Source Water Delineation and Assessment Report

11/99

City of Three Forks

Three Forks Water Department

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Montana Department of Environmental Quality

Source Water Protection

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List of Acronyms

BMP - Best Management Practices

CAFO - Confined Animal Feeding Operation

CECRA - Comprehensive Environmental Cleanup and Responsibility Act

CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act

DEQ – Department of Environmental Quality (Montana)

EPA – Environmental Protection Agency (United States)

LUST - Leaking Underground Storage Tank

MCL - Maximum Contaminant Level

MBMG-GWIC - Montana Bureau of Mines and Geology – Ground Water Information Center

MPDES - Montana Pollutant Discharge Elimination System

NPDES - National Pollutant Discharge Elimination System

PWS - Public Water System.

RCRA - Resource Conservation and Recovery Act

SMCL - Secondary Maximum Contaminant Levels

SWDAR - Source Water Delineation and Assessment Report.

SWPP - Source Water Protection Plan

SWL - Static Water Level

SOC - Synthetic Organic Compounds

TMDL - Total Maximum Daily Load

USGS – United States Geological Survey

UST - Underground Storage Tank

VOC - Volatile Organic Compounds

See glossary at end of text for definitions of acronyms and other terms used in this report

1.0 INTRODUCTION

The Safe Drinking Water Act (SDWA) Amendments of 1996 require states to develop and implement Source Water Assessment Programs (SWAP) to analyze existing and potential threats to the quality of the public drinking water supplies throughout the state. The Montana SWAP was formally approved by the US Environmental Protection Agency (EPA) in November 1999. The Montana SWAP was developed from the former Wellhead Protection Program, but includes surface water sources and requires a more rigorous inventory of potential contaminant sources. For communities that have already developed wellhead protection plans, SWAP revises these plans to meet the expanded requirements. DEQ also works with other groups such as Montana Rural Water Systems, Inc., and Midwest Assistance Programs to implement the program.

SWAP addresses only public water systems (PWS) regulated according to the Federal Safe Drinking Water Act. A public water supply system is defined, according to Federal and Montana regulations, as a system that supplies water for human consumption. A public water supply system has at least 15 service connections or regularly provides water to at least 25 persons daily for a minimum of 60 days in a calendar year. There are three types of public water supply systems:

- Community water systems provide water on a year-round basis, and have a minimum of 15 service connections or regularly serve at least 25 residents. In addition to incorporated towns, community systems may serve smaller areas such as housing subdivisions or trailer courts.
- Non-transient non-community systems do not serve communities, but provide water regularly to a minimum of 25 of the same people for at least 6 months of a year. These systems serve public buildings such as schools and hospitals, where people are employed but do not reside.
- Transient non-community systems do not serve communities, and do not regularly serve a minimum of 25 of the same people for at least 6 months of the year. These systems are usually seasonal, and are located in areas such as campgrounds and parks.

Source water protection is a common sense approach to guarding public health by protecting drinking water supplies. In the past, water suppliers have used most of their resources to treat water from rivers, lakes, and underground sources before supplying it to the public as drinking water. Source water protection means preventing contamination and reducing the need for treatment of drinking water supplies. Source water protection also means taking positive steps to manage potential sources of contaminants and contingency planning for the future by determining alternate sources of drinking water. Protecting source water is an active step towards safe drinking water; a source water protection program (along with treatment, if necessary) is important for a community's drinking water supply. A community may decide to develop a source water protection program based on the results of a source water assessment, which includes the delineation of the area to be protected and an inventory of the potential contaminants within that area.

The Montana Source Water Protection Program is intended to be a practical and cost-effective approach to help public drinking water supplies protect their water source from contamination. The Montana Source Water Protection Program is responsible for completing delineation and assessment reports for all public water supplies in Montana. The Source Water Delineation and Assessment Report (SWDAR) compiles the appropriate data and other technical information about an area to allow communities to develop source water protection plans. Delineation is a process whereby areas that contribute water to aquifers or surface waters used for drinking water, called source water protection areas, are identified on a map. Geologic and hydrologic conditions are evaluated in order to delineate source water protection areas. Assessment involves identifying potential contaminant sources in delineated source water protection areas, and evaluating the potential for contamination of drinking water from these sources under “worst-case” conditions such as a flood, fire or human error. Although voluntary, source water protection plans are the ultimate focus of source water delineation and assessment. This delineation and assessment report is written to encourage and facilitate the Three Forks area communities and public water supply operators develop source water protection plans that meets their specific needs.

Scope and Purpose

This report presents the source water delineation and assessments for the municipal public water supply for the Town of Three Forks in northwestern Gallatin County, Montana. This report is intended to meet the technical requirements for the completion of the delineation and assessment report for this PWS, as required by the Montana Source Water Protection Program (DEQ, 1999) and the federal Safe Drinking Water Act (SDWA) Amendments of 1996 (P.L. 104-182).

This report addresses the Three Forks area with a watershed-type approach, recognizing that potential contaminant sources may threaten more than one public water supply. The report presents all of the information for the Three Forks area, and will be used as a basis to develop SWDARs for additional public water supply sources in the area that have overlapping source water protection areas with similar threats.

Limitations

This report was prepared to assess threats to the Three Forks public water supply and is based on published information, and information obtained from local residents familiar with the community. The terms “drinking water supply” or “drinking water source” refer specifically to sources for regulated public water supplies, and not any other type of water supply. The inventory of potential contaminant sources focuses on the management areas delineated for the public water supplies in this report. As a result, other potential sources of contamination to surface and ground water in the area may not be identified.

The term “contaminant” is used in this report to refer to any chemical or biologic constituent in water that are listed as regulated under state and federal regulations. Water constituents are generally regulated based on health effects that may occur when ingested at certain levels. Water quality standards are based on maximum contaminant level goals (MCLGs) for a compound, which represents a concentration where adverse health effects are not considered likely to occur when ingested. However, as natural waters contain many dissolved constituents and MCLGs are frequently not attainable using economically viable water treatment alternatives, maximum concentration levels (MCLs) are used. MCLs represent concentrations that may result in chronic or acute health problems when ingested. MCLs are based on the relative risk, or likelihood that health problems may occur, and economics associated with a treatment technology for a specific constituent of water. In some cases, sources for constituents with Secondary MCLs are also evaluated in this report. Secondary MCLs are non-regulatory guidelines regarding cosmetic effects (such as tooth or skin discoloration) or aesthetic effects (such as taste, odor, or color) of drinking water.

2.0 BACKGROUND

The Community
The City of Three Forks is located in the northwestern part of Gallatin County, in the combined valley located at the confluence of the northern ends of the Jefferson and Madison River Valleys. Three Forks has a population estimated at 1,528 people in 1998. The local economy relies on agriculture, small businesses, and a limited amount of industry in the area. Recent urban growth in the Gallatin Valley is reflected in an increasing population and number of residential developments in the Three Forks area. Many new residents live in Three Forks but work in Bozeman and other area locations. The major highways through the area include US Interstate 90, present north of town connecting Three Forks with Bozeman to the east and Butte to the west. US Highway 287 runs west of town as a route to Helena to the north and West Yellowstone to the south. Montana Highway 2 runs through town where it joins with US 287 west of town for several miles, before splitting to the west.

Wastewater in Three Forks is collected with a sanitary sewer system, that pumps to treatment lagoons located east of town (Figure 2). The wastewater lagoons discharge into the Madison River northeast of town.

Geographic setting
Three Forks is located at approximately 45.8932°North latitude and 111.5513°West longitude, in Sections 25 and 36 of Township 2 North, Range 1 East. The area is a valley setting, away from any major mountain ranges located in all directions away from town. The Camp Creek Hills are located west of Three Forks, on the opposite side of the Madison River. A series of hills separates the Jefferson and Madison River valleys south of Three Forks. Three Forks is located between the Madison River (USGS HUC#10020007) to the east and the Jefferson River (USGS HUC#10020005) to the west, just south of their confluence with the Gallatin River (USGS HUC#10020008). These rivers combine to form the Missouri River (USGS HUC#10030101 – upper Missouri River), which flows north away from the area. The elevation of the town is approximately 4,030 feet above sea level. The elevation of the Camp Creek Hills due east of the Madison River from Three Forks is approximately 4,450 feet above sea level. The elevation of the hills south of Three Forks rise to over 5,000 feet approximately nine miles south of town. The elevations of the mountain areas surrounding the valleys are as high as 11,000 feet above sea level. Surface drainage in Three Forks generally flows north towards the area where the Jefferson and Madison Rivers meet. Several irrigation ditches are present in the area.

