Water Resources of the Ground-Water System in the Unconsolidated Deposits of the Colville River Watershed, Stevens County, Washington

Water-Resources Investigations Report 03-4128

Prepared in cooperation with the
COLVILLE RIVER WATERSHED PLANNING TEAM FOR THE 2000-2004 WRIA 59 COLVILLE RIVER WATERSHED PLANNING PROJECT

Photograph of U.S. Geological Survey stream-gaging station on the Colville River near Kettle Falls, Washington. Photograph taken by Bob McBlair, Natural Resources Educator, Colville, Washington.

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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By Sue C. Kahle, Claire I. Longpré, Raymond R. Smith, Steve S. Sumioka, Anni M. Watkins, *and* David L. Kresch

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Tacoma, Washington
2003

U.S. DEPARTMENT OF THE INTERIOR

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U.S. GEOLOGICAL SURVEY

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CONTENTS

PLATE

[Plate is in pocket]

FIGURES

TABLES

CONVERSION FACTORS AND DATUM

CONVERSION FACTORS

Multiply	By	To obtain
acre-foot (acre-ft)	1,233	cubic meter
acre-foot per day (acre-ft/d)	0.01427	cubic meter per second
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
cubic foot per day (ft^3/d)	0.02832	cubic meter per day
cubic foot per second per mile ($(ft^3/s)/mi$)	0.01760	cubic meter per second per kilometer
cubic foot per second per square mile ($(ft^3/s)/mi^2$)	0.01093	cubic meter per second per square kilometer
cubic mile (mi^3)	4.168	cubic kilometer
inch (in.)	2.54	centimeter
inch (in.)	25.4	millimeter
inch per year (in./yr)	25.4	millimeter per year
foot (ft)	0.3048	meter
foot per day (ft/d)	0.3048	meter per day
foot per mile (ft/mi)	0.1894	meter per kilometer
mile (mi)	1.609	kilometer
gallon (gal)	3.785	liter
gallon per day (gal/d)	0.003785	cubic meter per day
gallon per minute (gal/min)	0.06309	liter per second
million gallons (Mgal)	3,785	cubic meter
million gallons per year (Mgal/yr)	3,785	cubic meter per year
square foot (ft^2)	0.0929	square meter
square mile (mi^2)	2.590	square kilometer

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C=(°F-32)/1.8$$

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=1.8 \times °C+32.$$

Transmissivity: The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness $[(ft^3/d)/ft^2]ft$. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.

DATUM

Vertical coordinate information was referenced to the National Geodetic Vertical Datum of 1929 (NGVD29), referred to in this report as "sea level."

Horizontal coordinate information was referenced to the North American Datum of 1983 (NAD83).

Altitude, as used in this report, refers to distance above or below sea level.

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ABSTRACT

A study of the water resources of the ground-water system in the unconsolidated deposits of the Colville River Watershed provided the Colville River Watershed Planning Team with an assessment of the hydrogeologic framework, preliminary determinations of how the shallow and deeper parts of the ground-water system interact with each other and the surface-water system, descriptions of water-quantity characteristics including water-use estimates and an estimated water budget for the watershed, and an assessment of further data needs. The 1,007-square-mile watershed, located in Stevens County in northeastern Washington, is closed to further surface-water appropriations throughout most of the basin during most seasons. The information provided by this study will assist local watershed planners in assessing the status of water resources within the Colville River Watershed (Water Resources Inventory Area 59).

The hydrogeologic framework consists of glacial and alluvial deposits that overlie bedrock and are more than 700 feet thick in places. A map of the surficial geology was compiled and used with drillers' logs for more than 350 wells to construct 26 hydrogeologic sections. Seven hydrogeologic units were delineated: the Upper outwash aquifer, the Till confining unit, the Older outwash aquifer, the Colville Valley confining unit, the Lower aquifer, the Lower confining unit, and Bedrock.

Synoptic stream discharge measurements made in September 2001 identified gaining and losing reaches over the unconsolidated valley deposits. During the September measurement period, the Colville River gained flow from the shallow ground-water system near its headwaters to the town of Valley and lost flow to the shallow ground-water system from Valley to Chewelah. Downstream from Chewelah, the river generally lost flow, but the amounts lost were small and within measurement error. Ground-water levels indicate that the Lower aquifer and the shallow ground-water system may act as fairly independent systems. The presence of flowing wells completed in the Lower aquifer indicates upward head gradients along much of the Colville Valley floor.

Total surface- and ground-water withdrawals during 2001 were estimated to be 9,340 million gallons. Water use for 2001, as a percentage of the total, was 75.3 percent for irrigation, 16.3 percent for public supply, 6.5 percent for private wells, and about 1 percent each for industrial and livestock use. An approximate water budget for a typical year in the Colville River Watershed shows that 27 inches of precipitation are balanced by 4.2 inches of streamflow discharge from the basin, 0.3 inch of ground-water discharge from the basin, and 22.5 inches of evapotranspiration.

INTRODUCTION

The Colville River Watershed is a 1,007-square-mile area located mostly in Stevens County, northeastern Washington (fig. 1). It is a roughly north-south-oriented basin about 45 mi long and 23 mi wide and extends from near the towns of Springdale and Loon Lake at the southern end of the basin to near the town of Kettle Falls at the northwestern extent of the basin (pl. 1). The Colville River begins as Sheep Creek at the southern end of the basin, then flows generally north to the town of Chewelah and continues north-northwest to the town of Colville. Beyond Colville, the river follows a more westerly course and empties into Franklin D. Roosevelt Lake (also known as Lake Roosevelt) 2 mi southwest of the town of Kettle Falls.

In recent years, increased use of ground- and surface-water supplies in watersheds of Washington State has created concern that insufficient instream flows remain for fish and other uses. In response, the Washington State Legislature passed the Watershed Management Act of 1998 (HB 2514), which encourages and provides funding for local watershed planning and delegates the planning to a local level. As part of this planning, stakeholders within a Water Resources Inventory Area (WRIA) need to assess the status of water resources in the WRIA and determine if there is water available for allocation within the WRIA.

Presently, in WRIA 59, the Colville River Watershed, surface water is available for further appropriation only from the mainstem of the Colville River from October 1 through July 15, and all streams tributary to the Colville have been fully appropriated under existing water rights (Chung and Slattery, 1977). In 1994, issuance of new ground-water rights was halted by the Washington Department of Ecology because of possible hydraulic continuity between the ground- and surface-water systems. Although exempt wells are still available for single- and multiple-family uses, the closures put limits on economic growth within the Colville River Watershed.

With few options for new water rights available, growth and economic health in the watershed are a concern. Therefore, the WRIA 59 Colville River Watershed Planning Team (Planning Team) is developing a long-range sustainable watershed plan to meet the needs of current and future water demands within the watershed, while also working to protect and improve its natural resources. Toward this end, the U.S. Geological Survey, in cooperation with the Planning Team, conducted a ground-water study with the primary goal of investigating the ground-water system of the unconsolidated valley-fill deposits of the Colville River Watershed. The study was conducted under the watershed-planning grant administered by the Stevens County Conservation District (SCCD) and represents Phase I of a two-part study. Phase II, a ground-water modeling study, is planned to be conducted at the completion of Phase I and will build on the hydrogeologic framework described in this report. The objective of Phase II is to create a watershed management tool to evaluate the possible regional impacts of different ground-water use alternatives prior to their implementation.

Prior to this study, a comprehensive assessment of the ground-water resources of the Colville River Watershed had not been done, and the potential for further ground-water development in the alluvial valleys of the basin was not known (Mix, 1977). An assessment of the ground-water resources could provide the Planning Team the information needed to determine if there are previously unused sources of water whose use may have minimal impact on closed streams. In addition, such an assessment would identify hydrogeologic units that could be explored in the future for possible use of aquifer storage and recovery (ASR). A preliminary assessment of how the shallow and deeper parts of the ground-water systems interact with each other also may provide the information needed to explore additional uses of ground water in selected parts of the basin. An estimated water budget could assist the Planning Team in addressing water-quantity issues set forth in the Watershed Management Act (HB 2514).

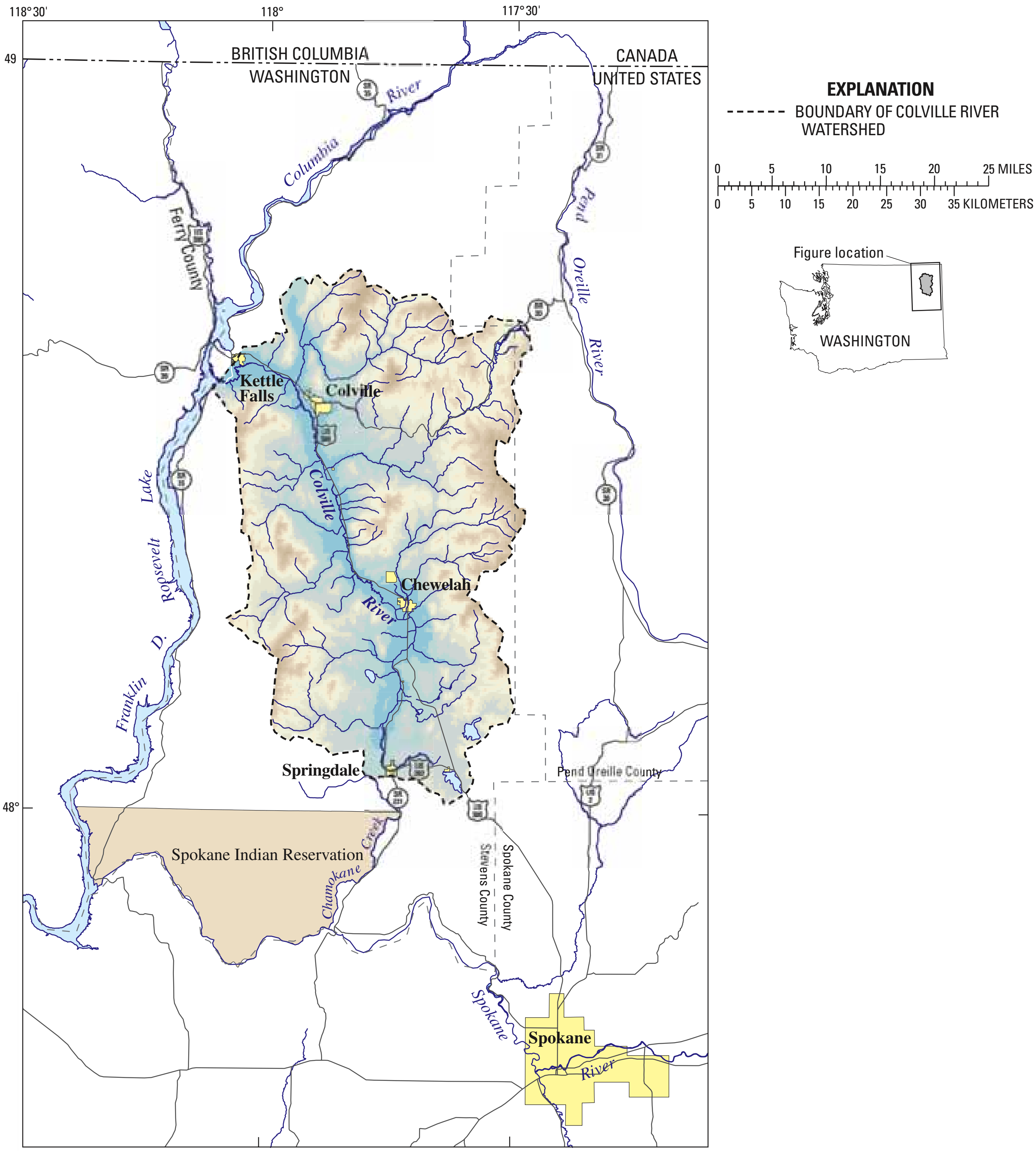


Figure 1. Location of the Colville River Watershed, Stevens County, Washington.

The objectives of this study were to:

- Define the hydrogeologic framework, including mapping the extent and thickness of aquifers and confining units in the unconsolidated deposits of the ground-water system;
- Make a preliminary determination of how the shallow and deeper parts of the ground-water system interact with each other and the surface-water system;
- Address water quantity issues, including estimating a water budget for the Colville River Watershed; and
- Evaluate the need for additional data required for the construction of a ground-water flow model.

Purpose and Scope

This report presents the results of the Phase I study of the hydrogeologic framework of the valley-fill deposits of the Colville River Watershed. It describes the extent and thickness of the significant hydrologic units; discusses interactions between aquifers and with the surface-water system; provides a water-budget estimate; and discusses additional data needs. The scope of the report includes the regional and local geologic history, the surficial geology of the Colville River Watershed, the physical characteristics of the hydrogeologic units, ground-water levels and flow directions, ground-water development and storage, characteristics of the streamflow network, summaries of surface- and ground-water withdrawals within the watershed, and estimates of ground-water recharge.

Description of Study Area

Physiographically, the Colville River Basin is composed of hilly and mountainous terrain of the Selkirk Mountains, which is bisected by the generally north-south river valley that in most places is less than 3 mi wide. Altitudes in the basin range from 1,290 ft at the mouth of the Colville River to near 7,000 ft in the upland areas. The altitude of Colville Valley, which occupies the central portion of the basin, ranges from 1,920 ft near Springdale to 1,620 ft at Kettle Falls, about 43 mi downstream. To the south, the low drainage divide between the north-flowing Colville River and south-flowing Chamokane Creek is underlain by recent alluvium, glacial outwash and till, and thick clay and silt deposited in large Ice Age lakes. These unconsolidated deposits form an anomalous drainage divide in an otherwise broad and continuous valley. A preglacial Columbia River may have flowed south through the present-day Colville River and Chamokane Creek valleys to the Spokane River (Willis, 1887).

Most of the mountainous areas in the basin are covered with pine, fir, and larch forests that are the basis for the large historical and present lumber industry in the area. Recreational use of the basin is commonplace because of its pristine setting and numerous lakes and streams. Although the Colville River and its tributaries are home to several species of fish, none of them is listed as endangered or threatened.

Geologically, the basin can be grouped into three types of formations: bedrock, glacial drift, and valley alluvium. The bedrock, consisting of sedimentary, metamorphic, and intrusive igneous rocks, forms the hills and mountains of the basin and underlies the lowland areas at generally unknown depths. Glacial deposits including silt, sand, gravel, clay, and till mantle much of the lowland areas and lower reaches of the hills and mountains. These deposits were laid down during repeated advances of the Colville Lobe of the Cordilleran ice sheet during the Pleistocene Ice Age. Sands and gravels deposited by outwash streams are significant sources of ground water in the basin. Recent valley alluvium is limited mostly to the Colville River valley, where it lies directly on the Pleistocene glacial drift.

The lowland areas of the basin support several towns, numerous farms with much grazing and hay production, and increasing light commercial and industrial development, mostly in Colville and Chewelah. A magnesium production facility in Addy operated for about 30 years until operations were discontinued in 2001 because of depressed metal prices. Colville, located in the north central part of the basin, is the County seat and has a population of about 5,000. The total estimated population for WRIA 59 is 22,430 residents, based on the 2000 Census for Stevens County (Linda Kiefer, WRIA 59 Watershed Coordinator, Stevens County Conservation District, written commun., March 2002). Population in the basin has nearly doubled since the 1970s, thereby increasing the demand on present water supplies, both for drinking water and other uses.

Well-Numbering System

In Washington, wells are assigned numbers that identify their location within a township, range, section, and 40-acre tract. Number 33N/40E-25E01 (fig. 2) indicates that the well is in Township 33 North and Range 40 East, north and east of the Willamette Base Line and Meridian, respectively. The numbers immediately following the hyphen indicate the section (25) within the township; the letter following the section gives the 40-acre tract of the section, as shown on figure 2. The two-digit sequence number (01) following the letter indicates that the well was the first one inventoried by project personnel in that 40-acre tract. A "D" following the sequence number indicates that the well has been deepened. In the illustrations of this report, wells are identified individually by only the section and 40-acre tract, such as 25E01; township and range are shown on the map borders.

