Town of Clyde Park Public Water Supply

PWSID # MT0000178

Date of Report: October 24, 2005
Revision Date: April 1, 2009

SOURCE WATER DELINEATION AND ASSESSMENT REPORT

Operator/Manager:

Ernie MacCracken
P.O. Box 177
Clyde Park, MT 59018
(406) 686-4719

Executive Summary

April 1, 2009

Report Format

This report begins with an Executive Summary that condenses information presented in each section of the main report. General findings are presented in the summary but not details. Information in this report comes primarily from the most recent sanitary survey, a hydrogeologic assessment conducted by the Montana Bureau of Mines and Geology (English, 1999), water quality data from the Clyde Park public water supply and submitted to the DEQ, and from other publicly available sources and studies. Figures referred to in both the Executive Summary and the main report are included in the back of the report starting on page 39. Figures are not imbedded in the report because they would have to be reduced in size and some mapping detail would be lost. A table of contents follows this Executive Summary. This report was written by Jim Stimson who is a hydrogeologist with the DEQ Source Water Protection Program. Mr. Stimson can be reached at (406) 444-6832 or by email at: jistimson@mt.gov. The report was revised by Craig Jenneskens of Robert Peccia & Associates Inc., POB 5653, Helena, Montana under contract with the town of Clyde Park.

Introduction and Background

Clyde Park is located in Park County about 15 miles north of Livingston and 10 miles south of the town of Wilsall (Figure 1). The U.S. Census Bureau estimates the 2000 population of Clyde Park at 337. The town's public water supply is classified as a community system under the Federal Safe Drinking Water Act. Clyde Park's public water supply services its residents with 163 active water service connections.

Clyde Park uses a spring source and two wells for its public water supply. The spring source is located about 1.5 miles northeast of town in the upper part of Spring Creek Coulee. The springs are located at the southwestern end of Cottonwood Bench and the water appears to originate from bedrock (English, 1999). The springs are classified as a ground water source by the DEQ based on an on-site hydrogeologic assessment (English, 1999) and the results of a micro-particulate analysis, both of which are included in Appendix C. Water from the spring source is chlorinated.

The wells are located about ¼ mile west of town next to Cottonwood Creek (Figure 3A and Figure 3B). Both wells were completed on January 7, 2002 (DEQ Sanitary Survey by Usuriello, 2006). Both wells appear to be completed in sandstone and shale beds that are part of the Fort Union Formation. Water from the wells is also treated with a hypochlorite solution at the pump house prior to distribution(DEQ Sanitary Survey by Usuriello, 2006).

Public water systems must conduct routine monitoring for contaminants in accordance with Federal Safe Drinking Water Act requirements. A community public water supply, like Clyde Park, must sample in accordance with schedules specified in the Administrative Rules of Montana (ARM). Clyde Park had a positive total coliform detection on May 2, 2001. However, follow-up samples tested negative indicating the water was not contaminated by bacteria. Over the last five years, there were no Maximum Contaminant Level (MCL) exceedances recorded for any other water quality constituents, this includes nitrate. However, nitrate values for Clyde Park's public water supply are elevated compared to ground water from other systems in Montana. The highest nitrate value recorded from the spring source is reported at 2.61 milligrams per liter (mg/l). Water from the wells has a high value of 1.25 mg/l. While the nitrate concentrations are elevated, they are significantly below the Maximum Contaminant Level (MCL) of 10 mg/l set by EPA. Possible sources of nitrate are discussed in some detail in this report starting on page 18.

Delineation of Source Water Protection Areas

The purpose of delineation is to map the source of drinking water for the public water supply and to define areas within which to prioritize source water protection efforts. Four types of management regions are mapped for Clyde Park (see Figure 3A and Figure 3B, Figure 7,and Figure 8). The source water protection areas include; 1) a 100-foot control zone for the wells and the springs, 2) separate inventory regions for the wells and the spring source, and 3) a recharge region corresponding to the watershed surrounding Clyde Park. The fourth protection area is a surface water buffer region and it is included because the Shields River and Cottonwood Creek flow on top of the aquifer that the wells are completed in. Of the four source water protection regions, the inventory region is of particular importance because it outlines land areas that are interpreted to directly contribute water to the aquifers used by the wells and the spring source. As a consequence, the inventory for potential contaminant sources is focused on the inventory regions and any efforts to protect the town's source water from more immediate threats will also need to be focused on the inventory region.

The inventory regions for both the springs and the wells are mapped based on general ground water hydrology principles and on the hydrogeologic setting of the area. As stated previously, the inventory region outlines land areas that contribute water to the springs and the wells over a period of months or years. For the springs, water very likely comes from a combination of precipitation and snowmelt runoff, and irrigation water applied to fields on top of Cottonwood Bench. Ground water beneath Cottonwood Bench is interpreted to be moving from the northeast to the southwest (Figure 3A and Figure 3B). The aquifer for the spring source is considered to be shallow and unconfined. A shallow unconfined aquifer is considered to have a high sensitivity to potential sources of contamination located at the land surface (DEQ, 1999).

The town's wells are located in the alluvial valley of the Shields River (Figure 3A and Figure 4A). Sand and gravel sediments make up the geologic materials beneath the valley floor and they are referred to as alluvium or as alluvial deposits. These alluvial deposits average about 20 feet thick but can be as thick as 30 feet in some places. The alluvial deposits sit on top of shale and sandstone bedrock that is part of the Fort Union Formation. Almost all of the wells in the vicinity of Clyde Park penetrate the alluvial deposits and they are completed in the older bedrock. The town's wells are also completed in the bedrock and they are constructed to draw water primarily from the bedrock aquifer (see well logs in Appendix A). Nevertheless, it is important to note that the many of the wells in the area report fractures in the bedrock material. These fractures very likely provide pathways for ground water flow within the bedrock aquifer and they may also allow water from the alluvial deposits to move down into the bedrock. This is important because it suggests that the shallow alluvial aquifer and the deeper bedrock aquifer may be connected. Aquifer tests and additional fieldwork would be needed to help determine if the two aquifers are hydraulically connected and how effective that connection is. Until such tests and fieldwork are conducted, it would be advisable to consider the alluvial deposits and bedrock as a single aquifer.

The fractured nature of the bedrock also makes it more difficult to determining the direction of ground water flow. With this in mind, the inventory region for the wells has been mapped in a fairly conservative manner and includes land areas within both the Shields River Valley and Cottonwood Creek Valley (Figure 3A and Figure 3B). The fractured bedrock complicate assessing how susceptible the public water supply is to potential contaminant sources identified in the inventory. In some cases a range of susceptibility ratings are used in Table 7 on page 23. For this report, ground water is interpreted to generally flow from upland areas towards lowland areas and toward the streams. Ground water flows toward the Shields River and Cottonwood Creek in the vicinity of Clyde Park (Figure 3A and Figure 3B). The aquifer tapped by the town's wells is interpreted to be relatively shallow and composed of fractured bedrock. This type of aquifer is considered to have a high sensitivity to potential sources of contamination located at the land surface (DEQ, 1999).

Inventory of Potential Contaminant Sources

The inventory of potential contaminant sources is used to assess the susceptibility of the Clyde Park public water supply to contamination and to identify priorities for source water protection planning. The inventory focuses on facilities that generate, use, store, transport, or dispose of potential contaminants, and on land types where potential contaminants are present. Maps of the inventory results are shown in Figure 3A and Figure 3B, Figure 6, Figure 7 and Figure 8.

Susceptibility is the potential for a public water supply to draw in water contaminated by inventoried potential contaminant sources. Susceptibility is determined by considering the hazard rating for each potential contaminant source and the existence of natural or man-made barriers. The barriers will decrease the likelihood that contaminated water will flow to the public water supply wells. Table 7 lists all of the potential contaminant sources identified in this inventory and includes the hazard and final susceptibility ratings.

Agricultural land is the dominant land use within the inventory regions (Figure 6). Agricultural land is considered be a significant potential contaminant source. Over application of fertilizers and/or pesticides can result in those ag-chemicals infiltrating into ground water and running off in to surface water bodies that may be hydraulically connected to aquifers. Approximately 47 percent of the inventory region for the wells is made up of agricultural land (Figure 6). This percentage represents a moderate hazard to the wells. The inventory region for the spring source is located on Cottonwood Bench, which is occupied almost entirely by agricultural land use. The large percentage of ag-land represents a high hazard for the spring source.

In the Cottonwood Creek Valley, other potential contaminant sources include individual septic systems and private wells located in and around town (Figure 3A and Figure 3B). It is interesting to note that from the year 2000 to present, 69 wells have been drilled in the vicinity of Clyde Park. Figure 3C shows the well locations and land parcels in the areas. Under some circumstances, wells can provide pathways for contaminants to enter an aquifer. Old and abandoned wells, or poorly constructed wells are of particular concern. In this particular case, wells located northeast of the town's wells could pose a threat to the town's source water. It appears that only about 1/3 of the town and the wells located there are directly up gradient from the public water supply wells. This means that ground water in that area, and any contaminants entering the aquifer through other wells, would tend to flow directly toward the public water supply wells.

Several inactive underground fuel storage sites are located just inside or very near the inventory region boundary. Three of the sites have histories of petroleum releases or leaks. According to available information, all of the sites have had the underground tanks removed. It would be advisable to verify this and to verify that remediation and clean-up of each of these sites were completed.

State Highway 89 passes through town and crosses the Shields River about one mile north of town (Figure 3A). Traffic volume on the road is considered low and it is not a major transportation route for large vehicles carrying hazardous materials. The rail line is located about 1,000 feet west of the public water supply wells and the rail line is down-gradient from the wells. This means that the ground water beneath the railroad bed is generally moving away from the wells and not toward them. The highway and railroad are not considered threats to the source water. This being said, it would still be advisable to vigilant for accidents involving large vehicles on the highway near the Shields River and Cottonwood Creek, and for derailments on the rail line near the river up-stream from the town's wells.

Other businesses and land uses in the area are also considered to be potential sources of contamination. However, businesses in Clyde Park are relatively small and are not considered to store or use commercial volumes of hazardous material.

Figure 3A, Figure 3B, Figure 3C , Figure 6, Figure 7, and Figure 8 show the locations of potential contaminant sources in relation to the public water supply. Inventory and susceptibility analysis results are shown in Table 7 and include additional potential contaminant sources not discussed in the executive summary. The inventory is based on data readily available through state documents, published reports, and other public sources. Documentation may not be readily available on some potential sources. As a result, all potential contaminant sources may not have been identified. In some instances, inadequate location information also prevents the inclusion of potential contaminant sources in the inventory. The inventory in this report should be considered as a starting point for the local community to expand upon and maintain.

Potential Sources of Nitrate

As mentioned previously, water from the Clyde Park public water supply has elevated nitrate concentrations as compared to other ground-water sources around the state. Nitrate concentrations in Clyde Park's water supply are well below the maximum contaminant level or MCL of 10 mg/l set by EPA. Possible sources of nitrate include agricultural lands within the source water protection regions, septic systems in town and septage land application sites near town but outside of the inventory region, and natural or geologic sources. Additional studies would be needed to help identify the source or sources of nitrate that are affecting Clyde Park's source water.

Management Recommendations

It should be noted that even small releases of some chemicals in close proximity to a well, spring, infiltration gallery, or surface water intake can have significant negative impact on water quality, and can represent a significant threat to a public water supply. Steps can be taken to reduce the likelihood of direct releases to the source water. Some of these management steps or options are listed in Table 7. General and specific management recommendations are provided in greater detail on page 28. This Source Water Delineation and Assessment Report (SWDAR) is required by EPA for every public water supply in Montana and the nation. The SWDAR is the first step in a source water protection effort and the second step is the development of a Source Water Protection Plan. EPA and the DEQ do not require this second step. However, if Clyde Park is interested in developing a Source Water Protection Plan, the DEQ Source Water Protection Program will provide assistance and staff time to complete the plan. A Source Water

Plan can be developed as a stand-alone planning document or can be incorporated into existing community planning efforts and documents.

Table of Contents

FIGURE 5: WELL HISTOGRAM – IMBEDDED IN TEXT ON PAGE 9. 46

INTRODUCTION

This Delineation and Assessment Report was prepared by Jim Stimson, a hydrogeologist with the Source Water Protection Program of the Montana Department of Environmental Quality (DEQ). Clyde Park public water supply (PWS) is located in Park County, Montana, about 15 miles north of Livingston (Figure 1). The DEQ PWS identification number, operator name, and operator number for the Clyde Park PWS appear on the title page of this report. This report was revised by Craig Jenneskens of Robert Peccia & Associates Inc., POB 5653, Helena, Montana under contract with the town of Clyde Park.

