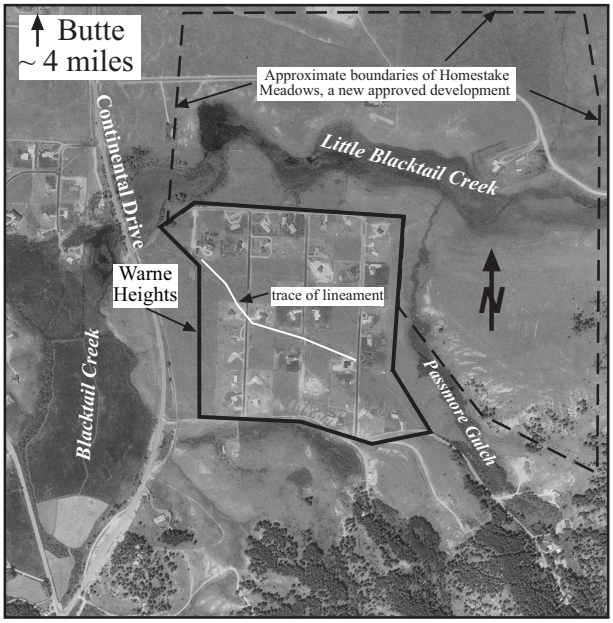

Figure 2. Warne Heights sits on a north-northwest grassy slope near timbered foothills of the Highland Mountains.

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

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.

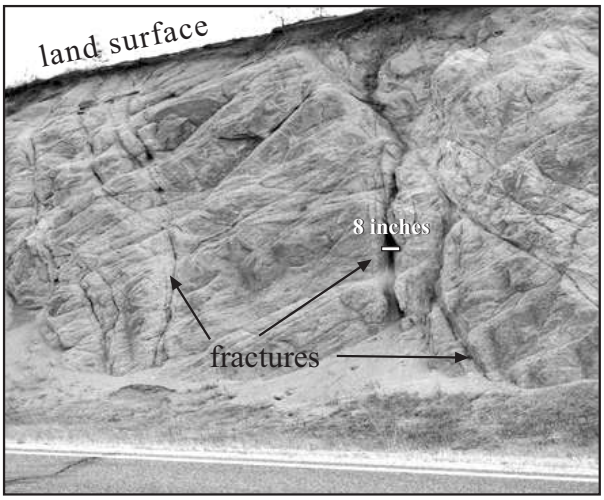

Figure 3. Fractures within the bedrock serve as paths for ground-water flow within the saturated zone and movement of fluid and possible contaminants from the land surface to the water table.

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

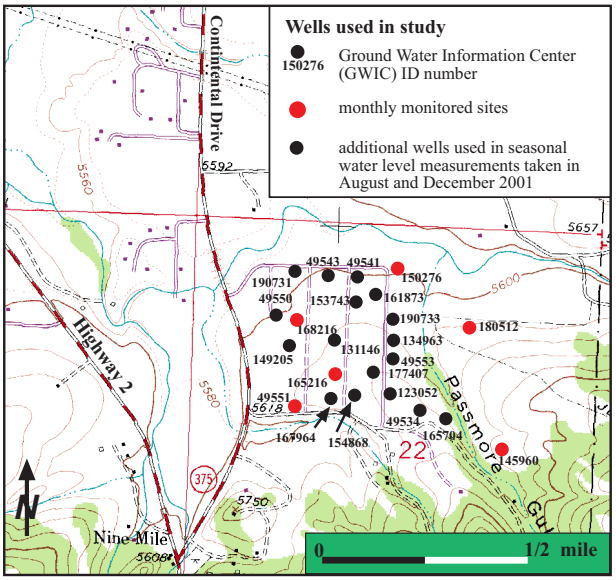

Figure 4. Seven wells were monitored monthly for water levels over a period of 2.5 yr. Seasonal water levels were collected in 16 additional wells in August and December 2001.

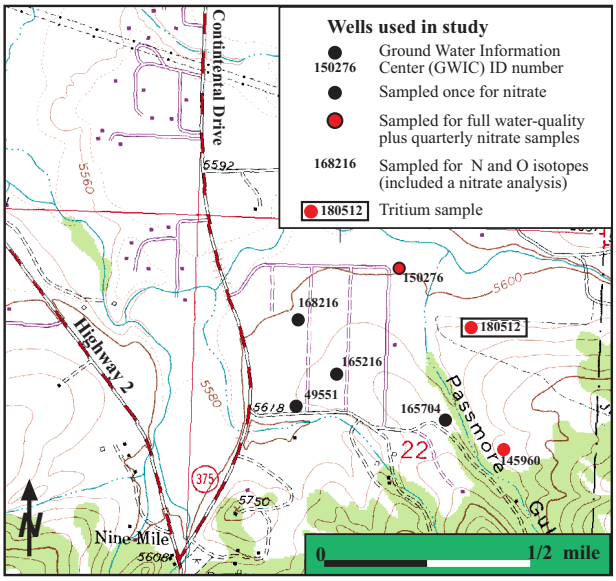

Figure 5. Wells 150276, 180512, and 145960 were sampled once for full water quality and quarterly for nitrate concentration.Wells 49551 and 168216 were sampled twice for nitrate and once for nitrogen and oxygen isotopes. Wells 165216 and 165704 were sampled once for nitrate concentration.

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

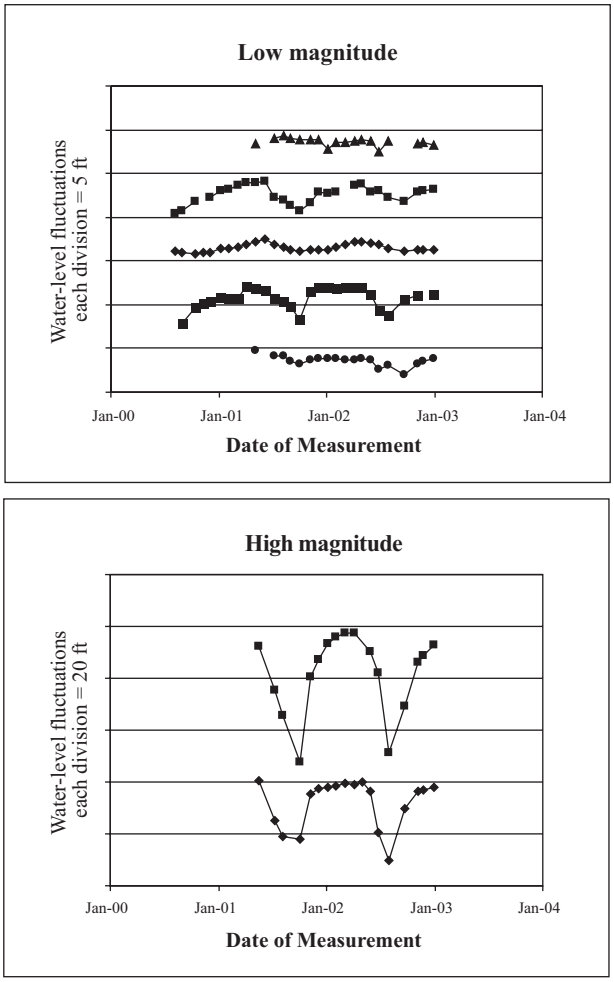

Figure 6. Hydrographs illustrate two magnitudes of the same response. All wells show a drawdown shortly after spring runoff that continues through August, followed by a recovery through the fall and winter. Most wells fluctuate by only 1–5 feet, while a few fluctuate 20–40 feet.

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

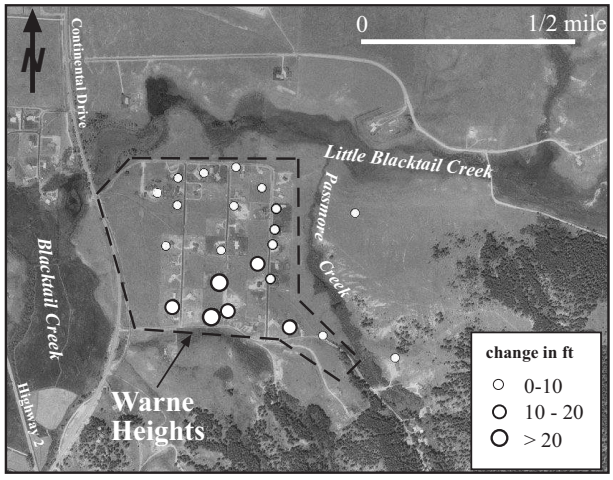

Figure 7. Wells that were measured in August and December of 2001 show varying degrees of seasonal change. Wells with >10 ft of change are clustered in the southern portion of the subdivision.