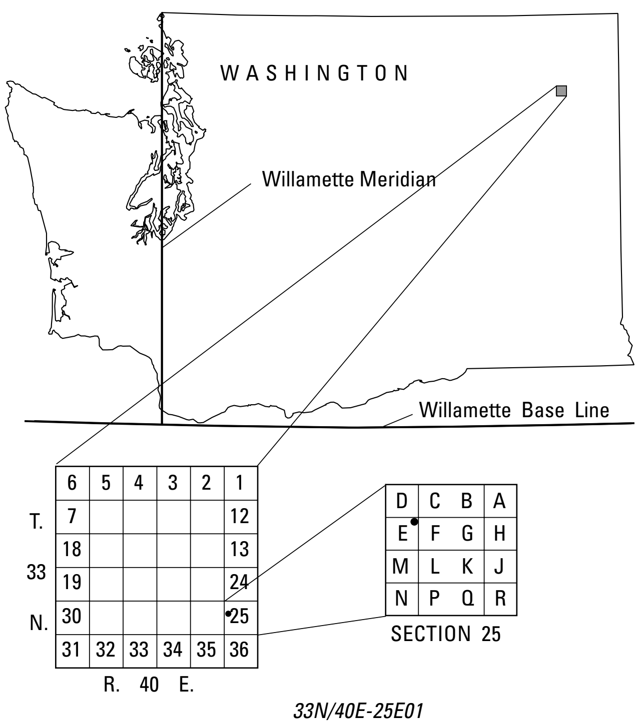


Figure 2. Well-numbering system used in Washington.

Acknowledgments

This study was completed with the assistance of many individuals and groups. We thank Linda M. Kiefer, WRIA 59 Watershed Coordinator, and the many dedicated members of the Watershed Planning Team who provided helpful information, dialogue, and insights into the watershed management issues of the Colville River Watershed. Staff members of the Stevens County Conservation District provided able assistance in collecting and reporting field data. Fogle Pump and Supply, K.C. Kane Drilling, and Sams Drilling provided additional drilling information that aided in the hydrogeologic interpretations. Many water purveyors, including the Cities of Colville, Chewelah, and Kettle Falls; Public Utility District No. 1 of Stevens County; Northwest Alloys; and numerous smaller water systems, provided historical information and access to wells for water-level measurements. The Stevens County Assessor's office responded to numerous inquiries and provided information on historical ownership of properties in order to match drillers' records to current well and property owners. We also thank the private landowners for granting permission to access their property for data collection. Without their consent, it would have been impossible to collect the majority of the data required for this study.

Numerous reviewers provided helpful comments on the draft report. The WRIA 59 Watershed Planning Team solicited comments on the draft report from its entire membership. Planning Team members who provided comments include Richard C.R. Price, Public Utility District No. 1 of Stevens County; David E. Martineau and Dennis D. Ferguson, City of Colville; Joel L. Gassaway, City of Kettle Falls; Brian R. Crossley, Spokane Tribe of Indians; Mimi L. Wainwright and others, Washington Department of Ecology; John P. Buchanan, Eastern Washington University; Linda M. Kiefer, Stevens County Conservation District; and members of the WRIA 59 Water Quantity Committee. Eugene P. Kiver and Dale F. Stradling, Eastern Washington University, retired, shared their expertise on the local geologic history by providing helpful review comments on the geology section of this report.

STUDY METHODS

Collecting the basic data required to characterize the hydrogeologic framework and analyze the direction of ground-water movement within the Colville River Watershed involved field inventory of wells, measurement of water levels in wells, and construction of hydrogeologic sections, hydrogeologic unit maps, and water-level maps. Methods used to collect and interpret the hydrogeologic data are presented in this section. Methods used to describe the ground- and surface-water interactions and the water quantity of the study area are included with those respective sections later in this report.

Well Inventory

Between August and November 2001, 362 wells were inventoried to acquire data throughout the study area (pl. 1). The physical and hydrologic data for these wells are provided in table 11 (at back of report). Criteria for site selection included availability of a driller's report and lithologic information (obtained from Washington Department of Ecology, local drillers, and owners), location and depth of the well, and the ease of access to the well. The intent was to collect data from inventoried wells evenly distributed throughout the unconsolidated deposits of the study area, including the main Colville Valley floor and side valleys. However, this was not possible in all areas, mostly because of lack of development in much of the watershed and to a much lesser extent, lack of permission to access some wells.

Information gathered at field-located wells included site location, land-surface altitude, and well-construction details. Depth to water (water level) was measured in most wells using a calibrated electric tape or graduated steel tape, both with accuracy to 0.01 ft. In some cases, water levels were not measured because a well was difficult to access. Site locations were plotted on USGS 1:24,000-scale topographic maps. Altitudes of the land surface at each site were interpolated from the topographic maps, with an accuracy of ±20 ft. Latitude and longitude locations were obtained for field-located wells using a Global Positioning System (GPS) receiver with a horizontal accuracy of one-half a second. Information collected during the inventory was entered into the USGS National Water Information System (NWIS) database.

In addition to the water levels measured during the inventory phase of this study, water levels in 121 wells were measured again during a 2-week period in May 2002. All water-level measurements are included in table 11. During the well inventory and the May 2002 synoptic water-level measurement, fieldwork was shared equally between personnel from the USGS and the Stevens County Conservation District. Coordination between the two agencies ensured that the field methods used were consistent and met standards required for USGS data collection.

Hydrogeology

Lithologic data from the field-inventoried wells were entered into the Rockworks 2002® software, a stratigraphic analysis package. Twenty-six hydrogeologic sections were constructed using Rockworks, in order to identify and correlate hydrogeologic units based primarily on grain size and stratigraphic position. Eight representative sections of the original 26 are published in this report. Thickness and extent-of-unit maps were constructed for two units using information from the hydrogeologic sections and data from additional wells. Water-level maps, showing estimated directions of ground-water movement, for the two principal aquifers in the study area, were constructed using water-level data collected during the well inventory phase in the autumn of 2001.

HYDROGEOLOGIC FRAMEWORK

This section describes the geologic and hydrogeologic framework, which defines the physical, lithologic, and hydrologic characteristics of the hydrogeologic units that compose the ground-water system of the Colville River Watershed. An understanding of these characteristics is important in determining the occurrence and availability of ground water within the watershed.

Geologic Setting

The geology of the Colville Basin is extremely complex and is composed of various types of bedrock (for example, shale, slate, dolomite, quartzite, granite, and basalt) overlain in many places with varying types and thicknesses of unconsolidated sediment such as silt, sand, gravel, and clay. These occur in till, outwash, alluvium, Lake Missoula flood deposits, and loess.

Bedrock units in the Colville Basin and surrounding areas record a complex structural history involving repeated periods of folding, faulting, and igneous intrusion (Miller and Clark, 1975; Lasmanis, 1991; and Miller, 2001). Regional geologic mapping (Stoffel and others, 1991) shows that Huckleberry Mountain, southwest of Chewelah, is composed mostly of alternating beds of argillite, dolomite, and slate; Dunn Mountain, west of Addy, is composed mostly of quartzite and greenstone; Mingo Mountain, south of Kettle Falls, is composed of quartzite and phyllite. On the east side of the Colville Valley near Chewelah, Chewelah Mountain and Round Top Mountain are composed mostly of argillite and quartzite. Much of the bedrock in the Little Pend Oreille Basin east of Arden, from Little Calispell Peak on the south to near Old Dominion Mountain to the north, is composed of granite. From Old Dominion Mountain west toward Echo Valley, the bedrock in the northern part of the basin is composed mostly of quartzite, dolomite, phyllite, and slate. Volcanic rocks are found in an area south of Kettle Falls and in the southern end of the basin south of Chewelah and near Springdale.

Overlying the bedrock of the Colville Basin is an equally complex assemblage of unconsolidated sediment deposited during glacial or interglacial periods. At least two periods of glacial activity have influenced the topography and sedimentation of the region. Although sediments from the earliest glaciations are encountered locally in deep wells, little surface evidence remains to reconstruct their depositional history. Only the most recent glacial history is recorded in exposed sediment in the study area.

During the climax of the most recent glaciation (about 15,000 years before present), much of northern Washington, including the Colville Valley, was covered by lobes of the Cordilleran ice sheet (fig. 3). This large ice sheet formed in the mountains of British Columbia and flowed south, filling valleys and overriding low mountain ranges in northern Washington, Idaho, and Montana. The Okanogan, Columbia River, Colville, and Pend Oreille River lobes of the Cordilleran ice sheet covered much of northeastern Washington. The Okanogan lobe to the west of the Colville Valley was the largest of the lobes and covered what is now the northern part of the Waterville Plateau. The Okanogan lobe dammed the Columbia River and created a vast lake referred to as glacial Lake Columbia (Waitt and Thorson, 1983), which deposited thick, fine-grained sediments throughout much of the region. This long-lived lake had a number of important stands, including two stands with lake levels reaching approximate altitudes of 1,700 and 2,400 ft.

As the Colville lobe advanced southward into the Colville Valley, large areas of outwash sands and gravels were deposited from glacial melt water, till was deposited beneath the ice, and fine-grained sediments were deposited as the lobe advanced into glacial Lake Columbia (Waitt and Thorson, 1983). The southern limit of the Colville lobe is marked by a well-developed terminal moraine near the town of Springdale, referred to as the Springdale moraine (Flint, 1936, Carrara and others, 1996). Stratigraphic evidence indicates that the glacial maximum of the Colville lobe, represented by the Springdale moraine, is younger than the Okanogan lobe ice dam that impounded high stands of glacial Lake Columbia (Richmond, 1986). As the Colville lobe wasted, a smaller lake developed within the Colville Valley behind the present position of the Springdale moraine. The lake drained south from the vicinity of Springdale, creating a large outwash plain in the upper Chamokane Creek area. Later, the lake surface declined and became confluent with a northern extension of a late stand of glacial Lake Columbia.

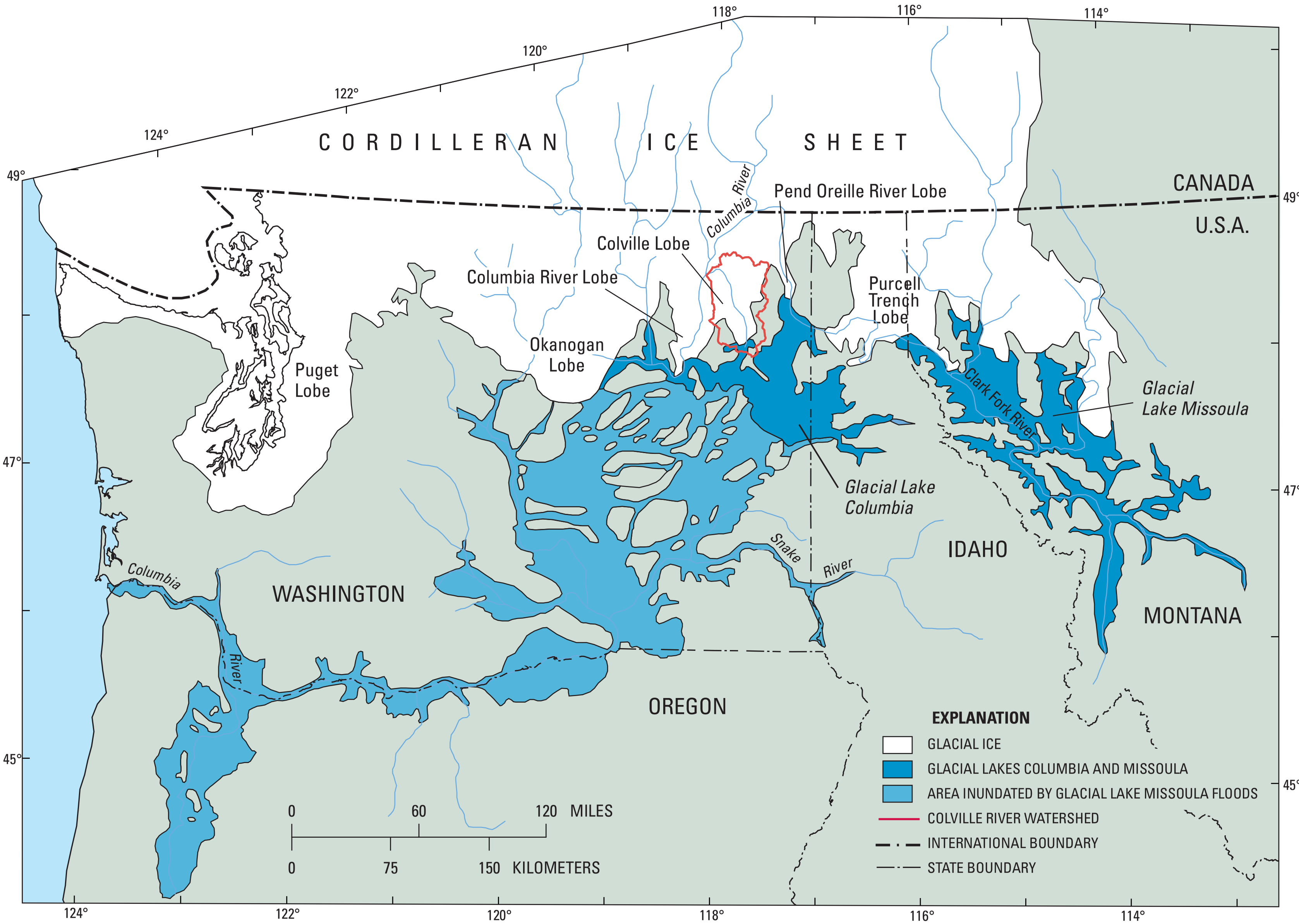


Figure 3. Extent of glacial ice and glacial lakes in northern Washington, Idaho, and part of Montana. (Modified from Allen and Burns, 1986, and Atwater, 1986).

Although most of the surficial unconsolidated deposits in the study area are the result of glacial processes involving the Colville and Okanogan lobes, the Purcell Trench lobe, in what is now northern Idaho, also contributed directly to sedimentation in the southern part of the Colville Basin. Glacial Lake Missoula, dammed behind the Purcell Trench Lobe (fig. 3), was about 600 mi^3 in volume and reached a maximum depth of 2,200 ft (Waitt, 1980). Large catastrophic floods occurred periodically when the ice dam of the Purcell Trench lobe failed, sending floodwaters west and southwest. Giant current dunes north of Loon Lake record floodwaters exiting westward through the Sheep Creek spillway into the Colville Valley near Springdale (Carrara and others, 1995). Stratigraphic evidence suggests that the Missoula flood outwash near Loon Lake was deposited before the Springdale moraine (Kiver and Stradling, 1982).

Following the glacial activity in the Colville Basin, the valley floor was slightly modified as streams reworked the surficial lake sediments to form a flood plain of variable width. The modern northward flow of the Colville River is the result of the outwash and moraine divide at Springdale. The present day Colville River is a classic example of an underfit stream, a stream too small to have eroded the valley through which it flows. The preglacial Columbia River that likely flowed southward through the present-day Colville and Chamokane Valleys, the effects of the Colville lobe, and the earlier structural history of the region including faulting are responsible for the general morphology of the basin.

The surficial geology of the Colville Basin consists of seven geologic units that are described below and are shown on a surficial geologic map compiled for this investigation (pl. 1). The surficial geology was compiled from existing maps including the surficial geologic map of the Chewelah 30' × 60' quadrangle (Carrara and others, 1995), the geologic map of Washington northeast quadrant (Stoffel and others, 1991), and the Soil Survey of Stevens County (U.S. Department of Agriculture, 1982, 1991). In some areas, modifications were made to existing maps based on stratigraphic evidence obtained during this investigation, primarily drillers' logs for field-located water wells.

Alluvial deposits (Qal): Includes channel and overbank deposits in the modern Colville River and tributary flood plains and alluvial-fan deposits at the mouths of streams tributary to the Colville River. The unit consists mostly of stratified silt, sand, gravel, and minor amounts of clay deposited by flowing water. Thickness of the unit is generally from 1 to 30 ft.