Figure 1 – Three Forks Location

The climate in the area is typical for southwestern Montana. Weather data is reported for Trident, located several miles north of Three Forks on the Missouri River. Trident receives an average of 12.31 inches of precipitation annually, with the wettest months in May and June averaging 2.13 and 2.40 inches. The driest months are December and February, with respective averages of 0.31 and 0.28 inches per month. Trident receives an average total of 30.4 inches of snowfall per year. The temperature ranges from an average high of 87.2°F in July (minimum July average of 52.0°F) to an average of 34.1°F in January (minimum January average of 11.2°F).

General description of the Source Water
The Three Forks PWS currently obtains water from wells installed into Tertiary basin fill sediments beneath the alluvium of the Jefferson and Madison Rivers. The alluvium in this area is less than 50 feet thick. The source aquifer(s) are coarse-grained beds in the Tertiary sediments, separated by thick deposits of shales and other fine-grained rocks. Based on the occurrence of the laterally extensive clay-rich deposits in the Tertiary

sediments, the aquifer for the Three Forks PWS is interpreted as confined. Based on this information, these wells are informally referred to as the deep Tertiary wells in this report. The wells are located in the northern end of the Jefferson River Valley before it combines with the Madison River Valley into a single valley. The PWS wells are installed with intake depths ranging from 110 feet to 300 feet below the ground surface. Based on the geologic setting, ground water in the Tertiary beds is interpreted to flow in a general northward direction; however detailed information on ground water flow in the deeper Tertiary beds has not been assembled.

Figure 2 – Madison River Watershed

Prior to developing the Tertiary basin fill as a water source, the Three Forks PWS utilized wells east of town adjacent to the Madison River for their PWS source. This water source is derived from shallow alluvium in the Madison River Valley, with ground water in communication with surface water and flowing generally parallel to the river. The use of these wells was discontinued due to the elevated concentrations of arsenic in the water. During the winter and spring of 2001, a pilot treatment system was evaluated for use at these wells to remove arsenic from the water. At the time of preparation of this report (May 2001), Three Forks plans to change back to using these wells as the primary water source for the community PWS. These wells are informally referred to as the Madison River wells in this report.

The location of the Madison River watershed relative to Gallatin County, and the confluence of the Madison, Jefferson and Gallatin River watersheds is shown in Figure 2. The headwaters of the Gallatin and Madison Rivers in Yellowstone National Park in Wyoming is not depicted.

The Public Water Supply

The Three Forks PWS serves an estimated resident population of 1,800 through 731 active service connections. The system has five active source wells located throughout the town as shown in Figure 3. A copy of the most recent sanitary survey for the system is included in Appendix A. The well logs for the PWS wells are included in Appendix B. The water does not receive any treatment prior to distribution to the consumers.

The following three deep Tertiary wells are currently (May 2001) the primary producing wells for the system.

- ***West Ash Street Well 4*** (Source 004), was installed in 1955 to a depth of 158 feet and has a yield of 260 gpm, with a pump producing up to 115 gpm.
- ***4th Ave. E. Well 5*** (Source 005), was installed in 1964 to a depth of 320 feet and has a yield of 1500 gpm, with a pump producing at 200 gpm.
- ***Headwater Lot 5 Well 6*** (Source 006), was installed in 1986 to a depth of 160 feet. The yield is not listed, although a pump in the well has a capacity of 40 gpm.

The following two deep Tertiary wells were disconnected from the system, and currently serve as backup wells.

- ***Well 8*** (Source 008), was installed in 1994 to a depth of 254 feet and has a yield of 192 gpm with a pump capable of producing at 150 gpm.
- ***Well 9*** (Source 009), was installed in 1994 to a depth of 220 feet and has a yield of 155 gpm with a pump capable of producing at 80 gpm.

Water from the wells feeds the distribution system maintaining pressure, with excess water flowing into the 1,000,000-gallon storage tank located on the hill southeast of town.

Figure 3 – PWS Well Locations

The initial PWS wells, the two Madison River wells (Source 002 and Source 003), are located adjacent to the

Madison River east of town. These wells are currently planned for integration back into the PWS as the primary source. The two wells were installed during the early 1930s. There is currently no information available on the depth and construction criteria of these wells. However, they are known to be installed into alluvium, have a relatively high yield, and draw water with elevated levels of arsenic.

Water Quality

Every PWS is required to perform monitoring for contamination to their water supply. The monitoring parameters typically include coliforms (as an indicator of pathogenic organisms), nitrates, metals and multiple chemicals. The monitoring schedule depends on many factors such as the size of the system, the water source for the PWS, the number of sources (e.g. wells), and land use in the vicinity. A specific monitoring program is designed for each PWS that follows the general protocols for operation of a PWS defined by DEQ following the guidelines originally established in the federal Safe Drinking Water Act. A review of the DEQ PWS database of monitoring results for the Three Forks PWS indicates no violations of any drinking water quality standards. Table 1 lists the concentrations of arsenic and common constituents of ground water in the Three Forks area. This data is considered to represent background concentrations for ground water in the Three Forks area away from the Madison River valley.

Both the Madison River and shallow ground water in the Madison River Valley have elevated concentrations of arsenic (Sonderegger and Sholes, 1989). Leakage from irrigation canals using Madison River water has resulted in elevated arsenic levels in shallow ground water in other areas. Several studies have evaluated the source of the arsenic in both surface and ground waters (see Table 2 in Chapter 3). The results of these studies attribute the source of the arsenic to natural conditions in the headwaters of the Madison River in Yellowstone National Park. Due to the arsenic problem, Three Forks abandoned the use of the two Madison River wells installed near the Madison River as the water source for the PWS.

The studies of Sonderegger and Sholes (1989) indicate that the typical concentration of arsenic in the Madison River is approximately 200 μg/L when it leaves Yellowstone National Park. This arsenic concentration is diluted to approximately 40 to 80 μg/L in the lower Madison River valley. The arsenic concentration in shallow ground water in the valley frequently has concentrations exceeding 100 μg/L. This includes wells in the Madison River valley within two miles of Three Forks (Tuck et. al., 1997). The MCL for arsenic is currently 50 μg/L; however, the EPA has proposed lowering the limit to as low as 5 μg/L. At the time of preparation of this report, the legal status of lowering of the MCL is still under debate by the federal government.

The information in Table 1 includes data on the ground water quality within the Three Forks area and the lower end of the Jefferson River Valley. This data indicates that the highest detected concentration of arsenic in the Three Forks area is 7.2 μg/L detected at a single location northeast of town. The remaining data indicate concentrations of arsenic less than 5 μg/L. Based on this data, the ground water system in Three Forks in the Jefferson River Valley is not in communication, or does not mix with, with either water from the Madison River or ground water in the Madison River alluvial system.

A review of the arsenic data for the Three Forks PWS system reflects concentrations that meet current standards but would not meet the proposed 5 μg/L standard. The concentration of arsenic typically does not exceed 20 μg/L; however, a high of 93 μg/L was detected in January 1978. This data suggest some limited effects of the use of irrigation water from the Madison River to the Tertiary source aquifer for the Three Forks PWS. As a result of the proposed rule change, Three Forks is currently evaluating arsenic treatment technology for the Madison River wells. Utilization of this treatment technology has resulted in a plan to change the primary water source from the deep Tertiary wells to the Madison River wells located. When the water source for the Three Forks PWS is changed, this report will be updated and revised accordingly.

