City of Polson's Public Water System

Source Water Delineation and Assessment Report

PWSID # MT0000308

Polson, Montana

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GLOSSARY*

Acute Health Effect. A negative health effect in which symptoms develop rapidly.

Alkalinity. The capacity of water to neutralize acids.

Aquifer. A water-bearing layer of rock or sediment that will yield water in usable quantity to a well or spring.

Barrier. A physical feature or management plan that reduces the likelihood of contamination of a water source from a potential contaminant source

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

Biennial Reporting System (BRS). An EPA database that contains information on hazardous waste sites. The data can be accessed through the EPA Envirofacts website.

Chronic Health Effect. A negative health effect in which symptoms develop over an extended period of time.

Class V Injection Well. Any pit or conduit into the subsurface for disposal of waste waters. The receiving unit for an injection well typically represents the aquifer, or water-bearing interval.

Coliform Bacteria. A general type of bacteria found in the intestinal tracts of animals and humans, and also in soils, vegetation and water. Their presence in water is used as an indicator of pollution and possible contamination by pathogens.

Community. A town, neighborhood or area where people live and prosper.

Confined Animal Feeding Operation (CAFO). Any agricultural operation that feeds animals within specific areas, not on rangeland. Certain CAFOs require permits for operation.

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 present above a confined aquifer that does not allow the flow of water, maintaining the pressure of the ground water in the aquifer. The physical properties of a confining unit may range from a five-feet thick clay layer to a shale that is hundreds of feet thick.

Comprehensive Environmental Cleanup and Responsibility Act (CECRA). Passed in 1989 by the Montana State Legislature, CECRA provides the mechanism and responsibility to clean up hazardous waste sites in Montana.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Enacted in 1980. CERCLA provides a Federal "Superfund" to clean up uncontrolled or abandoned hazardous-waste sites as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment. Through the Act, EPA was given power to seek out those parties responsible for any release and assure their cooperation in the cleanup. The Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) provides information about specific sites through the EPA Envirofacts website.

Delineation. The process of determining and mapping source water protection areas.

Geographic Information Systems (GIS). A computerized database management and mapping system that allows for analysis and presentation of geographic data.

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

Hazard. A relative measure of the potential of a contaminant from a facility or associated with a land use to reach the water source for a public water supply. The location, quantity and toxicity of significant potential contaminant sources determine hazard.

Hydraulic Conductivity. A constant number, or coefficient of proportionality, that describes the rate water can move through an aquifer material.

Hydrology. The study of water and how it flows in the ground and on the surface.

Hydrogeology. The study of geologic formations and how they affect ground water flow systems.

Inventory Region. A source water management area for ground water systems that encompasses the area expected to contribute water to a public water supply within a fixed distance or a specified three-year ground water travel time.

Leaking Underground Storage Tank (LUST). A release from a UST and/or associated piping into the subsurface.

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 to establish concentrations of contaminants in drinking water that are protective of human health.

Montana Bureau of Mines and Geology – Ground Water Information Center (MBMG/GWIC). The database of information on all wells drilled in Montana, including stratigraphic data and well construction data, when available.

Montana Pollutant Discharge Elimination System (MPDES). Database system to track entities that discharge wastewater of any type into waters of the State of Montana.

National Pollutant Discharge Elimination System (NPDES). A national database system to track entities that discharge wastewater.

Nitrate. An important plant nutrient and type of inorganic fertilizer that can be a potential contaminant in water at high concentrations. In water the major sources of nitrates are wastewater treatment effluent, 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. Nonpoint sources of pollution, such as the use of herbicides, can concentrate low levels of chemicals into surface and/or ground waters at increased levels that may exceed MCLs.

Pathogens. A microorganism 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.

Permit Compliance System (PCS). An EPA database that provides information on the status of required permits for specific activities for specific facilities. The data can be accessed through the EPA Envirofacts website.

Public Water System. A system that provides water for human consumption through at least 15 service connections or regularly serves 25 individuals.

Pumping Water Level. Water level elevation in a well when the pump is operating.

Recharge Region. A source water management region that is generally the entire area that could contribute water to an aquifer used by a public water supply. Includes areas that could contribute water over long time periods or under different water usage patterns.

Resource Conservation and Recovery Act (RCRA). Enacted by Congress in 1976. RCRA's primary goals are to protect human health and the environment from the potential hazards of waste disposal, to conserve energy and natural resources, to reduce the amount of waste generated, and to ensure that wastes are managed in an environmentally sound manner. The Resource Conservation and Recovery Information System (RCRIS) provides information about specific sites through the EPA Envirofacts website.

Secondary Maximum Contaminant Levels (SMCL). The maximum concentration of a substance in water that is recommended to be delivered to users of a public water supply, based on aesthetic qualities. SMCLs are non-enforceable guidelines for public water supplies, set by EPA under authority of the Safe Drinking Water Act. Compounds with SMCLs may occur naturally in certain areas, limiting the ability of the public water supply to treat for them.

Section Seven Tracking System (SSTS). SSTS is an automated system EPA uses to track pesticide producing establishments and the amount of pesticides they produce.

Source Water. Any surface water, spring, or ground water source that provides water to a public water supply.

Source Water Assessment Report. A report for a public water supply that delineates source water protection areas, performs an inventory of potential contaminant sources within the delineated areas, and evaluates the relative susceptibility of the source water to contamination from the potential contaminant sources under "worst-case" conditions.

Source Water Protection Areas. For surface water sources, the land and surface drainage network that contributes water to a stream or reservoir used by a public water supply. For ground water sources, the area within a fixed radius or three-year travel time from a well, and the land area where the aquifer is recharged.

Spill Response Region. A source water management area for surface water systems that encompasses the area expected to contribute water to a public water supply within a fixed distance or a specified four-hour water travel time in a stream or river.

Static Water Level (SWL). Water level elevation in a well when the pump is not operating.

Susceptibility (of a PWS). The relative 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. herbicides and 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.

Toxic Release Inventory (TRI). An EPA database that compiles information about permitted industrial releases of chemicals to air and water. Information about specific sites can be obtained through the EPA Envirofacts website.

Transmissivity. A number that describes the ability of an aquifer to transmit water. The transmissivity is determined by multiplying the hydraulic conductivity time the aquifer thickness.

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

Underground Storage Tanks (UST). A tank located at least partially underground and designed to hold gasoline or other petroleum products or chemicals, and the associated plumbing system.

Volatile Organic Compounds (VOC). Chemicals such as petroleum hydrocarbons and solvents or other organic chemicals, which evaporates readily to the atmosphere.

*** Definitions adapted from EPA's Glossary of Selected Terms and Abbreviations (http://www.epa.gov/ceisweb1/ceishome/ceisdocs/glossary/glossary.html)**

INTRODUCTION

This Source Water Delineation and Assessment Report (SWDAR) was completed by Roger A. Noble, Sr. Hydrogeologist, of Land and Water Consulting (LWC) under contract to the City of Polson (PWSID #00308) located in Lake County, Montana. This SWDAR was completed with assistance from Mr. John Campbell, Polson Water Superintendent and staff members Tony Prazzo and Travis Dolphin (see Table 1); Becky Dupuis, P.E., Osprey Environmental Consulting; and Scott Mason of LWC.

Table 1.
Contacts for the City of Polson Municipal Water Supply

Name and Title	Telephone	Address
John Campbell, Superintendent	406-883-8201	Polson Water Department PO Box 238 106 1st Street East Polson, MT 59860-0238
Tony Porrazzo, Certified Operator # 4988	406-883-8215	See above
Travis Dolphin, Certified Operator # 4089	406-883-2131	See above

This report is intended to meet the technical requirements for the completion of the delineation and assessment report for City of Polson (PWSID # 00308) as required by the Montana Source Water Protection Program (MSWPP), Department of Environmental Quality (DEQ) Circular PWS-6, and the federal Safe Drinking Water Act (SDWA).

The MSWPP is intended to be a practical and cost-effective approach to protecting public drinking water supplies from contamination. A major component of the MSWPP is termed delineation and assessment. The emphasis of this delineation and assessment report is identifying significant potential contaminant threats to public drinking water sources and providing the information needed to further develop the source water protection plan for the City of Polson.