Purpose

This report is intended to meet the technical requirements for the completion of the source water delineation and assessment report for the Clyde Park 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). The Montana Source Water Protection Program is intended to be a practical and cost-effective approach to the protection of public drinking water supplies from contamination. The primary purpose of this source water delineation and assessment report is to provide information to assist the Clyde Park PWS operator in the identification of potential contaminant sources near and upstream from the town's spring source and wells, and to encourage the development of a source water protection plan to help protect the town's drinking water for the long term.

Delineation and assessment constitute major components of the Montana Source Water Protection Program. Delineation entails mapping the boundaries of source water protection areas, which encompass ground water and/or surface water contributing to public water supply sources. Assessment involves identifying locations or regions within source water protection areas where contaminants may be generated, stored, transported, or disposed, and determining the relative susceptibility of drinking water to contamination from these sources.

Limitations

This report was prepared to assess threats to the Clyde Park public water supply and is based on published data including the most recent sanitary survey, and information obtained from local residents familiar with the community. The terms "drinking water supply" and "drinking water source" refer specifically to the sources of Clyde Park's public water supply, and not any other public or private water supply. Also, not all of the potential or existing sources of ground-water or surface-water contamination in the area of Clyde Park are identified. Only potential contaminant sources in areas that contribute water to the identified drinking water sources are considered.

The term "contaminant" is used in this report to refer to constituents for which maximum concentration levels (MCLs) have been specified under the national primary drinking water standards, and to certain carcinogenic or toxic constituents that do not have MCLs but are considered to be significant health threats.

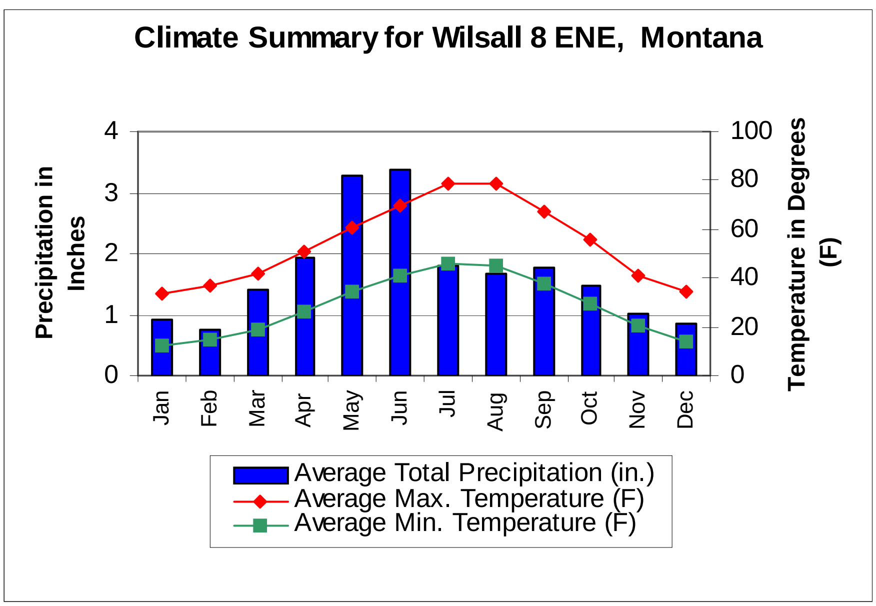
CHAPTER 1
BACKGROUND

The Community
Clyde Park is located in northern Park County about 15 miles north of Livingston and 10 miles south of the town of Wilsall (Figure 1). State Highway 89 and a branch of the Burlington Northern Railroad run through town.. The U.S. Census Bureau estimates the 2000 population of Park County at 15,694 people, 337 of whom reside in Clyde Park. Park County's population increased by about 8% since 1990 and Clyde Park has increased by about 10% during the same period.

Within the town limits, residents obtain their drinking water from the municipal public water supply. No sewer service is available for Clyde Park and residents utilize on-site septic systems for waste disposal. There are no other public water supplies in town.

Table 1. Other Public Water Supplies In The Area – Intentionally Left Blank

Figure 2. Climate Summary



Climate
A climate station in Wilsall is used to summarize climate statistics for Clyde Park. Based on Western Regional Climatic Center data for the period of record, annual precipitation averages 20.26 inches. Monthly average precipitation ranges from 0.74 inches in February to 3.38 inches in June. Summer thunderstorms and winter snows provide a majority of the precipitation in the area. The annual mean snowfall in the Clyde Park / Wilsall area is 99.8 inches. A summary of the available climatic data for the Clyde Park / Wilsall area is presented in Table 2 below.

Table 2. Climate Summary Detail.

WILSALL 8 ENE, MONTANA (249023)

Period of Record Monthly Climate Summary

Period of Record : 4/ 1/1957 to 3/31/2005

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	33.4	36.9	42.1	50.7	60.7	69.6	78.8	78.5	67.2	55.9	41.2	34.6	54.1
Average Min. Temperature (F)	12	14.7	18.9	26.2	34.2	41.1	45.8	44.9	37.5	29.9	20.2	14.1	28.3
Average Total Precipitation (in.)	0.92	0.74	1.41	1.95	3.27	3.38	1.81	1.67	1.77	1.46	1.02	0.86	20.26
Average Total SnowFall (in.)	16.2	12.9	18.5	13.6	6	0.4	0	0	2.3	5.1	10.3	14.4	99.8
Average Snow Depth (in.)	10	12	10	3	0	0	0	0	0	0	1	5	3

Western Regional Climate Center, wrcc@dri.edu

Geographic Setting

Clyde Park is located in the glaciated portion of the Northern Rocky Mountain physiographic province of North America. This area is also designated as the glaciated western mountain range region of the United States (Heath, 1984). The elevation at the town site is approximately 4,868 feet above mean sea level and the town is located near the Shields River and Cottonwood Creek (Figure 1 and Figure 3A , Figure 3B and Figure 3C). The Shields River valley is about 2/3 to 1 mile wide in the vicinity of Clyde Park. Topographic relief in the area is moderate with local highlands rising about 500 to 700 feet above the river valley. To the west of town, peaks of the Bridger Range rise in excess of 9,000 feet above sea level, and to the east peaks in the Crazy Mountains rise above 11,000 feet. Many of the creeks and tributaries to the Shields River have extensively incised channels.

Geology

This section provides an overview of the geology and hydrology of the vicinity of Clyde Park area. Reports and geologic mapping used for this section include Berg and Lopez (2000), Groff(1962) McDonald (2005), and Roberts (1972). The geology of the area can be used to determine the locations, boundaries, and hydraulic properties of local aquifers. An understanding of hydrogeologic conditions also provides an explanation for the sensitivity of local aquifers to potential contamination sources. Geology is also important for understanding the hydrologic conditions related for surface water supplies.

Clyde Park is located between the Bridger Range and the Crazy Mountains (Figure 1). This area is part of what geologists refer to as the Crazy Mountains Basin. Deposits of unconsolidated sand and gravel are associated with larger streams and tributaries within this basin. The alluvial deposits cover the older bedrock in the area and they are much younger than the bedrock formations. Alluvial gravel deposits in the vicinity of Clyde Park range from 20 to 30 feet thick. Aquifers within alluvial deposits are often highly productive and they are reliable sources of water.

There are also thin unconsolidated gravel deposits present on the top of many of the benches that slope away from the Crazy Mountains. The benches are referred to as pediment surfaces. Cottonwood Bench is a pediment surface. The pediments are relatively smooth upland surfaces that slope away from the Crazy Mountains. The pediment gravels are reported to be between 10 and 30 feet thick (Berg and Lopez, 2000). The pediment gravels have been cut through or incised by numerous streams that are tributaries to the Shields River. It is worth noting that there are few if any wells completed in the pediment gravels (English, 1999). The pediment gravel deposits appear to have drained as they were incised or eroded. The gravel beneath Cottonwood Bench does not appear to function as an aquifer.

The sandstone and shale beds that dominate the landscape in this area are part of the Fort Union Formation. In the Crazy Mountains Basin the Fort Union Formation can be divided into three general units (Roberts, 1972). The bottom-most and the top units consist of alternating beds of conglomerate and sandstone. There are also significant volumes of siltstone and mudstone within these two units. The middle part of the Fort Union Formation consists of sandstone and mudstone. In the western part of the Crazy Mountains Basin the Fort Union Formation overlies the Livingston Group. In the eastern part of the basin it is difficult to tell the two formations apart. A good number of wells are completed in the sandstone and shale beds of the Fort Union around Clyde Park and it is an important bedrock aquifer in this area. The Fort Union is considered to be Tertiary in age (Paleocene); forming between 65 and 55 million years before present. Sandstone beds in the Fort Union in this area are relatively fine grained and gray to dark gray or green. The sandstone was described in some detail in a report related to a leaking underground storage tank (LUST) in the town of Wilsall, about 10 miles north of Clyde Park. This report described the sandstone as fine grained and relatively soft. The report states that the sandstone beds were fractured and that carbonate minerals filled some of the fractures. Fracture filling carbonate was interpreted to have precipitated from ground water that flowed within the fractures. The LUST report also states that the clay content in the sandstone beds is relatively high, up to 40 percent of the rock matrix. The percentage of clay in the sandstone matrix is important because it reduces the effective porosity of the rock, which makes it harder for ground water to flow between the sand grains. As a result, the ground water moves more readily through the fractures. The fractures are important because they provide a network of pathways for ground water, and potential contaminants, to travel through the rock.

The Crazy Mountains Basin can be identified on a geologic map by noting that it is surrounded or rimmed by two other sandstone formations: the Hopper Formation and the Billman Creek Formation. Both sandstone formations have significant amounts of volcanic material and clay in the rock matrix. The Hopper and Billman Creek formations lie beneath the Fort Union Formation in the vicinity of Clyde Park. Outcrops of both formations occur approximately 10 to 15 miles north and south of Clyde Park. These formations are interpreted to be Cretaceous age; forming between 75 and 65 million years before present.

East and west of Clyde Park there are numerous igneous rock outcrops that are referred to as igneous dikes. The dikes radiate from a larger intrusion known as the Big Timber Stock, which makes up a large part of the southern Crazy Mountains. Close to town; the dikes trend southwest – northeast (Figure 4C). This is very similar to the trend of the lower segment of Cottonwood Creek and is probably related to the orientation of some fractures within the Fort Union Formation. The fractures very likely influence the direction of ground water flow in the vicinity of Clyde Park and in the vicinity of Wilsall to the north. Some stream segments appear to align in a northwest – southeast direction that may also reflect a second fracture set in the area. This will be discussed later in this report under the sections on hydrogeologic setting. The dikes are also associated with outcrops of rocks that are referred to by geologists as hornfels. Hornfels are a very hard fine-grained metamorphic rock that formed when igneous intrusions caused the host rock to bake and harden. The hornfels in the vicinity of Clyde Park often cap small upland areas and ridges, which reflects the rocks hardness and resistance to erosion. Nether the dikes or the hornfels are considered to be sources of ground water.

The Public Water Supply

The Clyde Park PWS is classified as a community system under the Federal Safe Drinking Water Act, because the system serves at least 25 year-round residents through at least 15 service connections. The PWS services about 337 residents with 163 active service connections.

Clyde Park uses a spring source and two wells for its public water supply. The spring source is located about 1.5 miles northeast of town in the upper part of a small valley below Cottonwood Bench. The small valley is known as Spring Creek Coulee. English (1999) observed that no surface water flows from the upper part of the valley where the springs are located. The springs are located topographically below the pediment gravel found beneath the top of Cottonwood Bench. The spring water appears to be originating from where bedrock would outcrop if it were not covered with vegetation (English, 1999). Five collection galleries and over 400 feet of infiltration lines are used to capture the spring water. The spring water moves down to a 350,000 gallon concrete storage tank that is located just north of town. Sodium hypochlorite is added to the spring water at this point. The 350,000 gallon tank was constructed in 2008 to replace an aging 165,000 gallon tank.

