MONTANA BUREAU OF MINES AND GEOLOGY
OPEN-FILE REPORT
MBMG 401-B

HYDROGEOLOGIC ASSESSMENT OF THE ROUNDUP, MONTANA PUBLIC WATER SUPPLY FOR GROUND WATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER

CITY OF ROUNDUP
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Prepared for

Montana Department of Environmental Quality
Water Quality Division

by

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INTRODUCTION AND PURPOSE

This report summarizes the results of a Hydrogeologic Assessment of the public water supply source for the city of Roundup, Montana (PWSID #00321). The Montana Bureau of Mines and Geology (MBMG) is under contract with the Montana Department of Environmental Quality (DEQ) to conduct preliminary assessments and hydrogeologic assessments for selected communities. The project was funded under DEQ contract number 430007, task order number 38.

The purpose of conducting this hydrogeologic assessment is to determine if the ground-water source used for the city of Roundup public water supply is under the direct influence of surface water as defined in 40 CFR part 141. Field inspections were undertaken on April 21, 1997 and January 28, 1998. Mr. Gary Thomas, Director of Public Works for Roundup, accompanied on field inspections and provided background information. **The city supply system currently includes an infiltration gallery and a mine void. In the future the infiltration gallery will be bypassed leaving the mine void as the only ground-water source. The results of this assessment indicate that the mine void, as a ground-water source used by the city of Roundup is not under the direct influence of surface water. Though not tested in detail, the infiltration gallery probably is under the direct influence of surface water.** This report summarizes information obtained during the inspection and follow-up investigation, which was used to make the determination. Information on system location and construction, geology, hydrology, and water quality is summarized. Conclusions and recommendations are presented at the end of the report. Site-access maps and photographs taken during the site inspection are provided as appendices.

BACKGROUND

The Surface Water Treatment Rule (SWTR) of the Federal Safe Drinking Water Act of 1986 requires each state to examine public water supplies that use ground water to determine if there is a direct surface water influence. In Montana, the Water Quality Division (WQD) of DEQ is evaluating public water supplies for compliance with the SWTR. This project is known as the **Ground Water Under the Direct Influence of Surface Water (GWUDISW) program**. The SWTR provides the following definition of ground water under the direct influence of surface water.

Any water beneath the surface of the ground with:

i) significant occurrence of insects or other macroorganisms, algae, or large diameter pathogens such as *Giardia lambia*, or *Cryptosporidium*; or

ii) significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH, which closely correlates to climatological or surface-water conditions.

The evaluation begins with a preliminary assessment (PA). If the PA indicates that the ground-water supply may be under the influence of surface water, further study is required. Further study may include conducting a hydrogeologic assessment, a water quality assessment or conducting microscopic particulate analysis (MPA) sampling.

PRELIMINARY ASSESSMENT

The city of Roundup draws water from two adjacent wells that are completed in same room of an abandoned underground coal mine. An infiltration gallery in alluvium along the Musselshell River is used for temporary storage in the pumping system, and could be providing some additional water. Completed preliminary assessment forms for each well and gallery are included as Appendix A. The well sources were assigned a score of 20 points each. The wells are covered in a single well house that is located 105 feet (ft) from the Musselshell River, for which they scored 10 points. The wells are 100 ft deep and have static water levels of about 20 ft, with seasonal variation. The wells received scores of 5 and 5 respectively for depth and water levels. The source of recharge to the mine voids is not well understood, so additional evaluation was carried out on the wells. The wells are intended to continue being part of the permanent water supply for the city.

Fifty-five points were assigned to the infiltration gallery. Forty points were assigned for the structure being an infiltration gallery. The horizontal distance to a surface water body is unknown, as the integrity of the laterals is not known, so a score of 15 was assigned. The total score of 55 indicates the source is at risk of being under the direct influence of surface water, and requires additional evaluation. Under current plans, the infiltration gallery will be removed from the city supply system.

Due to the potential for water quality problems associated with the infiltration gallery, the city has decided to bypass that part of the system. By excluding the infiltration gallery, the preliminary assessment score would then be adjusted to a total of 25 points. The evaluation performed in this study focused on the wells which are completed in the mine voids, as those will be the long-term water supply for the city.

SYSTEM DESCRIPTION

The Roundup Public Water Supply provides water for the community of Roundup, which has a population of approximately 2,000. Annual average daily production is about 400,000 gallons. There is no major manufacturing in the city, water is used for domestic purposes, fire fighting, and minor commercial interests. Highest usage is during the summer when residents use the water for lawn and garden watering.

Water is withdrawn from supply wells south of the Musselshell River, injected into the clearwell (or caisson) of an infiltration gallery in the alluvium north of the river, withdrawn from the clearwell at a slightly lower rate than the injection, and pumped to holding tanks on the north edge of town.

Location

The city of Roundup is located in Musselshell County, predominantly on the north side of the Musselshell River, in central Montana (figure 1). The supply wells are on the southern side of the Musselshell River, in the valley bottom at an altitude of 3,190 ft above mean sea level. The legal description of the well house is: Township 8 North, Range 25 East, section 24 SW 1/4 of SE 1/4 of NW 1/4 of NW 1/4 of NE 1/4 (latitude 46 26' 19", longitude 108 32' 10"). The clearwell for the infiltration gallery is at an elevation of 3,190 ft, located in the same section in SW 1/4 of NE 1/4 of NE 1/4 of NW 1/4 (latitude 46 26' 22", longitude 108 32' 21"). The holding tanks are located at an elevation of 3,360 in the same township, in section 12 NE 1/4 of SW 1/4 of NW 1/4 of SW 1/4. An additional well is currently being considered by the city, and it may be drilled in section 24, NW 1/4 of NE 1/4 at a surface elevation of 3,190 ft. Maps to the sites are included as Appendix B.

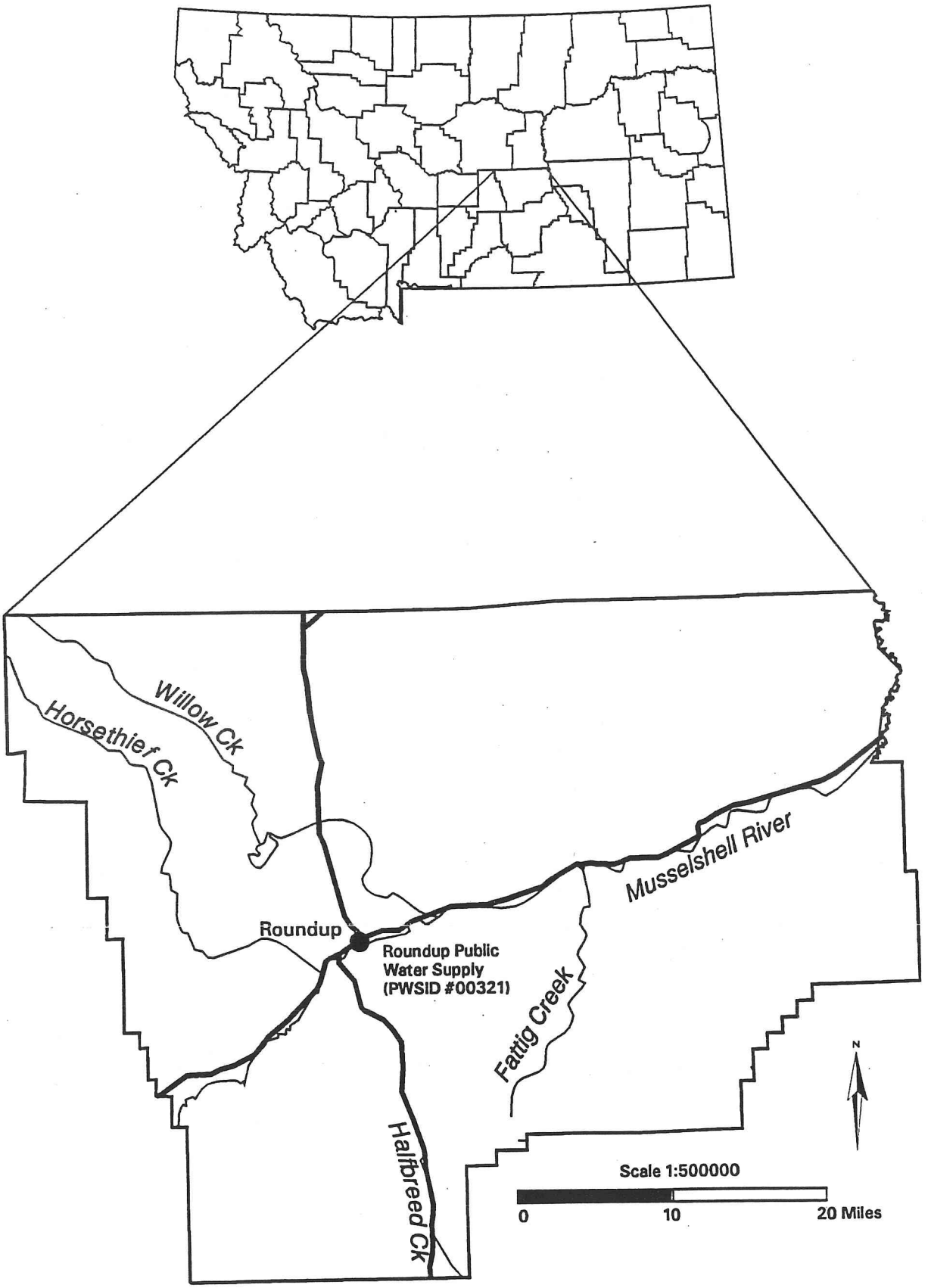


Figure 1. Site location map. Roundup is situated along the Musselshell River in central Montana.

Source history

The first recorded water supply for the city of Roundup was a dug well in the alluvium along the Musselshell River (Ellis and Meinzer, 1924). This 8-ft wide by 16-ft long by 35-ft deep well had a reported capacity of 500 gallons per minute (gpm). Water chemistry was dominated by calcium and sulfate ions, and the total dissolved solids (TDS) content was about 830 milligrams per liter (mg/L) (Wheaton, 1994).

By 1923 two, 7-inch diameter wells had been added to the system. These wells were 150-ft and 200-ft deep, completed in Tertiary sandstone units in the Tongue River Member of the Fort Union Formation, below the mined coal seams in the area. In addition to the wells, two infiltration galleries, 450-ft and 500-ft long, were constructed in the alluvium. These galleries were constructed of 12-inch and 15-inch tiles. Total daily consumption during this time was 500,000 gallons to 800,000 gallons. In good years drawdown was reported to be less than 2-ft, while in dry years demand was barely met. Consumption was higher during these times due to the larger population associated with active mining.

By 1954 two wells had been drilled and completed in abandoned mine workings along the south side of the Musselshell River valley. One of these wells was abandoned and replaced with a new well in 1977 (Gary Thomas, Roundup City Commissioner of Public Works, personal communication). Poor records exist on the well completions and no records exist for the method of abandonment of the old wells.

Currently, the main supply of water for Roundup comes from the two wells completed in the abandoned underground Republic Number 1 coal mine. Coal mining began in the Roundup coal field during the late 1800's with ranchers removing coal for their own use. The Northern Pacific Railroad opened test pits in the 1880's and finally the first commercial mine was opened in 1907. This first of many mines was the Republic Number 1, located south of the Musselshell River. Originally this mine was accessed by a mine roadway or slope under the alluvium of the Musselshell River. This slope was abandoned due to seepage problems and mining continued via a shaft and a slope on the south side of the river valley until it was closed in the late 1930's. Other mines continued to operate in the area until the mid-1960's, but closed due to the reduced demand by railroads as diesel replaced coal. Additional information about the mines and very colorful history of the area can be found at the Musselshell Valley Historical Society Museum in Roundup.

Today, the public water supply is pumped from two wells in the Republic Number 1 mine voids, and discharged to the alluvium through the clearwell for the infiltration gallery. A pump in the clearwell lifts the water to storage tanks north of town (Figure 2). Pumping rates from the mine wells are 1,250 gpm to 1,300 gpm, and from the clearwell slightly less at 1,200 gpm to 1,250 gpm. The difference in pumping rates is intended to decrease the mixing of alluvial water with the mine water. Water consumption averages about 400,000 gallons per day.

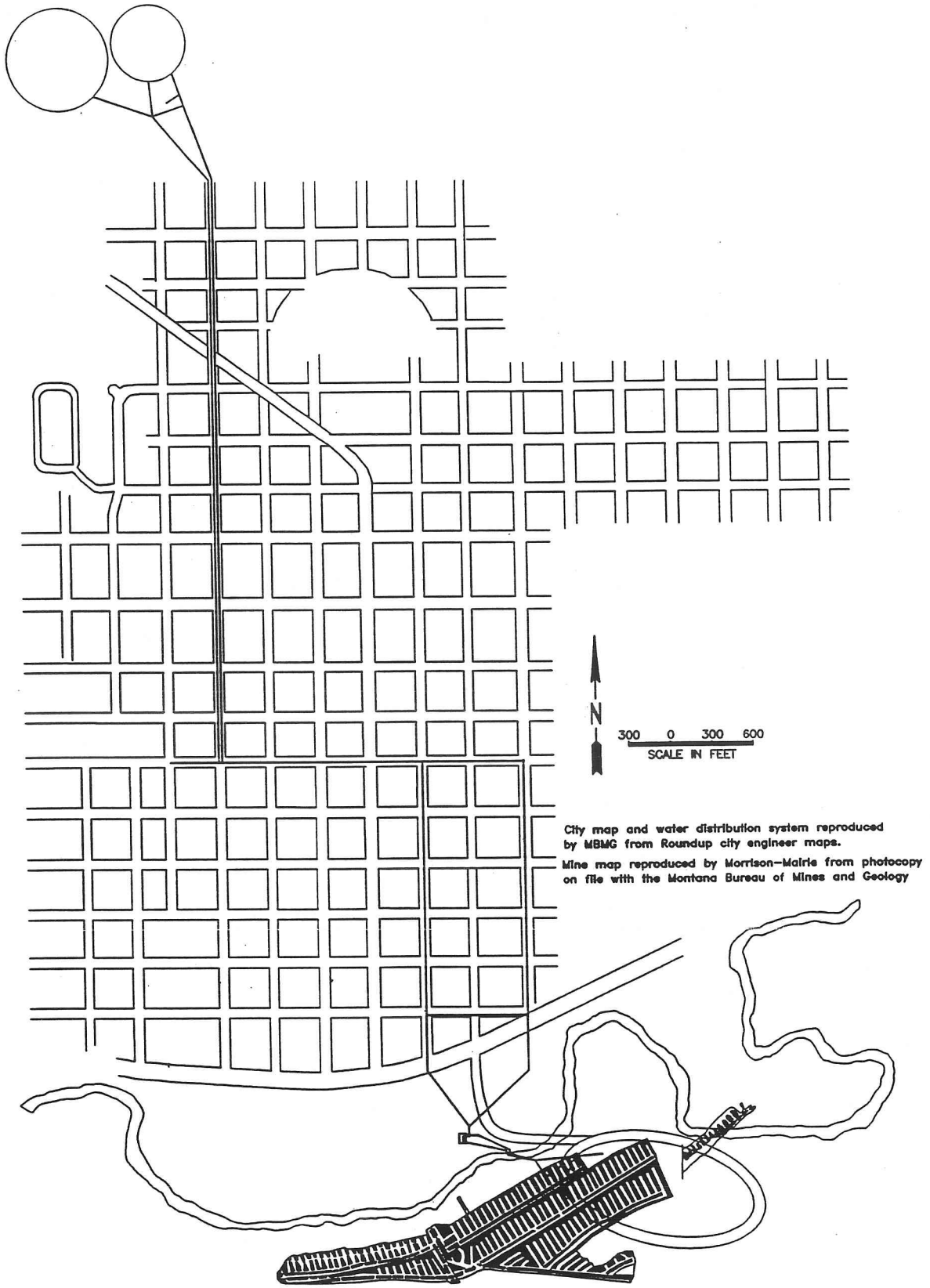


Figure 2. Roundup public water supply system configuration. Ground-water is withdrawn from mine voids south of the river, pumped to a clear well north of the river, then pumped to storage tanks north of town. Selected water mains are shown.