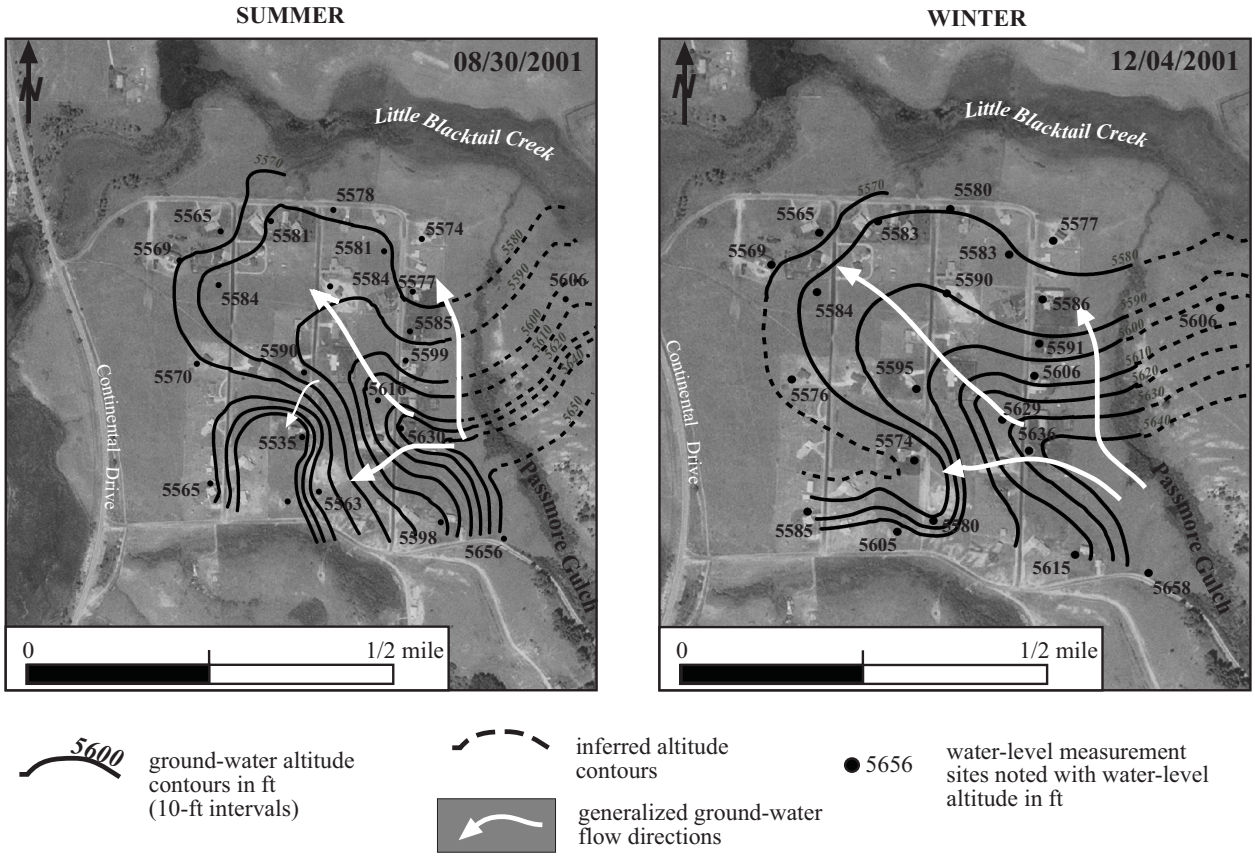

Figure 8. Water-level altitudes in Warne Heights do not show much change in ground-water flow directions between summer and winter, although in the south-central corner a cone of depression appears in the summer contour map.

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.

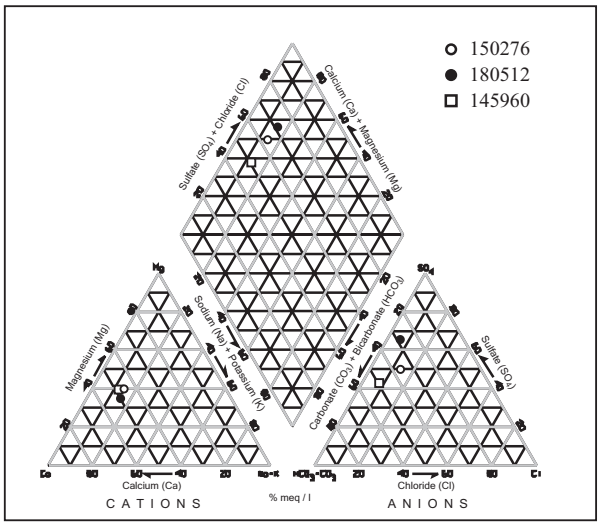

Figure 9. The three water-quality sample results were similar in total dissoved solid concentrations; 145960 is a calcium sulfate/bicarbonate type water while 150276 and 180512 are a calcium-sulfate-type water.

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

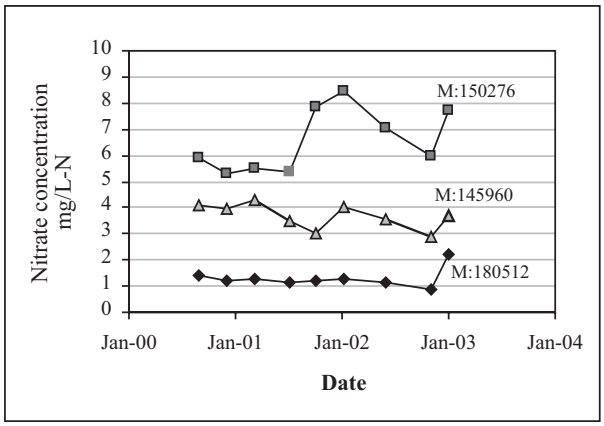

Figure 10. Nitrate concentrations fluctuate throughout the year, but are consistently above natural background levels.

(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

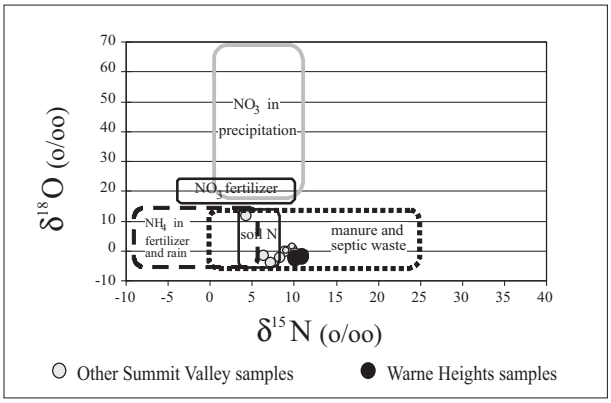

Figure 11. Results of nitrogen/oxygen isotope sampling suggest a septic/manure waste source for sites sampled in Warne Heights. This figure outlines possible nitrate sources as fields defined by the relative concentration of $\delta^{15}N$ to $\delta^{18}O$ (Kendall and Arvana, 2000).

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.

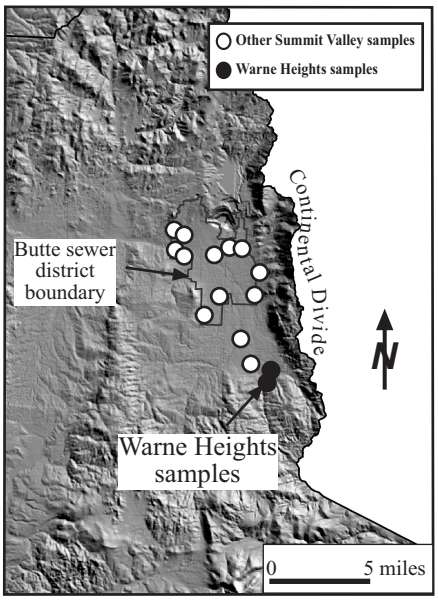

Figure 12. Warne Heights nitrogen and oxygen isotope samples were part of a larger sampling effort in the Summit Valley.

