Town of Columbus
Public Water Supply
PWSID # MT0000185

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SOURCE WATER DELINEATION AND ASSESSMENT REPORT

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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). Columbus public water supply (PWS) is located in Stillwater County, Montana, about 40 miles west of Billings and about 40 miles east of Big Timber (**Figure 1**). The DEQ PWS identification number, operator name, and operator number for the Columbus PWS appear on the title page of this report.

PURPOSE

This report is intended to meet the technical requirements for the completion of the source water delineation and assessment report for the Columbus public water supply 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 Columbus public water supply operator in the identification of potential contaminant sources near and upstream from the town's 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 waters 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 Columbus 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 Columbus public water supply, and not any other public or private water supply. Also, not all of the potential or existing sources of groundwater or surface-water contamination in the area of Columbus are identified. Only potential sources of contamination 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

Columbus is the county seat of Stillwater County and is located about near the Yellowstone River (**Figures 1** and **3**). Interstate 90 is located just north of town and the Northern Pacific/Burlington Northern Railroad is located on the southern edge of town near the river. The U.S. Census Bureau estimates the 2000 population of Stillwater County at 8,195 people, 1,748 reside in Columbus. Stillwater County's population has increased about 25% and Columbus' has increased by about 11%, since the 1990 census.

Within the town limits, residents obtain their drinking water from the municipal public water supply. The municipal sewer district services all residents within town limits and some areas outside the limits. The town is also served by a wastewater treatment plant with multicelled lagoons located about one mile southeast of town. Residents in areas outlying town limits where sewer services are not available utilize on-site septic systems for waste disposal. Other public water supplies in the area purchase water from the town's public water supply.

Table 1. Public Water Supplies in the Area (Not Used in This Report)

CLIMATE

The average daily high and low temperatures at Columbus are 87.6 °F and 52.3°F in July, and 35.7°F and 9.3°F in January (**Figure 2**). Based on Western Regional Climatic Center data for the period of record, annual precipitation averages 14.22 inches. Monthly average precipitation ranges from 0.5 inches in February to 2.66 inches in May. Summer thunderstorms and winter snows provide a majority of the precipitation in the area. The annual mean snowfall in Columbus is 35.3 inches. A summary of the available climatic data for the Columbus area is presented in **Table 2** below.

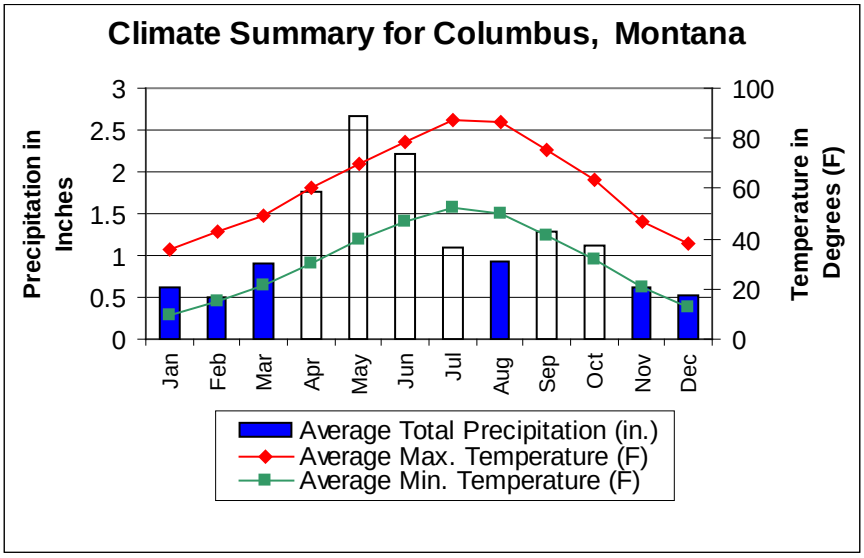

Figure 2. Average Temperatures and Precipitation

Table 2. Climate Summary

COLUMBUS, MONTANA (241938)

Period of Record Monthly Climate Summary
Period of Record :7/ 1/1948 to 12/31/2003

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	35.7	42.6	49.4	60.1	69.9	78.6	87.6	86.6	75.2	63.7	47 .1	38.2	61.2
Average Min. Temperature (F)	9.3	15.2	21.6	30.3	39.6	47.2	52.3	50.2	41.1	31.6	20.9	12.7	31
Average Total Precipitation (in.)	0.62	0.5	0.9	1.76	2.66	2.21	1.1	0.93	1.28	1.11	0.61	0.53	14.22
Average Total Snow Fall (in.)	7.2	5.4	6	3.1	0.8	0	0	0	0.4	2	3.7	6.8	35.3

Western Regional Climate Center, wrcc@dri.edu

GEOGRAPHIC SETTING

Columbus is located in the Rocky Mountain physiographic province of North America (Rocky Mountain Association of Geologists, 1972). This area is also designated as the Rocky Mountain region of the United States (Heath, 1984). The Yellowstone River valley is just under a mile wide up-stream from Columbus and the confluence of the Stillwater River, and about 2 miles wide below Columbus. Topographic relief in the area is moderate with nearby highlands rising about 500 feet above the river valley. Many of the creeks and tributaries to the Yellowstone have moderately incised channels.

GEOLOGY

This section provides an overview of the geology and hydrology of the vicinity of Columbus. The geologic quadrangle map is used to describe the general geology in the area (Lopez, 2000, Geologic Map of the Big Timber Quadrangle, South-Central Montana, Montana Bureau of Mines and Geology Open File Report 405). 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.

Unconsolidated alluvium is present in the Yellowstone River Valley and in many of the tributaries to the Yellowstone (**Figure 4**). The alluvium consists of lenses of unconsolidated clay, sand, and gravel. As much as 100 feet or more of alluvium may be present in the main Yellowstone Valley and less thick deposits are present in some of the tributaries. The Yellowstone River alluvium yields economic quantities of water to wells and in most places represents an important shallow unconfined aquifer.

Terrace deposits are also present within the main river valley and the tributaries. The terrace deposits represent older alluvium that was laid down by the ancestral Yellowstone River over the last 10,000 years or so. Some of the terraces are between tens and hundreds of feet above the streams and are considered to be Quaternary age, ranging from Pleistocene to Recent. These terrace deposits consist of gravel, sand, silt, and clay. Some of the gravel deposits within terraces are saturated where there is a source of ground water recharge. In some parts of Montana, the terrace deposits are important aquifers for water supply. However, most of the Terrace Deposits 2 and 3 have been dissected and largely removed by erosion in the vicinity of Columbus. Terrace 1 is present south and east of Columbus (**Figure 4**).

Columbus sits on an alluvial fan that consists of relatively thick sequences of silt and clay and "top soil" as described in driller's well logs (**Figure 4**). The alluvial fan deposit is dissected by Keyser Creek, which flows toward the Yellowstone River from the north (**Figures 3A** and **B**).

The wide valley where Columbus is located appears to be an abandoned river bend and, based on well driller's logs, is underlain by Yellowstone River alluvium. The alluvium is composed primarily of sands and gravel beds that are saturated and yield relatively large volumes of water to wells. Columbus' Beartooth Heights Well draws water from this aquifer. The alluvial fan acts as a confining layer for this aquifer and is present over much of the area as indicated by relatively thick sections of silt and clay reported from well driller's logs. The fact that the fan is dissected to some degree by Keyser Creek is important and will be discussed later in the report.

Bedrock exposed at the land surface in the vicinity of Columbus ranges in age from Upper Cretaceous to Tertiary. South of Columbus, the Fort Union Formation dominates the landscape (**Figure 4**) and sandstone units within this formation are important aquifers in some areas. The Hell Creek Formation (Upper Cretaceous) is below the Fort Union and is exposed at the land surface north and south of the modern Yellowstone River Valley in the vicinity of Columbus. The Hell Creek is also exposed over large areas of land to the northwest of Columbus. Just north and east of Columbus the landscape is dominated by outcrops of the Bearpaw Shale and the older Judith River Formation (**Figure 4**). Numerous driller's logs in the Columbus area report a "blue shale" underneath the sand and gravel deposits that provide water to many of the wells. The shale is very likely the Bearpaw and indicates that the Yellowstone River has cut down into the Bearpaw Shale. As in most areas along the Yellowstone River Valley, the modern alluvium is the most prolific aquifer and is tapped for public and private water supply by numerous shallow wells. Terrace deposits can also be important aquifers in parts of the valley when there are sources of recharge like irrigation return flow and leakage from streams and irrigation canals. Deeper wells are completed in the older bedrock formation in some areas of Montana including the Columbus area. They target sandstone beds within the Fort Union and Hell Creek formations. While the older bedrock formations can be sources of ground water, they usually yield smaller volumes of water to wells than the younger alluvial deposits. **Figure 4B** represents a conceptual ground-water model for the Columbus area and shows the general relationships between the younger alluvial deposits and the older bedrock formation. The figure is not drawn to scale and only represents an illustration of the conceptual model for the occurrence of ground water in the vicinity of Columbus.

THE PUBLIC WATER SUPPLY

The Columbus 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 1,748 residents. The number of active service connections was not reported in the sanitary survey.

According to the most recent sanitary survey, Columbus obtains water from an infiltration gallery located on an island in the Yellowstone River and the Beartooth Heights Well located on the northwest edge of town (**Figures 3A** and **B**). A third test well was drilled in one of the town's parks to explore the possibility of locating another public water supply well there sometime in the future. The test well has been converted into an irrigation well for the park and is not currently part of the Columbus public water supply.

Water is chlorinated at the gallery and well sites and is then pumped to two storage tanks. The primary storage tank has a capacity of about 1 million gallons and the backup tank holds about 135,000 gallons. The public water supply has a design capacity of just over 1 million gallons per day but is currently averaging about 360,000 gallons per day.

Both of the sources for Columbus' public water supply are considered to be ground water according to the sanitary survey. The infiltration gallery draws water from Yellowstone River alluvium that is essentially a shallow unconfined aquifer that has a high sensitivity to contamination. The Beartooth Heights Well taps a semi-confined alluvial aquifer and this source water is classified as moderately sensitive to contamination, in accordance with Montana Source Water Protection Program criteria (1999), also see **Table 3** below.

Table 3. Source Water Sensitivity Criteria (DEQ, 1999)

Source Water Sensitivity
High Source Water Sensitivity
Surface water and GWUDISW
Unconsolidated Alluvium (unconfined)
Fluvial-Glacial Gravel
Terrace and Pediment Gravel
Shallow Fractured or Carbonate Bedrock
Moderate Source Water Sensitivity
Semi-consolidated Valley Fill sediments
Unconsolidated Alluvium (semi-confined)
Low Source Water Sensitivity
Consolidated Sandstone Bedrock
Deep Fractured or Carbonate Bedrock
Semi-consolidated Valley Fill Sediments (confined)

Public water systems must conduct routine monitoring for contaminants in accordance with Federal Safe Drinking Water Act requirements. A community public water supply, like Columbus, 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.

COLUMBUS PWS WATER QUALITY

Within the past five years, no positive fecal coliform samples were collected during routine contaminant monitoring. No MCL exceedances were noted for any other constituents monitored over the past five years, this includes nitrate. The highest nitrate value recorded for the infiltration gallery is 2.11 milligrams per liter (mg/l), and an average value of 1.2 mg/l, which is significantly below the MCL of 10 mg/l (Appendix B). The highest nitrate value recorded for the Beartooth Heights Well is 2.24 milligrams per liter (mg/l), and an average value of 1.2 mg/l which is also significantly below the MCL of 10 mg/l (Appendix B). Nitrate levels do appear to fluctuate seasonally and possible causes for this are discussed later in the report.

CHAPTER 2: DELINEATION

The source water protection areas for the Columbus public water system are delineated in this chapter. 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. Normally for a public water supply using ground water, three source water protection regions are delineated for each well. They include: 1) a 100-foot control zone, 2) a 3-year Time-Of-Travel (TOT) inventory region, or an inventory region based on hydrogeologic mapping, and 3) a recharge region corresponding to the watershed that surrounds the public water supply. For ground water sources that are located close to streams, a surface water buffer region is also routinely delineated.

For Columbus, the three source water protection regions mentioned above are delineated for the Beartooth Heights Well and for the Park Well. The park well site is included in this report because it may be used in the future for a public water supply well. Currently the Park Well is used only for irrigation purposes in the park and this report does not consider the Park Well as part of the public water supply. Inventory and susceptibility information included in this report will help Columbus assess the advantages and disadvantages of establishing a public water supply well at the park location.

For the infiltration gallery the source water protection regions are delineated differently than for the wells. The reason for this is that the infiltration gallery collects water from alluvium within the Yellowstone River Valley and, according to the most recent sanitary survey, the infiltration gallery is considered to be a ground-water source like a well. The water collected by the gallery essentially flows down the river channel. This water flows relatively fast compared to other ground water sources and the 3-Year TOT inventory region will be large and will occupy much of the same area a surface water buffer region that is also required an infiltration gallery. For these reasons, the surface water buffer region will be used in this report as the inventory region for the infiltration gallery. For the infiltration gallery, three source water protection regions are mapped. They are 1) the 100-foot control zone around the gallery site, 2) a surface water buffer region extending ½ mile downstream from the infiltration gallery and 10 miles upstream. This surface water buffer region also extends ½ mile from each bank of the Yellowstone River. The third region delineated is 3) the recharge region corresponding to the watershed surrounding the Yellowstone and Stillwater river (**Figures 1, 3, 7,** and **8**).

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

GENERAL HYDROGEOLOGIC SETTING

Geologic Setting:
Within the Yellowstone River Valley, there are often up to five distinct alluvial terraces with varying thicknesses of gravel. Some of the terraces are more extensive than others and they are distinguished from each other by their distinct elevation above the modern Yellowstone River flood plain. Some of the gravel deposits within the terraces function as aquifers in some areas where they receive recharge from irrigation canals, streams, and flood irrigated fields (return flow). However, in the Columbus area, the terraces have been dissected and all but two have been removed by erosion. Remnants of terraces are

present immediately east of Columbus and south of town in and around the mouth of the Stillwater River (**Figure 4**).

It is interesting to note that the Yellowstone River Valley is noticeably wider downstream from the confluence of the Stillwater River and the Columbus town site (**Figure 10**). The morphology or shape of the Yellowstone River Valley in this area is interpreted to represent an abandoned river bend with saturate alluvial deposits extending north of town to the contact with Hell Creek Formation and Bearpaw Shale (**Figure 4**). Relatively high yields from multiple wells in the area that produce from a sand and gravel aquifer lend credence to this interpretation. An alluvial fan deposit is shown to extend from the Yellowstone River to the area north of town and in to the lower Keyser and Dry creek valleys (**Figure 4**). Based on driller's logs from about 400 wells and information from Mark Cunnane of Western Groundwater Services (Personal communication, 2004), the alluvial fan deposit is composed dominantly of silt and clay beds ranging that are 10 to more than 25 feet thick. The fine-grained fan deposits provide a confining layer for the alluvial sand and gravel aquifer below. However, it is important to note that based on the geologic map of the area, Keyser Creek appears to have dissected the alluvial fan to some degree just west of Columbus (**Figure 4**). Older bedrock formations underlie the modern alluvium, terrace deposits, and the alluvial fans and include the Fort Union Formation, Hell Creek Formation, Bearpaw Shale, and the Judith River Formation. **Figure 4B** shows a conceptual model for the Columbus area and depicts the general relations between the modern alluvial deposits, terraces, and older bedrock.

The Beartooth Heights Well is located near the contact between the alluvial fan deposit and the Keyser Creek alluvium (**Figures 3 and 4**). The well log shows that the well penetrates the fan deposits and is completed in the Yellowstone River alluvial aquifer that consists of about 40 feet of sand and gravel. This aquifer lies on top of a "blue shale" which is probably part of the Bearpaw Shale Formation. The aquifer appears to be quite productive with the well log reporting an initial yield of 950 gallons per minute for a test period of 24 hours and with a drawdown of water level of only 10 feet.

The Park Well also appears to be located on the alluvial fan deposit and penetrates it to tap into the Yellowstone River alluvial aquifer that is about 25 feet thick and consist of sand and gravel. The Park Well log also indicates that the aquifer is lies on top of the shale (Appendix A). The Park Well also indicates the alluvial aquifer is quite productive with the well log reporting a drawdown of only 1 foot during an 8 hour well test at 104 gallons per minute.

