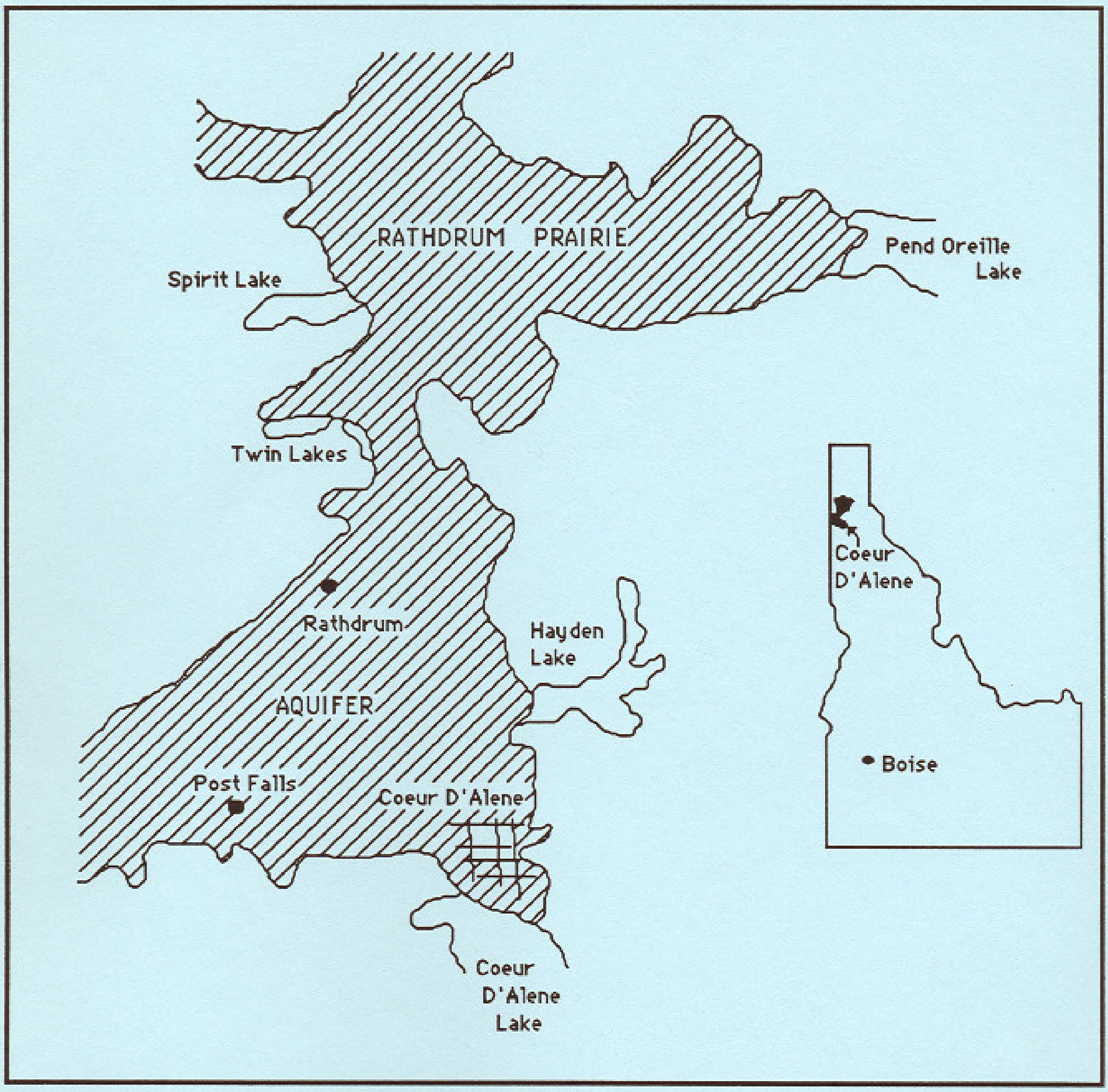
THE RATHDRUM PRAIRIE AQUIFER TECHNICAL REPORT



IDAHO DEPARTMENT OF HEALTH AND WELFARE
DIVISION OF ENVIRONMENTAL QUALITY
BUREAU OF WATER QUALITY

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RATHDRUM PRAIRIE AQUIFER
TECHNICAL REPORT

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ABSTRACT

The Rathdrum Prairie Aquifer lies in a valley filled with glacial outwash deposits generated during flooding from glacial Lake Missoula. Designated in 1978 as a sole source aquifer by the Environmental Protection Agency, this aquifer supplies drinking water to over 55,000 people in Idaho. In Washington, nearly 250,000 people obtain drinking water from groundwater which flows through the Rathdrum Prairie Aquifer.

Geohydrologic analysis of the Rathdrum Prairie Aquifer indicates high porosities, permeabilities and transmissivities. Groundwater flow, calculated in some places to be in excess of 50 feet/day, is generally from northeast, near Spirit and Pend Oreille Lakes, Idaho, to southwest, discharging into the Spokane River near Spokane, Washington. Recharge from tributary valleys in Idaho is the main contributor of recharge to the aquifer with lesser amounts coming from seepage from the Spokane River and precipitation.

Soils developed over the Rathdrum Prairie Aquifer are well drained to excessively well drained. The absence of major restrictive layers in the unsaturated zone results in high potential for contamination from surface activities. Water quality testing has linked nitrate contamination of the aquifer with high usage of subsurface sewage disposal systems.

Analysis of activity on the Rathdrum Prairie identified fourteen potential sources of groundwater contamination. Of these sources, agricultural activities, petroleum, surface runoff/drainwells, landfills, septic tanks and hazardous materials have been identified as having the highest pollution potential.

Prevention of contamination is viewed as the best possible method of managing the water quality of the Rathdrum Prairie Aquifer. Ambient water quality of the aquifer appears to be good at this time. The increased land use activities on the Rathdrum Prairie combined with the aquifer’s susceptibility to contamination indicate that judicious management of this sole source of drinking water is imperative.

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Chapter 1. Introduction

The Rathdrum Prairie-Spokane Valley Aquifer extends east and then northeast from near Spokane, Washington, to northern Kootenai County, Idaho (Figure 1). In Idaho, the Rathdrum Prairie varies from five to 17 miles in width, covers 283 square miles and is bounded on both sides by mountainous terrain and numerous lakes. Nearly 55,000 people in Idaho utilize groundwater obtained from the Rathdrum Prairie Aquifer. Down-gradient from Idaho, 250,000 people in and around Spokane are dependent upon the groundwater that flows through the Rathdrum Prairie-Spokane Valley Aquifer. Groundwater is the main source of water for the agricultural and domestic users on the Rathdrum Prairie. The Rathdrum Prairie-Spokane Valley Aquifer lies within the boundaries of both Washington and Idaho. This aquifer, designated in 1978 by the Environmental Protection Agency (EPA) as a sole source aquifer, provides drinking water for residents of both states. Groundwater flow is generally northeast to southwest with the major recharge occurring in Idaho. Consequently, the quality of the groundwater on the Washington side is, in large part, dependent upon activities occurring in Idaho. Cooperative management practices by local and state officials of both Idaho and Washington are crucial regarding groundwater quality.

Water quality has long been a concern. Over the Rathdrum Prairie Aquifer, the steadily growing population and associated industrial and recreational activities all point to an increased demand for groundwater. In 1975-76, the Panhandle District Health Department conducted a comprehensive groundwater quality monitoring study in response to a growing concern regarding activities on the Rathdrum Prairie in relation to groundwater contamination. From the results of this study, which are contained in the "Groundwater Quality Monitoring Rathdrum Prairie Technical Report," (Jones and Lustig, 1977) it became apparent that groundwater contamination was occurring in the Rathdrum Prairie Aquifer. Significant increases in nitrate concentrations were detected beneath or immediately down gradient from areas experiencing rapid suburban residential growth.

On October 11, 1977, the Panhandle District Health Department officially adopted the "Rathdrum Prairie Aquifer Regulations." These regulations state, in part, that (1) a minimum lot size of five acres is required for a septic system and (2) development would be allowed on lots less than five acres provided the land is located within a municipal area programmed for sewer service under a sewage management plan and agreement between the municipality and the Panhandle District Health Department.

In cooperation with the EPA, the U.S. Geological Survey prepared a report entitled "Spokane Valley-Rathdrum Prairie Aquifer, Washington and Idaho" (Drost and Seitz, 1978). This report summarizes the hydrology, land use and water quality of the Spokane Valley-Rathdrum Prairie area.

On February 7, 1978, the Rathdrum Prairie-Spokane Valley Aquifer system and major recharge area (Figure 1) was officially designated a sole-source aquifer by the EPA based on a petition filed by a coalition of citizens' interest groups. The Safe Drinking Water Act (Public Law 93-523) allow the designation of an aquifer as sole or principal source of drinking water

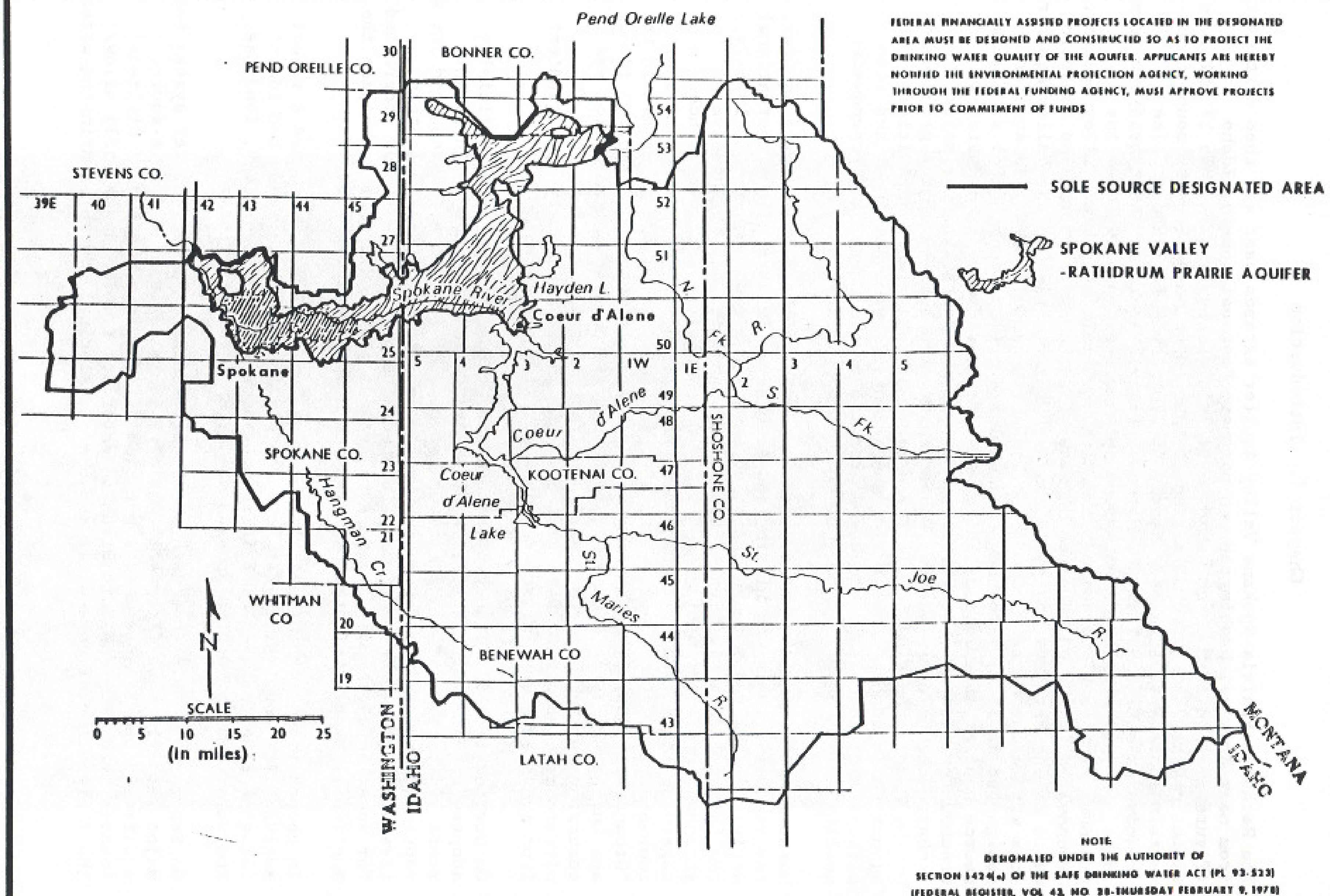

FIGURE 1. Vicinity Map of Rathdrum Prairie-Spokane Valley Sole Source Aquifer and Recharge Area

if it is determined that, by contamination, it would create a significant public health hazard. Designation of an aquifer as sole source gives the EPA review authority to help ensure that federally assisted or guaranteed projects are planned and designed to ensure that they will not contaminate the aquifer.

EPA considers the recharge zone a major factor in protecting the Spokane Valley-Rathdrum Prairie Aquifer system.

> "The drainage divide of the Spokane River-Coeur d'Alene Lake basin, approximately 5,000 square miles, is the prime area of recharge for the aquifer and, therefore, included in the area to be designated as sole source. Within this basin, the aquifer boundaries and recharge area have been delineated. Numerous lakes and streams provide the major recharge to the aquifer with some recharge occurring from precipitation on the recharge area. Figure 1 is an enlarged base map showing the Spokane Valley-Rathdrum Prairie Aquifer and its recharge and drainage area subject to sole-source designation. This chart should be used in conjunction with descriptive language when determining whether a federally financially assisted project is located in the designated area and therefore subject to EPA review under Section 1424E of the Safe Drinking Water Act" (Jorling and Dubois, 1977).

In September 1978, the Water Quality Management Plan for the Rathdrum Prairie Aquifer was developed under Section 208 of the Clean Water Act. Results of the 208 study indicate that water quality of the aquifer is tied to human activity over it (Jones and Lustig, 1977). In 1979, Whitehead and Parliman ranked the Rathdrum Prairie Aquifer third in pollution potential from a list of 84 hydrologic units in Idaho.

The State Groundwater Management Plan (Martin, 1983, updated 1985) identified the Rathdrum Prairie Aquifer as having a high pollution potential due to the extensive population growth which has occurred in the area and the highly porous nature of the aquifer. The Rathdrum Prairie Aquifer is designated a special resource under Idaho's Water Quality Standards. This important aquifer is managed jointly by the Department of Health and Welfare and the Panhandle Health District. Protection against degradation is currently provided by the Idaho Water Quality Standards and Wastewater Treatment Requirements (IDHW, 1985d) and the Panhandle Health District, Rathdrum Aquifer Subsurface Sewage Regulations. Groundwater quality monitoring is performed quarterly by the Panhandle Health District in cooperation with the Spokane 208 office.

The primary purpose of this report is to summarize the existing data with regard to the hydrology and land use patterns of the Rathdrum Prairie Aquifer and identify the major potential contaminant sources. By applying a rating and ranking system to these potential sources of contamination, they can be prioritized according to pollution potential. This rating of potential contaminant sources then forms the basis for strategy development for aquifer protection.

Chapter 2. Geology

The Rathdrum Prairie-Spokane Valley Aquifer system, which extends from Pend Orielle Lake, Idaho, to Long Lake, Washington, occupies a glacially scoured trough formed when continental glaciers extended down the Purcell Trench during the Pleistocene epoch. Fluvioglacial deposits form the aquifer material and are composed of poorly to moderately sorted sand and gravel. Fine sand and silt are rare except within the upper three to five feet. Minor clay lenses do occur, scattered throughout the deposit.

The dominant physiographic feature of the area is the Purcell Trench, a broad structural and erosional trough that extends down southward from Canada to Coeur d'Alene, thence westward toward Spokane. This trough has both glacial and fluvioglacial deposits, which are generally highly permeable and have a high storage capacity. The surface of the valley fill south of Athol is known as the Rathdrum Prairie in Idaho and as the Spokane Valley in Washington. The surface slopes southwesterly from an elevation of 2,450 feet at Athol to 1,900 feet at Spokane (Frink, 1968).

The trench is bordered by mountains, rising to an elevation of 5,000 feet in places, composed of sedimentary, metamorphic, and volcanic rocks ranging in age from Precambrian to Tertiary (Figure 2). These rocks, for the most part, are nonwater bearing and thus form the walls and floor of the groundwater reservoir.

Precambrian metamorphosed sediments with quartz diorite intrusives compose most of the Coeur d'Alene and Cabinet Mountains east of the Purcell Trench. Mesozoic granite and gneiss comprise the Selkirk Mountains west of the trench and higher mountains west of Coeur d'Alene. The Columbia River basalts were extruded in Tertiary time. These are very extensive south and west of Spokane. At one time these flows extended far up the Purcell Trench, but now most of the flows have been removed by erosion and only a few remnants are found along the valley sides in Idaho near Coeur d'Alene and north of Hayden Lake (Frink, 1968).

The geologic history since the beginning of Tertiary time is significant from the standpoint of groundwater occurrence. In pre-Miocene time, the drainage from a large area to the north and east was southward from the Purcell Trench and Clark Fork Valley through the Rathdrum Prairie and then westward through the Spokane Valley to the ancient Columbia River. The eastward advance of basalt flows near Spokane formed a lake in this drainage in which as much as 1,500 feet of clays and silts, called the Latah formation, were deposited before being covered by younger basalt flows. As a result of this blockage near Spokane, the entire drainage system was reversed to flow northward through the Purcell Trench into Canada. Subsequent erosion, prior to the first ice advance, removed much of the basalt and Latah clays from the Rathdrum Prairie-Spokane Valley area. Walker, 1964, provided the following summary of the glacial history of the area:

> During the first recognized stage of glaciation in this region - - the Spokane advance - - ice moved southward in the lowlands as far as the site of Coeur d'Alene. The valleys probably were deepened

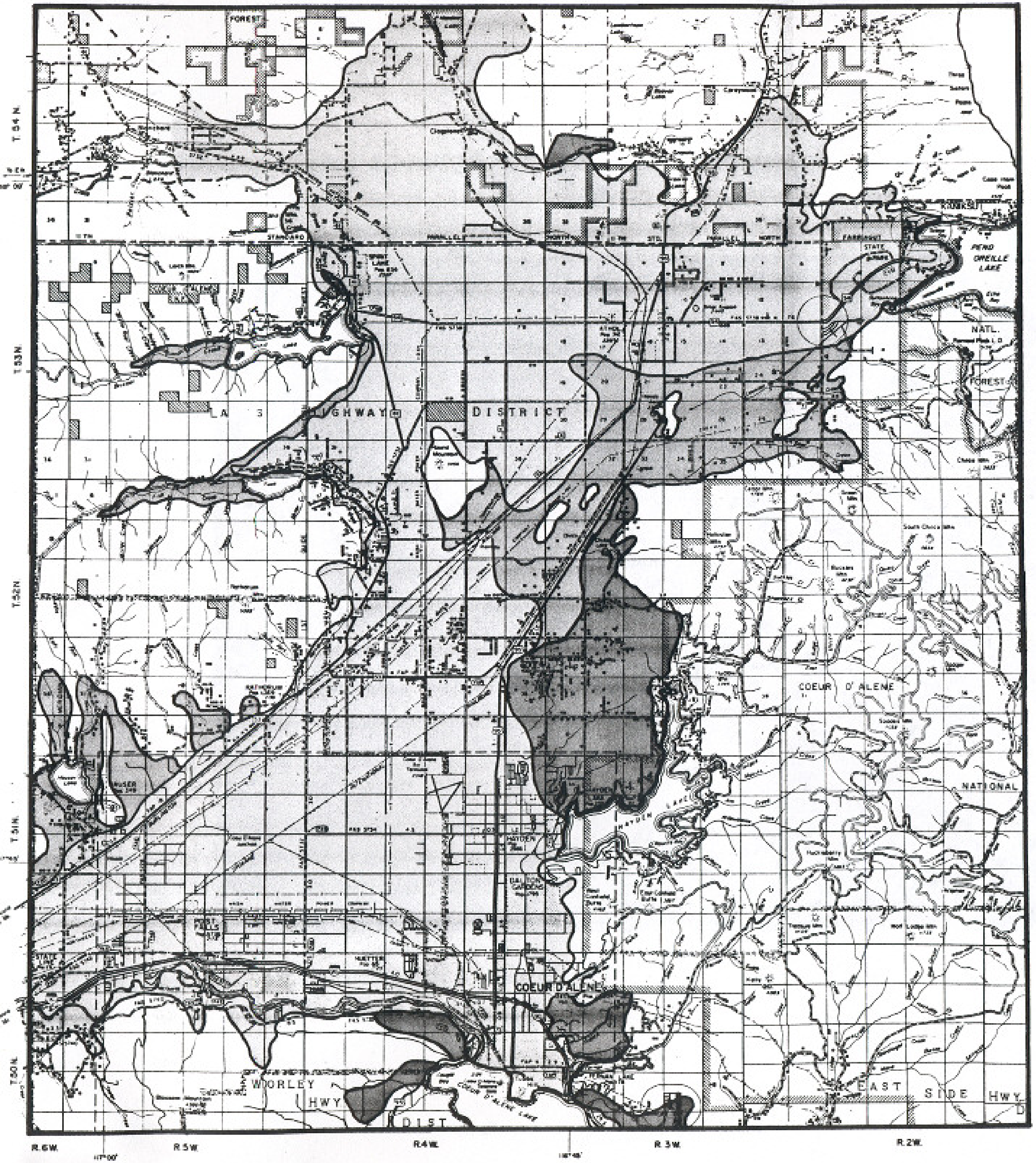

FIGURE 2. Geologic Map of Kootenai County

Explanation

- Rathdrum Prairie Aquifer
  Tertiary & Quaternary Alluvium and Glacial Outwash Deposits
- Other Deposits of Tertiary and Quaternary
  Alluvium and Glacial Outwash
- Miocene
  Basalt
- Cretaceous - Precambrian
  Granites and Metamorphic Belt Complex

Base Map: General Highway Map Of Kootenai County
Geology Modified From Anderson, 1940

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considerably during this stage. The ice probably was 5,000 feet thick above the bedrock floor of the trough of Pend Oreille Lake and overtopped all but a few of the higher mountains. The ice moved up the valley of Clark Fork for several miles and impounded Lake Missoula, whose surface rose to an altitude of about 4,200 feet. The lake was as much as 2,000 feet deep above the ice dam and had a total area of about 3,300 square miles (Alden, 1953, p. 155). The recognizable deposits of this ice are the moraines or accumulations of till, now much weathered and eroded, near Coeur d'Alene.

Fluvioglacial deposits, principally outwash, filled the Spokane Valley, Rathdrum Prairie and Hoodoo Valley to unknown depths (probably 500 feet or more in many places). These deposits dammed side drainages to form Hayden, Coeur d'Alene, Liberty, Newman, Hauser, Twin and Spirit Lakes. Of these lakes, only Coeur d'Alene has a perennial surface outlet (Anderson, 1927).

After retreat of this first ice sheet, the Clark Fork River was blocked by the glacial fill in the upper Rathdrum Prairie, and it occupied a new course westward from Sandpoint along the present Pend Oreille River channel.

During the Wisconsin Glaciation, the ice came down the Purcell Trench from Canada and left a terminal moraine near Athol at the south end of Pend Oreille Lake. This ice lobe cleared earlier gravels from the Purcell Trench at Pend Oreille Lake and possibly excavated some Latah clays to form a deep, U-shaped trough now occupied by the lake. The lake is more than 1,100 feet deep in places, according to the Coast and Geodetic Survey. This ice advance extended up the Clark Fork creating glacial Lake Missoula. Meltwater from Lake Missoula spread great masses of gravel out onto the Rathdrum Prairie and Spokane Valley.

Field evidence firmly establishes that the Rathdrum Prairie was the site of periodic colossal jökulhaups (glacier outburst floods) (Waitt, 1985). Numerous great floods fanned across the Rathdrum Valley from the margin of the continental glacier, depositing well-washed sands and gravels in their wake. These sands and gravels all have high porosities and permeabilities and form the material for the Spokane Valley-Rathdrum Prairie Aquifer and overlying unsaturated zone.

Chapter 3. Hydrology

The Spokane Valley-Rathdrum Prairie Aquifer is known to be one of the most prolific aquifers in the United States. This aquifer is the major source of drinking water for the cities of Spokane, Post Falls, Coeur d'Alene and Hayden Lake, as well as rural residents living over the aquifer.

