# Geyser Water Users Association
# Public Water System

**PWS ID # MT0000226**

# ***Source Water Delineation and Assessment Report***

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# Table of Contents



**TABLES**

**Figures**



**Appendices**

# EXECUTIVE SUMMARY

This Source Water Delineation and Assessment Report was prepared under the requirements and guidance of the Federal Safe Drinking Water Act and the US Environmental Protection Agency, as well as a detailed Source Water Assessment Plan developed by a statewide Montana citizens' advisory committee. The Department of Environmental Quality (DEQ) completes assessments of all public water systems in Montana. The purpose of an assessment is to provide information to the public water system staff/operator, consumers, and community citizens to enable them to develop strategies for protecting the source of their drinking water. The information that is provided includes identification of the areas most critical to maintaining safe drinking water: the Control, Inventory, and Recharge Regions, an inventory of potential sources of contamination within these areas, and an assessment of the relative threats that these potential sources pose to the water system.

The drinking water for Geyser Water Users Association is supplied by one well located near the intersection of Second East Street and Cook Avenue. Based on the sanitary survey, well log, and the depth of the well, it appears that sandstones of the Kootenai, Morrison and Swift Formations provide water to the PWS's well. In accordance with the Montana Source Water Protection Program criteria (MT DEQ, 1999), the aquifer (source water) is considered to have a low sensitivity to potential contaminant sources since it is a confined aquifer. Sensitivity is defined as the relative ease that contaminants can migrate to source water through the natural materials.

As part of this assessment, three types of source water protection management regions were mapped for the Geyser Water Users Association public water system. They are: the control zone, the inventory region, and the recharge region. Potential sources of contamination were identified within each of these three regions and the results are as follows:

- No potential sources of contamination were identified within the control zone. The goal of management in the control zone is to avoid introducing contaminants directly into the water supply's well or immediate surrounding areas. The control zone is delineated as a 100-foot radius around the well(s) and all sources of potential contaminants should be excluded in this region.
- Significant potential contaminant sources identified within the inventory region include: sewer mains, the landfill, Highway 87, and a leaking underground storage tank. The inventory region should be managed to prevent contaminants from reaching the well before natural processes reduce their concentrations.
- No potential contaminant sources were identified within the recharge region. This area is primarily undeveloped grassland. The goal of management in the recharge region is to maintain and improve water quality over long periods of time or increased usage. Recharge to the wells is likely from infiltration of precipitation and surface water into the Kootenai Formation where this formation outcrops upgradient north of the well.

The Geyser Water Users Association public water supply has a low susceptibility to the following potential contaminant sources: sewer mains, landfill, and leaking underground storage tank. The hazard rating for the remaining identified potential contaminant sources is low, because the PWS source water well is screened in a confined aquifer and potential contaminant source migration pathways through the confining layer (i.e. poorly sealed wells) were not identified in the inventory region. Susceptibility is the potential for a public water supply to draw water contaminated by inventoried sources at concentrations that would pose concern. Susceptibility is determined by considering the hazard rating for each potential contaminant source, relative to barriers that decrease the likelihood that contaminated

water will flow to the public water supply well intake. This provides a quick look at the existing potential sources of contamination that could, if improperly managed or released, impact the source water for Geyser Water Users Association. The susceptibility analysis provides the community and the public water system with information on where the greatest risk occurs and where to focus resources for protection of this valuable drinking water resource.

The costs associated with contaminated drinking water are high, and prevention is preferable to treatment. In this report, the Source Water Protection Program provides a summary description of the supply well setting, such as the local geology and well construction. The area most critical to preserving drinking water quality (the Inventory Region) has been identified, in addition to potential sources of contamination within that area. Furthermore, recommendations (i.e. Best Management Practices) are provided regarding the proper use and practices associated with some common potential contamination sources. Public awareness is a powerful tool for protecting drinking water. The information in this report will help increase public awareness about the relationship between land use activities and drinking water quality.

# INTRODUCTION

This Source Water Delineation and Assessment Report (SWDAR) was prepared for the Geyser Water Users Association (WUA) Public Water Supply, PWS ID No. MT0000226, located in Judith Basin County. It was completed by Joe Meek of the Source Water Protection Program at the Department of Environmental Quality with assistance from intern Bethany Haines.

## PURPOSE

This report is intended to meet the technical requirements for the completion of the delineation and assessment report for the Geyser Water Users Association Public Water System (PWS) as required by the Montana Source Water Protection Program (MT DEQ, 1999) and the federal Safe Drinking Water Act (SDWA) Amendments of 1996 (Public Law 104-182). The Montana Source Water Protection Program is intended to be a practical and cost-effective approach to protect public drinking water supplies from contamination. A major component of the Montana Source Water Protection Program is "delineation and assessment." Delineation is a process whereby areas that contribute water to aquifers or surface water bodies that are used to supply drinking water are identified on a map. These areas are called source water protection areas. Assessment involves identifying locations in the delineated areas where contaminants may be generated, stored, or transported, and then determining the relative potential for contamination of drinking water by these sources. The primary purpose of this source water delineation and assessment report is to provide information that helps Geyser Water Users Association protect its drinking water sources.

## LIMITATIONS

This report was prepared to assess threats to Geyser Water Users Association's public water supply, and is based on published information and information obtained from local residents familiar with the community. The terms "drinking water supply" or "drinking water source" refer specifically to the source of the Geyser Water Users Association public water supply and not to any other public or private water supply. Also, not all potential or existing sources of groundwater or surface water contamination in the area of the Geyser Water Users Association public water supply are identified. Only potential sources of contamination in areas that contribute water to its drinking water source are considered.

The term "contaminant" is used in this report to refer to constituents for which maximum concentration levels (MCLs) have been specified under the national primary drinking water standards, and to certain constituents that do not have MCLs but are considered to potentially represent health threats.

# CHAPTER 1
# BACKGROUND

## THE COMMUNITY

The Geyser Water Users Association is located in the Town of Geyser, which is in Judith Basin County of central Montana, as shown in Figure 1. The nearest town is Stanford, located approximately 15 miles southeast of the Town of Geyser. The community economy relies upon the agricultural industry.

The community includes both residential and small commercial water users. Geyser Water Users Association serves 299 people through 59 service connections. The commercial water users include: a vehicle repair facility, a small grocery store, a grain elevator, a school, and a bar. Geyser Water Users Association's public water system (PWS) is classified as a Community PWS because it serves more than 25 residents. Drinking water is supplied by one well located in the north portion of the town (Figure 1). Human waste and animal processing wastes are treated in wastewater treatment lagoons located approximately 1,700 feet northwest of town.

## GEOGRAPHIC SETTING

Geyser is located on the western edge of Judith Basin, a structural and physiographic basin in central Montana characterized by flat gravelly terraces dissected by steep sided coulees. The community is situated on a terrace between the northeast-flowing Hay Creek and the north-flowing Lone Tree Creek, approximately 10-15 miles north of the Little Belt Mountains.

Geyser Water Users Association is located in the Arrow Watershed, U.S. Geological Survey (USGS) hydrologic unit code (HUC) Number 10040102. The Arrow Watershed extends from the Highwood Mountains south to Granite Mountain, and is located within the Lower Missouri River Watershed Management Region of Montana.

***Figure 1*. Vicinity Map and Well Locations**

## CLIMATE

Information on climate in the Geyser Water Users Association area is based on the National Oceanic and Atmospheric Administration's (NOAA) nearby Raynesford climate station, located approximately 12 miles west of Geyser, at an elevation of 4,220 feet above mean sea level (Western Regional Climate Station). Average temperatures and total precipitation for the period of record are shown in Table 1.

***Table 1. Monthly Climate Summary: Raynesford, Montana Climate Station***
Station 246900 Period of Record: 5/18/1954 to 4/30/1970

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average Max. Temperature (F) | 34.3 | 37.7 | 42.8 | 53.6 | 63.9 | 72.1 | 82.1 | 81.2 | 69.3 | 59.6 | 45.6 | 39.7 | 56.8 |
| Average Min. Temperature (F) | 8.8 | 14.0 | 18.4 | 27.7 | 35.7 | 42.1 | 46.0 | 43.6 | 36.0 | 31.0 | 20.9 | 15.8 | 28.3 |
| Average Total Precipitation (in.) | 0.69 | 0.51 | 0.52 | 1.31 | 2.87 | 3.60 | 1.52 | 1.38 | 1.59 | 1.09 | 0.68 | 0.67 | 16.42 |
| Average Total SnowFall (in.) | 10.1 | 10.2 | 5.0 | 8.2 | 0.5 | 0.3 | 0.0 | 0.0 | 0.8 | 2.2 | 6.9 | 8.0 | 52.1 |
| Average Snow Depth (in.) | 2 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |

## GENERAL DESCRIPTION OF THE SOURCE WATER

Geyser WUA's drinking water is provided by one supply well. The well was installed to 900 feet in 1971 and redeveloped to the current depth of 1,060 feet in 1992. The well is a flowing artesian well; the static water level measured during drilling activities was 23.1 feet above grade, and shut-in pressure is 10 feet. The productive material is interpreted to be sandstone of the Kootenai Formation. Groundwater in the Geyser area likely originates as precipitation and related run-off in the Little Belt Mountains, which recharges the sandstone and limestone aquifers extending beneath the Judith Basin (Feltis, 1977). Groundwater flow beneath Geyser is generally to the north-northeast. Additional detail on the geology and hydrogeology of the area is provided in Chapter 2.

## THE PUBLIC WATER SUPPLY

Geyser Water Users Association serves 299 people through 59 service connections (hook ups). This is classified as a community public water system (PWS) since it serves at least 25 of the same people every day. Information on the water system was obtained from correspondence in the DEQ Public Water Supply Section files including the PWS-6 report completed on October 2003 (report dated 2003 included in Appendix A) and personal communication with the PWS operator.

The well discharge pipe runs to the nearby pump house, where a booster pump maintains summertime pressure in the pressure tanks. Artesian pressure is generally around 40 PSI throughout most of the year but peak summer demand requires the automatic activation of the booster pump. The seasonal increase in demand is caused by irrigation. The pump house stores water treatment equipment and chemicals that are used to treat the finished water.

A preliminary assessment of groundwater sources under the direct influence of surface water was completed in 1997 and the water is classified as groundwater.

## WATER QUALITY

Every PWS is required to perform regular sampling of their water supply to detect any contamination. The analytical parameters include coliform and other pathogenic organisms, nitrates, metals and multiple organic chemicals. The monitoring schedule depends on factors such as the size and source water of a PWS, the number of supplies (e.g. wells), and the population served. Each PWS has a specific monitoring program tailored to their system that follows the general protocols defined by DEQ for operation of a PWS. PWS monitoring schedules are available at: http://nris.state.mt.us/wis/swap/swapquery.asp. The Geyser Water Users Association PWS monitoring data from DEQ's PWS database for the past five years was for preparation of this section.

No health-based violations have been reported in the last five years. Health based violations are issued when the amount of contaminant in the treated drinking water exceeds the safety standard (maximum contaminant level or MCL), or water was not treated properly. The water system has had four monitoring violations in the previous five years (for missing monthly coliform sampling).

### Background Water Quality

Correspondence (various authors, 1981-2004) and sampling reports of untreated water from the supply well and private wells in the community (Plilcher, 2003) have reflected poor water quality in the source aquifer. Elevated sulfates, iron and manganese appear to be typical of this water source. These compounds generally exceed the SMCLs [U.S. Environmental Protection Agency maximum contaminant level or action level: revised October 13, 1999. This standard is based on aesthetic quality of water (i.e. odor, color, etc.) and is not a health standard]. None of the reported background water quality samples results exceeded established MCLs.

# CHAPTER 2
# DELINEATION

The source water protection area, the land area that contributes water to the Geyser Water Users Association PWS is identified in this chapter. Three management areas are identified for a PWS's source water protection area. These three regions: the control zone, the inventory region, and the recharge region, are delineated for the well. The control zone, also known as the exclusion zone, is an area of at least 100-foot radius around the wellhead. The inventory region represents the zone of contribution of the wells, which typically approximates a three-year groundwater time-of-travel. Analytical equations describing groundwater flow using estimates of pumping and aquifer characteristics and simple hydrogeologic mapping are used to calculate groundwater time-of-travel distance. The recharge region represents the area where the source aquifer for the Geyser Water Users Association water system well is replenished.

## GENERAL GEOLOGIC AND HYDROGEOLOGIC SETTING

This section provides an overview of the geology and hydrology of the Geyser area and is primarily based on a geologic map of the area by Vuke *et al*. (2002), the well logs for the Geyser Water Users Association PWS well, and regional well logs available from the Montana Bureau of Mines and Geology (MBMG) Ground-Water Information Center (GWIC). A regional geologic map is provided in Figure 2. An understanding of the local and regional geology is necessary to determine the locations, boundaries, and hydraulic properties of local aquifers. An understanding of hydrogeologic conditions also helps assess the sensitivity of local aquifers to potential contaminant sources.

The 1,060 feet deep well is drilled into the Kootenai, Morrison and Swift Formations. The lithology (rock type) descriptions provided in the well driller's log closely compare with descriptions of these units in the available literature (Noble *et al*. 1982; Vuke *et al*. 2002). The shales and siltstones in the upper Kootenai Formation create the confined condition and the artesian flow at Geyser. According to the well log, the well casing is screened below a depth of 530 feet. The screened interval intersects the basal sandstones of the Kootenai Formation, sandstone beds in the underlying Morrison and Swift Formations. The aquifer recharges where it is exposed at the surface in outcrops to the south-southeast of Geyser.

***Figure 2*. Geology of the Area**

## PWS WELL INFORMATION

Geyser WUA's drinking water is provided by one supply well, which is located in town. The well was completed at a depth of 1,060 feet and draws water from multiple sandstone beds in the Kootenai, Morrison and Swift Formations. The static water level measured at the time of drilling was 23.1 feet above grade. The aquifer is confined, and the interpreted groundwater flow direction in the vicinity of the wells is towards the north-northeast. Recharge to the wells is likely from infiltration of precipitation and surface water in outcrops exposing aquifer units in higher country to the south.

Copies of the well log showing encountered lithology and well construction information are included in Appendix B, and are summarized in Table 2.

***Table 2. Summary of PWS Well Log Information***

| **PWS Name Well Number** | **Well** |
|---|---|
| DEQ Well Name/ Source Code | Well #1<br>WL002 |
| GWIC ID | 130219 |
| DNRC Water Right | P08192-00 |
| Well Location | SE¼, SE`¼, NW¼, Sec.6, T17N, R10E |
| Well Elevation | Approx. 4,190 feet |
| Date Completed | 8/19/1992 |
| Total Depth (bgs) | 1,060 feet |
| Well Completion: Casing | 8" steel casing from 0 to 825 feet below surface; 5" PVC casing from 0 to 935 feet below surface; and 6" steel casing from 825 to 924 feet below surface |
| Well Completion: Screen | Casing perforated from 530-930 feet in "clay, shale, and sandstone" |
| Well Completion: Annular Seal | Cement annular seal from 0-800 feet |
| Static Water Level<br>(at time of drilling) | Flow (–23.10) |
| Well Pump Test Data | Not in GWIC records |

## CONCEPTUAL MODEL AND ASSUMPTIONS

Geyser Water Users Association's production well is located in the Arrow watershed (USGS Hydrologic Unit Code 10040102), which is located within the Lower Missouri River Watershed Management Region for Montana (Heath, 1984). Groundwater flow beneath Geyser is interpreted to be to the north. The aquifer is confined and recharge to the well is likely from infiltration of precipitation and surface water in outcrops exposing aquifer units in higher country to the south.

As the aquifer is confined, it is considered to have **Low Source Water Sensitivity** to contamination. This determination is according to the DEQ Source Water Protection Program criteria for ranking aquifer sensitivity (Table 3). Sensitivity is defined as the relative ease that contaminants can migrate to source water.

***Table 3. Source Water (Aquifer) Sensitivity Criteria***

Based on DEQ Source Water Protection Program Criteria (MT DEQ, 1999)

| High | Moderate | Low |
|---|---|---|
| • Surface water and GWUDISW<br>• Unconsolidated Alluvium (unconfined)<br>• Fluvial-Glacial Gravel<br>• Terrace and Pediment Gravel<br>• Shallow Fractured or Carbonate Bedrock | • Semi-consolidated Valley Fill sediments (semi-confined)<br>• Unconsolidated Alluvium (semi-confined) | • Consolidated Sandstone Bedrock<br>• Deep Fractured or Carbonate Bedrock<br>• Semi-consolidated<br>• Confined Aquifers |

**DELINEATION**

Methods and criteria for delineating source water protection areas are specified in the Montana Source Water Protection Program (MT DEQ, 1999). Source water protection areas delineated for the Geyser Water Users Association PWS include a control zone, an inventory region and a recharge region. The delineated management zones for the wells are shown on Figure 3.

*Control Zone* – A 100-foot radius control zone is delineated for Geyser Water Users Association well. All sources of potential contaminants should be excluded in this region.

*Inventory Region* - For the Geyser Water Users Association well, the DEQ's Source Water Protection Program criteria for a confined aquifer system was followed. The inventory zone was delineated based on a 1,000-foot radius. Conservative estimates for aquifer properties were made using available data from published reports and the information on the well logs. All sources of potential contaminants are inventoried in this region.

*Recharge Region* –The recharge region for the Geyser Water Users Association well includes the related run-off in the surrounding mountains, which recharge the sandstones and limestone aquifers. The inventory for the recharge region focuses on general land uses and large industrial facilities. The goal of management in the recharge region is to maintain and improve the long-term quality of groundwater in the aquifer.

## LIMITING FACTORS

Delineation of the source water protection areas for the Geyser Water Users Association PWS well is based on published reports and lithology indicated on the well logs. The delineation was completed using conservative assumptions to help ensure that the inventory zone reflects the actual area where contamination to the system may occur.

Figure 3. Drinking Water Protection Areas and Potential Sources of Contamination

# CHAPTER 3
# INVENTORY

## INVENTORY METHOD

An inventory of significant potential contaminant sources was conducted to assess the susceptibility of Geyser Water Users Association's well to contamination and to provide a foundation for source water protection planning. The inventory for Geyser Water Users Association focuses on facilities that generate, use, or store potential contaminants and certain land uses in the inventory region delineated in the previous section. Sources of all primary drinking water contaminants and pathogens are identified, although only potential sources of contaminants that are the greatest threat to human health were selected for detailed inventory.

It is important to remember that the sites and areas identified in this section are only potential sources of contamination to the drinking water. Contamination of the drinking water is not likely to occur when potential contaminants are properly used and managed. Not all of these inventoried activities pose actual high risks to your public water supply. The day-to-day operating practices and contamination awareness varies considerably from one facility or land use activity to another.

The inventory for the Geyser Water Users Association PWS focuses on all activities in the control zone for the well; certain types of municipal and private facilities or land uses in the inventory region; and general land uses and large facilities in the Recharge Region. Databases were searched to identify businesses and land uses that are potential sources of regulated contaminants. The process for completing the inventory included several steps, which are summarized as follows:

Step 1: Urban and agricultural land uses were identified from the U.S. Geological Survey's Geographic Information Retrieval and Analysis System (http://nris.state.mt.us/gis/datalist.html). Sewered and unsewered residential land uses were identified from boundaries of sewer coverage obtained from municipal wastewater utilities.