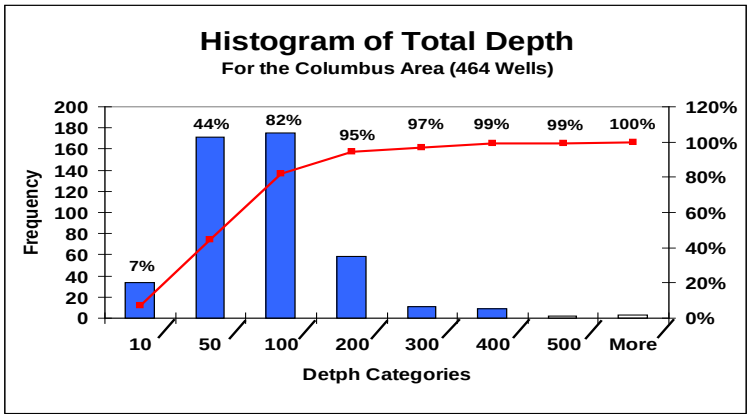

Figure 5. Well Depth Histogram for Wells in the Columbus Area

Columbus' infiltration gallery is imbedded in the Yellowstone River alluvium (**Figures 1, 3,** and **4**). The modern alluvium is consists primarily of gravel with some interbedded lenses of sand. Based on 24-hour pumping estimates, the gallery could produce about 430,000 gallons per day, if river flow levels are sufficient to support this level of pumping.

LOCAL HYDROGEOLOGIC SETTING

Ground water is present within the older bedrock formations, some of the terraces, and the modern alluvium. As in many other areas of the state, the most productive wells tend to be those completed in the modern alluvial deposits that flank and under lay the larger rivers and streams. Recharge for the aquifers in the area comes from a combination of precipitation, snowmelt runoff, irrigation return flows, and leakage from rivers, streams and irrigation canals.

Information for wells in the vicinity of Columbus was retrieved from the Montana Ground Water Information Center (GWIC) June 3, 2004. **Figure 5** shows a frequency distribution of total depth of these wells. **Figure 5** indicates that the majority of wells are relatively shallow. Eighty-two percent are less than 100 feet deep, and 44% are less than 50 feet deep. The average depth for all of the wells in the recharge region is 75 ft. below land surface (ft. bls) and the maximum depth is 635 ft. bls. Average static water level for these wells is 31 ft. bls. Pumping water level average is 29 ft. bls and average yield for wells in this area is 17 gallons per minute (gpm) with a maximum yield listed at 372 gpm. Well logs show that the majority of the wells are completed in sand and gravel deposits with a smaller number completed in what appears to be sandstone associated with the Fort Union Formation or other bedrock formations.

CONCEPTUAL MODEL AND ASSUMPTIONS

Source water for the Columbus public water supply comes from unconsolidated sand and gravel alluvial deposits associated with the Yellowstone River (**Figures 4** and **4B**). The Columbus water supply also uses an infiltration gallery that collects water flowing within the Yellowstone River alluvium. Yellowstone River alluvium tapped by the Beartooth Heights and Park wells is interpreted to be shallow and semi-confined by the fine grained alluvial fan. Keyser Creek appears to have cut into, and perhaps through, the alluvial fan just west of Columbus, and this could compromise the confining unit and could provide a conduit for potential contaminants into the aquifer. The infiltration gallery is interpreted to draw water from Yellowstone River alluvium that is shallow and unconfined.

Ground water flow direction is interpreted to be primarily from the west-northwest toward the east-southeast (**Figures 3A** and **B**). Close to the Yellowstone River the ground water flow direction is interpreted to be approximately parallel to the river. A lesser component of the total ground water flow in the area is interpreted to come from the north out of the Keyser and Dry creek valleys and is represented by somewhat smaller blue arrows in **Figures 3A** and **B**. Recharge comes from a combination of precipitation, snowmelt runoff, irrigation return flows, and leakage from rivers, streams and irrigation canals.

SUMMARY OF WELL INFORMATION

Table 4 summarizes well data for the Beartooth Heights Well, the Park Well, and several abandoned town wells.

Table 4. Information from Drillers Logs for the Columbus Wells

MBMG # DNRC WR#	Beartooth Heights Well 97551 P060353-00	City Park Well	Inactive Well 97553 P022831-00	Inactive Well 192363
Location	02S 20E 21 CABCD	02S 20E 21 DDB	02S 20E 21 CCA	02S 20E 22 CDD
Date Completed	10/23/1985	8/1/2002	1/1/1979	7/12/2001
Depth (ft bgs*)	69	41	62	31
Screened Interval (ft**)	48–64	40–52	42–52	Open Hole
SWL Depth (ft bgs*)	23	29	24	6
PWL Depth (ft bgs*)	32	30.2	25	-
Drawdown (ft**)	9	1.2	1	-
Test Pumping Rate (gpm***)	950	104	630	65
Specific Capacity (gpm/ft****)	106	87	630	-

*ft bgs = feet below ground surface, **ft = feet, ***gpm = gallons per minute, ****gpm/ft = gallons per minute per foot of drawdown.

DELINEATION RESULTS

Control Zones

The control zones for the Beartooth Heights Well and the Park Well consists of a 100 foot fixed radius circle, in accordance with the criteria specified in the Source Water Protection Program Document (1999). The control zones for the Infiltration Gallery Site is also a 100 foot fixed radius circle. All potential sources of contamination are inventoried within the control zone.

Inventory Region

A three-year time of travel distance calculated for both the Beartooth Heights and Park wells indicates that zone of influence for these wells very likely extends out to the limits of the alluvial aquifer where it terminates against the older bedrock formations, west and north of Columbus (**Figures 3A** and **3B**). As a result, hydrogeologic mapping is used to establish the western, northern, and southern boundaries of the inventory region. The Yellowstone River is use as the southern boundary. The down-gradient inventory region boundary was established to extend beyond the calculated stagnation point shown in **Table 5** and to correspond to several county roads and town streets, to make it easier to identify and discuss. All potential sources of contamination are inventoried within the inventory region.

Although the 3-year TOT distances are not used in this report to establish the inventory region, input values and calculation results are included in **Table 5**. Estimates of input parameters including well discharge rate, ambient ground water flow direction, ground water gradient, and aquifer flow properties are used to calculate one-year and three-year times-of-travel distances for each well (**Table 5**). Well discharge rates are based on estimated water use information included in the most recent sanitary survey and from Western Groundwater Services (Personal communication, 2004). Groundwater flow direction and gradient are taken from reports on ground-water contamination at the Shortridge Oil site

(Maxim, 2003) and from general interpretations of ground water flow direction based on land surface topography and river valley morphology. Effective porosity is estimated at 25%, the lowest value typical for a sand or gravel aquifer. Average transmissivity values come from the results of several aquifer tests in the Columbus area conducted by Western Groundwater Services (Personal communication, 2004). The thickness of water-producing intervals is used to estimate aquifer thickness and to calculate hydraulic conductivity [hydraulic conductivity equals transmissivity multiplied by aquifer thickness]. Results of time-of-travel calculations are most sensitive to uncertainty in hydraulic conductivity, hydraulic gradient, and porosity. Changes in pumping rate and thickness have relatively minor effects on results.

Table 5. Input Parameters and Calculated Times-of-Travel

Input Parameter	Range of Values and Units	Well 2 and Park Well
PWS Source Code	N/A	
Transmissivity	16,000–28,700 ft^2/day	26,000
Thickness	17–45 feet	27
Hydraulic Conductivity	240 feet/day	963
Hydraulic Gradient	0.003 feet/feet	0.003
Flow Direction		From the West - Northwest
Effective Porosity	25–50%	25
Pumping Rate	67,680–182,800 ft^3/day	127,000
1-Year TOT	feet	4,998
3-Year TOT	feet	13,686

Surface Water Buffer Region

The surface water buffer region extends ½ mile downstream from the infiltration gallery and 10 miles upstream, and is ½ mile from each bank of the Yellowstone River. Due to the fact that the surface water buffer region is used in this report as an inventory region for the infiltration gallery, all potential sources of contamination are inventoried.

Recharge Region

The Watershed Region for the Columbus wells and infiltration gallery encompasses the land area within the Upper Yellowstone – Lake Basin Watershed that includes the Fifth Code Hydrologic Units: 10070004040, 10070004020, and 10070005050 (**Figures 7** and **8**). The watershed has an area of about 412 square miles. General land uses and large potential contaminant sources are inventoried in this region.

LIMITING FACTORS

Detailed mapping and hydrogeologic reports focused on the ground-water resources in the Columbus area are not available. As a result, inventory regions are delineated based on general hydrogeologic mapping and interpretations of the general ground-water flow direction. The conceptual model presented in this report is a simplification of the real ground-water flow system near Columbus but is considered to be sufficiently accurate to assess the susceptibility of the Columbus 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 Columbus public water supply to contamination, and to identify priorities for source water protection planning. Inventories were conducted within the control zones, combined inventory, surface water buffer, and recharge 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.

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/CONTROL ZONES

Infiltration Gallery*:* The infiltration gallery is located in the Yellowstone River alluvium. The building housing the clearwells, disinfection equipment and pumps is located on an island near an abandoned channel of the Yellowstone River. The channel handles river discharge during higher water event but the island is rarely flooded. The land within the control zone for the infiltration gallery is undeveloped and there does not appear to be any potential contaminant sources present. Floodwater could pose a threat to the infiltration gallery clearwells but according to the public water supply operator, only the larger less frequent flood events affect the island.

Beartooth Heights Well*:* The control zone for this well includes a portion of several developed lots that are connected to the city sewer service, part of a city street, and a depressed area that is part of the Keyser Creek flood plane. The flood plane area is undeveloped. Potential contaminants present in the control zone include yard and lawn chemicals, small volumes of fuel related to lawn care equipment, and city sewer lines servicing several houses. Potential contaminants mentioned are not stored in commercial volumes and do not pose a threat to the well or the source water. It would be advisable for land owners and city personnel not to use fertilizers, pesticides, or herbicides near the well location.

Park Well (Not part of the PWS): The control zone for the Park well includes a play ground, part of the park, a segment of city street, and a small part of the high school fields. Potential contaminants in the area would include lawn care chemicals used in the park and high school fields and the city sewer lines associated with the street and surrounding neighborhood. If the Park Well site were to be used to site a public water supply well in the future, it would be advisable to restrict the use of fertilizers, pesticides, and herbicides near the wellhead. It would also be advisable to house the well in a structure that would protect it from vandalism or direct access from non-city personnel.

INVENTORY RESULTS/INVENTORY REGION

Infiltration Gallery:
The interstate and railroad run the length of the spill response-inventory region that is delineated for the Yellowstone River (**Figures 3A** and **B,** and **10**). In multiple locations these transportation routes are close to or cross the river and represent threats to the source water. The railroad runs close to the Yellowstone for about three miles directly upstream from the infiltration gallery location. The hazard comes from accidents resulting in spills and releases that could move directly into the Yellowstone River.

It is important to note that the Yellowstone River is a large river for this region and the volume of water discharging even during low flow periods is relatively large compared to the volume of hazardous

materials that could be released from truck and train accidents. The stream discharge provides a significant dilution potential and acts as an effective barrier to reduce the hazard posed by most of the potential contaminant sources. The exception to this would be for spills or releases occurring in close proximity to the infiltration gallery where there would be insufficient time for dilution to reduce the contaminant concentrations. As a result, the primary threat is the railroad corridor in the three-mile stretch directly upstream from the infiltration gallery.

Highway 78 is located within the spill response-inventory region delineated for the Stillwater River. However, this state highway is not a major truck route and truck traffic volume is not considered to be high. Highway 78 is not considered to pose a threat to the Columbus public water supply or the source water.

Five underground storage tank sites are located on the southern edge of town and within the spill response-inventory region (**Figure 3**). One of the sites has a leak history and is located up-gradient from the infiltration gallery site. That is to say, ground water moves from beneath the tank location and toward the river. It is not known if the fuel released from this tank site reached the river. It is assumed that the leaking tanks at this and the other sites have been removed, remediation efforts are completed, and that the sites no longer pose a threat to the source water. The other inactive tank sites with leak histories and an active tank with a leak history are located down-stream from the gallery. Several other tank sites lie just outside the spill response-inventory region and are also down-stream from the gallery.

Agricultural land use accounts for about 24% of the land area within the inventory region for the infiltration gallery. 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 have hydraulic connection with aquifers that supply water. The percentage of ag-land in the inventory region is assigned a moderate hazard rating in accordance with the Source Water Protection Program guidelines.

A relatively small area of town is located within the spill response-inventory region and is interpreted to be in a cross-gradient position relative to the gallery (**Figures 3A** and **B**). That means that the ground water in this area is flowing parallel to the river and gallery location and not towards it. Sewer service lines within this area are considered to be potential contaminant sources. Much of the spill response-inventory region is undeveloped or very sparsely developed (**Figures 8** and **10**). Residential development is low density and septic density is also low throughout the delineated region.

The Montana Silversmiths is located within the response-inventory region and is a permitted to release about 40,000 pounds of ammonia and dichromomethane to the air each year. The site is located down-stream from the infiltration gallery and is not considered to pose a threat to the source water.

Other potential contaminant sources in the Columbus area include a federal superfund site, the city wastewater treatment plant and lagoons, and possibly Class V injection wells. The superfund site and wastewater treatment plant are located downstream from the infiltration gallery and outside of the spill response-inventory region (**Figure 3**). The threat from Class V injection wells cannot be determined because an accurate inventory of these wells has not been completed for Montana.

Some exploratory mining and oil and gas exploration has occurred within the watershed surrounding the infiltration gallery's spill response-inventory region but not within the region (**Figure 10**).

Beartooth Heights Well:
A little less than 50% of the inventory region is agricultural land (**Figure 7**). This amount of ag-land in the inventory region is considered to represent a moderate hazard in accordance with the Source Water Protection Program guidelines.

Keyser and Dry Creek are intermittent streams that drain a fairly large area of agricultural land north of Columbus and, as mentioned previously, Keyser Creek appears to have dissected the alluvial fan deposit to some degree. The fan deposits act as a confining layer for the aquifer that provides water to the Beartooth Heights Well (**Figures 3A** and **B,** and **7**). The concern with the Keyser Creek is that it collects runoff from the ag-lands with elevated nitrate levels and probably loses some or all of this water to the aquifer. These recharge events would occur seasonally as the result of storm events and could result in fluctuations in the source water's nitrate levels. It should also be noted that both Keyser and Dry creeks drain valleys that have significant exposures of Bearpaw Shale. Marine shales are thought to be a possible source of "natural" or "geologic" nitrate. Fluctuations in nitrate indicated by water quality monitoring results could be related to agricultural and natural sources of nitrate. Water quality monitoring results indicate nitrate levels do fluctuate and range from lows of 0.79 to 2.24 milligrams per liter (mg/l) (Appendix B).

A section of Interstate 90 is located in the inventory region near the outer boundary (**Figure 3**). This places the highway in an area where the hazard from spills and releases is considered to be moderate to low due to the distance from the wells.

The Columbus Water User's Association Canal also passes through the inventory region near the outer boundary. The concern here is that the canal may recharge the aquifer with water that has elevated levels of nitrate and other ag-chemicals, and pathogens. Although it is very likely the canal does contribute water to recharge the aquifer, the quality of the Yellowstone River water is considered to be relatively high. In addition, the canal does not appear to intercept irrigation return flow, which reduces the potential that the canal water would have elevated levels of ag-chemicals and pathogens.

Municipal sewer mains are present within the inventory region. The sewer lines appear to be down-gradient from the Beartooth Heights Well. The northwest corner of Columbus with sewer service is located directly up-gradient of the Park Well (**Figures 3A** and **B**). The potential hazard from pathogens and nitrate coming from municipal sewer system is considered low for the Beartooth Well and moderate to high for the Park Well.

The inventory region and the area beyond its outer boundary are occupied by low-density development and the area has a low septic density. Individual septic systems do not pose a threat to the public water supply or the source water. This being said, it would be prudent for Columbus to encourage development away from the Keyser Creek drainage valley that is immediately west of the Beartooth well due to the fact that the creek has cut through part or all of the alluvial fan deposit that acts as a confining unit for the aquifer.

Several county dirt roads are located fairly close to the Beartooth Well and they are up-gradient of the well location. However, these roads do not carry a heavy traffic volume and they are not major truck routes. These roads are not considered to pose a threat to the source water.
Columbus has multiple businesses that could be considered potential contaminant sources but most of them are small and do not handle commercial volumes of hazardous materials. In addition, the majority

of the town is in a down- gradient location from the Beartooth. The businesses are not considered to pose a threat to the Public Water Supply.