The earliest studies of the Spokane Valley-Rathdrum Prairie aquifer were by Fosdick (1931) and Newcomb (1933), both of these authors outlined the basic geologic, physiographic, and hydrologic features of the aquifer and its recharge area. Newcomb concluded that a buried ridge of basalt near Spokane causes the ground-water flow to divide, one part moving northward into the Hillyard Trough, another part moving westward into the basalt and a third part moving through the Miocene Latah Formation into underlying basalt. Newcomb indicated that the Spokane River is a losing stream between Post Falls, Idaho, and Trent, Wash., and a gaining stream from Trent to Spokane. Newcomb felt that Pend Oreille Lake is the major source of recharge to the aquifer, while Fosdick suggested that precipitation directly over the aquifer and in adjacent highlands is the source.

Piper and Huff (1943), Huff (1943), and Piper and La Rocque (1944), studied the aquifer in more detail. Piper and Huff measured water levels in a series of wells and made estimates of the hydraulic gradient in different parts of the aquifer. They concluded that Hayden, Coeur d'Alene, and Pend Oreille Lakes, and the Spokane River are the major sources of recharge, with Pend Oreille Lake making the greatest contribution while the estimated discharge from the aquifer to springs and rivers was 900 ft^3/s. Huff estimated the total discharge from the aquifer to be about 1,100 ft^3/s, which included his estimated total pumpage of 100 ft^3/s in 1942.

In 1944 Piper and La Rocque estimated total flow through the aquifer to be about 1,000 ft^2/s. They also discussed Pend Oreille Lake as a possible recharge source, but not as a major source.

Nace and Fader (1950) tabulated all data then available in U.S. Geological Survey files on wells tapping the aquifer. In unpublished reports of the U.S. Bureau of Reclamation, Lenz (1950), Meneely (1951), and Anderson (1951), studied various aspects of different parts of the aquifer with the general intention of determining the sources and volumes of water that could be used for irrigation in the Rathdrum Prairie area. Lenz estimated water requirements, seepage losses, and storm flows that would be associated with a large irrigation project. Meneely studied the contribution of precipitation to the aquifer. Anderson calculated discharge from the aquifer to the Spokane and Little Spokane Rivers to be about 470 and 250 ft^3/s, respectively.

Broom (1951) and McDonald and Broom (1951), analyzed gaging-station records for the Spokane and Little Spokane Rivers for the 1950 water year (Oct. 1, 1949–Sept. 30, 1950). In addition to calculating the net annual gains and losses of the rivers, they observed large variations in the directions as well as amounts of flow between the Spokane River and the aquifer along various stretches of the river.

Fader (1951) compiled water-level data from wells in the Rathdrum Prairie of Idaho and in Pend Oreille, Hayden, and Coeur d'Alene Lakes, and Weigle and Mundorff (1952) compiled well records and data on water levels and water quality for wells in the Washington part of the aquifer.

In 1953, Newcomb used seismic profiles near the Washington-Idaho State line to estimate the thickness of the aquifer. His interpretations indicated a thickness of about 340 to 376 feet near the State line.

Thomas (1963) estimated a total of 1,200 ft^3/s inflow to the aquifer in 1959, exclusive of recharge from Pend Oreille Lake. He estimated total discharge to be 1,450 ft^3/s, which led to an indirect estimate of 250 ft^3/s of recharge from Pend Oreille Lake. Walker (1964) suggested the existence of an additional source of recharge from the Hoodoo Valley.

Frink (1964) evaluated the sources of recharge and agreed with Anderson (1951) that Pend Oreille Lake was only a minor source of recharge, about 50 ft^3/s. Frink also suggested that at least 600 ft^3/s of recharge occurred east of Post Falls, Idaho, and another 150 ft^3/s occurred between Post Falls and the State line.

Rorabaugh and Simons (1966) found that the ground-water flow to the rivers varied according to the water table altitude and predicted a decline of about 12 ft/yr in the aquifer if all recharge ceased.

The literature continues to show a conflict over the importance of Pend Oreille Lake as a recharge source. Pluhowski and Thomas (1968) developed a ground-water budget for the aquifer and assigned a recharge rate of 51 ft^3/s from Pend Oreille Lake in order to balance the budget. They also state that the contribution from the lake might be as great as 200 ft^3/s and they estimate that the ground-water flow at the State line at about 1,000 ft^3/s.

Cline (1969) estimated that the 1964 water use from the aquifer near Spokane was about 8 billion gallons per year (34 ft^3/s), and concluded that this rate of use had very little effect on the hydrologic system.

Hammond (1974) determined that the ground-water flow southward from Pend Oreille Lake and Spirit and Hoodoo Valley was confined between Twin Lake and Round Mountain. Earlier authors assumed that the aquifer extended eastward around Round Mountain. Hammond based his conclusion on his apparent identification of bedrock as occurring at relatively high elevations and underlying the unconsolidated materials east of Round Mountain. This theory was supported by the high water-level altitudes in wells tapping these unconsolidated materials, which indicated that the materials were a source of recharge to the aquifer but were not part of the aquifer.

In 1978, Drost and Seitz, in cooperation with the U.S. Environmental Protection Agency, compiled information on aquifer characteristics, water quality and water usage.

Whitehead and Parliman (1979) compiled data for hydrogeologic conditions, groundwater quality, cultural elements and pollution sources in Idaho. Using this information, they calculated a "hydrologic unit priority index" to rank the 84 hydrologic units of the state according to pollution potential. The Rathdrum Prairie Aquifer ranked third highest on this list.

Graham and Campbell (1981) further characterized the aquifers of Idaho in relation to media and groundwater resources and groundwater flow systems. Data from this report further substantiates the high pollution potential of the Rathdrum Prairie Aquifer.

Hydrogeological Setting

The aquifer is thought to be underlain in most places by the fine-grained sediments of the Latah formation, which has much lower permeability and, in general, is bounded laterally by consolidated bedrock of very low permeability. In some areas, however, the boundaries of the aquifer are more gradational, with the highly permeable deposits or sand and gravel grading laterally into less permeable unconsolidated materials.

The thickness of the aquifer is still not known. Previous geophysical surveys indicate a thickness of about 375 feet of alluvial fill near the state line. Since the water table is about 120 feet below land surface in this area, the saturated thickness of the aquifer amounts to about 255 feet. Since the aquifer is highly productive, few wells need to penetrate more than a few tens of feet below the water table in order to obtain the amount of water required. As a result, the full thickness of the aquifer elsewhere has not been penetrated by wells, except near the margins where the fill is relatively thin.

Aquifer Boundaries

The general boundaries of the aquifer are shown on Figure 3, but require some explanation. The boundary of the aquifer on the east side of the Rathdrum Prairie is somewhat arbitrary because of the nature of the underlying unconsolidated material, which is not considered part of the aquifer. These materials are relatively thin and are thought to directly overlie bedrock. As a result, the water table in this area (the Chilco Channel) is considerably higher than in the main body of the aquifer and probably represents an area of recharge to the main aquifer. Similar reasoning can be extended to the tributary valleys containing Spirit, Twin and Hauser Lakes on the west side of the Rathdrum Prairie. Boundaries were not drawn across the Spirit and Hoodoo Valleys because of insufficient subsurface data. Elsewhere, the boundaries represent the contact between the permeable valley fill material and the relatively impermeable bedrock bounding the valley.

Water Levels, Depth to Water and Direction of Groundwater Movement

The water table slopes from Hoodoo Valley and Pend Oreille Lake in a generally southerly and south-southwesterly direction to the Idaho-Washington state line. The water table slopes about 20 feet per mile from the northern extremity of the aquifer to about Round Mountain, then establishes a more modest slope of between 2-10 feet per mile from Round

Mountain to the state line. Approximate water table elevations range from about 2,180 feet above mean sea level in the northern part of the aquifer in Idaho to an elevation of about 1,980 feet at the state line. Water level contours shown on Figure 3 represent lines of equal water level elevation. Water moves down-gradient, generally perpendicular to the contour lines, as shown by the arrows indicating the general direction of movement.

Water levels fluctuate due to many influences of both a long-term and short-term nature. Examples of long-term influences include variations in recharge to the aquifer due to increased or decreased precipitation and development of groundwater for irrigation or municipal use. Short-term influences include seasonal pumpage for irrigation and high losses of water from the Spokane River during high flow periods of runoff. In general, water level fluctuations are less than 30 inches per year in most areas, with the larger fluctuations usually in those wells closest to the Spokane River, occurring in response to changing stages of the river. Although data are not plentiful, it appears that there has been no long-term decline in water levels anywhere within the Rathdrum Prairie Aquifer.

Depths to water from land surface range from a maximum of about 300-400 feet in the northern portion of the aquifer to about 153 feet in the vicinity of the state line (Figure 4).

Groundwater Hydraulics and Movement

Two major terms are commonly used to describe the hydraulic characteristics of an unconfined aquifer: transmissivity, the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient; and specific yield (or storage coefficient), the volume of water which will drain by gravity from a unit volume of the saturated aquifer material. Values for transmissivity based on results of pumping tests are about 13 million feet squared per day ($ft.^2$/day) near the Idaho-Washington state line. Transmissivities calculated by the USGS computer model indicate a transmissivity of about 3.3 million $ft.^2$/day. Values elsewhere in the Idaho portion of the aquifer range from 270,000 to 11 million $ft.^2$/day (Drost and Seitz 1978, p.8). Specific yield of the aquifer material could not be accurately calculated using the available data, but typical values for alluvium range from 0.1 to 0.3. In most of the aquifer, the values are expected to be in the highest part of this range. These figures indicate that the Rathdrum Prairie Aquifer has some of the highest transmissivities and storage coefficients within the state. Table 1 gives values of transmissivities for selected aquifers around the state.

Groundwater velocities through the permeable valley fill are calculated to be relatively high. For the aquifer near the state line, using values of transmissivity determined above, aquifer width and water table gradient, the calculated groundwater velocity is about 64 ft./day. The U.S. Army Corps of Engineers, using different data, indicate that the velocity could be as high as 90 ft./day (U.S. Army Corps of Engineers, 1976). Total flow through the aquifer at the state line is estimated to be about 960 cubic feet per second (cfs), which agrees closely with the estimate of between 930-1,010 cfs obtained using the groundwater budget approach.

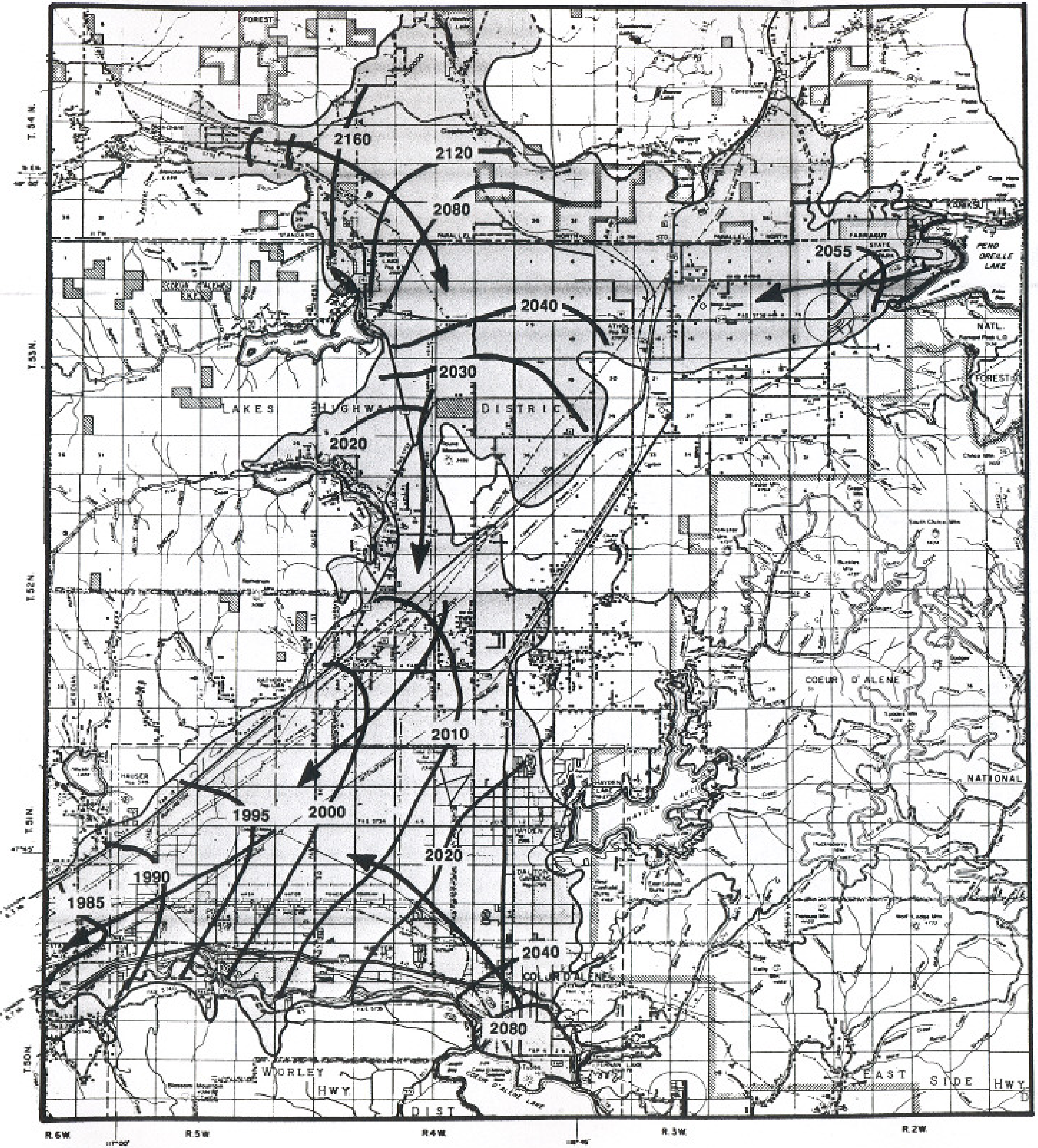

FIGURE 3. Map of Rathdrum Prairie Showing Aquifer Boundries, Water-Level Altitudes and Generalized Groundwater Flow Directions.

Explanation

Rathdrum Prairie Aquifer

2000 Water Level Contour (altitude of water table above mean sea level)

Generalized Direction of Groundwater Flow

Base Map: General Highway Map of Kootenai County, Idaho Department of Transportation

Hydrology Modified from Drost and Seitz 1978

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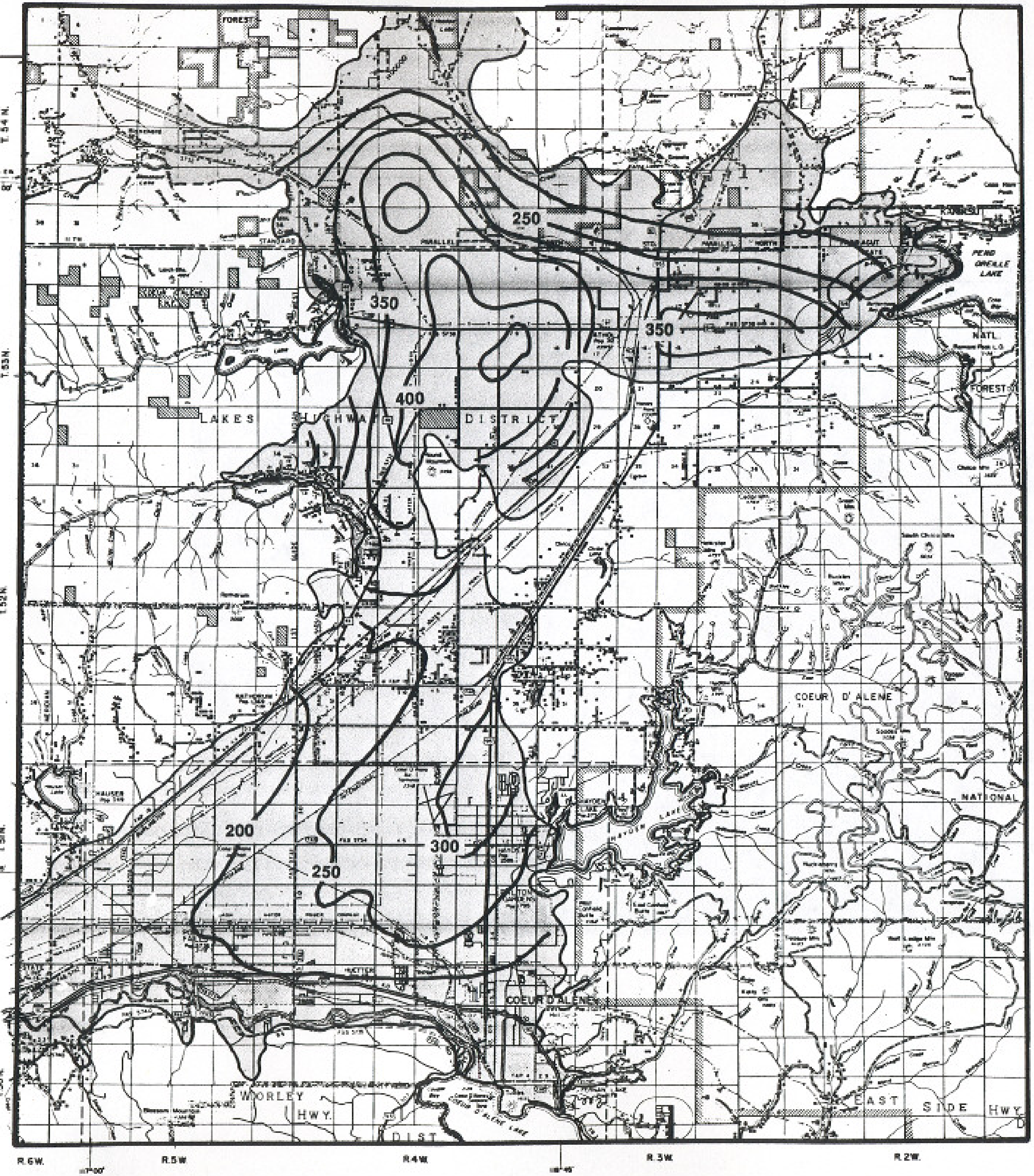

FIGURE 4: Map of Rathdrum Prairie Aquifer Showing Depth to Water

Explanation

Rathdrum Prairie Aquifer

Contour Lines Showing Depth to the Water Table (contour interval is 50 feet)

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1 2 3 4 5 6 7 8

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Base Map: General Highway Map of Kootenai County, Idaho Department of Transportation

Hydrology by Idaho Department of Water Resources.
Data from U.S. Geological Survey, Water Resources Division and Idaho Department of Water Resources.

TABLE 1
VALUES OF TRANSMISSIVITY AND STORAGE COEFFICIENT FOR SELECTED AQUIFERS IN IDAHO

AQUIFER	TRANSMISSIVITY ($ft.^2/d$)	STORAGE COEFFICIENT (DIMENSIONLESS)
1. Snake Plain Aquifer	500,000 to 13 million	3×10^{-2} to 1.7×10^{-5}
2. Glenns Ferry Formation, Nampa-Caldwell area	18,000 to 230,000	0.23 to 1×10^{-4}
3. Alluvial aquifers, upper Henry's Fork basin	670 to 23,000	
3. Basalt aquifers, upper Henry's Fork basin	200 to 8,700	
3. Rhyolite flows and tuffs, Upper Henry's Fork basin	400 to 12,000	
4. Pullman-Moscow Aquifer	3,300	1×10^{-4}
5. Bighole Basalt and Sunbeam Formation, eastern Michaud Flats	19,600 to 444,000	
6. Salt Lake Formation and Raft River Formation, southern Raft River basin	3,200 to 46,800	1.8×10^{-3} to 5.3×10^{-3}
7. Camas Prairie alluvial	9,400	
8. Rathdrum Prairie	130,000 to 13 million	

1. Mundorf et al., 1964
2. Nace et al., 1957
3. Whitehead, 1978
4. Smoot, 1987
5. Jacobson, 1984
6. Morilla and Ralston, 1975
7. Walton, 1962
8. Hammond, 1974

Recharge To and Discharge From the Aquifer

Yearly discharge from the aquifer due to pumping and river gains is approximately 954,000 acre feet. This is essentially balanced by recharge from valley underflow, precipitation and irrigation diversions (Table 2 and Figure 5).

TABLE 2*
RECHARGE TO AND DISCHARGE FROM
THE RATHDRUM PRAIRIE AQUIFER

RECHARGE	ACRE FEET PER YEAR	DISCHARGE	ACRE FEET PER YEAR
Flow into the aquifer from adjoining areas (chiefly valley underflow)	580,000		
Precipitation minus evapo-transpiration on the land surface above the aquifer in Idaho	94,000	Total pumping loss in Idaho	35,000
Inflow from surface water diversions (recharge by water diverted from Spokane River east of Post Falls and applied to land surface above the aquifer	36,000	Underflow to Spokane Valley Aquifer (underflow assumed to be equal to recharge less pumpage)	675,000
TOTAL	710,000		710,000

(*Modified after Drost and Seitz, 1978.)

Part of the water that flows into Coeur d'Alene, Pend Oreille, Spirit, Twin, Hayden and Hauser Lakes is evapotranspired, some is diverted, some increases storage in the lakes or becomes surface runoff and some percolates into the ground and becomes groundwater recharge. Seepage losses from the Spokane River between Post Falls and the state line also constitute a major source of recharge. An additional source of recharge comes from diversions of surface water for irrigation, particularly in the vicinity of Post Falls. Both seepage losses and irrigation diversion losses below Post Falls benefit only a small part of the aquifer in Idaho; the major benefit is felt in Washington.

These recharge sources initially flow through the aquifer as two separate channels, one channel coming from the northwest and the other from the southeast (Figure 3). The letter consists almost exclusively of infiltration from Coeur d'Alene Lake and the Spokane River. This channel, with a flow of approximately 250 cfs, merges with the larger channel, with a flow of 475 cfs, just west of the city of Coeur d'Alene.

Approximately 95 percent of the water in the aquifer leaves the state as underflow and is eventually discharged to the Spokane River or Little Spokane River in Washington or escapes as groundwater underflow near Nine Mile Falls, Washington. Although some water may be lost to the underlying Latah formation, the amount of this loss is thought to be insignificant.

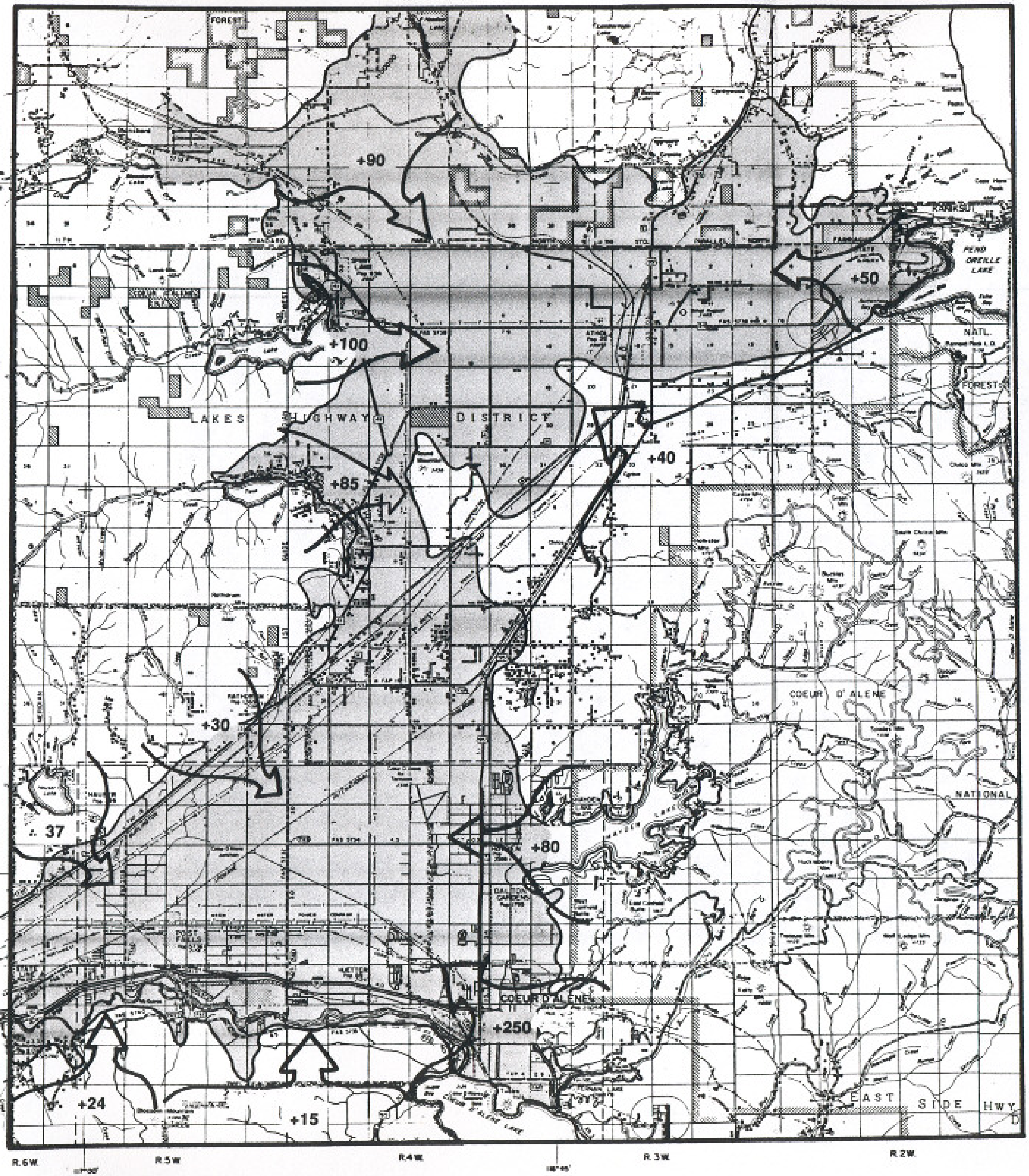


FIGURE 5: Map of Rathdrum Prairie Aquifer Showing Estimated Rates of Recharge

Explanation

Rathdrum Prairie Aquifer

+250 All numbers are in Cubic Feet per Second

Flow into the Aquifer from Adjoining Areas

+ 130 Net Recharge to the Aquifer due to Precipitation minus Evapotranspiration

N

1 2 3 4 5 6 7 8

Miles

Base Map: General Highway Map Of Kootenai County, Idaho Departmen. of Transportation.