System Configuration

Photographs of the surrounding area, and of the infiltration gallery clearwell and the pump house are included as Appendix C.

Construction details of the infiltration gallery are not known. Presumably trenches were dug, and perforated tile laid in the alluvial gravel. Whether those trenches were originally dug to the river is also not known. Based on conversations with the city public works director the perforated tiles may now have collapsed, and the gallery may be serving a reduced function (Thomas, 1997). Since the mine voids are pumped at a greater rate than the clearwell at the infiltration gallery, the gradient is probably causing recharge in the adjacent alluvium, indicating the galleries are functioning to some extent.

Several wells have been drilled to the mine voids and completed for city water supplies. As older wells have been taken out of service, they have been plugged and abandoned. Two wells exist now, located about 10 ft apart, and protected in a single well house. Drillers logs for two wells are included as Appendix D. However, due to poor records, it is not clear which log is for which well, or if these are the correct logs. Completion records indicate one well was drilled to 93 ft in 1950, encountering the coal bed at 63 ft. This depth is shallower than expected for the mine voids, and no comment about mine voids appears on the well log. As this is not the original log, but a transcribed copy, the accuracy is questionable. The well is recorded as having 13 3/8-inch steel casing cemented in place to 22 ft below ground surface. The remainder of the well is apparently completed as an open hole.

The second drill log for a well completed in 1977 indicates the well depth is 105 ft with the mine voids from 95 to 105 ft. Twenty-one-inch steel casing was cemented in place to 32 ft in a 24-inch borehole. The remainder of the hole was drilled with a 16-inch bit, and 12-inch steel casing cemented in place to a depth of 81 ft. The bottom 24 ft of the hole was left open.

Details of the pumping system are shown in Figure 3. In both wells, vertical line shaft turbine pumps are set with intake depths of about 95 ft. One pump is 60 horsepower; the other is 75 horsepower. Only one pump is in use at a particular time, and the second is maintained as a backup in case of equipment failure. Pumping rates from the mine voids are 1,250 gpm to 1,300 gpm. Discharge lines from both pumps converge in the pump house building and cross under the Musselshell River through a single 8-inch pipeline. Chlorine is added at an approximate rate of 40 pounds per day to the pipeline as it reaches the clearwell building, north of the river. The water receives no other treatment.

The discharge point of the pipeline is below water level in the clearwell of the old infiltration gallery. A vertical line shaft turbine pump at the clearwell withdraws water at a rate of 1,200 gpm to 1,250 gpm, and it is carried through a series of pipelines to the city distribution system and on to the storage tanks north of town.

The storage tanks are circular concrete reservoirs. One reservoir has a capacity of about 1,000,000 gallons, and the other about 2,000,000 gallons. Mineral precipitation settling to the bottom of the tanks has partially diminished the reservoir capacity.

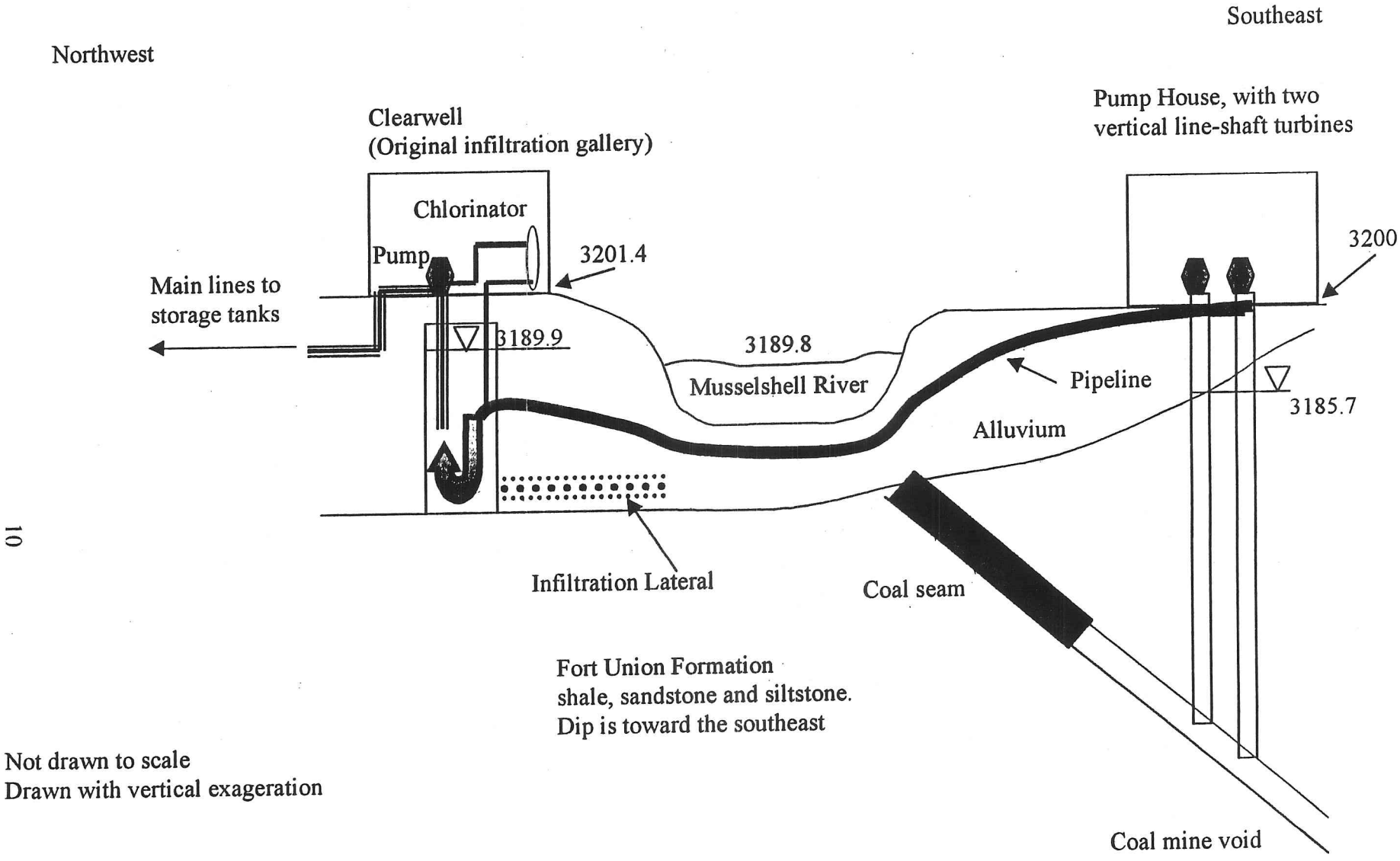


Figure 3. Details of water supply pump house and clearwell. Water from the mine void is pipelined to the clearwell, from where it is pumped to the storage tanks. Elevations are surveyed relative to pumphouse floor. Depth of alluvial deposits in vicinity of pump house is between 14 and 19 feet, and near the clearwell is between 25 and 30 feet (Wheaton, 1994). Drawing is not to scale, and is drawn with vertical exaggeration.

GEOLOGY

Local Topography and Land Use

Roundup lies on the north flanks of the Bull Mountains in semiarid central Montana. Roundup receives an average of about 12 inches of precipitation year (Omang, 1986). The temperature is moderate to cold in the winter with rapid fluctuations, and the summers are typically hot and dry. Average daily maximum temperature for Roundup is 58 degrees F. And the average daily minimum is 35 degrees F.

The abandoned coal mines near Roundup are in the Bull Mountains coal field, within the Musselshell River drainage. The Bull Mountains, south of Roundup, form a drainage divide between the Yellowstone and Missouri Rivers. The highest point in the mountains is about 4,700 ft above sea level, contrasting with the elevation at Roundup of about 3,200 ft. The divide consists of high ridges capped by erosion-resistant clinker and highlighted by steep-sided sandstone rimrocks. Valleys are typically formed in softer shale units. Flow is intermittent or ephemeral in most local watercourses (Knapton, 1982). Halfbreed Creek, along the western edge of the mined area, is ephemeral in its upper reaches and perennial in the lower reaches near its confluence with the Musselshell River. Recharge to the mine voids is along the northern flanks of the Bull Mountains, especially in clinker-capped ridges and sandy outcrops. Ground-water flow is a combination of shallow flow through colluvium and alluvium and vertical leakage to deeper units. Land use in the recharge areas is limited to ranching and a few scattered home sites. Near the top of the Bull Mountains, several coal strip mines sit idle. One underground mine, targeting a stratigraphically higher coal than that mined near Roundup, opened during the mid-1990's. It currently is closed, and its future remains uncertain.

Steep hills rise along the south edge of the Musselshell River valley (Figure 4). The pump house is located at the base of these hills, on the valley floor. The ground around the pumphouse is sloped to carry surface drainage away from the structure. The clearwell is in the flood plain. To protect the clearwell from surface drainage during times of high water, berms have been built surrounding the building. Flood water has reached the berm in the past, but not the building (Gary Thomas, 1997).

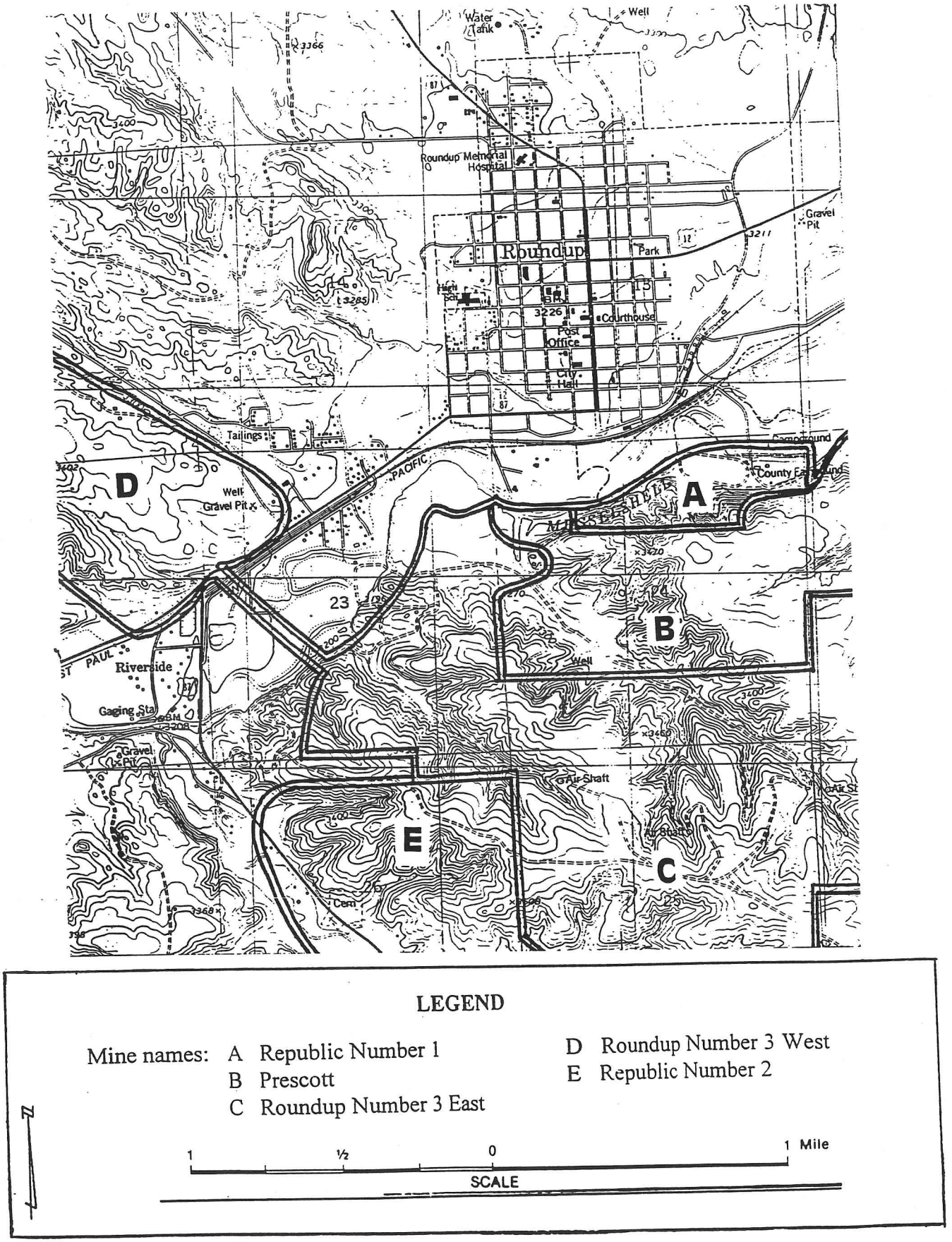


Figure 4. Topographic setting of the Roundup city water supply and location of nearby abandoned underground coal mines. Mine maps on file at MBMG.

