The Lumberjack Saloon
Public Water Supply
(PWS # MT0000803)

Source Water
Delineation and Assessment Report

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Table of Contents

INTRODUCTION

This source water delineation and assessment report (SWDAR) was prepared for The Lumberjack Saloon's water system, a Public Water Supply (PWS), located west of Lolo in Missoula County. Jeffrey Frank Herrick, a hydrogeologist with the Source Water Protection Program at the Montana Department of Environmental Quality (DEQ), completed this SWDAR. The report is based information derived from area Source Water Delineation and Assessment Reports (SWDARs) and other publicly available data sources.

Purpose

The primary purpose of this delineation and assessment report (SWDAR) is to provide information that helps the Lumberjack Saloon protect its drinking water source. Delineation is the process of identifying areas that contribute water to aquifers or surface water bodies used as drinking water supplies. The delineated areas are referred to as source water protection areas. Assessment involves identifying and inventorying potential sources of contamination within the source water protection areas, and then determining the potential for contamination of drinking water by these sources. This report is intended to meet the technical requirements for the completion of a SWDAR for the Lumberjack Saloon PWS, as required by the Montana Source Water Protection Program (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.

Limitations

This report was prepared to assess threats to the Lumberjack Saloon's public water supply, and is based on published information and information obtained from persons familiar with the area. The terms '*drinking water supply*' or '*drinking water source*' refer specifically to the source of the Lumberjack Saloon PWS, 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 vicinity of the Lumberjack Saloon public water supply are identified. Potential sources of contamination are considered only in areas that contribute water to the source water used by this PWS.

BACKGROUND

Geographic Setting

The Lumberjack Saloon is located on Graves Creek Road about 1.3 miles north of Highway 12 (and Lolo Creek) and about 16 miles west of the Town of Lolo along Highway 12. Lolo is located in the northern Bitterroot Valley, which is drained by the Bitterroot River. The river flows northward from the confluence of its two tributaries, the East Fork and the West Fork of the Bitterroot River, just south of Darby. It flows north towards Missoula where it joins the Clark Fork River on its journey to the Columbia River. The length of the valley is 60 miles and its width averages ~5 miles (Super, 1997). Figure 1 depicts the area along Lolo Creek and around the saloon. Near the intersection of Graves Creek Road and Highway 12 the valley floor is about 3,790 feet above sea level. The elevation near the Lumberjack Saloon appears to be around 3,910 feet elevation. The Sapphire Range climbs to 8,000 feet elevation to the east of Lolo. And to the west, some of the knife-edged ridges of the glaciated Bitterroot Mountains reach elevations up to 8,800 feet. The Bitterroot Valley is characterized by a semi-arid climate (Super, 1997).

Geologic and Hydrogeologic Setting

This section provides an overview of the geology and hydrology of the valley surrounding the Lumberjack Saloon and is based primarily on a geologic map of the area by Lonn and Berg (1999), other MBMG mapping and digital data sets, and well logs available from the Montana Bureau of Mines and Geology

(MBMG) Ground Water Information Center (GWIC). A geologic map for the area was developed and is seen on Figure 2. The geologic mapping for the area suggests that the saloon and other buildings in the Grave Creek and East Grave Creek drainages appear to be sitting on shallow and recent (Quaternary) alluvium deposited by the local streams. There are very few wells on record with the Montana Bureau of Mines and Geology – Ground Water Information Center (MBMG GWIC) for this valley. The well logs for these wells are attached at the end of this document. These logs suggest the presence of less than a couple of feet of alluvium or soil at the surface. The surface soil is underlain by ~15 feet of what is described as clay and broken rock or broken rock gravel. Beneath the clay and broken rock is the local bedrock. The local bedrock is comprised of various formations of the Belt Supergroup, which are thick tabular sequences and layers of meta-sedimentary mudstone (siltite), sandstone (quartzite), and carbonate rocks (limestone and dolomite). All of these rocks are very consolidated (hardened) with a low porosity and a relatively poor showing of interconnected water-bearing fractures. The Belt Supergroup bedrock seen in this area is the most common bedrock found throughout western Montana and northern Idaho. There are no granitic, metamorphic, or meta-sedimentary areas of bedrock nearby which are associated with the Idaho and Bitterroot Batholiths. In the area of the Lumberjack Saloon and other nearby facilities, the bedrock is at most 15-17 feet below ground surface (bgs). The sediments that blanket the bedrock in this area are Tertiary age alluvial fan or stream deposited sediments. The well logs for the area describe the sediment above the bedrock as clay and broken rock, and as broken rock and gravel. One or 2 feet of sediment at the surface are mapped as Qal, alluvium of modern stream channels, which is present in the area of the saloon and other local buildings. If this material is present at all, it is shallow and is draped over older Tertiary age sediments (Taf), its primary source is the Tertiary age sediment located upstream, and it probably consists of similar materials. In addition, there should be sand and gravel that eroded off of the older meta-sedimentary bedrock of the Belt Supergroup. The Tertiary age fluvial sediment is indicated as Taf on the geologic map (Figure 2). The Taf sediments are seen at the upper end of Graves Creek Road north of the saloon. The Taf deposit has been described as unconsolidated weathered cobbles and finer-grained sediment. The Tertiary aged sedimentary deposits are probably related to the common valley fill sediments that are found within all of the larger valleys of western Montana. These Tertiary valley fill deposits are almost always derived locally. The nearby streams draining the Bitterroot and Sapphire Mountains at several times during the Tertiary were involved in massive valley filling episodes. This happened during times when local streams (including the Bitterroot and Clark Fork Rivers) had insufficient stream flow to drain outside of the local basins/valleys due to a much drier climate. At these times local streams dropped all of their sedimentary load in the nearest valley and that valley had no stream that connected it to the next valley. The Tertiary fluvial sedimentary (Tsf) deposit found in the Grave Creek and East Fork Grave Creek drainages is typical of the sediments of this time being coarse-grained rock and gravel suspended in a fine matrix of clay and silt. The local deposits represent a basin that had been completely filled with locally derived sediments during Tertiary time. The original lateral extent of these deposits are hinted at by a scattering of isolated Tsf deposits south of the Grave Creek valley and along the north side of the Lolo Creek drainage. The original valley that received the old valley fill sediments we see in the Grave Creek valley must have been sufficiently isolated due to active faulting to prevent the erosion and complete removal of the older sediments by modern streams. Although a couple of smaller streams currently drain across these Tertiary age sediments, they have not yet been unable to completely remove them. These older Tertiary sedimentary deposits are actually a relic of a larger valley that occupied this location. The hills surrounding the valley and much of the sediments that filled it have been removed, leaving the valley floor and some of the oldest sediments filling it as a terrace at the north end of Graves Creek Road.