Delineation is a process whereby areas that contribute water to aquifers or surface waters used for drinking water, called source water protection areas, are identified on a map. Geologic and hydrologic conditions are evaluated in order to delineate source water protection areas. Assessment involves identifying locations or regions in source water protection areas where contaminants may be generated, stored, or transported and then determining the potential for contamination of drinking water by these sources.

Delineation and assessment is the foundation of source water protection plans, the mechanism City of Polson uses to protect their drinking water source. Although voluntary, source water protection plans are the ultimate focus of source water delineation and assessment. In 1994, the City of Polson enacted zoning and ordinances establishing Wellhead Protection Zones and limiting or regulating activities within the Protection Zones. Since 1994, the Polson Municipal Water Supply has shifted away from the use of surface water supplies toward reliance on groundwater supplies. This delineation and assessment report is written to facilitate updating of the City of Polson Wellhead Protection Zones.

BACKGROUND

The Community

The City of Polson, population 4,316, is a recreational and retirement community located at the southern end of Flathead Lake. Figure 1 is a general location map displaying local geographic features. Polson is the county seat of Lake County. The City serves as a local center for small manufacturing and agriculture in the surrounding 30-mile radius. Highway 93, the primary transportation route between Kalispell and Missoula, passes through Polson. Kerr Dam, a hydropower generating facility, is located approximately five miles southeast of Polson on the Lower Flathead River. The Flathead Indian Reservation encompasses much of Lake County and includes an area of about 1,950 square miles. The Confederated Salish and Kootenai Tribal (CSKT) Headquarters are located in Pablo, Montana.

Residents within the city limits of Polson have a public water supply (PWS) and community sewage collection and treatment system that serves the majority of the population. The public water supply provides potable water from a system of seven wells and associated storage and distribution systems (see Figure 2). The community sewage system, located on the western edge of town near the Flathead River, provides treatment of sewage with aerated lagoons. Treated sewage water is disposed by discharge to the Flathead River (MPDES Permit No. MT0030228). Septic systems are used outside of the city limits of Polson.

Geographic Setting

Polson is located at the base of a terminal moraine (Polson Moraine) that forms the prominent hill just south of Flathead Lake and Polson. Polson has been built on a north-facing slope that ranges in elevation between 2,900 and 3,000 feet above mean sea level (amsl). The Polson Moraine is an east-west elongated glacial feature formed at the end of the Pleistocene Glacial Epoch by the receding valley glacier. The Flathead River and its tributaries drain the entire area (USGS hydrologic unit code 17010208). The Flathead

River flows from the south end of Flathead Lake at Polson along the west side of the Mission Valley until its confluence with the Clark Fork River. Pablo Reservoir/Pablo National Wildlife Refuge, a lake with wetlands providing habitat for birds, is located approximately two miles south of Polson. Several irrigation canals are present within, and south of, Polson.

Mean annual precipitation in the valley generally ranges from 11 to 16 inches, whereas the annual precipitation in the Mission Mountains, which forms the eastern boundary of the Flathead Valley, is almost 100 inches. Most of the precipitation in the mountains occurs as snow with about 50 percent of the precipitation in the valley occurring as rain. The mean annual temperature in the valley is 45º F, but the temperature at the higher altitudes is much cooler as indicated by the presence of glaciers and permanent snowfields.

General Description of the Source Water

Source water for the City of Polson Municipal Water Supply is groundwater from seven wells. Locations of the wells are shown on Figure 2. Wells No. 1 through 5 derive groundwater from a confined unconsolidated to semi-consolidated valley-fill aquifer, whereas Wells No. 6 and 7 obtain water from a confined bedrock aquifer. Copies of driller's logs for the Municipal Wells and other wells in the vicinity are included in Appendix A.

Wells No. 1 through 5 are constructed within materials that comprise the Polson Moraine, on the east side of Polson. The aquifer utilized by Wells No. 1, 2, 3, 4, and 5 consists of permeable layers of moderately to well sorted gravel and sand with varying amounts of silt and very little clay. Portions of the aquifer are consolidated (e.g., sediments are cemented together resulting in hard, "rock-like" material). On the surface and interbedded with the permeable layers are poorly sorted gravels, sands, silts and clays that are relatively impermeable and act as confining units. Pumping tests on wells in the area demonstrate that the aquifer responds as a confined aquifer. Groundwater flow within the aquifer is to the north, toward Flathead Lake, and the aquifer is not hydraulically connected to the lake in the vicinity of the wells.

The City of Polson's Wells No. 6 and 7 obtain water from a bedrock aquifer on the west side of Polson and west of the Flathead River. The aquifer is composed of fractured argillite and siltite, overlain by glacial and lacustrine (lake sediments) units. Groundwater flow direction in the bedrock aquifer is from the west to east, towards Flathead Lake and the Flathead River. The aquifer thickness is at least 363 feet and occurs under confined conditions.

The Public Water Supply

The City of Polson’s water distribution system serves a population of 4,316 and has approximately 1,890 connections. Polson is entirely reliant on groundwater from seven wells for their water supply. The water distribution system consists of three zones: lower, middle, and upper. Water is stored in six reservoirs, with plans for additional reservoirs to serve the area west of the Flathead River. The May 2000 Sanitary Survey Inspection of the Polson Public Water System, conducted by the DEQ, describes the system in more detail and is included in Appendix B.

Municipal Well No. 1 is located at the Golf Course on the eastern edge of town. This 12-inch diameter well was constructed in 1969 at a total depth of 525 feet and was formerly rated at 450 gallons per minute (gpm) (TDH, 1989). However, in 1999 the well started pumping mud and was taken out of service. The City intends to maintain Well No. 1 as a backup and routine use of the well is not anticipated. The well is currently rated at 100 gpm.

Municipal Wells No. 2 and 3 are located in the old Claffey gravel pit on the south side of Polson, adjacent to Reservoir 1960 and the middle zone booster station. Well No. 2, the oldest well in the water supply, was constructed in 1960. The well is 14 inches in diameter, has a total depth of 165 feet, and has a reported pumping capacity of approximately 650 gpm (TDH, 1989). Average production from the well is 457 gpm (MDEQ, 2000). Well No. 3 was constructed in 1976, is 16 inches in diameter, is completed at a total depth of 200 feet, and is rated at 575 gpm (MDEQ, 2000). Both wells No. 2 and 3 are treated by chlorine injection at the wellhead and pump directly into Reservoir 1960 (500,000-gallon capacity). The middle zone booster station pumps from Reservoir 1960 to Reservoir 1977 (500,000-gallon capacity) to serve the upper zone.

Municipal Wells No. 4 and 5 are located in a semi-rural/residential area of the City adjacent to the Hillcrest Reservoirs (aka Reservoirs 1920) and were constructed in 2000. Both Wells No. 4 and 5 are 10 inches in diameter with total depths of 150 and 135 feet, respectively. Both wells have pumping capacities of 250 gpm each. Both reservoirs have a storage capacity of 125,000 gallons. Disinfection is provided through the injection of sodium hypochlorite at the wellheads. The reservoirs and wells are located in the lower distribution zone. Both wells are connected to the lower booster station that is capable of either supplying the Hillcrest Reservoirs or pumping into the middle distribution zone. Two additional 500,000-gallon storage facilities, Reservoirs 1992-1 and 1992-2, serve the middle zone.

Municipal Wells No. 6 (constructed in 1999) and No. 7 (constructed in 2001) are located in a rural area on the west side of Flathead Lake and the Flathead River, immediately west of the airport. Pumping-test analyses indicate the aquifer is capable of producing in excess of 600 gpm. These wells pump to the West Shore Reservoir (one million gallons), which is located approximately 600 feet west of Well No. 6.