Glaciofluvial deposits (Qgf): Includes mostly stratified and well-sorted sand-and-gravel outwash deposited by glacial meltwater and other glaciofluvial deposits, including well-stratified and well-sorted sand-and-gravel kame moraines deposited by the retreating Colville lobe (near the valley floor at Blue Creek and Twelve Mile Creek) and glacial-outburst flood deposits consisting of mostly stratified sand, gravel, and boulders (north side of Loon Lake). Although most of the Qgf is coarse-grained outwash, lenses of silt, clay, and till occur locally. The thickness of the unit generally is from 20 to 300 ft.

Glacial till (Qti): Includes mostly unsorted and unstratified clay, silt, sand, and gravel deposited by the Colville lobe. The unit overlies much of the areas of higher altitude in the basin and locally may contain till from previous glaciations. Near Springdale, the unit includes the terminal moraine of the Colville lobe. Locally, the unit contains stratified sand and gravel. Thickness of the unit generally is from 10 to 100 ft.

Glaciolacustrine deposits (Qla): Includes mostly clay and silt lake sediments deposited in ice-marginal lakes. The unit underlies large areas of the Colville Valley, but is overlain by Quaternary alluvial deposits (Qal) in many areas. The unit includes thin and discontinuous beds of sand and gravel. Overall thickness of the unit generally is 20 to 300 ft.

Mass-wasting deposits (Qmw): Includes poorly sorted angular rock fragments deposited as talus at the base of steep slopes and heterogeneous mixtures of unconsolidated surficial material and rock fragments deposited by landslides. Thickness of the unit varies, but usually is less than 100 ft.

Organic deposits (Qor): Includes peat, woody peat, muck, and organic-rich silt and clay that commonly occur in closed depressions. Thickness of the unit is from 1 to 30 ft.

Bedrock (Tertiary to Middle Proterozoic) (Tybr): Includes sedimentary, metasedimentary, and intrusive and extrusive igneous rocks. Specific rock types include conglomerate, sandstone, siltstone, shale, quartzite, dolomite, argillite, granite, and basalt. The unit is exposed in much of the higher-altitude areas of the basin where it is not overlain by till (Qti). The depth to bedrock in the Colville Valley beneath the unconsolidated sediments is largely unknown and likely varies considerably. In Addy, a depth to bedrock of near 663 ft was recorded in well 33N/39E-13F01. Based on information from other wells, the depth to bedrock along most of the central part of the Colville Valley is at least 300 ft.

Hydrogeologic Units

The surficial geologic units described previously and the deposits at depth were differentiated into aquifers and confining beds on the basis of areal extent and general water-bearing characteristics. An aquifer is saturated geologic material that is sufficiently permeable to yield water in significant quantities to a well or spring, whereas a confining bed has lower permeability that restricts the movement of ground water and limits the usefulness of the unit as a source of ground water. Generally, well-sorted, coarse-grained deposits have higher permeabilities than do fine-grained or poorly sorted deposits. In the Colville River Basin, saturated glacial outwash or other coarse-grained deposits form the aquifers, whereas deposits such as till or glaciolacustrine deposits form the confining beds. The aquifers and confining beds identified herein are referred to as hydrogeologic units because the differentiation takes into account both the geologic and hydraulic characteristics of the units. Seven hydrogeologic units were identified in the study area:

- Upper outwash aquifer (UA);
- Till confining unit (TC);
- Older outwash aquifer (OA);
- Colville Valley confining unit (VC);
- Lower aquifer (LA);
- Lower confining unit (LC); and
- Bedrock (BR).

Although there are thin and discontinuous aquifer materials, mostly Qal, on the Colville Valley floor, they aren't recognized in this study as a primary aquifer because of their limited extent and thickness. These deposits do, however, yield usable amounts of water, mostly to older, shallow dug wells, only a few of which were inventoried during this study. A simplified conceptual model of the hydrologic system of the Colville River Watershed is presented in figure 4.

The lithologic and hydrologic characteristics of the hydrogeologic units are summarized in a chart that includes the range of thicknesses for each unit, based on data from the inventoried wells, and the number of inventoried wells open to each unit (fig. 5). Wells open to more than one unit are not included in the chart but are indicated in table 11. The thickness and areal extent of the units are shown on eight hydrogeologic sections and exhibit considerable variation (pl. 1). There were adequate data to map the thickness and extent of the Upper outwash aquifer and the Colville Valley confining unit, but thickness data for the Till confining unit, the Older outwash aquifer, the Lower aquifer, and the Lower confining unit were too sparse over the study area to be mapped. The hydrogeologic units are commonly heterogeneous and locally discontinuous, therefore correlations are tentative in many places. Along much of the Colville Valley floor, the depth to bedrock, and therefore the total thickness of the unconsolidated deposits, is not known. In general, the deeper the units, the less certain are the correlations. The thickness data of hydrogeologic units for study-area wells are shown in table 12 (at back of report).

The Upper outwash aquifer (UA) is a discontinuous but productive and widely used aquifer. It is composed mostly of glacial outwash sand and gravel (geologic unit Qgf) with lenses of clay and till occurring locally (geologic unit Qti) and some sandy alluvium along stream channels (geologic unit Qal).

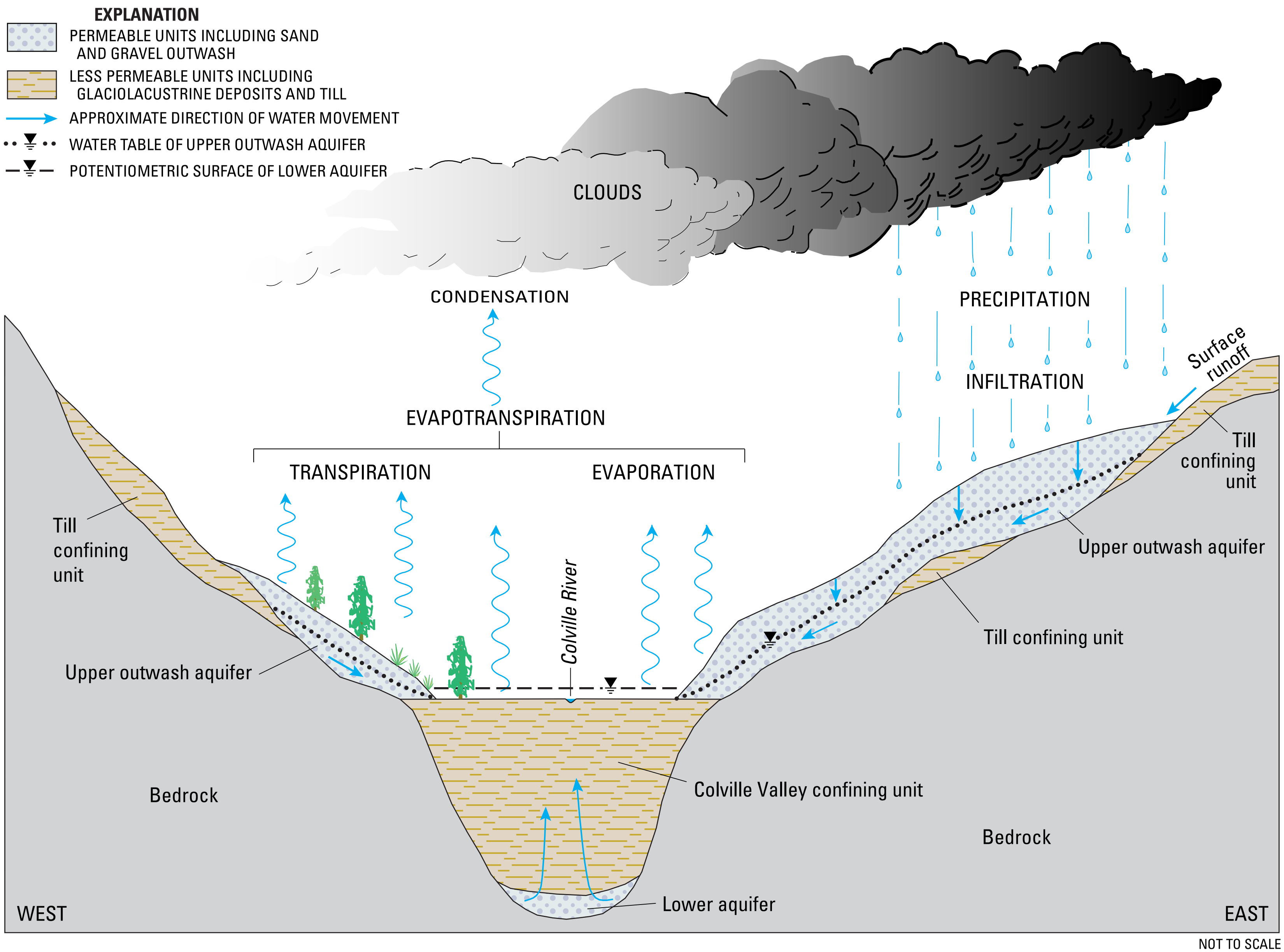


Figure 4. Simplified conceptual model of hydrologic conditions near the middle of the Colville River Watershed, Stevens County, Washington.

Hydrogeologic unit	Unit label	Range of thickness [estimated average thickness] (feet)	Lithologic and hydrologic characteristics	Number of inventoried wells open to unit
Upper outwash aquifer	UA	10–480 [100]	Unconfined aquifer consisting of sand, gravel, cobbles, and silt with minor clay or till interbeds. Unit occurs in most stream valleys and terraces tributary to the Colville River. Includes geologic units Qgf, Qal, and Qti.	114
Till confining unit	TC	4–250 [70]	Low-permeability unit consisting of compacted and poorly sorted clay, silt, sand, gravel, and cobbles with locally occurring sand and gravel lenses. Includes geologic unit Qti.	7
Older outwash aquifer	OA	2–56 [20]	Discontinuous confined aquifer consisting mostly of sand and gravel outwash underlying till and overlying bedrock. Unit occurs in places in tributary valleys.	13
Colville Valley confining unit	VC	1–570 [150]	Low-permeability unit consisting mostly of glaciolacustrine silt and clay overlain in places by mostly fine-grained stream alluvium. Unit occurs throughout the length of the Colville Valley and partway up some of the tributary valleys. Discontinuous lenses of aquifer material within the unit contribute usable quantities of water to some wells. Includes geologic units Qla and Qal.	27
Lower aquifer	LA	2–289 [60]	Generally confined aquifer consisting mostly of sand and some gravel. Unit occurs in most of the Colville Valley beneath the Colville Valley confining unit. The unit is unconfined where it is not fully saturated or is exposed at land surface (near Kettle Falls). Thickness and extent of unit is not well known.	87
Lower confining unit	LC	1–454 [unknown]	Low-permeability unit consisting mostly of glaciolacustrine silt and clay. Unit includes till in places.	0
Bedrock	BR	–	Unit includes conglomerate, sandstone, siltstone, shale, quartzite, dolomite, argillite, granite, and basalt. Locally yields usable quantities of water where rocks are fractured. Yields are generally small. Includes geologic unit Tybr.	79

Figure 5. Lithologic and hydrologic characteristics of the hydrogeologic units in the Colville River Watershed, Stevens County, Washington.

The Upper outwash aquifer exists mostly in the stream valleys and terraces that are tributary to the Colville River (fig. 6). The average thickness of the unit is 100 ft, and the thickness in inventoried wells ranged from 10 to 480 ft. The unit is thickest in tributary valleys on the east side of the Colville Valley, greater than 300 ft thick in areas along the Little Pend Oreille River, in Sand Canyon, along Cottonwood Creek, along an unnamed intermittent stream east of Valley, and between Deer and Loon Lakes. In places, the unit may be greater than 100 ft thick but was mapped as less than 100 ft thick because of insufficient well data. Of the inventoried wells, 114 are open to the Upper outwash aquifer, including the public-supply wells for the city of Colville. An additional 11 wells are open to the aquifer and other hydrogeologic units where the open intervals of those wells extend to more than one hydrogeologic unit (table 11).

The Till confining unit (TC) is a low-permeability unit consisting of compacted and poorly sorted clay, silt, sand, gravel, and cobbles with locally occurring sand-and-gravel lenses. The unit occurs over much of the mountainous areas of the study area where glacial till (geologic unit Qti) mantles bedrock. The estimated average thickness of the unit is 70 ft, and the thickness in inventoried wells ranged from 4 to 250 ft. Although this is a confining unit, it yields water in usable quantities to seven of the inventoried wells. There are an additional two wells open to the Till confining unit and other hydrogeologic units where open intervals of the wells extend to more than one hydrogeologic unit (table 11).

The Older outwash aquifer (OA) is a discontinuous confined aquifer consisting of sand-and-gravel outwash underlying till (TC) and overlying bedrock (BR). It generally occurs in the higher-altitude areas of the side basins tributary to the Colville Valley. The estimated average thickness of the Older outwash aquifer is 20 ft, and the thickness in inventoried wells ranged from 2 to 56 ft. None of the hydrogeologic sections show this aquifer because of its limited extent. Only 13 of the inventoried wells are open to the Older outwash aquifer. There are an additional two wells open to the aquifer and other hydrogeologic units where open intervals of the wells extend to more than one hydrogeologic unit (table 11).

The Colville Valley confining unit (VC) is a thick, low-permeability unit consisting mostly of extensive glaciolacustrine silt and clay (geologic unit Qla) with locally occurring sand or gravel lenses overlain in places by fine-grained stream alluvium (geologic unit Qal). In some areas, glacial till was included with this unit where lake sediments are directly overlain by till. The confining unit occurs throughout the length of Colville and Echo Valleys and in parts of some of the tributary valleys, including Mill Creek, Little Pend Oreille River, South Fork Chewelah Creek, Cottonwood Creek, and Jumpoff Joe Creek (fig. 7). The estimated average thickness of the Colville Valley confining unit is 150 ft, and the thickness in inventoried wells ranged from 1 to 570 ft. The greatest recorded thickness of the confining unit is more than 400 ft, in areas near Addy and Kettle Falls (fig. 7). Discontinuous lenses of sand or gravel within the unit contribute usable quantities of water to 27 of the inventoried wells. There are an additional four wells open to the Colville Valley confining unit and other hydrogeologic units where open intervals of the wells extend to more than one hydrogeologic unit (table 11).

The Lower aquifer (LA) consists of sand and some gravel and likely is continuous along the length of Colville and Echo Valleys (fig. 8). It occurs below the Colville Valley confining unit and above the Lower confining unit or Bedrock (pl.1). The unit also is mapped in two small places, near Jumpoff Joe Lake and Cottonwood and South Fork Chewelah Creeks, where it does not appear to be connected with the Lower aquifer in the Colville Valley floor (fig. 8). In most of the study area, the Lower aquifer is confined and many wells completed in this unit flow at land surface. Near the mouth of the watershed, however, the aquifer becomes unconfined where it is not fully saturated and is exposed at land surface along the Colville River downstream from Meyers Falls (pl. 1, hydrogeologic section *F-F'*, wells 36N/38E-30K01, 30K05, and 30K06). Based on drillers' records, the estimated average thickness of the unit is 60 ft. This may be an underestimate of thickness, however, because few wells actually penetrate the total thickness of the unit. Eighty-seven of the inventoried wells are open to the Lower aquifer, including the public-supply wells for the cities of Chewelah and Kettle Falls. There are an additional five wells open to the Lower aquifer and other hydrogeologic units where the wells are completed in more than one hydrogeologic unit (table 11). Based on available drilling records and water levels, parts of the Lower aquifer extend to the mouth of the watershed and discharge into Lake Roosevelt, probably diverging around a bedrock high near Meyers Falls — to the north beneath Kettle Falls and to the south beneath the present drainage of the Colville River (fig. 8; pl. 1, section *F-F'*).

