Anaconda Well Field
Source Water
Delineation and Assessment
Report

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INTRODUCTION

This report is intended to meet the technical requirements for the completion of the delineation and assessment report for the Anaconda Public Water Supply System (PWSS) as required by the Montana Source Water Protection Program and the federal Safe Drinking Water Act (SDWA).

The Montana Source Water Protection Program (MSWPP) is intended to be a practical and cost-effective approach to protecting public drinking water supplies from contamination. A major component of the MSWPP is termed delineation and assessment. The emphasis of this report is identifying significant potential contaminant threats to public drinking water sources and providing the information needed to develop a source water protection plan for the Anaconda Water System.

Delineation is a process whereby areas that contribute water to aquifers or surface waters used for drinking water, called source water protection areas, are identified on a map. Geologic and hydrologic conditions are evaluated in order to delineate source water protection areas. Assessment involves identifying locations or regions in source water protection areas where contaminants may be generated, stored, or transported and then determining the potential for contamination of drinking water by these sources.

Delineation and assessment is the foundation of source water protection plans, the mechanism the Anaconda Public Water Supply System (PWSS) can use to protect their drinking water source. Although voluntary, source water protection plans are the ultimate focus of source water delineation and assessment. This delineation and assessment report is written to encourage and facilitate the Anaconda PWSS operator and the community to complete a source water protection plan that meets their specific need.

BACKGROUND

The Community of Anaconda

Anaconda, a community of approximately 6000 residents, is located in the mountains of southwestern Montana (Figure 1). There have been dramatic employment changes in Anaconda from the days when mining was the major occupation and the Anaconda Company Smelter was the major employer. The current major employers include the Montana State Prison, Warm Springs State Hospital, Anaconda Community Hospital, School District No. 10, Anaconda-Deer Lodge County Government, Fairmont Hot Springs Resort, Discovery Basin Ski Corp., AWARE Inc., AFFCO Inc., and Northwestern (the former Montana Power Company), The remainder of the Anaconda work force can be found at retail, service, and professional businesses.[1]

The Anaconda Water Department, part of the local government, operates the public water supply system (PWSS) for the town of Anaconda. The system consists of six high volume groundwater wells located west of town (Figure 2). The wells are completed in a shallow but highly productive alluvial aquifer.

The Anaconda PWSS has undergone extensive upgrades in the 1990's with the addition of a new 3.5 million gallon storage tank, a new chlorination and flow control facility and water main replacement effort. The water system serves approximately 6,200 residential and commercial users with an average daily consumption of 3.5 million gallons.

Residents outside the city limits are serviced by individual domestic and/or commercial wells. Estimates of the average monthly water use from individual and public water supply wells in the watershed total approximately 150 million gallons per month or 5 million gallons per day[2].

A daily average of approximately 970,000 gallons of wastewater from Anaconda is treated in a tertiary treatment system[3]. Wastewater is piped to two wastewater treatment lagoons, located east of town. There, it is aerated and piped to holding ponds in the Lost Creek area, where it is used for ranch irrigation. Wastewater from areas outside the sewered city limits is treated in onsite sewage disposal systems (septic tank/drainfield).

Geographic Setting

Geographically, Anaconda is located in the mountainous region of southwestern Montana. The Anaconda Range forms the southern Anaconda valley border, while the Flint Creek Mountain Range forms the north. Mount Haggin towers to the south of town at an elevation of 10,379 feet[1]. The climate is influenced by its northerly latitude and high altitude. Average temperatures range from 80°F to 50°F in the summer and from 30°F to 15°F in the winter.[4] NOAA records from 1982 to 2002 show a mean yearly precipitation rate of 14.06 inches. Annual precipitation rates over this period vary from a low of 5.61 inches in 1999 to a high of 21.16 inches in 1993. Yearly mean total snowfall is 71.4 inches with the most snowfall occurring in March[4].

The Anaconda PWSS wells are located two miles upgradient of the largest Superfund site in the U.S. The site covers approximately 5,000 acres of land to the east of the water supply system and effectively negates water development to the east of Anaconda. The site contains hazardous substances released from the operation of a copper smelter. The smelter was operational from 1884 until 1980 when it was permanently closed[5]. Hazardous substances are primarily heavy metals, which were released from the smelter into the air, onto land surfaces and into the surface water. Because of extensive land and surface water contamination, the ground water east of Anaconda has also been impacted.

As a direct result of the contamination to the east of town, ninety percent of the new development within the valley has been west of town, upgradient of the Anaconda PWSS[6]. Extra vigilance needs to be exercised in the protection of the current ground water source for four main reasons:

- Small lateral extent and minimal depth of the valley alluvium;
- Shallow unconfined groundwater conditions, which are more easily contaminated;
- Lack of opportunity for water development to the east; and

- Expense of developing alternate water supply sources within the valley.

Source Water

The Warm Springs Creek watershed covers a total area of approximately 99,189 acres as measured from the headwaters of Warm Springs Creek to its outlet east of Anaconda[2] (Figure 3). The principal source of ground water in the watershed is the Warm Springs Creek alluvial aquifer, in which the Anaconda PWSS is located. This aquifer is recharged by direct precipitation and infiltration in the valley, runoff from snow pack and precipitation events in the surrounding mountains, seepage from the adjacent bedrock and losing stretches of streams within the watershed.

The major surface water source in the watershed is Warm Springs Creek and its tributaries – Cable, North Fork, Foster, Barker and Twin Lakes Creeks. Warm Springs Creek originates in the Flint Creek Range northwest of Anaconda. It flows to the south out of the mountain range and then east along the valley bottom, until its confluence with Silver Bow Creek in the southern portion of the Deer Lodge Basin. The confluence of Silver Bow Creek and Warm Springs Creek marks the origination of the North Fork of the Clark Fork River.

Hydrogeology

The Warm Springs Creek alluvial aquifers is glacio-fluvial in origin with deposits consisting of interlayered gravels, sand and silt with occasional boulder-size material. Each of the six PWSS wells has a detailed lithologic log, which illustrates the composition of the aquifer at each specific location. These logs are contained in Appendix A. Based on a search of Warm Springs Creek aquifer wells from the Montana Bureau of Mines and Geology (MBMG) Ground Water Information System (GWIC), the alluvial aquifer thickness in the valley varies from 25 to 100 feet (Figure 4).

The alluvium is a prolific water producer with measured hydraulic conductivities of 500to 600 ft/day from high volume, long duration aquifer testing near the water supply wells[2]. Transmissivities were calculated from the modified nonequilibrium (Jacob) equation to estimate the potential specific capacity and transmissivity of valley wells. The empirical equation is shown below:

$$T = 1500 * (Q/ s)$$

Where: T = Transmissivity (gpd/ft) Q = Well Yield (gpm) s = Well Drawdown (ft)

This equation gives an estimate of transmissivity based on an average well diameter, average duration of pumping and a typical value for the unconfined aquifer storage coefficient of 0.075. Using this equation, average transmissivities were calculated for domestic wells in the GWIC system, which reported the needed parameters. Calculated transmissivities are shown in Figure 5. The transmissivity values vary by two orders of magnitude. This variation indicates the heterogeneity of aquifer sediments. Measured aquifer test data from monitoring wells for the Superfund site in the alluvial valley east of Anaconda show the same variability of hydraulic conductivity and transmissivity[8].

The lateral extent of the alluvial aquifer is illustrated in Figure 6. The aquifer material is underlain by bedrock. The bedrock composition varies from sedimentary to metamorphic or igneous material, but all have a much lower hydraulic conductivity (3 to 5 orders of magnitude) than the overlying alluvial material. Therefore, it is unlikely that high volume wells could be completed beneath the valley alluvium.

A groundwater contour map using water levels measured in June 2000 is shown in Figure 7. The water levels in seventeen residential and test wells were measured as part of a monitoring program to ensure that the expansion of the Anaconda PWSS did not affect previous ground water rights within the valley. Also, measured water levels from several test wells near the PWSS wells were used in the map construction. The hydraulic gradient in the aquifer varies from a maximum of 0.022 ft/ft west of Anaconda to a minimum of 0.013 ft/ft near West Valley. As shown in Figure 7, the hydraulic gradient is steeper where the valley narrows and tends to flatten where the valley is wider (West Valley area).

Public Water Supply System

The Anaconda PWSS uses six 12-inch diameter water supply wells, which are located in Township 5 North, Range 11 West, Section 33, (Figure 2). The Public Water Supply ID number for the Anaconda PWSS is MT-0000016. Each well is permitted for 9200 residential users. Anaconda-Deer Lodge County holds water rights filed in 1937 in the amount of 3100 gpm with a maximum yearly volume of 4999.1 acre-ft/year. They have an additional water right filed in 1990 in the amount of 2400 gpm with a maximum annual volume of 1935 acre-ft/yr.

Well construction and performance data for each of the Anaconda PWSS wells is detailed in Table I and lithologic logs are included as Appendix A.

