Montana City School
SOURCE-WATER PROTECTION PLAN

Montana City, Montana

Public Water Supply MT0001393

MBMG Open-File Report 399-C

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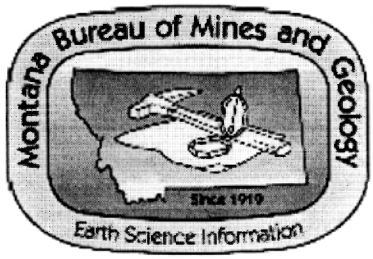

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ACKNOWLEDGMENTS
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PURPOSE
To meet the requirements of the Safe Drinking Water Act (SDWA) as amended, Montana has implemented a source-water protection program in which each public water supply submits a plan for certification review following a format prescribed by the Montana Department of Environmental Quality (MDEQ).

This report is intended to meet the technical requirements for the completion of the source-water protection plan for Montana City Public School in Montana City, Montana as required by the SDWA.

A source-water protection plan is designed to protect the ground water used by public water supplies from contamination. The plan establishes a protected area above the aquifer yielding water to a well; the protected area extends upgradient of the well and is determined by mapping and modeling the aquifer. The protection area is then surveyed to identify potential contaminant sources; management of the potential contaminant sources is considered and priorities are established. This long term planning is necessary to provide an early warning mechanism in the event of upgradient contamination; however, preventing the contamination of a water supply through education and public awareness remains the primary goal.

Most instances of aquifer contamination become known when trace levels of a contaminant are detected through routine monitoring. Drinking water systems that have completed a source-water protection plan will have information on ground-water flow and aquifer hydraulic characteristics as well as a contaminant source inventory and thus will be in a good position to determine the best response to ensure the continued quality of the water supply.

CHAPTER 1
INTRODUCTION

The Community

Montana City is an unincorporated town in southwest Montana, approximately 10 miles southeast of Helena (figure 1). It is located along the Prickly Pear Creek drainage near Route 518 and Interstate-15. The community has between 2,000 and 3,000 residents, many of whom commute to Helena to work. The town is comprised of several housing developments, some small businesses (restaurants, gas stations, storage rental facilities, car wash, bank, etc.), and some dryland pasture for grazing livestock. The largest employer in the town is the Ash Grove Plant that quarries limestone and produces cement. Land uses in the area are regulated by the Northern Jefferson County zoning ordinance.

Almost all businesses and residences in the area use individual on-site sewage disposal systems, and drinking water is provided through either domestic or small public water supplies.

Governance of Montana City is handled by Jefferson County Board of Commissioners (406/225-4025). Law enforcement and emergency services are provided by the Jefferson County Sheriff's Department (Emergency: 911; non-emergency: 406/225-4075).

Montana City Public School

Montana City Public School is in School District 27 (406/442-6779) and serves kindergarten through 8th grade. During the 1998-99 school year, enrollment was 337 students with 50 teachers and staff. Between 1990 and 1998, enrollment increased by 154 students (84%); heavy growth is expected to continue as more people move into the area.

The rock-walled building on the northwest end of the school was built in 1916 and is the original building at the site. As enrollment rose, additions were built in 1973, 1976, and 1989 to allow for more classrooms, a gymnasium, a cafeteria, a computer lab, and a library.

Water for drinking, food preparation, waste disposal, cleaning, and sprinkling is supplied by two wells on the school grounds. As required by state law, the water is routinely monitored for compliance with drinking water standards. The school repeatedly has had problems with bacterial contamination, most recently in December 1998.

Waste water from the school is treated using an on-site sewage disposal system comprised of two septic tanks and drain fields located on the east side of the building. The southernmost drain field was replaced in the summer 1998 because septic discharge began to rise to the ground surface.

Geographic Setting

Montana City (elevation 4,100 ft) is located along the Prickly Pear Creek drainage in the foothills just south of the Helena valley (figure 1). The Elkhorn Mountains (elevation 9,000 ft) rise southeast of town.

The climate of Montana City is cool and dry. Data from a National Weather Service station located in Helena show that average temperatures (°F) in July and August are typically in the mid to high 60's. The coldest months are typically December and January when average monthly temperatures are in the mid to low 20's (NOAA 1996). The area receives about 12 inches of precipitation annually, with 31% of the

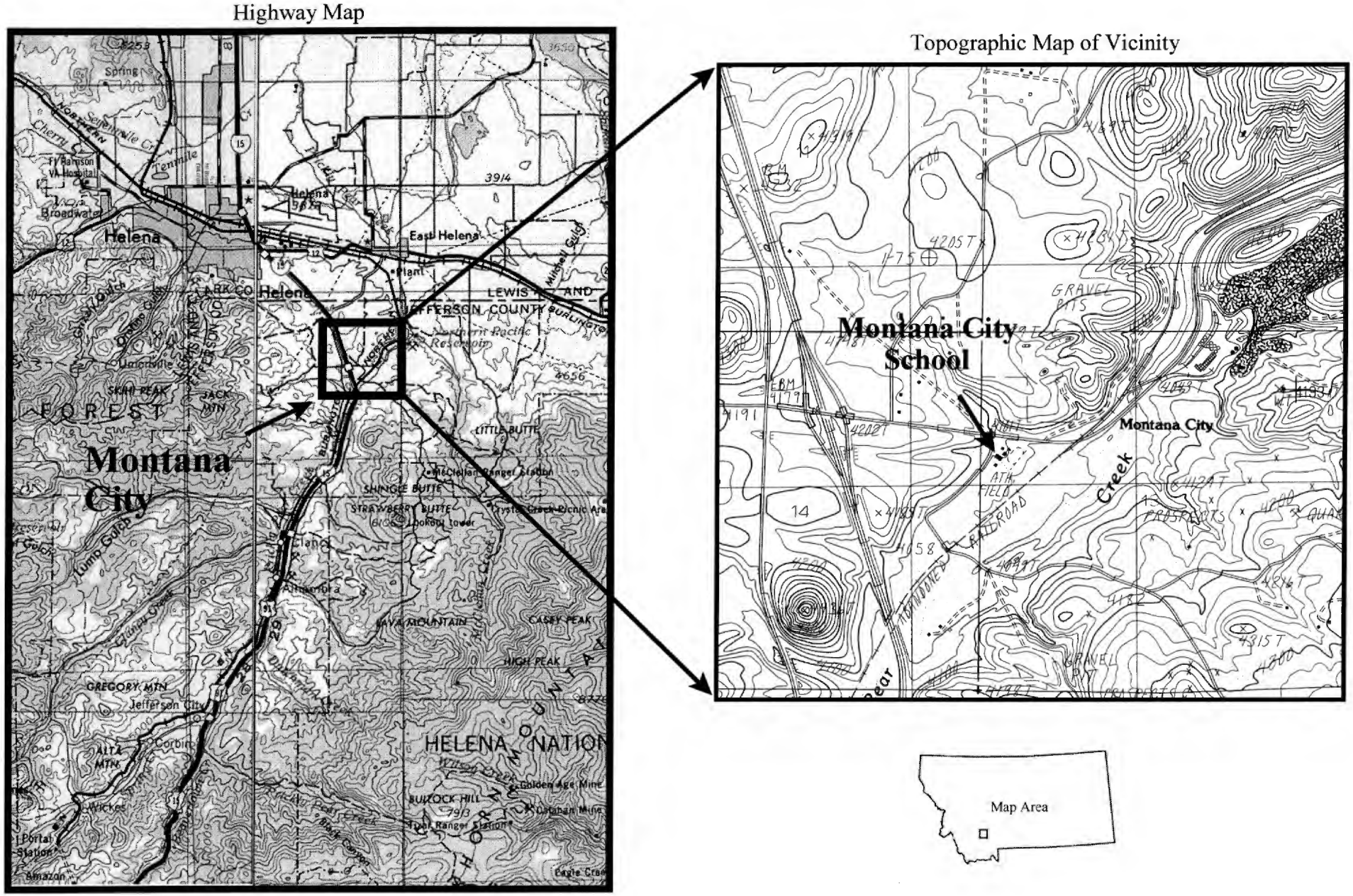


Figure 1. Vicinity maps for Montana City, Montana. Highway map modified from Butte (USGS, 1977) and White Sulfur Springs (USGS, 1972) 1° x 2° quadrangles. Topographic map modified from East Helena 7.5 minute quadrangle (USGS, 1985).

precipitation falling during May and June (NOAA 1996). The growing season in the area is usually about 100 days (Montagne *et al.* 1982).

Montana City is located on the northern margin of the Boulder batholith, a large body of Cretaceous-age igneous rocks. The bedrock directly beneath Montana City is composed of older Paleozoic sedimentary rocks (Meagher limestone, Wolsey siltstone, Flathead quartzite, Helena dolomite) that were uplifted and eroded during the emplacement of the batholith (figures 2 and 3). These formations are exposed north of the school, where they strike northeast and dip 30° to 35° southeast. Subsequent subsidence around the fringe of the batholith has produced numerous high-angle normal faults that often radiate outward from the batholith, cutting the sedimentary rocks. One of these faults crops out along the gully northwest of the school and is inferred to pass beneath the school. On the school grounds, the bedrock formations have been covered with Quaternary alluvium consisting of unconsolidated gravel, sand, silt, and clay.

General Description of the Aquifer

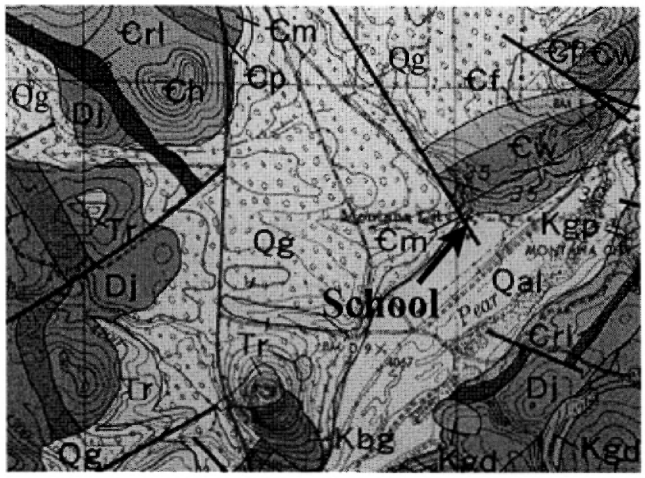
The hydrogeology of the Montana City area is complex. Most wells in the area are completed in Paleozoic and Precambrian sedimentary rocks that have been tilted, faulted, and fractured. Important water-bearing formations include the Madison, Jefferson, Red Lion, and Meagher limestones, and the Hasmark and Helena dolomites. These rocks are composed of calcium and magnesium carbonates that tend to slowly dissolve as water flows through them. Over time, the interconnected fractures and crevices have grown larger, increasing the porosity and permeability of the rock. As a result, the formations store and transmit good supplies of water.

Figure 4 is a ground-water flow map compiled from well inventory data collected by Montana City School students and the Montana Bureau of Mines and Geology (MBMG). The map shows that west of Prickly Pear Creek, ground water generally flows from west to east, toward the creek. The ground-water flow pattern is complicated by hydrologic differences between the bedrock formations as well as heterogeneity within formations. The MBMG's interpretation is that the bedrock aquifers in the area are interconnected by fractures and faults that crosscut the formations. The flow pattern suggests that the bedrock system is recharged by water from the mountainous area west of Montana City and is ultimately connected to the alluvial aquifer along Prickly Pear Creek.

The Public Water Supply

The Montana City Public School has two wells that supply water for approximately 340 students and 50 faculty and staff during the school year from September through June. One well (M:58654) is at the north end of the school; a second well (M:58500) is southeast of the school building (site plans, appendix B). The "M:number" is a well designation used by the Montana Bureau of Mines and Geology for tracking ground-water information for wells throughout Montana. Two other wells (M:58666 and M:58669) previously existed at the school but have now been grouted and sealed. The location of well M:58666 was beneath the stone building at the northwest end of the school; well M:58669 was beneath the present library (Koke 1998).

Well M:58654 was drilled in June 1976 by Lindsay Drilling of Clancy. The boring is 6 inches in diameter and 210 ft deep. According to the driller's log, the well is completed in limestone with 6-inch diameter



Age	SEDIMENTARY ROCKS	
Quaternary	Qal	Alluvium
	Qg	Gravel
Devonian	Dj	Jefferson Formation
Cambrian	Crl	Red Lion Formation
	Ch	Hasmark Dolomite
	Cp	Park Argillite
	Cm	Meagher Limestone
	Cw	Wolsey Formation
	Cf	Flathead Quartzite

Age	IGNEOUS ROCKS	
Not arranged in order of age	Tr	Rhyolite
	Kbg	Muscovite-biotite granite
	Kgd	Granodiorite, undivided
	Kgp	Granodiorite porphyry and related porphyries
		Fault

Figure 2. Geologic map of the Montana City area. Modified from Knopf (1963). See appendix A for more complete descriptions of the formations.

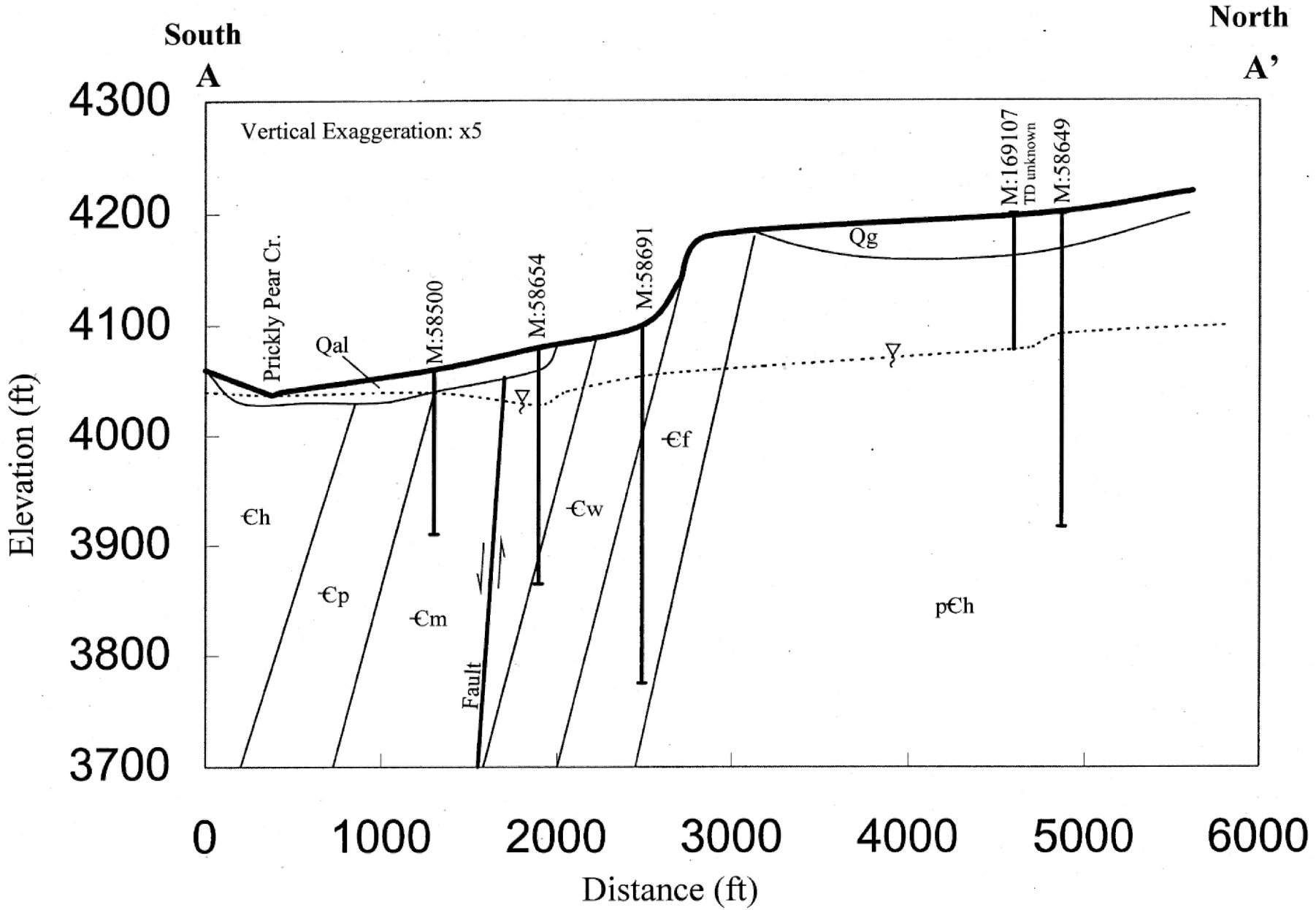


Figure 3. Hydrogeologic cross section near the Montana City School. The location of the cross section is shown on the ground-water flow map (figure 4). See appendix A for formation names and lithologic descriptions of units.

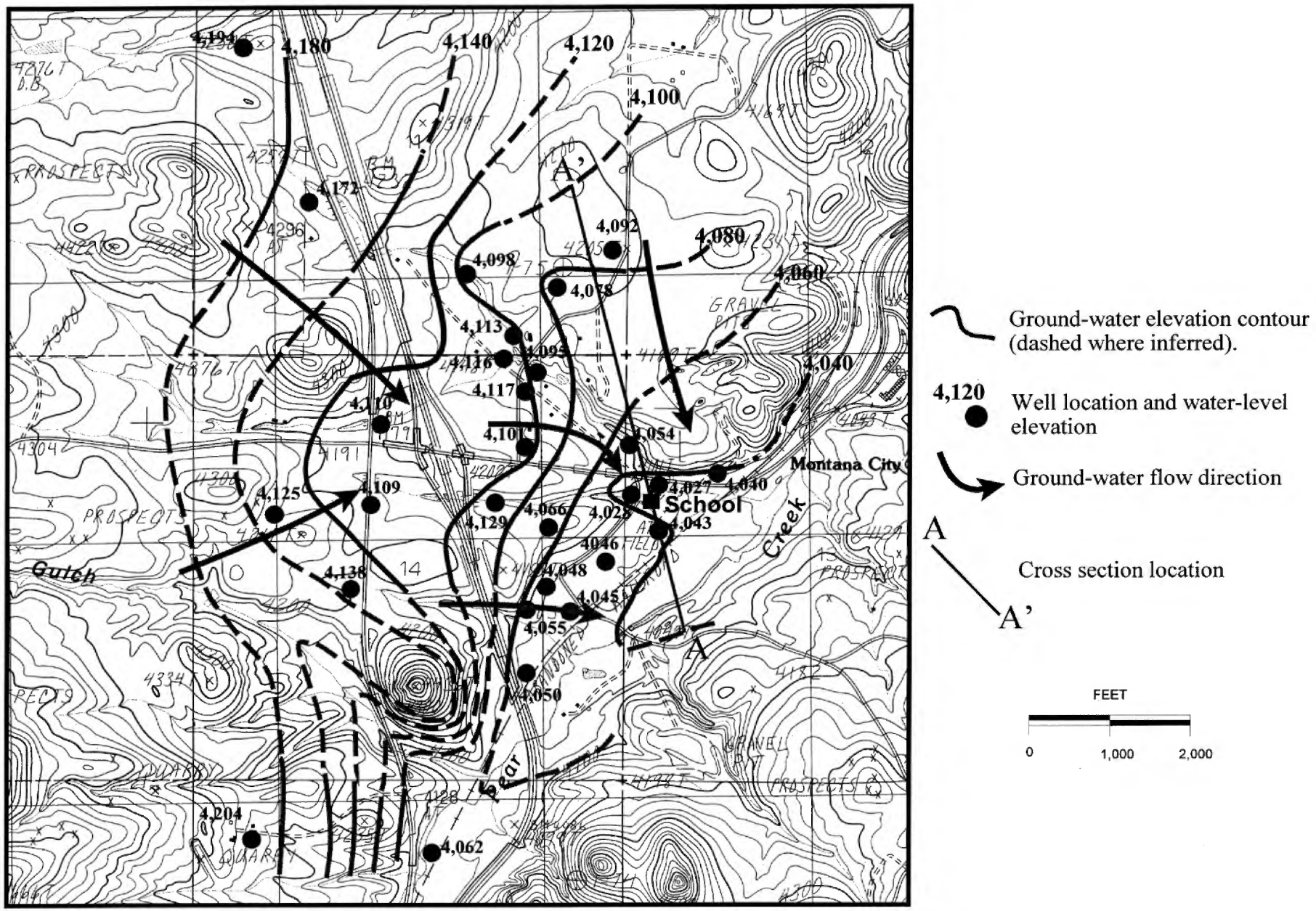


Figure 4. Ground-water flow map for the Montana City area. Compiled from data collected in 1996, 1997, and 1999. Note that well M:169104 southeast of the I-15 interchange (water-level elevation 4,129) has not been used for contouring.

steel casing from 0 to 21 ft and 4-inch diameter PVC pipe from 10 to 210 ft. The PVC is slotted to allow entry of water between 130 and 210 ft. Well M:58500 was drilled in October 1988 by H & L Drilling of East Helena. The boring is 8 inches in diameter and 150 ft deep. According to the driller's log, the well is completed in limestone; it is cased from 0-150 ft with 6-inch diameter steel pipe that is perforated from 110 to 150 ft. Submersible pumps were installed in both wells.

Water from the north well (M:58654) enters the school in the basement of the old stone building (see appendix B). At this location, there is a pressure tank, a hot water heater, a shutoff valve, and a power switch. Water from the southeast well (M:58500) enters the school in the southwest corner of the basement of the school's south wing where there are 8 pressure tanks, a hot water heater, and a shutoff valve. The power switch for this well is located in an electrical box near the well head.

After entering the school, the water from the wells is distributed through a system of copper pipes. A pipe with a shutoff valve is located in the ceiling of the hall between north and south wings of the school (see appendix B). By closing this valve, it is possible to isolate the water from the north well to the north wing of the school and the southeast well to the south wing.

The water is dispensed in the school building at hallway drinking fountains, at sink and toilet receptacles in the public restrooms, at sinks and cleaning facilities in the cafeteria, at utility sinks in the janitor closets, at sinks and drinking fountains in the classrooms, and at showers and restroom facilities in the gym. Water from the southeast well also is used for sprinkler irrigation of the lawn and athletic field, but this distribution system is separate from that within the school. A shutoff valve and back-flow preventer for the irrigation system are located near the well head (Newport 1999).

Waste water from the school is discharged to a septic tank and newly constructed drain field on the east side of the building.

Influencing Factors

The people who helped formulate this plan include teacher Stacy Fessenden and her students at the Montana City School, superintendent Penny Koke, head of maintenance Gary Newport, and the Montana City School Board Trustees. Factors that shaped the plan included concern about the rapid development that is occurring in the area and the influence that this may have on water availability and quality.

Source-water protection Management

The Montana City School Board will be responsible for implementing the plan along with participation from the school students and teachers. The primary operator is designated as Mike Rasmussen (406/443-5929); the backup operator is Gary Newport (406/442-6779). These designations will be reversed when Gary Newport receives his operator certification.

CHAPTER 2
DELINEATION

The purpose of this chapter is to describe how the source-water protection areas for the Montana City School wells were determined. These "delineated areas" define the portion of the aquifer or ground-water flow system that contribute water to the wells. The delineated areas include the recharge region as determined by application of analytical equations for ground-water flow and simple hydrogeologic mapping. The delineated source-water protection areas for the Montana City School wells have been subdivided into three regions for prioritization and ease in management. These three regions include the control zone, special protection region, and protection region.

The control zone also is defined by a 100-foot radius circle around each well. Certain spills or land use activities in this zone have the potential to quickly impact the well; hence, control of potential contaminants is critical.

The special protection region represents the zone of contribution to the wells for an upgradient distance of 6,900 ft, which approximates a time of travel of about 10 years. Because of uncertainty about the exact ground-water flow direction, the zone is very broad, encompassing all or parts of three or four ephemeral drainages west of the school, including Clark Gulch. The area also includes a portion of Prickly Pear Creek and the valley alluvium. The delineation is based on the pumping rates of the wells, aquifer characteristics, ground-water flow direction, and topographic watershed boundaries. Spills or leaks of certain contaminants and some land uses within this region are considered likely to contaminate the wells but early detection, response, and remediation will prevent the long-term loss of water quality.

The protection region represents the recharge area for the aquifer system that contributes water to the school wells as delineated by hydrogeologic mapping and topographic watershed boundaries. With the exception of the Clark Gulch drainage, this area encompasses the remainder of the ephemeral watersheds west of the school. The Clark Gulch drainage is included west to where Clark Creek passes through a narrow bedrock canyon.

Geologic Conditions and Aquifer Characteristics

Most wells in the Montana City area are completed in Paleozoic and Precambrian sedimentary rocks that have been tilted, faulted, and fractured. Important water-bearing formations include the Madison, Jefferson, Red Lion, and Meagher limestones, and the Hasmark and Helena dolomites, all of which are carbonates. Carbonates are an important class of water-bearing rock because they tend to dissolve as water flows through them. As a result, small fractures and crevices can become wide voids that store and transmit large volumes of water. The MBMG's interpretation is that the bedrock-aquifer system in the Montana City area is interconnected by fractures and faults that crosscut the various formations. No well-defined, continuous aquitards exist that prevent flow from one formation into another.

A ground-water flow map for the bedrock-aquifer system (figure 4) was compiled from well inventory data collected in 1996, 1997, and 1999 (appendix C). Elevation data for the wells were obtained from the East Helena 7.5-min USGS topographic map (contour interval: 20 ft). The well depths range from 79 to 400 ft, and the depth to water ranged from about 15 ft near the school to approximately 100 ft in the area west of I-15. The flow map shows that ground water generally flows from west to east, toward Prickly

Pear Creek, but there is considerable local variability. Ground-water gradients range from 0.01 to 0.07 ft/ft. The overall direction of ground-water flow suggests that the bedrock-aquifer system is recharged by water from the mountainous region west of Montana City. A small volume of recharge also is probably contributed by the rainfall and snowmelt that infiltrates the soils overlying the bedrock in and around Montana City. The ground-water flow pattern also suggests that the bedrock-aquifer system discharges to the alluvium along Prickly Pear Creek, but because the gradient is so flat near the creek, there is uncertainty about this relationship. In fact, the opposite could be true: the alluvial aquifer could actually be discharging to the bedrock system. Stream flow measurements and detailed survey work are needed to resolve this issue.

Near the school, the ground-water flow map shows that flow converges. Several possible explanations can be offered for this pattern. One is that a cone of depression has developed in the area due to ground-water withdrawals. This explanation seems unlikely because the school and domestic wells in this area probably are pumping less than 25 gpm and are not used continuously. A second possible explanation is that this area has a higher transmissivity, perhaps due to the fault that is inferred to pass beneath the school (figures 2 and 3). Several pumping tests would be necessary to test this hypothesis. A third possibility is that the relative elevations of the wells and water levels in this area have been misjudged. This possibility could be addressed by surveying the wells.