Regional Geology

Roundup is on the north edge of the Bull Mountains coal field, and is underlain by sedimentary rocks from Cambrian to Paleocene in age. Details and discussions of bedrock geology in the area are contained in several publications, including Wheaton, (1994), Wheaton (1992), Noble and others (1982), Rice (1976), and Woolsey and others (1917).

Geomorphic features at Roundup are controlled by the Tongue River Member of the Fort Union Formation (Figure 5). This formation is a sequence of Paleocene fluvial-deltaic sediments, which conformably overlie the Cretaceous Hell Creek Formation. The Tongue River Member contains interbedded tan to whitish-gray sandstone, grayish-green shale, coal and minor amounts of buff, fresh-water limestone. The sandstone beds range in thickness from a few inches where interbedded with shale, to more than 50 ft. They vary in thickness over relatively short distances but, due to their resistant nature, can commonly be traced for considerable distances as a series of cliffs and benches. Fine-grained sandstones are volumetrically the predominant lithologic units of the member. As a result of differential erosion, modern stream and river valleys commonly overlie Tongue River Member silts and shales. The Cretaceous Hell Creek Formation, and older units, outcrop north of Roundup and around the circumference of the Bull Mountains (Figure 5).

Local Geology

Twenty-six coal beds have been identified in the Bull Mountain coal field (Woolsey and others, 1917). The coal bed that was mined in the Roundup area is the Roundup bed of the Tongue River Member. The Roundup bed is classified as subbituminous, with an average calorific value of about 11,000 BTU's per pound and sulfur content typically less than 1 percent. Sand and gravel deposits of Tertiary/Quaternary age overlie the Tongue River member within the Musselshell River valley, occupying the present flood plain and the flat-lying terraces above it.

Roundup lies in the south-plunging portion of a NW-SE trending syncline, which is part of a larger structural feature known as the Bull Mountain basin. The rocks dip most steeply on the north limb of the syncline, reaching about 13 degrees near Roundup. The fold flattens toward the southeast. The Republic Number 1 mine extends from near the coal outcrop to depths as great as 200 ft below the river level.

The Republic mine voids cover an estimated area of 690,000 square ft. If the average void height is 5 ft, the total volume in the voids is about 3,500,000 cubic ft (about 26 million gallons). However, not all the voids are connected, and the actual volume of mine void being tapped by the city water supply system cannot be estimated.

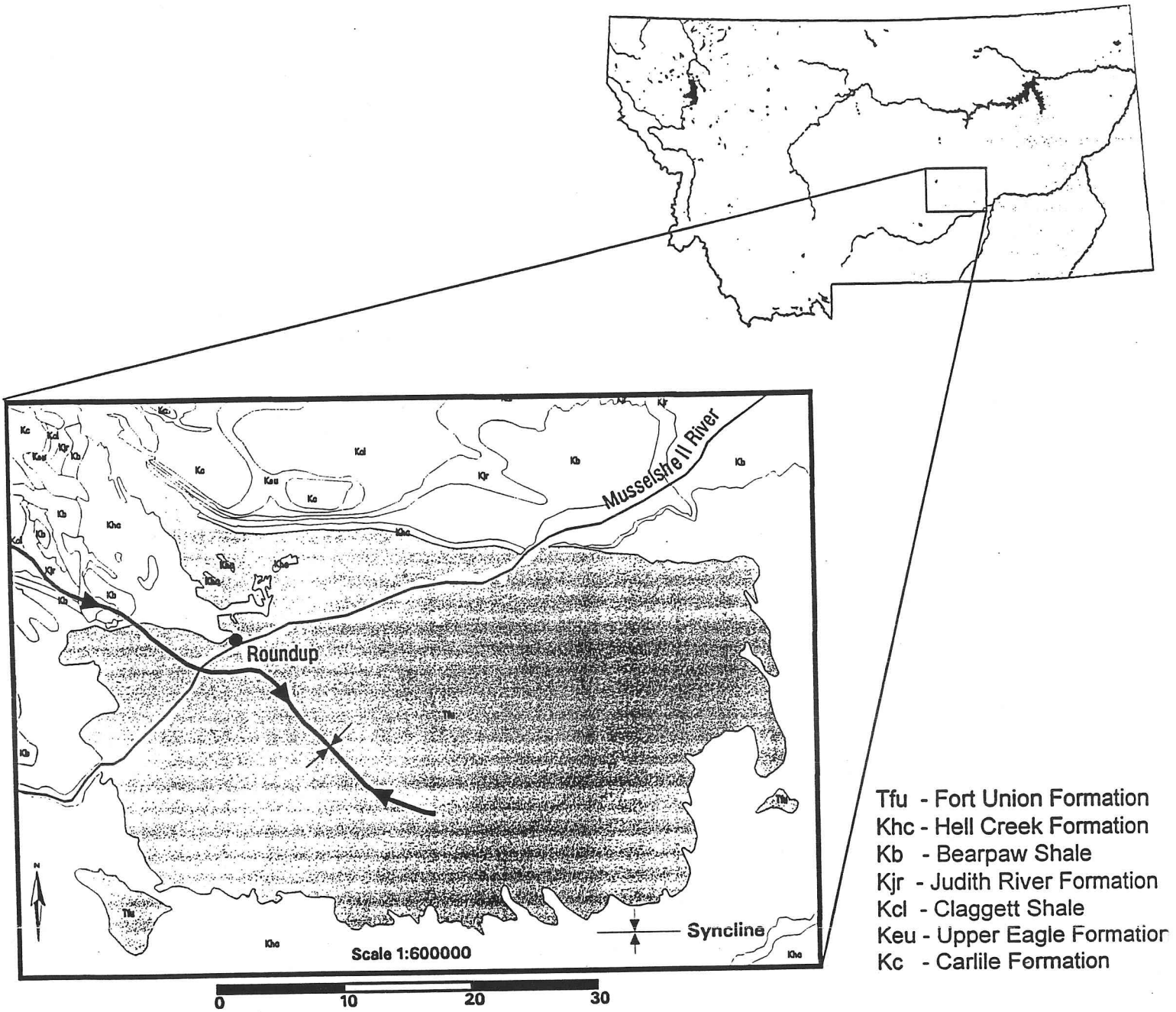


Figure 5. Generalized geologic setting in the Roundup area. The bedrock outcrops in the Bull Mountains, and in the immediate area around Roundup belong to the Tertiary Fort Union Formation. Beds at Roundup dip generally south, at 10 to 20 degrees.

HYDROLOGY

Surface Water

Monitor sites visited during this study, and discussed in the report are shown on Figure 6. The Musselshell River is approximately 100 ft from the mine pumphouse, and over 500 ft from the infiltration gallery clearwell. Average mean-daily discharge for the Musselshell river at Roundup for the period of 1947 through 1996 is 213 cubic ft per second (cfs) (U.S. Geological Survey, 1996). The highest reported daily mean flow was on June 8, 1967 at a rate of 8,180 cfs and the lowest daily mean flow was 0.13 cfs on September 10, 1988. River discharge rates show seasonal fluctuations, which are strongly influenced by irrigation demands. Upstream of Roundup, the river fills three irrigation reservoirs (Deadman' s Basin, Martinsdale, Bair reservoirs) with combined storage capacities of 100,000 acre-ft (just over four billion cubic feet).

Water quality in the Musselshell River exhibits a wide variety of seasonal fluctuations. Streamflow during spring run-off has lower concentrations of dissolved solids than streamflow during base flow periods. During spring runoff dissolved solids are low, as snowmelt from the headwaters in the Big Snowy, Crazy, Castle and Little Belt mountains dilutes the sodium-sulfate dominated baseflow with water rich in calcium, magnesium and bicarbonate. Concentrations of dissolved solids typically range from 450 mg/L during spring runoff to over 1,800 mg/L during fall and winter base flow (Knapton, 1982).

Regional Aquifers

Several aquifer systems exist in the Roundup and Bull Mountains area. At depth, a series of deep regional aquifers include the limestone of the Madison Formation, and sandstones in the Kootenai, Eagle and Judith River formations (Wheaton, 1994). These systems are recharged mainly in outcrop areas along the northern flanks of the Big Horn, Pryor and Beartooth mountain ranges and in outcrop areas between these

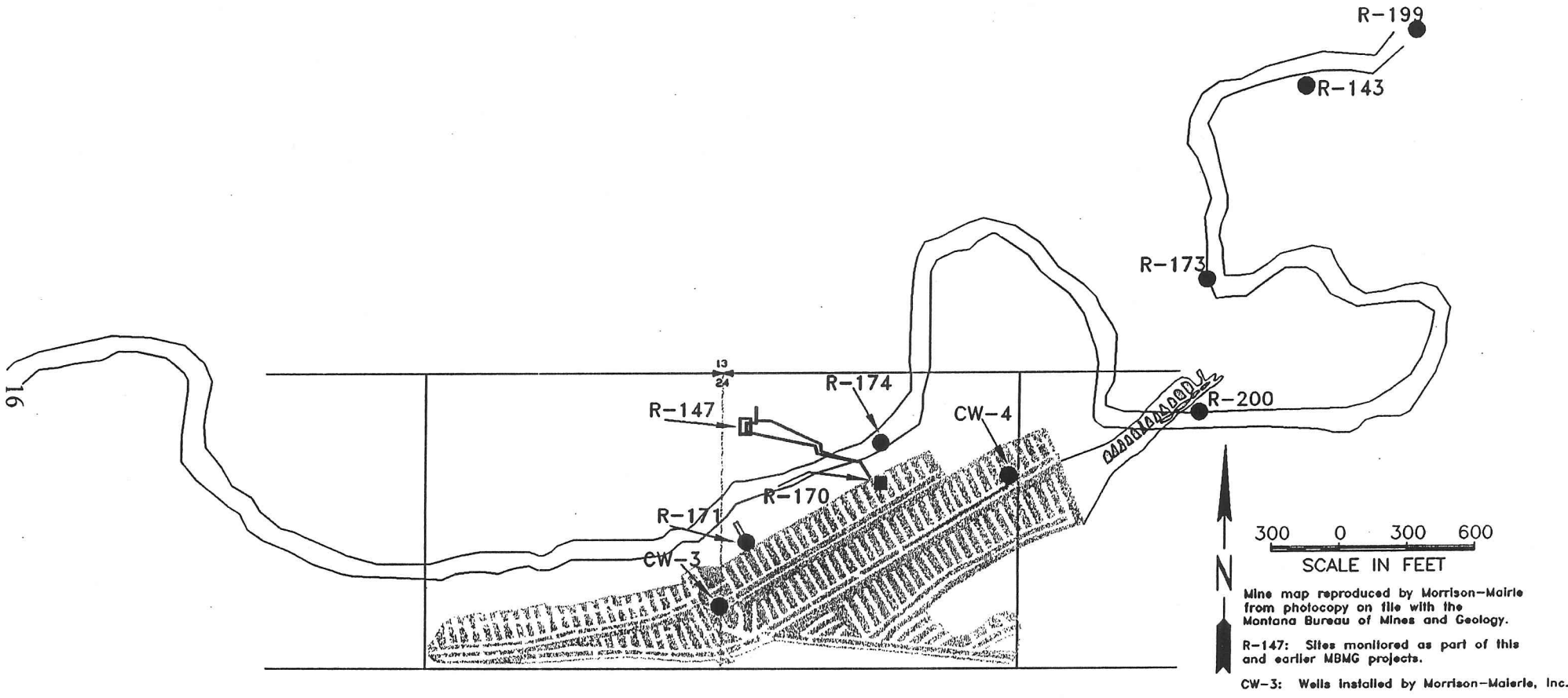


Figure 6. Map of wells and other sampling points related to the assessment of the Roundup public water supply system.

southern mountains and the Bull Mountains. Beneath Roundup and the Bull Mountains, ground-water flow in these aquifers is north toward the Missouri River.

Local and Intermediate Aquifers

The Bearpaw Shale separates the deep regional aquifers from the intermediate and local aquifers. The local and intermediate aquifers include the Cretaceous Fox Hills and Hell Creek aquifer and the Tertiary Fort Union aquifer (Wheaton, 1994). Recharge to the shallow bedrock aquifers is in the high areas in the Bull Mountains. Recharge occurs generally as precipitation on areas of clinker, and probably to a lesser degree on sandstone outcrops. Ground-water flow is both vertically downgradient to deeper aquifers, and laterally to the north.

Along the Musselshell River, a significant alluvial aquifer exists. Ground-water flow in the alluvium generally parallels the river which flows to the east in the Roundup area (Figure 7). Along some stretches the alluvium is recharged by bedrock aquifer discharge, which in turn provides baseflow to the river. In other areas and during periods of high river flow, alluvial water is supplied by leakage from the river.

The mine voids tapped by the Roundup water supply are in the discharge area of bedrock aquifers. Ground-water flow is northward through the sandstone and coal units, toward the river valley (Figure 7). The mine voids south of Roundup are part of this flow system. The mine voids, however, could be considered similar to karst features, in that they have extremely high storativity and hydraulic conductivity values. During periods when the mine-void water level is lower than the river stage and the alluvial water table, the ground-water gradient reverses, and ground water flows southward from the alluvial system, eventually reaching the mine voids. This interpretation is supported in part by the high rates of pumping from the mine voids, and fairly rapid recovery of water levels in the mine. Kaczmarek (1995) estimated recharge to the mine at about 700 gallons per minute. This quantity of flow is not consistent with hydraulic conductivity values for Fort Union Formation sediments, thus implying recharge from the alluvium.