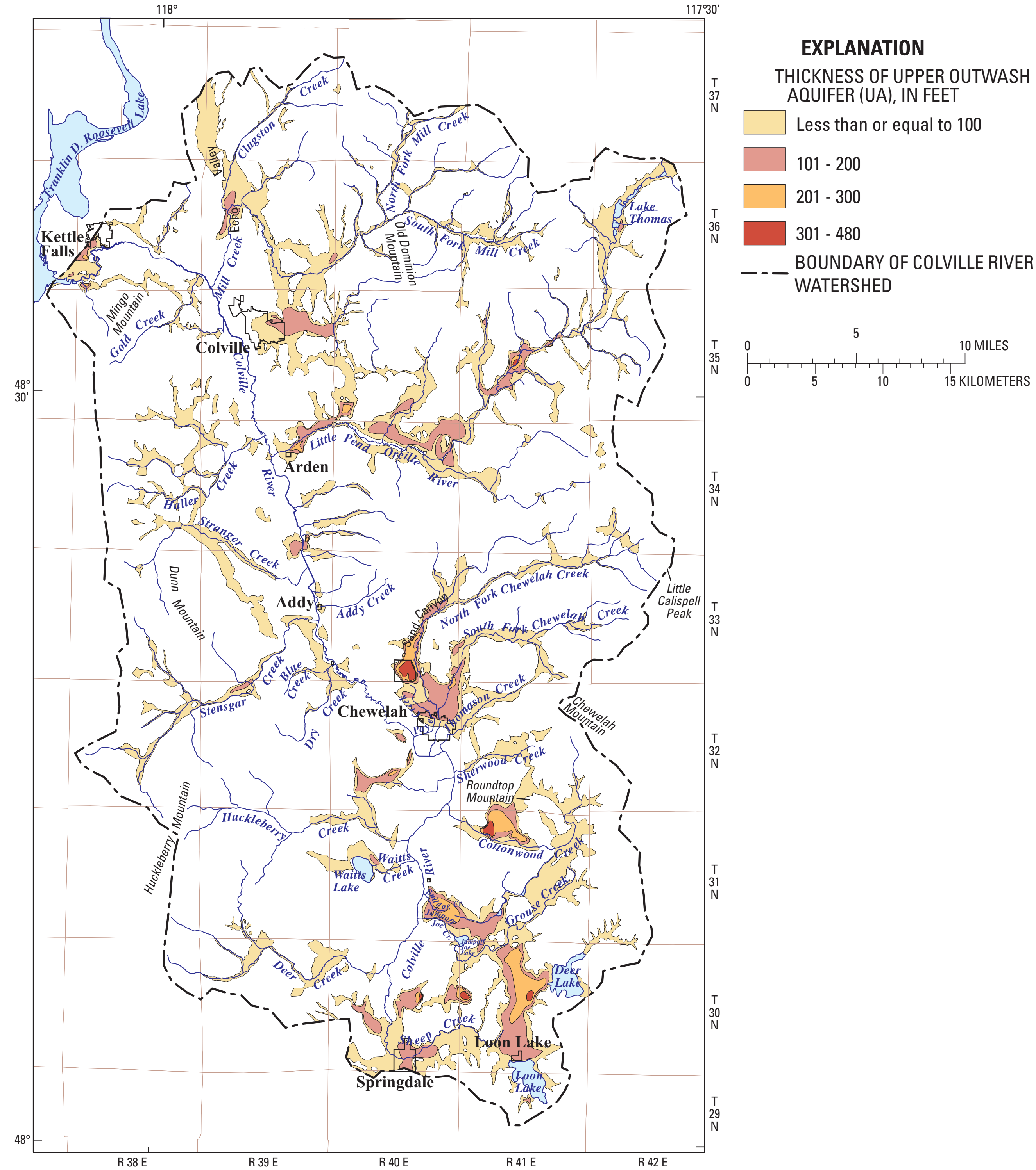


Figure 6. Thickness and areal extent of the Upper outwash aquifer in the Colville River Watershed, Stevens County, Washington.

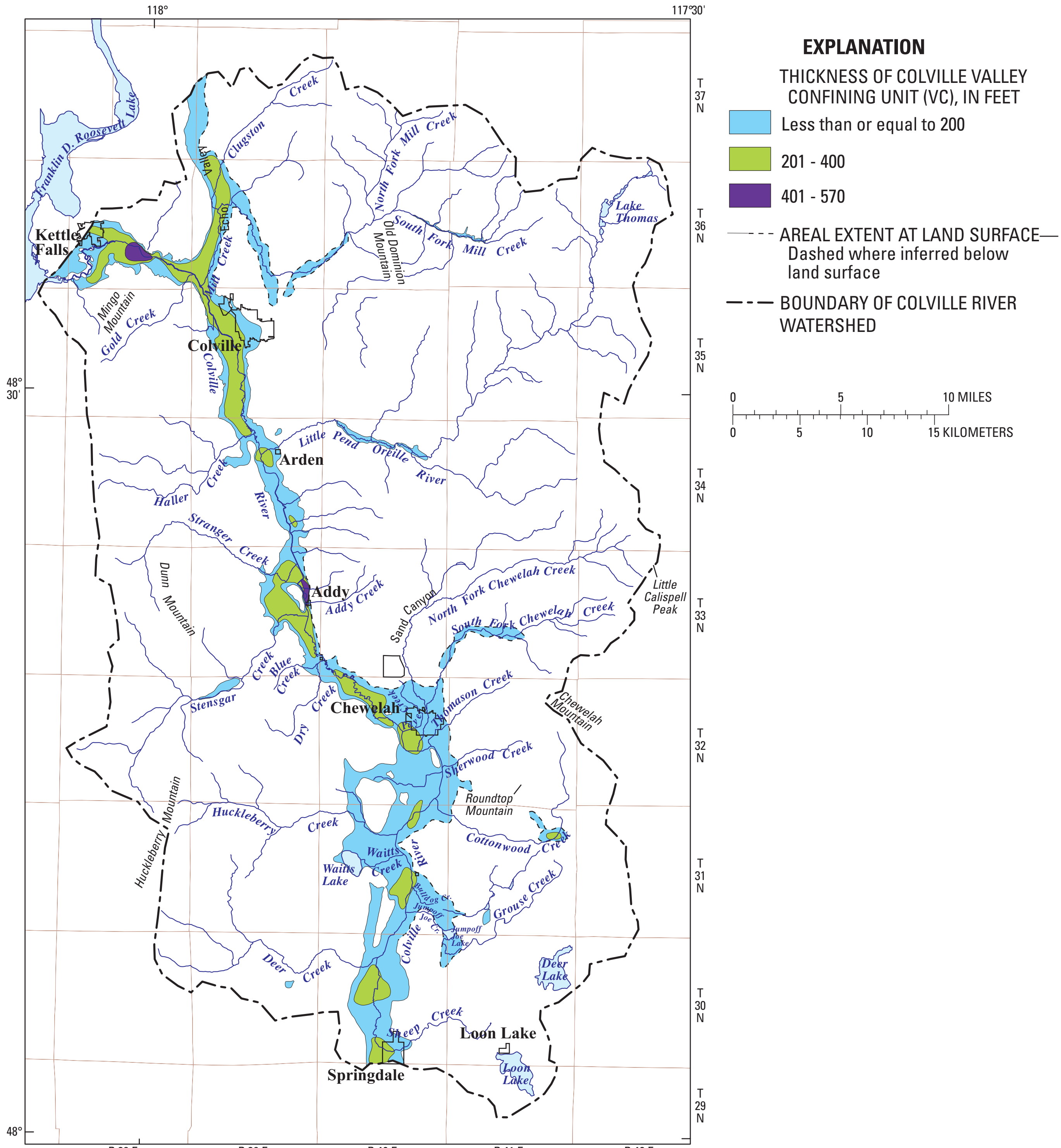


Figure 7. Thickness and areal extent of the Colville Valley confining unit in the Colville River Watershed, Stevens County, Washington.

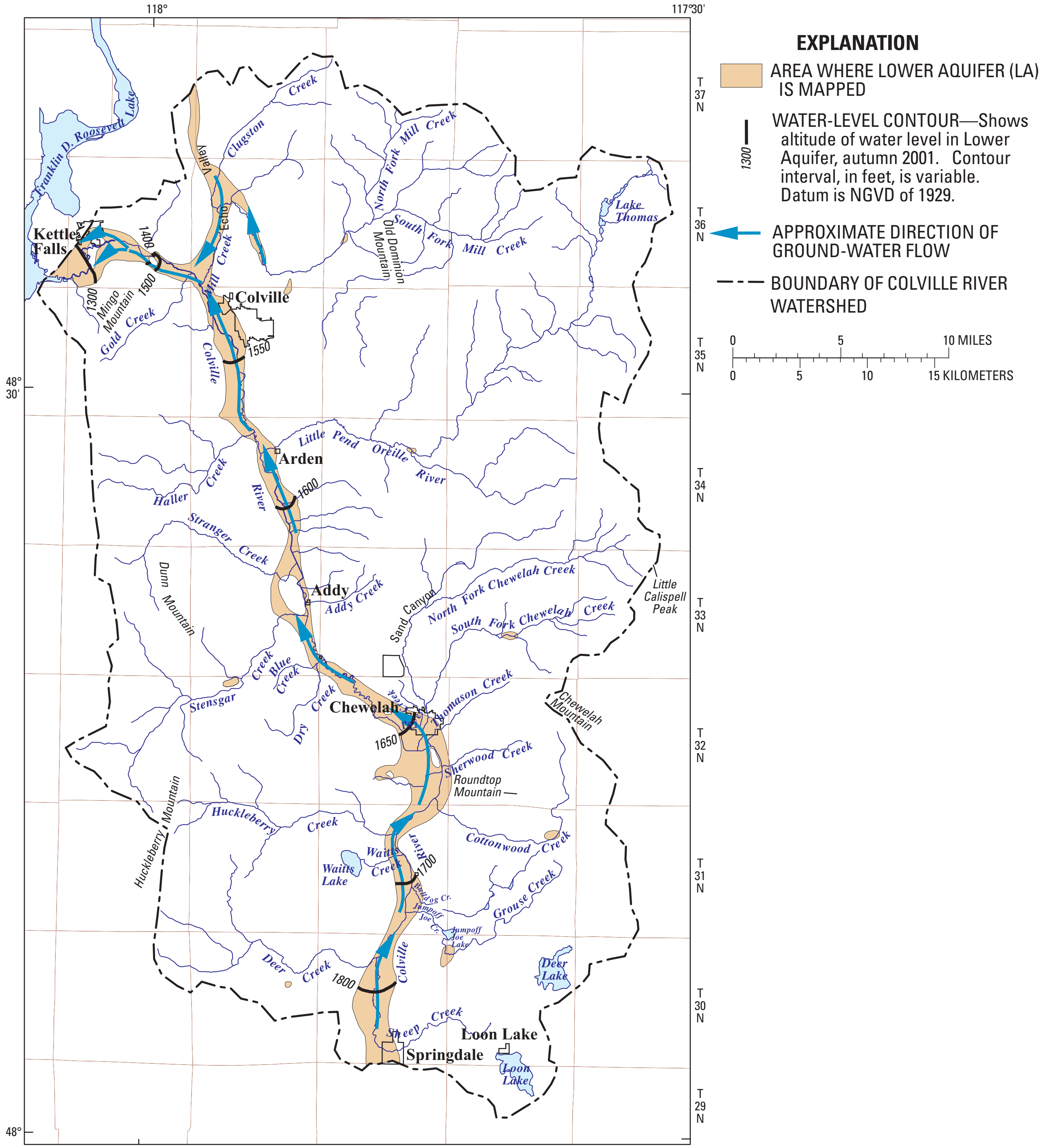


Figure 8. Areal extent, water-level altitudes, and inferred directions of ground-water flow in the Lower aquifer in the Colville River Watershed, Stevens County, Washington.

The Lower confining unit (LC) is a low-permeability unit consisting mostly of glaciolacustrine silt and clay, with glacial till in places. The unit underlies the Lower aquifer and overlies Bedrock. This deep unit was only noted in drillers' logs from 10 of the inventoried wells and none of the wells are open to the unit. The average thickness of the unit is generally unknown, but the thickness ranges from 1 to 454 ft in 10 of the inventoried wells.

The Bedrock (BR) underlies all of the previously described hydrogeologic units at depths as great as 600 ft along the Colville Valley. However, in most of the watershed, bedrock occurs at or near land surface, and is the only source of ground water for landowners who live in those areas. Bedrock typically has very low permeabilities, except where it has been fractured by folding and faulting. These fractures produce small but usable quantities of water in 79 of the inventoried wells. An additional 16 wells are open to the Bedrock and other hydrogeologic units where wells are completed in more than one hydrogeologic unit (table 11).

Hydraulic Properties

Hydraulic conductivity is a measure of a material's ability to transmit water, and in unconsolidated sediment is dependent on the size, shape, distribution, and packing of the particles. Because these characteristics vary greatly within each hydrogeologic unit, hydraulic conductivity values also vary greatly.

Horizontal hydraulic conductivity was estimated for the hydrogeologic units using drawdowns from drillers' logs that were observed after pumping wells for periods that ranged from 1 to 100 hours. Only data from those wells that had a driller's log containing discharge rate, time of pumping, drawdown, static water level, well-construction data, and lithologic log were used.

Two different sets of equations were used to estimate hydraulic conductivity, depending on well construction. For data from wells with a screened or perforated interval, the modified Theis equation (Ferris and others, 1962) was first used to estimate transmissivity of the pumped interval. Transmissivity is the product of horizontal hydraulic conductivity and thickness of the part of the hydrogeologic unit supplying water to the well. The modified equation is

$$s = \frac{Q}{4\pi T} ln \frac{2.25Tt}{r^2 S} \qquad (1)$$

where

s = drawdown in the well, in feet;

Q = discharge, or pumping rate, of the well, in cubic feet per day;

T = transmissivity of the hydrogeologic unit, in square feet per day;

t = length of time the well was pumped, in days;

r = radius of the well, in feet; and

S = storage coefficient, a dimensionless number, assumed to be 0.0001 for confined units and 0.1 for unconfined units.

Assumptions for using equation 1 are that aquifers are homogeneous, isotropic, and infinite in extent; wells are fully penetrating; flow to the well is horizontal; and water is released from storage instantaneously. Additionally, for unconfined aquifers, drawdown is assumed to be small in relation to the saturated thickness of the aquifer. Although many of the assumptions are not precisely met, the field conditions in the study area approximate most of the assumptions and the calculated hydraulic conductivities are reasonable estimates.

A computer program was used to solve equation 1 for transmissivity (T) using Newton's iterative method (Carnahan and others, 1969). The difference in computed transmissivity between using 0.1 and 0.0001 for the storage coeffecient is a factor of only about 2. Next, the following equation was used to calculate horizontal hydraulic conductivity:

$$K_h = \frac{T}{b} \qquad (2)$$

where

K_h = horizontal hydraulic conductivity of the geologic material in the vicinity of the well opening, in feet per day; and

b = thickness, in feet, approximated using the length of the open interval as reported in the driller's report.

The use of the length of a well's open interval for b may overestimate values of K_h because the equations assume that all the water flows horizontally within a layer of this thickness. Although some of the flow will be outside this region, the amount can be expected to be small because in most sedimentary deposits, vertical flow is inhibited by layering.

For data from wells having only an open end, a second equation was used to estimate hydraulic conductivities. Bear (1979) provides an equation for hemispherical flow to an open-ended well just penetrating a hydrogeologic unit. When modified for spherical flow to an open-ended well within a unit, the equation becomes

$$K_h = \frac{Q}{4\pi sr} \quad (3)$$

Equation 3 is based on the assumption that horizontal and vertical hydraulic conductivities are equal, which is not likely for the deposits within the study area. The result of violating this assumption probably is an underestimate of K_h by an unknown amount.