Table I. Anaconda PWSS Well Construction and Performance

	MBMG GWIC ID #	Driller	Completion Date	Total Depth (ft)	Screened Interval (ft)	Yield (gpm)	Static Water Level (ft)
Well #1	153862	O'Keefe	4/19/84	56	34-51	880	10
Well #2	154079	O'Keefe	4/12/94	43	21-43	1330	11.70
Well #3	153814	O'Keefe	7/9/94	48	25-48	1000	6.2
Well #4	153966	O'Keefe	2/28/94	51.5	29-45.5	820	9.6
Well #5	154387	Beck	4/2/94	48	28-48	800	8.2
Well #6	153868	O'Keefe	8/5/94	50	31-45	550	10.1

Each water supply well has its own pump house (Figure 8) and each pump house is connected by telemetry to the Anaconda Water Department building at 50 Main Street in Anaconda. From this building, pumpage from each of the wells is controlled, monitored and adjusted. Water is pumped from three of the six wells at any one time to the water treatment facility (Figure 9), where it is chlorinated and pumped into a 3.5 million gallon storage tank on the hill, south of Anaconda. The water system serves approximately 6,224 users with an average daily consumption of 3.5 million gallons per day (MGD). The maximum capacity of the system using all six wells is 6.6 MGD.

In addition to the well field, Anaconda-Deer Lodge County has surface water rights to Hearst Lake and the Fifer Creek Reservoir, which have a combined storage capacity of 315 million gallons[1]. These surface water supplies, however, would require investment in a costly water treatment plant to be used as a water supply to the city. A complete listing of county water rights is included as Appendix B.

Water Quality

The Anaconda PWSS is located within the Warm Springs Creek Watershed. The Warm Springs Creek Watershed is approximately 155 square miles and the average flow in the creek at the town of Anaconda is 52 to 100 cubic feet per second (cfs).

Water from the Anaconda PWSS is sampled regularly based on PWS regulations. The water quality is very good, although before the 1992 upgrades there were exceedances for coliform bacteria. Selected results, reporting limits, and regulatory limits are summarized in Table II.

Because of the large Superfund site located east of town, the majority of development within the Anaconda valley has been west of town, upgradient of the well field. This area is not sewered and numerous individual septic drainfields are being located upgradient of the water system wells. This is a concern as to the effect on the quality of water available to the PWSS.

Another water quality concern is that tailings from the metals smelting process were used as railroad bedding material in the valley. There is an unused rail line that generally bisects the valley upgradient of the water supply wells.

A limited nutrient and soil metals study was completed upgradient of the PWSS, to evaluate the effects of the rail bed material and the prevalence of individual septic drainfields. Eight ground water samples, two surface water samples and four soil borings were collected from the locations shown on Figure 10. All samples were collected using a truck mounted Geoprobe 5410. Four soil samples were collected in the rail bed material by advancing a 2-inch diameter "macro core" soil sampler to a depth of four feet. Ground water samples were collected by advancing a SP-15 water sampler to the top of the ground water surface and collecting a sample using a peristaltic pump.

Soil samples were collected at the depths shown in Table III and analyzed for a subset of metals prevalent in the smelter-related wastes. Results of the analyses are shown in

Table III. As expected, metals concentrations were quite high in the borings. All of the samples were collected in the vadose zone above the ground water surface, but ground water may be affected by infiltration of precipitation and runoff through the railroad bed materials.

Table II. Anaconda PWSS Water Quality Sample Results

Constituent (mg/l)	Water Quality Results 11/1995	Water Quality Results 9/1996	Water Quality Results 11/1995	Water Quality Results 10/2001	Water Quality Results 6/2002	Regulatory Limits (mg/L)
Antimony	<0.005			<0.002		0.006
Arsenic	<0.005		0.002	<0.001		0.020
Barium	<0.1		0.034	0.037		2
Beryllium	<0.001		0.001	<0.0001		0.004
Cadmium	<0.001			0.0006		0.005
Calcium	50	50				NA
Copper			0.979	0.37[2]		1.3
Chromium	<0.01			<0.009		0.1
Fluoride	0.4	0.38		<0.5		4.0
Iron	<0.01	<0.03				0.3
Lead			0.006	0.003[2]		0.006
Mercury	0.0003			<0.0001		0.002
Nickel	<0.01			<0.013		0.10
Nitrate	0.36		0.49	0.69	0.35[1]	10
Selenium	<0.005			<0.001		0.05
Sodium	4	4				NA
Sulfate	17	17				250
Thallium	<0.002			<0.001		0.002

na=not applicable
1 Average of concentration at each water supply well.
2 Average of 20 values from throughout the distribution system.

Eight groundwater samples were collected and analyzed for Nitrate + Nitrite as Nitrogen and Total Phosphorus content. The results of these analyses are shown in Table IV. Nitrate results were plotted next to their respective sampling locations as shown on Figure 11. Nitrate results indicate elevated values at the aquifer margins as compared to the values near the mid-valley regions. This is a result of the reduced amount of ground water flow at the valley margins as compared to the center of the valley. Ground water volume in the center of the valley dilutes effluent discharge to the aquifer, but a reduced volume at the valley margins results in increased nitrate concentrations at these locations. These data also indicate that septic drainfields located in gulches along the valley margins add a significant nutrient flux to the aquifer.

Table III. 2002 Railroad Bed Soil Survey Results

Constituent (mg/Kg)	Recreational Exposure Limits	Soil Boring #1	Soil Boring #2	Soil Boring #3	Soil Boring #4
Sample Depth		3 inches	6 inches	5 inches	6 inches
Arsenic	70	5.7	685	528	898
Cadmium		0.88	1.5	7.7	6.1
Copper	54,200	36.9	2310	1690	3190
Iron		11,400	96,900	39,400	97,700
Lead	2,200	11.9	550	247	712
Manganese		118	210	272	406
Mercury	220	0.03	0.097	0.23	0.16
Zinc		98.5	9390	2490	13,500

Table IV. Ground Water Nutrient Sample Results

Sample Location	Nitrate + Nitrite As N (mg/L)	Total Phosphorus (mg/L)
MCL (mg/L)	10	NA
GW-1	0.09	0.72
GW-2	1.46	1.01
GW-3	0.51	0.46
GW-4	0.47	0.11
GW-5	0.52	0.83
GW-6	0.58	0.28
GW-7	2.91	0.73
GW-8	3.09	0.74

NA – No listed MCL for this constituent.

Table V presents the results of two surface water samples collected in Warm Springs Creek. WSC UP was collected above the majority of the valley development. WSC DOWN was collected in Warm Springs Creek downgradient of the water supply wells as shown in Figure 10. The results of these analyses show relatively low nitrate concentrations in the stream water, but Total Phosphorus concentrations are well above EPA's recommended limits for a stream in our eco-region. This may indicate the use of fertilizers on lawns and agricultural land and waste disposal in septic drainfields in the valley is affecting nutrient concentrations in the stream. All analytical laboratory results are included as Appendix C.

Table V. Surface Water Nutrient Sample Results

Sample Location	Nitrate + Nitrite As N (mg/L)	Total Phosphorus (mg/L)
Recommended EPA Nutrient Levels (mg/L)	0.12*	0.01
WSC UP	0.09	0.47
WSC Down	0.06	0.92

- EPA recommended value for Total Nitrate, which is Nitrate + Nitrite + Kjeldahl Nitrate

SOURCE WATER DELINEATION

The source water protection area is the land area that contributes water to PWS ID# MT-0000016. Three management areas are identified within the source water protection area. These three regions are:

- Control Zone,
- Inventory Zone, and
- Recharge Region.

The Control Zone, also known as the Exclusion Zone, is an area at least 100 feet in radius around each well.

The Inventory Zone represents the zone of contribution of the well, which approximates a three-year groundwater time-of-travel. Analytical equations describing ground water flow using estimates of pumping and aquifer characteristics and simple hydrogeologic mapping were used to calculate the 3-year groundwater time-of-travel distance. In addition, ground water modeling of the aquifer system, using the USGS 3-dimensional ground water modeling program MODFLOW, was used to refine the delineation of the Inventory Zone of the Warm Springs Creek aquifer.

The Recharge Region represents the entire portion of the aquifer, which contributes water to the PWS ID# MT-00016 water system. The Recharge Region for the Anaconda PWSS is the entire region of the Warm Springs Creek watershed, which is shown in Figure 3.

Control Zone Delineation

The Control Zone for the Anaconda PWSS is defined as a one hundred foot radius around each water supply well. It is important to strictly protect this zone, because activities in this zone affect the water supply very quickly with little attenuation of dilution.

Inventory Zone Delineation

The Inventory Zone is a secondary zone of protection defined as any water, which could reach the PWS wells within a 3-year time period. This zone (as shown in Figure 12) was defined using two different methods: the simple travel time equation using estimates for aquifer parameters and ground water modeling of the Warm Springs Creek aquifer.