One difficulty with a spring is that it can be considered either surface water or ground water depending on how the water emerges from the ground and travels to the infiltration lines. The springs serving Clyde Park have been classified as ground water based on an on-site hydrogeologic assessment (HA) and the results of a micro-particulate analysis (MPA). The HA and results from the MPA, along with the official letter from DEQ stating that the springs are considered ground water are included in Appendix D.

The wells are located about ¼ mile west of town next to Cottonwood Creek (Figure 3A and Figure 3B). Well 1 was drilled in January 2002 to a depth of 62 feet. The static water level at the time of completion was reported as 10.77 feet below the ground surface and the pumping level was reported as 32.7 feet. Water yield was reported as 60 gallons per minute (gpm). Well 2 is located 8 feet west of Well 1. Well 2 was drilled on the same day as Well 1 and reported as 122 feet deep with a static water level of 3.31 feet below land surface, a pumping level of 82.3 feet, and a yield of 55 gpm. Both wells appear to be completed in sandstone and shale beds that are part of the Fort Union Formation. Water from the wells is also treated with a hypochlorite solution at the pump house prior to distribution to customers. The chlorination system is reported to be in good condition according to the sanitary survey.

Water Quality

Public water systems must conduct routine monitoring for contaminants in accordance with Federal Safe Drinking Water Act requirements. A community public water supply, like Clyde Park, must sample in accordance with schedules specified in the Administrative Rules of Montana (ARM). Monitoring includes coliform bacteria, lead, copper, nitrate, nitrite, volatile organic chemicals (including hydrocarbons and chlorinated solvents), inorganic chemicals (including metals), synthetic organic chemicals (including pesticides), and radiological contaminants. Transient, non-community PWSs are required to conduct routine monitoring only for pathogens (including coliform bacteria), nitrate, and nitrite. All contaminant concentrations detected in required samples must comply with numeric maximum contaminant levels (MCLs) specified in the Federal Safe Drinking Water Act.

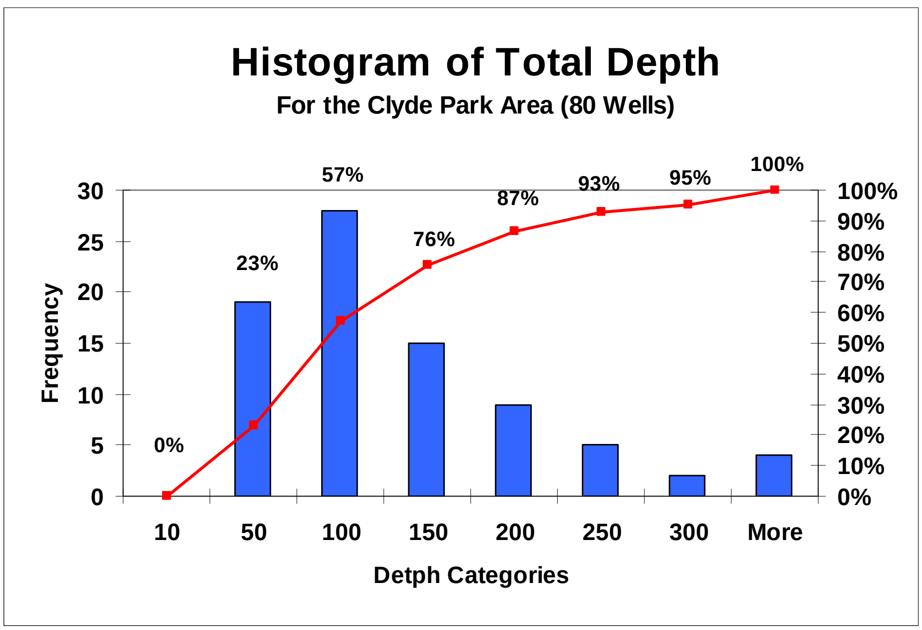
Clyde Park has one positive total coliform detection on May 2, 2001. Follow-up samples tested negative indicating the water was not contaminated by bacteria. No other MCL exceedances were noted for any constituents monitored over the past five years, this includes nitrate. However, nitrate values for Clyde Park's public water supply are elevated when compared to ground water from other systems in Montana. According to water quality data collected by Groff (1962), many of the springs in northern Park County have elevated nitrate concentration (see Groff's Table 2 in Appendix C). The highest nitrate value recorded from Terry Springs is reported at 2.61 milligrams per liter (mg/l). The lowest nitrate concentration from the spring source is 2.08 mg/l and the overall average is 2.20. Water from the wells has a high value of 1.25 mg/l, a low of 0.76 mg/l and an average of 1.02 mg/l. Nitrate in the distribution system is reported with a high value of 2.67 mg/l, a low of 0.196, and an average of 1.78 mg/l. While all of these values are somewhat elevated, they are significantly below the Maximum Contaminant Level (MCL) of 10 mg/l set by EPA.

CHAPTER 2
DELINEATION

The source water protection areas for the Clyde Park public water supply are delineated in this chapter. The purpose of delineation is to map the source of the water for the public water supply and to define areas within which to prioritize source water protection efforts. Four types of management regions are mapped and include; 1) a 100-foot control zone for the wells and the general spring location, 2) separate inventory regions for the spring source and the wells, 3) a recharge region base on the watershed boundaries surround the town, and 4) a surface water buffer region that includes land areas close to the Shields River and Cottonwood Creek. The surface water buffer region is required because Shields River and Cottonwood Creek flow on top of the aquifer that the wells are completed in.

The goal of management in the control zone is to avoid introducing contaminants directly into the water supply's well or immediate surrounding areas. The inventory region should be managed to prevent contaminants from reaching the well before natural processes reduce their concentrations. The goal of management in the recharge region and the surface water buffer is to maintain and improve water quality over long periods of time or increased usage.

Figure 5. Histogram for Well Depth



General Hydrologic Conditions:
Well information was retrieved from the Ground Water Information Center (GWIC) for 80 wells located in the four sections surrounding Clyde Park. Figure 5 shows a frequency distribution of total depth for these wells and indicates that the majority of wells are relatively shallow. About 60% are less than 100 feet deep (Figure 5). Average depth for wells in the area is 110 ft. below land surface (ft. bls) and the maximum depth is 403 ft. bls. Average static water level for these wells is 30 ft. bls. Pumping water level average is 108 ft. bls and average yield is 26 gallons per minute (gpm) with a maximum yield listed at 100 gpm.

According to driller's logs from the 80 wells, almost every one penetrates the alluvial deposits associated with the Shields River and Cottonwood Creek. The wells are completed within shale and sandstone bedrock that is part of the Fort Union Formation. Average thickness of the alluvial deposits is about 20 feet. A good number of the wells are perforated or have slotted sections within the shale and sandstone beds. Many of the driller's logs note that the bedrock is fractured. It is interesting to note that about 30% of the drillers logs record a clay layer at the top of the bedrock section. Average thickness for this clay is about 14 feet. The clay layer would act as a confining layer between the shallower alluvial aquifer and the aquifer within the bedrock. However, it is important to understand that the clay is not recorded in about 2/3 of the wells in the vicinity of Clyde Park. As will be discussed below, the fact that the clay layer is apparently not continuous throughout the area and the fact that the bedrock is fractured raises the possibility that the alluvial deposits and the bedrock are hydraulically connected and behave as a single aquifer. Further studies including aquifer tests would be needed to verify or refute this suggestion.

It is also interesting to note that 69 of the 80 wells near Clyde Park have been drilled between the years 2000 and 2005. If the completion dates from the driller's logs and the MBMG database are correct, this represents substantial drilling activity for a relatively small town. This could suggest that land areas around the town are being developed for individual dwellings or as part of multi-lot subdivisions.

Local Hydrogeologic Conditions

Clyde Park is located near the confluence of Cottonwood Creek with the Shields River (Figure 1). The town uses a spring source (Terry Springs) and two wells for its water supply. The spring source is located about 1 ½ miles northeast of town in the upper part of Spring Creek Coulee, which partially dissects the southern part of Cottonwood Bench (Figure 1). DEQ considers the spring source to originate from ground water based on a hydrologic assessment (English, 1999), and the results from a micro-particulate analysis or MPA conducted on April 19, 1999. The hydrologic assessment is a limited on-site investigation of the spring location. The MPA is a test where at least 1,000 gallons of water from the spring is passed through a filter and then the filter is examined for surface water indicators (algae, diatoms, organic debris, plant material, crustacea, insects, larvae, etc). Results of the MPA are included in Appendix D).

Based on the spring's location, it appears that the water originates from an aquifer within the Fort Union Formation, possibly the Tullock Member of the Fort Union (English, 1999). The aquifer is very likely composed of fractured sandstone and shale. Land areas that provide recharge to the spring source have not been precisely identified and discharge measurements for the springs are not available (English, 1999). Knowing the volume and seasonal variations of discharge would help to estimate the size of the recharge area and the extent to which natural precipitation and irrigation water contribute to the spring. In this report ground water beneath Cottonwood Bench is interpreted to be moving from the northeast to the southwest (Figure 3A and Figure 3B). Recharge probably comes from a combination of precipitation and snowmelt runoff, and irrigation water applied to fields on top of the Cottonwood Bench. Irrigated cropland dominates the land use on the bench. Water quality monitoring data from the spring source indicates that nitrate concentrations average 2.235 mg/l. This is higher than the water from the wells which average 1.02 mg/l. This could be related to the higher percentage of irrigated ag-land in the spring's recharge area.

It is interesting to note that the gravel beneath the bench surface does not appear function as an aquifer and very few wells are located on the bench (English, 1999). The lack of ground water within the Cottonwood Bench pediment gravel is likely due to the fact that the bench has been cut into and drained by surrounding streams. Some volume of the precipitation and irrigation water applied to the bench very likely moves through the pediment gravel and into the underlying sandstone and shale. The Fort Union formation is folded and fractured in the vicinity of Wilsall and Clyde Park. Folds and fractures are oriented along lines running southwest - northeast. As noted above, igneous intrusions located west and east of Clyde Park are also aligned in this direction. Cottonwood Creek also flows along this general trend. It appears that fractures in the bedrock controlled the orientation of the igneous intrusions and the streams valley development for some streams in the area.

Fractures within the sandstone and shale beds could facilitate ground-water flow from upland areas north - northeast of Clyde Park toward the Terry Spring's location. It is worth noting that Little Indian Creek and Cottonwood Creek dissect the northern part of Cottonwood Bench about 3 to 4 miles north of Clyde Park. If fractures in the bedrock are facilitating ground-water flow, it is possible that the two creeks are also providing some volume of recharge to the springs. English (1999) speculated that Cottonwood Creek could provide recharge to bedrock above the Fisher Ranch area, which is about 1 mile northeast of Clyde Park (Figure 1). For this report, Cottonwood Bench is interpreted to be the primary recharge area for the spring source and the direction of ground-water flow is generally from the northeast to the southwest (Figure 3A and Figure 3B). The aquifer for the spring source is considered to be shallow and unconfined. A shallow unconfined aquifer is considered to have a high sensitivity to potential sources of contamination located at the land surface (DEQ, 1999).

The town's two public water supply wells are located less than ¼ mile west of town near Cottonwood Creek and they are less than 10 feet apart (Figure 1 and see also the site layout map C1-17 included with the sanitary survey). According to the most recent sanitary survey by Matt Usuriello (09/20/2006), Well 1 is 62 feet deep and at the time of completion the static water level was 10.77 feet below the land surface. The driller's log for this well shows that the well penetrates about 30 feet of fine sand and gravel with cobbles. At 33 feet the well encounters bedrock composed primarily of shale with stringers of clay (See Appendix A). The log also indicates that the well is sealed with cement to a depth of 26 feet and a packer was set at 27 feet below the land surface. Perforations run from 30 to 38 feet below the land surface. With this construction, Well 1 draws water primarily from a shale bedrock aquifer that is part of the Fort Union Formation. The well is sealed off from the shallow aquifer associated with Cottonwood Creek's sand and gravel alluvium by the 26 feet of cement and the packer set at 27 feet. According to the sanitary survey, Well 2 is 122 feet deep with a static water level of 3.31 feet below the land surface. Both Well 1 and 2 were drilled on the same day, 01/07/2002. According to the driller's log for Well 2, about 24 feet of fine sand and gravel with cobbles is penetrated before encountering "weathered fractured shale." From 24 feet to the bottom of the well it appears that only bedrock is penetrated. Well 2 is sealed with 28 feet of cement and perforated from 85 to 105 feet below the land surface (Appendix A). Based on the driller's log, the perforations are set within a brown and green sandstone with lenses of clay, and fractured shale beds. Well 2 is constructed to draw water primarily from the sandstone and fractured shale beds that are interpreted to be part of the Fort Union Formation. The well's 28-foot cement seal would help prevent water from the shallow alluvial aquifer from entering the well.

