A HYDROGEOLOGIC CHARACTERIZATION AND RECONNAISSANCE WATER QUALITY STUDY OF THE CHILCO CHANNEL AREA, KOOTENAI COUNTY, IDAHO

Prepared for:

Idaho Division of Environmental Quality
Water Quality Bureau
Coeur d'Alene, Idaho

Prepared by:

William A. Graham
John P. Buchanan
Department of Geology
Eastern Washington University
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ABSTRACT

The Chilco channel aquifer, a peripheral aquifer contributing to the Rathdrum Prairie aquifer in northeastern Kootenai County, Idaho, was not designated a part of the sole source aquifer by the Environmental Protection Agency in 1978. Shallow water tables, varying from 35 to 230 feet (11 to 70 meters) below ground surface, coupled with moderate to highly permeable sediments similar to those of the Rathdrum Prairie aquifer, suggests that the area requires careful investigation and protection.

Thirty one wells were sounded as part of this study during Summer, 1993 to determine the extent of the aquifer and depth to ground water. Water was sampled for nitrate, chloride, iron, phosphorus, hardness, alkalinity, specific conductance, and fecal coliform.

Previous studies by Hammond (1974) and Painter (1991a) suggested that a saturated alluvial aquifer exists from Farragut State Park southwest to Garwood. Well logs indicate large subsurface channels within the subsurface draining generally east to west, that are presumably extensions of pre-Pleistocene drainage systems. The channels are partially to completely filled with glaciogenic sediments that are locally saturated. A deep channel within Eightmile Prairie bisects the originally defined aquifer, and a ground water divide exists at the north end of the Chilco channel. Based upon the presence of this ground water divide, the area was subdivided into two principle watersheds; the Sage-Lewellen watershed, a highland in the northeastern portion of the study area drained by Sage Creek and Lewellen Creek, and the Chilco channel watershed, south of the ground water divide.

The ground water flow within the main Chilco channel comes primarily from recharge off the west slopes of the Coeur d'Alene Mountains and infiltration from precipitation. The water table is 35 ft (11 m) below the ground surface at the north end of the main channel and 230 ft (70 m) near Garwood. The hydraulic gradient is 0.004 in the northern portion of the channel, and 0.04 north of Garwood. Ground water flow from the main channel to the Rathdrum Prairie aquifer is 2 to 4 cfs (56.6 to 113.2 l/s). Hydraulic

conductivity values for glaciogenic sediments found in the Chilco channel range from 30 to 75 ft/day (98 to 246 m/day) for coarse sediments and 3 to 9 ft/day (9.8 to 88.2 m/day) for finer grained sediments.

Ground water quality was found to be excellent within the Sage-Lewellen watershed, although fecal coliform was found in one well. Mean values for the measured water quality parameters were lower than comparable mean values from the Rathdrum Prairie aquifer. Shallow water tables in sand and gravel where Sage Creek and Lewellen Creek become influent could be susceptible to contamination and should be considered a recharge area.

Ground water quality within the Chilco channel is good but mean values of hardness, alkalinity, and specific conductance were higher than comparable mean values for the same parameters in the Rathdrum Prairie aquifer, and they increased downgradient. The presence of fecal coliform and lower than average hardness, alkalinity, and specific conductance from a well near a site where water from Chilco Lake becomes influent to the aquifer suggests that contamination could occur from the lake. Since this implies the lake is a significant source of recharge for the aquifer, it should be protected in terms of its recharge contribution as well as its potential to contaminate the aquifer.

Due to the similarity of hydrogeologic properties the Chilco channel alluvial aquifer shares with the Rathdrum Prairie aquifer, it is highly recommended that it receive the same level of protection as the Rathdrum Prairie aquifer. A wellhead protection program should be considered for the area.

ACKNOWLEDGMENTS

I would like to thank Brian Painter and John Sutherland of the Idaho Department of Environmental Quality who chose Eastern Washington University for the project and provided their assistance in the investigation.

Several other agencies, such as the Idaho Department of Health and Welfare, the Idaho Department of Water Resources, and the Soil Conservation Service were helpful in providing vital information for the study. The water quality lab at the Idaho Department of Health and Welfare deserves a special nod for their excellent analysis work.

I would like to acknowledge the efforts of Bill Deobald who aided in the sounding and water sampling in the field. Without his help, the project may not have been as rewarding an experience.

Several homeowners were particularly helpful in this study in various ways. A. E. "Red" Bishop, John and Mary Veylupek, Larry Tipke, Ray Dare, Russ Bohn, Dan and Linda Thackery, Jan Engwer, John Luster, and several others too numerous to mention made a difficult job easier. I would like to thank the people of north Idaho, who in their cooperation and hospitality made this study possible.

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INTRODUCTION

General statement

The Chilco channel aquifer as described by Painter (1991a, 1991b) is the largest contributing aquifer flowing into the Rathdrum Prairie aquifer. The Chilco channel aquifer, approximately 12 miles (20 kilometers) north of Coeur d'Alene, Idaho was not designated as part of the Rathdrum Prairie sole source aquifer in 1978 by the U. S. Environmental Protection Agency for reasons that are still unclear. Due to this omission, the Chilco channel has not received the same level of protection in terms of septic tank density or other zoning regulations as the Rathdrum Prairie aquifer has had imposed. Demographic changes within the region are placing greater pressures upon the aquifer as a result of growth. Expansion of the cities of Hayden and Athol will eventually encroach upon the channel. Recent industrial, commercial, and residential development within the region necessitates characterization of the aquifer to produce an appropriate aquifer protection program. State and county protection schemes such as a wellhead protection program could be imposed to protect the area. Since ground water depths are shallower in the channel as compared to the Rathdrum Prairie aquifer, the Chilco channel may be more susceptible to some types of ground water contamination, particularly microbiological contaminants. The Chilco channel has a history of contamination believed to be from the Louisiana Pacific Waferwood Plant in Chilco. Other sites such as abandoned landfills, gravel pits and feed lots that lie on top of the aquifer may also be sources of potential ground water contamination.

Purpose of study

This report will attempt to describe the extent of the Chilco channel aquifer, the configuration of the water table, and an estimate of its hydrogeologic properties. The specific objectives of the study can be summarized as follows:

1) Describe the hydrogeology of the Chilco channel using existing information such as previous investigations and drillers' well logs. Information contained in the

well logs was utilized to produce fence diagrams that define the extent of aquifer materials as well as aquifer boundaries.

2) Field investigate the area of the aquifer to produce hydrogeologic map showing the aquifer boundaries and the configuration of the water table. The field investigations also verified well locations.

3) Characterize the general water quality of the aquifer by sampling water from selected wells. Water samples to be analyzed for alkalinity, hardness, specific conductance, nitrate, chloride, iron, phosphorus, and fecal coliform bacteria.

4) Identify sites of potential ground water contamination, historically as well as in the present.

5) Recommend where monitoring wells should be drilled near sites of potential ground water contamination, and recommend a protection scheme for the study area.

Much of the data accumulated for this report was from previous geologic and hydrogeologic investigations, geologic maps, and U. S. Geological Survey topographic maps. The primary references used for general geology are Anderson (1927; 1940), Richmond et al. (1965), Savage, (1965; 1967), Griggs (1973), Conners (1976), Waitt and Thorson (1983), Rhodes and Hyndman (1984; 1988), and Richmond (1986). Important hydrogeologic references used are Hammond (1974), Drost and Seitz (1978), Parliman et al. (1980), Jehn et al.(1988), and Painter (1991a, 1991b). The base maps used in the study are principally 1: 24,000, 1: 62,500, and 1: 100,000 scale U.S. Geological Survey topographic maps. The 15 minute quadrangles containing the study area include the Athol and Spirit Lake maps. The 7.5 minute quadrangles used for this study include the Bayview, Athol, Spirit Lake East, Hayden and Hayden Lake maps. Well log data was obtained from the Idaho Department of Health and Welfare, Water Resources Division. Soil survey information was obtained from the Soil Conservation Service Kootenai County survey.

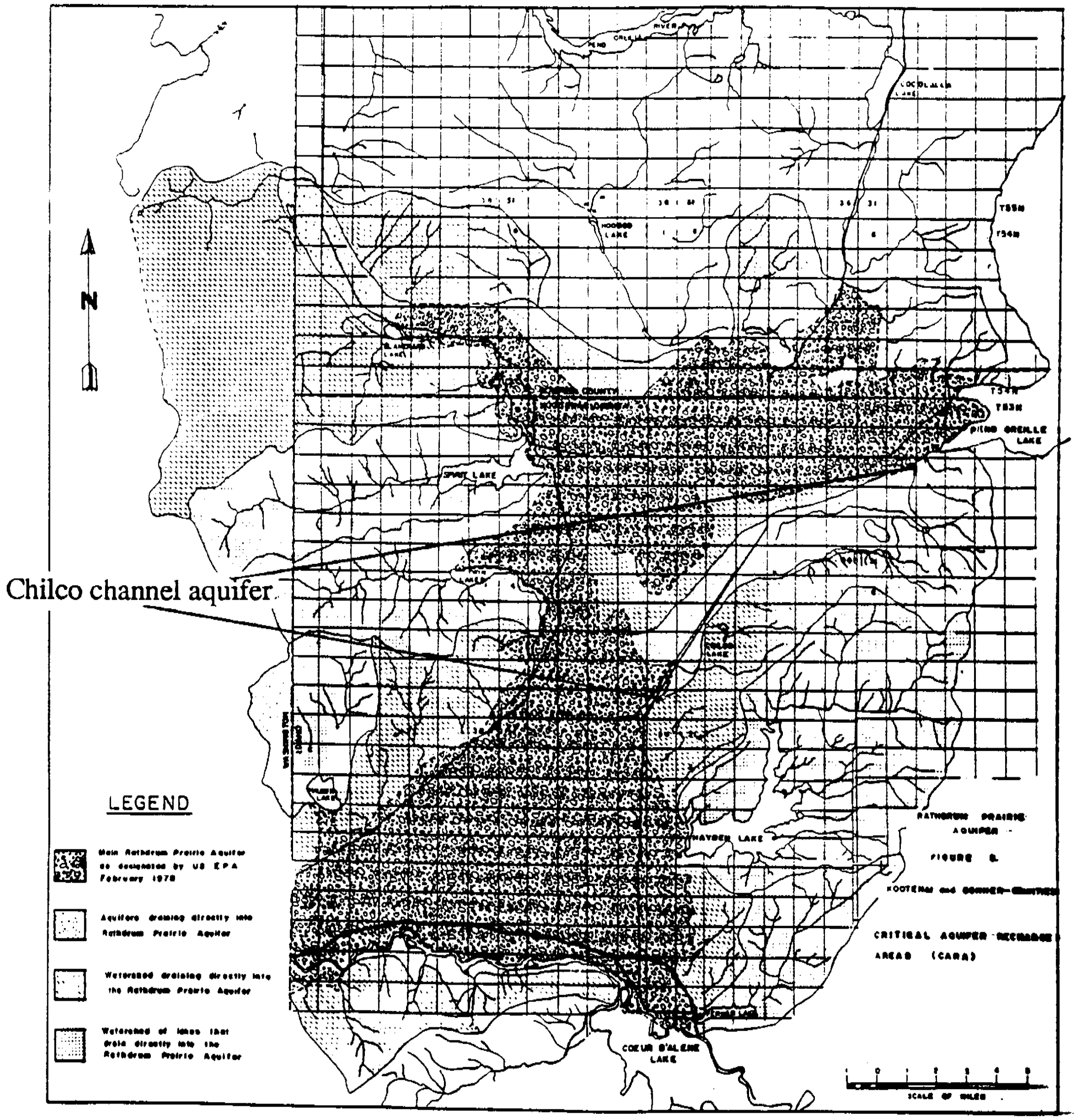

Figure 1. General location map of the Chilco channel aquifer and its relationship to the Rathdrum Prairie aquifer (Painter, 1991a).

DESCRIPTION OF STUDY AREA

Location

The Chilco channel is located within the Rathdrum Prairie (Figure 1) in Kootenai County approximately 12 mi (20 km) north of Coeur d'Alene, Idaho. State Highway 95 parallels the length of the main channel which is oriented approximately southwest to northeast. The Chilco channel is one of three channels which connect the northern Rathdrum Prairie with the southern portion. Each channel is oriented in a southwest to northeast direction. They are from west to east : the west channel, the middle channel, and the Chilco channel (Figure 2).

The Chilco channel study area extends northeastward from the main channel near Garwood to Farragut State Park on the southwest shore of Lake Pend Oreille, and south to the foothills of the Coeur d'Alene Mountains. The study are is bounded by Chilco ridge to the southwest and Eightmile Prairie to the west. The town of Athol roughly bounds the northwest corner of the study area.

Physiography

The study area lies mostly within the Northern Rocky Mountain Province (Howard and Williams, 1972). The Columbia River Plateau lies towards the west, but the presence of Columbia River basalts within the study area suggests that the area lies within the margins of the Columbia River Plateau Province.

The study area (Figure 3) , located within the northern Rathdrum Prairie, has a drainage area of 69 square miles (Painter, 1991a, 1991b). The Rathdrum Prairie is a flat to rolling lowland varying in elevation from 2,460 feet (750 meters) near Lake Pend Oreille to 2,130 ft (650 m) near the state line. The highlands framing the area are the Coeur d'Alene Mountains to the southeast, and the Selkirk Mountains to the northwest, which rise to elevations approximately 5,000 ft (1,500 m) and 6,000 ft (1,800 m) respectively, several miles away from the channels (Figure 3). The channels and the Rathdrum Prairie

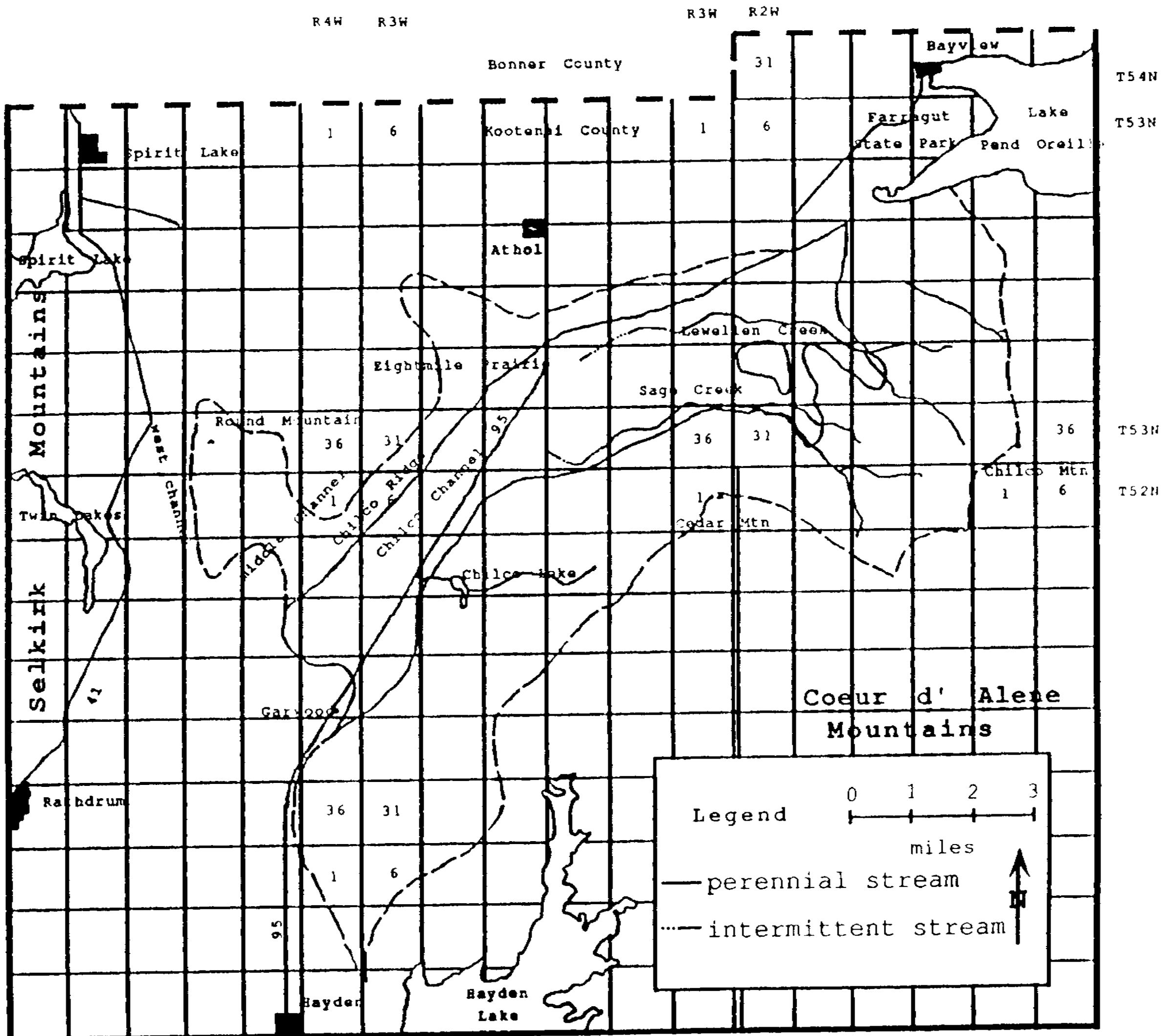

Figure 2. Location map of Chilco channel study area and surrounding region. Dashed line is the watershed boundary and the solid line is the aquifer boundary of the Chilco channel aquifer as defined by Painter (1991a) illustrated in Figure 1.

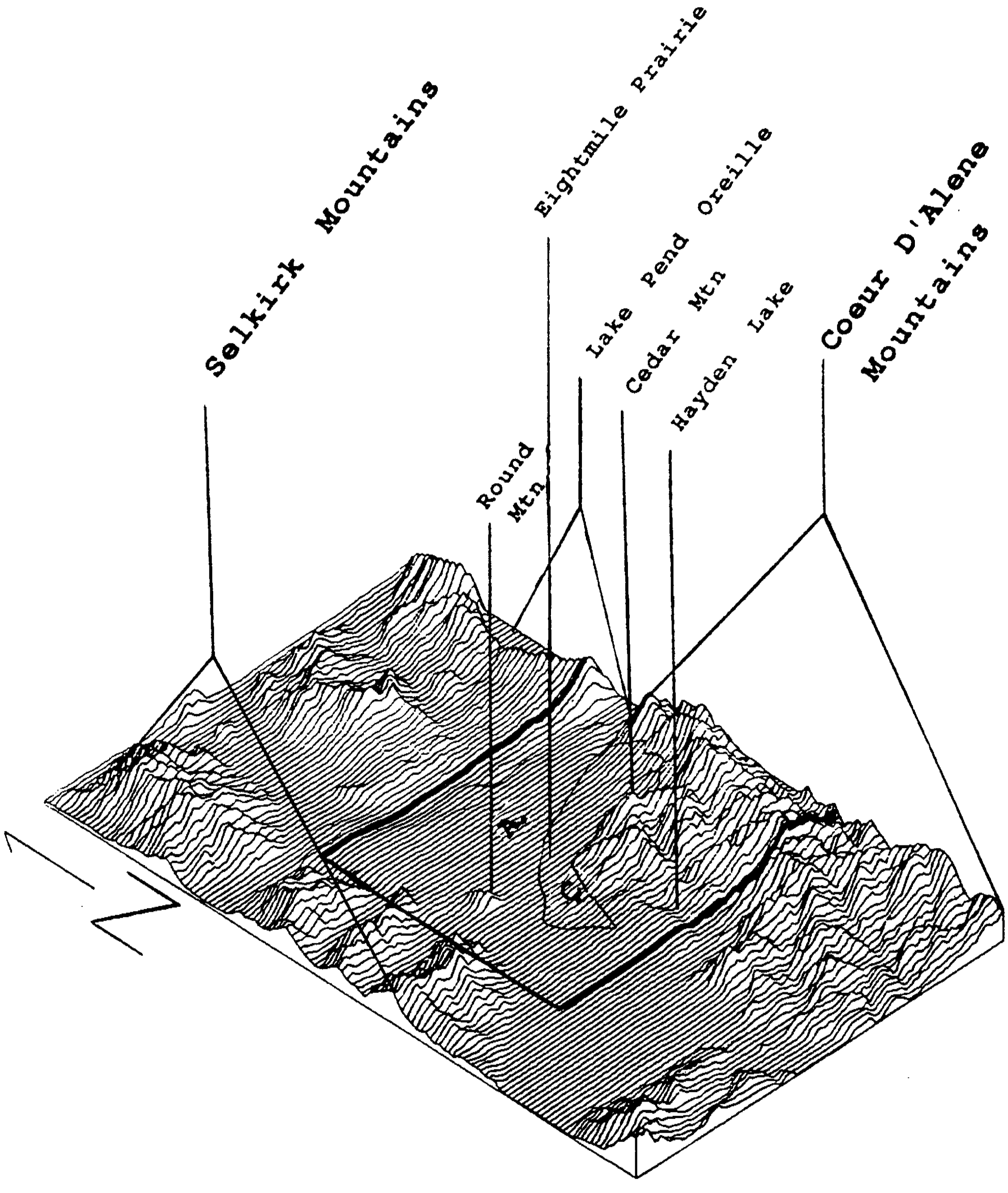

Figure 3. Three dimensional representation of the Rathdrum Prairie and regional physiographic features. A and C indicates Athol and Chilco, respectively. Inside the bold square is The Chilco channel aquifer is outlined as defined by Painter (1991a).

Trench is an unusually long structural and erosional depression which follows the length of the Rathdrum Prairie north into Canada. The trench narrows towards the south. Near the Bonner County line the trench is about 13 miles wide, eight miles wide near Rathdrum, and four miles wide at the state line (Anderson, 1940). Several hills stand in high relief within the Chilco channel area. Chilco ridge bounding the channel to the northeast rises 230 ft (70 m) above the channel floor. The ridge-bound portion of the Chilco channel study area is approximately four miles (6.5 km) long and one mile (1.6 km) wide. The ridge-bound portion of the Chilco channel will, for the remainder of the report, be called the main Chilco channel.

The northeastern section of the study area lies upon a conspicuous north-south trending gravel terrace which slopes gradually upward towards the east, eventually meeting the steep mountain slopes of the Coeur d'Alene Mountains. This is the only portion of the study area where streams flow across lowlands for any appreciable distance. The two principle streams in this area are Sage Creek and Lewellen Creek (Figure 2) which become influent on the gravel terrace. All streams, both perennial and intermittent, become influent shortly after leaving bedrock.

Climate

Historical climatological data obtained from National Oceanic and Atmospheric Administration (NOAA) in the form of mean monthly temperature and precipitation are presented in Tables 1 and 2, respectively. Other general climatological data was derived from a soil survey produced by the Soil Conservation Service (SCS, 1981).

Kootenai County area is characterized by dry summers, warm to hot in the lowlands and cooler in the mountains. The winters are wet and cold in the mountains. Valleys are colder than adjacent mountain slopes due to cold air drainage (SCS, 1981).

Table 1. Average monthly temperature for Bayview Model Basin.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Average**
° F	27.2	31.5	35.4	42.9	51.0	58.3	64.4	63.0	54.6	44.5	35.3	30.4	**44.9**
° C	-2.7	-0.3	1.9	6.1	10.6	14.6	18.0	17.2	12.6	6.9	1.8	-0.9	**7.2**

Table 2. Average monthly precipitation for Bayview Model Basin.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
inches	3.30	2.31	1.80	1.58	1.92	1.83	0.82	1.23	1.28	2.04	2.72	3.37	**24.20**
cm	8.38	5.87	4.57	4.01	4.88	4.65	2.08	3.12	3.25	5.18	6.91	8.56	**61.47**

The mountains are generally cooler year round, the average annual temperature is 38-42 ° F (3-6 ° C). The warmest area in the county, on the western Rathdrum Prairie, has an average annual temperature of about 47 ° F (8 ° C) (SCS, 1981).

Precipitation increases eastward towards the northern Rocky Mountains. Precipitation generally falls as snow in the late fall to early spring, and as rain during the late spring and summer. Snow accumulations are considerably higher in the mountains as compared with the lowlands.

Geology

The geologic setting of the region and its history since pre-Miocene time is of particular importance in interpreting the origin of the channels, and the deposition of sedimentary materials responsible for the aquifer system(s) framework. The following is description of the lithologic units which occur within the study area (Figure 4) as mapped by Griggs (1973).

Precambrian rocks

The oldest rocks within the study area are the Prichard Formation and Wallace Formation of the Belt Supergroup. The Belt Supergroup is a thick sequence of sedimentary and metasedimentary rocks that where deposited within the Cordilleran miogeosyncline during Precambrian time (King, 1977). The Prichard Formation is slightly metamorphosed argillite, siltite and quartzite with lesser amounts of mainly mica schist, gneiss and quartzite (Griggs, 1973). The Prichard Formation is primarily a highly metamorphosed gneiss within the study area and outcrops at Round Mountain approximately three miles northwest of Chilco according to Griggs (1973). These rocks were classified as gneiss and mylonites of Mesozoic age by Rhodes and Hyndman (1984).

The Wallace Formation within the study area has been subdivided by Griggs (1973) into an upper and lower part. The lower part consists of two distinguishable members: a

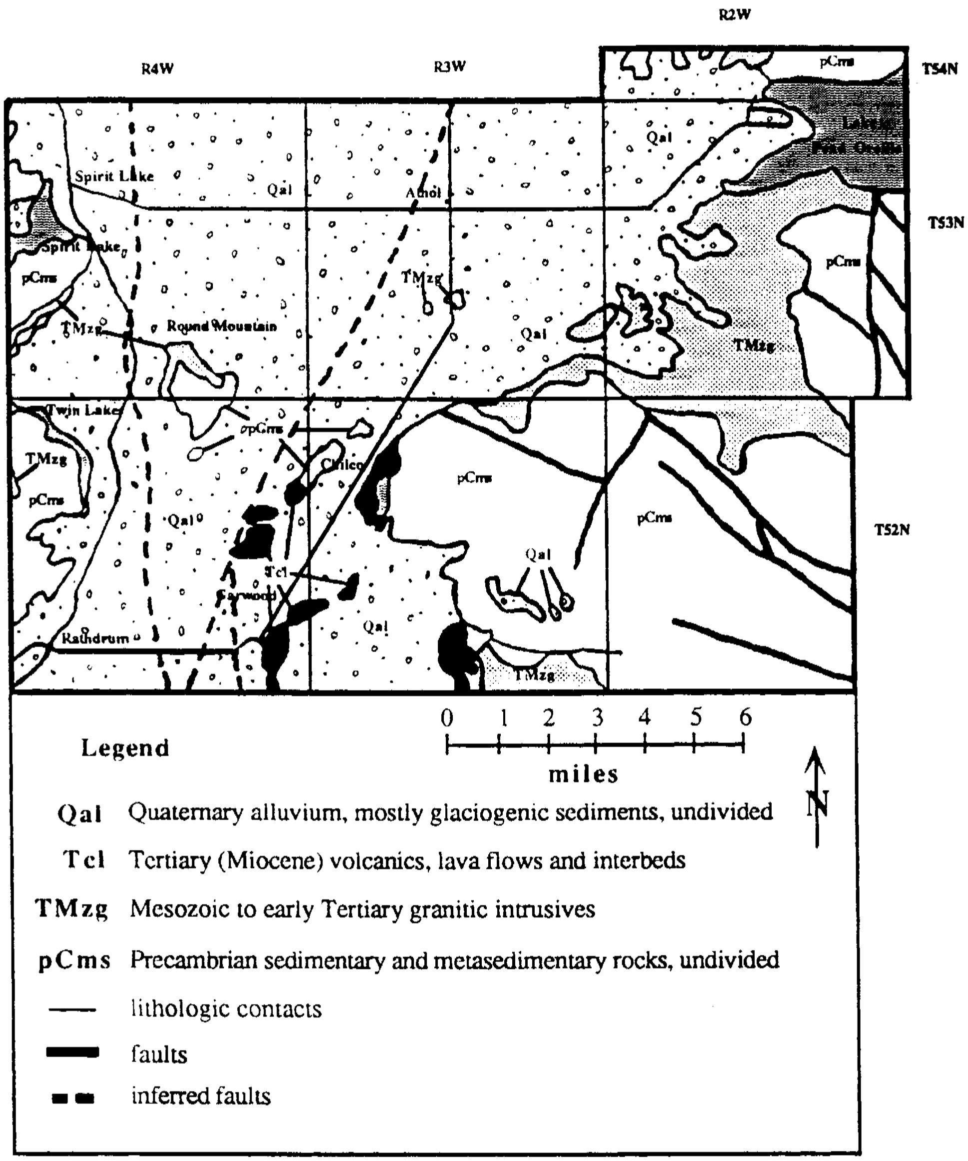

Figure 4. Geologic map of the Chilco channel study area (modified from Griggs, 1973).

black argillite and a light gray siltite or quartzite, the latter is carbonate bearing. These rocks are of lower metamorphic grade than the rocks of the Prichard Formation. Blocky weathering and a rusty weathering rind are common characteristics. The lower part of the Wallace Formation outcrops at Chilco ridge due west of Chilco and on the eastern shore of Chilco Lake where it is in contact with Tertiary lavas and interbeds. It also creates the southeastern boundary of the Chilco channel about two miles northeast of Chilco. The lower part is fault-bound three miles northeast of Chilco where it contacts the upper part of the Wallace Formation. The upper part of the Wallace Formation consists of very thinly bedded or laminated dark argillite, a light gray siltite, and minor carbonates (Griggs, 1973).

Mesozoic and early Tertiary granitic rocks

Plutons and batholithic complexes of quartz monzanite to granodiorite composition outcrop within the region. Most rocks are of medium to coarse-grained texture, commonly porphyritic (Griggs, 1973). Within the study area, K-Ar dating suggests that the granitic rocks east of the Purcell Trench are Mesozoic in age, and those rocks west of the Purcell Trench are early Tertiary in age (Miller and Engels, 1975). Fine-grained sill-like bodies exist where plutons have intruded the high grade metamorphic rocks. The granitic rocks outcrop on the northeast and northwest flanks of Round Mountain, the northeastern tip of Chilco Ridge and along the southeast boundary of the alluvial valley approximately three miles northeast of Chilco (Figure 4). Savage (1967) identifies the granitic rocks of this area as part of the Kaniksu batholith.

Tertiary volcanics and interbeds

The volcanic rocks and interbeds within the study area are respectively the Miocene age Columbia River Basalts and Latah Formation. The Columbia River Basalts are flows of dense tholeiitic basalt, generally flat-lying, commonly ranging in thickness from 50 to 150 ft (15 to 46 m) (Griggs, 1973). Pillow-palagonite complexes are common within the study area indicating that the flow of lava into water was common near the plateau margins (Griggs, 1976). The upper caprock is likely the Wanapum Basalt. Interbedded with basalt is the Latah Formation consisting of lacustrine beds of poorly indurated siltstone, claystone, sandstone and minor conglomerate tan to gray in color (Griggs, 1973). Columbia River Basalt outcrops on the southeastern portion of Chilco ridge and along the "Rimrock" area due east of Chilco (Griggs, 1973).

The Rimrock basalts, known formally as Wanapum basalt, stratigraphically lie above the "Valley" basalts. "Valley" or Grande Ronde basalts are located below about 2100-2200 ft (640-671 m). The Grande Ronde tends to weather into large bulbous masses along curved cooling joints and are often referred to as "haystacks". The Wanapum basalt is much more regular in shape and thinner than Grande Ronde type basalts (Robinson, 1991).

Outcrops along the Chilco ridge have large talus piles, slump blocks and haystacks associated with them, particularly along the eastern margin of the ridge. Based upon these observations, the basalt along Chilco ridge is probably Grande Ronde basalt. Outcrops along the terraced area east of Chilco are less disturbed, showing typical colonnade and entablature structure.

Pleistocene glaciogenic alluvium

The bulk of valley fill within the region consists of glaciofluvial sands, gravels and some silts and clays derived from glaciers, streams and lakes. Very coarse-grained material such as boulders are common perhaps occurring as till, dropstones or as bedload from the Lake Missoula floods. Generally, coarser-grained materials are closer to the valley center and finer-grained material is found near the valley margins. Much of the alluvium is derived from glacial outburst floods (Baker, 1973; O'Conner and Baker, 1992) which are described later. The remainder of the deposits are likely glacial outwash (Griggs, 1973).

Holocene alluvium

These deposits are sands and gravels derived from post-glacial depositional processes such as stream flow, hillslope processes and mass wasting. These sediments are largely insignificant compared to the glaciofluvial deposits and are mostly restricted to the valleys above the channel (Griggs, 1973).

Regional Geologic History

This section discusses the relevant regional geologic events within the study area which led to the development of the Rathdrum Prairie aquifer and the Chilco channel. The drainage system development in the region is also included in the discussion.

The drainage networks which evolved since early Tertiary time have been extensively studied by several workers mostly because of their relevance to the present day distribution of aquifer materials. Of principle interest are the geologic events that have occurred during Tertiary and Quaternary time, such as the formation of the Purcell Trench, the pre-Miocene drainage, the formation of lava-dammed lakes and their drainage, the pre-Pleistocene drainage, Pleistocene glaciation, and the present day drainage.