Horizontal hydraulic conductivities were calculated with data from those wells for which the data were available, and statistical summaries were prepared by hydrogeologic unit (table 1). Data were unavailable for the Lower confining unit. The median values of estimated hydraulic conductivities for the aquifers are similar in magnitude to values reported by Freeze and Cherry (1979) for similar materials: Upper outwash aquifer, 84 ft/d; Older outwash aquifer, 270 ft/d; and Lower aquifer, 49 ft/d (table 1). The medians of estimated hydraulic conductivities for the Till confining unit (5.6 ft/d), the Colville Valley confining unit (110 ft/d), and the Bedrock (1.3 ft/d) are higher than is typical for most of the material in these units because data for confining units usually are from zones where lenses of coarse material exist and, in the case of bedrock, where fractures exist. As a result, the data are biased toward the more productive zones in these units and are not representative of the entire unit. The minimum hydraulic conductivities for the hydrogeologic units illustrate that there are zones of low hydraulic conductivity in most units. Also, the range of hydraulic conductivities is at least three orders of magnitude for most units, indicating a substantial amount of heterogeneity.

Ground-Water Flow Directions

To estimate directions of horizontal ground-water flow, water-level maps were drawn for the Upper outwash aquifer (UA) and the Lower aquifer (LA). Contours of water-level altitudes were drawn only where the aquifers are continuous. The directions of flow were inferred to be from higher to lower water levels and perpendicular to water-level contours where data were sufficient to draw contours. Ground-water levels measured during the well inventory (autumn of 2001) were used to construct the maps of hydraulic head, or altitude of water level.

Horizontal ground-water flow in the Upper outwash aquifer generally mimics the surface-water drainage pattern of the watershed where the unit occurs. Ground-water flow moves from the topographically high tributary-basin areas toward the topographically lower Colville Valley floor (fig. 9).

Table 1. Summary of estimated horizontal hydraulic conductivities of selected hydrogeologic units in the Colville River Watershed, Stevens County, Washington

[–, not determined]

Hydrogeologic unit	Number of wells	Hydraulic conductivity (feet per day)		
		Minimum	Median	Maximum
Upper outwash aquifer (UA)	24	1.9	84	2,400
Till confining unit (TC)	4	2.5	5.6	28
Older outwash aquifer (OA)	1	–	270	–
Colville Valley confining unit (VC)	8	14	110	930
Lower aquifer (LA)	17	1.1	49	15,000
Bedrock (BR)	3	.0011	1.3	4.4

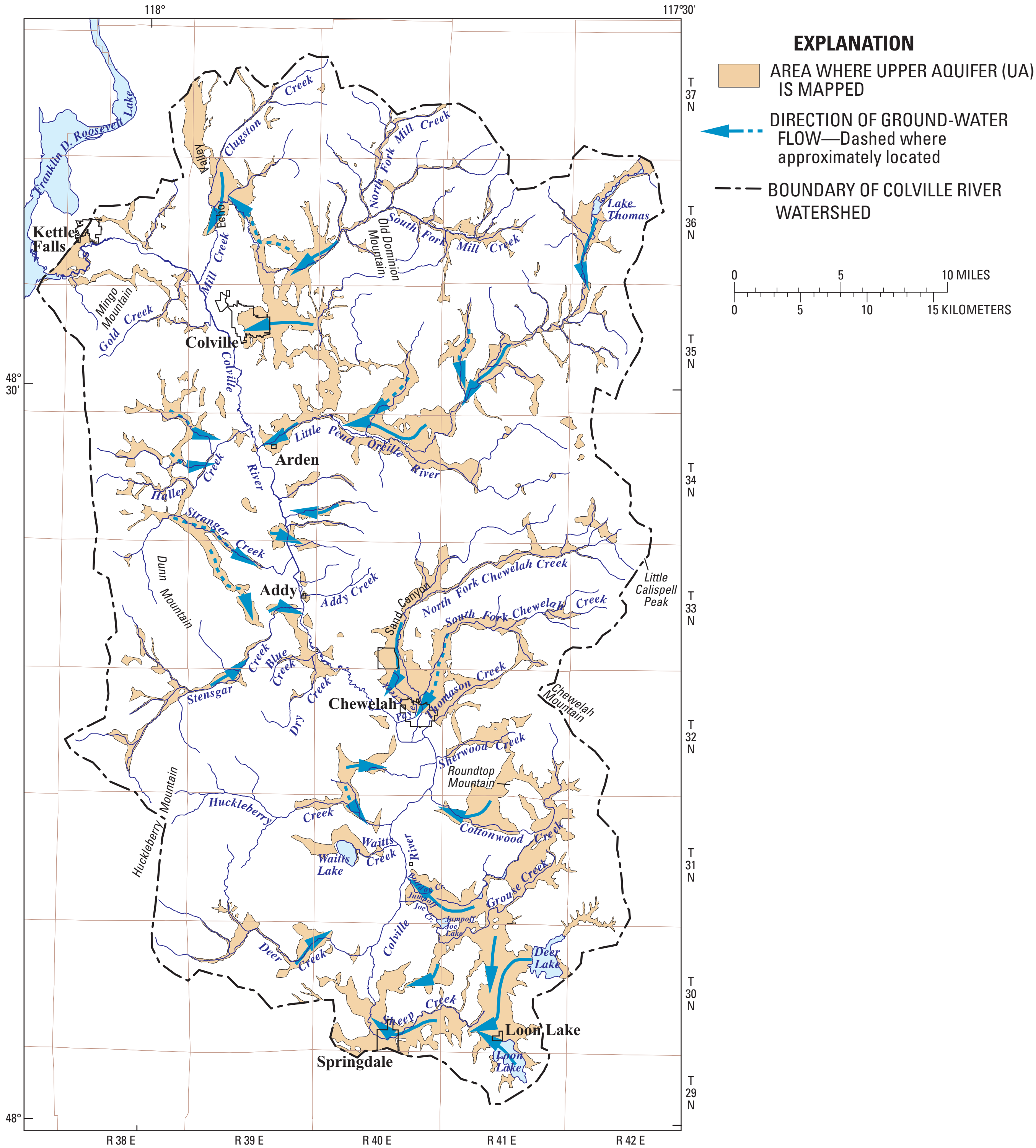


Figure 9. Inferred directions of ground-water flow in the Upper outwash aquifer in the Colville River Watershed, Stevens County, Washington.

Water-level contours were not drawn for the Upper outwash aquifer because of the discontinuous nature of the unit. Over the entire watershed, water-level altitudes in the Upper outwash aquifer range from 3,149 ft near Lake Thomas to 1,569 ft near Colville. The general distribution of horizontal gradients was 60 ft/mi between Loon Lake and Springdale, 100 ft/mi northeast of Jumpoff Joe Lake westward to Valley, 90 ft/mi in Sand Canyon, 70 ft/mi in the Little Pend Oreille River drainage, and 90 ft/mi in the terrace east of Colville. The smallest gradient in the Upper outwash aquifer, 20 ft/mi, occurred in the area between Deer and Loon Lakes. Most of the larger lakes in the watershed, including Deer, Loon, Jumpoff Joe, Waitts, and the Little Pend Oreille lakes, are fairly well connected with the Upper outwash aquifer, and although not determined during this study, their lake levels likely rise and decline with the water table of the aquifer. Vertical head gradients in the Upper outwash aquifer in most of the higher altitude tributary-basin areas are downward. Localized upward head gradients occur in a few places in the study area, and are indicated by flowing wells 30N/39E-01G01, 35N/39E-11R05, and 35N/39E-18A01.

Recharge to the Upper outwash aquifer occurs over its extent as direct precipitation in the form of rain and snow, as seepage along the downstream areas of lakes that are within the aquifer, and along losing stream reaches where streams flow directly over the aquifer and lose water to it. Discharge from the aquifer occurs near the mouth of each tributary basin as the aquifer unit generally ends near the Colville Valley floor. Discharge also occurs as seepage along the upstream areas of lakes, and as pumping to wells.

Horizontal ground-water flow in the Lower aquifer from near Springdale to Chewelah is toward the north, from Chewelah to Colville to the north-northwest, and from Colville to Kettle Falls to the northwest (fig. 8). In Echo Valley, ground-water flow is south toward the Colville Valley. At the outlet of the Colville River Basin, near Kettle Falls, ground-water flow directions are less certain, but likely diverge around the bedrock high near Meyers Falls, with flow going both toward the southwest along the present Colville River drainage and to the northwest toward the Marcus Flats area of Lake Roosevelt (fig. 8). Along the valley floor, water-level altitudes within the Lower aquifer range from 1,895 ft near Springdale to 1,284 ft near Kettle Falls. Also on the valley floor, many wells within the unit flow at land surface from 3 mi north of Springdale to the confluence of Colville and Echo Valleys, indicating upward ground-water gradients in those areas. Horizontal gradients are 20 ft/mi from Springdale to Valley, 7 ft/mi from Valley to Chewelah, and 5 ft/mi from Chewelah to Colville. Between Colville and Kettle Falls, however, the gradients become much greater and range from 60 to 200 ft/mi.

The ground-water divide for the Lower aquifer is uncertain, but may be near the surface-water divide for the basin, near Springdale. Additional work would be needed to determine the location of the ground-water divide, as well as the presence or absence of the Lower aquifer to the south of WRIA 59. This could be attempted by field-locating deep wells south of the basin in the Chamokane Creek area, by examining drillers' records for wells completed in the Lower aquifer, and by examining water levels in those wells to determine directions of ground-water flow and ultimately define the location of the ground-water divide.

Recharge to the Lower aquifer likely occurs in several areas. Water-level data indicate that recharge occurs from the southern extent of the watershed to about 3 mi north of Springdale where vertical head gradients generally are downward. A similar recharge area probably also exists at the head of Echo Valley, but no data were available to confirm this. Localized recharge also may occur along the walls of the Colville Valley where coarse talus slopes or glacial or alluvial outwash fans overlie and possibly interfinger with the otherwise continuous Colville Valley confining unit. Beyond the area 3 mi north of Springdale, downgradient and down-valley, many wells in the Lower aquifer flow at land surface, indicating upward vertical gradients that are, therefore, points of discharge for the aquifer. Discharge at the lower end of the basin, near Kettle Falls, is uncertain, but is likely through subareal flow into Lake Roosevelt near the mouth of the Colville River and near the Marcus Flats area of Lake Roosevelt. The upward vertical head gradients referred to previously indicate that in some areas along the Colville Valley, ground water may move upward from the Lower aquifer, through the overlying Colville Valley confining unit, and eventually discharge to surface-water features such as the Colville River. The Lower aquifer also discharges water to pumping wells.

Directions of vertical flow were inferred from water-level altitudes in the Upper outwash aquifer and the Lower aquifer in the few places where the units overlie one another and from the location of flowing wells. Water-level altitudes in closely spaced wells also were reviewed to assess if vertical gradients could be determined. In wells 34N/39E-25M01 and 25M02, the difference in water levels was more than 80 ft, with a downward gradient from the Upper outwash aquifer to the underlying Bedrock. In wells 33N/39E-23A01 and 23A02, water levels were essentially the same and there is no obvious vertical gradient. In wells 33N/40E-35P01 and 35P02, water-level differences were within the measurement error of determining water-level altitudes, and therefore were not useful in determining vertical gradients. Based on available water-level data, vertical flow in the basin generally is downward in the high-altitude areas of the side basins, downward on the valley floor from near Springdale to near the mouth of Sheep Creek, then upward along much of the valley floor (indicated by flowing wells) until near Colville, where vertical gradients change to downward again as far as the mouth of the watershed at Lake Roosevelt.

Ground-Water Level Fluctuations

In spring of May 2002, water levels were measured in 121 of the previously inventoried wells in order to determine the approximate seasonal fluctuation of water levels within the watershed from autumn to spring. The spring water levels were compared with the autumn water levels measured during the inventory, September-November 2001. Comparisons were made only when both water levels were reported as being static; that is, not pumping or not recently pumped. Only 73 wells have spring and autumn water levels that were static (table 11). For those 73 wells, the difference in water levels ranged from a decline of 12.79 ft in well 36N/38E-29J01 to a rise of 12.31 ft in wells 32N/40E-28G01D1 and 35N/39E-18A01. Most of the wells (82 percent) showed a rise in water level, with a median rise of 2.36 ft in 60 wells. The median decline in water level (13 wells) was 0.5 ft. The median rise in water level for the Upper aquifer unit was 1.94 ft (24 wells) and for the Lower aquifer unit 2.39 ft (17 wells). Although this comparison is useful for estimating the average gain in water levels from autumn to spring, a more thorough evaluation of seasonal water-level changes would require a long-term monthly network that would track both seasonal and long-term changes in the different hydrogeologic units.

Ground-Water Development and Storage

One objective of the study was to evaluate if there are previously unused sources of ground water whose use may have minimal impact on closed streams and to evaluate if there are hydrogeologic units that could be explored in the future for possible use of aquifer storage and recovery. The descriptions of the hydrogeologic units in the previous sections indicate two possible candidates for further consideration and exploration: the Upper outwash aquifer (UA) and the Lower aquifer (LA).

The Upper outwash aquifer, although discontinuous in nature, may be extensive enough in places to yield moderate quantities of ground water to additional production wells. At the time of this study, this aquifer supplies water to many of the production wells for the cities of Colville, Chewelah (Sand Canyon area), Springdale, and the Public Utility District No. 1 of Stevens County (Deer, Jumpoff Joe, and Loon Lakes and Valley). Site-specific studies including test drilling and ground-water flow modeling would be helpful in determining the appropriateness of certain areas for development and the effect on surface water.

The Lower aquifer is another candidate for further exploration as a source for additional pumping. This unit currently provides ground water to high-yield production wells for the cities of Chewelah and Kettle Falls, Northwest Alloys in Addy, and a few farming or irrigation wells. Additional high-yield areas probably exist within the Lower aquifer. The upward vertical head gradients and thick confining unit over much of the Lower aquifer indicate that pumping may at least have a delayed, if not small, effect on the Colville River in places. Long-term monitoring of water levels in Lower aquifer wells, coupled with pumping records, would aid in evaluating the effects of existing pumping from the unit. The effects of additional pumping centers within the Lower aquifer on the Colville River could be evaluated with a ground-water flow model.

Test drilling, water-quality testing, and ground-water flow modeling would aid in evaluating the suitability of various locations for further development.

Aquifer storage and recovery (ASR) involves injecting water into an aquifer through wells or by surface spreading and infiltration, and then pumping it out when needed. The aquifer essentially functions as a water bank. Deposits are made in times of surplus, typically during the rainy season, and withdrawals occur when available water falls short of demand (Washington Department of Ecology, accessed November 14, 2002). In WRIA 59, excess spring runoff (snowmelt) that generally occurs in April may be available for storage. The Upper outwash aquifer and the Lower aquifer may support some level of ASR, but additional site-specific studies would be required to make that determination. The water storage and recovery requirements within the watershed would need to be evaluated in conjunction with an evaluation of possible sites with the appropriate hydrogeologic conditions for a favorable ASR project. The hydrogeologic interpretations from this study would provide much of the initial hydrogeologic information required for such a project. Further considerations and requirements for ASR applications include addressing aquifer vulnerability, potential impairment of existing water rights, chemical compatibility of surface and ground waters, recharge and recovery treatment requirements, system operation, water rights and ownership of water stored for recovery, and environmental impacts (Washington Department of Ecology, accessed November 14, 2002).

GROUND- AND SURFACE-WATER INTERACTIONS

In order to describe the dynamics of the ground- and surface-water interactions in the watershed, streamflow measurements were made to identity stream reaches that either gain flow from or lose flow to the shallow ground-water system. The interactions between the deep and shallow aquifers in the watershed are described using the water-level maps described previously, data from closely spaced wells completed in different hydrogeologic units, and streamflow data presented in the following section.