Figure 1 – Location Map

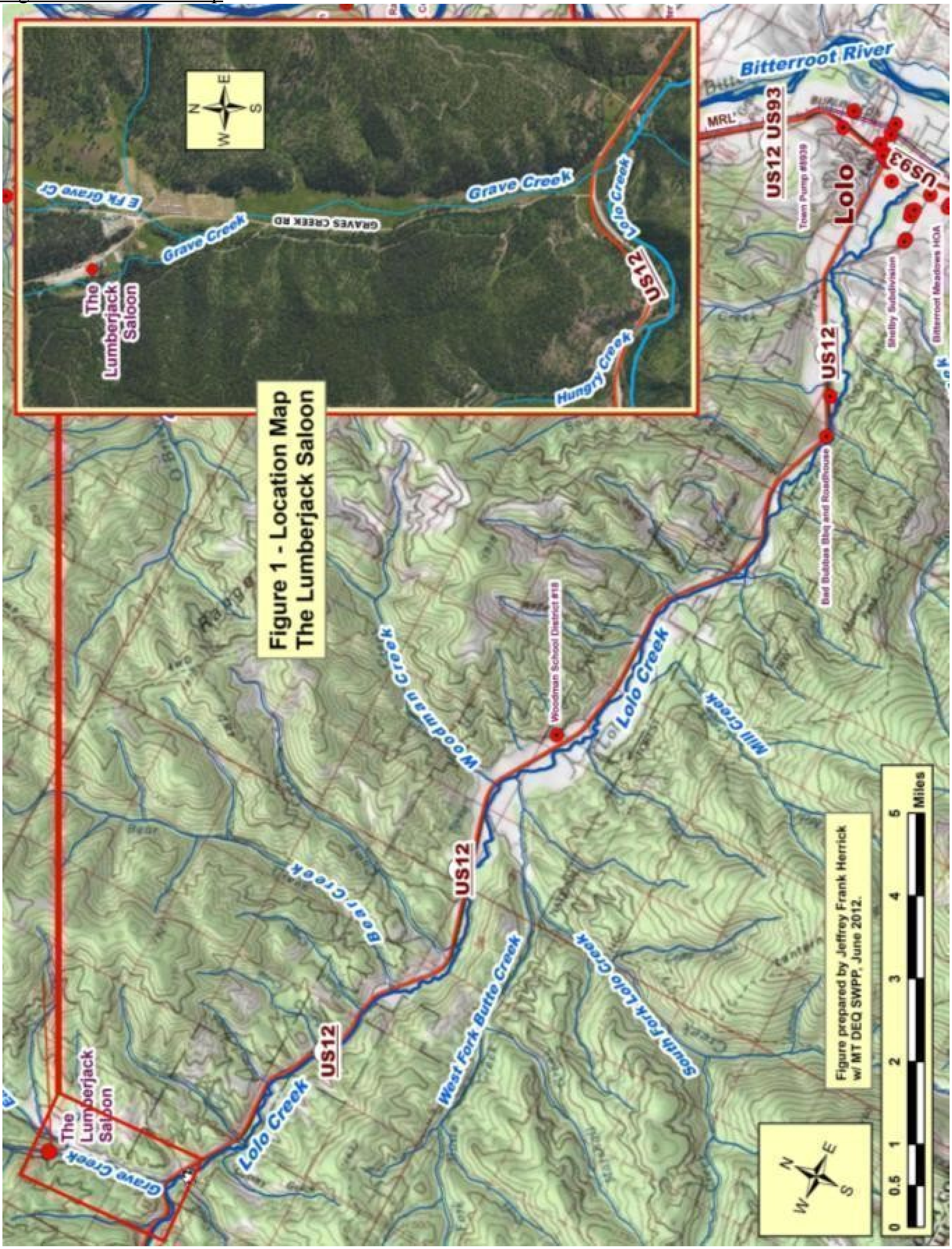


Figure 2 – Geologic Map

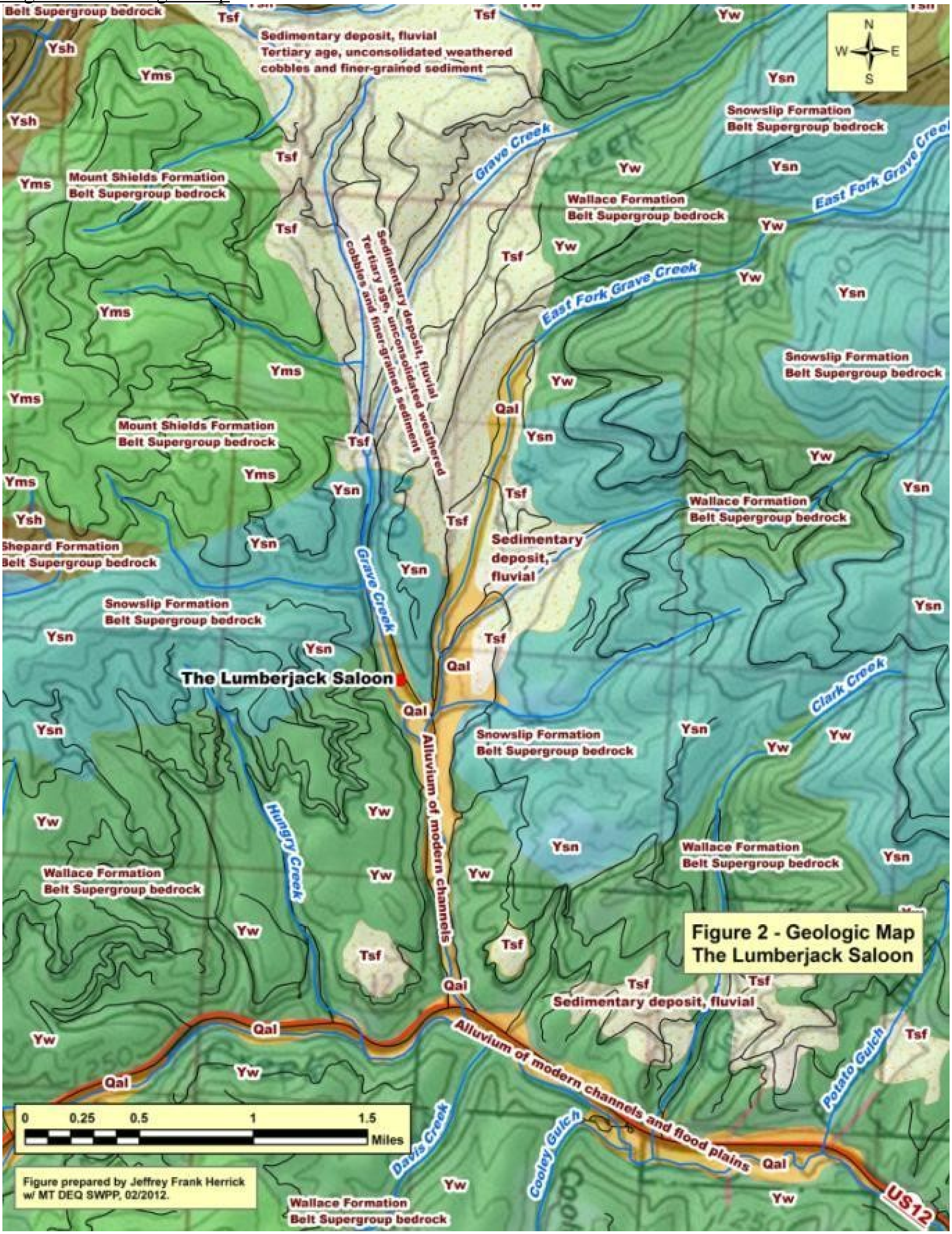
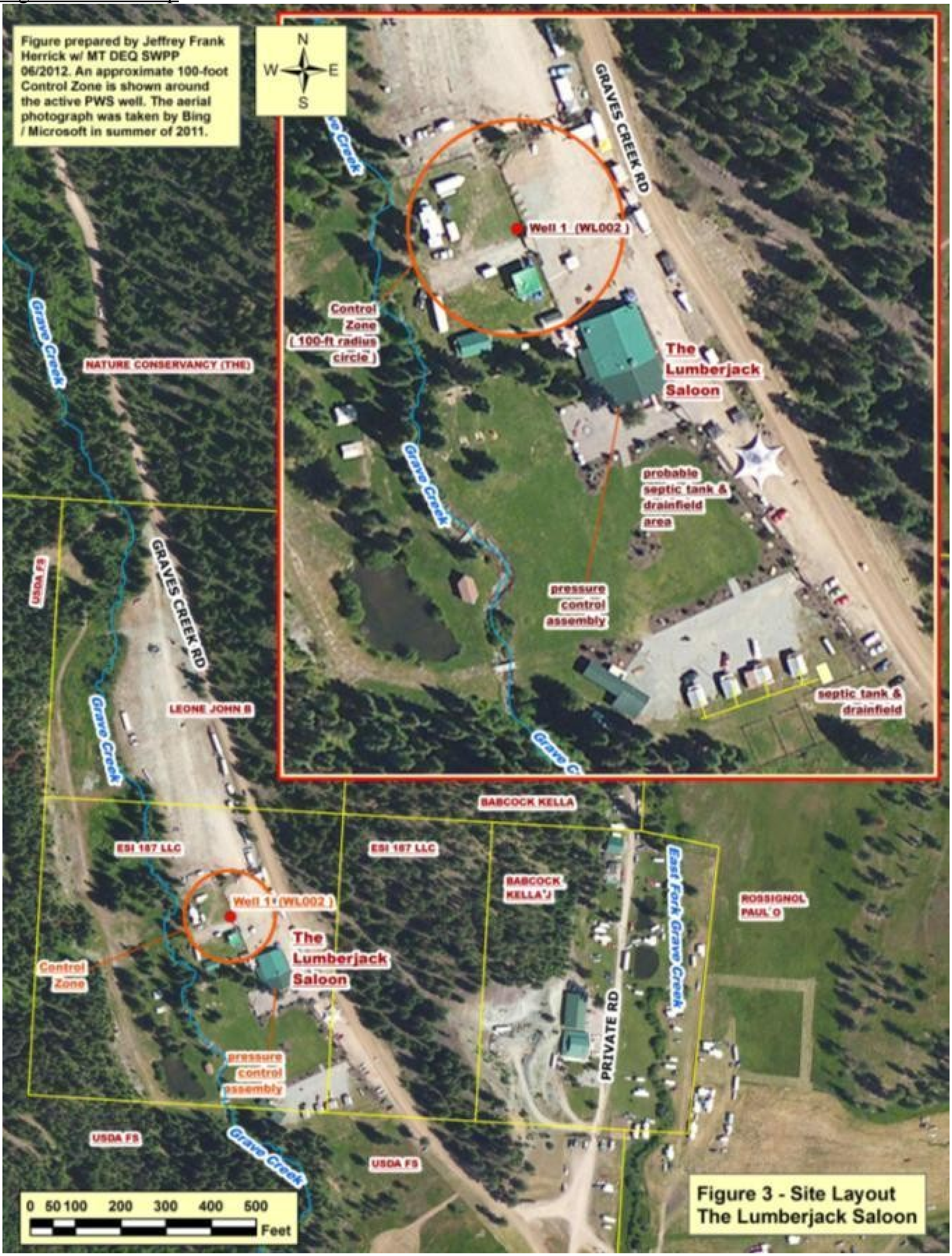


Figure 3 – Site Map



The Lumberjack Saloon and neighborhood buildings sit on Tertiary fluvial sedimentary deposits. These sediments are made up of shallow (15-17 feet thick) alluvial gravel and clay that blankets the local fractured meta-sedimentary bedrock. Nearby wells seem to have encountered groundwater at ~20 feet bgs (below ground surface), which places the groundwater below this sediment and within the fractured bedrock. Well depths are strictly dependent upon where sufficient inter-connected water-bearing fractures in the bedrock that are encountered during the well drilling process. The Lumberjack Saloon's well is 420 feet deep, the Babcock well is 260 feet deep, and the probably much older Larkin well is only 38 feet deep. These logs are found at the end of this SWDAR.