Based on the geology in the vicinity of Clyde Park, the town's wells are located on top of alluvium associated with the Shields River (Figure 4A; and see Berg et al, 2000). Cottonwood Creek flows on top of the Shield River alluvium. These alluvial deposits are roughly 20 and 30 feet thick and sit on top of shale and sandstone bedrock. Many of the driller's logs mention that the bedrock is fractured and the fractures very likely facilitate ground-water flow from the alluvial deposits into the bedrock and provide flow pathways within the bedrock aquifer. The aquifer tapped by the two wells may receive the bulk of its recharge from the Cottonwood Creek valley. As noted above, the public water supply wells are located close to each other and Well 1 is shallower than Well 2. At the time of completion Well 1 had a static water level of 10.77 feet below that land surface and Well 2 had a static water level of 3.31 feet. Assuming that both wells were properly developed, this suggests that the wells are located in a ground water discharge area where deeper ground water is moving up toward the land surface, or in this case, it is moving up to discharge into Cottonwood Creek. Because the wells are located closer to Cottonwood Creek than to the Shields River, it is likely that the bedrock aquifer in this area receives recharge primarily from the Cottonwood Creek drainage. Nevertheless, based on the location of the two wells, it is also possible that the Shields River alluvium provides some volume of recharge to the aquifer from upland areas north-northeast of the wells.

For this report, ground water is interpreted to generally flow from upland areas towards lowland areas and streams. Ground water flows toward the Shields River and Cottonwood Creek in the vicinity of Clyde Park (Figure 3A and Figure 3B). Closer to the river and creek there is very likely a component of flow that is generally parallel to the two streams. For this report, recharge areas for the town's public water supply wells include uplands along the Cottonwood Creek drainage and the Shields River Valley generally north and northeast of town. The aquifer tapped by the town's wells is interpreted to be relatively shallow and composed of fractured bedrock. This type of aquifer is considered to have a high sensitivity to potential sources of contamination located at the land surface (DEQ, 1999). It is important to understand that the fractured nature of the bedrock aquifer in the vicinity of Clyde Park raises the possibility that ground water may not simply flow directly from upland areas to lowlands as predicted by an examination of the topography. Instead, preferred flow pathways within the fracture network could modify this simple scenario. As a consequence, the ground-water flow direction as shown in the figures in this report is considered to be generalized and some variations could occur. In addition, a range of hazard and susceptibility ratings is used for some potential contaminant sources listed in Table 7 to help address uncertainties in the ground water flow direction.

Conceptual Model

Figure 4B shows a conceptual ground-water model for the Clyde Park area. It is important to note that Figure 4B is based on general hydrogeologic principles and ground-water information for the Clyde Park area. The model is not drawn to any scale and is presented only to help illustrate general concepts of ground-water flow near Clyde Park.

Terry Springs is interpreted to receive water from a shallow fractured bedrock aquifer within the Fort Union Formation (Tullock Member). The bedrock aquifer is overlain by the pediment gravel deposit that caps the Cottonwood Bench. The bench is considered to be the principle recharge area for the spring and recharge comes from several sources including precipitation, snowmelt, and irrigation water. Ground water flow is generally from the northeast from upland areas to the southwest. The bedrock aquifer providing water to the spring is considered to have a high sensitivity to potential sources of contamination because it is shallow and unconfined.

The town's two public water supply wells are completed in a relatively shallow fractured bedrock aquifer that is overlain by sand and gravel alluvium. The wells appear to be located in a ground water discharge area where deeper ground water is moving up toward Cottonwood Creek. Recharge is interpreted to come from upland areas generally north-northeast of town. Due to the proximity of the wells to Cottonwood Creek, the bulk of the recharge is interpreted to originate within the Cottonwood Creek Drainage but some portion of recharge could originate in the Shields River Valley. Recharge is interpreted to come from a combination of precipitation, snowmelt runoff, irrigation water, and leakage from the streams and irrigation canals. The aquifer tapped by the town's wells is considered to be relatively shallow, composed of fractured bedrock, and to have a high sensitivity to potential sources of contamination.

Well construction information is summarized in Table 3 below.

Table 3. Information from drillers logs for Clyde Park's Wells.

Name MBMG #	Well 1 194741	Well 2 194354
Location	02N 09E 33 ABA	02N 09E 33 ABA
Date Completed	01/07/2002	01/07/2002
Depth (ft. bgs*)	62	122
Screened Interval (ft)	30 - 38	85 - 105
SWL Depth (ft bgs)	10.77	3.31
PWL Depth (ft bgs)	32.7	82.3
Drawdown (ft)	21.93	78.99
Test Pumping Rate (gpm)**	60	55
Specific Capacity (gpm/ft dd*)**	2.74	0.70

*Feet below ground surface; ** Gallons per minute; *** Gallons per minute per foot of drawdown.

Delineation

Methods and criteria for delineating source water protection areas are specified in the Montana Source Water Protection Program (DEQ, 1999). Source water protection areas delineated for Clyde Park include controls zones for each well and for the general location around the spring infiltration lines/galleries; a common inventory region for the wells in the Shields and Cottonwood Creek valleys, and a separate inventory region for the spring source (Figure 3A and Figure 3B). The inventory regions are based on general ground water hydrology principles and the hydrogeologic setting of the springs and wells. Ground-water flow time-of-travel estimates are not used because the bedrock aquifer is fractured and the time-of-travel flow equations are not valid in this setting. A recharge region is also delineated and based on part of the 11 digit hydrologic unit or watershed: 10070003040. In addition to the source water protection regions just mentioned, a surface water buffer region is also included. Surface water buffers are delineated in areas where streams flow across an aquifer and have a high likelihood of being in hydraulic connection with the aquifer. The concern is that if a contaminant is introduced to the stream, the aquifer could also become contaminated, and visa versa. The surface water buffer is used to identify potential sources of nitrate and pathogens. All of the source water protection regions are used to help focus the inventory of potential contaminant sources.

Control Zones - 100-foot radius control zones are delineated for the wells and the general spring location; all sources of potential contaminants should be excluded in this region. All potential contaminant sources are identified within the control zones. On the maps, the dots representing the wells are approximately the radius of the control zone and the square symbol marking the spring location includes areas within 100 feet of the infiltration lines and galleries.

Inventory Region

Spring Source: The inventory region for the spring source begins a short distance down-gradient from the spring location and extends to the northeast on to Cottonwood Bench. This inventory region is delineated to encompass the land area that likely provides recharge water to the bedrock aquifer from which the springs originate. The northeast boundary of the spring's inventory region is arbitrarily set at one mile from the spring location. The inventory regions for the wells and the spring source encompass the land areas from which water or contaminants can flow into Clyde Park's ground water source over a period of months to years.

Wells: A common inventory region is delineated for the public water supply wells based on general hydrogeologic mapping of the aquifer beneath the Shields River and Cottonwood Creek valleys. The inventory regions outline a portion of the aquifer that is interpreted to provide water to the public water supply wells. The regions extend from a position just down-gradient, or down-stream from each well. In the Shields River Valley, the inventory region extends from areas near the wells to the northeastern valley margin where the alluvium terminates against bedrock. In the Cottonwood Creek Valley, the inventory region is delineated to encompass the entire width of the valley (Figure 3A and Figure 3B). An arbitrary distance of 1 mile is used to delineate the length of the inventory region. Time-of-travel calculations were not used to delineate the inventory region primarily due to the fact that the bedrock aquifer is fractured and overlain by saturated alluvial deposits. The procedure for estimating time-of-travel distances is not appropriate for fractured aquifers. Another reason the calculation was not used is because there are no local ground water studies available from which obtain aquifer characteristics and input parameters. All potential contaminant sources are identified within each inventory region.

Time-Of-Travel (TOT) Estimates
For reasons stated above, the TOT distance estimates were not calculated. Table 4 is left blank intentionally.

Table 4. Time-Of-Travel Estimate Calculations –Intentionally Left Blank.

Surface Water Buffer Region - This region extends one half mile from each bank of Shields River and the Cottonwood Creek (Figure 10). The region also extends approximately one half mile below the well locations and ten miles upstream from the well locations. Potential sources of pathogens and nitrate are identified within the region.

Recharge Region - A recharge region is delineated and based on three 11 digit hydrologic units: 10070003040. The watershed has an area of about 350 square miles. General land uses and large potential contaminant sources are inventoried in this region.

Limiting Factors
Detailed mapping and hydrogeologic reports that focused on the ground-water resources in the Clyde Park area are not available. As a result, inventory regions are delineated based on general hydrogeologic mapping and interpretations of the ground-water flow direction. The exact configuration of the fracture network within the bedrock aquifer cannot be determined for this report, and realistically, it may not be possible to map the fractures accurately where younger geologic deposits cover the bedrock. The conceptual model presented in this report is a simplification of the real ground-water flow system near Clyde Park but is considered to be sufficiently accurate to assess the susceptibility of the public water supply to potential sources of contamination in the area.

CHAPTER 3
INVENTORY

An inventory of potential sources of contamination was conducted to assess the susceptibility of the Clyde Park public water supply to contamination, and to identify priorities for source water protection planning. Inventories were conducted within the control zones, inventory regions, surface water buffer and the recharge (watershed) regions. The inventory focuses on facilities that generate, use, store, transport, or dispose of potential contaminants, and on land types on which potential contaminants are generated, used, stored, transported, or disposed. Additionally, the inventory identifies potential sources of all primary drinking water contaminants and Cryptosporidium. Only significant potential contaminant sources were selected for detailed inventory. The significant contaminants posing potential threats to the Clyde Park PWS include sources of nitrate, pathogens, herbicides, and pesticides. The inventory for Clyde Park focuses on all activities in the inventory region, as well as general land uses and large potential contaminant sources in the surface water buffer and watershed regions.

Inventory Method
Available databases were initially searched to identify businesses and land uses that are potential sources of regulated contaminants in the inventory region. The following steps were followed:

Step 1: Land cover is identified from the National Land Cover Dataset compiled by the U.S. Geological Survey and U.S. Environmental Protection Agency (U.S.G.S., 2000). Land cover types in this dataset were mapped from satellite imagery at 30-meter resolution using a variety of supporting information.

Step 2: EPA's Envirofacts System was queried to identify EPA regulated facilities. This system accesses the following databases: Resource Conservation and Recovery Information System (RCRIS), Biennial Reporting System (BRS), Toxic Release Inventory (TRI), Permit Compliance System (PCS), and Comprehensive Environmental Response Compensation and Liability Information System (CERCLIS). The available reports were browsed for facility information including the Handler/Facility Classification to be used in assessing whether a facility is a significant potential contaminant source.

Step 3: DEQ databases were queried to identify Underground Storage Tanks (UST), hazardous waste contaminated sites, landfills, and abandoned mines.

Step 4: A business phone directory was consulted to identify businesses that generate, use, or store chemicals in the inventory region. Equipment manufacturing and/or repair facilities, printing or photographic shops, dry cleaners, farm chemical suppliers, and wholesale fuel suppliers were targeted by Standard Industrial Codes.

Step 5: Major road and rail transportation routes were identified.

Step 6. All significant potential contaminant sources were identified in the inventory region and land uses and facilities that generate, store, transport, or dispose large quantities of hazardous materials were identified within the recharge region.

Potential contaminant sources are designated as significant if they fall into one of the following categories:

1) Large quantity hazardous waste generators
2) Landfills
3) Hazardous waste contaminated sites
4) Underground storage tanks
5) Major roads or rail transportation routes
6) Cultivated cropland
7) Animal feeding operations
8) Wastewater lagoons or spray irrigation
9) Septic systems
10) Sewered residential areas
11) Storm sewer outflows
12) Floor drains, sumps, or dry wells
13) Abandoned or active mines

Inventory Results - 100-foot Control Zone

Wells: The control zone for the two wells includes the pump house and relatively small portions of an access road, undeveloped pastureland, and Cottonwood Creek (Figure 3B). Other than water disinfection chemicals stored at the pump-house, there does not appear to be any significant potential contaminant sources near the well. Land areas along Cottonwood Creek that are upstream from the wells is undeveloped.