Streamflow

Historical streamflow records are available for one active USGS streamflow-gaging station (12409000, Colville River at Kettle Falls, Washington) and nine discontinued stations in the Colville River Watershed (table 2). Mean annual discharge for the Colville River at Kettle Falls for 1923-2001 is 309 ft^3/s. Snowmelt is the primary source of runoff in the watershed, with rainfall being of secondary importance, often contributing to peak flows as rain-on-snow events. There is no glacial storage in the basin, and the annual snowpack is entirely melted by mid-July. The mean daily discharge of the Colville River at Kettle Falls (fig. 10) typically reaches its low point by early August and remains low until early October, when autumn rains and decreased irrigation

Table 2. Continuous-record stream-gaging stations in the Colville River Watershed, Stevens County, Washington

[**Map No.**: Location of measurement sites are shown on figure 11. **Water year**: Period from October 1 through September 30, designated by the year in which it ends]

Map No. (see fig. 11)	Station No.	Station name	Period of record (water years)
A	12407000	Sheep Creek at Loon Lake	1950-59
B	12407500	Sheep Creek at Springdale	1953-72
C	12407520	Deer Creek near Valley	1959-72
D	12407700	Chewelah Creek at Chewelah	1957-74
E	12408000	Colville River at Blue Creek	1923-24; 1960-66; 1979
F	12408300	Little Pend Oreille River near Colville	1958-75
G	12408420	Haller Creek near Arden	1959-70
H	12408500	Mill Creek near Colville	1939-72; 1977-86
I	12408700	Mill Creek at mouth, near Colville	1959-65
J	12409000	Colville River at Kettle Falls	1923-present

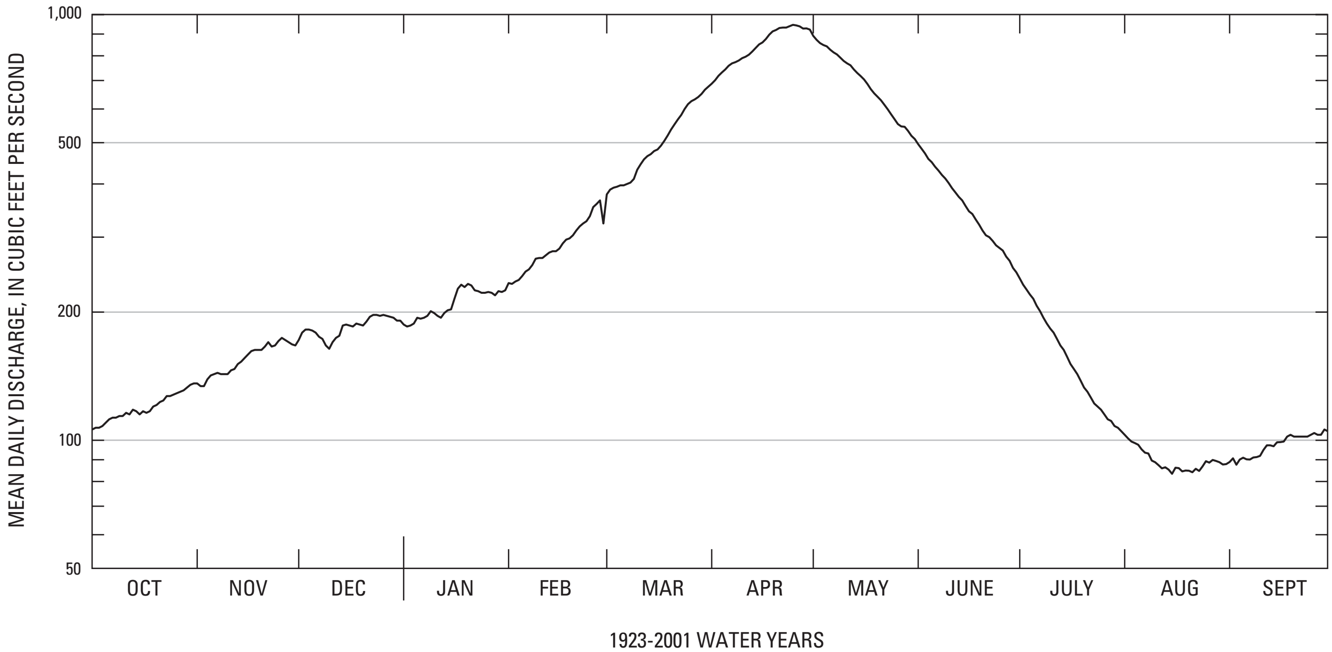


Figure 10. Mean daily discharges for the period of record (1923-2001) for U.S. Geological Survey streamflow-gaging station 12409000, Colville River at Kettle Falls in the Colville River Watershed, Stevens County, Washington.

withdrawals produce a modest rebound. The three largest tributaries by drainage area and runoff volume (Chewelah Creek, Mill Creek, and the Little Pend Oreille River) originate in a range of mountains that define the northeastern-eastern boundary of the drainage basin. The mountains in the western portion of the basin tend to be of lower altitude and somewhat drier.

Synoptic discharge measurements were made at 51 sites along the Colville River and its tributaries to quantify the surface water reaching the Colville Valley floor and to identify gaining and losing reaches over the unconsolidated valley deposits. This information was used to assist in developing a surface-water budget for the critical mid-July to mid-October dry season for the Colville River Watershed. A total of 78 discharge measurements plus three observations of no flow were made during the study (table 3). Some of these measurements were made at active or discontinued stream-gaging station locations, but most of them were made at sites that had not been previously measured (fig. 11).

To identify gaining and losing stream reaches, a low-flow seepage run (a set of discharge measurements representing approximately steady-flow conditions) was conducted during early September 2001, with a few follow-up measurements in early October 2001. The September time frame was chosen because flows are usually near their lows at this time and fluctuation due to precipitation is minimal, allowing for meaningful comparison of measurements. Streamflow and weather conditions were accommodating for this measurement effort: the September 2001 monthly mean flow of 50.9 ft^3/s at gaging station 12409000 was well below the long-term September mean of 97.5 ft^3/s, and no precipitation was measured at Colville during September 4-13 when most of the measurements were made (National Climatic Data Center, 2001).

A second set of measurements was made during April 11-24, 2002, to gather spring freshet high-flow information at some of the tributary locations and all of the Colville River locations measured in September 2001. Although measurements were not made precisely at the peak for each location, the timing was good because the 2002 water year peak flow (1,720 ft^3/s) for station 12409000 occurred on April 15.

Table 3. Miscellaneous discharge measurements made in the Colville River Watershed, Stevens County, Washington, 2001 and 2002

[**Map No.**: Location of measuring sites are shown on figure 11. **Site name:** Site names in **bold** are measurement sites located on the Colville River. All other measurement sites are located on streams tributary to the Colville River. **Abbreviations**: ft^3/s, cubic foot per second; ^oC, degrees Celsius; –, not measured]

Map No.	Site name	Date	Discharge (ft^3/s)	Water temperature (^oC)
B	Sheep Creek at Springdale (station 12407500)	09/04/01	5.55	–
		04/16/02	10.9	6.5
1	Sheep Creek at Forest Center Road, near Springdale	09/04/01	8.02	16.5
		04/16/02	11.9	9
2	Sheep Creek at mouth, near Springdale	09/11/01	6.91	14.5
3	Deer Creek near Springdale	09/05/01	4.66	11
		04/23/02	63.5	5.5
4	Deer Creek at mouth, near Springdale	09/11/01	4.13	13
5	**Colville River at Betteridge Road, near Valley**	09/05/01	12.9	15
		04/17/02	163	5.5
6	Jumpoff Joe Creek near Valley	09/05/01	2.77	15.5
		04/11/02	7.97	9.5
		04/16/02	9.92	10
7	Jumpoff Joe Creek at mouth, near Valley	09/11/01	2.75	18.5
8	Bulldog Creek near Valley	09/11/01	2.84	10
		04/11/02	4.00	9
		08/16/02	4.62	11
9	Bulldog Creek at mouth, at Valley	10/02/01	[1]7.32	–
		08/16/02	[1]7.97	13.5
10	Waitts Creek near Valley	10/02/01	.11	–
11	Waitts Creek at mouth, near Valley	10/02/01	.18	–
12	Huckleberry Creek near Valley	09/05/01	.52	13.5
		04/18/02	106	5
13	Huckleberry Creek at mouth, near Valley	09/11/01	.07	18
14	Cottonwood Creek near Chewelah	09/05/01	2.38	17.5
		04/12/02	46.4	7.5
15	Cottonwood Creek at mouth, near Chewelah	09/11/01	2.71	18
16	Sherwood Creek near Chewelah	09/05/01	.52	13.5
		04/15/02	12.0	4.5
17	Sherwood Creek at mouth, near Chewelah	09/13/01	.42	13
18	Thomason Creek near Chewelah	09/07/01	.89	10.5
		04/15/02	1.73	4.5
19	Thomason Creek at mouth, near Chewelah	09/13/01	.76	12.5
20	North Fork Chewelah Creek near Chewelah	09/07/01	3.73	10
		04/18/02	103	5.5
21	South Fork Chewelah Creek near Chewelah	09/07/01	3.65	10
		04/19/02	36.6	3.5
22	Chewelah Creek at mouth, at Chewelah	09/13/01	7.14	–
23	Paye Creek at Chewelah	09/07/01	3.39	11
		04/15/02	4.37	5.5
24	Paye Creek at mouth, at Chewelah	09/13/01	3.00	–
25	**Colville River at Schmidlekofer Road, at Chewelah**	09/11/01	31.6	14
		04/17/02	757	9
26	Blue Ceek near Blue Creek	09/06/01	.09	10
		04/15/02	2.88	7

Table 3. Miscellaneous discharge measurements made in the Colville River Watershed, Stevens County, Washington, 2001 and 2002 *(Continued)*

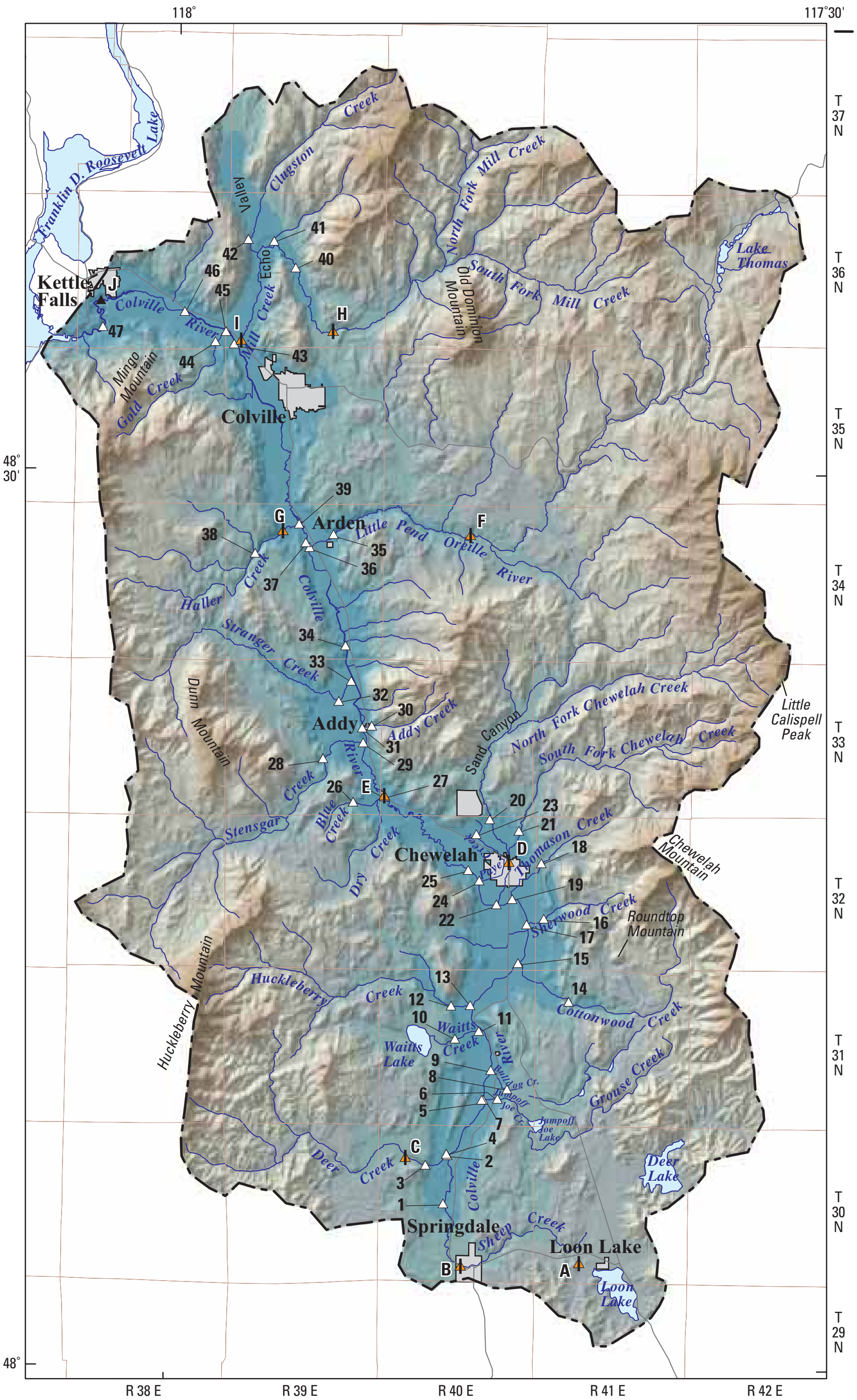
[**Map No.**: Location of measuring sites are shown on figure 11. **Site name:** Site names in **bold** are measurement sites located on the Colville River. All other measurement sites are located on streams tributary to the Colville River. **Abbreviations**: ft^3/s, cubic foot per second; °C, degrees Celsius; –, not measured]

Map No.	Site name	Date	Discharge (ft^3/s)	Water temperature (°C)
27	Blue Creek at mouth, at Blue Creek	09/13/01	0.04	–
E	**Colville River at Blue Creek (station 12408000)**	09/05/01	31.3	17
		04/17/02	707	9
28	Stensgar Creek near Addy	09/06/01	0.32	14
		04/15/02	90.2	5.5
29	Stensgar Creek at mouth, at Addy	09/13/01	.04	–
30	Addy Creek at Addy	09/06//01	.10	12
		04/16/02	11.8	4
31	Addy Creek at mouth, at Addy	09/13/01	.01	–
32	Stranger Creek near Addy	09/06/01	.24	14
		04/16/02	62.1	5
33	Stranger Creek at mouth, near Addy	09/13/01	.04	–
34	**Colville River at 12 Mile Road, near Addy**	09/06/01	30.9	15
		04/15/02	753	8.5
35	Little Pend Oreille River at Arden	09/05/01	13.6	15
		04/24/02	290	4
36	Little Pend Oreille River at mouth, at Arden	09/13/01	9.63	–
37	**Colville River at Arden**	09/05/01	40.6	16
		04/17/02	1,040	7.5
38	Haller Creek below Cole Creek, near Arden	09/06/01	.96	8
		04/12/02	22.3	5
39	Haller Creek at mouth, near Arden	09/13/01	no flow	–
H	Mill Creek near Colville (station 12408500)	09/04/01	4.73	13
		04/24/02	171	3
40	Mill Creek at Douglas Falls, near Colville	09/04/01	3.77	12
		04/24/02	197	5.5
41	Gillette Creek near mouth, near Colville	08/27/01	no flow	–
42	Clugston Creek near mouth, near Colville	09/07/01	.38	14
		04/19/02	3.95	4
43	Mill Creek at mouth, near Colville	09/13/01	6.41	19
44	Gold Creek near Colville	09/07/01	.003	14
		04/16/02	22.2	5
45	Gold Creek at mouth, near Colville	08/27/01	no flow	–
46	**Colville River at Greenwood Loop Road, near Kettle Falls**	09/04/01	46.7	18
		04/15/02	1,630	6.5
J	**Colville River at Kettle Falls (station 12409000)**	09/04/01	[2]46	–
		04/15/02	[2]1,560	–
		08/16/02	[3]61	21
47	**Colville River near mouth, near Kettle Falls**	08/16/02	59.4	23

[1] Includes 0.67 ft^3/s discharge from Lane Mountain Silica Plant.

[2] Daily mean discharge.

[3] Instantaneous discharge at time discharge was measured at Colville River near mouth, near Kettle Falls on August 16, 2002.