Hydrology Modified from Drost and Seitz 1978

Most of the water moving through the aquifer eventually discharges to the Spokane and Little Spokane Rivers, although where and how this occurs has not yet been fully defined. Broom (1951) and McDonald and Broom (1951) analyzed gauging station records from an expanded gauging network and estimated the amounts and locations of water being transferred from the aquifer to the river and vice versa. Their analyses showed there were large variations during the 1950 water year, not only in the magnitude of flow but also in the direction of flow. These variations take place most years and result from the relative levels of both the river stage and water table.

Chapter 4. Climate and Soils

Soils and climate are important to the water quality of the Rathdrum Prairie Aquifer. Soils store some of the moisture from precipitation for plant growth, thus reducing infiltration to groundwater. Soils are also media for the retention of nutrients and potential contaminants. Some potential contaminants are decomposed by the biological activity within the soil, thus preventing their entry into the groundwater system. The kinds of parent materials from which soils form, interacting with climate, give rise to soil characteristics that are important to water movement and potential contaminant retention and decomposition. These characteristics are soil depth, slope, texture, drainage, permeability, reaction (pH), cation exchange capacity, and organic matter content.

Climate

The climate is subhumid Mediterranean, with cold moist winters and dry summers. The average annual precipitation is about 24 inches at the southwest extreme and 33 inches in the northern part (Table 3). The months of November, December and January, have the highest precipitation, receiving about 3 to 5 inches of precipitation per month. This is mainly as snow (an average of 88 inches per year), which usually remains on the ground until early spring thaw. The spring months have about 2 to 2.5 inches of rain per month. This combined moisture usually enters into the soil in a period of about 2 weeks during the melt period, which is normally late February or March. This period gives the highest recharge. During the months of June, July, August and September, the evapotranspiration exceeds precipitation.

TABLE 3
MONTHLY PRECIPITATION NORMALS IN THE VICINITY OF THE RATHDRUM PRAIRIE AQUIFER, 1941-1980*

STATION	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	TOTAL
Coeur d'Alene	1.90	3.06	3.75	3.88	2.40	2.10	1.65	2.07	1.89	.74	1.24	1.11	25.79
Bayview Motel Basin	2.04	2.72	3.37	3.30	2.31	1.80	1.58	1.92	1.83	.82	1.23	1.28	24.20
Sandpoint	2.67	4.34	5.03	4.64	3.32	2.55	2.08	2.30	2.13	1.01	1.57	1.69	33.33

*Source: Climatology of the United States No. 81, National Oceanic and Atmospheric Administration, September 1982.

The climate in the mountains, east of the aquifer and in the watershed that drains into the aquifer, is mainly humid Mediterranean bordering on Continental. The mountains receive 24 to 80 inches of precipitation. Precipitation from November through April is in the form of snow. Snow on south slopes melts off in early spring, with snow on north slopes melting later, providing stream flow into the summer months. The maximum snowmelt period is April and May.

Soil Formation

Soils are a product of an interaction between the kinds of parent material from which they are formed, the climate and the biological conditions under which they developed. Topography and total development time are critical factors in soil development. Nearly all of the soils on the Rathdrum Prairie Aquifer formed in loess containing volcanic ash which overlies extremely gravelly sand that was deposited during a catastrophic flood event during the glacial melt period. These alluvial deposits are known as the “Missoula Flood Deposits.” The soil characteristics are discussed generally with the more detailed descriptions of the soils in the appendix.

Soil Thickness and Slopes

The soil depth and thickness of the soil column are important to water storage and contaminant retention and decomposition. Soils of the Rathdrum Prairie Aquifer are typically gravelly or very gravelly silt loam or loam that overlies extremely gravelly sand C-horizon at depths of 29 to 40 inches. Small areas in swales and toes of slopes are deeper than 40 inches to the loose, extremely gravelly sand. On some convex ridges, there are small areas where the depth to the loose, extremely gravelly sand is less than 20 inches.

Most of the Rathdrum Prairie is nearly level (0-2 percent) to moderately sloping (2-7 percent); and in these areas, most of the water infiltrates rather than runs off, except when the ground is frozen. A few steeper areas along drainageways and foothills have some runoff. The steeper the slope, the greater the runoff.

Soil Texture

Soil texture affects the amount of water, nutrients and potential contaminants that the soil can store.

The surface soil textures are mainly silt loams or gravelly silt loams. The silt contains a high amount of volcanic ash that has weathered to allophane can hold more moisture than soils without the ash.

Drainage and Permeability

Nearly all of the soils are well or excessively well-drained. A few small areas adjacent to streams or some concave areas are wetter.

Soil permeability (or rates that water moves through the soil) is mainly moderate in the soil and rapid or very rapid in the underlying extremely gravelly sand. There are no significant limiting layers or clay layers to interrupt the downward movement of water and contaminants.

Soil Reaction (pH) and Cation Exchange Capacity

Soil reaction (pH) and cation exchange are important soil characteristics that affect the ability of soil to store nutrients and potential contaminants. The soil pH ranges from 5.6 to 7.4. Most of the underlying extremely gravelly sand has pH values of 6.6 to 7.4. The upper two to four feet of the underlying extremely gravelly sand has iron coatings on the sand and gravel particles. These coatings may mostly immobilize phosphorus and some heavy metals.

The cation exchange capacity (CEC) of soils refers to the soil capacity to store or release positively charged ions (cations). The CEC is determined by soil properties such as organic matter content, clay content, kind of clay and allophane. Most of these soils are medium or high in organic matter and also have a large amount of volcanic ash that has weathered to allophane, in the silt and thus have high or very high CEC.

Organic Matter

Soils in this area generally contain 1 to 4 percent organic matter. Organic matter content of the soil is important to the control of surface water and subsurface water pollution. Organic matter in the surface soil tends to promote aggregation and improve soil tilth. Soils with high organic matter have a higher capacity for storing water, thus reducing the leaching of water containing contaminants. Infiltration of water into soils is generally greater if there is aggregation, thus reducing runoff and erosion. Organic matter also has a high CEC, thus increasing the ability of the soil to store nutrients and potential contaminants. Contaminants such as some pesticides biologically decompose more readily in soils with high organic matter.

Summary of Soil Characteristics

The major soil units of the Rathdrum Prairie Aquifer are: (1) Kootenai-Bonner association and (2) Avonville-Garrison-McGuire association (Figure 6). These soils and characteristics are discussed in more detail in the Appendix 1.

The soils of the Rathdrum Prairie provide some protection from the normal application of pesticides and most fertilizers. The surface soils have a high cation exchange capacity due to the organic matter and allophane content. Cationic contamination, such as heavy metals and fertilizers will likely be sorbed or attenuated within the soil. The allophane will retain phosphorus. Excessive application rates of chemical or spills could possibly result in some material moving through the soil into the underlying extremely gravelly material. Because there are no limiting layers, the material has the potential of being leached into the groundwater. Excessive nitrates applied as fertilizer will migrate through the soils with the soil water. These soils will generally treat the pathogens in septic tank effluent, but the nitrates will not be contained and can potentially leach into the groundwater.

The potential is high for the late winter and early spring melt water and precipitation to migrate through the soil and recharge the groundwater. Any residual pesticide and fertilizer that is water soluble will potentially leach with the migrating soil water. Some persistent organic chemicals may move through the soil into the subsurface.

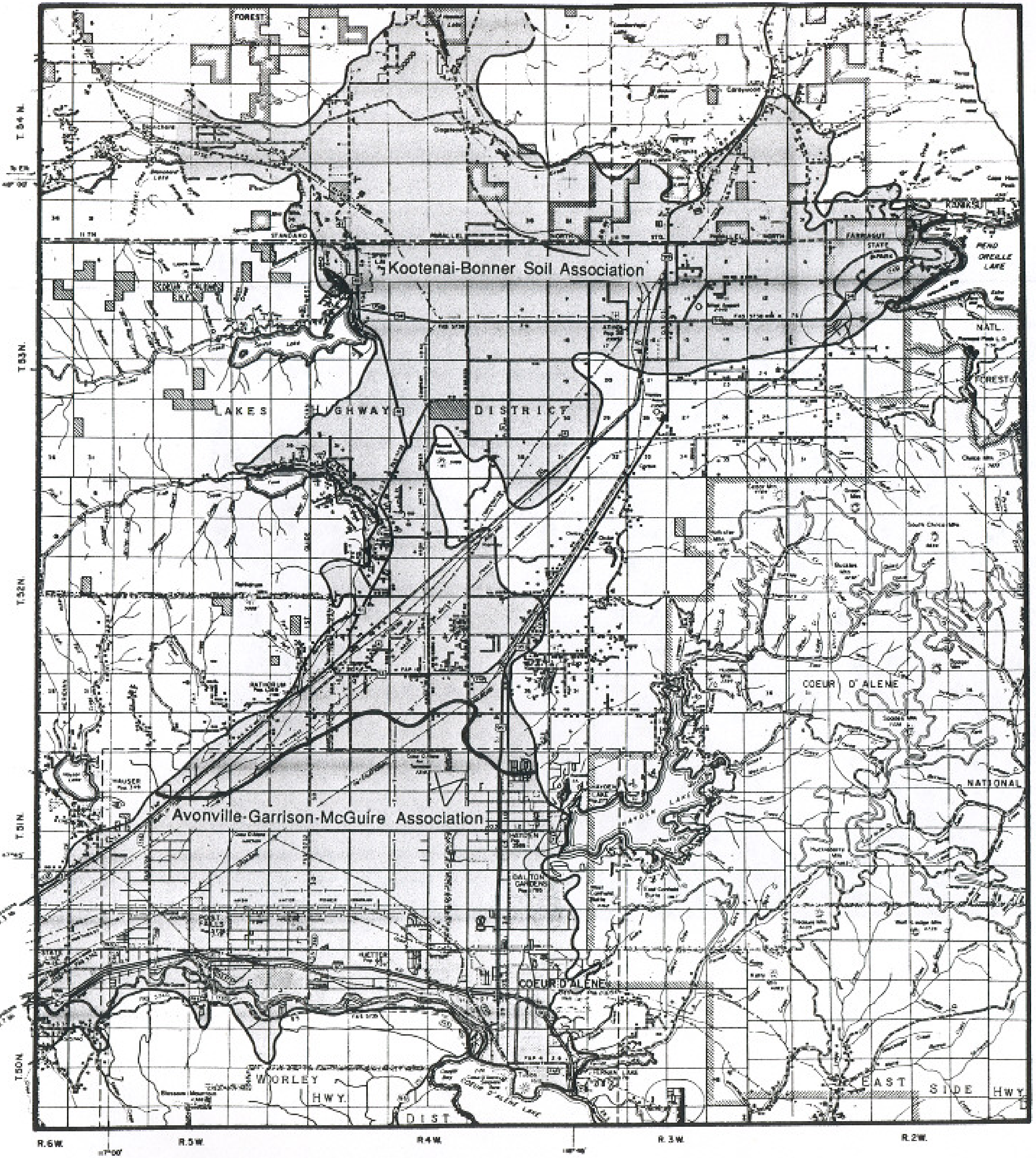


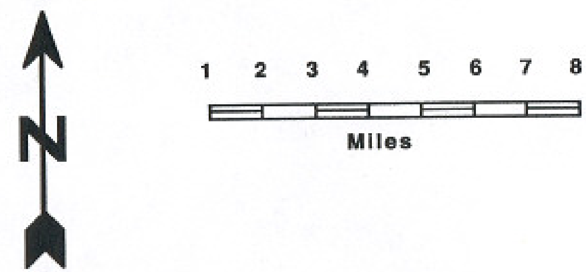
FIGURE 6. Map of Rathdrum Prairie Aquifer Showing Soil Dristributation

Explanation

☐ Rathdrum Prairie Aquifer

Kootenai-Bonner Soil Association: Well-drained soils formed in glacial outwash mantled with loess and volcanic ash.

Avonville-Garrison-McGuire Association: Well-drained to excessively well-drained soils formed in glacial outwash with a mantle of loess and volcanic ash.



Base Map: General Highway Map of Kootenai County, Idaho Department of Transportation.

Soil Information from Soil Conservation Service General Soils Map.

Chapter 5. Land Use and Groundwater Use

The Rathdrum Prairie extends east and then northeast from the Washington state line to northern Kootenai County, Idaho. Kootenai County is the geographic population and commercial center of the five northern counties of Idaho. Nine principal municipalities are located on the boundary of the Rathdrum Prairie Aquifer which covers 283 square miles. The prairie varies from 5 to 17 miles in width and is bounded on both sides by mountainous terrain and numerous lakes. Roughly half (69,000) of the people in northern Idaho live in Kootenai County and the majority of these (over 80 percent) live on the broad long prairie covering the north end of the county between two mountain ranges. Table 4 summarizes population distribution and shows growth characteristics in the area. The population of Kootenai County has doubled from 1970 to 1985. The county is dotted with small towns around the perimeter of the prairie with the majority of growth occurring along the Spokane River and north of Coeur d’Alene. The two largest towns, Coeur d’Alene and Post Falls, are within two miles of each other and Hayden and Dalton Gardens are less than a mile north of Coeur d’Alene.

Since 1980, the population growth has shifted back into the towns with 56% of the populace living in incorporated areas. The largest percent of growth occurred in Post Falls and Hayden.

TABLE 4
MAJOR POPULATION CENTERS IN KOOTENAI COUNTY
POPULATION SUMMARY, 1970-1985*

INCORPORATED COMMUNITY	POPULATION 1970	1975	1980	1985	PERCENT INCREASE (‘70-`85)
Athol	190	231	309	286	51
Hayden Lake	260	302	270	306	18
Hauser	349	433	306	294	-16
Spirit Lake	622	730	830	806	30
Rathdrum	741	957	1,319	1,629	120
Hayden	1,285	1,711	2,353	3,362	162
Dalton Gardens	1,559	1,867	1,779	1,955	25
Coeur d’Alene	16,228	17,994	19,434	23,700	46
	23,605	28,255	32,206	38,933	

Prins and Lustig, 1987.

Except for the southern and eastern perimeter of the prairie, which is occupied by a series of small- to moderate-sized towns with interconnecting transportation arteries, the majority of the prairie surface is utilized for agricultural purposes, primarily the growing of grass seed and hay crops, with a number of small- to medium-sized cattle ranches. Irrigation in these agricultural areas are from both surface and groundwater sources.

The Spokane River, which flows along the southern perimeter of the aquifer, is the only major watercourse on the prairie. Along its length are four major lumber mills and several plywood and veneer plants. These mills process logs hauled from the adjacent mountains. These lands are held predominantly by the U.S. Forest Service, state Department of Lands with some private ownership by timber companies.

The lumber, logging and agricultural industries are the mainstays of the economy, supplemented by the seasonal tourist recreational industry. The summer tourist trade is centered on the six major lakes around the edges of the prairie. Primarily, there are summer homes and fishing cabin resorts with an assortment of scout and church summer camps. These lakes supply fresh water for a variety of recreational activities as well as drinking water supplies.

Groundwater is nearly the sole source of water supply for agricultural and domestic users on the Rathdrum Prairie. All nine municipalities and an assortment of independent water districts obtain a majority of their water supply from the aquifer providing domestic, commercial and light industrial water supply to almost 55,000 people. The East Greenacres Irrigation District has several clusters of turbine wells that supply irrigation water to hundreds of square miles of grass seed growing farms. There are hundreds of individual wells serving small unincorporated areas and individual farms and ranches.

In 1975, the U.S. Geological Survey estimated that public water suppliers pumped approximately 1.2 billion gallons of water from the Rathdrum Prairie Aquifer. This served approximately 33,400 people with water for domestic, irrigation and industrial purposes.

Chapter 6. Groundwater Quality

Groundwater quality is affected by such factors as source of recharge, residence time in aquifer, geologic nature of the aquifer and unsaturated zone, and man's activity over recharge areas. The major recharges to the Rathdrum Prairie are valley underflow from tributary valleys and lakes, seepage from the Spokane River and infiltration from precipitation, irrigation, and wastewater disposal.

Infiltration is probably the most common groundwater contamination mechanism. Precipitation slowly infiltrates the soil through pore spaces in the soil matrix. As water percolates downward, it dissolves and mixes with material it comes in contact with. These dissolved contaminants, or leachate, continue to migrate downward until they reach the water table. Upon reaching the water table, the leachate will move in the direction of groundwater flow. This leachate may be a result of the dissolution of man-caused contaminants or the groundwater may become mineralized due to contact with the aquifer materials.

Direct migration occurs when contaminants directly enter the groundwater system from underground sources (e.g., storage tanks, injection wells, improperly installed septic systems) which lie in the saturated zone or seasonally saturated zone. Greater concentrations of contaminants occur from these sources and, therefore, groundwater vulnerability is much more acute.

Individual polluted groundwater sites generally are not large but, once polluted, groundwater may remain in an unusable or even hazardous condition for decades or even centuries. The comparatively low velocity of groundwater prevents a great deal of mixing and dilution. Consequently, a contaminant plume may maintain a high concentration as it slowly moves from points of recharge to zones of discharge.

The Idaho Regulations for Public Drinking Water Systems (July 1985, adopted from the federal standards under the Safe Drinking Water Act) established requirements for the chemical and bacteriological analysis of all public drinking waters on a routine, regular basis. Table 5 lists the required primary parameters for analysis by public water systems.

The mobility of groundwater contamination is determined by the velocity of groundwater, the solubility of the contaminant and the physical and chemical characteristics of the aquifer. Other factors which affect the quality of water used for drinking water supplies are total dissolved solids, microbial pathogens, organic chemicals and metals.

Total Dissolved Solids

Dissolved solids are a result of total mineral content in water. Dissolved solids consist mainly of the cations (calcium, magnesium, potassium and sodium) and anions (bicarbonate, carbonate, chloride, fluoride, nitrate and sulfate), plus silica (Parliman, et al. 1980). Total dissolved solids greater than 500 milligrams per liter (mg/l) (secondary drinking water standards) are not recommended for drinking water.

TABLE 5
SAFE DRINKING WATER ACT
PRIMARY DRINKING WATER STANDARDS

SUBSTANCE*	MAXIMUM ALLOWABLE CONCENTRATIONS MG/L
Arsenic	0.050
Barium	1.000
Cadmium	0.010
Chromium	0.050
Cyanide	0.200
Fluoride	4.000
Lead	0.050
Mercury	0.002
Nitrate (as N)	10.000
Selenium	0.010
Silver	0.050
Sodium	No maximum – suggested 20 as an optimum

SECONDARY QUALITY STANDARDS

CHARACTERISTIC	LIMIT
pH	6.5-8.5
Temperature	80° F.
Color	15 Units
Threshold odor number	3
Foaming Agents	0.5 mg/l
Copper	1 mg/l
Chloride	250 mg/l
Hydrogen Sulfide	0.05 mg/l
Iron	0.3 mg/l
Manganese	0.05 mg/l
Phenols	0.001 mg/l
Sulfate	250 mg/l
Total Dissolved Solids	500 mg/l
Zinc	5 mg/l
Coliform bacteria	less than 1 per 100 ml

*For each inorganic chemical shown, the limit is expressed as a total laboratory measurement.

TABLE 5 (CONCLUDED)
NATIONAL PRIMARY DRINKING WATER STANDARDS*
FOR VOLATILE ORGANIC CHEMICALS (VOCs)

VOC	Maximum Contaminant Level (mg/l)
Trichloroethylene	0.005
Carbon Tetrachloride	0.005
Vinyl Chloride	0.002
1,2 - Dichloroethane	0.005
Benzene	0.005
para-Dichloroethylene	0.075
1,1 - Dichloroethylene	0.007
1,1,1 - Trichloroethane	0.2

*Rules published in Federal Register, July 8, 1987 (52 FR 25690).

Source: Idaho Regulations for Public Drinking Water Standards, 1985.

Water hardness is caused mainly by calcium and magnesium dissolved in water. hardness is express in mg/l of calcium carbonate ($CaCO_3$). Hardness is a measure of the soap consuming potential of water. Calcium and magnesium react with soap to form precipitates of calcium and magnesium. After the reaction is complete, the remaining soap is available to produce lather.

Hardness in domestic water is generally not objectionable at concentration less than 100 mg/l (Parliman, et al. 1980). Hard water is generally not a health problem but may create an economic problem if water softening is necessary. The total dissolved solids of the Rathdrum Prairie Aquifer range from 42 to 220 with a median of 152 making it suitable for all uses (Graham and Campbell, 1981).

Microbial Pathogens

Microbial contamination occurs from a variety of sources which include septic systems, leaking sewers, livestock and log yard waste. State drinking water standards set a maximum for coliform bacteria of less than 1 colony per 100 ml. Public water systems regularly test for this microbe. The presence of coliforms may mean that other microbial pathogens (e.g., giardia and salmonella) are present in the water supply.

Groundwater monitoring is required for all systems which supply community drinking water. The U.S. Geological Survey conducted a water quality survey from 1975 to 1981. The Panhandle District Health Department additionally monitors 28 wells on a quarterly basis with analysis performed by the Idaho Department of Health and Welfare.

Because the depth of the water table is greater than 100 feet over most of the aquifer and as much as 400 feet in places, overall contamination of the aquifer by coliform bacteria is unlikely. Analysis by Drost and Seitz (1978), Parliman et al. (1981) and the Panhandle Health District (ongoing) show that the groundwater of the Rathdrum Prairie Aquifer only rarely tests positive for coliform bacteria. Where bacterial contamination of groundwater has occurred, it was generally found to be a result of improperly site or designed septic systems or poor well construction.

Organic Chemicals

A multitude of organic chemicals has been synthesized for home, industry and agriculture use. There are thousands in use today with more being added each year. There are no adopted drinking water standards for most organic chemicals. The EPA has recently begun regulating some volatile organic chemicals (VOCs) under the Safe Drinking Water Act, amended in 1986, (see Table 5, page 24). Table 6 lists some common organic compounds and their main use.

In the summer of 1975, a gasoline-like odor and frothy effervescence appeared in water from a Coeur d’Alene public supply well. Samples collected contained benzene, toluene and other organic compounds commonly found in gasoline. The source of the contamination was never definitely established, but possible sources include gasoline station drains which lead to a storm sewer about 1,000 feet from the supply well and a reported accidental dumping of about 500 gallons of gasoline into a dry well in the vicinity of the public supply well (Drost and Seitz, 1978).