Time of Travel Calculation

The simple Time of Travel Calculation used to delineate the upgradient distance in which ground water could travel to the water supply wells is shown as follows:

$$V_x = K * i / n_e$$

Where: *V_x = Ground Water Velocity in the X-downgradient Direction (ft/day) K = Average Hydraulic Conductivity of the Aquifer Material (ft/day) i = Average Hydraulic Gradient in the Aquifer (ft/ft) n_e = Average Effective Porosity of the Aquifer Material*

For the Anaconda PWSS:

$$V_x = 500 \text{ ft/day} * 0.018 / 0.27 = 33 \text{ ft/day}$$

$$\bullet = V_x * t$$

$$\bullet = \text{distance upgradient (ft)}$$

$$t = \text{time of travel in (days)}$$

$$\bullet = 33 \text{ (ft/day)} * 1095 \text{ days}$$

$$\bullet = 36{,}500 \text{ ft}$$

$$\bullet = 7 \text{ miles}$$

Ground Water Model

In an effort to delineate the Inventory Zone using site-specific data, a ground water model of the alluvial aquifer was constructed with detailed hydraulic conductivity, hydraulic gradient, aquifer geometry, stream, recharge and evapo-transpiration data.

A ground water elevation contour map for the valley alluvium, Figure 7, was used to define probable flow paths and ground water elevations. The Montana Bureau of Mines and Geology (MBMG) has collected water levels in several wells in the area. This data was reviewed from the Ground Water Information Center (GWIC) system and used to define spatial and temporal changes in water levels in the Warm Springs Creek aquifer over recent time.

A conceptual model of the aquifer was created and consists of two layers with an equivalent grid spacing, which covers the area shown in Figure 13. The grid is 80 rows by 600 columns with the rows oriented parallel to the direction of ground water flow. The columns are oriented perpendicular to this flow direction. Each grid cell is approximately 50 feet by 80 feet in dimension.

The model layers represent an upper and lower stratification of the alluvial aquifer and the low permeability bedrock beneath it. Evidence for stratification of the alluvial aquifer was provided by aquifer testing results from the Anaconda well field performed in 1992[2]. Model Layer 1 represents a near surface, unconfined, alluvial layer. It is assigned a permeability of 500 ft/d and ranges in thickness across the site from 5 feet near valley margins to approximately 25 feet in the mid-regions of the valley. Layer 2 represents the lower portion of the aquifer, which has a slightly higher hydraulic conductivity (550 ft/d) than model Layer 1. This layer varies in thickness from 5 feet near the valley margins to approximately 25 feet in the mid-valley region. Layer thicknesses were estimated from drilling logs from the valley wells listed in Table VI. The lithologic logs for these wells are included as Appendix D. Model hydraulic conductivity and porosity estimates (Table VII) were based on the 1992 aquifer testing results.

The depths of stratigraphic contacts for each of the layers were interpolated between well data points to provide top and bottom surfaces for each of the model layers. The bedrock beneath the alluvium is modeled as no-flow boundary. Therefore, there is no gain or loss of ground water through the bottom of the lower alluvial layer. Inflow from bedrock along the valley margins is simulated using injection wells in key areas. Using this method, bedrock infiltration can be located in specific areas with specific flows.

Precipitation in the valley has an average annual rate of 14.06 inches per year (NOAA, 2002). MODFLOW's Recharge package was used to apply an averaged precipitation rate of 3.2E-03 ft/day to the top model layer over the entire stress period. Evapotranspiration data for the Warm Spring Creek watershed was obtained from Montana State University's (MSU) Montana Agricultural Potentials System (MAPS). This data was used as input into the Evapotranspiration package. This package simulates the loss of water from the aquifer due to plant transpiration and surface water evaporation. MSU MAPS mean potential evapotranspiration value for the valley was 16.38 in/yr. Seventy percent of this value or 11.47 inches/year was used to estimate actual evapotranspiration in the valley.

Table VI. Model Construction and Calibration Wells

Well Owner	GWIC ID	Township/Range	Total Depth (ft.)
Howery	52164	5N12W33	33
Palakovich	189212	5N12W26	40
Spehar	178956	5N12W25	40
Vuicich	150297	5N12W25	115
Bogert	52138	5N12W25	80
Marinkovich	120353	5N12W25	33
Saddle Club	122355	5N12W25	40
Wyant	153770	5N11W30	60
Lussy	51878	5N11W30	52
Donahue	178950	5N11W30	61
Meloy	121976	5N11W30	60
Faulkner	51906	5N11W30	39
Bennett	162611	5N11W31	95
W. V. C. Club	51930	5N11W30	34
Vetter	125258	5N11W32	40
Schalk	153771	5N11W32	50
Derzay	143452	5N11W29	40
Grant	51857	5N11W29	50
Riddle	185920	5N11W29	80
Eide	133737	5N11W32	40
Brickley	159902	5N11W32	120
Richards	189210	5N11W33	280
Lescantz	52084	5N11W33	43
McCallum	52058	5N11W33	31
Bucholz	52074	5N11W33	35
Mills	52070	5N11W33	31
PW-1	153862	5N11W33	56
PW-2	154079	5N11W33	43
PW-3	153814	5N11W33	48
PW-4	153966	5N11W33	51.5
PW-5	154387	5N11W33	48
PW-6	153868	5N11W33	50
TH-1*	-	5N11W33	70
TH-2*	-	5N11W33	60
TH-3*	-	5N11W33	62
TH-4*	-	5N11W33	42
TH-5*	-	5N11W33	41
FH-1	125800	4N11W03	50
FH-2	125799	4N11W03	50
FH-3	125798	4N11W03	53
FH-4	125797	4N11W03	53
Town Pump	134542	4N11W03	180

***** Not included in the GWIC database. Included in Appendix D.

Table VII. Model Parameter Values

Hydraulic Property	Layer 1 Unconfined Silty, Gravel Sand	Layer 2 Confined/Unconfined Gravelly Sand
Horizontal Hydraulic Conductivity	500 ft/d	550 ft/d
Vertical Hydraulic Conductivity	50 ft/d	55 ft/d
Porosity	0.27	0.27

Steady State Model

After construction of the conceptual model, the USGS modular three-dimensional finite difference ground water flow modeling package MODFLOW (1996) was used to create a steady-state ground water flow model simulation of the conceptual model. The steadystate model had one stress period and was calibrated to the June 2000 ground water contour map. Year 2000 ground water elevations were used because the most extensive water level data in the model area was available for this year

Model boundaries consisted of a specified head boundary along the west-southwest model boundary and the eastern model boundary. The valley margins and the bedrock beneath the alluvium were modeled as no-flow boundaries. Bedrock recharge was simulated using injection wells along the valley margins.

An estimated 150 million gallons of ground water per month is pumped from the alluvial aquifer[2]. Of this, an average of 3.5 million gallons per day (MGD) is pumped by the municipal well field. Therefore, 1.5 MGD is the estimated withdrawal by the remainder of the domestic, commercial and industrial wells completed in the alluvial aquifer.

Although an average of 3.5 MGD is withdrawn by the PWSS wells, the sewage treatment plant receives only 970,000 gpd or about 1/3 of the average pumpage. This indicates that approximately 2/3 or 2.5 MGD is available for recharge to the aquifer. Because only three of six Anaconda PWSS wells are pumped at any one time, ground water usage in the model is simulated by three wells pumping a cumulative 1 million gallons per day (approximate amount of water lost from the aquifer to the sewage treatment plant).

The domestic, commercial and industrial well usage is simulated by two wells located in West Valley pumping a cumulative volume of 10,000 gallons per day and an additional well located between West Valley and Anaconda which pumps 5,000 gallons per day. The 15,000-gpd value is 10% of the estimated 1.5 MGD. Only ten percent of the water withdrawn from the aquifer is lost to the system, because septic drainfields return most of the pumpage back as recharge.

During model calibration, parameter values were varied until the model-calculated ground water elevations were within five feet of the measured elevations. Five feet was chosen as the calibration target, because it is approximately ten percent of the total change in water levels from the upgradient to downgradient edges of the model. A comparison of contoured model ground water elevations compared to the 2000 measured ground water elevations is shown in Figure 14.

Model calibration for this aquifer was time consuming and difficult, because of the relatively thin, highly conductive nature of the aquifer and the large ground water elevation change over the model area. The model parameter values that were varied during calibration include: the vertical and horizontal hydraulic conductivity, constant and no flow boundary conditions, pumping volumes and inflow from bedrock sources. The parameter values shown in Table VII are calibrated (final) model values. After the steady-state model was calibrated, a path line model was executed using the flow data from the steady state model.

Flowpath Model

Using the computer program MODPATH, particles were inserted into the flow field calculated by MODFLOW at the locations of the three PWSS production wells. The particles were tracked upgradient for the three-year period, thereby defining the threeyear capture zone of the production wells (Figure 15). The resulting capture zone indicates major sources of ground water to the PWSS wells include: inflow from the surrounding bedrock, throughflow down the valley and surface water infiltration from Warm Springs Creek.

Model Summary

In summary, the ground water flow model simulates ground water usage in an “averaged” flow field representing the Warm Springs Creek alluvial aquifer. MODFLOW assumes homogeneous, isotropic aquifer conditions, which are rarely encountered. Therefore, model layers are approximated, as are hydraulic parameters. Actual hydraulic connection in the aquifer at this site is less than in the model layers because of the interlayered character of the alluvial sediments. Delineation zones and time periods derived from the model are therefore, conservative values. The model indicates the general direction in which contaminants could enter the well bore and provides an approximate time frame for impacts to the well.