Water Quality

Every PWS is required to perform monitoring for contamination to their water supply. The monitoring constituents include coliforms and other signs of pathogenic organism, nitrates, metals and for multiple chemicals. The monitoring schedule depends on many factors such as the size and source water for a PWS, the number of sources (e.g. wells), and the population served. Each PWS has a specific monitoring program tailored to their system that follows the general protocols for operation of a PWS defined by the DEQ. In addition, water quality for the area is available from the Montana Bureau of Mines and Geology (MBMG) and the United States Geologic Survey (USGS). The quality of the groundwater source for the Polson PWS wells is generally good and meets or is better than State and Federal Drinking Water Standards

Prior to the mid-1980s, Polson relied primarily on surface water from Hell Roaring Creek for the public water supply. During this period groundwater was used primarily during periods of unusually cold weather or high turbidity in Hell Roaring Creek. Discoveries of *Giardia lamblia* cysts in the Hell Roaring Creek supply in 1985 led to temporary abandonment of the supply. After engineering evaluations and consideration of available options the City of Polson began developing additional groundwater supplies to replace the surface water system. This shift to groundwater for the Polson PWS appears to have eliminated the coliform problem. A search of the DEQ files in Kalispell revealed no drinking water quality standard violations on record for the Polson PWS in the last five years. A search of the Environmental Protection Agency (EPA) Safe Drinking Water Information System online database revealed that the most recent violation for the Polson system was for coliform bacteria in April 1995.

Well No. 1 was sampled and analyzed for general inorganic chemical parameters by USGS in 1984 and 1975. Results of these analyses (Appendix C) indicate that groundwater from Well No. 1 is hard to very hard calcium-bicarbonate type water containing low levels of nitrate (0.16 to 1.45 ppm) and metals. In December 2000, a water sample from the well was analyzed and found to be free of Gross Alpha emitters (<1 pCi/L).

Wells No. 2 and 3 were sampled and analyzed for general inorganic chemical parameters by USGS and MBMG in 1983 and 1975, respectively. Groundwater in both of these wells is hard to very hard calcium-bicarbonate type water. In February 2001 samples from Wells No. 2 and 3 were collected and submitted for laboratory analyses for Phase II/V analytes. In general, the water is of excellent quality. No volatile, semi-volatile, pesticides, or herbicides were detected in the sample collected from the wells. A copy of the laboratory report for the wells is provided in Appendix C.

Water-quality samples were collected from Municipal Wells No. 4 and 5 in February and March, 2001, respectively. The samples were submitted for laboratory analyses for Phase II/V analytes. In addition, the sample from the test well was analyzed for major anions, cations, and a suite of trace metals. In general, the water is of excellent quality. It is characterized as a calcium-bicarbonate type that has relatively low dissolved solids content of approximately 150 ppm (the recommended limit is 500 ppm). No volatile, semi-volatile, pesticides, or herbicides were detected in the two samples from the production wells. Copies of the laboratory reports for both wells are provided in Appendix C.

Water-quality samples were collected from well No. 6 in January 2000. The samples were submitted for laboratory analyses for Phase II/V analytes. In general, the water is of excellent quality. No volatile, semi-volatile, pesticides, herbicides or metals, except for total iron (1.27 ppm) were detected in the sample collected from the production well. A copy of the laboratory report for the well is provided in Appendix C.

Water-quality samples were collected from well No. 7 in May 2001. The samples were submitted for laboratory analyses for Phase II/V analytes. In general, the water is of excellent quality. No volatile, semi-volatile, pesticides, herbicides or metals, except for total barium (0.1 ppm) and total iron (0.04 ppm) were detected in the sample collected from Well No. 7. A copy of the laboratory report for the well is provided in Appendix C.

DELINEATION

The source water protection area, the land area that contributes water to the City of Polson Public Water System, is identified in this chapter. Three management areas are identified within the source water protection area. These three regions are the control zone, inventory region, and recharge region. The control zone, also known as the exclusion zone, is an area at least 100-foot radius around the well. The inventory region represents the zone of contribution of the well, which approximates a three-year groundwater time-of-travel. Analytical equations describing ground water flow (based on estimates of pumping and aquifer characteristics and simple hydrogeologic mapping) are used to calculate groundwater time-of-travel distance. The recharge region represents the entire portion of the aquifer, which contributes water to the City of Polson Public Water System. The City of Polson has enacted zoning and ordinances establishing Wellhead Protection Zones and limiting or regulating activities within the Protection Zones.

Hydrogeologic conditions are markedly different between the area east of the Flathead River (Wells No. 1, 2, 3, 4, and 5) and the area west of the Flathead River (Wells No. 6 and 7). The area east of the river is predominately unconsolidated to semi-consolidated valley-fill deposits (sand and gravel with varying amounts of silt and clay, cemented or lithified in places) whereas the area west of the river consists of a fractured bedrock aquifer that is overlain by a thin layer of lake deposits (varved clay and silt). Because of the differences between the areas, hydrogeologic conditions and delineation of source water protection zones for the eastern and western areas are discussed separately in this report.

A summary of the published and unpublished sources of information were used in this assessment and are presented in Tables 2 and 3.

Table 2
Geologic and Hydrogeological Investigations in the Area

Title of Project	Period of Project	Area Covered	Project Purpose
Geohydrology of the Flathead Indian Reservation, Northwestern Montana, USGS WRI Report 88-4142 by Steven Slagle (Slagle, 1988)	1983 and 1984	Flathead Indian Reservation and adjacent areas	Hydrogeologic Characterization
Statewide Hydrogeologic Characterization of Flathead and Lake Counties, MBMG, (LaFave and Others, in progress)	in progress	Flathead and Lake Counties	Hydrogeologic Characterization
Polson Wellhead Protection Plan Final (Shannon Environmental Services, 1994)	1993-1994	Polson Water Supply and Surrounding Area	Wellhead Protection
Annual Progress Report for P104016-76L – Westshore Well, Land & Water Consulting, November 1999	1999	Municipal Well No. 6	Hydrogeologic Characterization, Aquifer Testing
Source Water Delineation Assessment Report for Pablo-Lake County Water and Sewer District, Pablo Public Water Supply (MDEQ, 2000)	2000	Pablo Water Supply and Surrounding Area	Source Water Delineation and Assessment

Table 3 List of Geologic or Hydrogeologic Maps Available for the Area			
Title or Description	**Date**	**Area Covered**	**Reference**
Geologic and Structure Maps of the Wallace 1° x 2° Quadrangle, Montana, USGS Map I-1509-A by	1986	Mission Valley and adjacent areas south and west	Harrison and Others (1986)
Statewide Hydrogeologic Characterization of Flathead and Lake Counties, MBMG, in progress.	In Progress	Flathead and Lake Counties	LaFave and Others (in progress)

Hydrogeologic Conditions in the Valley-Fill Aquifer East of Flathead River

The aquifer material for the Polson PWS wells east of the Flathead River is interpreted to be comprised of glaciofluvial/lacustrine sands and gravel that are overlain and interbedded with clay-rich glacial tills and lacustrine silts and clays. The USGS geologic map of the area (Harrison and Others, 1986) indicates that Quaternary glacial and lacustrine deposits cover the majority of the Mission Valley including the Polson area (see Figure 3). These deposits include till (ground and end moraines), outwash and other fluvioglacial deposits, and lake sediments from Glacial Lake Missoula. As shown on Figure 3, Harrison and Others (1986) considered surficial deposits in the area of the PWS wells immediately south of Flathead Lake to be primarily lacustrine deposits consisting of varved clay and silt containing a few gravel lenses and scattered dropstones. This area of lacustrine deposits approximately corresponds to the northsloping portion of the Polson Moraine.

A similar geologic interpretation is provided by Slagle (1988), however Slagle used a slightly different terminology and differentiates glacial moraines from other glacial deposits. As shown on Figure 4, Slagle defined the majority of the Mission Valley and the area immediately south of Flathead Lake and east of the Flathead River as Quaternary valley-fill deposits. Slagle states that these valley-fill deposits in the Mission Valley reflect a complicated history of several glacial advances followed by inundation of the area by glacial Lake Missoula. It appears that Slagle’s "valley-fill deposits" are essentially the same as Harrison and others "glacial" deposits.