The potential hazard imposed by VOCs, SOCs, pathogens, nitrate, and other contaminants originating from the Class V injection wells cannot be determined due to the fact that no inventory of Class V well is complete for most of Montana or the current inventory is inadequate. It is assumed that if Class V wells are present in the Columbus area they would be concentrated in the town itself. As mentioned above, the town site is located in a down-gradient position from the Beartooth Well.

Park Well (Not Part of the Public Water Supply but Included for Future Planning Purposes):
As with the Beartooth Well, pathogens and nitrate originating from agricultural lands is considered to pose a moderate hazard to the Park Well based on the percentage of ag-land in the inventory region.

As mentioned above periodic flow events on Keyser and Dry creeks could bring water with elevated nitrate levels to recharge the aquifer used by the Park Well. Because the Park Well is not connected to the Columbus water supply it is not sampled for water quality and it is not known if the water has fluctuating nitrate levels like the Beartooth Well and the infiltration gallery water.

Interstate 94 crosses the inventory region somewhat closer than it does for the Beartooth Well. The hazard posed by the highway is considered to be moderate to low.

The Columbus Water User's Association Canal passes through the inventory region and very likely provides seasonal recharge to the aquifer. As mentioned previously, the water quality if considered to be relatively high quality and is not considered to pose a threat to the source water.

City neighborhoods surround the Park Well location and municipal sewer lines serve these areas. The bulk of this area is located directly up-gradient of the Park Well. The potential hazard is considered to be moderate, which is higher than for the Beartooth Well location. The alluvial fan deposits overlying the aquifer would help reduce the susceptibility of this well to the sewer lines.

City Park and high school fields surround the Park Well location. Concern over the use of fertilizers and other lawn-care chemicals near the well site and in relative close proximity to the well is the reason the park and school grounds are included in the inventory. If the park location is used in the future for a public water supply wells, an effort should be made to protect the wellhead with a well house and to restrict the use of lawn care chemicals near the well. Best management practices by both city personnel and school maintenance personnel could help lower the hazard posed from lawn-care chemicals.

Low septic density is present throughout the inventory region and the area beyond its outer boundary. Hazard from on-site septic systems appears to be low.

Several roads and paved streets are located near the Park Well and some are up-gradient of the well location. Traffic volumes are low and truck routes do not run past the well site. The roads and streets are not considered to pose a threat to the well or the source water.

Most businesses in town are located in a cross- or down-gradient position from the well site and as with the Beartooth Well, they are not considered to pose a threat to the source water.
The potential hazard imposed by VOCs, SOCs, pathogens, nitrate, and other contaminants originating from the Class V injection wells cannot be determined due to the fact that no inventory of Class V well is

complete for most of Montana or the current inventory is inadequate. It is assumed that if Class V wells are present, they would be concentrated in the town itself. As mentioned above, the town site is located in a down-gradient position from the Beartooth Well.

From the above list of potential contaminant sources, some are considered significant based upon the following factors: the volume of potential releases, the volume of hazardous materials typically handled, the potential of the released materials to impact nearby surface water or groundwater, and the proximity of the sources to the PWS surface water intakes. Significant potential contaminant sources from the above section are summarized for each source of water in **Table 6** below.

Table 6. Significant Potential Contaminant Sources Identified

Infiltration Gallery Spill Response-Inventory Region			
Source	**ID Number on Maps**	**Contaminant**	**Hazard**
Railroad Corridor	Not Numbered	Variety of hazardous materials including VOCs and SOCs, others?	Spills and releases related to accidents
USTs/LUSTs (4 inactive sites within surface water buffer region and near the infiltration gallery)	Not Numbered	VOCs, petroleum hydrocarbons	Spills, leaks impacting groundwater and or reaching surface water
Cultivated Cropland (24% in the spill response-inventory region)	Not Numbered	Fertilizers, pesticides, pathogens, nitrate	Spills, over application, surface runoff
Municipal Sewer Lines (Relatively small area within the spill response – inventory region)	Not Numbered on the map	Pathogens and nitrate, household hazardous waste	Infiltration into shallow ground water that is hydraulically connected to surface water.
Old State Highway 78	Not Numbered on the map	Variety of hazardous materials including VOCs and SOCs, others?	Spills and releases related to accidents
Regulated Toxic Release Site (Montana Silversmiths)	Not Numbered	Annual release between 40,000 and 38,000 pounds of ammonia and dichromomethane	Spills, leaks, and releases
Federal Superfund Site (MOUAT Industries)	Not Numbered	Spill or release of hazardous material	Infiltration into shallow ground water that is hydraulically connected to surface water.
Columbus Wastewater Treatment Plant and Lagoons	Not Numbered	Pathogens, nitrate, TDS	Spills, leaks, and releases
Assorted businesses in town	Not Numbered	VOCs, SOCs, petroleum hydrocarbons, metals, pathogens, nitrate	Releases or spills, mishandling of chemicals, improper disposal of chemicals anywhere near the river

Table 6. Significant Potential Contaminant Sources Identified

Infiltration Gallery Spill Response-Inventory Region			
Source	**ID Number on Maps**	**Contaminant**	**Hazard**
Class V Injection Wells (existence and locations are not known) where storm and/or wastewater is concentrated and recharges groundwater.	Not Numbered	VOCs, SOCs, petroleum hydrocarbons, metals, pathogens, nitrate	Leaks, spills, improper handling and disposal/discharge of chemicals used by various businesses and are released to systems that allow infiltration of contaminants to the subsurface or to the storm water system

Beartooth Heights Well			
Source	**ID Number on Maps**	**Contaminant**	**Hazard**
Cultivated Cropland (A little less than 50% in the inventory region)	Not Numbered	Fertilizers, pesticides, pathogens, nitrate	Spills, over application, surface runoff
Keyser Creek and Dry Creek	Not Numbered	Nitrate and pathogens	Water loss resulting in Infiltration into ground water
Interstate 94 (Near distal end of 3 Yr TOT Inventory Region)	Not Numbered	Variety of hazardous materials including VOCs and SOCs, others?	Spills and releases related to accidents
Irrigation Canals (Near distal end of 3 Yr TOT Inventory Region)	Not Numbered	Nitrate and pathogens	Water loss resulting in Infiltration into ground water
Municipal Sewer lines	Not Numbered	Nitrate, pathogens	Leaks in mains/lines, system failure, infiltration of untreated effluent into shallow ground water, which may in turn reach surface water
On-site residential septic systems (Inventory Region is Low Septic Density)	Not Numbered	Nitrate, pathogens	Leaks in septic tanks, leaks in collection lines, system failure, infiltration of untreated effluent into shallow ground water, which may in turn reach surface water
County Roads	Not Numbered	Variety of hazardous materials including VOCs and SOCs, others?	Spills and releases related to accidents
Assorted businesses in town	Not Numbered	VOCs, SOCs, petroleum hydrocarbons, metals, pathogens,	Releases or spills, mishandling of chemicals, improper disposal of chemicals anywhere near the river

Beartooth Heights Well			
Source	**ID Number on Maps**	**Contaminant**	**Hazard**
		nitrate	
Class V Injection Wells (existence and locations are not known) where storm and/or wastewater is concentrated and recharges groundwater.	Not Numbered	VOCs, SOCs, petroleum hydrocarbons, metals, pathogens, nitrate	Leaks, spills, improper handling and disposal/discharge of chemicals used by various businesses and are released to systems that allow infiltration of contaminants to the subsurface or to the storm water system

Park Well (Not part of the Public Water Supply System)			
Source	**ID Number on Maps**	**Contaminant**	**Hazard**
Cultivated Cropland	Not Numbered	Fertilizers, pesticides, pathogens, nitrate	Spills, over application, surface runoff
Dry Creek	Not Numbered	Nitrate and pathogens	Water loss resulting in Infiltration into ground water
Interstate 94 (Near distal end of 3 Yr TOT Inventory Region)	Not Numbered	Variety of hazardous materials including VOCs and SOCs, others?	Spills and releases related to accidents
Irrigation Canals (Near distal end of 3 Yr TOT Inventory Region)	Not Numbered	Nitrate and pathogens	Water loss resulting in Infiltration into ground water
Municipal Sewer Lines (About 30% of inventory region)	Not Numbered	Nitrate, pathogens	Leaks in mains/lines, system failure, infiltration of untreated effluent into shallow ground water, which may in turn reach surface water
City Park and High School Fields	Not Numbered	Nitrate, Fertilizers (SOCs)	Spills, over application, surface runoff
On-site residential septic systems (Inventory Region is Low Septic Density)	Not Numbered	Nitrate, pathogens	Leaks in septic tanks, leaks in collection lines, system failure, infiltration of untreated effluent into shallow ground water, which may in turn reach surface water
County Roads	Not Numbered	Variety of hazardous materials including VOCs and SOCs, others?	Spills and releases related to accidents
Assorted businesses in town	Not Numbered	VOCs, SOCs, petroleum hydrocarbons, metals, pathogens, nitrate	Releases or spills, mishandling of chemicals, improper disposal of chemicals anywhere near the river

Park Well (Not part of the Public Water Supply System)			
Source	**ID Number on Maps**	**Contaminant**	**Hazard**
Class V Injection Wells (existence and locations are not known) where storm and/or wastewater is concentrated and recharges groundwater.	Not Numbered	VOCs, SOCs, petroleum hydrocarbons, metals, pathogens, nitrate	Leaks, spills, improper handling and disposal/discharge of chemicals used by various businesses and are released to systems that allow infiltration of contaminants to the subsurface or to the storm water system

INVENTORY RESULTS/RECHARGE REGION

The inventory within the recharge region focuses on potential sources of nitrate and pathogen. It is assumed that distance from the public water supply infiltration gallery and wells and dilution will reduce the hazard posed by potential contaminant sources identified in the source water protection region.

Land cover in the recharge or watershed region is 10 percent forestland, 77 percent grassland, and 13% percent agricultural land (**Figure 9**). Forest and grasslands are not considered potential contaminant sources. Agricultural land is considered a potential contaminant sources due to the use of fertilizers, pesticides and herbicides. As mentioned previously, the concern here is the potential for mismanagement or over- application of fertilizers and/or pesticides on the agricultural lands that could result in SOCs entering the Yellowstone and Stillwater rivers up-stream from the infiltration gallery and wells. However, the percent of agricultural land in the area is small and is not considered to pose a threat to the source water.

A small number of oil and gas exploration wells and mine sites are located within the recharge region (**Figure 9**). Because there are so few exploration wells and mine sites in the recharge region they are not considered to pose a threat to the source water.

INVENTORY UPDATE

To make this SWDAR a useful document in the years to come, the owners, manager, or the certified water system operator(s) for the public water supply should update the inventory for their records every year. Changes in land uses or potential contaminant sources should be noted and additions made as needed. The complete inventory should be submitted to DEQ at least every 5 years to ensure that this report/plan 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 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 precluded the inclusion of potential sources in the inventory.

CHAPTER 4: SUSCEPTIBILITY ASSESSMENT

Susceptibility is the potential for a public water supply to draw 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 recharge region 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. Alternative management approaches are also recommended that could be pursued by the Columbus PWS operators, town, and county officials to reduce susceptibility.

Susceptibility is determined by considering the hazard rating for each potential contaminant source and the existence of barriers that decrease the likelihood that contaminated water will flow to the PWS well(s) and infiltration gallery (**Tables 7** and **8**). For point sources, hazard is rated by the proximity of a potential contaminant source to the well(s) and infiltration gallery. A high hazard rating is assigned to point sources located 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. Hazard ratings for potential contaminant sources in the spill response region-inventory region for the infiltration gallery are assigned based on their proximity to the infiltration gallery and whether they could release hazardous materials directly into the Yellowstone River. Hazard ratings for nonpoint sources are assigned based on the following criteria in **Table 7**.

Table 7. Hazard of Potential Contaminant Sources for the Public Water System Wells

	High Hazard	Moderate Hazard	Low Hazard
Point Sources of All Contaminants	Within 1-year TOT	1- to 3-year TOT	Over 3-year TOT
Septic Systems	More than 300 per sq. mi.	50 – 300 per sq. mi.	Less than 50 per sq. mi.
Municipal Sanitary Sewer (% land use)	More than 50 % of region	20 to 50 % of region	Less than 20 % of region
Cropped Agricultural Land (% land use)	More than 50 % of region	20 to 50 % of region	Less than 20 % of region

Barriers to contamination can be anything that decreases the likelihood that contaminants will reach a well or the infiltration gallery. 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 8** shows how barriers are used to adjust the final susceptibility ratings.

Table 8. 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 individually for each significant potential contaminant source and each associated contaminant on the following page (**Table 9**). It is important to note that the Park Well is not connected to the Columbus PWS and at this time only provides water for irrigation within the park. A susceptibility analysis is included for the Park Well site in this report in recognition that the park site may be used to establish another PWS well for the city in the future. The susceptibility analysis for the Park Well is included to help the city evaluate the hazards related to this site and to help plan for source water protection and future growth.

Table 9. Susceptibility Assessment Significant Potential Contaminant Sources in the Inventory, Surface Water Buffer, and Recharge Regions Columbus Public Water Supply

Infiltration Gallery Surface Water Buffer-Inventory Region							
Source	**ID Number on Maps**	**Contaminant**	**Hazard**	**Hazard Rating**	**Barriers**	**Susceptibility**	**Management Recommendations**
Railroad Corridor	Not Numbered	Variety of hazardous materials including VOCs and SOCs, others?	Spills and releases related to accidents	**High**	-Emergency response - Dilution	**Moderate**	- Maintain preparedness of local emergency personnel through active training, storm water diversion and other measures
USTs/LUSTs (4 inactive sites within surface water buffer region and near the infiltration gallery)	Not Numbered	VOCs, petroleum hydrocarbons	Spills, leaks impacting groundwater and or reaching surface water	**High**	-Leaking tanks are inactive and removed? -New tanks comply with current standards (Spill prevention, monitoring, and leak detection) Cross- or Down-gradient -Dilution	**Moderate to Low**	-Verify that remediation is complete -Request and review monitoring well water quality data -Carry out periodic inspections

Table 9. Susceptibility Assessment Significant Potential Contaminant Sources in the Inventory, Surface Water Buffer, and Recharge Regions Columbus Public Water Supply

Infiltration Gallery Surface Water Buffer-Inventory Region							
Source	**ID Number on Maps**	**Contaminant**	**Hazard**	**Hazard Rating**	**Barriers**	**Susceptibility**	**Management Recommendations**
Cultivated Cropland (24% in the spill response-inventory region)	Not Numbered	Fertilizers, pesticides, pathogens, nitrate	Spills, over application, surface runoff	**Moderate**	- Dilution	**Moderate**	Support the agricultural community's educational efforts to distribute materials and resources to land owners on the proper application and storage of pesticide and fertilizers; implement agricultural BMPs
Municipal Sewer Lines (Relatively small area within the spill response – inventory region)	Not Numbered on the map	Pathogens and nitrate, household hazardous waste	Infiltration into shallow ground water that is hydraulically connected to surface water.	**Moderate to Low**	-Dilution	**Moderate to Low**	-Conduct routine inspections to detect leaks and deteriorating lines. -Repair leaks and replace old lines. - Provide educational information, materials and resources to business owners and the public on proper waste disposal and recycling

Table 9. Susceptibility Assessment Significant Potential Contaminant Sources in the Inventory, Surface Water Buffer, and Recharge Regions Columbus Public Water Supply

Infiltration Gallery Surface Water Buffer-Inventory Region							
Source	**ID Number on Maps**	**Contaminant**	**Hazard**	**Hazard Rating**	**Barriers**	**Susceptibility**	**Management Recommendations**
Old State Highway 78	Not Numbered on the map	Variety of hazardous materials including VOCs and SOCs, others?	Spills and releases related to accidents	**High**	-Low traffic volume - Dilution	**Low**	- Maintain preparedness of local emergency personnel through active training, storm water diversion and other measures
Regulated Toxic Release Site (Montana Silversmiths)	Not Numbered	Annual release between 40,000 and 38,000 pounds of ammonia and dichromomethane	Spills, leaks, and releases	**Moderate**	-Site is located down-stream of the infiltration gallery -Regulated and Monitored Site - City / County Emergency Response - Dilution	**Low**	-Continue license compliance -Maintain preparedness of local emergency personnel through active training, and other measures
Federal Superfund Site (MOUAT Industries)	Not Numbered	Spill or release of hazardous material	Infiltration into shallow ground water that is hydraulically connected to surface water.	**High**	-Located down-stream from the infiltration gallery -Remediation efforts complete? -Dilution	**Low**	-Verify completion of remediation and inspect the site. -Continue monitoring activities at the site if needed.