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 (^3H) 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://mbmggwic.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.

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Appendix A

Location Information

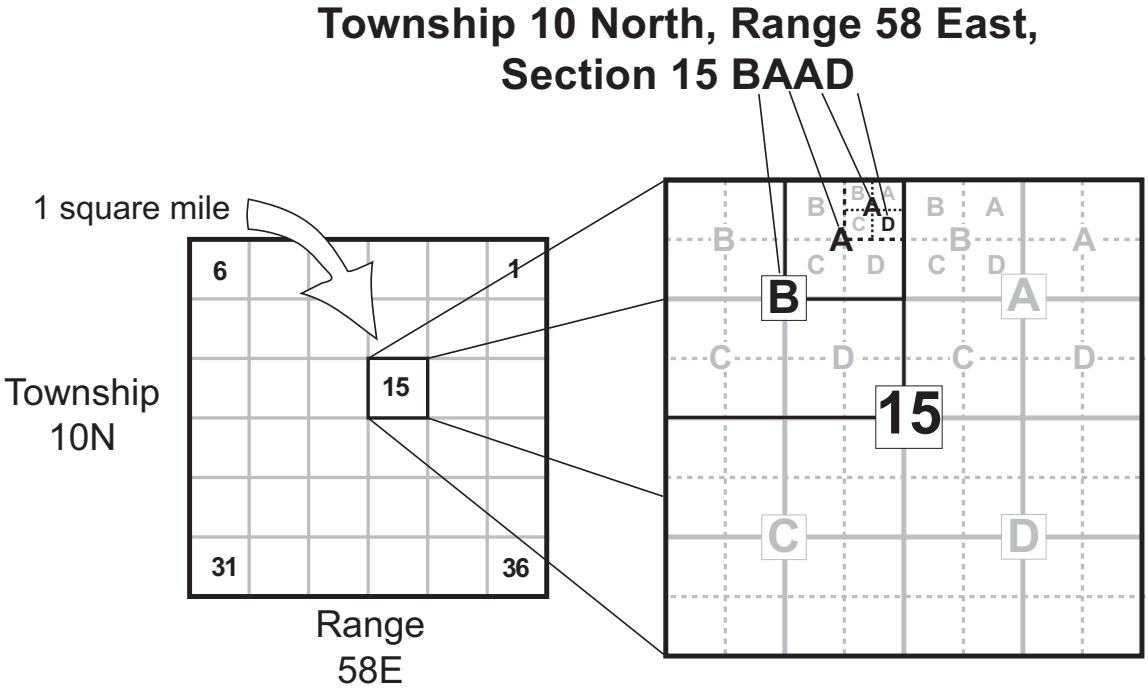
Locating a Well Using Township, Range, and Section and A-B-C-D Tract Information

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

GWIC No.	Township and Range	Latitude and Longitude (NAD 1927 datum, decimal degrees)	Land Surface Elevation (ft)	Total Depth (ft)	Depth that Water Enters[1] (ft)
165704	02N 07W 22 ACCA	45.9101, 112.4531	5,685	120	100
150276	02N 07W 22 ABBC	45.9146, 112.4555	5,605	160	140
49551	02N 07W 22 BDCB	45.9109, 112.4599	5,640	340	300
145960	02N 07W 22 ADCC	45.9095, 112.4501	5,740	100	80
168216	02N 07W 22 BACB	45.9140, 112.4599	5,620	95	70
165216	02N 07W 22 BDAB	45.9117, 112.4579	5,650	180	160
180512	02N 07W 22 AACB	45.9139, 112.4517	5,635	100	80
190731	02N 07W 22 BABC	45.9149, 112.4600	5,590	320	50
49550	02N 07W 22 BBDA	45.9143, 112.4609	5,595	54	47
149205	02N 07W 22 BDBB	45.9127, 112.4604	5,620	240	180
49543	02N 07W 22 BABD	45.9150, 112.4589	5,605	76	71
177407	02N 07W 22 BDAA	45.9121, 112.4563	5,670	150	56
131146	02N 07W 22 BDAB	45.9126, 112.4580	5,650	220	200
49534	02N 07W 22 ACCB	45.9118, 112.4548	5,690	260	180
167964	02N 07W 22 BDDB	45.9105, 112.4583	5,650	360	320
49541	02N 07W 22 BAAC	45.9152, 112.4575	5,600	54	44
161873	02N 07W 22 BADA	45.9146, 112.4561	5,610	120	100
153743	02N 07W 22 BADB	45.9139, 112.4575	5,630	520	440
134963	02N 07W 22 ABCC	45.9134, 112.4558	5,640	110	50
154868	02N 07W 22 BDDB	45.9110, 112.4558	5,670	390	350
190733	02N 07W 22 BADA	45.9139, 112.4558	5630	140	80
49553	02N 07W 22 ACBB	45.9128, 112.4558	5660	85	65
123052	02N 07W 22 ACBC	45.9118, 112.4558	5680	375	335

[1]In 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)

GWIC No.	Date of Measurement	Altitude of Water	Water Level below Ground (ft)
168216	05/18/01	5584.82	35.18
	07/08/01	5584.14	35.86
	08/07/01	5584.12	35.88
	08/30/01	5583.50	36.50
	10/03/01	5583.15	36.85
	11/08/01	5583.70	36.30
	12/04/01	5583.88	36.12
	01/07/02	5583.89	36.11
	02/01/02	5583.77	36.23
	03/05/02	5583.61	36.39
	04/04/02	5583.67	36.33
	04/30/02	5583.89	36.11
	05/29/02	5583.64	36.36
	06/25/02	5582.60	37.40
	07/30/02	5583.11	36.89
	09/20/02	5582.02	37.98
	11/04/02	5583.26	36.74
	11/24/02	5583.50	36.50
	12/30/02	5583.79	36.21
165216	05/19/01	5579.45	70.55
	07/08/01	5562.20	87.80
	08/07/01	5552.88	97.12
	08/31/01	5534.70	115.30
	11/08/01	5567.55	82.45
	12/04/01	5574.22	75.78
	01/07/02	5580.17	69.83
	02/01/02	5582.98	67.02
	03/05/02	5584.50	65.50
	04/04/02	5584.63	65.37
	05/29/02	5577.43	72.57
	06/25/02	5568.83	81.17
	07/30/02	5538.30	111.70
	09/20/02	5556.21	93.79
	11/04/02	5573.34	76.66
	11/24/02	5575.85	74.15
	12/30/02	5579.75	70.25
180512	08/08/00	5606.21	28.79
	08/28/00	5606.00	29.00
	10/11/00	5605.98	29.02
	11/08/00	5606.10	28.90
	12/04/00	5606.10	28.90
	01/07/01	5606.53	28.47
	01/07/01	5606.34	28.66
	01/11/01	5606.10	28.90
	02/02/01	5606.49	28.51
	03/05/01	5606.68	28.32
	04/04/01	5607.03	27.97
	05/06/01	5607.25	27.75
	06/05/01	5607.53	27.47
	07/08/01	5607.06	27.94
	08/07/01	5606.69	28.31
	08/30/01	5606.38	28.62
	10/03/01	5606.20	28.80
	11/08/01	5606.30	28.70
	12/04/01	5606.44	28.56
	01/07/02	5606.34	28.66
	02/01/02	5606.61	28.39
	03/05/02	5606.99	28.01
	04/04/02	5607.25	27.75
	04/30/02	5607.35	27.65
	05/29/02	5607.19	27.81
	06/25/02	5607.05	27.95
	07/30/02	5606.54	28.46
	09/20/02	5606.26	28.74
	11/04/02	5606.32	28.68
	11/24/02	5606.39	28.61
	12/30/02	5606.38	28.62