Step 2: EPA's Envirofacts System (http://www.epa.gov/enviro/) was queried to identify EPA regulated facilities located in the inventory region. This system accesses facilities listed in the following databases: Resource Conservation and Recovery Information System (RCRIS), Biennial Reporting System (BRS), Toxic Release Inventory (TRI), and Comprehensive Environmental Response Compensation and Liability Information System (CERCLIS) and the Permit Compliance System (PCS - for Concentrated Animal Feeding Operations with MPDES permits). The available reports were browsed for facility information including the Handler/Facility Classification to be used in assessing whether a facility should be classified as a significant potential contaminant source.

Step 3: Databases were queried to identify the following in the inventory region:

- Underground Storage Tanks (USTs) (http://www.deq.state.mt.us/UST/USTDownloads.asp)
- Hazardous waste contaminated sites (DEQ hazardous waste site cleanup bureau)
- Landfills (http://nris.state.mt.us/gis/datalist.html)
- Abandoned and active mines, including gravel pits (http://nris.state.mt.us/gis/datalist.html)

Any information on past releases and present compliance status was noted.

Step 4: A business phone directory was queried to identify businesses that generate, use, or store chemicals in the inventory region. Equipment manufacturing and/or repair facilities, printing or photographic shops, dry cleaners, farm chemical suppliers, and wholesale fuel suppliers were targeted by Standard Industrial Classification (SIC) code.

Step 5: Major road and rail transportation routes were identified throughout the inventory region (http://nris.state.mt.us/gis/datalist.html).

Step 6: Public water system officials, or someone they suggested to be knowledgeable of the area, were interviewed to identify potential sources that are not listed in databases or on maps elsewhere (such as animal feeding operations that are not required to obtain a permit) and to assist in locating potential sources listed in the state and federal databases.

Step 7. Significant potential contaminant sources were identified in the control zone and inventory region and land uses and facilities that generate, store, or use large quantities of hazardous materials were identified within the recharge region

Potential contaminant sources are designated as significant if they fall into one of the following categories:

1. Large quantity hazardous waste generators.
2. Landfills.
3. Underground storage tanks.
4. Known groundwater contamination (including open or closed hazardous waste sites, state or federal superfund sites, and UST leak sites).
5. Underground injection well.
6. Major roads or rail transportation routes.
7. Cultivated cropland greater than 20 % of the inventory region.
8. Animal feeding operations.
9. Wastewater treatment facilities, sludge handling sites, or land application areas.
10. Septic systems.
11. Sewer mains.
12. Storm sewer outflows.
13. Abandoned or active mines

## CONTROL ZONE INVENTORY RESULTS

The 100-foot control zone for the well includes the well house and adjacent buildings in the town. No potential sources of contamination were identified within the control zone

for the well. The PWS should be vigilant to ensure that potential sources of contamination are excluded from the control zone and that positive drainage away from the wellhead is maintained.

## INVENTORY REGION RESULTS

Potential point sources of contaminants in the inventory region include: the closed landfill, two USTs at the school, and seven USTs at the Rex Garage. Of these nine identified USTs, only one at the school is listed as active. Businesses or facilities listed on regulatory databases were not identified in the inventory region. Transportation routes (the highways and railroad) are considered a risk to the PWS. Sewer mains are a potential contaminant source.

Septic system density within the inventory region is low and is not considered a risk to the PWS drinking water. The majority of the inventory region area is undeveloped grassland.

The inventory results for Geyser Water Users Association's source water are summarized in Table 4 and are shown on Figure 4.

***Table 4. Summary of Potential Contaminant Sources in the Inventory Region***

| *Source Type* | *Potential Contaminants* | *Description/Concern* |
|---|---|---|
| **Land Use Cover (Step 1)** | | |
| Residential Development with Sewer Lines | Pathogens and nitrates | If not properly designed, installed, and maintained, sewer lines can be a point source of residential and commercial effluent in groundwater. |
| **EPA Envirofacts Sites (Step 2)** | | |
| None Identified | | |
| **DEQ Databases (Step 3)** | | |
| Geyser Landfill (closed 1994) | Various | Contaminants leaching into groundwater |
| Businesses that may use hazardous materials or have USTs: Geyser School (USTs, one active, one inactive)<br>Rex Garage (7 inactive USTs) | VOCs, petroleum hydrocarbons | Spills and leaks impacting groundwater |
| **Business – SIC Code Sites (Step 4)** | | |
| None Identified | | |
| **Miscellaneous Others, including Step 5 and 6** | | |
| Transportation Corridors | Pesticides, fertilizers, VOCs, SOCs, other | Spills, routine spraying, storm water runoff, infiltration into groundwater |

Notes: Individual sites identified are evaluated in Chapter 4.

***Figure 4*. Land Use and Potential Sources of Contamination in the Protection Areas**

## RECHARGE REGION INVENTORY RESULTS

According to the 1992 National Land Cover dataset, the primary land use in the recharge region is grasslands with surrounding agricultural land (Figure 4). The agricultural land is considered a moderate risk to the drinking water supply. Grasslands are not considered potential sources of contamination unless there are significant grazing operations in the area.

Septic system density within the watershed/recharge region is low and is not considered a risk to the PWS drinking water.

Additional sources of potential pollution (such as storage tanks, businesses or facilities listed on regulatory databases) were not identified in the recharge region.

## INVENTORY UPDATE

To make this SWDAR a useful document for the years to come, the certified water system operator should review the inventory every year. Changes in land uses or potential contaminant sources should be noted and additions made as appropriate. The complete inventory should be submitted to DEQ every five years to ensure the source water delineation and assessment remains current.

## INVENTORY LIMITATIONS

The potential contaminant sources described above are identified from readily available information. Consequently, unregulated activities or unreported contaminant releases may have been overlooked. The use of multiple sources of information, however, should ensure that the major threats to the source water for Geyser Water Users Association's public water supply have been identified. The lack of identification of a potential contaminant source in the inventory or susceptibility assessment of this report does not mean that the potential for contamination does not exist or there is not a threat. It is highly recommended that the PWS and community "enhance" or refine the identification of the potential contamination sources through further research and local input.

# CHAPTER 4
# SUSCEPTIBILITY ASSESSMENT

## GENERAL DISCUSSION

Susceptibility is the potential for a public water supply to draw water contaminated by inventoried sources at concentrations that would pose a concern. Susceptibility is assessed in order to prioritize potential pollutant sources for management actions by local entities, in this case the Geyser Water Users Association PWS managers and operators. The goal of Source Water Management is to protect the source water by 1) controlling activities in the control zone, 2) managing significant potential contaminant sources in the inventory region, and 3) ensuring that major land use activities or other significant activities in the recharge region pose minimal threat to the source water. Management priorities in the inventory region are determined by ranking the significant potential contaminant sources identified in the previous chapter according to susceptibility. Alternative management approaches that could be pursued by the PWS managers and operators to reduce susceptibility are recommended in this chapter.

## HAZARD DETERMINATION

The proximity of a potential contaminant source to a well intake, potential contaminant migration pathways, or the density of potential non-point contaminant sources determines the threat of contamination, referred to here as hazard. The criteria for determining hazards within the inventory regions are established in Montana Source Water Protection Program Table 6: Hazard of Potential Contaminant Sources (MT DEQ, 1999).

Due to the facts that the source aquifer is confined and the supply well is cased and sealed through the confining layer, the hazards posed by identified contaminant sources are low.

## DISCUSSION OF SUSCEPTIBILITY

Susceptibility is determined by considering the hazard rating for each potential contaminant source relative to any barriers present. This rational is established in the Montana Source Water Protection Program (MT DEQ, 1999) and summarized in Table 5.

***Table 5. Susceptibility Based on Hazard and Barriers***

| **Presence Of Barriers** | **Hazard** | | |
|---|---|---|---|
| | **High** | **Moderate** | **Low** |
| **No Barriers** | Very High Susceptibility | High Susceptibility | Moderate Susceptibility |
| **One Barrier** | High Susceptibility | Moderate Susceptibility | Low Susceptibility |
| **Multiple Barriers** | Moderate Susceptibility | Low Susceptibility | Very Low Susceptibility |

Barriers to contamination can be anything that decreases the likelihood that contaminants will reach a spring or well. Barriers can be engineered structures, management actions, or natural conditions. Examples of engineered barriers are spill catchment structures for industrial facilities and leak detection for underground storage tanks. Emergency planning and best management practices are considered management barriers. Thick clay-rich soils, a deep water table or a thick unsaturated zone above the well intake are examples of natural barriers.

The well log indicate that a significant (350-foot) layer of shale is present overlying the aquifer. Clay layers were also identified in other well logs in the area indicating that the layer is likely laterally extensive in the Geyser Water Users Association area. The clay serves as a natural barrier to the downward migration of potential contaminants from the surface.

A summary of the susceptibility assessment for Geyser Water Users Association PWS production well is provided in Table 6. This table only includes the potential contaminant sources (identified in Chapter 3) that were determined to present a significant potential risk to the drinking water supply. Therefore, this list is not exhaustive, and it is highly recommended that the PWS operator and community members familiar with the nature of businesses and land use in the area enhance the inventory through further research and local input.

The susceptibility assessment results for each significant potential contaminant source identified within the Inventory Region are described below. Sources located outside the Inventory Region, but within the Recharge Region, may still pose a threat over time, but are not discussed in detail.

***Underground Storage Tanks*** – The potential hazard imposed by spills or leaks from tanks is low. The clay layer confining the aquifer serves as a barrier, so the overall susceptibility is ranked as low.

***Residential Sewer System*** – Residential sewer mains are present in the inventory region. The potential hazard imposed by pathogens and nitrate originating from municipal sewer system is low. The clay layer serves as a barrier, and the overall susceptibility is rated as low.

***Vehicle Repair Shop*** – The garage poses a low potential hazard from petroleum products and other chemicals. The clay layer serves as a barrier and the overall susceptibility is rated as low.

***Landfills***- The Geyser Landfill is now closed. The hazard from various contaminants is low. The clay layer serves as a barrier and the overall susceptibility is rated as low.

***Transportation Corridors*** – The potential hazards imposed by spills and routine spraying along the highway and railroad are low. The clay layer serves as a barrier and the overall susceptibility is rated as low.

***Table 6. Susceptibility Assessment of Significant Potential Contaminant Sources***

| Potential Contaminant Source | Potential Contaminants | Hazard | Hazard Rating | Barriers | Susceptibility | Management Recommendations |
|---|---|---|---|---|---|---|
| ***Inventory Region*** | | | | | | |
| Active USTs | VOCs, petroleum hydrocarbons | Contaminants leaching into groundwater | ***Low*** | - Clay layers overly the aquifer | ***Low*** | Review permit status and ensure proper operation and maintenance, emergency planning, training of local emergency response personnel, groundwater monitoring, spill prevention, and BMPs. |
| Inactive USTs | VOCs, petroleum hydrocarbons | Historic spills or leaks may impact the drinking water supply. | ***Low*** | - Clay layers overly the aquifer | ***Low*** | Properly abandon and remove tanks if out-of-service. Encourage soil testing to evaluate potential impact from historic spills or leaks. |
| Landfills | Various | Contaminants leaching into groundwater | ***Low*** | - Clay layers overly the aquifer | ***Low*** | Contact DEQ's Waste and Underground Tank Management Bureau (406-444-5300) to review closure permit requirements (if any) and to find out if site assessment or cleanup is pending or completed. |
| Sewer Lines | Pathogens, nitrates | Ongoing or catastrophic leakage of sewage into groundwater | ***Low*** | - Clay layers overly the aquifer | ***Low*** | Ensure ongoing inspection and maintenance with rehabilitation or replacement of existing sewer mains if necessary. Use sewer main liners. Develop rapid response plan for leaks or ruptures. |
| Vehicle/Equipment Maintenance Areas/Shops | Petroleum products, maintenance products, VOCs, SOCs and others | Spills or leaks of chemicals used | ***Low*** | - Clay layers overly the aquifer | ***Low*** | Protect area from fuel or other chemical spills. Maintain sealed concrete floors. Ensure proper chemical and waste use, storage, and disposal/recycling. Ensure good housekeeping. |
| Transportation Routes<br>Highways and Railroad | Pesticides, fertilizers, VOCs, SOCs, other | Spills, routine spraying, storm water runoff, infiltration into groundwater | ***Low*** | - Clay layers overly the aquifer | ***Low*** | Encourage and support emergency planning, training of local emergency response personnel, use of levees and engineered storm drainage to carry any spills away and prevent infiltration into ground, cooperation with railroad managers or MDOT to reduce herbicide use. |

| | | | | | | |
|---|---|---|---|---|---|---|
| ***Recharge Region*** | | | | | | |
| Wastewater treatment facilities (lagoons), sludge handling sites, or land application areas | VOCs, SOCs, metals, pathogens, nitrates, others | Ongoing or catastrophic leakage of sewage into groundwater | ***Low*** | - Clay layers overly the aquifer<br>- Downgradient from well | Not Rated – Outside of Inventory Region | Review permit status (contact DEQ Permitting and Compliance Water Protection Bureau – 406-444-3080 for more information) and ensure proper operation and maintenance, emergency planning, training of local emergency response personnel, groundwater monitoring, spill prevention and BMPs. |
| Agricultural Crop Land | Nitrate and SOCs from fertilizer, pesticides and herbicides. Pathogens (if grazing occurs) | Contaminants leaching into groundwater | ***Low*** | - Clay layers overly the aquifer | Not Rated – Outside of Inventory Region | Encourage use of agricultural best management practices (BMPs) in the recharge region |

**Notes:** VOCs - Volatile organic compounds (i.e. solvents, fuel components) SOCs - Synthetic Organic Compounds (i.e. pesticides, herbicides, plasticizers)

## MANAGEMENT RECOMMENDATIONS

It should be noted that even small releases of some chemicals in close proximity to a public water supply well can have significant negative impact on water quality, and therefore are a significant threat to the public water supply. Steps can be taken to reduce the likelihood of releases in the source water for the PWS or in the vicinity of the sources. Management recommendations for protecting the Geyser Water Users Association drinking water supply are summarized in the susceptibility table (Table 6). If these, and other, management recommendations are implemented; they may be considered additional barriers that will reduce the susceptibility of the intake to specific sources and contaminants.

***Sewer/Wastewater Treatment System Maintenance and Leak Detection*** – Early warning of leaks and scheduled replacement of aging sewer lines and wastewater treatment systems may reduce the susceptibility of the PWS to contamination from septic wastes.

***Inactive USTs/LUSTs*** - It is recommended that the PWS operator or community members contact DEQ's Waste and Underground Tank Management Bureau (406-444-5300) to obtain further information on the cleanup status and any permits or monitoring networks to verify existing contamination is being properly assessed and remediated. The PWS can work with DEQ to encourage proper abandonment for out-of-service tanks and soil testing to evaluate potential impact from historic spills or leaks.

***Education*** - Educational workshops provided to the general public by the city, county, or state promote safe handling and proper storage, transport, use, and disposal of hazardous materials. Ongoing training provided to designated emergency personnel would promote the efficiency and effectiveness of emergency responses to hazardous material spills. Likewise, educational workshops provided to rural homeowners and agricultural landowners will promote best management practices for groundwater protection including proper maintenance and replacement of residential septic systems and proper management of small acreage. The EPA and the State of Montana can provide educational materials on these topics.

***Emergency Response Plan*** – Several counties have compiled Emergency Response Plans that were then adopted by the local communities. The usefulness and effectiveness of a response plan are maximized if it contains a clear listing of all emergency contacts, emergency numbers, and resources available within the county to respond to an emergency situation, such as a hazardous material spill. Emergency plans are not difficult to develop or distribute, but have a significant benefit to the citizens and municipalities within the county.

# CHAPTER 5
# MONITORING WAIVERS

## WAIVER RECOMMENDATION

The Geyser Water Users' Association PWS has a waiver for Phase 2 inorganics (which includes barium, cadmium, chromium, fluoride, mercury and selenium). The waiver allows the PWS to collect one sample round for these constituents on a nine-year cycle rather than every three years. In addition, the PWS was grandfathered under the radionuclide rule and is only required to sample once every nine years. Based on past monitoring results and the susceptibility assessment, the Geyser Water Users Association PWS may be eligible for other waivers, including Phase 5 inorganics and volatile organic compounds. Information on susceptibility and use waivers is provided in this section to give the PWS operators an opportunity to consider if waivers may be feasible.

Before a susceptibility or use wavier is requested, the PWS Operators are encouraged to carefully review the following section on Monitoring Waiver Requirements. If after reviewing this section it is determined that additional waivers are feasible, the PWS should submit a letter to DEQ requesting the specific monitoring waivers. The PWS must be in compliance with monitoring requirements to be considered. If requested by DEQ, the PWS may also need to provide additional information regarding chemical use in the area within the Inventory Region. Table 7 shows how identified potential contaminant sources affect the eligibility for monitoring waivers.

***Table 7. Susceptibility Assessment as it relates to Waiver Eligibility for Significant Potential Contaminant Sources in the Inventory Region***

| Source | Contaminant | Susceptibility | Waiver Eligibility |
|---|---|---|---|
| **Transportation Corridors** | VOCs, SOCs, petroleum products and other chemicals | **Low** | Chemical use in right-of-way may preclude waivers for some chemicals. PWS should confirm chemical use history along the right-of-way. Waivers might be rescinded if a spill occurred. |
| **Sewer System/ Wastewater Treatment** | Nitrates, pathogens | **Low** | Waivers are not available for pathogens and nitrate. Sewer system integrity may preclude waivers. The PWS should provide information of sewer assessment and maintenance. |

## MONITORING WAIVER REQUIREMENTS

The 1986 Amendments to the Safe Drinking Water Act require that community and non-community PWSs sample drinking water sources for the presence of volatile organic chemicals (VOCs) and synthetic organic chemicals (SOCs). The US EPA has authorized states to issue monitoring waivers for the organic chemicals to systems that have completed an approved waiver application and review process. All PWSs in the State of Montana are eligible for consideration of monitoring waivers for several organic chemicals. The chemicals diquat, endothall, glyphosate, dioxins, ethylene dibromide (EDB), dibromochloropropane (DBCP), and polychlorinated biphenyls are excluded from monitoring requirements by statewide waivers.

Use Waivers

A Use Waiver can be allowed if through a vulnerability assessment, it is determined that specific organic chemicals were not used, manufactured, or stored in the area of a water source (or source area). If certain organic chemicals have been used, or if the use is unknown, the system would be determined to be vulnerable to organic chemical contamination and ineligible for a Use Waiver for those particular contaminants.