Two wells in the area (M:58647 and M:134497) were monitored for several years by the USGS and MBMG (appendix D). Figure 5 shows the water-level fluctuations in these wells over the periods of record. Well M:134497, which is located approximately a half mile southwest of the school, had a 9 ft decline in water level from May 1996 through October 1997. The last measurement in January 1998 showed the water level recovered 4.6 ft. The seasonal high water levels in this well in 1994, 1995, and 1996 occurred in May, suggesting that the aquifer in this area is influenced by local recharge. The water level in well M:58647, which is located approximately 1.5 miles northwest of the school rose sharply at the beginning of monitoring (October 1993), was relatively stable from December 1993 through March 1996, and then rose several feet in April 1996. The water level then gradually declined until the end of monitoring in September 1996. This well has no regular seasonal water-level trend. Although water use in the Montana City area is expanding rapidly, the records from these wells do not show a problem with dewatering of the bedrock-aquifer system.

Well logs from the area (appendix E) indicate that the bedrock-aquifer system has a saturated thickness of at least 250 ft, but the total thickness is unknown. Typically, the productivity of a bedrock aquifer declines with depth because there are fewer fractures, and the fractures that do exist are pressed tightly shut by overburden pressure.

Very little hydraulic conductivity (K) and transmissivity (T) data have been collected in the Montana City area. Faber (1997) reports T as 428 ft^2/day from an aquifer test on a well in the City Lights Subdivision a half mile northwest of the school. Using an aquifer thickness of 30 ft (the difference between the water level in the well and bottom of the well), Faber (1997) determined that K was 14 ft/day. Using specific capacity data for 15 area wells that are completed in limestone, the MBMG calculated an average T of 636 ft^2/day.

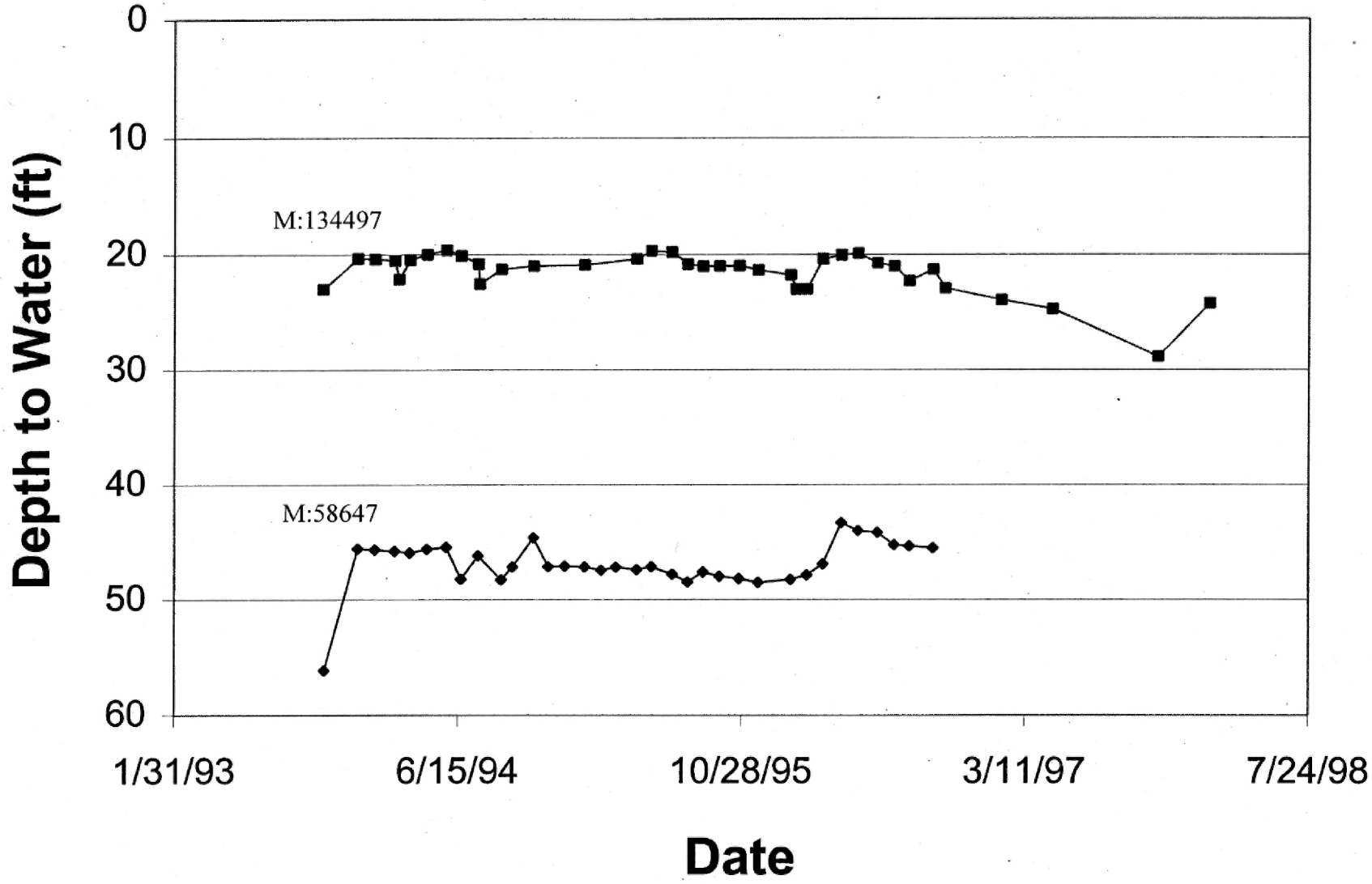


Figure 5. Hydrographs for wells M:58647 and M:134497. Data were collected by the MBMG and U.S. Geological Survey.

Ground-Water Quality

Very limited ground-water quality data are available in the study area. The school monitors for nitrate, coliform bacteria, metals, and organics periodically. Heterotrophic bacteria have been a recurring problem.

The MBMG's Ground-Water Information Center database was queried for information in township 9N, range 3W, sections 11, 12, 13, and 14. The only data retrieved were for school well M:58500, which was tested for radon by the MBMG in April 1995. The radon concentration in the water was about 1,800 piC/L.

Nitrate values reported by Faber (1997) range from <0.01 to 5.89 ppm in the vicinity of the City Lights subdivision, which is a half mile west of the school.

When the MBMG inventoried wells in January 1999, specific conductance was measured at several locations (table 1). Specific conductance is a measure of how easily water conducts electricity and is used to characterize the dissolved mineral content of the water. Values ranged from 468 to 1,750 µS/cm, with the highest value being measured at the school. The reason for the high value at the school is not understood, and again underscores how little is known about ground-water flow through the complex fractured bedrock-aquifer system.

Source Wells

School well M:58654 is located on the northeast end of the school grounds and was drilled in June 1976 by Lindsay Drilling of Clancy. It is 6 inches in diameter and 210 feet deep; it is screened from 130 to 210 ft (well log, appendix F). The well riser is 21 inches high and is covered with a standard cap. According to the driller's log, the well is completed in limestone (probably the Meagher); the hydrogeologic cross section (figure 3) suggests that the well also may extend into the Wolsey siltstone. At the time of completion, the well had a static water level of about 40 ft below ground surface; the water level measured in January 1999 was about 48 ft below ground.

School well M:58500 is located south of the school building, near two storage sheds. It was drilled in October 1988 by H & L Drilling of East Helena and is 8 inches in diameter and 150 feet deep (well log, appendix F). The well riser is 17 inches high and is covered with a standard cap. According to the driller's log, the well is completed in limestone (again, probably the Meagher, see figure 3) and is screened from 110 to 150 ft. The static water level in the well at the time of completion was about 28 ft below ground surface. When the water level was measured in April 1997, it was approximately 22 ft below ground.

In the fall 1997, water meters were installed on the two wells to obtain estimates of daily water use. Over a 22-day period, the combined average water use was 5,157 gallons per day (Rasmussen 1997). Well M:58654 supplied approximately two-thirds of the water.

Delineation Method

As previously noted, a source-water protection area was delineated for the school wells. Each well has a control region. Because ground-water flow apparently converges around the school, the special protection and protection regions for the two wells were combined into one. The delineation methods used for the various regions are discussed in the following sections.

Table 1. Specific conductance (SC) at selected wells in the Montana City area.

Well M:Number	Location (Township, Range, Section, Tract)	Uncorrected SC (µS/cm)	Temperature (°C)	SC @ 25°C (µS/cm)
58500/58654	09N03W13BCCA	1,250	10.3	1,750
58643	09N03W11DCDD	343	11.3	468
58692	09N03W14ADDD	460	9.8	652
58703	09N03W14ABAA	620	12.5	821
153917	09N03W11CACB	460	11.4	626

Control Region

The control region consists of the area within a 100-ft radius of each well (see site plan, appendix B). The extent of the area was defined based on MDEQ standard guidelines for establishing a control region.

Special Protection Region

The extent of the special protection region for the school wells is shown on figure 6 and is based on hydrogeologic mapping and modeling. The downgradient end of the region is the southeast side of the alluvial-filled Prickly Pear Creek drainage. This area was included because of the uncertainty about whether the bedrock-aquifer system discharges to the alluvium or vice versa. To the north, the boundary follows the topographic watershed divide for the ephemeral drainage northwest of the school. To the south, the boundary follows Prickly Pear Creek to where the creek passes under I-15. The boundary then follows the southern edge of the Clark Gulch drainage. The upgradient end of the zone is an arc with a radius of 6,900 ft that extends from the south edge of Clark Gulch watershed to the mountaintop that forms the westerly end of the northern ephemeral drainage.

The distance from the school to the upgradient end of the special protection region corresponds to a time-related capture zone of 10 years. The travel time was estimated by using the RESSQC module of the WHPA model, a semi-analytical ground-water flow model developed for the EPA to assist in source-water protection area delineation (EPA, 1991). A description of the RESSQC module is included in appendix G. A full discussion of the theoretical development of the module is presented in the model documentation (EPA, 1991).

To the extent possible, parameters used for calculating and/or modeling the capture zones of the wells were field data collected near the Montana City School. If no data were available, values were estimated based on measurements elsewhere in the basin or reported in the literature for similar hydrogeologic conditions. Input parameters are listed below with a brief explanation and/or justification.

Aquifer Thickness (D): 80 ft

The aquifer thickness is the thickness of the water-bearing zone. For the model, it was taken to be 80 ft because school well M:58654 has an 80-ft long screen. The actual thickness of the aquifer is unknown but could range up to several hundred feet.

Transmissivity (T): 636 ft^2/day

Transmissivity is the rate at which water can move through a unit width of an aquifer under a unit hydraulic gradient. It is a function of the type and thickness of the aquifer material. The transmissivity for the model was calculated to be 636 ft^2/day based on specific capacity data reported by drillers for 15 wells completed in limestone within one mile of the school.

Hydraulic Conductivity (K): 8 ft/day

Hydraulic conductivity is a measure of the rate of flow of water through a cross section of a unit area of the aquifer under a unit hydraulic gradient. The hydraulic conductivity used for the model was calculated by dividing transmissivity by aquifer thickness.

Porosity: 0.15

This value is within the typical porosity range for karst limestone (Freeze and Cherry 1979).

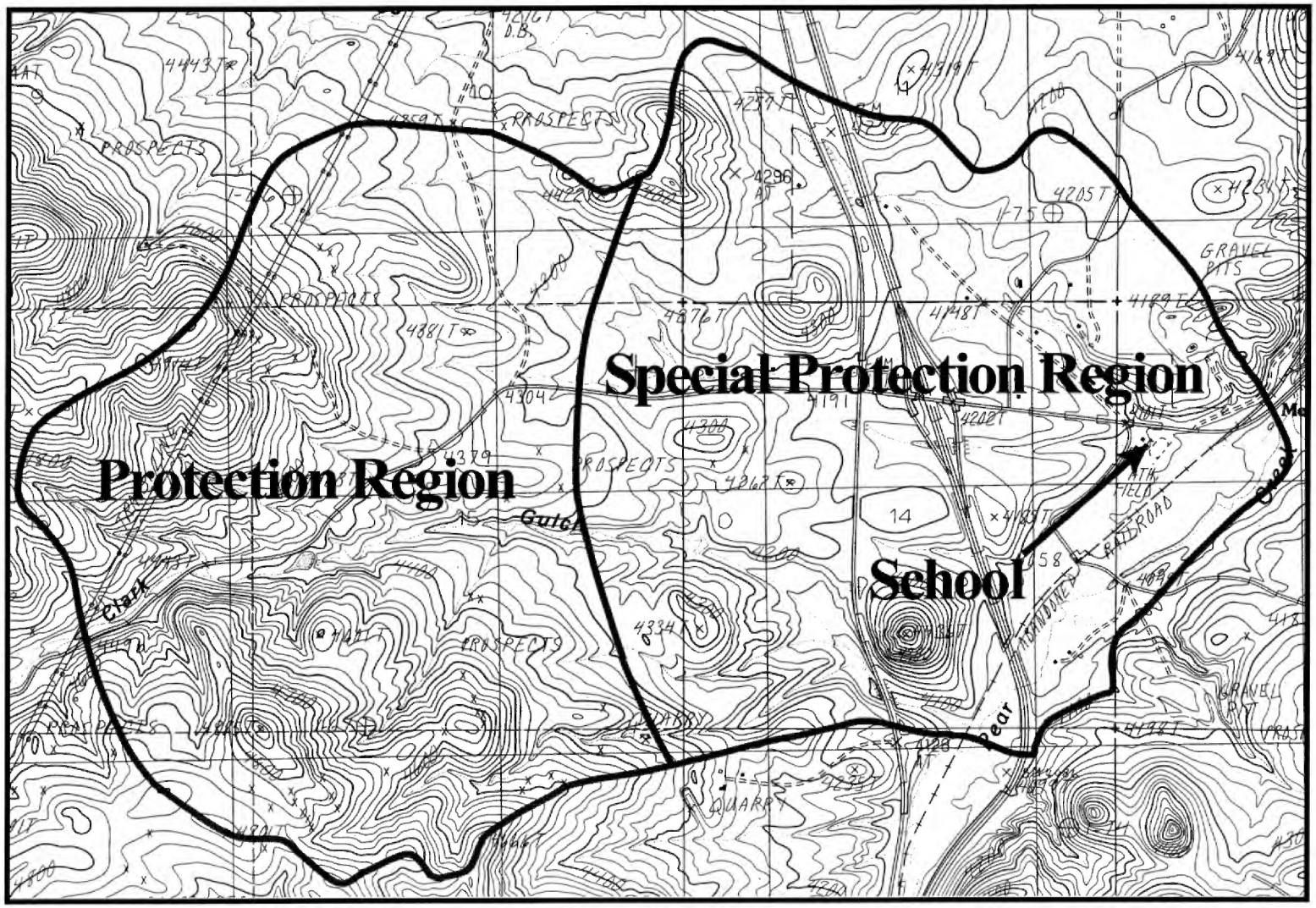


Figure 6. Delineation of the protection and special prtoection regions for the Montana City School wellhead protection area. The control regions for the wells are shown on the site plan in appendix B.

Gradient: 0.035 ft/ft

The gradient was obtained from the ground-water flow map compiled for this study. This value is the average gradient near the school.

Well Discharge: 1,350 ft^3/day

Although the school water use was metered in 1997 at 5,157 gallons per day, a larger water-use value was used in the model to obtain a more conservative 10-year travel distance. From the reference "Small Water Systems Serving the Public" (1981), a school with a cafeteria and showers uses about 25 gallons per day per person. Present enrollment at the school is 337 students with 50 teachers, for a total of 387 water users. This value was rounded to 400 people. Multiplying 25 gpd by 400 people yields 10,000 gpd; this value is equivalent to approximately 1,350 ft^3/day.

With these input parameters, the model yielded a 100 ft wide, 6,900 ft long zone upgradient of each well. The width of this modeled special protection region was not appropriate because the ground-water flow map shows that flow converges near the school. The width therefore was defined by hydrogeologic mapping.

Protection Region

The protection region was defined using the ground-water flow map and a topographic map. The extent of the region was determined based on the watershed boundary for the ephemeral drainages that are west of the school (figure 6). The entire extent of the Clark Gulch watershed was not included for practical reasons; instead, the upgradient boundary is defined by where a high-power transmission line crosses Clark Gulch creek in a narrow canyon.

Assumptions

Several assumptions were associated with the delineation of the special protection region. To prepare the ground-water flow map, elevations for each well had to be estimated using the 20-ft contours shown on the topographic base map. If elevations were not estimated accurately, ground-water flow directions and gradients could be incorrect.

When estimating the capture zone of the wells, values of hydraulic conductivity, transmissivity, and porosity had to be assumed because these properties have not been measured for the aquifer underlying the school. The values therefore were taken from general hydrogeologic reference texts or were calculated based on specific capacity data reported by drillers. It also was necessary to assume an aquifer thickness. Well logs provide a basis for a minimum thickness, but no existing wells fully penetrate the bedrock-aquifer system.

The numerical ground-water model used to define the special protection region assumes that the bedrock aquifer is isotropic and homogeneous. An aquifer is isotropic if hydraulic conductivity is the same regardless of ground-water flow direction; it is homogeneous if its properties are uniform throughout. These two conditions are clearly not met in the Montana City area because of the complexity of the hydrogeology. The model also assumes that the pumping well is screened across the entire saturated thickness of the aquifer and that it is pumped continuously year after year at the same rate. Finally,

because the model is two-dimensional, it assumes that vertical flow within the aquifer is negligible. Again, this is probably a poor assumption for the bedrock-aquifer system in the Montana City area.

Limiting Factors

Ground-water flow directions and gradients determined for this source-water protection plan seem reasonable based on the topography and surface hydrology of the Prickly Pear Creek valley. Flow directions are probably valid to within 60 degrees. Confidence in the map could be greatly improved if the relative elevations of the wells were surveyed. Measuring discharges and elevations along Prickly Pear Creek also would be useful to help understand the relationship between the alluvial and bedrock aquifers.

As noted above, major assumptions used in the application of the ground-water flow model are: 1) the bedrock-aquifer system is isotropic and homogeneous, 2) flow in the system is horizontal, 3) the well is screened across the entire thickness of the aquifer, and 4) the well is pumped continuously. A ground-water flow model for any specific set of conditions should be considered within these limitations as aquifers generally are neither isotropic nor homogeneous, and well construction and operation rarely fit the ideal. Any particular modeling effort merely represents the best estimate of ground-water flow conditions based on known and estimated hydrogeologic and pumping conditions and should be modified as additional information becomes available.

It follows that the aquifer-property estimates (K, T, and porosity) are probably the weakest aspect of the delineation. To compensate for this uncertainty, the pumping rates of the wells were overestimated, thus leading to an overestimate of the 10-year capture zone. As new data become available, a new model should be developed that reflects the complexity of the flow system and thus can be used to obtain more accurate estimates of travel time.

In summary, the delineation shown on the base map represents a conservative estimate of the capture zone and is based on a maximum daily pumping rate. The capture zone should continue to be safe even if water demand increases.

Ground Water Under the Direct Influence of Surface Water

A preliminary assessment score sheet was completed for each well to determine if it was possibly under the influence of surface water; both wells had a score of 20 (appendix H). The wells are cased to a depth of about 20 ft, are in good condition, and are more than 500 ft from Prickly Pear Creek; therefore, it is unlikely that they are influenced by surface water.

CHAPTER 3
INVENTORY

An inventory was undertaken in the delineated area to identify potential contaminant sources that could impact the aquifer used by the Montana City School. An intensive survey was done within the control zone and special protection region; potential contaminants also were inventoried in the protection region, but the effort was not as intensive due to the lower risk associated with this area.

Inventory Method

The methods used to inventory potential contaminant sources included a review of the East Helena 7.5-minute topographic map and an aerial photograph for transportation routes and land use, a "windshield" survey, interviews, and a search of the MDEQ's underground storage tank database. Land within the source-water protection region is primarily unsewered residential property, dryland pasture, and highway right-of-way. There is a small business district with a gas station, print shop, auto repair shop, beauty salon, kennel, car wash, restaurants, bank, and several other establishments located near Interstate 15. Also, construction of a micro-brewery just west of I-15 has been proposed. Inventory sheets were completed for specific activities or sites of concern (appendix I), and the locations of these sites were plotted on either the site plan (appendix B) or land-use (appendix J) maps. The inventory of each zone is described in greater detail in the following sections.

Inventory Results/Control Zone

Land within the 100 ft-radius control zone for well M:58654 contains a baseball diamond and backstop, school lawn, and the north end of the school gymnasium (appendix B). The land within 100 ft of well M:58500 contains school lawn, two storage sheds for athletic equipment, and undeveloped, wooded land to the east. No contaminant sources or concerns were noted around either well.

A professional lawn care contractor is hired annually to treat the school grounds with fertilizer and a broad-leaf herbicide, typically Trimec, for noxious weeds (site plan map, site ID no. 1, appendix B/inventory sheet no. 1 appendix I).

Inventory Results/Special Protection Region

The special protection region includes the school grounds, residential properties, part of the State Highway 518 and Interstate 15 right-of-ways, some dryland range, an undeveloped commercial subdivision, and several small businesses including several restaurants and casinos, rental storage facilities, a gas station, a beauty salon, a print shop, a car wash, a bank, a kennel, a dentist's office, and an automobile repair shop. Also, a proposal to construct a micro-brewery just west of the I-15 interchange is currently under review.

Within the school, several chemicals and cleaners are used routinely by the janitorial staff. These include Betco Q256 cleaner and disinfectant, Grit Grabber (phosphoric acid), and degreasers. These products are used in small volumes and through routine use are generally disposed of in waste water. The school science classes use several common acids and bases e.g. HCl, H_2SO_4, NaOH, for experiments, but the chemicals are neutralized before disposal down the laboratory sinks (Fessenden 1998). Waste water from the school is discharged to two septic tanks and drain fields on the southeast side of the school building, between the two school wells (site plan map, site ID no. 2, appendix B/inventory sheet no. 1, appendix I).

The southernmost drain field was replaced in 1998 and thus far the new system appears to function well. However, the school has had repeated problems with bacterial contamination, and water from the school wells has an unusually high specific conductance. These two indicators suggest that the septic systems and drain fields may be impacting the bedrock aquifer; this possibility should be investigated further.

Urban runoff from the ephemeral drainages west of the school poses another concern (site plan map, site ID no. 3, appendix B/inventory sheet no. 1, appendix I). The runoff generally occurs in the spring and is routed into unlined channels north and south of the school. Some of the water probably infiltrates the ground and contributes recharge to the aquifer. If the runoff contains oil and grease or other contaminants, it may have an impact on ground-water quality near the school.

During fire prevention week, a small area on the south end of the school's south parking lot is used for a fire extinguisher demonstration. This area has been doused with lighter fluid or some other fire starter, and grass will not grow (site plan map, site ID no. 4, appendix B/inventory sheet no. 1, appendix I).

The Department of Transportation occasionally sprays the herbicides Tordon and/or 2,4-D along the Highway 518 and Interstate-15 rights-of-way. Selective spot spraying of weed control herbicides along public road right-of-ways by licensed applicators has not resulted in any documented ground-water contamination (Meek 1999). Trucking of hazardous materials on Highway 518 and Interstate-15 is probably minimal. Fuel oil and gasoline are probably the most common potential contaminants transported along these routes (land-use map, site ID no. 5, appendix J/inventory sheet no. 2, appendix I).

Potential contaminant sources on the residential properties upgradient of the school were not inventoried intensively but are likely to include common fertilizers and herbicides, gasoline for lawnmowers and recreational vehicles, and standard cleaners and disinfectants. In addition, there are approximately 100 residential septic systems in the area, and more are planned for subdivisions that are not yet built upon. Because most homes in the area have been built in the last 10 years, it is unlikely that there are underground storage tanks on these properties.

Of the businesses observed upgradient of the school, the gas station poses the greatest concern to the school (land-use map, appendix J/inventory sheet no. 3, site ID no. 6, appendix I). The station has had two documented releases of gasoline. According to the MDEQ case manager (Scott Gestring, phone: 444-1388), free-product more than one foot thick was observed in monitoring wells that were installed when the spills were first reported in 1988 (MDEQ Site ID No. 2201822). The gasoline now is being removed from the ground using a vapor extraction system, and the observed thickness of free-product has been greatly reduced. Because this spill has occurred in a complex hydrogeologic setting, special attention should be paid to how it may impact drinking water for the entire Montana City community. The gas station continues to operate and maintain three underground storage tanks that are used for three grades of unleaded gasoline.

Other businesses that were investigated for potential contamination concerns included the car wash, print shop, and auto repair shop. The car wash recycles its water through an oil-water separator treatment system (land-use map, site ID no. 7, appendix J/inventory sheet no. 4, appendix I). Waste is held in a tank until it is hauled away for disposal. The print shop southwest of the I-15 interchange is a dry shop; all printing is done at another location; therefore this business is not a concern. The auto repair shop has

numerous vehicles on its lot, so there is some concern about oil, gas, and anti-freeze that might leak from vehicles (land-use map, site ID no. 8, appendix J/inventory sheet no. 5, appendix I).

The micro-brewery that has been proposed near the I-15 interchange could generate a large volume of waste water that probably would be disposed of using an on-site treatment system; this poses a possible future concern.

The septic systems serving many of the businesses in the area may be classified as Class V injection wells pursuant to the Safe Drinking Water Act and may be subject to future permitting requirements (Meek 1998). Class V injection wells are defined as septic systems that potentially receive chemical-related discharges or have the capacity to serve 20 or more people per day. Some of the establishments that could be required to seek permits include the restaurants and bars, gas station, kennel, auto repair shop, beauty salon, dentist's office, and the school itself.

The dryland range is used for horses, cattle, and llamas and is probably sprayed occasionally for noxious weeds but is otherwise free of contaminant hazards.

Inventory Results/Protection Region

The land in the protection region contains residential properties, undeveloped subdivisions, a limestone quarry, dryland range, several roads, and forested property. The inventory of hazards in this area was limited to a "windshield" survey and review of an aerial photograph.

The residential properties again probably have potential contaminant sources such as septic systems, gasoline for lawn mowers and recreation vehicles, and fertilizers and herbicides for lawn care. The limestone quarry uses ammonium-nitrate explosives for blasting; therefore, release of nitrates is a possible concern (land-use map, site ID no. 9, appendix J/inventory sheet no. 6, appendix I). The dryland range and forested properties have no obvious hazards.

Inventory Update

The teachers and students at the Montana City School will update the inventory every 5 years as per MDEQ guidelines. Changes in land uses or potential contaminant sources will be noted and modifications made as needed. The updated inventory will be submitted to MDEQ to ensure recertification of the source-water protection plan.