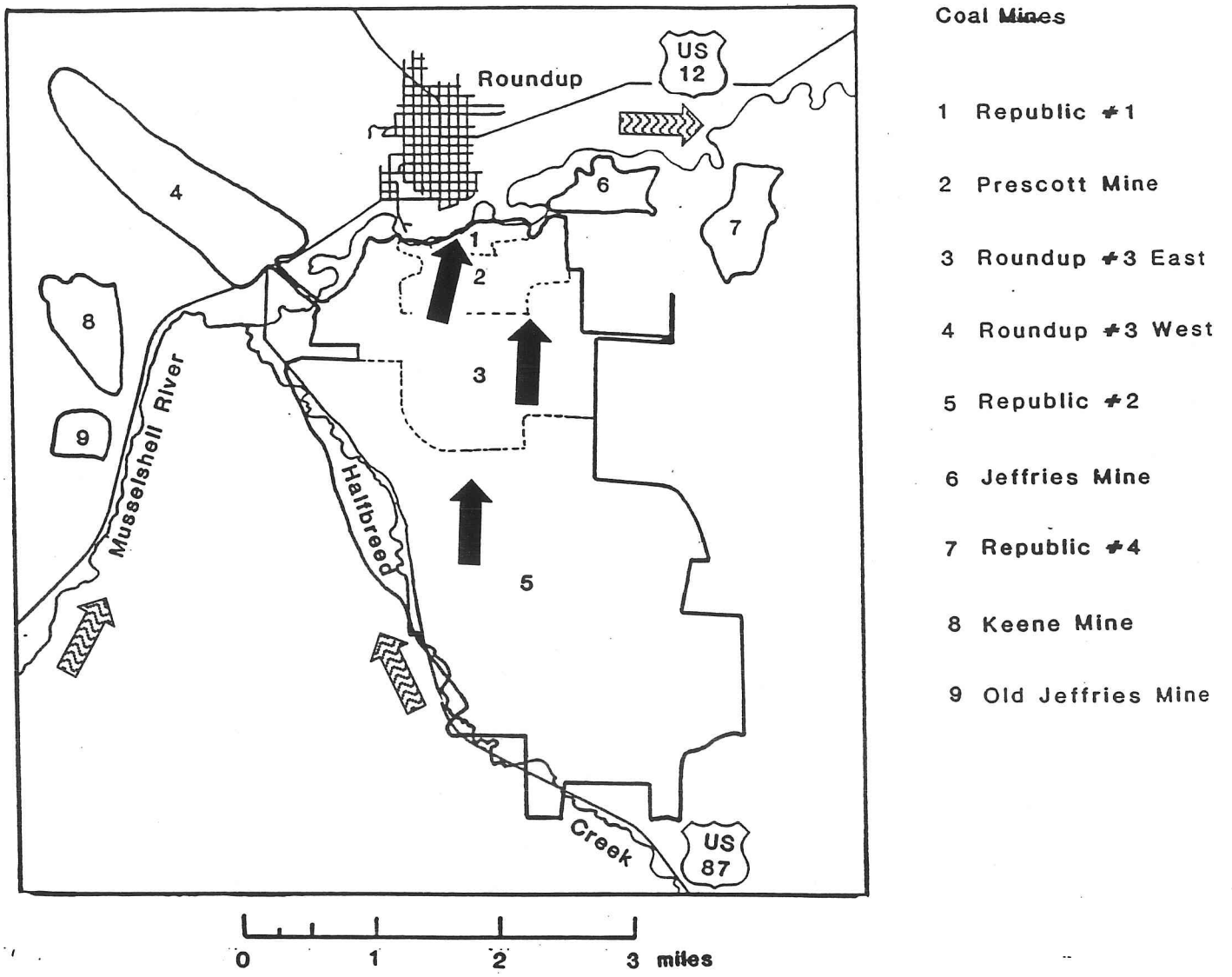


Figure 7. Generalized direction of ground-water flow in mine voids and alluvium. Flow directions are based on data collected during February, 1990 (Wheaton, 1992).

WATER QUALITY

Existing analytical data from the plant operator, DEQ public water supply file, and the MBMG Ground Water Information Center (GWIC) database were reviewed to assess the quality of water currently supplied in the Roundup system. Due to the nature of the pumping system the source of water represented by different samples is not always clear. Earlier samples may represent alluvial water from the infiltration gallery mixed with water from the mine. Samples collected after 1977 more likely represent water quality in the mine voids.

In general, the city water supply is providing water dominated by sodium and sulfate ions, along with calcium and bicarbonate. The pH is slightly basic, around 7.5 standard units. Total dissolved solids are high, between 2,500 and 2,600 mg/L. Iron and manganese concentrations are also a reported problem in the city supply system, with concentrations around 1.3 and 0.3 mg/L respectively.

Inorganic Chemistry

Table 1 summarizes the water-quality data available for the city supply systems, and for other samples collected in the vicinity . Monitor wells and river sites are shown on Figure 6. The city supply exceeds the secondary maximum contaminant levels (SMCL) for total dissolved solids (TDS), iron and for manganese. The SMCL for TDS is 500 mg/L and the city supply concentration ranges from 1,200 mg/L to 2,540 mg/L. The iron SMCL is 0.3 mg/L and the city supply concentration is 1.3 mg/L. Likewise the manganese SMCL is 0.05 mg/L and the city supply concentration is 0.3 mg/L. Concentrations of sulfate are high for the city supply, compared to the SMCL of 250 mg/L.

The mine void has been sampled, separate from the city supply, at monitor wells CW-3 and CW-4. Most constituent concentrations are similar to those reported for the city supply. However, iron concentrations are significantly lower in the monitor wells with values of 0.3 and 0.02 mg/L being reported.

Organic Chemistry

Samples of the supply system water were collected during the last two years as required by State regulation for organic analysis by the system operator. No volatile organic compounds (VOC) were detected using EPA method 524.2. No synthetic organic compounds were detected using EPA methods 505, 525.2, 515.1, and 531.1.

Microbiological Water Quality

A review of the DEQ public-water supply file for the city of Roundup indicates that all samples submitted have been negative for coliform bacteria over the period from January 1993 through October 1996. During the interview with the plant operator, it was reported that samples since October 1996 have also been negative for coliform bacteria. Based on the data obtained, the city supply does not appear to have bacterial contamination problems.

Table 1. Results of water-quality analysis for selected sites near Roundup, Montana[*1]

Well Number	Location	Sample Date	Hydrologic Source[*2]	Collecting[*3] Agency	Lab[*3]	Lab specific Conductance (umhos/cm)	Calculated Dissolved Solids (mg/L)	Field Specific Conductance (umhos/cm)	pH Lab	Temp. (Deg.C)
R-147	08N25E24ABCB	04/01/59	PWS	MDH	MDH		1200			
R-147	08N25E24ABCB	03/19/75	PWS	MDH	MDH	1730	1150		7.50	
R-147	08N25E24ABCB	01/05/89	PWS	MBMG	MDH	3000	2540		7.80	
R-147	08N25E24ABCB	10/27/93	PWS	MDH	IML		2520[*4]		7.00	
R-199	08N26E18DABC01	12/22/89	river	MBMG	MBMG	3110	2357	2550	8.20	1.0
R-200	08N25E24ABAA01	04/19/95	river			2400	1996	2375	8.34	
No. 22	08N26E18CBDD	01/11/18	alluvium	USGS	MSL		830[*4]			
R-143	08N26E18CBDD	07/16/89	alluvium	MBMG	ELI	2280	1690	1900	7.60	11.0
R-170	08N25E24AB	12/16/13	mine	CMSPRR	MRR		820[*4]			
R-170	08N25E24ABBD	07/14/86	mine	MBMG	MBMG		2530		7.20	
R-170	08N25E24ABBD01	10/28/93	mine			2190	1573	2340	7.57	
R-171	08N25E24BADD01	12/17/93	mine	MBMG	MBMG	1110	708		7.96	
CW-4	08N25E24AABC01	04/19/95	mine			1697	1320	1750	7.46	
R-170	08N25E24ABBD01	04/19/95	mine			3110	2736	3150	7.28	
CW-3	08N25E24BDAA01	04/19/95	mine			2770	2307	2675	7.16	
CW-4	08N25E24AABC01	05/04/95	mine			2200	1800	2275	7.29	
CW-3	08N25E24BDAA01	05/04/95	mine			3990	3364	4350	6.90	
R-145	08N26E18DCDC01	05/20/91	mine(J)			2042	1416	1175	8.41	
R-154	08N25E24CAAC	07/10/89	mine	MBMG	ELI	6260	5090	5250	6.90	13.0
M:1644	08N25E24CACC01	09/09/78	Tfu			2036	1387	1850	7.74	
R-145	08N26E18DCDC01	07/30/86	Tfu			1934	1329	2000	7.62	
M:14012308	N25E14DDDB01	05/15/96	Tfu			3360	3099	2675	7.37	
M:1645	08N26E05CBBB01	08/20/79	Khc			6581	4577	7000	7.96	

Well Number	Location	Sample Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Flouride (mg/L)	Nitrate (mg/L)	Iron (mg/L)	Manganese (mg/L)
R-147	08N25E24ABCB	04/01/59	120	80	167		12.0				
R-147	08N25E24ABCB	03/19/75	112	70	175	4.0	23.0				
R-147	08N25E24ABCB	01/05/89	204	121	483			0.26	0.03	1.150	0.307
R-147	08N25E24ABCB	10/27/93	211							1.200	0.340
R-199	08N26E18DABC01	12/22/89	187	155	356	5.8	39.2	0.41	0.3	0.107	0.04
R-200	08N25E24ABAA01	04/19/95	129	120	315	5.8	37.5	0.61	<.05	.004	.08
No. 22	08N26E18CBDD	01/11/18	116	50	64		18.0		0.20	<0.001	
R-143	08N26E18CBDD	07/16/89	165	97	251	5.0	34.0		<0.05	1.600	
R-170	08N25E24AB	12/16/13	99	41	115		15.0				
R-170	08N25E24ABCB	07/14/86	212	117	455	6.0	24.0	0.20	3.05	2.000	0.290
R-170	08N25E24ABBD01	10/28/93	143	74.9	265	5.2	22.3	0.45	<.1	1.332	0.334
R-171	08N25E24BADD01	12/17/93	86.8	68.2	75	7.7	10.3	0.45	4.10	0.011	<0.003
CW-4	08N25E24AABC01	04/19/95	123	75.6	194	5.0	20	0.62	<.05	.021	0.33
R-170	08N25E24ABBD01	04/19/95	224	119	478	7.3	25	0.58	<.05	1.584	0.323
CW-3	08N25E24BDAA01	04/19/95	135	72.6	500	10.3	25	1.0	<.05	0.311	0.148
CW-4	08N25E24AABC01	05/04/95	149	89.5	282	5.1	22.5	0.31	<.05	0.478	0.35
CW-3	08N25E24BDAA01	05/04/95	292	153	685	9.9	35	0.24	<.25	0.906	0.368
R-145	08N26E18DCDC01	05/20/91	81.6	40.9	346	5.43	29.4	0.44	0.063	1.94	0.141
R-154	08N25E24CAAC	07/10/89	472	204	891	14.0	27.0		0.12	1.81	
M:1644	08N25E24CACC01	09/09/78	63	52	343	4.6	8.2	0.4	<.1	.05	.04
R-145	08N26E18DCDC01	07/30/86	87.7	43.8	301	4.2	28.8	0.4	0.43	0.39	0.16
M:14012308	N25E14DDDB01	05/15/96	263	139	540	6.44	100	<1	<.25P	3.02	0.272
M:1645	08N26E05CBBB01	08/20/79	17.3	24	1464	5.5	258	1.4	<.023	0.68	.09

Table 1. Results of water-quality analysis for selected sites near Roundup, Montana[1] (continued)

Well Number	Location	Sample Date	Silica (mg/L)	Bicarbonate (mg/L)	Sulfate (mg/L)	Phosphate (mg/L)	Lithium (mg/L)	Aluminum (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Bromide (mg/L)	Cadium (mg/L)
R-147	08N25E24ABCB	04/01/59		323	669							
R-147	08N25E24ABCB	03/19/75		349	600							
R-147	08N25E24ABCB	01/05/89		538	1460				<0.001	0.020		<0.001
R-147	08N25E24ABCB	10/27/93										
R-199	08N26E18DABC01	12/22/89	8.30	457	1380		0.082	0.045		0.035	.1	<0.005
R-200	08N25E24ABAA01	04/19/95	2.3	369.4	1200	<.1	92	<80	1.3	42.0	150	<2
No. 22	08N26E18CBDD	01/11/18		180								
R-143	08N26E18CBDD	07/16/89		385	943	0.04	<0.100	<0.100				
R-170	08N25E24AB	12/16/13		333	359							
R-170	08N25E24ABCB	07/14/86	8.60	538	1440	0.10	0.040	<0.030	0.001		<0.100	<0.001
R-170	08N25E24ABBD01	10/28/93	9.8	401.4	853.4	<.1	43	<30	1.5	23.9	<500	1.8
R-171	08N25E24BADD01	12/17/93	8.70	559	171	<0.10	0.016	0.092	0.002	0.035	<0.500	0.002
CW-4	08N25E24AABC01	04/19/95	9.5	389.9	700	<.1	36	<80	1.2	18.5	100	<2
R-170	08N25E24ABBD01	04/19/95	9.5	615.4	1568	<.1	53	<80	1.6	19.7	100	<2
CW-3	08N25E24BDAA01	04/19/95	8.4	516.8	1300	<.1	42	<80	2.4	17.6	100	<2
CW-4	08N25E24AABC01	05/04/95	9.3	491.7	1000	<.5	44	<30	1.1	20.2	100	<2
CW-3	08N25E24BDAA01	05/04/95	10.2	766.2	1800	<.1	63	<30	1.2	18.0	100	<2
R-145	08N26E18DCDC01	05/20/91	6.3	450.6	675.3	0.207	39	<40	0.7	27	140	<5
R-154	08N25E24CAAC	07/10/89		953	3000	0.03	<0.100	0.200				
M:1644	08N25E24CACC01	09/09/78	6.7	454	685		20					
R-145	08N26E18DCDC01	07/30/86	9.4	465	624	0.1	30	<30			<100	<2
M:14012308N25E14DDDB0105/15/96			5.5	540.9	1775		44	<30	6.4	25.1	<125	<2
M:1645	08N26E05CBBB01	08/20/79	6.3	162	2720		98			50		