Table 9. Susceptibility Assessment Significant Potential Contaminant Sources in the Inventory, Surface Water Buffer, and Recharge Regions Columbus Public Water Supply

Infiltration Gallery Surface Water Buffer-Inventory Region							
Source	**ID Number on Maps**	**Contaminant**	**Hazard**	**Hazard Rating**	**Barriers**	**Susceptibility**	**Management Recommendations**
Columbus Wastewater Treatment Plant and Lagoons	Not Numbered	Pathogens, nitrate, TDS	Spills, leaks, and releases	**Low**	-Located downstream -Regulated and monitored discharge - City / County Emergency Response	**Low**	Ensure proper maintenance and operation of system; monitor leaks in system; develop an alternative treatment plan in the event of system failure
Assorted businesses in town	Not Numbered	VOCs, SOCs, petroleum hydrocarbons, metals, pathogens, nitrate	Releases or spills, mishandling of chemicals, improper disposal of chemicals anywhere near the river	**Low**	-Business district and most business locations are down gradient of the well field.	**Low**	Support efforts to provide educational workshops to the general public by the city, county, or state promote safe handling and proper storage, transport, use, and disposal of hazardous materials. Scheduled days for the collection of hazardous wastes from the public.

Table 9. Susceptibility Assessment Significant Potential Contaminant Sources in the Inventory, Surface Water Buffer, and Recharge Regions Columbus Public Water Supply

Infiltration Gallery Surface Water Buffer-Inventory Region							
Source	**ID Number on Maps**	**Contaminant**	**Hazard**	**Hazard Rating**	**Barriers**	**Susceptibility**	**Management Recommendations**
Class V Injection Wells (existence and locations are not known) where storm and/or wastewater is concentrated and recharges groundwater.	Not Numbered	VOCs, SOCs, petroleum hydrocarbons, metals, pathogens, nitrate	Leaks, spills, improper handling and disposal/discharge of chemicals used by various businesses and are released to systems that allow infiltration of contaminants to the subsurface or to the storm water system	**Unknown**	**Unknown**	**Unknown**	Inventory; Provide educational information, materials and resources to business owners and the public on proper waste disposal and recycling

Beartooth Heights Well							
Source	**ID Number on Maps**	**Contaminant**	**Hazard**	**Hazard Rating**	**Barriers**	**Susceptibility**	**Management Recommendations**
Cultivated Cropland (A little less than 50% in the inventory region) Recheck area with new inventory region	Not Numbered	Fertilizers, pesticides, pathogens, nitrate	Spills, over application, surface runoff	**Moderate**	- Alluvial fan deposit confining layer	**Moderate**	Support the agricultural community's educational efforts to distribute materials and resources to land owners on the proper application and storage of pesticide and fertilizers; implement agricultural BMPs
Keyser Creek and Dry Creek	Not Numbered	Nitrate and pathogens	Water loss resulting in Infiltration into ground water	**Moderate**	- Intermittent Flow on both creeks	**Moderate**	Maintain monitoring schedule for nitrate, treat water if nitrate levels increase to the action level of 5 mg/l quarterly or monthly monitoring will be required by the DEQ Public Drinking Water Program.
Interstate 94 (Near distal end of 3 Yr TOT Inventory Region)	Not Numbered	Variety of hazardous materials including VOCs and SOCs, others?	Spills and releases related to accidents	**Moderate to Low**	- City / County Emergency Response - Distance from wells	**Moderate to Low**	Maintain preparedness of local emergency personnel through active training, storm water diversion and other measures

Beartooth Heights Well							
Source	**ID Number on Maps**	**Contaminant**	**Hazard**	**Hazard Rating**	**Barriers**	**Susceptibility**	**Management Recommendations**
Irrigation Canals (Near distal end of 3 Yr TOT Inventory Region)	Not Numbered	Nitrate and pathogens	Water loss resulting in Infiltration into ground water	**Moderate**	-Operates seasonally -Carries Yellowstone River water -Likely does not intercept irrigation return flow	**Low**	Support efforts to line canals to reduce water loss. Support the agricultural community's educational efforts to distribute materials and resources to land owners on the proper application and storage of pesticide and fertilizers; implement agricultural BMPs
Municipal Sewer lines	Not Numbered	Nitrate, pathogens	Leaks in mains/lines, system failure, infiltration of untreated effluent into shallow ground water, which may in turn reach surface water	**Low**	-Most areas are down-gradient from the well	**Low**	Ongoing testing and maintenance of lines and system, replacement of old lines, compliance with current regulations for discharges
On-site residential septic systems (Inventory Region is Low Septic Density)	Not Numbered	Nitrate, pathogens	Leaks in septic tanks, leaks in collection lines, system failure, infiltration of untreated effluent into shallow ground water, which may in turn reach surface water	**Low**	- Distance from well	**Low**	Provide educational information to home owners on proper disposal of potential contaminants and on maintenance of septic systems. Support efforts to extend city sewer services.

Beartooth Heights Well							
Source	**ID Number on Maps**	**Contaminant**	**Hazard**	**Hazard Rating**	**Barriers**	**Susceptibility**	**Management Recommendations**
County Roads	Not Numbered	Variety of hazardous materials including VOCs and SOCs, others?	Spills and releases related to accidents	**Low**	**-Not a major truck route**	**Low**	Maintain preparedness of local emergency personnel through active training, storm water diversion and other measures
Assorted businesses in town	Not Numbered	VOCs, SOCs, petroleum hydrocarbons, metals, pathogens, nitrate	Releases or spills, mishandling of chemicals, improper disposal of chemicals anywhere near the river	**Low**	-Business district and most business locations are down gradient of the well.	**Very Low**	Support efforts to provide educational workshops to the general public by the city, county, or state promote safe handling and proper storage, transport, use, and disposal of hazardous materials. Scheduled days for the collection of hazardous wastes from the public.
Class V Injection Wells (existence and locations are not known) where storm and/or wastewater is concentrated and recharges groundwater.	Not Numbered	VOCs, SOCs, petroleum hydrocarbons, metals, pathogens, nitrate	Leaks, spills, improper handling and disposal/discharge of chemicals used by various businesses and are released to systems that allow infiltration of contaminants to the subsurface or to the storm water system	**Unknown**	**Unknown**	**Unknown**	Inventory; Provide educational information, materials and resources to business owners and the public on proper waste disposal and recycling

Park Well (Note: Park Well is not connected to the public water supply. Susceptibility ratings are provided in the event that a well at this location is added to the system sometime in the future).

Source	ID Number on Maps	Contaminant	Hazard	Hazard Rating	Barriers	Susceptibility	Management Recommendations
Cultivated Cropland (20% in the inventory region) Recheck area with new inventory region	Not Numbered	Fertilizers, pesticides, pathogens, nitrate	Spills, over application, surface runoff	**Moderate**	- Alluvial fan deposit confining layer	**Moderate**	Support the agricultural community's educational efforts to distribute materials and resources to land owners on the proper application and storage of pesticide and fertilizers; implement agricultural BMPs
Municipal Sewer Lines	Not Numbered	Nitrate, pathogens	Leaks in mains/lines, system failure, infiltration of untreated effluent into shallow ground water, which may in turn reach surface water	**Moderate**	- Alluvial fan deposit confining layer	**Moderate**	Ongoing testing and maintenance of lines and system, replacement of old lines, compliance with current regulations for discharges
City Park and High School Fields	Not Numbered	Nitrate, Fertilizers (SOCs)	Spills, over application, surface runoff	**Moderate**	- Alluvial fan deposits confining layer	**Moderate**	Support educational efforts of school personnel on the proper application and storage of pesticide and fertilizers; implement BMPs
County Roads and Town streets	Not Numbered	Variety of hazardous materials including VOCs and SOCs, others?	Spills and releases related to accidents	**High**	-Not a major truck route -Low traffic volume	**Moderate to Low**	Maintain preparedness of local emergency personnel through active training, storm water diversion and other measures

Park Well (Note: Park Well is not connected to the public water supply. Susceptibility ratings are provided in the event that a well at this location is added to the system sometime in the future).

Source	ID Number on Maps	Contaminant	Hazard	Hazard Rating	Barriers	Susceptibility	Management Recommendations
Interstate 94 (Near distal end of 3 Yr TOT Inventory Region)	Not Numbered	Variety of hazardous materials including VOCs and SOCs, others?	Spills and releases related to accidents	**Moderate**	- City / County Emergency Response - Distance from wells	**Moderate to Low**	Maintain preparedness of local emergency personnel through active training, storm water diversion and other measures
Irrigation Canals (Near distal end of 3 Yr TOT Inventory Region)	Not Numbered	Nitrate and pathogens	Water loss resulting in Infiltration into ground water	**Moderate**	-Operates seasonally -Carries Yellowstone River water -Likely does not intercept irrigation return flow	**Low**	Support efforts to line canals to reduce water loss. Support the agricultural community's educational efforts to distribute materials and resources to land owners on the proper application and storage of pesticide and fertilizers; implement agricultural BMPs
Dry Creek (Keyser Creek)	Not Numbered	Nitrate and pathogens	Water loss resulting in Infiltration into ground water	**Moderate**	-Intermittent Flow on creeks -Distance from Keyser Creek drainage.	**Low**	Maintain monitoring schedule for nitrate, treat water if nitrate levels increase to the action level of 5 mg/l quarterly or monthly monitoring will be required by the DEQ Public Drinking Water Program.

Park Well (Note: Park Well is not connected to the public water supply. Susceptibility ratings are provided in the event that a well at this location is added to the system sometime in the future).

Source	ID Number on Maps	Contaminant	Hazard	Hazard Rating	Barriers	Susceptibility	Management Recommendations
On-site residential septic systems (Inventory Region is Low Septic Density)	Not Numbered	Nitrate, pathogens	Leaks in septic tanks, leaks in collection lines, system failure, infiltration of untreated effluent into shallow ground water, which may in turn reach surface water	**Low**	- Distance from well	**Low**	Provide educational information to home owners on proper disposal of potential contaminants and on maintenance of septic systems. Support efforts to extend city sewer services.
Assorted businesses in town	Not Numbered	VOCs, SOCs, petroleum hydrocarbons, metals, pathogens, nitrate	Releases or spills, mishandling of chemicals, improper disposal of chemicals anywhere near the river	**Low**	-Business district and most business locations are down gradient of the well.	**Low**	Support efforts to provide educational workshops to the general public by the city, county, or state promote safe handling and proper storage, transport, use, and disposal of hazardous materials. Scheduled days for the collection of hazardous wastes from the public.

Park Well (Note: Park Well is not connected to the public water supply. Susceptibility ratings are provided in the event that a well at this location is added to the system sometime in the future).

Source	ID Number on Maps	Contaminant	Hazard	Hazard Rating	Barriers	Susceptibility	Management Recommendations
Class V Injection Wells (existence and locations are not known) where storm and/or wastewater is concentrated and recharges groundwater	Not Numbered	VOCs, SOCs, petroleum hydrocarbons, metals, pathogens, nitrate	Leaks, spills, improper handling and disposal/discharge of chemicals used by various businesses and are released to systems that allow infiltration of contaminants to the subsurface or to the storm water system	**Unknown**	**Unknown**	**Unknown**	Inventory; Provide 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 are described below:

INFILTRATION GALLERY

Railroad Corridor – Railroad tracks run parallel to the river for several miles upstream from the infiltration gallery. Spills related to multiple tank cars could result in the release of a relatively large volume of hazardous material directly into the Yellowstone River. As mentioned previously, the Yellowstone River is a large river in this region and its discharge, even during low flow periods, provides substantial dilution potential. Dilution represents a significant barrier to potential sources of contamination identified in the spill response region-inventory region. Nevertheless, if a large spill were to occur in close proximity to the infiltration gallery, dilution may not be sufficient to reduce the threat to the source water and the public water supply. Hazard for the railroad is rated as high and with emergency response and dilution recognized as barriers, the susceptibility is rated at moderate. Susceptibility will be higher if an accident and spill occurred close to the gallery.

UST/LUSTs- One underground storage tanks released product in the past within the spill response region-inventory region. Due to the fact that the tank site is located close to the infiltration gallery location, the hazard is rated as high. In December of 1999 EPA required all USTs to meet an updated set of standard. For most operators, meeting this requirement meant removing old tanks and replacing them with new tanks. Because the tank site is inactive, and it is assumed that leaking tanks have been removed and remediation was completed, the susceptibility is ranked as moderate for this one site and low for other UST sites.

Cultivated Crop lands – The potential hazard from pathogens and nitrate originating from agricultural lands is rated as moderate based on the percentage of ag-land in the spill response-inventory region. The susceptibility is rated as moderate with dilution recognized as a barrier.

Municipal Sewer System – Municipal sewer mains are present in the spill response region-inventory region but constitute a relatively small area within the spill response region. The potential hazard imposed by pathogens and nitrate originating from municipal sewer system is moderate to low. With multiple dilution identified as a barrier, susceptibility is also rated as moderate to low.

Old State Highway 78 – The old highway parallels the river for several miles directly above the infiltration gallery location. Hazard is rated as high because the road is close to the river and accidents could result in a release of hazardous materials directly into the river. It is recognized that the old highway is not a major truck route and traffic load is generally quite low. Dilution is also recognized as a barrier resulting in a susceptibility of low.

Regulated Toxic Release Site – Montana Silversmiths is permitted to release about 40,000 pounds of ammonia and dichromomethane into the air each year. The site is located downstream from the infiltration gallery and prevailing wind direction is generally not toward the gallery location. Hazard is rated as moderate and susceptibility is rated as low.

Federal Superfund Site – MOUAT Industries is identified as a superfund site but details on the nature of releases at this property were not available from the EPA web page. The site is located about ½ mile downstream from the gallery location. Hazard is rated as high and with multiple barriers identified the susceptibility is ranked as low.

Wastewater Discharges- The potential hazard from VOCs, SOCs, pathogens, and nitrate originating from city's wastewater treatment plant is low because the discharge site is located downstream from the infiltration gallery, and the plant is operating within its permit requirements. Susceptibility is also rated as low.

Assorted Businesses in Town - Based on their location with respect to the public water supply wells and infiltration gallery, these businesses are not considered to pose a threat to the Public Water Supply. Even though this is the case, a simple proactive step to reducing the risk of unnecessary contamination in the community is to provide educational information and resources to business owners and the public on proper waste disposal and recycling. Hazard for businesses in town is low, susceptibility is low.

Class V Injection Wells – The potential hazard imposed by VOCs, SOCs, pathogens, nitrate, and other contaminants originating from the class V injection wells cannot be determined due to the fact that no inventory of Class V well is complete for most of Montana or the current inventory is inadequate. The susceptibility of the intake to contaminants originating from this source is unknown.

BEARTOOTH HEIGHTS WELL

Cultivated Crop lands – The potential hazard from pathogens and nitrate originating from agricultural lands is rated as moderate based on the percentage of ag-land in the inventory region. The susceptibility is rated as moderate to low with the alluvial fan deposit counted as a barrier.

Keyser Creek and Dry Creek – Although both creeks appear to be relatively small and intermittent, they do drain areas where irrigated fields are present. Over-application, mis-management, and surface water runoff related to precipitation events could result in the creeks transporting fertilizers and other ag-chemicals toward the Beartooth Well. Because the creeks are dry most of the time, it appears that they lose water to the aquifer that provides water to both wells. This may explain the nitrate levels recorded in Well 2 (See water quality in Appendix B. Hazard is considered moderate because the creeks are intermittent and discharge events are not interpreted to be frequent. Susceptibility is moderate.

Interstate 94 - Interstate 94 crosses the inventory region near the northern boundary. Accidents on the highway could result in a variety of hazardous materials spilled within the inventory region. Due to the location of the Interstate, hazard is rated as moderate and susceptibility as moderate to low with several barriers identified.

Irrigation Canal – The Columbus Water User's Association Canal passes through the inventory region near the outer boundary. Although it is very likely the canal does contribute water to recharge the aquifer used by the Beartooth Well, the quality of that water is interpreted to be relatively high quality water. A hazard rating of moderate is assigned. With multiple barriers identified, susceptibility is rated as low.

Municipal Sewer System – Municipal sewer mains are present but they are down-gradient from the well. This means that the ground water from this area would flow away from the well but not toward it. The potential hazard imposed by pathogens and nitrate originating from municipal sewer system is low. With multiple barriers identified, susceptibility is also rated as low.