GWIC No.	Date of Measurement	Altitude of Water	Water Level below Ground (ft)
49551	05/18/01	5588.27	51.73
	07/08/01	5573.15	66.85
	08/30/01	5567.14	72.86
	10/03/01	5565.83	74.17
	11/08/01	5583.46	56.54
	12/04/01	5585.28	54.72
	01/07/02	5586.07	53.93
	02/01/02	5586.39	53.61
	03/05/02	5587.56	52.44
	04/04/02	5587.13	52.87
	04/30/02	5587.80	52.20
	05/29/02	5584.46	55.54
	06/25/02	5568.52	71.48
	07/30/02	5557.74	82.26
	09/20/02	5577.80	62.20
	11/04/02	5584.27	55.73
	11/24/02	5585.10	54.90
	12/30/02	5586.00	54.00
150276	08/07/00	5574.27	30.63
	08/25/00	5574.59	30.31
	10/11/00	5575.68	29.22
	12/04/00	5576.16	28.74
	01/11/01	5576.88	28.02
	02/02/01	5577.08	27.82
	03/05/01	5577.47	27.43
	04/04/01	5577.86	27.04
	05/06/01	5577.88	27.02
	06/05/01	5578.01	26.89
	07/08/01	5576.09	28.81
	08/07/01	5575.85	29.05
	08/30/01	5575.19	29.71
	10/03/01	5574.55	30.35
	11/08/01	5575.50	29.40
	12/04/01	5576.80	28.10
	01/07/02	5576.63	28.27
	02/01/02	5576.84	28.06
	04/04/02	5577.58	27.32
	04/30/02	5577.72	27.18
	05/29/02	5576.75	28.15
	06/25/02	5576.91	27.99
	07/30/02	5576.14	28.76
	09/20/02	5575.75	29.15
	11/04/02	5576.81	28.09
	11/24/02	5576.89	28.01
	12/30/02	5577.08	27.82

GWIC No.	Date of Measurement	Altitude of Water	Water Level below Ground (ft)
165704	05/18/01	5657.40	27.60
	07/08/01	5656.38	26.92
	08/07/01	5656.68	26.62
	08/30/01	5656.26	27.04
	10/03/01	5656.17	27.13
	11/08/01	5656.14	27.16
	12/04/01	5656.15	27.15
	01/07/02	5655.02	28.28
	02/01/02	5655.90	27.40
	03/05/02	5655.86	27.44
	04/04/02	5656.00	27.30
	04/30/02	5656.23	27.07
	05/29/02	5656.04	27.26
	06/25/02	5654.80	28.50
	07/30/02	5656.04	27.26
	11/04/02	5655.72	27.58
	11/24/02	5655.78	27.52
	12/30/02	5655.53	27.77

Seasonal Water-Level Measurements

GWIC No.	Date of Measurement	Altitude of Water	Water Level below Ground (ft)
190731	08/30/01	5564.80	25.20
	12/04/01	5565.18	24.82
49550	08/31/01	5569.47	25.53
	12/04/01	5569.09	25.91
149205	08/30/01	5570.23	49.77
	12/04/01	5575.65	44.35
49543	08/30/01	5580.65	24.35
	12/04/01	5582.59	22.41
177407	08/30/01	5615.50	54.50
	12/04/01	5628.94	41.06
131146	08/30/01	5589.98	60.02
	12/04/01	5594.50	55.50
49534	08/30/01	5597.16	92.84
	12/04/01	5614.52	75.48
167964	08/30/01	5468.51	181.49
	12/04/01	5605.09	44.91
49541	08/31/01	5578.15	21.85
	12/04/01	5579.54	20.46
161873	08/30/01	5580.98	29.02
	12/04/01	5582.69	27.31
153743	08/30/01	5584.30	45.70
	12/04/01	5589.75	40.25
134963	08/31/01	5584.79	55.21
	12/04/01	5591.02	48.98
154868	08/30/01	5562.90	107.10
	12/04/01	5580.22	89.78
190733	08/31/01	5576.50	53.50
	12/04/01	5586.45	43.55
49553	08/30/01	5599.33	60.77
	12/04/01	5606.05	54.05
123052	09/18/01	5629.88	50.12
	12/04/01	5636.41	43.59

Appendix C

Well Logs

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

Location Information

GWIC Id:	165704	Source of Data:	LOG
Location (TRS):	02N 07W 22 ACCA	Latitude (dd):	45.9101
County (MT):	SILVER BOW	Longitude (dd):	-112.4531
DNRC Water Right:	C111720-00	Geomethod:	NAV-GPS
PWS Id:		Datum:	NAD27
Block:		Altitude (feet):	5685.00
Lot:	D	Certificate of Survey:	
Addition:	PASSMORE PLACER	Type of Site:	WELL

Well Construction and Performance Data

Total Depth (ft):	120.00	How Drilled:	ROTARY
Static Water Level (ft):	25.00	Driller's Name:	OKEEFE
Pumping Water Level (ft):	110.00	Driller License:	WWD090
Yield (gpm):	25.00	Completion Date (m/d/y):	11/24/1997
Test Type:	AIR	Special Conditions:	
Test Duration:	1.00	Is Well Flowing?:	
Drill Stem Setting (ft):		Shut-In Pressure:	
Recovery Water Level (ft):	25.00	Geology/Aquifer:	211BDBT
Recovery Time (hrs):	1.00	Well/Water Use:	DOMESTIC
Well Notes:			

Hole Diameter Information

From	To	Diameter
0.0	120.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-2.0	38.0	6.0	0.256		WELDED	A53B STEEL
6.0	120.0	6.0			WELDED	PVC

Annular Seal Information

From	To	Description
0.0	18.0	CASING SEAL

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
100.0	120.0	6.0		1/4	TORCH CUTS

Lithology Information

From	To	Description
0.0	2.0	TOPSOIL
2.0	120.0	DECOMPOSED GRANITE

[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	Source of Data:	LOG
Location (TRS):	02N 07W 22 ABBC	Latitude (dd):	45.9146
County (MT):	SILVER BOW	Longitude (dd):	-112.4555
DNRC Water Right:	97395	Geomethod:	NAV-GPS
PWS Id:		Datum:	NAD27
Block:		Altitude (feet):	5605.00
Lot:	1-3	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):	30.00	Driller's Name:	DYNAMITE
Pumping Water Level (ft):	140.00	Driller License:	WWC431
Yield (gpm):	14.00	Completion Date (m/d/y):	1/20/1995
Test Type:	AIR	Special Conditions:	
Test Duration:	1.00	Is Well Flowing?:	
Drill Stem Setting (ft):	160.00	Shut-In Pressure:	
Recovery Water Level (ft):	30.00	Geology/Aquifer:	211BDBT
Recovery Time (hrs):	2.00	Well/Water Use:	DOMESTIC
Well Notes:			

Hole Diameter Information

From	To	Diameter
0.0	160.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-2.0	60.0	6.0	0.250		WELDED	17 LB STEEL
10.0	160.0	4.0		160.00		PVC

Annular Seal Information

From	To	Description
0.0	30.0	BENTONITE

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
140.0	160.0	4.0		1/8X4	SAW SLOTS

Lithology Information

From	To	Description
0.0	2.0	TOPSOIL
2.0	60.0	SANDY CLAY
60.0	160.0	GRANITE

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

Well Construction and Performance Data

Total Depth (ft):	340.00	How Drilled:	FORWARD ROTARY/CABLE
Static Water Level (ft):	40.00	Driller's Name:	OKEEFE
Pumping Water Level (ft):		Driller License:	WWD287
Yield (gpm):	14.00	Completion Date (m/d/y):	3/22/1977
Test Type:	AIR	Special Conditions:	
Test Duration:		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

From	To	Diameter
0.0	340.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
0.0	72.0	6.0			WELDED	STEEL
20.0	340.0	4.0				PVC

Annular Seal Information

No Seal Records currently in GWIC.