The water obtained in the Three Forks PWS deep Tertiary wells is interpreted to not be in direct communication with, or mix with, shallow ground water in the Three Forks area. This interpretation is based on the thick clay sequences present in the Tertiary strata acting as the confining layer for the aquifer. The relationship of the different rock types in the Tertiary beds is discussed in detail in Chapter 3. The data listed in Table 1 does not show any distinct chemical differences between the two types of water. However, the data is biased towards shallow ground water with only limited data on deep ground water in the area. The arsenic data suggests that the ground water system is also not in direct communication with water from the Madison River system. For approximate locations of the sampled wells, consult Figure 2 which shows the area in Township 2 N, Range 1 E where the sampled wells are located.

Table 1 – Background Ground Water Quality in Three Forks (Township 2 N, Range 1 E)

Sample Date	Location (section)	Well Depth Ft	Cond µS/cm	pH SU	Temp °C	As µg/L	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	HCO_3 mg/L	SO_4 Mg/L	Cl Mg/L	F mg/L	SiO_2 mg/L	NO_3 As N Mg/L
Quaternary Alluvium Wells																	
7/2/84	25ab	22	304	--	10.0	7.2	280	54	15	17	3.6	238	36	6.0	0.4	28	0.02
11/16/83	25bdbb	50	494	--	--	1.8	343	69	15	24	6.0	245	66	14	0.3	28	0.07
7/2/84	26aa	30	425	--	9.0	2.6	442	89	22	30	3.4	321	91	19	0.4	28	0.09
12/28/83	26dcdc	--	--	--	--	2.0	542	100	27	43	4.1	334	150	21	0.2	23	0.47
11/9/83	27bccb	50	1,110	--	--	2.4	880	140	30	100	4.6	373	260	50	0.5	25	18
11/10/83	27cbd	20	533	--	--	2.1	325	66	19	20	3.2	269	52	8.7	0.3	22	0.03
11/9/83	34aaad	15	595	--	--	1.6	379	76	19	26	3.5	281	77	14	0.4	23	0.09
11/16/83	34aaba		858	--	11.5	1.1	549	100	26	48	3.8	346	150	27	0.5	24	0.12
11/11/83	35baba	27	1,630	--	--	0.4	1,250	81	11	320	9.2	245	560	130	0.5	17	0.05
11/11/83	35baba	21	771	--	--	3.2	501	94	24	43	3.7	332	120	26	0.3	24	0.01
11/8/83	36bcdd	30	811	--	--	2.8	551	97	26	57	5.8	376	120	30	0.4	26	0.01
11/9/83	36cba	33	1,300	--	--	2.3	893	140	36	120	5.5	458	280	69	0.3	24	0.01
Tertiary Wells																	
11/9/83	25aacc	89	479	--	10.5	4.8	335	54	10	26	12	210	55	12	0.3	60	0.01
11/9/83	36bcbd	266	1,280	--	10.5	2.0	857	6.5	0.8	300	8.8	421	250	55	0.5	25	0.33

Source wells listed are all in from Township 2 North, Range 1 East, in the Three Forks Town area
Data from Tuck, Dutton and Nimick (1997).

3.0 DELINEATION

The source water protection area, the land area that contributes water to the Three Forks PWS, is identified in this chapter. For all of the PWS wells, three management areas are identified within the source water protection area; the control zone, inventory region, and recharge region. For the Madison River wells, a surface water buffer zone is also delineated around the Madison River since shallow ground water is in communication with the river. The control zone, also known as the exclusion zone, is an area at least 100-foot radius around the well. The inventory region for the deep Tertiary wells in a confined aquifer in the Tertiary beds represents an area of a 1,000 feet radius around each wellhead. The inventory region for the Madison River wells in an unconfined aquifer adjacent to the Madison River are delineated based on a three year time of travel distance for ground water in the shallow alluvium. The recharge region for the wells represents the area where the aquifer(s) are replenished. The surface water buffer zone represents an area of a one-half mile wide buffer on each side of a surface water body, for a distance of ten miles upstream from the PWS source.

Hydrogeologic Conditions

The information presented in this section is based predominantly on the detailed assessment of the geology of the area presented in Robinson (1963) and updated by Sonderegger and Sholes (1989). A geologic map of the region showing the major units is depicted in Figure 4. More detailed geologic information, including a map and a structural cross section are included in Appendix C. The Tertiary sediments that are the source aquifer for several of the Three Forks PWS wells represent a thick sequence of material that fills both the Gallatin and Madison River Valleys as a single structural basin, the Three Forks Basin. Quaternary alluvium is present in the river valleys superimposed over the Tertiary sediments. The Tertiary strata fill the Three Forks basin as a continuous sequence, with pre-Tertiary bedrock present at the basin boundaries (Figure 4). The Camp Creek Hills that separate the two valleys represent part of the surface of the modern drainage system incised into the older basin fill material, the Tertiary beds. The Tertiary beds have an estimated thickness up to 5,000 feet in the central part of the Basin near Belgrade, but the thickness near Three Forks is estimated at approximately 2,500 feet (Robinson, 1963; Davis et. al., 1965). The drainage system and the hills separating them do not reflect the deeper bedrock geology of the area. Bedrock is exposed in the hills across the Jefferson River from Three Forks, and the contact zone of the bedrock with the Tertiary basin fill strata may provide a conduit for communication of shallow surface water with deeper waters. The nature of the faulting and the contact between the Tertiary beds and the older bedrock at this location is not well understood at this time. The older bedrock is exposed at greater distances to the north, south and east of Three Forks as shown in Figure 4.

Quaternary alluvium is typically associated with the modern rivers in their valleys. The Madison River Valley located east of Three Forks is approximately 15 miles long where it flows from bedrock to over the Tertiary sediments in the Three Forks Basin. Within this valley, the alluvium comprises an upper coarse grained sand, gravel and cobble unit overlying a finer grained sand layer. The practical definition used to separate the alluvium from the Tertiary sediments is the change in lithology from coarse-grained material to finer-grained, clay-rich non water bearing material. The upper coarse-grained facies is approximately 100 feet thick in the southern part of this valley, thinning to approximately 25 feet thick in the north where the valley joins with the Jefferson and Gallatin River valleys. The shallow alluvial aquifer has boundaries at the walls of the valley, adjacent to the Tertiary strata or older bedrock, where alluvium is not present.

Ground water in the Madison River valley flows to the north, parallel to the Madison River, in the unconfined alluvial aquifer. The depth to ground water varies from approximately 30 to 40 feet below the ground surface in the southern part of the valley, to approximately 5 feet below ground surface in the north. A generalized map of the water table surface in the alluvium in the Madison River valley is included in Figure 4. The shallow alluvial aquifer is in communication with the Madison River, with flow rates and water elevation levels related to the

Figure 4 – Generalized Geologic Map of Three Forks Area

flow in the river regulated by the dam on Ennis Lake to the south. The aquifer is recharged by stream loss from the Madison River as it enters this portion of the valley, and from direct infiltration of precipitation within the valley. Ground water from the valley discharges into the combined valleys of the Jefferson, Madison and Gallatin Rivers at the headwaters of the Missouri River. This conclusion is supported by the piezometric contour across the valley, with the ground water flow from the Madison valley alluvial aquifer flowing outwards into the larger valley after they combine (Sonderegger and Sholes, 1989). This conclusion for the Three Forks area is supported by a hydrogeologic investigation at the Montana Department of Transportation (MDT) facility located north of Three Forks. This study noted that ground water flow is primarily to the west across the site – away from the Madison River and towards the Jefferson River. The classification of this aquifer system as unconfined and in communication with surface water results in the source having a ***high*** source water susceptibility to contamination.

The Tertiary beds represent deposits of wind blown (eolian) sediments, river (fluvial) sediments, and lacustrine sediments with large quantities of volcanic materials such as tuffs intermixed with some material eroded from older rocks in the area. These deposits are generally semi-consolidated as rocks, but are not as hard or coherent as Pre-Tertiary bedrock located outside of the valley (e.g. west of the Jefferson River). Robinson (1963) identified four Tertiary Formations in the Three Forks area which are differentiated predominantly on clay content and color. The two uppermost units with water bearing intervals developed as source aquifers in the area are summarized in the following discussion. The youngest unit nearest the surface are described first.