Septic Systems – Low septic density dominates the inventory region and the area beyond its outer boundary. Developed lots appear to be about a mile or more away from this well. Hazard is assigned as low and with multiple barriers recognized, susceptibility is assigned as low.

County Roads – Several county dirt roads run relatively close to the well and up-gradient of the well. The roads do not carry a heavy traffic volume and they are not major truck routes. Hazard is rated low and susceptibility is moderate to low.

Assorted Businesses in Town - Based on their location with respect to the public water supply wells and infiltration gallery, these businesses are not considered to pose a threat to the Public Water Supply. Even though this is the case, a simple proactive step to reducing the risk of unnecessary contamination in the community is to provide educational information and resources to business owners and the public on proper waste disposal and recycling. Hazard for businesses in town is low; susceptibility is low to very low.

Class V Injection Wells – The potential hazard imposed by VOCs, SOCs, pathogens, nitrate, and other contaminants originating from the class V injection wells cannot be determined due to the fact that no inventory of Class V well is complete for most of Montana or the current inventory is inadequate. The susceptibility of the intake to contaminants originating from this source is unknown.

PARK WELL

Cultivated Crop lands – The potential hazard from pathogens and nitrate originating from agricultural lands is rated as moderate based on the percentage of ag-land in the inventory region. The susceptibility is rated as moderate with the confining layer used as a barrier.

Keyser and Dry creeks – Because the creeks are dry most of the time, it appears that they lose water to the aquifer. Hazard is considered moderate. Susceptibility is low with several barriers identified.

Interstate 94 - Interstate 94 crosses the inventory region. Due to the location of the Interstate, hazard is rated as moderate and susceptibility as moderate to low with several barriers identified.

Irrigation Canal – A hazard rating of moderate is assigned. With multiple barriers identified, susceptibility is rated as low.

Municipal Sewer System –The potential hazard imposed by pathogens and nitrate originating from municipal sewer system is moderate. With one barrier identified, susceptibility is rated as moderate.

City Park and High School Fields – Hazard is rated as moderate and with one barrier identified the susceptibility is moderate.

Septic Systems – Hazard is assigned as low and with multiple barriers recognized, susceptibility is assigned as low.

County Roads and City Streets – The roads and streets do not carry a heavy traffic volume and they are not major truck routes. Hazard is rated low and susceptibility is moderate to low.

Assorted Businesses in Town - Hazard for businesses in town is low, susceptibility is low to very low.

Class V Injection Wells – The potential hazard imposed by VOCs, SOCs, pathogens, nitrate, and other contaminants originating from the class V injection wells cannot be determined due to the fact that no inventory of Class V well is complete for most of Montana or the current inventory is inadequate. The susceptibility of the intake to contaminants originating from this source is unknown.

Management Recommendations

It should be noted that even small releases of some chemicals in close proximity to a well can have significant negative impact on water quality, and is therefore a significant threat to the public water supply. Steps can be taken to reduce the likelihood of releases in the source water for the PWS or in the vicinity of the sources. Some of these steps (considered management recommendations) are listed below.

Some management recommendations are also included in the susceptibility table (**Table 8**). If these, and other, management actions are implemented; they may be considered additional barriers that will reduce the susceptibility of the intake to specific sources and contaminants.

Specific management recommendations for the Columbus Public Water Supply:

The public water supply serving Columbus is not highly susceptible to any potential contaminant sources identified in this report. This is largely due to the majority of potential contaminant sources being located down-stream or down-gradient from the public water supply infiltration gallery and the active well. The fact that the alluvial fan deposit provides a protective confining layer for the aquifer tapped by the Beartooth Heights Well also helps reduce the susceptibility ratings. The silt and clay layers within the alluvial fan deposit range up to 25 feet thick in places. It is important to understand that Keyser Creek has cut down into the fan deposit reducing the thickness of the silt and clay beds, and in some places, the erosion could have cut all the way through these beds and exposed the top of the alluvial sand and gravel aquifer. Additional examination or study would be required to determine if the alluvial fan cap has been compromised along the Keyser Creek drainage west and northwest of the Beartooth Heights Well site. If potential contaminant sources are located where the silt and clay confining layer is thin or absent, they could have a negative impact on the source water and public water supply. A management option that would address this issue would be to restrict development within 100 feet of Keyser Creek. This management option would not have a negative impact on development and growth in the community, but it would direct development out of the relatively narrow Keyser Creek floodplain and away from where the confining layer is thin or worse, absent.

An additional management option that would help protect the source water would be to guide future development generally west and north of town. Low-density development on relatively large land parcels would be preferable in this area if city services (water and sewer) are not extended or required. Or, if high-density development is allowed west and north of town, city services such as water and sewer should be required.

Other general management recommendations fall into the following categories:

- Sewer maintenance and leak detection
- Municipal sewer extension
- Agricultural best management practices
- Stormwater management
- Proper disposal and monitoring of oil and gas production wastewater

- Education
- Emergency Response Planning

Sewer Maintenance and leak detection – Early warning of leaks and scheduled replacement of aging sewer lines may reduce the susceptibility of the Columbus public water supply to contamination from municipal septic wastes, and could also benefit other public water supplies in the area.

Sewer Extension – Installation of advanced septic treatment systems such as sand filters can limit contamination from new rural residential development, however, annexation and extension of sewers is the only way to reduce contamination from existing unsewered developments.

Agricultural and silvicultural best management practices (BMPs) – BMPs that address application and mixing of fertilizer and pesticides are a viable alternative to prohibition of their use. BMPs may also be utilized to minimize surface runoff and soil erosion on cultivated fields. Erosion control, selective logging, and other silvicultural practices (essentially BMPs) should be considered on a county-wide basis. BMPs are generally voluntary but their implementation can be encouraged through education and technical assistance. County planning can help promote the implementation of BMP on lands that are outside city limits but indirectly affect the city PWS.

Education - Educational workshops provided to the general public by the city, county, or state promote safe handling and proper storage, transport, use, and disposal of hazardous materials. Ongoing training provided to designated emergency personnel will promote the efficiency and effectiveness of emergency responses to hazardous material spills. Likewise, educational workshops provided to rural homeowners will promote the proper maintenance and replacement of residential septic systems. 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.

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.

CHAPTER 5: MONITORING WAIVERS

WAIVER RECOMMENDATION

It appears that Columbus does not have any water quality waivers. Based on past monitoring results and the susceptibility assessment of the city's source water, the public water supply may be eligible for monitoring waivers. However, to be sure that eligibility for all available waivers is considered, the public water supply operators are encouraged to carefully review the following section on Monitoring Waiver Requirements. If, after reviewing this section it is determined that additional waivers are feasible, the PWS should submit a letter with the proper documentation to DEQ requesting monitoring waivers. **Table 8** in the Susceptibility Chapter can be used as a guide to request 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.

Use Waivers

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.

Susceptibility Waivers

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 will 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.

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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.

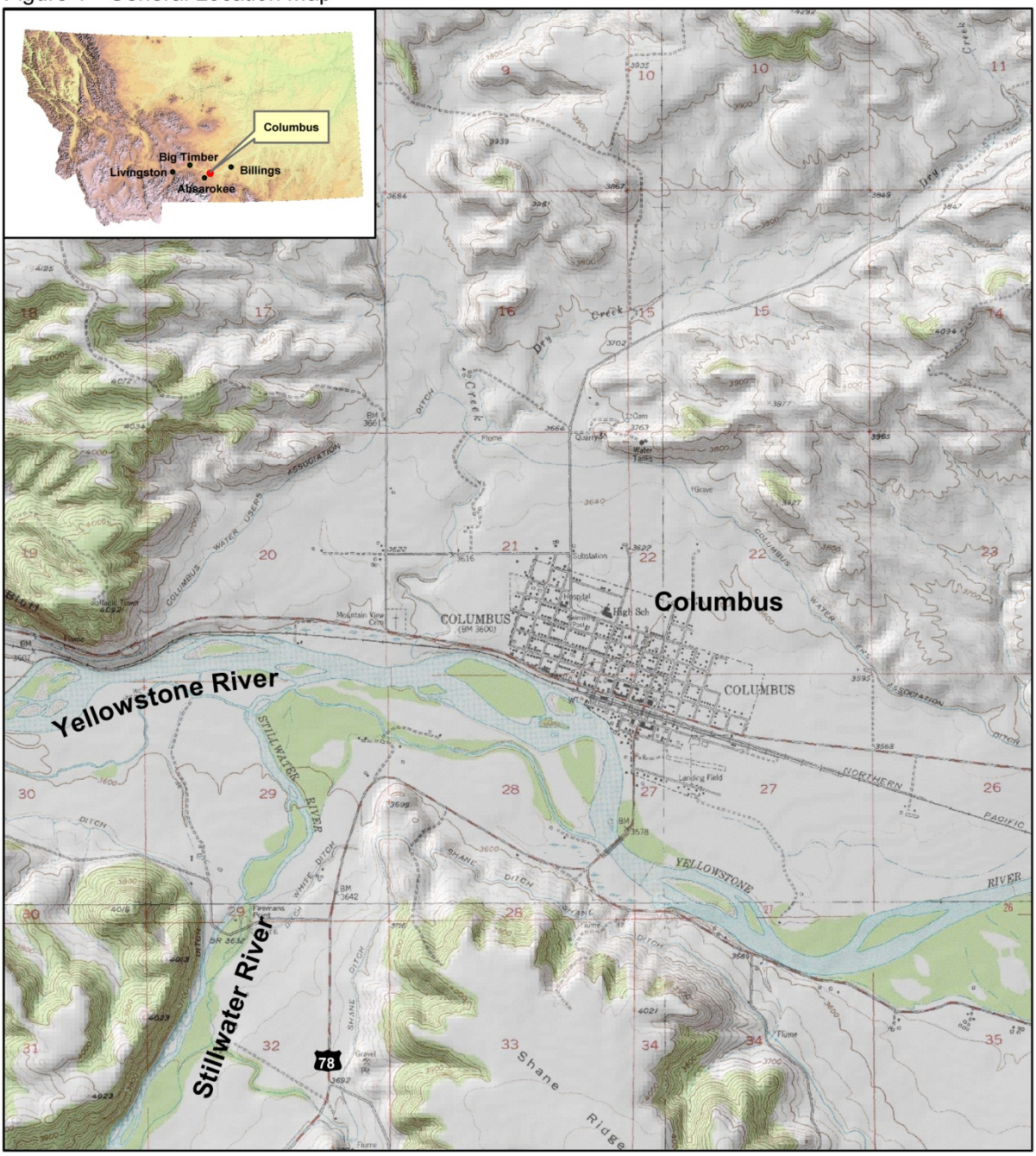
Volatile Organic Compounds (VOC). Any organic compound which evaporates readily to the atmosphere (e.g. fuels and solvents).

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



Town of Columbus, Montana

Population: 1,748
Source of Water: Ground Water and Infiltration Gallery
Producing Formation: Yellowstone River Alluvium

Montana Department of Environmental Quality

JRS - 02 - 2004

Figure 1. General Location Map

Figure 2. Average Temperatures and Precipitation
(Imbedded in Text on Page 2)

Figure 3A - Inventory of Potential Contaminant Sources

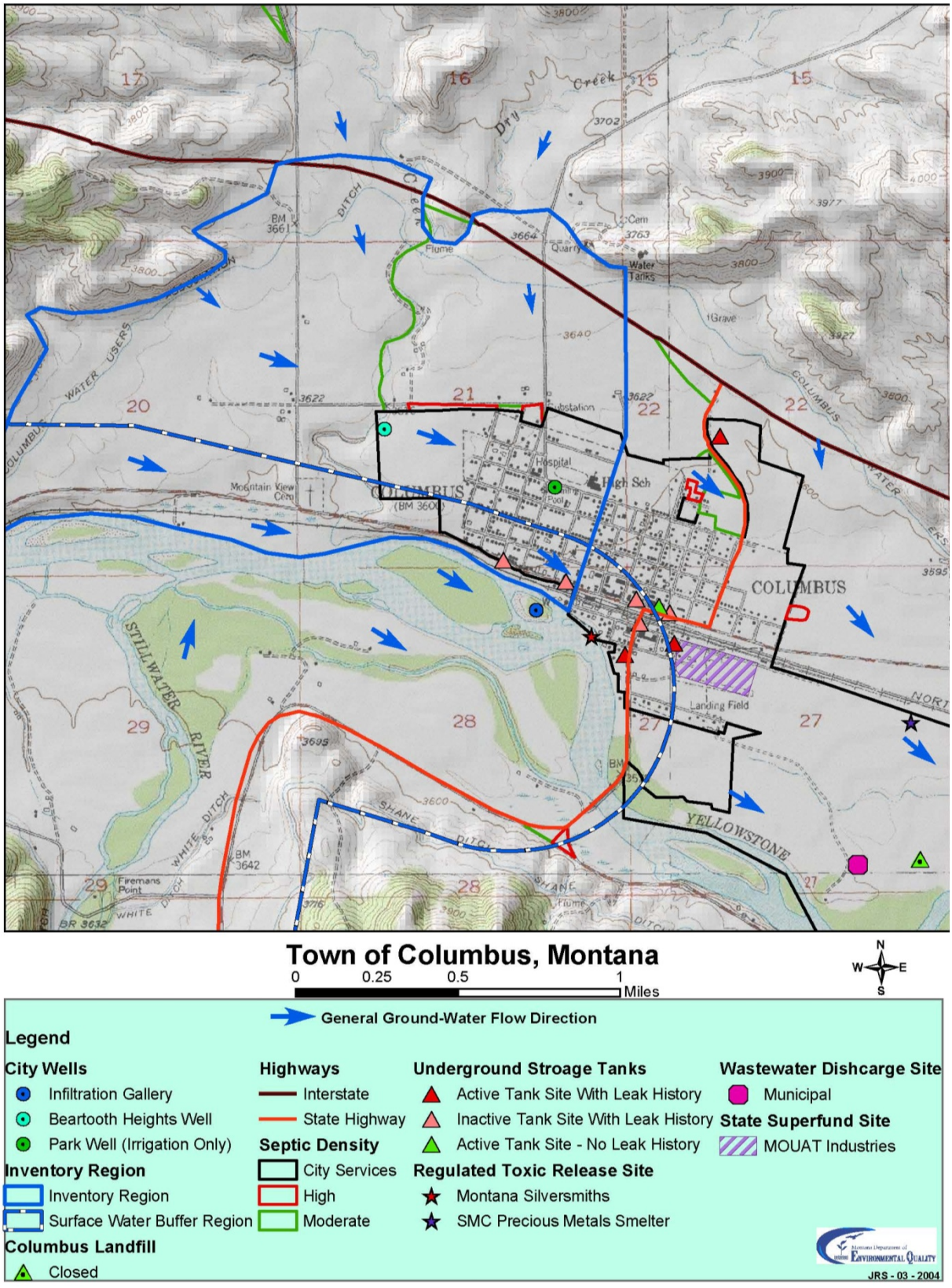


Figure 3(A). Inventory of Potential Contaminant Sources

Figure 3B - Inventory of Potential Contaminant Sources (w/Aerial Photo Base)