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
300.0	340.0	4.0		1/8	SLOTS

Lithology Information

From	To	Description
0.0	1.0	TOPSOIL (0-112 CABLE TOOL)
1.0	13.0	SANDY CLAY
13.0	40.0	DECOMPOSED GRANITE
40.0	112.0	GRAY GRANITE
112.0	140.0	GRANITE (112-340 FORWARD ROTARY)
140.0	320.0	GRANITE; PICKED UP 2 GPM @ 320 FT
320.0	340.0	GRANITE; PICKED UP 6 GPM

[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	Source of Data:	LOG
Location (TRS):	02N 07W 22 ADCC	Latitude (dd):	45.9095
County (MT):	SILVER BOW	Longitude (dd):	-112.4501
DNRC Water Right:	C090002-00	Geomethod:	NAV-GPS
PWS Id:		Datum:	NAD27
Block:		Altitude (feet):	5740.00
Lot:	4	Certificate of Survey:	
Addition:	DELEWARE PLACER 5524	Type of Site:	WELL

Well Construction and Performance Data

Total Depth (ft):	100.00	How Drilled:	CABLE
Static Water Level (ft):	31.00	Driller's Name:	OKEEFE
Pumping Water Level (ft):		Driller License:	WWC029
Yield (gpm):	10.00	Completion Date (m/d/y):	5/11/1994
Test Type:	AIR	Special Conditions:	
Test Duration:	1.00	Is Well Flowing?:	
Drill Stem Setting (ft):	100.00	Shut-In Pressure:	
Recovery Water Level (ft):	47.00	Geology/Aquifer:	211BDBT
Recovery Time (hrs):	1.00	Well/Water Use:	DOMESTIC
Well Notes:			

Hole Diameter Information

From	To	Diameter
0.0	100.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-1.5	18.0	6.0	0.250			STEEL
80.0	100.0	4.0				PVC

Annular Seal Information

From	To	Description
0.0	18.0	BENTONITE HOLE PLUG

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
80.0	100.0	4.0			TORCH CUTS

Lithology Information

From	To	Description
0.0	1.0	TOPSOIL
1.0	18.0	DECOMPOSED GRANITE
18.0	30.0	GRANITE
30.0	80.0	DECOMPOSED GRANITE AND SAND LAYERS
80.0	100.0	WATER

[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	Source of Data:	LOG
Location (TRS):	02N 07W 22 BACB	Latitude (dd):	45.9140
County (MT):	SILVER BOW	Longitude (dd):	-112.4599
DNRC Water Right:	C111694-00	Geomethod:	NAV-GPS
PWS Id:		Datum:	NAD27
Block:		Altitude (feet):	5620.00
Lot:	6	Certificate of Survey:	
Addition:	WARNE HEIGHTS	Type of Site:	WELL

Well Construction and Performance Data

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

Hole Diameter Information

From	To	Diameter
0.0	95.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-1.5	70.0	6.0	0.250		WELDED	STEEL
55.0	95.0	4.0		160.00		PVC

Annular Seal Information

From	To	Description
0.0	35.0	BENTONITE

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
70.0	95.0	4.0		1/8X6	SAW SLOTS

Lithology Information

From	To	Description
0.0	2.0	TOPSOIL
2.0	25.0	SANDY CLAY
25.0	60.0	DECOMPOSED GRANITE
60.0	95.0	GRANITE

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

Well Construction and Performance Data

Total Depth (ft):	180.00	How Drilled:	
Static Water Level (ft):	44.00	Driller's Name:	OKEEFE
Pumping Water Level (ft):		Driller License:	WWC462
Yield (gpm):	12.00	Completion Date (m/d/y):	6/28/1994
Test Type:	AIR	Special Conditions:	
Test Duration:	1.00	Is Well Flowing?:	
Drill Stem Setting (ft):	175.00	Shut-In Pressure:	
Recovery Water Level (ft):		Geology/Aquifer:	211BDBT
Recovery Time (hrs):	0.50	Well/Water Use:	DOMESTIC
Well Notes:			

Hole Diameter Information

From	To	Diameter
0.0	180.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-1.5	18.0	6.0	0.250			STEEL
10.0	180.0	4.0				PVC

Annular Seal Information

From	To	Description
0.0	20.0	BENTONITE/HOLE PLUG

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
160.0	180.0	4.0			TORCH CUTS

Lithology Information

From	To	Description
0.0	5.0	TOPSOIL
5.0	45.0	GRANITE
45.0	60.0	SILT
60.0	140.0	FINE SAND
140.0	180.0	GRANITE

[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:		Geomethod:	NAV-GPS
PWS Id:		Datum:	NAD27
Block:		Altitude (feet):	5635.00
Lot:		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	Special Conditions:	
Test Duration:	1.00	Is Well Flowing?:	
Drill Stem Setting (ft):	95.00	Shut-In Pressure:	
Recovery Water Level (ft):	28.00	Geology/Aquifer:	211BDBT
Recovery Time (hrs):	1.00	Well/Water Use:	DOMESTIC
Well Notes:			

Hole Diameter Information

From	To	Diameter
0.0	18.0	8.0
18.0	100.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-2.0	18.0	6.0			WELDED	STEEL
0.0	100.0	4.0			WELDED	PVC

Annular Seal Information

From	To	Description
0.0	18.0	BENTONITE CHIPS

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
80.0	100.0	4.0	54	1/8X6	SAW SLOTS

Lithology Information

From	To	Description
0.0	5.0	BROWN DECOMPOSED GRANITE
5.0	15.0	REDDISH BROWN DECOMPOSED GRANITE
15.0	20.0	TAN PARTIALLY DECOMPOSED GRANITE
20.0	25.0	REDDISH BROWN PARTIALLY DECOMPOSED GRANITE
25.0	40.0	LIGHT BROWN GRANITIC MATERIAL A FEW MICA FLAKES
40.0	45.0	LIGHT BROWN TO TAN WEATHERED GRANITIC MATERIAL WITH SOME MICA
45.0	60.0	TAN GRANITIC MATERIAL WITH MICA
60.0	65.0	WET TAN GRANITIC MATERIAL WITH MICA
65.0	80.0	TAN GRANITIC MATERIAL WITH MICA
80.0	100.0	WET TAN GRANITIC MATERIAL WITH MICA

[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	Geomethod:	MAP
PWS Id:		Datum:	NAD27
Block:		Altitude (feet):	5590.00
Lot:	4	Certificate of Survey:	
Addition:	WARNE HEIGHTS	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	Special Conditions:	
Test Duration:		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

From	To	Diameter
0.0	320.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
0.0	86.0	6.0				STEEL
50.0	290.0	4.0				PVC

Annular Seal Information

No Seal Records currently in GWIC.

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
50.0	290.0	4.0			SAW SLOTS

Lithology Information

From	To	Description
0.0	20.0	TOPSOIL & SAND
20.0	40.0	GRAVEL TOPSOIL & SAND
40.0	80.0	SAND
80.0	320.0	ROCK

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

Well Construction and Performance Data

Total Depth (ft):	54.00	How Drilled:	CABLE
Static Water Level (ft):	23.00	Driller's Name:	OKEEFE
Pumping Water Level (ft):		Driller License:	WWD287
Yield (gpm):	14.00	Completion Date (m/d/y):	10/26/1976
Test Type:	PUMP	Special Conditions:	
Test Duration:		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

From	To	Diameter
0.0	54.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-1.5	54.0	6.0			WELDED	STEEL

Annular Seal Information

No Seal Records currently in GWIC.

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
47.0	52.0	6.0		1/8	SLOTS

Lithology Information

From	To	Description
0.0	2.0	FILL
2.0	3.0	TOPSOIL
3.0	45.0	DECOMPOSED GRANITE SAND AND CLAY
45.0	53.0	SAND AND GRAVEL WATER
53.0	54.0	GRANITE

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

Well Construction and Performance Data

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

Hole Diameter Information

No Hole Diameter Records currently in GWIC.

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-1.5	60.0	6.0	0.250			STEEL
10.0	240.0	4.0				PVC

Annular Seal Information

From	To	Description
0.0	60.0	BENTONITE

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
180.0	240.0	4.0			SAW SLOTS

Lithology Information

From	To	Description
0.0	2.0	TOPSOIL
2.0	60.0	SAND
60.0	100.0	SANDY CLAY
100.0	180.0	GRANITE
180.0	240.0	DECOMPOSED GRANITE

[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	Source of Data:	LOG
Location (TRS):	02N 07W 22 BABD	Latitude (dd):	45.9150
County (MT):	SILVER BOW	Longitude (dd):	-112.4589
DNRC Water Right:	C017003-00	Geomethod:	MAP
PWS Id:		Datum:	NAD27
Block:		Altitude (feet):	5605.00
Lot:	21	Certificate of Survey:	
Addition:	WARNE HEIGHTS	Type of Site:	WELL

Well Construction and Performance Data

Total Depth (ft):	76.00	How Drilled:	CABLE
Static Water Level (ft):	20.00	Driller's Name:	OKEEFE
Pumping Water Level (ft):		Driller License:	WWC287
Yield (gpm):	5.00	Completion Date (m/d/y):	10/7/1977
Test Type:	BAILER	Special Conditions:	
Test Duration:		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

From	To	Diameter
0.0	76.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-2.0	76.0	6.0	0.250			17 LB STEEL

Annular Seal Information

No Seal Records currently in GWIC.