Spring Source: Infiltration galleries and infiltration lines are located in the upper part of Spring Creek Coulee, which is undeveloped land (Figure 3B). An access road is located north of the spring facilities but appears to be outside of the 100-foot control zone. Irrigated cropland surrounds the spring area but the fields also appear to be beyond the 100-foot control zone. *(Note: The small building referenced in the 2003 sanitary survey was located at the tank site, not at the spring source. There are no buildings or storage facilities located at the spring site. In addition, that old building at the tank site is no longer in service as it was replaced with a new disinfection room adjacent to the new storage tank with the 2008 project).*

Inventory Results - Inventory Region

Wells: Within the Shields River Valley and the Cottonwood Creek Valley, the inventory region consists of irrigated fields and pastureland, and riparian areas within the floodplain (Figure 3A and Figure 3B, and Figure 6). Approximately 47 percent of the wells inventory region is occupied by agricultural land (Figure 6). This percentage of ag-land represents a moderate hazard to the source water. The concern associated with the ag-land is the potential for mismanagement or over- application of fertilizers and/or pesticides, which could result in the ag-chemicals running off into surface water bodies and infiltrating into the aquifer used by the Clyde Park wells.

An irrigation ditch is located at the base of the southern end of Cottonwood Bench. The irrigation ditch coincides with the inventory region's northeastern boundary. Most irrigation ditches lose water through their channel base and sides. The ditch could have a negative impact on the town's source water if the water is of lower quality than the ground water in the area. It appears that the canal diverts water from Cottonwood Creek just north of town and discharges the water to the Shields River near where Highway 89 crosses the Shields River (Figure 3A and Figure 3B). It is assumed that the water in the canal is relatively high quality water that does not pose a threat to the town's source water.

Where the inventory region extends into the Cottonwood Creek Valley, potential contaminant sources include individual septic systems and private wells located in the northern $^{1}/_{3}$ of town. This area is has areas of moderate and high septic density. Clyde Park does not have a municipal sewer system. Septic systems can be sources of pathogens and nitrate. The private wells in town could also pose a threat to the source water. Many of the wells tap the same aquifer used by the public water supply wells. Poorly constructed or old wells with deteriorating casing can under certain circumstances provide pathways for contaminants to enter the aquifer. Based on the general ground-water flow direction it appears that only 1/3 of the town is directly up-gradient of the wells and no large businesses or other facilities are located in this part of town.

Several inactive underground fuel storage sites are located just inside or very near the inventory region boundary. Three of the sites have leak histories. According to available information, all of the sites have had the underground tanks removed. In addition, it is assumed that the fuel releases have been mitigated so as to no longer pose a threat to the source water. If this assumption is not correct the tanks could pose a threat to the source water and the town's public water supply wells. It is important to verify that the sites have been cleaned up and that leaking tanks are no longer on-site.

State Highway 89 passes through town and crosses the Shields River about one mile north of town. Traffic volume on the road is considered low and it is not a major transportation route for large vehicles carrying hazardous materials. The highway is not considered to pose a threat to the public water supply wells although it is still advisable to secure emergency services to help insure rapid respond to any accidents and spills on the highway near the river.   The rail line is located about 1,000 feet west of the public water supply wells is located close to the river about ½ mile north of the Bracket Creek Road Bridge (Figure 3A and Figure 3B). The location of the rail line is down-gradient from the wells. This means that the ground water beneath the railroad bed is generally moving away from the wells and not toward them. The railroad is not considered to pose a threat to the public water supply wells.   Again, it is advisable to have adequate emergency response available to respond to accidents and derailments. Derailments near the Shields River would result in negative impacts to the river and could affect water quality in the alluvial aquifer.

Spring Source: The inventory region for the spring source is located entirely on top of Cottonwood Bench (Figure 3A and Figure 3B), which is dominated by agricultural land use (Figure 6).   As mentioned above, ag-land is considered a potential source of contamination if ag-chemicals are not applied correctly. As with the wells, over-application of fertilizers and/or pesticides could result in the ag-chemicals infiltrating into the aquifer that supplies the town's spring source. The ag-land represents a high hazard to the spring source. All other potential contaminant sources in the area are located near the town site, which is down-gradient from the spring source and its inventory region. This means ethat ground water beneath the other potential contaminant sources is moving away from the spring source and do not pose a threat to the spring's source water.

Other businesses and land uses in the area are also considered to be potential sources of contamination. However, businesses in Clyde Park are relatively small and are not considered to store or use commercial volumes of hazardous material. In addition, the town site is down-gradient from the spring source and about 2/3 of the town is down-gradient from the wells.

Inventory Results - Surface Water Buffer Region

Land areas within the surface water buffer region is sparsely populated and fairly rural (Figure 7). The principal land cover in the surface water buffer region is ag-land (46%), grassland (38%), and forestland (15%). There are also small percentages of urban, open water and wetlands in this region. According to the Source Water Program criteria, the percentage of agricultural land in this region represent a moderate hazard or potential threat to Clyde Park's public water supply. It is important to note that a significant part of the ag-land is concentrated along the Shields River and Cottonwood Creek alluvial valleys (Figure 7 and Figure 8). Due to the location of ag-lands near the streams, there would be potential benefit to Clyde Park and other public water supplies like Wilsall to promote and encourage the use of best management practices (BMPs) by the agricultural industry.

A closed landfill site is located within the surface water buffer region about 1-½ miles northeast of town (Figure 8). The site appears to be relatively small and was closed in 1989. Due to the distance from the pubic water supply, this site is not considered to pose a threat to the source water.

Low septic densities occur over most of the surface water buffer region except near town. According to the available sources of information, a permit has been issued for land application of septic effluent on a field located about ¼ mile from Clyde Park. The permit belongs to Brown's Septic Service. The frequency and volume of the applications are not known. It is assumed that the septage is being applied in accordance with the permit. The field is between ½ and 1 mile from the public water supply wells (Figure 3A and Figure 3B). As mentioned in other places in this report, the fact that the bedrock aquifer serving the town's public water supply wells is fractured creates uncertainty in determining the ground-water flow direction. As a consequence, it is advisable to verify that the septage is being applied in accordance with the permit and that the requirements of the permit are reasonable given the fractured nature of the bedrock aquifer.

Inventory Results - Recharge Region

Land areas within the recharge region are also sparsely populated and rural (Figure 7). The principal land cover in the surface water buffer region is ag-land (42%), grassland (41%), and forest land (16%). There are also small percentages of urban, open water and wetlands in this source water protection region. According to the Source Water Program criteria, the percentage of agricultural land in this region represents a moderate hazard to Clyde Park's public water supply.

Transportation corridors for rail and highways within the recharge region are located within the Shields River Valley (Figure 8). As in the Spill Response Region, the concern is that accidents and spills along transportation routes where they cross or where they are in close proximity to the Shields River could result in relatively large volumes of hazardous material entering the river upstream from the public water supply. Spills occurring in the distal up-stream portions of this region are of less concern than those occurring closer to the town's wells. However, due to the fact that the river is down-gradient from the wells, contaminants entering would very likely move rapidly past the town without being pulled into the wells.

Low septic densities occur over the entire recharge region except near town. A second permitted septic land application site is located just outside the recharge region and does not pose a threat to the public water supply (Figure 3A and Figure 3B).

Potential Sources of Nitrate

As mentioned previously, water from the Clyde Park public water supply has elevated nitrate concentrations as compared to other ground-water sources around the state. Nitrate concentrations are well below the maximum contaminant level or MCL of 10 mg/l for both the spring source and the wells. Nitrate concentrations in the spring water has been consistently above 2.0 mg/l since 1993 (Appendix E). The well water is consistantly around 1.0 mg/l (Appendix E). Based on the inventory results and the hydrogeologic setting, several potential sources of nitrate exist in the vicinity of Clyde Park.

Agricultural land use: Figure 3B and Figure 6 show that almost all of the land within the spring source's inventory region consist of ag-land that appears to be irrigated. Irrigation water applied to the Cottonwood Bench is very likely the primary source of recharge to the aquifer that provides water to the spring source. Fertilizers applied to the fields on Cottonwood Bench are considered to one of the sources of nitrate in the water from the spring source. Figure 6 and Figure 7 show that a significant amount of land under cultivation is located within the Shield River and Cottonwood Creek valleys. The public water supply is considered to be highly susceptible to the ag-land based on the percentage of ag-land in the watershed and the surface water buffer region (Table 7). If fertilizers used on the ag-land are the source of nitrate in the source water used by Clyde Park, it may be possible to lower the nitrate concentration through the use of best management practices (BMPs) for agricultural lands. Reducing the amount of fertilizers apply to fields particularly on Cottonwood Bench could improve the public water supply's water quality. Keeping stock animals away from the riparian areas and the streams could also help to improve water quality..

Septic Systems: The multiple septic systems and drainfields in town are also potential sources of nitrate that could be impacting the public water supply wells (Figure 6). The spring source is up-gradient from the town and would not be impacted by the septic systems. Most of the town appears to be in a cross- or down-gradient location from the wells, which means that the ground water beneath most of the town would be moving parallel to the wells or away from the wells. On the other hand, the fact that many of the drillers logs for wells in the area mention that the bedrock is fractured raises the possibility that the fractures play a role in the elevated nitrate levels recorded in the wells.

Land application of septic effluent is also considered to be a potential source of nitrate. It is assumed that the effluent is being applied according the permit but it would be advisable to verify this with the permitee. It is advisable to insure that the land application is being applied according to the permit requirements and that those requirements are reasonable given the fractured nature of the bedrock aquifer.

Natural (geologic) sources: The other possible nitrate source in the Clyde Park area may be the Fort Union or other geologic formations associated with the Crazy Mountains. Recent studies on several types of geologic materials indicate that weathered bedrock and certain soils can contribute nitrate to surface water and ground water (Holloway and Smith, 2005). The volume of nitrate produced by the erosion of rock has to be in excess of what vegetation can use before it will be mobilized and transported to surface water or ground water. The studies indicate that rocks of volcanic origin and others referred to as metasediments and shales can be sources of nitrate under certain conditions. These rocks can contain significant volumes of ammonium silicates like certain mica and feldspar minerals, and these minerals can release nitrate during the weathering process (Holloway and Smith, 2005). It is interesting to note that tests conducted by Holloway and Smith on shale from the Fort Union Formation from North Dakota and Eastern Montana indicated that nitrate could be released from these rocks, at least under laboratory conditions. As mentioned previously, the Clyde Park area is underlain by sandstone and shale beds of the Fort Union Formation. It is also notable that a good number of the wells in Wilsall, including the public wells, are screened across intervals of sandstone and shale. Additional studies would be needed to verify or dismiss the local geologic formations as potential nitrate sources.

Inventory Update
To make this SWDAR a useful document in the years to come, the water system operator(s) for Clyde Park should update the inventory for their records every year. Changes in land uses or newly identified

potential contaminant sources should be noted and added to the inventory as needed. The complete inventory should be submitted to DEQ at least every 5 years to ensure that this report stays current in the public record.

Inventory Limitations

The extent of the potential contaminant source inventory is limited in several respects. The inventory is based on data readily available through state documents, published reports, and GIS data. Documentation may not be readily available on some potential sources. As a result, all potential contaminant sources may not have been identified. In some instances, inadequate location information precluded the inclusion of potential sources in the inventory.

CHAPTER 4
SUSCEPTIBILITY ASSESSMENT

Susceptibility is the potential for a public water supply to draw in water contaminated by inventoried sources. Susceptibility is assessed in order to help prioritize management actions for each potential contaminant source.

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 surface water buffer and recharge regions pose minimal threats 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. The PWS operators, town and county officials could pursue alternative management approaches to help reduce susceptibility that are listed in Table 7.

Susceptibility is determined by considering the hazard rating for each potential contaminant source and identifying barriers that can decrease the likelihood that contaminated water will flow to the wells or spring source (Tables 5 and 6). For point sources, hazard is rated by the proximity of a potential contaminant source to the wells. In general, the closer a potential contaminant source is to the public water supply well or spring, the higher the hazard assigned. When time-of-travel calculations are not used, hazard can be based on arbitrary distances from the well or spring location. In this report, point sources within ½ mile from the well or spring are assigned a high hazard. Point sources between ½ mile and one mile are assigned a moderate hazard and beyond the one-mile inventory region boundary a low hazard is assigned. Hazard ratings for nonpoint sources are assigned based on the following criteria in Table 5.