The area immediately south of Flathead Lake in the area of the PWS wells is mapped as lacustrine deposits by Harrison and Others. Although Slagle does not designate this area as lacustrine, his discussion of the area clearly indicates his agreement with this interpretation. According to Slagle (1988), the presence of a relatively high percentage (estimated 20 percent of total thickness) of sorted sand and gravel in this area is indicative of reworking of glacial till or lacustrine sands and deposition in shallow standing water. These layers of sorted sand, silt, and gravel comprise the aquifer in this area. On the surface of the area and at depth interbedded with the permeable sand and gravel layers are poorly sorted sand and gravel layers that are more typical of glacial till. These poorly sorted sand and gravel layers contain sufficient clay and silt to impede groundwater flow. Given the mode of deposition of these valley-fill sediments and the poor correlation of the sorted sands and gravels between wells in the area, it is not believed that the sorted layers are laterally extensive or continuous.

Immediately to the south of the City of Polson, Slagle indicates the presence of a geologic contact between the valley-fill deposits to the north and the Polson Moraine to the south (see Figure 4). Slagle's distinction between the Moraine and other glacial-derived sediments appears to be partly based on landform type and partly based on hydrogeological characteristics. The Polson Moraine is more poorly sorted, contains more clay and silt as typical of glacial till, and in general is a poorer aquifer. The few water wells completed in this area yield small amounts of often-turbid water (see well logs in Appendix A). The permeable sand and gravel layers present in the valley-fill aquifer are not believed to extend laterally into the Polson Moraine to any great extent.

Aquifer tests of the Polson PWS wells indicate type curves and very low storativity values that are considered to be representative of a confined aquifer response. Similar confined conditions have been noted in the aquifer further to the south in the Pablo area (MDEQ, 2000). Several potentiometric surface maps have been prepared by various researchers, including the USGS (Slagle, 1988) and the MBMG (see Figures 5 and 6, respectively), all of which depict the same findings. The aquifer is manifest as a single potentiometric surface representing a single valley-fill aquifer. Both maps suggest a lower transmissivity area, evident by more closely spaced potentiometric lines between Polson and Pablo Reservoir to the south. MBMG places this lower transmissivity area one-half to one mile south of Polson, approximately along the southern edge of the Polson Moraine as mapped by Slagle (1988). The presence of this lower transmissivity area is in agreement with conclusions that the Polson Moraine is more poorly sorted than the valley-fill deposits to the north and that the sorted sands and gravel in the valley-fill deposits likely do not significantly extend into the morainal deposits.

The groundwater flow direction in the vicinity of the south shore of Flathead Lake is generally from south to north, with groundwater discharging to Flathead Lake. Hence, the aquifer in the vicinity of the well sites does not receive water from Flathead Lake or Flathead River at the well sites. Potentiometric maps prepared by Shannon (1994) and Boettcher (1982) reflect similar conditions. In the vicinity of Well No. 1, groundwater flow has a northwesterly component. Kennett and Curry (1981) report that groundwater levels in the Polson area fluctuate by as much as 10 to 12 feet annually. However, water level fluctuations are not believed to significantly effect groundwater flow directions.

In addition to Flathead Lake and Flathead River, other important surface water features in the area are Pablo Reservoir located approximately two miles due south of Polson, the Pablo Feeder Canal which is located approximately one mile south of Polson, and the B and C irrigation canals which pass through the city limits of Polson.

Slagle (1988) concludes that recharge to aquifers in the Mission Valley is derived from rainfall and snowmelt in the Mission Mountains and in the valley. Recharge water enters the groundwater system by direct infiltration by leakage from streams and irrigation canals, and by irrigation return flows.

Based on the aforementioned hydrogeologic information, Wells No. 1, 2, 3, 4, and 5 are considered to have a Low Source Water Sensitivity as categorized using the table below. The wells are completed in confined valley-fill sediments that are semi-consolidated (i.e., well logs indicate cementation of sediments).

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)

Conceptual Model and Assumptions for the Valley-Fill Aquifer

A conceptual hydrogeologic model is a simplified representation of the hydrogeologic system. The conceptual hydrogeologic model for the area east of the Flathead River is shown in Figure 7. Groundwater occurs in a moderately sorted, permeable valley-fill or glacio/fluvial/lacustrine aquifer that is overlain and interbedded with poorly sorted, low permeability, glaciofluvial layers. These low permeability layers likely impede or limit direct surface infiltration of rain or snowmelt to the aquifer. The lateral extent of the aquifer is limited by Flathead Lake to the north. Groundwater flow direction is from the south to the north toward Flathead Lake. Recharge to the aquifer likely comes from surface infiltration of rain and snowmelt particularly around the valley margins in the foothills of the Mission Mountains and groundwater interflow from upgradient glacial moraine sediments. Water flows from the recharge area vertically downwards to the aquifer beds, then horizontally towards the central part of the Mission Valley beneath the thick clay-rich tills. Groundwater discharge occurs by discharge to Flathead Lake and Flathead River, and by groundwater withdrawal from wells.

Hydrogeologic Conditions in the Bedrock Aquifer West of Flathead River

As shown on Figure 3, surficial deposits near Wells No. 6 and 7 (west of Flathead Lake and the Flathead River) are geologically mapped as Quaternary lake deposits consisting of varved clay and silt. To the west of the PWS wells the surficial deposits consist of Quaternary glacial, fluvioglacial and flood deposits (poorly sorted clay, silt, sand and gravel). As can be seen on the drilling log in Appendix A, the lake deposits at Well No. 6 are approximately 22 feet thick. Underlying the lake deposits is the Middle Proterozoic Spokane Formation consisting of three lithologic units totaling 3,000 feet in thickness (Harrison and others, 1986). The Spokane Formation is composed predominantly of purple to green argillite and siltite and makes up the bedrock aquifer. Recharge to the bedrock aquifers occurs from infiltration of snowmelt and rainfall in the hills to the west, where the bedrock is exposed.

Driller's logs and aquifer test results indicate that the bedrock aquifer is a confined aquifer. In Well No. 6, water was encountered in a fracture at 265 feet below ground surface (bgs) and the static water level in the well rose to approximately 65 feet bgs, indicating artesian conditions in the aquifer. In addition, the results of the aquifer-test analyses, conducted on Well No. 6, indicate storativity values representative of a confined aquifer.

Two different potentiometric surface maps have been prepared by separate researchers, the USGS and the MBMG, both of which depict the same findings (see Figures 5 and 6, respectively). The groundwater flow direction in the vicinity of the west shore of Flathead Lake is generally from the west to the east. The bedrock aquifer is not hydrologically connected to surface water.

Because Wells No. 6 and No. 7 are completed in a relatively deep, confined, fractured bedrock aquifer they are considered to have a Low Source Water Sensitivity as categorized using the table below.

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)

Conceptual Model and Assumptions - Bedrock Aquifer West of Flathead River

The conceptual hydrogeological model for the bedrock aquifer is shown in Figure 8. Groundwater occurs at depth within fractures in argillite and siltite bedrock. The bedrock aquifer is overlain by low permeability clay and silt deposits. Groundwater flow in the bedrock is from west to east, from areas of higher elevation toward Flathead Lake. Groundwater recharge occurs primarily where bedrock is exposed at the surface, at higher elevations to the west of the wells. No information is available regarding seasonality in groundwater flows. However, given the hydrogeologic setting and the depth of the wells it is unlikely that water table elevations or flow directions vary appreciably from season to season.

Well Information

A summary of well construction and testing specifications is presented in Table 4. Copies of the Well Driller's Logs are contained in Appendix A. The wells completed in the valley fill aquifer (Wells No. 1 through 5) are cased with steel casing to the total depth of the well (Wells No. 2 through 5) or to bedrock (Well No. 1). Perforations in the casing are provided by slots cut in the steel casing (Well No. 1) or through the use of manufactured steel screens (Well Nos. 2, 3, 4 and 5). The lower portion of Well No. 1 is open hole in bedrock. No information regarding seals or grouting is available for Wells

No. 1 and 2. In Well No. 3 a 24-inch borehole was drilled to a depth of 12 feet in order to provide an annulus around the 16-inch surface casing. This annulus was filled with cement grout in order to provide a sanitary surface seal. In Wells No. 4 and 5, 14-inch boreholes were drilled to depths of 60 and 42 feet bgs, respectively, and the annulus around the 10-inch casing was filled with cement grout to form a sanitary seal.