Organic Chemical Monitoring Waivers

The Montana City School is required to monitor for organic chemicals in its well water. The most recent test was conducted in October 1997, and no contaminants were detected.

Inventory Limitations

The inventory in the control zone was very thorough. The school grounds were inspected for all potential contaminant sources. For the special protection area, the school janitor (Gary Newport), teacher Stacy Fessenden, and superintendent (Penny Koke) were interviewed concerning potential hazards, and the school grounds and building were toured. In the special protection and protection areas west of the school, hazards were identified from an aerial photograph, a "windshield" survey, phone interviews with the owners of the gas station and car wash, and discussions with representatives from the EPA and MDEQ;

some potential hazards may have been missed. In both these areas, it was not possible to inventory hazardous chemicals that are transported on the roads and highways; only the most likely chemicals (fuel oil and gasoline) are cited. The PCB content of the oil in the power company transformers is unknown, but because the transformers contain only a small volume of oil, they represent a fairly minor potential hazard.

CHAPTER 4
MANAGEMENT

The goal of the source-water protection plan is to 1) protect the source water by keeping potentially polluting materials and activities out of the control zone, and 2) to manage the special protection region to ensure that land use activities pose a minimal threat to the source water. Land uses within the protection area have been identified (see base map) and consist of residential properties, undeveloped subdivisions, small businesses, a limestone quarry, dryland range, and undeveloped forested land. Land use is changing rapidly in this area, and as this occurs, it will be scrutinized to determine if any new hazards will be introduced, and if so, how they will be controlled. Any spill of hazardous substances within the protection area will be reported to MDEQ to assure that proper measures are taken to mitigate the hazard to the aquifer.

Inventory sheets were completed for specific activities or sites of concern that have the potential to contaminate the source water for the school wells. Ten potential concerns were noted: 1) herbicide and fertilizer spraying on the school, 2) the school septic system, 3) urban runoff onto the school grounds, 4) fire extinguisher demonstration area, 5) power transformers that may contain PCBs, 6) chemicals transported along Hwy 518 and I-15, 7) gasoline releases and underground storage tanks at the gas station west of I-15, 8) waste-water treatment and storage facility at the car wash, 9) storage of damaged automobiles at an auto repair shop, and 10) ammonium-nitrate explosives at the limestone quarry. Increased use of on-site sewage disposal systems on the residential and commercial property upgradient of the school also is a serious concern. Steps to be taken to address each of these concerns are discussed in the following sections.

Control Zone Management

The caps on the wells will be inspected annually to make sure that they are secure and undamaged. During the spring or summer 1999, small fences (approximately 10 ft x 10 ft) will be placed around the wells in order to discourage tampering and to restrict access by dogs and other animals. If animal fecal material is found within this area, it will be removed with a shovel and disposed of properly. Fertilizer application will not be permitted within 10 ft of the wells, and herbicide spraying will not be permitted within the 100 ft. If weeds are found in the control zone, they will be pulled by hand. The school board or superintendent will notify the lawn-care contractor of this special restriction. The school board will ask to be notified immediately if an herbicide or fertilizer spill occurs on the school grounds.

Special Protection Region Management

Because the school uses a septic system, no hazardous substances e.g. strong acids and bases, and organic solvents, will be disposed of in the sinks or toilets at the school. Notices will be posted in the bathrooms, janitor's closets, and next to the classroom sinks to this effect. Also, the notices will list the name of a contact person (Gary Newport) who can be consulted if any questions arise about what can be poured down the drain. In the future, the fire department will be required to use a large metal bin or some other appropriate container to ensure that flammable liquids are not spilled on the ground when conducting fire extinguisher training.

The Montana City School Board will distribute source-water protection plan summaries to the owners of the gas station, car wash, and auto repair shop west of I-15. The owners will be asked to notify the school board if any hazardous materials are released on their properties.

Every five years, the school board will post informational fliers (appendix K) on public bulletin boards showing the delineation of the special protection and protection regions. The fliers will remind property owners that hazardous chemicals should be disposed of properly and that flushing chemicals such as antifreeze, waste oil, paint thinner, etc. into their septic systems or pouring them onto the ground could result in contamination of their drinking water supply. Local papers also will be asked to run an article about ground-water use and protection in the Montana City area.

The school board will provide the Jefferson County Disaster and Emergency Services coordinator with a copy of the plan and will asked to be notified in the event of a reportable spill that could impact the local aquifer. In such an event, the school board will ask the MDEQ to investigate whether or not special action is required.

The police and Montana City Volunteer fire departments will be issued summaries of the source-water protection plan so that they are aware of the sensitivity of this area.

Jefferson County zoning regulations state, in part, that "the purpose of the Northern Jefferson County zoning regulations is: to promote the health, safety, and general welfare of the community; to protect property values; to protect and conserve natural resources; and to facilitate the provisions for public works requirements such as schools, water, sewer, and environmental needs."

To ensure the purpose of the Jefferson County zoning regulations are met and to ensure that subdivision proposals for non-residential land uses in the special protection region undergo review for the effect on public health as it relates to drinking water quality, the school board will provide the Jefferson County Commissioners, the Planning Board, and the Board of Adjustments with copies of the source-water protection plan and will request the county require a water-quality assessment accompany any preliminary subdivision plats proposed within the special protection region. This assessment should include a description of every surface-water body that may be affected by the proposed subdivision, together with available ground-water information including a summary of the probable impacts of the proposed subdivision on the school's public water supply.

Further, the school board will request the county require the subdivider to design the subdivision to reasonably minimize potentially significant adverse impacts or prohibit non-residential subdivisions in the special protection region unless the hazards can be eliminated or overcome by approved construction techniques.

The school board also will request that the Montana office – U.S. EPA Region 8 conduct a preliminary Class V UIC permit needs assessment for all non-residential waste disposal facilities proposed or constructed within the special protection region.

Protection Region Management

Land use in the protection region will be reviewed every five years to determine if any changes have occurred, and if so, what new potential contamination problems exist that might affect the recharge area for the aquifer. The Ash Grove Plant will receive a summary of the source-water protection plan, so that the company is aware that its quarry is in the protection area.

Management Implementation

Once the Montana City School Board has reviewed and approved the source-water protection plan, copies and summaries will be distributed to the parties identified in the previous sections, to MDEQ, and to interested members of the public. The plan will be fully implemented once it has been certified by the MDEQ.

By adopting the plan, the school board agrees to undertake the specified tasks and responsibilities contained herein. Appendix L summarizes these tasks and responsibilities.

CHAPTER 5
EMERGENCY PLANNING

The emergency plan identifies the principal threats to the source water, designates an emergency coordinator, and then describes a series of potential responses planned in the event that a problem arises. Another important aspect of the plan is an estimate of the equipment and materials that would be needed in the event of an emergency, a description of how a short-term replacement water supply would be handled, and a description of the funding available to deal with an emergency response.

Identification of Possible Disruption Threats

The principal threat to the public water supply has been identified as a spill, leak, or discharge in the control zone that could contaminate the source water by entering through the well bore or perhaps along with contaminated shallow ground water through a failed casing. Included are spills from vehicles, spills from mobile liquid holding tanks, leaks from above or underground tanks, leaks from waste carrying pipes, spills from herbicide containers, and spills of household chemical products such as paint thinner and paints.

Designation of an Emergency Coordinator

The emergency coordinator for the Montana City School well is the school superintendent, currently Penny Koke. The superintendent's telephone number is 406/442-6779. The backup emergency coordinator is Diane Smith (406/442-6779).

The emergency coordinator is familiar with the county and state disaster and emergency services (DES) procedures and is responsible for contacting the appropriate officials should a spill or other threat to the source water occur. The Jefferson County DES coordinator is Pat McKelvey, and his phone number is 406/444-2729. The State of Montana 24-hour Spill Hotline phone number is 406/444-6911.

Equipment and Material Resources

Acute threats to the school wells are generally limited to spills in the control and special protection zones. Resources that may be needed to respond to a spill are heavy equipment for berm and excavation work and absorbent materials. It may be possible to obtain heavy equipment from a local contractor or from the Montana Department of Transportation, which has a maintenance shop in Helena. Should additional resources be needed due to the magnitude or chemical nature of a spill the Montana City School will contract with an emergency response firm properly trained and equipped. A list of possible contractors is maintained and updated by the MDEQ Enforcement Division (telephone: 406/444-0379).

A catastrophic loss of water will require the contracted services of a water hauler, a design engineer, and a well driller.

Procedures to Shut Down the Wells

The wells can be turned off and isolated from the water supply system. The shutoff valve and power switch for the northeast well (M:58654) is located in the basement beneath the old rock-walled school building; the shutoff valve for the south well (M:58500) is located in the janitor room in the basement of the south wing (see appendix B). The power switch for this well is located in an electrical box near the

wellhead. A valve to separate flow of water in the north and south wings of the school is located above the ceiling in the corridor between the two wings. Well shut down is the responsibility of the operator or backup.

Coordination Procedures

The Montana City School Source-Water Protection Plan has been made available to the Jefferson County disaster and emergency services coordinator (Pat McKelvey, 406/444-2729). Additionally, reportable spills will be handled as per the mandated reporting requirements as follows:

Agricultural chemical or fertilizer spills will be reported to the MT Department of Agriculture at 406/444-5400.

Any refined petroleum product such as gasoline, diesel, asphalt, road oil, kerosene, fuel oil, and derivatives of mineral, animal, or vegetable oil spills in excess of 25 gallons will be reported to the DES hotline at 406/444-6911.

Procedures to Communicate with Water Users

The nature of the public water supply should allow a well to be isolated from the distribution system in the event of a spill in the control zone that threatens source water quality. If it is determined that the source water was exposed to a contaminant, the well will remain off line until sampling proves the water to be safe, an evaluation done in cooperation with the MDEQ, Public Water Supply Section.

In the event of a water-quality emergency, the Montana City School Board and teachers will contact students' parents to notify them of the situation and of the measures that have been taken to mitigate the problem.

Source of Emergency Water

If one of the school's wells is out of service, the other well may be used to meet water needs. Conservation measures may need to be implemented in order for a single well to meet the school's demand. If both wells are affected, an emergency supply of water may need to be arranged. The short-term plan is to obtain bottled drinking water from a local supplier such as Big Spring Water Co., Culligan, or Summit Valley Bottled Water and Conditioning.

Because the wells also are used to operate the restroom facilities, a decision would need to be made as to whether continued use of the wells for this purpose would be acceptable. If not acceptable, then the Montana City Public School would contract with a portable chemical toilet contractor to provide temporary facilities.

Should a total loss of water occur, the services of a design engineer and well driller will be retained to assess the options. Plans and specifications for any new well will require MDEQ-Public Water Supply Section review and approval prior to construction.

Disinfection and Resumption of Water Service

The well(s) and pressure tanks can be disinfected for bacteriological contamination as per the Montana City Public School's standard disinfection and tank cleaning procedures under the direction of the operator.

Normal water service resumption will occur after sample results indicate the supply is safe as approved by MDEQ-Public Water Supply Section and the operator.

Funds

The school holds 10% of its general funds as a reserve for emergencies. Should a water-related emergency arise, the school will draw upon this reserve.

Important emergency contacts and phone

CONTACT NAME	TITLE	PHONE	RESPONSIBILITY
Mike Rasmussen	Water System Contractor	406/933-8986	Certified Operator
Gary Newport	Head of Maintenance, Montana City School	406/442-6779	Backup operator
Pat McKelvey	Jefferson County DES coordinator	406/444-2729	Hazardous materials emergency response
Montana 24-hr. Spill Hotline		406/444-6911	All reportable spills
Greg Murfitt	MT Dept of Agriculture	406/444-5400	All agricultural chemical or fertilizer spills or response questions
MDEQ Enforcement Division		406/444-0379	Responds to any event that will pollute surface or ground water

CHAPTER 6
ALTERNATE WATER SOURCES

The Montana City Public School wells currently are used by 337 students and 50 teachers and staff during the school year from September through June. The school may grow by 5% annually over the next 10 years, but the existing wells should be able to handle this additional demand.

If a new well becomes necessary, it probably should be sited on the south end of the school property, away from the parking area and septic drain field. The source-water protection area for this alternative location would consist of a 100-ft radius control region around the well and special protection and protection regions as defined for the existing wells.

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Appendix A
Descriptions of Geologic Formations

Description of Lithologic Units

Sedimentary Rocks

Qal — **Alluvium (Quaternary)**

Qg — **Gravel (Quaternary)**

Dj — **Jefferson Formation (Devonian)**
Alternating dolomites and light-colored limestone; dolomites are black-weathering, highly fetid, and smelling of petroleum; 750 ft thick

Crl — **Red Lion Formation (Upper Cambrian)**
Upper part, 25 ft or more thick, commonly contains crinkly cherty laminae. Interbedded limestone and dolomite, 100 ft thick. Argillites, generally metamorphosed to hornfels, 4 to 5 ft thick. May include the Maywood Formation of Late(?) Devonian age

Ch — **Hasmark Dolomite (Upper Cambrian)**
Upper part, light-colored dolomite. Lower part thick-bedded dark dolomite mottled in bizarre patterns. Density 2.81 to 2.86. Commonly is metamorphosed to white marble

Cp — **Park Argillite (Middle Cambrian)**
Dark compact rock. Density 2.72 to 2.80. Locally fossiliferous. Thickness, 200 ft.

Cm — **Meagher Limestone (Middle Cambrian)**
Upper part, massive pure limestone, 280 ft thick. Lower part, thin-bedded impure limestone, 360 ft thick

Cw — **Wolsey Formation (Middle Cambrian)**
Micaceous siltstone, largely detrital quartz, muscovite, and biotite, and possibly glauconite; phyllitic appearance on bedding surfaces; 200 ft thick

Cf — **Flathead Quartzite (Middle Cambrian)**
White, vitreous; almost 100% quartz; 90 to 170 ft thick

Igneous Rocks

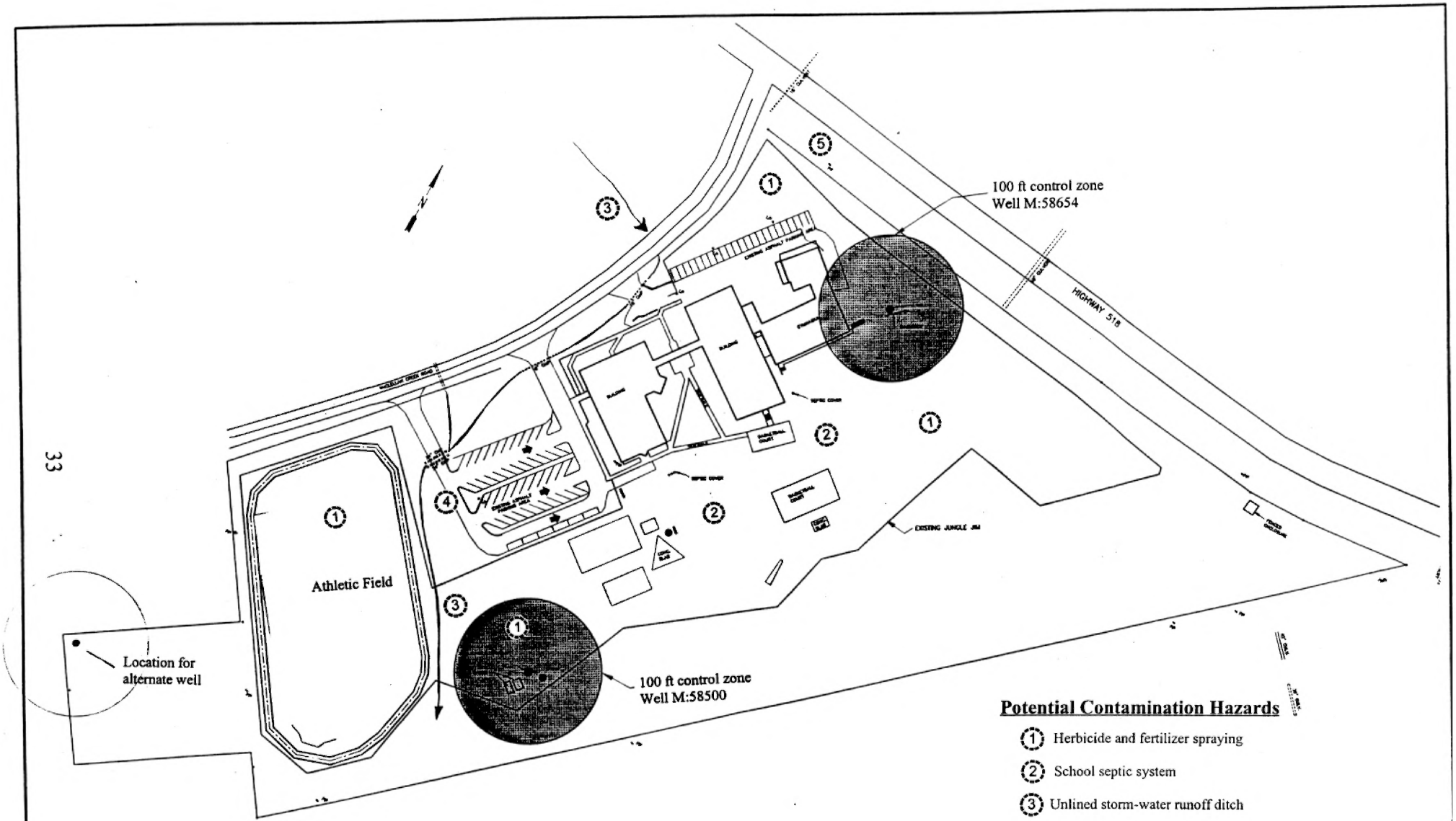
Tr — **Rhyolite (Tertiary)**

Kbg — **Muscovite-biotite granite (Cretaceous)**

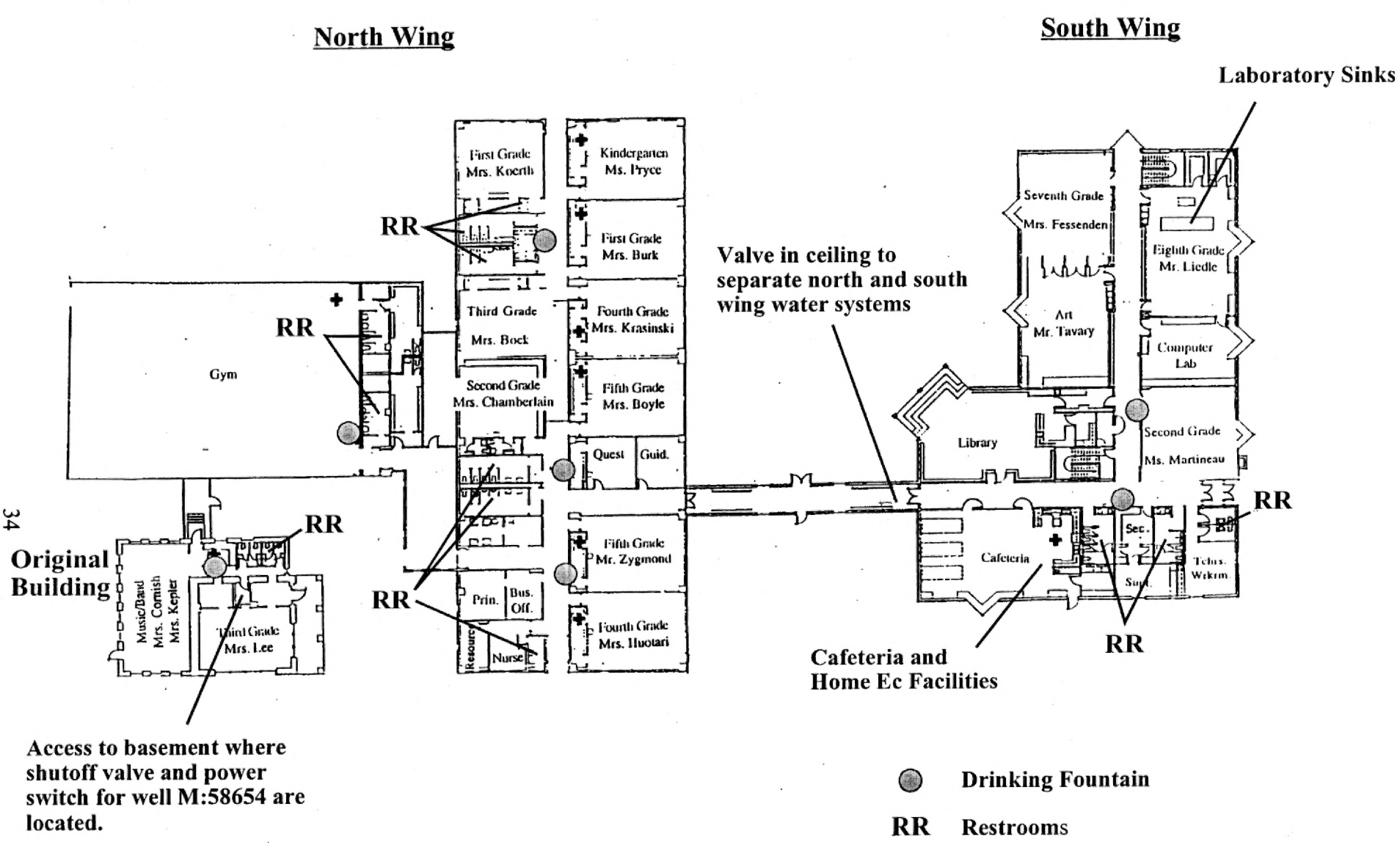
Kgd — **Granodiorite (Cretaceous)**

Kgp — **Granodiorite porphyry and related porphyries (Cretaceous)**

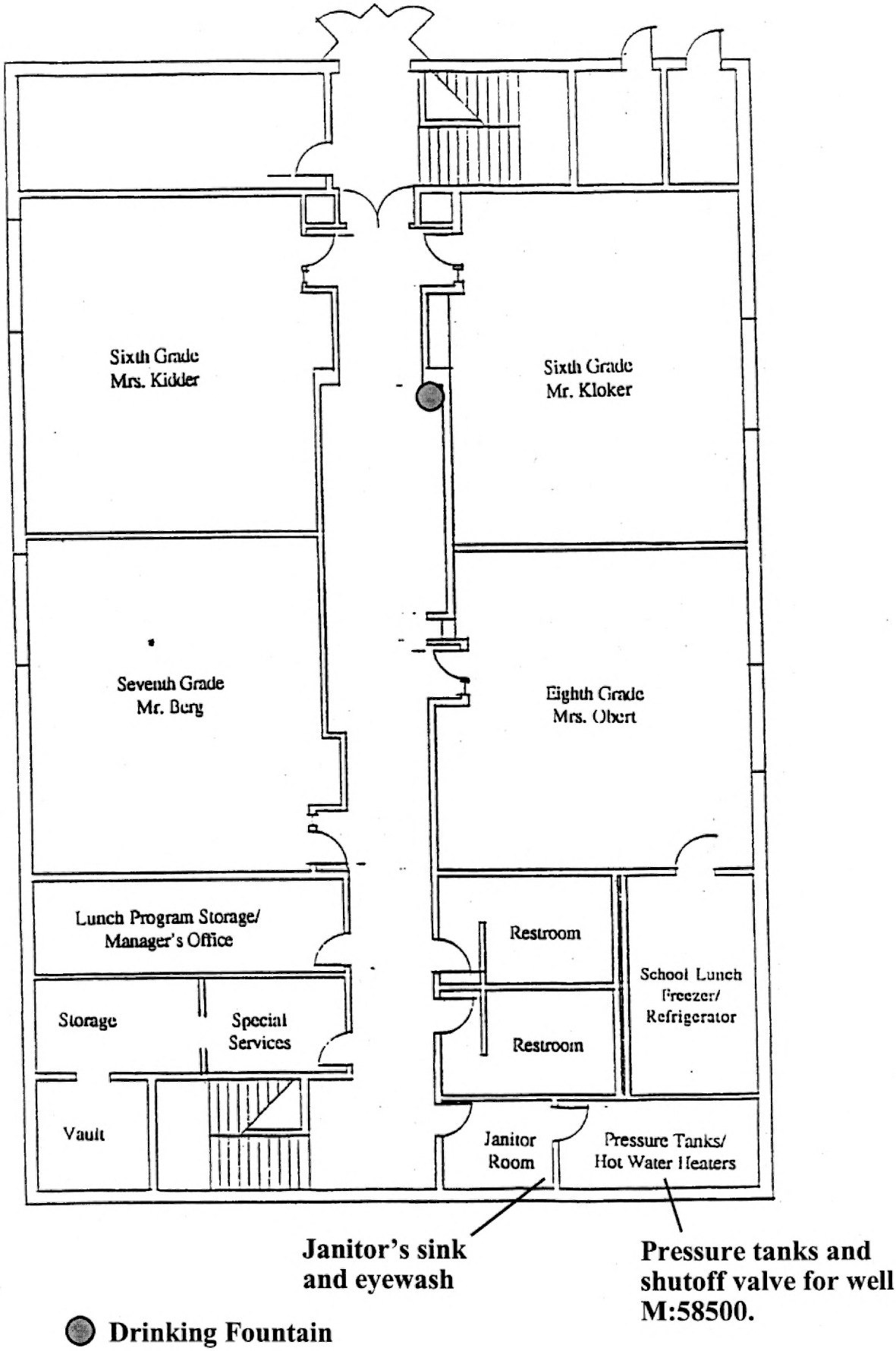
Appendix B
Public Water Supply Site Plans



Site plan for Montana City School grounds. Modified from map prepared by Morrison Maierle, Inc., September 1997. Map also shows delineation of control zones, location of potential contamination hazards, and alternate well location.



Floor plan for main floor of Montana City School. In addition to the water facilities shown, each classroom has a sink with a drinking fountain, and gymnasium restrooms have showers.



Floor plan for the basement of the south wing of the Montana City Public School.