Formation of the Purcell Trench

The Purcell Trench is a topographic low which extends over a distance of 120 mi (200 km) from the south end of Lake Coeur d'Alene to the Canadian border. Much of the trench contains an inferred fault which may be a low angle, eastward-dipping detachment fault which is never actually exposed. The fault is believed to be the result of crustal extension during Eocene time. The area containing the Rathdrum Prairie aquifer grew to its present size during Eocene time (Rhodes and Hyndman, 1988).

Pre-Miocene drainage

Earlier workers within the region cite the existence of a deeply dissected river valley flowing from what is now the Clark Fork River and Lake Pend Oreille Valley due west across the northern Rathdrum Prairie and turning south through the Rathdrum Prairie and Spokane Valley (Anderson, 1927,1940 ; Savage, 1967). Hammond (1974) inferred that the ancestral stream flowed through what is now the west channel. An alluvial fill of unknown thickness within the Hoodoo Valley could reflect the valley of the ancestral Priest River which is believed to have joined with the ancestral Clark Fork River (Anderson, 1927; Griggs, 1976) also known as the Rathdrum River (Figure 5) (Savage, 1965; 1967). The St. Joe River-Coeur d'Alene Rivers flowing from the south joined with the Rathdrum River flowing west and into the present day Spokane River Valley and ultimately, the ancestral Columbia River (Anderson, 1927; Savage, 1967). During this time granitic rocks would have developed deeply weathered zones. Deeper valleys than are present today may have been formed due to stream rejuvenation from uplift and alluvial aggradation in Quaternary time. The Rathdrum River valley elevation would have been about 950 ft (290 m) from the bottom of Lake Pend Oreille to approximately 500 ft (152 m), the estimated bottom of the ancient Spokane River valley assuming minimal glacial overdeepening of Lake Pend Oreille in Pleistocene time (Anderson, 1927).

Miocene-late Tertiary drainage

During Miocene time, the Columbia River Basalt flows moved through topographic lows such as river drainages, lakes and ponds. Moving northeastward, lava penetrated the Rathdrum River Valley near present day Spokane, creating a succession of lava dammed lake basins which inundated what is now the Spokane valley (Robinson, 1991) and probably the Rathdrum Prairie area as well. Deposition of clay, silt, sand and gravel in these lakes resulted in sedimentary interbeds of variable thickness known as Latah Formation. Most documented Latah occurrences are found at elevations of 1800-2200 ft

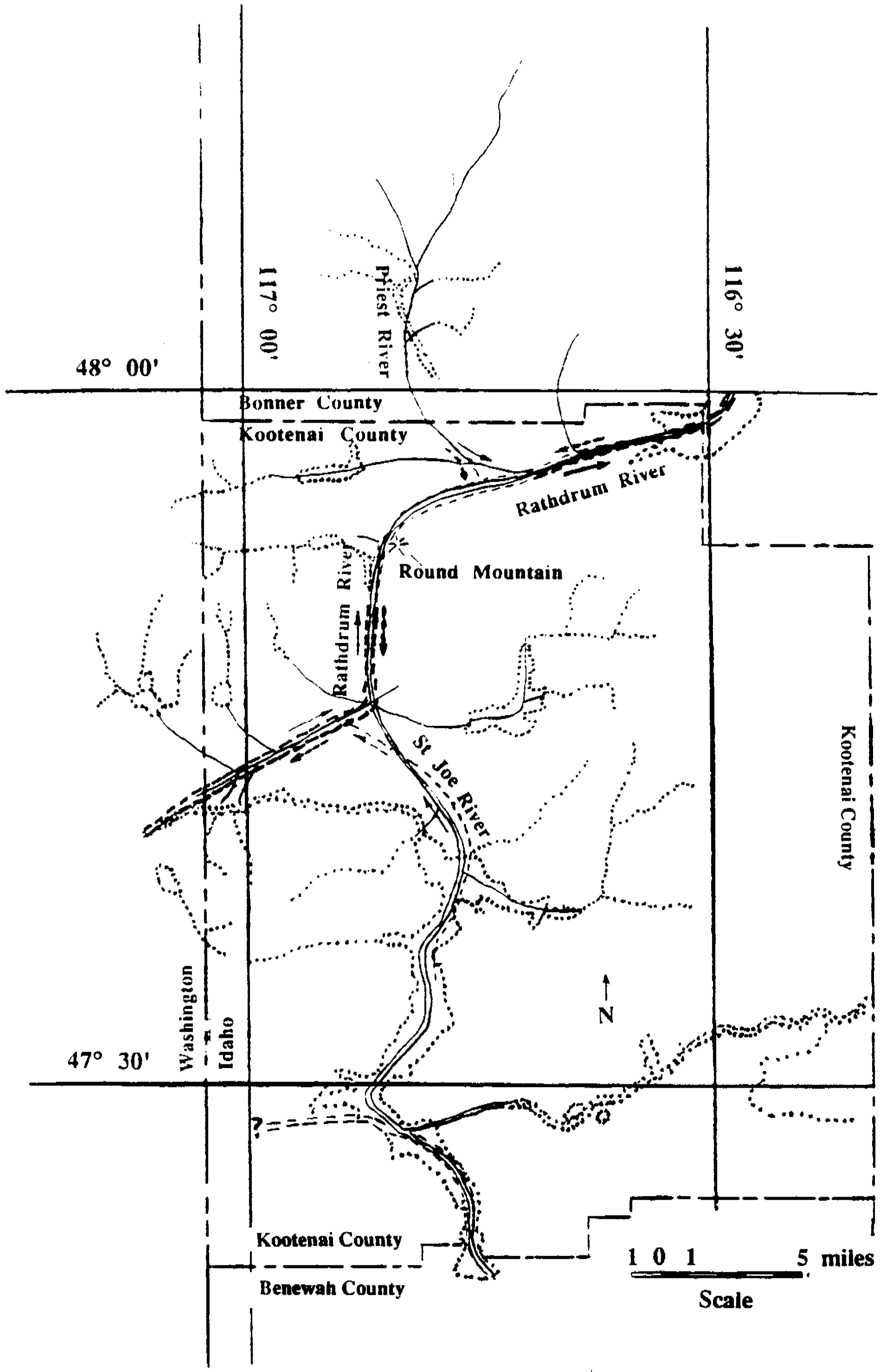

Figure 5. Changes in the drainage orientation from pre-Miocene to late Tertiary time in the Rathdrum Prairie. Dashed lines and arrows indicate pre-Miocene drainage direction. Solid lines and arrows indicate Miocene drainage direction. Dotted lines outline present day rivers and lakes (modified from Anderson, 1927).

(540-660 m) and especially 2050-2100 ft (615-630 m) in Spokane County, Washington (Robinson 1991). Latah thicknesses are often 20-40 ft (6-12 m) and thicknesses of 100 ft (30 m) and greater have been confirmed (Robinson, 1991). Seismic studies of the Spokane Valley purport to demonstrate 800 ft (244 m) of Latah (Robinson, 1991). The Chilco channel study area is located within the fringes of this depositional lake basin. Some of the coarser sands and gravels interpreted from the well logs, which are interbedded within the basalts, may represent deposition in Gilbert-type deltas along the lake margins. Basalt lava dams likely caused a drainage change to the north, down what is now the Kootenai Valley (Anderson, 1927). Streams later reclaimed old drainages within the basalts as the basalt dams eroded away (Savage, 1967).

Anderson (1927) believed that drainage outflow moved through the Kootenai Valley in pre-Pleistocene time. According to Robinson (1991), Latah deposition occurred over the span of 1.0-1.5 million years. Later, during dry climatic episodes or when streams breached the lava dam, lake sediments became sub-aerially exposed and may have eroded into a badlands-like topography or to crystalline bedrock. (Robinson, 1991). The Latah Formation was then overlain by the Grande Ronde and the Wanapum basalts, both of which occur within the study area.

Pleistocene glaciation

The Northern Rocky Mountains experienced several glaciations which advanced from the Cordilleran ice sheet during the Pleistocene. Within the study area gravels, sands, silts and clays were deposited directly or indirectly by glaciers as glacial till, moraine deposits, kame deposits, and flood deposits. Various glaciations have been recognized by comparing the relative degree of weathering of glacial tills. Tills of pre-Illinoisan, Illiniosan, early Wisconsin and late Wisconsin age have been recognized within the region. Existence of pre-Wisconsin (Bull Lake) age tills within the study area is debatable and has remained controversial. Only Wisconsin (Fraser) age moraines have been identified within the region. Earlier moraines, if they existed within the study area, are inferred to have been obliterated by glacial outburst flooding. Flood deposits and glaciolacustrine deposits constitute the majority of alluvial materials within the study area and are the principal aquifer media (Richmond, 1986; Richmond et al., 1965; Waitt and Thorson, 1983)

Pre-Wisconsin (Bull Lake) glaciation

The maximum extent of glaciation in the Rathdrum Prairie during pre-Bull Lake and Bull Lake time is debatable. No pre-Bull Lake till has been recognized in the Chilco channel study area although pre-Bull Lake flood deposits, located 90 mi (150 km) southwest of Spokane, suggests that Lake Missoula was impounded at least once in pre-Bull Lake time (Richmond, 1986; Baker, 1973). Richmond et al. (1965) drew the furthest extent of the early stade of Bull Lake glaciation just east of Spokane, a boundary which has been refuted by many subsequent workers (Kiver, personal communication, 1993). Late Fraser glacial outburst flooding within the Rathdrum Prairie has covered or obliterated evidence of pre-Bull Lake or Bull Lake glaciations (Richmond, 1986). Glacial deposits near Hayden Lake, believed by earlier workers to be Bull Lake age till, show well weathered soil horizons (Richmond et al., 1965). Glacial tills from the Bull Lake stade may remain buried within the Chilco channel since flood energies within the channel were probably not high compared to those flooding the west channel ; although it is unlikely that they are preserved. High-standing kame deltas or terraces of Bull Lake age are believed by some workers to bound the Rathdrum Prairie on both the slopes of the Coeur d'Alene and Selkirk Mountains (Richmond et al., 1965). Other workers have dismissed these deposits as being older Fraser age flood deposits from glacial Lake Missoula (Waitt and Thorson, 1983). Weathered soil profiles of Bull Lake age within the study area have not been identified.

Sometime during pre-Fraser time the waters of glacial Lake Missoula breached the ice dam at Clark Fork causing catastrophic flooding within the Rathdrum Prairie (Bretz et al., 1956; Bretz, 1969, Baker, 1973). It is inferred that the catastrophic flooding occurred at least once during Bull Lake time because Bull Lake age flood deposits have been located within various coulees on the Columbia Plateau (Richmond et al., 1965). Floods were likely directed down the Little Spokane River valley and the Rathdrum Prairie-Spokane valley, eventually debouching upon the Columbia Plateau. Early workers cite the existence of a Bull Lake age glacial Lake Spokane which was formed when the Colville lobe dammed the Spokane River at Long Lake (Richmond et al., 1965). This glacial Lake Spokane was low standing at 2075 ft (640 m) and probably did not extend into the northern Rathdrum Prairie (Waitt and Thorson, 1983).

Late Wisconsin glaciations (late Fraser)

Advances of the Cordilleran ice sheet during late Wisconsin (late Fraser) resulted in the impoundment of two major glacial lakes which influenced sedimentation within the study area. These include glacial Lake Columbia and glacial Lake Missoula.

Glacial Lake Columbia was formed by the damming of the Columbia River by the Okanogan ice lobe near the vicinity of present day Grand Coulee Dam (Richmond et al., 1965). Maximum stable lake level elevations for glacial Lake Columbia is determined to be 2345 ft (715 m) (Atwater, 1986; 1987). The lake drained itself over low divides near Cheney, Grand Coulee, and Hawk Creek (Waitt, 1980; Atwater, 1986). At this elevation glacial Lake Columbia would have inundated all three of the channels in the Chilco channel study area in the northern Rathdrum Prairie. High water stages of glacial Lake Columbia were dependent upon the extent of the advance of the Okanogan lobe near Grand Coulee (Atwater, 1986). No later than 15,550 ± 450 yr B.P.? (late Fraser time) the Purcell Trench lobe dammed glacial Lake Missoula and retreated from that position about 13,350 ± 550 yr B. P. (Atwater, 1986). It is likely that the terminal moraine west of Lake Pend Oreille represents the maximum extent of the Pend Oreille lobe in late Wisconsin time (Savage, 1967). All moraines appear to have formed when the ice was at its maximum extent and

Lake Missoula was at an elevated level (Richmond, 1986). Atwater (1986) suggests that the Okanogan lobe was slightly later in its advance and retreat than the Purcell Trench lobe, and that glacial Lake Missoula preceded, but was outlasted by, glacial Lake Columbia.

Glacial Lake Missoula outburst flooding

The Purcell Trench lobe of the Cordilleran ice sheet dammed the Clark Fork River impounding glacial Lake Missoula which ultimately flooded the northern Rathdrum Prairie and Columbia Plateau westward to the Pacific Ocean. Several times during late Wisconsin time, perhaps as many as 40 times, the ice dam at Clark Fork failed causing catastrophic flooding when the water level in the lake rose to nine-tenths that of the ice dam (Waitt, 1985; 1980). Flood waters entered glacial Lake Columbia which was already present in the Chilco channel study area (Figure 6). Recent work suggests that the peak discharges in the Spokane valley are estimated at 600 ± 106 million $ft^3 \cdot sec^{-1}$ (17 ± 3 million $m^3 \cdot sec^{-1}$) (O'Connor and Baker, 1992). Scabland topography at elevations of 2680 ft (817 m) and 2601 ft (793 m) near Round Mountain and Hayden Lake, respectively, indicate the minimum and maximum water elevation or stage during the floods (O'Connor and Baker, 1992). A large flood bar southwest of Round Mountain, at 2601 ft (793 m) elevation suggests that substantial time was required for its formation and was therefore submerged for a significant amount of time (O'Connor and Baker, 1992). Also during the flooding episodes, multiple flood paths would have developed with portions of the flow moving down the Little Spokane River as well as the Rathdrum Prairie-Spokane Valley drainage (O'Connor and Baker, 1992). It is likely that turbulent eddies formed on the valley wall side of flow boundaries and were important depositional sinks in this region. O'Connor and Baker (1992) describe an effective flow boundary line in a southwest to northeast line turning north at the Chilco channel. During the final phase of each flooding episode, discharges would have waned and flow boundaries, and therefore eddies and their associated deposits, would have probably wandered across the prairie, perhaps following

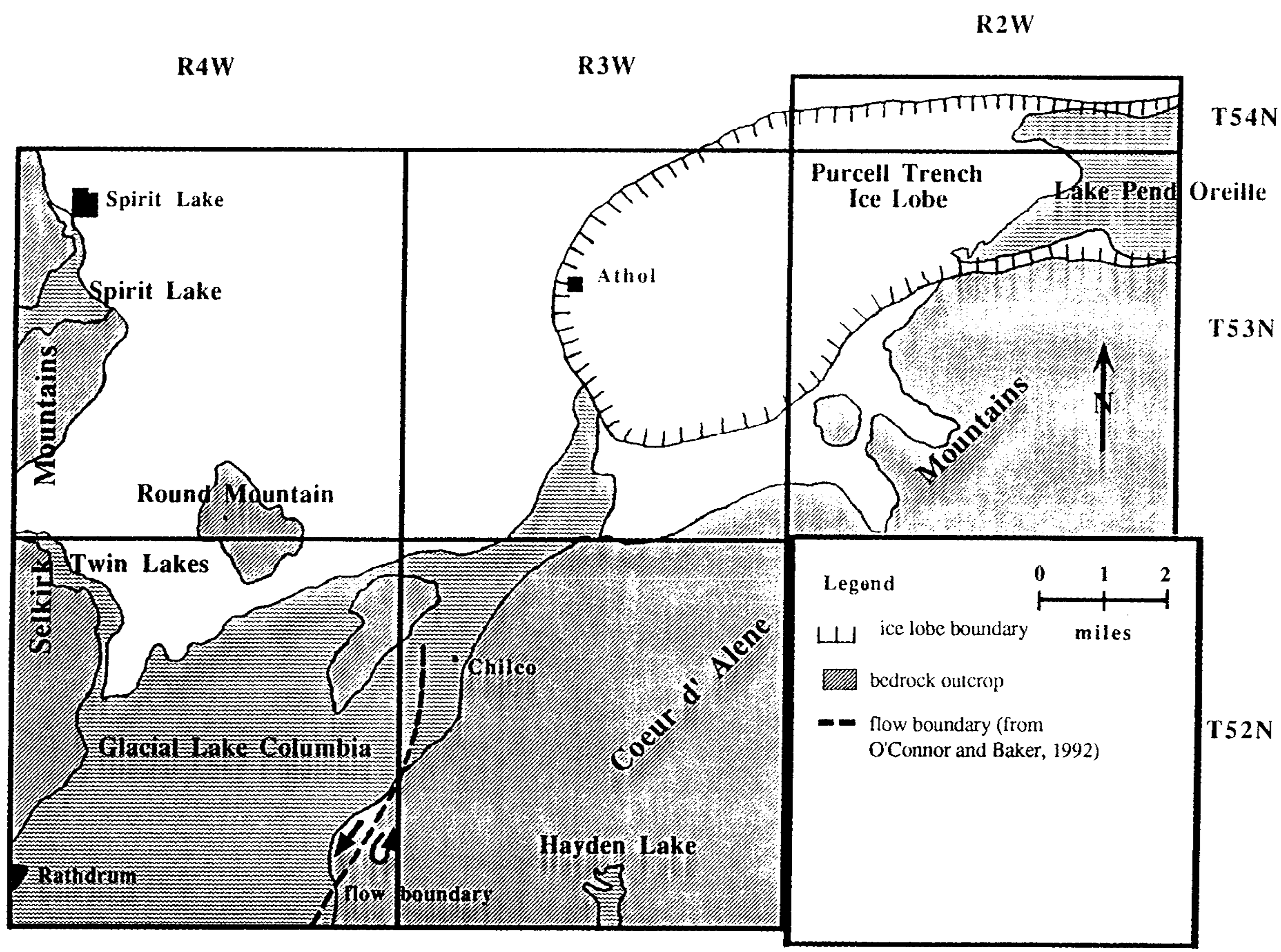

Figure 6. Orientation of glacial Lake Columbia and the Purcell Trench lobe in the northern Rathdrum Prairie during the late Wisconsin glaciation.

topographic lows. The overall topography and relict drainage indicates a braided to meandering river channel system in the northern Rathdrum Prairie (Conners, 1973). Flows within the thalweg side of the boundary would transport sediments whereas flows south of the boundary within an eddy would deposit more poorly sorted sediments.

It is important to note that the outburst floods varied greatly in volume, as much as 50-fold (Atwater, 1987). Weaker flood discharges, or the waning stages of large floods, would have followed topographic lows, anastamosing across the Rathdrum Prairie much like a braided stream due to a high gradient and high sediment load. During these events, the older Rathdrum River valley aggraded with glaciofluvial and flood deposits to a depth such that the old Rathdrum River stream valley became completely buried. The deepest buried valley, which could contain from 750 to 1000 ft (229 to 305 m) of alluvial fill, is the west channel in the northern Rathdrum Prairie. The topographically higher aggradational surface in the west channel would have deflected low discharge floods, or the waning stages of major floods, further eastward causing the middle channel and the Chilco channel to aggrade last. If this inference is true, then only the largest floods (and the latest floods) actually deposited sediments in the Chilco channel. Atwater (1987) cites evidence of varved sediments in the Okanogan region in Washington, suggesting that progressively smaller floods into glacial Lake Columbia from Lake Missoula in late Fraser time, and the persistence of glacial Lake Columbia for several decades after the last outburst flood.

Relict drainage pattern

The entire length of the Rathdrum Prairie and Spokane valley exhibits relict braided to dendritic stream patterns from the glacial outburst floods. The broad, shallow nature of these remnant features suggests that not only a large discharge of water and sediment had occurred, but an abrupt cessation of flow took place as well (Conners, 1973).

A gravel terrace located one half mile east of Athol, oriented in a north to south direction, represents a slipoff bank of a poorly developed meander which grades gradually into higher outwash levels without a major break in slope. This represents channeling contemporaneous with outburst flooding (Conners, 1973).

The Chilco channel is topographically the lowest channel and is the shallowest in depth of the three channels connecting the southern Rathdrum Prairie with the northern Rathdrum Prairie. This suggests that the Chilco channel was the last channel to drain flood waters, and that the west and middle channels had aggraded to levels higher than the flood waters during later floods.

Present day drainage

There are no major streams which flow across or along the length of the Chilco Channel study area. All streams that do occur in this area drain the bedrock highlands adjacent to the channels and are perennial or intermittent, and at lower reaches become influent when they reach the alluvium. The sandy and gravelly sediments in the study area are too porous and too permeable to support a small stream for significant distances. The largest creeks within the study area are Lewellen Creek and Sage Creek (see Figure 2) which drain the northern slope of the Coeur d'Alene Mountains. Most tributaries of these streams drain towards the north, and the main stream channels drain towards the west. Perhaps both Sage Creek and Lewellen Creek captured relict stream drainages created by the floods.

A natural spillway over bedrock draining Chilco Lake cascades onto the Chilco channel and flows into a small pond where it becomes influent. Other very small intermittent streams and springs drain into the Chilco channel near the "inlet" near Garwood, and southeastern Chilco Ridge.

It is likely that many small springs exist in the subsurface, particularly near where the basalts contact the pre-Tertiary basement rock, and where the lowlands meet the mountains at the slope break. Several of these springs were identified and mapped during the field investigation.

Pedology

Soils within the study area are very similar to those found in other parts of the Rathdrum Prairie. A notable difference is the presence of soil-rock outcrop associations near the Chilco Channel. These soil-rock outcrop associations were compiled onto a map and they aided in the definition of the boundaries of the aquifer. All information regarding soils and their properties was taken from the Soil Survey of Kootenai County Area, Idaho (SCS, 1981).

The vast majority of soils in the study area are of the Kootenai-Bonner association and the Avonville-Garrison-McGuire association. These soils are located within the lowlands from elevations of about 2,100 to 2,600 ft (640 to 793 m). The Kootenai Series is common within the main channel. The Bonner Series soils nearly cover the northeastern terrace. Avonville soils occur predominantly in the Eightmile Prairie area and are the least abundant in the area. Highland soils are of the Vassar association which are not as significant since the majority of the aquifers are in lowlands (SCS, 1981).

The Kootenai soil is a very deep, well drained, slightly weathered glacial till (?) which is mantled by volcanic ash and loess. The supposition that these soils are derived from tills is improbable, but are more likely derived from glaciolacustrine deposits. The soils have a very low available water capacity and are drier than the Bonner soils. The Kootenai soils are gravelly silt loams and very gravelly loams up to about 26 inches in depth with a very gravelly coarse sand substratum. Kootenai soils have very high permeability which limits the function of sanitary facilities. Community septic systems are recommended because of the potential for ground water pollution in areas of high population density (SCS, 1981).

Bonner soils are very deep, well drained soils derived from glacial outwash capped by volcanic ash and loess. The top horizon is a gravely silt loam grading into a gravelly loam sand in the substratum. Permeability is rapid, and runoff is slow to medium. The potential for ground water pollution from septic sources is significant within the Bonner soils, perhaps greater than the Kootenai soils (SCS, 1981).

Stratigraphy

Analysis of the stratigraphy of the unconsolidated sediments within the northern Rathdrum Prairie and the Chilco channel study aids in determining which sedimentary units are aquifers, the extent of the aquifers, and whether or not they are confined. Drillers' well logs indicate a complex depositional history within the Chilco channel area. The sediments deposited within the study area are limited to the lacustrine Latah Formation of Miocene age, and the late Wisconsin age outburst flood deposits. An unconformity exists between the pre-Tertiary age basement rock and the Latah Formation as well as between the Latah Formation and the Pleistocene sediments. The depositional history of the Latah Formation has already been discussed, this section will endeavor to describe depositional history and environments which resulted in the characteristic facies observed in the sub-surface of the Chilco channel area.

Description of facies

Several different flow conditions existed during and in between flood events resulting in very different sediment assemblages. During flood events, large channels in the main track of the flow could have transported and deposited extremely coarse-grained, moderately well-sorted material. Outside the main flow track, more poorly sorted material would have been deposited. It is important to note that not all of the floods would have influenced the Chilco channel area. The stratigraphic record displayed in the sub-surface is incomplete, largely representing deposition during the floods of greatest magnitude and interflood deposition into glacial Lake Columbia. The sediment assemblages within the Chilco channel area have been divided into facies and are described below.

Thalweg or channel flood facies

Alluvium which was transported and then deposited within the main flow track during an outburst flood has been designated as thalweg or channel flood facies. The thalweg or channel flood facies are very coarse-grained, moderately well sorted sands, gravels, cobbles and boulders. Those coarse deposits showing a moderate to high degree of sorting are regarded as thalweg flood facies. Thalweg deposits occur generally in the center of the channel within the main track of flow which likely anastamosed across the channel as flood velocities surged and subsided. They are particularly abundant and thicker near the channel outlet where flow velocities decreased causing the deposition of boulders and other coarse grained materials. The flow boundary as defined by O'Connor and Baker (1992) is near the main channel outlet to the Rathdrum Prairie as well (Figure 6). This coarse-grained, moderately well-sorted facies most closely resembles those deposits constituting the bulk of the alluvial fill in the Rathdrum Prairie and Spokane Valley.

Eddy facies

As an outburst flood advanced across the Rathdrum Prairie eddies formed between flow boundaries within the main channel of flow and the valley wall. Eddies cause a decrease in flow velocity resulting in the deposition of poorly sorted, coarse to fine-grained sediments at or adjacent to the flow boundaries near the valley walls or small embayments. The eddy facies is characterized as poorly sorted deposits of boulders, gravels, sands, and some clay. Eddy bar deposits are common along the eastern margin of the Channeled Scabland (Baker, 1973), but have not been identified within the study area in previous studies. Perhaps higher flow velocities and greater water depths, due to the proximity of the site to the actual outburst, prevented the development of identifiable eddy bars within the study area. Deposition from this area should be expected since much of the area lies upon lowlands marginal to the Coeur d'Alene Mountains.

Dropstone-lacustrine facies

During interflood periods quiet water conditions in glacial Lake Columbia may have occurred where icebergs would have drifted into the lake, and as they melted would result in the deposition of dropstones. Dropstones the size of gravel to boulders may also have been deposited after flooding when icebergs were most abundant, and in locations where eddies moved the bergs into quiet bays. As the floods waned, still water conditions within glacial Lake Columbia allowed for the deposition of fines such as clay and silt as well as dropstones. Lake levels would have fluctuated causing beaches to dry and form calcareous "hard pan". Hard pan is present in some well logs but is discontinuous.

Only fine-grained deposits which were far enough from the main flow track, and those deposits laid within glacial Lake Columbia after the last flood episode, would not have been eroded by the high flood water velocities and are therefore preserved. These deposits are mostly located near the valley walls and small embayments. All deposits containing abundant clay have been classified as dropstone lacustrine facies since this is the only depositional environment in which significant amounts of clay and very coarse grained sediments could have been deposited simultaneously.

Glacial till

Another possible facies within the study area is a glacial till facies. As stated earlier, the flood energies affecting the Chilco channel varied greatly and were perhaps low enough to preserve Bull Lake age tills. A soil survey performed within the area reports soils derived from slightly weathered glacial tills located south of Eightmile Prairie and other large portions of the Rathdrum Prairie. It is likely that the survey mistook glaciolacustrine deposits for till. The presence of till near the surface is unlikely since the furthest advance of Late Fraser glaciation was near Athol and outburst flood deposits, and glaciolacustrine deposits would have subsequently covered any glacial tills. It is possible that glacial tills became exposed within the Chilco channel during flooding and are the substrate for soils today, but highly unlikely.

Descriptions of fence diagrams

Several fence diagrams (Figure 8,9 and 10) were drawn to attempt to correlate sedimentary units and aquifers, delineate the channel dimensions and boundaries. Figure 7 is a location map illustrating the locations of wells for the sections. Wells used in the fence diagrams were either sounded (depth to water table measured) or their location was confirmed in the field.

The cross-sections are helpful in deciphering the complex depositional history of the Chilco channel and surrounding area. The position of the area, marginal to main tract of the flow from the glacial Lake Missoula floods, is perhaps the most important factor to consider in the interpretation of the depositional history of the Chilco channel area.

Only wells with drillers' logs were used for the fence diagrams. Appendix A lists the soundings, location, homeowner names, aquifer, and other important information. Appendix C lists all well logs used for the investigation. Wells which were sounded for the study are listed in Appendix A. Each sounding is designated a well sounding number (S1, S2, S3,...) in the order in which it was sounded in the investigation. In Appendix C, each well is designated a well log number in the order in which the well was recorded from the logs. Wells will be referred to by sounding numbers, and name of homeowner, name on well log, or well log number. The sounding number will correspond to a well log number in Appendix A, if a well log exists for that well.

Section A-A'

The fence diagram A-A'(Figure 8) illustrates the stratigraphic history and complexity along the margin of the Rathdrum Prairie. The section is longitudinal to the main track of the Chilco channel, and is oriented northeast to southwest. All well logs used

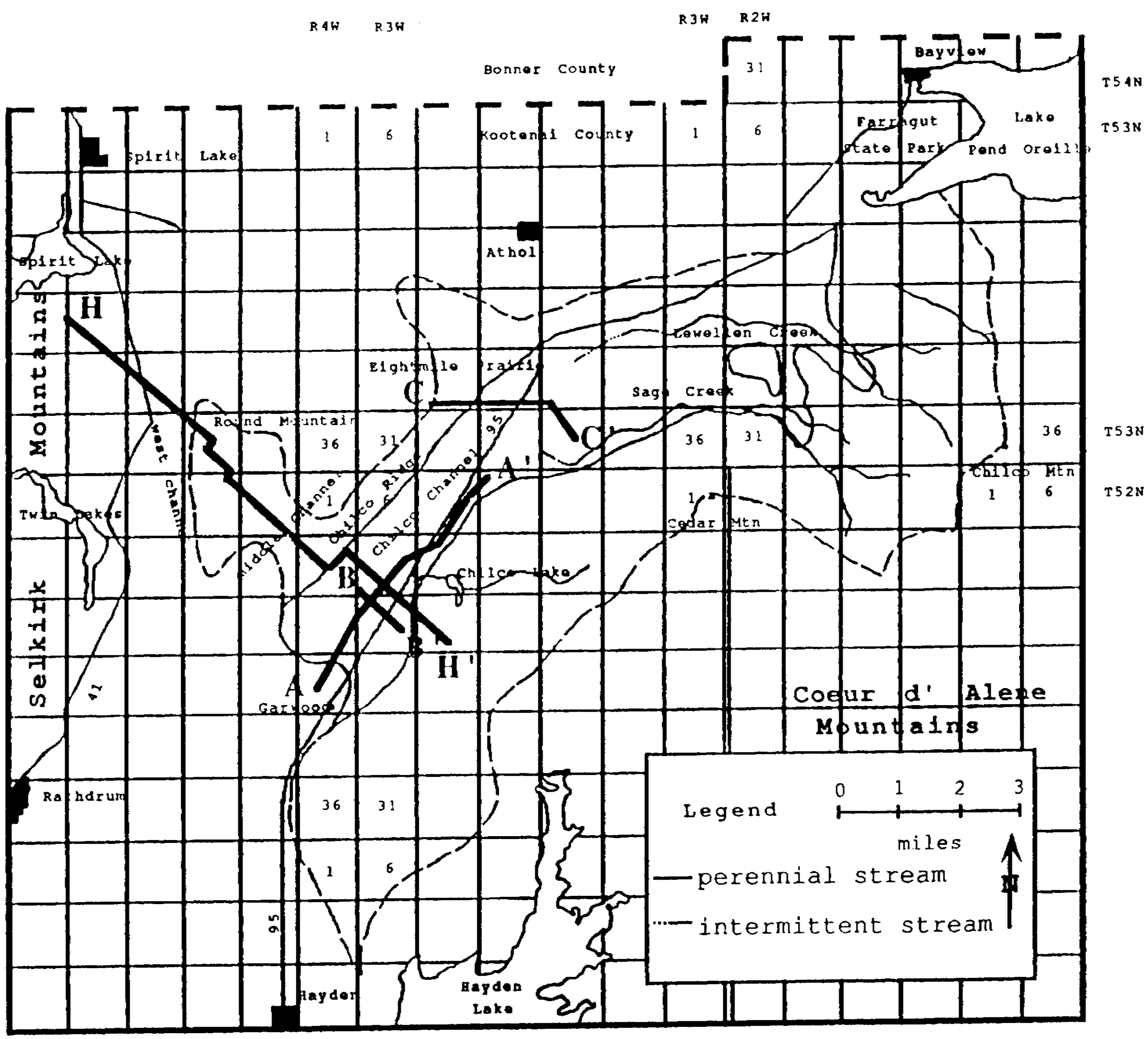

Figure 7. Location map for sections A-A', B-B', C-C' and H-H'.

within the section A-A' were sounded in the study. Only one well penetrates bedrock basement (S4). The fence diagram illustrates an irregular bedrock surface within the Chilco channel which slopes steeply to the southwest .