Susceptibility Waivers

If a Use Waiver is not granted, a system may still be eligible for a Susceptibility Waiver, if through a vulnerability assessment it is demonstrated that the water source would not be susceptible to contamination. Susceptibility is based on prior analytical or vulnerability assessment results, environmental persistence, and transport of the contaminants, natural protection of the source, wellhead protection program efforts, and the level of susceptibility indicators (such as nitrate and coliform bacteria). The vulnerability assessment of a surface water source must consider the watershed area above the source, or a minimum fixed radius of 1.5 miles upgradient of the surface water intake. PWSs developed in unconfined aquifers should use a minimum fixed radius of 1.0 mile as an area of investigation for the use of organic chemicals. Vulnerability assessment of spring water sources should use a minimum fixed radius of 1.0 mile as an area of investigation for the use of organic chemicals. Shallow groundwater sources under the direct influence of surface watershould use the same area of investigation as surface water systems; that is, the watershed area above the source, or a minimum fixed radius of 1.5 miles upgradient of the point of diversion. The purpose of the vulnerability assessment procedures outlined in this section is to determine which of the organic chemical contaminants are in the area of investigation.

Given the wide range of landforms, land uses, and the diversity of groundwater and surface water sources across the state, additional information is often required during the review of a waiver application. Additional information may include will logs, pump test data, or water quality monitoring data from surrounding public water systems; delineation of zones of influence and contribution to a well; time-of-travel or attenuation studies; vulnerability mapping; and the use of computerized groundwater flow and transport models. DEQ's PWS Section and DEQ's Source Water Protection Program will conduct review of an organic chemical monitoring waiver application. Other state agencies may be asked for assistance.

Susceptibility Waiver for Confined Aquifers

Confined groundwater is isolated from overlying material by relatively impermeable geologic formations. A confined aquifer is subject to pressures higher than atmospheric pressure that would exist at the top of the aquifer if the aquifer were not geologically confined. A well that is drilled through the impervious layer into a confined aquifer will enable the water to rise in the borehole to a level that is proportional to the water pressure (hydrostatic head) that exists at the top of a confined aquifer.

The susceptibility of a confined aquifer relates to the probability of an introduced contaminant to travel from the source of contamination to the aquifer. Susceptibility of an aquifer to contamination will be influenced by the hydrogeologic characteristics of the soil, vadose zone (the unsaturated geologic materials between the ground surface and the aquifer), and confining layers. Important hydrogeologic controls include the thickness of the soil, the depth of the aquifer, the permeability of the soil and vadose zones, the thickness and uniformity of low permeability and confining layers between the surface and the aquifer, and hydrostatic head of the aquifer. These factors will control how readily a contaminant will infiltrate and percolate toward the groundwater.

The susceptibility waiver has the objective of assessing the potential of contaminants reaching the groundwater used by the PWS. A groundwater source that appears to be confined from surface infiltration in the immediate area of the wellhead may eventually be affected by contaminated groundwater flow from elsewhere in the recharge area. Contaminants could also enter the confined aquifer through improper well construction or abandonment where the well provides a hydraulic connection from the surface to the confined aquifer. The extent of confinement of an aquifer is critical to limiting susceptibility to organic chemical contamination. Regional conditions that define the confinement of a groundwater source must be demonstrated by the PWS in order to be considered for a confined aquifer susceptibility waiver. Confinement of an aquifer can be demonstrated by pump test data (storage coefficient), geologic mapping, and well logs. Site-specific information is required to sufficiently represent the recharge area of the aquifer and the zone of contribution to the PWS well. The following information should be provided:

- Abandoned wells in the region (zone of contribution to the well),
- Other wells in the region (zone of contribution to the well),
- Nitrate/coliform bacteria analytical history of the PWS well, and
- Organic chemical analytical history of the PWS well.

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Western Regional Climate Center Montana Climate Summaries. wrcc@dri.edu

# GLOSSARY

**Acute Health Effect.** A negative health effect in which symptoms develop rapidly.

**Alkalinity.** The capacity of water to neutralize acids.

**Aquifer.** A water-bearing layer of rock or sediment that will yield water in usable quantity to a well or spring.

**Barrier.** A physical feature or management plan that reduces the likelihood of contamination of a water source from a potential contaminant source

**Best Management Practices (BMPs).** Methods for various activities that have been determined to be the most effective, practical means of preventing or reducing non-point source pollution.

**Biennial Reporting System (BRS).** An EPA database that contains information on hazardous waste sites. The data can be accessed through the EPA Envirofacts website.

**Chronic Health Effect.** A negative health effect in which symptoms develop over an extended period of time.

**Class V Injection Well.** Any pit or conduit into the subsurface for disposal of waste waters. The receiving unit for an injection well typically represents the aquifer, or water-bearing interval.

**Coliform Bacteria.** A general type of bacteria found in the intestinal tracts of animals and humans, and also in soils, vegetation and water. Their presence in water is used as an indicator of pollution and possible contamination by pathogens.

**Comprehensive Environmental Cleanup and Responsibility Act (CECRA).** Passed in 1989 by the Montana State Legislature, CECRA provides the mechanism and responsibility to clean up hazardous waste sites in Montana.

**Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).** Enacted in 1980. CERCLA provides a Federal "Superfund" to clean up uncontrolled or abandoned hazardous-waste sites as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment. Through the Act, EPA was given power to seek out those parties responsible for any release and assure their cooperation in the cleanup.

**Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS).** A database that provides information about specific sites through the EPA Envirofacts website.

**Confined Animal Feeding Operation (CAFO).** Any agricultural operation that feeds animals within specific areas, not on rangeland. Certain CAFOs require permits for operation.

**Confined Aquifer.** A fully saturated aquifer overlain by a confining unit such as a clay layer. The static water level in a well in a confined aquifer is at an elevation that is equal to or higher than the base of the overlying confining unit.

**Confining Unit.** A geologic formation present above a confined aquifer that inhibits the flow of water and maintains the pressure of the groundwater in the aquifer. The physical properties of a confining unit may range from a five-foot thick clay layer to shale that is hundreds of feet thick.

**Delineation.** The process of determining and mapping source water protection areas.

**Glacial.** Of or relating to the presence and activities of ice or glaciers. Also, pertaining to distinctive features and materials produced by or derived from glaciers.

**Geographic Information Systems (GIS).** A computerized database management and mapping system that allows for analysis and presentation of geographic data.

**Hardness.** Characteristic of water caused by presence of various calcium and magnesium salts. Hard water may interfere with some industrial processes and prevent soap from lathering.

**Hazard.** A relative measure of the potential of a contaminant from a facility or associated with a land use to reach the water source for a public water supply. The location, quantity and toxicity of significant potential contaminant sources determine hazard.

**Hydraulic Conductivity.** A constant number or coefficient of proportionality that describes the rate water can move through an aquifer material.

**Hydrology.** The study of water and how it flows in the ground and on the surface.

**Hydrogeology.** The study of geologic formations and how they effect groundwater flow systems.

**Inventory Region.** A source water management area for groundwater systems that encompasses the area expected to contribute water to a public water supply within a fixed distance or a specified three year groundwater travel time.

**Lacustrine.** Pertaining to, produced by, or formed in a lake or lakes.

**Large Capacity Septic System.** Defined by Underground Injection Control regulations as an on-site septic system serving 20 or more persons.

**Leaking Underground Storage Tank (LUST).** A release from a UST and/or associated piping into the subsurface.

**Maximum Contaminant Level (MCL).** Maximum concentration of a substance in water that is permitted to be delivered to the users of a public water supply. Set by EPA under authority of the Safe Drinking Water Act to establish concentrations of contaminants in drinking water that are protective of human health.

**Montana Bureau of Mines and Geology – Groundwater Information Center (MBMG/GWIC).** The database of information on all well drilled in Montana, including stratigraphic data and well construction data, when available.

**Montana Pollutant Discharge Elimination System (MPDES).** A permitting system that utilizes a database to track entities that discharge wastewater of any type into waters of the State of Montana.

**National Pollutant Discharge Elimination System (NPDES).** A national permitting system that utilizes a database to track entities that discharge wastewater into waters of the United States.

**Nitrate.** An important plant nutrient and type of inorganic fertilizer that can be a potential contaminant in water at high concentrations. In water the major sources of nitrates are wastewater treatment effluent, septic tanks, feed lots and fertilizers.

**Nonpoint-Source Pollution.** Pollution sources that are diffuse and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. Examples of nonpoint- source pollution include agriculture, forestry, and run-off from city streets. Nonpoint sources of pollution, such as the use of

herbicides, can concentrate low levels of these chemicals into surface and/or groundwaters at increased levels that may exceed MCLs.

**Pathogens.** A microorganism typically found in the intestinal tracts of mammals, capable of producing disease.

**Phase II (and IIb) Rules.** EPA updated or created legal limits on 38 contaminants. The rules became effective July 30, 1992 and January 1, 1993. Some of these contaminants are frequently-applied agricultural chemicals such as nitrate and others are industrial solvents.

**Phase V Rule.** EPA set standards for 23 contaminants in addition to those addressed by the Phase II Rules. The Phase V Rule became effective January 17, 1994. Some of these contaminants include inorganic chemicals such as cyanide and other Phase V contaminants are pesticides that enter water supplies through run-off from fields where farmers have applied them or by leaching through the soil into groundwater. Six are probable cancer-causing agents. Others can cause liver and kidney damage, or problems of the nervous system and brain.

**Point Source.** A stationary location or a fixed facility from which pollutants are discharged. This includes any single identifiable source of pollution, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fracture, container, rolling stock (tanker truck), or vessel or other floating craft, from which pollutants are or may be discharged.

**Pollutant.** Generally, any substance introduced into the environment that adversely affects the usefulness of a resource (e.g. groundwater used for drinking water).

**Permit Compliance System (PCS).** An EPA database that provides information on the status of required permits for specific activities for specific facilities. The data can be accessed through the EPA Envirofacts website.

**Public Water System (PWS).** A system that provides water for human consumption through at least 15 service connections or regularly serves 25 individuals.

**Pumping Water Level.** Water level elevation in a well when the pump is operating.

**Recharge Region.** An area in which water is absorbed that eventually reaches the zone of saturation in one or more aquifers. As a source water management region, the term generally describes the entire area that could contribute water to an aquifer used by a public water supply. Includes areas that could contribute water over long time periods or under different water usage patterns.

**Resource Conservation and Recovery Act (RCRA).** Enacted by Congress in 1976. RCRA's primary goals are to protect human health and the environment by regulating hazardous waste “from the cradle to the grave”. This includes ensuring that wastes are created, managed, and disposed of in an environmentally sound manner.

**Resource Conservation and Recovery Information System (RCRIS).** Is a database that provides information about specific RCRA sites through the EPA Envirofacts website.

**Secondary Maximum Contaminant Levels (SMCL).** The maximum concentration of a substance in water that is recommended to be delivered to users of a public water supply based on aesthetic qualities. SMCLs are non-enforceable guidelines for public water supplies, set by EPA under authority of the Safe Drinking Water Act. Compounds with SMCLs may occur naturally in certain areas, limiting the ability of the public water supply to treat for them.

**Section Seven Tracking System (SSTS).** SSTS is an automated system EPA uses to track pesticide producing establishments and the amount of pesticides they produce.

**Source Water**. Any surface water, spring, or groundwater source that provides water to a public water supply.

**Source Water Delineation and Assessment Report (SWDAR).** A report for a public water supply that delineates source water protection areas, provides an inventory of potential contaminant sources within the delineated areas, and evaluates the relative susceptibility of the source water to contamination from the potential contaminant sources under "worst-case" conditions.

**Source Water Protection Areas.** For surface water sources, the land and surface drainage network that contributes water to a stream or reservoir used by a public water supply. For groundwater sources, the area within a fixed radius or three-year travel time from a well, and the land area where the aquifer is recharged.

**Spill Response Region.** A source water management area for surface water systems that encompasses the area expected to contribute water to a public water supply within a fixed distance or a specified four-hour water travel time in a stream or river.

**Standard Industrial Classification (SIC) Code.** A method of grouping industries with similar products or services and assigning codes to these groups.

**Static Water Level (SWL).** Water level in a well when the pump is not operating.

**Susceptibility (of a PWS).** The relative potential for a PWS to draw water contaminated at concentrations that would pose concern. Susceptibility is evaluated at the point immediately preceding treatment or, if no treatment is provided, at the entry point to the distribution system.

**Synthetic Organic Compounds (SOC).** Man made organic chemical compounds (e.g. herbicides and pesticides).

**Total Dissolved Solids (TDS).** The dissolved solids collected after a sample of a known volume of water is passed through a very fine mesh filter.

**Total Maximum Daily Load (TMDL).** The total pollutant load to a surface water body from point, nonpoint, and natural sources. The TMDL program was established by section 303(d) of the Clean Water Act to help states implement water quality standards.

**Toxicity.** The quality or degree of being poisonous or harmful to plants, animals, or humans.

**Toxicity Characteristic Leachate Procedure.** A test designed to determine whether a waste is hazardous or requires treatment to become less hazardous.

**Toxic Release Inventory (TRI).** An EPA database that compiles information about permitted industrial releases of chemicals to air and water. Information about specific sites can be obtained through the EPA Envirofacts website.

**Transmissivity.** A number that describes the ability of an aquifer to transmit water. The transmissivity is determined by multiplying the hydraulic conductivity time the aquifer thickness.

**Turbidity.** The cloudy appearance of water caused by the presence of suspended matter.

**Unconfined Aquifer.** An aquifer containing water that is not under pressure. The water table is the top surface of an unconfined aquifer.

**Underground Storage Tanks (UST).** A tank located at least partially underground and designed to hold gasoline or other petroleum products or chemicals, and the associated plumbing system.

**Volatile Organic Compounds (VOC).** Chemicals such as petroleum hydrocarbons, solvents , alcohols or other organic chemicals that evaporate readily to the atmosphere.

**Watershed.** The region drained by, or contributing water to, a stream, lake, or other water body of water.

* With the exception of the definitions for Lacustrine, Phase II and Phase V Rules, and Standard Industrial Classification Code, definitions were adapted from EPA's Term References System (formerly known as Glossary of Selected Terms and Abbreviations) which can be found at: http://www.epa.gov/trs/index.htm . The definitions of glacial and lacustrine were taken from the Glossary of Geology by Robert L. Bates and Julia A. Jackson.

The definitions for Phase II and Phase V Rules were adapted from:
http://www.epa.gov/OGWDW/source/therule.html#PhaseII
http://www.epa.gov/OGWDW/source/therule.html#PhaseV

The definition for Standard Industrial Classification Code was adapted from:
EPA/Office of Enforcement and Compliance Assurance: Guide to Environmental Issues: Glossary of Terms & Acronyms *Term Detail*

# Appendix A
# PWS-6 Report

## DELINEATION

The new wells will be completed in an aquifer that appears confined based on well logs of other wells in the area. With the aquifer being confined the delineation includes a 100-foot radius control zone, a 1000-ft fixed radius inventory region, and a recharge region (Figure 1).

*Hydrologic Conditions*

Surface geology in the Geyser area consists of Tertiary/Quaternary-aged alluvial material and terrace deposits ranging from 10 to 20 feet thick. The Kootenai formation underlies surface drift in the Geyser area at a depth of approximately 10 to 20 feet below ground surface (bgs). The Kootenai consists of a mixture of conglomerates, sandstone units, limestone, and shale; purplish to green beds are common (Ross, Andrews, and Witkind 1955). The Madison limestone formation lies under the Kootenai and other undifferentiated strata at a depth of 1700 feet bgs (Feltis 1980). Geologic information from the Geyser area indicates the sedimentary strata dip to the northeast (approximately 200 feet/mile). Additionally, the Geyser basin sits between the Little Belt and Highwood Mountain ranges in an area of relatively complex structure, so that the depth of contact to the above mentioned formations is approximated. (Maxim, 2002)

*Conceptual Model and Assumptions*

Based on a potentiometric map of the shallow wells in the Geyser area, ground-water flow appears to be generally to the north-northeast. As a consequence, potential contaminant sources of concern for Geyser's new source water are those located to the south-southwest and upgradient of the well field.

*Well Information*

The well logs from two private wells in the area of the proposed two new municipal wells indicates the anticipated target water bearing strata is overlain by approximately 25 feet of alluvial gravel, followed by approximately 95 feet of gray clay and shale with some sandstone layers. Because of the thickness of the gray clay and shale layers, the target aquifer is interpreted to be confined, and is assigned a rank of "low source water sensitivity" to potential contaminants, in accordance with Table 2 of the PWS-6 template for Community or Non-Community Non-Transient Public Water Supplies (DEQ PWS-6 Template, 2000). Confined? maybe

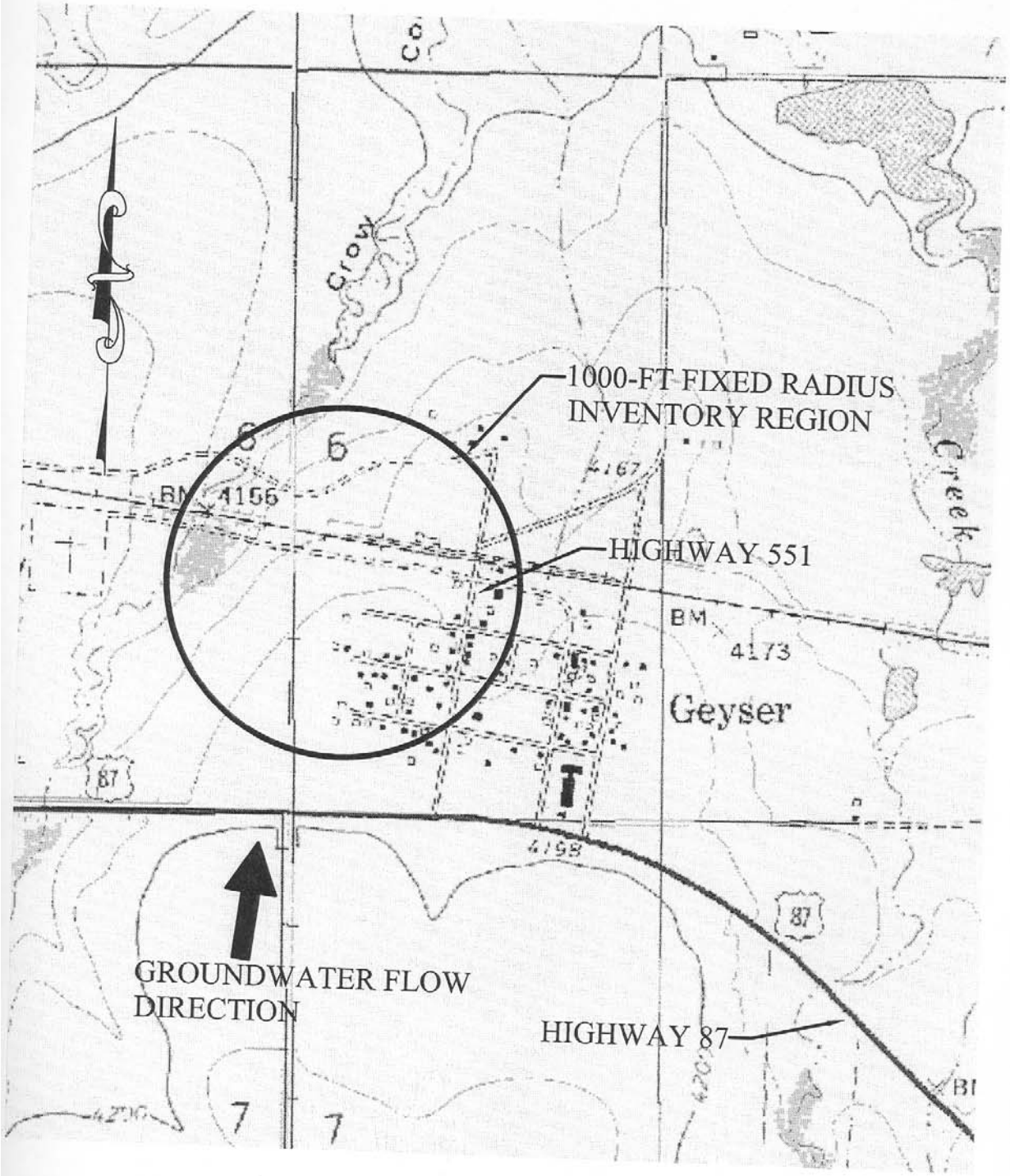
## INVENTORY

Table 2 lists the significant potential contaminant sources for the control zone and a 1000-foot fixed radius inventory zone for each of the two new wells. Hay production and grazing are the primary land uses near the new wells. Based on an analysis of the USGS National Landcover Dataset (USS 2000), land use within the entire inventory zone is approximately 14% agriculture, 67% grassland and 19% developed residential and commercial.