- ***Dunbar Creek Formation*** **–** The uppermost unit is exposed in the cliffs along the Madison River Valley southeast of Three Forks (Figure 3). The unit is a yellowish-white siltstone, with some sandstones and a few gravel beds. This lower contact of this formation is gradational with the under
- ***Climbing Arrow Formation*** **–** The upper part of this formation is exposed in the hills to the southwest of Three Forks, and is present under the Quaternary gravels in other areas of the hills (Figure 4). This formation comprises thick clay-rich mudstones (montmorillonitic clays – volcanic ash), tuffaceous siltstones and coarse sandstones. The sandstones within this unit represent the aquifer beds for the Three Forks PWS. The upper part of the formation has a higher concentration of coarse-grained deposits and is considered to have more potential productivity as an aquifer for source water than other Tertiary units. The formation can be identified during drilling based on the first occurrence of olive-green mudstones.

The source aquifer for the deep Tertiary PWS wells is characterized as semi-consolidated valley fill sediments under confined conditions. The extensive clay-rich lenses that separate coarser grained water-bearing layers within the Tertiary sediments provide a natural protective barrier to contamination from the surface (see well logs in Appendix B). Based on this criteria, the aquifer is classified as having a ***low*** source water sensitivity to contamination. Appendix C includes additional well logs obtained from the MBMG-GWIC for the area.

The intake for the deep Tertiary PWS wells are located at depths ranging from 111 feet below ground surface to 320 feet (Table 3). The well logs for the area (Appendix C) indicate that the base of shallow well in recent alluvium are at an approximate depth of 30 feet, with the majority of these wells completed on top of a blue clay or shale. The logs show a predominance of clay-rich facies to between depths of 40 to 90 feet. This unit represents the uppermost confining unit in the Three Forks area. The wells completed at greater depths show more clay rich units separating the coarse-grained water bearing intervals.

When water quality testing was initiated during the 1970s, water obtained for the Three Forks PWS from the

Madison River wells did not meet water quality standards. This reflects arsenic in shallow water of the Madison River alluvium, which resulted in the installation of deep Tertiary PWS wells in the Jefferson River Valley, away from the Madison River system. Problems have also been encountered with water from the deeper source aquifer with high dissolved solids, iron, sulfates and hardness resulting in the two newer wells (Wells 8 and 9) being discontinued from the PWS system. These wells currently represent emergency backup wells for the system.

Water quality naturally varies in all aquifers, reflecting the chemistry of the minerals included in the rocks that are in contact with the water. Under certain circumstances, water quality may change rapidly over short distances within the same aquifer. This effect is much more common in confined aquifers in sedimentary rocks, such as the Tertiary strata in the Three Forks area, which are located away from their recharge areas. These types of aquifers usually have very slow ground water flow rates. This allows the water to remain in contact with specific portions of the aquifer over a longer period of time. The increased contact time allows larger amounts of localized deposits of naturally occurring sedimentary minerals such as gypsum to dissolve, which can result in high concentrations of sulfates and total dissolved solids. In summary, pockets of poor water may naturally occur in certain areas within the aquifer, even though the aquifer in general is a good source for water on a regional basis. While this ground water may not meet some quality standards related to aesthetics, the classification of the deep Tertiary strata water source as having a low sensitivity to contamination indicates that the water source is well protected from contamination from activities or sources at or near the ground surface.

Table 2 – Geologic and Hydrologic Investigations in the Three Forks area.

Title of Project	Reference Information	Significant Maps	Area Covered	Project Purpose
Geology of the Three Forks Quadrangle, Montana	Robinson, G.D., 1963 U.S. Geological Survey Professional Paper 370	Geologic Map of Three Forks Quadrangle	Three Forks Quadrangle	Provide detailed geologic information on the area
Bouguer Gravity, Aeromagnetic and Generalized Geologic Map of the Western Part of the Three Forks Basin, Jefferson, Broadwater, Madison and Gallatin Counties, Montana	Davis, W.E.; Kinoshita, W.T.; and G.D. Robinson, 1965; U.S. Geological Survey Geophysical Investigations Maps GP-497 and GP-498	Geologic Structure maps of Three Forks Basin; and Bouguer Gravity and Aeromagnetic maps of basin	Three Forks Structural Base	Determine the structural geologic setting of the Three Forks basin using geophysical methods
Arsenic data for streams in the upper Missouri River Basin, Montana and Wyoming, 1987	Knapton, J.R. and A.A. Horpestad, 1987; U.S. Geological Survey Open-File Report 87-124	----	Madison River Watershed	Evaluate the presence of Arsenic in surface and ground waters in the Madison River Valley
Supplemental arsenic data for selected streams in the Missouri River basin, Montana, 1987	Knapton, J.R. and T.M. Brosten, 1987 U.S. Geological Survey Open-File Report 87-697	----	Upper Missouri River Watershed	Compare Arsenic data from the Madison River watershed to other areas of the Missouri River Watershed
Arsenic and chloride data for five stream sites in the Madison River drainage, Montana, 1988	Knapton, J.R. and T.M. Brosten, 1988 U.S. Geological Survey Open-File Report 88-722	----	Madison River Watershed	Update previous work with additional data.
Complete data compilation, the lower Madison Valley, accompanying a reprint of arsenic contamination of aquifers caused by irrigation with diluted geothermal water	Sonderegger, J.L. and B.R. Sholes, 1989 Montana Bureau of Mines and Geology Open-File Report 210	Shallow ground water flow in Madison River Valley; well sampling locations	Madison River Valley	Evaluate the sources of Arsenic in surface and ground waters in the Madison River Valley
Hydrologic and water-quality data related to the occurrence of arsenic for areas along the Madison and Upper Missouri Rivers, Southwestern and West-Central Montana	Tuck, L.K.; Dutton, D.M and D.A. Nimick, 1997 U.S. Geological Survey Open-File Report 97-203	Surface and ground water sampling sites in Madison River Valley	Madison River Valley	Compile all data on surface and ground water in the Madison River Valley

The Tertiary aquifer is bounded by the older bedrock in the mountains surrounding the Three Forks/Gallatin Valley. Recharge is considered likely to occur along these boundaries, as leakage from surface water bodies that flow from the relatively impermeable bedrock onto the valley fill material. In the Three Forks area, a potentially significant source of recharge may be from where the Jefferson River flows adjacent to older bedrock, as shown in the cross section in Appendix C. The nature of this area as a source is not well understood, and the majority of recharge to the Tertiary Beds is considered to occur south of the Three Forks area. The arsenic data for the aquifer, as discussed in Chapter 2, suggest that the recharge area is away from areas impacted by water from the Madison River and related ground water system.

While not well understood, ground water is considered likely to flow in a general northern direction in the Tertiary strata, following the regional topographic gradient coincident with the surface drainage system. While the general flow directions may be similar, this does not indicate or reflect any communication of these surface waters with the deeper waters, except potentially in the vicinity of the Jefferson River west of Three Forks, as previously discussed.

Conceptual Model and Assumptions

A conceptual hydrogeologic model is a simplified representation of the hydrogeologic system. For the Three Forks area, there are two relatively distinct systems. For the Madison River wells, ground water occurs at shallow depths and is in communication with the Madison River. The aquifer is recharged by stream loss from the Madison River and direct infiltration of precipitation. Ground water flows north, parallel to the general direction of the valley and Madison River. For the deep Tertiary wells, ground water occurs in basin fill sediments that are recharged by surface water infiltration into alluvium and other surficial material along the margins of the Three Forks and Gallatin Valleys. Ground water flows in a general northward direction in the strata, following the regional topographic gradient. In the Three Forks area, the deeper ground water system in the Tertiary basin fill strata is separate from the shallow alluvial water system associated with the Jefferson and Madison Rivers.

Well(s) Information

The deep Tertiary wells for the Three Forks PWS are located across the town as depicted in Figure 2. The Madison River wells are located east of town. Copies of the well logs showing stratigraphy and well construction criteria are included in Appendix B. Well information is summarized in Table 3.

Table 3 - Source well information for Three Forks.