Appendix C
Well Inventory Data

M:Number	Name	Legal Description TR	ST	Surface Elevation (ft)	Stick-up (ft)	Total Depth (ft)	Screened From	To	Date	Depth to Water from TOC (ft)	Ground-water Elevation (ft)
58500	School (2)	09N03W	13BCCA	4065	1.4	150	110	150	11/01/96	23.0	4043
58500	School (2)								04/12/97	22.8	4044
58500	School (2)								01/14/99	22.4	4044
58643	Hutchison	09N03W	11DCDD	4145	1	178	140	178	01/07/99	33.1	4113
58647	Gannon	09N03W	11BCBA	4240	1.5?	79	59	79	09/30/96	45.5	4194
58649	Tomaskie	09N03W	11DDAA	4205	1	288	188	208	01/07/99	114.2	4092
58654	School (1)	09N03W	13BCBD	4070	1.8	210	130	210	01/07/99	49.8	4022
58691	Bessler	09N03W	13BBCC	4100	1.8	325	--	--	04/12/97	48.3	4054
58692	Meyers	09N03W	14ADDD	4070	2.3	177	155	175	01/07/99	26.8	4046
58693	Kmet	09N03W	14DABA	4080	2.1	205	160	205	04/12/97	33.8	4048
58695	Toombs	09N03W	14AACC	4170	1.9	205	160	205	04/12/97	71.1	4101
58696	Watne	09N03W	14AABC	4150	1.5	100	60	100	Oct-97	36.0	4115
58696	Watne								01/07/99	34.2	4117
58697	Ferriter	09N03W	14AABB	4135	-5	90	--	--	Oct-97	35.4	4095
58703	Adams	09N03W	14ABAA	4150	0.9	97	7	79	Oct-97	36.0	4114
58703	Adams								01/07/99	34.4	4116
124513	Sharbono	09N03W	23BBDB	4235	1.7	370			01/07/99	33.0	4204
134497	Cogley	09N03W	14DACC	4075	1.5?	145	--	--	04/28/97	24.7	4050
143485	Martin (upper)	09N03W	14ADCA	4145	1.6	400	210	400	11/01/96	80.2	4066
143485	Martin (upper)								04/12/97	72.9	4074
143487	Martin (lower)	09N03W	13BCBC	4085	1.6	360	220	360	11/01/96	60.8	4026
143487	Martin (lower)								04/12/97	62.9	4024
143487	Martin (lower)								01/07/99	58.4	4028
147260	Munson	09N03W	14BDAC	4185	1.1	234	214	234	04/12/97	77.0	4109
153917	Coman	09N03W	11CACB	4220	1.5	160	100	160	01/07/99	49.3	4172
158872	Rasmussen	09N03W	23ABCD	4080	1	100			01/07/99	19.4	4062
165637	Staly	09N03W	14CABA	4200	1.5	199	159	199	01/07/99	63.7	4138
168185	Herrera	09N03W	11DCAB	4160	3	377	357	377	01/07/99	65.2	4098
169099	Cahill	09N03W	14DABD	4070	1.7	--	--	--	11/01/96	27.0	4045
169099	Cahill								04/12/97	25.4	4046
169100	Cashell	09N03W	14DABC	4100	2.1	--	--	--	11/01/96	47.0	4055
169100	Cashell								04/12/97	46.3	4056
169101	Ohler	09N03W	13BCAA	4060	1.4	--	--	--	04/12/97	21.3	4040
169102	Dickson (North)	09N03W	14BCDA01	4220	2.5	--	--	--	01/07/99	97.4	4125
169103	Dickson (South)	09N03W	14BCDA02	4222	1.7	--	--	--	01/07/99	98.5	4125
169104	Thares	09N03W	14ACAD	4145	2.5	280?	--	--	01/07/99	18.1	4129
169105	H & L (South)	09N03W	14BADB	4180	15	--	--	--	01/07/99	84.6	4110
169106	H & L (North)	09N03W	14BAAD	4195	1.5	150	--	--	01/07/99	85.1	4111
169107	Talbert	09N03W	11DDBD	4180	1	--	--	--	01/07/99	103.0	4078

Appendix D
Water-Level Data for Wells
M:58647 and M:134497

M:Number	Township	Range	Section	Tract	Date	Static Water Level (ft)
58647	09N	03W	11	BCBA	10/22/93	56.14
					12/20/93	45.59
					01/19/94	45.68
					02/23/94	45.79
					03/22/94	45.95
					04/21/94	45.62
					05/25/94	45.47
					06/20/94	48.24
					07/20/94	46.20
					08/30/94	48.29
					09/19/94	47.17
					10/26/94	44.64
					11/21/94	47.15
					12/20/94	47.11
					01/24/95	47.17
					02/22/95	47.48
					03/20/95	47.20
					04/26/95	47.41
					05/22/95	47.15
					06/28/95	47.80
					07/25/95	48.49
					08/21/95	47.62
					09/19/95	47.99
					10/24/95	48.19
					11/27/95	48.53
					01/23/96	48.28
					02/21/96	47.88
					03/20/96	46.93
					04/22/96	43.33
					05/21/96	44.03
					06/24/96	44.16
					07/23/96	45.25
					08/19/96	45.35
					09/30/96	45.52
134497	09N	03W	14	DACC	10/20/93	22.98
					12/20/93	20.33
					01/19/94	20.41
					02/23/94	20.51
					03/02/94	22.11
					03/22/94	20.46
					04/21/94	19.98
					05/25/94	19.62
					06/20/94	20.11
					07/20/94	20.80
					07/22/94	22.54

M:Number	Township	Range	Section	Tract	Date	Static Water Level (ft)
134497	09N	03W	14	DACC	08/30/94	21.27
					10/26/94	20.99
					01/24/95	20.89
					04/26/95	20.39
					05/22/95	19.69
					06/27/95	19.79
					07/25/95	20.81
					08/21/95	21.02
					09/19/95	21.00
					10/24/95	20.98
					11/27/95	21.34
					01/23/96	21.77
					02/02/96	22.98
					02/21/96	22.98
					03/20/96	20.38
					04/22/96	20.05
					05/21/96	19.92
					06/24/96	20.75
					07/23/96	21.02
					08/19/96	22.28
					09/30/96	21.29
					10/21/96	22.92
					01/28/97	23.93
					04/28/97	24.72
					10/30/97	28.87
					01/29/98	24.23

Appendix E
Well Construction and Lithologic Logs for Wells in the Montana City Area

M:Number	Site Name	T	R	S	T	TD	SWL	Screen From	Screen To	Screen Dia	Screen Description	Completion Date	Log?
58646	SENN DAVID & SHERRIL	09N	03W	11	BA	260	125	220	260	4	1/8" SAW	11/07/89	Y
150587	BADGER RALPH & SAUNDRA	09N	03W	11	BBD	60	17	40	60	4	2X.02 SLOT	02/17/95	Y
58647	GANNON TOM	09N	03W	11	BCBA	79	49	59	79	4	1/8 SLOTS	09/07/88	Y
58648	STEINMETZ JERRY	09N	03W	11	C	125	76	5	125	4	PVC LINER	08/28/77	Y
153917	COMAN STAN	09N	03W	11	C	160	50	100	160	4	1/8X4 SAW	07/20/95	Y
154619	STEINMETZ JERRY	09N	03W	11	C	191						08/27/77	Y
158413	FUNDAK CAROL	09N	03W	11	C	200	112	160	200	4	1/8X4 SAW	06/08/96	Y
153919	HUEBNER DIXIE	09N	03W	11	CC	80	50					05/04/95	Y
140632	HENDERSON CINDY	09N	03W	11	CDC	193	93	173	193	4	1/8X4 SAW PERFS	12/06/93	Y
58649	TOMASKIE BUZZ	09N	03W	11	DAA	288	111	188	208	4	1/8" SLOTS	10/26/84	Y
58649	TOMASKIE BUZZ	09N	03W	11	DAA	288	111	248	288	4	1/8" SLOTS	10/26/84	Y
135473	STONER SCOTT	09N	03W	11	DAB	243	120	180	240	4	1/8X4 SAW	09/24/92	Y
58650	POCHA JOSEPH	09N	03W	11	DBC	140	20					01/01/15	
143482	FIUDAK ANDREW	09N	03W	11	DC	241	111	181	201	4	2X.025 FACT PFS	05/24/94	Y
143482	FIUDAK ANDREW	09N	03W	11	DC	241	111	221	241	4	2X.025 FACT PFS	05/24/94	Y
168185	HERRERA DANIEL & KATIE	09N	03W	11	DC	377	63	357	377	4	1X.020 FACTORY SLOT	04/22/98	Y
122369	SCHECK RUSSELL L	09N	03W	11	DD	110	60	80	110	4	SAW PERFS	02/09/91	Y
130872	SCHECK RUSSELL L	09N	03W	11	DD	249	80	110	130	6	PERFS	06/08/86	Y
130872	SCHECK RUSSELL L	09N	03W	11	DD	249	80	229	249	4	PERFS	06/08/86	Y
58643	HUTCHINSON TOM	09N	03W	11		178	35	140	178	4	1/4" SLOTS	05/04/77	Y
58644	FORD F J	09N	03W	11		273	164	213	273	5	1/8" SLOTS	10/16/86	Y
58645	FORD MIKE	09N	03W	11		500						09/26/86	Y
58652	AT&T	09N	03W	12	1	504	400					06/11/65	
58651	AT&T	09N	03W	12	ABD	505		396	505	6		12/22/65	Y
58653	ASH GROVE CEMENT CO	09N	03W	12	BCA	310	80	10	310	4	PVC PERFS	08/18/78	Y
58663	STELLAR DAVID	09N	03W	13	A	205	67	5	205	4	PVC	03/16/78	Y
58664	PERMANENTE CEMENT	09N	03W	13	AB	120	33	114	120	13		04/25/62	
58665	PERMANEMTE CEMENT COMPANY	09N	03W	13	ABB	100	65					12/20/61	Y
58666	SCHOOL DISTRICT #27	09N	03W	13	ACB	131	20					09/08/61	Y
58667	PERMANENTE CEMENT	09N	03W	13	BAA	99	10	30	95	6		12/19/61	Y
143485	RASMUSSEN DAVID L	09N	03W	13	BB	400		210	400	5	1/4X6 SLOT	03/30/94	Y

M:Number	Site Name	T	R	S	T	TD	SWL	Screen From	Screen To	Screen Dia	Screen Description	Completion Date	Log?
143487	RASMUSSEN DAVID L	09N	03W	13	BB	360	55	220	360	5	1/4X6 SLOT PERF	04/19/94	Y
58668	HARNE ROGER	09N	03W	13	BC	150	46					11/05/65	Y
58500	MONTANA CITY SCHOOL * WELL #2	09N	03W	13	BCBC	150	28	110	120	6	1/4X1.5	09/26/88	Y
58500	MONTANA CITY SCHOOL * WELL #2	09N	03W	13	BCBC	150	28	125	150	6	1/4X1.5	09/26/88	Y
58669	SCHOOL DISTRICT #27	09N	03W	13	BCBD	131	58					01/01/61	
123825	WELSH FRANK	09N	03W	13	BDC	461	63	401	421	4	8X3/16 SAW CUT	08/27/91	Y
123825	WELSH FRANK	09N	03W	13	BDC	461	63	441	461	4	8X3/16 SAW CUT	08/27/91	Y
147261	HOOD KENNETH L	09N	03W	13	CAC	225	90	170	225	4		08/09/94	Y
153920	HOOD KENNETH L	09N	03W	13	CAD	580	80					01/17/95	Y
58670	MARONICK CONSTRUCTION COMPANY	09N	03W	13	CB	70	5	40	66	10	5/16X3/2	02/11/72	Y
58672	HILL SKIP	09N	03W	13	CB	84	20	64	84	4	1/4X4 SLOTS	03/10/77	Y
58673	MARONICK CONSTRUCTION COMPANY	09N	03W	13	CB	78	5	42	75	6	5/16X3/2	08/15/71	Y
123117	TOMISH LEONARD J. & KNUDSEN DEBARAH	09N	03W	13	CB	30	4	20	30	4	SAW CUT	06/27/91	Y
156275	DEWOLF JOSEPH & NIKKI	09N	03W	13	CB	170	85	150	170	4	1X.02 FACTORY	05/14/96	Y
143483	BROWN TONY	09N	03W	13	CBC	106	17	86	106	4	2X.020 FACT.	03/25/94	Y
123826	BALCERZAK BEN	09N	03W	13	CBD	202	27	162	202	4	8X3/16 SAW CUT	07/30/91	Y
58674	JEFFERSON COUNTY	09N	03W	13	CC	200	60	140	200			05/17/90	Y
137152	SHARBONO LOREN & SHERYL	09N	03W	13	CCC	175	41	135	175	4	2X.020 FACTORY	05/03/93	Y
164498	BLOW MARK & TERESA	09N	03W	13	CD	358	56	338	358	4	1 X .02 SLOT	03/20/97	Y
168082	BEAVIS ALAN AND LINDA	09N	03W	13	CD	250	80	2	18	6	STEEL	04/10/98	Y
168082	BEAVIS ALAN AND LINDA	09N	03W	13	CD	250	80	10	10	4	PLASTIC	04/10/98	Y
147262	COMON STAN	09N	03W	13	CDB	190	120	180	190	5	.008 SCREENS	09/30/94	Y
58675	SANDILAND & SCHULTZ	09N	03W	13	D	140	40					11/01/78	Y
58676	DONALDSON JIM & TERRI	09N	03W	13	DAC	400	40	150	400	4	1/4X4	11/17/87	Y
58671	MARONICK CONSTRUCTION COMPANY	09N	03W	13	DAD	250						10/01/71	
156276	ROBINSON GERALD A	09N	03W	13	DB	168	71	148	168	4	1X.02 FACTORY	05/13/96	Y
150222	CLOUD JERRY	09N	03W	13	DC	470	115					04/12/95	Y
58677	SCHAFF DUANE A.	09N	03W	13	DD	38	5	24	38	4	TORCH	08/06/70	Y
58654	MONTANA CITY SCHOOL	09N	03W	13		210	40	130	210	4	1/4X4 SLOTS	06/30/76	Y
58655	TAYLOR CORY	09N	03W	13		240	80	170	240	4	1/4X4	04/17/79	Y
58656	ROSS DOUGLAS	09N	03W	13		300	18					07/28/77	Y
58657	SCHOFF DUANE A.	09N	03W	13		220	30	180	220	4	1/4X4	04/11/85	Y
58658	PICOTTE GENE	09N	03W	13		268	3	200	268	4	1/4X4	12/21/79	Y
58659	DEADMOND WENDELL	09N	03W	13		92	16					08/05/85	Y
58660	LAMPING RON	09N	03W	13		140	40	100	140	4	1/4X4	02/07/84	Y

M:Number	Site Name	T	R	S	T	TD	SWL	Screen From	Screen To	Screen Dia	Screen Description	Completion Date	Log?
58661	STOCKER DON	09N	03W	13		180	30	160	180	5	1/4X4	08/20/82	Y
58691	BESSLER PAUL	09N	03W	14	A	325	45					09/03/79	Y
58692	DEADMAN WENDALL	09N	03W	14	A	177	41	155	175	4	2X5/16	09/12/80	Y
58693	KMET KAREN	09N	03W	14	A	205	35	160	205	4	4X1/4	08/19/82	Y
58694	KAWALTNEY BOB	09N	03W	14	AA	120	40	100	120	4	1/4X4 SLOTS	05/16/74	Y
58695	TAUMBS FW & KA	09N	03W	14	AA	205	80	160	205	6	KNIFE	01/01/70	Y
58696	WATNE TIM	09N	03W	14	AA	100	55	60	100	4		03/09/87	Y
120724	PRICE PRESTON AND BECKY	09N	03W	14	AA	201	114	160	201	4	SAW PERFS	09/20/90	Y
163529	BOMPART PAMELA	09N	03W	14	AA	458	23	398	418	4	1 X .02 SLOT	06/03/97	Y
163529	BOMPART PAMELA	09N	03W	14	AA	458	23	438	458	4	1 X .02 SLOT	06/03/97	Y
163530	BOMPART PAMELA	09N	03W	14	AA	207	40.5	147	207	6	1 X .02 SLOT	05/20/97	Y
120007	BARRY HAROLD	09N	03W	14	AAA	280	73	260	280	4	3/8 X 6 SLOTS	08/26/90	Y
58697	GWALTNEY ROBERT D.	09N	03W	14	AAB	90	60					04/19/63	Y
58699	GWALTNEY ROBERT D.	09N	03W	14	AAD	85	70					01/01/33	
154582	O'REILLY MAUREEN	09N	03W	14	AAD	214	67	195	210	6	1/4X1.5	05/22/90	Y
58698	GWALTNEY ROBERT D.	09N	03W	14	AADB	40	20					04/01/22	
58700	CALNAN JOSEPH	09N	03W	14	AB	310	80					08/15/78	Y
58701	REINART WALTER	09N	03W	14	AC	155	40	115	155	4	1/4X3 SLOTS	10/15/73	Y
166921	THOMPSON DWAYNE	09N	03W	14	AC	320	120	300	315	6	MILL KNIFE	02/10/98	Y
58702	HAMLIN JERRY	09N	03W	14	AD	125	16	80	125	4	2X5/8	06/18/80	Y
58703	DOUGLAS JEFF	09N	03W	14	AD	97	35	7	79	4	PVC	03/29/79	Y
58704	DOUGLAS JEFF	09N	03W	14	AD	97	35	7	97			01/01/79	
152685	ASSUED CURT & DEBORAH	09N	03W	14	AD	198	22	178	198	4	.02X2 FACTORY	04/27/95	Y
58705	BARBER JOLINE	09N	03W	14	ADA	120	75					12/12/81	Y
156978	RASMUSSEN DAVID L. & JULIE O.	09N	03W	14	ADC	116	62	92	110	6	1X3/16 MILL KNF	04/12/95	Y
58706	ZEDNICK JOE	09N	03W	14	B	175	78	15	175	4	PVC	07/13/78	Y
58707	LANNING IKE	09N	03W	14	B	250	110	170	250	4	2X5/16	10/15/80	Y
58708	ZEDNICK JOE	09N	03W	14	B	175	78	15	175			01/01/78	
58709	THOMPSON WARD	09N	03W	14	B	200	70	140	200	4	1/4X4	01/17/85	Y
58710	STOCKER DAN	09N	03W	14	BA	165	60	125	165	4	5/16X2	07/26/79	Y
147260	MUNSON CHRIS	09N	03W	14	BCA	234	78	214	234	4	.025X2 FACTORY	02/11/94	Y
122508	RASMUSSEN DAVE	09N	03W	14	BCB	292	61	267	282	7	JOHNSON SLOT SN	03/29/91	Y
126686	WALTEE MARK	09N	03W	14	BCC	160	94	140	160	4	SAW CUT	02/06/92	Y

M:Number	Site Name	T	R	S	T	TD	SWL	Screen From	Screen To	Screen Dia	Screen Description	Completion Date	Log?
152686	BOULDER VALLEY FIRST BANK	09N	03W	14	BD	230	70	180	230	4		06/29/95	Y
156277	CALNAN JOE #1	09N	03W	14	BD	240	100	140	240	4		11/30/95	Y
156278	CALNAN JOE #2	09N	03W	14	BD	280	96	240	280	4		12/13/95	Y
128254	THORSEN DAVE & JANE	09N	03W	14	BDC	130	100	110	130	4	1X0.2 FACT PERF	05/18/92	Y
58712	MERRITT JAY	09N	03W	14	C	148	70	85	145	4	1/4X4	04/21/86	Y
165637	MONTANA CITY RANCHES LLC	09N	03W	14	CA	199	63.73	159	199	4	1X.02 FACTORY	11/25/97	Y
165638	MONTANA CITY RANCHES LLC	09N	03W	14	CB	133	80.5	113	133	4	1X.02 FACTORY	11/26/97	Y
165639	MONTANA CITY RNCHES LLC	09N	03W	14	CB	364	38.5	344	364	4	1X.02 FACTORY	12/05/97	Y
58711	PICOTTE PAMELA	09N	03W	14	CBA	400	150	200	400	2		12/22/78	Y
165640	MONTANA CITY RANCHES LLC	09N	03W	14	CC	402	101	382	402	4	1X.02 FACTORY	12/15/97	Y
165641	MONTANA CITY RANCHES LLC	09N	03W	14	CC	111	45.35	71	111	4	1X.02 FACTORY	12/08/97	Y
168330	MCDONALD JACKIE	09N	03W	14	CDA	150	60	110	150	4	1/4X6 SLOTS	07/02/98	Y
106925	SADDLE MTN HOMEOWNERS	09N	03W	14	DA	350	7.5	92	112	8	S.STEEL SCREEN	06/21/91	Y
106925	SADDLE MTN HOMEOWNERS	09N	03W	14	DA	350	7.5	133	153	8	S.STEEL SCREEN	06/21/91	
106925	SADDLE MTN HOMEOWNERS	09N	03W	14	DA	350	7.5	280	290	8	S.STEEL SCREEN	06/21/91	
134497	COGLEY DAVID	09N	03W	14	DACC	145	25					04/09/93	Y
163205	REYNOLDS JOHN A AND CLAIR	09N	03W	14	DB	260	40	100	260		UNKNOWN	08/02/97	Y
143489	BAUM CALVIN	09N	03W	14	DBC	302	25					10/20/94	Y
150224	COGLEY DAVID	09N	03W	14	DC	120	30					12/21/94	Y
58713	GUFFEY ROBERT	09N	03W	14	DD	145	27	5	145	8	PVC	08/28/78	Y
58678	MILLER	09N	03W	14		138	80	118	138	4	1/4X4 SLOTS	05/17/76	Y
58679	DEADMOND WENDELL	09N	03W	14		205	40	180	205	4	1/4X4	07/11/80	Y
58680	BARRY HAROLD	09N	03W	14		120	60					06/15/72	Y
58681	WILDFISH JOHN W.	09N	03W	14		15	5					04/01/58	
58682	RASMUSSEN DAVE	09N	03W	14		295	65	80	295	5	1/4X4	11/06/81	Y
58683	RASMUSSEN DAVE	09N	03W	14		280	50	240	280	5	1/4X4	11/06/81	Y
58684	DEADMOND WENDALL	09N	03W	14		136	15					10/21/80	Y
58685	HJORT BARRY	09N	03W	14		310	78					07/10/78	Y
58686	RHOADES J. H.	09N	03W	14		186	60	160	180	4	SLOTS	05/20/76	Y
58687	HJART BARRY	09N	03W	14		310	78	10	310			01/01/78	
58688	BUSON ROGER E.	09N	03W	14		280	80	200	280	4	1/4X4	05/21/84	Y
58689	BENSON RANDY	09N	03W	14		160	50	120	160	4	1/4X4	09/20/83	Y
58690	ENGSTROM DAVID E.	09N	03W	14		100	35	80	100	5	1/4X4	01/25/83	Y
154581	VOEKLE GLEN	09N	03W	14		100	31	60	100	4	1/4X4	11/22/82	Y
158414	REDMON TIM	09N	03W	14		240	50	160	240	4	PERFS	07/22/96	Y

M:Number	Townshi	Range	Section	Tract	From	To	Description
58643	09N	03W	11		0	4	TOPSOIL
					4	20	CLAY
					20	178	BEDROCK
58644	09N	03W	11		0	215	SANDY CLAY
					215	273	LIMESTONE
58645	09N	03W	11		0	260	SAND & CLAY
					260	500	LIMESTONE
58646	09N	03W	11	BA	0	2	TOPSOIL
					2	86	LIMESTONE
					86	95	FRACTURED LIMESTONE
					95	222	LIMESTONE
					222	260	FRACTURED LIMESTONE & WATER
150587	09N	03W	11	BBD	0	1	TOPSOIL
					1	3	CLAY
					3	12	GRAVEL CLAY
					12	60	LIMESTONE
58647	09N	03W	11	BCBA	0	79	LIMESTONE
153917	09N	03W	11	C	0	1	TOPSOIL
					1	15	ROCK & DIRT
					15	160	ROCK
154619	09N	03W	11	C	1	4	TOPSOIL & GRAVEL
					4	21	CLAY
					21	120	LIMESTONE BEDROCK
158413	09N	03W	11	C	0	0.5	TOPSOIL
					0.5	200	ROCK
58648	09N	03W	11	C	0	4	TOPSOIL & GRAVEL
					4	21	CLAY
					21	125	LIMESTONE BEDROCK
153919	09N	03W	11	CC	0	3	TOPSOIL
					3	30	SAND/GRAVEL
					30	35	GRAVEL
					35	75	SAND/GRAVEL
					75	80	GRAVEL
140632	09N	03W	11	CDC	0	1	TOPSOIL
					1	16	CLAY- SHALE AND DIRT
					16	193	ROCK
58649	09N	03W	11	DAA	0	1	TOPSOIL
					1	10	COARSE SAND
					10	17	SAND & GRAVEL
					17	288	CLAY & COARSE SAND
135473	09N	03W	11	DAB	0	1	TOPSOIL
					1	17	CLAY AND ROCK
					17	243	ROCK
143482	09N	03W	11	DC	0	1	TOPSOIL
					1	175	LIMESTONE W/CLAY SEAMS
					175	241	LIMESTONE
168185	09N	03W	11	DC	0	1	TOPSOIL
					1	275	HARD CLAY
					275	377	ANDESITE
122369	09N	03W	11	DD	0	80	CLAY
					80	90	ROCK
					90	105	WATER SAND
					105	110	ROCK

M:Number	Townshi	Range	Section	Tract	From	To	Description	
130872	09N	03W	11	DD	0	110	BENTONITE	
					110	135	BENTONITE	
					135	249	LIME	
58651	09N	03W	12	ABD	0	400	ENCOUNTERED DOLMITE & LIMESTONE FROM SURFACE TO	
					400	500	PRODUCED WATER FROM FRACTURED DOLOMITE	
					400	400		400
58653	09N	03W	12	BCA	0	4	TOPSOIL	
					4	30	CLAY	
					30	60	CLAY AND GRAVEL	
					60	310	ARGELITH AND LIMESTONE BEDROCK	
58654	09N	03W	13		0	4	TOPSOIL	
					4	20	CLAY	
					20	240	LIMESTONE BEDROCK	
58655	09N	03W	13		0	3	BOULDERS	
					3	18	BROKEN ROCK	
					18	240	GRANITE BEDROCK	
58656	09N	03W	13		0	4	TOPSOIL & BOULDERS	
					4	11	ROTTEN LIMESTONE-BEDROCK	
					12	300	LIMESTONE-BEDROCK	
58657	09N	03W	13		0	2	TOPSOIL	
					2	18	CLAY & BROKEN ROCK	
					18	220	GRANITE BEDROCK	
58658	09N	03W	13		0	2	TOPSOIL	
					2	16	DECOMPOSED GRANITE	
					16	268	GRANITE BEDROCK	
58659	09N	03W	13		0	3	CLAY & TOPSOIL	
					3	16	CLAY & GRAVEL	
					16	92	SUGAR LIME BEDROCK	
58660	09N	03W	13		0	4	TOPSOIL	
					4	20	CLAY & BROKEN ROCK	
					20	140	LIMESTONE BEDROCK	
58661	09N	03W	13		0	3	TOPSOIL	
					3	18	GRAVEL & SAND	
					18	180	WHITE LIMESTONE SAND & BEDROCK	
58663	09N	03W	13	A	0	3	BOULDERS & TOPSOIL	
					3	21	DECOMPOSED GRANITE	
					22	205	GRANITE -BEDROCK	
58665	09N	03W	13	ABB	0	25	LOOSE GRAVEL & BOULDERS NOT TESTED	
					25	34	BEDROCK BROWN CLAY & HARD LIME ROCK (NO WATER)	
					34	35	BLUE CLAY (NO WATER)	
					35	44	BROWN CLAY & BROKEN LIME ROCK	
					44	65	BROWN CLAY (NO WATER)	
					65	80	BROWN LIMESTONE SEMI DECOMPOSED	
					80	94	BROKEN UP LIME ROCK	
					94	100	HARD LIMESTONE	
58666	09N	03W	13	ACB	0	5	SOIL SOME SHARP GRAVEL	
					15	16	GRAY CLAY SOME SHARP GRAVEL	
					16	21	LIMESTONE CLAY	
					21	40	CLAY SOME SHARP GRAVEL	
					40	65	TIGHT STRATA LIMESTONE	
					65	78	SOFT LIMESTONE SOME CLAY	
					78	81	BROWN CLAY	
					81	108	TIGHT LIMESTONE SOME CLAY	
					108	120	ALTERNATE SHALLOW STRATUS OF SOFT & TIGHT BLOCKY LIMESTONE CLAY FILLED VOIDS	
					120	130	VERY TIGHT CLEAN BLUE LIMESTONE	
					130	131	SOFT SOAPSTONE LIKE MATERIAL	