Climate

Information on climate in the area is based on the National Oceanic and Atmospheric Administration's (NOAA) Missoula climate station located at an elevation of 3,200 feet above mean sea level (Western Regional Climate Station). Average temperatures and total precipitation for the period of record are shown in Table 1 (as follows).

Table 1. Monthly Climate Summary
Missoula, Montana Climate Station
Station 245740 Period of Record: 04/05/1893 to 12/31/2005

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	30.7	36.8	46.6	58.8	67.2	74.6	85.8	83.5	71.7	58.4	42.2	33.3	57.5
Average Min. Temperature (F)	14.1	18.6	25.3	32.4	39.5	45.6	50.5	48.8	41.2	32.9	24.8	18.5	32.7
Average Total Precipitation (in.)	1.04	0.76	0.86	1.04	2.02	1.97	0.91	0.92	1.34	1.03	1.01	1.11	14.00
Average Total SnowFall (in.)	10.5	7.0	4.5	0.9	0.5	0.2	0.0	0.0	0.1	0.7	3.8	8.2	36.6
Average Snow Depth (in.)	4	1	0	0	0	0	0	0	0	0	0	2	1

Source: Western Regional Climate Center wrcc@dri.edu

General Description of the Source Water

Groundwater beneath the Lumberjack Saloon PWS and nearby facilities is present in the shallow and deep fractured sedimentary bedrock. The bedrock is covered by 15-17 feet of unconsolidated Tertiary alluvial clay and gravel. The static water level recorded during drilling in the 2 local wells is 20 feet bgs. The aquifer is probably essentially unconfined near the shallow bedrock surface, but it may act semi-confined. Locally, water flowing across the ground surface (in the creek) or standing in ponds at the surface as seen near the saloon is probably perched and not connected to (and might have little immediate interaction with) the top of the water table down in the bedrock. It is likely that the fine-grained sediments in the clay and gravel overburden actually perch any water on the surface. The Lumberjack Saloon's well consists of a 6-inch steel casing that extends from 2 feet above the ground to 420 feet bgs. There is a hint that some bentonite was used to seal around the well casing (per the driller regulations). This suggests that bentonite (probably in the dry granular form) was fed along the outside of the well casing as the 6-inch steel casing was advanced down the hole. This methodology has been and is acceptable by drillers' rules, but there is no assurance to what depth the seal extends or the adequacy the seal around the casing. In addition, the borehole drilled through the bedrock (with an unknown diameter) extends from 17 feet bgs to 420 feet bgs. There is no record or packers, grout, or other sealing methodology that would prevent water from seeping out of the fractured bedrock at 20 feet bgs and draining into the borehole, then flowing down the open borehole along the outside of the steel casing. The well was built with well screen section from 380-420 feet that acts as the intake for water to enter the well. Unfortunately, there seems to be no mechanism to prevent shallow near-surface water from entering the bedrock borehole near the top of the bedrock and flowing down the borehole to the well screen intake. Therefore, the effective intake interval for this well is between 17-20 feet bgs and 420 feet bgs. The bedrock aquifer used by this water system is recharged principally by precipitation and infiltration (rain and snowmelt), subsurface flow from upgradient, and water loss from streams through the shallow subsurface where bedrock is exposed at the surface in the vicinity of the stream channel. The depth to groundwater is probably around 20 feet bgs (below ground surface), which places it just below the top of the bedrock surface. Groundwater flow beneath this area is almost certainly from up-valley toward the south where it can discharge into Lolo Creek. Thus groundwater flow direction is sub-parallel to surface water flow in this area.

It should be noted that under current rules and requirements for new private and public water supply wells (by DEQ and Board of Water Well Contractors), the Lumberjack's PWS well (as currently built) would not meet acceptable construction standards. Current standards require new wells to be grouted/sealed to a minimum of 25 feet bgs. Because the water table was listed on the well log as 20 feet bgs, continuous feed of dry bentonite granules during casing advancement would probably not be an acceptable methodology to seal a new well. In addition, the well casing may be required to have one or more packers and/or seals in place at various depths to avoid the >380 feet of open borehole (the annulus around the well casing) above the well intake as seen in the PWS's well. These construction standards would be part of the plans and specifications required by DEQ prior to drilling the well. As a condition to operating the water system's new well, DEQ may also require the PWS to disinfect this water supply. Currently, public water systems with a static water table of 25 feet (or less) bgs are required to disinfect the water prior to serving the public. The Lumberjack Saloon is an older public water supply that was in operation and has a well installed prior to the newer requirements. So, for the moment it is not being required to adhere to the more protective above-mentioned restrictions.

The Public Water Supply

The Lumberjack Saloon public water supply has 1 commercial service connection that provides water each day for up to ~35 transient users and around 2 non-transients (day workers). At a guess, I suggest that the daily maximum number of transients and non-transients should be probably be greater to reflect the occasional summer peak days. The managers of this PWS should check these figures and update them with DEQ if they are inaccurate. The water system is served by a 420-foot well that was completed on 09 December 1994, and is located north of the saloon and west of the large parking area (see Figure 3). The precise location of the well was estimated based on older aerial photographs, so it is requested that the location of the well be confirmed using the provided map and a common hand-held GPS device. I've included the MBMG GWIC database well log printout for the PWS well with this report. DEQ classifies this water system as a Transient Non-Community PWS due to the nature of the population served. Tables 2 and 3 on the following page provide a tabular summary of this PWS and the PWS wells.

Table 2. The Lumberjack Saloon / Christian School PWS

DEQ PWS ID # MT0000803		**Transient Non-Community PWS**	
Total Population: 35 transients 2 non-transients		Service Connections: 1 commercial connection	
DEQ Facilities List		**Location**	
Facility Name	**DEQ ID**	**Latitude**	**Longitude**
Well #1 1994	**WL003**	**46.8031**	**-114.4062**
Well #1 Sample Pt.	EP503 RW003	*Well is Active*	
Spring 1 Abandoned	**SP002**		
Spring's Sample Pt.	EP502	*Spring is Inactive, sample point is inactive*	
Pressure Control Assembly for Well 1 1994	**PC001**		
Distribution System	**DS001**	Service to the saloon and grounds	
Distr. Sample Pt.	SP001	Sample point for the distribution lines	

Table 3. Well Log Information

W ell 1 1994 (WL003)	
Site Name on Log	**Lumberjack Saloon**
GWIC ID	**146109**
Owner Name	Lumberjack Saloon / Larkin Stuart
Location	See Table 2, above
Completion Date	09 December 1994
Driller	Jeromes Drilling Co. – Lic. WWC-249
Casings	-2-420 feet: 6 inch steel 380-420 feet: 6 inch screen
Well Seal	Bentonite mentioned, but no interval or method recorded
Total Depth	**420 feet bgs TD**
Static Water Level	**20 feet bgs – at time well was drilled**
Pumped at 7 gpm w/ drawdown to UNK feet bgs	

Note: The above information was drawn from the MBMG GWIC well logs. The MBMG GWIC well log is attached.

Water Quality

Every PWS is required to perform regular sampling of their water supply to detect contamination. The analytical parameters for transient non-community PWSs include: coliform bacteria and other pathogenic organisms, and nitrate-nitrite. The Lumberjack Saloon PWS's list of facilities, monitoring schedule, monitoring data (analytical history), and a summary of the regulatory history for the PWS are available from DEQ's PWS database (http://www.deq.mt.gov/wqinfo/pws/reports.mcpx).

Coliform bacteria have very occasionally detected in the system, but fecal coliform bacteria have never been detected at confirmed levels in the source water. The nitrite + nitrate concentrations from Well 1 1994 ranged from "not detected" to 0.38 mg/L. The concentrations detected are below EPA primary maximum contaminant level (MCL) of 10 mg/L. The low concentrations of nitrate + nitrite in the well water suggest that the overburden sediment (probably the Tertiary gravel & clay) is acting as a barrier to contamination at the surface. The owners and operators of this water system should watch these concentrations over time. If a pattern emerges or if the concentration of nitrate-nitrite seems to increase with time, steps can be taken to treat the water to reduce the concentration that reaches the consumers. At higher concentrations, nitrite and nitrate can have detrimental health effects on some individuals.

DELINEATION

Conceptual Model and Assumptions

Beneath this site are recent and ancestral (primarily Tertiary age) alluvial deposits comprised of gravel/rock and clay sediment. These deposits are generally 15-17 feet thick and overlie the local bedrock. The local bedrock is comprised of the Belt Supergroup meta-sedimentary rock and is generally a poor aquifer. Water within the rock is difficult to find in useful quantities. The ability of water to reach a well installed into bedrock is dependent on the presence of interconnected, open, and water-bearing fractures that are intersected by the well's borehole during drilling. The static water level was recorded during the drilling of 2 local wells as being encountered at 20 feet bgs. This places the static water level in the upper fractured bedrock, just below the surface of the bedrock. There is an active stream (Grave Creek) and a pond in the vicinity of the well, but the static water level in the well is believed to be deeper (at 20 feet bgs). This suggests that there may be a separation between the water at the surface and the groundwater present in the fractured bedrock. Although there is no evidence of a confined aquifer beneath this site, I believe that the fine-grained overburden at this location is acting as a localized aquitard that is restricting surface infiltration and other surface water interactions with the aquifer present in the bedrock. It is likely that the groundwater in the bedrock is behaving as a semi-confined aquifer at this location in the Grave Creek valley. The good bacteriological and nitrate + nitrite analytical history for this water system support the above assertion. Groundwater flow is likely to be directly down-valley, which is sub-parallel to surface water flow in the valley. The aquifer is recharged primarily from infiltration of surface water and precipitation through the overlying sand and gravel, but especially in areas where the bedrock is exposed at the surface. These recharge areas are on the flanks of the valley and higher in the mountains.