As mentioned previously, the fractured nature of the bedrock aquifer in the vicinity of Clyde Park raises the possibility that ground water may not simply flow directly from upland areas to lowlands as predicted by an examination of the topography. Instead, preferred flow pathways within the fracture network could modify this simple scenario. As a result, assigning hazard to some potential contaminant sources is complicated. To address this, a range of hazard ratings is used to help account for uncertainties.

When time-of-travel calculations are performed, high hazard is assigned to point sources within the 1-year time-of-travel distance to a well. A moderate hazard rating is assigned to point sources located between the 1-year time-of-travel distance and the 3-year time-of-travel distance to a well. A low hazard rating is assigned to point sources located farther than the 3-year time-of-travel distance to a well.

Table 5. Hazard Assignment for Unconfined Aqufiers

Potential Contaminant Source	High Hazard	Moderate Hazard	Low Hazard
Point Sources	Within 1 year TOT	Between 1 to 3 years TOT	Over 3 years TOT
Septic Systems	More than 300 per sq. mi.	50 – 300 per sq. mi.	Less than 50 per sq. mi.
Municipal Sanitary Sewer (percent land use)	More than 50 percent of region	20 to 50 percent of region	Less than 20 percent of region
Cropped Agricultural Land (percent land use)	More than 50 percent of region	20 to 50 percent of region	Less than 20 percent of region

Barriers to contamination can be anything that decreases the likelihood that contaminants will reach a spring or well. Barriers can be engineered structures, management actions, or natural conditions. Examples of engineered barriers are spill catchment structures for industrial facilities and leak detection for underground storage tanks. Emergency planning and best management practices are considered management barriers. Thick clay-rich soils, a deep water table or a thick saturated zone above the well intake can be natural barriers.

Table 6. Susceptibility of Source Water based on Hazard rating and the presence of Barriers

	High Hazard Rating	Moderate Hazard Rating	Low Hazard Rating
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

Susceptibility ratings are presented for each significant potential contaminant source and each associated contaminant listed in Table 7 below. As mentioned previously, Table 7 also lists some management options for creating additional barriers that could lower the susceptibility of the public water supply to potential contaminant sources identified in the inventory. Additional management recommendations are provided beginning on page 28.

Susceptibility Assessment Results

Table 7. Susceptibility Assessment of Significant Potential Contaminant Sources

Potential Contaminant Source	Potential Contaminants	Hazard	Hazard Rating	Barriers	Susceptibility	Management Recommendation
Cropped Agricultural Land Use	SOCs, Nitrates, Pathogens	Contaminants leaching into groundwater	**Moderate** (for the Wells) **High** (for the springs)	None	**High** **to Very High**	Notify landowners of well and protection area locations. *E*ncourage and support efforts to provide educational information, materials, and resources to land owners on the proper application and storage of pesticides and fertilizers and implementing agricultural best management practices (BMPs). Retire the Spring Source which is more susceptible to ag-chemicals. Increase the number of wells if needed.
Other Wells In Town (Could include inactive or abandoned wells)	Pesticides, fertilizers, VOCs, SOCs, other	Old and deteriorating wells, or improperly installed or maintained wells may provide a direct conduit for surface contamination into groundwater.	**High**	About 2/3 of the town site is in a cross-gradient location from the well Upward gradient: Based on static water levels at the time the wells were drilled, they appear to be located in a discharge region where deeper ground water is moving upward.	**High** **to Very High**	Inventory and encourage proper abandonment or renovation of inactive, failing or unused wells. Encourage use of best management practices (BMPs) such as having positive drainage away from wells and ensuring hazardous materials are not stored or used around wells. Encourage and support local and county efforts to provide educational materials and workshops to the public on proper handling and disposal of industrial and household hazardous wastes and recycling.

Septic Systems Town is unsewered and has a high septic density	Nitrates, Pathogens	Ongoing or catastrophic leakage of sewage into groundwater	**High**	Down- or cross-gradient location: About 2/3 of the town is located in a cross-gradient location from the wells and down-gradient from the springs. Upward gradient: The towns wells appear to be located in a ground water discharge area.	**High to Very High**	Properly operate and maintain the on-site septic system and distribution lines. A two to three year septic tank pumping maintenance schedule is recommended. Consider connecting to municipal sewer system, if available. Encourage and support town and county efforts to extend city sewer or to promote installation of community or advanced treatment septic systems and regular maintenance of septic tanks and distribution lines. Encourage and support town and county efforts to provide educational materials and workshops to the public on proper handling and disposal of industrial and household hazardous wastes and recycling.
Transportation Routes Highways and Railroad	Pesticides, fertilizers, VOCs, SOCs, other	Spills, routine spraying, storm water runoff, infiltration into groundwater	**Moderate**	Low traffic volume for both highway and railroad. Down-gradient from spring sources. Railroad is down-gradient from the wells. County Emergency Response Plan, training and preparation of local response personnel	**Low to Moderate**	Notify MDOT of well and protection area locations. Encourage and support emergency planning, training of local emergency response personnel, use of levees and engineered storm drainage to carry any spills away and prevent infiltration into ground, cooperation with railroad managers or MDOT to reduce herbicide use.
Irrigation Canals / Ditches	Pesticides, fertilizers, VOCs, SOCs, other	Leakage and infiltration to ground water	**Moderate**	Water appears to be diverted from Cottonwood Creek, which is relatively high quality water.	**Low to Moderate**	Contact canal / ditch owners and request that the ditch be lined to prevent water losses. Collect samples from the ditch and verify water quality.

Businesses that may use hazardous materials or have USTs:	Pesticides, fertilizers, VOCs, SOCs, other	Spills and leaks impacting groundwater	**Low**	Down- or cross-gradient location: About 2/3 of the town is located in a cross-gradient location from the wells and down-gradient from the springs. Size of business facility: Use or store non-commercial volumes (Less than 500 gallons)	**Low**	Encourage pollution prevention education; training in waste reduction, handling and recycling; regulatory oversight; and promotion of good housekeeping. Review permit status for USTs and ensure proper operation and maintenance. Verify existing contamination is being properly removed or remediated. Properly abandon and remove USTs if out-of-service. Consider wellhead protection ordinance to restrict chemical use, handling and storage or to implement BMPs
Active USTs with Leak History (1 site)	VOCs, petroleum hydrocarbons	Contaminants leaching into groundwater	**High**	Compliance with 1998 upgrades Spill prevention Groundwater monitoring Down- or cross-gradient location from wells	**Low to Moderate**	Review permit status and ensure proper operation and maintenance, emergency planning, training of local emergency response personnel, groundwater monitoring, spill prevention, and BMPs.
Inactive USTs	VOCs, petroleum hydrocarbons	Historic spills or leaks may impact the drinking water supply.	**High**	Removal of leaking tanks Completion of previous remediation efforts Down- or cross-gradient location from wells	**Low to Moderate**	Properly abandon and remove tanks if out-of-service. Encourage soil testing to evaluate potential impact from historic spills or leaks.
Landfills	Various	Contaminants leaching into groundwater	**Low**	Closed Facility – Relatively small facility	**Low to Moderate**	Contact DEQ's Waste and Underground Tank Management Bureau (406-444-5300) to review closure permit requirements (if any) and to find out if site assessment or cleanup is pending or completed.
Class V Injection Wells	VOCs, SOCs, pathogens, nitrate	Infiltration of contaminants into aquifer	**Unknown**	None	**Unknown**	Encourage EPA to inventory the area Support providing educational information, materials and resources to business owners and the public on proper waste disposal and recycling

The susceptibility assessment results for each significant potential contaminant source identified is described below:

Agricultural lands – The potential hazard from pathogens and nitrate originating from agricultural lands is moderate for the town's wells and high for the spring site. Cropped agricultural lands occupy a significant part of the inventory region for the spring site and no barriers are identified that could slow the movement of potential contaminants toward the spring site.

Other Wells In Town **–** There are about 50 wells located within the town site and an additional 30 or more in the four sections surrounding the town site. Old wells or poorly constructed wells can act as conduits for contaminants to enter the aquifer used by the town's public water supply wells. As a result they are assigned a high hazard. However several barriers are recognized that lower the final susceptibility. Roughly 2/3s of the town site is interpreted to be in a cross-gradient location from the public wells. This means that the ground water beneath that part of town is flowing parallel to the public well locations and Cottonwood Creek, and not toward the public water supply wells. As a consequence, if contaminants were entrained in the ground water they wound not move toward the public wells. In addition the town's public wells appear to be located in a ground water discharge area where ground water is flowing up from depth to discharge into Cottonwood Creek. This interpretation is based on the static water levels recorded for the two wells when they were initially drilled. The deeper well records a static water level of about 3 feet below land surface and the shallow well recorded a static water level of about 11 feet below the land surface The public water supply wells susceptibility to contaminants in town and the other wells is assigned as Moderate.

Septic Systems – Clyde Park does not have a municipal sewer system and human and household wastes are handle by individual septic systems and drainfields. These can be a source of pathogens and nitrate, as well as household hazardous wastes. Hazard is set at high and the barriers just mentioned above allow the susceptibility to be set a Moderate.

Railroads and Highways – The potential hazard represented by pesticides, fertilizers, VOCs and SOCs from spills along the railway pose a moderate hazard to the well site. The railroad and highway are in close proximity to the Shields River at multiple locations upstream from Clyde Park. The highway is up-gradient from the town's wells but it is about ½ mile east of the wells. In addition, the traffic volume on the highway is considered to be relatively low and it is not a major transportation route for large vehicles carrying hazardous material. The same cannot be said of the railroad but it is located down-gradient from the town's wells. Hazard is set at low and susceptibility is also set at low.

Assorted Businesses in Town - The businesses located in Clyde Park are not considered to pose a threat to the source water largely due to the fact that they are relatively small and are unlikely to use or store commercial volumes of hazardous materials.

UST/LUSTs - Based on the available information, there are about six underground fuel storage tank sites in Clyde Park. All but one of these sites are inactive and the tanks have been removed from the ground. One active site is present and it did have a leak event in 1996. Several tanks were removed from the site and it appears that the leaks were remediated. New tanks were installed in 1999 that conform to current construction standards and monitoring requirements.

Landfill **–** There is a landfill site located about 1 mile northeast of town. The site is listed as closed. The site is assumed to be relatively small and to not pose a threat to the town's source water.

Class V Injection Wells – The potential hazard imposed by VOCs, SOCs, pathogens, nitrate, and other contaminants originating from the class V injection wells is considered low. The susceptibility of the intake to contaminants originating from this source is unknown due to the fact that no inventory of Class V well is complete or the current inventory is inadequate.

Management Recommendations
It should be noted that even small releases of some chemicals in close proximity to a public water supply well can have significant negative impact on water quality, and therefore are a significant threat to the public water supply. Steps can be taken to reduce the likelihood of releases in the source water for the public water supply or in the vicinity of the sources (wells, springs, surface water intakes, etc). Some of management recommendations are mentioned in the susceptibility table (Table 7). If these, and other, management recommendations can be implemented; they can be considered additional barriers that will reduce the susceptibility of the source water to specific sources and contaminants. The list of management recommendations below is a general list and some may apply directly to this public water supply and some may not. The Montana Source Water Protection Program can be contacted to help answer questions concerning whether specific options listed below are appropriate for this public water supply.

As mentioned previously, between the years 2000 and 2005 about 69 wells have been drilled in the four sections surrounding Clyde Park. It is difficult to know for sure what this means but it could indicate that land parcels in the area are being prepared for development. In the event that this is the case, the septic density in some areas surrounding the wells could increase. If the increase takes place on land parcels that are up-gradient from the public water supply wells, the town's source water could become more susceptible to contamination from nitrate and pathogens. It is important to understand that growth and development does not have to be prevented but can be guided or directed away from land areas directly up-gradient from the public water supply. For Clyde Parks management options could include, but not be excluded to the following: 1) Working with developers and other land owners to guide development generally away from the inventory regions for the wells and the spring source. 2) If development does occur within the inventory regions, require low-density developments on large lots (2 to 5 acres or more) would be better than high-density development on small lots. 3) If a parcel were developed adjacent to the town's wells, insuring that septic systems and drainfields are kept well beyond the 100-foot control zone would be advisable. 4) Require all new septic systems and drainfields to be of modern design to include pressure dosing and sand filtration.