The bedrock Well No. 6 was drilled with 14.75-inch diameter borehole from surface to 22 feet bgs, 12-inch diameter borehole from 22 to 260 feet bgs, and 8-inch borehole from 260 feet bgs to total depth of the well at 385 feet bgs. The well is cased with 8-inch steel casing to 258 feet bgs and is open hole to total depth of the well. Sanitary surface seal is provided by cement grout within the annular space to a depth of 165 feet bgs. Bedrock Well No. 7 was drilled with 17.25-inch diameter borehole from surface to 40 feet bgs; 14.25-inch diameter borehole from 40 to 239 feet bgs, and 10-inch borehole from 239 to 350 feet bgs (total depth). The well is cased with 10-inch steel casing to 239 feet bgs. Sanitary surface seal is provided by cement grout within the annular space to a depth of 100 feet bgs. A gravel pack was placed in the annular space from 100 to 239 feet bgs.

Table 4
Source Well Information for City of Polson Public Water System (#00308)
Valley-Fill Aquifer Wells

Information	Well No. 1	Well No. 2	Well No. 3	Well No. 4	Well No. 5
PWS Source Code	004	003	005	006	007
Well Location (T, R, Sec or lat, long)	SE¼NW¼SW¼ of Section 2, T22N R20W	NE¼SW¼SW¼ of Section 10, T22N R20W	NE¼SW¼SW¼ of Section 10, T22N R20W	NE¼NW¼NE¼ of Section 10, T22N R20W	NE¼NW¼NE¼ of Section 10, T22N R20W
MBMG #	76955	76956	76957	NA	NA
Water Right #	214453-76LJ	148956-76LJ	148956-76LJ	099791-76LJ	099791-76LJ

Date Well was Completed	May 1969	May 1960	December 1976	April 5, 2000	March 6, 2000
Total Depth (feet)	525	166	177	150	135
Perforated Interval (feet)	251 to 262 287 to 292 open hole 490 to 525	150 to 160	152 to 164.66	128 to 140	113 to 125
Static Water Level (feet)	56	126	99	81	80
Pumping Water Level (feet)	Unknown	125.8	Unknown	102.8	94
Drawdown (feet)	Unknown	0.25	Unknown	21.8	14
Test Pumping Rate (gpm)	380	1000	1400	300	250
Specific Capacity (gpm/foot)	14	4000	Unknown	13.8	17.8

Table 4. Source Well Information for City of Polson Public Water System (#00308) – continued Westshore Bedrock Wells.		
Information	**Well No. 6**	**Well No. 7**
PWS Source Code	008	Not yet assigned
Well Location (T, R, Sec or lat, long)	NE¼NE¼SW¼ of Sec. 5, T22N, R20W	NW¼NW¼SE¼ of Sec. 5, T22N, R20W
MBMG #	NA	NA
Water Right #	104016-76LJ	104016-76LJ
Date Well was Completed	October 1999	May 2, 2001
Total Depth (feet)	385	350
Perforated Interval (feet)	Open Hole 258 to 385	Open Hole 239 to 350
Static Water Level (feet)	64.5	51
Pumping Water Level (feet)	107.3	103.5
Drawdown (feet)	42.8	52.5
Test Pumping Rate (gpm)	600	400
Specific Capacity (gpm/foot)	14.02	7.6

Methods and Criteria

Source water protection areas are divided into zones or regions according to the amount of time water takes to reach the water supply intake. Intakes for the Polson water supply are the water supply wells. Source water protection areas for groundwater-based systems, in order of increasing size and time of travel to intakes are the control zone, inventory region, and recharge region. The methods and criteria used to delineate the source water protection zones for the Polson water system are specified in the DEQ's SWPP (DEQ, 1999). For the Polson system, the criteria for confined systems were followed for all wells including those completed in the valley-fill aquifer (Well Nos. 1, 2, 3, 4, and 5) and those completed in bedrock (Wells No. 6 and 7).

For all wells, the control zone is based on a fixed distance of 100 feet radius from each well; the inventory region is based on a modified fixed radius of 1,000 feet, and the recharge region is based on geologic mapping and locations of hydrologic boundaries. In general, the fixed radius of 1,000 feet for the inventory was modified by 1) reducing the radius of the control zone downgradient of the well to approximate the time-of-travel null distance; 2) expanding the radius of the control zone upgradient of the well to yield a pie-shaped control zone; and 3) modifying the radius to correspond with geographic boundaries (e.g., adjacent roads). The null distance is defined as the maximum distance downgradient from which the well may capture groundwater.

The analytical method used to calculate groundwater time-of-travel is the Uniform Groundwater Flow Equation described in Appendix H of the SWPP (DEQ, 1999). Copies of the uniform flow equation time-of-travel calculations are in Appendix D and are summarized in Table 5. For the Polson PWS system, the primary consideration in calculating and interpreting time-of-travel estimates is the heterogeneity of the groundwater system. Overall, the geologic units in which the Polson PWS wells are completed (argillite bedrock and glacial deposits) are poor aquifers as they often yield little water. However, the Polson wells are completed in specific zones within these geologic units (fractured zones and sand and gravel layers) that yield large amounts of water. Time-of-travel distances in this delineation are based on the aquifer properties in the vicinity of the Polson wells and therefore are likely overestimates of actual time-of-travel distances. In some cases (Wells No. 2, 3, 4, and 5), the calculated three-year time-of-travel zones exceed the extent of the aquifer. In spite of these limitations, time-of-travel estimates provide useful information for delineation of potential source areas for the wells.

Aquifer Properties

Aquifer properties used to delineate the inventory region are based on site-specific information derived from Well Drilling Logs, hydrogeologic maps, aquifer pumping tests and other physical measurements made on the wells. A summary of the hydrogeologic characteristics for the municipal wells is presented in Table 5.

Table 5 Estimates of Aquifer Properties and Pumping Demand Valley Fill Aquifer Wells					
Input Parameter	**Well #1**	**Well #2**	**Well #3**	**Well #4**	**Well No. 5**
PWS Source Code	004	003	005	006	007
Transmissivity (ft^2/day)	3,400	20,000	20,000	3,700	4,760
Thickness (ft)	50	16	42	16	26
Hydraulic Conductivity (ft/day)	68	1,250	476	308	397
Hydraulic Gradient	0.006	0.01	0.01	0.01	0.01
Flow Direction	Southeast to Northwest	South to North	South to North	South to North	South to North
Effective Porosity	0.3	0.25	0.25	0.25	0.25
Pumping Rate (gpm)	100	480	560	220	200
1-Year TOT*	770	18,800	7,350	5,000	6,100
3-Year TOT*	1880	55,500	21,350	14,150	17,750

Table 5 Estimates of Aquifer Properties and Pumping Demand - Continued. Confined Bedrock Aquifer Wells		
Input Parameter	**Well #6**	**Well #7**
PWS Source Code	Not yet assigned	Not yet assigned
Transmissivity (ft^2/day)	4000	4600
Thickness (ft)	127	115
Hydraulic Conductivity (ft/day)	31.5	40
Hydraulic Gradient	0.01	0.01
Flow Direction	West to East	West to East
Effective Porosity	0.20	0.20
Pumping Rate (gpm)	600	400
1-Year TOT	1,151 ft.	1,223 ft.
3-Year TOT	2,598 ft.	2,910 ft.

Aquifer Properties and Model Input Values – Valley Fill Aquifer

Hydraulic gradients for all wells were calculated from the potentiometric maps of Slagle (1988) and MBMG (in progress) presented as Figures 5 and 6 in this report. Both maps indicate identical regional gradients of approximately 100 feet in 11,400 feet, or 0.0088. Because local gradients may vary from this regional gradient, a slightly higher gradient of 0.01 was assumed for all wells except Well No. 1 to yield conservative time-of-travel estimates. The MBMG map indicates a flatter gradient of approximately 0.006 closer to Flathead Lake and this gradient was chosen for Well No. 1, the closest well to the lake. Use of this flatter gradient for Well No. 1 is appropriate since it is likely that gradients flatten as the discharge point, Flathead Lake, is approached. The flatter gradient is also conservative in that it results in a larger calculated null distance in the analytical model and therefore a greater likelihood that the protection zone would extend to Flathead Lake.