Sampling of selected wells from 1981 to 1987 by the Panhandle District Health Department indicates the presence of minor amounts of volatile organic compounds in the Rathdrum Prairie Aquifer (Appendix 2). The fact that these compounds are present at all indicates the susceptibility of the aquifer to contamination.

Inorganics

Concerns over health effects of inorganics has focused on nitrate and heavy metal concentrations such as mercury, lead and cadmium. Nitrate (NO_3 as N) is the end product of the aerobic stabilization of organic nitrogen. Natural sources of nitrogen are minor contributors of nitrogen to most groundwater (Parliman, et al. 1983). The major contributors of nitrate contamination of groundwater include effluent from septic tank drainfields, excessive fertilizer application and runoff from feedlots and dairies. Appendix 2 lists the analytical results of groundwater testing from wells in the Rathdrum Prairie Aquifer over the last 15 years. (Parliman, et al. 1980) concluded that background levels of nitrate in the Rathdrum Prairie Aquifer are 0.5 mg/l. Yee and Souza (1984) summarized the existing statewide nitrate data (Table 7).

Parliman and Whitehead (1979) prioritized Idaho’s aquifers based upon the sources of potential pollution, groundwater use and population. They made their assessment on hydrologic units. Those units are surface features which define general recharge areas for aquifers. Applying the same rating system directly to major aquifers, their potential for pollution can be determined. These aquifers, ranked in priority, are shown in Figure 7. Aquifers ranked first are those with the greatest potential for pollution (IDHW, 1985).

TABLE 6
TOXIC OR HAZARDOUS COMPONENTS OF COMMON PRODUCTS

Product	Toxic or Hazardous Components
Antifreeze (gasoline or coolant systems)	Methanol, ethylene glycol
Automatic transmission fluid	Petroleum distillates, xylene
Battery acid (electrolyte)	Sulfuric acid
Degreasers for driveways and garages	Petroleum solvents, alcohols, glycol ethers, chlorinated hydrocarbons, tuluene, phenols, dichloroperchloro-ethylene
Engine and radiator flushes	Petroleum solvents, ketones, butanol, glycol ethers
Hydraulic fluid (including brake fluid)	Hydrocarbons, fluorocarbons
Motor oils and waste oils	Hydrocarbons
Gasoline and jet fuel	Hydrocarbons, benzene, toluene, xylene
Diesel fuel, kerosene, #2 heating oil	Hydrocarbons
Other petroleum products: grease, lubes	Hydrocarbons
Rustproofers	Phenols, heavy metals
Carwash detergent	Alkyl benzene sulfonates
Asphalt and roofing tar	Petroleum distillates, hydrocarbons
Paints, varnishes, stains, dyes	Heavy metals, toluene
Paint and laquer thinners	Acetone, benzene, toluene, butyl acetate, methyl ketones
Paint and varnish removers, deglossers	Methylene chloride, toluene, acetone, xylene ethanol, benzene, methanol
Paint brush cleaners	Hydrocarbons, toluene, acetone, methyl ethyl ketones, methanol, glycol ethers
Floor and furniture strippers	Xylene
Metal polishes	Petroleum distillates, petroleum naphtha, isopropanol
Laundry soil and stain removers	Petroleum distillates, tetrachloroethylene
Spot removers and dry cleaning fluids	Hydrocarbons, benzene, trichloroethylene, 1,1,1 trichloroethylene
Other cleaning solvents	Pure strength benzene, acetone
Rock salt (halite)	Sodium concentration
Refrigerants	1,1,2 trichloro-1,2,2 trifluoroethane
Bug and tar removers	Petroleum distillates, xylene
Household cleaners, oven cleaners	Xylenols, glycol ethers, isopropanol
Drain cleaners	1,1,1 trichloroethane

TABLE 6 (CONCLUDED)

Product	Toxic or Hazardous Components
Toilet cleaners	Xylene, sulfonates, cholorinated phenols
Cesspool cleaners	Tetrachloroethylene, dichlorobenzene, methylene chloride
Disinfectants	Cresol, xylenols
Pesticides (insects, weeds, rodents)	Naphthalene, Phosphorus, xylene, chloroform, heavy metals, chlorinated hydrocarbons
Photochemicals	Phenols, sodium sulfite, cyanide, silver halide, potassium bromide
Printing ink	Heavy metals, phenol-formaldehyde
Wood preservatives (creosote or salt)	Pentachlorophenols, copper, arsenic, chromium
Swimming pool chlorine	Sodium hypochlorate
Lye or caustic soda	Sodium hydroxide
Jewelry cleaners	Sodium cyanide
Leather dyes	Formic acid
Fertilizers	Arsenic, nitrates, ammonium, sulfuric acid, heavy metals, formaldehyde, phosphoric acid, chlorinated hydrocarbons
Polychlorinated Biphenyls (PCBs)	Chlorinated hydrocarbons
Carbon tetrachloride	Chlorinated hydrocarbons

SOURCE: Horsley, 1986

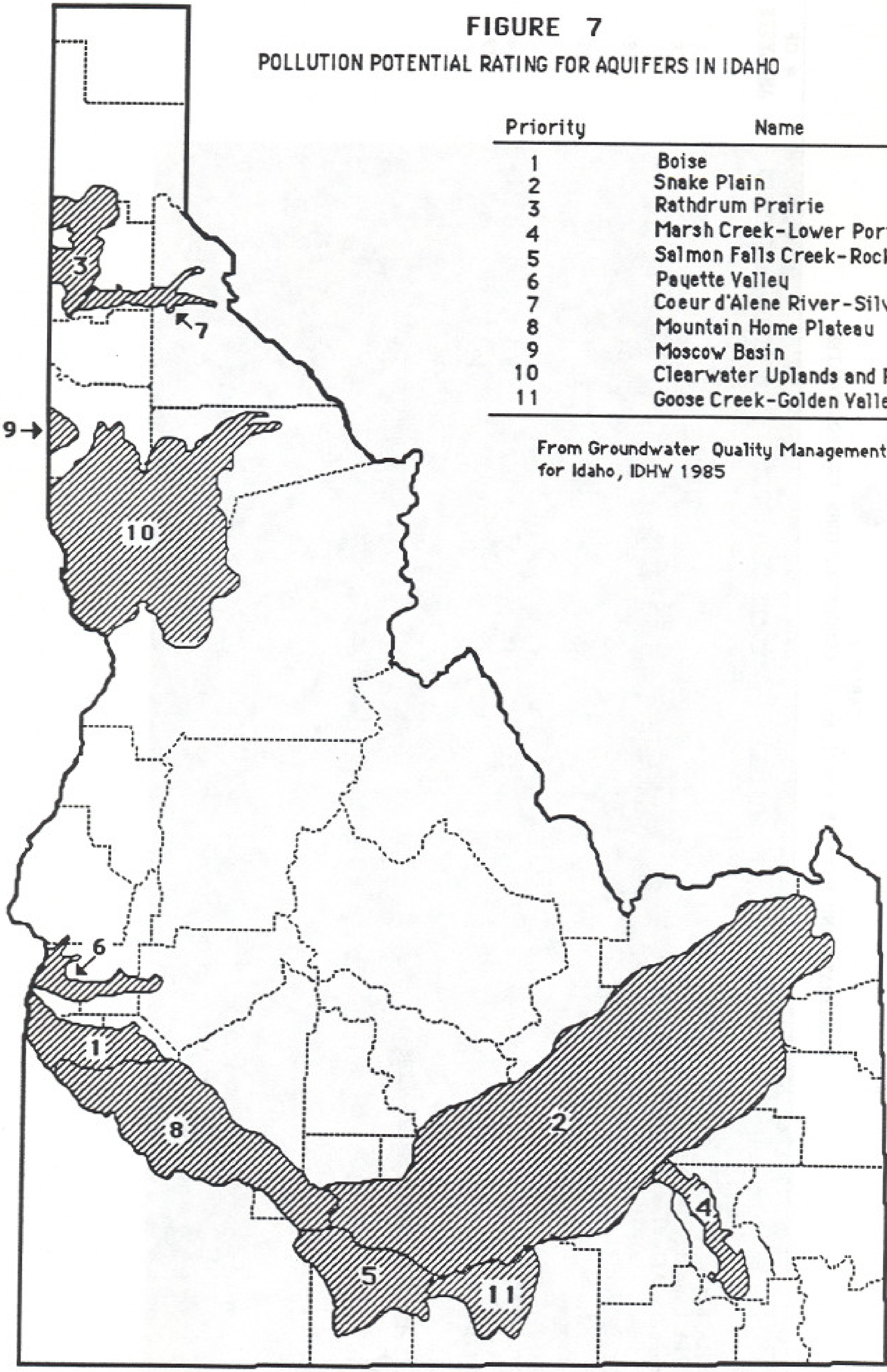
TABLE 7
NITRATE AND NITRITE (MG/L AS N) CONCENTRATIONS IN GROUNDWATER

	AQUIFER REFERENCE FROM FIGURE 7	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	# OF ANALYSIS
Panhandle Basin							
Glacial Deposits	3	0.1	25	0.1	0.7	2.7	84
Quaternary Alluvium	7	0.1	0.47	0.2	0.21	0.18	8
Columbia River Basalt	9, 10	0.0	9.4		0.32		68
Boise-Nampa	1	0.4	10.5	2.6			31
Eastern Snake Plain							
Snake River Basalt	2	0.1	13	1.1	1.3	1.1	214
Quaternary Sediments	2	0.02	19	0.8	2.3	4.1	29

(Modified for Yee and Souza, 1984)

FIGURE 7

POLLUTION POTENTIAL RATING FOR AQUIFERS IN IDAHO



Priority	Name
1	Boise
2	Snake Plain
3	Rathdrum Prairie
4	Marsh Creek-Lower Portneuf
5	Salmon Falls Creek-Rock Creek
6	Payette Valley
7	Coeur d'Alene River-Silver Valley
8	Mountain Home Plateau
9	Moscow Basin
10	Clearwater Uplands and Plateau
11	Goose Creek-Golden Valley

From Groundwater Quality Management Plan for Idaho, IDHW 1985

Elevated levels of nitrate in groundwater have traditionally been considered the first component of sewage contamination or excessive fertilizer application. This is due to the fact that nitrate is extremely stable, soluble in water, and highly mobile.

In a 1977 study, Jones and Lustig reported elevated levels of nitrate in the Rathdrum Prairie Aquifer over a background level of 0.5 mg/l (adjusted from NO_3 to NO_3 as N). The well monitoring program of this study showed that specific high nitrate values were located down-gradient from Post Falls, Dalton Gardens and Coeur d'Alene. All of these areas have experienced intense population growth during the years 1970 to 1976, utilizing individual subsurface sewage disposal methods exclusively. This trend was not apparent in wells located in agricultural areas where there were no intervening housing developments.

The Spokane 208 study concluded that 60 percent of the contaminant loading in the Spokane Valley Aquifer was due to subsurface sewage systems and 40 percent to diverse nonpoint sources, such as storm water (Miller and Esvelt, 1978).

Appendix 2 gives specific nitrate values of the Rathdrum Prairie Aquifer. While these numbers are below the drinking water standard of 10 mg/l, they do show the aquifer is susceptible to nitrate contamination.

Elevated levels of zinc (.10 to .60 mg/l) in the Spokane River and Coeur d'Alene Lake raised concern over heavy metal concentrations in the Rathdrum Prairie Aquifer. The Silver Valley mining district lies in the drainage basin of Lake Coeur d'Alene. For about 80 years, the South Fork of the Coeur d'Alene River received mining wastes which were carried into Coeur d'Alene Lake (Seitz and Jones, 1981). Funk (1975), and Seitz and Jones (1981) and the Panhandle Health District studied the relationship of water quality of the Rathdrum Prairie Aquifer and the Spokane River-Coeur d'Alene Lake surface waters. While the Idaho State Water Quality Standards were not exceeded, elevated values of heavy metals do exist in some surface waters. Groundwater sampling indicates trace metal (lead, mercury, zinc, arsenic and cadmium) concentrations are beneath the detection limit in the Rathdrum Prairie Aquifer proximal to these surface water sources. It is generally believed that much of the metals contained in the surface water are exchanged and held by the fine grained lake and river sediments.

In 1978, Drost and Seitz concluded that the Spokane Valley-Rathdrum Prairie Aquifer yields good quality of water. On the Washington side of the aquifer, approximately one-half of 1 percent of the samples (9,723 analysis) showed values of contaminants which exceeded the drinking water standards. Among the contaminants involved were phenols, diesel fuel, gasoline, nitrate and dissolved solids. The Rathdrum Prairie component of the aquifer showed results from eleven wells which met or slightly exceeded the drinking water standards of total dissolved solids, nitrates (4 wells) and zinc (1 well). Additional sampling by Parliman (et al. 1980) and the Panhandle District Health Department (Appendix 2) indicates that while the aquifer generally supplies good quality of drinking water, minor levels of contaminants are nonetheless present. The current monitoring network provides generalized information on water quality of the aquifer. Local variations in water quality may exist and there is potential for these monitoring wells to be unaffected by contaminant plumes.

Chapter 7. Potential Contamination Sources

Groundwater quality can be affected by both natural and man-influenced activities. The Rathdrum Prairie Aquifer is particularly susceptible to surface activities because of the highly porous and permeable nature of the aquifer and overlying unsaturated zone. The pollution potential of this aquifer is intensified by the extensive and diffuse population growth that has occurred in the last 15 years. The main area of concern has been focused on contamination from individual septic tank systems. With the highly permeable sand and gravel underlying the prairie, percolation from these septic tank drain fields has caused increased nitrate levels in the groundwater in some areas of the region. Other potential contaminant sources do exist on the prairie, and the fact that nitrate contamination has been documented (Jones and Lustig, 1977) indicates that prudent management of this aquifer is imperative.

With the adoption of the Groundwater Quality Management Plan for Idaho (Martin, 1983; updated 1985), the Department of Health and Welfare's Division of Environment began a comprehensive groundwater quality management plan. The following list of potential contamination sources is modified from the 1985 Groundwater Quality Management Plan for Idaho:

I. Agriculture Chemicals
II. Surface Runoff/Drywells
III. Petroleum Handling and Storage
IV. Landfills
V. Hazardous Materials, Transportation and Spills
VI. Subsurface Sewage Disposal Systems
VII. Industrial Wastewater
VIII. Land Application of Sludges and Septage
IX. Pits, Ponds and Lagoons
X. Dairies and Feedlots
XI. Potential Water Quality Problems from Radioactivity
XII. Silvicultural Activities
XIII. Well Drilling
XIV. Mining

I. Agricultural Chemicals

Agricultural activities over the aquifer consist of dry-land and irrigated farming. Total acreage in cropland is about 26,000 acres, which comprises 20 percent of the area of the aquifer. Two-thirds of this land is under irrigated agriculture. The amount of irrigated acreage is expected to increase in the future.

The major crops grown over the aquifer are bluegrass (8,000 acres), wheat (5,000 acres), barley and oats (5,000 acres) dry peas and beans (3,000 acres) and alfalfa (minor). Agricultural Conservation Reserves over the aquifer are between 3,000 and 4,000 acres. Seventy-five percent of the gross agricultural revenue is derived from bluegrass, wheat, barley and oats.

The chemicals that are applied to agricultural lands can be divided into two categories: fertilizers and pesticides. The major nutrients that are applied in fertilizers are nitrogen, phosphorus, potassium and sulfur. Micronutrients such as trace metals are infrequently applied and then only in minimal quantities. Typical application rates are shown below in Table 8.

TABLE 8
FERTILIZER APPLICATION RATES FOR AGRICULTURAL LANDS OF THE RATHDRUM PRAIRIE AQUIFER

CROP TYPE	NITROGEN (lb./acre as N)	PHOSPHORUS (lb./acre as P_2O_5)	SULFUR (lb./acres as S)
Bluegrass	130-180	80	20-25
Wheat	180-200	75-80	20-25
Oats and Barley	130	50	15-20
Peas and Beans	40	50	20

Lustig, et al. (1986)

Nitrates are the end product of the aerobic stabilization of organic nitrogen; and as such, they occur in polluted waters that have undergone self-purification or aerobic treatment processes. Nitrates also occur in percolating groundwaters as a result of excessive application of fertilizer or leachings from septic tank drainfields (Brower, 1986). Data from Jones and Lustig (1977) indicate that high mean nitrate levels were found in areas beneath or immediately down-gradient from these areas that have experienced intense housing growth between 1970-1977 and utilize individual subsurface sewage disposal systems exclusively. This trend is not apparent in wells located in agricultural areas nor in areas immediately downstream from strictly agricultural areas where there are not intervening housing developments.

Agricultural chemicals applied to cropland for pest control include insecticides, herbicides and fungicides. In the Rathdrum Prairie, agricultural use of herbicides and fungicides exceeds the limited use of insecticides. In addition to agricultural land, pesticides are also used for roadside weed control, aquatic weed control in surface water bodies and on private residential land.

No single agency tracks the quantity of pest control products sold and the acreage to which they are applied. Consequently, quantitative data on pesticide use are not available. Table 9, which is based on data from the Panhandle Health Department and the Idaho Department of Agriculture, shows the major products that are used on agricultural land in the prairie.

TABLE 9
HERBICIDE AND FUNGICIDE APPLICATIONS ACCORDING TO CROP TYPE

BLUEGRASS	WHEAT	OATS AND BARLEY	PEAS AND BEANS
MCPA*	2,4-D*	2,4-D*	Treflan*
Ductril*	MCPA*	MCPA*	Fargo*
Bronate*	Glean	Glean	Dinoseb*
Banvel*	Banvel*	Banvel*	Pre-emerge
	Mertect		
	Baleton		
	Roundup		

*Pesticides on EPA list of leachable pest control chemicals, Cohen et al., 1984.

To help identify those pest control products that may be sufficiently mobile in soil to be leached into groundwater, EPA has developed a list of products with the greatest potential to impact groundwater (Cohen et al., 1984). This list is based on characteristics such as water solubility, persistence and soil mobility. Of the major pesticides used on the Rathdrum Prairie, several are on this list, as noted by an asterisk in Table 9. To further evaluate the extent of use of leachable pesticides in Idaho, a survey was conducted in 1986 as a cooperative effort between the Idaho Water Quality Bureau, the Idaho Department of Agriculture and the University of Idaho Cooperative Extension Service. Table 10 below shows the number of pesticides used on various crops grown in Kootenai County.

In spite of limitations on rates of applications of pesticides based on environmental persistence and mobility, recent groundwater monitoring studies in other states have shown that some pesticides have leached in significant quantities into groundwater. This leaching occurs even under normal and accepted agricultural practices (Cohen et al., 1984). The potential for groundwater contamination is dependent on soil structure, soil chemistry, recharge rate and depth to groundwater. An assessment of the

TABLE 10
NUMBER OF LEACHABLE PESTICIDES USED ACCORDING TO CROP TYPE

CROP TYPE	NUMBER OF LEACHABLE PESTICIDES
Bluegrass	3
Wheat	13
Barley	12
Oats	8
Peas	10
Alfalfa	14

Idaho Water Quality Bureau, unpublished data, 1986

likelihood of groundwater contamination by pesticides from agricultural practices in the Rathdrum Prairie has not been conducted at this time. Groundwater monitoring has not been conducted to determine whether a problem exists.

The disposal of pesticide waste products represents another area of concern. Waste products include pesticide containers, excess spray and wash water generated by pesticide applicators. For proper disposal, pesticide containers are required to be triple rinsed, punctured or crushed to prevent reuse and disposed of at an approved landfill.

II. Surface Runoff/Drywells

Formal storm water collection is fairly limited because of the general lack of necessity. The highly permeable gravel outwash of the prairie is extremely receptive to accepting rain or snow runoff. In the majority of the area, surface runoff from highways and county roads is discharged into open fields or drainageways. The only really formal storm water collection system is associated with the City of Coeur d'Alene. The remaining small towns and subdivisions that experience periodic flooding or runoff due to frozen ground have traditionally established grated sumps at the lower elevations using dry wells inserted below the frost line as the receiving chamber. Some components of runoff are contained in Table 11.

In northern Idaho, there have not been any studies on the quality of storm water runoff from urban areas, but data available from the Spokane Aquifer Management Office, Spokane County Engineers may closely parallel future results from the Idaho Panhandle, since geologically and geographically the areas are similar. This data is contained in Table 12.

Storm waters are dispersed of in the City of Coeur d'Alene almost entirely via a separate storm sewer system. According to the City of Coeur d'Alene Engineer's Office, there are only 10 to 15 old dry well sumps left where storm water dissipates into the ground. These are situated in the northeast corner of the city.

TABLE 11
COMPONENTS OF URBAN RUNOFF

Domestic garbage	Animal and bird fecal matter
Eroded soil	Construction debris
Road and parking lot material (e.g., gasoline, oil and antifreeze)	Air pollution fallout
Leaves and lawn litter	Fertilizers
Salt and de-icers	Insecticides/herbicides

TABLE 12*
FLOW-WEIGHTED AVERAGE CONCENTRATIONS
FOR SELECTED CONTAMINANTS IN STORM WATER RUNOFF

	FLOW-WEIGHTED CONCENTRATION -- mg/l			ANNUAL CONTAMINANT LOADING – lb./Acre		
LAND USE CONTAMINANT	RESIDEN-TIAL	COMMER-CIAL	INDUST-RIAL	RESIDEN-TIAL	COMMER-CIAL	INDUST-RIAL
Total Dissolved Solids	44.00	182.00	113.00	149.00	629.00	558.00
Chemical Oxygen Demand	89.00	215.00	271.00	283.00	742.00	1,338.00
Total Organic Carbon	17.10	29.00	39.90	58.00	100.00	197.00
Total Phosphorus	0.28	0.39	0.70	0.93	1.34	3.48
Total Kjeldahl Nitrogen	1.65	2.30	2.31	5.58	7.94	11.40
Nitrate-Nitrogen	0.79	0.83	0.78	2.30	2.20	3.10
Chloride	2.12	62.50	23.60	5.80	129.00	76.00
Calcium	8.20	31.40	16.50	27.80	108.00	81.60
Sodium	1.39	16.48	14.88	4.70	56.90	73.50
Copper	0.02	0.04	0.07	0.05	0.13	0.35
Lead	0.04	0.40	0.53	0.15	1.39	2.63
Zinc	0.06	0.29	0.30	0.20	1.00	1.48

*Final report prepared under contract 82-087 between Washington State Department of Ecology and Spokane County.

The collected storm waters are discharged into Coeur d’Alene Lake at various outlet points. A portion of this collection system consists of unlined trenches, which allows for subsurface infiltration. In the northwest section of Coeur d’Alene, the storm water is discharged into the Spokane River or infiltrates into the subsurface when the ground is not frozen.

The storm water and urban runoff for Post Falls is either discharged into the old abandoned Greenacres irrigation canal (unlined) or discharged into the sumps below the frost line.

The Lakes Highway District and Airport use sumps and dry wells to dissipate storm water.

The sands and gravels of the Rathdrum Prairie Aquifer have accommodated the use of shallow injection wells (dry wells) for storm water because of their high permeability. The most current estimate of the number of these disposal structures over the aquifer is 374 (Graham and Campbell, 1987). The Department of Water Resources is charged with administering the Idaho injection well program under Title 42, Chapter 39, of the Idaho Code. Other common disposal methods are gravel-filled trenches and borrow ditches which allow water to percolate into the porous subsoils or evaporate.

Innovative solutions to disposal of storm water generally consist of variations of the use of grassy swales or vegetated open space to treat and absorb storm water runoff. Data generated by the Spokane County Aquifer Water Quality Management Program suggests that the first portions of a storm water runoff flow contain the largest amount of contaminants and that these can be effectively removed by filtration through the root zones of vegetated disposal areas (Miller, 1984). This practice has only been tried on a limited scale on commercial parking lots in northern Idaho. The potential may exist for degradation of the Rathdrum Prairie Aquifer from storm water runoff if future development continues at an intensive pace and large amounts of land are paved.

III. Petroleum Handling and Storage

Petroleum storage and handling in the Rathdrum Prairie represents a potential source of groundwater contamination. Activities involving petroleum are diverse and include the following:

1. Bulk storage including aboveground and underground tanks
2. Pipelines
3. Transportation via highway and railroad
4. Various handling and transfer practices include tank facilities.

Petroleum Storage

Petroleum is stored in aboveground and underground tanks. Both types of tanks are regulated under the Uniform Fire Code, which is administered locally by the State Fire Marshal and the local fire departments. Aboveground tanks are required by the code to be surrounded by a bermed containment area to retain spills or leaks. Permits for installation, abandonment and tank testing in the suspicion of a leak are required for underground tanks.