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
71.0	76.0	6.0		1/8	TORCH CUTS

Lithology Information

From	To	Description
0.0	40.0	SOFT DIRT
40.0	75.0	SAND & DECOMPOSED ROCK
75.0	76.0	ROCK

[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	Geomethod:	MAP
PWS Id:		Datum:	NAD27
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):		Driller License:	WWC596
Yield (gpm):	12.00	Completion Date (m/d/y):	8/7/1999
Test Type:	AIR	Special Conditions:	
Test Duration:	1.00	Is Well Flowing?:	
Drill Stem Setting (ft):	140.00	Shut-In Pressure:	
Recovery Water Level (ft):		Geology/Aquifer:	211BDBT
Recovery Time (hrs):		Well/Water Use:	DOMESTIC
Well Notes:			

Hole Diameter Information

From	To	Diameter
0.0	18.0	8.0
18.0	160.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-2.0	18.0	6.0	0.250		WELDED	STEEL

Annular Seal Information

From	To	Description
6.0	18.0	BENTONITE
60.0	60.0	V TYPE PACKER

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
56.0	60.0	4.0		0.025	PVC
120.0	150.0	4.0		0.025	PVC

Lithology Information

From	To	Description
0.0	1.0	TOPSOIL
1.0	140.0	SANDY CLAYS - SAND LENSES
140.0	160.0	GRANITE

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

Well Construction and Performance Data

Total Depth (ft):	220.00	How Drilled:	ROTARY
Static Water Level (ft):	45.00	Driller's Name:	BRAZILL
Pumping Water Level (ft):	180.00	Driller License:	WWC355
Yield (gpm):	12.00	Completion Date (m/d/y):	11/27/1992
Test Type:	AIR	Special Conditions:	
Test Duration:	2.00	Is Well Flowing?:	
Drill Stem Setting (ft):	210.00	Shut-In Pressure:	
Recovery Water Level (ft):	45.00	Geology/Aquifer:	211BDBT
Recovery Time (hrs):	2.00	Well/Water Use:	DOMESTIC
Well Notes:			

Hole Diameter Information

From	To	Diameter
0.0	220.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-2.0	38.0	6.0				STEEL
20.0	220.0	4.0				PVC

Annular Seal Information

From	To	Description
0.0	18.0	BENTONITE

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
200.0	220.0	4.0		1/8X4	SAW SLOTS

Lithology Information

From	To	Description
0.0	1.0	TOPSOIL
1.0	35.0	SANDY SOIL
35.0	220.0	ROCK

[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	Source of Data:	LOG
Location (TRS):	02N 07W 22 ACCB	Latitude (dd):	45.9103
County (MT):	SILVER BOW	Longitude (dd):	-112.4548
DNRC Water Right:		Geomethod:	MAP
PWS Id:		Datum:	NAD27
Block:		Altitude (feet):	5690.00
Lot:		Certificate of Survey:	
Addition:		Type of Site:	WELL

Well Construction and Performance Data

Total Depth (ft):	260.00	How Drilled:	AIR ROTARY
Static Water Level (ft):	70.00	Driller's Name:	LINDSAY
Pumping Water Level (ft):	240.00	Driller License:	WWC253
Yield (gpm):	20.00	Completion Date (m/d/y):	4/30/1980
Test Type:	AIR	Special Conditions:	
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

From	To	Diameter
0.0	260.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
0.0	22.0	6.0				17 LB STEEL
6.0	260.0	4.0				PVC

Annular Seal Information

From	To	Description
0.0	20.0	MUD

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
180.0	260.0	4.0		1/4X4	SLOTS

Lithology Information

From	To	Description
0.0	3.0	TOPSOIL
3.0	18.0	DECOMPOSED RHYOLITE
18.0	260.0	RHYOLITE BEDROCK

[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	Source of Data:	LOG
Location (TRS):	02N 07W 22 BDDB	Latitude (dd):	45.9105
County (MT):	SILVER BOW	Longitude (dd):	-112.4583
DNRC Water Right:	C104341-00	Geomethod:	MAP
PWS Id:		Datum:	NAD27
Block:		Altitude (feet):	5650.00
Lot:	30	Certificate of Survey:	
Addition:	WARNE HEIGHTS	Type of Site:	WELL

Well Construction and Performance Data

Total Depth (ft):	360.00	How Drilled:	ROTARY
Static Water Level (ft):	35.00	Driller's Name:	OKEEFE
Pumping Water Level (ft):	350.00	Driller License:	WWD090
Yield (gpm):	8.00	Completion Date (m/d/y):	6/3/1998
Test Type:	AIR	Special Conditions:	
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

From	To	Diameter
0.0	297.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-2.0	24.0	6.0	0.256		WELDED	A53B STEEL
6.0	360.0	5.0			WELDED	PLASTIC

Annular Seal Information

From	To	Description
0.0	18.0	BENTONITE

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
320.0	360.0	5.0		1/4	TORCH CUTS

Lithology Information

From	To	Description
0.0	2.0	TOPSOIL
2.0	60.0	DECOMPOSED
60.0	80.0	CLAY
80.0	420.0	DECOMPOSED GRAVEL. SEEPAGE AT 230 FT.

[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

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

Well Construction and Performance Data

Total Depth (ft):	54.00	How Drilled:	CABLE
Static Water Level (ft):	21.00	Driller's Name:	OKEEFE
Pumping Water Level (ft):		Driller License:	WWC459
Yield (gpm):	12.00	Completion Date (m/d/y):	12/12/1986
Test Type:	PUMP	Special Conditions:	
Test Duration:		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

From	To	Diameter
0.0	54.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-2.0	54.0	6.0	0.250			STEEL

Annular Seal Information

No Seal Records currently in GWIC.

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
44.0	52.0	6.0			TORCH CUTS

Lithology Information

From	To	Description
0.0	1.0	TOPSOIL
1.0	30.0	CLAY
30.0	40.0	DECOMPOSED GRANITE
40.0	53.0	BROKEN GRANITE
53.0	54.0	HARD GRANITE

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

Well Construction and Performance Data

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

Hole Diameter Information

From	To	Diameter
0.0	120.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-1.5	18.0	6.0	0.250			STEEL
15.0	120.0	4.0				PVC

Annular Seal Information

From	To	Description
0.0	20.0	BENTONITE/HOLE PLUG

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
100.0	120.0	4.0			SAW SLOTS

Lithology Information

From	To	Description
0.0	17.0	SAND
17.0	25.0	SAND AND DECOMPOSED GRANITE
25.0	120.0	DECOMPOSED GRANITE

[1] - All diameters reported are **inside** diameter of the casing.

Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
KEELER JANET

Location Information

GWIC Id:	153743	Source of Data:	LOG
Location (TRS):	02N 07W 22 BADB	Latitude (dd):	45.9139
County (MT):	SILVER BOW	Longitude (dd):	-112.4575
DNRC Water Right:		Geomethod:	MAP
PWS Id:		Datum:	NAD27
Block:		Altitude (feet):	5630.00
Lot:	37	Certificate of Survey:	
Addition:	WARNE HEIGHTS	Type of Site:	WELL

Well Construction and Performance Data

Total Depth (ft):	521.00	How Drilled:	CABLE/ROTARY
Static Water Level (ft):	33.00	Driller's Name:	DYNAMITE
Pumping Water Level (ft):	480.00	Driller License:	WWC431
Yield (gpm):	16.00	Completion Date (m/d/y):	7/11/1995
Test Type:	AIR	Special Conditions:	
Test Duration:	1.00	Is Well Flowing?:	
Drill Stem Setting (ft):	521.00	Shut-In Pressure:	
Recovery Water Level (ft):	33.00	Geology/Aquifer:	211BDBT
Recovery Time (hrs):	6.00	Well/Water Use:	DOMESTIC
Well Notes:			

Hole Diameter Information

From	To	Diameter
0.0	521.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-1.5	170.0	6.0	0.250		WELDED	17 LB STEEL
21.8	521.0	4.0		160.00		PVC

Annular Seal Information

From	To	Description
0.0	40.0	BENTONITE

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
480.0	520.0	4.0		1/8X6	SAW SLOTS