Effective porosity values were estimated based on literature values (Freeze and Cherry, 1979) for sand and gravel. A slightly higher porosity values was assumed for Well No. 1 to account for finer grain size and lower hydraulic conductivity value in the well.

Numerous pumping tests have been conducted to estimate the hydraulic properties of the valley fill aquifer. Boettcher (1982) reported a transmissivity value for Well No. 1 of 3,400 ft^2/day. Assuming a thickness of 50 feet, equivalent to the sum of the perforated interval and open-hole length of the well, yields a calculated hydraulic conductivity of 68 feet/day.

Numerous investigators have conducted pumping tests on Wells Nos. 2 and 3. Because the wells are in close proximity, they are discussed together. Shannon (1994) summarizes prior test results as follows:

- Newman and Spratt (1980) report that Morrison-Maierle, Inc. performed a pumping test on Well No. 3 in 1976 and calculated a transmissivity of 17,380 ft^2/day.

- Newman and Spratt (1980) recalculated the data from the 1976 test and determined transmissivity values of 24,000 to 28,500 ft^2/day.

- Newman and Spratt (1980) conducted pumping tests of Wells No. 2 and 3. Calculated transmissivity for No. 2 was 72,000 +/- 10,000 ft^2/day, although this value is questionable as Newman and Spratt deem the test inconclusive. Calculated transmissivity for Well No. 3 ranged from 19,600 to 25,400 ft^2/day.

- Shannon Environmental conducted a pumping test of the Polson Ready Mix Well as an alternate to the municipal wells, since the municipal wells could not be tested at that time. Shannon reported transmissivity values to range from 29,000 to 62,000 ft^2/day.

In November 2001 LWC conducted a pumping test of Well No. 3 using Well No. 2 as an observation well. Based on this test, transmissivities were estimated to range from 21,000 to 46,000 ft^2/day. All of these tests are in general agreement and indicate a fairly transmissive aquifer. In all of these tests, approximately 20,000 ft^2/day is the most commonly calculated transmissivity value; therefore this value was assumed for both wells No. 2 and 3. Thickness of the aquifer was estimated based on driller's logs and assumed to be equal to the thickness of the sand and gravel layer in which the wells are screened. This approach yields a higher calculated hydraulic conductivity for Well No. 2, which is consistent with the driller's observation of clean sand and gravel in the well.

The best estimates of storativity for the aquifer come from the numerous pumping tests of Wells No. 2 and 3 and range from 0.0008 to 2 x 10^{-9}. These values are low to very low and are consistent with the interpretation that the aquifer is confined. Shannon reports similarly low values of 0.00002 to 0.00005 for the Polson Ready Mix Well. Freeze and Cherry (1979) report that storativities for confined aquifers range from 0.005 to 0.00005 whereas unconfined aquifers have much higher values usually in the range of 0.01 to 0.3.

Well No. 4 and 5 are approximately 150 feet apart and therefore will be discussed together. Twenty-four hour constant-rate pumping tests were conducted on Well No. 4 (300 gpm) on December 2, 1999 and on March 30, 2000 on Well No. 5 (250 gpm) by LWC (2000). Results of these tests indicate lower transmissivities and hydraulic conductivities in these wells compared to Wells No. 2 and 3. Thickness of the aquifer was estimated based on driller's logs and assumed to be equal to the thickness of the sand and gravel layer in which the wells are screened. The screened interval (12 feet) was used to calculate the hydraulic conductivity and varies from the actual aquifer thickness.

Aquifer Properties and Model Input Values – Bedrock Aquifer and Wells

Hydraulic parameters for Wells No. 6 and 7 are based on results of pumping tests conducted by LWC. A step-drawdown test was initially conducted on Well No. 6 on November 1, 1999 and a 24-hour constant-rate (600 gpm) pumping test was conducted the following day. Results of both tests are detailed in LWC (1999). A 24-hour constant-rate (400 gpm) pumping test of Well No. 7 was conducted on May 19 and 20, 2001.

Pumping test results indicate a slightly higher transmissivity in Well No. 7 than No. 6. Aquifer thickness was assumed to approximately equal the length of the open-hole portion of the well. This assumed thickness is a little less than the thickness of fractured portion of the bedrock noted in the driller's logs. Calculated hydraulic conductivity for Well No. 7 is also a little higher than for Well No. 6.

An effective porosity of 0.2 was assumed for both wells based on literature values given by Freeze and Cherry (1979). This value was selected assuming primary porosity of the rock at the upper end of the range given for shale (0.1) and allowing an additional 0.10 to account for secondary porosity provided by fracturing.

Hydraulic gradient for the bedrock aquifer was calculated from the potentiometric maps of Slagle (1988) and MBMG (in progress) presented as Figures 5 and 6 in this report. Both maps indicate identical regional gradients of approximately 50 feet per mile or 0.01 ft/ft.

Delineation Results – Valley-Fill Aquifer Wells Nos. 1, 2, 3, 4, and 5

Delineation results for Wells No. 1, 2, 3, 4, and 5 are shown on Figures 9 and 10. Figure 9 is a relatively large-scale map, which also shows the three-year time-of-travel regions on a topographic map base. Because of the large scale of this map and because many new streets have been built since the topographic map was made in 1964, the inventory regions and control zones are also shown on the current City of Polson street map in Figure 10. Locations of Underground Storage Tanks (USTs), RCRA sites, gravel pits and landfills are also shown on Figures 9 and 10 for reference. Control zones for all wells are assumed to equal a 100-foot radius from each well. The rationale for the delineation of inventory and recharge zones for the wells is described below.

One and three year time-of-travel distances and null distance for Well No.1 are 770, 1,880, and 150 feet, respectively. The fixed radius of 1,000 feet for the inventory region was initially modified by 1) reducing the radius of the control zone downgradient of the well to approximate the null distance of 150 feet; and 2) expanding the radius of the control zone upgradient of the well to approximate the three-year time-of-travel zone and yield a pie-shaped control zone. The final inventory zone for Well No. 1 (see Figures 9 and 10) was expanded further to correspond with adjacent roads.

The inventory regions for Wells Nos. 2, 3, 4, and 5 were combined. The 1,000-foot fixed radius distances and three-year time-of-travel distances for the wells are shown on Figure 9. The three-year time-of-travel distances exceed the likely extent of the aquifer and therefore were not given much weight in delineation of the inventory region. The fixed radius was modified to delineate the inventory regions by 1) reducing the inventory regions downgradient of the wells to approximate the null distances from the time-of-travel estimates, 2) expanding the inventory regions upgradient of the wells to yield pie-shaped control zones, and 3) modifying the inventory regions to combine the regions from the four wells and to match geographical features (streets). Inventory regions for Wells No. 4 and 5 were delineated previously in source water delineation assessments conducted for PWS-6 evaluations (LWC, 2000). In the previous delineation, the protection zone was 800 feet in width and extended nearly to Wells Nos. 4 and 5, a distance of approximately 2,700 feet. The final combined inventory region for Wells No. 2 through 5 expands the previously delineated inventory region for Wells No. 2 and 3 to connect with the inventory region for Wells No. 4 and 5 (see Figures 9 and 10).

The recharge region (see Figure 11) is the same for all wells completed in the valley-fill aquifer. The recharge region for Wells No. 1 through 5 was delineated based on groundwater flow directions, topography and geology (areal extent of the valley-fill aquifer). The recharge region includes the area where valley-fill aquifer is exposed allowing infiltration of rainfall and snowmelt and where groundwater flow direction is toward the wells. This recharge region extends to the east into the foothills of the Mission Mountains to the extent of the valley-fill sediments. The region is bounded on the south and west by a groundwater divide that is apparent on the potentiometric maps (see Figures 5 and 6). The groundwater divide starts in the Mission Mountains near Pointer Creek and extends westerly to approximately the northern edge of Pablo Reservoir and then northwest to the Flathead River. South of this divide, groundwater flows to the south and west away from the Polson PWS wells.