The aquifer serving this PWS is present in shallow fractured bedrock that is locally blanketed by 15-17 feet of clay-rich sediments. As such, the aquifer is considered semi-confined. Therefore, it has a Moderate Source Water Sensitivity to contamination at or near the surface. DEQ has defined sensitivity as the degree of ease with which contaminants may migrate to the source water aquifer. This determination is according to the DEQ Source Water Protection Program criteria for ranking aquifer sensitivity (DEQ 1999).

Delineation Results

Control Zone

A 100-foot radius Control Zone is delineated for the Lumberjack Saloon's active PWS well. All potential contaminant sources should be excluded from this region. Refer to Figure 3 – Site Map for a depiction of the Control Zone and surrounding properties.

Inventory Region

The Inventory Region for the Lumberjack Saloon PWS consists of a 1-mile radius circle around the PWS well. To make this region more appropriate, it was modified to eliminate much of the down-gradient area, resulting in a somewhat fan-shaped section that extends ~1-mile to the northwest (uphill) from the PWS. Refer to Figure 4 – Inventory Region. Potential sources of nitrate or pathogens are inventoried within this region.

Limiting Factors

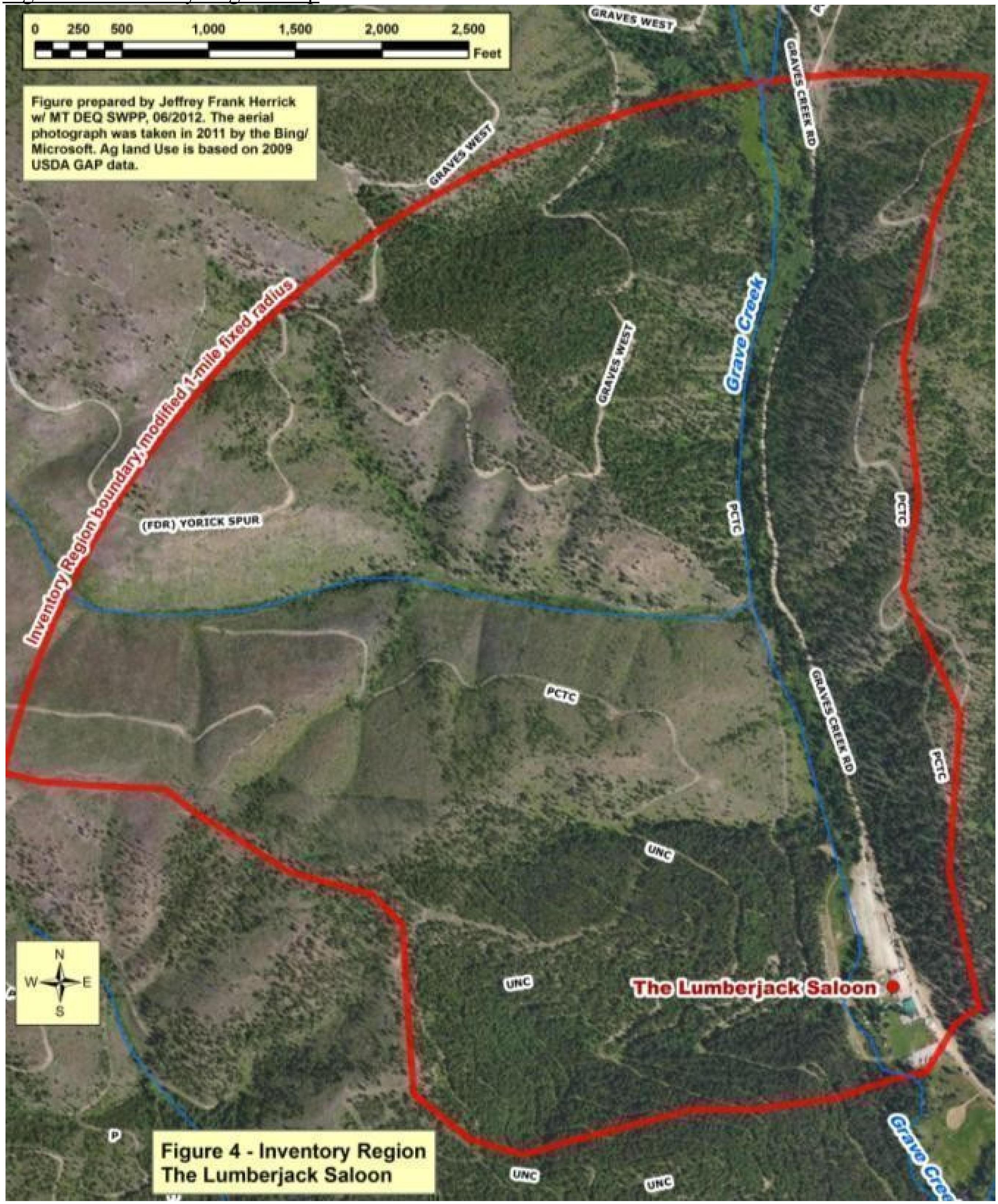
Delineation of the source water protection areas for the Lumberjack Saloon PWS well is based on a simplified approach using an arbitrary modified fixed radius. The interaction of surface water with the buried bedrock fracture patterns is complex and not completely understood (especially within a small area) and the changes in the flow regime under seasonal conditions are not known. This delineation was completed using conservative assumptions to help ensure that the source water protection areas reflect the actual area where contamination to the PWS may occur.

INVENTORY

Inventory Method

Significant potential contaminant sources (PCSs) in the source water protection areas (the Control Zone and Inventory Region) were inventoried to assess the susceptibility of the Lumberjack Saloon's PWS well to contamination, and to provide a foundation for protection planning. The inventory for this PWS's protection regions focuses on facilities or features that generate, use, store, or transport potential contaminants (pathogens and nitrate-nitrite). 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 drinking water sources is less likely when potential contaminants are properly used, managed, and/or disposed.

Figure 4 – Inventory Region Map



The inventory for the Lumberjack Saloon focuses on all activities in the Control Zone for the well and certain types of facilities and land uses in the Inventory Region. Information on facilities and land uses that are potential sources of regulated contaminants comes from a number of databases and other publicly available information sources.

Inventory Results

Control Zone

The Control Zone includes an open lot north of the saloon building and a grassed area directly west of the open lot. Grave Creek is located directly west of the Control Zone. The high-resolution aerial photo base used for Figure 3 was collected in the summer of 2011, so it is actually the most recent aerial photo of the property available at the time of this report. There are at least a couple of onsite septic disposal systems (septic tanks; pump chambers; sewer lines; and drainfields) servicing this property. One septic collection and disposal system appears to service the 4 cabins (and possibly a mobile home) located south of the saloon. The submittal plans and specification documents for this septic system indicated that the septic tank and drainfield are located to the east and probably southeast of the cabins. I assume that a septic tank and drainfield are associated with the saloon, but I couldn't find records to describe its construction or location. This septic system is classified as a large capacity septic system because of the number of people using it. My estimation is that the septic tank and drainfield servicing the saloon is in the lawn area directly south of the saloon building. If this assumption is wrong, please contact DEQ and provide a more accurate location. I did not find any records indicating that any of the mobile homes or house trailers seen in the aerial photo (located northwest of the saloon) connect directly to its septic system or are allowed to periodically dump to this system. It appears that both onsite septic systems (for the saloon and cabins) are located downgradient and outside of the Control Zone. The 2011 aerial photograph indicates the presence of several unidentified buildings in the area near the wellhead. These structures may be temporary/seasonal tents or other similar structures. If these small buildings are used to store chemicals, paint products, or fuel, then they should be moved outside of the Control Zone for the well. There are a couple of mobile homes / house trailers located within or on the perimeter of the Control Zone. If these trailers are connected to the septic system servicing the saloon, their septic lines would probably run through the Control Zone. The integrity of these lines would be a concern. If these trailers are not serviced by the saloon's septic system (which is more likely), they will have on-board wastewater and septic waste reservoirs. It appears that the wellhead is located directly adjacent to the parking lot and to a roadway used to move these trailers in and out of this area. The hazard from these and other mobile homes occurs when moving, maneuvering, and parking these vehicles or trailers. During passage of these vehicles past or near the wellhead, they might back into or collide with the wellhead and rupture their sewage and wastewater storage tanks. Such a spill near the well may increase the odds that this sewage will migrate down along the outside of the well casing and reach the water table 20 feet below the ground surface.

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 well casing is maintained. A positive drainage away from the wellhead can be created by the placement of sufficient soil in the area of the well such that no water can collect and pool at the surface. Even when a well is properly grouted, the sediment along the outside of the well casing is a preferred pathway for surface water infiltration. The positive drainage away from the wellhead will significantly reduce the likelihood of this sort of water movement that can seriously contaminate water quality in the drinking water system.