Approximately 2400 feet of railroad right of way lies within the inventory zone, however it is approximately 250 feet downgradient of the new well locations. Approximately 1500 feet of highway lies within the inventory zone, however it runs parallel to the groundwater flow direction, and is not upgradient of the wells.

## SUSCEPTIBILITY

The susceptibility of the proposed wells to contamination is assessed in this section. The proximity of a potential contaminant source to the well site or the density of non-point potential contaminant sources determines the threat of contamination. Hazard and the existence of barriers to contamination determine susceptibility, see Table 11 of the PWS-6 template (Montana DEQ, 2000). Barriers can be anything that decreases the likelihood that contaminants will reach a well. Barriers can be engineered structures, management actions or natural conditions. Examples of engineered barriers are spill catchment structures for industrial facilities and leak detection for underground storage tanks. Emergency planning and best management practices can be considered management barriers. Thick clay-rich soils, a deep water table or a thick saturated zone above the well intake can be natural barriers. In the case of the new wells in Geyser, a natural barrier of clay and shale exists.

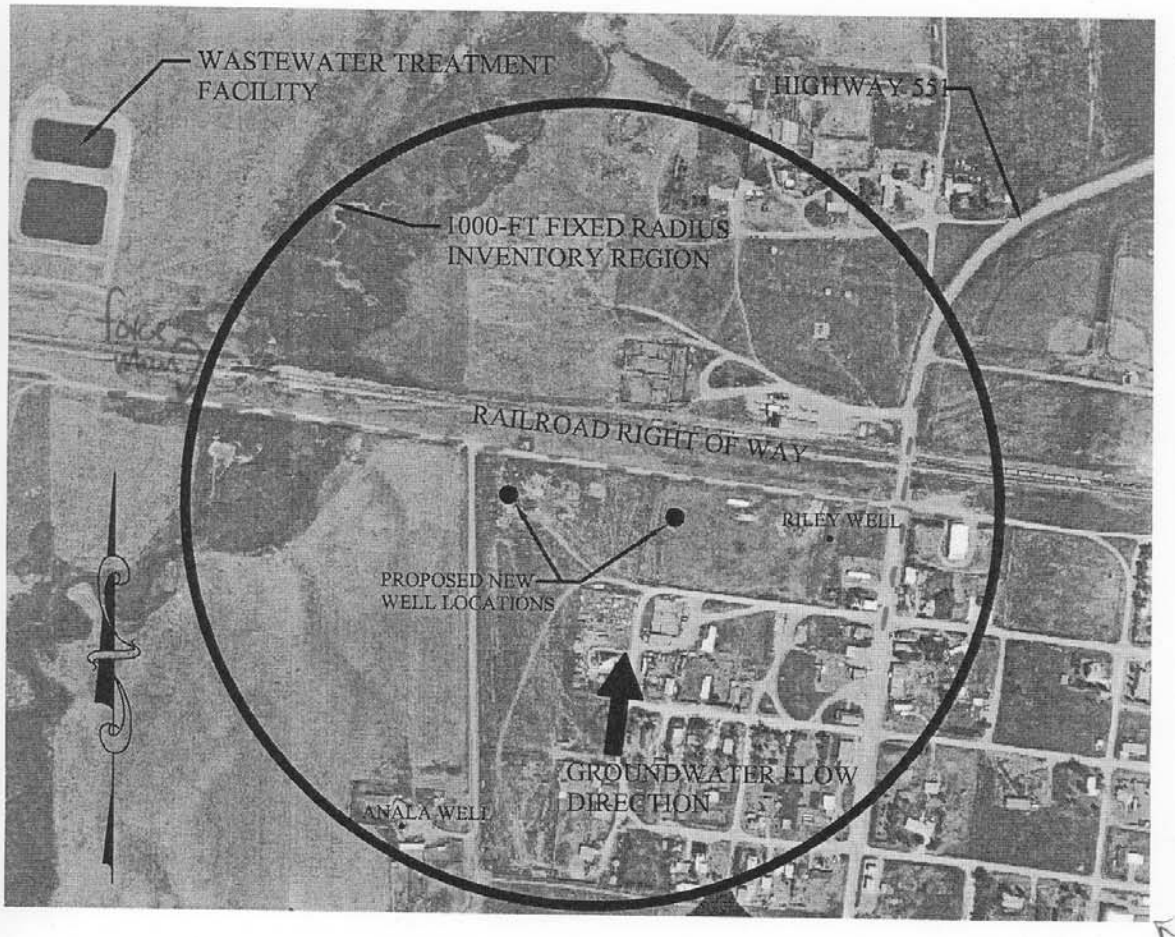



SCALE: 1"=1000'

GEYSER WATER SYSTEM
IMPROVEMENTS
PWS-6 REPORT
SITE PLAN

FIGURE 1

entranco
2030 11TH AVE., SUITE 11
HELENA, MONTANA 59601
(406)449-8627




LUST @ school

SCALE: 1"=500'

GEYSER WATER SYSTEM IMPROVEMENTS
PWS-6 REPORT
SITE PLAN

FIGURE 2

entranco
2030 11TH AVE., SUITE 11
HELENA, MONTANA 59601
(406)449-8627

Table 2 list results from the susceptibility analysis for significant potential contaminant sources. The susceptibility assessment is based on criteria in Table 9 of the PWS-6 template (DEQ, 2000). Agricultural lands make up about 14% of the inventory zone and are assigned a low hazard rank.

Municipal sewer lines within the Geyser City Limits are ranked as a low hazard because they underlie less than 20% of the inventory zone.

A segment of Highway 551 is located within the inventory zone, although it is ranked as a low hazard due to the fact that it parallels the groundwater flow direction, and is not upgradient of the wells. A segment of railroad right of way crosses through the inventory zone, however it is downgradient of the well locations and therefore is ranked as a low hazard.

**REFERENCES**


- DEQ Source Water Protection Program, 2000, PWS-6 Template for Community or Non-Community Non-Transient Public Water Supplies. Available from the DEQ web site: http://www.deq.state.mt.us/wqinfo/SWP/Circulars.htm
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## TABLES

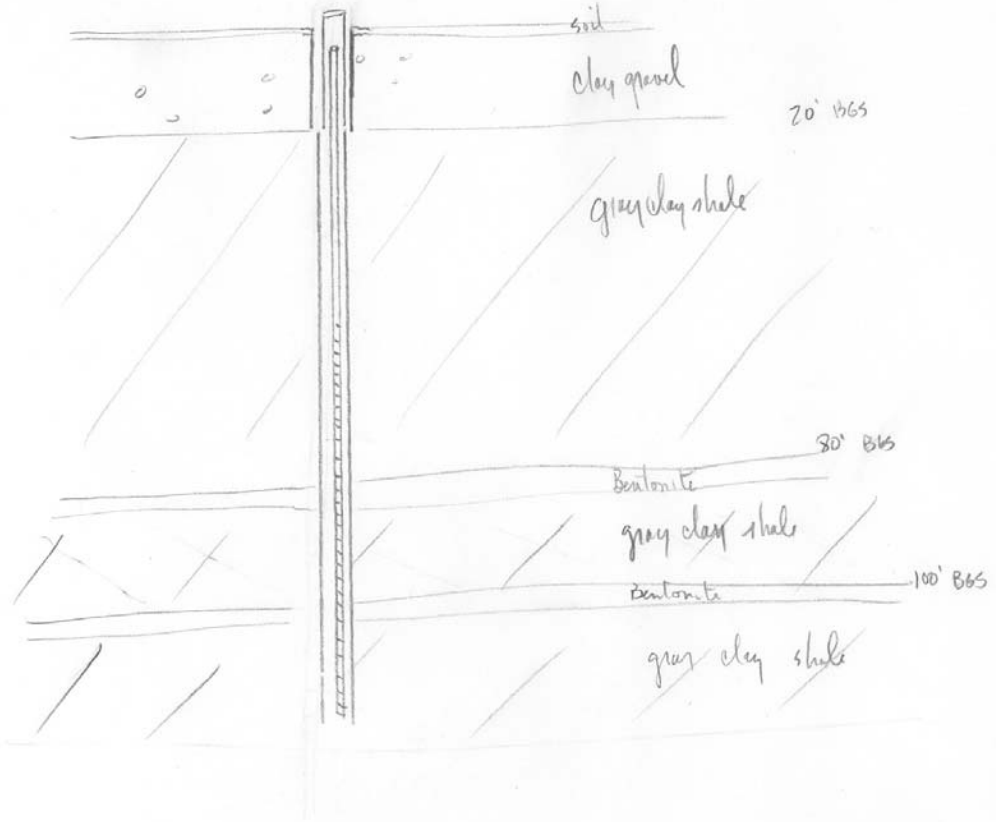
**Table 1.** Nearby private well information for Geyser. Source: MBMG GWIC. (Table 4 of template). NR = Not Reported

| Well Information | Ken Anala | Roger Riley |
|---|---|---|
| **Well Location (T, R, Sec or lat, long)** | 17N 10E 6 CDA | 17N 10E 6 CBD |
| **MBMG #** | 182757 | 193112 |
| **Water Right #** | NR | NR |
| **Date Well was Completed** | 11/07/99 | 10/10/01 |
| **Total Depth** | 120 | 120 |
| **Perforated Interval** | 100 - 120 | 60 - 120 |
| **Static Water Level** | 62 | 20 |
| **Pumping Water Level** | NR | NR |
| **Drawdown** | NR | NR |
| **Test Pumping Rate** | 100 | 20 |
| **Specific Capacity** | NR | NR |

**Table 2.** Significant potential contaminant sources for Geyser Source Water.

| Source | Contaminants | Description *(Location and nature of hazard)* | Hazard Rating | Barriers | Susceptibility |
|---|---|---|---|---|---|
| 1. Dryland Agricultural Crop Lands and grazing | SOC, Nitrate | 14% ag-land in the inventory zone | Low | ~~Natural~~ intake >50 | Low |
| 2. Sanitary Sewer Main | Pathogens & Nitrates | Inventory zone is about 19% sewered | Low Moderate | Natural intake >50 B Sewer | Low |
| 3. Highway ~~Crossing~~ | Hazardous Materials (VOC's and SOC's) | About 1600 feet is in the inventory zone, however it is parallel to the groundwater flow ?, direction | Low | ~~Natural~~ intake depth | Low |
| 4. Railroad ROW | Hazardous Materials (VOC's and SOC's) | About 2400 feet is in the inventory zone, however it is approximately 250 feet downgradient of the new well locations | Low | ~~Natural~~ intake depth. | Low |

Riley Well construction XS.




gray clay shale is aquifer

grout not described.

Riley well

**ntana Bureau of Mines and Geology**
**Ground-Water Information Center Site Report**
**RILEY ROGER**

Plot this site on a topographic map

**ocation Information**

GWIC Id: 193112
Location (TRS): 17N 10E 06 CB
County (MT): JUDITH BASIN
DNRC Water Right:
PWS Id:
Block:
Lot:
Addition:
Site Notes:

Source of Data: LOG
Latitude (dd): 47.2631
Longitude (dd): -110.5077
Geomethod: TRS-TWN
Datum: NAD27
Certificate of Survey:
Type of Site: WELL

**Vell Construction and Performance Data**

Total Depth (ft): 120.00
Static Water Level (ft): 20.00
Pumping Water Level (ft):
Yield (gpm): 20.00
Test Type: AIR
Test Duration: 1.00
Drill Stem Setting (ft): 100.00
Recovery Water Level (ft): 20.00
Recovery Time (hrs): 0.33
Well Notes:

How Drilled: ROTARY
Driller's Name: MURRAY
Driller License: WWC351
Completion Date (m/d/y): 10/10/2001
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: Not Reported
Well/Water Use: DOMESTIC

**e Diameter Information**

| om | To | Diameter |
|---|---|---|
| 0.0 | 20.0 | 8.0 |
| 0.0 | 120.0 | 6.0 |

**ular Seal Information**

| From | To | Description |
|---|---|---|
| 0.0 | 0.0 | BENTONITE |

**Casing Information[1]**

| From | To | Dia | Description |
|---|---|---|---|
| -1.5 | 20.0 | 6.0 | STEEL |
| 10.0 | 120.0 | 4.0 | 160 LB PVC |

**Completion Information[1]**

| From | To | Dia | Description |
|---|---|---|---|
| 60.0 | 120.0 | 4.0 | 1/4X5 SAW PERFS |

**ithology Information**

| m | To | Description |
|---|---|---|
| 0.0 | 2.0 | TOPSOIL |
| .0 | 20.0 | CLAY GRAVEL |
| .0 | 80.0 | GRAY CLAY SHALE |
| 80.0 | 83.0 | BENTONITE |
| .0 | 100.0 | GRAY CLAY SHALE |
| .0 | 104.0 | BENTONITE |
| 04.0 | 120.0 | GRAY CLAY SHALE |

water bearing

this well isn't sealed -
6" bore w/ 4" PVC Casing

ll diameters reported are **inside** diameter of the casing.

**ıtana Bureau of Mines and Geology**
**ıround-Water Information Center Site Report**
**NALA KEN**

Plot this site on a topographic map

This well is several miles north Northwest of Geyser

**ɔcation Information**

GWIC Id: 182757
Location (TRS): 18N 09E 06 CDD
County (MT): JUDITH BASIN
DNRC Water Right: C112214-00
PWS Id:
Block:
Lot:
Addition:
Site Notes:

Source of Data: LOG
Latitude (dd): 47.3501
Longitude (dd): -110.6325
Geomethod: TRS-TWN
Datum: NAD27
Certificate of Survey:
Type of Site: WELL

**/ell Construction and Performance Data**

Total Depth (ft): 120.00
Static Water Level (ft): 62.00
Pumping Water Level (ft):
Yield (gpm): 100.00
Test Type: AIR
Test Duration: 1.00
Drill Stem Setting (ft): 100.00
Recovery Water Level (ft): 75.00
Recovery Time (hrs): 0.17
Well Notes:

How Drilled: ROTARY
Driller's Name: CENTRAL
Driller License: WWC581
Completion Date (m/d/y): 11/7/1999
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: Not Reported
Well/Water Use: DOMESTIC

**'e Diameter Information**

| m | To | Diameter |
|---|---|---|
| 0.0 | 120.0 | 5.0 |

**Casing Information[1]**

| From | To | Dia | Description |
|---|---|---|---|
| -2.0 | 38.0 | 6.0 | .250 STEEL |
| 10.0 | 120.0 | 4.0 | 220LB PVC |

**ular Seal Information**

| rom | To | Description |
|---|---|---|
| 0.0 | 38.0 | BENTONITE |
| .0 | 99.0 | RUBBER PACKER |

sealed into shale

**Completion Information[1]**

| From | To | Dia | Description |
|---|---|---|---|
| 100.0 | 120.0 | 4.0 | 1/8X6IN SAW PERF |

**ology Information**

| om | To | Description |
|---|---|---|
| 0 | 27.0 | GRAVEL |
| 0 | 35.0 | TAN CLAY |
| 5.0 | 80.0 | GRAY SHALE |
| 0.0 | 102.0 | GRAY SHALE WITH SOME SAND LAYERS GRAY |
| 0 | 105.0 | SANDSTONE GRAY WITH TRACES OF COAL |
| 5.0 | 120.0 | GRAY SHALE WITH 60 PERCENT SANDSTONE BACKING GRAY TO GREEN |

Y
water

diameters reported are **inside** diameter of the casing.

se data represent the contents of the GWIC databases at the Montana Bureau of Mines and Geology at the time and date of the retrieval. The information is dered unpublished and is subject to correction and review on a daily basis. The Bureau warrants the accurate transmission of the data to the original end user. nsmission of the data to other users is discouraged and the Bureau claims no responsibility if the material is retransmitted. Note: non-reported casing, pletion, and lithologic records may exist in paper files at GWIC.

**Montana Bureau of Mines and Geology**
**Ground-Water Information Center Site Report**
**KARJALA SYBIL E. AND GERALD K.**

**Plot this site on a topographic map**

**Location Information**

3/4 mile NW of new well

GWIC Id: 193110
Location (TRS): 17N 10E 06 BB
County (MT): JUDITH BASIN
DNRC Water Right:
PWS Id:
Block:
Lot:
Addition:
Site Notes:

Source of Data: LOG
Latitude (dd): 47.2706
Longitude (dd): -110.5077
Geomethod: TRS-TWN
Datum: NAD27
Certificate of Survey:
Type of Site: WELL

**Well Construction and Performance Data**

Total Depth (ft): 140.00
Static Water Level (ft): 45.00
Pumping Water Level (ft):
Yield (gpm): 20.00
Test Type: AIR
Test Duration: 1.00
Drill Stem Setting (ft): 100.00
Recovery Water Level (ft): 45.00
Recovery Time (hrs): 0.50
Well Notes:

How Drilled: ROTARY
Driller's Name: CENTRAL
Driller License: WWC581
Completion Date (m/d/y): 10/1/2001
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: Not Reported
Well/Water Use: DOMESTIC

**Hole Diameter Information**

| From | To | Diameter |
|---|---|---|
| 0.0 | 140.0 | 5.0 |

**Casing Information[1]**

| From | To | Dia | Description |
|---|---|---|---|
| -2.0 | 30.0 | 6.0 | .250 STEEL |
| 10.0 | 140.0 | 4.0 | PVC |

**Annular Seal Information**

| From | To | Description |
|---|---|---|
| 0.0 | 30.0 | BENTONITE |
| 88.0 | 88.0 | RUBBER |

**Completion Information[1]**

| From | To | Dia | Description |
|---|---|---|---|
| 90.0 | 95.0 | 4.0 | 1/8X6 SAW PERFS |

**Lithology Information**

| From | To | Description |
|---|---|---|
| 0.0 | 25.0 | CLAY AND GRAVEL |
| 25.0 | 40.0 | GRAY CLAY AND SHALE |
| 40.0 | 90.0 | MOSTLY SOFT GRAY CLAY AND SHALE |
| 90.0 | 95.0 | SHALE BACKED SANDSTONE FRACTURED |
| 95.0 | 130.0 | GRAY SHALE AND GREENISH GRAY SILTY SAND |
| 130.0 | 140.0 | RED SHALE |

SWL 45' ▽ Screen

outside 1000' ~~DAR~~ Seal? 6" borehole w/ 4" PVC

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

These data represent the contents of the GWIC databases at the Montana Bureau of Mines and Geology at the time and date of the retrieval.