All four hydrofacies occur along the A-A' section. The Timbercraft (S1) well has over 100 ft (30 m) of poorly sorted clay, boulders and gravel interpreted as a diamicton which were likely deposited in glacial Lake Columbia. Below the diamicton deposit is moderately well sorted, normal graded sequence of flood gravels and boulders. The coarse-grained flood sequence overlays sand-gravel and clay-gravel associations interpreted as eddy deposits which could have been deposited along the flood flow margin which likely anastamosed eastward as the west channel aggraded. Eventually the eddy deposit was buried by subsequent flood channel deposits. The bedrock slope is believed to be steep towards the southwest in this region so these could represent slump or distal periglacial facies as well.

The McKay well (S11) shows the bimodal grain size distribution of clay and gravel and correlates with similar sediments in the Timbercraft (S1) well. Theses sediments are believed to overlay flood sediments. The well driller noted that the hole became sandier with depth. The bimodal grain size associations of clay-gravel, and clay-boulders commonly overlays flood deposits in several well logs in the Chilco channel. This would suggest that large accumulations of glaciolacustrine, and perhaps glaciofluvial sediments, were deposited after large flood events within glacial Lake Columbia.

The new North Idaho Propane well (S4) penetrates 120 ft (37 m) of very coarse material interpreted as flood gravels. Under the flood gravels is 20 ft (6 m) of clay which perhaps was deposited in glacial Lake Columbia prior to a large flood event. This clay could feasibly be Latah Formation since it contacts bedrock and is at a location in which the occurrence of Latah Formation is most common at 2100 ft (640 m) (Robinson, 1991).

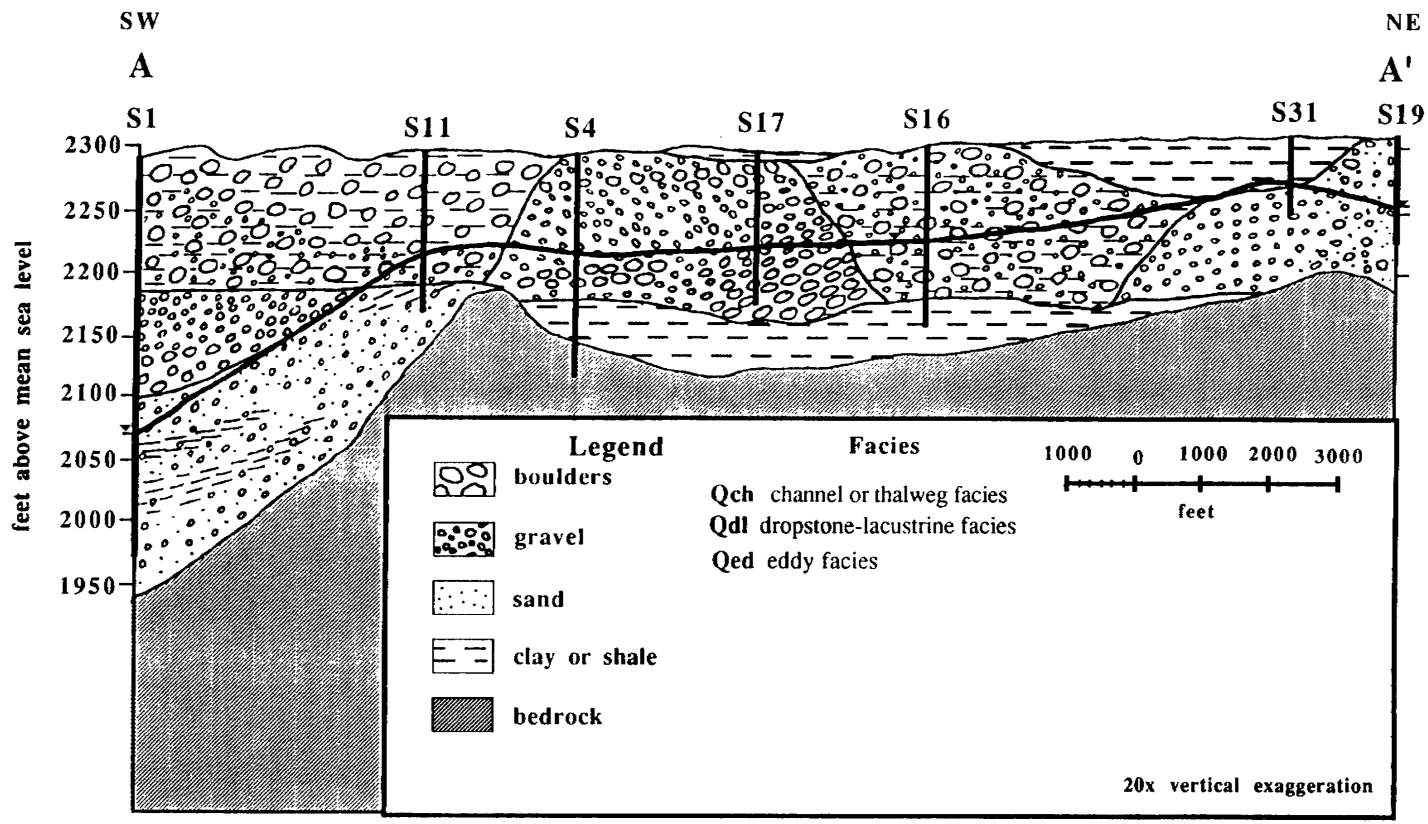

Figure 8. Cross-section A-A'. A longitudinal section through the main Chilco channel from NE to SW. S prefix and number indicates sounding order. See Figure 7 for location of the line of section.

Another well penetrating flood deposits to the northeast, is the Tipke well (S17). This well is topped by five feet (1.5 m) of lacustrine clays. Several wells within Section 18, T52N, R3W penetrate thick sequences of flood gravels.

The Veylupek well (S16) to the northeast penetrates nearly 130 ft (40 m) of clay, gravel, and cobbles. This thick deposit of glaciolacustrine material overlays clay which correlates with clays found in the North Idaho Propane well (S4).

The Luster well (S31) has a thick sequence of lacustrine sediments overlaying flood deposits. The clays may have been deposited on the margins of post-flood glacial Lake Columbia, or in a small post-flood lake. This inference is made because of the prevalence of clay exclusive of coarse-grained sediments.

The Henderson well (S19) penetrates only coarse-grained sediments which are interpreted as flood deposits. Perhaps this area was beyond the influence of the late stand of glacial Lake Columbia.

The section A-A' illustrates the influence of interflood glaciolacustrine and diamicton deposition which occurred in glacial Lake Columbia. Thick sequences of clay-rich gravels and boulders which appear to overlay flood gravels are not likely the product of direct land glacier deposition as in the case of tills. Clearly glaciolacustrine and diamicton deposits overlay flood gravels, therefore deposition must have been after major flood events within the stillwater confines of glacial Lake Columbia. It does not seem probable to the author that pre-Bull Lake age flood deposits would be overlain by early Wisconsin age till and remain preserved, especially considering the magnitude of the Fraser age floods. Still, this area would have been marginal to the flow of ice during Bull Lake time and, therefore, large morainal deposits would have developed within the Chilco channel. No lateral moraine deposits of early Wisconsin age have been identified within the study area, and were likely reworked by Fraser age floods if they ever existed. It is far more probable that the unusual bimodal grain-size distribution is the product of glaciolacustrine-dropstone deposition in glacial Lake Columbia rather than till deposition.

The ground water flow across the section is towards the southwest. The hydraulic gradient is uniform within the middle of the section (0.0048), but steepens quickly towards the southwest near the outlet (0.063). The hydraulic gradient is inferred to be more of a function of the bedrock contact rather than hydraulic conductivity. A ground water divide appears to exist near the Luster well (S31) where the water table slopes toward the Henderson well (S19).

Section B-B'

Section B-B' (Figure 9) crosscuts the channel roughly perpendicular to the flow of ground water. Only two well logs were used to make the cross-section since only two wells are in a line across the channel in this area and that penetrate bedrock (or aquicludes), thereby allowing an estimation of saturated area of the aquifer in this cross-section.

At the west end of the channel is the Brook-MacDonald well (well log no. 102) which was sampled for water quality but could not be sounded. The well penetrates 60 ft (19 m) of outwash sand and gravel, and then five feet (1.5 m) of sand (sand is rare in well logs within the channel). The low topographic location suggests that this location may have been the site of a post-Pleistocene stream channel. At a depth of 65 to 93 ft (20 to 28 m), there is an assemblage of saturated gravel with sand and clay representing the glaciolacustrine facies. From 93 to 114 ft (28 to 35 m) a sequence of gravels rest upon shale, probably Latah Formation. The shale sequence is at least 61 ft (18 m) thick. The bedrock surface elevation is lower here than the eastern margin of the channel at the Bonham well (S5).

The Bonham well (S5) penetrates predominantly coarse gravel, and several boulders to a depth of 110 ft (34 m), before penetrating bedrock, representing channel deposits from the outburst floods. The J. Green well several hundred feet to the north has a depth to bedrock of 144 ft (44 m). The surface elevation at each wellhead is nearly identical,

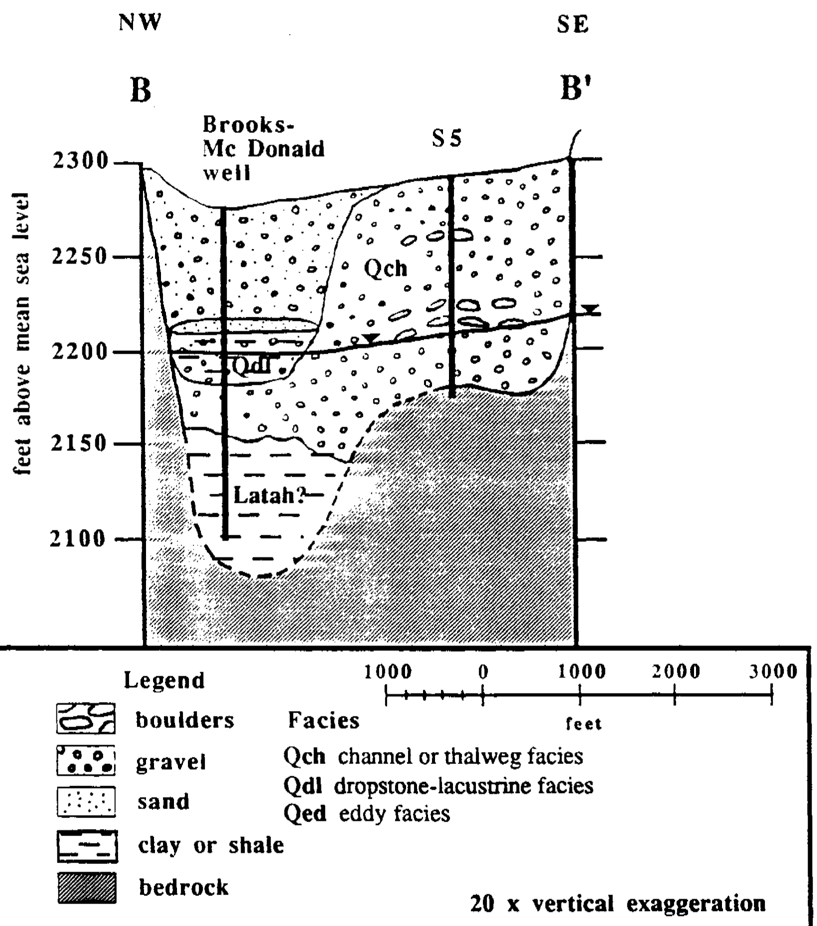

Figure 9. Cross-section B-B'. A perpendicular section through the main Chilco channel from NW to SE. S prefix and number indicates sounding order. See Figure 7 for location of the line of section.

therefore there is a great deal of relief within the subsurface which helps explain the northwestward hydraulic gradient in this area.

The NW-SE cross section in the main channel illustrates that the hydraulic gradient is across the channel on the eastern margin. Some water is in fact flowing northwestward, then southwest within the cross-section. This complicates attempting to calculate discharge from this channel cross-section. This area is however downgradient of all major recharge areas and has the best depth to bedrock and saturated thickness data. Reasonable cross-sectional area data can be obtained for calculating discharge from the main channel (see Hydrogeology - Discharge Calculation) .

Section C-C'

Section C-C' (Figure 10) is oriented E-W and crosses north of the "inlet" of the Chilco channel within Eightmile Prairie onto a gravel terrace to the east. Only two of these wells were sounded in the study, but well locations were confirmed in the field.

The bedrock-alluvium contact show a high degree of relief from east to west (C'-C), approximately 250 ft (76 m) in two miles (3.2 km). A subsurface channel may exist within this section which moves south of S24. The site beneath S24 appears to be a buttress or buried valley slope facing south. This inference is supported by the fact that rock outcrops in the north end of the same section (Section 28), and the water table is higher within bedrock. Saturated alluvium exists east and west of S24, therefore a channel connecting these areas hydraulically appears probable.

The Rickel well (well log no. 177) in the far west portion of the section is a 400 + ft (122 + m) well penetrating sands, gravels and boulders. This is typical of well logs within the Rathdrum Prairie aquifer in depth and in aquifer material.

The Henley well (S24) due east of the Rickel well (well log no. 177) does not appear to have any significant accumulations of channel (thalweg) flood deposits in the column. Nearly the entire log consists of glaciofluvial and glaciolacustrine deposits. This

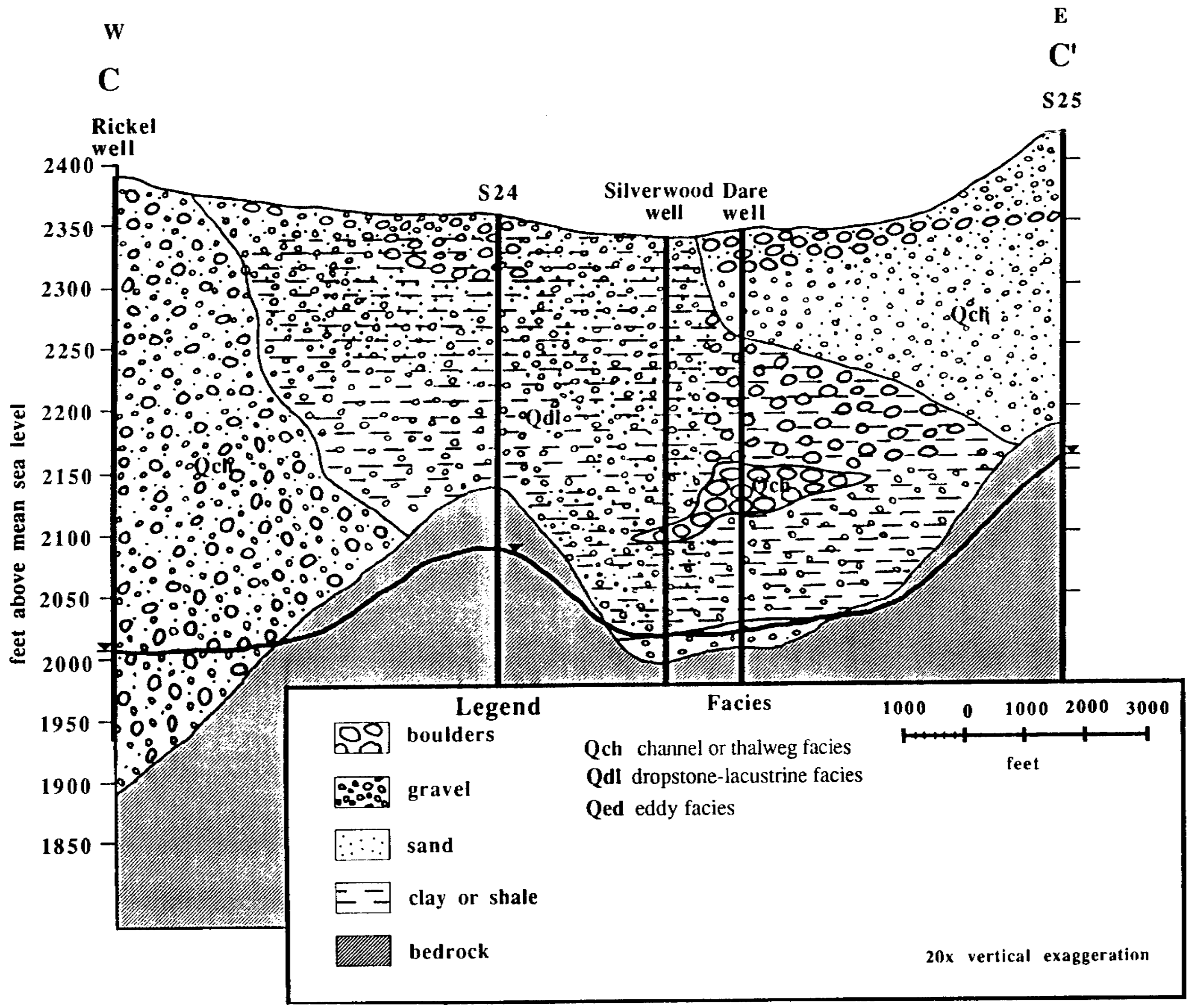

Figure 10. Cross-section C-C'. A section through the Eightmile Prairie and western edge of the Sage-Lewellen watershed from W to E. S prefix and number indicates sounding order. See Figure 7 for location of the line of section.

area was perhaps stripped to bedrock during the floods and quickly aggraded in the waning stages of the floods, but mostly during the last stand of glacial Lake Columbia. At this time downwasting ice of the Purcell Trench lobe and periglacial streams would have been actively depositing sediments into glacial Lake Columbia. The bedrock contact here is relatively shallow at 220 ft (67 m) from the surface and slopes to the south, west, and east as is indicated from other well logs in Section 28, T53N, R3W.

The Silverwood well (well log no.75) penetrates a thick sequence of clay, sand, and gravel interpreted to correlate with the glaciofluvial and glaciolacustrine sediments in the Henley well (S24). Again, the proximity of the site to the terminal moraine of the Purcell Trench lobe greatly affected deposition in this area. Deposition of interflood and post-flood sediments in glacial Lake Columbia would have been thicker in the subsurface channels as well as proximal to the glaciers terminus. The lowest gravel unit contacting the bedrock surface may be channel lag deposits from a pre-Pleistocene stream channel.

The Ray Dare well (well log no. 84) to the east of the Silverwood well (well log no. 75) has what appears to be two sequences of flood deposits and interflood glaciofluvial and glaciolacustrine deposits. The lower flood gravels contacting the bedrock surface may be channel lag correlating with the lower gravel unit in the Silverwood well.

The Hoit well (S25) to the southeast of the Ray Dare well (well log no. 84) lies upon a gravel terrace which was marginal to the main flow of the floods. The entire sequence of sands and gravels within the column could have been deposited during one or two large flood events. The area was probably far enough away from the influence of glacial Lake Columbia that no interflood glaciolacustrine sediments were deposited. The bedrock contact probably slopes to the north towards Bunco Road and the Ray Dare well (well log no 84).

The ground water table slopes towards the west with a gradient of about 0.002. The water table in the Henley well (S24) is higher because the bedrock slopes towards the south and the water table roughly follows the bedrock slope. Well logs from Section 28, T53N, R3W illustrate that the water table drops towards the south. As for the Chilco Channel it is believed that the water table within the alluvium is more a function of the bedrock configuration than of the hydraulic conductivity of the material.

Hydrogeology

Aquifers within the study area have been divided into four categories based upon their hydrogeologic properties. The basis of description of the various aquifers was derived from 177 well drillers' logs from the Chilco channel study area. The aquifers recognized are: 1) metasedimentary basement aquifers: 2) granitic basement aquifers; 3) aquifers in Columbia River Basalts and interbeds; and 4) glaciogenic alluvial aquifers. Glaciogenic alluvium is the most abundant and productive aquifer material throughout the main Chilco channel. Due to important sedimentological differences it is appropriate to subdivide the glaciofluvial alluvial aquifer into three distinct hydrofacies: 1) thalweg or channel flood facies; 2) eddy facies; and 3) dropstone/lacustrine facies.

Previous hydrogeologic investigations

The principle work performed within the Chilco Channel and Athol area was done by Hammond (1974) where the configuration of the water table in the northern Rathdrum Prairie was determined by geophysical survey (gravity), test drilling, and mass measurements of water levels. Through his investigation Hammond concluded that the west channel, representing the ancestral Rathdrum River channel, contributed 170 million gallons per day to the Rathdrum Prairie aquifer. Contribution was negligible from the middle channel which represents a bedrock divide, and 30 million gallons per day flowed through the Chilco channel into the Rathdrum Prairie aquifer. The channels decrease in depth to bedrock from west to east, and decrease in surface elevation from west to east. The estimated bedrock elevation (Figure 11) of the west channel is approximately 900 ft (274 m), the middle channel approximately 2050 ft (626 m), and the Chilco channel at

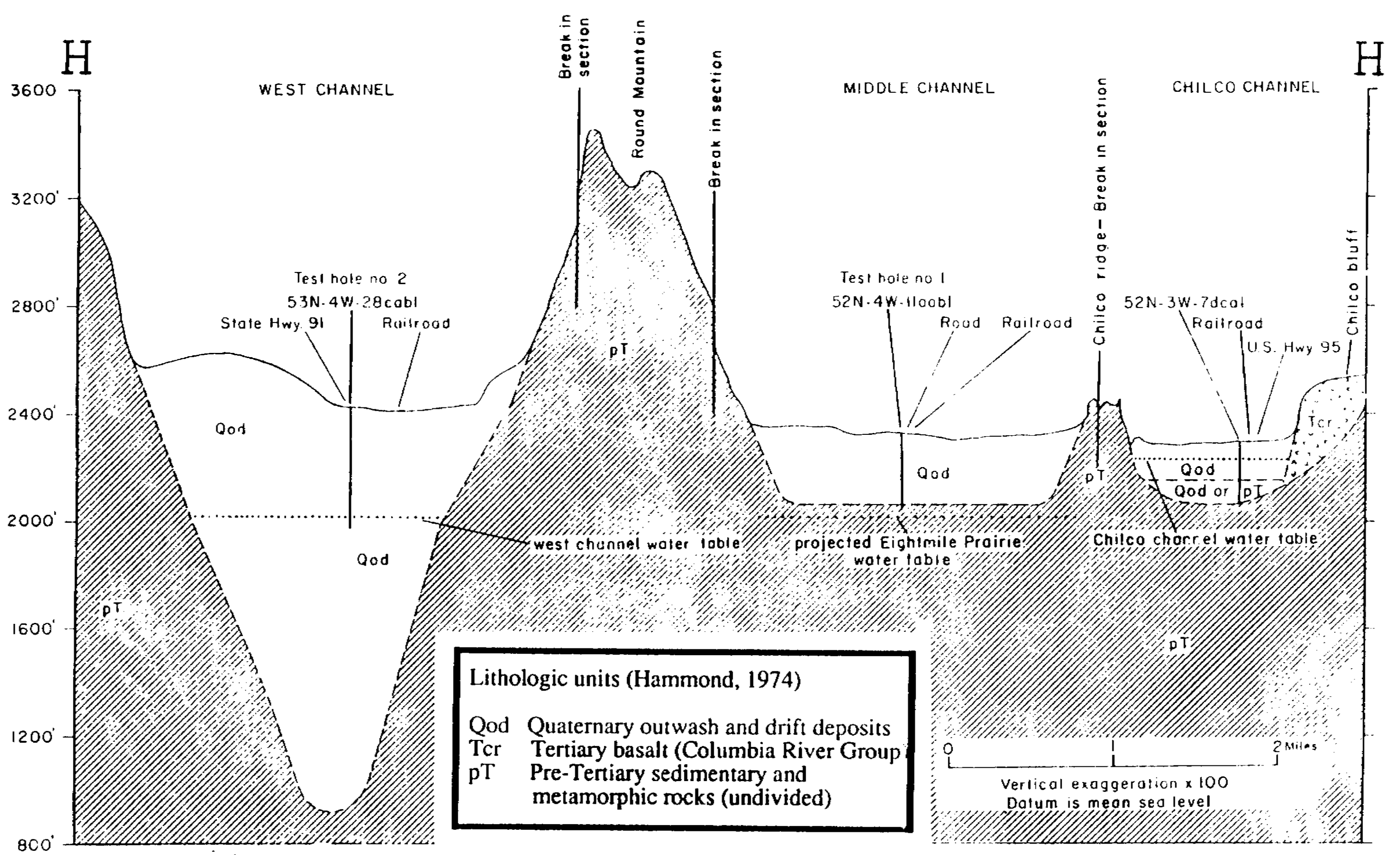

Figure 11. Cross section H-H' taken from Hammond (1974). See Figure 7 for location of line of section.

approximately 2050 ft (626 m) (Hammond, 1974).

Much of Hammond's study has been the basis of continual work to draw the boundaries of the Rathdrum Prairie aquifer, the Chilco channel aquifer and its watershed. Perhaps the most influential study performed on the Rathdrum Prairie aquifer was by Drost and Seitz (1978) which resulted in the sole source aquifer designation for the Rathdrum Prairie aquifer, and the subsequent omission of the Chilco channel from the designation. The report states that the peripheral aquifers draining into the Rathdrum Prairie aquifer "are less desirable than the Spokane Valley-Rathdrum Prairie aquifer because of insufficient supplies, poor water quality, and (or) remoteness from areas of need (Drost and Seitz, 1978).

In an attempt to delineate the areas recharging the Rathdrum Prairie aquifer, Painter (1991a, 1991b) attempted to map the Chilco channel aquifer and its surrounding watershed to determine the contribution of recharge to the Rathdrum Prairie aquifer. The borders of the Chilco channel aquifer and its watershed as defined by Painter (1991a, 1991b) are used extensively within this report, however, these borders have since been redefined based upon the information gathered during this more recent study.

Aquifer boundaries

A depth to bedrock map was created for the Chilco channel area which demonstrates a high degree of complexity and structure (Figure 11). Although well locations taken directly from well logs are reliable only within approximately one sixteenth of a square mile (1/4, 1/4, Section), the map was beneficial in alluding to the configuration of the bedrock surface. A deep channel flows towards the northwest near the "inlet" to the main channel, north of Chilco ridge (Figure 12). Another large channel within the main Chilco channel, flows towards the southwest into the Rathdrum Prairie aquifer near Garwood at the "outlet" (Figure 12). Approximately one mile east of Garwood, a channel

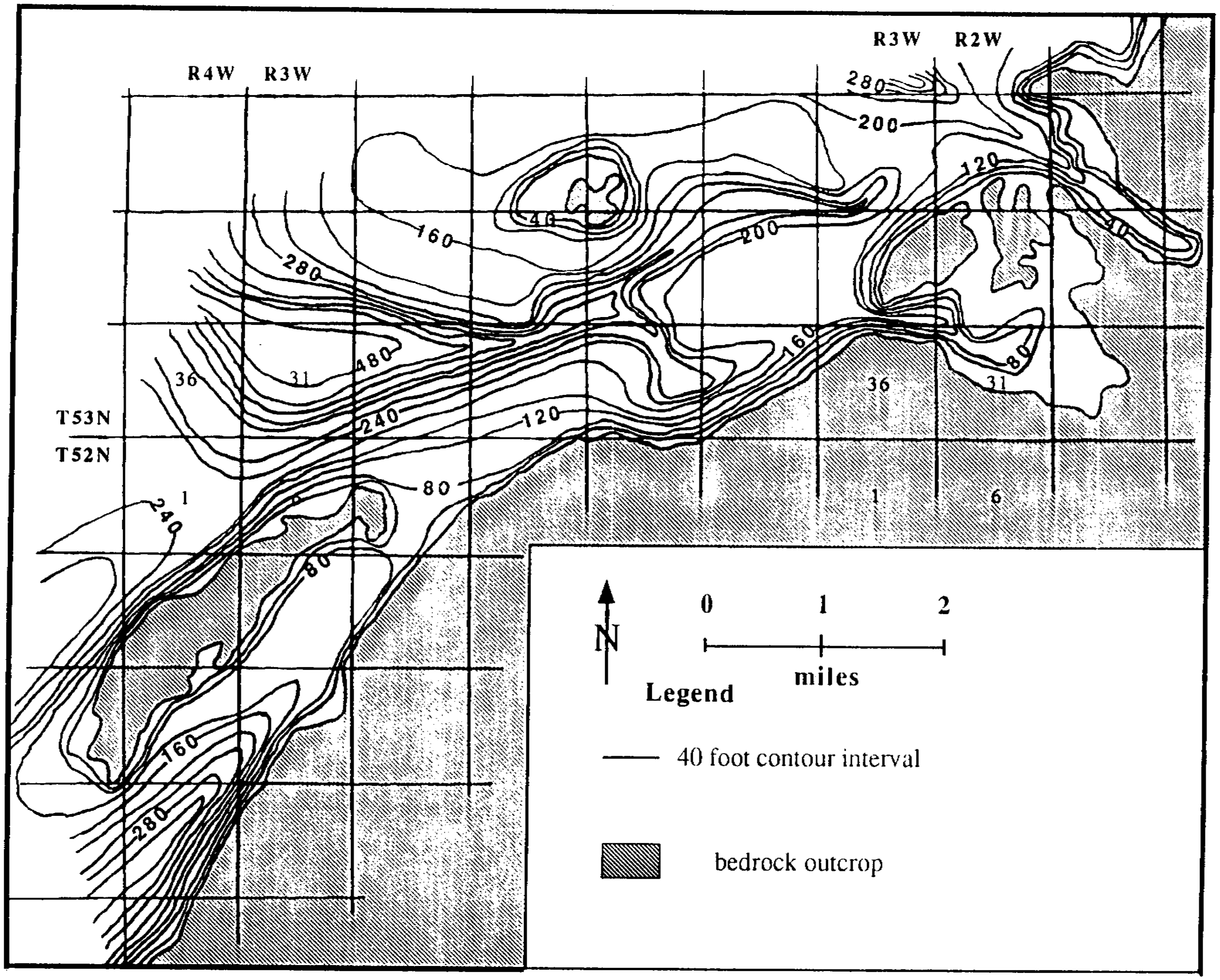

Figure 12. Depth to bedrock map for the Chilco channel study area. Contours show depth in feet.

flows due westward into the Rathdrum Prairie. This channel consists of alluvial valley fill not previously recognized as part of the Rathdrum Prairie or Chilco channel aquifers. An intermittent stream flows across the flat valley surface which was likely a lake at one time which has since filled. Presently a small intermittent stream flows across the valley floor surface and is likely influent into the valley fill.

All of the subsurface bedrock drainages inferred from the well logs appear to be the continuation of the surface stream channels which drain the Coeur d'Alene Mountains and likely converge with a deep channel which turns to the west side of Round Mountain (Hammond, 1974); the inferred location of the ancient Rathdrum River valley.

The depth of the main Chilco channel is inferred to be fairly uniform and shallow at about 120 ft (37 m) throughout the length of the constricted portion of the channel north of Chilco southwest to Garwood where is descends quickly into the Rathdrum Prairie aquifer bedrock contact. Few well logs exist which show wells penetrating bedrock, therefore well depths were used as estimates for minimum depth to bedrock.

Since the bedrock contact descends to the northwest and southwest from the inlet of the Chilco channel, the northeastern end of the Chilco channel is therefore more of a subsurface divide than a channel, probably representing a divide between tributary basins within the ancient Rathdrum River drainage.

The lateral boundaries of the aquifer were defined based upon information provided by well logs as well as by field investigation. The main channel is more constricted than as originally defined by Painter (1991a, 1991b). The main channel opens southwestward, perhaps only one quarter mile wide at the inlet, and just over a mile wide near Garwood. Lateral aquifer boundaries do not necessarily coincide with alluvium-bedrock contacts, but instead was deliberately delineated where saturated alluvium was either confirmed or strongly suspected based upon well logs or other evidence.

Aquifer types

Metasedimentary basement aquifer

The metasedimentary basement aquifer are largely composed of the Precambrian age Prichard and Wallace Formations which are generally low grade metasedimentary rocks of quartzite, siltite, and argillite with minor marble. No wells penetrating the metasedimentary basement aquifer have been identified conclusively, although several are suspected in the northern main Chilco channel (Sections 4 and 5, T52N, R3W). The aquifer is unconfined, and wells in these rocks depend ground water in secondary porosity as a result of localized fracturing, perhaps due to faulting and shearing. Although wells penetrating these rocks near a fault zone have the greatest chance of producing enough water for a domestic well, drilling for water within these rocks is considered a gamble. No significant yields (from the suspected wells) were reported in these wells in the study area. The metasedimentary basement rock is, therefore, not considered a significant aquifer.

Granitic basement aquifer

Granites and gneissic textured rocks of Mesozoic to Early Tertiary age constitute the granitic basement aquifer. Similar to the metasedimentary basement, the granitic basement aquifer's hydrogeologic characteristics are dependent upon the degree of fracturing, jointing and weathering. Granitic rocks within the study area commonly possess deep saprolitic zones which greatly increases the permeability of the rock. Wells penetrating large numbers of joints also have a greater possibility of high yields. Those wells which penetrate joints linked to deep saprolite zones have access to water which is stored in the weathered zones. Saprolitic layers commonly have high porosity and low permeability due to the presence of clays (Fetter, 1988). Granitic rocks can be significant aquifers for domestic purposes, yet rarely produce discharges sufficient for agricultural or irrigation purposes.