Inventory Region

The inventory results for the Lumberjack Saloon PWS's Inventory Region are summarized in Table 4 and are shown on Figure 4. The inventory of significant potential contaminant sources (PCSs) includes the large capacity septic system serving the Lumberjack Saloon. Also present in the region are extensive scattered areas that have been clear-cut logged. Erosion of soil (and nitrate from these soils) off of the clear-cut slopes and roads has a small potential of allowing contamination reach groundwater beneath the valley floor of Grave Creek. Large vehicles such as trucks and motor homes have the capacity to carry large amounts of fuel. If one of these vehicles that is parked along Graves Road and near the valley margin (near very shallow soils or exposed bedrock), any spill of fuel (or septic effluent) would easily recharge groundwater through the fractured rock. I believe this to be an extremely infrequent event with a very small potential of impacting groundwater. As such, it is mentioned here, but will not be included in the list of hazards or the assessment of susceptibility in the following pages. It is not considered a significant potential contaminant source. All the same, I suggest that you do not park fuel trucks along the valley margin and near areas that are essentially windows into the bedrock.

Of these inventoried PCSs found outside of the Control Zone, but within the Inventory Region, only the large capacity septic system has any real potential to allow nitrates and/or pathogens to reach groundwater near the PWS well. The potential hazard assigned these PCSs is presented in Table 4 below. The actual potential susceptibility of the PWS well to these PCSs is assessed in the next section. Susceptibility reflects the fact that there are several types of barriers that may stand between a PCS and the PWS well.

Table 4. Inventory Of Potential Contaminant Sources
(For significant potential contaminant sources in the Inventory Region)

Source	Contaminant	Hazard	Hazard Rating
Collisions of trailers or motor homes with the wellhead. These collisions may result in the rupturing of a septic waste tank at or near the wellhead.	Pathogens and nitrate	Spills of effluent at the wellhead that may infiltrate along the outside of the well's casing and reach the open annulus around the well casing inside the bedrock borehole.	High Due to the close proximity of traffic to the wellhead.
The Lumberjack Saloon's onsite septic systems. This includes the tanks, lines, and drainfield. This is a large capacity septic system.	Pathogens and nitrate	Leaks, effluent discharge that may be poorly treated that might reach the water table.	High Due to proximity of the large septic systems to the PWS well.
Heavily logged USDA Forest Service Land Any potential for contamination from this activity may be from excessive erosion of logging roads. This is generally very soon after the logging activities end.	Nitrate. This would be nitrate that is contained in eroded soils. Generally this is only a small by-product of erosion and has little effect on groundwater.	Non-point source contamination on valley margins that may reach groundwater in the shallow bedrock.	Low This is an activity that is very unlikely to have any impact to groundwater in the deep bedrock beneath the saloon.

SUSCEPTIBILITY ASSESSMENT

Hazard and Susceptibility

The threat of contamination is referred to as hazard. The degree of hazard is determined by: the proximity of a potential contaminant source (PCS) to a well intake; potential contaminant migration pathways; or by the density of potential non-point contaminant sources. Table 4 (above) lists the inventoried PCSs and Figure 4 (in the previous section) depicts their locations.

Susceptibility is an expression of the probability for a public water supply to be contaminated by inventoried PCSs at concentrations that would pose a concern. Susceptibility is assessed to prioritize potential pollutant sources and focus attention on management strategies that may reduce the likelihood of contamination events. Several management strategies that could be used by the PWS managers and operators are recommended in this chapter. Susceptibility is determined by considering the hazard rating for each PCS relative to any barriers that may stand between the PCS and the PWS well. Barriers to contamination are anything that decreases the likelihood that contaminants will reach a spring or well. Barriers can be any of the following items: a) engineered structures, b) management actions, or c) natural conditions.

- Examples of engineered barriers include spill catchment structures and leak detection for underground storage tanks.
- Emergency planning and best management practices (BMPs) are considered management barriers.
- Thick clay-rich soils, a deep water table, or a thick saturated zone above the well intake are examples of natural barriers.

A summary of the susceptibility assessment for the Lumberjack Saloon production well is provided in Table 5 (below).

The greatest threats to the Lumberjack Saloon PWS well (i.e., the PCS for which the well is most susceptible) appears to be 1) the location and movement of house trailers or motor homes around the wellhead; and 2) the facility's own onsite large capacity septic disposal system. The PWS well has a moderate susceptibility to nitrate and pathogenic contamination from both of these potential sources. The well has a very low susceptibility to potential contamination from the erosion of soils off some of the logged areas in the watershed.

Management Recommendations

Note that even small releases of some chemicals in close proximity to a public water supply well might have significant negative impact on water quality, and therefore are a significant threat to the public water supply. System managers can take steps to reduce the likelihood of releases into the source water for the PWS. The susceptibility table (Table 5) details management recommendations for protecting the Lumberjack Saloon and school's drinking water supply. Implementing these management recommendations together with other similar actions should act as additional barriers between a contaminant source and the PWS well. Collectively they should reduce the susceptibility of the well intake to specific contaminant sources.

Table 5. Susceptibility Assessment
(For significant potential contaminant sources in the Control Zone and Inventory Region)

Source	Contaminant	Hazard	Hazard Rating	Barriers	Susceptibility	Management
Collisions of trailers or motor homes with the wellhead. These collisions may result in the rupturing of a septic waste tank at or near the wellhead.	Pathogens and nitrate	Spills of effluent at the wellhead that may infiltrate along the outside of the well's casing and reach the open annulus around the well casing inside the bedrock borehole.	High Due to the close proximity of traffic to the wellhead.	• There is 15-17 feet of clay-rich sediments beneath the site (and above the fractured bedrock). This clay-rich sediment probably behaves as a local natural barrier. If the PWS well is properly grouted, the seal and the sediment can add significant protection as they together stand between the surface and the well's intake. • More than 50 feet separate the static water level from the intake of the well. The static water level is probably at ~20 feet bgs, the well's intake (slots in the well casing) are at 380-420 feet bgs.	**Moderate Susceptibility**	• Attempt to manage the how close these trailers can get to the wellhead using traffic barriers and guards. If a good separation distance is maintained between the wellhead and any vehicles parking or moving near the well, then most of this threat is eliminated.
The Lumberjack Saloon's onsite septic systems. This includes the tanks, lines, and drainfield. This is a large capacity septic system.	Pathogens and nitrate	Leaks, effluent discharge that may be poorly treated that might reach the water table.	High Due to proximity of the large septic systems to the PWS well.	• The tanks and drainfields are presumed to be south of the well, which is not upgradient from the well (if groundwater flows to the south). Thus the mixing zones from the drainfields are believed to extend to the south. • There is 15-17 feet of clay-rich sediments beneath the site (and above the fractured bedrock). This clay-rich sediment probably behaves as a local natural barrier. If the PWS well was properly grouted, the seal and the sediment can add significant protection as they together stand between the surface and the well's intake. • More than 50 feet separate the static water level from the intake of the well. The static water level is probably at ~20 feet bgs, the well's intake (slots in the well casing) are at 380-420 feet bgs.	**Moderate Susceptibility**	• Attempt to manage the volumes and types of chemicals that are dumped to the onsite septic systems. This can be done by posting notices at all sinks and drains. Some of these chemicals are extremely difficult for bacteria to eliminate or will actually kill off the bacteria that treat septic effluent. • Ensure that the septic tanks are pumped on a regular basis to maintain proper treatment. These systems can build up solids and reach a point where they fail to treat the effluent, and may do so without the septic lines backing up. • Montana DEQ Source Water Protection can and does provide free training classes on the management of small well and septic systems.

Table 5. Susceptibility Assessment
(For significant potential contaminant sources in the Control Zone and Inventory Region)

Source	Contaminant	Hazard	Hazard Rating	Barriers	Susceptibility	Management
Heavily logged USDA Forest Service Land Any potential for contamination from this activity may be from excessive erosion of logging roads. This is generally very soon after the logging activities end.	Nitrate. This would be nitrate that is contained in eroded soils. Generally this is only a small by-product of erosion and has little effect on groundwater.	Non-point source contamination on valley margins that may reach groundwater in the shallow bedrock.	Low This is an activity that is very unlikely to have any impact to groundwater in the deep bedrock beneath the saloon.	• There is 15-17 feet of clay-rich sediments beneath the site (and above the fractured bedrock). This clay-rich sediment probably behaves as a local natural barrier. If the PWS well is properly grouted, the seal and the sediment can add significant protection as they together stand between the surface and the well's intake. • More than 50 feet separate the static water level from the intake of the well. The static water level is probably at ~20 feet bgs, the well's intake (slots in the well casing) are at 380-420 feet bgs.	**Very Low Susceptibility**	• Coordinate road maintenance or restoration activities with Plum Creek Timber Company, the USDA Forest Service, and/or the Nature Conservancy.

Note : The above susceptibility determination is for a well that withdraws water from a semi-confined aquifer. Groundwater flow direction is to the south.

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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.

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.

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

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.

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.

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.

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.

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

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.

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 groundwater at increased levels that may exceed MCLs.

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

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).

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.

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.

Static Water Level (SWL). Water level elevation 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.

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

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.

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

APPENDIX A – WELL LOGS

Note: Well logs are available through the Montana Bureau of Mines and Geology's Ground-Water Information Center (MBMG GWIC). What follows is the Lumberjack Saloon PWS's well logs; followed by a couple of nearby well logs.

MONTANA WELL LOG REPORT

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

Site Name: LUMBERJACK SALOON
GWIC Id: 146109

Section 1: Well Owner

Owner Name
LUMBERJACK SALOON/LARKIN STUART
Mailing Address
7000 GRAVES CREEK RD.