Limiting Factors – Valley-Fill Aquifer Wells

The ground water flow rate calculations use values that are considered representative of actual conditions. This approach reflects the uncertainties in the data used in the modeling process, with estimates reflecting conservative, or worst-case conditions. The assumed values are consistent with published data on the ground water system in the Mission Valley and Polson study area (Table 2). While the inventory regions are delineated using criteria for confined aquifers, ground water flow rates were estimated to demonstrate the general properties of the ground water flow system for assessments on a more regional scale. As a result, the calculations of flow rates for the aquifer are considered as estimates.

Additional limitations result from the use of the Uniform Flow Equation for analysis of flow rates, which does not account for pumping from multiple wells. Uncertainty in flow conditions for the valley fill aquifer also include the relationship between surface water and the aquifer, and the density and frequency of pumping from wells installed at various locations across the study area. An additional limitation on this assessment reflects the nature of glacial strata, where deposit types reflect variable shapes, and can exhibit rapid changes in hydraulic properties, hydraulic gradients and flow directions over very short distances. The assumed groundwater flow direction and gradients in the area are based on regional data, actual local gradients, and flow directions may vary.

Delineation Results – Bedrock Aquifer Wells No. 6 and 7

Delineation results for Wells No. 6 and 7 are shown on Figures 9 and 10. Figure 9 is a relatively large-scale map, which also shows the 3-year time-of-travel regions on a topographic map base. Because of the large scale of this map and because many new streets have been built since the topographic map was made in 1964, the inventory regions and control zones are also shown on the current City of Polson street map in Figure 10. Locations of USTs, RCRA sites, gravel pits and landfills are also shown on Figures 9 and 10 for reference.

For Wells Nos. 6 and 7 in the confined bedrock groundwater system, the control zone is based on a fixed distance of 100 feet radius from each well; the inventory region is based on a modified fixed radius of 1,000 feet (modified based on analytical time-of-travel calculations), and the recharge region is based on geologic mapping and locations of hydrologic boundaries. The SWPP allows for use of a 1,000 feet fixed radius inventory zone for wells in confined groundwater systems. However, a modified fixed radius approach that also considers calculated groundwater time-of-travel was used for Wells No. 6 and 7. This approach is believed to be more conservative and may offset some of the uncertainties that arise in fractured aquifers regarding the presence of preferential flowpaths.

Calculated three-year time-of-travel zones and 1,000-foot radius distances for the wells are shown on Figure 9. Because the area is largely undeveloped, it is not possible to closely match the boundaries of the inventory zone to geographic features. Instead, the boundaries of the inventory zone were chosen to roughly parallel Highway 93 on the north and the county road (Irvine Flats Road) on the south.

The recharge region for Wells No. 6 and 7 is shown on Figure 11. The recharge region was delineated based on topography and geology (areal extent of the bedrock aquifer). The recharge region includes the area where the Spokane Formation, which comprises the bedrock aquifer, is exposed allowing infiltration of rainfall and snowmelt and where groundwater flow direction is toward the wells. These recharge areas include the area approximately 500 to 1,000 feet northwest of the wells where a small of bedrock is exposed and the ridge approximately five miles west-northwest where bedrock outcrops and dips to the east toward Flathead Lake. Recharge areas are limited to the north by a groundwater divide that is present in the vicinity of Jette Lake. To the south, a small area of bedrock exposed along the Flathead River likely represents the southern boundary of the recharge area. The bedrock undoubtedly extends beneath the river, but any bedrock south of the river is clearly downgradient of the wells.

Limiting Factors – Bedrock Aquifer Wells

The groundwater flow rate calculations use values that are considered representative of actual conditions. This approach reflects the uncertainties in the data used in the modeling process, with estimates reflecting conservative, or worst-case conditions. The assumed values are consistent with published data on the ground water system in the Mission Valley and Polson study area. While the inventory zones are delineated using criteria for confined aquifers, ground water flow rates were estimated to demonstrate the general properties of the ground water flow system for assessments on a more regional scale. As a result, the calculations of flow rates for the aquifer are considered as estimates. Further refinement of the hydrogeologic conceptual model and time of travel flow calculations would require collection of additional data.

Additional limitations result from the use of the Uniform Flow Equation for analysis of flow rates, which does not account for pumping from multiple wells, or from uncertainties that arise regarding flow in fractured bedrock systems.

INVENTORY

An inventory of potential sources of contamination was conducted for the City of Polson Public Water System within the control and inventory regions. Potential sources of all primary drinking water contaminants and Cryptosporidium were identified, however, only significant potential contaminant sources were selected for detailed inventory. The significant potential contaminants in the City of Polson Public Water System inventory region are primarily related to agriculture, transportation, and sewer/septic systems and include nitrate, pathogens, fuels, solvents, and herbicides/pesticides.

The inventory for the City of Polson Public Water System focuses on all activities in the control zone, certain sites or land use activities in the inventory region, and general land uses and large facilities in the recharge region.

Inventory Method

The inventory method relied primarily on door-to-door surveys by members of the Polson Water Department who are knowledgeable about historical land use practices in the area. This survey was supported by searches of government databases and telephone directories. These database searches did not identify any additional sources within the inventory zone but did identify sources within the recharge zone. Available databases were searched as follows:

Step 1: Urban and agricultural land uses were identified using data from the GAP program implemented at the University of Montana. The GAP program classified the state at 90-meter pixels for approximately 50 land use and vegetation types. This information was obtained in electronic format from the Montana State Library NRIS website. Urban and agricultural land use for the Mission Valley area is depicted in Figure 12.

Detailed land use information for the inventory regions was collected during the door-to-door survey and is summarized in Appendix E. Sewered and unsewered residential areas were identified from the boundaries of sewer coverage obtained from the City of Polson.

Step 2: EPA's Envirofacts System (http://www.epa.gov/enviro/) was queried to identify EPA regulated facilities located in the Inventory Region. This system accesses facilities listed in the following databases: Resource Conservation and Recovery Information System (RCRIS), Biennial Reporting System (BRS), Toxic Release Inventory (TRI), 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 should be classified as a significant potential contaminant source. No sources within the inventory regions were identified. Locations of RCRA sites within the recharge region are shown on Figure 13.

Step 3: The Permit Compliance System (PCS) was queried using Envirofacts (http://www.epa.gov/enviro/) to identify Concentrated Animal Feeding Operations with MPDES permits. The door-to-door survey verified that there are no animal feeding operations within the inventory zone that are required to obtain a permit.

Step 4: Databases were queried to identify the following in the inventory region: UST (http://webdev.deq.state.mt.us/UST/), hazardous waste contaminated sites (DEQ hazardous waste site cleanup bureau), landfills (http://nris.state.mt.us/gis/datalist.html), abandoned mines (http://nris.state.mt.us/gis/datalist.html) and active mines including gravel pits (a query of DEQ database was performed and provided by Mr. Rod Samdahl of the Open Cut Mining Bureau in Kalispell). Locations of USTs are shown on Figure 13 and also on the detailed maps in Appendix E. Active mines in the area are limited to gravel pits. All gravel pits and the Lake County landfill are located outside of the inventory regions (see Figure 9).

Step 5: Major road and rail transportation routes were identified throughout the inventory region based on topographic and highway maps.

Step 6: All wells located within the inventory region were identified and well logs were obtained when available (see Appendix A for well logs).

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

Inventory Results/Control Zone

Hazard inventory survey forms from the door-to-door survey are in Appendix F. Maps showing locations and results of potential contaminant sources and land uses within the control and inventory zones are in Appendix E. With the exception of Well No. 1, there are no significant potential contaminant sources in the control zones for any of the Polson PWS wells. Highway 93 is within the control zone of Well No. 1. With the exception of Well No.1, all of the land in the control zones for all wells is owned and administered by the City of Polson. A portion of the land within the control zone for Well No. 1 is within the Highway 93 right-of-way, which is owned and controlled by the State of Montana.