There are at least 74 wells tapping the granitic aquifer, and 49 wells exclusively access granitic aquifers within the study area. The aquifer is unconfined, except where overlain by clay or shale. Static water levels in all granitic wells range from 7 ft to 550 ft (2 m to 168 m). The average depth to ground water from the ground surface or static water level (SWL) is 169 ft (52 m). The northeastern area near the alluvium-bedrock contact has the shallowest water table, whereas the deepest water table is on the north and west slopes of the Coeur d'Alene Mountains. The range of yields was from 0.2-75 gallons per minute (gpm) or 0.8-284 liters per minute (lpm) in wells penetrating granitic aquifers exclusively. Average well yields in these wells is 14.6 gpm (55.3 lpm). The high yield wells are nearly exclusively in the northeastern region of the study area and are perhaps associated with the deep saprolitic zones, buried tributary channels, as well as areas of intense fracturing from faulting. This high average well yield value is misleading for the study area and should only be considered valid for the sub-basins draining Sage Creek and Lewellen Creek.

Columbia River basalt and interbed aquifer

The Columbia River Basalts and their interbeds, formally known as the Latah Formation, of Miocene age constitute another bedrock aquifer in the study area. Hydrogeologic properties depend on the degree if fracturing and jointing within the basalt. Interbed conductivities vary depending on sediment type. Shales, sandstone and gravels of various degrees of induration have been described in well logs, but are difficult to identify conclusively based upon only well log information. Basalt flows are discontinuous and are not easily correlated, perhaps due to pre-glacial and post-glacial mass wasting and erosion from the outburst floods. Much of the southeastern region of the channel, east of Highway 95 and south of Chilco Road to Garwood, appears to be underlain by basalts (probably Grande Ronde) which are capped by alluvium. Both the Tertiary volcanics and interbeds can produce significant discharges for domestic use, but are discontinuous and not considered to be important aquifers in the study area.

Well yields are widely variable within this aquifer, and range from 1-100 gpm (4-379 lpm) within the basalts, and 0.1-12 gpm (0.4-45 lpm) within interbeds as reported in 25 well logs in the study area. Fifteen well logs were within basalts and 10 were within "shale" or interbeds as indicated by the well logs. Well yields for all Tertiary volcanics average 15.6 gpm (59.1 lpm). Depth to ground water mean values are greater for those wells penetrating basalts at 176.8 ft (53.9 m) than those penetrating shales at 151.2 ft (46.1 m). Mean depth to ground water for all wells penetrating Tertiary volcanics is 166.6 ft (50.8 m).

Glaciogenic alluvial aquifer

The vast majority of the valley fill sediments within the Rathdrum Prairie is Quaternary age glaciofluvial and glaciolacustrine alluvium derived from the outburst floods and outwash, and perhaps glacial till. The glaciofluvial aquifers are the most productive within the study area as well as the most susceptible to contamination. Glaciolacustrine sediments which overlay glaciofluvial aquifers create locally semi-confined to confined conditions. At least 66 wells within the Chilco channel study area tap alluvial aquifers, essentially all in glaciogenic aquifers. The average SWL for wells not considered part of the Rathdrum Prairie aquifer is 116 ft (35 m) as indicated from drillers' logs. Fourteen well logs from wells in Eightmile Prairie, Athol and areas northwest of the main channel, proximal to the Rathdrum Prairie aquifer, average 315 ft (96 m) in depth from ground surface. Static water levels within the main channel range from 15-60 ft (5-18 m) in the northern portion of the channel to 220-275 ft (67-84 m) in the southern portion. Well yields average approximately 35 gpm (132 lpm) for all wells in alluvial aquifers within the study area. This figure is misleading since many of the wells pump 10 gpm (38 lpm) or less. Aquifer materials consist generally of bimodal associations of sediments such as fine sand and gravel, clay and gravel, clay and boulders; or sediments of limited size range such as course sand and gravel, but rarely exclusively fine-grained sediments. Several distinct associations of sediments necessitate dividing the valley fill into three hydrofacies based upon information from well logs, lithologies, hydrologic properties, and processes inferred to have operated in their deposition. Hydraulic conductivity data was obtained by estimating transmissivity from the specific capacity (well discharge per unit drawdown) of a well (Theis, 1963). Since no observation wells were available the K value for r=1/4 foot was used in the formula. A storativity coefficient of 0.2 was assumed, the same value used in the derivation of the formula. The range of values calculated are listed with each facies.

Thalweg or channel flood facies

These deposits most closely resemble those that comprise the bulk of the sediments in the Rathdrum Prairie.. Like the Rathdrum Prairie aquifer these deposits have extremely high porosities similar to those for well-sorted sands and gravels, ranging from 25-50 % (Fetter, 1988). Permeabilities are high, perhaps as high as the maximum range for a well-sorted gravel from 28.4-2835 ft / day (8.7-866 m / day) (Fetter, 1988) Calculated hydraulic conductivity values ranged from 30 to 75 ft/day (9 to 23 m). These high values are limited to the main channel.

Eddy facies

The eddy facies has a moderately high porosity probably similar to mixed sand and gravel as defined by Fetter (1988), ranging from 20-35%. Permeability are lower than the channel facies and are perhaps similar to glacial outwash sands which range from 2.8-284 ft / day (0.9-87 m / day) (Fetter, 1988). Calculated values ranged from 3 to 9 ft/day (1 to 3 m/day). The values were calculated from wells proximal to the eastern margin of the main channel as well as in the Sage Creek -Lewellen Creek area which tapped alluvium.

Dropstone-lacustrine facies

The significant proportion of clay suggests this unit can behave as a confining to semi-confining layer as well as an aquifer. This facies has high porosity, probably close to that of clay, ranging from 33-60% (Fetter, 1988), yet it probably has moderate to low permeability similar to clayey sands and silts, ranging from 0.0028-0.28 ft / day (0.0009-0.86 m / day) (Fetter, 1988), probably at the upper end of the range. The only well tapping a dropstone-lacustrine facies aquifer tapped several other aquifers as well, therefore no hydraulic conductivity calculation was made.

In sum, the glaciogenic aquifer constitutes the bulk of the Chilco channel aquifer system and will therefore be the focus of the remainder of this report. Secondary aquifers that occur primarily in the bedrock will be discussed briefly when appropriate.

Recharge

Recharge to the Chilco channel aquifer is derived from small, intermittent streams, small bedrock (joint and contact) springs, and infiltration from precipitation. The northeastern portion of the watershed is drained via several small streams from the Coeur d'Alene Range, principally Sage Creek and Lewellen Creek. Both streams become influent when they reach porous and permeable alluvial materials. Other sources of recharge come from a perennial stream draining Chilco Lake and it's watershed, and springs near Chilco ridge.

Recharge estimates were made based upon water balance data taken from water budget studies of the several nearby lakes (Painter, 1991b).The Chilco channel watershed area (Figures 13) was calculated as 69.4 square mile (mi^2) or 179.7 square kilometers (km^2) . Basin topography, morphology, soil type and rainfall were assumed uniform, and an average recharge rate of 0.59 cubic ft per second (cfs) per mi^2 or 43 liters per second (l/s) per km^2 for three watersheds was used for the Chilco channel watershed. By using this method, the average recharge for the Chilco channel is 40.6 cfs (1150 l/s)

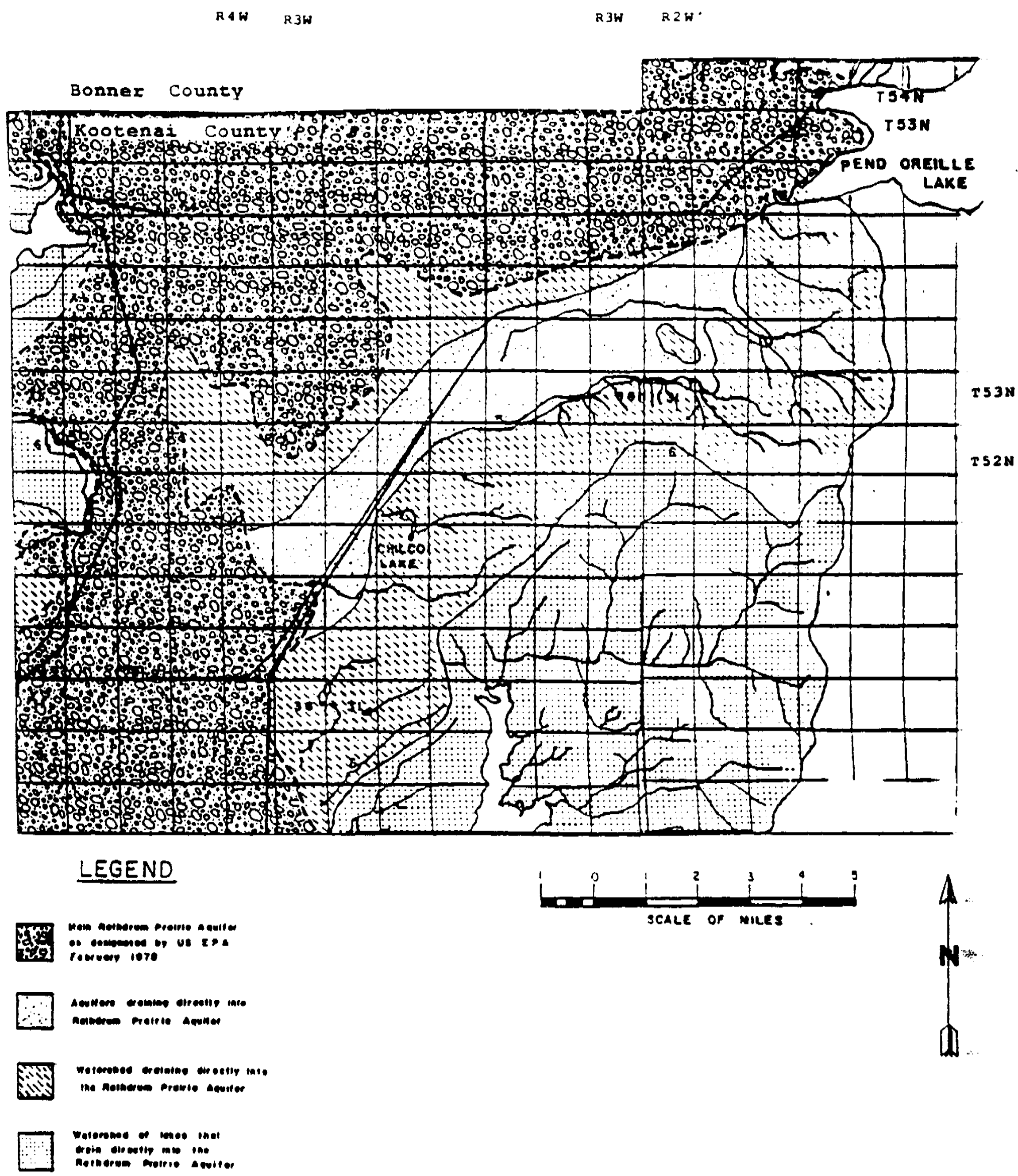

Figure 13. Chilco channel aquifer and watershed as defined by Painter (1991a).

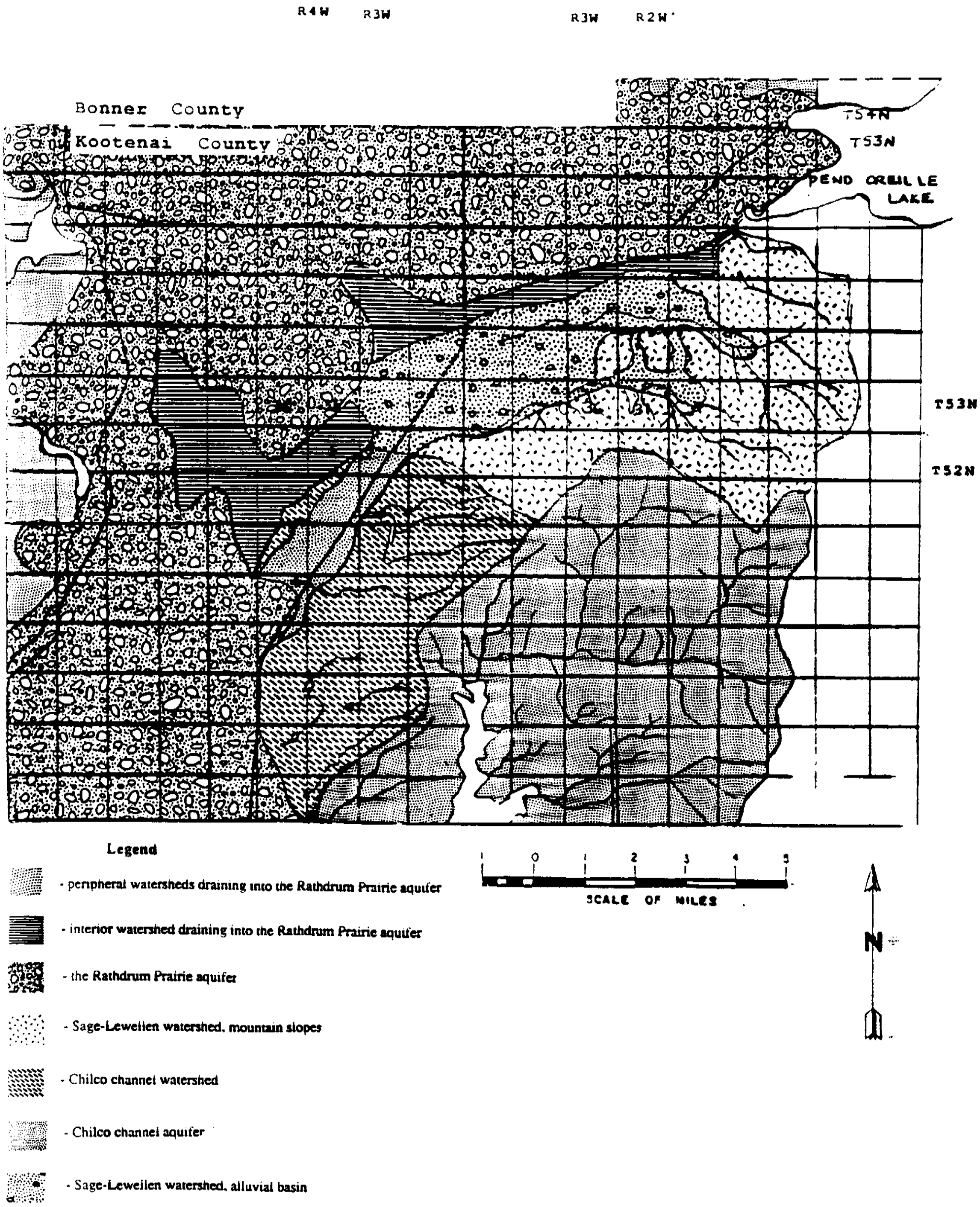

Figure 14. Distribution of aquifers, watersheds, and recharge areas within the Chilco channel area created for this report.

Table 3. Recharge area data for the Chilco channel area.

Name	Area (square miles)	Area (square kilometers)
Sage-Lewellen watershed		
Sage-Lewellen Watershed-mountain slopes	24.2	62.7
Sage-Lewellen Watershed-alluvial basin	12.3	31.9
outcrop area within alluvial basin	0.8	2.1
Total Sage-Lewellen watershed recharge area	37.3	96.7
Chilco channel watershed		
Chilco watershed-east of main channel	15.8	40.9
Chilco Lake watershed-within area east of main channe	2.2	5.6
Chilco ridge watershed	0.7	1.9
Chilco channel alluvial aquifer	3.2	8.3
Area effectively recharging the Chilco channel	7.7	19.9
Total Chilco channel recharge area	19.7	51.1
total recharge area		
total recharge area of study area	57.1	147.8
recharge area defined by Painter (1991b)	69.4	179.7

(Painter, 1991b). If flow from Sage Creek and Lewellen Creek contributes directly to the Rathdrum Prairie, then recharge estimates of the contribution of flow to the Rathdrum Prairie aquifer from the outlet of the Chilco channel made by Painter (1991b) would be over-estimates.

Since the Chilco channel aquifer as originally defined (Figure 13) does not drain the entire watershed as was suspected, the recharge area needs to be redefined. The well logs and field investigation implies that the study area be divided into two recharge regions: 1) the Sage-Lewellen watershed, and; 2) the Chilco channel watershed. A map illustrating how these areas are redefined is shown in Figure 14, and the new areas are listed in Table 3.

The entire Chilco channel watershed area (Figure 14) is 19.9 mi^2 (51.1 km^2). Only the sub-basins draining Chilco Lake, a small area north of Chilco Lake to the divide with the Sage-Lewellen watershed, the east side of Chilco ridge, and the main channel itself (a total area of 7.7 mi^2 or 20.0 km^2) actually contribute to recharge to the main Chilco channel. Over 60%, or 12.2 mi^2 (36.8 km^2) of the total Chilco channel watershed area, is in the sub-basin south of Chilco Lake which does not appear to contribute much flow to the main channel as indicated by topographic maps, but instead flows directly into the Rathdrum Prairie aquifer.

The Sage-Lewellen watershed includes the drainages of the perennial streams Sage Creek and Lewellen Creek. Theses streams become influent and do not flow into the main Chilco channel . The area contributing to recharge in the Sage-Lewellen watershed (36.5 mi^2 or 94.5 km^2) is much larger than the total watershed area for the Chilco channel (19.7 mi^2 or 51.1 km^2). The northern boundary of the Sage-Lewellen watershed was estimated based upon surface topography as well as subsurface information. The southern boundary follows a ridge from Hollister Mountain westward to the ground water divide at the north end of Chilco ridge.

Ground water table and flow direction

In general, the ground water table is irregular, sloping westward in the Sage Creek-Lewellen Creek area towards Eightmile Prairie (Figure 15), and southwestward within the main Chilco channel. Four water table maps were constructed for the study area to illustrate the water table in particular areas. A ground water map for the glaciogenic aquifer was constructed for the entire study area (Figure 15), the Sage-Lewellen watershed including the Eightmile Prairie area (Figure 16), and the main Chilco channel (Figure 17). Each map has the sounding or sample number for each site performed in that area.

The water table lies within granite in most of the Sage Creek-Lewellen Creek area except near influent streams. The gradient within the area is highly variable, but appears most variable within the granites. The water table is within glaciogenic alluvium at Eightmile Prairie where is appears to receive water from the granites and perhaps buried valleys from the Sage Creek-Lewellen Creek drainage.

The water table in the main Chilco channel is towards the southwest throughout the majority of the channel. The exception is the north end of the channel where flow is towards the north, towards Eightmile Prairie. This area represents an important ground water divide, demonstrating that flow within the Chilco channel study area is divided; flow from the Sage Creek-Lewellen Creek area is westward towards the Rathdrum Prairie, and does not flow through the main Chilco channel. Each area will be described in greater detail in the Ground water occurrence section, and in Appendix D.

Ground water occurrence in the study area

Ground water occurrence within the Chilco channel study area is limited principally to granites and isolated unconfined alluvial aquifers in the Sage Creek-Lewellen Creek area, and a continuous glaciogenic aquifer in the Chilco and Garwood areas which merges with the Rathdrum Prairie aquifer.

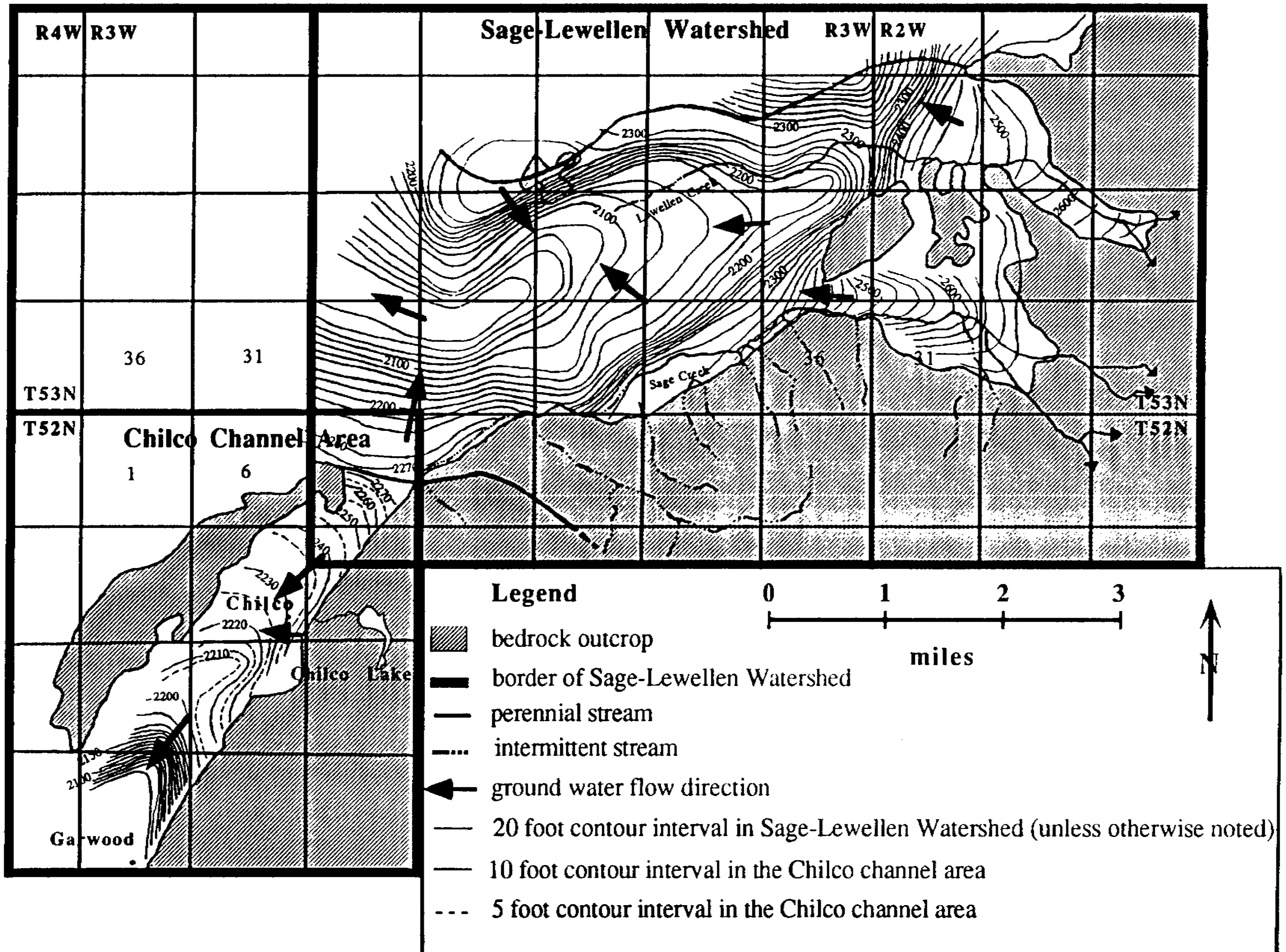

Figure 18. Graph illustrating an increase in hardness, alkalinity, and specific conductance downgradient in the Chilco channel. See Figure 16 and Figure 17 for location and distances between sampling sites.

The ground water occurrence will be discussed in each of these areas as determined by this investigation. Detailed field observations made in each of the aforementioned areas are listed Appendix D.

Sage Creek-Lewellen Creek area

The unconfined sand and gravel aquifers in the Sage -Lewellen watershed (Figure 16) are generally proximal to the surface water and have a fairly shallow water table, ranging from 10 -125 ft (3-38 m), and averages about 60 ft (18 m) in depth as indicated from drillers' logs. The saturated thickness of these aquifers is largely unknown, but the base of these deposits likely follows irregular subsurface bedrock channels. The Sage-Lewellen watershed can be subdivided into two regions; 1) The highland area close to the foothills, bound by north, west, and east facing spur ridges in which their drainages coalesce, and 2) the lowland area which drains only the north slope of the Coeur d' Alene Mountains and opens into Eightmile Prairie.

The highland area is located in Sections 20, 21, 29, 30, and 31, T53N, R2W. The static water level for all 29 wells in this area averages 54 ft (16.5 m), 64 ft (19.5 m) in 23 wells tapping granite aquifers, and 45 ft (14 m) in the 9 wells accessing alluvial aquifers as is indicated in the drillers logs. Yields from all 29 wells average 14.3 gpm (54.1 lpm). Granite aquifers average 12.1 gpm (45.8 lpm) and alluvial aquifers average 16.9 gpm (64.0 lpm). All wells in the highland region penetrating sand and gravel aquifers are proximal, up to several hundred feet (several tens of meters), to surface sources of recharge Sage Creek, Lewellen Creek and irrigation ditches.

The lowland area lies within Sections 21, 22, 23, 24, 25, 34, 35, 36, T53N, R3W. The static water level for all 30 wells in this area averages 206 ft or 63 m (significantly deeper than in the highland area), 218 ft (66 m) in 26 wells tapping granite aquifers, and 147 ft (45 m) in only four alluvial aquifers. Well yields are slightly lower than those wells in the highland area. Average well yields for all wells is 13.1 gpm (49.6 lpm). Wells in

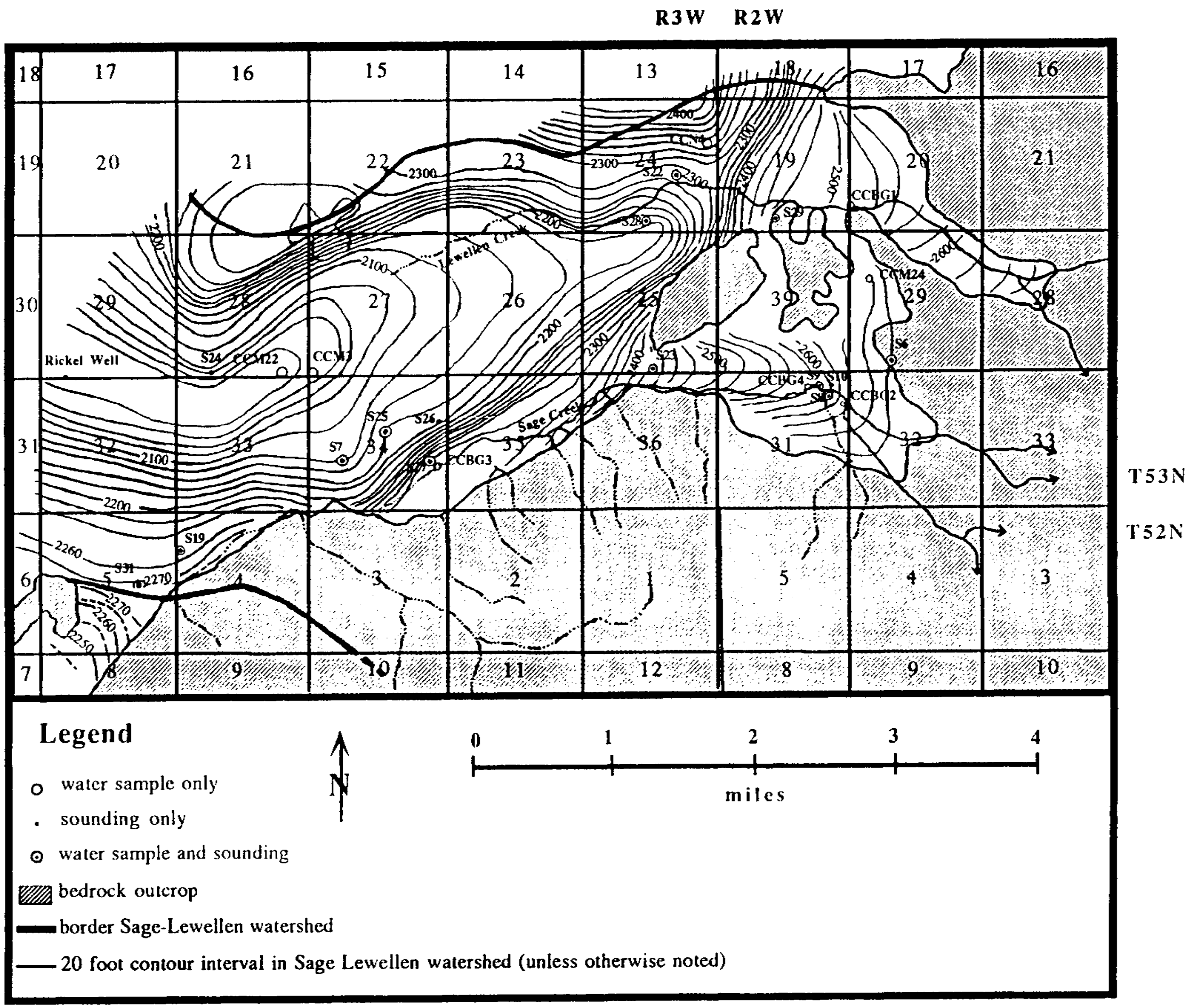

Figure 16. Detailed water table map of the Sage-Lewellen watershed and Eightmile Prairie.

granite aquifers average 13.0 gpm (49.2 lpm), and wells in alluvial aquifers average 13.8 gpm (52.2 lpm).

The saturated sands and gravels occur only where there is influent stream flow in the Sage Creek-Lewellen Creek area. Since the depth to bedrock map (Figure 12) suggests that there are sub-surface channels connecting this area with the Rathdrum Prairie and, therefore, the ancient Rathdrum River valley. These subsurface channels are probably buried valleys which drained the north slope of the Coeur d'Alene Mountains in a northwest-west direction that was established prior to the Pleistocene.

Wells penetrating granites within this area have highly variable water tables and are likely dependent upon degree of fracturing, jointing and their orientation, depth, and recharge. Alluvial aquifers exist within this region, but are uncommon. Better well coverage is required to determine how extensive they are.

Eightmile Prairie

The hydraulic gradient east of where Bunco Road meets Highway 95 gradually drops towards the west at Eightmile Prairie (Figure 16). Three wells tap sands and gravels at considerable depth below the surface, at 300+ ft (100+ m), the logs showing a decline in head westward. Wells in the Eightmile Prairie area are located in Sections 28, 29, 30, 31, 32, and 33, T53N, R3W. Static water levels in all 15 wells average 275 ft (84 m), 357 ft (109 m) in five wells tapping alluvium, 241 ft (73 m) in nine wells granite aquifers, and one well tapping shale at 135 ft (41 m). The gradient is steep where the water table is within granite and gradual where the water table is within alluvium, similar to the main channel at approximately 0.005. A discharge calculation from the Eightmile area into the Rathdrum Prairie aquifer was not attempted due to the lack of cross-sectional data within the ancient valley fill. Well yields for all 15 wells averages 23.3 gpm (88.2 lpm), 61.2 gpm (231.7 lpm) in wells accessing alluvial aquifers, 18.8 gpm (71.2 lpm) in granite aquifers, and 5 gpm (19 lpm) in the one well tapping shale. Approximately one mile (1.6

km) south from Highway 95, along Corbin Hill Road, the static water level was measured at 57.5 ft (17.5 m) in the Henderson well (S19) in alluvium. Approximately one half mile (0.6 km) southwest of the Henderson well, the Luster well (S31) with a static water level of 38 ft (12 m) indicates there is flow northward within the alluvium, probably beginning within the main Chilco channel. The presence of a subsurface channel flowing northward into Eightmile Prairie from the north end of the Chilco channel has not been confirmed, yet evidence based upon the surface topography of bedrock exposures and well logs suggests flow is likely north-northeast joining with the subsurface channel flowing west under Eightmile Prairie.

Chilco area

Several soundings performed near Chilco (Sec 7, 8, 18, T52N, R3W) were in wells that are developed in the glaciogenic alluvial aquifer (Figure 17) and demonstrate a fairly uniform hydraulic gradient in the northern portion of the channel of 0.004, and a steep gradient of 0.04 north of Garwood . The static water level is shallow at the north end of the channel, as shallow as 15 ft (4.6 m), to about 80 ft (24 m) deep in the Chilco area as is indicated in drillers logs and field investigation. The average static water level for 22 wells in the Chilco area is 64 ft (19.5 m), 59 ft (18 m) in 16 wells tapping alluvium, 93 ft (28 m) in 3 wells which tap granite and alluvium, and 58 ft (17.7 m) in 3 wells tapping shales according to drillers' logs. Well yields average 32.7 gpm (123.8 lpm) for all wells, 38.9 gpm (147.3 lpm) in wells tapping alluvium, 27 gpm (102 lpm) in wells tapping granite and alluvium, and 5.3 gpm (20 lpm) in wells tapping shales. The saturated thickness appears to increase downgradient, although there is not enough data to determine if this is factual. Recharge to the aquifer principally occurs from the west-northwest slopes of the Coeur d'Alene Mountains on the east boundary of the channel, from areas at the north end of the channel including Chilco ridge, and the perennial stream which drains Chilco Lake and its watershed.