Information	Well 1	Connors Well 2	W. Ash St. Well 4	4th Ave E. Well 5	Headwater Lot 5 Well 6	Well 8	Well 9
PWS Source Code	002	003	004	005	006	008	009
Well Location	T2N, R2E Sec 30 DC	T2N, R2E Sec 30 DC	T2N, R1E Sec 25 CBB	T2N, R1E Sec 36 AA	T2N, R1E Sec 26 DD	T2N, R1E Sec 26 DDC	T2N, R1E Sec 35 BBA
MBMG #	12681	12682	766	12595	*Not listed*	147405	147445
Water Right #	*Not listed*	*Not listed*	W009020	W009021	*Not listed*	P060815	P060815 ??
Date Completed	1933	1935	2/2/55	2/15/64	1986	3/15/94	6/26/94
Total Depth	125 feet	150 feet	158 feet	320 feet	160 feet	254 feet	220 feet
Perforated Interval	75' – 125'	76' – 150'	111' – 121' 148' – 158'	Casing to 320'	*Not listed*	Casing to 254'	Casing to 216'
Static Water Level	*Not listed*	18 feet	30 feet	21 feet	*Not listed*	9.08 feet	9.8 feet
Pumping Water Level	105 feet	*Not listed*	103 feet	*Not listed*	*Not listed*	71.8 feet	149 feet
Drawdown	*Not listed*	*Not listed*	73 feet	*Not listed*	*Not listed*	62.72 feet	139.2 feet
Yield –Test Pumping Rate	*Not listed*	150 gpm	260 gpm	1500 gpm	*Not listed*	192 gpm	155 gpm
Specific Capacity	*Not listed*	*Not listed*	3.56 gpm/ft	*Not listed*	*Not listed*	3.06 gpm/ft	1.11 gpm/ft
Pumping Rate	*Not listed*	*Not listed*	115 gpm	200 gpm	40 gpm	150 gpm	80 gpm

Methods and Criteria

The methods and criteria used to delineate the source water protection zones for the Three Forks water system are specified in the Montana Department of Environmental Quality Source Water Protection Program (DEQ, 1999). For the deep Tertiary wells, the criteria for confined aquifer systems was applied. This incorporates using a fixed radius to identify the control and inventory zones around each well. The inventory zones for these wells defined by this criteria, a 100 foot radius for the control zone and a 1,000 foot radius for the inventory zone, are depicted in Figure 5. The recharge area was identified using available geologic maps (Robinson, 1963; Davis et. al., 1965).

For the Madison River wells, the criteria for an unconfined aquifer system was followed. The control zone was established using a fixed radius of 100 feet around each wellhead. The inventory zone was delineated based on a ground water time of travel distance of three years. This distance was determined using a simple ground water flow model using the uniform flow equation (EPA, 1991). Conservative estimates for aquifer properties were made using available data from published reports, as discussed in the following. The inventory zones for the wells were broadened to reflect potential changes in the flow system during seasonal periods of high and/or low flow. Since the water system is in communication with and influenced by surface water, the recharge area is considered to be the area of the valley where the aquifer is present upgradient from the wells. The recharge area also considers the watershed for the Madison River. The surface water buffer zone was delineated based on a standard distance criteria of ten miles upstream from the wells, with buffers encompassing the land area of one-half mile width on each side of the river.

Model Input

The values selected for the calculation of time of travel represent conservative assumptions made to identify areas that may potentially impact the Madison River and the Three Forks PWS. These values assume that flow to the two wells in the system reflect similar properties as the two wells are installed into the same aquifer at the same approximate depth. The criteria for selection of each value used for this delineation are as follows:

- ***Transmissivity***: The transmissivity value is estimated at 100,000 gpd/ft from Sonderegger and Sholes (1989). This corresponds to 13,400 ft^2/day
- ***Thickness***: The value for the thickness of the aquifer is estimated at 40 feet, based on the estimated thickness of the aquifer and the depth to ground water.
- ***Hydraulic Conductivity***: A value for hydraulic conductivity is estimated using the basic relationship
  T = Kb, where T = transmissivity – 13,400 ft^2/day
  b = aquifer thickness – 40 feet
  The estimated value for the hydraulic conductivity (K) is 335 ft/day.
- ***Hydraulic Gradient***: The hydraulic gradient was measured from the potentiometric surface map in Sonderegger and Sholes (1989) shown in Figure 5. The gradient shows an approximate change of 60 meters over a distance of 10 miles, for an estimated gradient of 0.0037. This study used a rounded value of 0.004.
- ***Flow Direction***: The flow direction is considered due north, parallel to the direction of the Madison River and the valley.
- ***Porosity***: The value for effective porosity is estimated from (Todd, 1980) at 30%. The estimated value is considered representative of medium to coarse grained gravel.
- ***Pumping Rate***: The pumping rate for the wells was estimated at 1000 gpm, reflecting the needs of the system.

Delineation Results

The results of the calculations indicate an estimated distance of 2,610 feet (0.49 miles) for a one-year time of travel (TOT), and a distance of 6,325 feet (1.20 miles) for a three-year TOT. A summary of the time of travel calculations is included in Appendix D. The delineated inventory zone for the Madison River wells are depicted in Figure 5. The inventory zone has been broadened to account for potential seasonal variations in flow. The inventory zone also reflects the boundaries of the shallow aquifer within the Madison River valley. The surface water buffer zones for the Madison River is shown in Figure 5, and includes the Francis Walbert Irrigation canal on the west side of the valley. The recharge region for the aquifer comprises the aquifer upgradient from the supply wells, delineated in the inventory zone. The watershed system that recharges the aquifer is delineated as part of the surface water buffer zone.

Limiting Factors
The interaction of surface water in the Madison River with shallow alluvium is not completely understood at this time due to the limited amount of data on the system. In particular, the changes in the flow regime under seasonal conditions of high and low flow are not known. The delineation was completed using conservative assumptions to help ensure that the inventory zone reflects the actual area where contamination to the system may occur. For the deep Tertiary wells, the nature of the deep flow system within the Tertiary strata is not well understood, and would require a significant amount of time and resources to evaluate in detail. As a result, the interpretations and conclusions on ground water flow in the Tertiary aquifer are based on general principles of hydrogeology, and the mechanics of the actual ground water flow system are likely more complicated than presented here.

Figure 5 – Delineated Source Water Protection Management Areas

4.0 INVENTORY

An inventory of potential sources of contamination was conducted for the all of Three Forks PWS wells within the control, and inventory zones. Potential sources of all primary drinking water contaminants, including pathogens, were identified. However, only significant potential contaminant sources were selected for detailed inventory. The inventory for the Three Forks PWS focuses on all activities in the control zone, certain sites or land use activities in the inventory zones, and general land uses and large facilities in the recharge region. The inventory results from the following steps are summarized in Table 4. The inventory was performed consistent with the requirements of the Montana Source Water Assessment Program (1999). The significant potential contaminants in the Three Forks PWS inventory region for the deep Tertiary wells include petroleum from underground storage tanks, nitrates and pathogens from sanitary sewers, septic systems and agriculture; and herbicides and pesticides from cropped agricultural land. The significant potential contaminants in the Three Forks PWS inventory region for the Madison River wells include nitrates and pathogens from sanitary sewers, septic systems and agriculture; and herbicides and pesticides from cropped agricultural land.

Inventory Method
The initial inventory steps comprise querying existing state and federal electronic databases for regulated facilities that use, store or release regulated chemicals. The steps to the database searches, and the results from each step are listed in Appendix E. The assessment of agriculture land use and urban areas, and major transportation routes through the area are shown on Figure 6. The limits of the municipal sewer system and relative density of septic systems in the area are shown on Figure 7. The database search is supplemented and verified with a “windshield survey” and a business directory search of the delineated inventory zones for each PWS in the study area. The results of the business directory search are included in Appendix E. This method helps ensure the inventory is a complete data collection exercise to identify all potential contaminant sources.