EXPLANATION

- - - BOUNDARY OF COLVILLE RIVER WATERSHED

USGS STREAMFLOW-GAGING STATION—Letter designation corresponds to station name

▲ **Continuous-record station**

J Colville River at Kettle Falls (12409000)

Discontinued station

A Sheep Creek at Loon Lake (12407000)
B Sheep Creek at Springdale (12407500)
C Deer Creek near Valley (12407520)
D Chewelah Creek at Chewelah (12407700)
E Colville River at Blue Creek (12408000)
F Little Pend Oreille River near Colville (12408300)
G Haller Creek near Arden (12408420)
H Mill Creek near Colville (12408500)
I Mill Creek at mouth, near Colville (12408700)

△ DISCHARGE-MEASUREMENT SITE —Number designation corresponds to site name

1 Sheep Creek at Forest Center Road, near Springdale
2 Sheep Creek at mouth, near Springdale
3 Deer Creek near Springdale
4 Deer Creek at mouth, near Springdale
5 Colville River at Betteridge Road, near Valley
6 Jumpoff Joe Creek near Valley
7 Jumpoff Joe Creek at mouth, near Valley
8 Bulldog Creek near Valley
9 Bulldog Creek at mouth, at Valley
10 Waitts Creek near Valley
11 Waitts Creek at mouth, near Valley
12 Huckleberry Creek near Valley
13 Huckleberry Creek at mouth, near Valley
14 Cottonwood Creek near Chewelah
15 Cottonwood Creek at mouth, near Chewelah
16 Sherwood Creek near Chewelah
17 Sherwood Creek at mouth, near Chewelah
18 Thomason Creek near Chewelah
19 Thomason Creek at mouth, near Chewelah
20 North Fork Chewelah Creek near Chewelah
21 South Fork Chewelah Creek near Chewelah
22 Chewelah Creek at mouth, at Chewelah
23 Paye Creek near Chewelah
24 Paye Creek at mouth, at Chewelah
25 Colville River at Schmidlekofer Road, at Chewelah
26 Blue Creek near Blue Creek
27 Blue Creek at mouth, at Blue Creek
28 Stensgar Creek near Addy
29 Stensgar Creek at mouth, at Addy
30 Addy Creek at Addy
31 Addy Creek at mouth, at Addy
32 Stranger Creek near Addy
33 Stranger Creek at mouth, near Addy
34 Colville River at 12 Mile Road, near Addy
35 Little Pend Oreille River at Arden
36 Little Pend Oreille River at mouth, at Arden
37 Colville River at Arden
38 Haller Creek below Cole Creek, near Arden
39 Haller Creek at mouth, near Arden
40 Mill Creek at Douglas Falls, near Colville
41 Gillette Creek near mouth, near Colville
42 Clugston Creek near mouth, near Colville
43 Mill Creek at mouth, near Colville
44 Gold Creek near Colville
45 Gold Creek at mouth, near Colville
46 Colville River at Greenwood Loop Road, near Kettle Falls
47 Colville River near mouth, near Kettle Falls

0 5 10 MILES
0 5 10 15 KILOMETERS

Figure 11. Locations of U.S. Geological Survey continuous-record streamflow-gaging stations and other sites at which measurements of stream discharge were made during 2001-02 in the Colville River Watershed, Stevens County, Washington.

A few additional measurements were made on August 16, 2002: a pair of measurements on Bulldog Creek at the edge of the Colville River Valley and at the mouth of the creek, and a single measurement near the mouth of the Colville River.

All discharge measurements were made by personnel from the Stevens County Conservation District (SCCD) and the USGS. Coordination between the two agencies ensured that the field methods used met USGS standards. SCCD personnel made most of the measurements on the Colville River and on the tributary sites near the edges of the valley. The USGS made the measurements near the mouth of each tributary. All discharge measurements were made with Price AA or pygmy streamflow velocity meters except for the measurement of 0.003 ft^3/s at Gold Creek near Colville on September 7, 2001, which was made using the volumetric method. USGS streamflow-measurement techniques used in the study are documented in Buchanan and Somers (1969) and Rantz and others (1982).

Estimates of withdrawals from and discharges to the Colville River, corresponding with the synoptic low-flow measurement period, were made in order to include the amounts in the Colville River surface-water budget. The WRIA 59 Watershed Planning Team provided Stimson Lumber Mill's reported estimates of surface-water withdrawal from the Colville River for industrial use (Linda Kiefer, written commun., February 2003). The estimated withdrawal was 0.7 ft^3/s for 8 hours each day during the period of the synoptic low-flow measurements. The surface-water budget based on the synoptic measurements was adjusted to account for this 0.7 ft^3/s withdrawal plus an additional estimated withdrawal of 0.91 ft^3/s from the Colville River for irrigation of 41 acres between Chewelah and the mouth of the Colville River (Linda Kiefer, written commun., February 2003) and for a City of Colville sewage facility discharge of 0.87 ft^3/s into the Colville River (Harlan Elsasser, City of Colville, oral commun., February 2003). There was a reported discharge of 0.67 ft^3/s by the Lane Mountain Silica Plant into Bulldog Creek, which is included in the flow measured at the mouth of Bulldog Creek. Adjustments for evaporation or transpiration were not made.

A total of 52.9 ft^3/s of tributary flow was measured at 21 sites at or near the sides of the Colville Valley during the September-October 2001 low-flow seepage run. The average discharge leaving the valley from September 4 to 11, 2001, when most of the tributary flow measurements were made, was 47.2 ft^3/s, as measured at station 12409000. The difference, 5.7 ft^3/s or 11.3 acre-ft/d, represents a loss of 10.8 percent of the flow reaching the valley floor. This is the amount of flow reaching the valley floor that did not show up as outflow from the basin as measured at the gaging station. Losses are likely attributable to evapotranspiration and movement of water into the shallow ground-water system and, to a lesser extent, surface-water diversions.

The Colville River surface-water budget developed from the low-flow measurements is detailed in table 4. The net gain or loss between each consecutive pair of discharge measurements along the Colville River was calculated as the difference between the sum of the upstream Colville discharge plus the intervening tributary discharge(s) and the downstream Colville River discharge. A 16.8-percent (1.86 ft^3/s) gain in discharge is observed between the confluence of Sheep and Deer Creeks and the Colville River at Betteridge Road near Valley. A 15.2-percent (5.65 ft^3/s) loss in discharge is noted between measurements made at Betteridge Road near Valley and Schmidlekofer Road at Chewelah. The Colville River was measured at five additional locations downstream from Schmidlekofer Road, including gaging station 12409000, and no gains or losses exceeding 2.5 percent were observed between consecutive locations. A second, separate analysis was made of the reach of the Colville River between Schmidlekofer Road and Kettle Falls because the information provided on agricultural irrigation did not identify where withdrawals occurred. A 2.2-percent (1.03 ft^3/s) loss was observed in this reach (see bottom of table 4). An additional measurement made August 16, 2002, at Colville River near the mouth was 2.6 percent (1.60 ft^3/s) less than the flow computed simultaneously at the gaging station. This was within the accuracy limits of the measurement and indicates that no significant flow was bypassing the gaging station.

Table 4. Surface-water budget for the Colville River based on discharge measurements made during the September-October 2001 seepage run, Colville River Watershed, Stevens County, Washington

[**Map No.**: Location of measuring sites are shown on figure 11. **Site name:** Site names in **bold** are measurement sites located on the Colville River. All other measurement sites are located on streams tributary to the Colville River. **Abbreviations:** ft^3/s, cubic foot per second]

Map No.	Site name	Date	Discharge (ft^3/s)	Cumulative tributary inflow to Colville River between consecutive Colville River measurement locations (ft^3/s)	Net gain or loss between consecutive Colville River measurement locations	
					(ft^3/s)	(percent)
2	Sheep Creek at mouth, near Springdale	09/11/01	6.91			
4	Deer Creek at mouth, near Springdale	09/11/01	4.13	11.04		
5	**Colville River at Betteridge Road, near Valley**	09/05/01	12.9		1.86	16.8
7	Jumpoff Joe Creek at mouth, near Valley	09/11/01	2.75			
9	Bulldog Creek at mouth, at Valley	10/02/01	[1]7.32			
11	Waitts Creek at mouth, near Valley	10/02/01	.18			
13	Huckleberry Creek at mouth, near Valley	09/11/01	.07			
15	Cottonwood Creek at mouth, near Chewelah	09/11/01	2.71			
17	Sherwood Creek at mouth, near Chewelah	09/13/01	.42			
19	Thomason Creek at mouth, near Chewelah	09/13/01	.76			
22	Chewelah Creek at mouth, at Chewelah	09/13/01	7.14			
24	Paye Creek at mouth, at Chewelah	09/13/01	3.00	24.35		
25	**Colville River at Schmidlekofer Road, at Chewelah**	09/11/01	31.6		-5.65	-15.2
27	Blue Creek at mouth, at Blue Creek	09/13/01	.04	.04		
E	**Colville River at Blue Creek (station 12408000)**	09/05/01	31.3		-.34	-1.1
29	Stensgar Creek at mouth, at Addy	09/13/01	.04			
31	Addy Creek at mouth, at Addy	09/13/01	.01			
33	Stranger Creek at mouth, near Addy	09/13/01	.04	.09		
34	**Colville River at 12 Mile Road, near Addy**	09/06/01	30.9		-.49	-1.6
36	Little Pend Oreille River at mouth, at Arden	09/13/01	9.63	9.63		
37	**Colville River at Arden**	09/05/01	40.6		[2].77	1.9
39	Haller Creek at mouth, near Arden	09/13/01	no flow			
43	Mill Creek at mouth, near Colville	09/13/01	6.41			
45	Gold Creek at mouth, near Colville	08/27/01	no flow	6.41		
46	**Colville River at Greenwood Loop, near Kettle Falls**	09/04/01	46.7		[3]-1.18	-2.5
J	**Colville River at Kettle Falls (station 12409000)**	09/04/01	[4]46		-.70	-1.5
	Analysis for the reach of the Colville River between Schmidlekofer Road and Kettle Falls					
25	**Colville River at Schmidlekofer Road, at Chewelah**	09/11/01	31.6	16.17		
J	**Colville River at Kettle Falls (station 12409000)**	09/04/01	[4]46		[5]-1.03	-2.2

[1] Includes 0.67 ft^3/s discharge from Lane Mountain Silica Plant.
[2] Adjusted for estimated surface-water withdrawal of 0.7 ft^3/s by Stimson Lumber Mill.
[3] Adjusted for discharge of 0.87 ft^3/s from City of Colville sewage treatment facility.
[4] Daily mean discharge.
[5] Adjusted for estimated surface-water withdrawal of 0.7 ft^3/s by Stimson Lumber Mill, estimated surface-water withdrawal of 0.91 ft^3/s for irrigation of 41 acres, and discharge of 0.87 ft^3/s from City of Colville sewage treatment facility.

The net gain or loss in flow per unit length of channel also was estimated for the individual channel reaches of the Colville River (table 5). The 1.86 ft^3/s gain in the 2.8-mile reach from the confluence of Sheep and Deer Creeks to Betteridge Road indicates a net gain per unit of channel length of 0.66 $(ft^3/s)/mi$. The 5.65 ft^3/s loss from Betteridge Road to Schmidlekofer Road, a 12.1-mile reach, results in a 0.47 $(ft^3/s)/mi$ net loss per unit of channel length. The gains and losses per unit of channel length for the remaining downstream reaches range from a gain of 0.16 $(ft^3/s)/mi$ to a loss of 0.18 $(ft^3/s)/mi$. Analysis of the reach between Schmidlekofer Road and gaging station 12409000 showed a loss of 1.03 ft^3/s over 35.3 mi, a net loss of 0.03 $(ft^3/s)/mi$ per unit of channel length.

The results of the September-October 2001 low-flow seepage run represent conditions at only one point in time, therefore they should not be assumed to be representative of other periods. This is clearly evident when the results of the seepage run are compared with seepage-run data that were collected by the USGS on many of the same streams during the 1960 and 1961 water years as part of an unpublished investigation of the surface-water resources of Stevens County, conducted in cooperation with the Stevens County Public Utility District No. 1 (Richard C.R. Price, Public Utility District No. 1 of Stevens County, written commun., February 2003). Seepage runs were made in both August and September of the 1960 and 1961 water years.

The September-October 2001 measurements were made near the end of a period of significant drought. The total precipitation in 2001 at most northeastern Washington precipitation gages was only about 50 percent of the long-term average annual amounts. A comparison of hydrographs of the mean daily discharges for the period of record for gaging station 12409000 (1923-2001) and the daily mean discharges for the 2001 water year clearly shows that flows during most of the 2001 water year were significantly below long-term average flows. In contrast, hydrographs for the 1960 and 1961 water years indicate that flows in those years, especially during the spring and early summer months, were significantly higher than average flows. This is consistent with statements in the unpublished reports of the measurements made in 1960 and 1961 that the spring was unusually wet during those water years.

Table 5. Net gain or loss between consecutive Colville River discharge measurement locations during the September-October 2001 seepage run, Colville River Watershed, Stevens County, Washington

[ft^3/s, cubic foot per second; mi, mile; $(ft^3/s)/mi$, cubic foot per second per mile]

Reach of Colville River (from upstream to downstream end)	Net gain or loss (ft^3/s)	Channel length (mi)	Net gain or loss per unit channel length [$(ft^3/s)/mi$]
Confluence of Sheep and Deer Creeks to Colville River at Betteridge Road	1.86	2.8	0.66
Betteridge Road to Schmidlekofer Road	-5.65	12.1	-.47
Schmidlekofer Road to Blue Creek bridge	-.34	6.7	-.05
Blue Creek bridge to 12 Mile Road	-.49	6.9	-.07
12 Mile Road to Arden (junction of Little Pend Oreille River and Colville River)	[1].77	4.7	.16
Arden to Greenwood Loop Road	[2]-1.18	13.0	-.09
Greenwood Loop Road to Colville River at Kettle Falls gaging station (12409000)	-.70	4.0	-.18
Schmidlekofer Road to Colville River at Kettle Falls gaging station (12409000)	[3]-1.03	35.3	-.03

[1] Adjusted for estimated surface-water withdrawal of 0.7 ft^3/s by Stimson Lumber Mill.

[2] Adjusted for discharge of 0.87 ft^3/s from City of Colville sewage treatment facility.

[3] Adjusted for estimated surface-water withdrawal of 0.7 ft^3/s by Stimson Lumber Mill, estimated surface-water withdrawal of 0.91 ft^3/s for irrigation of 41 acres, and discharge of 0.87 ft^3/s from City of Colville sewage treatment facility.

The low flows measured during the 1960 and 1961 water years, when precipitation was above normal, are significantly higher than those measured during the 2001 water year, a drought year. Most flows measured during the 1960 and 1961 water years are at least twice as high as those measured at about the same locations during the 2001 water year. Most of the reaches between consecutive Colville River sites during the 1960 and 1961 water years gained significant amounts of flow, ranging from about 4 to 13 ft^3/s, whereas most during the 2001 water year lost small amounts of flow. One of the most significant differences in the two sets of data is for the reach of the Colville River from Betteridge Road to Schmidlekofer Road. Whereas the flow in that reach increased by amounts ranging from about 8 to 13 ft^3/s during 1960 and 1961, the flow in that reach decreased by 5.65 ft^3/s in 2001.

A comparison of the data collected between a Colville River site between Haller and Mill Creeks and the Colville River at station 12409000 during the 1960 and 1961 water years indicates how quickly flow conditions can change in the basin. The measurements made in August of those years indicated gains of 6 to 7 ft^3/s in that reach, whereas those made in September of those years indicated losses of about 10 ft^3/s in that reach. Another interesting observation is that of the six locations where the discharge of the Colville River was measured, the flows measured in September of each year were higher than those measured in August of the same year except for those measured at station 12409000, which were lower than those measured in August.