City	State	Zip Code
LOLO	MT	59847

Section 2: Location

Township	Range	Section	Quarter Sections
12N	22W	18	NW¼ SW¼ NE¼ NE¼

County	Geocode
MISSOULA	

Latitude	Longitude	Geomethod	Datum
46.803	114.4052	NAV-GPS	NAD27

Ground Surface Altitude	Method	Datum	Date
3920			6/18/1999

Measuring Point Altitude	Method	Datum	Date Applies
3921.7			6/18/1999 1:21:00 PM

Addition	Block	Lot

Section 3: Proposed Use of Water

DOMESTIC (1)

Section 4: Type of Work

Drilling Method: ROTARY

Section 5: Well Completion Date

Date well completed: Friday, December 09, 1994

Section 6: Well Construction Details

There are no borehole dimensions assigned to this well.

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
-2	420	6				STEEL

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
380	420	6			4IN PRE-SLOTTED

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
0	0	BENTONITE	

Section 7: Well Test Data

Total Depth: 420
Static Water Level: 20
Water Temperature:

Air Test *

_7_ gpm with drill stem set at _ feet for _4_ hours.
Time of recovery _ hours.
Recovery water level _ feet.
Pumping water level _ feet.

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

Section 8: Remarks

JEROME'S DRILLING FILE NO: 6186

Section 9: Well Log

Geologic Source
400BELT - BELT SUPERGROUP

From	To	Description
0	4	SOIL CLAY
4	9	CLAY BROKEN ROCK
9	17	CLAY BROKEN ROCK
17	110	ROCK
110	155	ROCK
155	420	ROCK

Driller Certification

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

Name:	
Company:	JEROMES DRILLING CO
License No:	WWC-249
Date Completed:	12/9/1994

Location Information

Sample Id/Site Id:	1999Q0848 / 146109	Sample Date:	6/18/1999 1:21:00 PM
Location (TRS):	12N 22W 18 AACB	Agency/Sampler:	MBMG / CAC
Latitude/Longitude:	46° 48' 10" N 114° 24' 18" W	Field Number:	146109
Datum:	NAD27	Lab Date:	8/4/1999
Altitude:	3920	Lab/Analyst:	MBMG / BJK
County/State:	MISSOULA / MT	Sample Method/Handling:	/ 4220
Site Type:	WELL	Procedure Type:	DISSOLVED
Geology:	400BELT	Total Depth (ft):	420
USGS 7.5' Quad:	GARDEN POINT	SWL-MP (ft):	57.94
PWS Id:		Depth Water Enters (ft):	380
Project:	GWCP04		

Major Ion Results

	mg/L	meq/L		mg/L	meq/L
Calcium (Ca)	12.100	0.604	Bicarbonate (HCO3)	197.600	3.239
Magnesium (Mg)	11.000	0.905	Carbonate (CO3)	0.000	0.000
Sodium (Na)	41.800	1.818	Chloride (Cl)	1.006	0.028
Potassium (K)	2.590	0.066	Sulfate (SO4)	11.900	0.248
Iron (Fe)	0.008	0.000	Nitrate (as N)	<.5 P	0.000
Manganese (Mn)	0.004	0.000	Fluoride (F)	0.217	0.011
Silica (SiO2)	8.790		Orthophosphate (as P)	<.05	0.000
Total Cations		3.410	**Total Anions**		3.526

Trace Element Results (µg/L)

Aluminum (Al):	<30	Cesium (Cs):	NR	Molybdenum (Mo):	<10	Strontium (Sr):	572.000
Antimony (Sb):	5.240	Chromium (Cr):	<2	Nickel (Ni):	<2	Thallium (Tl):	<5
Arsenic (As):	<1	Cobalt (Co):	<2	Niobium (Nb):	NR	Thorium (Th):	NR
Barium (Ba):	198.000	Copper (Cu):	<2	Neodymium (Nd):	NR	Tin (Sn):	NR
Beryllium (Be):	<2	Gallium (Ga):	NR	Palladium (Pd):	NR	Titanium (Ti):	<10
Boron (B):	<30	Lanthanum (La):	NR	Praseodymium (Pr):	NR	Tungsten (W):	NR
Bromide (Br):	<50	Lead (Pb):	<2	Rubidium (Rb):	NR	Uranium (U):	NR
Cadmium (Cd):	<2	Lithium (Li):	<50	Silver (Ag):	<1	Vanadium (V):	<5
Cerium (Ce):	NR	Mercury (Hg):	NR	Selenium (Se):	<1	Zinc (Zn):	87.700
						Zirconium (Zr):	<5

Field Chemistry and Other Analytical Results

**Total Dissolved Solids (mg/L):	187.720	Field Hardness as CaCO3 (mg/L):	NR	Ammonia (mg/L):	NR
**Sum of Diss. Constituents (mg/L):	288.190	Hardness as CaCO3:	75.490	T.P. Hydrocarbons (µg/L):	NR
Field Conductivity (µmhos):	309	Field Alkalinity as CaCO3 (mg/L):	NR	PCP (µg/L):	NR
Lab Conductivity (µmhos):	303	Alkalinity as CaCO3 (mg/L):	162.39	Phosphate, TD (mg/L as P):	<.1
Field pH:	8.5	Ryznar Stability Index:	8.113	Field Nitrate (mg/L):	0.000
Lab pH:	8.3	Sodium Adsorption Ratio:	2.103	Field Dissolved O2 (mg/L):	NR
Water Temp (°C):	10.9	Langlier Saturation Index:	0.093	Field Chloride (mg/L):	NR
Air Temp (°C):	NR	Nitrite (mg/L as N):	NR	Field Redox (mV):	281.8
Nitrate + Nitrite (mg/L as N)	NR	Hydroxide (mg/L as OH):	NR	Lab, Dissolved Organic Carbon (mg/L):	NR
Total Kjeldahl Nitrogen (mg/L as N)	NR	Lab, Dissolved Inorganic Carbon (mg/L):	NR	Lab, Total Organic Carbon (mg/L):	NR
Total Nitrogen (mg/L as N)	NR	Acidity to 4.5	NR	Acidity to 8.3	NR
As(III) (ug/L)	NR	As(V) (ug/L)	NR		

Notes

Sample Condition:
Field Remarks:
Lab Remarks:

Explanation: **mg/L** = milligrams per Liter; **µg/L** = micrograms per Liter; **ft** = feet; **NR** = No Reading in GWIC

Qualifiers: **A** = Hydride atomic absorption; **E** = Estimated due to interference; **H** = Exceeded holding time; **J** = Estimated quantity above detection limit but below reporting limit; **K** = Na+K combined; **N** = Spiked sample recovery not within control limits; **P** = Preserved sample; **S** = Method of standard additions; **U** = Undetected quantity below detection limit; * = Duplicate analysis not within control limits; ** = Sum of Dissolved Constituents is the sum of major cations (Na, Ca, K, Mg, Mn, Fe) and anions (HCO3, CO3, SO4, Cl, SiO2, NO3, F) in mg/L. Total

Dissolved Solids is reported as equivalent weight of evaporation residue.

Ground-Water Information Center — Isotope Tracer Report

Site Name: LUMBERJACK SALOON — **Report Date:** 6/18/2012

Location Information

Sample Id/Site Id:	1999R0044 / 146109	Sample Date:	6/18/1999 1:21:00 PM
Location (TRS):	12N 22W 18 AACB	Agency/Sampler:	MBMG /
Latitude/Longitude:	46° 48' 10" N 114° 24' 18" W	Field Number:	
Datum:	NAD27	Lab Date:	
Altitude:	3920	Lab/Analyst:	WATE /
County/State:	MISSOULA / MT	Sample Method/Handling:	/
Site Type:	WELL	Procedure Type:	
Geology:	400BELT	Total Depth (ft):	420
USGS 7.5' Quad:	GARDEN POINT	SWL-MP (ft):	57.94
PWS Id:		Depth Water Enters (ft):	380
Project:	GWCP04		

Radon (Rn222 - pC/L):	NR	Argon (Ar39):	NR
Carbon (C13):	NR	Silicon (Si32):	NR
Carbon (C14):	NR	Chlorine (Cl36):	NR
Tritium (H3 - TU):	<0.8	Lithium (Li6):	NR
H3/He3 Ratio:	NR	Krypton (Kr85):	NR
Deuterium (H2):	NR	Boron (B11)	NR
Oxygen (O18):	NR	Strontium (Sr87)	NR
Sulphur (S34):	NR	Chloro-fluorocarbon (CFC-11):	NR
Iodine (I129):	NR	Chloro-fluorocarbon (CFC-12):	NR
Nitrogen (N15):	NR	Chloro-fluorocarbon (CFC-113):	NR
Nitrogen (N15 of Nitrate):	NR	Oxygen (O18 of Nitrate):	NR
Sulphur (S34 of Sulfate):	NR	Oxygen (O18 of Sulfate):	NR

Explanation: **pC/L** = picocuries per Liter; **TU** = Tritium Units; **NR** = No Reading in GWIC

Form No. 603 (R 2-89)

WELL LOG REPORT

File No. 6186 1076

State law requires that the Bureau's copy be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name LumberJack Saloon

2. CURRENT MAILING ADDRESS
7000 Graves Cr.Rd. LoLo MT.59847

3. WELL LOCATION
SE ¼ NE ¼ ¼ Section 18
Township 12 N/S Range 22 E/W County Msla
Govn't Lot ____, or Lot ____, Block ____
Subdivision Name ____
Tract Number ____

4. PROPOSED USE: Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify ____

5. TYPE OF WORK:
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☒
Reconditioned ☐ Rotary ☒ Jetted ☐

6. DIMENSIONS: Diameter of Hole
Dia. ____ in. from ____ ft. to ____ ft.
Dia. ____ in. from ____ ft. to ____ ft.
Dia. ____ in. from ____ ft. to ____ ft.