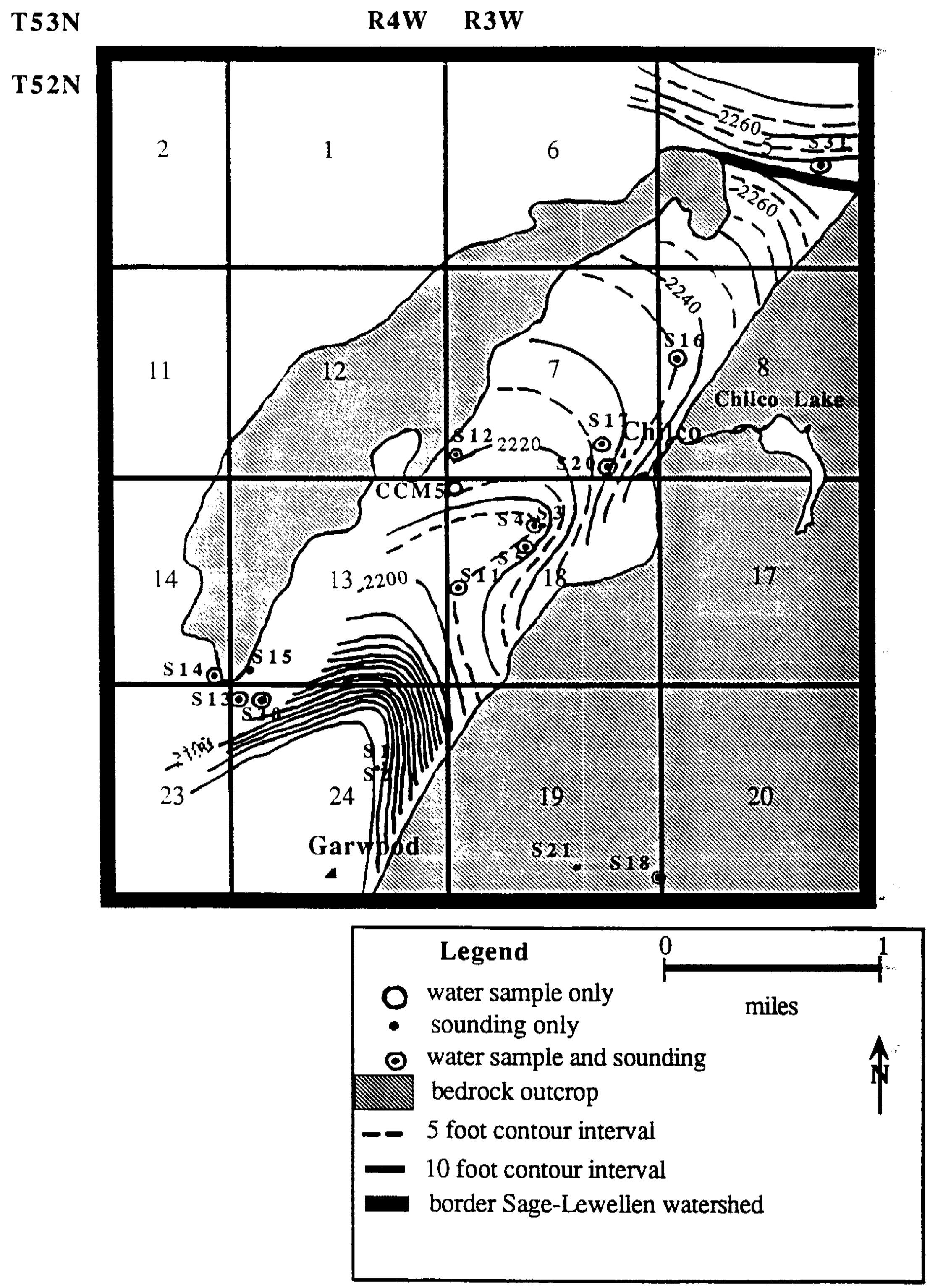

Figure 17. Detailed water table map of the main Chilco channel area.

Garwood area

Soundings taken in the Garwood area west of Highway 95 (Sec. 13, 14, 23, T52N, R4W) showed much deeper static water levels, over 100 ft (30 m) greater in the channel center than those in the Chilco area (Figure 18), and the highest average well yields. Of 26 total wells in the Garwood area, the average static water level is 205 ft (62.5 m), 212 ft (64.6 m) in 16 wells penetrating alluvium, 110 ft (33.5 m) in one well penetrating granite, and 203 ft (62 m) in 9 wells tapping basalts and interbeds. Well yields from all wells average 34.1 gpm (129.1 lpm), 44.2 gpm (167.3 lpm) from alluvial aquifers, 0.2 gpm (0.8 lpm) from granite aquifers, and 19.9 gpm (75.3 lpm) from basalt and interbed aquifers. East of Highway 95, the alluvial aquifer pinches out within a mile (1.5 km) of the Highway 95. Soundings primarily define the boundary of the aquifer since the majority of soundings were taken from wells tapping granites, basalts, and interbeds.

Comments on ground water occurrence

The well logs and on-site observations made in the field suggest that the Chilco channel aquifer is not as large and continuous as was originally suspected. Comparing the original Chilco channel aquifer as defined by Painter (1991a) (Figure 13) with the aquifer map created for this report (Figure 14) illustrates the differences in the extent and nature of the aquifer materials in the Chilco channel study area from previous studies.

These differences become most evident in the Sage Creek-Lewellen Creek area where the sand and gravel aquifers are rare, discontinuous, and located proximal to the surface flowing creeks or irrigation ditches. No sand and gravel aquifers were tapped further than 500 ft (150 m) away from an influent stream or irrigation ditch in this area. A well closer than 200 ft (60 m) from Lewellen Creek (Haines well) did not access saturated sands and gravels, but granite instead. Therefore, the discontinuous nature of these sand and gravel aquifers suggests these aquifers perhaps should not be mapped as an alluvial aquifer, but more appropriately be regarded as a granite aquifer, or as simply part of a watershed.

Wells tapping into granites are generally productive enough for domestic use, a minimum of 3-5 gpm (10-20 lpm) in much of the Sage-Lewellen watershed, although several dry holes were drilled north of Parks Road. The most productive wells are at higher elevations in the far eastern (highland) portion of the study area, in particular near the alluvium-bedrock contact or where the well is located within small sub-basins as is the case at higher elevations. West of this area production is spotty. Wells along Lewellen Creek Road have progressively deeper static water levels and poorer productivity towards the north. Wells west of Lewellen Creek Road along both Parks and Bunco Road generally have low productivity, but is generally higher near the foothills to the south (McCoy Road and Cedar Mountain Road). Direction of ground water flow within this region is difficult to define, but evidence suggests a westward flow toward Eightmile Prairie, and perhaps northward in the Belmont area.. Flow is likely within joints and fractures in the bedrock, and in pre-Miocene to pre-Pleistocene age alluvium-filled channels flowing into the Rathdrum Prairie aquifer.

The subsurface beneath Eightmile Prairie may represent an ancient channel which flowed westward, ultimately converging with the Rathdrum River. Evidence from well logs, field investigations, and soil surveys suggest that a bedrock channel does exist, and that ground water table is deep (300+ ft) within alluvial material with a gradient towards the west joining with the Rathdrum Prairie aquifer. The deep water table in an alluvial aquifer suggests this area may be part of the Rathdrum Prairie aquifer. Although this area is small, it represents a significant discovery; that the prior defined Chilco channel watershed is, in fact, two hydrologically distinct watersheds, and the Eightmile Prairie is essentially part of the Rathdrum Prairie aquifer.

Within the main Chilco channel the hydraulic gradient is fairly uniform, between about 0.004 and 0.006 . The channel aquifer has been mapped more narrowly than originally defined. The new information is largely based upon well logs, soil survey, and the field investigation. Heads are believed higher near the eastern margin of the channel most likely because recharge is principally from the west slope of the Coeur d' Alene Mountains. Principal sources of recharge within the main channel are from the spillway of Chilco Lake, small intermittent streams draining the west slope of the Coeur d' Alene Mountains, aerial precipitation and possibly surface and sub-surface springs. The influx of water is so strong from the eastern margin that in some places within the interior of the channel, flow is towards the west and even the northwest. This is largely due to the stream from Chilco Lake becoming influent to the main channel creating a small, localized ground water mound. The mound pushes ground water to the west for a short distance before turning southwest. Static water levels near the western aquifer boundary are shallow, perhaps due to the presence of springs, particularly near the Red Bishop well.

Between Chilco and Garwood, the head elevation drops rapidly losing over 150 feet in a mile, a gradient of approximately 0.03. Several wells were sounded marginal to the alluvial aquifer in this region which served to help define the boundary of the aquifer which again is narrower here than originally defined.

Seasonal fluctuations

Water tables in the alluvial aquifer within the Chilco channel area should be expected to vary seasonally, rising during spring runoff and decreasing during the late summer to early fall. Some land owners report winter declines in water table as well, and surges of high water in the spring . Areas which appear most susceptible to this phenomenon are the shallow wells in the Sage Creek-Lewellen Creek area. Summer declines in water table were reported in wells in alluvium south of Garwood and in the Chilco area at North Idaho Propane and World of Carpets.

Spring recharge raises the water table throughout the area perhaps from 5 to 15 ft (1.5 to 4.6 m) and alters the gradient within the main channel, perhaps carrying contaminants downgradient to areas where they would not be normally be transported during the course of a year. These temporal variations need to be considered in addition to of the data presented in this report.

Ground water discharge from the Chilco channel

A discharge estimate was calculated based upon the cross-sectional area of the main channel obtained from the fence diagram B-B', the hydraulic gradient determined from the ground water map (Figure 15), and hydraulic conductivity data based upon grain size descriptions from drillers' logs. This was the only region of the main channel where two well logs were in line across the channel (both of which penetrate bedrock), therefore, it was the only place where a reasonably accurate cross-sectional area calculation could be made. Two other means of calculating ground water discharge were employed for comparison. One method used the recharge per unit watershed area devised by Painter (1991b), and the other method estimated the amount of runoff expected in one year based on precipitation data.

The cross-sectional area calculated for the main Chilco channel is 150,325 ft^2 (13,973 m^2) at cross-section B-B' (Figure 15). The clay or shale bounding the bedrock surface is treated as bedrock since it is assumed that it acts as an aquatard. The surface of the clay or shale contact was regarded as flat for the area calculation (Figure 9).

Hydraulic gradient values in the area of this cross-section were calculated by averaging three values which were read from the ground water map (Figure 17). The hydraulic gradient for this area of the channel is 0.029.

Hydraulic conductivity values are perhaps the most uncertain variable in the discharge calculation. The aquifer material is largely sand and gravel as indicated on well logs. The range of hydraulic conductivity used was for the channel flood facies, 30-75 ft/day which was obtained by using the equation obtained from Theis (1963).

By using this range of hydraulic conductivity for the discharge calculation, the range of discharge for the main Chilco channel is 131,000 to 327,000 ft^3/day (3710 to 9260 m^3/day) or 1.6 to 3.8 cfs (45.3 to 107.6 l/s). It is important to note that this calculation is for B-B' and not for the outlet of the channel near Garwood.

A second, independent method of calculating discharge at B-B' was made by using the formula for calculating recharge per unit area watershed used by Painter (1991b). At B-B' the area of watershed inferred to be contributing to recharge (and therefore discharge across B-B') is 6.01 square miles. By multiplying this area by 0.59 cfs per mi^2 (43 l/s per km^2), the amount water discharging across B-B' is calculated to by this method to be 3.5 cfs (99.1 l/s).

Another method of estimating discharge across B-B' uses an estimate of the annual expected runoff from the watershed. Runoff generally occurs from the months of September to April. The total cumulative depth of precipitation for that period is multiplied by the area of watershed for an annual volume of water available for runoff. The watershed area of 6.01 square miles, and a cumulative depth of precipitation of 1.53 ft or 0.41 m (see Climate section) was used to obtain an annual volume which reduces to 8.1 cfs (229.4 l/s). It is assumed that only about 25 to 50% of runoff actually reaches the water table, therefore a more realistic figure would be 2.0 to 4.0 cfs (56.6 to 113.2 l/s).

Since three very different methods of calculation of ground water discharge seem to corroborate each other with three very similar values, the discharge rate of the Chilco channel aquifer at B-B' is probably no more than 4.0 cfs (113.2 l/s). The method of estimating recharge based upon recharge per unit area of watershed appears valid for this portion of the Rathdrum Prairie watershed, and may be used appropriately for estimating the contribution of flow from the Sage-Lewellen watershed to the Rathdrum Prairie aquifer. There are no significant sources of recharge between B-B' and the "outlet" of the main channel north of Garwood, consequently the contribution from the Chilco channel aquifer to the Rathdrum Prairie aquifer is probably not much more than 4.0 cfs (113.2 l/s). This contribution of flow to the Rathdrum Prairie aquifer is significantly lower than the original estimate (based upon the original watershed area) of 40.6 cfs or 1150 l/s (Painter, 1991b).

History of ground water contamination within the study area

Since the mid-1980's the Louisiana Pacific Waferwood Processing plant in Chilco has been suspected of compromising ground water quality (J. Sutherland, per. comm., 1993). Several wells on and off the Louisiana Pacific property (SW 1/4, Sec 7, T52N, R3W) became contaminated with fecal coliform, tannin and lignin in the late 1980's. The Department of Environmental Quality, and a consulting firm retained by Louisiana Pacific attempted to identify the source of the contamination. Wells downgradient of the mill were found to be contaminated with fecal coliform, such as in the A.E."Red" Bishop well (S12), as well as tannins and lignins in the Brooks-MacDonald well (CCM5). An X-ray probe analysis of the Bishop well showed that the well casing was cracked and the well could have been contaminated by various sources. A well upgradient (Chilco Estates) also showed fecal coliform contamination, although not consistently during the study. Another well, the Tipke well (S17), north of the Louisiana Pacific Plant, showed no contamination. The conclusions drawn by George Maddox and Associates based upon this data were inconclusive, and the firm viewed the occurrence of fecal coliform as random and exonerated Louisiana Pacific from responsibility for the contamination (from Idaho Department of Environmental Quality unpublished reports).

Several septic drain fields located near the center of Sec 6, T52N, R3W were permitted for several years. The fields at the time of the study were overgrown with vegetation and do not appear to have been utilized for some time. The son of A.E."Red" Bishop videotaped the site after it was used (April, 1991?). The tape showed raw effluent, feminine hygiene products, tissue paper, and discolored soil in several pits. A.E. Bishop currently owns a copy of the videotape (from Idaho Department of Environmental Quality unpublished reports).

Two gravel pits located in the center of Sec. 5, T52N, R3W were brought to the attention of the author by John Luster, a nearby homeowner and well owner. Mr. Luster proclaimed that the state of Idaho extracted gravel from the pit west of Highway 95, then filled the pit with tires and other materials and then graded over the fill. No dates were obtained from Mr. Luster to indicate when the pits were filled. Both pits were mapped by the Kootenai Soil Survey (SCS, 1981). No conclusive data exists to suggest the area is contaminated. Yet, the shallow water table in the area implies this area is highly susceptible to contamination (from Idaho Department of Environmental Quality unpublished reports).

A feedlot north of the Louisiana Pacific plant owned by Jim Carney was reported to be contaminating the aquifer in February, 1988. The pit was believed to be an old cesspool. or seepage pit and was promptly filled (from Idaho Department of Environmental Quality unpublished reports).

WATER QUALITY TESTING

General statement

Ground water sampling and well sounding was performed for this study between July 27, 1993 and September 9, 1993. Sampling was done at a reconnaissance level of testing representative of water quality only for the time period tested. Three surface water samples were also taken to determine probable background levels for the analyzed parameters tested. Fecal coliform tests were performed to determine if these surface and well waters were biologically contaminated. One water sample was taken from a well where no current static water level information was available.

Sampling and sounding procedure

Wells were selected based upon the following criteria: a) accessibility of well, b) a well log exists and water level measurement is possible, c) a good water sample is attainable suitable for analysis, d) its relative position to a suspected source of contamination (either up or down gradient). Point sources and contaminated wells were identified and monitored both up and down gradient where ever possible. Most wells met three of the four criteria. Some wells were sampled which had no well logs or were sounded without taking water samples. Three wells were sounded with no known well log record.

The sounding of wells consisted of using a Powers electronic well sounder to determine depth to water. Depth to the water table was determined by subtracting the well collar height from the sounder reading at the well collar. Well collar elevation was extrapolated based upon location on topographic map (contour interval was 10 ft in main channel and 20 ft elsewhere). Often if the well could not be sounded a water sample was taken in order to spatially distributed water quality samples of the study area. Water samples were taken from taps as close to the well as possible. Taps were allowed to flow for approximately five minutes to flush plumbing in order to obtain a representative sample. Soundings were performed only when pump was inactive.

Water samples were analyzed for nitrate, chloride, specific conductance, alkalinity, phosphorus, hardness and fecal coliform bacteria. For wet chemistry analysis, three plastic cubitainer (500 ml) bottles were used for each sample which were carefully labeled then placed in a cooler for transport. Specific sample locations were estimated in the field based upon well log location information and field verification. Upon arrival at the lab, samples for wet chemistry were then acidified with 2 ml of concentrated sulfuric acid before stored for later analysis. Samples for metal analysis were preserved with 2 ml of concentrated nitric acid. For fecal coliform analysis sterilized 250 ml Nalgene bottles treated with sodium thiosulfate were used to contain samples for analysis. Samples scheduled for fecal coliform analysis were transported to the lab within four to six hours of being collected whenever possible. Analysis of samples was performed by the Idaho Department of Health and Welfare Water Quality Laboratory in Coeur d'Alene, Idaho. Nitrate analysis was performed by a regional Idaho Department of Health and Welfare Water Quality Laboratory in Boise, Idaho.

Parameters tested

Nitrate

Nitrate is derived from decaying organic matter, sewage, fertilizers and soil bacteria. Natural sources of nitrogen are minor contributors of nitrogen to most ground water (Parliman, et al. 1980). The concentration of nitrate ions will be discussed in terms of overall nitrogen (NO_3 and NO_2 as N). Generally considered the precursor to other organic contaminants due to its high solubility, nitrate also encourages the growth of algae and other organisms which produce undesirable tastes and odors in drinking water. Excessive concentrations of nitrate are generally caused only by human activity. Potential sources for nitrate contamination are municipal, and industrial waste water, leachates from feedlots, fertilizers, human and animal effluent, septic tank effluent, and garbage and landfill leachates. Concentrations of 10 mg/l and greater are believed to cause methemoglobinemia (bluebaby disease) in infants. The maximum limit for public water supplies is 10 mg/l (EPA, 1986). Due to a miscommunication with the lab in Coeur d'Alene, several samples were analysed for N as NO_3 only and not for N as NO_3 and NO_2. This should not result in a problem however since nitrite concentration are usually very low.

Chloride (Cl)

Sources of chloride are dissolved from rocks and soils, sewage and industrial wastes. Large concentrations of chloride near residential areas would suggest septic tank contamination. Chloride, in combination with other water related properties, can cause corrosion of pipes (American Water Works Association, 1990). High levels increase the corrosion of iron, copper, and galvanized steel (American Water Works Association, 1990). Average septic tank concentration of chloride is 80 mg/l (Jehn, et al., 1988). Large concentrations increase water corrosiveness. The recommended maximum limit for public use is 250 mg/l.

Alkalinity

Alkalinity is the measure of the ability of water to neutralize acids and bases. Concentrations of bicarbonate and carbonate are related to the pH of the water and dissolved inorganic carbon (DIC) concentration in the water due to the dissociation of carbonic acids. Bicarbonate and carbonate are important is creating metallic carbonate coatings such as $CaCO_3$, $FeCO_3$, $Cu_2CO_3(OH)_2$ and other carbonates of lead and zinc. Also strong soluble complexes can form with metals such as copper, zinc, and lead which can accelerate corrosion or cause high level of metal pickup if pH-alkalinity or pH- DIC conditions are appropriate (American Water Works Association, 1990).

Specific Conductance

Specific conductance is the measure of the capacity of water to conduct an electrical current. Specific conductance varies with the concentration of ions from minerals and contaminants dissolved in solution; the higher the degree of ionization, the greater the specific conductance.

Iron

Iron concentrations are largely due to dissolution of minerals in the local geologic formations. Iron is considered objectionable in water because it causes turbidity, staining, changes in food and beverage taste, and deposition in plumbing. Water containing high concentrations of iron can be improved by using commercial filters.

Phosphorus

Phosphorus is particularly toxic in elemental form and subject to bioaccumulation similar to mercury (EPA, 1986). Phosphorus as phosphate is an essential nutrient for plant and animal life. Excessive phosphorus loading is believed to cause increased standing crop growth of aquatic plants, and accelerate eutrophication (EPA, 1986; American Water Works Association, 1990).

Hardness

Hardness measures the soap consuming capacity of water and is caused principally by dissolved calcium and magnesium in water. Iron, strontium, and manganese can contribute to hardness if in sufficient concentration. When hard water is heated, calcium and magnesium react to form precipitates with bicarbonate, carbonate, sulfate and silica to form a heat-retarding, pipe-clogging scale.

High concentrations of hardness are of no health concern but can present an economic problem. The costs of softening water can be considerable for domestic use, and even greater for industrial purposes. Domestic water hardness concentrations of 100 mg/l are generally considered non-objectionable (Jehn et al., 1988).

Fecal Coliform Bacteria

Fecal coliform bacteria are derived from the fecal material of humans and other warm-blooded animals. They are often the indicators of presence potentially pathogenic bacteria. Wells showing the presence of fecal coliform bacteria indicate contamination from human and/or animal waste. Sources of bacterial pathogens such as fecal coliform include septic systems, leaking sewers, livestock and log yard waste (Jehn, et al., 1988). Where ground water depths are greater than 100 ft (30 m) the potential for fecal coliform contamination is low, however, several wells within the Chilco channel aquifer are shallower than 100 ft (30 m) and are therefore susceptible. Mandatory maximum limits for public water supplies varies with sampling method and frequency. Generally, the presence of 1 colony in a sample is grounds for concern. The state standard is less than 1 colony per 100 ml (Jehn, et al., 1988).

WATER QUALITY RESULTS

Discussion of water quality results has been separated into samples obtained from Sage-Lewellen watershed and the Chilco channel area. A summary of all water quality data is presented in Appendix B.

The Sage-Lewellen watershed

Water quality within the Sage-Lewellen watershed is very good (Table 4). All measured parameters were generally much lower than samples measured within the Chilco channel. One surface water sample from Lewellen Creek and three from Sage Creek were taken in order to estimate background levels of the parameters tested and to test for the presence of fecal coliform bacteria. All parameters were generally low compared to the ground water samples, except phosphorus and fecal coliform. Phosphorus levels averaged 0.032 mg/l, and may have been elevated due to biologic activity within the stream. Fecal coliform numbers were high. Values increase downstream in Sage Creek, from 7 to 34 colonies /100 ml, and were the highest (40 colonies/ 100 ml) adjacent to Don Howard's residence. Although three samples do not necessarily indicate a trend, the presence of fecal coliform is cause for concern.

In well water samples, hardness values range from 28 to 176 mg/l $CaCO_3$, and averages 83 mg/l CaCO3. The lower hardness values are from samples from wells tapping sands and gravel which is in stark contrast to hardness values attained from Chilco channel samples. High hardness, alkalinity, and specific conductance values came from wells tapping into granite aquifers in the Belmont area. The inorganic water quality parameters which indicate contamination from septic effluent (nitrate, chloride, and total phosphorus)

Table 4. Water quality in the Sage-Lewellen area.

sample number	location	date sampled	depth to water (ft)	nitrate (mg/l)	chloride (mg/l)	hardness (mg/L as CaCO3)	alka-linity (mg/L as CaCO3)	specific conductance (umhos/cm)	total phosphorous (mg/l)	iron (mg/l)	fecal coliform colonies/100 ml
CCM3	SW1/4, SW1/4, Sec 27, T53N, R37	7/29/93	na	0.306	0.8	144	141	283	0.009	na	<1
	L. Bek-well log										
	Ray Dare										
CCN1	NE1/4, SW1/4, Sec 29, T53N, R27	7/28/93	19.5	0.784	1.8	60	57	132	0.023	na	<1
	Brian Painter										
CCM4	SW1/4, SW1/4, Sec. 34, 53N, 3W	8/3/93	212.0	0.207	0.8	60	57	129	0.005	na	<1
	Milton Anderson										
CCN2	NE1/4, NE1/4, Sec. 31, 53N, 2W	8/3/93	22.0	0.035	0.5	33	24	68	0.006	0.04	29
	Brandt, G- well log										
	J. Howard										
CCN3	NE1/4, NE1/4, Sec. 31, 53N, 2W	8/3/93	17.0	0.882	0.8	28	30	72	0.011	0.04	<1
	Don Howard										
CCN4	NE1/4, NE1/4, Sec. 24, 53N, 3W	8/4/93	na	<0.005	<0.5	176	176	352	0.007	0.01	<1
	George Bomar										
CCM15	NW1/4, SE1/4, Sec 24, 53N, 3W	8/18/93	165.0	0.599	1.4	124	127	278	0.015	0.01	<1
	Morrow-well log										
	Haines										
CCM16	SW1/4, SE1/4, Sec. 25, 53N, 3W	8/18/93	86.5	0.435	0.7	48	50	114	0.007	0.02	<1
	Russ Bohn										
CCM17	SW1/4, NE1/4, Sec. 34, 53N, 3W	8/19/93	267.0	0.005	1	24*	107	270	0.003	0.01	<1
	C. Heit										
CCM18	NE1/4, SE1/4, Sec 34, 53N, 3W	8/19/93	119.5	0.116	0.5	60	69	149	0.007	0.18	<1
	Bouchard-well log										
	J. Engwer										
CCM19	SW1/4, SE1/4, Sec. 24, 53N, 3W	8/19/93	293.0	1.550	0.9	172	172	376	0.007	0.05	<1
	Dan & Linda Thackery										
CCM20	SE1/4, SW1/4, Sec. 19, 53N, 2W	8/20/93	7.0	0.041	1.7	180	185	388	0.002	0.14	<1
	Terry Trefz										
CCM22	SE1/4, SE1/4, Sec. 28, 53N, 3W	9/9/93	na	0.357	0.5	126	129	238	0.008	0.038	<1
	Silverwood										
CCM24	NW1/4, SW1/4, Sec. 29, 53N, 2W	9/9/93	na	1.340	0.5	32	36	81	0.028	0.11	<1
	W. Starr-well log										
	J. & C. Ryan										
	range			<0.005-1.34	<0.5-1.35	28-180	24-185	68-388	<0.002-0.028	0.01-0.18	<1-29
	mean values			0.454	0.79	83	87	189	0.009	0.06	na

are very low within the Sage-Lewellen watershed, where nitrate values range from 0.005-1.558 mg/l N, averaging 0.45 mg/l N. The only well water sample in the Sage-Lewellen area to show fecal coliform present at greater than one colony per 100 ml was from the John Howard well where the sample tested at 29 colonies/100 ml. The John Howard well is downgradient of his pig feed lot and should have his water tested again. Another test of the Don Howard well, downstream also, should be performed.

Chloride values within the Sage-Lewellen watershed range from 0.05 to 1.8 mg/l, averaging 0.79 mgl/l. The sources of the slightly enriched chloride concentration is unknown, but largely insignificant.

Both iron and phosphorus concentrations within samples in the Sage-Lewellen watershed are negligible. Iron values ranged from 0.01 to 0.18 mg/l with a mean value of 0.06 mg/l. Phosphorus values were lower, ranging from 0.002 to 0.028 mg/l with a mean value of 0.009 mg/l. The highest values were in shallow wells, less than 40 ft (12 m), tapping granite aquifers in the far eastern portion of the study area.

In sum, water quality data from the Sage-Lewellen watershed suggests that flow is minimal through sands and gravels as is indicated from the low hardness, specific conductance and alkalinity values. Waters flowing within alluvium for significant distances in this area should dissolve high amounts of calcium and magnesium, particularly since much of the alluvium is derived from carbonate rich pre-Tertiary rocks.

The Chilco channel

Water quality is not as good in the Chilco channel as in the Sage-Lewellen watershed (Table 5). Water samples within the main Chilco channel demonstrate an increase in hardness, alkalinity, and specific conductance downgradient. Iron concentrations are higher within the channel (average value is 0.36 mg/l) than in the Sage-Lewellen watershed (average value is 0.06 mg/l) and likely are higher due to effluent from

Table 5. Water quality in the Chilco channel area.

sample number	location	date sampled	depth to water (ft)	nitrate (mg/l)	chloride (mg/l)	hardness (mg/L as CaCO3)	alka-linity (mg/L as CaCO3)	specific conductance (umhos/cm)	total phosphorous (mg/l)	iron (mg/l)	fecal coliform (colonies/100 ml)
CCM1	NE1/4, NW1/4, Sec. 18, 52N, 3W	7/27/93	89.0	0.651	2.5	292	276	515	0.003	na	<1
	J. Green-well log	7/28/93									
	North Idaho Propane										
CCM2	NE1/4, NW1/4, Sec 18, 52N, 3W	7/28/93	80.5	1.680	2	292	271	515	< 0.002	na	<1
	B. Bonham-well log	7/29/93									
	Carpet World										
CCM5	NE1/4, NE1/4, Sec. 18, 52N, 3W	8/4/93	na	0.490	2.1	252	237	454	0.005	0.018	<1
	J. Carney-well log										
	Brooks-Mac Donald										
CCM6	SW1/4, NW1/4, Sec. 18, 52N, 3W	8/4/93	79.5	0.884	2.8	300	294	552	0.003	0.015	<1
	Wade & Diane McKay										
CCM7	SW1/4, SW1/4, Sec. 7, 52N, 3W	8/4/93	66.0	0.402	1.8	240	240	454	0.008	0.700	<1
	A. E. "Red" Bishop										
CCM8	NE1/4, SE1/4, Sec. 7, 52N, 3W	8/5/93	75.0	1.850	2.6	160	148	309	0.014	0.010	<1
	Larry Tipke										
CCM10	SW1/4, NW1/4, Sec. 8, 52N, 3W	8/11/93	75.0	0.708	1.3	144	142	304	0.007	0.708	<1
	John & Mary Veylupek										
CCM12	SW1/4, NW1/4, Sec 4, 52N, 3W	8/17/93	57.5	0.483	0.7	116	116	240	0.012	0.010	<1
	Bill Henderson										
CCM13	SE1/4, SE1/4, Sec. 7, 52N, 3W	8/17/93	71.0	0.155	0.9	68	69	154	0.041	1.080	1
	Shamrock Open House										
	M & M Realty										
CCM23	SW1/4, NE1/4, Sec. 5, 52N, 3W	9/9/93	38.0	0.558	1	32	36	81	0.028	1.420	<1
	C. Gamble-well log										
	John Laster										
	range			0.155-1.85	0.7-2.8	32-300	36-294	81-552	<0.002-0.041	0.01-1.42	<1-1
	mean values			0.715	1.6	172	166	325	0.011	0.360	na

Chilco Lake which lies a top of Wanapum basalt. The iron concentrations varied from 0.01-1.42 mg/l.

Hardness values range from 32 to 300 mg/l $CaCO_3$, with an average value of 172 mg/l $CaCO_3$. The highest value of 300 mg/l $CaCO_3$ at the McKay Well (S11) is at the site furthest south sampled within the channel boundary; it is likely that higher hardness values exist within the boundary of the Chilco channel since values appear to increase downgradient. The lowest value of 32 mg/l $CaC0_3$ is from the Luster well (S31) at the head of the main Chilco channel (Figure 17) at or near the ground water divide. This value is comparatively low for ground water in alluvium and has not flowed far from a recharge source, such as an influent stream. Another significant low value (68 mg/l $CaC0_3$) from the Shamrock Open House is unexpected, perhaps representing water which traveled a short distance from the perennial stream draining Chilco Lake. Hardness values increase downgradient from the Shamrock Open House, and from the "inlet" of the Chilco channel.

Alkalinity values are similar to hardness but are generally slightly lower, except where near sources of recharge where alkalinity is slightly higher. Alkalinity values range from 36 to 294 mg/l $CaCO_3$ .Average alkalinity values are 166 mg/l $CaCO_3$; a value significantly higher than the mean value of 120 mg/l $CaCO_3$ for the Rathdrum Prairie aquifer in 1988 (Young et al., 1988).

Figure 18 illustrates the observed increase in hardness, alkalinity, and specific conductance downgradient at selected sampling sites within the Chilco channel. The Henderson well (S19) north of the ground water divide has higher values than the Luster well (S31) located at the divide. The water quality parameters increase downgradient to the Shamrock Open House well (S20) where they decrease substantially. The increasing trend continues for the remainder of the length of the channel.

Nitrate values range from 0.115 to 1.85 mg/l N in this area of the aquifer, having an average value of 0.715 mg/l N. The background level of nitrate was determined by Parliman et al. (1980) to be less than 0.5 mg/l N for the Rathdrum Prairie aquifer which the

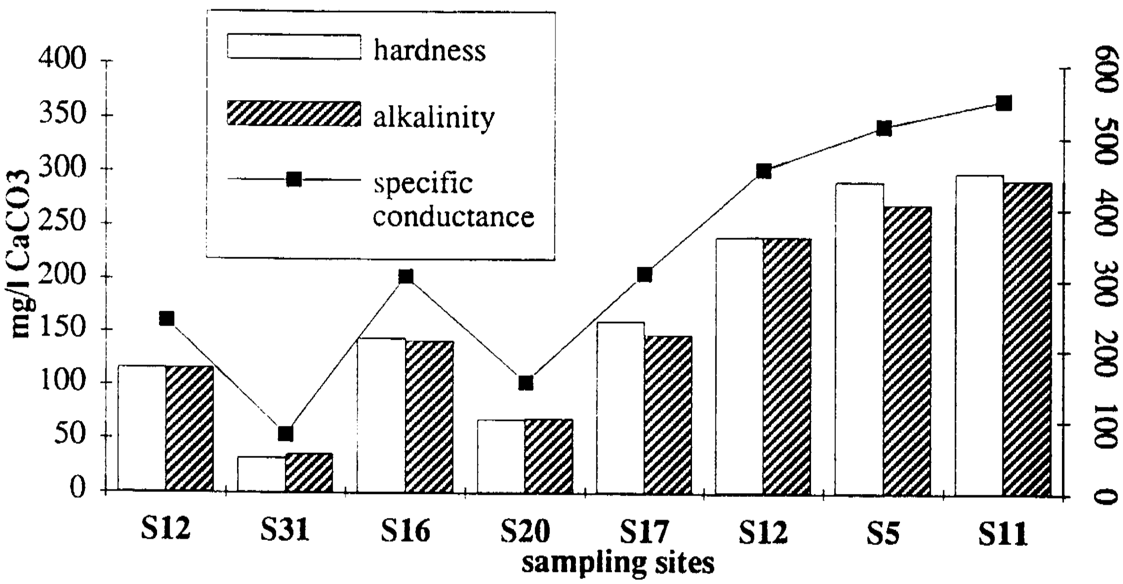

Figure 18. Graph illustrating an increase in hardness, alkalinity, and specific conductance downgradient in the Chilco channel. See Figure 16 and Figure 17 for location and distances between sampling sites.