Well Number	Location	Sample Date	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Molybdenum (mg/L)	Selenium (mg/L)	Silver (mg/L)	Strontium (mg/L)	Sodium Adsorption Ratio
R-147	08N25E24ABCB	04/01/59										2.90
R-147	08N25E24ABCB	03/19/75										2.90
R-147	08N25E24ABCB	01/05/89	<0.005		<0.005	<0.001			<0.001	<0.001		6.60
R-147	08N25E24ABCB	10/27/93		<0.020	<0.005							
R-199	08N26E18DABC01	12/22/89	<0.005	0.010	<0.050		<0.020	<0.040	0.004	<0.004	3.03	4.70
R-200	08N25E24ABAA01	04/19/95	<2	3.3	<2		4.6	<10	4.3	<1	2407	4.80
No. 22	08N26E18CBDD	01/11/18										
R-143	08N26E18CBDD	07/16/89	<0.020	<0.010			<0.030	<0.005		<0.005	2.20	3.80
R-170	08N25E24AB	12/16/13										2.40
R-170	08N25E24ABCB	07/14/86	<0.001	0.001		0.001	<0.100	-0.020	<0.001	<0.001	5.80	6.20
R-170	08N25E24ABBD01	10/28/93	1.2	5.2	<1		2.8	4.4	1.1	<1	3391	4.47
R-171	08N25E24BADD01	12/17/93	0.002	0.008	<0.001		0.002	0.006	0.004	0.018	2.97	1.46
CW-4	08N25E24AABC01	04/19/95	<2	2.8	<2		3.2	<10	<1	<1	2291	3.39
R-170	08N25E24ABBD01	04/19/95	<2	4.8	<2		5.4	<10	<1	<1	5991	6.42
CW-3	08N25E24BDAA01	04/19/95	<2	4.2	<2		3.6	<10	<1	<1	5449	8.64
CW-4	08N25E24AABC01	05/04/95	5.1	2.8	<2		3.8	<10	<1	<10	3331	4.51
CW-3	08N25E24BDAA01	05/04/95	12.3	5.7	<2		7.1	<10	1.0	<1	1.0E+04	8.09
R-145	08N26E18DCDC01	05/20/91	<5	<4		0.18	<20	<40	<0.1	<4	3464	7.80
R-154	08N25E24CAAC	07/10/89	<0.020	0.010			<0.030	<0.005		<0.005	12.60	8.60
M:1644	08N25E24CACC01	09/09/78							<1			7.75
R-145	08N26E18DCDC01	07/30/86	<2	<2			<10	<20		<2	3210	6.56
M:14012308N25E14DDDB01		05/15/96	<2	4.6	<2		43.2	<10	<1	<1	6662	6.70
M:1645	08N26E05CBBB01	08/20/79							<1		3720	53.47

Table 1. Results of water-quality analysis for selected sites near Roundup, Montana*1 (continued)

Well Number	Location	Sample Date	Titanium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)	Zirconium (mg/L)	Hardness (mg/L as CaCO3)	Alkalinity (mg/L as CaCO3)	Oil and Grease (mg/L)	Comments
R-147	08N25E24ABCB	04/01/59								City Supply
R-147	08N25E24ABCB	03/19/75								City Supply
R-147	08N25E24ABCB	01/05/89								City Supply
R-147	08N25E24ABCB	10/27/93						479		City Supply
R-199	08N26E18DABC01	12/22/89	0.009	<0.004	0.013	<0.006	1105			Musselshell River
R-200	08N25E24ABAA01	04/19/95	<10	<5	<2	<20	816			
No. 22	08N26E18CBDD	01/11/18					495			Musselshell River Alluvium
R-143	08N26E18CBDD	07/16/89			<0.100					Musselshell River Alluvium
R-170	08N25E24AB	12/16/13								Republic No. 1 Mine
R-170	08N25E24ABCB	07/14/86	0.001	<0.001	<0.001	<0.003	1010	441		City Supply
R-170	08N25E24ABBD01	10/28/93	<20	<1	12.4		664			
R-171	08N25E24BADD01	12/17/93	<0.020	<0.001	0.006		498	459		Republic No.1 Mine, slope
CW-4	08N25E24AABC01	04/19/95	<10	<5	11.1	<20	619			
R-170	08N25E24ABBD01	04/19/95	<10	<5	6.0	<20	1048			
CW-3	08N25E24BDAA01	04/19/95	<10	<5	16.9	<20	635			
CW-4	08N25E24AABC01	05/04/95	<10	<5	4.7	<20	740			
CW-3	08N25E24BDAA01	05/04/95	<10	<5	14.0	<20	1359			
R-145	08N26E18DCDC01	05/20/91	<4	<4	9	<6	372			
R-154	08N25E24CAAC	07/10/89			0.230				1	
M:1644	08N25E24CACC01	09/09/78					371			
R-145	08N26E18DCDC01	07/30/86	<1	<1	<3	<4	399			
M:14012308	N25E14DDDB01	05/15/96	<10	<5	36.8	<20	1229			
M:1645	08N26E05CBBB01	08/20/79					142			

*1 -Blank values indicate missing data or constituents that were not analyzed.
Less than values (i.e., <0.1000 or <1) indicate the detection limits of the technique or instrument used and that the constituent was not detected.

Sources: Ellis and Meinzer, 1924; Wheaton and Donato, 1992; MDHES file data; MBMG file data.

*2 -Source: PWS - Public Water System; river - Musselshell River; alluvium - Musselshell River alluvium; mine - Republic #1, except J=Jefferies Mine; Tfu - Tertiary Fort Union Formation; Khc - Cretaceous Hell Creek Formation

*3 -Collecting Agency and Lab: MBMG - Montana Bureau of Mines and Geology; USGS - US Geological Survey; MDHES - Montana Department of Health & Environmental Sciences; CMSPRR - Chicago, Milwaukee, ST Paul Railroad, IML - Inter-Mountain Laboratories, Inc., Bozeman, MT; ELI - Energy Lab, Inc; MSC - Montana State College, Bozeman.

*4 - 10/27/93 CDS is actually measured TDS at 180° C.

On January 28, 1998 a microscopic particulate analysis (MPA) sample was collected. The sample was collected at the wellhead, in the pumphouse, and represented water that was coming directly from the Republic Number 1 mine void, and was not collected from the city distribution system. The well was pumped for a normal 8 hour 45 minute cycle at 1,200 gpm to 1,250 gpm. From the discharge, 1 gallon per minute of flow was diverted through the MPA filter. Results indicate non-detect for all parameters. Based on the consensus method to determine influence of surface water on ground-water supplies, the mine void wells are not under the direct influence of surface water. Field sheets and sample results are in Appendix E.

Field observations of water quality parameters

Table 2 contains field measurements made during the process of this investigation, and during previous work by Morris and Mairle, Inc, on contract to the city. Water temperature and specific conductance in the mine voids is substantially higher than in the river during winter. Iron concentration in the river on January 28, 1998 was 0.4 mg/L. Of that amount, 0.1 mg/L was in the reduced ferrous state. On the same day, iron concentration in water pumped from the mine was 1.4 mg/L, and was totally in the ferrous state. Turbidity on March 2, 1998 was 0 NTU in the mine discharge, and 20 NTU in the river.

Table 2.		Roundup Public Water Supply field parameters from Jan 15 and Jan 28, 1998.						
SITE	SOURCE	DATE	TIME	TEMP	SC	pH	Fe (tot)	Fe (+2)
				C	umhos/cm		mg/L	mg/L
					@ 25 C			
CW-3	Mine	01/15/98	11:20 AM		5040	7.4	0.45	
CW-3	Mine	01/15/98	04:30 PM	12	4780	6.6	0.65	
CW-4	Mine	01/15/98	11:20 AM	11	2120	7.4	0.45	
CW-4	Mine	01/15/98	04:30 PM	12	1850	7	0.4	
R-173	River	01/16/98	09:30 AM	2	1710	7.7	0.1	
R-173	River	01/28/98	02:20 PM	0	1200	8.1	0.4	0.1
R-173	River	03/02/98	11:00 AM	0	1380			
R-170	Mine (PWS)	01/28/98	06:32 AM	9.5	2795	7	1.4	1.4
R-170	Mine (PWS)	01/28/98	09:00 AM	10	2900			
R-170	Mine (PWS)	01/28/98	12:10 PM	10	2960		1.4	1.4
R-170	Mine (PWS)	01/28/98	02:45 PM	10	2980	6.9	1.4	1.4
R-170	Mine (PWS)	03/02/98	08:30 AM	10.3	2800			
R-170	Mine (PWS)	03/02/98	01:00 PM	10.3	2950			

SITE	DATE	TIME	H2S	Hardness	Alkalinity	CO2	D.O.	Turbidity
			mg/L	mg/L CaCO3	mg/L CaCO3	mg/L	mg/L	NTU
CW-3	01/15/98	11:20 AM	0.1		390	374	0.3	
CW-3	01/15/98	04:30 PM	<0.1	>1000	546	186	0.46	
CW-4	01/15/98	11:20 AM	0.1	600	223	110	0.3	
CW-4	01/15/98	04:30 PM	<.1	500	277	88	0.78	
R-173	01/16/98	09:30 AM		700	283	78	10.2	
R-173	01/28/98	02:20 PM						
R-173	03/02/98	11:00 AM						20
R-170	01/28/98	06:32 AM						
R-170	01/28/98	09:00 AM						
R-170	01/28/98	12:10 PM						
R-170	01/28/98	02:45 PM						
R-170	03/02/98	08:30 AM						0
R-170	03/02/98	01:00 PM						0

GENERAL OBSERVATIONS

In addition to the hydrogeologic assessment, general problems related to system design and water quality are noted during field inspections. During the field inspection at the Roundup Public Water Supply, the following items of concern were noted:

1) The infiltration galleries on the north side of the river are probably under the influence of surface water. The operator indicated that the city plans to bypass this part of the system during a general rebuilding process. The schedule for this work has not been established.

2) The chlorine injection system delivers chlorine to the clearwell, rather than directly into the distribution system plumbing. The residual chlorine levels indicate the method is working, however a more direct delivery may be better. Bypassing the clearwell will necessitate a new delivery system.

CONCLUSIONS AND RECOMMENDATIONS

Determination of Direct Surface-water Influence

Based on the field inspection, literature review, water-level trends, water chemistry, MPA results and the bacteriological history of the mine voids, the voids do not appear to be under the direct influence of surface water as defined in the Surface Water Treatment Rule (page 2 of this report). The continued use of the clearwell makes the current city supply at risk for potential of direct surface water influence.

The source of the ground water in the mine appears to be from a combination of intermediate bedrock flow, and local alluvial flow. Bedrock recharge areas are south of town in the foothills and clinker capped ridges of the Bull Mountains. Travel time to the city supply system for bedrock ground water could probably be measured in tens or hundreds of years, with little potential for surface water contamination along the flow path. Although it has not been quantified, travel time for alluvial ground water would be much shorter.

Recharge to the alluvial system is from intermediate bedrock flow systems discharging along subcrops, local precipitation on the valley floor, and stream loss from the Musselshell River. The alluvial water table is in equilibrium with the river level. A direct influence of the river on the alluvial water is likely. However, alluvial water recharging the mine voids through a subcrop of the coal is apparently without direct surface water influence; presumably due to the length of the flow path, and the naturally fine grained texture of the alluvial sediments.

Supporting Evidence

The primary evidence supporting the above determination that the mine voids are not under the direct influence of surface water is as follows:

1) The results of the MPA sample indicate no surface-water influence.

2) The high iron concentrations in the city water supply. High iron concentrations are normally seen as indicating ground-water sources rather than surface-water sources.

3) The lack of direct correlation between the river water level and the mine void water level.

4) The difference in field parameter measurements between the river and the mine void discharge (temperature, iron, specific conductance).

5) The lack of turbidity in the mine void discharge during 4.5 hours of pumping.

6) The lack of documented bacterial contamination problems in the city supply.

7) The dissolved-solids concentration in the mine void water is much higher than in the baseflow of the river, also indicating ground water rather than surface water sources.

Recommendations

Further evaluation of the Roundup Public Water Supply under the Ground Water Under the Direct Influence of Surface Water (GWUDISW) Program is recommended at this time if the infiltration gallery remains connected to the system. Further evaulation of the existing mine-void wells is not recommended at this time. The operator has indicated that the city will be bypassing the infiltration gallery and clearwell at a future date. Additional production wells may be drilled in the mine voids at that time. Though highly mineralized, the mine voids appear to provide a supply of ground water that is not contaminated by surface-water organisms. It is recommended that MPA samples be collected from the pumphouse well during spring high water, and at periods of high and low river flow from any future production wells completed in the mine voids.

REFERENCES

Ellis, A.J., Meinzer, O.E., 1924, Ground water in Musselshell and Golden Valley counties Montana: US Geological Survey Water Supply Paper 518, 92 p.

Kaczmarek, Michael B., 1995, Results of Pumping Tests of the Republic No. 1 Mine for the Roundup Municipal Water Supply, Roundup, Montana, Morrison-Maierle, Inc.

Knapton, J.R., 1982, Quality of streams in the Bull Mountains region, south-central Montana: U.S. Geological Survey Water Resources Investigations Report 82-2, 50 p.

Noble, Roger A., Bergantino, R.N., Patton, T.W., Sholes, B., Daniel, F., and Scholfield, J., 1982, Occurrence and Characteristics of ground water in Montana, Vol I: Montana Bureau of Mines and Geology, MBMG Open-file Report 99, 82 p.

Omang, R.J., 1986, *Section on climate, in* Hydrology of Area 48, northern Great Plains and Rocky Mountain coal provinces, Montana and Wyoming, S.E. Slagle and others: U.S. Geological Survey Open-file Report 84-141, p 8.

Thomas, Gary, 1997, personal communication.

U.S. Geological Survey, 1996, Water resources data, Montana (Water Year 1996): U.S.Geological Survey Water Data Report MT-96-1, 449 p.

Wheaton, John, 1992, Hydrologic Assessment of abandoned coal mines in the Bull Mountains near Roundup, Montana, MBMG Memoir 63, 29 p.

Wheaton, John, 1994, City Water Supply Assessment for Roundup, Montana: Montana Bureau of Mines and Geology, MBMG Open-File Report 275, 40 p.

Wheaton, John and Donato, Teresa, 1991, Hydrologic data from the Roundup and Bull Mountain area, Montana: Montana Bureau of Mines and Geology, MBMG Open-file Report 243, 5 p.

Woolsey, L., Richards, R.W., and Lupton, C.T., 1917, The Bull Mountains Coal Field, Musselshell and Yellowstone Counties, Montana: US Geological Survey Bulletin 647, 218 p.