The results of the inventory process are summarized in Table 4, which summarizes the properties or sites within the study area. The potential contaminants are listed, with a description of the potential release mechanism for the site. In all cases, releases may occur due to unavoidable conditions such as flooding, lightning or fire. The sites where this is the primary potential release mechanism are identified as concerns resulting from such a disaster. For other sites where other release mechanisms may be more common, the potential for a release from such a disaster is assumed.

The results of the “windshield survey” were consistent with the results from database searches, and did not indicate any additional facilities to review. Storm water drains were observed as french-drains, which represent injection wells of surface water into shallow ground water. Class V injection wells are classified as waste disposal conduits that discharge directly to shallow ground water. The evaluation of the use of Class V injection wells in Montana is currently the responsibility of the EPA.

The Montana Source Water Protection Program identifies specific types of potential contaminant sources as significant, for further evaluation of the susceptibility of the water source to these sources. The following categories of potential contaminant sources are considered significant:

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

Figure 6 – Land Use Classification

Figure 7 – Septic System Density and Limits of City Sewer Area

Table 4 - Summary of Inventory Results for Three Forks PWS.

ID#	Source Type	Potential Contaminants	Description/Concern
Step 1 Results			
1	Agricultural Land Use	Pathogens and Nitrates; Pesticides and Herbicides	Non-point source pollution, concentration of fertilizers/chemicals in surface/ground water
2	Urban Land Use	Spills of various chemicals	Non-point source pollution, small spills of household chemicals
3	Sanitary Sewer System	Pathogens and Nitrates	Leakage from sewer lines
4	Wastewater Treatment Lagoons	Pathogens and Nitrates	Leakage from lagoon bottom
5	Septic Systems	Pathogens and Nitrates	Non-point source pollution, loading o f ground water system with effluent
6	Storm Water French Drains	Various chemicals	Non-point source releases from urban land use concentrated into point source to ground water
EPA Envirofacts Sites (Step 2)			
7	J & R Precast Concrete, Inc	Spills of various chemicals	Spill of stored or handled chemicals
8	Landers Auto Shop	Spills of various chemicals	Spill of stored or handled chemicals
9	Luzenac America – Three Forks Plant	Spills of various chemicals	Spill of stored or handled chemicals
DEQ Database – Active USTs (Step 4)			
10	USTs – Normon's Conoco	Petroleum Hydrocarbons	Leak from UST
11	USTs – Three Forks Sinclair	Petroleum Hydrocarbons	Leak from UST
DEQ Database – LUST Sites (Step 4)			
12	LUST Sites – Three Forks Airport (2 sites)	Petroleum Hydrocarbons	Residual contamination after site closure
13	LUST Site – Larry'sService	Petroleum Hydrocarbons	Residual contamination after site closure
14	LUST Sites – Residential Areas	Petroleum Hydrocarbons	Residual contamination after site closure
15	LUST Site – MDT Shop	Petroleum Hydrocarbons	Contaminated ground water exist, Residual contamination after site closure s
16	LUST Site – Normon's Conoco	Petroleum Hydrocarbons	Contaminated ground water exists, Residual contamination after site closure
DEQ Database – Mines (Step 4)			
17	Gravel Pit	Spills of fuels, lubricants, and other chemicals	Quarry provides direct conduit for contamination to shallow ground water system
18	Placer Gravel Operation	Spills of fuels, lubricants, and other chemicals	Quarry provides direct conduit for contamination to shallow ground water system
Business SIC Code Search Results* (Step 5)			
19	Greenhouse (1)	Spills of Pesticide/Herbicides and fertilizers	Natural Disaster or accidental spill of stored chemicals
20	Veterinarian (1)	Pathogens (medical waste)	Management and disposal of medical waste
21	Furniture Manufacturer (1)	Volatile organic chemicals	Accidental spill of wood finishing chemicals
22	Printers and Publishers (2)	Inks (Volatile organic chemicals)	Natural Disaster – spill/release of ink
23	Manufacturing – various (4)	Volatile organic chemicals	Natural Disaster or accidental spill of stored chemicals
24	Storage Area (3)	Commercial Storage of unknown chemicals	Natural Disaster or accidental spill of stored chemicals
25	Aircraft Servicing and Maintenance (1)	Various chemicals and fuels	Natural Disaster or accidental spill of stored chemicals
26	Lumber, Hardware and Motor Supply Stores (3)	Various chemicals	Natural Disaster or accidental spill of stored chemicals
27	Gasoline Service Stations (3)	Petroleum Fuels and various chemicals	Natural Disaster or accidental spill of stored chemicals
28	Beauty Parlors (2)	Various chemicals	Natural Disaster or accidental spill of stored chemicals
29	Mortuary/Taxidermy (2)	Various chemicals	Natural Disaster or accidental spill of stored chemicals

Table 4 (continued) - Summary of Inventory Results for Three Forks PWS.

ID#	Source Type	Potential Contaminants	Description/Concern
30	Auto Repair/Service (2)	Petroleum, antifreeze, lubricants, cleaning solvents	Natural Disaster or accidental spill of stored chemicals
31	Public Golf Course	Pesticides and Herbicides; Fertilizers	Non-point source pollution, concentration of fertilizers/chemicals in surface/ground water; Natural Disaster – spill/release of chemicals and fuels stored on site
32	Health Services (5)	Pathogens (medical waste)	Management and disposal of medical waste
33	Three Forks City facilities (3)	Various chemicals	Natural Disaster or accidental spill of stored chemicals
Miscellaneous Others, including Step 6			
34	Major Roads	Spills of various chemicals	Disaster – spill/release of chemicals and fuels transported on Highway
35	Railroad Lines	Spills of various chemicals	Disaster – spill/release of chemicals and fuels transported on railroad line
36	Class V Injection Wells	Various organic chemicals	Direct discharge of chemical to shallow ground water system

* Note: Sites identified from multiple search queries are listed with the first step that identified the specific site. The results of the business SIC code search reflect types of facilities, with the number of facilities indicated in parentheses. Individual sites identified as significant potential contaminant sources are evaluated in Chapter 4.

Inventory Results/Control Zones

The control zone represents the most critical point to protecting the integrity of the wellhead for ground water sources. The significant potential contaminant sources are listed in Table 5, with the locations shown on Figure 8. The land around the control zones for the deep Tertiary wells is predominantly urban, with one well located in a residential area (Well 5), and the others in formerly developed areas near railroad tracks. The area around the wells is connected to the local sewer system.

The control zone for the land around the Madison River wells is predominantly undeveloped land within the floodplain of the Madison River.

Inventory Results/Inventory Regions

The inventory region represents the area near wells where any contamination spilled onto the ground or subsurface has the potential to migrate directly into the PWS well. The results of the inventory of significant potential contaminant sources are listed in Table 5, with the locations shown on Figure 8. Completed inventory summary sheets for the significant potential contaminant sources are included in Appendix F.

The inventory region for the deep Tertiary wells is defined as the area within a 1,000 foot radius of each wellhead. Land use in this area is classified as urban, with a limited amount of agriculture in the immediate vicinity of Three Forks (Figure 6). The identified potential contaminant sources include the railroad tracks, the sewer system, Septic tanks, UST sites, LUST sites, and several garage/machine shops.

The inventory region for the Madison River wells is defined by the distance ground water will travel to the well in three years. Land use in this area is classified primarily as non-agricultural, with limited areas of agricultural land. There are no point potential contaminant sources identified in this area using the standard database searches.

Inventory Results/Surface Water Buffer Zone

The surface water buffer zone is the area of one half mile on each side of the surface water bodies for a distance of ten miles upstream from the Madison River wells. This area includes both the Madison River and Francis

Walbert irrigation canal, as shown in Figure 5. The inventory of the surface water buffer zone focuses on potential contaminants with acute health risks, such as pathogens or nitrates. This area includes limited agricultural development, with related potential contaminants.

Inventory Results/Recharge Regions

The recharge region for the deep Tertiary wells upgradient from the Three Forks area is predominantly agricultural land, with both irrigated and dryland farming present. The area adjacent to the inventory zones for the wells within the town boundaries is predominantly urban, with a limited number of potential contaminant sources summarized with Table 5.