**Montana Bureau of Mines and Geology**
**Ground-Water Information Center Site Report**
**HARRIS JACK**

**Plot this site on a topographic map**

**Location Information**

close to new well

GWIC Id: 120634
Location (TRS): 17N 10E 06 DC
County (MT): JUDITH BASIN
DNRC Water Right: 76384
PWS Id:
Block: 10
Lot: 5
Addition: GEYSER 1ST ADDITION
Site Notes:

Source of Data: LOG
Latitude (dd): 47.2594
Longitude (dd): -110.4966
Geomethod: TRS-TWN
Datum: NAD27
Certificate of Survey:
Type of Site: WELL

**Well Construction and Performance Data**

Total Depth (ft): 96.00
Static Water Level (ft): 15.00
Pumping Water Level (ft): 90.00
Yield (gpm): 6.00
Test Type: AIR
Test Duration: 0.25
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):
Well Notes:

How Drilled: UNKNOWN
Driller's Name: SINGLEY
Driller License: WWC398
Completion Date (m/d/y): 9/11/1990
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: Not Reported
Well/Water Use: IRRIGATION

**Hole Diameter Information**

No Hole Diameter Records currently in GWIC.

**Casing Information[1]**

| From | To | Dia | Description |
|---|---|---|---|
| -1.5 | 18.0 | 6.0 | STEEL |
| 18.0 | 40.0 | 6.0 | PVC |
| 36.0 | 96.0 | 4.0 | PVC |

**Annular Seal Information**

| From | To | Description |
|---|---|---|
| 0.0 | 25.0 | CEMENT |

**Completion Information[1]**

| From | To | Dia | Description |
|---|---|---|---|
| 25.0 | 96.0 | 4.0 | 3/8X6 DRILL |

**Lithology Information**

| From | To | Description |
|---|---|---|
| 0.0 | 1.0 | TOPSOIL |
| 1.0 | 17.0 | SAND AND CLAY W/ROCKS VERY LITTLE GRAVEL |
| 17.0 | 30.0 | TAN CLAY |
| 30.0 | 45.0 | BLUE SHALE W/BENTONITE STREAKS |
| 45.0 | 96.0 | BLUE SHALE LIGHT W/SANDSTONE AND SANDY SHALE LAYERS MIXED |

5" SWLD

Screen

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

**Montana Bureau of Mines and Geology**
**Ground-Water Information Center Site Report**
**MCALLISTER TIMOTHY OR DELORES**

**Plot this site on a topographic map**

## Location Information

GWIC Id: 162299
Location (TRS): 17N 10E 06 DDC
County (MT): JUDITH BASIN
DNRC Water Right: 101547
PWS Id:
Block:
Lot:
Addition:
Site Notes:

Source of Data: LOG
Latitude (dd): 47.2585
Longitude (dd): -110.4925
Geomethod: TRS-TWN
Datum: NAD27
Certificate of Survey:
Type of Site: WELL

## Well Construction and Performance Data

Total Depth (ft): 300.00
Static Water Level (ft): 9.00
Pumping Water Level (ft):
Yield (gpm): 4.00
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: CENTRAL
Driller License: WWC581
Completion Date (m/d/y): 4/2/1997
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: Not Reported
Well/Water Use: STOCKWATER

### Hole Diameter Information

No Hole Diameter Records currently in GWIC.

### Casing Information[1]

| From | To | Dia | Description |
|---|---|---|---|
| -2.0 | 18.0 | 6.0 | STEEL |
| 10.0 | 300.0 | 4.0 | PLASTIC |

### Annular Seal Information

| From | To | Description |
|---|---|---|
| 0.0 | 18.0 | BENTONITE |

### Completion Information[1]

| From | To | Dia | Description |
|---|---|---|---|
| 120.0 | 140.0 | 4.0 | 1/8X6 SLOTS |

### Lithology Information

| From | To | Description |
|---|---|---|
| 0.0 | 1.0 | TOPSOIL |
| 1.0 | 11.0 | GRAVEL |
| 11.0 | 45.0 | LIGHT GRAY STICKY SHALE |
| 45.0 | 116.0 | SOFT GRAY SHALE WITH HARD LIGHT GRAY SAND LAYERS |
| 116.0 | 140.0 | GREENISH SANDSTONE WITH SILTSTONE LAYERS AND GRAY |
| 140.0 | 165.0 | HARD GRAY SHALE |
| 165.0 | 207.0 | RED AND GRAY SHALE |
| 207.0 | 238.0 | SILTY GRAY SAND |
| 238.0 | 300.0 | GRAY SHALE WITH A FEW SAND LAYERS |

SWL 9' ∇

Screen

outside 1000' Seal? 6" borehole w/ 4" PVC?

1

Water Quality Analyses

ENERGY LABORATORIES, INC. • P.O. Box 5688 • 3161 East Lyndale Ave. • Helena, MT 59604
877-472-0711 • 406-442-0711 • 406-442-0712 fax • helena@energylab.com

## LABORATORY ANALYTICAL REPORT

**Client:** Entranco Inc
**Project:** Geyser Water System
**Lab ID:** H03100063-001
**Client Sample ID:** Riley Well #1

**Report Date:** 10/29/03
**Collection Date:** 10/13/03 13:00
**Date Received:** 10/14/03
**Matrix:** Aqueous

| Analyses | Result | Units | Qual | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **PHYSICAL PROPERTIES** | | | | | | | |
| Solids, Total Dissolved TDS @ 180 C | 1440 | mg/L | | 10 | | A2540 C | 10/17/03 15:56 / cwh |
| **INORGANICS** | | | | | | | |
| Sulfate | 680 | mg/L | D | 30 | | A4500-SO4 E | 10/29/03 09:00 / cwh |
| Fluoride | 2.24 | mg/L | | 0.10 | | A4500-F C | 10/28/03 08:53 / cwh |
| Hardness as CaCO3 | 799 | mg/L | | 1 | | A2340 B | 10/17/03 13:07 / jdh |
| **METALS, DISSOLVED** | | | | | | | |
| Calcium | 135 | mg/L | | 1 | | E200.7 | 10/17/03 07:08 / jdh |
| Magnesium | 112 | mg/L | | 1 | | E200.7 | 10/17/03 07:08 / jdh |
| Sodium | 127 | mg/L | | 1 | | E200.7 | 10/17/03 07:08 / jdh |
| **METALS, TOTAL** | | | | | | | |
| Iron | 2.15 | mg/L | | 0.0300 | | E200.7 | 10/16/03 09:47 / jdh |
| Manganese | ND | mg/L | | 0.100 | | E200.7 | 10/16/03 09:47 / jdh |

high sulfate
Fluoride > SMCL but < MCL of 4.0 of 2.0

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix interference.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

Riley Well

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877-472-0711 • 406-442-0711 • 406-442-0712 fax • debg@energylab.com

# LABORATORY ANALYTICAL REPORT

**Client:** Entranco Inc
**Project:** Geyser Water Improvements
**Lab ID:** H02030071-001
**Client Sample ID:** Water Samples

**Report Date:** 04/01/02
**Collection Date:** 03/14/02 15:00
**Date Received:** 03/15/02
**Matrix:** AQUEOUS

| Analyses | Result | Units | Qual | RL | MCL/ QCL | Method | Analysis Date / By |
|---|---|---|---|---|---|---|---|
| **PHYSICAL PROPERTIES** | | | | | | | |
| Solids, Total Dissolved TDS @ 180 C | 955 | mg/L | | 10 | | A2540 C | 03/21/02 09:57 / jdh |
| **INORGANICS** | | | | | | | |
| Sulfate | 270 | mg/L | D | 2 | | E300.0 | 03/20/02 13:47 / ldv |
| Fluoride | 0.80 | mg/L | | 0.10 | | A4500-F C | 03/20/02 17:15 / cfd |
| Hardness as CaCO3 | 57 | mg/L | | 1 | | A2340 B | 03/25/02 13:37 / lab |
| **NUTRIENT PARAMETERS** | | | | | | | |
| Nitrogen, Nitrate+Nitrite as N | 0.28 | mg/L | | 0.05 | 10 | E353.2 | 03/21/02 16:33 / dlb |
| **METALS, DISSOLVED** | | | | | | | |
| Calcium | 13 | mg/L | | 1 | | E200.7 | 03/20/02 22:08 / rlh |
| Magnesium | 6 | mg/L | | 1 | | E200.7 | 03/20/02 22:08 / rlh |
| Sodium | 324 | mg/L | | 1 | | E200.7 | 03/20/02 22:08 / rlh |
| **METALS, TOTAL** | | | | | | | |
| Iron | 0.10 | mg/L | | 0.03 | | E200.7 | 03/21/02 02:31 / rlh |
| Manganese | 0.04 | mg/L | | 0.01 | | E200.7 | 03/21/02 02:31 / rlh |

**Report Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix interference.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

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# LABORATORY ANALYTICAL REPORT

**Client:** Entranco Inc
**Project:** Geyser Water Improvements
**Lab ID:** H02030071-001
**Client Sample ID:** Water Samples

**Report Date:** 04/01/02
**Collection Date:** 03/14/02 15:00
**Received Date:** 03/15/02 10:30
**Matrix:** AQUEOUS
**Sampled By:** Not Given

| Analyses | Result | Units | Safe/Unsafe | Qual | Method | Analysis Date / By |
|---|---|---|---|---|---|---|
| Coliform, Total | Absent | P/A | SAFE | | A9223 | 03/15/02 17:00 / dag |
| Coliform, E-Coli | Absent | P/A | | | A9223 | 03/15/02 17:00 / dag |

**Comments:** The notation "SAFE" indicates that the water was bacteriologically SAFE when sampled.
The notation "UNSAFE" indicates that the water was bacteriologically UNSAFE when sampled.

**Method Reference:** E - EPA / MCAWW Methodology A - Standard Methods 19th Ed.

# GEOLOGIC MAP OF THE BELT 30' x 60' QUADRANGLE, CENTRAL MONTANA

Susan M. Vuke, Richard B. Berg, Roger B. Colton, and Hugh E. O'Brien

Montana Bureau of Mines and Geology
Open-File Report MBMG 450

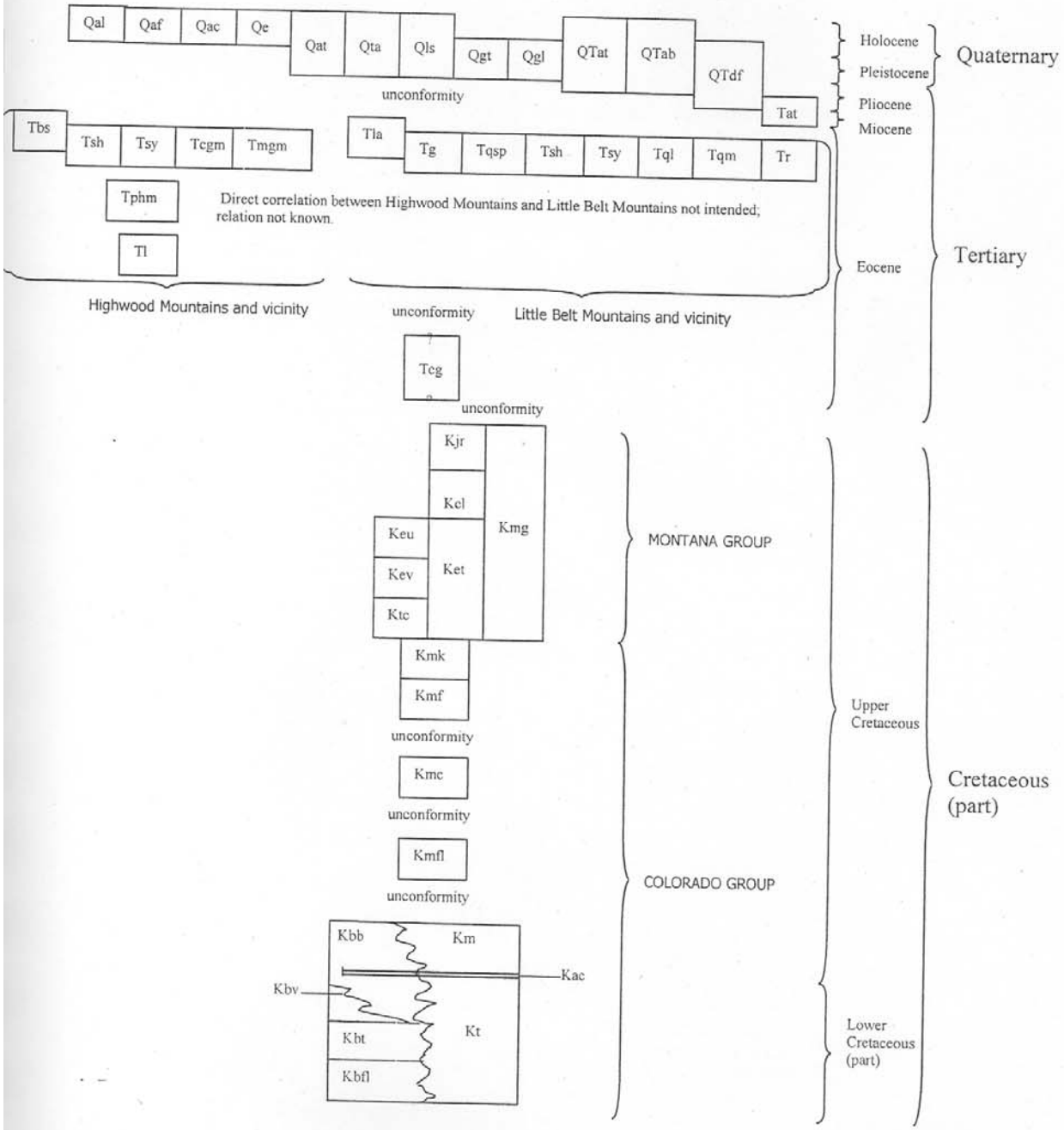
2002

REVISIONS
Text: 10/03

This report has had preliminary reviews for conformity with Montana Bureau of Mines and Geology's technical and editorial standards.

Partial support has been provided by the STATEMAP component of the National Cooperative Geologic Mapping Program of the U.S. Geological Survey under contract number 01-HQ-A6-0096.

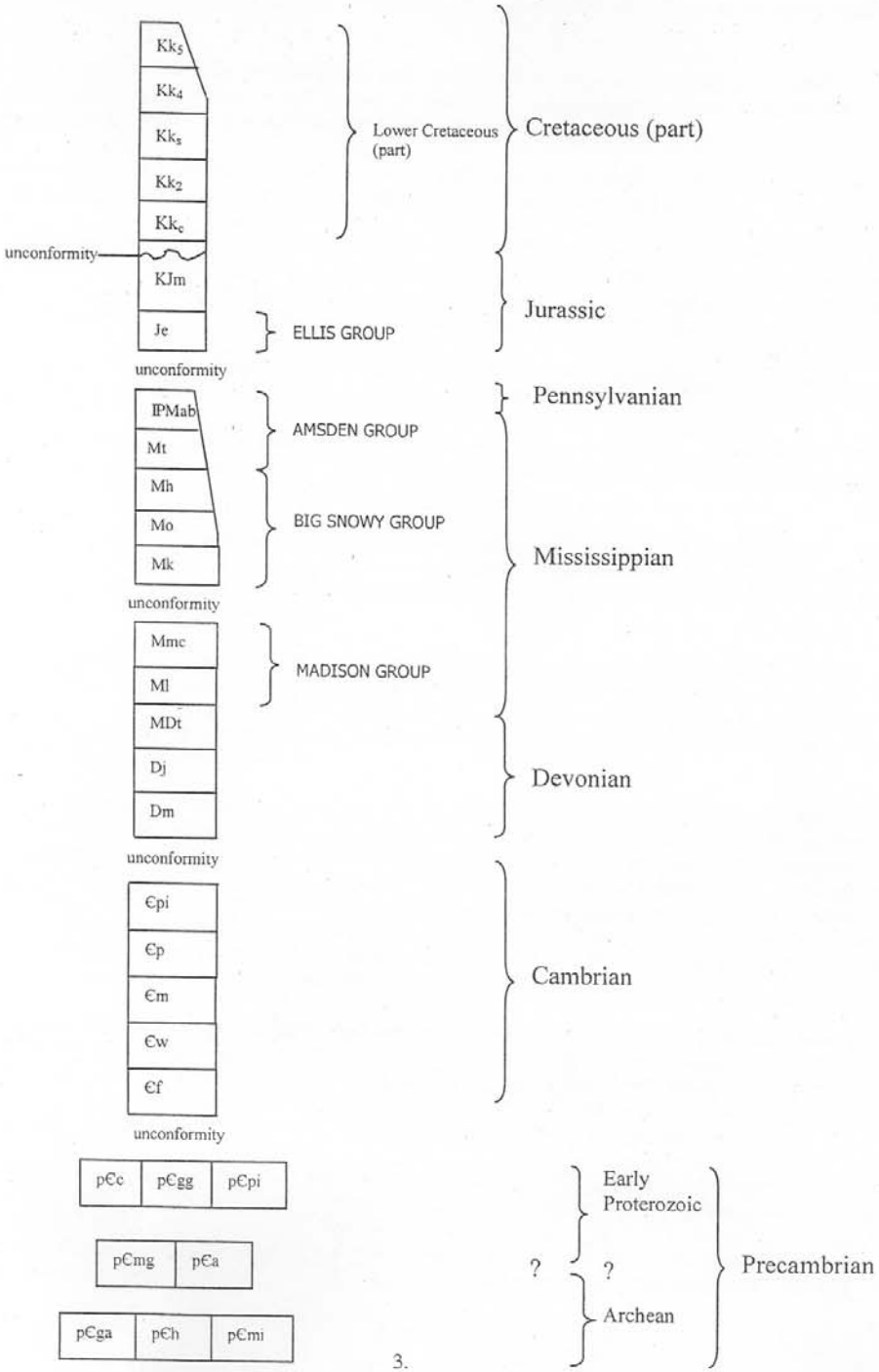
# CORRELATION DIAGRAM
# BELT 30'x 60' QUADRANGLE






Continued on next page.