M:Number	Townshi	Range	Section	Tract	From	To	Description
58667	09N	03W	13	BAA	0	25	GRAVEL & BOULDERS & SOME SAND
					25	34	BEDROCK BROWN CLAY & QUARTZ ROCK
					34	35	BLUE CLAY
					35	44	RED SHALE & QUARTZ (HARD)
					44	65	BROWN CLAY
					65	80	BROWN LIMESTONE
					80	94	BROKEN UP LIMESTONE
					94	100	VERY HARD LIMESTONE
143485	09N	03W	13	BB	0	2	TOPSOIL
					2	30	CLAY/BOULDERS ROCK
					30	200	LIMESTONE
					200	400	SHALE/GRANITE
143487	09N	03W	13	BB	0	2	TOPSOIL
					2	30	CLAY/BOULDER ROCK
					30	360	HARD LIMESTONE
58668	09N	03W	13	BC	0	73	BENTONITE WITH A GRANITE SAND MIX
					73	78	ROCK WITH CREVIS
					78	79	HARD ROCK
					79	82	SOFT ROCK
					82	85	ROCK GRAY LIME
					85	98	BROWN
					98	102	MEDIUM HARD
					102	112	HARD LIME ROCK
					112	117	MEDIUM LIME ROCK
					117	147	MEDIUM GRAY LIME
					147	150	SOFT CLAY
58500	09N	03W	13	BCBC	0	6	CLAY
					6	13	GRAVEL & SAND
					13	17	CLAY
					17	150	LIMESTONE
123825	09N	03W	13	BDC	0	461	ARGILLITE
147261	09N	03W	13	CAC	0	4	TOPSOIL
					4	12	CLAY & BROKEN LIMESTONE
					12	18	DECOMPOSED LIMESTONE
					18	225	LIMESTONE BEDROCK
153920	09N	03W	13	CAD	0	3	TOPSOIL
					3	94	CLAY & GRANITE
					94	150	LIMESTONE
					150	490	CLAY & GRANITE
					490	530	LIMESTONE
					530	558	CLAY
					558	580	LIMESTONE
123117	09N	03W	13	CB	0	20	BROWN SHALE
					20	30	BROWN LIME
					30	30	WATER
156275	09N	03W	13	CB	0	1	TOPSOIL
					1	5	WEATHERED GRANITE
					5	170	GRANITE
58670	09N	03W	13	CB	0	8	TOPSOIL & GRAVEL
					8	19	GRAVEL
					19	28	DECOMPOSED LIME ROCK
					29	39	LIME HARD LIME ROCKS
					39	82	HARD LIME ROCK
58672	09N	03W	13	CB	0	4	TOPSOIL
					4	22	BROKEN GRANITE
					22	84	BLUE GRANITE

M:Number	Townshi	Range	Section	Tract	From	To	Description
58673	09N	03W	13	CB	0	6	TOPSOIL - GRAVEL
					6	18	SAND & GRAVEL
					18	31	GRAVEL & BROKEN LIME
					31	78	DECMPOSED LIME ROCK
143483	09N	03W	13	CBC	0	66	BROKEN SANDSTONE & CLAY
					66	106	SANDSTONE
123826	09N	03W	13	CBD	0	7	SAND COBBLES
					7	202	SANDSTONE
58674	09N	03W	13	CC	0	15	CLAY ROCKS
					15	45	CLAY DECOMPOSED LIME
					45	200	LIMESTONE BEDROCK
137152	09N	03W	13	CCC	0	2	TOPSOIL
					2	8	BROKEN GRANITE & CLAY
					8	175	GRANITE
164498	09N	03W	13	CD	0	4	TOPSOIL
					4	8	WEATHERED GRANITE
					8	358	GRANITE
168082	09N	03W	13	CD	0	1	TOPSOIL
					1	7	WEATHERED GRANITE
					7	250	GRANITE
147262	09N	03W	13	CDB	0	1	TOPSOIL
					1	190	DECOMPOSED GRANITE VERY SANDY
58675	09N	03W	13	D	0	4	TOPSOIL
					4	20	BROKEN ROCK
					20	140	SUGAR LIMESTONE BEDROCK
58676	09N	03W	13	DAC	0	4	TOPSOIL
					4	12	CLAY & BROKEN ROCK
					12	22	DECOMPOSED GRANITE
					22	400	GRANITE BEDROCK
156276	09N	03W	13	DB	0	1	TOPSOIL
					1	5	WEATHERED GRANITE
					5	168	GRANITE
150222	09N	03W	13	DC	0	2	TOPSOIL
					2	8	DECOMPOSED GRANITE
					8	22	BROKEN GRANITE
					22	470	GRANITE BEDROCK
58677	09N	03W	13	DD	0	6.5	TOPSOIL & LOAM
					6.5	19	LOOSE DECOMPOSED GRANITE
					19	34	FIRM DECOMPOSED GRANITE
					34	38	HARD GRAY GRANITE
154581	09N	03W	14		0	3	TOPSOIL
					3	16	SAND & GRAVEL
					15	38	CLAY
					38	100	SOFT LIMESTONE BEDROCK
158414	09N	03W	14		0	4	TOPSOIL
					4	12	CLAY & BROKEN LIMESTONE
					12	40	DECOMPOSED LIMESTONE
					40	240	LIMESTONE
58678	09N	03W	14		0	4	TOPSOIL
					4	60	DECOMPOSED BROKEN LIME
					60	138	LIMESTONE
58679	09N	03W	14		0	3	TOPSOIL
					3	140	CLAY & BROKEN ROCK
					140	205	LIMESTONE

M:Number	Townshi	Range	Section	Tract	From	To	Description
58680	09N	03W	14		0	8	TOPSOIL
					8	70	BROKEN LIMESTONE
					70	120	SOLID BLUE LIMESTONE
58682	09N	03W	14		0	3	TOPSOIL
					3	16	CLAY & GRAVEL
					16	58	CLAY
					58	295	LIMESTONE BEDROCK
58683	09N	03W	14		0	2	TOPSOIL
					2	16	CLAY & GRAVEL
					16	280	LIMESTONE BEDROCK
58684	09N	03W	14		0	3	TOPSOIL
					3	20	CLAY & SAND
					20	136	LIMESTONE SAND BEDROCK
58685	09N	03W	14		1	4	TOPSOIL GRAVEL
					4	58	CLAY & GRAVEL
					58	142	BENTONITE & CLAY
					142	310	LIMESTONE & BEDROCK
58686	09N	03W	14		0	15	TOPSOIL & DECOMPOSED GRANITE
					15	86	SEMI HARD GRANITE
					86	186	HARD GRANITE
58688	09N	03W	14		0	2	TOPSOIL
					2	100	CLAY (BENTONITE)
					100	280	LIMESTONE
58689	09N	03W	14		0	2	TOPSOIL
					2	15	DECOMPOSED LIME
					15	160	LIMESTONE BEDROCK
58690	09N	03W	14		0	2	TOPSOIL
					2	40	CLAY
					40	100	LIMESTONE BEDROCK
58691	09N	03W	14	A	0	10	OVER BURDEN
					10	40	ROCK
					40	45	ROCK FRACTURES
					45	65	ROCK
					65	70	ROCK FRACTURES
					70	140	ROCK
					140	155	SOFT BROWN ROCK
					155	165	ROCK FRACTURES
					165	240	HARD ROCK
					240	300	GRAY ROCK
					300	305	GRAY ROCK WITH WATER
					305	325	GRAY ROCK
58692	09N	03W	14	A	0	3	TOPSOIL
					4	16	CLAY
					16	21	SAND & GRAVEL
					21	157	SUGAR LIMESTONE BEDROCK
					157	177	LIMESTONE BEDROCK
58693	09N	03W	14	A	0	3	TOPSOIL
					3	18	DECOMPOSED CLAY
					18	100	BLUE LIMESTONE
					100	205	YELLOW LIMESTONE-SAND & BEDROCK
120724	09N	03W	14	AA	0	144	CLAY
					144	160	QUARTES HARD
					160	201	QUARTES VERY HARD

M:Number	Townshi	Range	Section	Tract	From	To	Description
163529	09N	03W	14	AA	0	1	TOP SOIL
					1	23	GRAVEL & CLAY
					23	155	CRS SAND & CLAY
					155	165	WEATHERED LIMESTONE
					165	355	CLAY & GRAVEL
					355	458	LIMESTONE
163530	09N	03W	14	AA	0	1	TOPSOIL
					1	45	SAND & GRAVEL & CLAY
					45	155	CLAY
					155	207	LIMESTONE
58694	09N	03W	14	AA	0	4	TOPSOIL
					4	20	BROKEN LIMESTONE
					20	120	LIMESTONE BEDROCK
58695	09N	03W	14	AA	0	20	SOIL
					20	205	ROCK & SHALE
58696	09N	03W	14	AA	0	70	BENTONITE & SHALE
					70	73	WATER SAND
					73	90	GRAY SHALE
					90	95	WATER SAND
					95	100	SHALE
120007	09N	03W	14	AAA	9	11	SAND
					11	75	GRANITE
					75	280	SANDSTONE
58697	09N	03W	14	AAB	0	3	OVERBURDEN
					3	32	CLAY & SOME ROCK
					32	38	BLOCKY LIMEROCK VERY TIGHT
					38	44	FIRM BLOCY LIMEROCK CONSIDERABLE CLAY
					44	48	DENSE TIGHT SHELVE ROCK
					48	62	FIRM CONG 10 MERATE CLAY
					62	74	VERY TIGHT STRATA GRAY LIME
					74	85	TIGHT BLOCKY LIME INTERMIXED WITH CLAY
					85	90	CLEAN BLOCKY GRAY LIME
154582	09N	03W	14	AAD	0	16	GRAVEL SAND & CLAY
					16	214	ARGILLITE
58700	09N	03W	14	AB	0	5	CLAY & TOPSOIL
					5	105	CLAY & ROTTEN ROCK
					105	310	HARD LIME ROCK
166921	09N	03W	14	AC	0	1	TOPSOIL
					1	230	BROKEN LIMESTONE & CLAY
					230	320	LIMESTONE
58701	09N	03W	14	AC	0	3	TOPSOIL
					3	19	DECOMPOSED GRANITE
					19	155	BLUE GRANITE
152685	09N	03W	14	AD	0	1	TOPSOIL
					1	30	GRAVELY CLAY
					30	50	CLAY
					50	98	BROKEN LIMESTONE & CLAY
					98	198	LIMESTONE
58702	09N	03W	14	AD	0	3	TOPSOIL
					4	16	SAND & GRAVEL
					16	36	SUGAR LIMESTONE
					36	125	LIMESTONE BEDROCK
58703	09N	03W	14	AD	0	4	TOPSOIL
					4	18	CLAY & GRAVEL
					18	97	DECOMPOSED LIMESTONE BEDROCK

M:Number	Townshi	Range	Section	Tract	From	To	Description
58705	09N	03W	14	ADA	0	1	TOPSOIL
					1	10	BROWN CLAY
					10	20	GRAY CLAY
					20	50	GRAY CLAY
					50	85	BROWN BROKEN SANDSTONE
					85	115	BROWN BROKEN SANDSTONE
					115	120	GRAY BROKEN SANDSTONE
156978	09N	03W	14	ADC	0	1	TOPSOIL
					1	35	WEATHERED SANDSTONE
					35	110	WEATHERED SANDSTONE W/ CLAY
					110	130	LIMESTONE W/ CLAY SEAMS
					130	340	LIMESTONE
58706	09N	03W	14	B	1	3	TOPSOIL & GRAVEL
					3	27	BOULDERS & CLAY
					27	175	LIMESTONE & BEDROCK
58707	09N	03W	14	B	0	3	TOPSOIL
					3	150	SUGAR LIMESTONE
					150	250	LIMESTONE BEDROCK
58709	09N	03W	14	B	0	2	TOPSOIL
					2	11	BROKEN ROCK
					11	200	LIMESTONE BEDROCK
58710	09N	03W	14	BA	0	4	TOPSOIL
					4	14	BROKEN BEDROCK
					14	165	LIMESTONE BEDROCK
147260	09N	03W	14	BCA	0	1	TOPSOIL
					1	145	CLAY
					145	175	BROKEN LIMESTONE & CLAY
					175	234	LIMESTONE
122508	09N	03W	14	BCB	0	292	FRACTURED LIMESTONE AND CLAY
126686	09N	03W	14	BCC	0	160	LIMESTONE
152686	09N	03W	14	BD	0	1	TOPSOIL
					1	100	BENTONITE CLAY & ROCKS
					100	180	DECOMPOSED LIME
					180	230	LIMESTONE
156277	09N	03W	14	BD	0	18	LT YELLOW/ORANGE LIMESTONE HARDER W/ DEPTH
					18	40	MED GRAY LIMESTONE HARD
					40	42	LT TAN-YELLOW LIMESTONE
					42	58	LT TAN LIMESTONE SILICA CEMENT ALTERNATING LAYERS GREY/TAN/ORANGE
					58	140	NOT REPORTED
					140	230	GREY LIMESTONE GREATER WATER W/ DEPTH
					230	240	BLACK SILICEAOUS SHALE LOOSE
156278	09N	03W	14	BD	0	2	TOPSOIL
					2	6	BENTONITE
					6	28	DECOMPOSED LIME
					28	190	GREY WEATHERED LIME
					190	215	BLACK SHALE
					215	258	FAULTED SHALE
					258	280	QUARTZITE SUGAR LIME
128254	09N	03W	14	BDC	0	130	LIMESTONE
58712	09N	03W	14	C	0	4	TOPSOIL
					4	12	CLAY BROKEN ROCK
					12	17	DECOMPOSED LIMESTONE
					17	148	LIMESTONE BEDROCK

M:Number	Townshi	Range	Section	Tract	From	To	Description
165637	09N	03W	14	CA	0	1	TOPSOIL
					1	47	CLAY AND GRAVEL
					47	63	FRACTURED LIMESTONE AND CLAY
					63	199	LIMESTONE
165638	09N	03W	14	CB	0	1	TOPSOIL
					1	22	BROWN CLAY
					22	29	CLAY AND GRAVEL
					29	133	FRACTURED LIMESTONE AND CLAY
165639	09N	03W	14	CB	0	1	TOPSOIL
					1	22	TAN CLAY
					22	364	FRACTURED LIMESTONE AND CLAY
58711	09N	03W	14	CBA	0	4	TOPSOIL
					4	400	LIMESTONE BEDROCK W/BROKEN ZONES BETWEEN LIME LYRS
165640	09N	03W	14	CC	0	1	TOPSOIL
					1	6	GRAVEL AND CLAY
					6	18	CLAY
					18	67	SAND AND CLAY
					67	133	CLAY
					133	402	FRACTURED LIMESTONE AND CLAY
165641	09N	03W	14	CC	0	111	FRACTURED LIMESTONE AND CLAY
168330	09N	03W	14	CDA	0	2	TOPSOIL
					2	20	DECOMPOSED GRANITE
					20	150	GRANITE
106925	09N	03W	14	DA	0	3	FILL MATERIAL
					3	7	ROCKS
					7	22	BLACK CLAY
					22	50	LIMESTONE
					50	85	BROKEN LIME WATER SOUPY
					85	165	FRACTURED LIME WATER
					165	260	HARD WHITE LIME
					260	290	BROKEN ZONE WATER LIME
					290	350	HARD WHITE LIME
134497	09N	03W	14	DACC	0	4	TOPSOIL
					4	12	CLAY & GRAVEL
					12	60	DECOMPOSED LIMESTONE
					60	145	LIMESTONE
163205	09N	03W	14	DB	0	2	TOP SOIL
					2	20	CLAY AND ROCKS
					20	160	BROKEN SHALE AND CLAY
					160	260	SHALE
143489	09N	03W	14	DBC	0	1	TOPSOIL
					1	6	CLAY
					6	12	SAND & GRAVEL
					12	14	GRAVELLY CLAY
					14	105	WEATHERED SANDSTONE & CLAY
					105	117	FRACTURED LIMESTONE
					117	302	TREMOLITE ?
150224	09N	03W	14	DC	0	2	TOPSOIL
					2	4	CLAY
					4	19	SAND GRAVEL COBBLES
					19	120	TREMOLITE CLAY
58713	09N	03W	14	DD	0	3	TOPSOIL
					3	16	SAND & GRAVEL
					17	145	LIMESTONE & BEDROCK

Appendix F
School Well Logs

...Springs ... 9N 3W 13 B C BC ... Jefferson

043

Form No. 603 (R 6-87)

OCT 3 - 1988

File No. M:58500

MONT. DEPT. of NATURAL RESOURCES & CONSERVATION

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of t

044540

1. WELL OWNER
Name Montana City School

2. CURRENT MAILING ADDRESS
PO Box ... Star Route
... MT 59635

3. WELL LOCATION
County Jefferson
Township 9 N S Range 2 E W
W SW NW SW 1/4 1/4 1/4 Section 2
Lot ____ Block ____
Subdivision ____
Tract Number ____

4. PROPOSED USE Domestic X Stock ☐ Irrigation ☐
Other ☐ specify ____

5. DRILLING METHOD ____ cable, ____ air rotary,
X forward rotary, ____ reverse rotary, ____ jetted,
____ other (specify) ____

6. WELL LOG

Depth (ft.) From	To	Formation
0	6	Clay
6	13	Gravel + Sand
13	17	Clay
17	150	Limestone

BA

ATTACH ADDITIONAL SHEETS IF NECESSARY

7. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and PSI Rating of casing	From (feet)	To (feet)	Perforations X and/or Screen — Kind Size	From (feet)	To (feet)
12"	6 5/8	0	20			
	+ 18		150			
8"	18.97	20	150	6x12	110	120
					125	150

Was casing left open end? S Yes ____ No
Was a packer or seal used? X Yes ____ No
If so, what material Rubber Shale Trap
Was the well gravel packed? ____ Yes X No
To what depth was the well grouted? 20 ft
Material used in grouting Cement
Well head completion: Pitless adapter ____ Yes X No
Top casing 18 in. or greater above grade X Yes ____ No

8. WELL TEST DATA
The pump test information request in this section is required for all wells. All depth measurements shall be from the top of the well casing unless otherwise specified.
All wells under 100 gpm must be tested for a minimum of one hour and provide the following information:
a) Air X Pump ____ Bailer ____
b) Static water level immediately before testing 28 ft, if flowing; closed-in pressure ____ psi ____ gpm
Controlled by: ____ valve, ____ reducers, ____ other, (specify) ____
c) Depth at which pump is set for test ____
d) The pumping rate and means of discharge (i.e., bailing, airlift, pumping) 75 gpm
e) Maximum drawdown during the test 120 ft
f) Duration of test: Pumping time 2 hrs
Recovery time ____ hrs
g) Recovery water level ____ ft
Amount of time after pumping recovery level water data was taken ____ hrs
Wells intended to yield 100 gpm or more shall be tested for a period of 8 hours or more. The test shall follow the development of the well, and shall be conducted continuously at a constant discharge at least as great as the intended appropriation. In addition to the above information, water level data shall be collected and recorded on the Department's "Aquifer Test Data" form included in each packet of well logs.
NOTE: All wells shall be equipped with an access port ½ inch minimum or a pressure gauge that will indicate the shut-in pressure of a flowing well. Removable caps are acceptable as access ports.

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

10. DATE COMPLETED Sep 26 1988

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

Oct 27 1988
Date

H & L DRILLING
Firm Name
P. C. Box 1022
East Helena, MT 59635
Address

Harold Reid 334
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
1520 EAST SIXTH AVENUE HELENA, MONTANA 59620-2301 444-6610
DNRC

Form No. 603 (Rev. 3/75) File No.

STATE OF MONTANA
Department of Natural Resources and Conservation
WELL LOG REPORT

coded CODE 43 09N 03W 13 JEFFERSON

White-Department
Pink-Bureau
Yellow-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 Montana City School Current address Montana City

2. WELL LOCATION Lot J, Block , Subdivision
County Jefferson, or ¼ ¼ ¼ Sec. 13, T. 9 N-S, R. 3 E-W

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

4. METHOD DRILLED cable, bored, forward rotary, reverse rotary, jetted, X other (specify) Air Rotary

5. WELL CONSTRUCTION
Diameter of hole 6 in.; depth 210 ft.
Casing: 21 steel, 200 plastic, concrete, threaded, welded, other (specify)

Pipe weight:

	Dia.	From	To
19 lb/ft	6 in.	0 ft.	21 ft.
lb/ft	4 in.	10 ft.	210 ft.

Was casing left open end? X Yes No
Was a well screen installed? Yes X No
Material , dia. in. (stainless steel, bronze, etc.)
Was perforated pipe used? X Yes No
Perforation type: X slots holes
Size ¼ X 4 set from 170 ft. to 210 ft.
Size set from ft. to ft.
Was a packer or seal used? Yes X No
If so, what material
Well type: Straight screen Graveled
Was the well grouted: X Yes No
To what depth: 21 ft.
Material used in grouting Mud
Well head completion: Pitless adapter
12 in. above grade , other
(if other, specify)
Was well disinfected? Yes X No

6. WATER LEVEL
Static water level 40 ft. below land surface
If flowing: closed-in pressure psi
gpm flow through inch pipe
Controlled by: valve reducers
other (specify)

7. WELL TEST DATA Pump Bailer Y Other
(if other, specify) Air
Pumping level below land surface:
200 ft. after 3 hrs. pumping 12 gpm
ft. after hrs. pumping

8. WELL LOG

Depth (ft) From	To	Formation
0	4	Topsoil
4	20	Clay
20	210	Limestone Bedro

(use separate sheet if necessary)

9. DATE STARTED 6-29-76
DATE COMPLETED 6-30-76

10. WAS WELL PLUGGED OR ABANDONED? Yes X No
If so, how?

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
Lindsay Drilling 253
Driller's or firm name License No.
Clancy, Mont.
Address
Terry Lindsay 6-30-
Signed by date

Appendix G
RESSQC Module

6.0 RESSQC Module

6.1 Introduction

The RESSQC module is a slightly modified version of the RESSQ code presented by Javandel et al., 1984. The "C" was added to the program name because the code was specifically modified for "C"apture zone delineation purposes. RESSQ was originally designed to delineate contaminant fronts about injection wells, and this capability is retained in RESSQC.

6.2 Capabilities

RESSQC can be used to delineate time-related capture zones for a system of one or more pumping/injection wells that fully penetrate a homogeneous aquifer. The presence of a stream or barrier boundary can be simulated using image well theory, but the image wells need to be supplied explicitly to the code. If a stream or barrier boundary exists, the user may save time and avoid mistakes by using the MWCAP or semi-analytical GPTRAC option. The effects of well interference are accounted for through superposition of solutions. A maximum of 50 pumping wells and 20 injection wells may be used in RESSQC.

The number of pathlines reverse tracked from each pumping well may be defined interactively by the user. In addition, particles can be released at any point within the system to be subsequently forward or reverse tracked (depending upon whether contaminant fronts or capture zones are delineated).

6.3 Assumptions and Limitations

Capture zones and contaminant fronts delineated using RESSQC are valid for fully penetrating pumping and injection wells screened in aquifers that are essentially homogeneous. Ground-water flow must be two-dimensional in the x-y plane, and therefore the aquifer may be confined or unconfined if the drawdown-to-initial saturated thickness ratio is small (less than approximately 0.1). Steady ground-water flow is assumed.

If a stream or a barrier boundary is implemented using image well theory, the boundary is assumed to be a straight line and fully penetrate the aquifer. The latter assumption is often violated in cases where stream boundaries exist. The effect of a partially penetrating stream may be an important one and each application should be examined on a site-by-site basis. In general, the greater the depth and breadth of the stream in relation to the aquifer thickness, the more valid the fully penetrating stream assumption. Also, stream boundary partial penetration effects decrease as the distance from the stream to the well increases. The stream and the aquifer are assumed to be in perfect hydraulic connection; the effects of a "clogging layer" between the streambed and the aquifer are not considered.

If, in actuality, the stream is partially penetrating and/or there is a clogging layer of fine grained material that lines the streambed, the capture zone obtained using RESSQC will be smaller than the "true" capture zone. The amount of error incurred will be dependent upon the degree to which the above assumptions are violated.

6.4 Input Requirements

The input requirements for the RESSQC option are outlined in Table 6.1. The well-specific parameters must be input for each well specified in the study area.

6.5 Example Applications

Two examples are presented that illustrate use of the RESSQC module. The first example is a hypothetical one taken from Javandel et al. (1984). The second example is a site application in the vicinity of Corning, New York.

6.5.1 Hypothetical Example

Because the RESSQC module is an amended version of the RESSQ code (Javandel et al. 1984), the example problems presented in Javandel et al. were run using RESSQC to ensure that the changes made to the code did not alter its original capability. The original RESSQ code has been verified, field validated and used extensively by numerous users (van der Heijde and Beljin, 1988).