APPENDIX A

Completed
Preliminary Assessment Form

MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY
Metcalf Building
1520 E. 6th St.
Helena, MT 59620-0901

Preliminary Assessment of Groundwater Sources that may be under the Direct Influence of Surface Water

SYSTEM NAME Roundup City Water PWS ID# 00132

SOURCE NAME Republic No 1 Mine Wells COUNTY Musselshell

DATE 4-21-94 NC NTNC (C) POPULATION 1807 (1990)

	Index Points
A. TYPE OF STRUCTURE (Circle One)	
Well	(GO TO SECTION B)
Spring	40
Infiltration Gallery	40
B. HISTORICAL PATHOGENIC ORGANISM CONTAMINATION	
History or suspected outbreak of *Giardia*, or other pathogenic organisms associated with current system configuration	40
No history or suspected outbreak of *Giardia*	(0)
C. HISTORICAL MICROBIOLOGICAL CONTAMINATION (Circle all that apply)	
Record of acute MCL violations of the Total Coliform Rule over the last 3 years (circle the one that applies)	
No violations	(0)
One violation	5
Two violations	10
Three violations	15
Record of non-acute MCL violations of the Total Coliform Rule over the last 3 years (circle the one that applies)	
One violation or less	(0)
Two violations	5
Three violations	10
DHES-verified complaints about turbidity	5
D. HYDROLOGICAL FEATURES	
Horizontal distance between a surface water and the source	
greater than 250 feet	0
175 - 250 feet	5
100 - 175 feet	(10)
less than 100 feet	15

E. WELL CONSTRUCTION

Unknown well construction 30

Poorly constructed well (uncased, or casing not sealed to depth of at least 18 feet below land surface), or casing construction is unknown 15

In wells tapping unconfined or semiconfined aquifers, depth below land surface to top of perforated interval or screen

greater than 100 feet	0
50 - 100 feet	~~5~~
25 - 50 feet	10
0 - 25 feet	15
unknown	15

F. WELL INTAKE CONSTRUCTION

Unknown intake construction 25

In wells tapping unconfined or semiconfined aquifers, depth to static water level below land surface

greater than 100 feet	0
50 - 100 feet	5
0 - 50 feet	~~10~~
unknown	10

jw

Poor sanitary seal, seal without acceptable material, or unknown sanitary seal type 15

TOTAL SCORE 20

PRELIMINARY ASSESSMENT DETERMINATION (Circle the one that applies)

i) PASS: Well is classified as groundwater.
ii) FAIL: Well must undergo further GWUDISW determination.
~~iii)~~ FAIL: Spring or Infiltration Gallery; must undergo further GWUDISW determination.
iv) FAIL: Well will PASS if well intake construction deficiencies (section F) are repaired.
v) FAIL: Well may PASS if well construction details (section E) become available.

ANALYST John W Poulton ANALYST AFFILIATION MBMG

COMMENTS: This is one well out of a system that includes 2 wells and an infiltration gallery

MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY
Metcalf Building
1520 E. 6th St.
Helena, MT 59620-0901

Preliminary Assessment of Groundwater Sources that may be under the Direct Influence of Surface Water

SYSTEM NAME Roundup City Water PWS ID# 00132

SOURCE NAME Republic No. 1 Mine Wells COUNTY Musselshell

DATE 4-21-97 NC NTNC (C) POPULATION 1807 (1990)

	Index Points
A. TYPE OF STRUCTURE (Circle One)	
Well	GO TO SECTION B
Spring	40
Infiltration Gallery	40
B. HISTORICAL PATHOGENIC ORGANISM CONTAMINATION	
History or suspected outbreak of *Giardia*, or other pathogenic organisms associated with current system configuration	40
No history or suspected outbreak of *Giardia*	(0)
C. HISTORICAL MICROBIOLOGICAL CONTAMINATION (Circle all that apply)	
Record of acute MCL violations of the Total Coliform Rule over the last 3 years (circle the one that applies)	
No violations	(0)
One violation	5
Two violations	10
Three violations	15
Record of non-acute MCL violations of the Total Coliform Rule over the last 3 years (circle the one that applies)	
One violation or less	(0)
Two violations	5
Three violations.....	10
DHES-verified complaints about turbidity	5
D. HYDROLOGICAL FEATURES	
Horizontal distance between a surface water and the source	
greater than 250 feet	0
175 - 250 feet	5
100 - 175 feet	(10)
less than 100 feet	15

E. WELL CONSTRUCTION

Unknown well construction	30
Poorly constructed well (uncased, or casing not sealed to depth of at least 18 feet below land surface), or casing construction is unknown	15

In wells tapping unconfined or semiconfined aquifers, depth below land surface to top of perforated interval or screen

greater than 100 feet	0
50 - 100 feet	(5)
25 - 50 feet	10
0 - 25 feet	15
unknown	15

F. WELL INTAKE CONSTRUCTION

Unknown intake construction	25

In wells tapping unconfined or semiconfined aquifers, depth to static water level below land surface

greater than 100 feet	0
50 - 100 feet	(5) JW
0 - 50 feet	~~10~~
unknown	10

Poor sanitary seal, seal without acceptable material, or unknown sanitary seal type	15

TOTAL SCORE 25

PRELIMINARY ASSESSMENT DETERMINATION (Circle the one that applies)

i) PASS: Well is classified as groundwater.
(ii) FAIL: Well must undergo further GWUDISW determination.
~~iii) FAIL:~~ Spring or Infiltration Gallery; must undergo further GWUDISW determination.
iv) FAIL: Well will PASS if well intake construction deficiencies (section F) are repaired.
v) FAIL: Well may PASS if well construction details (section E) become available.

ANALYST John W Pardon ANALYST AFFILIATION MBMG

COMMENTS: This is one well out of a system that includes 2 wells and an infiltration gallery

MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY
Metcalf Building
1520 E. 6th St.
Helena, MT 59620-0901

Preliminary Assessment of Groundwater Sources that may be under the Direct Influence of Surface Water

SYSTEM NAME Roundup City Water PWS ID# 00132

SOURCE NAME Musselshell River Alluvium COUNTY Musselshell

DATE 4-21-97 NC NTNC (C) POPULATION 1807 (1990)

	Index Points
A. TYPE OF STRUCTURE (Circle One)	
Well ..... GO TO SECTION B	
Spring	40
Infiltration Gallery	(40)
B. HISTORICAL PATHOGENIC ORGANISM CONTAMINATION	
History or suspected outbreak of *Giardia*, or other pathogenic organisms associated with surface water, with current system configuration	40
No history or suspected outbreak of *Giardia*	(0)
C. HISTORICAL MICROBIOLOGICAL CONTAMINATION (Circle all that apply)	
Record of acute MCL violations of the Total Coliform Rule over the last 3 years (circle the one that applies)	
No violations	(0)
One violation	5
Two violations	10
Three violations	15
Record of non-acute MCL violations of the Total Coliform Rule over the last 3 years (circle the one that applies)	
One violation or less	(0)
Two violations	5
Three violations.....	10
DHES-verified complaints about turbidity	5
D. HYDROLOGICAL FEATURES	
Horizontal distance between a surface water and the source	
greater than 250 feet	0
175 - 250 feet	5
100 - 175 feet	10
less than 100 feet ....Unknown..... ?	(15)

E. WELL CONSTRUCTION

Unknown well construction	30
Poorly constructed well (uncased, or casing not sealed to depth of at least 18 feet below land surface), or casing construction is unknown	15

In wells tapping unconfined or semiconfined aquifers, depth below land surface to top of perforated interval or screen

greater than 100 feet	0
50 - 100 feet	5
25 - 50 feet	10
0 - 25 feet	15
unknown	15

F. WELL INTAKE CONSTRUCTION

Unknown intake construction	25

In wells tapping unconfined or semiconfined aquifers, depth to static water level below land surface

greater than 100 feet	0
50 - 100 feet	5
0 - 50 feet	10
unknown	10
Poor sanitary seal, seal without acceptable material, or unknown sanitary seal type	15

TOTAL SCORE 55

PRELIMINARY ASSESSMENT DETERMINATION (Circle the one that applies)

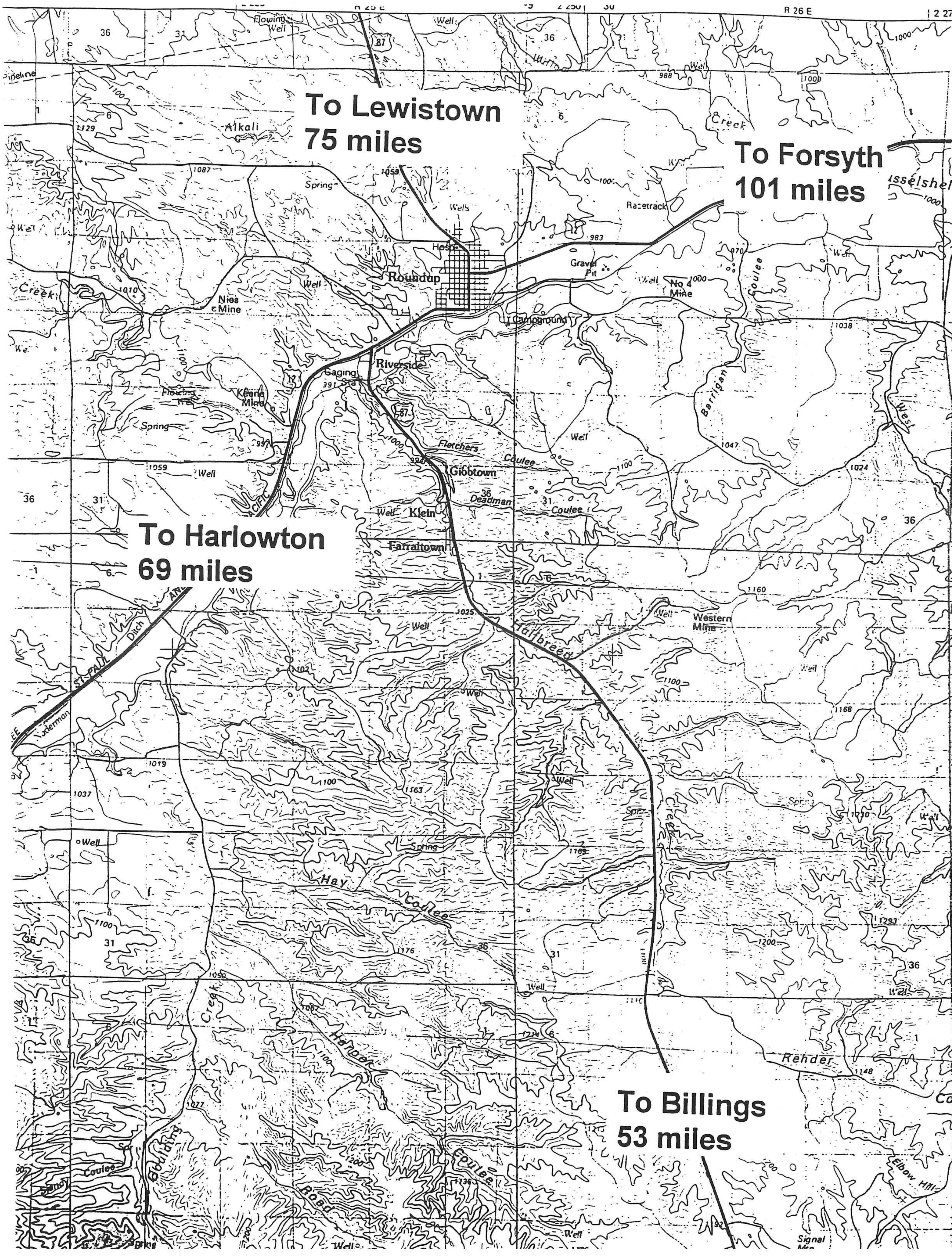
i) PASS: Well is classified as groundwater.
ii) FAIL: Well must undergo further GWUDISW determination.
(iii) FAIL: Spring or Infiltration Gallery; must undergo further GWUDISW determination.
iv) FAIL: Well will PASS if well intake construction deficiencies (section F) are repaired.
v) FAIL: Well may PASS if well construction details (section E) become available.

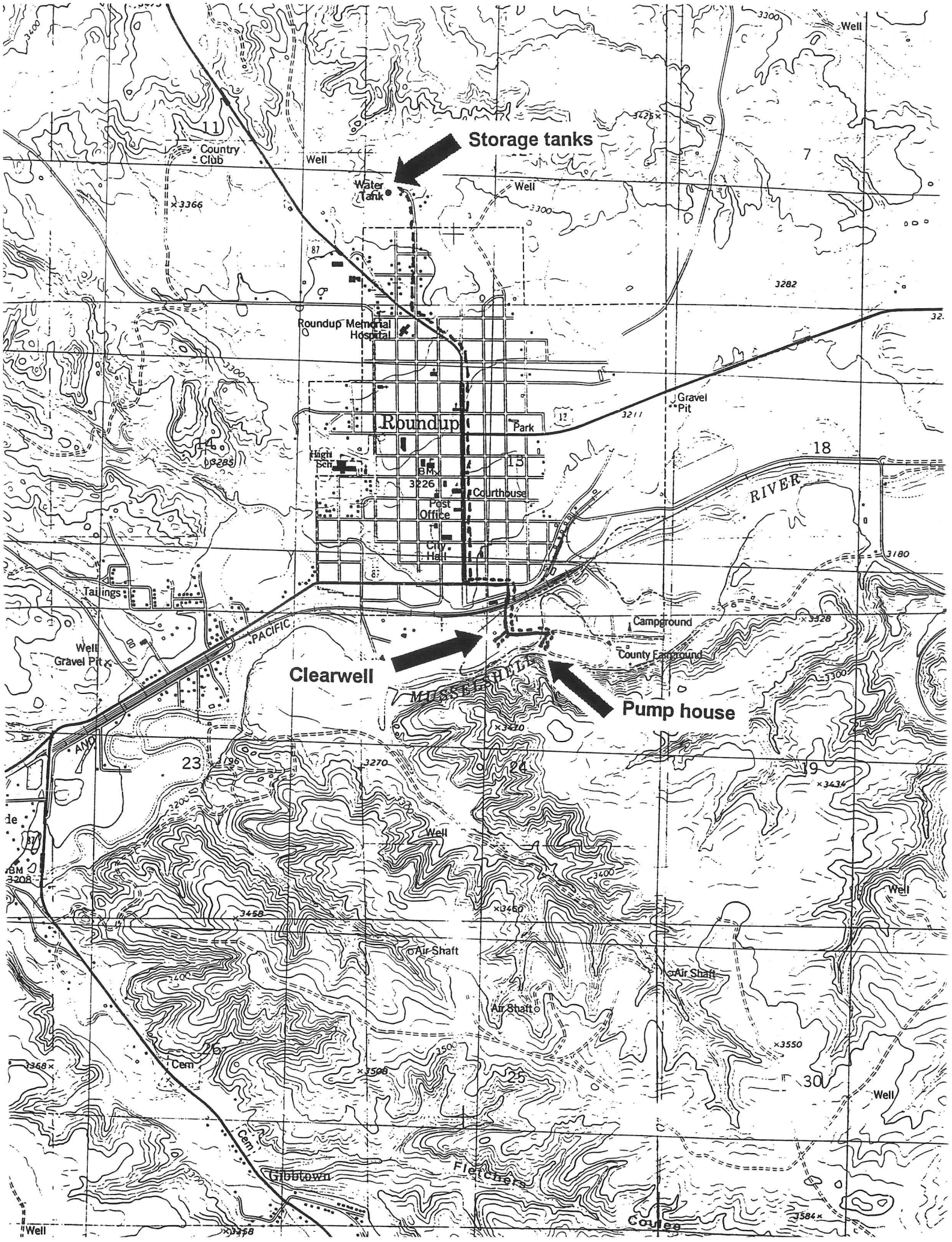
ANALYST John Wheaton ANALYST AFFILIATION MBMG

COMMENTS: This is an infiltration gallery in a system that is predominantly supplied by 2 wells.