CORRELATION DIAGRAM (Continued)
BELT 30' x 60' QUADRANGLE



# DESCRIPTION OF MAP UNITS
## BELT 30' x 60' QUADRANGLE

Note: Thicknesses are given in feet because original field maps were on 7.5' quadrangles with contour intervals in feet. To convert feet to meters (the contour interval unit on this map), multiply feet x 0.3048. Many units are combined on the cross sections. The explanation for the cross sections is shown at the bottom of the map.

Qal **Alluvium of modern channels and flood plains (Holocene)**—Yellowish-brown to gray gravel, sand, silt, and clay beneath flood plains and in valleys of active streams. Deposits are well to poorly stratified and moderately well sorted. Maximum clast diameter 12 ft. Thickness as much as 15 ft.

Qaf **Alluvial fan deposit (Holocene)**—Yellowish-brown to gray, poorly stratified and poorly sorted clay, silt, sand, and sandy gravel in small fans at mouths of tributary streams. Thickness as much as 15 ft.

Qac **Alluvium-colluvium (Holocene)**—Grayish-orange to brownish-gray, poorly sorted to moderately well sorted, locally derived sediment deposited on slopes; particle size ranges from clay and silt to gravel depending on source. Colluvium generally present only on slopes steeper than 8 percent. Contains a significant component of glacial-lake and loess deposits near glaciated areas. Thickness as much as 200 ft.

Qe **Eolian deposit (Holocene)**—Light-brown to light-gray, stratified wind-blown sand and silt in dunes on windward sides of some benches. Thickness of dunes as much as 55 ft.

Qat **Alluvium of terrace deposit (Holocene and Pleistocee)**—Light-brown to light-gray, unconsolidated crudely to well-stratified and moderately to well-sorted sand and gravel in alluvial terraces adjacent to and higher than modern meandering streams. Thickness as much as 29 ft.

Qta **Talus deposit (Holocene and Pleistocene)**—Locally derived angular rock fragments, generally cobble size or larger that occur in piles or aprons on mountain slopes; color reflects parent rock. Includes boulder fields developed where frost action has formed slabby boulders from the underlying igneous rock in the Little Belt Mountains. Thickness as much as 20 ft.

Qls **Landslide deposit (Holocene and Pleistocene)**—Mass-wasting deposit that consists of stable to unstable, unsorted mixtures of clay- to boulder-size particles or rotated blocks of bedrock. Includes block-glide masses of bedrock, slumped blocks of bedrock and surficial sediment, earthflow deposits, and mudflow deposits. Color and lithology reflect parent rock and transported surficial materials. Thickness as much as 200 ft, but generally less than 100 ft.

Qgt **Glacial till (Pleistocene, Illinoian)**—Reddish-brown, brownish-gray, and gray, unstratified, compact, unsorted clay, silt, sand, and gravel with sparse matrix-supported granules, pebbles, cobbles, and boulders. Deposits mark approximate limit of Illinoian continental glaciation in northern part of quadrangle. Matrix dominantly calcareous clay loam, silty clay loam, and loam. Typically, 2 to 10 percent pebbles, cobbles, and boulders by volume. Glacial erratics are chiefly limestone, dolostone, orthoquartzite, and igneous and metamorphic rocks. Not mapped where thin and discontinuous. In northwest corner of quadrangle, unit includes outcrops of pre-Illinoian till not mappable at scale of map, and is covered by a veneer of glacial-lake clay, silt, and fine sand in many places. Thickness as much as 50 ft, but generally 30 to15 ft thick.

Qgl **Glacial Lake Great Falls deposit (Pleistocene) and reworked G.L.G.F. deposit (Pleistocene and/or Holocene)**—Dark-gray to reddish-brown, massive (in northwestern part of quadrangle) or grayish-orange, thinly bedded (in northeastern part of quadrangle) clay, silt, and fine sand with scattered boulders, cobbles, pebbles, and granules. Northeast of Square Butte, unit probably includes many small areas of Illinoian till, and lake deposits locally veneered by sheetwash alluvium. Thickness as much as 20 ft.

QTab **Alluvium of braid plains (Pleistocene and/or Pliocene)**—Light-brown to light-gray, crudely to well-stratified, and moderately to well-sorted sand and gravel that is older than alluvium of active stream channels (Qal). Occurs as remnants of braided-plain alluvial deposits and dissected deposits of coarse sediment derived from coalesced alluvial fans adjacent to Highwood Mountains (dominantly volcanic clasts), Little Belt Mountains (dominantly limestone clasts), Square Butte and Round Butte (dominantly shonkinite and

syenite clasts), or from reworked older alluvium. Underlies at least five different topographic surfaces of different ages. On all but lowest surfaces upper part of deposit is in many places cemented by calcium carbonate. Unit is covered by loess as much as 4 ft thick on all but the very lowest (youngest) surfaces. Thickness ranges from 20 inches to 100 ft.

QTat **Alluvium of alluvial terrace deposit (Pleistocene and/or Pliocene)**—Light-brown to light-gray, unconsolidated, crudely to well-stratified, and moderately to well-sorted sand and gravel in alluvial terraces adjacent to and higher than modern meandering streams. Thickness as much as 30 ft.

QTdf **Debris flow deposit (Pleistocene and/or Pliocene)**—Brownish-gray, dissected, mass-wasting deposits of poorly sorted sediment. Contains abundant angular and subangular, locally derived, matrix-supported clasts ranging from pebbles to boulders; matrix dominantly mud. Matrix locally eroded, leaving lag deposit of larger clasts. Thickness ranges from 10 to 50 ft.

Tat **Alluvium of alluvial terrace deposit (Pliocene)**—Light-brown to light-gray, crudely to well sorted, coarse sand and gravel. Upper part locally cemented by calcium carbonate. Thickness as much as 40 ft, but generally about 20 ft.

Tbs **Block-slide deposit (Eocene)**—Gravity-slide blocks of bedrock (up to several kilometers wide) that have maintained internal integrity, but in most cases have rotated during transport so that beds strike at angles to, and have dips from $5^{0}$ to $35^{0}$ steeper than the dips of adjacent undisturbed rock. **Tbs(Kmu)** and **Tbs(Kmk)** indicate block-slide deposits composed primarily of Montana Group rocks and of upper Kevin Member, respectively, along the flanks of the Highwood Mountains. These blocks probably slid on bentonite beds in the lower part of the Kevin Member. **Tbs(Tmmc)** indicates block-slide deposit composed primarily of contact-metamorphosed Colorado and Montana Group rocks. **Tbs(Tl)** indicates block-slide deposits composed primarily of latite, and **Tbs(Tphm, Tl)** indicates block-slide deposits composed primarily of both mafic phonolite and latite south of Highwood Mountains. Many Eocene dikes were partially detached, transported, and rotated within block-slide deposits. Age of block-slides inferred from younger Eocene dikes that cut across the blocks.

Tla **Lamprophyre (Eocene)**—Gray- to dark-gray-weathered, fine-grained igneous alkalic rock characterized by prominent biotite phenocrysts and less abundant pyroxene phenocrysts; includes vogesite and minette-kersantite. Vogesite contains biotite and clinopyroxene phenocrysts in a groundmass of orthoclase, plagioclase, biotite, and clinopyroxene. Minette-kersantite contains biotite, feldspar, and some hornblende.

Tsy **Syenite (Eocene)**—Light-gray-weathered, medium- to coarse-grained igneous rock composed of orthoclase, plagioclase, and diopsidic augite phenocrysts in an orthoclase-rich groundmass. Locally contains sparse quartz phenocrysts.

Tsh **Shonkinite (Eocene)**—Dark-gray-weathered alkalic igneous rock composed of more than 50 percent mafic minerals, primarily diopsidic augite with some biotite and olivine. Barium sanidine and lesser nepheline make up the felsic component.

Tqsp **Quartz syenite porphyry (Eocene)**—Light-brown- to light-gray-weathered igneous intrusive rock of Tiger Butte that contains potassium feldspar, quartz, plagioclase, and biotite phenocrysts in a fine-grained groundmass that consists mainly of potassium feldspar and quartz. Sphene, apatite, and pyrite are accessory minerals. Miarolitic cavities several millimeters across are common (Berg, 1991). Exposed thickness 500 ft.

Tqm **Quartz monzonite (Eocene)**—Dark-brown- to grayish-brown-weathered igneous rock near Hughesville (T15N, R9E) with scattered large, brown feldspar phenocrysts. Dominant minerals are feldspar, quartz, biotite, and augite.

Tql **Quartz latite (Eocene)**—Light-gray- to medium-gray-weathered igneous rock that contains tabular phenocrysts of white feldspar and dark mafic minerals scattered in a fine-grained to aphanitic groundmass. In the Highwood Mountains, unit is intruded by numerous shonkinite and syenite dikes that are too closely spaced to show at scale of map.

Tphm **Mafic phonolite (Eocene)**—Dark-reddish-brown-, dark-gray-, and black-weathered extrusive rock and associated dikes and sills. Extrusive rocks are primarily flows, but map unit also includes some clastic rocks. Pyroxene is most abundant phenocryst, with less abundant pseudoleucite phenocrysts and relatively sparse olivine phenocrysts that typically are altered. Some vesicles are filled with zeolites.

Tqm **Quartz monzonite (Eocene)**—Southwestern corner of quadrangle: Light-brown- to light-gray-weathered intrusive rock that contains abundant large, round phenocrysts of smoky quartz and white feldspar. Hughesville area (T15N, R9E, Sec. 6 and 7): Hughesville quartz monzonite (Walker, 1991) is brownish-gray, fine- to coarse-grained, generally equigranular, but porphyritic in peripheral areas of the intrusion with phenocrysts of feldspar laths or clots of microcline (Walker, 1991).

Tl **Latite (Eocene)**—Pale-reddish-brown-, brownish-gray- to light-gray-, and medium-gray-weathered flows, tuff, breccia, and agglomerate that contain abundant hornblende phenocrysts, and less common biotite and small tabular feldspar phenocrysts.

Tr **Rhyolite (Eocene)**—Light-gray-weathered, dense, aphanitic volcanic rock that contains widely scattered feldspar, biotite, and rare topaz phenocrysts. Gold Run Tuff (Walker, 1991) in a diatreme near Hughesville (T15N, R9E, sec. 18) is a light-brown- to gray-weathered, heterogeneous mixture of angular to well rounded clasts in a finer-grained groundmass. Typical clast compositions are granite, quartz monzonite, quartz rhyolite, and sedimentary and metamorphic rock. (Walker, 1991)

Tmgm **Montana Group rocks metamorphosed to quartzite, siltite, and hornfels (Eocene)**— Upper Cretaceous Montana Group rocks metamorphosed by adjacent Eocene intrusions to light-gray-weathered quartzite, dark-brownish-gray-weathered siltite, and dark-gray-weathered hornfels. In areas transitional between metamorphosed and unmetamorphosed rock, sandstone is unchanged but shale is metamorphosed to hornfels. As much as 1,150 ft of section is metamorphosed. Shonkinite and syenite dikes in some areas of hornfels constitute more than 30 percent of the bedrock, but are too closely spaced to show at scale of map.

Tcgm **Colorado Group rocks metamorphosed to hornfels, siltite, and quartzite (Eocene)**—Upper and Lower(?) Cretaceous Colorado Group rocks metamorphosed to light-gray-, dark-gray-, and dark-brownish gray-weathered hornfels by adjacent Eocene intrusions. As much as 1,640 ft of section is metamorphosed. Shonkinite and syenite dikes in some areas of hornfels constitute more than 30 percent of bedrock, but are too closely spaced to show at scale of map.

Tcg **Conglomerate (Eocene ?)**—Poorly exposed and poorly sorted conglomerate in the Highwood Mountains composed of abundant limestone (Madison Group?) and quartzite clasts. Typically recognized by an abundance of clasts in residual soil. Thickness as much as 400 ft.

Kmg **Montana Group undivided (Upper Cretaceous)**—Includes Telegraph Creek, Eagle, Claggett, and Judith River Formations in areas of poor exposure. May include Kevin Member of the Marias River Shale (upper Colorado Group).

Kjr **Judith River Formation (Upper Cretaceous)**—Yellowish-brown- to gray-weathered, ledge-forming quartzose sandstone interbedded with poorly exposed black-weathered shale. Prominent very pale-orange-weathered, cross-bedded feldspathic sandstone at base; top not exposed. Thickness may be more than 500 ft.

Kcl **Claggett Formation (Upper Cretaceous)**—Dark-brown- to black-weathered, poorly exposed shale. Thickness ranges from 200 to 400 ft.

Ket **Eagle and Telegraph Creek Formations, undivided (Upper Cretaceous)**

**Eagle Formation**

Keu **Upper member of Eagle Formation (informal)(Upper Cretaceous)**—Dark-gray- to brownish-gray-weathered shale that contains thin, discontinuous coal beds, and yellowish-brown-weathered, fine- to medium-grained, trough-cross-bedded sandstone beds with scour bases. Thickness about 490 ft.

Kev **Virgelle Member of Eagle Formation (Upper Cretaceous)**—Very light-gray, yellowish-brown-, or grayish-brown-weathered, fine- to medium-grained sandstone. Planar bedded, trough cross-bedded,

hummocky bedded, or bioturbated; contains rip-up clasts of siltstone and shale. Sandstone is well-sorted to moderately well sorted and contains small clay chips and organic fragments. Liesegang banding is common. Member generally weathers to form steep fluted surfaces. Uppermost bed of member is carbonaceous shale or coal. Thickness ranges from 65 to 130 ft.

Ktc **Telegraph Creek Formation (Upper Cretaceous)**—Interbedded, yellowish-brown or brownish-gray-weathered, planar-bedded sandstone and siltstone, and dark-gray- to brownish-gray-weathered shale. Abundance of sandstone and bed thickness increase upward. Thickness ranges from 60 to 148 ft.

**Marias River Shale**

Kmk **Kevin Member of Marias River Shale (Upper Cretaceous)**—Dark-gray-weathered, partly calcareous shale with abundant gray septarian limestone concretions. Lower part of member contains many thin bentonite beds and medium-gray to moderate-yellowish-brown-weathered fossiliferous limestone concretions. Middle part of member contains ferruginous and calcareous fossiliferous concretions and beds, and a conglomeratic limestone bed with black, well-rounded chert pebbles. Upper part of member contains thin siltstone beds. Thickness about 660 ft.

Kmf **Ferdig Member of Marias River Shale (Upper Cretaceous)**—Noncalcareous, dark-gray-weathered, fissile shale that contains lenticular-bedded siltstone, fine-grained sandstone, and distinctive reddish-orange ferruginous dolostone concretions that weather into small chips. Thin beds of fine-grained, planar-bedded sandstone or siltstone are present in upper part. Thickness about 200 ft.

Kmc **Cone Member of Marias River Shale (Upper Cretaceous)**—Lower part consists of dark-gray-weathered, calcareous shale that contains a basal zone of gray septarian concretions and a thick persistent bentonite bed. Upper part consists of thin beds of platy, medium-gray- or grayish-orange-weathered petroliferous limestone with blue fish scales, *Inoceramid*, and oyster fragments. Thickness about 60 ft.

Kmfl **Floweree Member of Marias River Shale (Upper Cretaceous)**—Dark-gray-weathered, fissile shale that contains several thin beds of grayish-orange-weathered siltstone, fine-grained sandstone, and also light-yellowish-gray, low-swelling, thin bentonite beds. Locally contains septarian concretions and ferruginous dolostone concretions that weather to small chips similar to those in the Ferdig Member. Thickness about 60 ft.

Km **Mowry Formation (Upper and Lower Cretaceous)**—Dark-gray-weathered, thinly interbedded siliceous shale, siltstone, and fine-grained sandstone. Pale-yellowish-brown to light-olive-gray, medium-grained sandstone that grades laterally into a chert-granule conglomerate with local concentrations of fish scales and bones present at top of formation. The formation grades laterally into the upper part of the Bootlegger Member of the Blackleaf Formation (exposed in western part of quadrangle). Thickness about 260 ft.

Kac **Arrow Creek Bed of Mowry and Blackleaf Formations**—Very light-gray and yellowish-gray-weathered porcellanite, locally zeolitized tuff, and bentonite. Some porcellanite contains contorted bedding produced by soft-sediment deformation. Unit occurs at base of the Mowry Formation where Mowry is present, or is within the Bootlegger Member of the Blackleaf Formation. Thickness ranges from 5 inches to 65 ft.

Kt **Thermopolis Shale (Lower Cretaceous)**—Dark-gray-weathered, fissile shale that contains many thin bentonite beds and several sandstone beds including a yellowish brown-weathered, thin-bedded, and fine-grained basal sandstone bed. Middle of formation contains a brownish-gray-weathered, medium-grained, trough-cross-bedded, hummocky or ripple-bedded sandstone bed and a reddish-brown, lenticular, fine- to medium-grained, limonite-cemented sandstone bed. Formation grades laterally into lower Bootlegger Member of Blackleaf Formation (western part of quadrangle). On Windham Dome (T16N, R12E, Sec. 18) a small area of sandstone preserved overlying hornfels is probably in Thermopolis Shale, but possibly is in Mowry Formation. Thickness about 600 ft.

**Blackleaf Formation**

Kbb **Bootlegger Member of Blackleaf Formation (Upper and Lower Cretaceous)**—Dark-gray-weathered, fissile shale that contains 2 to 6 prominent sandstone beds, each 10 to 40 ft thick, separated by 50 to 100 ft of shale. Many thin bentonite beds and an unnamed porcellanite bed similar to the Arrow Creek Bed (but stratigraphically below it), are present near top of member in central part of quadrangle. The light-brown- to

yellowish-brown-weathered, fine- to medium-grained sandstone beds commonly are ripple-laminated, with abundant trace fossils on bedding surfaces. Trough cross-bedding and hummocky bedding are common in upper part of member, and fish scales and bones are common in the uppermost sandstone beds. Tops of sandstone beds locally contain black chert pebbles. A well-cemented chert-pebble conglomerate or coarse-grained sandstone is present at top of member. Sandstone beds are laterally persistent over many square kilometers. In the eastern part of the quadrangle, the upper part of the Bootlegger Member grades laterally into the Mowry Formation and the lower part of the Bootlegger Member grades laterally into the Thermopolis Shale. Thickness ranges from 60 to 330 ft.

Kbv **Vaughn Member of Blackleaf Formation (Lower Cretaceous)**—Poorly exposed, very bentonitic, silty, gray-weathered shale with thin bentonite beds. Member present only in western part of quadrangle. Thickness about 100 ft.

Kbt **Taft Hill Member of Blackleaf Formation (Lower Cretaceous)**—Medium-dark-gray- to medium-light-gray-weathered, bentonitic silty shale with several thin, glauconitic sandstone beds. Member grades laterally into the Thermopolis Shale (eastern part of quadrangle). Thickness about 120 ft.

Kblf **Flood Member of Blackleaf Formation (Lower Cretaceous)**—Black- to dark-gray-weathered fissile shale that contains pods and lenses of bioturbated sandstone at its base. Lacks two prominent sandstone beds that are present west of the quadrangle. Member grades laterally into the Thermopolis Shale (eastern part of quadrangle). Thickness ranges from 100 to 130 ft.