Lithology Information

From	To	Description
0.0	2.0	TOPSOIL
2.0	18.0	SAND
18.0	95.0	SANDSTONE
95.0	150.0	DECOMPOSED GRANITE (FAULT AREA)
150.0	180.0	LAYERS OF HARD & SOFT DECOMPOSED GRANITE (4 GPM)
180.0	220.0	GRANITE (GRAY)
220.0	480.0	BROWN & GRAY (GRANITE) 6.5 GPM WATER
480.0	521.0	BROKEN LAYERS GRANITE 16 GPM (WATER)

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

Well Construction and Performance Data

Total Depth (ft):	110.00	How Drilled:	ROTARY
Static Water Level (ft):	38.00	Driller's Name:	OKEEFE
Pumping Water Level (ft):		Driller License:	WWC462
Yield (gpm):	20.00	Completion Date (m/d/y):	4/12/1993
Test Type:	AIR	Special Conditions:	
Test Duration:	1.00	Is Well Flowing?:	
Drill Stem Setting (ft):	105.00	Shut-In Pressure:	
Recovery Water Level (ft):	38.00	Geology/Aquifer:	211BDBT
Recovery Time (hrs):	1.00	Well/Water Use:	DOMESTIC
Well Notes:			

Hole Diameter Information

From	To	Diameter
0.0	110.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-1.5	18.0	6.0	0.250			STEEL
10.0	110.0	4.0				PVC

Annular Seal Information

From	To	Description
0.0	28.0	BENTONITE CRUMBLES

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
50.0	110.0	4.0			SAW SLOTS

Lithology Information

From	To	Description
0.0	2.0	TOPSOIL
2.0	28.0	SAND & GRAVEL
28.0	64.0	GRANITE
64.0	105.0	SAND AND GRAVEL LAYERS
105.0	110.0	GRANITE

[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
Location (TRS): 02N 07W 22 BDDBB
County (MT): SILVER BOW
DNRC Water Right: C096192-00
PWS Id:
Block:
Lot: 32
Addition: WARNE HEIGHTS
Source of Data: LOG
Latitude (dd): 45.9110
Longitude (dd): -112.4576
Geomethod: MAP
Datum: NAD27
Altitude (feet): 5670.00
Certificate of Survey:
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
Well Notes:
How Drilled: ROTARY
Driller's Name: OKEEFE
Driller License: WWC462
Completion Date (m/d/y): 7/18/1995
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 211BDBT
Well/Water Use: DOMESTIC

Hole Diameter Information

From	To	Diameter
0.0	440.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-1.5	20.0	6.0	0.250			STEEL
0.0	390.0	4.0				PVC

Annular Seal Information

From	To	Description
0.0	20.0	BENTONITE/HOLE PLUG

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
350.0	390.0	4.0			SAW SLOTS

Lithology Information

From	To	Description
0.0	3.0	TOPSOIL
3.0	7.0	DECOMPOSED GRANITE
7.0	90.0	BROKEN ROCK
90.0	220.0	HARD GRANITE
220.0	350.0	BROKEN ROCK & WATER
350.0	440.0	HARD GRANITE

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

Well Construction and Performance Data

Total Depth (ft):	140.00	How Drilled:	AIR ROTARY
Static Water Level (ft):		Driller's Name:	OKEEFE
Pumping Water Level (ft):		Driller License:	WWC462
Yield (gpm):		Completion Date (m/d/y):	9/8/1992
Test Type:	AIR	Special Conditions:	
Test Duration:	1.50	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

From	To	Diameter
0.0	140.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
0.0	80.0	6.0	0.250			STEEL
10.0	140.0	4.0				PVC

Annular Seal Information

From	To	Description
0.0	20.0	BENTONITE CRUMBLES

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
80.0	140.0	4.0			SAW SLOTS

Lithology Information

From	To	Description
80.0	100.0	GRANITE
100.0	140.0	BROWN SAND GRAVEL WATER

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

Well Construction and Performance Data

Total Depth (ft):	85.00	How Drilled:	FORWARD ROTARY
Static Water Level (ft):	50.00	Driller's Name:	OKEEFE
Pumping Water Level (ft):	70.00	Driller License:	WWC008
Yield (gpm):	15.00	Completion Date (m/d/y):	1/16/1975
Test Type:	AIR	Special Conditions:	
Test Duration:	2.00	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

From	To	Diameter
0.0	85.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
0.0	40.0	6.0			WELDED	STEEL
15.0	85.0	4.0			SOLVENT WELD	PVC

Annular Seal Information

No Seal Records currently in GWIC.

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
65.0	85.0	4.0			SLOTS

Lithology Information

From	To	Description
0.0	40.0	SOFT SANDY MATERIAL
40.0	60.0	HARDER GRANITE
60.0	85.0	HARD GRANITE & SEAMS WITH WATER

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

Well Construction and Performance Data

Total Depth (ft):	375.00	How Drilled:	ROTARY
Static Water Level (ft):	30.00	Driller's Name:	DYNAMITE
Pumping Water Level (ft):	270.00	Driller License:	WWC431
Yield (gpm):	10.00	Completion Date (m/d/y):	6/5/1991
Test Type:	AIR	Special Conditions:	
Test Duration:	2.00	Is Well Flowing?:	
Drill Stem Setting (ft):	370.00	Shut-In Pressure:	
Recovery Water Level (ft):	30.00	Geology/Aquifer:	211BDBT
Recovery Time (hrs):	4.00	Well/Water Use:	DOMESTIC
Well Notes:			

Hole Diameter Information

From	To	Diameter
0.0	375.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-2.0	20.0	6.0	0.250		WELDED	17 LB STEEL
10.0	375.0	4.0		160.00		PVC

Annular Seal Information

From	To	Description
0.0	20.0	BENTONITE

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
335.0	375.0	4.0		1/8X6	SAW SLOTS

Lithology Information

From	To	Description
0.0	2.0	TOP SOIL
2.0	42.0	COARSE SAND
42.0	96.0	DECOMPOSED GRANITE
96.0	360.0	HARD GRANITE
360.0	375.0	BROKEN GRANITE - WATER

[1] - All diameters reported are **inside** diameter of the casing.

Appendix D

Water Quality

Full Water-Quality Results

Sample Id / Site Id: 2001Q0497 / 180512
Location (TRS): 02N 07W 22 AACB
Latitude/Longitude: 45° 54' 50" **N** 112° 27' 06" **W**
Datum: NAD27
Altitude: 5635.00
County/State: SILVER BOW / MT
Site Type: WELL
Geology: 211BDBT
USGS 7.5' Quad: HOMESTAKE
Project Code(s): GWCP05
Drainage Basin: PA

Sample Date: 08/28/2000
Agency/Sampler: MBMG / CAC
Field Number: 180512
Lab Date: 01/02/2001
Lab/Analyst: MBMG / JMC
Sample Method/Handling: NOT REPORTED / 4220
Procedure Type: DISSOLVED
PWS Id:
Total Depth (ft): 100.00
Depth Water Enters: 80.0 ft BGS
SWL (ft below MP): 30.40

Cations	mg/L	meq/L	Anions	mg/L	meq/L
Calcium (Ca)	23.00	1.15	Bicarbonate (HCO_3)	41.20	0.68
Magnesium (Mg)	5.96	0.49	Carbonate (CO_3)	0.00	0.00
Sodium (Na)	8.74	0.38	Chloride (Cl)	2.97	0.08
Potassium (K)	2.02	0.05	Sulfate (SO_4)	58.90	1.23
Iron (Fe)	<.005	0.00	Nitrate (as N)	1.38 P	0.10
Manganese (Mn)	<.001	0.00	Fluoride (F)	0.09	0.00
Silica (SiO_2)	19.80		Ortho-Phosphate (OPO_4)	<.05	0.00
Total Cations		**2.07**	**Total Anions**		**2.09**

Trace Element Results (µg/L)

Aluminum (Al):	<30	Cadmium (Cd):	<2	Mercury (Hg):	NR	Tin (Sn):	NR
Antimony (Sb):	<2	Chromium (Cr):	<2	Molybdenum (Mo):	<10	Titanium (Ti):	<1
Arsenic (As):	<1	Cobalt (Co):	<2	Nickel (Ni):	<2	Thallium (Tl):	<5
Barium (Ba):	32.10	Copper (Cu):	<2	Silver (Ag):	<1	Uranium (U):	NR
Beryllium (Be):	<2	Lead (Pb):	<2	Selenium (Se):	<1	Vanadium (V):	6.96
Boron (B):	<30	Lithium (Li):	9.22	Strontium (Sr):	158.00	Zinc (Zn):	<2
Bromide (Br):	<50					Zirconium (Zr):	<2