Model results indicate three major contributing sources of ground water to the Anaconda PWSS wells. These three sources include:

- Ground water throughflow in the alluvial sediments,
- Infiltration of surface water from Warm Springs Creek,
- Inflow from the surrounding bedrock aquifer.

Protection Zone Delineation

The Protection Zone delineation for the Anaconda PWSS wells is simple. Any water, which could conceivably reach the water supply wells, is included in this zone. This protection zone, therefore includes all of the Warm Springs Creek Watershed, near and upgradient of the wells as shown in Figure 12.

INVENTORY OF POTENTIAL CONTAMINANT SOURCES

Potential Contaminant Sources

The inventory for Anaconda Water System focuses on all activities in the Control Zone, municipal and private facilities in the Inventory Zone, and general land uses and large facilities in the Recharge Region.

The following potential contaminant sources were examined:

- Septic tanks/sewer district;
- Wastewater discharge locations;
- Class II & V Wells:
- Hazardous spill sites;
- Leaking underground storage tanks;
- Federal Superfund sites;
- Highways and Railroads;
- Cropped agricultural land;
- Comprehensive mine locations;
- High priority abandoned mines;
- Municipal landfills;
- RV Dump Sites;
- Crude oil Pipelines; and
- State Superfund sites.

An examination of the septic tank density data for 2000 from the Natural Resource Information System (NRIS) within a 5-mile radius of Anaconda is summarized in Table VIII. In addition, a septic survey upgradient of the PWSS wells was completed in April of 2002. This data was categorized low, medium, or high density using the same breakdowns as NRIS and plotted on Figure 16.

Table VIII. 2000 Septic Density[5]

	Acres	Percentage	Septic Systems Per Square Mile	People Per Square Mile
City Sewer	540.2	20.8%	na	na
Low Septic Density	1,963.3	75.6%	<50	125
Medium Septic Density	36.9	1.4%	>50 but <300	125-750
High Septic Density	55.2	2.1%	>300	750

na=not applicable

Three industrial storm water discharge sites are located within a 3-mile radius of the Anaconda PWSS[5]. These sites are listed in Table IX.

Table IX. Industrial Storm Water Discharge Sites[5]

	NPDES #	Receiving Water
AFFCO	MTR000068	Warm Springs Creek
Nazer & Son Towing Inc.	MTR000263	Warm Springs Creek
Karst Stage	MTR000401	Anaconda Municipal Storm Sewer

There are no Class II (Oil and Gas) wells within the Inventory Zone of the Anaconda PWSS and no hazardous spills sites are on record for the town of Anaconda with a 3-mile buffer zone.

There are eighteen underground storage tanks within a 3-mile radius and they are listed in Table X.[5].

Table X. Underground Storage Tank Facilities

Facility ID	Facility Name	Facility Location	Facility Status	Leak Status	Active Tanks
1201470	Ted's Gas and Repair Service	701 E. Park	Active	Active	3
1201879	Classic Cleaners	1621 E Commercial	Active	Active	1
1207938	Thriftway Super Stop #3	1420 E Park	Active	Active	5
1208668	Town Pump (Anaconda #2)	819 W Park	Active	Active	4
1210912	RDM Multi-Enterprises Inc.	Old Arbitor Site	Active	Active	1
1209326	Town Pump (Anaconda #1)	Hwy 10A E	Active	Active	4

The Anaconda PWSS is located two miles upgradient of a federal Superfund site, EPA Comprehensive Environmental Response, Compensation and Liability System (CERLIS) site.[5] The site totals 5000 acres of affected land. The major soil, ground water and surface water threats are arsenic and heavy metals such as copper, zinc, cadmium, and lead.[5]

There are twenty active mine sites within five miles of the Anaconda PWSS. There are listed in Table XI.

Table XI. Active Mine Sites

Facility Name	Activity	Commodity	Operation Type
Anaconda Hot Springs	Producer	Geothermal Iron	Hot Spring
Anaconda Reduction Dept. (Smelter)	Producer		Processing Plant
Anaconda Slag Dump	Unknown	Iron	Processing Plant
Arbiter Plant (Refinery)	Producer		Processing Plant
Big Six Prospect	Unknown	Tungsten	Mineral Location
Deniff Quarry	Past Producer	Clay	Surface Quarry
Diamond Placer	Unknown	Gold, Silver & Lead	Placer Mine
Girard	Unknown	Gold, Silver & Lead	Mineral Location
Hoodoo Gulch	Past Producer	Calcium	Underground Mine
Limestone Occurrence	Unknown	Stone	Mineral Location
Lost Creek Placer	Develop Deposit	Gold	Placer Mine
Mill & Clear Creek Placer	Develop Deposit	Gold	Placer Mine
Northwest	Unknown	Copper, Lead	Mineral Location
Placer Fire Clay Pit	Producer	Clay	Surface Quarry
Sand n Gravel Pit	Past Producer	Sand, Gravel	Surface Quarry
Sioux Placer	Unknown	Gold	Mineral Location
Stuckey Ridge	Unknown	Calcium	Unknown
Tri-City Concrete Products	Past Producer	Sand, Gravel	Unknown
Weather Vane Hill	Unknown	Fluorine	Mineral Location
White Cliff Quarry	Producer	Stone	Surface Quarry

Montana Highway 1, and an unused spur of the Rarus Railroad Line and their respective Right-of-Ways bisect the length of the Warm Springs Creek watershed.

Table XII lists the land use within a three-mile radius of the Anaconda PWSS wells.

Table XII. Land Use

Area (Acres)	Type of Landuse	Percentage (%)
702.69	Mines/Quarries	35.0
555.15	Brush Rangeland	27.6
460.15	Residential	22.9
161.67	Commercial/Services	8.0
41.52	Evergreen Forest	4.8
35.04	Industrial	35.04
34.42	Transitional	1.7
17.65	Transportation/Utilities	0.9

The Anaconda-Deer Lodge County Landfill is located approximately two-miles downgradient of the Anaconda PWSS wells. This landfill is closed, covered and reclaimed and the ground water is monitored semi-annually.

Of the other sources examined, there were no threats from high priority abandoned mines, crude oil pipelines, and state superfund sites.

Control Zone

Method

The Control Zone, a 100-foot radius around each water supply well was visually inspected for any possible sources of contamination. The wells are located on county property and the property is fenced. Each wellhead is secured with a locking gate and a cement block pump house with a locking door.

Results

The only source of contamination found within this zone is animal wastes. The property surrounding the wells is leased for part of the year for livestock grazing. The animals have access to the land surface up to the pump houses for the water supply wells.

Inventory Zone

Method

The Inventory Zone surrounding the Anaconda PWSS was evaluated for possible contaminant sources by investigating listed sources from Montana DEQ and EPA websites, by conducting a windshield survey and use of a city directory.

Results

A Source Water Protection (SWP) Inventory of potential sources of contamination within the Inventory Zone can be found in Table XIII.

Table XIII. Inventoried Potential Sources of Contamination

Name	Contaminants	Description
Septic Systems	Pathogens and Nutrients	Widespread upgradient of wells. High densities in some areas.
Underground Storage Tanks	Fuels	Hydrocarbon releases. All located downgradient of PWSS.
Trailer Parks w/ Septics	Pathogens and Nutrients	Within 1-mile radius of wells. Septic systems designed before 1972.
Animal Wastes Near Wellheads	Pathogens and Nutrients	Pasturing animals near wells.
Railroad Bed	Metals	Mining-related materials used for bedding material. Potential for leaching.
MT Highway 1	Various	Unknown shipping of hazardous materials and chemicals.
Mines/Quarries	Metals, Chemicals	Leaching of heavy metals and chemical spills.
Dry Cleaners	Solvents	Chemical releases. All located downgradient of PWSS wells.
Agricultural Land Applications/ Household Fertilizers	Nutrients	Increasing nutrient load in streams and ground water.

Potential sources of all primary drinking water contaminants were identified; however, only significant potential contaminant sources were selected for detailed inventory. The significant potential contaminants in the Anaconda PWSS Inventory Zone are pathogens and nutrients, fuels, automobile fluids, solvents, and assorted chemicals.

Recharge Region

Because the 3-year Time of Travel for the Anaconda PWSS is so large and the valley becomes more rural towards the head of the watershed, the Inventory Zone and the Recharge Region are basically coincident. Therefore, the potential contaminant sources identified in the Inventory Zone, Table XIII, are the same as those for the Recharge Region.

SUSCEPTABILITY ASSESSMENT

Objectives

Susceptibility is the potential for a public water supply to become contaminated by an inventoried source in concentrations that could become a public health risk. Susceptibility is assessed in order to prioritize potential sources for purposes of water supply management.[9]

The goal of Source Water Management is to protect the source water by:

- Controlling activities in the Control Zone,
- Managing significant potential contaminant sources in the Inventory Zone and,
- Ensuring that land use activities in the Recharge Region pose minimal threat to the source water.

Management priorities in the Inventory Zone are determined by ranking the inventoried significant potential sources.