**Kootenai Formation**

$Kk_5$ **Fifth member of Kootenai Formation (informal)(Lower Cretaceous)**—Red-weathered mudstone that contains lenses of sandstone and limestone. Uppermost part of member consists of massive, color-banded, greenish-gray, grayish-red-purple, moderate-red and very dark red mudstone with lenses of fine- to medium-grained, trough-cross-bedded, greenish-gray-weathered sandstone. Not present in southeastern part of quadrangle. Thickness about 120 ft.

$Kk_4$ **Fourth member of Kootenai Formation (informal)(Lower Cretaceous)**—Dusky-red to pale-reddish-brown-weathered, fine- to medium-grained, thin- to medium-bedded, ripple-laminated, argillaceous, platy-bedded sandstone interbedded with very-dark-red-weathered mudstone. In the southern part of quadrangle, light-brown-weathered, medium-grained, trough-cross-bedded sandstone beds are also present. Thickness about 100 ft.

$Kk_s$ **Sunburst Sandstone Member of Kootenai Formation (Lower Cretaceous)**—Light-yellowish-brown-weathered, well-sorted, resistant quartzose sandstone with interspersed limonite specks. Scour base with rip-up clasts and chert pebbles cuts into second member and locally into Cutbank Sandstone Member. As much as 20 percent interstitial dark chert at base, but dark chert is almost completely lacking higher in the section. Member pinches out east of Raynesford. Thickness from 0 to 80 ft.

$Kk_2$ **Second member of Kootenai Formation (informal)(Lower Cretaceous)**—Red-weathered, poorly resistant mudstone that contains dense, medium-gray micrite and argillaceous, light-brownish-gray micritic concretions that laterally become lenticular, irregular beds. Thin, lenticular, chert-rich quartzose sandstone beds are present locally. A bed of intraformational, micrite-clast conglomerate is present near top of member. Thickness about 110 ft.

$Kk_c$ **Cutbank Sandstone Member of Kootenai Formation (Lower Cretaceous)**—Basal, resistant, festoon-cross-bedded, moderately well sorted quartz sandstone with 20 to 50 percent black, dark-gray, and light-gray chert; appears to be depositionally related to underlying Morrison Formation coal bed. Coarse-grained sandstone, chert-granule conglomerate, or chert-pebble conglomerate present at scour base of member, typically with rip-up clasts of coal, plant fragments, and plant impressions. Becomes finer-grained upward, and in some areas upper part of sandstone contains very little chert. Thickness ranges from 20 to 100 ft.

KJm **Morrison Formation (Lower Cretaceous and Jurassic)**—Light-greenish-gray mudstone or locally light-red weathered-sandstone with interbedded lenses of medium-gray micrite, and fine- to medium-grained, calcareous, thin-bedded, yellowish-brown-weathered sandstone. Subbituminous coal bed as much as 12 ft thick at or near top of formation. Gradational contact with underlying Swift Formation and overlying

Kootenai Formation, but contains a significant unconformity below the dark shale and coal of the upper Morrison (Lloyd Furer, Indiana Geological Survey, personal communication, 1999.) Thickness ranges from 100 to 200 ft.

Je **Ellis Group,** undivided

**Swift Formation**—Grayish-orange-weathered, calcareous, fine- to coarse-grained, glauconitic sandstone that contains interbeds of gray-, red-, and green-weathered shale with fragments of oysters and pelecypods, and a basal chert-pebble conglomerate. Thickness ranges from 50 to 120 ft.

**Piper and Rierdon Formations**—Grayish-green shale, dusky-red and grayish red-purple gypsiferous shale, and gray limestone beds. Thickness ranges from 0 to 30 ft.

**Amsden Group**

PMab **Alaska Bench Formation (Pennsylvanian and Mississippian)**—Medium-gray-, light-gray-, and yellowish-gray-weathered resistant limestone and dolostone in beds ranging from 10 inches to 3 ft thick, interbedded with red mudstone. Formation not present in part of quadrangle because of pre-Jurassic erosion. Thickness ranges from 0 to 230 ft.

Mt **Tyler Formation (Mississippian)**—Pale-reddish-brown, dusky-red, and grayish-red-weathered mature quartzose sandstone and conglomerate beds that range from 1 to 7 ft thick, interbedded with dark-gray-, grayish-red-, and dusky-red-weathered shale. Formation not present in part of quadrangle because of pre-Jurassic erosion. Thickness ranges from 0 to 300 ft.

**Big Snowy Group**

Mh **Heath Formation (Mississippian)**—Dark-gray-weathered, fissile, locally petroliferous shale that contains dark-gray- and light-gray-weathered, micritic limestone beds. Locally contains dark-gray chert and a very-light-gray-weathered gypsum bed. Generally intruded by one or more basic sills. Highly prone to landsliding. Formation not present in western part of quadrangle because of pre-Jurassic erosion. Thickness ranges from 0 to 500 ft.

Mo **Otter Formation (Mississippian)**—Brilliant-green-, moderate-yellowish-green-, and dark-greenis-gray-weathered shale and siltstone with thin platy micrite beds that locally contain black chert, oölites, stromatolites, and other algal structures. Thickness ranges from 300 to 500 ft.

Mk **Kibbey Formation (Mississippian)**—Light-red, moderate-red, and dark-reddish-brown-weathered, interbedded sandstone, siltstone, and shale. Pale-yellowish-orange, mature quartzose sandstone in upper part. Contains gypsum bed as much as 30 ft thick, and thin lenses of gypsum interbedded with shale. Thickness ranges from 65 to 100 ft.

**Madison Group**

Mmc **Mission Canyon Limestone (Mississippian)**—Light-gray- to dark-gray-weathered, resistant, massive, or thick-bedded, fossiliferous limestone that contains black or dark-orange chert and solution breccia. Thickness about 800 ft.

Ml **Lodgepole Limestone (Mississippian)**—Light-gray, brownish-gray-, and dark-gray-weathered, dominantly thin-bedded fossiliferous limestone that contains abundant black chert. Thickness about 700 ft.

MDt **Three Forks Formation (Mississippian and Devonian)**—Light-gray- and greenish-gray-weathered shale that contains reddish-gray-weathered, thin-bedded siltstone beds and brownish-gray-weathered dolomite beds. Formation rarely exposed. Thickness about 65 ft.

Dj **Jefferson Formation (Devonian)**—Upper unit (Birdbear Member) light-gray-weathered resistant dolomite with saccharoidal texture, about 60 ft thick. Middle unit medium- to dark-gray-weathered, coarsely crystalline dolomite with petroliferous odor. Lower unit light-gray-weathered limestone that contains black chert, corals, and algal structures. Total thickness about 250 ft.

Dm **Maywood Formation (Devonian)**—Yellowish-brown- and reddish-brown-weathered, thin-bedded siltstone interbedded with medium-gray-weathered shale. Thickness about 80 ft.

$\epsilon$pi **Pilgrim Limestone (Cambrian)**—Light-gray- to medium-gray-weathered limestone and thin beds of dark-gray-weathered shale. Intraformational flat-pebble conglomerates common. Thickness about 148 ft.

$\epsilon$p **Park Shale (Cambrian)**—Light-gray to greenish-gray-weathered, micaceous shale that contains irregular thin beds of light-gray limestone in upper part. Metamorphosed to dark gray hornfels near intrusions. Thickness ranges from 170 to 250 ft.

$\epsilon$m **Meagher Limestone (Cambrian)**—Medium-gray- to light-gray-weathered, thin- and irregular-bedded, glauconitic limestone with irregular yellowish-orange, silty claystone mottles. Metamorphosed to skarn and marble near intrusions. Thickness about 75 ft.

$\epsilon$w **Wolsey Shale (Cambrian)**—Dark-gray- and dark-greenish-gray-weathered, glauconitic and micaceous shale. Metamorphosed to very dark-gray hornfels near intrusions. Thickness about 150 ft.

$\epsilon$f **Flathead Formation (Cambrian)**—Pinkish-gray to reddish-brown-weathered, well-cemented and indurated, cross-bedded, coarse- to medium-grained, conglomeratic sandstone and conglomerate. Contains thin shale beds in middle part and very-light-gray-weathered sandstone in upper part. Thickness about 50 ft.

p$\epsilon$pi **Pinto Diorite (Early Proterozoic)**—Mottled gray to greenish gray, massive, locally gneissic, medium- to coarse-grained diorite. Clusters of hornblende phenocrysts in a feldspathic groundmass. Dominant minerals are hornblende, sodic and calcic plagioclase, microcline, quartz, and augite-salite.

p$\epsilon$gg **Granite gneiss (Archean)**—Gray, massive, locally gneissic, medium- to coarse-grained orthogneiss(?). Dominant minerals are quartz, microcline, sodic plagioclase, biotite, hypersthene, and augite.

p$\epsilon$c **Amphibolite and pegmatite (Archean)**—Complex assemblage of dark-gray to black foliated amphibolite and white, massive, coarsely crystalline pegmatite.

p$\epsilon$mg **Metagabbro (Archean)**—Grayish brown to gray, massive (little to no foliation), medium- to coarse-grained metagabbro. Dominant minerals are andesine, hypersthene, augite-salite, and biotite.

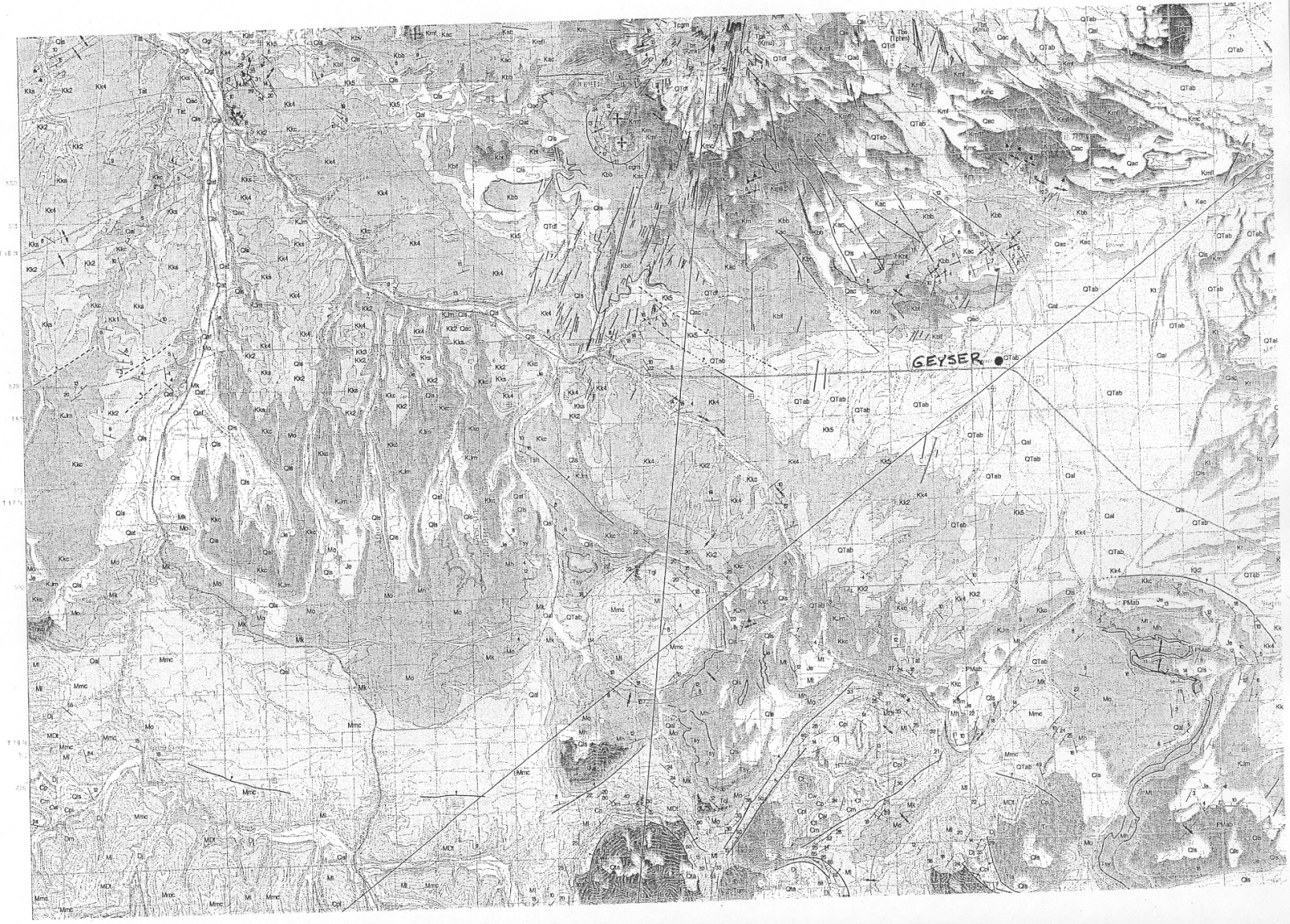
p$\epsilon$a **Augen gneiss (Archean)**—Red- to reddish-brown-weathered, gray, with prominent gneissic structure locally and large orthoclase porphyroblasts. Dominant minerals are alkalic feldspar, oligoclase, biotite, quartz, hornblende, hypersthene, and augite-salite. Includes thin band of light-gray-foliated rock that encircles reddish-brown augen gneiss and contains many small feldspar porphyroblasts.

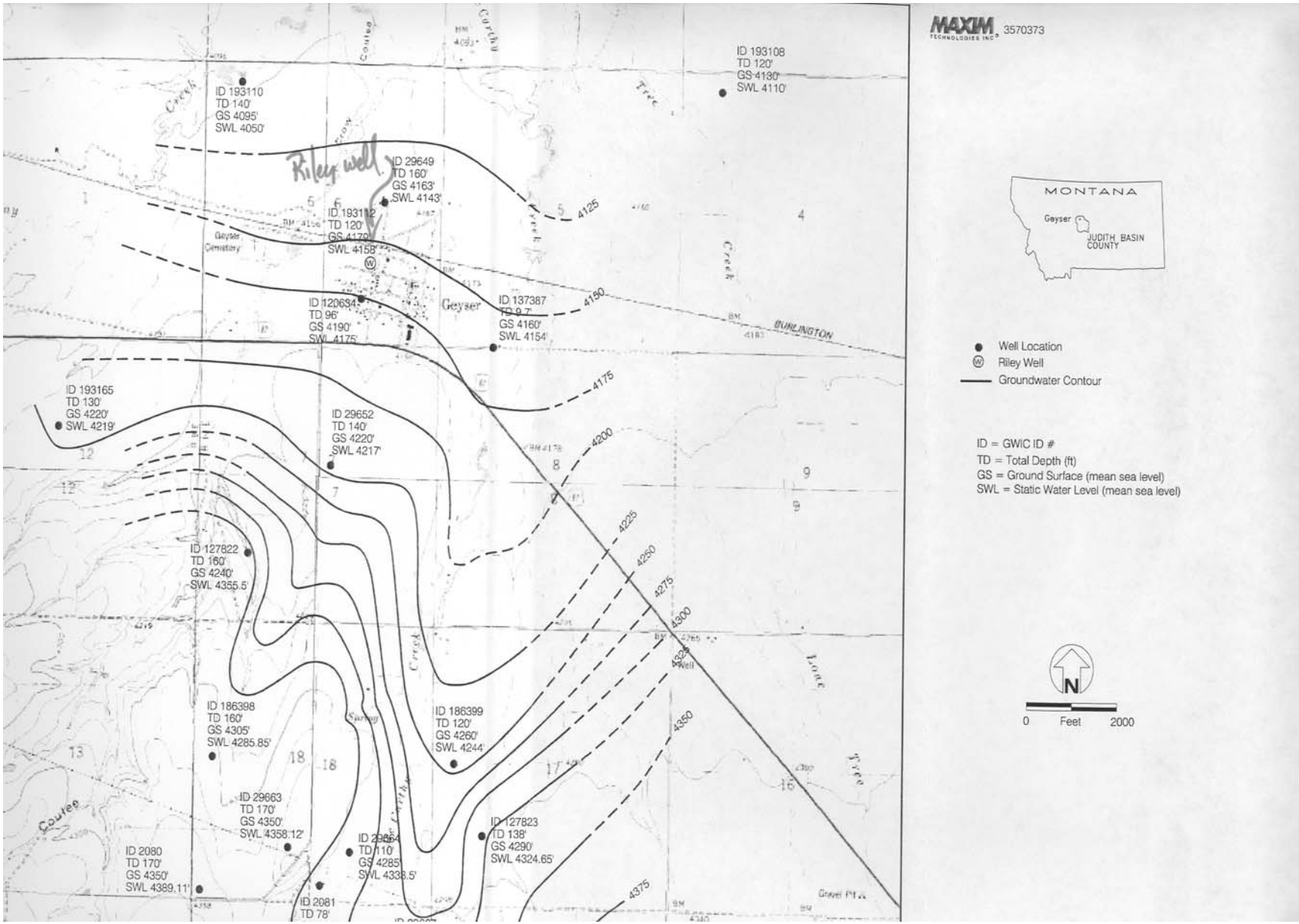
p$\epsilon$ga **Granite gneiss (Archean)**—Gray paragneiss(?). Narrow layer rich in garnets and pyroxenes that may be a result of contact metamorphism by Precambrian intrusions. Dominant minerals are garnet, andesine, biotite, hypersthene, augite-salite, and quartz.

p$\epsilon$h **Hornblende biotite gneiss (Archean)**—Gray to dark-gray, well-layered, locally severely contorted fine- to medium-grained paragneiss(?). Dominant minerals are hornblende, biotite, oligoclase, quartz, and alkalic feldspar.

p$\epsilon$mi **Microcline gneiss (Archean)**—Light-gray quartzofeldspathic, well-foliated, light-gray paragneiss(?). Contains polycrystalline blebs of quartz, xenoblastic grains of microcline and albite, and small amounts of biotite, epidote, and opaque iron ores.

Precambrian unit descriptions from Witkind, 1971.