APPENDIX B

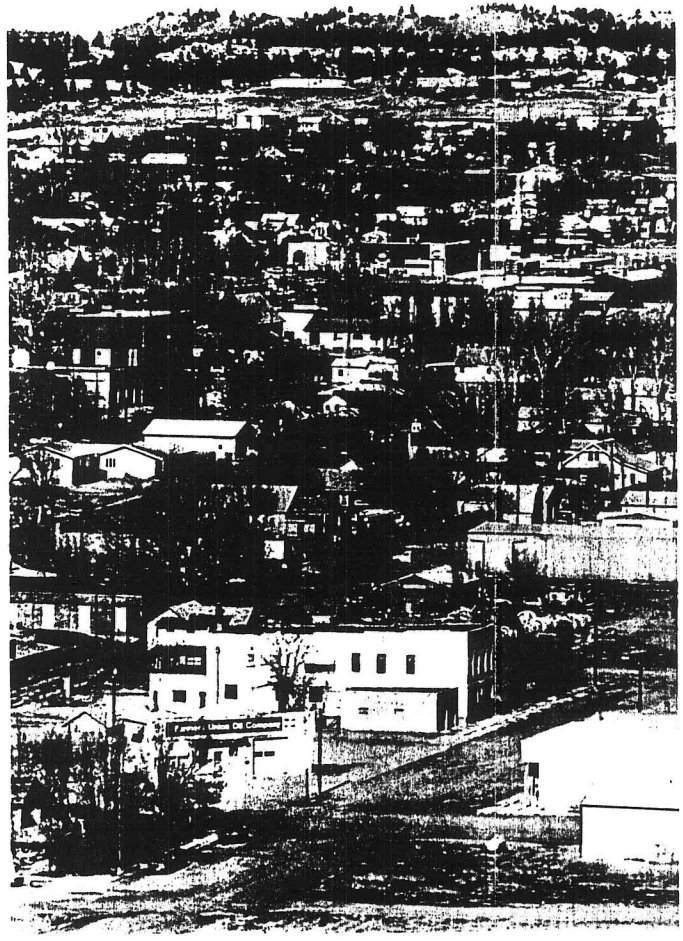
Site Access Maps


To Lewistown
75 miles
To Forsyth
101 miles
To Harlowton
69 miles
To Billings
53 miles
Roundup
Riverside
Gibbtown
Klein
Farraltown
Racetrack
Gravel Pit
No 4 Mine
Campground
Nies Mine
Western Mine
Fletchers Coulee
Deadman Coulee
Halfbreed
Hay Coulee
Barrigan Coulee
Rehder
Alkali
Spring
Well
R 26 E

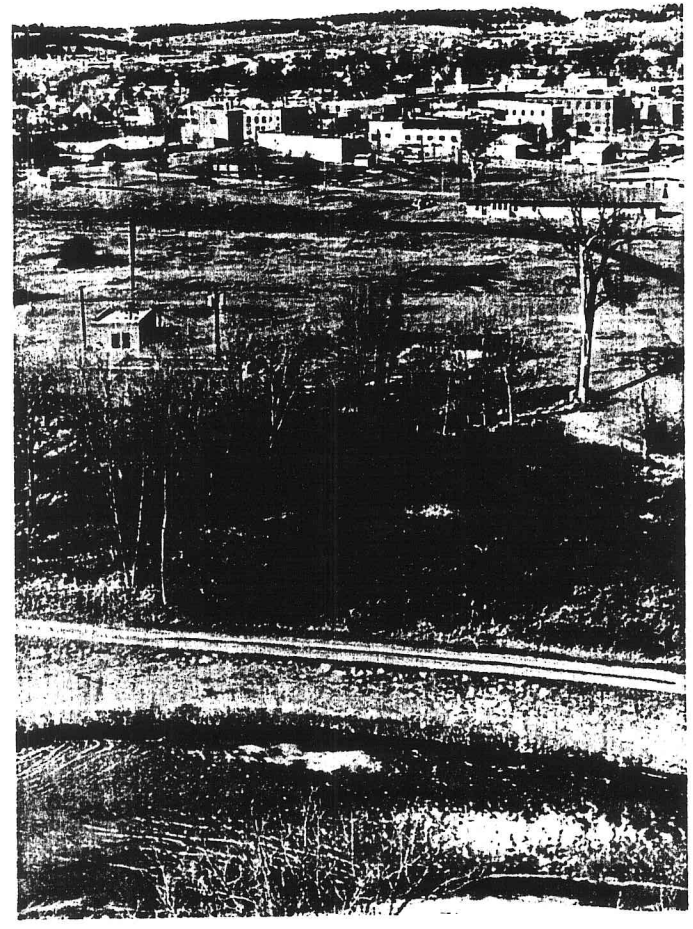

Storage tanks
Clearwell
Pump house
Country Club
Well
Water Tank
Roundup Memorial Hospital
Roundup
Park
High Sch.
BM 3226
Courthouse
Post Office
City Hall
Gravel Pit
RIVER
Tailings
PACIFIC
Campground
County Campground
Air Shaft
Cem
Gibbtown
Fletchers
Coulee

APPENDIX C

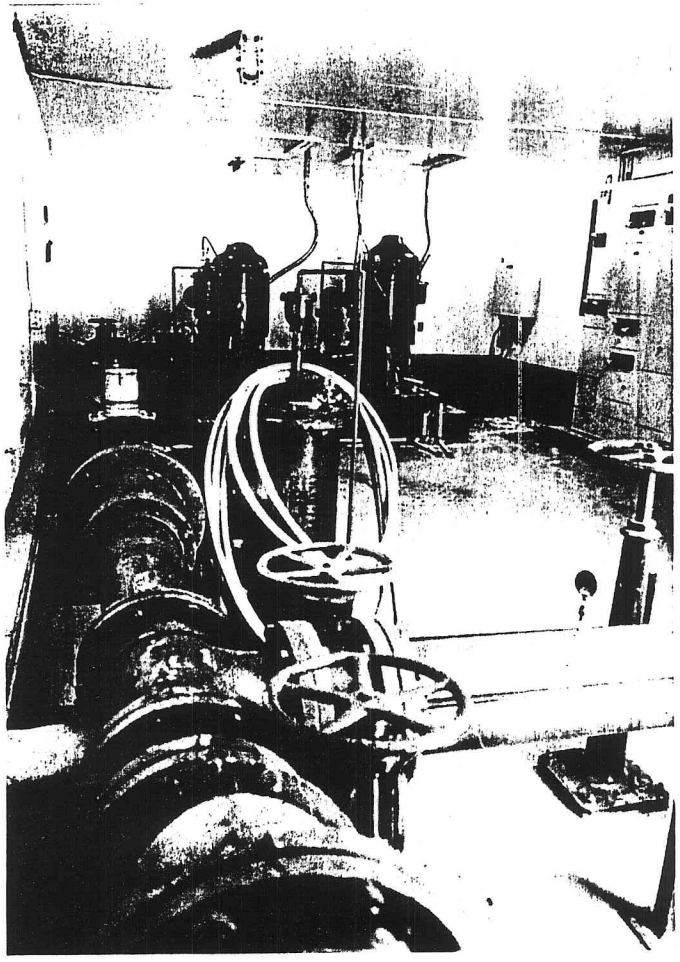
Photographs of the supply system and surrounding area



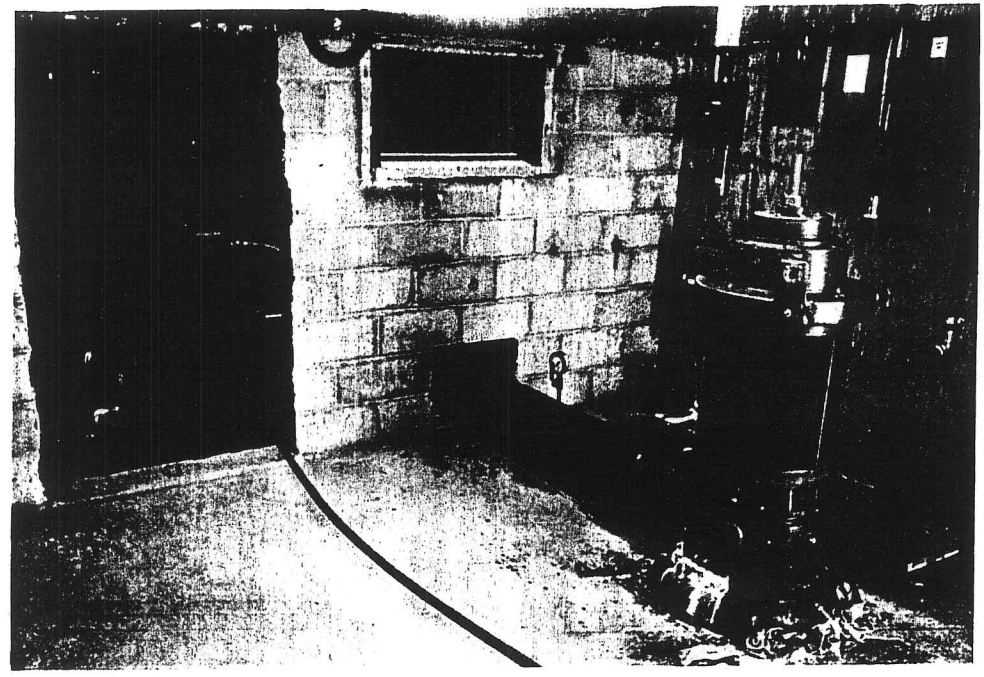
General view of area from hills south of Roundup, looking toward water storage tanks on far north of valley.



View from hills south of town, looking across Musselshell River toward town, with clearwell building near center left edge.



City supply line inside clearwell building. Clearwell is in background, under the two vertical turbine pump motors.



Pumphouse on south of river. Two vertical turbine pumps, one in foreground and one barely visible in background tap the Republic Number 1 mine voids.

APPENDIX D

Well logs and water right forms for city well

APPENDIX 4 (cont.)

CODED

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Musselshell T. 8 (N or S) R. 25 (E or W) SEC. 24 TRACT A

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN ____ SUBDIVISION ____ BLOCK

023029

OWNER'S NAME City of Roundup ADDRESS ____

____ PHONE NUMBER ____ YEAR ____

ALT. LAND SURF. AT WELL MSL ____ ft.
TOTAL DEPTH BELOW LSD 93 ft.
PUMPING LEVEL BELOW LSD ____ ft.
STATIC WATER LEVEL* BELOW LSD ____ ft.
YIELD IN GALLONS PER MIN. ____
HOW TESTED ____ TIME (HR.) ____
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O ____

CASING DIA 13¾ in. FROM 0 ft. TO 22 ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE 34 #
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.

PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED 1950
HOW DRILLED ____
BY WHOM ____ LIC. ____
WELL USE ____
SOURCE OF INFO: WELL APPROP. ____
DRILLER ____ OWNER ____ USGS ____ SCS ✓
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED ____
BY WHOM ____ AGENCY ____
DATE VERIFIED ____

MEAS. POINT ABOVE LSD	____ ft.	DATE
TOTAL DEPTH BELOW LSD	____ ft.	____
PUMPING LEVEL BELOW LSD	____ ft.	____
SWL* BELOW LSD	____ ft.	____
YIELD IN GPM	____	____
WATER TEMP. °C	____	____
SPECIFIC COND. at 25 °C	____	____

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

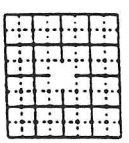
REMARKS: Casing — 22FT. - CEMENTED w/ 35 SACKS.
MUNICIPAL WELL.

IF FLOWING

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	11	TOP SOIL
11	16	SAND & GRAVEL
16	32	GRAY SANDSTONE
32	38	GREEN SHALE - hard
38	48	GRAY SANDSTONE
48	62	GRAY SANDY SHALE
62	68	COAL BED (Roundup bed)
68	69	GRAY SANDY SHALE
69	75	GRAY SANDSTONE
75	84	Green Shale - dark
84	93	GRAY SANDSTONE

SKETCH MAP



May be ~~Production~~ one of the city wells at the pumphouse south of the river.

Form No. 603 (Rev. 7/76)

STATE OF MONTANA 8-25-5[illegible] File No. _____

Department of Natural Resources and Conservation

WELL LOG REPORT 08N 25E 24 BA

White-Department
Yellow-Department
Pink-Well Owner
Gold-Driller

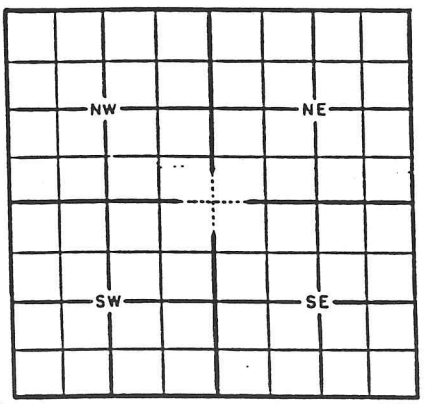
State law requires that this form be filed by the water well driller within 60 days after completion of the well, and Form 602, Notice of Completion of Groundwater Development, be filed by the well owner within 60 days after the water has been put to beneficial use.