Hazard ranking for specific ground water contaminants is determined by the proximity of a well to point contaminant sources (UST's) and by the density of non-point source contaminants (septic density) within the inventory region.

Susceptibility is determined by considering the hazard ranking for each potential contaminant source and the existence of barriers that decrease the likelihood that contaminated water will flow to the Anaconda PWSS (Table XIV). 9

Table XIV. Susceptibility Determination by Hazard Ranking

Presence of Barriers	Hazard		
	High	**Medium**	**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 natural conditions, engineered structures or management actions. Natural barriers to a groundwater source may include a continuous clay layer, a deep water table, contaminant attenuation capacity of the vadose zone and aquifer materials and dilution. Engineered barriers provide physical containment or early detection of potential contaminants and include double walled underground storage tanks, spill catchment basins and monitoring wells installed for leak detection. PWS wells that meet state construction standards are considered engineered barriers to contamination in Control Zones. [9]

Table XV shows the inventoried sources and their respective susceptibility ranking based on the number of barriers present. Contaminant sources were ranked in the table in order of decreasing susceptibility.

The possibility of contamination from animal wastes in the control zone was ranked as number one in terms of susceptibility of contaminants reaching the Anaconda PWSS. At times animals are pastured in the fields where some of the PWSS wells are located. The only barrier to contaminants from animal wastes reaching the wells within the control zone is the proper completion of the wells as PWS wells as dictated by MDEQ. Livestock should be excluded from the control zone.

The number two susceptibility is from pathogens from nearby trailer parks on septic systems. One trailer park septic system was installed before regulations were emplace on septic system design. This park has had documented violations due to its system. In addition, the park is upgradient and within ½ mile of the Anaconda PWSS wells. The only barrier for this contaminant is the distance to the PWSS. Extension of the city sewer line to the nearby trailer parks, would alleviate susceptibility to contamination from this source.

Upgradient septic systems provide the next two contaminants in the susceptibility ranking table. Pathogens from upgradient septic systems have one barrier – distance, while nutrients have two – vadose zone attenuation and dilution.

Most of the land in the inventory zone upgradient of the well field is used for agricultural purposes, although several hay fields have been sold and subdivided. Nutrients, fertilizers and pesticides land applied to fields and lawns have a moderate susceptibility to migration into the PWSS. The two barriers to migration are dilution and vadose zone attenuation.

An unused portion of the Rarus Railroad bed contains metals contamination, because it was constructed using metals-laden tailings materials. There is a potential for leaching of metals into the ground water. The susceptibility is moderate because vadose zone attenuation, dilution and distance all provide barriers to migration.

MT Highway 1 provides a corridor for hazardous material surface spills. Susceptibility was ranked as moderate due to three barriers – vadose zone attenuation, dilution, and distance.

Metals and chemicals associated with mines and Quarries provide a moderate risk. Barriers include: vadose zone attenuation, dilution, and distance.

Dry Cleaners and Underground Storage Tank facilities provide a very low risk because they are located more than a ½ mile downgradient of the well field. Additionally barriers include ground active ground water monitoring of the UST sites and flow direction and dilution as barriers.

Table XV. Susceptibility Assessment

Source	Contaminant	Hazard Rating	Barriers	Susceptibility	Management Practice
Animal Wastes in Control Zone	Pathogens & Nutrients	Very High	1	High	Exclude Livestock from Control Zone
Trailer Parks with Septic Systems	Pathogens	Very High	1	High	Extend Sewer
Septic Systems	Pathogens	Very High	1	High	Extend Sewer
Septic Systems	Nutrients	High	2	Moderate	Extend Sewer/ Upgrade Septic Systems
Ag Land Applications/ Lawn Fertilization	Nutrients, Fertilizers, Pesticides	High	2	Moderate	Public Education on Source Water Protection
Railroad Bed	Metals	High	3	Moderate	Remediate
MT Highway 1	Various	High	3	Moderate	Develop Management Plan
Mines Quarries	Metals, Various Chemicals	Moderate	3	Low	Develop Management Plan
Dry Cleaners*	Solvents	Low	2	Very Low	Develop Management Plan
Underground Storage Tanks*	Hydrocarbons	Low	2	Very Low	Monitor & Remediate

* Sources over ½ mile downgradient of well field.

ASSESSMENT SUMMARY

The results of the source water assessment, shown in Table XV, indicate that the greatest threat to the quality of water in the Anaconda PWSS is upgradient nutrient-adding influences – septic systems, application of fertilizers and animal wastes. These influences are non-point source contaminants and upon entering the water supply, the source is difficult to pinpoint and the contaminants are difficult to remove. It is much easier to adopt a proactive protection program to safeguard the water supply in advance of nutrient problems.

A large volume of water moves through the Warm Springs Creek aquifer; as a result the aquifer system has the ability to dilute contaminants. A prime example of the power of dilution is illustrated by the large nitrate concentration in the sample point at the outlet of English Gulch as compared to the nitrate values in the mid-valley region. The higher volume of water mid-valley dilutes the nitrate concentration from 3.09 mg/l to approximately 0.5 mg/l. The background nitrate concentration for the aquifer is generally <0.1 mg/l, therefore even 0.5 mg/l concentrations indicate an impact to the aquifer. Total phosphorus concentrations in Warm Springs Creek already exceed levels recommended by the EPA.

The Warm Springs Creek aquifer is a prolific water producer, but ground water levels are shallow and the water table aquifer is unconfined. The shallow water levels and coarse surficial sediments increase the likelihood of surface impacts to the aquifer. The vertical thickness of the aquifer is relatively small (approximately 40 ft. of saturated thickness in the area of the water supply wells) and the aquifer is underlain by bedrock; therefore, deepening of the wells for water supply is not an option. Alternate water sources within the valley are surface water sources, which would require investment in a costly water treatment plant.

Because of the Superfund site east of the town, the majority of growth/development potential for Anaconda is to the west. The Anaconda PWSS is an asset to area growth. It provides high volume, low cost, high quality water; thereby encouraging development. The aquifer system must be protected for future use and the following best management practices are recommended:

- Adopt a long-term plan to provide sewer service to high septic density areas upgradient of the PWSS, beginning with those areas closest to the supply wells and extending the system to encompass the capture zone of the water supply wells;
- Develop a management plan for compatible land uses in upgradient areas; and
- Promote an educational program for residents/businesses in the valley and adjacent drainages on source water protection practices.

REFERENCES

[1] www.anacondamt.org, October 2002

[2] Assessment of the Warm Springs Creek Aquifer in Response to Pumping of AnacondaDeer Lodge Test Well TH-2, Hydrometrics, April 1993

[3] Opportunity Water & Sewer Feasibility Study, Robert Peccia &Associates, July 2000 [4]

National Oceanic & Atmospheric Administration (NOAA), 2000.

[5] *www.epa.gov, Oct. 4, 2002*

[6] personal communication, Susan Blume, ADLC Planning Department, December 2002

[7] Geology and Ground Water Resources of the Deer Lodge Valley, USGS Water Supply Paper 1862, 1968

[8] Anaconda Regional Water and Waste Operable Unit - Final Remedial Investigation Report, February 1996

[9] Montana Source Water Protection – Technical Guidance Manual, MGMG 378, July 1998

FIGURES

APPENDIX A
ANACONDA PWSS WELL LITHOLOGIC LOGS

[redacted]

[redacted]

29.0	30.0	80% COARSE SAND 20% COARSE GRAVEL
30.0	31.0	80% COARSE SAND 20% COARSE GRAVEL
31.0	32.0	80% COARSE SAND 20% COARSE GRAVEL
32.0	33.0	75% COARSE SAND 25% COARSE GRAVEL WATER GOT CLEANER
33.0	34.0	70% COARSE GRAVEL 30% COARSE SANDS
34.0	35.0	70% COARSE GRAVEL 30% COARSE SAND
35.0	36.0	70% COARSE GRAVEL 30% COARSE SAND
36.0	37.0	85% COARSE GRAVEL 15% COARSE SAND
37.0	38.0	38 FT WATER STOPPING POSSIBLE BEDROCK COARSE GRAVEL 50% FINE SAND 50% WATER CHANGE COLOR SAND
38.0	39.0	GROUND UP BEDROCK 95% 5% COARSE GRAVEL
39.0	40.0	GROUND UP BEDROCK
40.0	43.0	GROUND UP BEDROCK

Site Notes

LAT\LONG FROM DEQ

Montana Bureau of Mines and Geology
Ground-water Information Center Site Report
ANACONDA-DEERLODGE COUNTY *WELL C(3)

Plot this site on a topographic map

Location Information

GWIC Id: 153814
Location (TRS): 05N 11W 33 DBAB
County (MT): DEER LODGE
DNRC Water Right: C072455-00
PWS Id: 00016009
Block: Not Reported
Lot: Not Reported
Certificate of Survey: Not Reported

Source of Data: LOG\DEQ
Latitude (dd): 46.1433
Longitude (dd): -112.9806
Geomethod: MAP
Datum: 1927
Addition: Not Reported
Type of Site: WELL