7. CONSTRUCTION DETAILS:
Casing; Steel Dia. 6" from +2 ft. to 420 ft.
Threaded ☐ Welded ☒ Dia. ____ from ____ ft. to ____ ft.
Type A53B Wall Thickness .250
Casing; Plastic Dia. 4" from -20 ft. to 420 ft.
Weight ____ Dia. ____ from ____ ft. to ____ ft.
PERFORATIONS: Yes ☒ No ☐
Type of perforator used Pre-slotted PVC
Size of perforations ____ in. by ____ in.
4" perforations from 380 ft. to 420 ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

SCREENS: Yes ☐ No ☒
Manufacturer's Name ____
Type ____ Model No. ____
Dia. ____ Slot size ____ from ____ ft. to ____ ft.
Dia. ____ Slot size ____ from ____ ft. to ____ ft.

GRAVEL PACKED: Yes ☐ No ☒ Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

GROUTED: To what depth? ____ ft.
Material used in grouting Bentonite. Sealed as required by rule #36-21-654.

8. WELL HEAD COMPLETION:
Pitless Adapter ☐ Yes ☒ No

9. PUMP (if installed)
Manufacturer's name ____
Type ____ Model No. ____ HP. ____

10. WELL TEST DATA
The information requested in this section is required for all wells. All depth measurements shall be from the top of the well casing.
All wells under 100 gpm must be tested for a minimum of one hour and provide the following information:
a) Air X Pump ____ Bailer ____
b) Static water level immediately before testing 20 ft. If flowing; closed-in pressure ____ psi. ____ gpm.
Flow controlled by: ____ valve, ____ reducers, ____ other, (specify) ____
c) Depth at which pump is set for test ____
d) The pumping rate: 7 gpm.
e) Pumping water level ____ ft. at ____ hrs. after pumping began.
f) Duration of test: Pumping time 4 hrs.
g) Recovery time 1 hrs.
h) Recovery water level 40 ft. at 4 hrs. after pumping stopped.

Wells intended to yield 100 gpm or more shall be tested for a period of 8 hours or more. The test shall follow the development of the well, and shall be conducted continuously at a constant discharge at least as great as the intended appropriation. In addition to the above information, water level data shall be collected and recorded on the Department's "Aquifer Test Data" form.

NOTE: All wells shall be equipped with an access port ½ inch minimum or a pressure gauge that will indicate the shut-in pressure of a flowing well. Removable caps are acceptable as access ports.

11. WAS WELL PLUGGED OR ABANDONED? ____ Yes X No
If yes, how? ____

12. WELL LOG

Depth (ft.) From	To	Formation
0	4	soil, clay
4	9	clay, broken rock
9	17	clay, broken rock
17	110	rock
110	155	rock
155	420	rock

PE

ATTACH ADDITIONAL SHEETS IF NECESSARY

13. DATE COMPLETED 12-9-94

14. DRILLER/CONTRACTOR'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

12-12-94
Date

Jerome's Drilling Co; Inc.
Firm Name

P O Box 4845, Missoula, MT 59806
Address

[signature] 249
Signature License No.

MONTANA WELL LOG REPORT

Site Name: BABCOCK KELLA
GWIC Id: 193694
DNRC Water Right:

Section 1: Well Owner

Owner Name		
BABCOCK KELLA		
Mailing Address		
PO BOX 224		
City	**State**	**Zip Code**
LOLO	MT	59847

Section 2: Location

Township	Range	Section	Quarter Sections
12N	22W	18	SW¼ NE¼

County	Geocode
MISSOULA	

Latitude	Longitude	Geomethod	Datum
46.799876	114.41062	TRS-SEC	NAD83

Ground Surface Altitude	Method	Datum	Date

Addition	Block	Lot

Section 3: Proposed Use of Water
DOMESTIC (1)

Section 4: Type of Work
Drilling Method: ROTARY

Section 5: Well Completion Date
Date well completed: Thursday, December 06, 2001

Section 6: Well Construction Details

Borehole dimensions

From	To	Diameter
0	260	6

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
-3	100	6	0.250			STEEL

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
30	95	6		3/16X1	FACTORY/ HOLTE
220	260	6		3/16X1	FACTORY/ HOLTE

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
0	0	BENTONITE	

Section 7: Well Test Data

Total Depth: 260
Static Water Level: 20
Water Temperature:

Air Test *

_4_ gpm with drill stem set at _250_ feet for _2_ hours.
Time of recovery _2_ hours.
Recovery water level _20_ feet.
Pumping water level _ feet.

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

Section 8: Remarks

Section 9: Well Log
Geologic Source
400BELT - BELT SUPERGROUP

From	To	Description
0	2	SOIL
2	15	BROKEN ROCK GRAVEL
15	95	GREEN FRACTURED ROCK
95	260	GREEN RED ROCK WITH SEEPAGE

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

Name:
Company: JEROMES DRILLING CO
License No: WWC-600
Date Completed: 12/6/2001

MONTANA WELL LOG REPORT

Form No. 603 R2-99

Well ID# 8533

This log reports the activities of a licensed Montana well driller and serves as the official record of work done within the borehole and casing and describes the amount of water encountered. **This form is to be completed by the driller and filed with DNRC within 60 days of completion of the work. Acquiring Water Rights is the well owner's responsibility and is not accomplished by the filing of this report.**

Well log information is stored in the Groundwater Information Center at the Montana Bureau of Mines and Geology (Butte) and water right information is stored in the Water Rights Bureau records (Helena).

For fields that are not applicable, enter NA. Optional fields have a grayed background. Record additional information in the REMARKS section.

1. WELL OWNER:
Name Kella Babcock
Mailing address P.O. box 224
Lolo Montana 59847

2. WELL LOCATION: List ¼ from smallest to largest
SW ¼ NE ¼ ____ ¼ ____ ¼, Section 18
Township 12N N/S Range 22W E/W County Missoula
Lot ____, Tract/Blk ____ Subdivision Name ____
Well Address ____
GPS ☐ Yes ☒ No
Latitude ____ Longitude ____
Error as reported by GPS locator (± feet) ____
Horizontal datum ☐ NAD27 ☐ WGS84

3. PROPOSED USE: ☒ Domestic ☐ Stock ☐ Irrigation ☐ Public water supply ☐ Monitoring Well ☐ Other: ____

4. TYPE OF WORK:
☒ New well ☐ Deepen existing well ☐ Abandon existing well
Method: ☐ Cable ☒ Rotary ☐ Other: ____

5. WELL CONSTRUCTION DETAILS:

Borehole:
Dia. 6" in. from G-Level ft. to 260' ft.
Dia. ____ in. from ____ ft. to ____ ft.
Dia. ____ in. from ____ ft. to ____ ft.

Casing:
Steel: Wall thickness .250 ☐ Threaded ☒ Welded
Dia. 6" in. from +2 ft. to 100' ft.
Dia. ____ in. from ____ ft. to ____ ft.

Plastic: Pressure Rating ____ lbs. ☐ Threaded ☐ Welded
Dia. ____ in. from ____ ft. to ____ ft.

Perforations/Slotted Pipe:
Type of perforator used Holte / Factory
Size of perforations/slots 3/16 in. by 1" in.
65+ no. of perforations/slots from 30' ft. to 95' ft.
40+ no. of perforations/slots from 220' ft. to 260' ft.

Screens: ☐ Yes ☒ No
Material ____
Dia. ____ Slot size ____ from ____ ft. to ____ ft.
Dia. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel Packed: ☐ Yes ☒ No
Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Packer: ☐ Yes ☒ No
Type ____ Depth(s) ____

Grout: Material used Bentonite
Depth from ____ ft. to ____ ft. OR ☒ Continuous feed

6. WELL TEST DATA:
A well test is required for all wells. (*See details on well log report cover.*)
☒ Static water level 20' ft. below top of casing **or**
☐ Closed-in artesian pressure ____ psi.
How was test flow measured:
~~bucket/stopwatch~~, weir, flume, flowmeter, etc ____

Yellowstone Controlled Groundwater Area - Water Temperature ____ °F
☐ AQUIFER TEST DATA FORM ATTACHED

Test - 1 hour minimum
Drawdown is the amount water level is lowered below static level.
All depth measurements shall be from the top of the well casing.
Time of recovery is hours/minutes since pumping stopped.

Air test*
4 gpm with drill stem set at 250' ft. for 2hrs hours
Time of recovery 2hrs hrs/min. Recovery water level 20' ft.

OR Bailer test*
____ gpm with ____ ft. of drawdown after ____ hours
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Pump test*
Depth pump set for test ____ ft.
____ gpm pump rate with ____ ft. of drawdown after ____ hrs pumping
Time of recovery ____ hrs/min. Recovery water level ____ ft.