1. WELL OWNER
Name City of Roundup

2. CURRENT MAILING ADDRESS
Roundup, Mont

3. PROPOSED USE _____ domestic (includes lawn and garden); _____ stock; X municipal; _____ industrial; _____ irrigation; _____ other (specify) _____

4. WELL LOCATION



NE ¼ NW ¼ ____ ¼ ____ ¼ Section 24
T. 8 N or S R. 25 E or W
OR, Lot _____ Block _____
Subdivision _____
City Roundup County Musselshell
Elevation _____ Accuracy: ___ ±10'; ___ ±50'; ___ ±100';

5. DRILLING METHOD _____ cable, _____ bored, X forward rotary, _____ reverse rotary, _____ jetted, _____ other (specify) _____

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations _____ and/or Screen _____ Kind Size	From (feet)	To (feet)
24"	21" Cemented w/66 Sks Cement	0	32	None		
16"	12" 40# Cemented w/80 Sks Cement	0	81	None		

Was casing left open end? X Yes, ___ No
Was a packer or seal used? ___ Yes, ___ No
If so, what material _____
Was the well gravel packed? ___ Yes, ___ No
Was the well grouted? X Yes, ___ No
To what depth? 81 Ft
Material used in grouting Cement
Well head completion: Pitless adapter _____
12 in. above grade X, other _____
(if other, specify) _____
Pump horsepower 100, pump type _____
Pump intake level _____ feet below land surface
Power (electric, diesel, etc.) Elec

7. WATER LEVEL
Static water level 28 feet below land surface
If flowing, closed-in pressure _____ psi
_____ gpm flow through _____ inch pipe
Controlled by: ___ valve, ___ reducers, ___ other (if other, specify) _____

8. WELL TEST DATA ___ pump ___ bailer ___ other (if other, specify) Drilled into Mine
Pumping level below land surface:
28 ft. after ___ hrs. pumping 1000 gpm
___ ft. after ___ hrs. pumping ___ gpm

9. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If yes, how? _____

10. DATE STARTED August 23, 1977
DATE COMPLETED Sept 2, 1977
Enlarge to 12" Casing Oct. 4, 1977
Drilled out 15' Plug of Mine

11. WELL LOG

Depth (ft.) From	To	Formation
0	10	Topsoil Brown Sandy Soil
10	14	Gravel
14	17	Sandy Bentonite
17	21	Sand
21	29	Blue gray Shale
29	30	Hard gray Sand
30	35	Blue gray Shale
35	36	Hard gray Sand
36	40	Blue gray Shale
40	42	Dirty Coal Bent
42	50	Blue gray Shale & Bentonite
50	51	Sand (Bsg)
51	60	Blue gray Shale
60	62	Coal
62	69	Blue gray Shale & Bentonite
69	71	Hard Sand (Wet)
71	95	Blue gray Shale
	T.D.	
Top of Mine = 95 ft w/10 ft of Mine coal = 105 ft in Depth		

(use separate sheet if necessary)

12. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
Oct 29, 1977 Date
Merle E Hunt Signature License No.
Firm name
Address

The well of the City of Roundup

ENDIX 4

GW ←Helena Independent Record

File No. 065 08N 25E 24AB

TRIPLICATE Musselshell

065

T. 8 N., R. 25 E. 24

County Musselshell

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

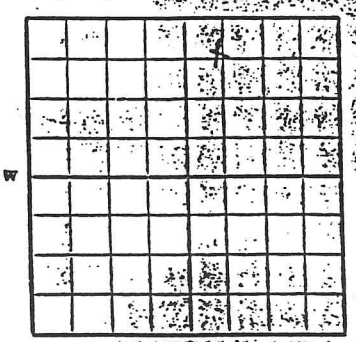
023030

RECEIVED
SEP. 6 1962
Montana Bureau of Mines and Geology

Declaration of Vested Groundwater Rights

(Under Chapter 237, Montana Session Laws, 1961)

1. City of Roundup, Montana (Name of Appropriator) of (Address) Roundup (Town)
County of Musselshell State of Montana
have appropriated groundwater according to the Montana laws in effect prior to January 1, 1962, as follows:



NW ¼NE¼ Sec. 24 T 8N R 25E

Indicate point of appropriation and place of use, if possible. Each small square represents 10 acres.

2. The beneficial use on which the claim is based City Water Supply

3. Date or approximate date of earliest beneficial use, and how continuous the use has been 1934 and continuously thereafter

4. The amount of groundwater claimed (in miner's inches or gallons per minute) 4,000 gal. per minute

5. If used for irrigation, give the acreage and description of the lands to which water has been applied and name of the owner thereof Not applicable

6. The means of withdrawing such water from the ground and the location of each well or other means of withdrawal Deep well and centrifical pump

7. The date of commencement and completion of the construction of the well, wells, or other works for withdrawal of groundwater Commenced and completed in 1934. New pump added in 1954

8. The depth of water table approximately 75'

9. So far as it may be available, the type, size and depth of each well or the general specifications of any other works for the withdrawal of groundwater 90'. The well is drilled into the old Prescott No. 1 mine that has filled with water.

Note! Probably Republic No. 1 mine. Prescott is further South

10. The estimated amount of groundwater withdrawn each year 200 million gallons

11. The log of formations encountered in the drilling of each well if available unknown

12. Such other information of a similar nature as may be useful in carrying out the policy of this act, including reference to book and page of any county record not applicable

City of Roundup, Montana

Signature of Owner By: John J. White Mayor

Date September 5, 1962

Three copies to be filed by the owner with the County Clerk and Recorder of the county in which the well is located.

Please answer all questions. If not applicable or state otherwise the form will be returned

T 8N R 25E Section 24 AB Probably near the city wells of the pumphouse south of the Older river. well

APPENDIX 4 (cont.)

Approved Stock Form—State Publishing Co., Helena, Montana—38496

File No. Musselshell 003

T. 8 N. R. 25 E. 24/E

TRIPLICATE

County Musselshell

RECEIVED
SEP 3 1962
Montana Bureau of Mines and Geology

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

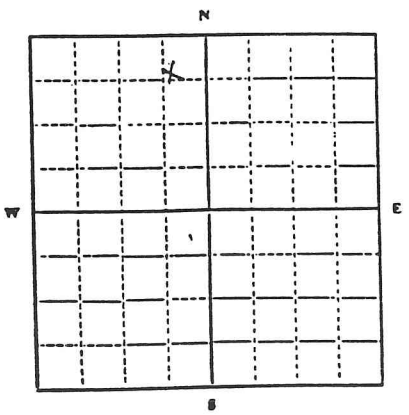
023031

Declaration of Vested Groundwater Rights

(Under Chapter 237, Montana Session Laws, 1961)

1. City of Roundup, Montana (Name of Appropriator) of (Address) Roundup (Town)

County of Musselshell State of Montana have appropriated groundwater according to the Montana laws in effect prior to January 1, 1962, as follows:



NE 1/4 NW 1/4 Sec. 24 T. 8N R. 25E

Indicate point of appropriation and place of use, if possible. Each small square represents 10 acres.

2. The beneficial use on which the claim is based City Water Supply

3. Date or approximate date of earliest beneficial use; and how continuous the use has been 1919 and continuously thereafter

4. The amount of groundwater claimed (in miner's inches or gallons per minute) 5,000 gal. per minute

5. If used for irrigation, give the acreage and description of the lands to which water has been applied and name of the owner thereof Not applicable

6. The means of withdrawing such water from the ground and the location of each well or other means of withdrawal Deep well and centrifical pumps

7. The date of commencement and completion of the construction of the well, wells, or other works for withdrawal of groundwater Commenced and completed in 1919. Larger pump added 1947

8. The depth of water table 4 to 8 feet.

9. So far as it may be available, the type, size and depth of each well or the general specifications of any other works for the withdrawal of groundwater This well is approximate 40' and has drainage pipe to it from north, south, west and east.

10. The estimated amount of groundwater withdrawn each year 200 million gallons

11. The log of formations encountered in the drilling of each well if available unknown

12. Such other information of a similar nature as may be useful in carrying out the policy of this act, including reference to book and page of any county record not applicable

City of Roundup, Montana

Signature of Owner By: John J. White Mayor

Date September 5, 1962

Three copies to be filed by the owner with the County Clerk and Recorder of the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

8N R25E
Section 24 BA
4 wium, north side
of river.
At, or near
city pumphouse

APPENDIX E

Results of Micro-Particulate Analysis (MPA) of water supply well

Analysis Request*

Client: City of Roundup Date: 1-28-98 PO#: NA

Person(s) designated to receive results: Gary Thomas - Director of Public Works

Address: 34-3rd Ave W. P.O. Box 660 - Roundup, MT. 59072

Phone: (406) - 323-2804 Fax: (406) 323-3452

Address for cooler return: John Wheaton, Campus Box 112 - 1500 N. 30th Billings, MT. 59101

Sample Information: (please print clearly)

Sample Location: Mine Well hose bib

Sample ID: Roundup PWS

PWSID#: 00321

ICR Sample ID#: ___ - ___ - ___ - ___ - PROT

Treatment Plant ID # - Month - Year - ICR Sample Location

ICR Sample ID Check Digit: _____

Start:

Date: 1-28-98 Time: 0630

Temperature: 10°C pH: 7.0 NTU: NA

Stop:

Date: 1-28-98 Time: 1515

NTU: _____

Gallons Sampled: 506 (_____ Liters)

Sample exposed to chlorine? Yes _____ No X

Sample dechlorinated? Yes _____ No X

Sampler's Name: John Wheaton

Please fill in where applicable for this sample:

This sample is a raw surface water _____

finished surface water _____ ground water X or

other, please explain _____

Type of Raw Water Source:

_____ Spring
_____ Dug well
X Drilled well
_____ Horizontal well
_____ Artesian well
_____ Lake/Reservoir
_____ Stream/River
_____ Irrigation canal

If well, depth: 100 ft and distance from river/stream/lake: 100 ft

Type of Disinfection:

_____ Pre-chlorination
_____ Post chlorination
_____ Post chloramines
_____ Ozone
_____ Other

Type of Analysis Requested:
(please initial request)

1. **Microscopic Particulate Analysis (MPA)** of known **surface water** $175 _____
2. **MPA of ground water** for direct surface water influence $295 D.T.
3. **ICR *Cryptosporidium & Giardia*** following Information Collection Rule Laboratory Manual $350 _____
4. **Combination of MPA & *Giardia* & *Cryptosporidium*** by methods #1 or #2 and #3 $450 _____
5. **Electronic Particle Counting** following Standard Methods 18th Edition Supplement $90 _____
6. **Combination of MPA & *Cryptosporidium & Giardia*** plus **Electronic Particle Counting** by methods #1 or #2, #3 & #5 $495 _____

(see price list for analysis descriptions)

7. **Other Requests** _____

Type of Treatment:

X None
_____ Disinfection only
_____ Conventional treatment
_____ Direct filtration
_____ Filter to waste cycle
_____ Infiltration gallery
_____ Diatomaceous earth
_____ Slow sand
_____ Pressure filter
_____ Other

Filter(s) hydraulic loading _____ gpm/sq.ft.

_____ "Clean" filter bed put on line

*For samples taken following protocol established by:
CHDiagnostic & Consulting Service, Inc., 214 SE 19th Street, Loveland, CO 80537

ANALYSIS FOR WATERBORNE PARTICULATES

CHDiagnostic and Consulting Service, Inc.
214 SE 19th Street, Loveland, CO 80537
Carrie M. Hancock, President Telephone (970) 667-9789

Invoice 982077

1/29/98

Customer 980889
City of Roundup
34-3rd Avenue West, PO Box 660
Roundup, MT 59072

PWSID# 00321

Laboratory Information

Federal Express; 1/29/98; 0945 Hrs; Wound; Excellent; Results submitted by: Tricia Klonicki

Sample Information: Mine Well, Roundup PWS, Source: Drilled well, 100' deep and 100' from river/stream/lake, unchlorinated, 10°C, pH 7.0

Date/Start: 1/28/98; 0630 Hrs **Date/Stop:** 1/28/98, 1515 Hrs **Sampler:** John Wheaton

Gallons: 506 **Filter Color:** Tan **Centrifugate:** 0.49 mL/100 gals

Amorphous Debris: Silt and clay, 1-50 µM diameter
Other Algae: None Detected (ND)
Diatoms: ND
Plant Debris: ND
***Giardia*:** ND
Coccidia: ND
Rotifers: ND
Nematodes: ND
Pollen: ND
Ameba: ND
Ciliates: ND
Colorless Flagellates: ND
Crustaceans: ND
Insects/Larvae: ND
Other: ND

This sample was analyzed for particulates following the Environmental Protection Agency Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA). All limitations stated in the method apply.

Comments: Score: 0 - Low Risk per EPA Consensus Method referenced above.

From: E.P.A. Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA)

TABLE 1. Numerical range of each primary bio-indicator (particulate) counted per 100 gallons water.

Indicators of surface water[1]	EH[3]	H	M	R	NS
Giardia[2]	>30	16-30	6-15	1-5	<1
Coccidia[2]	>30	16-30	6-15	1-5	<1
Diatoms[4]	>150	41-149	11-40	1-10	<1
Other Algae[4]	>300	96-299	21-95	1-20	<1
Insects/Larvae	>100	31-99	16-30	1-15	<1
Rotifers	>150	61-149	21-60	1-20	<1
Plant Debris[4]	>200	71-200	26-70	1-25	<1

1. According to EPA "Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources", March, 1991 ed.
2. If Giardia cysts or coccidia are found in any sample, irrespective of volume, score as above.
3. Key= EH -extremely heavy M -moderate NS -not significant
   H -heavy R -rare
4. Chlorophyll containing

TABLE 2. Relative surface water risk factors associated with scoring of primary bio-indicators (particulate) present during MPA of subsurface water sources.

Indicators of surface water[1]	Relative Risk Factor[3]				
	EH[2]	H	M	R	NS
Giardia	40	30	25	20	0
Coccidia	35	30	25	20	0
Diatoms	16	13	11	6	0
Other Algae	14	12	9	4	0
Insects/Larvae	9	7	5	3	0
Rotifers	4	3	2	1	0
Plant Debris	3	2	1	0	0

1. According to EPA "Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources", March 1991 ed.

2. Refer to Table 1 for range of indicators counted per 100 gallons.

   Key= EH -extremely heavy M -moderate NS -not significant
   H -heavy R -rare

3. Risk of surface water contamination:
   ≥20 - high risk
   10-19 - moderate risk
   ≤9 - low risk