For practical purposes, the recharge area for the Madison River wells is considered to be the Madison River valley for a distance of approximately 15 miles south of the wells. This area represents the length of the valley within the structurally defined Three Forks basin, where the river flows from over relatively impermeable bedrock onto Tertiary strata. This area has a limited amount of agricultural land present.

Inventory Update

The certified operator for the Three Forks PWS will update the inventory every year. Changes in land uses or potential contaminant sources will be noted and additions made as needed. The complete inventory will be submitted to DEQ every five years to ensure re-certification of the source water delineation and assessment report.

Figure 8 – Inventory Results

Table 5 - Significant potential contaminant sources for Three Forks PWS.

ID#	Source	Contaminants	Description
	Deep Tertiary Wells		
1	*Agricultural Land Use*	*Pathogens and Nitrates; Pesticides and Herbicides*	*Limited amount of cropped agricultural land in recharge area*
2	*Urban Land Use*	*Spills of various chemicals*	*Wells in urban area within town*
3	*Sanitary Sewer Main*	*Pathogens and Nitrates*	*Crosses inventory zone for wells*
4	*Waste Water Treatment Lagoons*	*Pathogens and Nitrates*	*Located downgradient from well location*
5	*Septic Systems*	*Pathogens and Nitrates*	*Limited areas adjacent to town*
6	*Storm Water French Drains*	*Spills of various chemicals*	*Located throughout town, provide direct conduit to shallow ground water system*
8 and 30-2	*Landers Auto Shop (Elite Towing and Repair)*	*Spills of various chemicals*	*Located in inventory zone*
9	*Luzenac – Three Forks Talc Plant*	*Spills of various chemicals*	*Located adjacent to inventory zone for Well 5*
10, 16 and 27	*UST/LUST – Normon's Conoco*	*Petroleum Hydrocarbons*	*Existing source for ground water contamination, active LUST site, active service station with USTs*
11 and 27	*USTs – Three Forks Sinclair*	*Petroleum Hydrocarbons*	*Petroleum stored in USTs*
12	*LUST – Three Forks Airport (2 Sites)*	*Petroleum Hydrocarbons*	*Two sites with ground water impacts detected; sites have been closed; located upgradient from PWS inventory zones*
13	*LUST – Larry's Service*	*Petroleum Hydrocarbons*	*Small leak from pump island, site file closed*

14	*LUST – Residential Areas (3 Sites)*	*Petroleum Hydrocarbons*	*Small leaks in residential area, sites closed*
15	*LUST – MDT Maintenance Shop*	*Petroleum Hydrocarbons*	*Active LUST site with free product on shallow ground water surface, located downgradient from town*
17	*Gravel Pit*	*Spills of various chemicals*	*Located north of town, downgradient from PWS inventory zones*
18	*Placer Gravel Operation*	*Spills of various chemicals*	*Located upgradient from PWS inventory zones, status uncertain at this time*
25	*Bridger Aviation Service*	*Petroleum Hydrocarbons*	*Located at Three Forks Airport, south of town upgradient from PWS inventory zones*
27	*Jenkins Garage and Service Station*	*Petroleum Hydrocarbons*	*Located in inventory zone for Well 8 within town, former gasoline service station with USTs now closed.*
30-1	*M&W Motor Machine*	*Petroleum and various other chemicals*	*Located in central part of town, within well inventory zones*
31	*Public Golf Course*	*Pesticides/Herbicides; and Fertilizers*	*Located northeast of town, downgradient from well inventory zones*
33	*Three Forks City Shop*	*Spills of various chemicals*	*Located in town adjacent to well inventory zones*
34-1	*I-90*	*Spills of various chemicals*	*East-West highway north of twon*
34-2	*US Hwy 287*	*Spills of various chemicals*	*North-South highway west of town,*
34-3	*MT Hwy 2*	*Spills of various chemicals*	*Runs through town, minor traffic route through town*
35	*Railroad Lines*	*Spills of various chemicals*	*Run through town and inventory zones*
36	*Class V Injection Wells*	*Spills of various chemicals*	*To be evaluated by EPA*

Table 5 - Significant potential contaminant sources for Three Forks PWS (continued).

ID#	Source	Contaminants	Description
	Madison River Wells		
1	*Agricultural Land Use*	*Pathogens and Nitrates; Pesticides and Herbicides*	*Limited amount of cropped agricultural land in inventory zone and recharge area*
2	*Urban Land Use*	*Spills of various chemicals*	*Wells away urban area within town*
3	*Sanitary Sewer Main*	*Pathogens and Nitrates*	*Outside of inventory zone for wells, but may cross western edge of surface water buffer zone*
4	*Waste Water Treatment Lagoons*	*Pathogens and Nitrates*	*Located adjacent to edge of surface water buffer zone*
5	*Septic Systems*	*Pathogens and Nitrates*	*Limited to several ranches within Madison River valley*

Inventory Limitations

The inventory is limited by the accuracy of information in databases used for the assessment. The windshield survey provides a level of quality assurance that the information presented reflects current conditions at the time of preparation of this report. The location of Class V injection wells is not complete at this time, and is currently being compiled by EPA for the area.

The data from the MBMG-GWIC database on wells in the area may not be complete, as not all wells are included in the database. The location of the wells on Figure 9 is based on relative location with the township-section-range method for locating points. Depending on the level of detail provided, this method may account for significant errors in locating points. In other cases, multiple wells are depicted at a single point. The need for accurate information on these wells is further discussed in Chapter 5 of this document.

5.0 SUSCEPTIBILITY ASSESSMENT

Susceptibility is the potential for a public water supply to draw water contaminated by inventoried sources at concentrations that would pose concern. Susceptibility is assessed in order to prioritize potential pollutant sources for management actions by local entities, in this case the Three Forks PWS.

The goal of Source Water Management is to protect the source water by 1) controlling activities in the control zone, 2) managing significant potential contaminant sources in the Inventory Region, and 3) ensuring that land use activities in the Recharge Region pose minimal threat to the source water. Management priorities in the Inventory Region are determined by ranking the significant potential contaminant sources identified in the previous chapter according to susceptibility. Alternative management approaches that could be pursued by the Three Forks PWS to reduce susceptibility are recommended.

Susceptibility is determined by considering the hazard rating for each potential contaminant source and the existence of barriers that decrease the likelihood that contaminated water will flow to the Three Forks PWS wells (Table 6). Susceptibility ratings are presented individually for each significant potential contaminant source and each associated contaminant (Table 8). The susceptibility of each well to each potential contaminant source is assessed separately.

Table 6 - Relative susceptibility to specific contaminant sources as determined by hazard and the presence of barriers.

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

For point sources, the relative hazard for the potential contaminant sources is assigned based on the type of aquifer. For confined aquifer such as the Tertiary beds, the relative hazard of the significant potential contaminant sources reflects the location of the sites relative to the PWS Well inventory zones, and the integrity of the PWS wells and other wells installed into the aquifer. If the seal around the PWS wells is does not meet DEQ construction standards, the relative hazard is assigned as high for all potential contaminant sources in the inventory zone. If the PWS wells are constructed properly, but other wells are present in the inventory zone without adequate seals, then the relative hazard for potential contaminant sources is moderate. In all other cases, the relative hazard for potential contaminant sources is low.

For an unconfined aquifer such as the Madison River alluvium, the relative hazards for point source are based on the location of the potential contaminant source relative to the well. Potential sources within a one-year time of travel distance to the well are assigned a relative hazard of high. Potential contaminant sources located between a one-year and thee-year time of travel distance are assigned a relative hazard of moderate. Any other potential contaminant sources within the recharge area are assigned a relative hazard of low.

For non-point sources, the relative hazard is assigned following the same criteria for both confined and unconfined aquifers. The hazard is based on the relative concentrations present within the delineated inventory zone for the aquifers, following the criteria listed in Table 7.