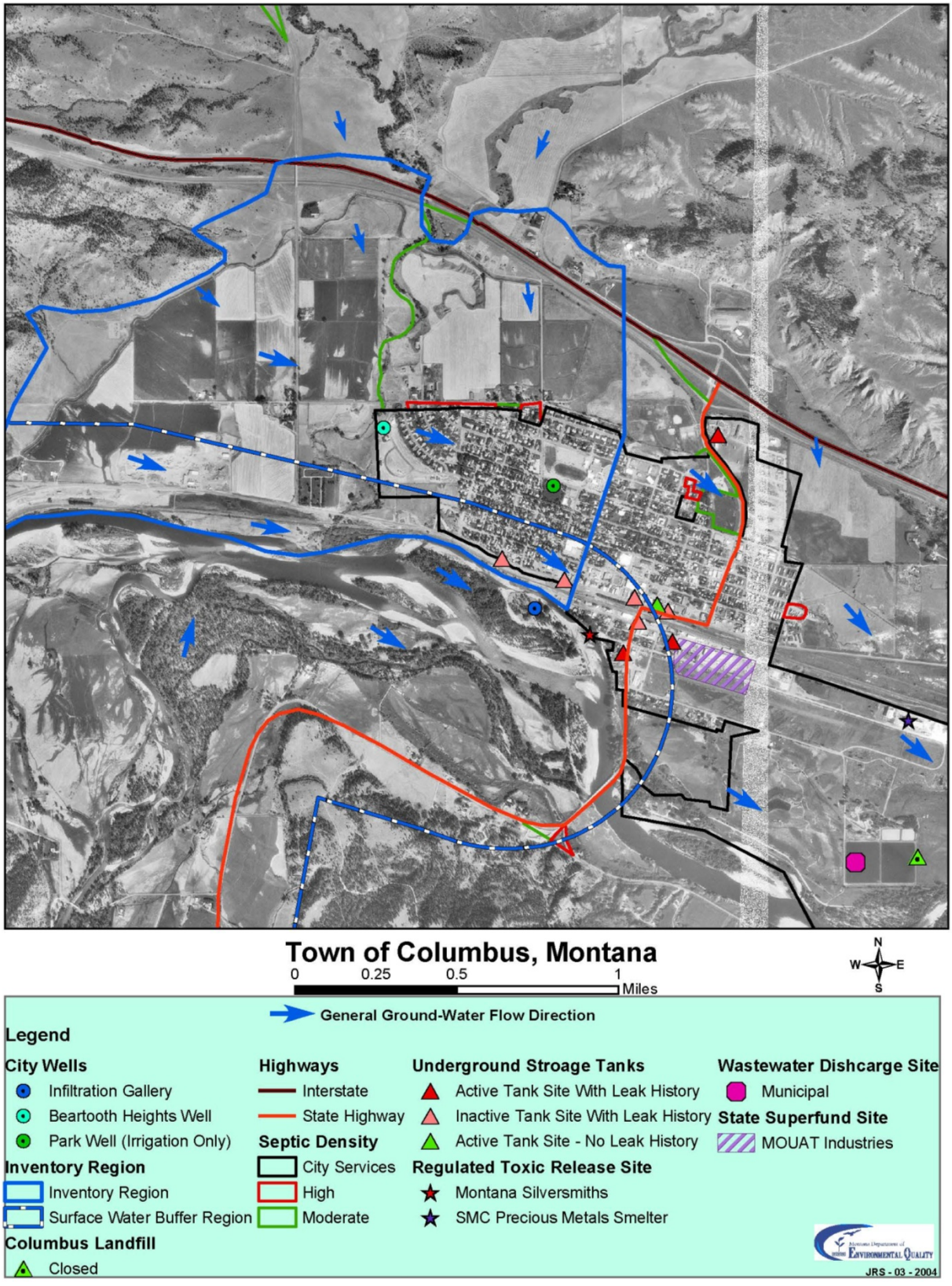
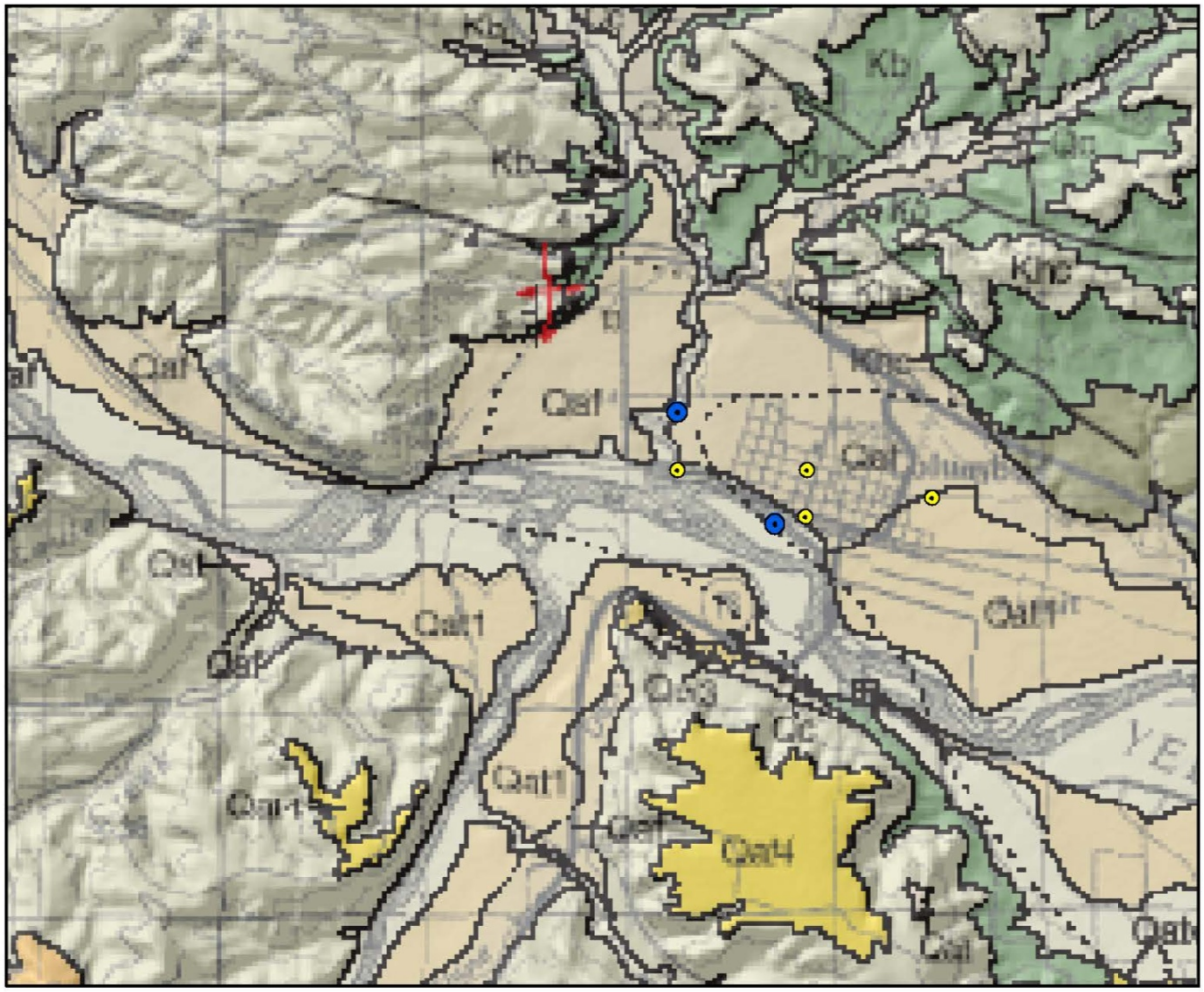


Figure 3(B). Inventory of Potential Contaminant Sources

Figure 4 - General Geology (Modified from David A. Lopez, 2000, MBMG OF # 405)



Modified from David A. Lopez, 2000, Geologic Map of the Big Timber 30 X 60 Quadrangle, South-Central Montana: MBMG OF # 405. Note: The map on this page is for illustration purposes only and is not drawn to the original scale. The original scale for the map is 1:100,000.

Qal	**Alluvium of modern channels and flood plains**
Qc	**Colluvium**
Qaf	**Alluvial Fan Deposit**
	← **Break in Section - Some deposits not represented**
Qat	**Alluvium of alluvial terrace deposits**
Qat1	**Alluvium of youngest alluvial terrace level**
Qat2	**Alluvium of second youngest alluvial terrace level**
Qat3	**Alluvium of third youngest alluvial terrace level**
Qat4	**Alluvium of fourth youngest alluvial terrace level**
Qat5	**Alluvium of fifth youngest alluvial terrace level**
	← **Break in Section - Some deposits not represented**
Tat	**Alluvium of alluvial terrace deposits**
Tftr	**Tongue River Member of the Fort Union Formation**

N
W E
S

Montana Department of Environmental Quality
JRS - 03 - 2004

Figure 4. General Geology Map

Figure 5. Well Depth Histogram for Wells in the Columbus Area
(Imbedded in Text on Page 7)

Figure 6 - Inventory Region With Landcover / Landuse.

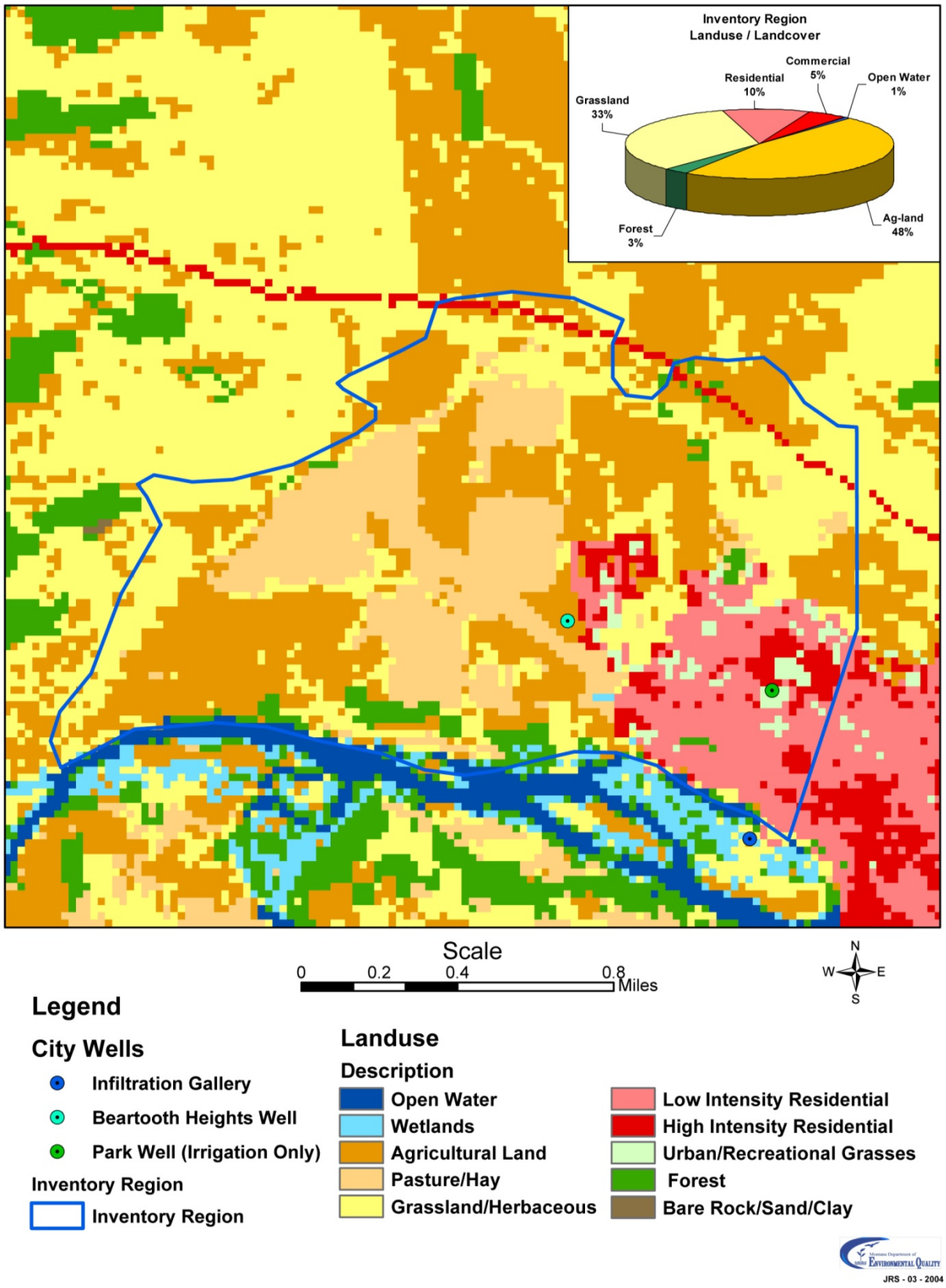


Figure 6. Inventory Region Map with Landcover / Landuse

Figure 7 - Surface Water Buffer Region With Landuse

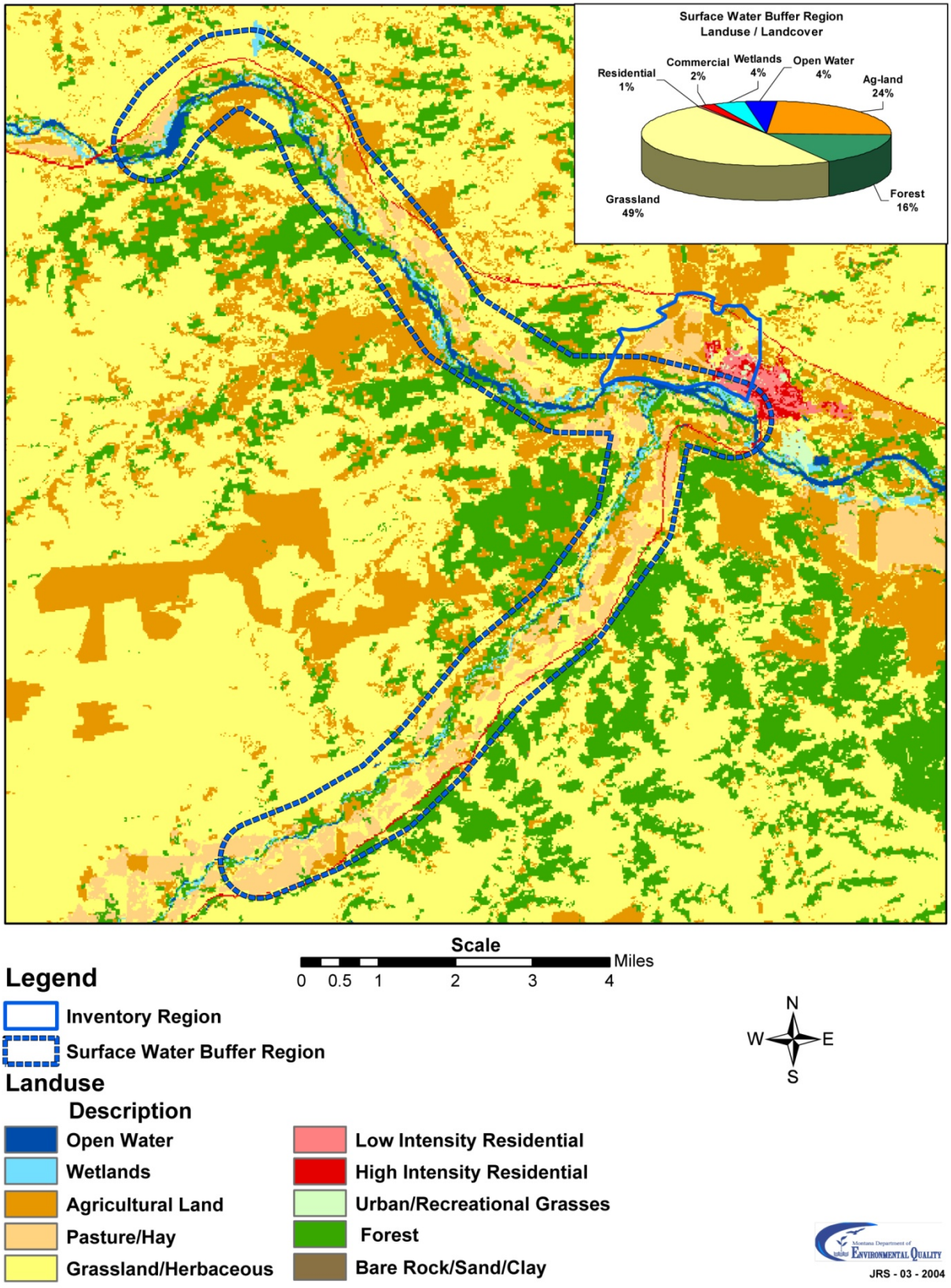


Figure 7. Surface Water Buffer Region Map with Landcover / Landuse

Figure 8 - Recharge Region With Landcover / Landuse.