GEYSER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MONTANA
Geyser
JUDITH BASIN COUNTY
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Riley Well
Groundwater Contour
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TD = Total Depth (ft)
GS = Ground Surface (mean sea level)
SWL = Static Water Level (mean sea level)
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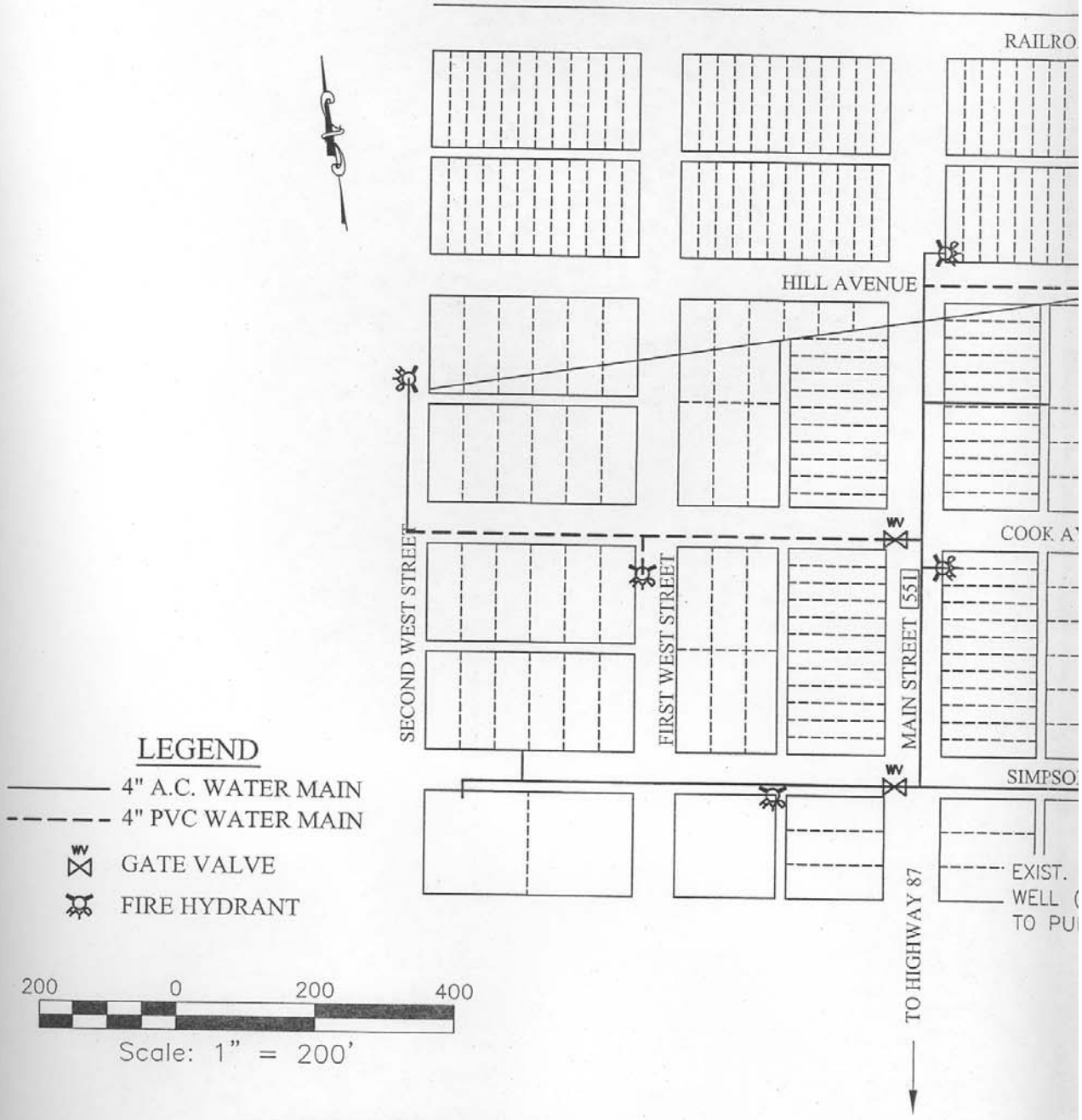


LEGEND

4" A.C. WATER MAIN

4" PVC WATER MAIN

WV GATE VALVE

FIRE HYDRANT

200 0 200 400

Scale: 1" = 200'

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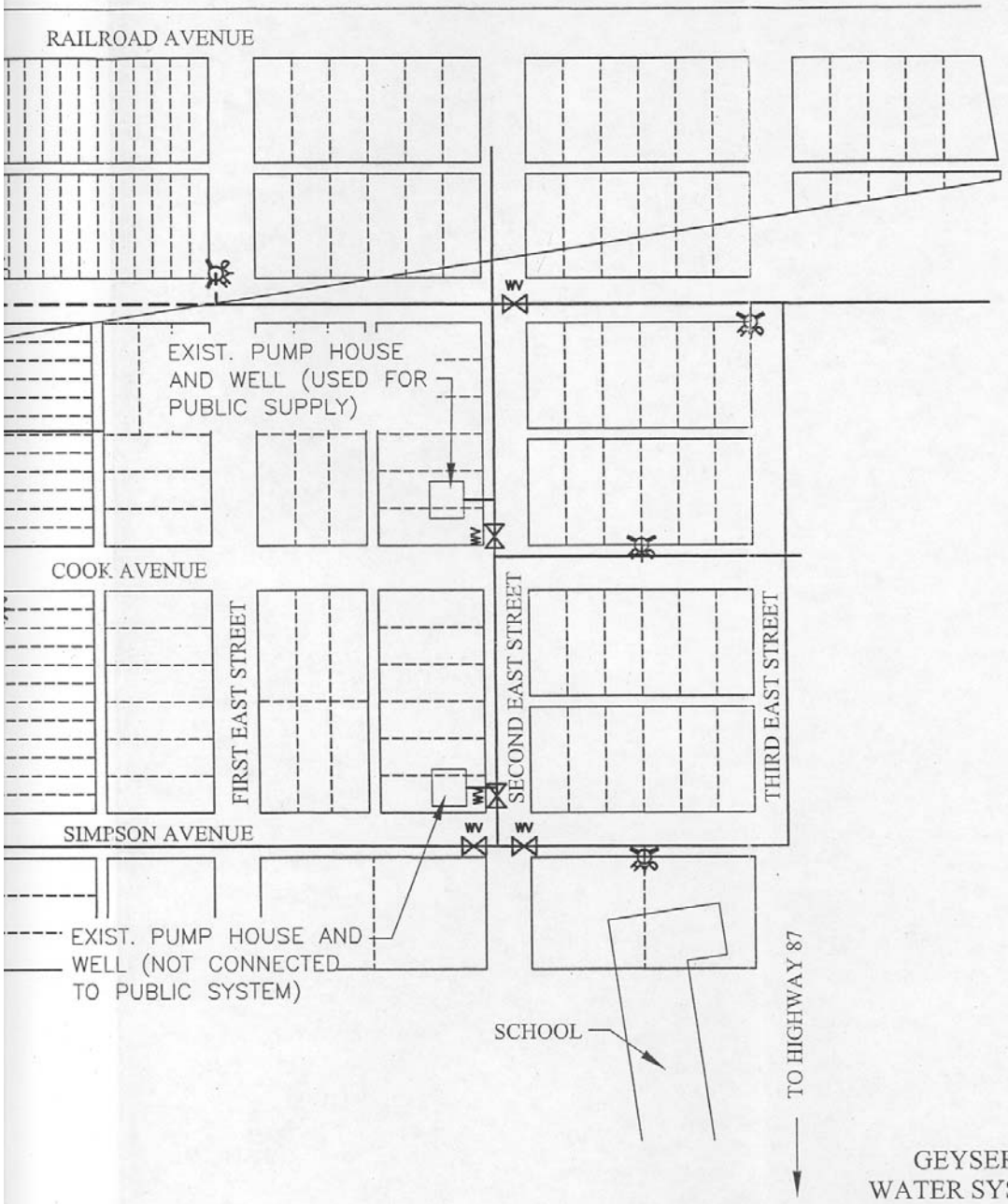
HELENA, MONTANA 59604

# TOWN OF GEYSER
## EXISTING WATER SYSTEM




GEYSER, MONTANA
WATER SYSTEM ANALYSIS
EXISTING WATER SYSTEM
FIGURE 1-2

# Appendix B
# Geyser PWS Well Log

**Montana Bureau of Mines and Geology**
**Ground-Water Information Center Site Report**
**TOWN OF GEYSER**

Plot this site on a topographic map

## Location Information

GWIC Id: 130219
Location (TRS): 17N 10E 06 DDBC
County (MT): JUDITH BASIN
DNRC Water Right: P083192-00
PWS Id: 00226002
Block: 4
Lot:
Addition: GEYSER SPECIAL IMPROVEMENT DISTRICT

Source of Data: LOG
Latitude (dd): 47.2589
Longitude (dd): -110.4943
Geomethod: MAP
Datum: NAD27
Altitude (feet):
Certificate of Survey:
Type of Site: WELL

## Well Construction and Performance Data

Total Depth (ft): 1060.00
Static Water Level (ft): -23.10
Pumping Water Level (ft):
Yield (gpm): 75.00
Test Type:
Test Duration:
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):
Well Notes:

How Drilled: ROTARY
Driller's Name: SINGLEY
Driller License: WWC280
Completion Date (m/d/y): 8/19/1992
Special Conditions: DEEPENED
Is Well Flowing?: YES
Shut-In Pressure: 10.00
Geology/Aquifer: 217KOTN
Well/Water Use: PUBLIC WATER SUPPLY

### Hole Diameter Information

| From | To | Diameter |
|---|---|---|
| 0.0 | 30.0 | 12.0 |
| 30.0 | 825.0 | 8.0 |
| 825.0 | 930.0 | 6.0 |
| 930.0 | 1060.0 | 5.0 |

### Casing Information[1]

| From | To | Dia | Wall Thickness | Pressure Rating | Joint | Type |
|---|---|---|---|---|---|---|
| 0.0 | 825.0 | 8.0 | | | | 28 LB STEEL |
| 0.0 | 935.0 | 5.0 | | | | PVC |
| 825.0 | 924.0 | 6.0 | | | | 19 LB STEEL |

### Annular Seal Information

| From | To | Description |
|---|---|---|
| 0.0 | 800.0 | CEMENT |

### Completion Information[1]

| From | To | Dia | # of Openings | Size of Openings | Description |
|---|---|---|---|---|---|
| 530.0 | 930.0 | 4.0 | | | 3/8 DRILL PERFS |

### Lithology Information

| From | To | Description |
|---|---|---|
| 0.0 | 6.0 | WASH ... |
| 6.0 | 11.0 | GRAVEL AND SILT |
| 11.0 | 30.0 | SHALE |
| 30.0 | 150.0 | SHALE |
| 150.0 | 170.0 | GREEN AND RED SHALE |
| 170.0 | 200.0 | BROWN CLAY SHALES |
| 200.0 | 353.0 | BENTONITE COLORED SHALES |

| | | |
|---|---|---|
| 353.0 | 385.0 | RED AND GREEN SHALE SAND STREAKS |
| 385.0 | 401.0 | HARD LIME STREAKS CHERT |
| 401.0 | 414.0 | SAND STREAKS FRACTURED LIME WATER 10 GPM |
| 414.0 | 445.0 | LIMESTONE STREAKS |
| 445.0 | 485.0 | CLAYSTONE STREAKS OF FINE SANDSTONE SOME PYRITES CHERT |
| 485.0 | 530.0 | GREY AND WHITE SAND STREAKS FINE TO MEDIUM |
| 530.0 | 560.0 | GREY SILTY SAND W/RED CLAY |
| 560.0 | 598.0 | GREY SILTY SAND W/RED CLAY |
| 598.0 | 620.0 | SALT AND PEPPER SAND WATER INCREASED TO 26 GPM |
| 620.0 | 628.0 | COAL STREAKS |
| 628.0 | 660.0 | COAL STRINGERS RED GRAY & GREEN SHALE VERY LITTLE SAND |
| 660.0 | 670.0 | LIMEY SHALE-GREEN SILTYSAND-RED & GREY SHALE (MORRISON TOP) |
| 670.0 | 675.0 | SILTSTONE WHITE QUARTZ LIMEY SHALE |
| 675.0 | 755.0 | FINE DIRTY SAND STREAKS |
| 755.0 | 785.0 | DARK GRAY SAND W/RED SPECKS-PYRITIC... CARBON SPECKS. |
| 785.0 | 797.0 | GREENISH CLAYSTONE PYRITIC |
| 797.0 | 820.0 | SILTSTONE LIGHT BROWN SANDSTONE STREAKS DARK SHALE STREAKS |
| 820.0 | 825.0 | THIN GLAUONITIC SANDSTONE POOR POROSITY |
| 825.0 | 856.0 | LIMESTONE & SHALE-TITE HARD SAND CLAUNIT |
| 856.0 | 909.0 | SANDSTONE LIMEY BASE FAIR TO GOOD POROSITY WATER FLOW 30 GPM |
| 909.0 | 920.0 | WHITE AND GREY SAND W/WHITE QUARTZ |
| 920.0 | 924.0 | SANDY LIMEY SHALE ORIGINAL WELL COMPLETED 9-22-71 BY MUNSON |
| 924.0 | 927.0 | SANDY LIMEY SHALE |
| 927.0 | 932.0 | WHITE SANDSTONE HARD FRACTURED |
| 932.0 | 945.0 | GRAY HAD SHALE W/WHITE LAYERS |
| 945.0 | 950.0 | WHITE SANDSTONE W/GRAY FLECKS HARD NO POROSITY |
| 950.0 | 965.0 | GRAY HARD BRITTLE SHALE |
| 965.0 | 970.0 | SANDSTONE WHITE TO BLACK FRACTURED TIGHT |
| 970.0 | 980.0 | BLUE AND GRAY SHALE (SOME HARD LAYERS) |
| 978.0 | 1012.0 | CLEAR WHITE-HARD LAYERS W/SHALE |
| 980.0 | 991.0 | GYPSUM WHITE |
| 991.0 | 993.0 | HARD GYPSUM CLEAN WHITE |
| 993.0 | 998.0 | GREEN GRAY SHALE W/GYPSUM LAYERS |
| 1012.0 | 1020.0 | GREEN AND GREY SHALE SOME GYPSUM |
| 1020.0 | 1030.0 | CLEAR WHITE HARD LAYERS |
| 1030.0 | 1050.0 | BROWN SHALE TURN INTO RED W/GYPSUM SANDSTONE SHOW AT 1037' |
| 1050.0 | 1058.0 | GYPSUM |
| 1058.0 | 1060.0 | BROWN LIMESTONE NO INCREASE FROM DRILLING DEEPER.WATER FLOWED MORE AFTER CLEANING HOLE OUT AND REAMING ORIGINAL HOLE. |

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

# Appendix C
# List of Potential Contaminant Sources

## DEQ UST List

http://www.deq.state.mt.us/UST/USTDownloads.asp

Notes:
Active USTs have usually been upgraded to 1998 standards (which includes leak detection and monitoring) Spills or improper handling during tank filling or product distribution at these facilities may impact the drinking water supply.

DEQ classifies inactive USTs as temporarily out of service and requires that the product in the tank be removed. However, testing of the tanks, distribution lines or soils around the tank is not required to evaluate the potential for historic leaks or spills that may impact subsurface soils and groundwater.

| Alt Facility ID | Facility Name | Facility Location Address | City | County | Active Tanks | Non-active Tanks |
|---|---|---|---|---|---|---|
| 23-05450 | Broken Beam Ranch | RR 1 Box 14 | Geyser | Judith Basin | | 1 |
| 23-04179 | Clarence O & Frances Anderson | RR 1 Box 27 | Geyser | Judith Basin | | 2 |
| 23-03299 | Clifford L. Backa | US 87 | Geyser | Judith Basin | | 2 |
| 23-05582 | Dale Backa | Address Unknown | Geyser | Judith Basin | | 2 |
| 23-00688 | Elmer Pollari | 11 Mi NE | Geyser | Judith Basin | | 2 |
| 23-07488 | Evans Brthers | PO Box 35 | Geyser | Judith Basin | | 2 |
| 23-05832 | Francis Stenzel | Address Unknown | Geyser | Judith Basin | | 1 |
| 23-03795 | Geyser School | 103 3rd Street East | Geyser | Judith Basin | 1 | 1 |
| 23-00299 | Jerome F. Kolar | Hill St | Geyser | Judith Basin | | 1 |
| 23-02751 | John F. Hill | 16 Mi NE of Geyser | Geyser | Judith Basin | | 1 |
| 23-04402 | John J. Schmitt | PO Box 13 | Geyser | Judith Basin | | 1 |
| 23-04180 | Johnny Cripps | Address Unknown | Geyser | Judith Basin | | 1 |
| 23-08055 | Keith Harlow | Address Unknown | Geyser | Judith Basin | | 1 |
| 23-03490 | Kenneth Kolar | RR 1 | Geyser | Judith Basin | | 1 |
| 23-02324 | Klind Ranch Inc. | 2nd St & Railroad Ave | Geyser | Judith Basin | | 2 |
| 23-04653 | Leroy Hill | N of Geyser | Geyser | Judith Basin | | 1 |
| 23-08977 | Malmstrom AFB A-3 | US Hwy 87 | Geyser | Judith Basin | 1 | 1 |
| 23-08986 | Malmstrom AFB B-1 | US 87 | Geyser | Judith Basin | 1 | 3 |
| 23-08995 | Malmstrom AFB B-10 | US Hwy 87 | Geyser | Judith Basin | 1 | 1 |
| 23-08996 | Malmstrom AFB B-11 | US Hwy 87 | Geyser | Judith Basin | 1 | 1 |
| 23-08992 | Malmstrom AFB B-7 | US Hwy 87 | Geyser | Judith Basin | 1 | 1 |
| 23-08993 | Malmstrom AFB B-8 | US Hwy 87 | Geyser | Judith Basin | 1 | 1 |
| 23-08994 | Malmstrom AFB B-9 | US Hwy 87 | Geyser | Judith Basin | 1 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 23-12063 | Mamie Hankins | Unknown | Geyser | Judith Basin | | 1 |
| 23-02891 | Merrimac Cattle Company | RR 1 Box 10 | Geyser | Judith Basin | | 2 |
| 23-11729 | Nan Triplett | Corner of Hill & Main St | Geyser | Judith Basin | | 1 |
| 23-05834 | Rex Garage | PO Box 126 | Geyser | Judith Basin | | 7 |
| 23-05831 | Robert D. Evans Jr. | PO Box 15 | Geyser | Judith Basin | | 1 |
| 23-00867 | St Cyril Parish Church | Geyser Township | Geyser | Judith Basin | | 1 |
| 08-02212 | Strand Ranch (Geyser) | 17 Miles NE | Geyser | Judith Basin | | 3 |
| 23-04885 | W Oscar Hill | Address Unknown | Geyser | Judith Basin | | 2 |

## DEQ LUST List

http://www.deq.state.mt.us/UST/USTDownloads.asp

| City | SiteName | Location | AltEventID | Date | Confirmed Release Date | Project Officer | Active |
|---|---|---|---|---|---|---|---|
| Geyser | B-1 | Hwy 87 | 2308986*3577 | 06-Nov-98 | 05-Nov-98 | Patrick Skibicki | Yes |
| Geyser | B-7 | US Hwy 87 | 2308992*2003 | 09-Oct-92 | 10-Oct-92 | | No |
| Geyser | Farmers Union Co-Op | Geyser Township 1st Addition Lots 10 and 11 | 2312703*1109 | 14-Feb-92 | 12-Feb-92 | | No |
| Geyser | Geyser School Dist # 58 | 103 3rd St E | 2303795*755 | 24-May-91 | 24-May-91 | | No |
| Geyser | Rex Garage | | 2305834*1100 | 14-Feb-92 | 13-Feb-92 | | No |
| Geyser | Strand Ranch | 17 Miles NE | 0802212*1031 | 19-Dec-91 | 19-Dec-91 | | No |

# Appendix D
# Concurrence Letter