Chilco channel has exceeded. There is no obvious distribution pattern. Higher concentrations appear to be within the central portion of the channel but do not appear to concentrate downgradient. The lowest value was from the Shamrock Open House well. Again, this suggests that water here is moving a short distance and has not traveled far down the channel.

Iron concentrations are low, ranging from 0.01-1.42 mg/l, and average 0.36 mg/l. The highest value is from the Shamrock Open House. The elevated iron concentration suggests this water resided on or flowed across iron-rich rocks such as basalts from Chilco Lake.

The nitrate, hardness, alkalinity, and specific conductance values from the Shamrock Open House well are among the lowest measured in the main channel implying the water is poorly mineralized and close to where it had recharged the aquifer.

The Shamrock Open House well was the only well to indicate the presence of fecal coliform bacteria at one colony per 100 ml. Although one colony does not constitute significant contamination, its mere presence is cause for concern. Several samples need to be taken to verify contamination. The proximity of this sample to the stream draining Chilco Lake suggests that the point source is between the Shamrock Open House and the stream, or the source of the contamination is Chilco Lake. The later is the more probable since the well is only about 1/4 mile (0.4 km) from where the water from Chilco Lake, and no one has yet lived in the Open House or used the septic tank. Other old cesspools could exist between the well and where the lake water becomes influent. The M & M Realty company or future homeowner should be advised to test their well regularly.

Comparison of water quality of the study area with the Rathdrum Prairie aquifer

The overall water quality of the Chilco channel study area closely resembles that of the Rathdrum Prairie aquifer, particularly within the alluvial aquifer in the main Chilco channel. Several parameters have mean values which deviate significantly from values obtained from surveys of Rathdrum Prairie water quality in the past. Alkalinity, specific conductance, and hardness mean values obtained for this study exceeded mean values obtained in three previous surveys (Table 6) performed between 1980 and 1988 (Young et al., 1989; Yee and Souza, 1987, and; Parliman et al., 1980). Means that were calculated for alkalinity, hardness and specific conductance in the entire study area were close to the mean and median values of the three surveys.

Nitrate values show an increasing trend through time in the Rathdrum Prairie aquifer. Nitrate concentrations in the main Chilco channel (mean is 0.715 mg/l) are at about the same value as the median value observed in 1987 of 0.7 mg/l (Yee and Souza, 1987) for glacial alluvial aquifers in north Idaho. The mean value for the entire study area is 0.495 mgl/l, close to the mean value for the Sage-Lewellen area (0.45 mg/l). Chloride concentrations within the main Chilco channel are slightly higher (1.6 mg/l) than the mean value of 1.5 mg/l calculated in the most recent survey (Young et al., 1989). For the most part, the means calculated for most water parameters in the main Chilco channel exceed those calculated for the Rathdrum Prairie aquifer in the recent past. The water quality from the Sage-Lewellen area has mean values which are much lower than those obtained for the Chilco channel, and past surveys.

<u>Comments on water quality</u>

The overall water quality in the study area is good, although within the Chilco channel there is an approximately two-fold increase in nearly all parameters compared to the water quality within the Sage-Lewellen watershed, particularly downgradient within the Chilco channel. All water quality parameters tested were well within acceptable limits in the entire study area. The shallow water tables near the far eastern area of the watershed do have a fairly high potential to become contaminated due to their proximity to the surface and surface waters, yet there does not appear to be any serious degradation in water quality.

Table 6. Comparison of water quality of the Rathdrum Prairie aquifer area with the Chilco channel study area.

Reference	Nitrogen, Nitrate Nitrite, Dissolved (mg/l as N)	Chloride, Dissolved (mg/ as Cl)	Alkalinity (mg/L CaC03)	Specific Conductance (micromhos)	Iron , dissolved (mg/L)	Hardness (mg/L CaC03)	Phosphorous, total (mg/L as P)	fecal coliform total colonies per 100 ml
Young et al., 1989								
range	0.3-4.2	<1-6.0	16-300	36-457	na	na	na	na
mean	1.2	1.5	120	247	na	na	na	na
Yee and Souza, 1987								
range	0.1-25	na	na	32-1050	0-5.3	14-610	na	<1
median	0.7	na	na	231	0.35	120	na	<1
Parliman et al., 1980								
range	0.01-25	na	na	na	0-5.3	14-610	na	na
mean	0.32	na	na	na	0.02	120	na	na
Sage-Lewellen area (this report)								
range	<0.005-1.34	<0.5-1.35	24-176	38-388	0.01-0.18	28-180	<.002-0.028	<1-29
mean	0.45	0.79	87	189	0.06	83	0.009	na
main Chilco channel (this report)								
range	0.155-1.85	0.7-2.8	36-294	81-552	0.01-1.42	32-300	<0.002-0.41	<1-1
mean	0.715	1.6	172	325	0.36	172	0.011	na
entire study area (this report)								
range	<0.005-1.85	<0.05-4.0	20-294	42-552	0.01-33	16-300	<0.002-0.214	<1-40
mean	0.495	1.2	118	242	1.98	118	0.02	na

Note: na = data not avaialable.
from Yee and Souza, 1987 and Parliman, et al. (1980), data
from glaciogenic aquifers (including Rathdrum Prairie) in north Idaho.
Young et al.(1988) from Rathdrum Prairie aquifer only.

Specific conductance, hardness, and alkalinity values increase downgradient within the Chilco channel . Continual exposure of ground water to alluvium results in a gradual increase in ionization downgradient, therefore this trend is expected. The parameters of greatest concern such nitrate and chloride are well within acceptable limits and do not appear to define a contaminant plume. The water chemistry and fecal coliform sample from the Shamrock Open House has water quality more closely resembling values from the surface water samples. This well is proximal to a major source of recharge, the stream draining Chilco Lake, which may have caused fecal contamination in other wells within the channel in the past. The Louisiana Pacific Plant, although still a suspect point source of ground water contamination, may not have been responsible for fecal contamination of ground water in the channel. Previous reports did not consider the impact of the recharge from Chilco Lake upon the gradients and water quality of the channel. The impact of Chilco Lake needs to be further investigated.

It is important to note that these values were measured during the summer months of 1993. Water quality during the beginning of the runoff season (late winter and early spring) could be very different as potential contaminants become mobilized by infiltration into the aquifer. Annual variations in recharge could also affect water quality as well as the gradient of the water table.

In sum, although water quality within the study area is good it is important to note that this area is subject to a high potential for contamination. The increase in alkalinity, hardness, and specific conductance downgradient within the main channel demonstrates how parameters can compound downgradient. Since flow within the study area has been demonstrated to diverge at Eightmile Prairie, less water is flowing through the main channel than originally believed. Less water suggests less dilution of contaminants. Perhaps the increase in alkalinity, hardness, and specific conductance over a relatively short traveling distance is a representation of a lack of dilution within the aquifer. This tendency to increase certain parameters downgradient is not unusual for the Rathdrum Prairie aquifer, but is unusual for these parameters to increase so rapidly over a short traveling distance in the main Chilco channel. Although other more important water parameters concerning human health were not demonstrated to increase downgradient or to be above maximum contaminant levels, it is important to reiterate that the water sampling was performed for a single point in time, and water quality could be very different at another time of the year. In the future, water quality testing in the Chilco channel should be performed routinely throughout the year to carefully monitor any changes in the water table and in water quality.

FUTURE MONITORING WELLS

Given the reconnaissance level of the investigation performed here, sites worthy of future water quality monitoring have become more apparent in the Chilco channel aquifer. The selection of future monitoring well sites was a priority in the Chilco channel investigation. Only the Louisiana Pacific Plant was an anticipated source of contamination before the investigation. Several other sites have since become areas of concern during the investigation due largely to information acquired from residents and information gathered from the Idaho Department of Environmental Quality in Coeur d'Alene.

Areas that have demonstrated a high degree of contamination will have the highest priority for monitoring well sites. Other important criteria are:

1) relative position of monitoring well site to source of potential contamination; is the monitoring well site upgradient or downgradient from source of contamination. Areas of high contamination necessitate monitoring wells both upgradient and downgradient to characterize degree of contamination from point source.
2) sites where little or no well coverage exists and contamination has been demonstrated or suspected upgradient.
3) cooperation from property owner, will the landowner allow a well to be drilled on their property (Rowe and Dulaney, 1991).

Another important consideration is drilling a monitoring well to characterize background levels of elements and compounds being measured. This should be done be done far enough upgradient so as the potential for contamination is essentially zero. Due to the reconnaissance nature of this water quality study, only four surface water samples were taken to determine background level in the Chilco channel study area.

Choices for monitoring well sites

Based upon the field investigation, the history of contamination within the Chilco channel suspected to be caused by Louisiana Pacific, and the ground water map created for the Chilco channel, areas for drilling monitoring wells have been selected (Figure 19).

Water quality investigations performed by the state of Idaho and other independent consultants have demonstrated that contamination has occurred near the Louisiana Pacific Waferwood Processing Plant SE1/4, SW1/4 and SW1/4, SE1/4 Section 7, T52N, R3W). There has been inconclusive, yet compelling evidence presented to date that does imply the plant is a source of contamination. Assumptions made regarding the gradient near the plant may have led to erroneous conclusions. The Chilco Estates well about 1/4 mile (0.4 km) northeast of the Louisiana Pacific Plant was assumed to be upgradient of the plant. The investigation of the water table for this report suggests that the gradient near this site is much more complex, and is towards the west at the time of this report. Water discharging into the glaciogenic aquifer from the Chilco Lake spillway is mounding and pushing water westward. The gradient beneath the Louisiana Pacific Plant is west-southwest. The best possible site to drill a monitoring well upgradient of the plant would be slightly north of a line from the plant to the spillway, drilling wells on the east side of Highway 95 (Figure 19) . One to two monitoring wells should be drilled southwest (downgradient) of the plant, but east of the Brooks-MacDonald well along Chilco Road. Drillers should anticipate very coarse gravels and boulders several feet or meters in diameter. Well depths will not exceed 100 ft (34 m), and should not encounter bedrock. Two monitoring wells would provide

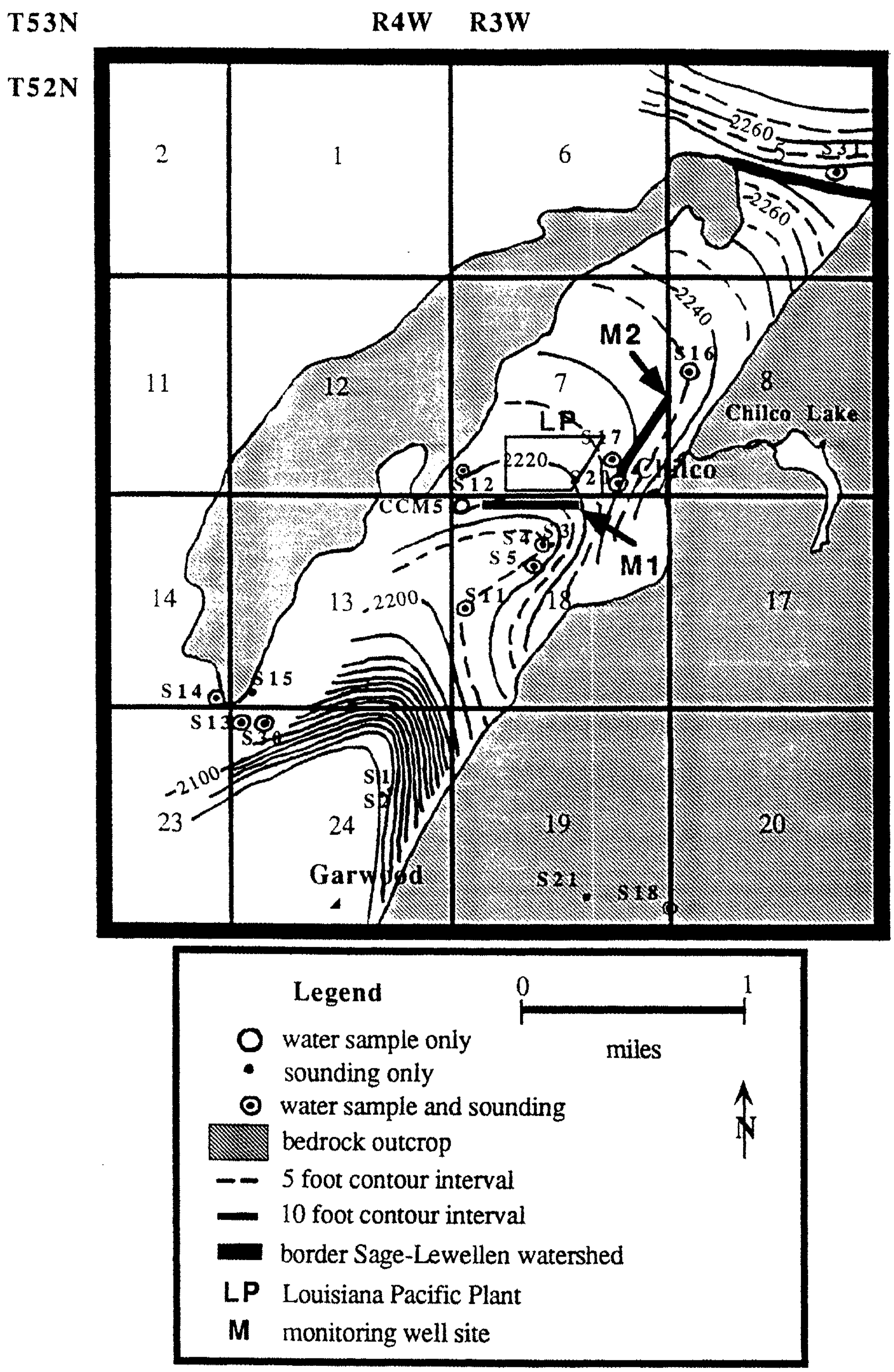

Figure 19. Recommended sites for future monitoring wells in the Chilco channel area.

optimal coverage and would take into account possible seasonal variations in gradient direction.

A gravel pit suspected to have been converted into a landfill (center of Section 5, T52, R3W) by the state of Idaho is a possible site of contamination since the water table is shallow, at about 40 ft (12 m) below the ground surface and little information is known regarding the site. Also there is a deficiency of water table data in this region since there are few residences and no well logs. Considering the remoteness of the site, the lack of water quality data suggesting contamination, this site should be considered secondary in priority to sites near production wells and residences which have a history of contamination.

Water quality testing without the use of monitoring wells could also be employed to gather valuable information. For instance, a water sample from Chilco Lake or near the stream which drains Chilco Lake could provide water quality data for the influent water entering the main channel, and information regarding the degree of eutrophication of the lake. If water quality from these samples is found to be poor, then water quality within the Chilco channel may also be poor, particularly along the eastern margin of the channel which the spillway recharges.

In sum, the following monitoring well sites are recommended:

1) Southwest (downgradient) of Louisiana Pacific Plant and NE1/4, NW1/4, Section 18, T52N, R3W). One well. Well should penetrate coarse sands, gravels and boulders to a depth of 100 to 120 ft (30 m).

2) East northeast (upgradient) of the Louisiana Pacific Plant (SE1/4, Section 7, T52N, R3W). One well. Well should penetrate coarse sands, gravels and boulders to a depth of 100 to 120 ft (30 m).

SUMMARY

For the most part, the preliminary investigation of well logs, maps and other data sources performed before entering the field was verified during the field investigation. The Chilco channel aquifer is not the continuous, southwestward-flowing sand and gravel aquifer as originally defined by Painter (1991b). It is in fact two distinct watershed systems which connect with the Rathdrum Prairie aquifer at different sites; the Sage-Lewellen watershed near Eightmile Prairie, and the Chilco channel watershed and aquifer near Garwood. Underlying the entire study area is a complex drainage system of channels which developed prior to the Pleistocene that ultimately drain westward through the Rathdrum River valley. It is this buried channel system which appears to control the configuration of the water table and the flow direction of ground water to the Rathdrum Prairie aquifer.

Water quality with the study area was generally good, particularly within the Sage-Lewellen watershed. Although water quality parameters were well within maximum contaminant levels, the rate of increase of certain water parameters such as hardness, alkalinity, and specific conductance downgradient within the main channel implies the aquifer can concentrate contaminants rapidly over a short distance. Recognition of the influence of the perennial stream draining Chilco Lake upon both water quality and the configuration of the water table may provide further clues and monitoring opportunities to determine what factors influence water quality and quantity within the Chilco channel. Only a ground and surface water monitoring study done over the course of at least one year with repeated seasonal sampling could provide adequate data to determine overall patterns in water quality.

The previous studies describing the hydrogeology within the Chilco area and the extent of the Chilco channel aquifer are incompatible with data compiled within this report. Based upon this data, a new management scheme needs to be employed in order to insure the preservation of the aquifer.

New data complied within this report implies that the management of the aquifer should be reconsidered. This is based upon the following rationale:

1) Previously unidentified or ignored bedrock outcrops and shallow soil-rock associations mapped from soil surveys narrow the main channel therefore narrowing the aquifer to smaller dimensions than originally defined.

2) The presence of a ground water divide where the channel opens northward into Eightmile Prairie indicates that ground water flow to the north into the Rathdrum Prairie aquifer contradicts the findings of Hammond (1974). This information necessitates redefining recharge areas supplying water to the main Chilco channel.

3) The presence of deep, 300+ foot (100 + m) wells tapping alluvium east of Eightmile Prairie with decreasing heads, a hydraulic gradient of about 0.005, towards the west suggests a westward flow directly into the Rathdrum Prairie contradicts Hammond (1974) who mapped the area as a bedrock divide (Figure 16).

4) Fecal coliform from a well water sample near the Chilco Lake spillway suggests that contamination could originate from Chilco Lake, a potential point source not previously recognized by other workers.

These findings suggest that redefinition of the Chilco channel aquifer boundaries, and perhaps the Rathdrum Prairie aquifer boundaries as has been performed in this study, is necessary. The water table (itself much shallower than the Rathdrum Prairie aquifer), increasing population density, and the clustering of single household septic systems within the Chilco channel requires regulations similar to those governing the Rathdrum Prairie aquifer in order to insure ground water quality. The potential for ground water contamination may be higher within the Chilco channel than in the Rathdrum Prairie and should perhaps be more stringently monitored and regulated. Several management and monitoring alternatives exist to insure a minimum degree of protection to the Chilco channel. Each area within the Chilco channel study area should be considered separately.

The Sage-Lewellen watershed

Since there are very few wells in this area penetrating productive sands and gravels, it should not be considered part of the Chilco channel or Rathdrum Prairie alluvial aquifers. A more appropriate designation would be the Sage-Lewellen watershed which appears to empty directly into the Rathdrum Prairie aquifer. The Sage-Lewellen watershed does have several small alluvial aquifers, yet there is insufficient well coverage to determine the extent of the aquifer. The area nearest to the foothills and streams has a shallow water table, in places within alluvium, and is susceptible to contamination. This area should perhaps be regarded as a recharge area. An independent designation as a watershed recharging directly into the Rathdrum Prairie aquifer is the most accurate and appropriate classification for the data available and the observed conditions.

The ground water divide

The presence of a shallow ground water divide near the north end of the Chilco channel (Section 5, T52N, R3W) requires special consideration. The water table slopes to the north quickly to static water level depths typical of the Rathdrum Prairie aquifer. Flow to the southwest within the Chilco channel is much closer to the surface and is quickly dissociated from the influence of the divide probably within Section 5, T52N, R3W. Since several wells within Eightmile Prairie (Sections 27, 28 and 29, T53N, R3W) have well logs indicating flow within alluvium towards the west at depths greater than 300 ft (100 m), the area north of the ground water divide should be considered hydrologically connected to the Rathdrum Prairie aquifer (Figure 15). The area around the ground water divide considered for the eventual implementation should be incorporated within a wellhead protection program to insure protection at the state and county level. This would at least recognize the area as not being a bedrock divide, as described by Hammond (1974), but as an inlet into the Rathdrum Prairie aquifer. A mile long seismic line could be run parallel to the Old Highway from Corbin Junction north past the intersection with Brunner Road to confirm the existence of a channel.

Assigning the area of the divide as part of the Rathdrum Prairie aquifer, or at least including it within a wellhead protection program. is the most logical course of action considering the hydrologic conditions of the divide area.

The Chilco channel

Since static water levels are much shallower than those of the Rathdrum Prairie aquifer, and the aquifer materials are similar, pollution potential in the Chilco channel is higher. In lieu of the discovery of a ground water divide, areas such as newly defined watersheds recharging the aquifer in the main Chilco channel must be less than originally defined. Less water from recharge would decrease dilution and potentially increase pollution potential. Regulations concerning septic density within the Rathdrum Prairie aquifer may be adequate to insure ground water quality within the Chilco channel. Although the population in this portion of the channel is low at the time of the writing of this report, low population density at this time should not be considered a criteria for more lenient septic regulations considering the expanding development within the area. Therefore, the alternatives for monitoring and regulating the Chilco channel are:

1) Separate the Chilco channel as an independent aquifer and establish similar (or more stringent) septic density regulations as those governing the Rathdrum Prairie aquifer. Consider implementing a wellhead protection program..
2) Incorporate the Chilco channel into the Rathdrum Prairie aquifer (sole source aquifer), imposing the same regulations concerning septic density as those governing the Rathdrum Prairie aquifer.

By incorporating the Chilco channel aquifer into the Rathdrum Prairie aquifer, the Chilco channel can receive the minimum amount of protection which is required for preserving water quality. This should be considered a long term goal for protection. The process of amending of the Chilco channel aquifer to the sole source aquifer designation would require federal assistance as well as public interaction which could prolong the time in which the area above the aquifer is developed without regulation. Unfortunately, it is not likely that the Chilco channel aquifer will ever be incorperated into the Rathdrum Prairie aquifer. However, the aquifer can be protected by a wellhead protection program to insure water quality in the future . The most practical alternative for preserving water quality would be the first alternative listed.

Designing a wellhead protection program

A wellhead protection area is defined as the surface and subsurface area surrounding a well or wellfield that supplies a public water supply through which contaminants are likely to pass and eventually reach the water well(s) (WSDOH, 1993). These areas can be identified by several means which vary in degrees of complexity and expense from simple formulas to complex analytical models. The Environmental Protection Agency (EPA) provides guidelines for communities to design their own Wellhead Protection Programs (EPA, 1990; 1989). A recent wellhead protection program proposal has been published by the Washington State Department of Health (WSDOH, 1993) and can perhaps serve as a model for one in the Chilco channel area.

Basically, for a wellhead protection program to be implemented, several tasks must be accomplished, including:

1) a characterization study of the hydrogeologic setting,

2) a susceptibility assessment of the area needs to be performed,

3) a delineation method needs to be chosen and implemented, and

4) the resultant wellhead protection area mapped.

The definition of wellhead protection area is commonly based on the travel time of ground water within an aquifer to reach a well or spring. Typically, areas are delineated for 1, 5, and 10 years of travel. These areas can be calculated by simple formulas or more complex but better representative analytical models. Generally, the more people who are served by a well, the more carefully defined and representative the wellhead area should be. For the Chilco channel alluvial aquifer, the entire surface area should be designated a wellhead protection area since it is small with relatively high hydraulic conductivities and porosities. A more precise definition of a wellhead protection area would be costly and would likely result in including the entire aquifer anyway.

Since the Chilco channel aquifer and the Sage-Lewellen watershed are independent entities and vary hydrogeologically, they should not necessarily be protected under the same wellhead protection guidelines. Perhaps designation as a critical recharge area to the Rathdrum Prairie aquifer would be more appropriate for the Sage-Lewellen watershed.

CONCLUSIONS

The information derived from studying the well logs and the sounding survey suggest the Chilco channel aquifer is less extensive than originally defined by initial workers. The presence of the ground water divide south of Eightmile Prairie and the nearby previously unidentified subsurface channels containing saturated sands and gravels require reconsidering distribution of flow from recharge to the Rathdrum Prairie aquifer. Also this information implies special considerations for ground water protection similar to the Rathdrum Prairie aquifer. The shallow Chilco channel area also requires similar protection.

The area contributing recharge to the Chilco channel aquifer was greatly reduced due to the discovery of the ground water divide. This reduction of area also resulted in a reduced contribution of ground water flow to the Rathdrum Prairie aquifer from 40.6 cfs to 4.0 cfs.

Although sediment associations of fine clays and coarse gravels exist within the Chilco channel area, aquifer properties should be considered similar to the Rathdrum Prairie aquifer. The extensive glaciolacustrine deposits could lower permeabilties slowing the advance of contaminants such as waste water and septic effluent. Yet, these deposits overlay highly permeable flood deposits which readily transport contaminants. These findings coupled with the shallow water table ranging in depth from 35 to 230 ft (11 to 70 m) across the length of the main channel suggest that this area should be considered as having a high potential for contamination.

Water quality data from the Sage-Lewellen Creek watershed suggests flow is minimal through sands and gravels as is indicated from the low hardness, specific conductance and alkalinity values. Water levels within the Sage-Lewellen Creek watershed are generally deep, 200+ ft (60 + m) within granites with highly variable discharges. However, the wells closed within small basins within the upper watershed and near surface waters show shallow water tables, and a potential for contamination. Designating the upper watershed as a critical recharge area is appropriate.

Water quality data within the Chilco channel indicates little contamination at the time of the testing. Water quality was found to be good overall. No obvious distribution of chloride, nitrate, and fecal coliform was discovered, and values were well below contaminant levels. However, the presence of fecal coliform within the Shamrock Open House well near the stream draining Chilco Lake may indicate possible contamination from the lake. A ground water mound from recharge derived from the lake could not only mound ground water causing local changes in gradient, but potentially contaminate the aquifer as well. Such a possibility necessitates regulating and monitoring the lake's watershed, and perhaps incorporating the watershed into a wellhead protection area to insure the integrity of the ground water in the area.

RECOMMENDATIONS

In sum, the recommendations for future monitoring and protection of the Chilco channel study area are:

1) In the event that the Chilco channel aquifer will not be incorporated into the Rathdrum Prairie aquifer, establish a wellhead protection program for the Chilco channel aquifer

for long term protection of water quality as well as imposing septic density regulations comparable to or more stringent than those for the Rathdrum Prairie aquifer.

2) List the Sage-Lewellen Creek watershed as a critical recharge area to the Rathdrum Prairie aquifer.

3) Drill monitoring wells near the Louisiana Pacific Plant and the inlet to the main Chilco channel aquifer in order to monitor water quality downgradient from probable contaminant sources.

4) Establish a water quality monitoring program which encompasses both the monitoring of ground water and surface water, particularly the water from Chilco Lake, over the course of at least one year. Sampling should be performed repeatedly over four seasons for a more comprehensive suite of water quality parameters than that which was done for this study.

These recommendations should be considered since the area is being developed without the same restrictions that govern the Rathdrum Prairie aquifer. Inaction could prove to be harmful to the water quality of the aquifer in this area.

REFERENCES CITED

American Water Works Association, 1990, Water quality and treatment- a handbook of com-munity water supplies: 4 ed. Pontius, F. W., ed., McGraw-Hill, New York, 1194p.

Anderson, A.L., 1927, Some Miocene and Pleistocene drainage changes in northern Idaho: Idaho Bureau of Mines and Geology, pamphlet no.18, University of Idaho, Moscow, Idaho.

Anderson, A.L., 1940, Geology and metalliferous deposits of Kootenai County,Idaho: Idaho Bureau of Mines and Geology, pamphlet no. 53, University of Idaho, Moscow, Idaho, 67 p.

Atwater, B.F., 1987, Status of glacial Lake Columbia during the last floods from glacial Lake Missoula: Quaternary Research, v. 27, p. 182-201.

Atwater, B.F., 1986, Pleistocene glacial lake deposits of the Sanpoil River valley, northeastern Washington: U.S. Geological Survey Bulletin 1661, 39p.

Baker, V.R., 1973, Paleohydrology and sedimentology of Lake Missoula flooding in eastern Washington: U.S. Geological Survey Bulletin Special Paper 144, 79p.

Bretz, J.H., 1969, The Lake Missoula Floods and the Channeled Scabland: Journal of Geology, vol. 77, p. 505-543.

Bretz, J.H., Smith, H.T.U., and Neff, G.E., 1956, Channeled Scabland of Washington, new data and interpretations: Geological Society of America Bulletin, vol. 67, p. 957-1047.

Conners, J.A., 1976, Quaternary history of northern Idaho and adjacent areas: PhD. dissertation, University of Idaho, Moscow, Idaho, 504 p.

Drost, B.W. and Seitz, H.R., 1978, Spokane valley-Rathdrum Prairie Aquifer, Washington and Idaho: U.S. Geological Survey Open File Report 77-829, 76 p.

Fetter, C.W., 1988, Applied hydrogeology, (2 ed.): Mac Millan, New York, 592 p.

Griggs, A.B., 1973, Geologic map of the Spokane quadrangle, Washington, Idaho, and Montana: U. S. Geological Survey Map I-768, 1:250,000 scale.

Griggs, A.B., 1976, The Columbia River Basalt Group in the Spokane Quadrangle,Washington, Idaho, Montana: U. S. Geologic Survey Bulletin 1413, 39 p.

Hammond, R.E., 1974. Ground water occurrance and movement in the Athol area and the northern Rathdrum Prairie, northern Idaho, Idaho Department of Water Administration, Water Information Bulletin, No. 35, 19p.

Howard, A.D., and Williams, J.D., 1972, Physiography. *in* Geologic atlas of the Rocky Mountain region, Rocky Mountain Association of Geologists, Denver, p. 29-31.

Jehn, P.et al, 1988, Rathdrum Prairie Aquifer Technical Report: Idaho Department of Health and Welfare, Division of Environmental Quality, Bureau of Water Quality, 90 p.

King, P.B., 1977, The evolution of North America (rev. ed.): Princeton University Press, New Jersey, 197 p.

Miller, F.K., and Engels, J.C., 1975, Distribution and trends of discordant ages of the plutonic rocks of northeastern Washington and northern Idaho. Geological Society of America Bulletin, v. 86, p. 517-528.

National Oceanic and Atmospheric Administration, 1989, Climatological data annual summary, Idaho: NOAA, vol. 92, no. 13, Asheville, North Carolina.

O'Connor, J.E. and Baker, V.R., 1992, Magnitudes and implications of peak discharges from glacial Lake Missoula: Geological Society of America Bulletin, vol. 104, p.267-279.

Painter, B.D., 1991a, Ground water contamination and monitoring activities on the Rathdrum Prairie aquifer, Kootenai County: Idaho Department of Health and Welfare, Division of Environmental Quality, Ground Water Quality Status Report No. 1., 32p.

Painter, B.D., 1991b, An estimate of recharge to the Rathdrum Prairie aquifer in Idaho from all sources: Idaho Department of Health and Welfare, Division of Environmental Quality, Water Quality Bureau, 6p.

Parliman, D.J., Seitz, H.R., and Jones, M.L., 1980, Ground-water in North Idaho: U. S. Geological Survey, Water-Resources Investigations Open-File Report 80-596, 34p.

Richmond, G.M., 1986, Tentative correlation of deposits of the Cordillerian Ice-Sheet in the Northern Rocky Mountains. In "Quaternary Glaciations in the United States of America. Part I of Quaternary Glaciations in the Northern Hemisphere." Pergamon, London, p.129-144.

Richmond, G.M., Fryxell, R., Neff, G.E., and Weis, P.L., 1965, The Cordilleran Ice Sheet of the northern Rocky Mountaians and related Quaternary history of the Columbia Plateau. *in* Wright, H.E., Jr. and Frey, D.G. eds., The Quaternay of the United States, Princeton, New Jersey, Princeton University Press, p.231-242.

Rhodes, B.P. and Hyndman, D. W., 1984, Kinematics of mylonites in the Priest River "metamorphic core complex", northeast Idaho and northeastern Washington: Canadian Journal of Earth Sciences, v. 21, p.1161-1170.

Rhodes, B.P. and Hyndman, D.W., 1988, Regional metamorphism, structure, and tectonics of northeastern Washington and northern Idaho, in Metamorphism and crustal evolution of the western United States, (Ernst, W. G., ed.), Rubey vol. VII, Prentice Hall, New Jersey, p.271-295.

Robinson, J. D. 1991, The stratigraphy and sedimentology of the Latah Formation, Spokane County, Washington (M. S. thesis): Eastern Washington University, Cheney, 141 p.

Rowe, G.W., Dulaney, S.J., 1991, Building and using a groundwater database: Lewis, Michigan, 218 p.