Restrict Chemical Handling, Use and Storage in the Control Zone for the Well **–** The public water supply should restrict chemical handling, use and storage within the 100' radius Control Zone of the public water supply's wells. Ongoing training should be provided to promote safe handling and proper storage, transport, use, and disposal of hazardous materials if these materials are used near the wells.

Agricultural Best Management Practices (BMPs) **–** The water system should encourage land users to utilize BMPs to limit the application of pesticides, herbicides, and fertilizers in the inventory and recharge region. If significant grazing occurs in the recharge region, land users should be encouraged to keep the concentration of livestock low and to keep livestock away from the stream immediately up gradient of the well. BMPs are generally voluntary but their implementation can be encouraged through education and technical assistance.

High Septic System Density Areas **–** An education program to raise the awareness of residents on proper operation and maintenance of septic systems can reduce the susceptibility of the PWS's drinking water to septic wastes. Installation of advanced septic treatment systems such as sand filters can limit contamination from new rural residential development. However, annexation and extension of a community sewer is the only way to reduce contamination from existing unsewered developments.

Land Application of Septic Effluent and Sludge - Land application sites are permitted through the DEQ. It is important that land application be carried out in accordance with the permit requirements and with BMPs. DEQ can provide information on whether the applicant is in compliance with their permits. Working with the land applicator to inform them of the location of the public water supply wells and spring source and monitoring application activities to verify that application is done properly will help reduce the hazard posed by this potential contaminant sources.

Inactive USTs/LUSTs - It is recommended that the PWS operator or community members contact DEQ's Waste and Underground Tank Management Bureau (406-444-5300) to obtain further information on the cleanup status and any permits or monitoring networks to verify existing contamination is being properly assessed and remediated. The PWS can work with DEQ to encourage proper abandonment for out-of-service tanks and soil testing to evaluate potential impact from historic spills or leaks.

Stormwater Management - Stormwater planning should address source and drainage control. Source control can be accomplished through educational programs focusing on residential and commercial chemical use, disposal, and recycling. Drainage control and pollutant removal can be accomplished through the use of vegetated retention basins at outfall locations.

Emergency Response Plan **–** Several counties have compiled Emergency Response Plans that were then adopted by the local communities. The usefulness and effectiveness of a response plan are maximized if it contains a clear listing of all emergency contacts, emergency numbers, and resources available within the county to respond to an emergency situation, such as a hazardous material spill. Emergency plans are not difficult to develop or distribute, but have a significant benefit to the citizens and municipalities within the county.

Education - Educational workshops provided to the general public by the town, county, or state promote safe handling and proper storage, transport, use, and disposal of hazardous materials. Ongoing training provided to designated emergency personnel would promote the efficiency and effectiveness of emergency responses to hazardous material spills. Likewise, educational workshops provided to rural homeowners and agricultural landowners will promote best management practices for groundwater protection including proper maintenance and replacement of residential septic systems and proper management of small acerage. The EPA and the State of Montana can provide educational materials on these topics.

Hazardous Materials Collection Days **–** Several counties in the state that have vulnerable water supplies have implemented scheduled days for the collection of hazardous wastes from the public. These vary in the inclusiveness of what materials are collected, how the materials are handled, and how they are disposed of, but they all act to reduce the amount of unauthorized or improper disposal of these wastes. Used motor oil collection station could be established and available to the public on a regular basis.

Growth and development planning - Several areas in the vicinity of town have been subdivided and will likely be developed in the coming years. As in other parts of the county, subdivision and development could continue to occur for some time and growth could be fairly rapid. It would be advisable to encourage and guide growth and development in areas that would not pose a threat to source water. For the most part this means guiding the growth to land areas that are outside of the well and spring source control zones, and inventory regions.

It would also be advisable for the town to initiate advanced planning that would examine potential growth and identify funding and assistance for developing a community or municipal sewer system. While a municipal sewer for Clyde Park may be some years away, it would be advisable to stop using individual septic systems for waste disposal at the town site, which is generally up-gradient from the water supply wells. This will be come increasingly important as the town grows in population and as businesses in town service a growing population in the surrounding areas.

Drinking Water Protection Plan – The next phase of source water protection for the public water supply would be for the community to take the information presented in this report and use it to continue development of a Drinking Water Protection Plan. This plan could be part of a larger grown planning effort and would focus on clearly identifying: 1) strategies to reduce the likelihood of contaminant releases within the inventory region, 2) the procedures to follow (emergency response plan) in the event that the wells and spring source become threatened by contaminants, and 3) identify alternate sources of drinking water.

CHAPTER 5
Monitoring Waivers

Waiver Recommendation

It does not appear that Clyde Park currently has any water quality monitoring waivers. Based on the susceptibility assessment of the subdivision's source water, the Source Water Protection Program does not recommend waivers. This is due in part to the fact that the aquifer serving the town is relatively shallow and some of the water used by the town is from a spring source. The large percentage of agricultural land in the spring's inventory region also supports maintaining a full regiment of water quality monitoring. From a source water protection standpoint, water quality monitoring will act as a first defense to detect problems with water quality in the area if they should arise.

However, to be sure that eligibility for all available waivers is considered, the PWS Operators are encouraged to carefully review the following section on Monitoring Waiver Requirements. If after reviewing this section it is determined that an additional waivers are feasible, the PWS should submit a letter with the proper documentation to DEQ requesting monitoring waivers.

Monitoring Waiver Requirements
The 1986 Amendments to the Safe Drinking Water Act require that community and non-community PWSs sample drinking water sources for the presence of volatile organic chemicals (VOCs) and synthetic organic chemicals (SOCs). The US EPA has authorized states to issue monitoring waivers for the organic chemicals to systems that have completed an approved waiver application and review process. All PWSs in the State of Montana are eligible for consideration of monitoring waivers for several organic chemicals. The chemicals diquat, endothall, glyphosate, dioxins, ethylene dibromide (EDB), dibromochloropropane (DBCP), and polychlorinated biphenyls are excluded from monitoring requirements by statewide waivers.

<u>Use Waivers</u>
A Use Waiver can be allowed if through a vulnerability assessment, it is determined that specific organic chemicals were not used, manufactured, or stored in the area of a water source (or source area). If certain organic chemicals have been used, or if the use is unknown, the system would be determined to be vulnerable to organic chemical contamination and ineligible for a Use Waiver for those particular contaminants.

<u>Susceptibility Waivers</u>
If a Use Waiver is not granted, a system may still be eligible for a Susceptibility Waiver, if through a vulnerability assessment it is demonstrated that the water source would not be susceptible to contamination. Susceptibility is based on prior analytical or vulnerability assessment results, environmental persistence, and transport of the contaminants, natural protection of the source, wellhead protection program efforts, and the level of susceptibility indicators (such as nitrate and coliform bacteria). The vulnerability assessment of a surface water source must consider the watershed area above the source, or a minimum fixed radius of 1.5 miles upgradient of the surface water intake. PWSs developed in unconfined aquifers should use a minimum fixed radius of 1.0 mile as an area of investigation for the use of organic chemicals. Vulnerability assessment of spring water sources should use a minimum fixed radius of 1.0 mile as an area of investigation for the use of organic chemicals. Shallow groundwater sources

under the direct influence of surface water (GWUDISW) should use the same area of investigation as surface water systems; that is, the watershed area above the source, or a minimum fixed radius of 1.5 miles upgradient of the point of diversion. The purpose of the vulnerability assessment procedures outlined in this section is to determine which of the organic chemical contaminants are in the area of investigation.

Given the wide range of landforms, land uses, and the diversity of groundwater and surface water sources across the state, additional information is often required during the review of a waiver application. Additional information may include well logs, pump test data, or water quality monitoring data from surrounding public water systems; delineation of zones of influence and contribution to a well; Time-of-Travel or attenuation studies; vulnerability mapping; and the use of computerized groundwater flow and transport models. DEQ's PWS Section and DEQ's Source Water Protection Program will conduct review of an organic chemical monitoring waiver application. Other state agencies may be asked for assistance.

Susceptibility Waiver for Confined Aquifers

Confined groundwater is isolated from overlying material by relatively impermeable geologic formations. A confined aquifer is subject to pressures higher than atmospheric pressure that would exist at the top of the aquifer if the aquifer were not geologically confined. A well that is drilled through the impervious layer into a confined aquifer will enable the water to rise in the borehole to a level that is proportional to the water pressure (hydrostatic head) that exists at the top of a confined aquifer.

The susceptibility of a confined aquifer relates to the probability of an introduced contaminant to travel from the source of contamination to the aquifer. Susceptibility of an aquifer to contamination will be influenced by the hydrogeologic characteristics of the soil, vadose zone (the unsaturated geologic materials between the ground surface and the aquifer), and confining layers. Important hydrogeologic controls include the thickness of the soil, the depth of the aquifer, the permeability of the soil and vadose zones, the thickness and uniformity of low permeability and confining layers between the surface and the aquifer, and hydrostatic head of the aquifer. These factors will control how readily a contaminant will infiltrate and percolate toward the groundwater.

The Susceptibility waiver has the objective of assessing the potential of contaminants reaching the groundwater used by the PWS. A groundwater source that appears to be confined from surface infiltration in the immediate area of the wellhead may eventually be affected by contaminated groundwater flow from elsewhere in the recharge area. Contaminants could also enter the confined aquifer through improper well construction or abandonment where the well provides a hydraulic connection from the surface to the confined aquifer. The extent of confinement of an aquifer is critical to limiting susceptibility to organic chemical contamination. Regional conditions that define the confinement of a groundwater source must be demonstrated by the PWS in order to be considered for a confined aquifer susceptibility waiver. Confinement of an aquifer can be demonstrated by pump test data (storage coefficient), geologic mapping, and well logs. Site specific information is required to sufficiently represent the recharge area of the aquifer and the zone of contribution to the PWS well. The following information should be provided:

- Abandoned wells in the region (zone of contribution to the well),
- Other wells in the region (zone of contribution to the well),
- Nitrate/Coliform bacteria analytical history of the PWS well,
- Organic chemical analytical history of the PWS well,

Susceptibility Waiver for Unconfined Aquifers

Unconfined aquifers are the most common source of usable groundwater. Unconfined aquifers differ from confined aquifers in that the groundwater is not regionally contained within relatively impervious geologic strata. As a result, the upper groundwater surface or water table in an unconfined aquifer is not under pressure that produces hydrostatic head common to confined aquifers.

Unconfined aquifers are usually locally recharged from surface water or precipitation. In general, groundwater flow gradients in unconfined aquifers reflect surface topography, and the residence time of water in the aquifer is comparatively shorter than for water in confined aquifers. Similar water chemistry often exists between unconfined groundwater and area surface water, and physical parameters and dissolved constituents can be an indicator of the hydraulic connection between groundwater and surface water. Consequently, unconfined aquifers can be susceptible to contamination by organic chemicals migrating from the ground surface to groundwater.

The objective of the susceptibility waiver application is to assess the potential of organic chemical migration from the surface to the unconfined aquifer. The general procedures make use of a combination of site specific information pertaining to the location and construction of the source development, monitoring history of the source, geologic characteristics of the unsaturated soil and vadose zones, and chemical characteristics of the organic chemicals pertaining to their mobility and persistence in the environment. The zone of contribution of the unconfined groundwater source must be defined and plotted. This should describe the groundwater flow directions, gradients, and a 3-year time-of-travel. All surface bodies within 1,000 feet of the PWS well(s) must be plotted. Analytical monitoring history of the PWS well and those nearby should be provided as well.

REFERENCES

Alt, David, and Hyndman, Donald W., 1990, Roadside Geology of Montana, Mountain Press Publishing Company, Missoula.

Alt, David, and Hyndman, Donald W., 1998, Northwest Exposures, A Geologic Story of the Northwest, Mountain Press Publishing Company, Missoula.

Berg, R.B., Lopez, D.A., 2000, Geologic map of the Livingston 30' x 60' quadrangle, south-central Montana, Montana Bureau of Mines and Geology: Open File Report 406, 1 sheet(s), 1:100,000.

Board of Water Well Contractors, Administrative Rules of Montana, 01/30/2001. 36.21.656-.660

Department of Environmental Quality, 1999. Montana Source Water Protection Program, Approved by EPA in November 1999, inclusive of personal communications with Joe Meek & others.

DEQ Permitting and Compliance Division, 2006. Sanitary Survey for Clyde Park Public Water Supply by Matt Usuriello.