Underground tanks pose the greatest threat to groundwater from petroleum sources. Corrosion of buried tanks or associated piping results in leaks that may remain undetected until groundwater contamination has occurred. To reduce this threat to groundwater, Congress passed legislation in 1984 and amended the Resource Conservation and Recovery Act to require that regulations be developed to promote improved leak detection and leak prevention practices. The first step in the new program was the requirement that an inventory be made of all underground tanks. This information was reported by tank owners to the Idaho Water Quality Bureau. As of February 1987, 187 owners have reported on 513 tanks in Kootenai County. The oldest tank that was reported was installed in 1936. The mean tank age is 26 years and the median age is 13 years. Tanks are generally designed to last for 20 years. Most of the tanks in Idaho have been installed without protection from corrosion or systems to readily detect leaks. Given the age of the underground storage tanks in Kootenai County, it is possible that there have been many leaks that have gone undetected.

The federal legislation also required that regulations be developed to address tank installation, leak detection and monitoring and cleanup procedures. A draft of the federal regulations was released for public comment in April 1987. The final regulations are due in August 1988.

It was Congress's intention that states develop similar programs and assume the responsibility for enforcing the new program. To this end, a state advisory committee for underground storage tanks has been formed; and the process of drafting Idaho's program is underway. Final promulgation is expected in 1989. This new program will be developed and administered in conjunction with local fire officials and will greatly enhance prevention and early detection of leaks.

The Idaho Water Quality Bureau maintains a log of contamination incidents that have impacted or potentially could impact groundwater. Over the ten-year period of record of the contamination log, eight incidents involving losses from leaking underground storage tanks or piping were reported over the aquifer. One affected a public drinking water supply well, one contaminated a private well, two contaminated groundwater and there were four spills that were retained in the soils and did not reach groundwater. (Idaho Water Quality Bureau, unpublished data, 1988).

Pipelines

Thirteen miles of the Yellowstone oil and gas pipelines traverse the southern portion of the Rathdrum Prairie Aquifer. Two types of problems are associated with pipelines. In spite of the requirements for cathodic protection, periodic pressure testing and frequent surveillance, leaks may occur. Secondly, surface activities such as construction and grading of roads may rupture the pipeline due to its shallow cover. Losses of product associated with pipeline leaks may be greater than from storage tanks or other accidents due to the large volume of petroleum conveyed by the pipeline. Such a leak occurred eight miles east of Coeur d'Alene in 1983. Twenty-two thousand gallons of unleaded gasoline were reported to have been lost (Idaho Water Quality Bureau, unpublished data, 1983). Careful surveillance and maintenance are required to minimize this threat to the groundwater in the Rathdrum Prairie Aquifer.

Transmission lines for natural gas are located in urban areas throughout the Rathdrum Prairie. However, a leak or rupture of a natural gas line would not be likely to impact groundwater. The gas would be expected to diffuse upward through the soils and be lost to the atmosphere.

Transportation

Aboveground transportation of petroleum involves the entire extent of the road network over the aquifer as well as the railroad lines. Most commonly, losses of petroleum are due to accidents involving tanker trucks or railroad tank cars. The Water Quality Bureau's contamination log shows four such accidents over the last ten years resulting in minor and moderate releases. While releases are always a threat to groundwater due to the permeable nature of the soils in the Prairie, no detectable groundwater contamination has yet been associated with these incidents. The U.S. Department of Transportation regulates all transportation of petroleum products including pipelines. There are no provisions within these regulations that specifically address prevention of groundwater contamination.

Handling and Transfer Practices

The final category, petroleum handling, includes the numerous procedures for filling tanks and transferring petroleum between storage facilities. Carelessness and human error are the most frequent causes of petroleum spills of this type. A common problem is the overfilling of tanks during delivery. Two minor incidents of this type are reported in the contamination log to have occurred in the Rathdrum Prairie. The new regulations for underground tanks, that were previously mentioned, will require that all tanks be equipped to prevent overfill losses.

IV. Landfills

Landfills on the Rathdrum Prairie Aquifer receive wastes primarily from small industry, agriculture and municipal household sources. Since the aquifer is not protected by impermeable soil layers from precipitation that percolates through the solid waste, it is susceptible to contamination from landfill activities. Almost any material that is placed in a disposal site above the aquifer poses a threat of contamination to the water underlying the site. Some of the typical leachate constituents are contained in Table 13.

TABLE 13
TYPICAL CHARACTERISTICS OF LANDFILL LEACHATES

PARAMETER	NATIONAL LEACHATES[1] (mg/l)	IDAHO LEACHATES[2] (mg/l)
Alkalinity	-	74-13,600
Ammonia	-	0.28-480
BOD	9-54,610	to 14,000
COD	1-89,520	-
Chloride	1-2,800	106-1,020
Copper	1-9.9	0.09-40
Hardness	1-22,800	168-4,800
Iron	1-5,500	2-995
Lead	1-5.0	.01-100
Phosphate	1-154	to 0.031
Potassium	2.8-3,770	to 325
Sodium	1-7,700	25-550

[1]EPA, 1977
[2]Bureau of Hazardous Materials, unpublished material 1987.

There are two active landfills over the Rathdrum Prairie Aquifer and nine dumps or landfills that have been covered but are still capable of producing leachate (Figure 8). The two active landfills are operated by Kootenai County. The cover material used was natural soil consisting of loam and sandy loams. The abandoned sites are in diverse ownership. The landfills over the aquifer are summarized in Table 14 along with the quantities of solid waste that they receive or have received. None of the landfills have leachate collection or control systems. The total amount of solid waste deposited annually is approximately 80,000 tons at the two active sanitary landfills.

TABLE 14
SUMMARY OF LANDFILLS AND ABANDONED SOLID WASTE DISPOSAL FACILITIES OVER THE RATHDRUM PRAIRIE AQUIFER

FACILITY	AREA ACRES	DEPTH IN FEET	TONS/ DAY	YEARS IN USE	STATUS
Kootenai Co.--Ramsey Road	25	50	153.8	19	Active
Kootenai Co.--Granite	20	30	71.3	13	Active
Pleasantview Landfill	3	15	-	3	Closed
------- Active 1970-1973---------					
Port of Entry Landfill	4	15	-	Unknown	Closed
Spirit Lake Dump	1	5	-	Unknown	Closed
Rathdrum Dump	3	10	-	Unknown	Closed
Bayview/Farragut Dump	15	40	-	Unknown	Closed
Garwood	15	20	-	3	Closed
Blackwell Island Dump	15	10	-	Unknown	Closed
Howard Street Dump	10	10	-	Unknown	Closed

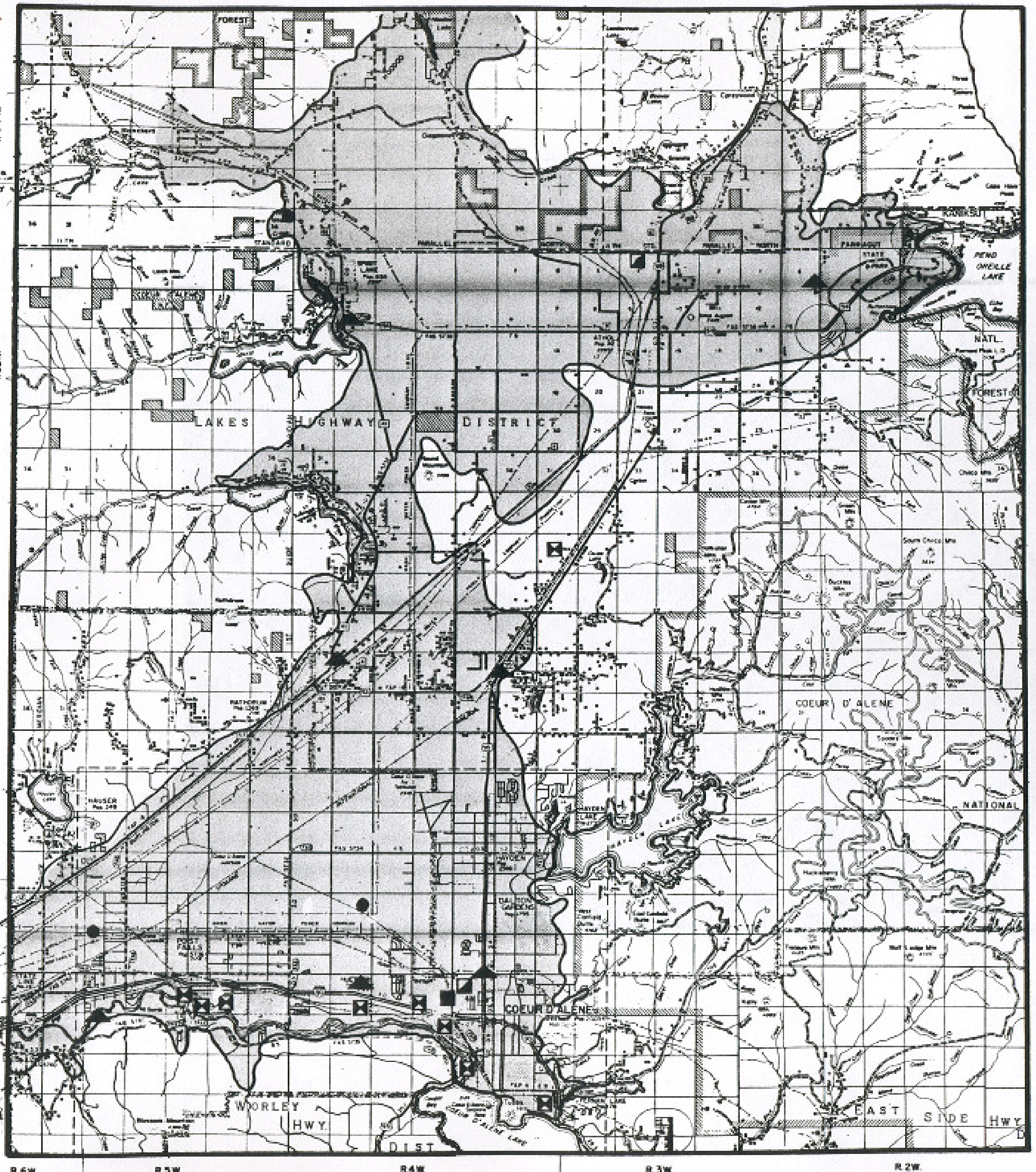


FIGURE 8: Map of Rathdrum Prairie Aquifer Showing locations of Landfills, Dumps, Dairies, and Timber Processing Plants

Explanation

- Rathdrum Prairie Aquifer
- Active Landfill
- Inactive Landfill
- Dump - covered landfill of unknown size an no specifications on material used t
- Dairy
- Timber Processing Plant

(locations are approximate)

N

1 2 3 4 5 6 7

Miles

Base Map: General Highway Map of Kootenai County, Idah
Data From Panhandle Health District

Maximum contaminant levels (MCLs) have not been exceeded in water samples taken near the Ramsey Road landfills. A study commissioned by Kootenai County suggests that there is a possibility of a dilute leachate plume moving northwesterly from the Ramsey site and, although no specific data is available, they urge that the landfill be closed and capped at the earliest possible opportunity (Esvelt Environmental Engineering, 1985). Relocation of the landfill is currently being intensely studied by Kootenai County and is one of their highest priorities. Site selection has been narrowed from 24 down to 3 sites. Proper closing and capping of the entire landfill will slow down or eliminate leachate from reaching the water table. Solid waste regulations are currently being written for the siting and closing of sanitary landfills.

V. Hazardous Materials, Transportation and Spills

Contamination of groundwater by toxic or hazardous chemicals has been reported nationwide and has caused the closing of both public and private wells. Hazardous wastes are defined on the basis of ignitability, corrosivity, reactivity and toxicity. Congress has given the EPA authority to establish and enforce standards and regulations to protect and clean up groundwater.

The Resource Conservation and recovery Act (RCRA), originally passed in 1976, regulates the management of active hazardous waste treatment, storage and disposal facilities (e.g., tanks, lagoons, landfills). Permits issued by RCRA specify concentration limits in groundwater, which if exceeded, trigger corrective action to remediate the release of hazardous wastes from a facility. Hazardous constituents must comply with RCRA groundwater protection standards based on one of the following: background levels, maximum contaminant levels (MCLs) as set by the Safe Drinking Water Act, or alternate concentration limits (ACLs). New regulations are added frequently.

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund), passed into law in December 1980, is principally concerned with the cleanup of toxic releases of uncontrolled or abandoned hazardous waste sites. The program provides for the identification of sites from which releases of hazardous substances into the environment might occur. The National Priorities List (NPL) names sites that are eligible for cleanup under Superfund, as rated by the Hazardous Ranking System. Even if a site is not on the NPL but poses immediate risk to health or environment, it can be cleaned up through a CERCLA removal action.

The Superfund Amendments and Reauthorization Act (SARA), signed into law in October 1986, is a five year extension of the Superfund program. SARA also creates a separate fund for cleanup of leaking underground storage tanks containing petroleum. An important part of SARA is Title III or emergency planning and community right-to-know. Title III establishes requirements for federal, state and local governments regarding emergency planning and community right-to-know reporting on hazardous and toxic chemicals. The community right-to-know provisions of Title III will help to increase the public's knowledge and access to information about the presence of hazardous chemicals in their communities and their potential release into the environment.

The Safe Drinking Water Act, initially enacted in 1974 and amended in 1986, established national drinking water standards and regulations to protect human health from contaminants. The federal Sole Source Aquifer program is authorized under the Safe Drinking Water Act.

The Wellhead Protection Program, introduced in the 1986 amendments to the Safe Drinking Water Act, authorizes EPA to make grants to states for developing and implementing protection programs for public wells and recharge areas. Programs would identify potential threats to groundwater within wellhead areas and outlines measures for protecting wells.

A major provision within RCRA for addressing potential groundwater contamination is the State Hazardous Waste Site Inventory Program mandated by Section 3012. This program, which is implemented through Superfund, involves the compilation of a list of sites at which hazardous wastes have at any time been stored or disposed of. As site investigations occur, determinations of no hazard to the public or the environment result in removal from the list. A determination of a significant potential problem results in further investigation. Action under RCRA or CERCLA (Superfund), depending on ownership and financial solvency, may ensue.

The Idaho Water Quality Standards and Wastewater Treatment Requirements (Idaho Department of Health and Welfare 1985) regulates the storage, disposal and accidental release of hazardous and deleterious materials. The Idaho Division of Environmental Quality is charged with enforcement of the various regulations. Permits are required to treat, store and dispose of hazardous wastes. Plans for land disposal of hazardous wastes must specifically address the protection of groundwater. For all land disposal facilities, groundwater monitoring is required. Monitoring is required for up to 30 years after the closure of a disposal facility to ensure that no contamination occurs.

There are 31 sites on EPA's Region X RCRA list where hazardous wastes are either generated, transported, stored or disposed of. The fact that a site is on the RCRA list does not imply a threat of groundwater contamination. Pollution risk is reduced because of the accountability imposed by RCRA. Table 15 provides a breakdown of RCRA sites over the Rathdrum Prairie Aquifer.

TABLE 15
RCRA SITES OVER THE RATHDRUM PRAIRIE AQUIFER[+]

TYPE OF PRODUCT	CITY	GENERATOR*	TRANSPORTION	STORAGE OR DISPOSAL
Gas and oil	Athol	2		
Forest products	Coeur d'Alene	2		
Electronics	Coeur d'Alene	2		
Auto body	Coeur d'Alene	1		
Auto body	Coeur d'Alene	2		
Solvents	Coeur d'Alene	2		
Auto body	Coeur d'Alene	1		
Electronics	Coeur d'Alene	2		
Highway chemicals	Coeur d'Alene	2		
	Coeur d'Alene	2		
Forest products	Coeur d'Alene		X	X
Auto body	Coeur d'Alene	2		
Solvents	Coeur d'Alene	1		
Gas	Coeur d'Alene		X	X
Dry cleaner	Coeur d'Alene	2		
Aluminum casting	Hayden Lake			X
Wood preservatives	Hayden Lake	2	X	
Electronics	Hayden Lake	1		
Gas and oil	Post Falls		X	
Forest products	Post Falls	2		
Forest products	Post Falls		X	
Forest products	Post Falls	2		
Electronics	Post Falls	2		
Fertilizer	Rathdrum		X	X
EPA	Rathdrum		X	X
Solvents	Rathdrum	1	X	X
Electronics	Rathdrum	2		
Solvents	Rathdrum	1	X	

[+] From EPA's Region X RCRA list.
*1 = less than 1,000 kg.
2 = greater than 1,000 kg.

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund) authorizes the federal government to respond directly to releases or threatened releases of hazardous substances that may present an imminent or substantial danger to public health, welfare or environment. A review of EPA Region X's CERCLA list identifies three sites over the Rathdrum Prairie Aquifer that is under Superfund investigation. A site contained on this list has either known or alleged environmental contamination by a hazardous substance(s).

Located north of Hayden, a wood preservative operation has allegedly contaminated the soil with chromated copper arsenate and other wood preservatives. This site is currently undergoing a preliminary assessment to determine the extent, if any, of contamination. Additional soil and water samples will be taken to determine the future course of action.

A site located one-half mile from a Coeur d'Alene public water supply well is another Superfund site currently undergoing a preliminary assessment. Toxic, corrosive and persistent substances (i.e., chromic acid, trichloroethylene, sulfuric acid and a cyanide stripper solution) were allegedly disposed of in a drain field or allowed to percolate into the ground. Further sampling will determine if remedial action is required at this site.

A site located three miles north of Rathdrum, Idaho, is currently on CERCLA's national priority list (NPL). At this site, a company was engaged in the recycling of waste oil prior to 1982. These waste oils were contaminated with organic solvents including chloroform, benzene, toluene, xylene, acetone, methylene chloride, tetrachloroethane, ethyl benzene and polychlorinated biphenyls. This 1.2 acre site is located over the Rathdrum Prairie Aquifer. The depth of water is about 135 feet deep. Approximately 6,300 people obtain drinking water from public and private wells within three miles of the site. The site was abandoned in 1982 by the operators. In 1983, the EPA removed 9,700 gallons of contaminated oil from storage tanks on the site. In May 1987, the oil-contaminated soil was removed from the site. Cleanup appears to be complete, and an additional assessment will determine if the site can be removed from the National Priority List (NPL). There has been no apparent contamination of groundwater from this site.

The following is EPA's listing of hazardous household waste:

Household cleaners:
- Drain openers (C)
- Oven cleaners (C)
- Wood and metal cleaners and polishes (I)
- Toilet bowl cleaners (C)
- General purpose cleaners (C or I)
- Disinfectants (C or I)

Automotive products:
- Oil and fuel additives (I or E)
- Grease and rust solvents (I)
- Carburetor cleaners (I)
- Starter fluids (I)
- General lubricating fluids (I)
- Radiator fluids or additives (I)
- Waxes, polishes and cleaners (I or C)
- Body putty (I)
- Transmission additives (I)

Home maintenance products:
- Paint thinners (I)
- Paint strippers and removers (I)

Adhesives (I)
Paints (I)
Stains, varnishes and sealants (I)

Lawn and garden products:
- Herbicides (E)
- Pesticides (E)
- Fungicides or wood preservatives (E)

Miscellaneous:
- Batteries (E or C)
- Fingernail polish remover (I)
- Pool chemicals (R)
- Photo processing chemicals (E, C or I)
- Electronic items (E)

(I): Ignitable (R): Reactive
(C): Corrosive (E): Toxic

All these items have the potential for contaminating groundwater supplies. Direct disposal of these products into septic systems increases the vulnerability of the aquifer to contamination. It has already been shown that nitrates from septic systems are leaching into the aquifer (Chapter 6 and Lustig and Jones, 1977). It is widely accepted that nitrate contamination is the first sign of more serious pollution potential. Some hazardous wastes used in homes are potentially harmful in the parts-per-billion category (e.g., in IDHW's proposed groundwater standards, the limits set for tetrachloroethylene, a common automotive degreaser, is set at "none detectable").

Disposal of these products in a community sewer system only transfers the pollution problem to the community treatment facility.

There are no regulations in northern Idaho for the siting of facilities that use hazardous materials and there are no landfills in this region, which are approved for the disposal of hazardous wastes.

Transportation

The primary concern for groundwater quality related to transportation routes is the possibility of accidental release or spill of hazardous materials in transit. This concern is compounded on the Rathdrum Prairie Aquifer because of the extremely high permeability of the soils overlying the unprotected groundwater. Soluble materials could also be transported with percolating rainwater. Precipitation over the aquifer averages 26 inches per year (Table 3). Rapid cleanup of spilled materials and underlying contaminated soils is of primary concern in protecting the aquifer from hazardous material spills.

The primary transportation routes over the aquifer are as follows:

1. I-90 from Spokane through Coeur d'Alene.
2. Highway 95 from Bonner County through Coeur d'Alene.
3. Burlington Northern Railroad from Spokane to Bonner County.
4. Union Pacific Railroad from Spokane to Bonner County.

Secondary Highways 41 and 53 and numerous other country roads also cross the aquifer and are used for local deliveries of hazardous materials.

In a study conducted by William J. Kelley, of Eastern Washington University, it was shown that an average of 67 placarded hazardous materials trucks cross the Washington/Idaho border on I-90 each weekday; in addition, another 27 vehicles each weekday were shown to be carrying small quantities of hazardous materials, 1,000 pounds or less, and so were not required to bear hazardous material by placards. Major categories of bulk hazardous material by truck were as follows:

Flammable liquids (e.g., petroleum)	48%
Flammable gas	16%
Corrosives (e.g., sulfuric acid)	9%
Dangerous (e.g., magnesium pellets)	9%
Radioactive	5%
Explosives	9%
	90% of total

This study also estimated that 28 bulk freight cars (average of 165,000 pounds) of hazardous material were transported on the Burlington Northern and Union Pacific lines through Spokane County and the Idaho Panhandle. In addition, another 10 to 12 cars carry limited quantities of hazardous materials each day. Although Kelley's report showed over 100 different hazardous materials being transported by rail through the region, the greatest percentages were as follows:

LPG (propane)	35%
Anhydrous ammonia	12%
Sulfuric acid	7%
Caustic soda	6%
Ammonium nitrate	5%
	65% of total

Spills

Although significant advances in the packaging and transportation of hazardous materials have been made and continue to be made, accidents and resulting spills continue to occur. The Panhandle District Health Department and Division of Environmental Quality responds to 8 to 20 spills each year, and although no major spills have occurred over the aquifer, there is a possibility of groundwater contamination as a result of a hazardous material spill.

VI. Subsurface Sewage Disposal Systems

Subsurface sewage disposal over the Rathdrum Prairie is regulated, in general, by Idaho's Rules and Regulations for Individual Subsurface Sewage Disposal as adopted by the State Board of Health in October 1985, and specifically for the Rathdrum Aquifer by the Environmental Health Code of the Panhandle District Health Department as amended in October 1977. Septic System program is administered by the Panhandle Health District. The net effects of both sets of regulations are as follows:

1. Construction standards are established for septic tanks and drain fields (IDHW).

2. The depth of the new drain fields is limited to 48 inches (Panhandle Health Department PHD code).

3. Density of use is established at five acres per installation for areas that do not have a sewage management plan that will eventually lead to a community sewage disposal system (PHD code).

4. High-density use is permitted in managed areas to build populations great enough to support the construction of community collection disposal facilities (PHD code).

5. Industrial and commercial wastewater discharges through septic tanks are regulated and permitted only if toxic chemicals are not present and volumes of domestic wastes are low (PHD code).

To date, these regulations have been very effective because of their adaptability to the growth plans of the various municipalities over the aquifer. The potential for serious contamination of the groundwater from septic tanks, however, still exists. The cities of Athol, Coeur d'Alene, Dalton Gardens, Hauser, Hayden Lake, Huetter, Post Falls, Rathdrum, Bayview and Stateline still rely on subsurface sewage disposal to meet 50 to 100 percent of their sewage disposal needs (Table 16).

Many older cesspools and dry wells still exist and drain rapidly through the porous sands and gravels into the aquifer. These percentages are constantly changing as the municipalities become more sophisticated in the management of their wastewater. As of 1985 there was an estimated total of 14,233 septic systems over the Rathdrum Prairie. These systems serve an estimated population of 35,583 individuals (14,233 x 2.5 people per dwelling unit) and discharge an estimated 3,558,250 gallons per day (gpd) into the ground over the aquifer (14,233 x 250 gpd) (data from the PHD files). Table 17 illustrates the yearly total of septic tank systems since 1978.