The second example problem presented by Javandel et al. is depicted in Figure 6.1. In this example there is one injection well and one pumping well with equal rates of injection and pumping. Uniform ambient flow within the aquifer occurs at an angle of 45°

Table 6.1

RESSQC Input Requirements For Delineation of Capture Zones (Input Differs Slightly For Delineation of Contaminant Fronts)

Program Variable	Description
For each problem --	
IUNIT:	Default units of input parameters (feet and days or meters and days)
NWP:	Number of pumping wells within the study area
NWI:	Number of recharge (injection) wells within the study area
XMIN:	Minimum x-coordinate of study area (ft or m)
XMAX:	Maximum x-coordinate of study area (ft or m)
YMIN:	Minimum y-coordinate of study area (ft or m)
YMAX:	Maximum y-coordinate of study area (ft or m)
TRANSM:	Transmissivity of the aquifer (ft^2/d or m^2/d)
GRADNT:	Regional hydraulic gradient (ft/ft or m/m)
ALPHA:	Angle of ambient ground-water flow (0-360°)
POR:	Aquifer porosity (dimensionless)
HEIGHT:	Aquifer saturated thickness (ft or m)
DL:	Largest allowable step length, $d\ell$ (ft or m) see section 4.1
TMAX:	Maximum amount of time for calculating the trace of a pathline (days)
NCAPZ:	Number of time-related capture zones to be calculated for each pumping well (maximum = 7)
NRPATH:	Number of reverse-tracked pathlines started at arbitrary locations within the study area
For each capture zone (I=1, NCAPZ) --	
DATE(I):	Time value for capture zone (days)

Table 6.1 (cont'd)

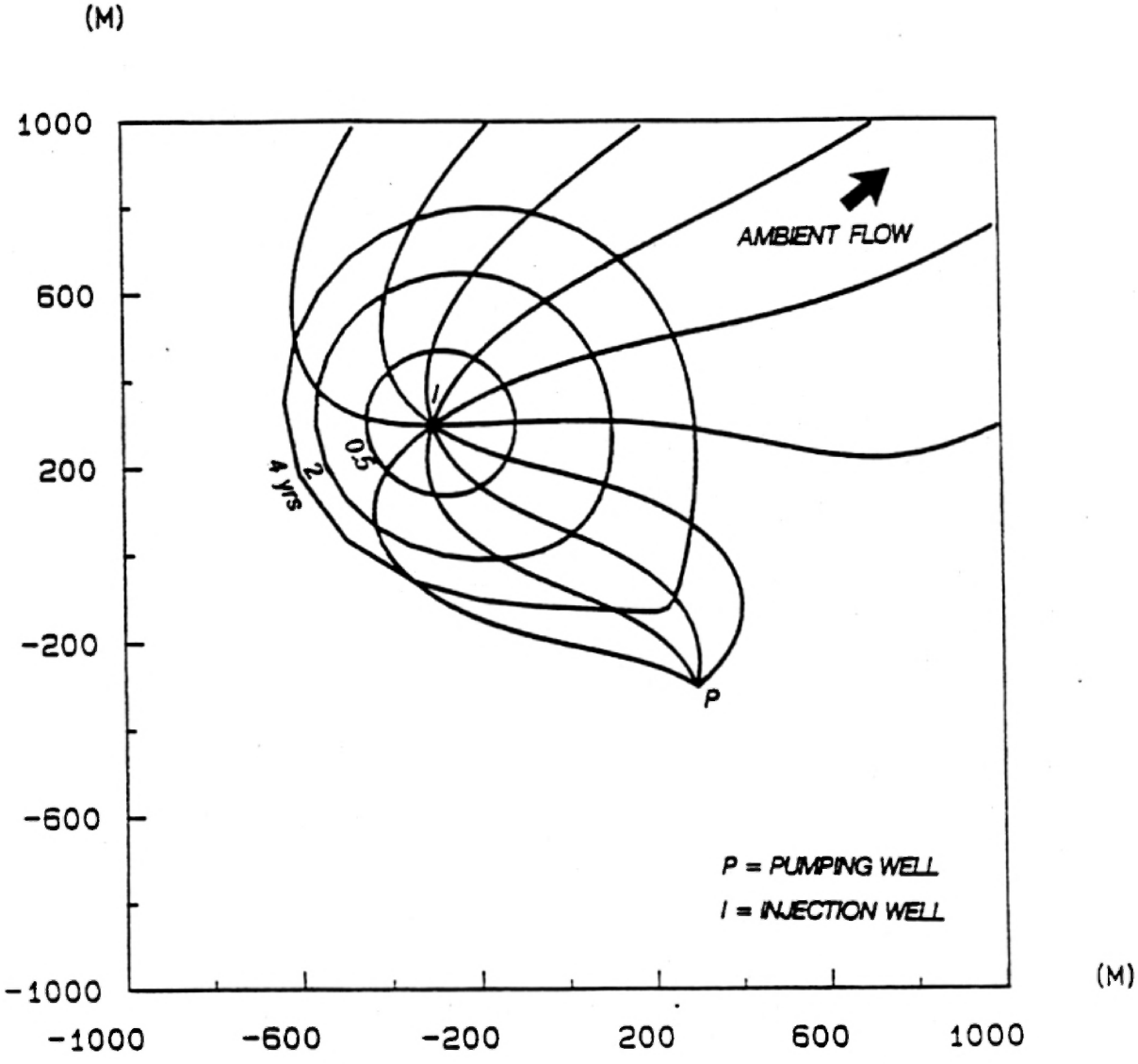
RESSQC Input Requirements For Delineation of Capture Zones (Input Differs Slightly For Delineation of Contaminant Fronts)

Program Variable	Description
For each pumping well (I=1, NWP) --	
XW(1,I):	x-coordinate of well (ft or m)
XW(2,I):	y-coordinate of well (ft or m)
QPWELL(I):	Well discharge rate[a/] (ft^3/d or m^3/d)
RADW(I):	Well radius (ft or m) - default = 0.3 ft or 0.1 m
ITRW(I):	Ratio of number of pathlines to the number plotted (=1 to plot all pathlines, =2 to plot every other pathline, etc.)
NPATH(I):	Number of pathlines to be computed to delineate time-related capture zone (default = 20)
For each injection well (I=NWP + 1, NWP + NWI) --	
XW(1,I):	x-coordinate of well (ft or m)
XW(2,I):	y-coordinate of well (ft or m)
QPWELL(I):	Well recharge rate[a/] (ft^3/d or m^3/d)
RADW(I):	Well radius (ft or m) - default = 0.3 ft or 0.1 m
For each forward tracked pathline (I=1, NRPATH) --	
RSTART(I,1):	x starting coordinate (ft or m)
RSTART(I,2):	y starting coordinate (ft or m)

[a/] The sign (+,-) of the discharge or recharge rate need not be specified.

Figure 6.1

Contaminant Fronts Delineated Using RESSQC for Hypothetical Example



Simulation Options	Aquifer Properties	Injection Well	Pumping Well
Units = m and days	T = 100	X = -300	X = 300
Step Length = 10	b = 10	Y = 300	Y = -300
Simulation time = 73,000	θ = 0.25	Q = 1,200	Q = 1,200
No. Fronts = 3	i = 0.00343	r = 1.0	r = 1.0
@ 183, 730 and 1,460 days	α = 45	No. Pathlines = 40	
		Plotting Interval = 4	

with respect to the x-axis. Note that the values of transmissivity (T) and hydraulic gradient (i) agree with the 0.14 m/d pore water velocity specified by Javandel et al.

Because the original RESSQ code was designed to track the location of contaminated water emanating from injection wells, option 2 of RESSQC (delineate contaminant fronts about injection wells) was used to obtain Figure 6.1. In addition, 40 pathlines (plotted at intervals of four) were specified. A comparison of Figure 6.1 with Figure 19 in Javandel et al. (1984) shows a perfect correspondence. The three concentric rings about the injection well in Figure 6.1 represent the areal extent of the injected water front for the time periods of 0.5, 2 and 4 years.

To test the capture zone delineation capability of the RESSQC code, the problem specified above was rerun with the only change being that simulation option 1 was used (delineate capture zones about pumping wells). The results of this run are shown in Figure 6.2. As expected, Figure 6.2 is a rotated image of Figure 6.1. In Figure 6.2, the concentric rings about the pumping well represent the 0.5-, 2- and 4-year capture zones for the pumping well. Note that when delineating contaminant fronts the forward tracking method is used (particles are tracked in the direction of ground-water flow), while when delineating capture zones the reverse tracking method is used (particles are tracked in the direction opposite to that of ground-water flow).

6.5.2 Corning Example

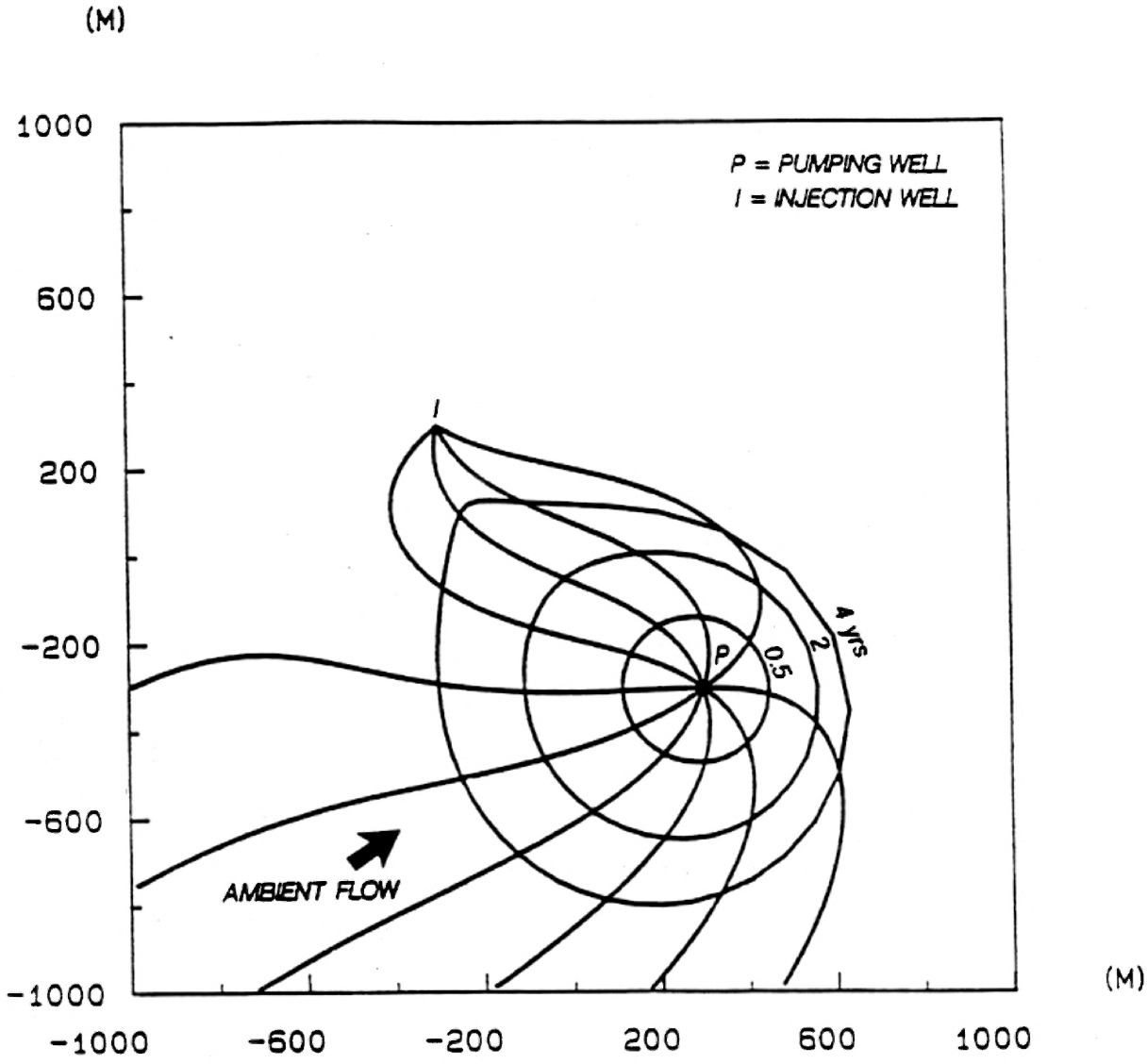
For the next example, RESSQC was used to delineate the capture zones for three wells withdrawing water from the surficial aquifer in the vicinity of Corning, New York. The data for this example was taken from Ballaron (1988).

Figure 6.3 is a general site map of the study region. The valley sediments in the vicinity of Corning consist of stratified glacial drift deposits that are primarily interbedded silty to clean sands and gravels. Relatively thin deposits of lacustrine clay, silt and fine sand exist over much of the valley and separate a surficial, unconfined aquifer from a confined to semi-confined aquifer at depth. Two cross sections through the study area are presented in Figure 6.4.

For the current example three wells screened in the surficial aquifer are considered. Recharge from the Chemung River, local recharge from precipitation, and leakage between the surficial and lower aquifer units were neglected. Hence, the capture zones computed

Figure 6.2

Capture Zones Delineated Using RESSQC for Hypothetical Example



Simulation Options	Aquifer Properties	Injection Well	Pumping Well
Units = m and days	T = 100	X = -300	X = 300
Step Length = 10	b = 10	Y = 300	Y = -300
Simulation time = 73,000	θ = 0.25	Q = 1,200	Q = 1,200
No. Fronts = 3	i = 0.00343	r = 1.0	r = 1.0
@ 183, 730 and 1,460 days	α = 45	No. Pathlines = 40	
		Plotting Interval = 4	

Figure 6.3

General Site Map of Chemung River Valley in the Vicinity of Corning, New York

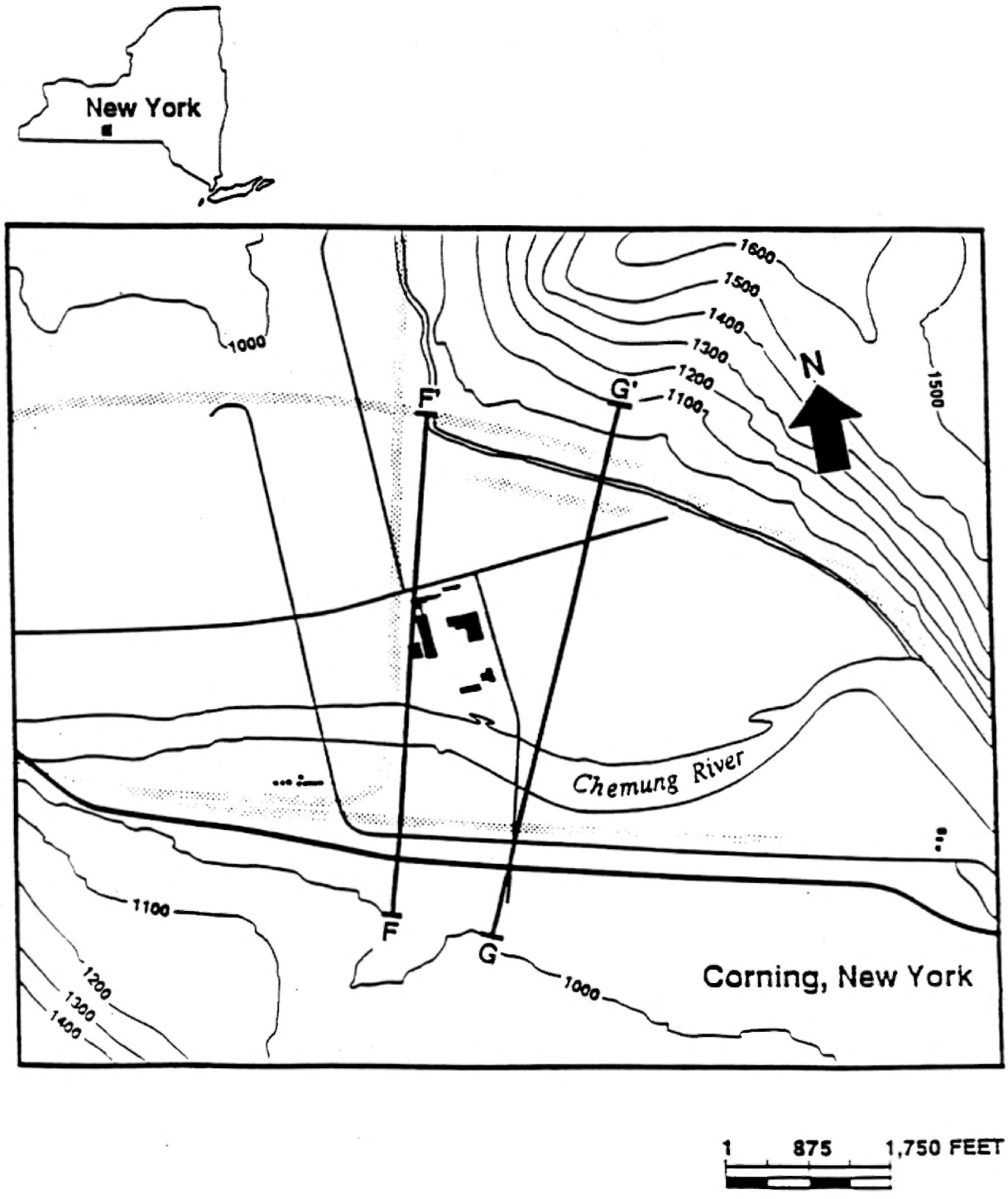
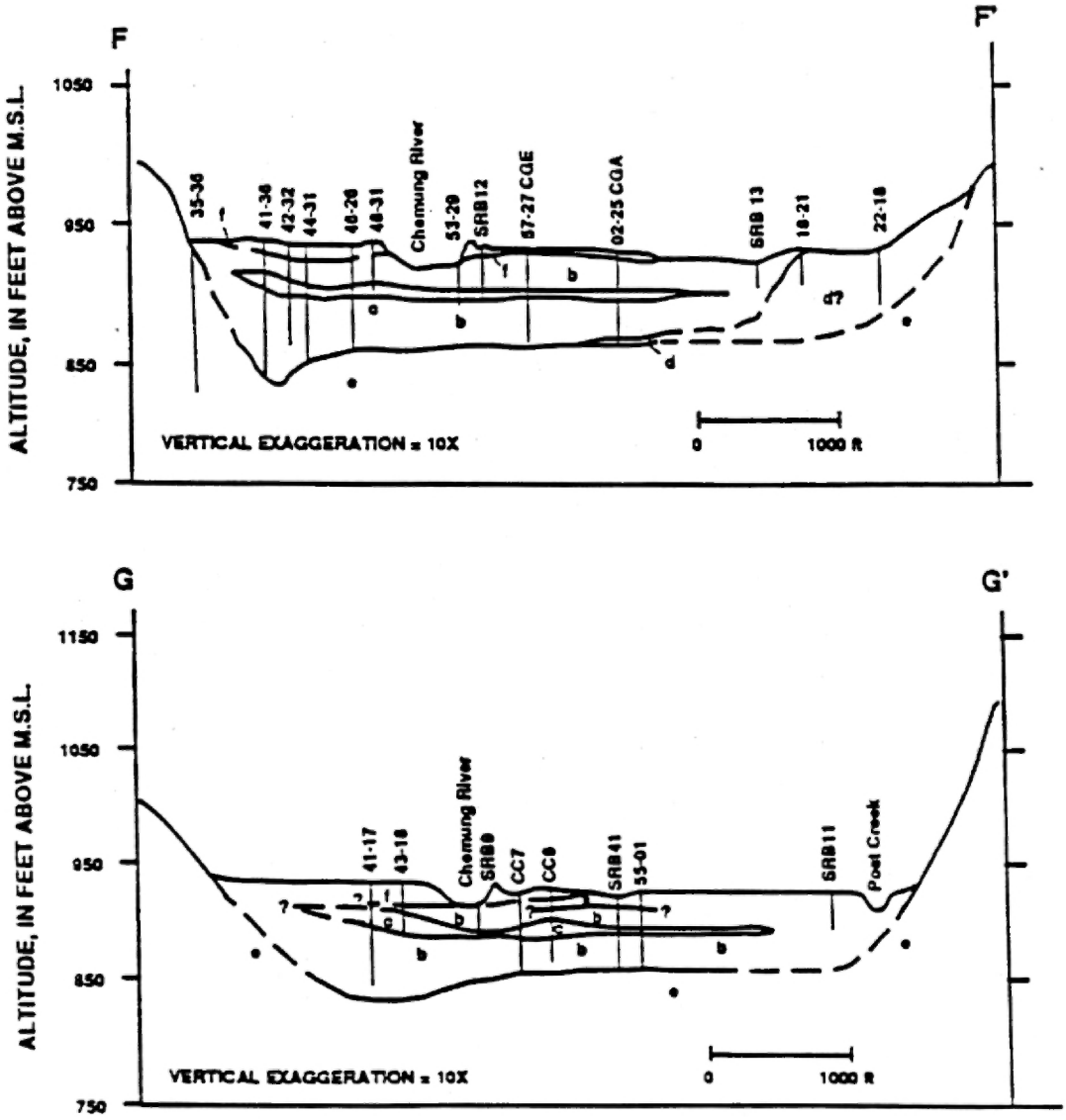


Figure 6.4

Cross Sections F-F' and G-G' in the Vicinity of Corning
Reproduced from Ballaron (1988)



using RESSQC are conservative estimates (they are larger in areal extent than they would be if all sources of recharge to the well were incorporated into the analysis).

The locations of the three pumping wells are superimposed on a pre-pumping steady-state head map (refer to Section 8.3.4.2 for details on how the head map was obtained) in Figure 6.5. From this map the hydraulic gradient (≈0.0019) and the direction of ambient ground-water flow (-45°) was obtained. Additional required information such as reasonable pumping rates for the wells, an average hydraulic conductivity of 150 ft/d, and an average saturated thickness of 25 ft were taken from Ballaron (1988).

The five-year capture zones for the three pumping wells delineated using RESSQC, as well as the input data used, are illustrated in Figure 6.6. Note that in this example interference effects between the three wells are significant; the two wells farthest upgradient (about in the middle of the study area) intercept a major portion of the ambient aquifer flow that would otherwise supply recharge to the third well. The capture zone of the third well, therefore, assumes a complex, contorted shape because it must draw water from regions of the aquifer that are not enclosed by the capture zones of the first two wells.

The three pumping wells examined in this exercise were assumed to be screened over the entire saturated thickness of the surficial aquifer. Because the aquifer is unconfined, its saturated thickness decreases as water is withdrawn by pumping wells due to dewatering of the effective pore space. The assumptions inherent in the RESSQC, MWCAP, and MONTEC modules are only valid for this type of system if the ratio of the drawdown at (or near) the pumping well(s) is small compared to the initial saturated thickness of the aquifer. In general this ratio should not exceed 20%, or 10% if one desires to be conservative. As a GPTRAC example in Chapter 8, the Corning case study was modeled using a numerical ground-water flow code. The results of this simulation indicate a maximum drawdown to initial saturated thickness ratio of approximately 15-20%. This ratio is small enough that errors incurred due to using the confined aquifer ground-water flow equations are acceptable for demonstration purposes.

Finally, the Corning example was rerun using the input parameters from Figure 6.6, only for this run one capture zone for 1,825 days (5 years) was specified. The results are shown in Figure 6.7. The crescent shapes are the 5-year capture zones that RESSQC delineates for each well.

Figure 6.5

Predevelopment Water Table Map for Corning Region (Obtained From Numerical Simulation) and Locations of Three Surficial Aquifer Pumping Wells

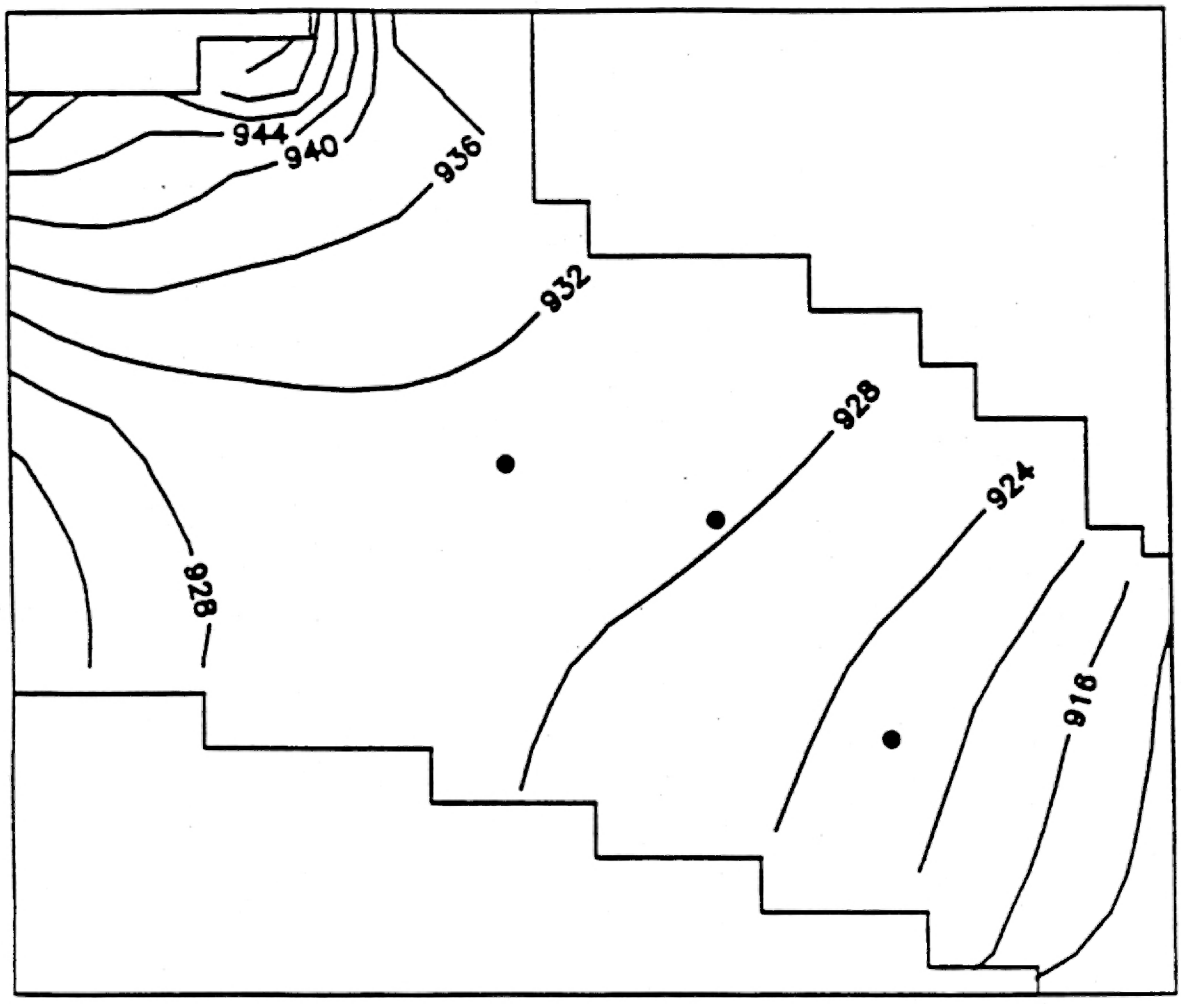
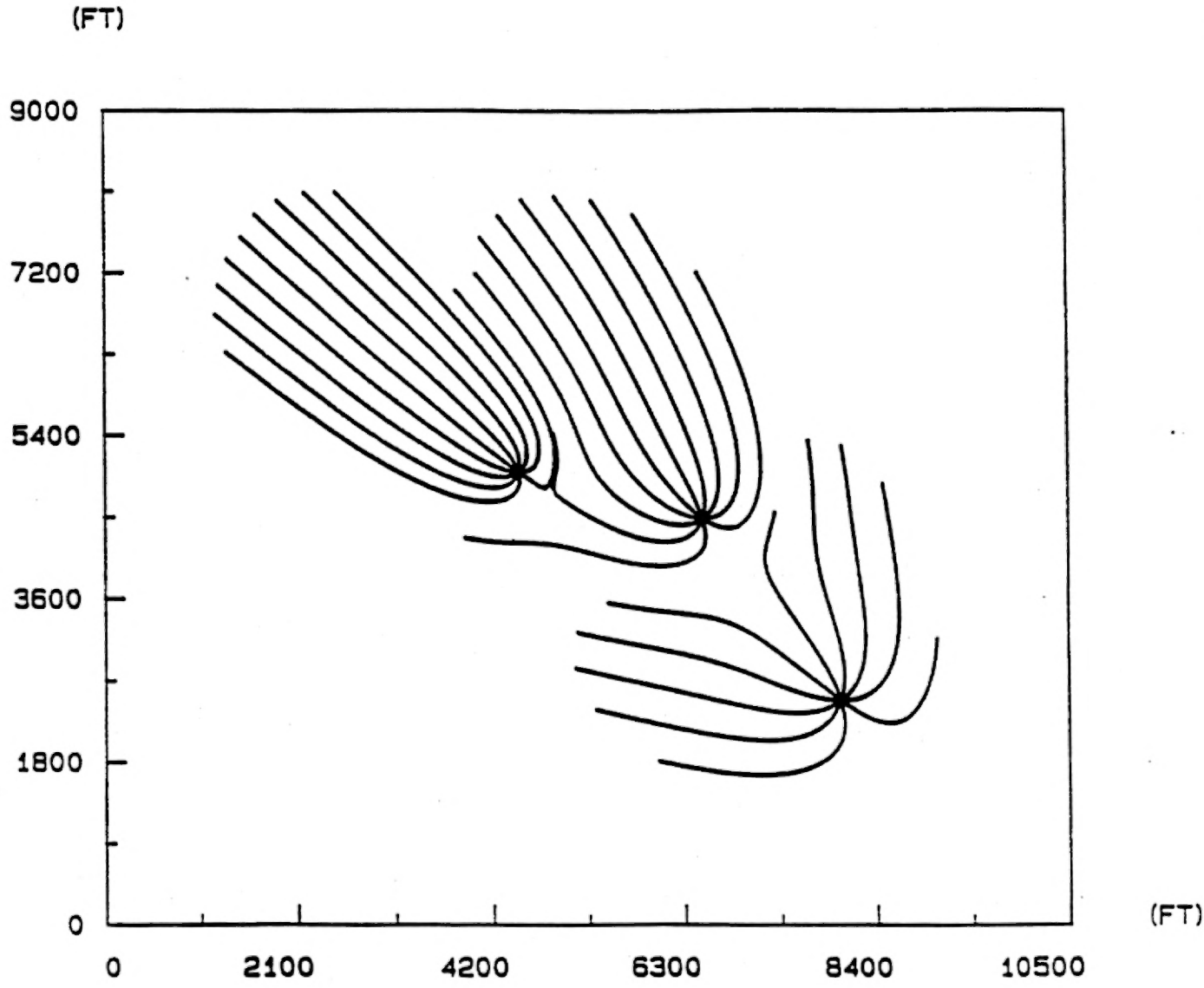