Inventory Results/Inventory Region

Maps showing locations and results of potential contaminant sources and land uses within the control and inventory zones are in Appendix E. Significant potential contaminant sources in the inventory zones are detailed in Table 6 and include major roads, railroads, agricultural chemical usage and storage, irrigated land, irrigation canals, and septic tanks. Detailed identification, location, and ownership of all potential sources are tabulated in Appendix F. Minor potential contaminant sources identified on the maps include water wells and utility substations. Available well logs for water wells in the area are included in Appendix A.

Table 6
Significant Potential Contaminant Sources for the City of Polson Public Water System

Inventory Region	Source	Contaminants
Well 1	8 Sites of Agricultural Chemical Usage/Storage	Pesticides/Herbicides/Nitrates
	2 Parcels of Irrigated Land	Pesticides/Herbicides/Nitrates
	11 Septic Systems	Pathogens and Nitrates
	Irrigation Canal	Pathogens, Pesticides/Herbicides/Nitrates
	Highway 93	Transported Hazardous Materials
	Railroad	Transported Hazardous Materials
Wells 2, 3, 4, and 5	Irrigation Canal	Pathogens, Pesticides/Herbicides/Nitrates
	13 Septic Systems	Pathogens and Nitrates
	Sanitary Sewer Main	Pathogens and Nitrates
Wells 6 & 7	22 Sites of Agricultural Chemical Usage/Storage	Pesticides/Herbicides/Nitrates

Inventory Results/Recharge Region

The significant potential contaminant sources located within the Recharge Region include USTs, gravel pits, roads and railroads, the Lake County landfill, Polson waste water treatment lagoons, irrigation canals and irrigated agriculture. Locations of these potential sources are shown on Figures 9 and 13. General land use for the area is depicted in Figure 12.

Inventory Update

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

Inventory Limitations

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

The location of Polson on the Flathead Reservation may limit the completeness of the databases used. Leaking UST sites under the direction of CSKT staff may not have any information reported to the DEQ database. In other cases, wells may be installed with no record to any Montana state databases. In these and other cases, this report relies on the local knowledge of the operator.

SUSCEPTIBILITY ASSESSMENT

Susceptibility is the potential for a public water supply to draw water contaminated by inventoried sources at concentrations that would pose concern. Susceptibility is assessed in order to prioritize potential pollutant sources for management actions by local entities, in this case the City of Polson Public Water System.

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

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 City of Polson Public Water System well(s) (see Table 7). Hazard for confined aquifers is low if all wells in the inventory region are constructed to current state standards. Hazard is high if the PWS well is not sealed into the confining layer and moderate if only other wells are not properly constructed.

A query of the MBMG-GWIC database indicated no other wells installed within the inventory zones. For purposes of the susceptibility assessment, the PWS wells for the Polson system are considered to be properly constructed with adequate seals. Although the well logs do not indicate the nature of the sanitary seal for the older wells in the water supply (Wells Nos. 1, 2, and 3), these wells are considered to be properly sealed because they were constructed with driven casing and because of the high clay content of the confining layers in the area. Compliance with Montana Water Well regulations only requires the feeding of bentonite along the casing as it is driven in order to form an effective seal. This requirement is believed to be met with the older wells.

There are no other wells within the inventory zone for Well No. 1; therefore, the relative hazard assigned for most sources in this inventory zone is **low**. However, the highway is considered to be a **moderate** hazard for Well No. 1 because the highway is within the control zone of the well. With limited information available, there is a potential that one or more of the additional wells in the inventory zone for Wells No. 2, 3, 4, and 5 may not have proper seals to shallow ground water; therefore the relative hazard assigned for all of the potential contaminant sources in the inventory zone is **moderate**. There are no other wells within the inventory zone for Wells No. 6 and 7; therefore, the relative hazard assigned for all sources in this inventory zone is **low**. All potential contaminant sources located in the Recharge Region, and outside of the inventory zones, are assigned a relative hazard of **low**.

Susceptibility ratings are presented individually for each significant potential contaminant source and each associated contaminant (see Table 8). The susceptibility of each well to each potential contaminant source is assessed separately.

Table 7 Relative Susceptibility to Specific Contaminant Sources as Determined by Hazard and the Presence of Barriers			
Presence Of Barriers	**Hazard High**	**Moderate**	**Low**
No Barriers	Very High Susceptibility	High Susceptibility	Moderate Susceptibility
One Barrier	High Susceptibility	Moderate Susceptibility	Low Susceptibility
Multiple Barriers	Moderate Susceptibility	Low Susceptibility	Very Low Susceptibility

Table 8. Susceptibility Assessment for Significant Potential Contaminant Sources in the Control Zones and Inventory Regions Well No. 1						
Source	**Contaminant**	**Hazard**	**Hazard Rating**	**Barriers**	**Susceptibility**	**Management**
8 Sites of Agricultural Chemical Usage/Storage	Pesticides/Herbicides /Nitrates	Non-point source	Low	Clay-rich Confining Layer	Low	Educate community of BMPs for agriculture
2 Parcels of Irrigated Land	Pesticides/Herbicides /Nitrates	Non-point source	Low	Clay-rich Confining Layer	Low	Educate community of BMPs for agriculture
11 Septic Systems	Pathogens and Nitrates	Leak	Low	Clay-rich Confining Layer	Low	Connect to sanitary sewer
Irrigation Canal	Pathogens, Pesticides/Herbicides /Nitrates	Non-point Source	Low	Clay-rich Confining Layer	Low	Educate community of BMPs for agriculture
Highway 93	Transported Hazardous Materials	Spills	Moderate	Clay-rich Confining Layer	Low	Spill Response Plan
Railroad	Transported Hazardous Materials	Spills	Low	Clay-rich Confining Layer	Low	Spill Response Plan

Wells 2, 3, 4, and 5						
Source	**Contaminant**	**Hazard**	**Hazard Rating**	**Barriers**	**Susceptibility**	**Management**
Irrigation Canal	Pathogens, Pesticides/Herbicides/Nitrates	Non-point Source	Moderate	Clay-rich Confining Layer	Moderate	Educate community of BMPs for agriculture
13 Septic Systems	Pathogens and Nitrates	Leaks and Seepage	Moderate	Clay-rich Confining Layer	Moderate	Connect to sewer
Sanitary Sewer Main	Pathogens and Nitrates	Leak	Moderate	Clay-rich Confining Layer	Moderate	Monitoring

Wells 6 and 7						
Source	**Contaminant**	**Hazard**	**Hazard Rating**	**Barriers**	**Susceptibility**	**Management**
22 Sites of Agricultural Chemical Usage/Storage	Pesticides/Herbicides/Nitrates	Non-point source	Low	Confining Layer	Low	Educate community of BMPs for agriculture

The results of the susceptibility assessment indicate that the Polson PWS wells are generally well protected from contamination. The primary threats are considered to result from irrigation canals, septic systems, sewer mains, and spills from an accident on the highway and railroad lines.

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Appendix A

Well Logs

Source Water Delineation and Assessment Report

for the City of Polson's Public Water System

PWSID # 00308

Polson, Montana

Appendix B

Sanitary Survey

Source Water Delineation and Assessment Report

for the City of Polson's Public Water System

PWSID # 00308

Polson, Montana

Appendix C

Water Quality Data

Source Water Delineation and Assessment Report

for the City of Polson's Public Water System

PWSID # 00308

Polson, Montana

Appendix D

Groundwater Time-of-Travel Calculations

Source Water Delineation and Assessment Report

for the City of Polson's Public Water System

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Polson, Montana

Appendix E

Detailed Assessment Maps

Source Water Protection Zone - Municipal Well 1
Source Water Protection Zone - Municipal Wells 2,3,4, & 5
Source Water Protection Zone - Municipal Wells 6 & 7

Source Water Delineation and Assessment Report

for the City of Polson's Public Water System

PWSID # 00308

Polson, Montana

Appendix F

Hazard Inventory Forms and Summary Table

Source Water Delineation and Assessment Report *for the City of Polson's Public Water System*

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Polson, Montana