TABLE 16
POPULATION OVER THE RATHDRUM PRAIRIE AQUIFER SERVED BY COMMUNITY SEWER SYSTEMS IN 1985

INCORPORATED COMMUNITY	POPULATION	POPULATION PERCENT SEWERED
Athol	286	0
Hayden Lake	306	0
Hauser	294	0
Spirit Lake	806	85
Rathdrum	1,629	0
Hayden	3,362	0
Dalton Gardens	1,955	0
Post Falls	6,595	30
Coeur d'Alene	23,700	46

Lustig, et al. 1986.

TABLE 17
EQUIVALENT RESIDENTIAL UNIT SUBSURFACE SYSTEMS INSTALLED BETWEEN 1978-1985
(Official Adoption of Panhandle Aquifer Regulations, Oct. 1977)

	TOTAL OVER AQUIFER	INSIDE SEWER MANAGEMENT AREAS	OUTSIDE SEWER MANAGEMENT AREAS
Total Pre-June 1978 (Estimate)	11,199	5,454 (49%)	5,745 (51%)
1978 (June-December)	410	265 (65%)	145 (35%)
1979	802	476 (59%)	326 (41%)
1980	385	241 (63%)	144 (37%)
1981	311	206 (66%)	105 (34%)
1982	161	91 (57%)	70 (43%)
1983	263	117 (45%)	146 (55%)
1984	320	179 (56%)	141 (44%)
1985	372	195 (52%)	177 (48%)
TOTAL (Since June 1978)	3,024	1,770 (58%)	1,254 (42%)
GRAND TOTAL	14,233	7,224 (51%)	6,999 (49%)

Source: Lustig, et al. 1986

The impact of septic tanks has been tied to the presence of nitrate in waters of the aquifer. Measurements conducted on a monthly basis from July 1975 through November 1976 and quarterly since then have documented an increase of nitrate contamination under areas where high-density septic tank use exists (Jones and Lustig, 1977). Table 18 lists some of the characteristics of septic tank effluent.

TABLE 18
TYPICAL SEPTIC TANK EFFLUENT CHARACTERISTICS

DETERMINATION	SEPTIC TANKS EFFLUENT VALVES
Bacteria per ml, Agar, 36°C, 24 hr.	76,000,000
Coliform group MPN (organism per 100 ml)	110,000,000
Color	3.5
Turbidity	50
Odor	4.5
pH	7.4
Temperature (°C)	17
BOD, 5-day (mg/l)	120-140
DO (mg/l)	0
DO saturation (%)	0
Nitrogen, total (mg/l)	36
Oxygen consumed (mg/l)	80
Chlorides (mg/l)	80
Alkalinity (mg/l)	400
Total solids (mg/l)	820
Suspended solids (mg/l)	101

Kreissl, 1978

Jones and Lustig (1977) showed that there was an increase in nitrate above historical background levels in areas experiencing rapid growths in population (Figure 9). Specific high nitrate levels and well locations were down-gradient from Post Falls, Coeur d'Alene and Dalton Gardens. All these areas had experienced rapid housing growth during the years 1970-1976, utilizing subsurface sewage disposal methods exclusively.

On October 11, 1977, the Panhandle District Health Department officially adopted the "Rathdrum Prairie Aquifer Regulations." These regulations state, in part, that (1) a minimum lot size of five acres is required for a septic system and (2) development would be allowed on lots less than five acres provided the land is located in an area programmed for a sewer system in compliance with a Sewage Management Agreement developed between the municipality and the Panhandle Health District Board of Health.

In certain instances, the aquifer tends to be more sensitive to impacts from subsurface sewage disposal than in others. A municipal well in Rathdrum was shut down after tests revealed nitrate levels in excess of MCLs for drinking water. Intensive septic tank usage in the city of Rathdrum is the probable source of the nitrate contamination.

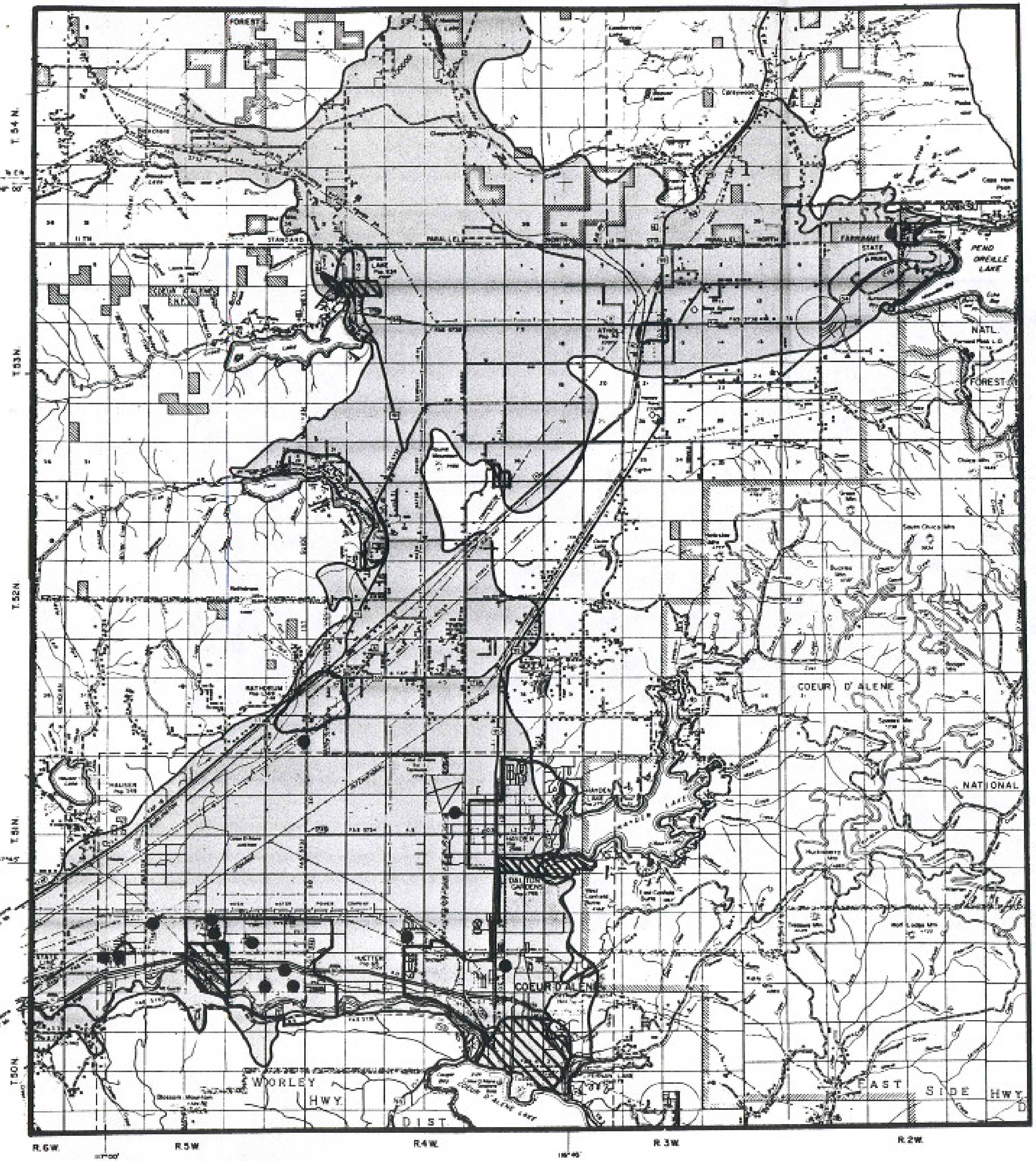


FIGURE 9: Map of Rathdrum Prairie Aquifer Showing Types of Sanitary Sewers in Use.

Explanation

- Rathdrum Prairie Aquifer
- Areas of High-Density Septic Tank Usage (approximately 1-5 dwellings/acre)
- Areas Serviced by Community Sewer Systems
- Septage Disposal Sites
- Monitoring Wells that Exceed 1 mg/l Nitrate as N (locations are approximate)

1 2 3 4 5 6 7 8

Miles

Base Map : General Highway Map of Kootenai, Idaho Department of Transportation

To address the problems created by the use of septic tanks, the State of Idaho, the Environmental Protection Agency and the local municipalities have spent over $16,000,000 on sewage treatment plants between 1975 and 1985. Table 19 details the distribution of these funds.

TABLE 19
FUNDS SPENT ON SEWAGE COLLECTION AND TREATEENT SYSTEMS
1975 THROUGH 1985

CITY	TOTAL	FEDERAL	STATE	CITY
Bayview	$ 35,000	$ 26,000	$ 5,000	$ 4,000
Coeur d'Alene	6,400,000	4,061,000	85,000	2,254,000
Hayden	446,000	26,000	210,000	210,000
Post Falls	8,820,000	6,310,000	870,000	1,640,000
Rathdrum	20,000	_	15,000	5,000
TOTAL	$15,721,000	$10,423,000	$1,185,000	$4,113,000

ADDITIONAL FUNDS PROVIDED TO THE HAYDEN/HAYDEN LAKE
REGIONAL TREATMENT FACILITIES

TOTAL	KOOTENAI COUNTY	EPA GRANT	BLOCK GRANT
$437,000	$52,000	$55,000	$330,000

(Lustig, et al. 1986)

Septic tanks are, and probably will continue to be, used for wastewater management over the aquifer, particularly in the more rural areas.

Domestic wastewater is applied to soils over the aquifer through both individual and community wastewater disposal systems. A community wastewater disposal system is one that will treat 2,000 gallons or more of sewage per day. Engineered plans and specifications for such facilities are reviewed by the Division of Environmental Quality as required under Section 39-118 of Idaho Code.

Treatment is usually done in subsurface drain fields or by land application on the surface. There are three typical community wastewater disposal systems utilized on the Rathdrum Prairie Aquifer. They are as follows:

1. Individual septic tanks from which effluent is collected by gravity and/or pressure lines. The effluent is disposed of in community absorption beds or drain fields.

2. Collection of raw sewage from individual homes to large community septic tank(s). Effluent disposal is to a drain field.

3. Raw sewage is collected by gravity lines and treated in one or more aerated or facultative lagoons. The lagoons are designed for approximately nine months of storage during fall, spring and winter. During the summer, the lagoon level is lowered by land application of effluent using irrigation sprinklers. Crop produced is cut or removed and used as cattle feed.

Table 20 lists community sewage disposal systems that are sited over the Rathdrum Prairie Aquifer or those that are sited on the margins and could have an influence on the aquifer. Sewage systems in the Hayden Lake area were connected to the Hayden Lake Regional Sewer District (HLRSD) treatment plant in November 1987, when it was completed. This plant is a mechanical treatment plant with discharge to an interim drain field near the Coeur d'Alene Air Terminal and is designed for 750 connections. Within a couple of years, outfall design will be completed, and discharge will be to the Spokane River.

TABLE 20
COMMUNITY SEWAGE DISPOSAL SYSTEMS OVER THE RATHDRUM PRAIRIE AQUIFER

SYSTEM NAME	TREATMENT	DISPOSAL	CONNECTIONS DESIGN	CONNECTIONS ACTUAL
Avondale 6th Addn*	ST	DF	41	30
Loch Haven Hills*	ST	DF	100	70
Twin Lakes Village	ST	DF	306	154
YJ's Slaughterhouse	ST/ABC/SED	LA	**	
Willow Creek Mobile Home Park	IT	DF	134	45
Woodland Heights*	ST	DF	200	150
City of Spirit Lake	LA	LA	375	225
Hayden Lake*	ST	DF	750	0

IT – Imhoff tank (upright septic tank)
ST – Septic tank
DF – Drain field
LA – Land application
ABC – Rotating biological contactor
SED – Sedimentation
*Systems will eventually connect to the Hayden Lake regional wastewater treatment plant.
**Flow is variable and dependent upon activity.

VII. Industrial Wastewater

The major and virtually sole sources of industrial wastewater discharges on the Rathdrum Prairie are from the lumber mills and associated industries. These consist of point sources of water that are introduced onto or into the Rathdrum Prairie. The inventory of industrial sites was conducted in conjunction with the Idaho Department of Health and Welfare, which has jurisdictional responsibility for industrial wastewater management. There are quite a number of discharges from any single mill. They consist of boiler conditioning water, runoff from log decks, cooling, etc. Because of limitation imposed upon the mills by the EPA National Pollution Discharge Elimination System (NPDES) permits, an increasing amount of land disposal of wastes can be expected as the mills attempt to come into compliance. This does not necessarily mean that the mills are degrading the groundwater, because very little is known about the movement of complex organic compounds through the soil. The mills inventoried were:

1. Potlatch Forest Industry Rutledge Mill east of Coeur d'Alene.
2. The DeArmond Stud Mill near the Coeur d'Alene sewage treatment plant.
3. Northwest Timber near Northwest Boulevard and Lincoln Way.
4. Idaho Forest Industries on old U.S. 10 west of Coeur d'Alene.
5. The Diamond Mill on the Spokane River near Huetter.
6. The Potlatch Forest Industry particle board plant near Post Falls.
7. The Idaho Veneer Plant in Post Falls.
8. The Louisiana Pacific Mill in Post Falls.
9. The Louisiana Pacific Mill in Chilco.
10. The Louisiana Pacific Waferwood Plant at Chilco.

Other industrial activity on the Rathdrum Prairie includes two post and pole wood treating plants located in Sec. 18, T52, R3 and the Coeur d'Alene Industrial Park. Both areas have potential for groundwater contamination because of the highly permeable soils and the nature of materials used in the various operations.

VIII. <u>Land Application of Sludges and Septage</u>

Prior to January 1979, septage (the contents of septic tanks) disposal occurred at the Coeur d'Alene Wastewater Treatment Plant. However, at that time, the City of Coeur d'Alene decided to no longer accept septage at their treatment plant, and alternative disposal methods had to be established. With no other treatment plants available land application at privately owned sites was the only alternative available and two such sites came into existence (Figure 9). One site is located partially over the aquifer, and both are immediately adjacent to the aquifer boundaries established by the USGS, and are therefore included in this discussion. Both sites incorporate lagooning of wastes for winter operation and land spreading for summer operation. Sludge (the solids left after dewatering sewage treatment lagoons) is also land spread in the summer. Together both sites have a combined maximum septage loading of 3.3 million gallons per year. For the one area partially over the aquifer, septage application rates, summer only, are limited to the nitrogen uptake of cover crops, which is approximately 36,000 gallons of septage per acre per year for grass fields. Application rates for land spreading on those areas not over the aquifer are limited by solids loading at 62,000 gallons septage per acre per year. It is estimated that less than 15 pounds per acre per year of nitrogen loss to groundwater should occur from these loading rates. Table 21 gives common characteristics of septage.

TABLE 21*
SEPTAGE CHARACTERISTICS

All values in mg/l unless indicated.

PARAMETER	MEAN	STD DEV	RANGE	NO. SAMPLES
TS (total solids)	38,800	23,700	3,600-106,000	25
TVS (total volatile solids), % OF TS	65.1	11.3	32-81	22
SS (suspended solids)	13,014	6,020	1,770-22,600	15
VSS (volatile suspended solids), % OF SS	67.0	9.3	51-85	15
BOD_5 (biological oxygen demand)	5,000	4,570	1,460-18,600	13
COD_T (chemical oxygen demand, total)	42,850	36,950	2,200-190,000	37
COD_S (chemical oxygen demand, solids)	2,570(.06 COD_T)	-	-	21
TOC (total organic carbon)	9,930	6,990	1,316-18,400	9
TKN (total Kjeldahl nitrogen)	677	427	66-1,560	37
NH_3-N (ammonia)	157	120	6-385	25
Total P (phosphorus)	253	178	24-760	37
pH (units)	6.9 (median)	-	6.0-8.8	25
Grease	9,090	6,530	604-23,468	17
Fe	205	184	3-750	37
Zn	49.0	40.2	4.5-153	38
Al	48	61	2-200	9
Pb	8.4	12.7	1.5-31	5
Cu	6.4	8.3	0.3-38	19
Mn	5.02	6.25	0.5-32	38
Cr	1.07	0.64	0.3-2.2	12
Ni	0.90	0.59	0.2-3.7	34
Cd	0.71	2.17	0.05-10.8	24
Hg	0.28	0.79	.0002-4.0	35
As	0.16	0.18	0.03-0.5	12
Se	0.076	0.074	0.02-0.3	13

*Handbook of Septage Treatment and Disposal, EPA, 1984.

IX. Pits, Ponds and Lagoons

For the most part, discussion of pits, ponds and lagoons has been included in other sections of this plan. There is only one community sewage treatment lagoon located over the aquifer, and it is listed in Table 14 of the section entitled “Land Application of Wastewater From Community Sewage Systems.” Pits created from the sand and gravel extraction operations are discussed in the section entitled “Mining.”

In the past, some lumber mills have utilized pits or ponds for soaking of logs or disposal of glue, resins, blowdown water, etc. Due to nearby well contamination with fecal coliform, the Chilco waferwood plant has installed concrete-lined tanks for this purpose. The extent and status of disposal at other mills located over the aquifer is not known at this time.

Pits have been used in the past for disposal of various products from activities in the Coeur d'Alene Industrial Park/Coeur d'Alene Airport area. Some of these industrial activities have since ceased to exist, and others have been connected to sewers. Therefore, extent of disposal from these activities is also not known at this time.

X. Dairies and Feedlots

There are six dairies, one cattle-holding operation and numerous small individual sheep, cattle and horse operations located over the aquifer. These are located mainly on the west and north portion of the aquifer.

It has been estimated that a single cow can generate 11 to 12 tons of manure per year; 80 percent of this is in liquid form. The bacterial count of manure for one cow per a 24-hour period can be as high as 5.4 billion fecal coliforms and 13 billion fecal streptococci (Kreissl, 1978).

The Idaho Department of Health and Welfare, Bureau of Water Quality, has published the Idaho Waste Management Guidelines for Concentrated Animal Feeding Operations (Nautch, 1987). The purpose of this document is to provide operators and regulators with generally accepted waste management practices and design criteria for control options that prevent water pollution. The guidelines are also intended to assist operators in complying with federal and state regulations. The EPA has begun issuing National Pollutant Discharge Elimination System (NPDES) permits to regulate surface discharges from some of the larger concentrated animal feeding operations in Idaho.

XI. Potential Water Quality Problems From Radioactivity

Radioactive materials may enter the waters of the Rathdrum Prairie Aquifer from natural or human sources. Radionuclides used at educational and medical facilities are strictly regulated by the Bureau of Hazardous Materials and should not be a source of aquifer contamination in properly handled.

Of the natural sources of radiation, radon 222 in aquifer waters may play a significant part in the very high levels of radon 222 found in homes over the Rathdrum Prairie Aquifer. In the Bonneville Power Administration weatherization program, over 13,000 homes were tested for indoor air pollutants. Radon was found to be above 5 pCi/l in many areas of the Northwest. Further studies implemented by the

Panhandle District Health Department found houses with the highest readings in the State of Idaho are located over the Rathdrum Prairie-Spokane Aquifer. The source of radon is probably underlying uranium-bearing granite or, more likely, uranium-bearing granitic gravels glacially derived from an unknown source in Canada. Radon has been found in water supplies in other parts of the United States and Europe. The main problem associated with radioactivity in groundwater is the high radon concentration in the air of dwellings where radon-rich household water is used. Radon entrained in the groundwater may be a contributing factor in the elevated radon levels of some homes built over the aquifer.

Prichard and Gesell (1983) reported that radon 222 in domestic water supplies can be an important source of radon in the indoor atmosphere, producing an increment of 1 pCi/l in the indoor air for every 10,000 pCi/l in the water.

While drinking water standards do not address radon levels, the Pennsylvania Department of Health has estimated that a person drinking water with 20,000 pCi/l of radon 222 would have a 0.2 percent chance of terminal stomach cancer.

XII. Silvicultural Activities

Silvicultural activities are limited over the aquifer. With shallow, well-drained soils, timber production is slow and predominately lodgepole pine. There were approximately 50,500 acres in timber on the aquifer as of 1977.

Of potential concern to aquifer management are silvicultural activities on land surrounding the aquifer. These steep, forested, slopes produce significant quantities of recharge to the aquifer.

It is known that land-use activities such as timber harvesting will affect both the quality and spatial distribution of runoff generated. Recharge quality is affected by increasing suspended and dissolved solids. Most suspended solids are filtered before reaching the aquifer. However, most soluble fractions will eventually reach the water table. Recharge quantity will be affected by increasing the amount of direct runoff compared to that of infiltration. Where this direct runoff enters surface streams and is routed off the aquifer, recharge quantity may be reduced.

Forest practices within the State of Idaho are regulated under the Idaho Forest Practices Act. Federal and state land management agencies must comply with the rules and regulations of the Idaho Forest Practices Act.

XIII. Well Drilling

Well drilling for municipal, irrigation, rural-domestic, livestock and industrial use is an active business on the Rathdrum Prairie. Approximately 400 drillers’ reports of wells drilled in northern

Idaho were received by the Idaho Department of Water Resources in 1986. Of this number, the majority were drilled on the Rathdrum Prairie.

Well drilling activities themselves have little potential for contamination of the Rathdrum Prairie Aquifer. The two most commonly used types of drill rigs, the cable-tool and air rotary, typically use only natural materials, such as water and, rarely, bentonite, in the drilling process. Considerable contamination could occur if contaminated water is used for the drilling operation; however, drillers are well aware of the contamination potential and are usually conscientious about supplying potable water for the drilling process.

Under some conditions, practices used to condition the drilling fluid (water or air) to overcome drilling problems encountered are potentially less benign. In the air-rotary drilling method, for instance, surfactants (detergents) may be added, along with small amounts of water, to the pressurized air to increase the removal of drill cuttings from the bore hole and to suppress dust. Spills of diesel fuel, gasoline, thread lubricating compound and other materials commonly used around drill rigs could be accidentally introduced into the bore hole or into the unsealed annular space around the casing.

The greatest potential for groundwater contamination due to well drilling is from improper well construction- -in particular, poor annular seals. This has been the most common well construction violation on the Rathdrum Prairie, as well as in other areas of the state. Drillers have been known to provide no surface annular seal around the casing or to stuff rags or sacks down the annular space and backfill only the upper 2-3 feet of annular space with drill cuttings rather than provide an adequate seal of bentonite or cement grout. The use of PVC casing as a liner in a well which uses steel surface casing has not been a problem to date, but has the potential to cause problems if the PVC liner is cracked or broken due to improper installation.

Abandonment of existing unused wells is a difficult aspect of well construction to enforce. A well owner or driller often simply cuts off the well casing a few feet below land surface and backfills the hole, perhaps without the minimum protection offered by welding a steel plate over the top of the cut off casing. Only one specific case of well abandonment is known on the Rathdrum Prairie and, in this case, the bore hole of the well was reportedly filled with cement from bottom to top.

Rules and regulations regarding the minimum well construction standards for water, geothermal and injection wells are administered by the Idaho Department of Water Resources. These rules and regulations also address accepted methods and purposes for abandonment of each class of well. General guidelines for well construction, distances to potential sources for contamination, such as septic tanks and drain fields, and requirements for public drinking water supplies are administered by the Idaho Department of Health and Welfare. Other controls on well drilling are provided by the licensure requirements for well drilling contractors and operators, a program administered by the Department of Water Resources.

XIV. Mining

Mining activities over the Rathdrum Prairie Aquifer are limited to sand and gravel extraction operations. These activities consist of overburden removal in order to extract sand and gravel. Also on site are crushers, washers and associated stockpiles of aggregate materials. Wash water is typically diverted to settling ponds. These ponds are usually lined with fine-grained material or topsoil local to the area. Due to fines settled in the ponds, a mat develops quickly. This mat provides filtration of wash water, removing most suspended material. Any dissolved material that may be present will be recharged to the aquifer.

With the protective soil blanket removed, only porous aquifer media separates land surface and the water table. This presents a “window” into the aquifer. These open windows are potential shortcuts for contamination entering the aquifer. It is important that any activities detrimental to water quality not be allowed in old unreclaimed pits.