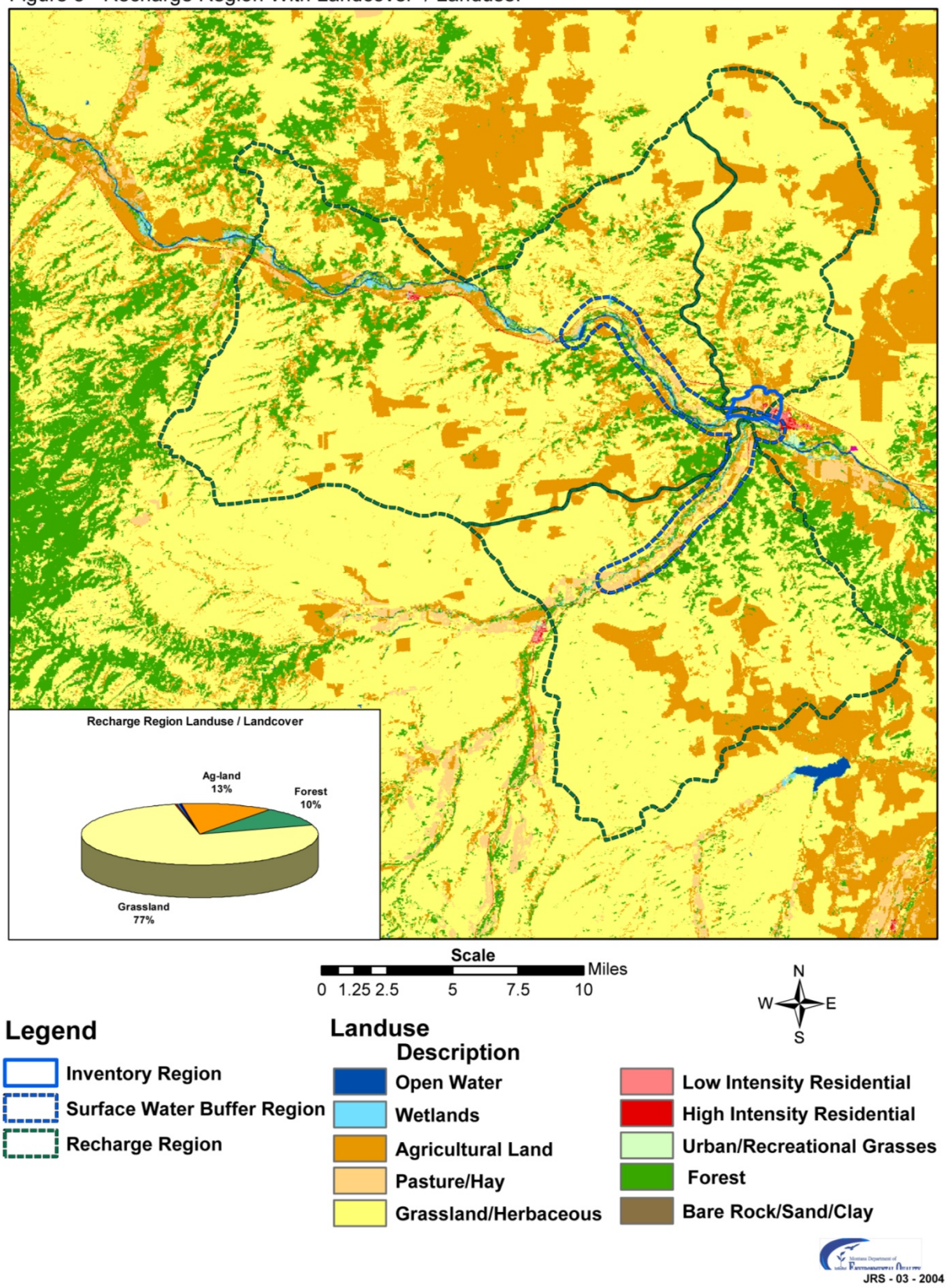


Figure 8: Recharge Region Map with Landcover / Landuse

Figure 9 - Recharge Region Inventory

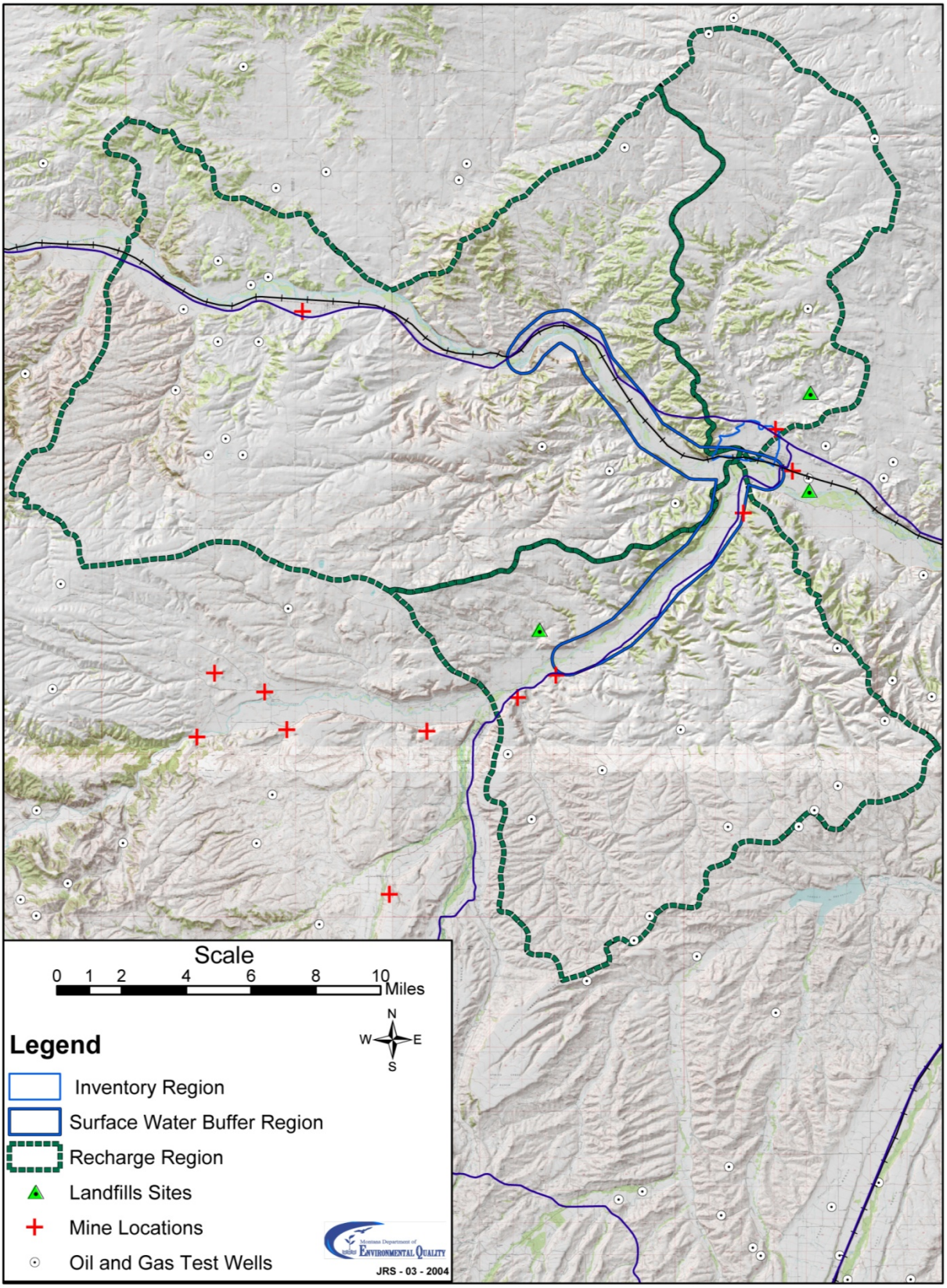


Figure 9. Recharge Region Inventory Map

APPENDICES

APPENDIX A – WELL LOGS FOR THE CITY OF COLUMBUS

Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
TOWN OF COLUMBUS - WELL 1 – Island Infiltration Lines

Location Information

GWIC Id:	188827	Source of Data:	DEQ
Location (TRS):	02S 20E 28 ABADC	Latitude (dd):	45.6370
County (MT):	STILLWATER	Longitude (dd):	-109.2587
DNRC Water Right:		Geomethod:	MAP
PWS Id:	00185002	Datum:	NAD27
Block:		Certificate of Survey:	
Lot:		Type of Site:	WELL
Addition:			

Well Construction and Performance Data

Total Depth (ft):		How Drilled:	
Static Water Level (ft):		Driller's Name:	
Pumping Water Level (ft):		Driller License:	
Yield (gpm):	800.00	Completion Date (m/d/y):	
Test Type:		Special Conditions:	
Test Duration:		Is Well Flowing?:	
Drill Stem Setting (ft):		Shut-In Pressure:	
Recovery Water Level (ft):		Geology/Aquifer:	Not Reported
Recovery Time (hrs):		Well/Water Use:	PUBLIC WATER SUPPLY

Well Notes: THIS IS AN INFILTRATION GALLERY LOCATED ON AN ISLAND IN THE CENTER OF YELLOWSTONE RIVER. WELL RECORD CREATED FROM DEQ SANITATION SURVEY.

Hole Diameter Information
No Hole Diameter Records currently in GWIC.

Casing Information[1]
No Casing Records currently in GWIC.

Annular Seal Information
No Seal Records currently in GWIC.

Completion Information[1]
No Completion Records currently in GWIC.

Lithology Information
No Lithology Records currently in GWIC.

Ground-Water Information Center **Water Quality Report**
Site Name: TOWN OF COLUMBUS - WELL 1 - Water Quality **Report Date:** 2/24/2004

Location Information

Sample Id/Site Id: 2002Q1442 / 188827
Location (TRS): 02S 20E 28 ABADC
Latitude/Longitude: 45° 38' 13" N 109° 15' 31" W
Datum: NAD27
Altitude:
County/State: STILLWATER / MT
Site Type: WELL
Geology:
USGS 7.5' Quad: COLUMBUS WEST
PWS Id: 00185002
Project: PWSINV

Sample Date: 6/5/2002 9:00:00 AM
Agency/Sampler: MBMG / TED
Field Number: COL-IG1
Lab Date: 8/14/2002
Lab/Analyst: MBMG / JMC
Sample Method/Handling: PUMPED / 3120
Procedure Type: DISSOLVED
Total Depth (ft): NR
SWL-MP (ft): NR
Depth Water Enters (ft): NR

Major Ion Results

	mg/L	meq/L		mg/L	meq/L
Calcium (Ca)	36.500	1.821	Bicarbonate (HCO3)	235.900	3.866
Magnesium (Mg)	13.100	1.078	Carbonate (CO3)	0.000	0.000
Sodium (Na)	40.000	1.740	Chloride (Cl)	6.780	0.191
Potassium (K)	2.350	0.060	Sulfate (SO4)	47.000	0.979
Iron (Fe)	0.010	0.001	Nitrate (as N)	0.363	0.026
Manganese (Mn)	0.002	0.000	Fluoride (F)	0.451	0.024
Silica (SiO2)	17.100		Orthophosphate (OPO4)	<.05	0.000
Total Cations		4.730	**Total Anions**		5.086

Trace Element Results (µg/L)

Aluminum (Al):	<30	Cadmium (Cd):	<2	Mercury (Hg):	NR	Tin (Sn):	NR
Antimony (Sb):	<2	Chromium (Cr):	<2	Molybdenum (Mo):	<10	Titanium (Ti):	<1
Arsenic (As):	8.240	Cobalt (Co):	<2	Nickel (Ni):	<2	Thallium (Tl):	<5
Barium (Ba):	46.000	Copper (Cu):	2.340	Silver (Ag):	<1	Uranium (U):	1.950
Beryllium (Be):	<2	Lead (Pb):	<2	Selenium (Se):	<1	Vanadium (V):	<5
Boron (B):	199.000	Lithium (Li):	34.100	Strontium (Sr):	487.000	Zinc (Zn):	7.370
Bromide (Br):	<50					Zirconium (Zr):	<2

Field Chemistry and Other Analytical Results

**Total Dissolved Solids:	279.870	Field Hardness as CaCO3:	NR	Ammonia (mg/L):	NR
**Sum of Diss. Constituents:	399.570	Hardness as CaCO3:	145.060	T.P. Hydrocarbons (µg/L):	NR
Field Conductivity (µmhos):	345.000	Field Alkalinity as CaCO3:	NR	PCP (µg/L):	NR
Lab Conductivity (µmhos):	376.000	Akalinity as CaCO3:	193.480	Phosphate, TD (mg/L as P):	<.05
Field pH:	7.320	Ryznar Stability Index:	7.922	Field Nitrate (mg/L):	NR
Lab pH:	7.380	Sodium Adsorption Ratio:	1.450	Field Dissolved O2 (mg/L):	NR
Water Temp (°C):	9.900	Langlier Saturation Index:	-0.271	Field Chloride (mg/L):	NR
Air Temp (°C):	NR	Nitrite (mg/L as N):	<.05	Field Redox (mV):	542.000

Sample Condition: CLEAR * CHLORINATOR TURNED OFF BEFORE SAMPLING
Field Remarks: INFILTRATION GALLERY. SAMPLE COLLECTED AT TAP IN PUMPHOUSE.
Lab Remarks:

Notes

Comparison of Well 1 water quality with Water Quality Standards

Sample Id	GWIC Id	Sample Date	Site Name	Location	Site Type
2002Q1442	188827	6/5/2002 9:00:00 AM	TOWN OF COLUMBUS - WELL 1	02S 20E 28 ABADC	WELL

Constituent	This Sample	Drinking Water	Stock Water	Irrigation Water
Calcium (Ca)	36.500 mg/L	---	---	---
Magnesium (Mg)	13.100 mg/L	---	2,000 mg/L	---
Sodium (Na)	40.000 mg/L	250 mg/L [smcl]	2,000 mg/L	see SAR
Potassium (K)	2.350 mg/L	---	---	---
Iron (Fe)	0.010 mg/L	0.3 mg/L [smcl]	---	---
Manganese (Mn)	0.002 mg/L	0.05 mg/L [smcl]	---	2.0 mg/L
Silica (SiO2)	17.100 mg/L	---	---	---
Bicarbonate (HCO3)	235.900 mg/L	---	---	---
Carbonate (CO3)	0.000 mg/L	---	---	---
Chloride (Cl)	6.780 mg/L	250 mg/L [smcl]	1,500 mg/L	---
Sulfate (SO4)	47.000 mg/L	250 mg/L [smcl]	1,500 mg/L	[b]
Nitrate (NO3 as N)	0.363 mg/L	10 mg/L [mcl]	100 mg/L	---
Fluoride (F)	0.451 mg/L	4 mg/L [mcl]	2 mg/L	---
Ortho-Phosphate (as P)	<.05 mg/L	500 mg/L [smcl]	5,000 mg/L	2,000 mg/L [c]
Aluminum (Al)	<30 ug/L	50-200 ug/L [smcl]	---	1,000 ug/L
Antimony (Sb)	<2 ug/L	6 ug/L [mcl]	---	---
Arsenic (As)	8.240 ug/L	10 ug/L [mcl]	50 ug/L	100 ug/L
Barium (Ba)	46.000 ug/L	2,000 ug/L [mcl]	---	---
Boron (B)	199.000 ug/L	---	---	---
Cadmium (Cd)	<2 ug/L	5 ug/L [mcl]	10 ug/L	5 ug/L
Chromium (Cr)	<2 ug/L	100 ug/L [mcl]	1,000 ug/L	100 ug/L
Cobalt (Co)	<2 ug/L	---	1,000 ug/L	50 ug/L
Copper (Cu)	2.340 ug/L	1,300 ug/L [mcl]	500 ug/L	200 ug/L
Lead (Pb)	<2 ug/L	15 ug/L [mcl]	50 ug/L	5,000 ug/L
Lithium (Li)	34.100 ug/L	---	---	2,500 ug/L
Molybdenum (Mo)	<10 ug/L	---	---	5 ug/L
Nickel (Ni)	<2 ug/L	---	---	200 ug/L
Phosphate (P)	<.05 ug/L	---	---	---
Selenium (Se)	<1 ug/L	50 ug/L [mcl]	50 ug/L	20 ug/L
Silver (Ag)	<1 ug/L	100 ug/L [smcl]	---	---
Strontium (Sr)	487.000 ug/L	---	---	---
Titanium (Ti)	<1 ug/L	---	---	---
Vanadium (V)	<5 ug/L	---	---	---
Zinc (Zn)	7.370 ug/L	5,000 ug/L [smcl]	24,000 ug/L	2,000 ug/L
Zirconium (Zr)	<2 ug/L	---	---	---

Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
TOWN OF COLUMBUS - WELL 2 – Beartooth Heights Well

Location Information

GWIC Id: 97551
Location (TRS): 02S 20E 21 CABCD
County (MT): STILLWATER
DNRC Water Right: P060353-00
PWS Id: 00185003
Block:
Lot:
Addition:
Source of Data: LOG
Latitude (dd): 45.6449
Longitude (dd): -109.2684
Geomethod: MAP
Datum: NAD27
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 69.00
Static Water Level (ft): 23.00
Pumping Water Level (ft): 32.00
Yield (gpm): 950.00
Test Type: PUMP
Test Duration: 24.00
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):
Well Notes:
How Drilled: FORWARD ROTARY
Driller's Name: B & H
Driller License: WWC-309
Completion Date (m/d/y): 10/23/1985
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 110ALVM
Well/Water Use: PUBLIC WATER SUPPLY