Well Construction and Performance Data (measurements are reported below land surface)

Total Depth (ft): 48.00
Static Water Level (ft): 6.20
Pumping Water Level (ft): 21.70
Yield (gpm): 1000.00
Test Type: PUMP
Test Duration: 24.00
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):

How Drilled: AIR ROTARY
Driller's Name: OKEEFE
Driller License: WWC048
Completion Date: Jul 09, 1994
Special Conditions: None Reported
Is Well Flowing?: No
Shut-In Pressure:
Well/Water Use: PUBLIC WATER SUPPLY
Geology/Aquifer: Not Reported

Hole Diameter Information

From (ft)	To (ft)	Dia (in)
0.0	27.0	12.0

Annular Seal Information

From (ft)	To (ft)	Description
0.0	20.0	BENTONITE CEMENT

Casing Information

From (ft)	To (ft)	Dia (in)	Description
-1.5	27.0	12.0	STEEL

Completion Information

From (ft)	To (ft)	Dia (in)	Description
25.0	27.0	12.0	0 SCREEN
27.0	35.0	12.0	.130 SCREEN
35.0	41.0	12.0	.100 SCREEN
41.0	43.0	12.0	.150 SCREEN
43.0	48.0	12.0	000 SCREEN

Lithology Information

From (ft)	To (ft)	Description
0.0	2.0	TOPSOIL
2.0	15.0	VERY DARK CLAY & SILT-INADEQUATE RETURN-BOULDER AT 13'
15.0	18.0	DARK BROWN SAND & SILT-SOME MEDIUM TO FINE GRAVEL SUBROUNDED TO SUBANGULAR-LITTLE WATER 5 GPM
18.0	23.0	FINE SAND & SILT-MEDIUM TO FINE GRAVEL SUBROUNDED TO SUBANGULAR-LITTLE WATER 5 GPM
23.0	24.0	FINE SAND & FINE GRAVEL SUBROUNDED TO SUBANGULAR SOME SILT 5-10
24.0	25.0	COARSE TO FINE SAND & GRAVEL SUBROUNDED TO SUBANGULAR STILL SILTY 10%
25.0	26.0	FINE SAND & GRAVEL SUBROUNDED TO SUBANGULAR VERY SITLTY
26.0	27.0	FINE TO MED SAND & GRAVEL SUBROUNDED TO SUBANGULAR SILT 5-10%
27.0	28.0	MED TO FINE SAND & GRAVEL-SUBROUNDED TO SUBANGULAR-LESS SILT-MORE WATER-15GPM+
28.0	29.0	MED TO FINE SAND & GRAVEL-SUBROUNDED TO SUBANGULAR LESS SILT-LESS WATER
29.0	30.0	MED TO FINE SAND-SOME MED GRAVE-10-15%SILT
30.0	31.0	MED TO FINE SAND & GRAVEL-SUBROUNDED TO SUBANGULAR LESS SILT-LITTLE MORE WATER-10GPM
31.0	32.0	COARSE SAND TO MED GRAVEL-SUBROUNDED TO SUBANGULAR VERY LITTLE SILT-10GPM
32.0	33.0	FINE TO MED GRAVEL COARSE SAND SUBROUNDED TO SUBANGULAR-10-15%SILT-LESS WATER
33.0	34.0	FINE TO MED GRAVEL & SAND-SUBROUNDED TO SUBANGULAR 10-15% SILT 5-10 GPM
34.0	35.0	FINE TO MED GRAVEL & SAND-SOME COARSE GRAVEL-VERY SILTY 15-20%-5-10 GPM
35.0	36.0	FINE TO MED SAND & GRAVEL-SUBROUNDED TO SUBANGULAR VERY SILTY 10-15%-10 GPM
36.0	37.0	MED TO COARSE SAND-MED GRAVEL-SUBROUNDED TO SUBANGULAR-LESS SILT 5%-MOR WATER 20 GPM
37.0	38.0	FINE TO MED SAND & SILT-LOTS OF WATER 30-40 GPM
38.0	39.0	FINE TO MED SAND-FINE GRAVEL SUBROUNDED TO TO SUBANGULAR 5-10% SILT-30-40 GPM
39.0	40.0	FINE TO MED SAND & GRAVEL-ANGULAR TO SUBANGULAR SILT-10%-20-30 GPM H2O DIRTY
40.0	41.0	COARSE TO FINE GRAVEL & SAND-ANGULAR TO SUBANGULAR LESS H2O VERY DIRTY 10-15% SILT VERY DEFINITE COLOR CHANGE
41.0	42.0	VERY COARSE TO FINE GRAVEL & SAND-ANGULAR TO SUBANGULAR-5% SILT-5% CLAY-NO H20
42.0	43.0	VERY COARSE TO MED GRAVEL & SAND-ANGULAR TO SUBANGULAR-5% CLAY-NO H2O
43.0	44.0	VERY COARSE TO MED GRAVEL & SAND - ANGULAR TO SUBANGULAR-NO H2O-5% CLAY-CLOSE TO BEDROCK
44.0	45.0	MED TO FINE GRAVEL & SAND-ANGULAR TO SUBANGULAR MORE CLAY VERY STIFF-BEDROCK-PURPLE COLOR DIFFERENT FROM PREVIOUS SAMPLES-PURPLE
45.0	48.0	PURPLE COLORED SANDY CLAY-GRAVEL MED TO FINE ANGULAR TO SUBANGULAR-NO WATER-BEDROCK
48.0	49.0	MED TO FINE GRAVEL-FEW CLAY WADS-GRAVEL PREDOMINATELY BLACK

Site Notes

LAT\LONG FROM DEQ, LOCATED WEST OF ANACONDA

Montana Bureau of Mines and Geology
Ground-water Information Center Site Report
ANACONDA-DEERLODGE COUNTY *WELL D-2 (4)

Plot this site on a topographic map

Location Information

GWIC Id: 153966
Location (TRS): 05N 11W 33 CABA
County (MT): DEER LODGE
DNRC Water Right: C017054-00
PWS Id: 00016010
Block: Not Reported
Lot: Not Reported
Certificate of Survey: Not Reported

Source of Data: LOG\DEQ
Latitude (dd): 46.1432
Longitude (dd): -112.9848
Geomethod: MAP
Datum: 1927
Addition: Not Reported
Type of Site: WELL

Well Construction and Performance Data (measurements are reported below land surface)

Total Depth (ft): 51.50
Static Water Level (ft): 9.60
Pumping Water Level (ft): 19.80
Yield (gpm): 820.00
Test Type: PUMP
Test Duration: 24.00
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):

How Drilled: ROTARY
Driller's Name: OKEEFE
Driller License: WWC048
Completion Date: Feb 28, 1994
Special Conditions: None Reported
Is Well Flowing?: No
Shut-In Pressure:
Well/Water Use: PUBLIC WATER SUPPLY
Geology/Aquifer: Not Reported

Hole Diameter Information

From (ft)	To (ft)	Dia (in)
0.0	27.0	12.0

Annular Seal Information

From (ft)	To (ft)	Description
0.0	20.0	BENTONITE/CEMENT

Casing Information

From (ft)	To (ft)	Dia (in)	Description
-1.5	27.0	12.0	STEEL

Completion Information

From (ft)	To (ft)	Dia (in)	Description
29.0	45.5	12.0	.130 SLOT SCRN

Lithology Information

From (ft)	To (ft)	Description
0.0	2.0	TOPSOIL
2.0	4.0	FINE SAND SILT-GREY COLOR TURNING TO RUSTY BROWN
4.0	5.0	FINE SAND & SILT-BACK TO GREY COLOR
5.0	8.0	SAME FINE GREY SAND & SILT-MOIST AT 8'
8.0	10.0	ROUNDED TO SUBROUNDED GRAVEL & SAND MED TO COARSE
10.0	15.0	SUBROUNDED TO SUBANGULAR GRAVEL & SAND-MED TO COARSE-SOME SILT APPROX 5%
15.0	20.0	MED TO FINE SAND & GRAVEL-SUBROUNDED TO SUBANGULAR SOME COARSE-MOIST BLEW WATER AFTER 10 MIN
20.0	21.0	FINE SILT & CLAY VERY STICKY
21.0	25.0	MED TO FINE SAND & GRAVEL-ANGULAR TO SUBANGULAR APPROX 20 GPM
25.0	28.0	MED TO FINE GRAVEL & SAND ANGULAR TO SUBANGULAR
28.0	29.0	VERY COARSE GRAVEL-ANGULAR TO SUBANGULAR