Figure 6.6

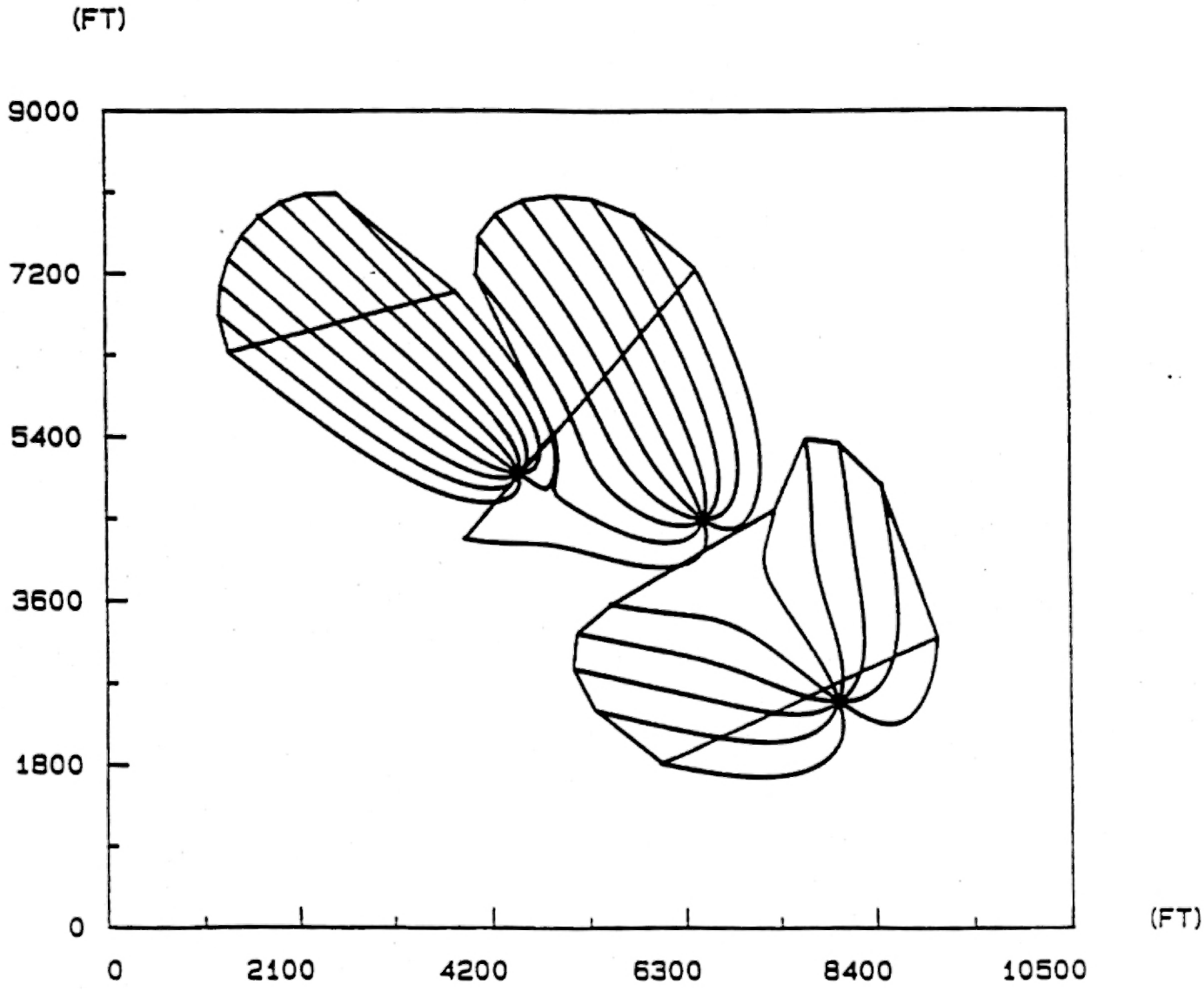
Five-Year Capture Zones Delineated Using RESSQC and Corresponding Input Parameters for Corning Example



Simulation Options	Aquifer Properties	Well #1	Well#2	Well #3
Units = ft and days	T = 3,750	X = 8,000	6,500	4,500
Step Length = 25	b = 25	Y = 2,500	4,500	5,000
Simulation time = 1,825	θ = 0.22	Q = 30,000	30,000	25,000
No. Capture Zone times = 0	i = 0.0019	No. Pathlines = 10	10	10
	α = -45°	Plotting Interval = 1	1	1

Figure 6.7

Five-Year Capture Zones for Corning Example Delineated Using RESSQC With One Capture Zone·Time Specified



These odd shapes often occur when capture zones are delineated using RESSQC for long periods of time - they obviously do not enclose the entire capture zone of the well. They occur because, in order to delineate time-related capture zones, the code traces a series of reverse pathlines from each well for a specified period of time. When a capture zone time is reached, the corresponding point on each pathline is saved. These points are then connected in sequential order (i.e. the point on pathline 1 is connected to the corresponding point on pathline 2, then the point on pathline 2 is connected to pathline 3, etc.) When the last pathline is reached, its capture zone point is connected to the capture zone point on pathline 1; this final connection causes the line to be drawn that cuts across the pathlines and truncates the capture zone. The simplest way to avoid this shortcoming is to set the simulation time equal to the capture zone time desired, and then specify zero capture zone time values as was done for the first Corning run. This method produces clear plots and there is no ambiguity as to what area is enclosed by the capture zone(s).

Appendix H
Ground Water Under the Direct Influence of Surface Water
Preliminary Assessment Forms

DEPARTMENT OF ENVIRONMENTAL QUALITY
METCALF BUILDING
POB 200901
Helena, MT 59601-0901

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

SYSTEM NAME Montana City Public School PWS ID# _____
SOURCE NAME Southeast School Well M:58654 COUNTY Jefferson
DATE November 9, 1998 NC NTNC C POPULATION

	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. HYDROGEOLOGICAL FEATURES (Circle all that apply)	
Horizontal distance between a surface water and the source*	
greater than 500 feet	**0**
250-500 feet	5
100-250 feet	10

less than 100 feet..... 15

E. WATER CONSTRUCTION (Circle all that apply)

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

great than 100 feet.....	**0**
50 -100 ft.....	5
25 - 50 ft.....	10
0 - 25 ft.....	15
unknown.....	15

D. 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 ft.....	5
0 - 50 ft.....	**10**
unknown.....	10

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

ANALYST Richard Marvin, Hydrogeologist, MBMG
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 futher GWUDISW determination.
IV)		FAIL: Well will Pass if intake construction deficiencies (section F) are repaired.
V)		FAIL: Well may PASS if well construction details (section E) become available.

COMMENTS

DEPARTMENT OF ENVIRONMENTAL QUALITY
METCALF BUILDING
POB 200901
Helena, MT 59601-0901

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

SYSTEM NAME Montana City Public School PWS ID# _____
SOURCE NAME North School Well M:58500 COUNTY Jefferson
DATE November 9, 1998 NC NTNC C POPULATION

	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. HYDROGEOLOGICAL FEATURES (Circle all that apply)	
Horizontal distance between a surface water and the source*	
greater than 500 feet	**0**
250-500 feet	5
100-250 feet	10
less than 100 feet	15

E. WATER CONSTRUCTION (Circle all that apply)

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

great than 100 feet..... **0**
50 -100 ft..... 5
25 - 50 ft..... 10
0 - 25 ft..... 15
unknown..... 15

D. 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 ft..... 5
0 - 50 ft..... **10**
unknown..... 10

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

ANALYST Richard Marvin, Hydrogeologist, MBMG
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 intake construction deficiencies (section F) are repaired.
V) FAIL: Well may PASS if well construction details (section E) become available.

COMMENTS

Appendix I
Potential Contaminant Inventory Sheets

PWSID Name & ID # Montana City School Site ID Number 1, 2, 3, 4

(Corresponds with map location number)

WHP Region Control / Special Protection Inventory Person Rich Marvin and Gnette Abds

WHP INVENTORY FORM

Site Name Montana City School Owner Name Montana City School Board

Site Address 11 McClellan Creek Rd.

City Clancy Zip Code 59634 County Jefferson Phone 406/442-6779

T/R/S/T T9N R3W Sec. 13 BCBC

Lat/Long N 46° 32' 21" W 111° 56' 01".

Property owner (if different from above)

Address _____ Phone _____

City _____ Zip Code _____ _____

NATURE OF PROPERTY

__Service Business __Industrial/Mfg. __Retail Business __Agricultural

__Residential ✓Government __Other (describe on back)

LAND USES or POTENTIAL CONTAMINANT SOURCES

Place a check by the letter or number of each land use activity or potential source found at this site. Also place the number or letter and the map locator number (found in upper right corner of this sheet) on the base map to indicate the location of each important land use activity or potential contaminant source. List the chemicals used or stored and approximate volume on back of the form. Also include any other important or useful site information.

✓(A) Ag chemical use site
__(B) Brine pit
__(C) Chemical storage
__(D) Chemigation well
✓(E) Chemical mixing/loading site
✓(F) Drain ditch/canal
__(G) Feedlot
__(H) Grain storage
__(I) Greenhouse/nursery/orchard
__(J) Highway/county road
__(F) Injection well
__(L) Irrigated land
__(M) Irrigation canal
__(N) Land application of waste site
__(O) Landfill/dump
___(P) Mine/quarry/gravel pit
___(Q) Oil/gas well or exploration borehole
___ (R) Pipeline
___(S) Railroad right-of-way
___(T) Salvage yard
✓(U) Septic tank
___(V) Service Station dry well/sump
___(W) Stormwater drain/sump
___(X) Stream/river/lake/pond
___(Y) Underground storage tank
___(Z) Utility substation/transformer storage
___(1) Wastewater lagoon
✓(2) Water well in use

(1)

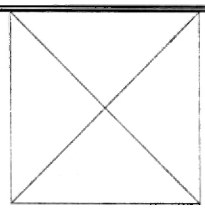
CHEMICALS USED OR STORED AT THIS SITE

Map Locator # and Source ID	Land Use	Associated Chemicals
1 - A	School Lawn and Athletic Field	Fertilizer and Herbicide (Trimec)
2 - U	Septic Tank and Drain Field	Sewage and Waste Water from School
3 - F	School Lawn, Storm Runoff Ditch	Storm Water Runoff
4 - E	Fire Extinguisher Demonstration Area	Petroleum Hydrocarbons to start fire

Additional site information

2 - U Waste water from school includes small quantities of neutralized acids and bases from science labs. School janitorial staff use phosphoric acid and degreasers for cleaning.

Sketch of Site (optional)



PWSID Name & ID # Montana City School Site ID Number 5
(Corresponds with map location number)

WHP Region Special Protection Inventory Person Rick Klemm and Garth Ahl

WHP INVENTORY FORM

Site Name Interstate Hwy 15 and State Hwy 518 Owner Name MT Dept of Transportation
Site Address
City Montana City Zip Code 59634 County Jefferson Phone 406/225-3919

T/R/S/T T9N R3W Sec 11, 13, 14
Lat/Long N46° 32' 30" W111° 57'

Property owner (if different from above)
Address Phone 406/444-7220
City Helena Zip Code 59601

NATURE OF PROPERTY

__Service Business __Industrial/Mfg. __Retail Business __Agricultural

__Residential ✓Government __Other (describe on back)

LAND USES or POTENTIAL CONTAMINANT SOURCES

Place a check by the letter or number of each land use activity or potential source found at this site. Also place the number or letter and the map locator number (found in upper right corner of this sheet) on the base map to indicate the location of each important land use activity or potential contaminant source. List the chemicals used or stored and approximate volume on back of the form. Also include any other important or useful site information.

✓(A) Ag chemical use site
__(B) Brine pit
__(C) Chemical storage
__(D) Chemigation well
__(E) Chemical mixing/loading site
__(F) Drain ditch/canal
__(G) Feedlot
__(H) Grain storage
__(I) Greenhouse/nursery/orchard
✓(J) Highway/county road
__(F) Injection well
__(L) Irrigated land
__(M) Irrigation canal
__(N) Land application of waste site
__(O) Landfill/dump
___(P) Mine/quarry/gravel pit
___(Q) Oil/gas well or exploration borehole
___(R) Pipeline
___(S) Railroad right-of-way
___(T) Salvage yard
___(U) Septic tank
___(V) Service Station dry well/sump
___(W) Stormwater drain/sump
___(X) Stream/river/lake/pond
___(Y) Underground storage tank
___(Z) Utility substation/transformer storage
___(1) Wastewater lagoon
___(2) Water well in use

(2)

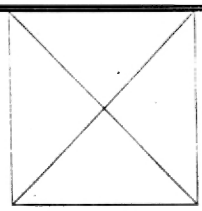
CHEMICALS USED OR STORED AT THIS SITE

Map Locator # and Source ID	Land Use	Associated Chemicals
5 - A	Highway Right-of-way	County and State spray Tordon and 2,4 D for weed control
5 - J	Highway Right of Way	Hazardous chemicals are transported on these highways

Additional site information

5-J Typical chemicals transported on highways include gasoline, diesel, and fuel oil

Sketch of Site (optional)



(3)

PWSID Name & ID # Montana City School Site ID Number 6
(Corresponds with map location number)

WHP Region Special Protection Inventory Person Rich Marvin and Garth Hicks

WHP INVENTORY FORM

Site Name Montana City Store (Conoco) Owner Name John and Marian Calnan
Site Address _____
City Clancy Zip Code 59634 County Jefferson Phone 406/443-0150

T/R/S/T T9N R3W Sec. 14 BADC
Lat/Long N 46° 32' 27" W 111° 56' 51".

Property owner (if different from above)
Address _____ Phone _____
City _____ Zip Code _____ _____

NATURE OF PROPERTY

__Service Business __Industrial/Mfg. ✓Retail Business __Agricultural

__Residential __Government __Other (describe on back)

LAND USES or POTENTIAL CONTAMINANT SOURCES

Place a check by the letter or number of each land use activity or potential source found at this site. Also place the number or letter and the map locator number (found in upper right corner of this sheet) on the base map to indicate the location of each important land use activity or potential contaminant source. List the chemicals used or stored and approximate volume on back of the form. Also include any other important or useful site information.

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___(R) Pipeline
___(S) Railroad right-of-way
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___(W) Stormwater drain/sump
___(X) Stream/river/lake/pond
✓(Y) Underground storage tank
___(Z) Utility substation/transformer storage
___(1) Wastewater lagoon
✓(2) Water well in use

(3)

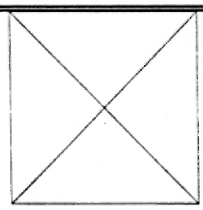
CHEMICALS USED OR STORED AT THIS SITE

Map Locator # and Source ID	Land Use	Associated Chemicals
6 - Y	Gas Station and Convenience Store	Gasoline

Additional site information

6-Y This site has had two releases of gasoline that have impacted groundwater. A vapor extraction system is in place. Releases were identified in 1
MDEQ Contact: Scott Gestring : 406/444-1388 Site ID: 2201822
Atlatl Consultants: Doug Anderson : 406/723-7980
Presently, there are 3 underground storage tanks in use : 2 - 10,000 gallon tanks
1 - 4,000 gallon tank

Sketch of Site(optional)



(4)

PWSID Name & ID # Montana City School Site ID Number 7
(Corresponds with map location number)

WHP Region Special Protection Inventory Person Rich Marvin, Ginette Abdo

WHP INVENTORY FORM

Site Name Montana City Car Wash Owner Name John Ballantyne
Site Address
City Clancy Zip Code 59634 County Jefferson Phone 406/443-4150 ext. 122

T/R/S/T T9N R3W Sec 14 BDAC
Lat/Long N 46° 32' 21" W 111° 56' 51".

Property owner (if different from above)
Address Phone
City Zip Code

NATURE OF PROPERTY

__Service Business __Industrial/Mfg. __Retail Business __Agricultural

__Residential __Government __Other (describe on back)

LAND USES or POTENTIAL CONTAMINANT SOURCES

Place a check by the letter or number of each land use activity or potential source found at this site. Also place the number or letter and the map locator number (found in upper right corner of this sheet) on the base map to indicate the location of each important land use activity or potential contaminant source. List the chemicals used or stored and approximate volume on back of the form. Also include any other important or useful site information.

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__(J) Highway/county road
__(F) Injection well
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___(S) Railroad right-of-way
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___(U) Septic tank
___(V) Service Station dry well/sump
___(W) Stormwater drain/sump
___(X) Stream/river/lake/pond
✓(Y) Underground storage tank
___(Z) Utility substation/transformer storage
___(1) Wastewater lagoon
___(2) Water well in use

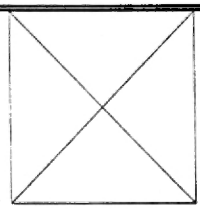
CHEMICALS USED OR STORED AT THIS SITE

Map Locator # and Source ID	Land Use	Associated Chemicals
7 - C, Y	Car Wash	Oily Waste water

Additional site information

8 - C, Y Waste water from car wash is held in a storage tank. It is hauled away for treatment off-site.

Sketch of Site (optional)



(5)

PWSID Name & ID # Montana City School Site ID Number 8
(Corresponds with map location number)

WHP Region Special Protection Inventory Person Rich Marvin

WHP INVENTORY FORM

Site Name Montana City Towing (Repair Shop) Owner Name _____
Site Address _____
City Clancy Zip Code 59634 County Jefferson Phone 406/443-8500

T/R/S/T T9N R3W Sec 11 CDDD
Lat/Long N 46° 32' 39" W 111° 56' 47".

Property owner (if different from above)
Address _____ Phone 443-8500
City _____ Zip Code _____ _____

NATURE OF PROPERTY

✓Service Business __Industrial/Mfg. __Retail Business __Agricultural

__Residential __Government __Other (describe on back)

LAND USES or POTENTIAL CONTAMINANT SOURCES

Place a check by the letter or number of each land use activity or potential source found at this site. Also place the number or letter and the map locator number (found in upper right corner of this sheet) on the base map to indicate the location of each important land use activity or potential contaminant source. List the chemicals used or stored and approximate volume on back of the form. Also include any other important or useful site information.

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__(N) Land application of waste site
__(O) Landfill/dump
__(P) Mine/quarry/gravel pit
__(Q) Oil/gas well or exploration borehole
__(R) Pipeline
__(S) Railroad right-of-way
✓(T) Salvage yard
__(U) Septic tank
__(V) Service Station dry well/sump
__(W) Stormwater drain/sump
__(X) Stream/river/lake/pond
__(Y) Underground storage tank
__(Z) Utility substation/transformer storage
__(1) Wastewater lagoon
✓(2) Water well in use

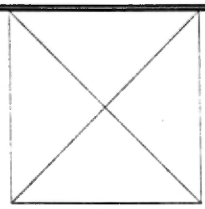
(5)

CHEMICALS USED OR STORED AT THIS SITE

Map Locator # and Source ID	Land Use	Associated Chemicals
8 - T	Auto Repair / Transmission Shop	Oil, gas, antifreeze, other automobile fluids

Additional site information

Sketch of Site (optional)



(6)

PWSID Name & ID # Montana City School Site ID Number 9

(Corresponds with map location number)

WHP Region Protection Inventory Person Rich Moran Gaetta Addo

WHP INVENTORY FORM

Site Name Ash Grove Quarry Owner Name Ash Grove Cement

Site Address _____

City Clancy Zip Code 59634 County Jefferson Phone _____

T/R/S/T T9N R3W Sec. 10 DC

Lat/Long N 46° 32' 40" W 111° 57' 48".

Property owner (if different from above)

Address _____ Phone _____

City _____ Zip Code _____

NATURE OF PROPERTY

__Service Business ✓Industrial/Mfg. __Retail Business __Agricultural

__Residential __Government __Other (describe on back)

LAND USES or POTENTIAL CONTAMINANT SOURCES

Place a check by the letter or number of each land use activity or potential source found at this site. Also place the number or letter and the map locator number (found in upper right corner of this sheet) on the base map to indicate the location of each important land use activity or potential contaminant source. List the chemicals used or stored and approximate volume on back of the form. Also include any other important or useful site information.

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__(N) Land application of waste site
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___(Q) Oil/gas well or exploration borehole
___ (R) Pipeline
___(S) Railroad right-of-way
___(T) Salvage yard
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___(V) Service Station dry well/sump
___(W) Stormwater drain/sump
___(X) Stream/river/lake/pond
___(Y) Underground storage tank
___(Z) Utility substation/transformer storage
___(1) Wastewater lagoon
✓(2) Water well in use

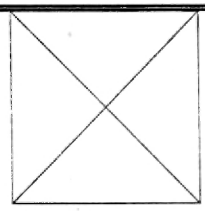
CHEMICALS USED OR STORED AT THIS SITE

Map Locator # and Source ID	Land Use	Associated Chemicals
9 - P	Limestone Quarry	Ammonium Nitrate Explosives

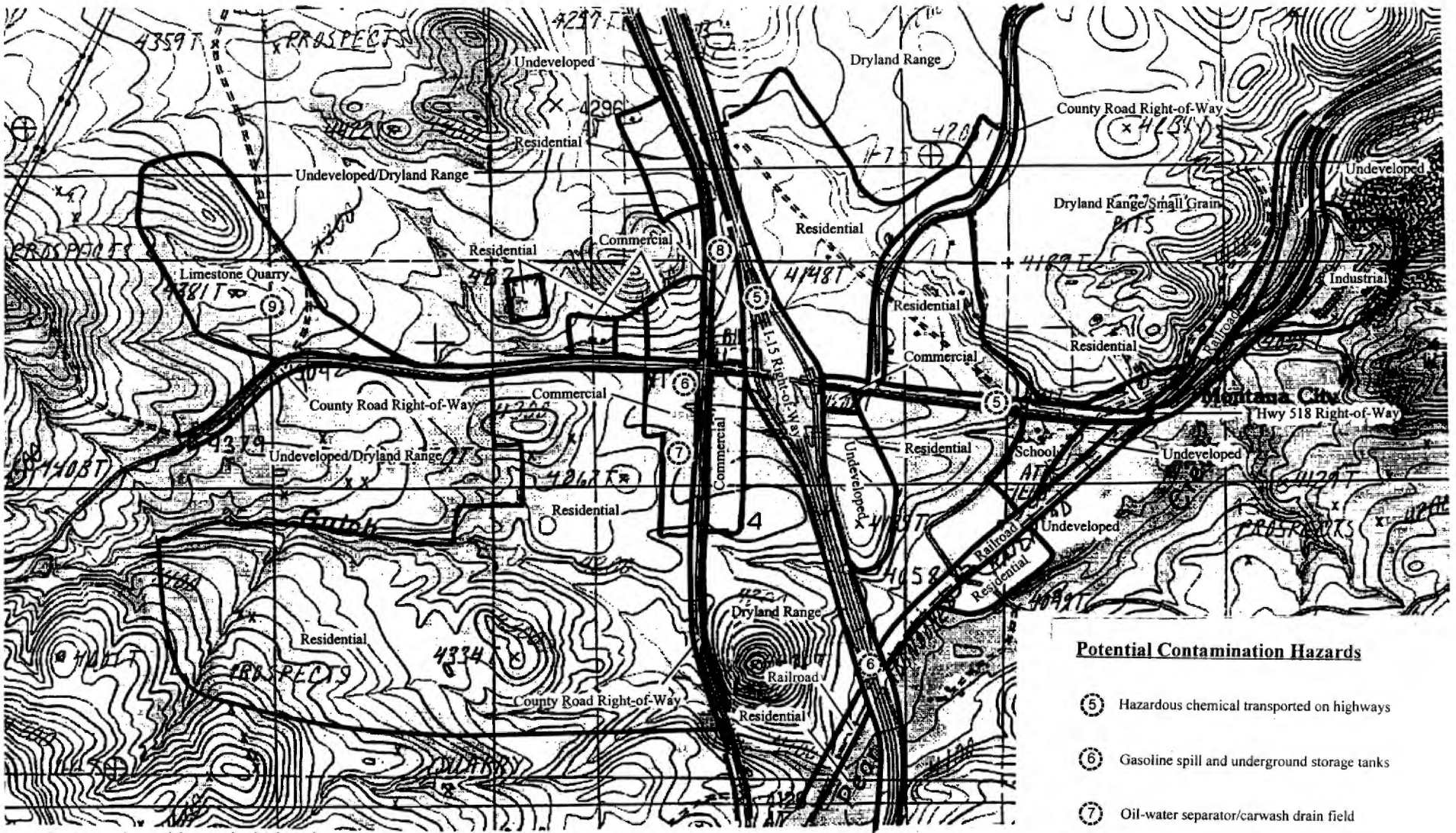
Additional site information

9 - P Explosives may be a source of nitrates

Sketch of Site (optional)



Appendix J
Land-Use Map



Land use and potential contamination hazard map.