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 (µg/L):	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
Site Type: WELL
Geology: 211BDBT
USGS 7.5' Quad: HOMESTAKE
Project Code(s): GWCP05
Drainage Basin: PA

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
Total Depth (ft): 100.00
Depth Water Enters: 80.0 ft BGS
SWL (ft below MP): 43.34

Cations	mg/L	meq/L	Anions	mg/L	meq/L
Calcium (Ca)	42.70	2.13	Bicarbonate (HCO_3)	135.40	2.22
Magnesium (Mg)	12.80	1.05	Carbonate (CO_3)	0.00	0.00
Sodium (Na)	13.60	0.59	Chloride (Cl)	6.96	0.20
Potassium (K)	2.96	0.08	Sulfate (SO_4)	72.50	1.51
Iron (Fe)	0.01	0.00	Nitrate (as N)	4.09 P	0.29
Manganese (Mn)	<.001	0.00	Fluoride (F)	0.07	0.00
Silica (SiO_2)	23.10		Ortho-Phosphate (OPO_4)	<.05	0.00
Total Cations		**3.86**	**Total Anions**		**4.22**

Trace Element Results (µg/L)

Aluminum (Al):	<30	Cadmium (Cd):	<2	Mercury (Hg):	NR	Tin (Sn):	NR
Antimony (Sb):	<2	Chromium (Cr):	<2	Molybdenum (Mo):	<10	Titanium (Ti):	<1
Arsenic (As):	<1	Cobalt (Co):	<2	Nickel (Ni):	<2	Thallium (Tl):	<5
Barium (Ba):	51.90	Copper (Cu):	2.56	Silver (Ag):	<1	Uranium (U):	NR
Beryllium (Be):	<2	Lead (Pb):	<2	Selenium (Se):	<1	Vanadium (V):	5.17
Boron (B):	<30	Lithium (Li):	11.30	Strontium (Sr):	361.00	Zinc (Zn):	19.00
Bromide (Br):	<50					Zirconium (Zr):	<2

Field Chemistry and Other Analytical Results

**Total Dissolved Solids:	245.51	Field Alkalinity as CaCO3:	82.00	Langlier Saturation Index:	-0.24
**Sum of Diss. Constituents:	314.21	Alkalinity as CaCO3:	111.05	Ammonia (mg/L):	NR
Field Conductivity (µmhos):	340.00	Field Nitrate (mg/L):	NR	T.P. Hydrocarbons (µg/L):	NR
Lab Conductivity (µmhos):	412.00	Nitrite (mg/L as N):	NR	Field Dissolved O2 (mg/L):	NR
Field pH:	7.40	Water Temp (°C):	8.90	PCP (µg/L):	NR
Lab pH:	7.58	Air Temp (°C):	NR	Phosphate, TD (mg/L as P):	0.06
Field Hardness as CaCO3:	NR	Ryznar Stability Index:	8.07	Field Chloride (mg/L):	NR
Hardness as CaCO3:	159.31	Sodium Adsorption Ratio:	0.47	Field Redox (mV):	305.50

Sample Id / Site Id: 2001Q0498 / 150276
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
Site Type: WELL
Geology: 211BDBT
USGS 7.5' Quad: HOMESTAKE
Project Code(s): GWCP05
Drainage Basin: PA

Sample Date: 08/25/2000
Agency/Sampler: MBMG / CAC
Field Number: 150276
Lab Date: 01/18/2001
Lab/Analyst: MBMG / JMC
Sample Method/Handling: NOT REPORTED / 4220
Procedure Type: DISSOLVED
PWS Id: NR
Total Depth (ft): 160.00
Depth Water Enters: 140.0 ft BGS
SWL (ft below MP): 31.91

Cations	mg/L	meq/L	Anions	mg/L	meq/L
Calcium (Ca)	40.70	2.03	Bicarbonate (HCO_3)	91.20	1.49
Magnesium (Mg)	13.00	1.07	Carbonate (CO_3)	0.00	0.00
Sodium (Na)	15.60	0.68	Chloride (Cl)	11.70	0.33
Potassium (K)	2.64	0.07	Sulfate (SO_4)	77.70	1.62
Iron (Fe)	<.005	0.00	Nitrate (as N)	5.9 P	0.42
Manganese (Mn)	0.00	0.00	Fluoride (F)	0.15	0.01
Silica (SiO_2)	25.90		Ortho-Phosphate (OPO_4)	<.05	0.00
Total Cations		**3.85**	**Total Anions**		**3.87**

Trace Element Results (µg/L)

Aluminum (Al):	<30	Cadmium (Cd):	<2	Mercury (Hg):	NR	Tin (Sn):	NR
Antimony (Sb):	<2	Chromium (Cr):	<2	Molybdenum (Mo):	<10	Titanium (Ti):	<1
Arsenic (As):	<1	Cobalt (Co):	<2	Nickel (Ni):	<2	Thallium (Tl):	<5
Barium (Ba):	51.20	Copper (Cu):	<2	Silver (Ag):	<1	Uranium (U):	NR
Beryllium (Be):	<2	Lead (Pb):	<2	Selenium (Se):	<1	Vanadium (V):	<5
Boron (B):	<30	Lithium (Li):	19.20	Strontium (Sr):	318.00	Zinc (Zn):	11.30
Bromide (Br):	<50					Zirconium (Zr):	<2

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

Nitrate Sampling Results

GWIC No.	Date Sample Collected	Nitrate Concentration (mg/L-N)
180512	8/28/2000	1.38
	12/4/2000	1.24
	3/5/2001	1.29
	7/8/2001	1.17
	10/3/2001	1.19
	1/7/2002	1.26
	5/29/2002	1.16
	11/4/2002	0.90
	12/30/2002	2.20
150276	8/25/2000	5.90
	12/4/2000	5.28
	3/5/2001	5.52
	7/8/2001	5.36
	10/3/2001	7.84
	1/7/2002	8.45
	5/29/2002	7.06
	11/4/2002	6.00
	12/30/2002	7.70
145960	8/25/2000	4.09
	12/4/2000	3.94
	3/5/2001	4.32
	7/7/2001	3.50
	10/3/2001	3.02
	1/7/2002	4.02
	5/29/2002	3.55
	11/4/2002	2.90
	12/30/2002	3.70
49551	5/1/2001	11.60
	10/1/2001	8.98
165704	6/1/2001	4.82
165216	5/1/2001	5.18
168216	5/1/2001	3.90
	10/1/2001	6.72

Note. Nitrate values are reported as nitrogen in milligrams per liter of concentration (mg/L-N).

Isotope Sampling Results

GWIC No.	Latitude and Longitude (NAD 1927 datum, decimal degrees)	Aquifer Material/ Geologic Unit	$\delta^{15}N$ ($^{o}/oo$)	$\delta^{18}O$ ($^{o}/oo$)
128029	45.9990, -112.5027	younger basin fill	11.1	-1.69
50092	45.9814, -112.4721	Boulder Batholith	6.35	-1.29
128027	45.9943, -112.5184	younger basin fill	11.1	-1.00
129262	45.9975, -112.4932	older basin fill	9.73	0.52
155514	45.9899, -112.5472	younger basin fill	8.91	-0.11
175667	45.9933, -112.5508	younger basin fill	4.29	11.86
153760	45.9667, -112.5125	older basin fill	10.93	-0.91
129387	45.9674, -112.4784	older basin fill	8.93	0.20
49421	45.9211, -112.4786	older basin fill	10.03	-2.08
49551	45.9109, -112.4599	Boulder Batholith	9.78	-1.99
168216	45.9140, -112.4599	Boulder Batholith	10.05	-0.76
49336	45.9362, -112.4872	older basin fill	9.67	1.66
50356	46.0078, -112.5588	Boulder Batholith	7.17	-3.69
890997	46.0055, -112.5537	Boulder Batholith	8.21	-2.16
158435	45.9527, -112.5266	Boulder Batholith	10.52	

Note. ^{15}N and ^{18}O isotope values are reported in parts per mil ($^{o}/oo$). $\delta^{15}N$ 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).