Hole Diameter Information

From	To	Diameter
0.0	69.0	16.0

Casing Information[1]

From	To	Dia	Description
-2.0	49.0	12.0	50 LB STEEL
48.0	64.0	11.0	SCREEN
64.0	69.0	11.0	STEEL

Annular Seal Information

From	To	Description
0.0	20.0	CEMENT

Completion Information[1]

From	To	Dia	Description
48.0	64.0	12.0	60 SLOT JOHNSON SCREEN

Lithology Information

From	To	Description
0.0	25.0	TOPSOIL
25.0	64.0	SAND AND GRAVEL
64.0	69.0	BLUE SHALE

Ground-Water Information Center **Water Quality Report**

Site Name: TOWN OF COLUMBUS - WELL 2 - Water Quality **Report Date:** 2/24/2004

Compare to Water Quality Standards

Location Information

Sample Id/Site Id: 2002Q1443 / 97551
Location (TRS): 02S 20E 21 CABCD
Latitude/Longitude: 45° 38' 41" N 109° 16' 6" W
Datum: NAD27
Altitude:
County/State: STILLWATER / MT
Site Type: WELL
Geology: 110ALVM
USGS 7.5' Quad: COLUMBUS WEST
PWS Id: 00185003
Project: PWSINV, RADON

Sample Date: 6/5/2002 10:20:00 AM
Agency/Sampler: MBMG / TED
Field Number: COLWEL1
Lab Date: 8/14/2002
Lab/Analyst: MBMG / JMC
Sample Method/Handling: PUMPED / 3120
Procedure Type: DISSOLVED
Total Depth (ft): 69.000
SWL-MP (ft): NR
Depth Water Enters (ft): 48.000

Major Ion Results

	mg/L	meq/L		mg/L	meq/L
Calcium (Ca)	44.300	2.211	Bicarbonate (HCO3)	332.200	5.445
Magnesium (Mg)	21.500	1.769	Carbonate (CO3)	0.000	0.000
Sodium (Na)	38.100	1.657	Chloride (Cl)	4.590	0.129
Potassium (K)	2.140	0.055	Sulfate (SO4)	26.500	0.552
Iron (Fe)	0.015	0.001	Nitrate (as N)	0.751	0.054
Manganese (Mn)	<.001	0.000	Fluoride (F)	0.625	0.033
Silica (SiO2)	16.300		Orthophosphate (OPO4)	<.05	0.000
Total Cations		5.736	**Total Anions**		6.213

Trace Element Results (µg/L)

Aluminum (Al):	51.000	Cadmium (Cd):	<2	Mercury (Hg):	NR	Tin (Sn):	NR
Antimony (Sb):	<2	Chromium (Cr):	<2	Molybdenum (Mo):	<10	Titanium (Ti):	<1
Arsenic (As):	1.190	Cobalt (Co):	<2	Nickel (Ni):	<2	Thallium (Tl):	<5
Barium (Ba):	48.600	Copper (Cu):	<2	Silver (Ag):	<1	Uranium (U):	3.030
Beryllium (Be):	<2	Lead (Pb):	<2	Selenium (Se):	<1	Vanadium (V):	<5
Boron (B):	163.000	Lithium (Li):	15.900	Strontium (Sr):	972.000	Zinc (Zn):	12.200
Bromide (Br):	<50					Zirconium (Zr):	<2

Field Chemistry and Other Analytical Results

**Total Dissolved Solids:	318.530	Field Hardness as CaCO3:	NR	Ammonia (mg/L):	NR
**Sum of Diss. Constituents:	487.080	Hardness as CaCO3:	199.110	T.P. Hydrocarbons (µg/L):	NR
Field Conductivity (µmhos):	425.000	Field Alkalinity as CaCO3:	NR	PCP (µg/L):	NR
Lab Conductivity (µmhos):	536.000	Akalinity as CaCO3:	272.460	Phosphate, TD (mg/L as P):	<.05
Field pH:	7.450	Ryznar Stability Index:	7.177	Field Nitrate (mg/L):	NR
Lab pH:	7.660	Sodium Adsorption Ratio:	1.180	Field Dissolved O2 (mg/L):	NR
Water Temp (°C):	12.500	Langlier Saturation Index:	0.242	Field Chloride (mg/L):	NR
Air Temp (°C):	NR	Nitrite (mg/L as N):	<.05	Field Redox (mV):	326.000

Sample Condition: CLEAR * CHLORINATOR TURNED OFF BEFORE SAMPLING
Field Remarks: CASING WAS PULLED SPRING 2002 AND PUMP BOWLS WERE LOWERED 5 FT. TD 74 W/SCREEN INTERVAL LOWERED 5 FT TO 53-69 * STRAINER AT 72 FT.
Lab Remarks:

Notes

Comparison of Well 2 water quality with Water Quality Standards

Sample Id	GWIC Id	Sample Date	Site Name	Location	Site Type
2002Q1443	97551	6/5/2002 10:20:00 AM	TOWN OF COLUMBUS - WELL 2	02S 20E 21 CABCD	WELL

Constituent	This Sample	Drinking Water	Stock Water	Irrigation Water
Calcium (Ca)	44.300 mg/L	---	---	---
Magnesium (Mg)	21.500 mg/L	---	2,000 mg/L	---
Sodium (Na)	38.100 mg/L	250 mg/L [smcl]	2,000 mg/L	see SAR
Potassium (K)	2.140 mg/L	---	---	---
Iron (Fe)	0.015 mg/L	0.3 mg/L [smcl]	---	---
Manganese (Mn)	<.001 mg/L	0.05 mg/L [smcl]	---	2.0 mg/L
Silica (SiO2)	16.300 mg/L	---	---	---
Bicarbonate (HCO3)	332.200 mg/L	---	---	---
Carbonate (CO3)	0.000 mg/L	---	---	---
Chloride (Cl)	4.590 mg/L	250 mg/L [smcl]	1,500 mg/L	---
Sulfate (SO4)	26.500 mg/L	250 mg/L [smcl]	1,500 mg/L	[b]
Nitrate (NO3 as N)	0.751 mg/L	10 mg/L [mcl]	100 mg/L	---
Fluoride (F)	0.625 mg/L	4 mg/L [mcl]	2 mg/L	---
Ortho-Phosphate (as P)	<.05 mg/L	500 mg/L [smcl]	5,000 mg/L	2,000 mg/L [c]
Aluminum (Al)	51.000 ug/L	50-200 ug/L [smcl]	---	1,000 ug/L
Antimony (Sb)	<2 ug/L	6 ug/L [mcl]	---	---
Arsenic (As)	1.190 ug/L	10 ug/L [mcl]	50 ug/L	100 ug/L
Barium (Ba)	48.600 ug/L	2,000 ug/L [mcl]	---	---
Boron (B)	163.000 ug/L	---	---	---
Cadmium (Cd)	<2 ug/L	5 ug/L [mcl]	10 ug/L	5 ug/L
Chromium (Cr)	<2 ug/L	100 ug/L [mcl]	1,000 ug/L	100 ug/L
Cobalt (Co)	<2 ug/L	---	1,000 ug/L	50 ug/L
Copper (Cu)	<2 ug/L	1,300 ug/L [mcl]	500 ug/L	200 ug/L
Lead (Pb)	<2 ug/L	15 ug/L [mcl]	50 ug/L	5,000 ug/L
Lithium (Li)	15.900 ug/L	---	---	2,500 ug/L
Molybdenum (Mo)	<10 ug/L	---	---	5 ug/L
Nickel (Ni)	<2 ug/L	---	---	200 ug/L
Phosphate (P)	<.05 ug/L	---	---	---
Selenium (Se)	<1 ug/L	50 ug/L [mcl]	50 ug/L	20 ug/L
Silver (Ag)	<1 ug/L	100 ug/L [smcl]	---	---
Strontium (Sr)	972.000 ug/L	---	---	---
Titanium (Ti)	<1 ug/L	---	---	---
Vanadium (V)	<5 ug/L	---	---	---
Zinc (Zn)	12.200 ug/L	5,000 ug/L [smcl]	24,000 ug/L	2,000 ug/L
Zirconium (Zr)	<2 ug/L	---	---	---

Ground-Water Information Center **Isotope Tracer Report**
Site Name: TOWN OF COLUMBUS - WELL 2 - Radon Sample **Report Date:** 2/24/2004

Location Information

Sample Id/Site Id: 1996R0814 / 97551
Location (TRS): 02S 20E 21 CABCD
Latitude/Longitude: 45° 38' 41" N 109° 16' 6" W
Datum: NAD27
Altitude:
County/State: STILLWATER / MT
Site Type: WELL
Geology: 110ALVM
USGS 7.5' Quad: COLUMBUS WEST
PWS Id: 00185003
Project: PWSINV, RADON

Sample Date: 6/26/1996 1:08:00 PM
Agency/Sampler: MBMG / KHS
Field Number: COL-2
Lab Date: 6/28/1996
Lab/Analyst: MBMG / TSH
Sample Method/Handling: / 1000
Procedure Type: DISSOLVED
Total Depth (ft): 69.000
SWL-MP (ft): NR
Depth Water Enters (ft): 48.000

Radon (Rn222 - pC/L):	650.000	Argon (Ar39):	NR
Carbon (C13):	NR	Silicon (Si32):	NR
Carbon (C14):	NR	Chlorine (Cl36):	NR
Tritium (H3 - TU):	NR	Lithium (Li6):	NR
H3/He3 Ratio:	NR	Krypton (Kr85):	NR
Deuterium (H2):	NR	Boron (B11)	NR
Oxygen (O18):	NR	Strontium (Sr87)	NR
Sulphur (S34):	NR	Chloro-fluorocarbon (CFC-11):	NR
Iodine (I129):	NR	Chloro-fluorocarbon (CFC-12):	NR
Nitrogen (N15):	NR	Chloro-fluorocarbon (CFC-113):	NR

Ground-Water Information Center **Isotope Tracer Report**
Site Name: TOWN OF COLUMBUS - WELL 2 - Radon Sample **Report Date:** 2/24/2004

Location Information

Sample Id/Site Id: 1996R0813 / 97551
Location (TRS): 02S 20E 21 CABCD
Latitude/Longitude: 45° 38' 41" N 109° 16' 6" W
Datum: NAD27
Altitude:
County/State: STILLWATER / MT
Site Type: WELL
Geology: 110ALVM
USGS 7.5' Quad: COLUMBUS WEST
PWS Id: 00185003
Project: PWSINV, RADON

Sample Date: 6/26/1996 1:05:00 PM
Agency/Sampler: MBMG / KHS
Field Number: COL-1
Lab Date: 6/27/1996
Lab/Analyst: MBMG / TSH
Sample Method/Handling: / 1000
Procedure Type: DISSOLVED
Total Depth (ft): 69.000
SWL-MP (ft): NR
Depth Water Enters (ft): 48.000

Radon (Rn222 - pC/L):	660.000	Argon (Ar39):	NR
Carbon (C13):	NR	Silicon (Si32):	NR
Carbon (C14):	NR	Chlorine (Cl36):	NR
Tritium (H3 - TU):	NR	Lithium (Li6):	NR
H3/He3 Ratio:	NR	Krypton (Kr85):	NR
Deuterium (H2):	NR	Boron (B11)	NR
Oxygen (O18):	NR	Strontium (Sr87)	NR
Sulphur (S34):	NR	Chloro-fluorocarbon (CFC-11):	NR
Iodine (I129):	NR	Chloro-fluorocarbon (CFC-12):	NR
Nitrogen (N15):	NR	Chloro-fluorocarbon (CFC-113):	NR

Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
THE TOWN OF COLUMBUS - City Park Well

Plot this site on a topographic map

Location Information

GWIC Id: 197734
Location (TRS): 02S 20E 21 DDB
County (MT): STILLWATER
DNRC Water Right:
PWS Id:
Block:
Lot:
Addition:

Source of Data: LOG
Latitude (dd): 45.6408
Longitude (dd): -109.2554
Geomethod: TRS-TWN
Datum: NAD27
Altitude (feet):
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 41.00
Static Water Level (ft): 29.00
Pumping Water Level (ft): 30.20
Yield (gpm): 104.00
Test Type: PUMP
Test Duration: 8.00
Drill Stem Setting (ft):
Recovery Water Level (ft): 29.00
Recovery Time (hrs): 0.08
Well Notes:

How Drilled: ROTARY
Driller's Name: B AND H
Driller License: WWC309
Completion Date (m/d/y): 8/1/2002
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: Not Reported
Well/Water Use: IRRIGATION

Hole Diameter Information

From	To	Diameter
0.0	18.0	9.6
18.0	55.0	6.0

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-2.0	41.0	6.0	0.250			STEEL

Annular Seal Information

From	To	Description
0.0	18.0	BENTONITE

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
40.0	52.0	5.0			.70 SLOT STEEL SCREEN

Lithology Information

From	To	Description
0.0	26.0	CLAY AND TOPSOIL
26.0	31.0	SAND AND GRAVEL
31.0	41.0	BIGGER SAND AND GRAVEL
41.0	51.0	SAND AND GRAVEL
51.0	53.0	SHALE

Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
TOWN OF COLUMBUS – Inactive Well

Plot this site on a topographic map

Location Information

GWIC Id: 97553
Location (TRS): 02S 20E 21 CCA
County (MT): STILLWATER
DNRC Water Right: P022831-00
PWS Id: 00185
Block:
Lot:
Addition:
Source of Data: LOG
Latitude (dd): 45.6408
Longitude (dd): -109.2684
Geomethod: TRS-TWN
Datum: NAD27
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 62.00
Static Water Level (ft): 24.00
Pumping Water Level (ft): 25.00
Yield (gpm): 630.00
Test Type: AIR
Test Duration: 24.00
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):
Well Notes:
How Drilled: CABLE
Driller's Name: B & H
Driller License: WWC309
Completion Date (m/d/y): 1/1/1979
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: Not Reported
Well/Water Use: IRRIGATION

Hole Diameter Information

From	To	Diameter
0.0	62.0	8.0

Casing Information[1]

From	To	Dia	Description
-1.0	42.0	8.0	STEEL
52.0	62.0	7.0	PVC

Annular Seal Information

From	To	Description
0.0	3.0	PUDDLED CLAY

Completion Information[1]

From	To	Dia	Description
42.0	52.0	8.0	SCREEN

Lithology Information

From	To	Description
0.0	12.0	TOPSOIL
12.0	52.0	SAND & GRAVEL
52.0	62.0	BLUE SHALE

Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
CITY OF COLUMBUS – Inactive Well

Plot this site on a topographic map

Location Information

GWIC Id: 192363
Location (TRS): 02S 20E 22 CDD
County (MT): STILLWATER
DNRC Water Right:
PWS Id:
Block:
Lot:
Addition:
Source of Data: LOG
Latitude (dd): 45.6388
Longitude (dd): -109.2430
Geomethod: TRS-TWN
Datum: NAD27
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 31.00
Static Water Level (ft): 6.00
Pumping Water Level (ft):
Yield (gpm): 65.00
Test Type: AIR
Test Duration: 1.00
Drill Stem Setting (ft): 31.00
Recovery Water Level (ft): 6.00
Recovery Time (hrs): 0.08
Well Notes:
How Drilled: ROTARY
Driller's Name: AAQUA
Driller License: WWC542
Completion Date (m/d/y): 7/12/2001
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: Not Reported
Well/Water Use: IRRIGATION

Hole Diameter Information

From	To	Diameter
0.0	11.0	8.0
11.0	21.0	7.0
31.0	32.0	6.0

Casing Information[1]

From	To	Dia	Description
-2.0	31.0	6.0	STEEL

Annular Seal Information

From	To	Description
0.0	0.0	BENTONITE

Completion Information[1]

From	To	Dia	Description
31.0	32.0	6.0	OPEN HOLE

Lithology Information

From	To	Description
0.0	1.0	TOPSOIL TAN SOFT
1.0	17.0	CLAY TAN SOFT
17.0	31.0	GRAVEL GRAY MED

APPENDIX B - DEQ PWS's DATABASE OUTPUT

Available upon request

APPENDIX C – SANITARY SURVEY

Available upon request

APPENDIX D – CONCURRENCE LETTER AND OTHER CORRESPONDENCE

Available upon request