OR Flowing Artesian*
____ gpm for ____ hours
Flow controlled by ____

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

7. WELL LOG:

Depth, Feet		Material: color/rock and type/descriptor (example: blue/shale/hard, or brown/gravel/water, or brown/sand/heaving)
From	To	
0	2'	Soil
2'	15'	Broken Rock, Gravel
15'	95'	Green Fractured Rock
95'	260'	Green, Red Rock w/Seepage

☐ ADDITIONAL SHEETS ATTACHED

8. DATE WELL COMPLETED: 12-6-01

9. REMARKS: ____

10. DRILLER/CONTRACTOR'S CERTIFICATION:
All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name, firm, or corporation (print) Jerome's Drilling co., Inc.
Address P.O. Box 17020 Missoula Mt 59808
Signature [signature]
Date 12-27-01 License no. 600

MBMG ID#

MONTANA WELL LOG REPORT

Site Name: LARKIN STUART
GWIC Id: 171600

Section 1: Well Owner

Owner Name		
LARKIN STUART		
Mailing Address		
PO BOX 429		
City	**State**	**Zip Code**
LOLO	MT	59847

Section 2: Location

Township	Range	Section	Quarter Sections
12N	22W	18	SE¼ SW¼ NE¼ NE¼

County	Geocode
MISSOULA	

Latitude	Longitude	Geomethod	Datum
46.8023	114.4045	NAV-GPS	NAD27

Ground Surface Altitude	Method	Datum	Date
3920			7/9/1999

Measuring Point Altitude	Method	Datum	Date Applies
3921.67			7/9/1999 4:11:00 PM

Addition	Block	Lot

Section 3: Proposed Use of Water
PUBLIC WATER SUPPLY (1)

Section 4: Type of Work
Drilling Method:

Section 5: Well Completion Date
Date well completed: N/A

Section 6: Well Construction Details
There are no borehole dimensions assigned to this well.
There are no casing strings assigned to this well.
There are no completion records assigned to this well.
Annular Space (Seal/Grout/Packer)

There are no annular space records assigned to this well.

Section 7: Well Test Data

Total Depth: 38
Static Water Level:
Water Temperature:

Unknown Test Method *

Yield _ gpm.
Pumping water level _ feet.
Time of recovery _ hours.
Recovery water level _ feet.

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

Section 8: Remarks

Section 9: Well Log
Geologic Source
400BELT - BELT SUPERGROUP
Lithology Data

There are no lithologic details assigned to this well.
Driller Certification
All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name:
Company:
License No:-
Date Completed:

Location Information

Sample Id/Site Id:	2000Q0047 / 171600	Sample Date:	7/9/1999 4:11:00 PM
Location (TRS):	12N 22W 18 AACD	Agency/Sampler:	MBMG / KAP
Latitude/Longitude:	46° 48' 8" N 114° 24' 16" W	Field Number:	122218
Datum:	NAD27	Lab Date:	8/24/1999
Altitude:	3920	Lab/Analyst:	MBMG / JMC
County/State:	MISSOULA / MT	Sample Method/Handling:	PUMPED / 4220
Site Type:	WELL	Procedure Type:	DISSOLVED
Geology:	400BELT	Total Depth (ft):	38
USGS 7.5' Quad:	GARDEN POINT	SWL-MP (ft):	1.72
PWS Id:		Depth Water Enters (ft):	NR
Project:	GWCP04		

Major Ion Results

	mg/L	meq/L		mg/L	meq/L
Calcium (Ca)	9.330	0.466	Bicarbonate (HCO3)	213.300	3.496
Magnesium (Mg)	8.820	0.726	Carbonate (CO3)	0.000	0.000
Sodium (Na)	57.800	2.514	Chloride (Cl)	1.742	0.049
Potassium (K)	2.620	0.067	Sulfate (SO4)	10.350	0.216
Iron (Fe)	<.01	0.000	Nitrate (as N)	<.5	0.000
Manganese (Mn)	<.002	0.000	Fluoride (F)	0.508	0.027
Silica (SiO2)	8.270		Orthophosphate (as P)	<.05	0.000
	Total Cations	3.783		**Total Anions**	3.787

Trace Element Results (µg/L)

Aluminum (Al):	<30	Cesium (Cs):	NR	Molybdenum (Mo):	<10	Strontium (Sr):	414.000
Antimony (Sb):	7.540	Chromium (Cr):	<2	Nickel (Ni):	<2	Thallium (Tl):	<5
Arsenic (As):	6.170	Cobalt (Co):	<2	Niobium (Nb):	NR	Thorium (Th):	NR
Barium (Ba):	121.000	Copper (Cu):	4.500	Neodymium (Nd):	NR	Tin (Sn):	NR
Beryllium (Be):	<2	Gallium (Ga):	NR	Palladium (Pd):	NR	Titanium (Ti):	<20
Boron (B):	<30	Lanthanum (La):	NR	Praseodymium (Pr):	NR	Tungsten (W):	NR
Bromide (Br):	<50	Lead (Pb):	<2	Rubidium (Rb):	NR	Uranium (U):	NR
Cadmium (Cd):	<2	Lithium (Li):	<100	Silver (Ag):	<1	Vanadium (V):	<5
Cerium (Ce):	NR	Mercury (Hg):	NR	Selenium (Se):	<1	Zinc (Zn):	7.750
						Zirconium (Zr):	<10

Field Chemistry and Other Analytical Results

**Total Dissolved Solids (mg/L):	205.090	Field Hardness as CaCO3 (mg/L):	NR	Ammonia (mg/L):	NR
**Sum of Diss. Constituents (mg/L):	313.160	Hardness as CaCO3:	59.600	T.P. Hydrocarbons (µg/L):	NR
Field Conductivity (µmhos):	321	Field Alkalinity as CaCO3 (mg/L):	200	PCP (µg/L):	NR
Lab Conductivity (µmhos):	337	Alkalinity as CaCO3 (mg/L):	174.7	Phosphate, TD (mg/L as P):	<.2
Field pH:	8.49	Ryznar Stability Index:	8.286	Field Nitrate (mg/L):	0.000
Lab pH:	8.29	Sodium Adsorption Ratio:	3.269	Field Dissolved O2 (mg/L):	NR
Water Temp (°C):	9.1	Langlier Saturation Index:	0.002	Field Chloride (mg/L):	NR
Air Temp (°C):	NR	Nitrite (mg/L as N):	NR	Field Redox (mV):	373.5
Nitrate + Nitrite (mg/L as N)	NR	Hydroxide (mg/L as OH):	NR	Lab, Dissolved Organic Carbon (mg/L):	NR
Total Kjeldahl Nitrogen (mg/L as N)	NR	Lab, Dissolved Inorganic Carbon (mg/L):	NR	Lab, Total Organic Carbon (mg/L):	NR
Total Nitrogen (mg/L as N)	NR	Acidity to 4.5	NR	Acidity to 8.3	NR
As(III) (ug/L)	NR	As(V) (ug/L)	NR		

Notes

Sample Condition: CLEAR
Field Remarks:
Lab Remarks:

Explanation: **mg/L** = milligrams per Liter; **µg/L** = micrograms per Liter; **ft** = feet; **NR** = No Reading in GWIC

Qualifiers: **A** = Hydride atomic absorption; **E** = Estimated due to interference; **H** = Exceeded holding time; **J** = Estimated quantity above detection limit but below reporting limit; **K** = Na+K combined; **N** = Spiked sample recovery not within control limits; **P** = Preserved sample; **S** = Method of standard additions; **U** = Undetected quantity below detection limit; * = Duplicate analysis not within control limits; ** = Sum of Dissolved Constituents is the sum of major cations (Na, Ca, K, Mg, Mn, Fe) and anions (HCO3, CO3, SO4, Cl, SiO2, NO3, F) in mg/L. Total Dissolved Solids is reported as equivalent weight of evaporation residue.

Ground-Water Information Center | Isotope Tracer Report

Site Name: LARKIN STUART | **Report Date:** 6/18/2012

Location Information

Sample Id/Site Id:	2000R0088 / 171600	Sample Date:	7/9/1999 4:11:00 PM
Location (TRS):	12N 22W 18 AACD	Agency/Sampler:	MBMG /
Latitude/Longitude:	46° 48' 8" N 114° 24' 16" W	Field Number:	
Datum:	NAD27	Lab Date:	
Altitude:	3920	Lab/Analyst:	WATE /
County/State:	MISSOULA / MT	Sample Method/Handling:	/
Site Type:	WELL	Procedure Type:	
Geology:	400BELT	Total Depth (ft):	38
USGS 7.5' Quad:	GARDEN POINT	SWL-MP (ft):	1.72
PWS Id:		Depth Water Enters (ft):	NR
Project:	GWCP04		

Radon (Rn222 - pC/L):	NR	Argon (Ar39):	NR
Carbon (C13):	NR	Silicon (Si32):	NR
Carbon (C14):	NR	Chlorine (Cl36):	NR
Tritium (H3 - TU):	<0.8	Lithium (Li6):	NR
H3/He3 Ratio:	NR	Krypton (Kr85):	NR
Deuterium (H2):	NR	Boron (B11)	NR
Oxygen (O18):	NR	Strontium (Sr87)	NR
Sulphur (S34):	NR	Chloro-fluorocarbon (CFC-11):	NR
Iodine (I129):	NR	Chloro-fluorocarbon (CFC-12):	NR
Nitrogen (N15):	NR	Chloro-fluorocarbon (CFC-113):	NR
Nitrogen (N15 of Nitrate):	NR	Oxygen (O18 of Nitrate):	NR
Sulphur (S34 of Sulfate):	NR	Oxygen (O18 of Sulfate):	NR

Notes

Sample Condition:

Field Remarks:

Lab Remarks:

Explanation: **pC/L** = picocuries per Liter; **TU** = Tritium Units; **NR** = No Reading in GWIC