Groff, S. L., 1962, Reconnaissance Ground-Water Studies, Northern Park County, Montana; Montana Bureau of Mines and Geology Special Publication 26.

Freeze, R. Allan and Cherry, John A., 1979. Groundwater, Prentice-Hall, Inc.

Heath, R. C, 1984, Ground-Water Regions of the United States, U.S. Geological Survey Water Supply Paper 2242, p. 78.

McDonald, Catherine, 2005, Preliminary geologic map of the Ringling 30' x 60' quadrangle, central Montana, Montana Bureau of Mines and Geology: Open File Report 511, 1 sheet(s), 1:100,000.

Montana Department of Environmental Quality, Permitting & Compliance Division and the Drinking Water Assistance Program - Montana Water Center: Ground Water Manual for Small Water Systems, January 1999.

Montana Bureau of Mines and Geology tabular well information, 2005:
http://mbmgsun.mtech.edu/ & http://mbmggwic.mtech.edu/

Montana State Library - Natural Resource Information Service, 2005. Graphical and tabular information:
http://nris.state.mt.us/mapper/

Roberts, A. E., 1972, Cretaceous and early Tertiary Depositional and Tectopnic History of the Livingston Area, Southwester Montana; U.S. Geological Survey Professional Paper 526-C.

Slagle, S.E., 1983, Water resources of the Fort Union coal region, east-central Montana; U.S. Geological Survey Water-Resources Investigations WRI 83-4151-U.S. Geological Survey, 42 p.

Stone, W.D., 1972, Stratigraphy and exploration of the lower Cretaceous Muddy Formation, northern Powder River Basin, Wyoming and Montana, The Mountain Geologist. 9; 4, Pages 355-378; Rocky Mountain Association of Geologists (RMAG), Denver, CO.

U. S. Environmental Protection Agency (US EPA), 1991. Manual of Small Public Water Supply Systems, US EPA Office of Water (WH-550), EPA 570/9-91-003.

U.S. Geological Survey, 2000. National Landcover Dataset, Montana. 30-meter electronic digital landcover / land use data set interpreted from satellite imagery.

U.S. Geological Survey, 2002. Real-time streamflow and water quality information: http://mt.waterdata.usgs.gov/nwis/rt

Western Regional Climate Center, 2002. Climate Summary Data by City: http://www.wrcc.dri.edu/summary/climsmmt.html

GLOSSARY*

Acute Health Effect. An adverse health effect in which symptoms develop rapidly.

Alkalinity. The capacity of water to neutralize acids.

Best Management Practices (BMPs). Methods that have been determined to be the most effective, practical means of preventing or reducing pollution from nonpoint sources.

Coliform Bacteria. Bacteria found in the intestinal tracts of animals. Their presence in water is an indicator of pollution and possible contamination by pathogens.

Confined Aquifer. A fully saturated aquifer overlain by a confining unit such as a clay layer. The static water level in a well in a confined aquifer is at an elevation that is equal to or higher than the base of the overlying confining unit.

Confining Unit. A geologic formation that inhibits the flow of water.

Delineation. A process of mapping source water management areas.

Effective Porosity. The percent of soil, sediment, or rock through which fluids, such as air or water, can pass. Effective porosity is always less than total porosity because fluids can not pass through all openings.

Hardness. Characteristic of water caused by presence of various salts. Hard water may interfere with some industrial processes and prevent soap from lathering.

Hazard. A measure of the potential of a contaminant leaked from a facility to reach a public water supply source. Proximity or density of significant potential contaminant sources determines hazard.

Hydraulic Conductivity. A coefficient of proportionality describing the rate at which water can move through an aquifer.

Inventory Region. A source water management area that encompasses an area expected to contribute water to a public water supply well within a fixed distance or a specified groundwater time-of-travel distance.

Maximum Contaminant Level (MCL). Maximum concentration of a substance in water that is permitted to be delivered to the users of a public water supply. Set by EPA under authority of the Safe Drinking Water Act.

Nitrate. An important plant nutrient and type of inorganic fertilizer. In water the major sources of nitrates are septic tanks, feed lots and fertilizers.

Nonpoint-Source Pollution. Pollution sources that are diffuse and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet.

Pathogens. A bacterial organism or virus typically found in the intestinal tracts of mammals, capable of producing disease.

Point-Source. A stationary location or fixed facility from which pollutants are discharged.

Porosity. The percent of soil, sediment, or rock filled by air, water, or other fluid.

Public Water Supply (PWS). A system that provides piped water for human consumption to at least 15 service connections or regularly serves 25 individuals.

SIC Code. The U.S. Standard Industrial Classification (SIC) Codes classify categories of businesses. SIC Codes cover the entire range of business categories that exist within the economy.

Source Water Protection Area. For surface water sources, the land and surface drainage network that contributes water to a stream or reservoir used by a public water supply.

Susceptibility (of a PWS). The potential for a PWS to draw water contaminated at concentrations that would pose concern. Susceptibility is evaluated at the point immediately preceding treatment or, if no treatment is provided, at the entry point to the distribution system.

Synthetic Organic Compounds (SOC). Man made organic chemical compounds (e.g. pesticides).

Total Dissolved Solids (TDS). The dissolved solids collected after a sample of a known volume of water is passed through a very fine mesh filter.

Total Maximum Daily Load (TMDL). The total pollutant load to a surface water body from point, non-point, and natural sources. The TMDL program was established by section 303(d) of the Clean Water Act to help states implement water quality standards.

Turbidity. The cloudy appearance of water caused by the presence of suspended matter.

Transmissivity. The ability of an aquifer to transmit water.

Unconfined Aquifer. An aquifer containing water that is not under pressure. The water table is the top surface of an unconfined aquifer.

Volatile Organic Compounds (VOC). Any organic compound which evaporates readily to the atmosphere (e.g. fuels and solvents).

Recharge Region / Watershed. The land area that drains into a stream; the watershed for a major river may encompass a number of smaller watersheds that ultimately combine at a common delivery point.

* Definitions taken from EPA's Glossary of Selected Terms and Abbreviations and other sources.

FIGURES

FIGURE 1 - General Location Map

FIGURE 2 - Climate Summary Graph – Imbedded in text on page 3.

FIGURE 3A - Inventory Region Map With Topographic Map As Background

FIGURE 3B - Inventory Region Map With Aerial Photograph As Background

FIGURE 3C - Land Parcels and Wells In Sections 27, 28, 33, and 34

FIGURE 4A - General Geologic Map

FIGURE 4B - Conceptual Model for Ground Water Flow

FIGURE 4C – Portion of Geologic Map By Roberts (1972)

FIGURE 5: Well Histogram – Imbedded in text on page 9.

FIGURE 6: Inventory Region With Landuse / Landcover.

FIGURE 7: Surface Water Buffer and Recharge Regions With Landuse / Landcover.

FIGURE 8: Recharge Region Inventory.

APPENDICES

APPENDIX A – Drillers Logs for Town Wells

Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
TOWN OF CLYDE PARK*WELL #1

Plot this site on a topographic map

Location Information

GWIC Id:	194741	Source of Data:	LOG
Location (TRS):	02N 09E 33 ABA	Latitude (dd):	45.8856
County (MT):	PARK	Longitude (dd):	-110.6091
DNRC Water Right:		Geomethod:	TRS-TWN
PWS Id:		Datum:	NAD27
Block:		Altitude (feet):	
Lot:		Certificate of Survey:	
Addition:		Type of Site:	WELL

Well Construction and Performance Data

Total Depth (ft):	62.00	How Drilled:	ROTARY
Static Water Level (ft):	10.77	Driller's Name:	RED TIGER
Pumping Water Level (ft):	32.70	Driller License:	WWC386
Yield (gpm):	60.00	Completion Date (m/d/y):	1/7/2002
Test Type:	PUMP	Special Conditions:	
Test Duration:	24.00	Is Well Flowing?:	
Drill Stem Setting (ft):		Shut-In Pressure:	
Recovery Water Level (ft):	11.20	Geology/Aquifer:	Not Reported
Recovery Time (hrs):	1.30	Well/Water Use:	PUBLIC WATER SUPPLY
Well Notes:			

Hole Diameter Information

From	To	Diameter
0.0	62.0	8.0
0.0	26.0	12.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-2.0	39.0	8.0	0.250		WELDED	STEEL

Annular Seal Information

From	To	Description
0.0	26.0	CEMENT
27.0	27.0	K PACKER

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
30.0	38.0	7.5		.04	SLOT SS 304 SCREEN

Lithology Information

From	To	Description
0.0	3.0	TOPSOIL FINE SILT SAND
3.0	25.0	FINE SAND M GRAVEL AND GRAVEL WITH COBBLES
25.0	33.0	GREEN SHALE WITH RUSTY BROWN STREAKS
33.0	35.0	STRINGERS CLAY AND GRAY SHALE
35.0	48.0	GRAY SHALE
48.0	52.0	GREEN SHALE WITH STREAKS RUSTY BROWN
52.0	62.0	STRINGERS CLAY AND GRAY SHALE

Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
TOWN OF CLYDE PARK*WELL#2

Plot this site on a topographic map

Location Information

GWIC Id:	194354	Source of Data:	LOG
Location (TRS):	02N 09E 33 ABA	Latitude (dd):	45.8856
County (MT):	PARK	Longitude (dd):	-110.6091
DNRC Water Right:		Geomethod:	TRS-TWN
PWS Id:		Datum:	NAD27
Block:		Altitude (feet):	
Lot:		Certificate of Survey:	
Addition:		Type of Site:	WELL

Well Construction and Performance Data

Total Depth (ft):	122.00	How Drilled:	ROTARY
Static Water Level (ft):	3.31	Driller's Name:	RED TIGER
Pumping Water Level (ft):	82.30	Driller License:	WWC386
Yield (gpm):	55.00	Completion Date (m/d/y):	1/7/2002
Test Type:	AIR	Special Conditions:	
Test Duration:	24.00	Is Well Flowing?:	
Drill Stem Setting (ft):		Shut-In Pressure:	
Recovery Water Level (ft):	4.45	Geology/Aquifer:	Not Reported
Recovery Time (hrs):	3.00	Well/Water Use:	PUBLIC WATER SUPPLY

Well Notes: REMOVE 10FT CONDUCTOR DURING CEMENT GROUT

Hole Diameter Information

From	To	Diameter
0.0	61.0	10.0
61.0	122.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-2.0	62.0	6.0	0.250		WELDED	STEEL
-1.0	28.0	10.0	0.250		WELDED	STEEL
62.0	105.0	5.0	0.250		WELDED	STEEL

Annular Seal Information

From	To	Description
0.0	28.0	CEMENT
105.0	122.0	3/16 PEA GRAVEL

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
85.0	105.0	5.5		1040	1040 304 SS V WRAP SCREEN

Lithology Information

From	To	Description
0.0	2.0	TOPSOIL
2.0	24.0	FINE SAND M GRAVEL AND GRAVEL WITH COBBLES
24.0	26.0	WEATHERED FRACTURED SHALE
26.0	29.0	BROWN SHALE
29.0	38.0	BROWN SHALE WITH TRACES OF GRAY SHALE
38.0	43.0	TRACES GYPSUM AND GRAY SHALE
43.0	45.0	TRACE OF CLAY SHALE AND CONGLOMERATE
45.0	49.0	GRAY SHALE WITH BROWN STREAKS
49.0	60.0	TRACES OF GYPSUM GRAY SHALE WITH BR STREAKS
60.0	75.0	TRACE GYPSUM GRAY SHALE

75.0	76.0	SANDSTONE GREENISH BR AND HARD FRACTUR
76.0	81.0	SANDSTONE GRAY AND STREAKS OF BROWN
81.0	82.0	GREEN SANDSTONE WITH BROWN STREAKS
82.0	91.0	BROWN SANDSTONE
91.0	96.0	GREEN SANDSTONE AND BROWN STREAKS OF SHALE
96.0	98.0	TRACES OF CLAY GREEN SHALE WITH HARD GRAY T
98.0	112.0	TRACES OF CLAY D GRAY SHALE FRACTURED
112.0	114.0	TRACES GYPSUM BROWN SHALE FRACTURED
114.0	122.0	TRACES OF CLAY GRAY SHALE HARD FRACTURED

APPENDIX B – Sanitary Survey

APPENDIX C - Hydrogeologic Assessment and MPA Results

APPENDIX D – Concurrence Letter & Other Correspondence

APPENDIX E - Water Quality Monitoring Data