29.0	30.0	VERY COARSE GRAVEL & SAND SOME FINE SAND & SILT -20% 30-50 GPM
30.0	31.0	VERY COARSE GRAVEL & SAND-ANGULAR TO SUBANGULAR 30-50 GPM
31.0	32.0	VERY COARSE GRAVEL & SAND-SUBROUNDED TO SUBANGULAR 30-50 GPM
32.0	33.0	MED TO FINE SAND-SOME VERY COARSE GRAVEL 30-50 GPM
33.0	34.0	MED TO FINE SAND-SOME VERY COARSE GRAVEL 20%
34.0	35.0	COARSE TO FINE SAND-MED GRAVEL-SUBROUNDED TO SUBANGULAR 30-50 GPM
35.0	36.0	FINE GRAVEL & COARSE SAND SUBROUNDED TO SUBANGULAR 5% SILT 30-50 GPM
36.0	37.0	FINE TO MED GRAVEL & COARSE SAND-5% SILT 30-50 GPM
37.0	38.0	FINE SAND & SILT-MED GRAVEL-SOME COARSE GRAVEL UNSORTED 20-25 GPM
38.0	39.0	INCREASE IN FINE SAND & SILT-MED GRAVEL-SOME COARSE-WATER DIRTY 20-25 GPM
39.0	40.0	MED TO FINE GRAVEL-SILTY SUBROUNDED TO SUBANGULAR- SILT 25% 20-25 GPM
40.0	41.0	GRAVELLY SAND-20% SILT-WATER DIRTY-COARSE TO MED GRAVEL-SAND COARSE TO FINE 20-25 GPM
41.0	42.0	COARSE TO FINE GRAVEL-WATER-SILT-15% 10 GPM
42.0	43.0	SANDY GRAVEL-20% SILT-INCREASE IN SAND & SILT 10 GPM
43.0	44.0	MED TO FINE GRAVEL SILT 20%-LESS WATER 10 GPM
44.0	45.0	MED TO COARSE SAND-MED GRAVEL-15% SILT-55% CLAY MED TO FINE GRAVEL 10 GPM
45.0	46.0	MED GRAVEL TO FINE SAND 5 GPM
46.0	47.0	FINE TO MED SAND-ANGULAR CHIPS OF GREY SLTAE- BEDROCK AT 46.5'-VERY LITTLE WATER
47.0	48.0	MOSTLY GREY TO BLACK SHALE-RED & GREEN COLORS ALSO PRESENT-NO WATER(0-5 GPM) WATER

Site Notes

LAT\LONG FROM DEQ

Montana Bureau of Mines and Geology
Ground-water Information Center Site Report
ANACONDA-DEER LODGE COUNTY * WELL E (5)

Plot this site on a topographic map

Location Information

GWIC Id: 154387
Location (TRS): 05N 11W 33 DBBC
County (MT): DEER LODGE
DNRC Water Right: C017054-00
PWS Id: 00016011
Block: Not Reported
Lot: Not Reported
Certificate of Survey: Not Reported

Source of Data: LOG\DEQ
Latitude (dd): 46.1422
Longitude (dd): -112.9836
Geomethod: TRS-TWN
Datum: 1927
Addition: Not Reported
Type of Site: WELL

Well Construction and Performance Data (measurements are reported below land surface)

Total Depth (ft): 48.00
Static Water Level (ft): 8.20
Pumping Water Level (ft): 42.10
Yield (gpm): 800.00
Test Type: PUMP
Test Duration: 24.00
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):

How Drilled: ROTARY
Driller's Name: BECK
Driller License: WWC048
Completion Date: Apr 02, 1994
Special Conditions: None Reported
Is Well Flowing?: No
Shut-In Pressure:
Well/Water Use: PUBLIC WATER SUPPLY
Geology/Aquifer: Not Reported

Hole Diameter Information

From (ft)	To (ft)	Dia (in)
0.0	28.0	12.0

Annular Seal Information

From (ft)	To (ft)	Description
0.0	20.0	BENTONITE GROUT

Casing Information

From (ft)	To (ft)	Dia (in)	Description
-1.5	28.0	12.0	STEEL

Completion Information

From (ft)	To (ft)	Dia (in)	Description
28.0	30.0	12.0	.0 SLOT SCREEN
30.0	43.0	12.0	.12 SLOT SCREEN
43.0	48.0	12.0	.0 SLOT SCREEN

Lithology Information

From (ft)	To (ft)	Description
0.0	5.0	TOPSOIL - BIG ROCK AT 4.5'
5.0	10.0	CEMENTED GRAVEL & VERY FINE SAND (SEEPAGE AT 8')
10.0	12.0	CEMENTED GRAVEL - BIG BOULDER AT 12'
12.0	15.0	COARSE GRAVEL & SAND - STICKY AT 15'
15.0	19.0	CEMENTED GRAVEL & SAND
19.0	20.0	VERY COARSE GRAVEL - GOOD WATER
20.0	25.0	VERY COARSE GRAVEL - WATER HALF CLEAN
25.0	28.0	VERY COARSE GRAVEL
28.0	29.0	COARSE GRAVEL & VERY FINE SILT (WATER DIRTY)

29.0	30.0	COARSE GRAVEL WITH MEDIUM & FINE SAND
30.0	33.0	COARSE GRAVEL WITH FINE SAND & SILT - WATER DIRTY
33.0	35.0	MEDIUM GRAVEL - (WATER CLEANER)
35.0	37.0	MEDIUM GRAVEL & SILT - SOME COARSE GRAVEL - WATER VERY DIRTY
37.0	38.0	FINE SAND & SILT
38.0	39.0	VERY COARSE GRAVEL - WATER MUCH CLEANER
39.0	41.0	VERY CAORSE GRAVEL & SAND - SILTY - WATER DIRTY
41.0	43.0	VERY COARSE GRAVEL - VERY SILTY WATER VERY DIRTY SMALL BALLS OF SILTY DARK BROWN CLAY
43.0	45.0	SILTY DARK BROWN CLAY - SLATE - BEDROCK

Site Notes
LAT\LONG FROM DEQ

[redacted]

[redacted]

APPENDIX B.
ANACONDA/DEER LODGE WATER RIGHT LISTING

OWNER	BASIN	W R NUMBER	USE	SOURCE	SEC	TWP	RNG	PRIORITY
ACKERLUND, VIRGINIA B	76GJ	95804	MD	UNNAMED TRIBUTARY OF FLINT CREEK	8	5N	13W	JAN 13, 1913
ADAMS, SUSAN E	76G	106674	DM	GROUNDWATER	30	5N	11W	JUL 22, 1957
ADAMS, SUSAN E	76G	106674	LG	GROUNDWATER	30	5N	11W	JUL 22, 1957
ADAMS, JR, EVERETT K	76G	106674	DM	GROUNDWATER	30	5N	11W	JUL 22, 1957
ADAMS, JR, EVERETT K	76G	106674	LG	GROUNDWATER	30	5N	11W	JUL 22, 1957
AHO, GINNY	76G	49992	ST	UNNAMED TRIBUTARY OF WARM SPRINGS CREEK	34	5N	11W	JAN 01, 1950
AHO, GINNY	76G	49993	ST	WARM SPRINGS CREEK	34	5N	11W	JAN 01, 1906
AHO, GINNY	76G	49994	DM	UNNAMED TRIBUTARY OF WARM SPRINGS CREEK	34	5N	11W	JUN 01, 1932
AHO, GINNY	76G	49995	DM	GROUNDWATER	34	5N	11W	MAR 01, 1952
AIDLIN, JOSEPH W	76G	91043	RC	UNNAMED TRIBUTARY OF CABLE CREEK	10	5N	13W	MAY 13, 1940
AIDLIN, JOSEPH W	76G	91044	MN	UNNAMED TRIBUTARY OF CABLE CREEK	10	5N	13W	MAY 13, 1940
AIDLIN, JOSEPH W	76G	91045	FW	UNNAMED TRIBUTARY OF CABLE CREEK	10	5N	13W	MAY 13, 1940
ALSPAUGH, ALGA	76G	92273	DM	GROUNDWATER	33	5N	11W	MAY 15, 1947
AMERICAN GEM CORP,	76G	71170	MN	SOUTH FORK DRY COTTONWOOD CREEK	16	5N	8W	MAY 15, 1989
AMERICAN GEM CORP,	76G	71170	WW	SOUTH FORK DRY COTTONWOOD CREEK	16	5N	8W	MAY 15, 1989
AMERIMONT INC,	76G	5588	IR	WARM SPRINGS CREEK	30	5N	12W	SEP 15, 1879
AMERIMONT INC,	76G	23408	ST	GROUNDWATER	19	5N	11W	SEP 27, 1979
AMOREX LAND CO,	76G	94012	ST	MILL CREEK	28	4N	11W	JUL 31, 1880
AMOREX LAND CO,	76G	101820	DM	GROUNDWATER	20	4N	11W	SEP 02, 1997
AMOREX LAND CO,	76G	111843	DM	GROUNDWATER	29	4N	11W	JUL 03, 2000
AMOREX LAND CO,	76G	115660	DM	GROUNDWATER	28	4N	11W	APR 24, 2001
ANACONDA GOSPEL ASSEMBLY,	76G	73280	DM	GROUNDWATER	30	5N	11W	DEC 23, 1959
ANACONDA SADDLE CLUB,	76G	45885	CM	GROUNDWATER	25	5N	12W	MAY 03, 1982
ANACONDA SADDLE CLUB,	76G	45885	DM	GROUNDWATER	25	5N	12W	MAY 03, 1982
ANACONDA SADDLE CLUB,	76G	45885	ST	GROUNDWATER	25	5N	12W	MAY 03, 1982
ANACONDA SADDLE CLUB,	76G	45885	LG	GROUNDWATER	25	5N	12W	MAY 03, 1982
ANACONDA SADDLE CLUB,	76G	77595	DM	GROUNDWATER	25	5N	12W	APR 15, 1991
ANACONDA SADDLE CLUB,	76G	77595	ST	GROUNDWATER	25	5N	12W	APR 15, 1991
ANACONDA-DEER LODGE CITY-COUNTY,	76G	5786	DM	GROUNDWATER	18	4N	10W	JUN 23, 1975
ANACONDA-DEER LODGE CITY-COUNTY,	76G	5786	ST	GROUNDWATER	18	4N	10W	JUN 23, 1975
ANACONDA-DEER LODGE CITY-COUNTY,	76G	6769	IR	MILL CREEK	18	4N	10W	JUN 30, 1881
ANACONDA-DEER LODGE CITY-COUNTY,	76G	15408	DM	GROUNDWATER	18	4N	10W	OCT 03, 1977
ANACONDA-DEER LODGE CITY-COUNTY,	76G	17054	MC	GROUNDWATER	33	5N	11W	OCT 26, 1937
ANACONDA-DEER LODGE CITY-COUNTY,	76G	17055	MC	GROUNDWATER	33	5N	11W	OCT 26, 1937
ANACONDA-DEER LODGE CITY-COUNTY,	76G	17056	MC	GROUNDWATER	33	5N	11W	OCT 26, 1937
ANACONDA-DEER LODGE CITY-COUNTY,	76G	17059	MC	FIFER GULCH	5	4N	11W	FEB 23, 1888
ANACONDA-DEER LODGE CITY-COUNTY,	76G	17060	MC	FIFER GULCH	5	4N	11W	MAY 15, 1871
ANACONDA-DEER LODGE CITY-COUNTY,	76G	17061	MC	GRAYS GULCH	15	4N	12W	MAR 08, 1898
ANACONDA-DEER LODGE CITY-COUNTY,	76G	26799	DM	GROUNDWATER	18	4N	10W	MAR 06, 1980
ANACONDA-DEER LODGE CITY-COUNTY,	76G	28410	DM	GROUNDWATER	18	4N	10W	MAY 05, 1980
ANACONDA-DEER LODGE CITY-COUNTY,	76G	44616	DM	GROUNDWATER	18	4N	10W	MAY 03, 1982
ANACONDA-DEER LODGE CITY-COUNTY,	76G	44616	LG	GROUNDWATER	18	4N	10W	MAY 03, 1982
ANACONDA-DEER LODGE CITY-COUNTY,	76G	49961	IR	MILL CREEK	18	4N	10W	DEC 31, 1913