Potential Contamination Hazards

(5) Hazardous chemical transported on highways

(6) Gasoline spill and underground storage tanks

(7) Oil-water separator/carwash drain field

(8) Wrecked auto storage

(9) Ammonium-nitrate explosives at quarry

Appendix K
Source-Water Protection Plan Summary

MONTANA CITY SCHOOL
WELLHEAD PROTECTION PLAN SUMMARY

The Montana City School along with the Montana Bureau of Mines and Geology and the Department of Environmental Quality has developed a Wellhead Protection Plan in an effort to understand and protect the availability and quality of the school's water supply. To develop the plan, information on local geology, hydrology, and land use was gathered and then used to define protection zones around the school's wells. Certain land uses within the protection areas are a concern because they have the potential to directly influence the ground water reaching the school's wells.

The Montana City School has two wells for drinking water. The wells pump from a limestone aquifer about 100 feet beneath the ground. Limestone produces good supplies of water because of the large, interconnected voids that are present. The Lewis and Clark Caverns are an example of how large the voids can be. Because water tends to move quickly through a limestone aquifer, little filtering occurs, and the aquifer is more vulnerable. Care must be taken to avoid contamination.

The protection areas around the school wells include:

1) a control zone (100-ft radius around each well),

2) a special protection region (a large area that includes the school grounds and extends over a mile uphill from the school), and

3) a protection region (the largest of the zones; it extends upgradient of the wells and generally follows topographic boundaries).

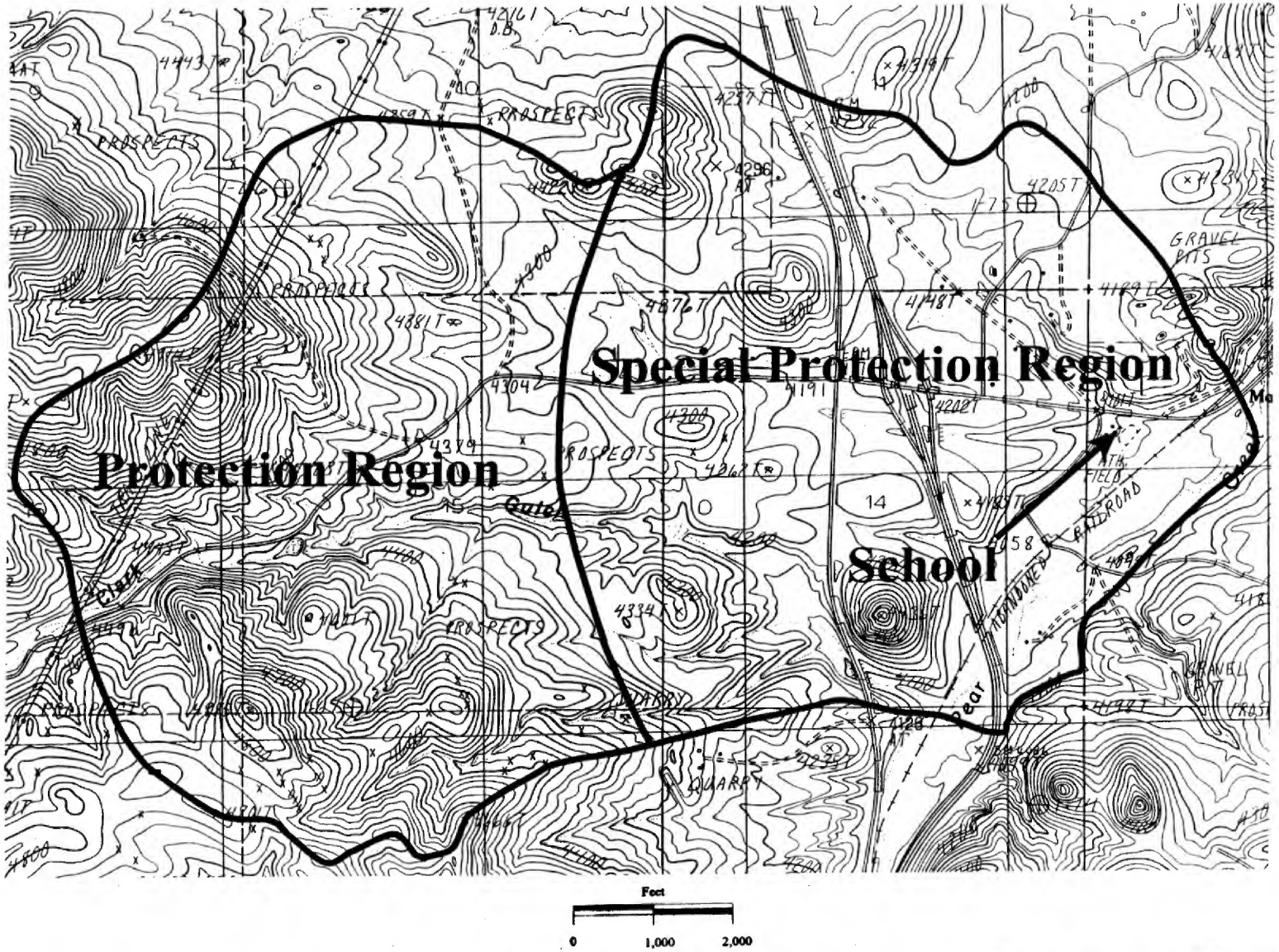
The special protection and protection regions are shown on the figure accompanying this handout.

Much of the land in the special protection and protection regions is used for residential housing. Residents use wells to supply water and septic systems with drain fields to treat their sewage. Residents are urged to be cautious when handling or applying chemicals such as gasoline, motor oil, antifreeze, paint thinner, herbicides and pesticides because accidental spills or improper disposal could contaminate the aquifer. Contact your county Health Department or the MDEQ – Pollution Prevention Bureau for advice on how to properly dispose of such items.

In addition to residential properties, numerous businesses are located in the special protection and protection areas. Several businesses handle gasoline or automotive wastes; they have been asked to notify the school in case of a leak or spill. The Ash Grove Plant operates a limestone quarry within the protection region; a copy of this summary has been supplied to the company. Other potential concerns identified by the school include transport of hazardous materials on Interstate 15 and use of oil-filled transformers by the power company.

Because of the rapid residential and commercial development in the Montana City area and its potential impact on the ground-water supply, the school has asked the Jefferson County Planning Board require a water-quality assessment accompany any preliminary subdivision proposals within the special protection area.

If interested, a copy of the Wellhead Protection Plan is available for review in the school library.



Delineation of the protection and special prtoection **regions for the Montana** City School wellhead protection area. The control regions for the wells are shown on the site plan in appendix B.

Appendix L
Summary of School Board Responsibilities

By accepting the Montana City School Source-Water Protection Plan, the Montana City School Board agrees to the following obligations:

1) Update the plan every five years and submit the updated version to the Montana Department of Environmental Quality (MDEQ) for recertification. Updating the plan involves assessing if new hydrogeologic data are available to better characterize the aquifer, reviewing land use, and inventorying potential contaminant hazards within the protection areas. The MDEQ will assist the school board with the update process.

2) Inspect the two wellheads annually to ensure that the caps on the wells are secure and undamaged.

3) Construct small (10 ft x 10 ft) fenced areas around the two wellheads to discourage tampering and to restrict access by dogs and other animals. If animal fecal material is found in the fenced area, it will be removed promptly using a shovel and will be disposed of properly.

4) Provide the school lawn-care contractor with a summary of this plan and notify the contractor that no fertilizer application is permitted within the fenced area and that no herbicides application is permitted within 100 ft of the wells. If weeds are present, they must be pulled by hand.

5) Post notices in the bathrooms, janitor's closets, and next to classroom sinks warning that no hazardous substances e.g. strong acids and bases, and organic solvents, are to be poured down the drains or toilets because it could impact the septic system and the aquifer. A contact person (Gary Newport) will be listed and will answer any questions that arise.

6) Provide the fire department with a summary of the plan and notify the department that a metal bin or some other appropriate container must be used during future fire extinguisher demonstrations so that flammable organic liquids are not spilled directly on the ground.

7) Provide the Montana City Store (Conoco Station), the Montana City Car Wash, and the Montana City Wrecking business owners with summaries of the plan and ask to be notified if any hazardous materials are spilled on their properties.

8) Post informational fliers on public bulletin boards to educate residents and business owners about the school's source-water protection area and to remind them hazardous chemical should be disposed of properly to avoid contamination of the local aquifer. The residents and businesses also will be notified that they can review a copy of the source-water protection plan upon request.

9) Provide the Jefferson County Commissioners, the Planning Board, and the Board of Adjustments with copies of the plan and request that the county require a water-quality assessment accompany any preliminary subdivision plats proposed within the special protection area. The school board also will request that the county require subdividers to design the subdivision to reasonably minimize potentially significant adverse impacts or prohibit non-residential subdivisions in the special protection region unless the hazards can be eliminated or overcome by approved construction techniques.

10) Request that the Montana office – U.S. EPA Region 8 conduct a preliminary Class V UIC permit needs assessment for all non-residential waste disposal facilities proposed or constructed within the special protection region.

11) Provide the Ash Grove Plant with a summary of the plan and notify the operator that the quarry is in the protection region.

12) Provide the Jefferson County DES coordinator with a copy of the plan and ask to be notified if a reportable spill occurs that might impact the local aquifer. If a spill does occur, the school board will contact MDEQ to investigate whether or not special action is required.

13) Inspect power transformers near the school annually and provide a copy of the source-water protection plan to the Montana Power Company.

14) Maintain sufficient funds to cover the cost of an emergency water supply and other emergency services.

Appendix M
Source-Water Protection Plan
Certification Checklist

DEPARTMENT OF ENVIRONMENTAL QUALITY January 2, 1997

WHPP CERTIFICATION CHECKLIST

In order to certify a Source-water protection Plan (WHPP), a community submits their plan to the Source-water protection Program of the Department of Environmental Quality (MDEQ) for review. The purpose of the review and certification is to verify that the WHPP meets the requirements of the Safe Drinking Water Act and the Montana Source-water protection Program (MWHPP). MDEQ staff will evaluate the plan to determine if it contains the information described in the MWHPP and as outlined by this checklist (see also MWHPP 2.1.7).

CHECKLIST INSTRUCTIONS:

This checklist is used to help determine that all information necessary for certification is included with your plan. It is purposefully quite detailed to help make sure that you've created a "working WHPP". The reader of your WHPP should be able to fully understand your entire water system including efforts to protect the source from identified threats based on the information you provide in the report.

An entry should be made for each item on the checklist. If an item is not checked "yes", include an explanation in the space provided on page 4 or on a separate sheet of paper. Pages five and six describe the analytical method of WHPA delineation and the technical information that should be included with your plan to support the delineation.

All the information making up your WHPP should be consolidated into one report or package for certification review. Your report should closely follow the outline of this checklist. Be sure to include copies of completed inventory forms and any other relevant attachments. Suggestions concerning report format such as section or chapter titles, map insertions, appendicies, etc., are included on the checklist within parentheses and marked with and double asteriks.

Department certification will be given in writing within 60 days of submittal if all necessary information is included and your WHPP meets the minimum criteria described in the Montana Source-water protection Plan (MWHPP). If the plan is incomplete or does not meet the requirements of the Safe Drinking Water Act and the Montana Source-water protection Program, MDEQ will notify the PWS of the deficiencies within 60 days of receiving the submittal. If it is resubmitted within 60 days, the community retains its original priority standing relative to other submittal. If it is resubmitted after 60 days, the community loses its original standing.

A. *(**Include the following in your report as the title page)*

NAME OF SYSTEM_____ PWSID #

OPERATOR NAME _____

WHP CONTACT _____
(PERSON TO RECEIVE WHP CORRESPONDENCE)

ADDRESS _____

_____

B. **(**Include this information in report as chapter entitled "Introduction")**

1. Is a description of the community included? yes

   Is the number of residents included? yes
   Is the geographic setting described? yes

   (Include a vicinity map showing the location of the PWS)**
   Is the PWS source and distribution system described? yes

   (Include a layout map of the PWS system showing mains, valves, wells, etc.)**
   Is a general description of the aquifer(s) included? yes
   Is a description of the factors influencing decisions included? yes

2. Is a list of key persons involved with WHPP development included? yes

3. Is a description of who will manage the WHPA included? yes

C. **(**Include this information in report as chapter entitled "Delineation")**

1. Is a base map showing existing wells, replacement wells, WHPA boundaries, and management regions included? yes

2. Has the WHPA been delineated using the appropriate method meeting the minimum criteria? yes

UNCONFINED AQUIFERS

Aquifer	Region	Method	Criteria - Minimum Value
Alluvial valley	1) Control 2) Special Protection 3) Protection	1) Fixed radius 2) Analytical method 3) Hydrogeologic mapping	1) Distance - 100 feet 2) Distance - 1,000 feet upgradient or 3 year TOT 3) Flow boundaries - physical and hydrologic
Bedrock	1) Control 2) Special Protection 3) Protection 4) Recharge	1) Fixed radius 2) Analytical method 3) Hydrogeologic mapping 4) Hydrogeologic mapping	1) Distance - 100 feet 2) TOT - 3 years or flow boundary 3) Flow boundaries - physical and hydrologic 4) Flow boundaries - physical and hydrologic

CONFINED AQUIFERS

Aquifer	Region	Method	Criteria - Minimum Value
Alluvial valley	1) Control 2) Protection 3) Recharge	1) Fixed radius 2) Analytical method 3) Hydrogeologic mapping	1) Distance - 100 feet 2) TOT - 5 years 3) Flow boundaries - physical and hydrologic
Bedrock	1) Control 2) Protection 3) Recharge	1) Fixed radius 2) Analytical method 3) Hydrogeologic mapping	1) Distance - 100 feet 2) TOT - 10 years 3) Flow boundaries - physical and hydrologic

3. Is documentation supporting the delineation method meeting the minimum criteria included? yes

(Include a hydrogeologic map, geologic map, or similar documentation, potentiometric map, and all model/equation input parameter details; see also page 5)**

4. Are the well construction details described? yes
   Are the source well logs included? yes

D. (**Include this information in report as chapter entitled "Inventory")

1. Have all potential contaminant sources been inventoried? yes
   Has the inventory method been described? yes
   Are potential contaminant sources shown on the base map? yes

(the source number on each individual inventory sheet should correspond to the same number at the correct location on the base map)**

Is the contaminant inventory included in proper format? yes

(append your WHP plan with copies of the inventory sheets)**

Have annual update schedule and method been described? yes

2. For organic chemical monitoring waiver application purposes, have you:
   - -delineated an area within a one mile radius of each well on a 7.5 minute USGS topographical map? yes
   - -identified **all** land uses within the one mile radius including road right-of-ways? yes
   - -included a completed MDHES Form #1 and #2 (blank forms available from MT Monitoring Waiver Program)? yes
   - -included a completed MDHES Form #3 for each identified land use within the area of investigation? yes

E. (**Include this information in your report as chapter entitled "Management")

1. Are WHP management methods described by region? yes
   Is schedule for management option implementation included? yes

2. Is a list of the persons who will manage the WHPA included by name and position title? yes
   Are the specific responsibilities under the WHPP of these persons described? yes

   (Include a list with names, positions, addresses, phone numbers, and specific WHP responsibilities)**

3. Are any necessary agreements or Memos of Understanding included? yes

4. Are goals of WHPP described? yes
   Is a schedule for evaluating success of implementation included? yes

F. (**Include this information in report as chapter entitled "Emergency Planning")

1. Is an emergency plan included? yes
   Is an emergency coordinator listed? yes
   Are the procedures to coordinate with other emergency response agencies included? yes
   Have procedures to communicate the emergency to users been? described? yes

2. Have written procedures been included which describe how to shut down or isolate a threatened or contaminated well? yes

3. Has a source of temporary or emergency water supply been described? yes
Is a transportation method for an emergency supply described? yes
Have disinfection methods been described? yes
Is a method to distribute emergency water described? Yes

4. Have procedures to decontaminate the distribution system been described? yes
Has a funding method for emergency water been described? yes

G. **(**Include this information in report as chapter entitled "Alternate Water Sources")**

1. Has a replacement well or wellfield been designated? yes

(if none needed, describe reasoning)**

Has a control region been delineated? yes

(Show on base map)**

Has a WHPA been for the replacement well(s)been delineated? yes

(Show on base map)**

(explanation section)

WHPA Delineation

Your source-water protection report should include a map delineating the WHPA by regions using the methods and meeting the minimum requirements described in the chart on page 2 of the checklist. Supporting technical information must also be included. This section of your plan is called the WHPA Delineation Package. It is described separately here as well as on the checklist because delineations may be provided by an outside source. As the person completing the WHP report you need to make sure all technical aspects of the delineation have been included. This portion of your report may be subjected to critical technical review hence good documentation is of the utmost importance. If your delineation is completed by an outside source, it should include all the information described here and may be inserted in your report as the chapter entitled "Delineation".

****

The base map should be a 7.5 minute quadrangle map, when available. The base map may be enlarged or reduced as dictated by the size of the WHPA. At least one delineation map shall be prepared for each PWS. A base map may show the WHPA for more than 1 source for each PWS. Other maps such as a community plat map or air photo may be used.

An alternate or replacement well WHPA or well field WHPA should be included when deemed necessary due to predicted growth or diminishing supply. The recommended alternate or replacement well site(s) may be delineated on the base map using a 2500-foot fixed radius or as provided in the chart below.

The WHPA Delineation Package should include the following:

(1) a description of the geologic and hydrogeologic conditions relevant to each source including lithologies of aquifers, lateral extent of aquifers, thickness of aquifer, vertical succession of units, structural trends affecting aquifers, and local topography;

(attach hydrogeologic map, geologic map, copies of geologic or hydrogeologic investigations, etc.)**

(2) a description of the local ground water flow system and water use;

(include copy hydrogeologic investigations, potentiometric map, etc.)**

(3) a description of the pump(s), pump cycles, pumping rates, and specific capacity upon which the WHPA delineation is based;

(include copies of pumping records, pump test results, record of water system user numbers, etc.)**

(4) a description of how the items described in (1), (2), and (3) above affect the WHPA delineation including considerations of hydraulic conductivity, porosity, hydraulic gradient, velocity, and specific yield, as appropriate;

(include a description of the origins of model or equation input parameters)**

(5) a record of PWS owner and/or operator contact and justification for decision not to delineate a replacement or alternate well WHPA

(6) a description of site specific limiting or adjustment factors;

(7) a description of a confidence factor relevant to the WHPA delineation; and,

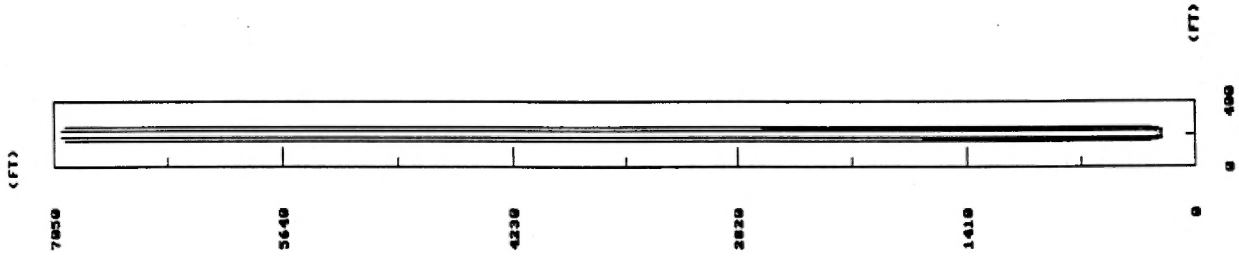
(8) a statement as to whether or not the source appears to be in hydraulic connection with a surface water.

(attach a completed "preliminary assessment" form from GWUDISW program)**

Special Protection Region Delineation using the Analytical Method

The WHPA is divided into 3 regions for ease in management. The Special Protection Region coincides with the area that contributes water to a pumping well. The Special Protection Region shall be delineated using an analytical method to determine how the pumping well modifies regional groundwater flow. The Special Protection Region shall extend a distance of at least 1,000 feet upgradient from the well for alluvial aquifers and leaky confined aquifers, or a time of travel (TOT) equal to three years, or to a flow boundary, whichever is less.

The Special Protection Region shall be calculated using the forms of the uniform flow equation shown below to determine the distance to the down gradient stagnation point and boundary limits.



INSERT UNIFORM FLOW ANALYTICAL MODEL DIAGRAM HERE (TODD, 1980)

The Time of Travel (TOT) distance (X) shall be calculated using the formula:
X=Kit/n

where: X= distance from well to TOT limit in feet
K= hydraulic conductivity in feet/day
i= hydraulic gradient
t= TOT limit in days
n= aquifer porosity

PWSID Name & ID #_____ Site ID Number_____.

(Corresponds with map location number)

WHP Region _____ Inventory Person_____

WHP INVENTORY FORM

Site Name_____Owner Name_____

Site Address _____

City_____ Zip Code _____ County_____Phone _____

T/R/S/T _____

Lat/Long_____.

Property owner (if different from above)

Address_____ Phone _____

City_____Zip Code _____ _____

NATURE OF PROPERTY

__Service Business __Industrial/Mfg. __Retail Business __Agricultural

__Residential __Government __Other (describe on back)

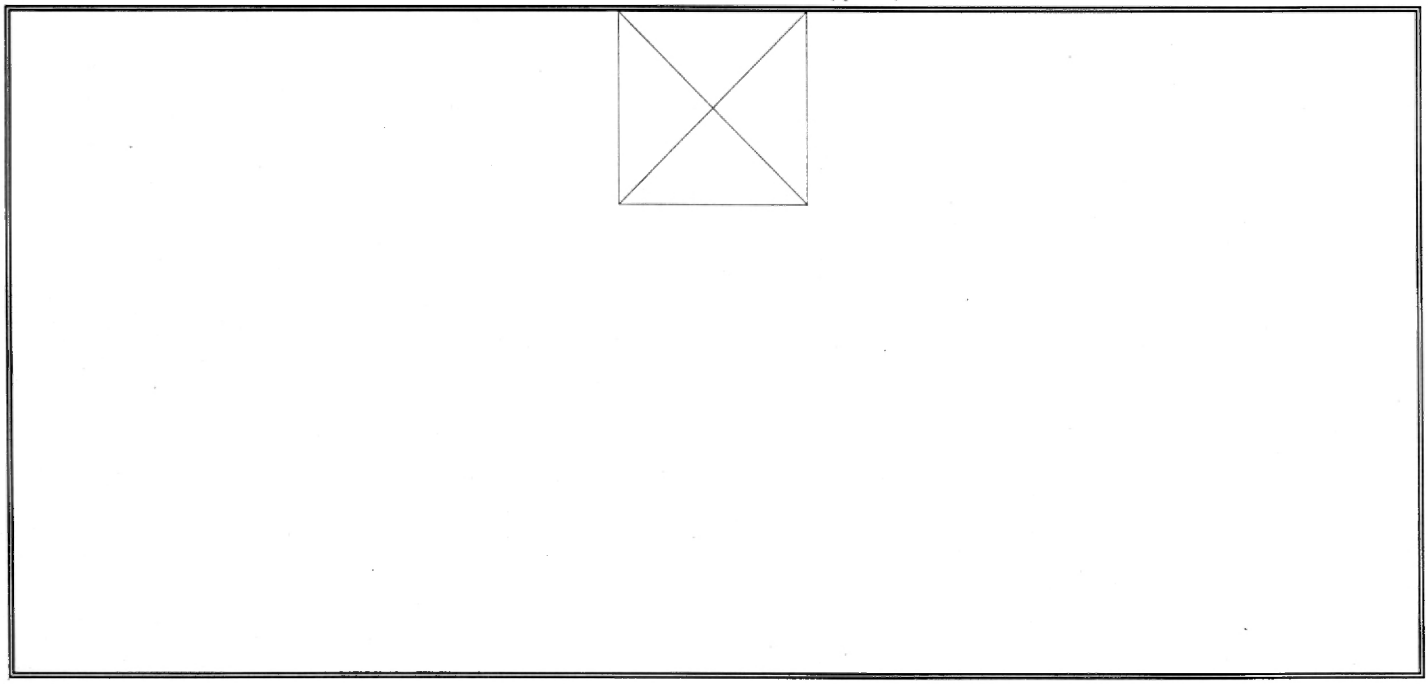
LAND USES or POTENTIAL CONTAMINANT SOURCES

Place a check by the letter or number of each land use activity or potential source found at this site. Also place the number or letter and the map locator number (found in upper right corner of this sheet) on the base map to indicate the location of each important land use activity or potential contaminant source. List the chemicals used or stored and approximate volume on back of the form. Also include any other important or useful site information.

__(A) Ag chemical use site
__(B) Brine pit
__(C) Chemical storage
__(D) Chemigation well
__(E) Chemical mixing/loading site
__(F) Drain ditch/canal
__(G) Feedlot
__(H) Grain storage
__(I) Greenhouse/nursery/orchard
__(J) Highway/county road
__(F) Injection well
__(L) Irrigated land
__(M) Irrigation canal
__(N) Land application of waste site
__(O) Landfill/dump
___(P) Mine/quarry/gravel pit
___(Q) Oil/gas well or exploration borehole
___ (R) Pipeline
___(S) Railroad right-of-way
___(T) Salvage yard
___(U) Septic tank
___(V) Service Station dry well/sump
___(W) Stormwater drain/sump
___(X) Stream/river/lake/pond
___(Y) Underground storage tank
___(Z) Utility substation/transformer storage
___(1) Wastewater lagoon
___(2) Water well in use

CHEMICALS USED OR STORED AT THIS SITE

Map Locator # and Source ID	Land Use	Associated Chemicals

Additional site information

Sketch of Site (optional)