Savage, C.N., 1965, Geologic history of Pend Oreille Lake Region in north Idaho: Idaho Bureau of Mines and Geology pamplet no.134, Moscow, Idaho, 18 p.

Savage, C.N., 1967, Geology and mineral resources of Bonner County: Idaho Bureau of Mines and Geology County Report no. 6, Moscow, 131 p.

Soil Conservation Service, 1981, Soil Survey of Kootenai County area, Idaho: U.S. Department of Agriculture, 255 p.

Theis, C.V., Estimating the transmissibility of a water-table aquifer from the specific capacity of a well, *in* Bentall, Ray, compiler, Methods of determining permeability, transmissibility, and drawdown,: U.S. Geological Survey Water-Supply Paper 1563-I, p. 332-336.

U.S. Environmental Protection Agency, 1986. Quality criteria for water, Office of Water Regulations and Standards, Washington D. C..

U.S. Environmental Protection Agency, April, 1989. Wellhead protection program: tools for local governments, Office of Water, Washington D. C., 50p.

U.S. Environmental Protection Agency, Office of Water, September, 1990. Developing a state wellhead protection program / a user's guide to assist state agencies under the Safe Drinking Water Act, Washington D.C., 44p.

Waitt, R.B. Jr., 1980, About forty last-glacial Lake Missoula jokulhlaups through southern Washington: Journal of Geology v. 88, p. 653- 679.

Waitt, R.B. Jr., 1984, Periodic jokulhlaups from Pleistocene glacial Lake Missoula - New evidence from varved sediments in northern Idaho and Washington: Quaternary Research v. 22, p.46-58.

Waitt, R.B. Jr., 1985, Case for periodic colossal jokulhlaups from Pleistocene glacial Lake Missoula: Geological Society of America Bulletin v. 96., p. 1271-1286.

Waitt, R.B. Jr. , and Thorson, R.M., 1983, The Cordilleran ice sheet in Washington, Idaho, and Montana. *in* Late-Quaternary environments of the United States, Volume 1: Minneapolis, Minnesota, University of Minnisota Press, Minneapolis. p 53-70.

Washington State Department of Health, June 1993, Washington State Proposed Wellhead Protection Program, Olympia, 87p.

Yee, J.J.S., and Souza, W.R., Quality of ground water in Idaho: U.S. Geological Survey Water Supply Report, 2272.

Young, H. W., Jones, M. L. and Parliman, D. J., 1989, Selected water-quality data for the Rathdrum Prairie aquifer, north Idaho, September 1988 microform. U. S. Geologic Survey Open File Report, 88-703.

Appendix A

Wells Sounded and Sampled in Field Investigation

Explanation of symbols

S-	Prefix indicating sounding to water table; number indicates order in which sounding was performed in the field.
CCBG-	Prefix indicating background water sample taken from surface water; number indicates order in which sampling was performed in the field.
CCN-	Prefix indicating sample was taken in the northern portion of the study area; number indicates order in which sampling was performed in the field. This system was abandoned early in the study.
CCM-	Prefix indicating sample was taken in the main portion of the study area. This system was used for the entire duration of the study.
na-	Information not available.
well log number-	Well log are listed in a geographical order by township, range and section. Well logs 164-177 are newer and were gathered after the majority of the logs were tabulated.

sounding number	water sample	location	depth to water (feet)	well log number	date(s) sampled	miscellaneous information
na	CCBG1	SW1/4, SW1/4, Sec 20, 53N, 2W	0	na	7/28/93	50 ft E of Good Hope Rd., stream dim.
					7/29/93	3 ft w x 0.5 ft d x 2 ft/sec v
						Lewellen Creek, 3-6 cfs
na	CCBG2	NE1/4, NE1/4, Sec 31, 53N, 2W	0	na	7/28/93	from culvert W side of Good Hope Rd.
					7/29/93	(downstream), stream dim. 2.5 ft w x
						0.5 ft d x 4 ft/sec v, Sage Creek, 5-10 cfs
na	CCBG3	SE1/4, SE1/4, Sec 34, 53N, 3W	0	na	7/28/93	from culvert w side of Mc Coy Rd.
						Sage Creek, 1 cfs est.
na	CCBG4	NE1/4, NE1/4, Sec. 31, 53N, 2W	0	na	8/3/93	sample taken adjacent to Don Howard's
						house
S1	na	SW1/4, NE1/4, Sec. 24, 52N, 4W	230	155	7/27/93	broken casing, broke electrode
		Timbercraft				north well of two wells
						alluvial aquifer
S2	na	SW1/4, NE1/4, Sec. 24, 52N, 4W	231.5	154	7/27/93	south well, 300 ft from north well
		Timbercraft				alluvial aquifer
S3	na	NE1/4, NW1/4, Sec. 18, 52N, 3W	87	104	7/27/93	well went dry in 92', now has water
		N. Ida. Propane			7/28/93	one of two wells on property
						alluvial aquifer
S4	CCM1	NE1/4, NW1/4, Sec. 18, 52N, 3W	89	169	7/27/93	drilled in 92', 50 ft from other well
		N. Ida. Propane			7/28/93	alluvial and granite aquifer

sounding number	water sample	location	depth to water (feet)	well log number	date(s) sampled	miscellaneous information
S5	CCM2	NE1/4, NW1/4, Sec 18, 52N, 3W	80.5	170	7/28/93	new well (92'), old well went dry
		Carpet World, B. Bonham			7/29/93	alluvial aquifer
na	CCM3	SW1/4, SW1/4, Sec. 27, 53N, 3W	na	84	7/29/93	probe hung up, SWL data
		Ray Dare				unattainable, water sample taken only
		E. 6505 Bunco Road				granite aquifer
		Athol, ID, 83801				
S6	CCN1	SW1/4, SW1/4, Sec. 29, 53N,2W	19.5	9	7/28/93	well deepened (86')
		Brian Painter				alluvial aquifer
S7	CCM4	SW1/4, SW1/4, Sec. 34, 53N, 3W	212	na	8/3/93	well log unknown
		Milton Anderson				aquifer type uncertain, believed granite
S8	CCN2	NE1/4, NE1/4, Sec. 31, 53N, 2W	22	16	8/3/93	one of three wells near Sage Creek
		John Howard (G. Brandt-well log)				owned by Howard's, well on south bank
		E. 12550 Nunn Rd.				alluvial aquifer
		Athol, ID, 83801				
S9	CCN3	NE1/4, NE1/4, Sec. 31, 53N, 2W	17	18	8/3/93	well on north bank
		Don Howard				alluvial aquifer
		E. 12450 Nunn Rd.				
		Athol, ID, 83801				
S10	na	NE1/4, NE1/4, Sec. 31, 53N, 2W	15.5	22	8/3/93	well on north bank
		Phelps- well log				alluvial aquifer
		Tom Howard				

sounding number	water sample	location	depth to water (feet)	well log number	date(s) sampled	miscellaneous information
na	CCM5	NE1/4, NE1/4, Sec. 18, 52N, 3W	na	102	8/4/93	could not access well
		Brooks-Mac Donald				interbed? aquifer
		E. 1720 Chilco Rd.				
		Athol, ID, 83801				
S11	CCM6	SW1/4, NW1/4, Sec. 18, 52N, 3W	79.5	108	8/4/93	alluvial aquifer
		Wade & Diane McKay				
		P.O. Box 571				
		Hayden Lake, ID, 83835				
S12	CCM7	SW1/4, SW1/4, Sec. 7, 52N, 3W	66	na	8/4/93	history of contamination
		Red Bishop				fecal coliform, nitrate, chloride
		Chilco Rd.				Louisiana Pacific suspected
		Athol, ID, 83801				aquifer uncertain, beleived alluvial
na	CCN4	NE1/4, NE1/4, Sec. 24, 53N, 3W	na	44	8/4/93	lost probe on 300' well sounder
		George Bomar				probe and 1' section of wire fell to
						bottom of well
S13	CCM11	NE1/4, NE1/4, Sec. 23, 52N, 3W	47.5	na	8/10/93	abandoned well w/ no well log
		Mazzuca Residence				perhaps a dry well to drain field
		7904 Ohio Match Rd.				water sample not representative
		Rathdrum, ID, 83858				of water quality (not used in study)
S14	CCM9	SE1/4, SE1/4, Sec. 14, 52N, 3W	208	145	8/11/93	good sample and data
		Lelond Barnes Well				well log-Barnes, L
		7655 Ohio Match Rd.				basalt and interbed aquifer
		Rathdrum, ID, 83858				

sounding number	water sample	location	depth to water (feet)	well log number	date(s) sampled	miscellaneous information
S15	na	SW1/4, SW1/4, Sec. 13, 52N, 3W	157.5	138	8/11/93	abandoned well, well log name
		Doering well log				Doering
						granite aquifer
S16	CCM10	SW1/4, NW1/4, Sec. 8, 52N, 3W	75	167	8/11/93	alluvial aquifer
		John & Mary Veylupek				
		N. 21600 Highway 95				
		Athol, ID, 83801				
S17	CCM8	NE1/4, SE1/4, Sec. 7, 52N, 3W	75	97	8/5/93	water sample taken 8/5/93
		Larry Tipke			8/11/93	sounding taken 8/11/93
		N. 21255 Old Highway 90				alluvial aquifer
		Athol, ID, 83801				
S18	CCM11	SE1/4, SE1/4, Sec. 10, 52N, 3W	36.5	125	8/12/93	water sample taken out of unused
		Cooper well log				well, highly discolored, minimal draw
S19	CCM12	SW1/4, NW1/4, Sec. 4, 52N, 3W	57.5	88	8/17/93	shallow well, alluvial aquifer
		Bill Henderson				
		N. 23520 Corbin Hill Rd.				
		Athol, ID, 83801				
S20	CCM13	SE1/4, SE1/4, Sec. 7, 52N, 3W	71	na	8/17/93	Jim Carney well log?
		M & M Reality				uncertain of name log is under
		P.O. Box 977				alluvial, interbed aquifer?
		Hayden Lake, ID, 83835				
S21	na	SW1/4, SE1/4, Sec. 19, 52N, 3W	161	124	8/17/93	one of several deep granite aquifer wells
		Wall Residence				nearby, none are very productive

sounding number	water sample	location	depth to water (feet)	well log number	date(s) sampled	miscellaneous information
S22	CCM15	NW1/4, SE1/4, Sec. 24, 53N, 3W	165	50	8/18/93	granite aquifer
		Roger Haines				
		10700 E. Parks				
		Athol, ID, 83801				
S23	CCM16	SW1/4, SE1/4, Sec. 25, 53N, 3W	86.5	55	8/18/93	alluvial aquifer
		Russ Bohn				
		E. 10205 Nunn Rd				
		Athol, ID, 83801				
S24	na	SE1/4, SW1/4, Sec. 28, 53N, 3W	263	80	8/19/93	granite aquifer
		C. E. Henley well				
		abandoned				
S25	CCM17	SW1/4, NE1/4, Sec. 34, 53N, 3W	267	62	8/19/93	granite aquifer
		C. Hoit				
		24905 N. Cedar Mtn. Rd.				
		Athol, ID, 83801				
S26	na	NE1/4, SE1/4, Sec. 34, 53N, 3W	280	63-64?	8/19/93	granite aquifer
		M. D. Masterson-well log				
S27	CCM18	NE1/4, SE1/4, Sec. 34, 53N, 3W	119.5	61	8/19/93	alluvial aquifer
		Jan Engwer (Bouchard-well log)				
		N. 24655 McCoy Rd.				
		Athol, ID, 83801				

sounding number	water sample	location	depth to water (feet)	well log number	date(s) sampled	miscellaneous information
S28	CCM19	SW1/4, SE1/4, Sec. 24, 53N, 3W	293	54	8/19/93	granite aquifer
		Dan & Linda Thackary				
		E. 10455 Bunco Rd.				
		Athol, ID, 83801				
S29	CCM20	SE1/4, SW1/4, Sec. 19, 53N, 2W	7	na	8/20/93	granite springs
		Terry Trefz				
		E. 11805 Bunco Rd.				
		Athol, ID, 83801				
S30	CCM21	NW1/4, NW1/4, Sec. 24, 52N, 4W	105	151	8/20/93	granite aquifer
		Ray Straight				
na	CCM22	SE1/4, SE1/4, Sec. 28, 53N, 3W	na	75	9/9/93	alluvial aquifer
		Silverwood				
		N. 26225 Highway 95				
		Athol, ID, 83801				
S31	CCM23	SW1/4, NE1/4, Sec. 5, T52N, R3W	38	91	9/9/93	alluvial aquifer
		John Luster (C. Gamble-well log)				
		P.O. Box 112				
		Athol, ID, 83801				
na	CCM24	NW1/4, SW1/4, Sec. 29, 53N, 2W	na	12	9/9/93	granite aquifer
		J. & C. Ryan				
		N. 25870 Goodhope Rd.				
		Athol, ID, 83801				

Appendix B

Water Quality

Explanation of symbols

S-	Prefix indicating sounding to water table; number indicates order in which sounding was performed in the field.
CCBG-	Prefix indicating background water sample taken from surface water; number indicates order in which sampling was performed in the field.
CCN-	Prefix indicating sample was taken in the northern portion of the study area; number indicates order in which sampling was performed in the field. This system was abandoned early in the study.
CCM-	Prefix indicating sample was taken in the main portion of the study area. This system was used for the entire duration of the study.
na-	Information not available.
well log number-	Well log are listed in a geographical order by township, range and section. Well logs 164-177 are newer and were gathered after the majority of the logs were tabulated.

sounding number	water sample number	location	date sampled	depth to water (feet)	nitrate (mg/l)	chloride (mg/l)	hardness (mg/L as CaCO3)	alkalinity (mg/l as CaCO3)	specific conductance (umhos/cm)	total phosphorous (mg/l)	iron (mg/l)	fecal coliform (colonies/100 ml)
na	CCBG1	T53N,R2W, Sec 20	7/28/93	0.0	0.006	1.2	24	29	60	0.038	na	2
		50 ft upstream of culvert	7/29/93									
		Lewellen Creek										
na	CCBG2	T53N, R2W, Sec31	7/27/93	0.0	0.006	0.8	16	20	42	0.035	na	7
		west(downstream) of culvert	7/28/93									
		Sage Creek										
na	CCBG3	T53, R2W, Sec 34	7/27/93	0.0	< 0.005	0.5	20	24	48	0.041	na	34
		west(downstream) of culvert	7/28/93									
		Sage Creek										
na	CCBG4	Sage Creek near Don Howard's	8/4/93	0.0	0.006	< 0.5	22	24	46	0.015	0.050	40
S4	CCM1	NE1/4, NW1/4, Sec. 18, 52N, 3W	7/27/93	89.0	0.651	2.5	292	276	515	0.003	na	<1
		J. Green-well log	7/28/93									
		North Idaho Propane										
S5	CCM2	NE1/4, NW1/4, Sec 18, 52N, 3W	7/28/93	80.5	1.68	2.0	292	271	515	< 0.002	na	<1
		B. Bonham-well log	7/29/93									
		Carpet World										
na	CCM3	SW1/4, SW1/4, Sec 27, T53N, R3W	7/29/93	na	0.306	0.8	144	141	283	0.009	na	<1
		L. Belt-well log										
		Ray Dare										
S6	CCN1	NE1/4, SW1/4, Sec 29, T53N, R2W	7/28/93	19.5	0.784	1.8	60	57	132	0.023	na	<1
		Brian Painter										
S7	CCM4	SW1/4, SW1/4, Sec. 34, 53N, 3W	8/3/93	212.0	0.207	0.8	60	57	129	0.005	0.030	<1
		Milton Anderson										
S8	CCN2	NE1/4, NE1/4, Sec. 31, 53N, 2W	8/3/93	22.0	0.035	0.5	33	24	68	0.006	0.040	29
		Brandt, G- well log										
		J. Howard										
S9	CCN3	NE1/4, NE1/4, Sec. 31, 53N, 2W	8/3/93	17.0	0.882	0.8	28	30	72	0.011	0.040	<1
		Don Howard										

sounding number	water sample number	location	date sampled	depth to water (feet)	nitrate (mg/l)	chloride (mg/l)	hardness (mg/L as CaCO3)	alkalinity (mg/l as CaCO3)	specific conductance (umhos/cm)	total phosphorous (mg/l)	iron (mg/l)	fecal coliform (colonies/100 ml)
na	CCM5	NE1/4, NE1/4, Sec. 18, 52N, 3W	8/4/93	15.5	0.49	2.1	252	237	454	0.005	0.018	<1
		J. Carney-well log										
		Brooks-Mac Donald										
S11	CCM6	SW1/4, NW1/4, Sec. 18, 52N, 3W	8/4/93	79.5	0.884	2.8	300	294	552	0.003	0.015	<1
		Wade & Diane McKay										
S12	CCM7	SW1/4, SW1/4, Sec. 7, 52N, 3W	8/4/93	66.0	0.402	1.8	240	240	454	0.008	0.700	<1
		A. E. "Red" Bishop										
na	CCN4	NE1/4, NE1/4, Sec. 24, 53N, 3W	8/4/93	na	< 0.005	< 0.5	176	176	352	0.007	0.010	<1
		George Bomar										
S17	CCM8	NE1/4, SE1/4, Sec. 7, 52N, 3W	8/5/93	75.0	1.85	2.6	160	148	309	0.014	0.010	<1
		Larry Tipke										
S14	CCM9	SE1/4, SE1/4, Sec 14, 52N, 3W	8/11/93	208.0	0.005	0.5	80	92	183	0.035	9.800	<1
		Lelond Barnes-well log										
S16	CCM10	SW1/4, NW1/4, Sec. 8, 52N, 3W	8/11/93	75.0	0.708	1.3	144	142	304	0.007	0.708	<1
		John & Mary Veylupek										
S18	CCM11	SE1/4, SE1/4, Sec. 10, 52N, 3W	8/12/93	36.5	0.005	4.0	76	82	168	0.214	33.000	<1
		Cooper-well log										
S19	CCM12	SW1/4, NW1/4, Sec 4, 52N, 3W	8/17/93	57.5	0.483	0.7	116	116	240	0.012	0.010	<1
		Bill Henderson										
S20	CCM13	SE1/4, SE1/4, Sec. 7, 52N, 3W	8/17/93	71.0	0.155	0.9	68	69	154	0.041	1.080	1
		M & M Realty										
S22	CCM15	NW1/4, SE1/4, Sec 24, 53N, 3W	8/18/93	165.0	0.599	1.4	124	127	278	0.015	0.010	<1
		Morrow-well log										
		R. Haines										

sounding number	water sample number	location	date sampled	depth to water (feet)	nitrate (mg/l)	chloride (mg/l)	hardness (mg/L as CaCO3)	alkalinity (mg/l as CaCO3)	specific conductance (umhos/cm)	total phosphorous (mg/l)	iron (mg/l)	fecal coliform (colonies/100 ml)
S23	CCM16	SW1/4, SE1/4, Sec. 25, 53N, 3W	8/18/93	86.5	0.435	0.7	48	50	114	0.007	0.020	<1
		Russ Bohn										
S25	CCM17	SW1/4, NE1/4, Sec. 34, 53N, 3W	8/19/93	267.0	0.005	1.0	24*	107	270	0.003	0.010	<1
		C. Hoit										
S27	CCM18	NE1/4, SE1/4, Sec 34, 53N, 3W	8/19/93	119.5	0.116	0.5	60	69	149	0.007	0.180	<1
		Bouchard-well log										
		J. Engwer										
S28	CCM19	SW1/4, SE1/4, Sec. 24, 53N, 3W	8/19/93	293.0	1.55	0.9	172	172	376	0.007	0.050	<1
		Dan & Linda Thackary										
S29	CCM20	SE1/4, SW1/4, Sec. 19, 53N, 2W	8/20/93	7.0	0.041	1.7	180	185	388	0.002	0.140	<1
		Terry Trefz										
S30	CCM21	NW1/4, NW1/4, Sec. 24, 52N, 4W	8/20/93	105.0	0.795	0.7	204	205	430	0.009	0.070	<1
		Ray Straight										
na	CCM22	SE1/4, SE1/4, Sec. 28, 53N, 3W	9/9/93	na	0.357	0.5	126	129	238	0.008	0.038	<1
		Silverwood										
na	CCM23	SW1/4, NE1/4, Sec. 5, 52N, 3W	9/9/93	38.0	0.558	1.0	32	36	81	0.028	1.420	<1
		C. Gamble-well log										
		John Luster										
na	CCM24	NW1/4, SW1/4, Sec. 29, 53N, 2W	9/9/93	na	1.34	0.5	32	36	86	0.010	0.110	<1
		W. Starr										
		J. & C. Ryan										
				range	<0.005-1.85	<0.5-4.0	16-300	20-294	42-552	<.002-0.214	0.01-33	<1-40
				mean	0.495	1.2	118	118	242	0.020	1.982	na

Appendix C

Well Log Summary

Explanation of symbols

well log number-	Well log are listed in a geographical order by township, range and section. Well logs 164-177 are newer and were gathered after the majority of the logs were tabulated.
location-	Location is listed by township, range, and 1/4, 1/4 section or whichever system the well driller used.
landowner-	Name listed on well log.
total depth-	Depth of well hole drilled.
casing depth, screen depth-	Casing depth is listed first, there may be several casing ranges, the last numbers (if present) are the range which the well is screened.
depth to water-	The distance from the ground surface to the water table.
aquifer-	Aquifer types are listed by type; multiple aquifers are indicated by a backslash, such as sand/granite.
well yield-	Well yield if present listed in gallons per minute (gpm).

Abbreviations

lev.-	level
dd-	drawdown
hr-	hour
incr.-	increase
gpm-	gallons per minute
est-	estimated
na-	information not available

well log number	township/ range/ section	1/4, 1/4, section	landowner	total depth ft	casing depth screen depth ft	depth to water	aquifer(s)	well yield gpm	date drilled and miscellaneous information
1	53N/2W/20	E1/2, W1/2,SE1/4	Abbs, W.	175	1-137 125-130	95	sand, gravel/ granite	7.5	6/21/77-6/30/77 no pump lev. or hrs pumped data
2		W1/2,W1/2,SE1/4	Antonelli, S. E.	300	1-95 1-90	80	granite	3	6/24/77-6/28/77 no pump lev. or hrs pumped data
3		SE1/4, SW1/4	Couture, D.	165	1-117 106-116	dry	granite	seep	6/8/78-6/9/78 no pump lev. or hrs pumped data
na		NW1/4, SW1/4	Gardiner, W. I.	300	1-118	70	granite	6	9/25/81-9/28/81 pump lev. 0 ft/ 1hr pumped
na		NW1/4, SW1/4	Gardiner, W. I.	325	118-134	75	granite	6	10/1/82-10/1/82 same as above, well deepened
5		SW1/4, SW1/4	Lengyel, E.	140	1-140 100-140	75	granite	7-8	5/21/90-5/23/90 air test est.
6		SW1/4, SW1/4	Ridnour, R.	200	1-165	125	sand, gravel, clay/ granite	6-7	5/9/80-5/15/80 no pump lev. or hrs pumped data
7		SE1/4, NW1/4	White, R.	200	1-20	160	granite	4	6/3/82-6/5/82 air test est., no other data
8	53N/2W/21	SW1/4, SW1/4	Strong, J. R.	52	1-52	15	granite	7	6/18/75-6/18/82 no pump lev. or hrs pumped data
9	53N/2W/29	SW1/4, SW1/4	Painter, B.	250	na	19	granite	3-6	6/26/86-6/27/86 well deepened, gpm incr. from 3 to 6
9		SE1/4, SW1/4	Painter, B	75	2-61 56-61	10	granite	3	12/31/80-12/31/80 var pump lev./1 hr pumped
10		SE1/4, SW1/4	Hertig, W. K.	65	2-60	20	sand	20	3/15/88-3/17/88 pump lev 65 ft/24 hr pumped
11		SW1/4, SW1/4	Starr, L.	202	1-79 72-75 49-52	50	granite	75	11/29/77-11/30/77 no pump lev. or hrs pumped data

well log number	township/ range/ section	1/4, 1/4, section	landowner	total depth ft	casing depth screen depth ft	depth to water	aquifer(s)	well yield gpm	date drilled and miscellaneous information
12	53N/2W/29	SW1/4, SW1/4	Starr, W.	75	2-42	15	granite	12	9/24/81-9/24/81
					37-42				pump lev. 0 ft/ 1 hr pumped, air
13	53N/2W/30	SW1/4, SW1/4	Davies, G. & M.	350	1-167	155	granite	na	10/3/80-10/13/80
									no discharge data
14		NE1/4, NE1/4	Pratt, M.	300	1-46	47	granite	1	7/9/77-7/10/77
									no pump lev. or hrs pumped data
15		SW1/4, SW1/4	Thornton, B.	350	2-178	224?	granite	20	7/9/79-7/11/79
									pump lev. 0 ft/ 1 hr pumped, air
16	53N/2W/31	NE1/4, NE1/4	Brandt, G.	48	1-43	18	sand and gravel	18	5/8/84-5/10/84
					43-48				pump lev. 48 ft./4 hrs pumped
17		N1/2,NE1/4,NE1/4,	Hawkey, R.L. or C.E.	100	1-79	25	granite	30	10/5/79-10/5/79
		SE1/4,			71-79				pump lev. 0 ft/ 1 hr pumped, air
18		SE1/4, NE1/4	Howard, D.	55	1-48	18	clay, sand, gravel	30	6/12/83-6/15/83
					48-53				pump lev. 53 ft/2.5 hr pumped
									bailer test
19	48N/5 W/17	SE1/4, NE1/4	Kelso, S.	35	2-35	10	gravel, sand	10	11/5/88-11/7/88
					29-35				pump lev. 35 ft/4 hrs pumped
20	53N/2W/31	SE1/4, NE1/4	Krackenburg, J. & L.	150	2-150	8	granite	18	2/25/85-2/25/85
					90-130				pump lev. var. ft/1/2 hr pumped
21		SE1/4, NE1/4	Near, R.B. & P.	75	25-75	10	granite	35	7/9/79-7/10/79
					29-34				pump lev. 0 ft/ 1 hr pumped, air
					35-55				
22		NE1/4, SW1/4	Phelps, B.	50	1-50	20	clay, gravel/gravel	30	10/2/78-10/7/78
									no pump lev. or hrs pumped data
									bailer
23		NE1/4, NW1/4	Randolph, A.J.	605	1-605	96	granite	4-5	6/2/91-7/1/91
					545-605				est. by air test
24		NW1/4, NE1/4	Shadwhick, L	225	2-225	80	sand, gravel, clay/	10+	9/26/90-9/28/90
					185-225		granite		est by air test

well log number	township/ range/ section	1/4, 1/4, section	landowner	total depth ft	casing depth screen depth ft	depth to water	aquifer(s)	well yield gpm	date drilled and miscellaneous information
25	53N2W/31	Sec 31/govt lot	Williams, D.L. & A.L.	350	2-30	20	granite	5	5/20/85-5/31/85
		west 412.5 ft of g.l.			26-30				est by air test, poor location
		1,2,3,4							data
26		SE1/4, SE1/4	Miller, C.V & B/Jolvin	300	2-50	15	granite	5	7/28/83-7/29/83
									pump lev. var./.5 hrs pumped
27		NE1/4, NE1/4	Tibbitts, A.	105	2-98	20	coarse sand	20	10/20/86-10/21/86
									pump lev. var./1 hrs pumped
28		SW1/4, NW1/4	Williams, D	300	1-19	200?	granite	0.3	7/26/88-7/27/88
									no pump lev. or hrs pumped data
29	53N2W/32	NE1/4, NW1/4	Anderson, A.H. & J.G.	400	2-58	30	granite	15	9/4/86-9/5/88
									pump lev. var./1/2 hrs pumped
30	53N3W/13	SE1/4, SE1/4	White, R.W. & F.C	650	0-331	375	granite	5	2/29/80-3/24/80
									dry well
na		SE1/4, SE1/4	White, R.W. & F.C	325	1-304	dry	dry	na	2/18/80-2/28/80
									no pump lev. or hrs pumped data
na	53N3W/15	SE1/4, SE1/4	Guiler, J.	200	na	dry	na	na	7/20/81-8/13/82
									dry well
31		SW1/4, NE1/4	Henry, V.	405	0-405	350	sand, gravel, cobbles	20	1/24/91-2/12/91
									pump lev. 405 ft/4.5 hrs pumped
32	53N3W/16	NW1/4, NE1/4	City of Athol	440	2-412	341	gravel	300	8/13/87-10/19/87
					410-430			400	4 pump tests, 4 discharges, pump
								500	lev. unchanged in all 4 at 341.5 ft
								700	1 hr pumped(1st 3), 3 hrs 700 gpm
33	53N3W/20	NW1/4, NW1/4	Shamrock Land Co.	490	0-481	450	gravel w boulders	20	5/2/83-6/7/83
							gravel		pump lev 0 ft/3 hrs pumped
34	53N3W/21	SW1/4, NE1/4?	Bruse, W. & P.	501	na	210	granite	3	6/18/89-6/20/89
									well deepened, no pump lev. data
									air test, poor location data
35		SW1/4, NE1/4	Bruse, W. & P.	198	0-194	156	granite?	25	5/6/71-6/17/71
					156-194				unsure of granite aquifer, dd 0 ft
									3 hrs pumped

well log number	township/ range/ section	1/4, 1/4, section	landowner	total depth ft	casing depth screen depth ft	depth to water	aquifer(s)	well yield gpm	date drilled and miscellaneous information
36	53N/3W/21	SE1/4, SE1/4	Hendley, A.D.?	645	1-20	dry	na	na	11/14/75-11/22/75
									dry well, name not clear
37		NE1/4, SW1/4	Kegley, R.L.	505	1-141	250	granite	2.5	8/19/89-9/13/89
					120-138				no pump lev. data/4 hrs pumped
									air test
38		NE1/4, SE1/4	Walker, R.	210	1-49	45	granite?	2.5	8/1/77-8/2/77
					29-49				no dd or hrs pumped data
									unsure of aquifer type
39	53N/3W/22	NW1/4, SW1/4	Turner, B.H.	525	1-55	105	granite	1.5-2	4/18/72-4/21/72
									no dd or hrs pumped data
40		NE1/4, SW1/4	Turner, B.H.	523	1-152	dry	na	na	4/26/72-5/2/72
									dry well
41		NW1/4, SE1/4	Turner, B.H.	523	1-192	dry	na	na	5/3/72-5/6/72
									dry well
42		NW1/4, SE1/4	Wakefield, D.	410	1-128	285	granite	22	8/17/66-9/16/66
									8 ft dd/2 hrs pumped
43	53N/3W/23	NE1/4, NE1/4	Petit, R.	1280	1-182	175	granite	10	4/22/87-6/2/87
									pump lev 1280 ft/1 hr pumped
44	53N/3W/24	NE1/4, NE1/4	Bomar, G.	450	2-189	200?	granite	40	11/1/88-11/22/88
									pump lev.450 ft/4 hrs pumped
45		NW1/4, NE1/4	Bourgois, P.	500	1-254	250	granite	1-2	10/2/75-10/6/75
									dd 0 ft/2 hrs pumped
46		SE1/4, NW1/4	Garage, C. & L.	700	1-250	375	granite	5	1/21/85-1/27/85
									pump lev. 695 ft/1 hr pumped
47		?1/4 S?1/4	Echhart, L	294	1-294	282	clay, sand, gravel	5	5/24/78-6/30/85
					290-294				no pump lev. or hrs pumped data
									poor copy
									no SWL data
48		NW1/4, NE1/4	Jones, P.A. & Wilson	687	na	?	granite	0.5	8/7/81-8/14/81
			C.B.						well deepened, casing broke

well log number	township/ range/ section	1/4, 1/4, section	landowner	total depth ft	casing depth screen depth ft	depth to water	aquifer(s)	well yield gpm	date drilled and miscellaneous information
49	53N/3W/24	NW1/4, SW1/4	Marston, D.S.	700	1-187	243	granite	2	4/13/82-4/21/82
									pump lev. 0 ft/1 hr pumped
50		SE1/4, SW1/4	Morrow, D.	460	1-152	150	granite	6	8/7/90-8/31/90
									pump lev 400 ft/4 hrs pumped
51		SW1/4, NW1/4	Mortensen, T.	800	1-800	315	granite/quartzite?	10	2/8/91-2/14/91
					660-800				no pump lev. or hrs pumped data
									belt rocks penetrated?, air test
52		SE1/4, SW1/4	Morton, P.	477	1-290	290	granite	10	7/2/74-7/11/74
					268-270				no pump lev. data/ air blown 1 hr
					288-290				
53		SE1/4, SW1/4	Schlepp, W.	375	1-253	290	granite	5	5/5/81-6/17/81
					240-250				pump lev. 350 ft/ 2 hrs pumped
									air test
54		SW1/4, SE1/4	Thackray, D	306	1-301	280	granite	na	11/12/84-4/2/85 no test
					290-300				
55	53N/3W/25	SE1/4, SW1/4	Bohn, R.	100	1-100	86	coarse gravel, clay	10+	10/23/83-10/25/83
									air test, no other data
56	53N/3W/36	NE1/4, NW1/4	Fisher, W. R. & C.C.	175	1-37	65	granite	10	5/30/80-5/30/80
									pump lev. 0 ft/1/2 hr pumped
57	53N/3W/35	SW1/4, NW1/4	Sizemoore, M.	454	1-299	250	granite	3-4	7/13/77-7/20/77
					294-299				air test
58		NW1/4, NE1/4	Doyle, J. O.	175	0-169	155	granite	50	8/17/69-9/10/69
					159-169				dd 0 ft/2.5 hrs pumped
59		NW1/4, SE1/4	Bolt, F. & D.	651	1-276	490	granite	5-6	3/4/85-4/17/85
					274-275				air test, no other data
60	53N/3W/34	SE1/4, NE1/4	Norlander, Q.	125	1-125	22	granite	15	9/24/90-9/24/90
					69-125				pump lev. 120 ft/2 hrs pumped
61		NE1/4, SE1/4	Bouchard, R.A. & J.L.	153	1-149	120	gravel	20	7/29/80-7/30/80
									pump lev 0 ft/1 hr pumped