APPENDIX C.
2002 GROUND WATER ANALYSES
LABORATORY REPORT

Water & Environmental Technology - ADCM02
Metals in soils
Batch No.: 5544
Results per dry weight basis

SAMPLE ID	FIELD ID	As (mg/Kg)	Cd (mg/Kg)	Cu (mg/Kg)	Fe (mg/Kg)	Pb (mg/Kg)	Mn (mg/Kg)	Hg (mg/Kg)	Zn (mg/Kg)
CRDL		11.3	0.96	4.8	19.2	9.2	2.9	0.014	3.8
IDL	ARL 3560	5.7	0.87	0.46	1.9	4.6	0.50	0.038	1.1
020924Q011	SB#1	5.7 U	0.88 U	36.9	11400	11.9	118	0.030 B	98.5
020924Q012	SB#2	685	1.5	2310.0	96900	550	210	0.097	9390
020924Q013	SB#3	528	7.7	1690	39400	247	272	0.23	2490
020924Q014	SB#4	898	6.1	3190	97700	712	406	0.16	13500

HKM Laboratory

Reviewed by [signature]

HKM ENGINEERING

25-Oct-02 10:50 am

Client: WATER & ENVIRONMENTAL TECH
BIF: 009853

Sample ID	Collected Date, Time	Customer's Sample ID	NO3/NO2-N (mg/L)	Total Phos (mg/L)
020924Q001	09/23/2002 9:40:00 AM	GW#1	0.09	0.72
020924Q002	09/23/2002 10:30:00 AM	GW#2	0.46	1.01
020924Q003	09/23/2002 11:15:00 AM	GW#3	0.51	0.46
020924Q004	09/23/2002 12:10:00 PM	GW#4	0.47	0.11
020924Q005	09/23/2002 12:50:00 PM	GW#5	0.52	0.83
020924Q006	09/23/2002 1:15:00 PM	GW#6	0.58	0.28
020924Q007	09/23/2002 3:30:00 PM	GW#7	2.91	0.73
020924Q008	09/23/2002 4:15:00 PM	GW#8	3.09	0.74
020924Q009	09/23/2002 4:30:00 PM	WSC UP	0.09	0.47
020924Q010	09/23/2002 4:45:00 PM	WSC DOWN	0.06	0.92

Review hwm

APPENDIX D.
RESIDENTIAL WELL SAMPLING PROGRAM
LITHOLOGIC LOGS

Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
HOWERY FAY

Plot this site on a topographic map
View Hydrograph for this Site

Location Information

GWIC Id: 52164
Location (TRS): 05N 12W 26 ABBB
County (MT): DEER LODGE
DNRC Water Right:
PWS Id:
Block:
Lot:
Certificate of Survey:

Source of Data: LOG
Latitude (dd): 46.1648
Longitude (dd): -113.0654
Geomethod: NAV-GPS
Datum: 1927
Addition:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 33.00
Static Water Level (ft): 12.00
Pumping Water Level (ft):
Yield (gpm): 40.0
Test Type: BAILER
Test Duration:
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):

How Drilled: CABLE
Driller's Name: OKEEFE
Driller License: WWC287
Completion Date (m/d/y): 6/28/1984
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 112SNGR
Well/Water Use: DOMESTIC

Hole Diameter Information

No Hole Diameter Records currently in GWIC.

Annular Seal Information

No Seal Records currently in GWIC.

Casing Information[1]

From	To	Dia	Description
-2.0	33.0	6.0	

Completion Information[1]

From	To	Dia	Description
28.0	33.0	0.0	TORCH

Lithology Information

From	To	Description
0.0	1.0	TOPSOIL
1.0	8.0	GRAVEL & BOULDER
8.0	25.0	CEMENTED SAND & GRAVEL
25.0	33.0	SAND GRAVEL & WATER

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

[redacted]

Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
MARINKOVICH DAN

Plot this site on a topographic map

Location Information

GWIC Id: 120353
Location (TRS): 05N 12W 25 DB
County (MT): DEER LODGE
DNRC Water Right:
PWS Id:
Block:
Lot:
Certificate of Survey:

Source of Data: LOG
Latitude (dd): 46.1560
Longitude (dd): -113.0407
Geomethod: TRS-TWN
Datum: 1927
Addition:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 33.00
Static Water Level (ft): 4.00
Pumping Water Level (ft): 27.0
Yield (gpm): 25.0
Test Type: AIR
Test Duration: 2.00
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):

How Drilled: AIR ROTARY
Driller's Name: LINDSAY
Driller License: WWC253
Completion Date (m/d/y): 8/28/1990
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: Not Reported
Well/Water Use: DOMESTIC

Hole Diameter Information

No Hole Diameter Records currently in GWIC.

Annular Seal Information

From	To	Description
0.0	20.0	BENTONITE

Casing Information[1]

From	To	Dia	Description
-2.0	33.0	6.0	STEEL

Completion Information[1]

No Completion Records currently in GWIC.

Lithology Information

From	To	Description
0.0	4.0	TOPSOIL
4.0	12.0	CLAY AND SAND
12.0	30.0	BOULDER AND GRAVEL
30.0	33.0	GRAVEL

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

Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
SCHALK JOHN

Plot this site on a topographic map

Location Information

GWIC Id: 52059
Location (TRS): 05N 11W 33
County (MT): DEER LODGE
DNRC Water Right:
PWS Id:
Block:
Lot:
Certificate of Survey:

Source of Data: LOG
Latitude (dd): 46.1444
Longitude (dd): -112.9805
Geomethod: TRS-TWN
Datum: 1927
Addition:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 34.00
Static Water Level (ft): 18.00
Pumping Water Level (ft):
Yield (gpm): 30.0
Test Type: BAILER
Test Duration:
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):

How Drilled: CABLE
Driller's Name: OKEEFE
Driller License: WWC287
Completion Date (m/d/y): 1/1/1978
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: Not Reported
Well/Water Use: DOMESTIC

Hole Diameter Information

From	To	Diameter
0.0	34.0	6.0

Annular Seal Information

No Seal Records currently in GWIC.

Casing Information[1]

From	To	Dia	Description
-1.0	34.0	6.0	STEEL

Completion Information[1]

From	To	Dia	Description
27.0	32.0	6.0	1/8 TORCH

Lithology Information

From	To	Description
0.0	18.0	BOULDERS
18.0	20.0	ROCKS AND GRAVEL AND SOME WATER
20.0	34.0	GRAVEL AND SAND

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