There are several companies that dominate the local sand and gravel industry operating within the confines of the Rathdrum Prairie Aquifer. The extent of sand and gravel extraction pits is not known at this time. Since the materials are easier and less expensive to extract than other sources in the area, sand and gravel extraction will likely continue in the future.

Mining activities over the aquifer are regulated by the Idaho Department of Lands, Minerals Leasing Bureau. Title 47, Chapter 15, of Idaho Code addresses surface mining. Effective since May 1972, it requires a reclamation plan for all surface-mining activities. Reclamation plans are on file in the Boise office of the Department of Lands.

A typical reclamation plan requires the following: plan views, cross-sectional views (both before and after), effective area of extraction, and salvage of topsoil for replacement, contouring and reseeding to stabilize the site.

Mining Activities in the Recharge Area

The EPA has included the drainage basin of Coeur d’Alene Lake in sole source designation (Figure 1). Present in the drainage basin is Idaho’s Silver Valley Mining District and the Bunker Hill Smelter complex. The Bunker Hill Smelter is the site of the nation’s largest Superfund project.

Sagstad and Ralston (1976) studied the relationship of heavy metal concentration in Lake Coeur d'Alene and the Spokane River to recharge of the Rathdrum Prairie Aquifer. They reported that zinc concentrations in the Spokane River in the recharge area to the aquifer (between Coeur d'Alene and Post Falls, Idaho) ranged from 0.1 mg/l to 0.6 mg/l. Zinc concentrations in the associated part of the Rathdrum Prairie Aquifer were below the detection limits of 0.01 mg/l. A localized anomaly occurs in wells located on Harbor Island, where zinc concentrations averaged 0.5 mg/l. This anomaly is believed by Sagstad to be due to vertical leakage of river water either through the basalt or along the basalt-alluvial contact.

Funk (1975) indicated that high concentrations of zinc were found in the upper few inches of river and lake sediments. It is believed that much of the zinc from the river water is exchanged and held by the fine-grained river sediments.

Historic mining activity in the Coeur d'Alene drainage basin does not appear to have affected the water quality of the Rathdrum Prairie Aquifer.

Chapter 8. Rating and Ranking Potential Sources of Contamination

Since man's activities on the Rathdrum Prairie are the most significant potential sources of groundwater contamination, their management is necessary. In order to address the most significant potential sources first and provide for their timely management, all sources were reviewed collectively, then rated and prioritized.

A potential contaminant source's ability to actually impact groundwater is influenced by three factors: (1) the physical and chemical characteristics of the aquifer, (2) the management activity associated with the contaminant and (3) the risk of harm from the contaminant.

The characteristics of the aquifer include the geology, the rate of recharge, transmissivity, the mineral makeup of the aquifer and the time water resides in the aquifer. Also important are the precipitation, the nature of the overlying soils and the climate.

Management activities may be well developed and specific, such as regulations with a permitting system and groundwater monitoring, or they may be general, in the form of guidelines. In some cases, there may be no management for a specific activity. The level of monitoring may also be an important consideration in evaluating a potential contaminant. A substance may actually occur in the groundwater and not be detected. Unless adequate monitoring is continued, steady increases in contaminant levels may not be noticed.

The risk of harm associated with the contaminated can be rated by how toxic it is to man, how persistent or mobile it may be in the environment, the population it may impact and the actual quantity of the substance potentially available to the environment.

Factors which comprise the rating and ranking scheme are:

1. Regulatory Factors:

    a. The regulatory effort in effect for the particular contaminant.
    b. The occurrence of violations of MCLs or the level of effort to monitor for such violations.

2. Risk Factors:

    a. The toxicity of the contaminant.
    b. The population at risk.
    c. The quantity of the contaminant over the aquifer.
    d. The chemical mobility and persistence of the contaminant.

Each factor is rate 1 through 3 based on the guidelines in Table 22.

TABLE 22
GUIDELINES FOR RATING FACTORS

		1	2	3
A.	Regulations	Regulations with permits	Regulations or guidelines	No regulations
B.	Violations/ Monitoring	No MCL violations with monitoring	Some MCL violations; no monitoring	Numerous MCL violations
C.	Toxicity	No harm	Reversible harm	Irreversible harm or death
D.	Population	Low density $< 20/mi^2$	Moderate density $20\text{-}100/mi^2$	High density $>100/mi^2$
E.	Quantity	Pounds or gallons	Thousands of pounds or gallons	Millions of pounds or gallons
F.	Mobility/ Persistence	Totally contained; low persistence	Some mobility, moderate persistence	Extremely mobile, very persistent

The regulatory activity which pertains to the various potential contaminant sources has been described in the previous sections.

The lack of monitoring for a contaminant is considered as important as the determination that some violations of maximum contaminant levels exist. Such a lack of data shows where there are additional monitoring needs. The toxicity index is based on Sax (1984).

Each of the factors has been considered just as important as each of the other factors in the rating scheme used. However, the total rating score (RS_{Total}) of the contaminant was determined from the following formula (Canter and Knox, 1985):

$$RS_{Total} = \sqrt{\frac{\left(\frac{A + B}{2}\right)^2 + \left(\frac{C + D + E + F}{4}\right)^2}{2}} \times 100$$

The formula is a simple application of the Pythagorean theorem and provides for emphasis on the most heavily weighted mechanism. For instance, if the risk of a compound was very high, but there was good regulatory control available, the total rating score would reflect more strongly the risk from the compound. The formula makes a vector addition of the two mechanisms after normalizing them to a common denominator. This means combining them gives added weight to the rating score that is higher. The raw rating score is then multiplied by 100 to provide a significant whole number.

After a rating value was applied to each of the factors, the total rating score was then calculated. Results of those calculations, along with a summary of the individual factor rating scores, are shown in Table 23. The highest rating score represents the contaminant with the greatest potential pollution capability over the aquifer. The lowest possible total rating score is 100; the highest is 300. The contaminants have been ranked in Table 23 in priority order based on their rating score.

TABLE 23
SUMMARY OF RATING AND RANKING OF POTENTIAL CONTAMINANTS

		RS REGULATORY			RS RISK			
RANK NO.	LAND USE OR CONTAMINANT SOURCES	REGULATIONS A	VIOLATIONS B	TOXICITY C	POPULATION D	QUANTITY E	MOBILITY F	TOTAL RATING SCORE
1	Agriculture	3	2	2	2	3	3	250
2	Petroleum	2	3	3	3	2	2	250
3	Landfills	2	3	2	2	3	2	237
4	Hazardous Materials	2	2	3	2	3	2	226
5	Subsurface Sewage Disposal Systems	1	2	2	3	3	3	221
6	Surface Runoff/Dry Wells	2	2	2	3	2.5	2	220
7	Industrial Wastewater	2	2	2	2	3	2	212
8	Land Application of Septage and Sludges	2	2	2	1	3	2	200
9	Pits, Ponds and Lagoons	2	2	2	2	2	2	200
10	Dairies and Feedlots	1	2	2	2	3	2	191
11	Radioactivity	2	1	2	2	1	2	162
12	Silvicultural Activities	2	2	1	1	1	1	158
13	Well Drillings	1	2	2	1	1	2	150
14	Mining	2	1	1	1	1	1	127

CONCLUSIONS AND RECOMMENDATIONS

Although ambient water quality of the Rathdrum Prairie Aquifer appears to be good, testing has shown that the aquifer is susceptible to contamination. Monitoring has shown the existence of nitrate and trace amounts of volatile organic compounds in some areas of the Rathdrum Prairie Aquifer. These contamination incidents commonly occur down gradient from areas of high urban development. The highly porous and permeable nature of the aquifer, vadose zone and soil cover provides little chance for filtration, sorption, or other attenuating effects on pollutants.

Pollution potential from agricultural activities, surface runoff/dry wells, petroleum, landfills, hazardous materials and subsurface sewage disposal systems have been identified as the activities which have the highest groundwater pollution potential.

Prevention of contamination is the best option currently available to manage groundwater quality. Ongoing public education and information programs should be developed in combination with monitoring and regulatory activities. The following programs are recommended to effectively manage the groundwater quality of the Rathdrum Prairie Aquifer.

<u>Education</u>: Successful groundwater quality management programs and their continued support emerge from circumstances where the public is aware of groundwater problems and issues. Proposed educational activities include:

1. Develop a public information program for presentation at service clubs, city councils, planning and zoning departments, county commissions and professional organizations.

2. Develop public information brochures describing groundwater protection efforts (e.g., underground storage tanks, wellhead protection, emergency response).

3. Increase cooperation and program coordination with the Spokane County 208 office (aquifer protection coordinator).

<u>Monitoring</u>: Protection of groundwater supplies requires a sound and appropriately designed hydrologic information base to determine on a continuing basis what groundwater contamination problems may exist. A continuing sampling and monitoring program is needed to identify groundwater quality trends. Recommended monitoring and assessment programs include:

1. Review the existing monitoring program to assess its reliability and effectiveness.

2. Expand the ongoing monitoring program in areas where pollution potential is high, where deteriorated groundwater quality exists and where the current program is inadequate.

3. Develop expanding sampling program including localized one-time surveys and seasonal trend monitoring.

4. Utilize trend analysis obtained in the monitoring program to help direct activities.

Management/Regulatory: One of the most effective long-term preventive strategies for groundwater quality protection is to reduce or eliminate the sources of contamination. Recommended management activities include:

1. Develop a wellhead protection program to help assure the quality of drinking water from community supply wells. This program should define the area of influence of a community supply well, identify the role of recharge in maintaining groundwater quality and develop and implement management approaches to prevent contamination within the wellhead protection areas.

2. Develop best management practices (BMPs) for agricultural chemicals used over the aquifer. This program should identify the areas over the aquifer that agricultural chemicals are applied, evaluate or develop best management practices for aquifer protection and develop techniques for program implementation.

3. Develop and implement a program to manage stormwater runoff. Drywells potentially provide a direct conduit for contaminants to groundwater. This problem is further aggravated because of the lack of data on the locations and quality of water entering these drywells. Program development includes inventorying the locations of drywells located over the aquifer, assess the quality of stormwater runoff which enters those drywells and evaluate the potential impact on groundwater quality. Stormwater management programs include assessing management options (e.g., grassy swales, storm sewers, landscape design), developing the best options identified to effectively manage stormwater runoff and implementing the identified programs through local ordinances and building codes.

4. Petroleum leaks from underground storage tanks (USTs) have been identified as posing a serious threat to groundwater quality. Program development includes cooperating with the local fire departments to identify and ensure proper closure and abandonment of USTs. A program to implement the new federal regulations should be developed and then an evaluation of the federal and state UST regulations should then be performed to determine if additional local provisions are necessary for installation over the aquifer.

5. Leachate for disposal of solid waste in landfills poses a serious threat to groundwater quality. Recommended management options include the proper closure and monitoring of existing solid waste disposal facilities, promotion of public awareness with respect

to disposal of household hazardous wastes at landfills, conducting household hazardous waste collection days and updating the current state landfill regulations to comply with the new RCRA Subtitle D requirements which the EPA is in the process of finalizing.

6. Develop and implement a management program for the storage and handling of critical materials. In conjunction with SARA Title III, local emergency planning, sites should be identified where critical materials are stored, handled and used. A spill response plan should be developed to identify local capabilities for responding to and containing spills and to evaluate the need for local ordinances to address the storage and handling of critical materials.

7. The overuse of septic system has been linked with nitrate contamination of the aquifer. Recommended management activities include evaluating and updating sewage management agreements and identifying long-term septage and sludge management options.

8. Develop a geographic information database for mapping groundwater vulnerability, potential contaminant sources and for compiling existing data on aquifer quality. Specific activities include developing a computer interface with the Spokane 208 office to access Idaho groundwater monitoring data, develop a geographic information system to map aquifer vulnerability based on soil characteristics, recharge, depth to water and vandose zone characteristics. Additionally, the geographic information system should be utilized to plot all potential contaminant sources such as landfills, underground storage tanks, critical materials storage and drain wells and to plot all community water supply wells.

9. To be effective, an aquifer management program must be supported by an adequate funding source. Funding options include the development of an aquifer protection district, a groundwater discharge permit and fee, water use and UST permits and fees.

Implementation of the proposed aquifer protection activities will likely involve a cooperative effort between state and local authorities. Almost every human activity has some potential for contaminating the underlying groundwater. Combining land use awareness with implementation strategies and source control activities, significantly increases the level of groundwater quality protection and provides a program which can effectively manage the aquifer.

GLOSSARY

Adsorption – A process of collecting soluble substances in a solution onto an interface, such as soil or rock particles.

Aggregate Soil – Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks or prisms, are called peds. Clods are man-caused aggregates produced mainly by tillage.

Alluvial – Pertaining to or composed of alluvium (unconsolidated sand, silt, clay, gravel or similar material), deposited by a stream or running water.

Alluvium – Material, such as sand, gravel or silt, transported and deposited on land by moving water.

Amorphous Clay – A clay that lack crystalline form.

Aquifer – A geologic formation, group of formations or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Arid Climate – A climate that lacks sufficient moisture for crop production without irrigation.

Aridic – Soil moisture class. Soils too dry for common plant growth for more than 50 percent of the time during the growing season.

Basalt – An extrusive, usually dark-colored igneous rock with a fine-grained texture. Often dense to highly fractured and jointed.

Bedrock – The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Biochemical Oxygen Demand (BOD_5) – The amount of dissolved oxygen, measured in milligrams per liter, required by microorganisms in the chemical breakdown of organic matter.

Bulk Density – The mass of dry soil per unit volume.

Cation Exchange Capacity – The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity, but is more precise in meaning.

Chemical Oxygen Demand (COD) – The total amount of dissolved oxygen, measured in milligrams per liter, required to oxidize organic matter in water.

Clay – Mineral soil particles less than 0.002 millimeter in diameter.

Clinker – Rough, jagged pyroclastic fragments that resemble the clinker or slag of a furnace.

Course Fragments – Mineral or rock particles 2 millimeters to 10 inches in diameter.

Cobblestone – A rounded or partly rounded fragment of rock 3 to 10 inches in diameter.

Cryic – Soil temperature class. Soils with an average annual soil temperature less than 47 degrees F. and an average summer soil temperature less than 59 degrees F. at a 20-inch depth.

Duripan – A subsurface horizon that is cemented by silica. They commonly contain accessory cements, including calcium carbonate. They vary in appearance, but all have very firm moist consistence and are brittle even after prolonged wetting.

Eolian – Pertaining to the wind, and deposits of silt, sand and other materials which were transported and laid down by the wind (sand dunes, loess blankets).

Evapotranspiration – Loss of water from a land area through transpiration of plants and evaporation from the soil. Also, the volume of water lost through evapotranspiration.

Flood Plain – A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Fluvioglacial – Pertains to meltwater streams flowing from glaciers, ice and especially to the deposits and landforms produced by such streams.

Frigid – Soil temperature class. Soils with an average annual soil temperature less than 47 degrees F. and an average summer soil temperature greater than 59 degrees F. at a 20 inch depth.

Glacial Outwash – Gravel, sand and silt, commonly stratified, deposited by glacial melt water.

Gravel – Rounded or angular fragments of rock up to 3 inches in diameter.

Head (Hydraulic Gradient) – The height of the free surface of fluid above any point in a hydraulic system; a measure of the pressure or force exerted by the fluid.

Horizon, Soil – A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. The major soil horizons are:

A Horizon. The mineral horizon at or near the surface in which an accumulation of humidified organic matter is mixed with mineral material. It is also a plowed surface horizon which had once been a B, C or E soil horizon.

B Horizon. The mineral horizon that formed below an A, E or O horizon. It has (1) accumulated clay, iron, aluminum, humus, carbonates, gypsum or silica, (2) evidence of removal of carbonates, (3) redder or browner colors from coatings of oxides than overlying or underlying horizons, (4) granular, blocky or prismatic structure or (5) any combination of these.

C Horizon. Horizon or layer, excluding hard bedrock, that is little affected by soil forming processes described in A, B or E horizons.

E Horizon. A mineral horizon which has lost a significant amount of clay, iron or aluminum, leaving a concentration of sand and silt particles, mainly quartz.

O Horizon. Layer dominated by organic material, such as undecomposed or partially decomposed leaves, needles and twigs on the surface of mineral soils. Other O layers are in peat or muck which were deposited under water and that have decomposed to varying stages.

R Layers. Hard bedrock.

Infiltration – The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Interbed – A bed or layer, typically thin, of one kind of rock material occurring between or alternating with beds of another kind.

Isotope – A radioactive form of chemical element.

Lacustrine – Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Lime – Calcium carbonate.

Loam – Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles and less than 52 percent sand particles.

Loess – Fine grained material, dominantly of silt-sized particles, deposited by wind.

Mesic – Soil temperature class. Soils with an average annual soil temperature between 47 degrees F. and 59 degrees F.

Moderately Well Drained – The soil is wet for short but significant periods of time usually because of a slow permeable layer or intermittently high water table. Some mottled colors may occur at depths of about 30-40 inches.

Montmorillonite – A kind of clay characterized by swelling with wetting and shrinking with drying. It has a high capacity for exchange of cations (see Cation Exchange Capacity).

National Pollution Discharge Elimination System (NPDES) – Permitting system under the Clean Water Act.

Organic Matter – Plant and animal residue in the soil in various stages of decomposition.

Pan – A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, duripan, fragipan, claypan and plowpan.

Parent Material – The unconsolidated organic and mineral material in which soil forms.

Perched Water Table – The surface of a local zone of saturation held above the main body of groundwater by an impermeable layer of stratum, usually clay, and separated from the main body of groundwater by an unsaturated zone.

Permeability (Aquifer) – Is the ease with which the aquifer transmits water, and is measured by volume of water moved in a unit of time, under a unit hydraulic gradient, through a unit area.

Permeability (Soil) – The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are:

	Inches Per Hour
Very Slow	Less than 0.06
Slow	0.06 to 0.2
Moderately Slow	0.2 to 0.6
Moderate	0.6 to 2
Moderately Rapid	2 to 6
Rapid	6 to 20
Very Rapid	20 or more

pH Value – A numerical designation of acidity and alkalinity in soil (see Reaction, Soil).

Poorly Drained – Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slow permeable layer within the profile, seepage or a combination of these.

Pyroclastic Rocks – Rocks composed of materials fragmented by volcanic explosion. They are characterized by a lack of sorting.

Quaternary – The second period of the geologic era (Cenozoic), in which we live, covering the past 2-3 million years. Informally designated the Age of Man.

Radionuclide – Any radioactive chemical element.

Reaction, Soil – A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that test pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as:

	pH
Extremely Acid	Below 4.5
Very Strongly Acid	4.5 to 5.1
Strongly Acid	5.1 to 5.6
Medium Acid	5.6 to 6.1
Slightly Acid	6.1 to 6.6
Neutral	6.6 to 7.4
Mildly Alkaline	7.4 to 7.9
Moderately Alkaline	7.9 to 8.5
Strongly Alkaline	8.5 to 9.1
Very Strongly Alkaline	9.1 and higher

Residuum – Unconsolidated, weathered or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Rhyolite (Rhyolitic) – A group of extrusive igneous rocks with the general composition of granite, typically exhibiting flow texture.

Rock Fragments – Rock or mineral fragments having a diameter of 2 millimeters or more; includes gravel cobblestones, stones and boulders.

Sand – Individual rock or mineral fragments from 0.05 millimeters to 2.0 millimeters in diameter. Most sand grains are quartz.

Series, Soil – A group of soils that have about the same profile, except for differences in texture of the surface layer or of the underlying material. All of the soils of a series have horizons that are similar in composition, thickness and arrangement.

Shrink-Swell – The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations and other structures. It can also damage plant roots.

Silica – A combination of silicon and oxygen. The mineral form is called quartz.

Silt – Individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter).

Soil – A natural three-dimensional body at the earth's surface. It is capable of supporting land plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil Depth – The depth of a soil to a layer which essentially inhibits root growth – bedrock, duripan, fragipan. Depth groupings are:

	Inches
Very Deep	60 or more
Deep	40 to 60
Moderately Deep	20 to 40
Shallow	10 to 20
Very Shallow	Less than 10

Soil Slope – Expressed in terms of percentage – the difference in elevation in feet for each 100 feet horizontal distance. Normally each slope class has variable limits but those chosen for this atlas are:

	Slope (Percent)
Nearly Level	0 to 2
Gently Sloping	2 to 6
Moderately Sloping (or Rolling)	6 to 12
Moderately Sloping (or Hilly)	12 to 25
Steep	25 to 50
Very Steep	50 and more

Solum – The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in mature soil consists of the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Somewhat Excessively Drained – Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly permeable. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Somewhat Poorly Drained – The soils are wet for significant periods but not all the time. Usually has mottled colors within about 20 inches of the surface.

Storage Coefficient – The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head, e.g., $ft^3/ft^2/ft$ = dimensionless.

Subsoil – Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum – The part of the soil below the solum.

Subsurface Layer – Technically, the E horizon. Generally refers to a leached horizon lighter in color and lower in content of organic matter than the overlying surface layer.

Surface Soil – The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches. Frequently designated as the “plow layer” or the “AD horizon”.

Terrace (Geologic) – An old alluvial plain, ordinarily flat or undulating, generally bordering a river or a lake.

Texture, Soil – The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles are: sand, loamy sandy, sandy loam, loam, silt, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay and clay. The sand, loamy sand and sandy loam classes may be further divided by specifying “coarse,” “fine” or “very fine.”

Tilth, Soil – The condition of the soil, especially the soil structure, as related to the growth of plants. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable structure. A soil in poor tilth is nonfriable, hard, nonaggregated and difficult to till.

TKN (Total Kjeldahl Nitrogen) – A measure of the amount of organic nitrogen, in milligrams per liter.

Transmissivity – The rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient.

Trihalomethanes – A family of organic compounds named as derivatives of methane, wherein three of the four hydrogen atoms in the molecular structure are substituted by either fluorine, chlorine, bromine or iodine. Standards are applied to the sum of analytically determined concentrations of chloroform, dichlorbromomethane, chlorodibromomethane and bromoform.

Volcaniclastic – Pertaining to a clastic rock (one composed of broken fragments) containing volcanic material in whatever proportion and without regard to its origin or environment.

Well Drained – Water is removed from the soil readily but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Xeric – Soil moisture class. Soils with a Mediterranean-type climate with moist winters and springs and dry summers. These soils are moist more than one-half the time during the growing season.

SELECTED REFERENCES

Alden, W. C., 1953, Physiography and Glacial Geology of Western Montana and Adjacent Areas: U.S. Geological Survey Prof. Paper 231.

Anderson, A. L., 1927, Some Miocene and Pleistocene Drainage Changes in Northern Idaho: Id. Bur. Mines and Geol., Pamph. 18, 28 p.

Anderson, A. L., 1940, Geology and Metalliferous Deposits of Kootenai County, Idaho: Id. Bur. Mines and Geol., Pamph. 53, 67 p.

Anderson, K. E., 1951, Geology and Groundwater Resources of the Rathdrum Prairie Project and Contiguous Area, Idaho-Washington: unpubl. U.S. Bur. Recl. Rept.

Braker, R. J., McDole, R. E., and Logan, G. H., 1983, The University Press of Idaho.

Brower, C., 1986, Proceeding of the 37th Annual NW Fertilizer Conference, Boise, July 8-9, 1986.

Broom, H. C., 1951, Gaging Station records in Spokane River Basin, Washington, from Post Falls, Idaho, to Long Lake, Washington, including Little Spokane River, water years 1948 to 1950: U.S. Geol. Survey open-file report, Tacoma 29 p.

Campbell, L., 1985, An Assessment of Shallow Injection Wells in Idaho: Idaho Department of Water Resources Open File Report.

Canter, L. W., and Knox, 1985, Groundwater Pollution Control, Lewis Publishing Inc., Chelsea, Michigan, 522 p.

Cline, D. R., 1969, Groundwater Resources and Related Geology, North Central Spokane and Southeastern Stevens Counties, Washington: Washington Department of Water Resources, Water Supply Bulletin 27, 195 p.

Cohen, S. Z., Creeger, S. M., Carsel, R. F., and Enfield, C. G., 1984, Potential Pesticide Contamination of Groundwater from Agricultural Uses, In Treatment and Disposal of Pesticide Wastes: R. F. Krueger and J. N. Seiber, eds., American Chemical Society Symposium Series 259, ACS, Washington, DC, pp. 297-325.

Drost, B. W., and Seitz, H. R., 1978, Spokane Valley-Rathdrum Valley Aquifer, Washington and Idaho: U.S. Geological Survey open-file report, pp. 77-829.