well log number	township/ range/ section	1/4, 1/4, section	landowner	total depth ft	casing depth screen depth ft	depth to water	aquifer(s)	well yield gpm	date drilled and miscellaneous information
62	53N/3W/34	SW1/4, NE1/4	Hait, C.D. & G.N.	550	2-241	250	granite	9	10/1/85-10/7/85 pump lev. var./1/2 hr pumped
63		S1/2,NE1/4,NE1/4	Masterson, M. D.	200	1-200	dry	na	na	3/2/81-3/6/81 dry well
?		E1/2,S1/2,NE1/4 NE1/4 Sec 34 ?	Masterson, M. D.	530	2-205	235	granite	40	3/9/81-3/11/81 pump lev. 0 ft/1/2 hr pumped
64		NE1/4, NW1/4	Phippen, C.	300	1-94	250	sandstone (Latah?)	0.1 seep	7/24/74-8/10/74 max dd/ 1 hr pumped
65		SE1/4, NE1/4	Norlander, O.	290	1-280	240	granite ?	15	11/81-11/81 no pump lev., hrs pumped data no water indication data
66		NW1/4, NE1/4	Theiness, S.	525	1-290	275	granite	20	2/72-3/29/72 dd ?/2 hrs pumped, poor date
67		SE1/4, NW1/4	Mc Kelvy, K.	508	na	123	granite	1-2	no date well deepened, poor report
68		NE1/4, SE1/4	Craun, S.	130	1-130	100	gravel, sand	20	5/30/90-6/5/90 bailer test, no other data
69		SE1/4, NE1/4	Berry, W. & N.	600	2-600 320-340 360-600	250	granite	3.5	10/27/86-11/3/86 var. pump lev./1 hr pumped
70	53N/3W/33	SW1/4, SW1/4	Rickel, R.	205	2-131	135	shale (Latah?)	5	6/7/90-6/21/90 bailer test, no other data shale could be Latah
71	53N/3W/31	E1/2, SW1/4	Young, R. & H.	440	1-440 409-414 435-439	358	clay, granite	3	8/14/80-9/19/80 pump lev. 360 ft/ 6 hrs pumping good data
72	53N/3W/30	NE1/4, NW1/4	Pac. Gas Transmission	446	0-446	425	gravel	20	9/7/68-12/11/68 pump lev. 425 ft/17 hrs pumped
73		SW1/4, SE1/4	Mortensen, J.	434	2-433 403-433	370	gravel	50	9/10/90-9/26/90 pump lev. 370 ft/4 hrs pumped

well log number	township/ range/ section	1/4, 1/4, section	landowner	total depth ft	casing depth screen depth ft	depth to water	aquifer(s)	well yield gpm	date drilled and miscellaneous information
74	53N/3W/30	SE1/4, SE1/4	Mortensen, J.	320	1-300	na	na	na	6/27/90-7/12/90
									broken drive shoe
75	53N/3W/28	SW1/4, SE1/4	Silverwood	365	2-361	328	gravel/ granite	100	7/18/90-?
					328-350				incompl. date data, air test
									no pump lev data, 4 hrs pumped
76		NW1/4, NE1/4	Silverwood	910	1-910	240	granite	30	3/7/88-3/19/88
					450-575				pump lev. 910 ft/6 hrs pumped
					700-775				
					800-900				
na		Sec 28	Silverwood Hendley	400	1-400?	320	sandstone (Latah?)	100	3/11/88-3/26/88
			Airport		320-355				pump lev. 340 ft/20 hrs pumped
									poor location data
77		NE1/4, NE1/4	Norton Aero, Ltd	575	2-43	75	granite	2	5/28/86-5/30/86
									pump lev. var./1 hr pumped
78		NE1/4, NE1/4	Norton Aero, Ltd	575	2-575	100	granite	15	6/2/86-6/5/86
					265-285				pump lev. var/1hr pumped
					385-405				
					465-475				
					535-555				
79		NW1/4, NW1/4	Kegley, R. L.	575	na	250	granite	3-5	5/7/90-5/8/90
									well deepeened, pump lev. 575 ft
									1 hr pumped
80		SE1/4, SW1/4	Henley, C. E.	550	2-435	265	granite	2	12/2/75-3/9/76
									dd to 285 ft/ 5 hrs pumped
81		NW1/4, SE1/4	Henley's Aerodome	578	2-302	350	granite	5	9/22/75-11/7/75
									dd to 578 ft/ 2 hrs pumped
82		NE1/4, SE1/4	Henley, C. E.	153	1-144	dry	dry	1-2	11/6/73-11/26/73
									no dd or hrs pumped data
na	53N/3W/28	NE1/4, SE1/4	Henley, C. E.	400	2-205	310	granite	6	9/10/72-7/4/72
									100 ft dd?/4 hrs pumped
83	53N/3W/27	SW1/4, SE1/4	Mortensen, V. J.	815	2-815	250	granite	7	2/25/91-3/26/91
					715-815				pump lev. 813 ft 2 1/2 hrs
									pumped
84		SW1/4, SW1/4	Bell, L.F.	335	0-335	315	gravel, silt	4-8	11/15/73-1/15/74
									pump lev. 335 ft/ 2 hrs pumped

well log number	township/ range/ section	1/4, 1/4, section	landowner	total depth ft	casing depth screen depth ft	depth to water	aquifer(s)	well yield gpm	date drilled and miscellaneous information
85	52N/3W/3	NW1/4, NW1/4	Boyer, E.	300	1-165	160	broken basalt (2 layers)	80	8/13/75-8/15/75
									no dd or hr pumped data
86	52N/3W/4	SW1/4, SE1/4	Essary, R. & K.	245	1-39	50	fract. shale? (4 layers)	3	10/23/89-10/24/89
									no dd or hr pumped data
87		SW1/4, SE1/4	Gore, B.	400	1-19	25	fract. shale (2 layers)	3-4	5/31/89-6/2/89
									400 ft pump lev./1.5 hrs
88		NE1/4, SE1/4	Henderson, B.	81	1-80	58	fine sand, gravel/ coarse	30	6/2/72-6/8/72
					66-76		sand, gravel		10 ft dd/4.5 hrs pumped
89		SW1/4, SE1/4	Rogers, C. & S.	300	1-54	38	shale (2 layers)	2	11/10/87-11/13/87
									no dd or hr pumped data
90		NE1/4, SW1/4	Whitaker, T.	650	1-640	454	shale	0.2	10/26/90-11/1/90
					510-650				pump lev. 625 ft/4 hrs pumped
91	52N/3W/5	SE1/4, SE1/4	Gamble, C.	60	1-60	30	gravel	40	9/19/85-9/19/85
									no dd or hr pumped data
92		SE1/4, SE1/4	Turner, L. (Roger)	60	1-60	35	gravel and sand	20	9/19/85-9/19/85
									no dd or hr pumped data
93		SE1/4, SE1/4	Way, G. or V.	400	2-42	15	shale	1.5	7/31/86-8/4/86
									pump lev. variable/1/2 hr pumped
94	52N/3W/7	NW1/4, SE1/4	Dolan, B. & Shepard, I.	117	1-117	69	sand, gravel, clay/ sand,	30	6/14/75-6/14/75
					95-115		gravel		pump lev. 0 ft/2 hrs pumped
95		SE1/4, SE1/4	Guerro, F.	78	1-78	70	gravel (large)	12	7/22/74-8/8/74
									dd 0 ft./2 hrs pumped
96		SW1/4, SE1/4	Hedlund Lumber Co.	270	1-270	212	sand, gravel, clay (3 layers)	1200	2/12/69-3/15/69
					105-129				no dd or hr pumped data
97		NE1/4, SE1/4	Tipke, L.	120	1-120	80	gravel, cobbles	20	1/27/78-1/28/78
					110-120				no dd or hr pumped data

well log number	township/ range/ section	1/4, 1/4, section	landowner	total depth ft	casing depth screen depth ft	depth to water	aquifer(s)	well yield gpm	date drilled and miscellaneous information
98	52N3W/7	SE1/4, SW1/4	Louisiana Pacific	107	2-105	76	sand, gravel	90-100	no date 95 ft pump lev/4 hrs pumped
na		Sec 7 & 8	Hankey, J	110	1-109	90	gravel	20	2/2/76-2/11/76 no dd or hr pumped data
99	52N3W/8	SW1/4, SW1/4	Ford, C.	136	2-136 120-127 130-134	15	gravel	100	3/29/78-3/29/78? 0 ft pump lev./4 hrs
100		NW1/4, SW1/4	Fuhrman, H. T.	125	1-110 115-120	40	sand	15	12/13/76-12/15/76 0 ft pump lev./1 hrs
101	52N3W/18	NE1/4, NW1/4	Bonham, B	95	1-95 80-91	80	sand, gravel, clay	6	5/17/91-5/18/91 93 ft pump lev./2 hrs pumped
102		NW1/4, NW1/4	Carney, J. L.	175	1-141	75	gravel, sand, clay	3	5/16/83-5/17/83 dd 0 ft?/1 hr pumped
103		NW1/4, NE1/4	Edwards, H. O	107	1-107 90-104	77	sand, gravel	120	5/25/70-6/25/70 pump lev. 0/4.5 hrs pumped
104		NE1/4, NW1/4	Green, J N. Idaho Propane	115	1-116	90	sand, gravel, and clay	20+	5/1/90-5/1/90 pump lev. 115 ft/1 hr pumped
105		SW1/4, NW1/4	*unreadable	102	1-102 91-100	89	sand, gravel	28	11/29/72-12/26/72 dd 0 ft/2 hrs pumped, poor copy
106		SW1/4, NW1/4	Johnson, A	505	189-191	dry	na	na	9/19/72-9/23/72 dry well
107		SE1/4, SW1/4	McCallum, M. A.	260	2-247	173	basalt /gravel?	40	9/14/87-9/17/87 no pump lev./hrs pumped data good data
108		E1/2?, NW1/4	McKay, W.	127	1-127	36	gravel, sand, some clay	35	1/22/90-1/26/90 no pump lev./hrs pumped data formation sandier w depth
109		NE1/4, SW1/4	Pope, S.	374	2-368	94	gravel/fine sand/ coarse sand, gravel	14	6/13/74-8/13/74 dd 256 ft/2 hrs pumped

well log number	township/ range/ section	1/4, 1/4, section	landowner	total depth ft	casing depth screen depth ft	depth to water	aquifer(s)	well yield gpm	date drilled and miscellaneous information
110	52N/3W/18	SW1/4, NE1/4	Reed, J.	136	1-136	101	gravel, clay/gravel, sand	10	4/28/75-7/18/75
							sand, some clay		dd 7 ft/2 hrs pumped
112		NW1/4, SE1/4	Souther, S. A.	235	1-220	160	broken basalt	15	7/1/76-7/7/76
									dd ?/1 hr pumped
113		SW1/4, SE1/4	Souther, S. A.	200	1-74	dry	na	na	6/21/77-6/23/77
									dry well in alluvium
114	52N/3W/19	SE1/4, SW1/4	Saunders, W. M. Jr.	375?	?	dry	na	na	11/21/81-11/24/81
									dry well, poor copy
115		SE1/4, SW1/4	Saunders, W. M. Jr.	200	2-188	155	broken basalt	10	7/3/81-7/7/81
									no pump lev. data/1 hr pumped
116		SE1/4, SW1/4	Saunders, W. M. Jr.	260	2-232	180	broken basalt	8	7/1/82-7/8/82
									no pump lev. data/1.5 hr pumped
117		SE1/4, SW1/4	Saunders, W. M. Jr.	400	186-194	dry?	na	na	6/25/82-6/28/82
									well deepened, dry well ?
118		SE1/4, SE1/4	Wall, M.	1000	1-510	550	granite	1-2	1/4/85-1/12/85
									pump lev 995 ft/3 hrs pumped
119		NE1/4, NE1/4	Linde, W. E. or K.	300	1-294	185	sand, gravel (w in basalt)	10	8/2/77-8/16/77
					286-294				dd 0 ft/1 hr pumped
120		NE1/4, NE1/4	Linde, W. E. or K.	335	1-310	174	gravel	5	10/6/72-11/13/72
					245-260				dd 0 ft/4 hr pumped
					265-275				
					290-305				
121		NE1/4, NE1/4	Leake, J.	125	1-97	97	gravel	10	10/31/77-10/31/77
					100-120				no dd/ hrs pumped data
									good data
122		NW1/4, NW1/4	Geddes, J.	265	1-20	?	basalt	0	12/19/78-12/22/78
									water indicated, no discharge data
123		SE1/4, SW1/4	Geddes, J.	165	1-30	70	basalt/shale	5-6	10/26/77-10/27/77
									discharge est. from blowing

well log number	township/ range/ section	1/4, 1/4, section	landowner	total depth ft	casing depth screen depth ft	depth to water	aquifer(s)	well yield gpm	date drilled and miscellaneous information
124	52N/3W/19	SW1/4, SE1/4	Geddes, J.	210	1-20	102	basalt	20	2/5/77-2/7/77
									discharge est. from blowing ?
125		SE1/4, SE1/4	Cooper, B.	380	1-50	94	basalt	1	6/12/73-6/14/73
									discharge est. from blowing
126		NE1/4, SE1/4	Butler, S	369	1-369	225	clay/sand, gravel	12	10/8/83-10/12/83
					349-364				discharge est. from blowing/3 hrs
									pumped
127	52N/3W/30	NE1/4, NW1/4	Averson, A.	305	1-48	dry	some water from basalt,	0	6/11/79-6/15/79
									dry well, only data in Sec 30
128	52N/4W/1	SW1/4, SE1/4	Backman, S.E. or L.	360	10-28	260	gravel	30	4/10/84-1/15/84
									dd varible/1.5 hrs
									good data/poor copy
129	52N/4W/2	NE1/4, SW1/4	Umphrey, W	363	1-82	325	sand and gravel	10	1/15/86-1/28/86
					340-360				pump lev. 360/3hrs
									good data
130	52N/4W/3	NE1/4, SE1/4	Rower, D.	300	1-90	150	decomp. granite		5/11/80-5/14/80
					1-114				
131	52N/4W/10	NW1/4, SE1/4	Grier, R.L.&L	635	2-222	260	granite	30	11/9/84-11/13/84
									pump lev. variable/1/2 hr
na		NW1/4, SE1/4	Grier, R.L.&L	211	2-211	dry	na	na	5/7/84-5/9/84
									cement, gravel same as above
132		N1/2, NE1/4	Loftin, H.	562	1-130	?	granite	1.5	8/30/76-9/2/76
									water encountered at 540-560 ft
133		NW1/4, SE1/4	?	305	0-280	dry	na	na	11/6/68-12/1/68
									poor copy
134	52N/4W/11	NW1/4, NW1/4	Clark, C.	400	na	dry	na	na	10/22/76-10/22/76
135		SW1/4, NW1/4	Kulich, S &	350	1-350	310	sand, gravel, clay	80	4/1/84-4/6/84
			Jerome, W		340-350				pump lev. 347/2.5 hrs

well log number	township/ range/ section	1/4, 1/4, section	landowner	total depth ft	casing depth screen depth ft	depth to water	aquifer(s)	well yield gpm	date drilled and miscellaneous information
136	52N/4W/11	NW1/4, NW1/4	Thomas, D.C.	318	0-245	dry	na	na	8/29/69-8/30/69 poor copy
137		NW1/4, NE1/4	USGS	285	0-278	248	sand, gravel, clay	10	7/22/70-11/1/70 no dd data, 2 hrs pumped
138	52N/4W/13	SW1/4, SW1/4	Doeking, J.	400	2-350	110	clay, granite	0.2	5/15/74-6/20/74 dd max?, 2 hrs pumped
139		SE1/4, SE1/4	Gish, R.	225	1-220	180	broken basalt, gravel	100	4/12/79-4/26/79 no dd or pump lev data, 2 hrs pumped
140		SW1/4, SW1/4	Gish, R.	151	1-150	139	gravel	10	1/15/79?-1/16/79? 3 ft dd, 3 hrs pumped, good data
141		SW1/4, SW1/4	Grant, R.	325	1-105	?	granite	0.25	7/17/78-7/19/78 water at 290-325 ft
142		SE1/4, SE1/4	Nagel, S.	370	1-42	100	granite	4-5	10/12/79-10/14/79 no pump lev., 2 hrs pumped
143		SE1/4, SW1/4	Oldham, D.	500	0-497	207	sand w/ clay, granite	3	12/16/75-12/1/75 dd 0 ft, 3 hrs pumped
144		NW1/4, NE1/4	Thomson, B. & B.	302	1-40	75	granite	1	3/26/87-3/29/87 no dd, or hours pumped data
145	52N/4W/14	NE1/4, SW1/4	Lelond, Barnes	300	1-300 240-280	145	fine sand, (interbed)	5-10	8/4/71-8/7/71 no dd data, 4 hrs pumped
146		SW1/4, SE1/4	Hartsham, R. L. ?	325	12-317	299	clay, sand (interbed) broken basalt	6	6/6/72-8/21/72 14-0 ft dd, 4 hours pumped good data
147		NE1/4, SE1/4	Honacker, R.	422	1-410 260-265	150	gray shale, white sand interbed?	20	10/25/72-11/2/72 no dd data, 2 hrs pumped, gd data
148		NW1/4, SE1/4	Norvell, J.L. or W.	75	1-21	35	basalt	2.5	10/5/78-10/5/78 no dd data, 1 hr pumped

well log number	township/ range/ section	1/4, 1/4, section	landowner	total depth ft	casing depth screen depth ft	depth to water	aquifer(s)	well yield gpm	date drilled and miscellaneous information
149	52N/4W/23	NE1/4, NE1/4	Brooks, R.	295	1-295	269	broken basalt and clay	10	12/6/76-12/20/76 no dd data, 6 hr pumped
150		NE1/4, NE1/4	Reed, L.	375	na	200	na	15	5/1/80-5/1/80* *date of cleaning casing, no pump level data/2 hrs pumped
151		NW1/4, NW1/4	Straight, R. & E.	387	1-99 79-97	100	clay	1.5	7/21/78-7/25/78 clay seep, mica rich (Latah?) good data
152		NW1/4, NW1/4	Straight, R. & E.	125	2-84	dry	na	na	2/24/86-2/25/86 granite at hole bottom
153		NW1/4, NE1/4	Uptagrafft?, P	254	0-250 208-250	220	basalt/ves basalt/basalt	15	7/10/?-8/8/? 15 ft dd/6 hrs pumped
154	52N/4W/24	SW1/4, NE1/4	Timber Craft	335	0-268 325-330	250	boulders, sand/gravel w heavy clay/ gravel, sand, clay	100	3/1/85-3/8/85 320 ft dd/2 hrs pumped
na		SW1/4, NE1/4	Timber Craft	320	0-320	na	na	na	1/26/85-1/31/85 casing broke during deepening procedure, well abandoned
155		SW1/4, NE1/4	Timber Craft	320	0-320 250-260	240	gravel, sand/sand, gravel	20	1/20/72-3/8/72 no dd data/2 hrs pumped good data
156		SW1/4, SW1/4	Thienes, K	322	1-322	290	boulders/gravel	10	6/24/77-8/23/77 dd 0/1 hr pumped
157		SE1/4, SW1/4	Rose, H. M	302	1-302	258	sand, gravel, clay	15	3/5/81-5/15/81 300 ft dd/3.5 hrs pumped
158		SW1/4, SE1/4	Quiroz, J.	355	1-355 335-555	260	broken basalt and clay (Latah?)	5	1/4/74-1/12/74 no dd data/no pump data
159		E1/2, NE1/4	Pope, F. Jr.	335	1-329 335-339	295	basalt	8	1/18/78-1/27/78 no dd data/2 hrs pumped
160		SE1/4, NW1/4	Ohio Match Road Water District	317	1-306	251	fine sand w gravel/fine sand /clay w fine sand	210	11/3/80-1/13/81 pump lev 268/2 hrs pumped good data

well log number	township/ range/ section	1/4, 1/4, section	landowner	total depth ft	casing depth screen depth ft	depth to water	aquifer(s)	well yield gpm	date drilled and miscellaneous information
161	52N/4W/24	SE1/4, NW1/4	Idaho Post & Pole	320	1-320	220	sand and gravel	75-100	2/2/84-7/6/84*
					310-320				no pump lev. data/ no hrs pumped
									data *date well deepened
161*		W1/2, NE1/4	Idaho Post & Pole	295	1-275	260	gravel and sand?	15	7/25/80-8/5/80
									no pump lev. data/ no hrs pumped
									aquifer uncertain
162		NW1/4, NW1/4	Doughy, W.&G	97	1-97	65	gravel	25	4/15/80-4/16/80
					82-97				no pump. lev. data/1 hr pumped
163		NW1/4, NW1/4	Cooper, B.	327	1-327	230	sand and gravel	50	4/12/74-4/29/74
									no pump lev. data/ no hrs pumped
na		SW1/4, NE1/4	Timber Craft	275	1-274	240	sand, gravel, clay	15	11/7/74-11/16/74
					264-274				no pump lev. data/ no hrs pumped
									data
na		SE1/4	Palomuck?, C	500	?	270	clay or granite?	10	5/1/1969-
									poor copy, little data
164		NE1/4, SE1/4	Wheeler, J.	332	1-312	276	sand, gravel/clay, sand,	100+	3/5/86-10/29/86
							gravel/ sand, gravel		pump lev. 282'/24 hrs pumped
165	52N/3W/5	SW1/4, SW1/4	Cottongin, C.	84	0-84	40	granite	25-30	11/16/92-11/16/92
					64-84				no dd info
166	52N/3W/8	SW1/4, SE1/4	Haney, D.	147	1-80	80	sandstone, Latah?	2.5	11/24/92-11/28/92
									pumping level 175 ft, 2 hr
167		NE1/4	Veylupek, J.	140	34-699	75	clay, gravel and	25	9/17/91-9/19/91
							boulders		no hrs pumped data
168	52N/3W/18	NE1/4, SW1/4	Scrabeck, B. & E.	225	1-222	80	clay, silty sand	12	4/15/93-4/20/93
							Latah		pump lev. 200-210, 4 hr
169		NE1/4, NW1/4	N. Idaho Propane	180	1-158	120	granite	45	9/23/92-9/25/92
			Jim Green						pump lev 180 ft, 1 hr
170		NE1/4, NW1/4	Bonham, B.	240	1-138	120	gravel	7-10	9/17/92-9/18/92
									pump lev. 240 ft, 1 hr

well log number	township/ range/ section	1/4, 1/4, section	landowner	total depth ft	casing depth screen depth ft	depth to water	aquifer(s)	well yield gpm	date drilled and miscellaneous information
171	52N/4W/3	SE1/4, SE1/4	Schawel, K.	300	1-302 262-302	120	granite	16	4/1/93-4/2/93 pump lev. 300 ft, 1 hr
172	52N/4W/13	NE1/4, NW1/4	Cordon, L.	152	1-21	17	gravel and clay	39	11/15/92-5/5/93 no pump data
173	53N/2W/17	NE1/4, SW1/4	Nursall, D.	438	1-438 398-438	na	granite	1.5	6/22/92-6/25/92 pump lev. 436 ft, 1 hr
174		NW1/4,SE1/4	Fillius, R.	69	1-69 64-69	50	sand, gravel	25	2/10/92-2/11/92 pump lev. 64 ft, 1 hr
175	53N/3W/14	NW1/4,SW1/4	Martinez, J.	460	1-460 430-460	380	gravel, cobbles boulders	20	8/21/91-9/6/91 pump lev. 460 ft, 3 hrs
176	53N/3W/15	NW1/4, NW1/4	Henderson, T. S.	400	1-375	370	gravel, boulders	10-20	9/11/92-9/24/92 pump lev. 395 ft, 8 hr
177	53N/3W/29	SW1/4, SW1/4	Rickel, K.	447	1-447 417-443	381	sand, gravel, boulders	30	12/3/92-12/7/92 pump lev. 444 ft, 1 hr

Appendix D

Field Observations

Sage Creek-Lewellen Creek Area

Nunn Road

Several closely spaced wells were sounded in the NE1/4, NE1/4, Sec 31, T53N, R2W (Figure 16). None of these wells penetrate bedrock. The Brandt well (S8), Howard well (S9) and Phelps well (S10) had static water levels of 22 ft (6.7 m), 17 ft (5.2 m), and 15.5 ft (4.7 m), respectively. The minimum saturated thicknesses in each well were 26 ft (7.9 m), 38 ft (11.6 m), and 35 ft (10.7 m), respectively. The two wells on the north side of Sage Creek (the Howard well and the Phelps well) may be semi-confined by overlying clay/sand and clay/gravel assemblages. The Brandt well on the south side of Sage Creek is unconfined with no clay logged between the water table and surface. These water tables are perhaps dependent to their proximity to the influent Sage Creek, Lewellen Creek, and irrigation ditches (Figure 16).

Bunco Road

The next closest well to the west penetrating productive sands and gravels is the Bohn well (S23). This well is located next to an irrigation ditch (SW1/4, SE1/4, Sec. 25, 53N, 4W) which diverts water from Sage Creek. The age of this diversion is unclear, however, the size of the trees adjacent to the ditch suggests at least 20 years of growth which exceeds the age of the well (drilled in 1983). The static water level was 85.5 ft (26 m), total depth of well was 100 ft (30 m), therefore the minimum saturated thickness of the aquifer is 14.5 ft (4.4 m).

Parks Road

The Haines well (S22) penetrated granite at 152 ft (46 m) and had a static water level of 165 ft (50 m). This well is close to Lewellen Creek, (NW1/4, SE1/4, Sec. 24, 53N, 3W) yet the creek does not saturate the alluvium at the well. This well may not border the alluvial aquifer since the difference in depth to bedrock and static water level is significant. Also diversions of Lewellen Creek by early settlers in the past have obscured its pre-settlement course, therefore this site was probably not part of an ancient stream channel, a channel which should be accompanied by a deep fill of saturated sands and gravels.

McCoy Road

Downgradient of the Bohn well along Sage Creek is the Bouchard well (S27). The well is less than 100 ft (30 m) away from the creek (NE1/4, SE1/4, Sec. 34, 53N, 3W). The static water level was 119.5 ft (36.4 m) with a minimum saturated thickness of approximately 33 ft (10 m). An adjacent well (S26) approximately 1000 ft (300 m) to the north (NE1/4, SE1/4, Sec. 34, 53N, 3W) penetrates bedrock without producing water from sands and gravels.

Cedar Mountain Road

No wells penetrating saturated sands and gravels were identified in this area. One well was sounded, the Hoit well (S25), located just off of Cedar Mountain Road (SW1/4, NE1/4, Sec. 34, 53N, 3W). The static water level was 267 ft (81 m) in granite, overlain by 236 ft (72 m) of sands and gravel. It does not appear that the sand and gravel aquifer passes through this portion of the section but passes further to the north.

Chilco Area

West of Highway 95, Chilco Road

Two wells (NE1/4, NW1/4, Sec. 18, T52N, R3W) within the area went dry in the summer of 1992 at World of Carpets (B. Bonham well) and at North Idaho Propane (J. Green well) located 300 ft (100 m) to the northeast of the Bonham well. Each company drilled a new well in September, 1992, and both wells penetrate granite. No other wells sounded within the Chilco area penetrate bedrock. The depth to bedrock at the J. Green well (S4) is 144 ft (44 m); the Bonham well (S5) encounters bedrock at 110 ft (33. 5 m) suggesting a high amount of relief in the bedrock subsurface. Soundings indicated static water levels of 89 ft (27.1 m) and 80.5 ft (24.5 m) in the J. Green well and the Bonham well respectively. Saturated thickness between these two wells is from 55 ft (16.8 m) to 30 ft (9 m).

Closer to Chilco Ridge, the McKay well (S11) (SW1/4, NW1/4, Sec. 18, T52N, R3W) exhibited a slightly shallower water table of 79.5 ft (24.2 m). The water bearing gravel, sand and clay appears to be confined or semi-confined by 100 ft (30 m) of mostly clay, cobbles and gravel and has a saturated thickness of at least 24 ft (7.3 m).

Still closer to Chilco Ridge, the Bishop well (S12) (SW1/4, SW1/4, Sec. 7, T52N, R3W) had a static water level of 66 ft (20 m). Adjacent to the Bishop well several hundred yards (about 100 m) to the west are several perennial springs on Chilco ridge and may be contributing flow to the well. At the time of the writing of this report, no well log exists for the Bishop well. (Figure 18)

Immediately north of the Louisiana Pacific Wood Processing Plant in Chilco is the Tipke well (S17). The static water level was 75 ft (23 m) with water bearing lithologies to the bottom of the well at 120 ft (36.6 m) indicating a minimum saturated thickness of 45 ft (13.7 m) with no potentially semi-confining layers above the water table.

East of Highway 95

The Veylupek well (S16) located approximately 75 ft (23 m) from Highway 95 (SW1/4, NW1/4, Sec. 8, T52N, R3W) had a static water level of 75 ft (23 m). This well penetrates 123 ft (37.5 m) of water bearing clay, gravel and cobbles and 17 ft (5.2 m) of brown clay. The aquifer material here is perched over the clay acting as an aquitard and therefore has a saturated thickness of 48 ft (14.6 m).

The Henderson well (S19) located in the northern portion of the main channel (SW1/4, NW1/4, Sec. 4, 52N, 3W) had a shallow static water level of 57.5 ft (17.5 m) and a minimum saturated thickness of 23 ft (7 m) within fine sand and gravel and coarse sand and gravel. Such a shallow water table here is suggestive of a recharge area nearby perhaps from overland flow from the west slope of Cedar Mountain and springs. The contact between the Columbia River Basalt Group and Pre-Tertiary Rocks is on the adjacent west facing slope and a likely position for contact springs. No springs were confirmed in this area.

The John Luster well (S31) located in the narrow inlet of the main Chilco channel (SW1/4, NE1/4, Sec. 5, T52N, R3W) has a shallow static water level of 38 ft (11.6 m). This was the shallowest well sounded in the investigation, and is probably near or within a ground water divide. South of this well site the main Chilco channel flow is towards the southwest (Figure 18).

Garwood Area

West of Highway 95, Ohio Match Road

Well soundings taken near the Chilco Ridge indicate the complexity of the southwestern boundary of the Chilco channel aquifer. The Lelond Barnes well (S14) located on Ohio Match Road (SE1/4, SE1/4, Sec. 14, T52N, R4W) had a SWL of 208.5 ft (64 m). The aquifer material is at least 75 ft (23 m) of fine sand overlain by 145 ft (44 m) of blue-gray clay. The clay is overlain by 60 ft (18 m) of soft basalt(?). The proximity of this well to the Chilco Ridge, the nature of the aquifer material and the well discharge estimated at 5-10 gpm (19-38 lpm) suggests that the aquifer material is probably Latah Formation and not part of the Chilco channel aquifer. About 1000 ft (300 m) southeast of the Barnes well (NE1/4, NE1/4, Sec. 23, T52N, R4W) an undocumented abandoned well (S13)was sounded which had a SWL of 47.5 (14.5 m). The well was located in a poorly drained field southeast of Chilco Ridge and may have been installed as a dry well. The area may have been a lake bottom after the Lake Missoula floods. A pond located nearby on Chilco Ridge may be discharging in this region via subsurface springs. Nearby approximately 1000 ft (300 m) to the northeast of the abandoned well (SW1/4, SW1/4, Sec. 13, T52N, R4W) is the Doering well (S15). This well penetrates granite at 328 ft (100 m), and had a SWL of 157.5 ft (48 m). A seep of water was found at 42 ft (13 m) and again in the granite. The entire thickness of sediment overlaying the granite is clay and boulders representing the lacustrine-dropstone facies. Since the lacustrine/ dropstone facies here is unproductive, the Chilco channel aquifer boundary has been drawn further east towards the center of the channel.

About 600 ft (200 m) to the southeast of the Doering well is the Straight well (S30), which had a static water level of 105 ft (32 m) in granite indicating the aquifer lies further to the east.

No wells penetrating sands and gravels were sounded in this area. Only the Ohio Match Water District well (SE1/4, NW1/4, Sec. 24, T52N, R4W) was confirmed to still exist and produce water from alluvium. The well log static water level estimate was 251 ft (77 m). Aquifer boundaries here are based upon well logs.

The two Timbercraft well soundings (S1 and S2) suggests that the well sites may be located near where the Chilco channel aquifer flows into the Rathdrum Prairie aquifer. Both wells are over 300 ft (90 m) deep and do not penetrate bedrock. Static water levels are 230.0 ft (70.1 m) and 231.5 ft (70 .6 m) for S1 and S2 respectively. The depth to the water table from the surface is 150 ft (46 m) lower than in wells near the Chilco area. Since the