Table 7 – Relative Hazards for Non-Point Potential Contaminant Sources

Source Type	***High Hazard***	***Moderate Hazard***	***Low Hazard***
Septic Systems	> 300 per sq. mi.	50 – 300 per sq. mi.	< 50 per sq. mi.
Municipal Sanitary Sewer (% Land Use)	> 50% of region	20% – 50% of region	< 20% of region
Cropped Agricultural Land(% Land Use)	> 50% of region	20% – 50% of region	< 20% of region

Susceptibility for Deep Tertiary Wells

A query of the MBMG-GWIC database indicated multiple wells in the Three Forks area installed to the Tertiary strata that is the source aquifer for the Three Forks PWS (Table 8 and Figure in Appendix C). While many of these wells are not installed to the same depths as some of the Three Forks PWS wells, they are completed into the same formation, through the shallow alluvium that represents the local unconfined ground water system. The logs for these wells from MBMG-GWIC are presented in Appendix C. The exact location of many of the wells in town, relative to the delineated inventory zones, cannot be established with the data available.

For purposes of the susceptibility assessment, the three currently active PWS wells for the Three Forks system are not considered to be properly constructed with adequate seals. This is based on the age of well construction for two wells, Well 4 constructed in 1955 and Well 5 constructed in 1964. At the time these wells were constructed, seals were not required for wells. Well 6 was constructed in 1986 when well construction standards were in place; however, there is currently no available information for the wells. The remaining two wells, Well 8 and Well 9, were constructed in 1994 and are considered to have been properly completed.

The susceptibility assessment presented in Table 8 is applied only to the three wells (Wells 4, 5 and 6) currently used by the Three Forks PWS for their water supply. Based on the well construction criteria for these PWS wells, the relative hazard assigned to potential contaminant sources located in the inventory region is ***high***. The potential contaminant sources located in the recharge region, or outside of the inventory zone, are assigned a relative hazard of ***moderate***. When assessing the relative susceptibility of the aquifer to contamination, the integrity of other wells in the area should be evaluated. These wells represent potential conduits for contaminants to flow from the upper water bearing units through the source confining layer separating and protecting the lower source aquifer for the Three Forks PWS. With limited information available, there is a potential that one or more of the additional wells in the inventory zone may not have proper seals to shallow ground water, based on the age of the wells.

While the susceptibility for contamination to Wells 8 and 9 is not evaluated here as the wells are currently not used for the PWS, the relative hazard assigned to potential contaminant sources can be assigned for these wells based on the criteria outlined above. For potential contaminant sources in the inventory zone, the relative hazard for these wells is ***moderate***. The relative hazard assigned to potential contaminant sources outside the inventory zone for these wells is ***low***.

The barriers to contamination of the water sources are identified for each source listed in Table 7. In general, a barrier of clay-rich soils is assigned to potential sources that use or store only limited quantities of chemicals, and do not have any underground storage such as USTs. For sites with subsurface sources such as underground storage tanks or LUST sites where soil and ground water contamination already exists, this barrier is not considered applicable. For the transportation corridors, no barriers are considered since a spill/emergency could result in large quantities of released chemicals.

Susceptibility for Madison River Alluvium Wells

The database review of potential contaminant sources indicates that none are present within the delineated inventory zone for the Madison River alluvium wells. As a result, the only potential contaminant sources identified with this assessment are the non-point sources related to agricultural land use. The limited amount of agriculture in the area results in a classification of the relative hazard as moderate. The location of the shallow wells in the unconsolidated alluvial aquifer results in no natural or engineered barriers being present to mitigate any potential contamination from anthropogenic sources.

Susceptibility Assessment Results

The results of the susceptibility assessment indicate several potential threats to the Deep Tertiary Three Forks PWS wells. The primary threats are considered to result from LUST sites in town, and the sanitary sewer mains. Additional hazards are present related to spills from the highways and railroad transportation corridors in the area. An additional concern that has not been fully evaluated at this time is the impact of Class V injection wells to shallow ground water quality.

The results of the susceptibility assessment for the Madison River wells identified agricultural land use as the primary potential contaminant. Since there are no barriers, the moderate hazard results in a susceptibility rating of high. Additional areas of concern represent bridges and other potential sources further upstream adjacent to the Madison River.

The results of the susceptibility assessment should be considered as the relative potential of each source to impact the source aquifers for the Three Forks PWS under "worst-case" conditions, such as a natural disaster or fire. Management options are recommended as methods of developing additional barriers to reduce the relative susceptibility of the water supply to the identified potential contaminant sources.

Table 8 - Susceptibility assessment for significant potential contaminant sources in the Control Zone and Inventory Region.

Source	Contaminant	Hazard	Hazard Rating	Barriers	Susceptibility	Management
Agricultural Land Use (Deep Tertiary Wells)	Pesticides and herbicides; Nitrates	Non-point source, concentration	Low	Clay-rich soils	Low	Educate community of BMPs for agriculture
Agricultural Land Use (Madison River Wells)	Pesticides and herbicides; Nitrates	Non-point source, concentration	Moderate	None	High	Educate community of BMPs for agriculture
Urban Land Use	Various chemicals	Spills, non-point source concentration	High	Clay-rich soils	High	Develop stormwater management plan
Sanitary Sewer Main	Nitrates and Pathogens	Leak from sewer lines	High	None	Very High	Leak monitoring and prompt repair
Waste Water Treatment Lagoons	Nitrates and Pathogens	Leakage from lagoons	Moderate	None	High	Leak monitoring and prompt repair
Septic Systems	Nitrates and Pathogens	System failure	Moderate	None	High	Connect to sanitary sewer
Storm Water French Drains	Various chemicals	Non-point source concentration	High	None	Very High	Develop stormwater management plan

Table 8 - Susceptibility assessment for significant potential contaminant sources in the Control Zone and Inventory Region (continued)

Source	Contaminant	Hazard	Hazard Rating	Barriers	Susceptibility	Management
Landers Auto Shop	Various chemicals	Spills	High	Clay-rich soils	High	Educate owners on BMPs for chemical use
Luzenac	Various chemicals	Spills	Moderate	Clay-rich soils	Moderate	Educate owners on BMPs for chemical use
Normon's Conoco (Active USTs)	Petroleum Hydrocarbons	Spill, leak	High	Compliance with 1998 upgrades	High	Monitor compliance status
Normon's Conoco (LUST Site)	Petroleum Hydrocarbons	Spill, leak	High	None	Very High	Monitor status of Remediation
Three Forks Sinclair	Petroleum Hydrocarbons	Spill, leak	High	Compliance with 1998 upgrades	High	Monitor compliance status
Three Forks Airport (2 LUST sites)	Petroleum Hydrocarbons	Spill, leak	Moderate	None	High	LUST sites closed, Monitor compliance status
Larry's Service	Petroleum Hydrocarbons	Spill, leak	High	Compliance with 1998 upgrades (closed tanks)	High	Monitor compliance results
Residential LUST Sites	Petroleum Hydrocarbons	Residual contamination	Moderate	None	High	Sites Closed
MDT Maintenance Shop	Petroleum Hydrocarbons	Spill, leak – existing ground water contamination	Moderate	None	High	Monitor compliance and status of remediation
Gravel Pit	Various chemicals	Spill	Moderate	None	High	Monitor site status, use of chemicals
Placer Gravel Operation	Various chemicals	Spill	Moderate	None	High	Monitor site status, use of chemicals
Bridger Aviation Service	Various chemicals	Spill	Moderate	Clay-rich soils	Moderate	Educate owners on BMPs for chemical use
Jenkins Garage	Various chemicals	Spill	High	Clay-rich soils	High	Educate owners on BMPs for chemical use
M&W Motor Machine	Various chemicals	Spill	High	Clay-rich soils	High	Educate owners on BMPs for chemical use
Public Golf Course	Pesticides and herbicides; fertilizers	Non-point source pollution	Moderate	Clay-rich soils	Moderate	Educate owners on BMPs for chemical use
Three Forks City Shop	Various chemicals	Spill	Moderate	Clay-rich soils	Moderate	Educate owners on BMPs for chemical use
I-90, US Hwy 287, and MT Hwy 2	Various	Spill	Moderate	None	High	Develop emergency response procedures
Railroad Lines	Various	Spill	High	None	Very High	Develop emergency response procedures
Class V Injection Wells	Various	Direct discharge to shallow ground water	High	None	Very High	Locate and educate public on BMPs

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