EPA, 1984, Handbook of Septage Treatment and Disposal: EPA 625/6-84-009.

Esvelt Environmental Engineering, 1985, Unpublished report submitted to the Kootenai County Commissioners.

Fader, S. W., 1951, Water Levels in Wells and Lakes in Rathdrum Prairie and Contiguous Areas, Bonner and Kootenai Counties, Northern Idaho: U.S. Geological Survey Basic Data Report, 90 p.

Fosdick, E. R., 1931, A Study of Groundwater in the Spokane and Rathdrum Valleys, The Washington Water Power Company.

Frink, J. W., 1968, An Appraisal of Potential Groundwater Supply for Avondale and Hayden Lake Irrigation Districts, Rathdrum Prairie Project, Idaho, U.S. Bureau of Reclamation.

Funk, W. H., 1975, An Integrated Study on the Impact of Metallic Trace Element Pollution in the Coeur d'Alene-Spokane Rivers and Lake Drainage System: Pullman, Washington, Washington State University, and Moscow, Idaho, University of Idaho, 332 p.

Graham, W. G., and Campbell, L. J., and Sather, I., 1987, Idaho Assessment of Class V Injection Wells: Idaho Department of Water Resources.

Graham, W. G., and Campbell, L. J., 1981, Groundwater Resources of Idaho: unpublished report by the Idaho Department of Water Resources, 100 p.

Hammond, R. E., 1974, Groundwater Occurrence and Movement in the Athol Area and the Northern Rathdrum Prairie, Northern Idaho: U.S. Geological Survey, Water Information Bulletin No. 35, 19 p.

Horsley, S. C., 1986, Beyond Zoning: Municipal Ordinances to Protect Groundwater, Cape Cod Planning and Economic Development Commission.

Huff, L. C., 1943, Geology and Groundwater Resources of the Spokane Valley and Vicinity, Washington, Idaho: U.S. Geological Survey, unpublished report, 153 p.

Idaho Department of Health and Welfare, 1985, Idaho Regulations for Public Drinking Water Supplies, 46 p.

Idaho Department of Health and Welfare, 1977, Idaho Regulations for Public Water Systems: Boise, Idaho, 44 p.

Idaho Department of Health and Welfare, 1985, Groundwater Quality Management Plan for Idaho, 23 p.

Idaho Department of Health and Welfare, 1985d, Idaho Water Quality Standards and Wastewater Treatment Requirements.

Jacobson, N. D., 1984, Hydrology of Eastern Michaud Flats, Fort Hill Indian Reservation, Idaho: U.S. Geological Survey Water-Resources Investigations Report 84-4201, 31 p.

Jones, F. O., and Lustig, K. W., 1977, Groundwater Quality Monitoring – - Rathdrum Prairie Aquifer, 208 Technical Report of the Panhandle Health Department, 94 p.

Jorling, T., and Dubois, D. P., 1977, Spokane Valley–Rathdrum Prairie Aquifer, Notice of Determination, U.S. Environmental Protection Agency, Region X.

Kelley, W. J., 1986, Transportation of Hazardous Materials in the Inland Northwest: Report for the City of Spokane and the Inland Empire Regional Conference, January 1986.

Kreissl, J. F., 1978, Management of Small Waste Flows, EPA 600/2-78-173.

Lenz, A. T., 1950, Irrigation Water Requirements, Seepage Losses and Return Flow, Rathdrum Prairie Project, Idaho: U.S. Bureau of Reclamation, Boise, Idaho, unpublished memorandum, December 1950.

Lustig, K. W., Belmont, L. M., and Burmaster, D. E., 1986, A Case Study of Innovative Subsurface Sewage Management Over the Rathdrum Prairie Aquifer. Prepared for Office of Policy, Planning and Evaluation, U.S. EPA.

Lustig, K., 1988, Public Awareness and Municipal Involvement in Septic System Management and Groundwater Protection, Proceedings of the National Environmental Health Association.

Martin, S. B., 1983, Groundwater Quality Management Plan for Idaho, Idaho Department of Health and Welfare, 24 p.

McDonald, C. C., and Broom, H. C., 1951, Analysis of Increments of Discharge in Spokane River, Post Falls, Idaho, to Long Lake, Washington: U.S. Geological Survey open-file report, 19 p.

Meneely, E. N., 1951, Contribution of Precipitation to Groundwater, Rathdrum Prairie-Spokane Valley Area: U.S. Bureau of Reclamation, mimeographed report.

Mink, L. L., Williams, R. E., and Wallace, A. T., 1971, Effect of Industrial and Domestic Effluents on the Water Quality of the Coeur d’Alene River Basin: Idaho Bureau of Mines and Geology Pamphlet 149, 30 p.

Morilla, A. G., and Ralston, D. R., 1975, Preliminary Assessment of the Feasibility of Using a Shallow Groundwater System for the Cooling Cycle of a Geothermal Power Plant: Completion Report Contract No. AT(10-1)-1522 between University of Idaho and Energy Research and Development Administration, 127 p.

Mundorf, M. J., Crosthwaite, E. G., and Kilburn, Chabot, 1964, Groundwater for Irrigation in the Snake River Basin in Idaho: U.S. Geological Survey Water-Supply Paper 1654, 224 p.

Nace, R. L., and Fader, S. W., 1950, Record of Wells on Rathdrum Prairie, Bonner and Kootenai Counties, Northern Idaho: U.S. Geological Survey, Basic Data Report, 50 p.

Nace, R. L., West, S. W., and Mower, R. W., 1957, Feasibility of Groundwater Features of the Alternate Plan for the Mountain Home Project, Idaho: U.S. Geological Survey Water-Supply Paper 1376, 116 p.

Nautch, I. M., 1987, Idaho Waste Management Guidelines for Concentrated Animal Feeding Operations, Idaho Department of Health and Welfare, Division of Environmental Quality, Water Quality Bureau Report, 57 p.

Newcomb, R. C., 1933, Underground Water of the Upper Spokane River Valley: Washington State College (Pullman), Undergraduate Competition Paper, Submitted to Columbia Section, American Institute of Mining and Metallurgical Engineers, 16 p.

----- 1953, Seismic Cross Sections Across the Spokane River Valley and the Hillyard Trough, Idaho and Washington: U.S. Geological Survey open-file report, 16 p.

Parliman, D. J., Seitz, H. R., and Jones, M. L., 1980, Groundwater Quality in North Idaho, U.S. Geological Survey Water Resource Publication open-file report, 80-596.

Parliman, D. J., and Whitehead, 1979, A Proposed Groundwater Quality Monitoring Network for Idaho, U.S. Geological Survey Open File Report 79-1477, 67 p.

Piper, A. M., and Huff, L. C., 1943, Some Groundwater Features of Rathdrum Prairie, Spokane Valley Area, Washington-Idaho, with Respect to Seepage Loss from Pend Oreille Lake: U.S. Geological Survey open-file report, 13 p.

Piper, A. M., and LaRocque, G. A., Jr., 1944, Water Table Fluctuations in the Spokane Valley and Contiguous Area, Washington-Idaho: U.S. Geological Survey Water Supp. Paper 889-B, 137 p.

Pluhowski, E. J., and Thomas, C. A., A Water Balance Equation for the Rathdrum Prairie Groundwater Reservoir, near Spokane, Washington: U.S. Geol. Surv. Prof. Paper 600 D, p.75-78.

Prins, C. J., and Lustig, K. W., 1987, Innovative Septic System Management in North Idaho, Published in the Proceedings of the 60th Annual Conference of the National Water Pollution Control Federation.

Rorabaugh, M. I., and Simons, W. D., 1966, Exploration Methods of Regulating Groundwater to Surface Water – Columbia River Basin, second phase: U.S. Geological Survey open-file report, 62 p.

Sagsted, S. R., and Ralston, D. R., 1976, Analysis of a Groundwater Flow System in Northern Idaho Related to Heavy Metal Concentrations: Paper presented at 14th Annual Engineering Geology and Soils Symposium, Boise, Idaho, 14 p.

Sax, N. I., 1984, Dangerous Properties of Industrial Materials. Von Nortrand, Reinhold, New York, 310 p.

Seitz, H. R., and Jones, M. L., 1981, Flow Characteristics and Water Quality conditions with Spokane River, Coeur d'Alene Lake to Post Falls Dam, Northern Idaho: U.S. Geological Survey open-file report 82-102, 56 p.

Simons, W. D., and others, 1953, Subsurface Facilities of Water Management and Patterns of Supply-Type Area Studies, ch. 10, Spokane-Coeur d'Alene River basin, Washington-Idaho, in The Physical and Economic Foundation of Natural Resources; House of Representatives, Internal and Insular Affairs Committee, U.S. Congress, p. 162-185.

Smoot, J. L., and Ralston, D.R., 1987, Hydrology and a Mathematical Model of Groundwater Flow in the Pullman-Moscow Region, Washington and Idaho: Idaho Water Resources Research Institute, University of Idaho, 118 p.

Thomas, C. A., 1963, Investigation of the Inflow to the Rathdrum Prairie-Spokane Valley Aquifer, U.S. Geological Survey, open-file report, Water Resources Division, Boise, Idaho, 46 p.

United States Department of Agriculture, 1975, Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys: Soil Conservation Service, U.S. Department of Agriculture Handbook, 436, 754 p.

U.S. Army Corps of Engineers, 1976, Metropolitan Spokane Region Water Resources Study: Summary Report, Technical Report and appendices A to J: U.S. Army Corps of Engineers, Seattle, 3781 p.

Waitt, R. B., 1985, Case for Periodic Colossal Jökulhlaups from Pleistocene Glacial Lake Missoula: Geological Society of America Bulletin, v. 96, p. 1271-1286.

Walker, E. H., 1964, Groundwater in the Sandpoint Region, Bonner County, Idaho: U.S. Geological Survey Water Supply Paper 1779-I, 29 p.

Walston, W. C., 1962, Groundwater Resources of Camas Prairie, Camas and Elmore Counties, Idaho: U.S. Geological Survey Water-Supply Paper 1609, 57 p.

Water Quality Management Plan- -Rathdrum Prairie Aquifer, Sept. 1978, Panhandle Area Council, 208 Areawide Management Planning Study, 139 p.

Weigle, J. M., and Mundorff, M. J., 1952, Records of Wells, Water Levels and Quality of Groundwater in the Spokane Valley, Spokane County, Washington: U.S. Geological Survey open-file report, 102 p.

Whitehead, R. L., 1978, Water Resources of the Upper Henrys Fork Basin in Eastern Idaho: Idaho Department of Water Resources Water Information Bulletin No 46, 91 p.

Yee, J. J. S., and Souza, W. R., 1984, Quality of Groundwater in Idaho, U.S. Geological Survey open-file report 83-50, 78 p.

APPENDIX I
SOILS AND CHARACTERISTICS

The major soils in the Rathdrum Prairie Aquifer area are: (1) Kootenai-Bonner association and (2) Avonville-Garrison-McGuire association. These soils and related characteristics are discussed below:

(1) Kootenai-Bonner Soil Association:

These are nearly level to steep, well-drained soils formed in glacial outwash mantled with loess and volcanic ash.

Percentage of Unit

Kootenai soils--55 percent
Bonner soils--25 percent

Kootenai Soils

Typically these soils have a:

Surface--0 to 6 inch depth that is very dark grayish brown, slightly acid, gravelly silt loam.

Subsurface--6 to 29 inch depth that is dark brown, slightly acid, very gravelly loam and silt loam.

Substratum--29 to greater than 60 inch depth that has variegated colors; neutral, loose, extremely gravelly sand.

Permeability--moderate in upper part; rapid or very rapid in the substratum.

Surface Organic Matter--moderate (1 to 2 percent).

Surface Cation Exchange Capacity--high (25-35 meg/100 g).

Substratum Cation Exchange Capacity--very low (<5 meg/100 g).

Depth--20 to 40 inches to loose, extremely gravelly sand.

Slope--mostly 0-4 percent, some areas up to 55 percent.

Drainage--well.

Frost-Free Season--100-115 days.

Classification--coarse, loamy over sandy or sandy skeletal, mixed, frigid Typic Xerochrepts.

Potential for Recharge or Aquifer Contamination--high. There are no limiting layers in the soil or substratum to limit the downward movement of water or contaminants.

Bonner Soils

Typically these soils have a:

Surface--0 to 8 inch depth that is dark yellowish brown, slightly acid silt loam (high in volcanic ash).

Subsurface--8 to 26 inch depth that is a pale brown, slightly acid, gravelly silt loam and sandy loam.

Substratum--26 to greater than 60 inch depth that is dark brown, neutral (loose), extremely gravelly loamy sand.

Permeability--moderately rapid in the upper part and rapid in the substratum.

Surface Organic Matter--moderate (1 to 5 percent).

Surface Cation Exchange Capacity--very high (> 35 meg/100 g).

Substratum Cation Exchange Capacity--very low (< 5 meg/100 g).

Depth--20 to 40 inches to loose, extremely gravelly sand.

Slope--mostly 0-4 percent, some small areas up to 65 percent.

Drainage--well.

Frost-Free Season--100-115 days.

Classification--coarse loamy over sandy or sandy skeletal, mixed, frigid Andic Xerochrepts.

Potential for Recharge or Aquifer Contamination--high. There are no limiting layers in the soil or substratums to limit the downward movement of water and contaminants. The high content of volcanic ash in the soil surface has a high fixation for nutrients.

(2) Avonville-Garrison-McGuire Association:

These are nearly level to undulating, well-drained and somewhat excessively drained soils that formed in glacial outwash with a mantle of loess and volcanic ash.

Percentage of Unit

Avonville--40 percent

Garrison--30 percent
McGuire--15 percent

Avonville Soils

Typically these soils have a:

Surface--0 to 5 inch depth that is a very dark brown, medium acid, gravelly silt loam.

Subsurface--5 to 37 inch depth that is a dark yellowish brown, neutral, very gravelly silt loam and sandy loam.

Substratum--37 to greater than 60 inch depth that has variegated colors, neutral (loose) extremely gravelly sand (at depth of 20 to 40 inches).

Permeability--moderate in the upper part and rapid or very rapid in the substratum.

Surface Organic Matter--high.

Surface Cation Exchange Capacity--high (25-35 meg/100 g).

Substratum Cation Exchange Capacity--very low (< 5 meg/100 g).

Depth--20 to 40 inches to loose, extremely gravelly sand.

Slope--Mainly 0 to 7 percent, ranges to 20 percent.

Drainage--well.

Frost-Free Season--140 days.

Classification--loamy-skeletal, mixed, frigid Andic Xerumbrepts.

Potential for Aquifer Recharge and Pollution--high. There are no limiting layers in the soil or substratum to limit the downward movement of water or contaminants.

Garrison Soils

Typically these soils have a:

Surface--0 to 12 inch depth that is a black, neutral, gravelly silt loam.

Subsurface--12 to 38 inch depth that is a dark brown, neutral, very gravelly loam and sandy loam.

Substratum--38 to greater than 60 inch depth that has variegated colors, neutral, loose extremely gravelly and cobbly sand.

Permeability--moderate in the upper part and rapid or very rapid in the substratum.

Surface Organic Matter--high (about 3-4 percent).

Surface Cation Exchange Capacity--very high (> 35 meg/100 g).

Substratum Cation Exchange Capacity--very low (< 5 meg/100 g).

Depth--20 to 40 inches to loose extremely gravelly sand.

Slope--0 to 7 percent.

Drainage--well.

Frost-Free Season--140-150 days.

Classification--loamy-skeletal, mixed, mesic, Typic Haploxerolis.

Potential for Recharge and Aquifer Contamination--high. There are no limiting layers in the soil or substratum to limit the downward movement of water or contaminants.

McGuire Soils

Typically these soils have a:

Surface--0 to 8 inch depth that is a very dark brown, neutral, gravelly sandy loam.

Subsurface--8 to 26 inch depth that is a dark brown, neutral, very gravelly sandy loam.

Substratum--26 to greater than 60 inch depth that has variegated colors, neutral, loose extremely gravelly sand.

Permeability--moderately rapid in the upper part and rapid or very rapid in the substratum.

Classification--loamy-skeletal, mixed, mesic, Ultic Haploxerolis.

Potential for Recharge or Aquifer Contamination--high. There no limiting layers in the soil or substratum to limit the downward movement of water or contaminants.

APPENDIX II
WATER QUALITY DATA FOR THE RATHDRUM PRAIRIE AQUIFER (Nitrate-Nitrogen)

WELL #		LOCATION		NITRATE (MG/L)												
USGS	PHD	TRS		'75	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87
37		54N-5W-18 A A A 1				2.0										
38		54N-5W-30 A B D 1				2.0										
39		54N-5W-36 A A D 1				.11										
40		54N-4W-17 C A D 1				.16										
41		54N-4W-19 B C D 1				.18										
42		54N-4W-31 D D D 1				.12										
43		54N-3W-25 B C B 1				.21										
44		54N-3W-27 D D C 1				.39										
45		54N-2W-19 C B A 1				.30										
46		54N-2W-34 C C B 1														
	1	54N-2W C D B	SILVER W.A.	4.1	2.48					1.75	2.57	2.67	2.81	2.39	1.99	2.14
47	8	53N-4W-6 D D D 2	SPIRIT LAKE WELL #3	.20		.33				.11	.13	.19	.24	.26	.23	.16
48		53N-4W-22 C D D 1				.64										
49		53N-4W-24 B B A 1				.34										
50		53N-4W-33 C B B 1				.21										
51		53N-4W-36 B B A 1				.40										
52		53N-3W-3 B A B 1				.37										
53	5	53N-3W-9 C D D 1	ATHOL WELL #1	.31		.85				.32	.29	.43	.46	.48	.42	.49
54		53N-3W-21 C D D 1				.28										
55		53N-3W-22 D A B 1														
56		53N-2W-7 C A A 1				.34										
	3	53N-2W-4 B A C 1	FARRAGUT	.11	.19					.10	.12	.23	.21	.21	.17	.157
57		53N-2W-19 A D D 1				.15										
58		52N-4W-10 D A B 1				.05										
59		52N-4W-14 D C D 1				.01										
60		52N-4W-17 D D D 1				.26										
61		52N-4W-20 C C B 1														
62		52N-4W-27 D C D 1														
63		52N-4W-31 D A B 1														
	23	52N-4W-31 C A C	RATHDRUM DOG POUND		.22					.96	1.08	1.19	.54	1.17	1.10	.89
64		52N-4W-32 A B C 1														

WELL #		LOCATION		NITRATE (MG/L)												
USGS	PHD	TRS		'75	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87
65		52N-4W-35 D C B 1														
66		52N-3W-7 D A C 1				.38										
67		52N-3W-7 D C A 1				1.2										
68		52N-3W-19 A A B 1				.37										
69		51N-5W-11 D D B 1														
70		51N-5W-12 A B A 1														
71		51N-5W-19 C A D 1				.85										
72		51N-5W-25 D A B 1				1.0										
73		51N-5W-26 B C A 1				.27										
74		51N-5W-27 B B B 1				.37										
75		51N-5W-31 A C A 1				.92										
76		51N-5W-35 B D C 1				2.2										
	249	51N-4W-1 A A A	RATHDRUM NEW WELL								2.24	1.79	.76	1.70	1.81	2.91
77		51N-4W-6 A D A 1														
	34	51N-5W-36 C D A	ROSS PT HY 41	1.80						1.18	1.34	1.63	1.07	.98	.50	1.93
	37	51N-5W-34 A D D	P.F. IDAHO ROAD #3	1.18	1.36					.51	1.02	1.20	1.40	1.67	1.69	1.37
	38	51N-5W-34 A B C	P.F. #2	1.91	1.52					.87	1.06	1.38	2.43	2.05	1.48	1.07
	39	51N-5W-35 A B C	P.F. #1	1.86	1.32					1.47	1.93	1.10	1.52	1.91	2.44	2.64
	43	51N-5W-32 C A C	MT. VIEW TERRACE	.65	.88					1.14	1.44	1.55	1.69	1.89	1.78	1.90
	44	51N-5W-31 D C A	PACIFIC SUPPLY	.60	.77					1.02	1.19	.93	1.07	1.21	1.27	1.23
	190	51N-4W-24 C A A	HAYDEN WELL							.30	.09	.15	.18	.19	.24	.27
	134	51N-5W-28 C C B	EAST GREENACRES							1.13	1.13	1.21	1.19	1.24	1.30	1.26
	253	51N-5W-27 D C C	POST FALLS #5								.68	.92	1.21	1.15	1.09	1.02
TCR 78		51N-4W-12 A B A 1				.35										
79	252	51N-4W-15 A A A 1	COEUR D'ALENE AIRPORT								1.75	1.53	1.22	1.27	1.21	1.21
80	25	51N-4W-15 D A B 1	L.A. ALUMINUM	.40	.53	.61				.53	1.23	.93	.98	.90	.69	.66
81		51N-4W-17 C B C 1				2.0										
		51N-4W-35 B B A 1			11											
82		51N-4W-19 D C C 2				1.6										
83		51N-4W-22 B C A 1				2.1										
84		51N-4W-23 D A A 1														
85		51N-4W-24 A B B 1				.34										
	27	51N-4W-25 B B A	DALTON GARDENS #1	1.50	1.71					1.45	1.19	2.04	1.52	2.20	2.38	

WELL #		LOCATION		NITRATE (MG/L)												
USGS	PHD	TRS		'75	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87
86		51N-4W-27 D D B 1				1.6										
87		51N-4W-29 D B B 1														
	194	51N-4W-34 C D A	USFS NURSERY							.37	.21	.29	.37	.32	.34	.30
88		51N-4W-35 A D B 1				2.9										
89		51N-3W-19 B A B 1				.17										
	26	51N-3W-18 B C C	AVONDALE WELL	.15	.12					.17	.13	.18	.18	.69	.17	.21
90		50N-5W-1 A A D 1				.86										
	35	50N-5W-1 B B C	P.F. GREENFERRY #4	.51	.34											1.54
	36	50N-5W-1 A A A	ROSS PT. SYRINGA	1.91	1.44											2.32
91		50N-5W-1 C B B 1				.26										
92		50N-5W-6 D C C 1				.54										
93		50N-5W-7 A D D 1				.34										
94		50N-4W-5 D D A 1				.57										
	28	50N-4W-1 C C D	COEUR D'ALENE FOURTH STREET	1.46	1.40					1.12	.85		1.12			
	31	50N-4W-4 A A D	COEUR D'ALENE ATLAS	.62	.91					.81	1.06	1.24	1.31	1.22	.85	
	262	50N-4W-2 C C B	TURRELL WELL									.23	.16	.10	.15	.13
	29	50N-4W-12 C B B	COEUR D'ALENE LOCUST	.56	.62					.68	.67	.62	1.01	.81	.76	.75
	30	50N-4W-12 C C B	COEUR D'ALENE LINDEN	.48	.39					.31	.36	.67	.57	.57	.35	.56
			RATHDRUM OLD WELL							4.95	7.57	6.41				
			DALTON #2							2.10	.90					
	213		RIVERVIEW TERRACE							1.26	1.31	1.28	2.09	.73	.81	2.05

VALUES OF VOLATILE ORGANIC COMPOUNDS
FROM SELECTED WELLS ON THE RATHDRUM PRAIRIE

Rathdrum New Well	4/87	Chloroform	.142 ng/l*
Silver W. Association	7/87	Chloroform	.049 ug/l**
	7/87	Bromodichloromethane	.48 ug/l
	7/87	Dibromochloromethane	1,255 ug/l
	7/87	Bromoform	.16 ug/l
Coeur d'Alene Linden	7/87	Bromoform	.598 ug/l
Rathdrum New Well	7/87	Chloroform	.136 ug/l
	7/87	Bromodichloromethane	.18 ug/l
	7/87	Dibromochloromethane	.44 ug/l
	7/87	Bromoform	.38 ug/l
Post Falls #2	4/86	Chloroform	.1 ug/l
	4/86	Bromodichloromethane	1.8 ug/l
	4/86	Dibromochloromethane	6.4 ug/l
Turrell Well	4/86	Chloroform	.1 ug/l
	4/86	Bromoform	.1 ug/l
Rathdrum New Well	1/86	Chloroform	.7 ug/l
Coeur d'Alene Linden	4/85	Chloroform	1.2 ug/l
Rathdrum New Well	4/85	Chloroform	.8 ug/l
Turrell Well	4/85	Chloroform	1.5 ug/l

*Nanogram per liter
**Microgram per liter

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