An analysis of the 2001 data, similar to that done for the Colville River reaches, was done to determine net gain or loss of most tributaries across the unconsolidated material of the valley floor (table 6). Net gain or loss per unit of channel length was less than 0.50 $(ft^3/s)/mi$ for most of the tributaries. Two tributaries, Bulldog Creek and Little Pend Oreille River, had relatively high values of 3.67 $(ft^3/s)/mi$ and -3.31 $(ft^3/s)/mi$, respectively. The sum of the net gain or loss for all tributaries across the valley floor was only 1.09 ft^3/s, or 2.1 percent of flow measured at the valley's edge. If the 0.67 ft^3/s gain at Bulldog Creek attributed to discharge from the Lane Mountain Silica plant is excluded, the sum of the net gain or loss is 0.42 ft^3/s, or 0.8 percent of the flow measured at the valley's edge. In either case, the difference is less than the ±5-percent accuracy for the measurement totals at both the edge of the valley and the tributary mouths.

Peak flows for the tributaries were not determined during this study, but a measurement was made on each major tributary during the spring freshet of 2002. These measurements are listed for comparison with the peaks of record for the seven streams that have historical record (table 7). Unit discharges (table 7) computed from the peaks of record can provide insight into the effects of elevation, topography, precipitation, land cover, and storage within a subbasin. The unit discharge for the peak of record on the Colville River at the Kettle Falls gaging station (station 12409000) is 3.42 $(ft^3/s)/mi^2$. Sheep Creek and Deer Creek, the two source streams for the Colville River, have the lowest and highest unit discharges of the seven streams for which a period of continuous record exists. The low unit discharge for Sheep Creek [1.70 $(ft^3/s)/mi^2$] probably is explained primarily by natural storage in Deer Lake and Loon Lake and their underlying aquifer. Deer Creek, a relatively small tributary basin of 36 mi^2, has the highest unit discharge at 12.6 $(ft^3/s)/mi^2$, indicating very little storage in the basin. The Little Pend Oreille River and Mill Creek, the largest and third largest tributary basins respectively, both have unit discharges that exceed 8 $(ft^3/s)/mi^2$. Both basins appear to have ground-water storage capacity, and the Little Pend Oreille has several small lakes capable of temporary natural storage. However, the accumulation of snowpack in the upper altitudes in these tributaries, located in the northern portion of the Colville River Watershed, can be sufficient to produce unit discharges more than twice that for the Colville River. The low unit discharge for the Colville River indicates that flooding is not a major problem in the Colville Valley, but local flooding at the mouths or in tributary basins occurs infrequently, and often is the result of rain-on-snow events.

Table 6. Net gain or loss of tributary flow across Colville Valley floor based on discharge measurements made during the September-October 2001 seepage run, Colville River Watershed, Stevens County, Washington

[ft^3/s, cubic foot per second; mi, mile; (ft^3/s)/mi, cubic foot per second per mile]

Stream reach	Net gain or loss (ft^3/s)	Channel length (mi)	Net gain or loss per unit channel length [(ft^3/s)/mi)]
Sheep Creek, Springdale to Forest Center Road	2.47	3.7	0.67
Forest Center Road to mouth	-1.11	2.52	-.44
Deer Creek, edge of valley to mouth	-.53	1.11	-.48
Jumpoff Joe Creek, edge of valley to mouth	-.02	.58	-.03
Bulldog Creek, edge of valley to mouth	[1]4.48	1.22	3.67
Waitts Creek, edge of valley to mouth	.07	1.14	.06
Huckleberry Creek, edge of valley to mouth	-.45	.85	-.53
Cottonwood Creek, edge of valley to mouth	.33	2.88	.11
Sherwood Creek, edge of valley to mouth	-.10	.81	-.12
Thomason Creek, edge of valley to mouth	-.13	2.22	-.06
North Fork Chewelah Creek, edge of valley to mouth	[2]-.24	4.35	-.06
Paye Creek, edge of valley to mouth	-.39	3.2	-.12
Blue Creek, edge of valley to mouth	-.05	1.53	-.03
Stensgar Creek, edge of valley to mouth	-.28	2.4	-.12
Addy Creek, edge of valley to mouth	-.09	.47	-.19
Stranger Creek, edge of valley to mouth	-.20	1.71	-.12
Little Pend Oreille River, edge of valley to mouth	-3.97	1.2	-3.31
Haller Creek, edge of valley to mouth	-.96	2.29	-.42
Mill Creek, from station 12408500 to Douglas Falls	-.96	2.74	-.35
From Douglas Falls to mouth	[3]2.26	6.37	.35
Gold Creek, edge of valley to mouth	-.003	.3	-.01
Net gain from all tributaries measured	[4]1.087		

[1] Includes 0.67 ft^3/s discharge from Lane Mountain Silica Plant.
[2] Includes discharge from South Fork Chewelah Creek.
[3] Includes discharge from Clugston Creek.
[4] Loss from Mill Creek gaging station 12408500 to Douglas Falls not included in net gain.

Table 7. High-flow discharge measurements made in the Colville River Watershed, Stevens County, Washington, April 2002

[**Station No.**: Number of nearest U.S. Geological Survey streamflow-gaging station. **Abbreviations**: ft^3/s, cubic foot per second; mi^2, square mile; $(ft^3/s)/mi^2$, cubic foot per second per square mile]

Site name	Date	Discharge (ft^3/s)	Historical peak discharges at streamflow-gaging stations				
			Station No.	Date	Peak discharge (ft^3/s)	Drainage area (mi^2)	Unit discharge [$(ft^3/s)/mi^2$]
Sheep Creek at Forest Center Road near Springdale[1]	4/16/02	11.9	12407500	04/08/69	82	48.2	1.70
Deer Creek near Springdale[2]	4/23/02	63.5	12407520	01/16/74	454	36.0	12.6
Chewelah Creek[3] (sum of North Fork and South Fork)	4/18-19/02	140	12407700	01/17/74	392	94.1	4.17
Little Pend Oreille River at Arden[4]	4/24/02	290	12408300	05/10/61	1,060	132	8.03
Mill Creek near Colville[5]	4/24/02	171	12408500	04/24/69	694	83.0	8.36
Haller Creek below Cole Creek near Arden[6]	4/12/02	22.3	12408420	03/29/60	148	37.0	4.00
Colville River at Kettle Falls[7]	4/15/02	[8]1,720	12409000	01/21/74	3,440	1,007	3.42

[1]Located about 3.7 miles downstream from discontinued gaging station 12407500.
[2]Located about 0.9 mile downstream from discontinued gaging station 12407520.
[3]Located about 1.9 and 1.4 miles upstream from discontinued gaging station 12407700, respectively.
[4]Located about 5.8 miles downstream from discontinued gaging station 12408300.
[5]Located at discontinued gaging station 12408500.
[6]Located about 1.6 miles upstream from discontinued gaging station 12408420.
[7]Located at currently operating gaging station 12409000.
[8] Recorded annual peak discharge.

Interactions Between Ground and Surface Water and Between the Deep and Shallow Aquifers

The streamflow data presented in the previous section indicate that there is considerable interaction between the near-surface hydrogeologic units and the surface water of the basin. Gaining and losing stream reaches vary from month to month and from year to year. During the low-flow measurements made during this investigation, discharge increased from the confluence of Sheep and Deer Creeks to the Colville River near Valley and discharge decreased from Valley to Chewelah. At five measurement sites from Chewelah to the gage at Kettle Falls (station 12409000), discharge generally decreased, but was small. These data indicate that during September 2001, the Colville River gained flow from the shallow ground-water system near its headwaters and lost flow to the shallow ground-water system from Valley to Chewelah. Downstream from Chewelah, the river generally lost flow, but amounts were small and possibly within measurement error. In September 1960 and 1961, however, most reaches measured on the Colville River gained flow from the shallow system. Although the interactions of the shallow ground- and surface-water systems are important, the variability over space and time is not well understood. A more complete understanding of the shallow ground- and surface-water system could be gained by studying the interactions between the Colville River and the shallow ground water by monitoring water levels in the river and in nearby shallow wells or piezometers at different times during the year.

The interactions between the deep and shallow aquifers of the basin can be inferred using data from closely spaced wells completed in different hydrogeologic units, and streamflow data. It appears that the Lower aquifer and the shallow part of the Colville Valley confining unit, which includes shallow and discontinuous aquifer material in places, may act as fairly independent systems. Ground-water levels indicate that there are upward head gradients in the Lower aquifer, from about 3 mi north of Springdale to the mouth of Echo Valley. However, most reaches on the Colville River and paired locations on the tributaries lost water to the ground-water system in

September 2001, perhaps to shallow and discontinuous lenses within the Colville Valley confining unit or to the Upper outwash aquifer along the margins of the valley. There may be some connection with the losing stream reaches and the Lower aquifer near the edges of the valley where the Colville Valley confining unit is thinner or possibly absent.

WATER QUANTITY

Surface- and ground-water withdrawals, recharge to the ground-water system, and an approximate water budget of the Colville River Watershed were estimated in order to assist the WRIA 59 Colville River Watershed Planning Team in addressing water-quantity issues set forth in the Watershed Management Act (HB 2514). A comprehensive water-use and water-right inventory was conducted by the Planning Team in order to quantify the amount of water being used or appropriated in the Colville River Watershed (Linda Kiefer, written commun., March 2002). Results of the water-use inventory are included in Appendix 1, as reported by the Planning Team. The results of the water-use survey are summarized in this report for comparison with the overall water budget for the watershed.

Surface- and Ground-Water Withdrawals

Water is withdrawn from surface- and ground-water sources within the study basin for public and domestic supply and for commercial, industrial, irrigation, and livestock uses. The water-use data will be compared with overall precipitation, or inflow to the watershed, in the section "Estimated Water Budget."

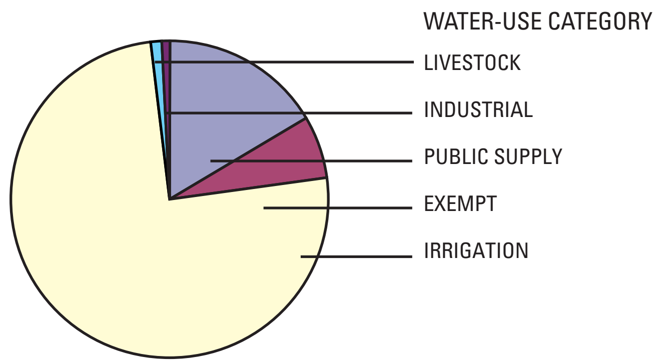
Total surface- and ground-water withdrawals during 2001 were estimated to be 9,340 Mgal, or 28,700 acre-ft (table 8). Surface water supplied 65 percent of the total estimated withdrawals for the study basin, and ground water supplied 35 percent. There were 4,243 water rights and claims registered at the Washington Department of Ecology for the study basin in 2001 for an estimated 36,680 Mgal of water (Appendix 1*A*).

Return flow to the Colville River from municipal wastewater treatment plants during 2001 was estimated to be 386 Mgal. Return flow from the Colville Fish Hatchery to a small stream adjacent to the hatchery was reported to be 186 Mgal. Seasonal spray irrigation of municipal wastewater in the study basin was estimated to be 5.89 Mgal during 2001 (some portion of this is lost through evapotranspiration). Return flow to the ground-water system through septic systems was estimated to be 258 Mgal. The total return flow to ground- and surface-water systems for 2001 was approximately 830 Mgal or 2,600 acre-ft (Appendix 1*B*), or 9 percent of the total estimated water use for the watershed (9,340 Mgal or 28,700 acre-ft).

Table 8. Water-use categories and withdrawals, Colville River Watershed, Stevens County, Washington, 2001

[**Water-use category:** Data are provided in Appendix 1. Values may not add up to totals due to rounding. **Abbreviations:** Mgal, million gallons; acre-ft, acre-foot]

Water-use category	Total for 2001		Percentage of total
	Mgal	acre-ft	
Public supply	1,520	4,670	16.3
Exempt	610	1,870	6.5
Irrigation	7,030	21,600	75.3
Livestock	101	310	1.08
Industrial	77.8	239	.83
Total	9,340	28,700	100



Irrigation accounted for 75.3 percent (7,030 Mgal or 21,600 acre-ft) of the total water used in the study basin (Appendix 1*C*). Surface-water sources provided 87 percent of the total irrigation withdrawals. Irrigation withdrawals were based on the total estimated number of irrigated acres in the study basin (7,190 acres) and an estimated application rate (3 acre-ft/yr). Crops grown in the Colville River Watershed (predominately alfalfa grass and small grains, with minor amounts of corn and potatoes) generally require 2 acre-ft/yr. However, with an efficiency estimate of 70 percent for the irrigation systems in the area, 3 acre-ft/yr was used to estimate total irrigation withdrawals.

Water withdrawn for public supply accounted for 16.3 percent (1,520 Mgal or 4,670 acre-ft) of the total water used in the study basin (Appendix 1*D*). Public withdrawals are supplied by ground-water sources. A few group A water systems rely on surface-water sources for seasonal and emergency uses. Public-supply withdrawals were derived from reported and estimated water-use data. Water-use estimates for unreported water systems were based on the average daily water use per home (1998-2001) from several representative public water systems, multiplied by the number of connections for each water system from the 2001 Washington Department of Health records. Water-use estimates for systems that included non-residential connections were based on non-residential water demand values provided by Washington Department of Health.

Water withdrawn from exempt wells (private wells or springs) accounted for 6.5 percent (610 Mgal or 1,870 acre-ft) of the total water used in the study basin (Appendix 1*E*). Exempt wells are supplied by ground-water sources. Exempt-well withdrawal estimates were based on information from the 2000 U.S. Bureau of Census on population and the average household size in the study basin. The total estimated number of exempt wells in the study basin (2,969 wells) was based on the total estimated number of residents using exempt wells (7,954 residents) and the average household size (2.68 persons). Water withdrawal estimates for homes with exempt wells were determined by multiplying the number of exempt wells by the average daily water use per home (1998-2001) in the study area.

Industrial and livestock withdrawals each accounted for about 1 percent (77.8 and 101 Mgal or 239 and 310 acre-ft, respectively) of the total water used in the study area (Appendix 1*F* and 1G) . Industrial withdrawal records were provided by users in the study area. Livestock withdrawals were based on the number of animals, provided by the Washington State University Extension Office, multiplied by species-specific water-use amounts provided by the Natural Resource Conservation Service.

Ground-Water Recharge

In order to estimate the average annual ground-water recharge in the Colville River Watershed, the PULSE computer model (Rutledge, 1997) was used to analyze streamflow data for six subbasins and the entire watershed based on the availability of long-term streamflow data collected at USGS gaging stations. The resulting recharge estimates provide an indication of the variability of the recharge within the watershed.

The PULSE computer model uses measured streamflow data and analytical equations to simulate a hydrograph of ground-water discharged to a stream. The user of the model calibrates the model by adjusting recharge values until estimated ground-water discharge approximates streamflow for those periods where the primary source of water in the stream is baseflow. General assumptions for the successful application of the model include: all, or most, ground water in the basin should discharge to a stream, except for minor losses to evapotranspiration or flow to deeper aquifer systems; the flow system should be dominated by rainfall rather than snowmelt runoff; the effects on streamflow from wetlands, extensive losing reaches of the stream, ground-water evapotranspiration, or ground-water withdrawals should be minimal; rain should fall uniformly over the basin, leading to uniform distribution of recharge; no more than a negligible amount of flow regulation or diversion of the modeled stream should occur; and the drainage area of the basin should not be greater than 500 mi^2. For additional details on the application, assumptions, and limitations of the PULSE computer model, the reader is referred to Rutledge (1997).

Data required to run PULSE for a basin are drainage area, daily streamflow values, and the recession index. The recession index, in days per log cycle, is found by identifying periods of linear recession on a streamflow hydrograph plotted on semi-log paper and determining the number of days per log cycle. Depending on the number and duration of periods of streamflow recession, the median value of a range of recession indexes may be used.

In this study, PULSE was applied to streamflow records for six subbasins in the Colville River Watershed: Sheep, Deer, Haller, Mill, and Chewelah Creeks and the Little Pend Oreille River, and also for the entire watershed (fig. 12).

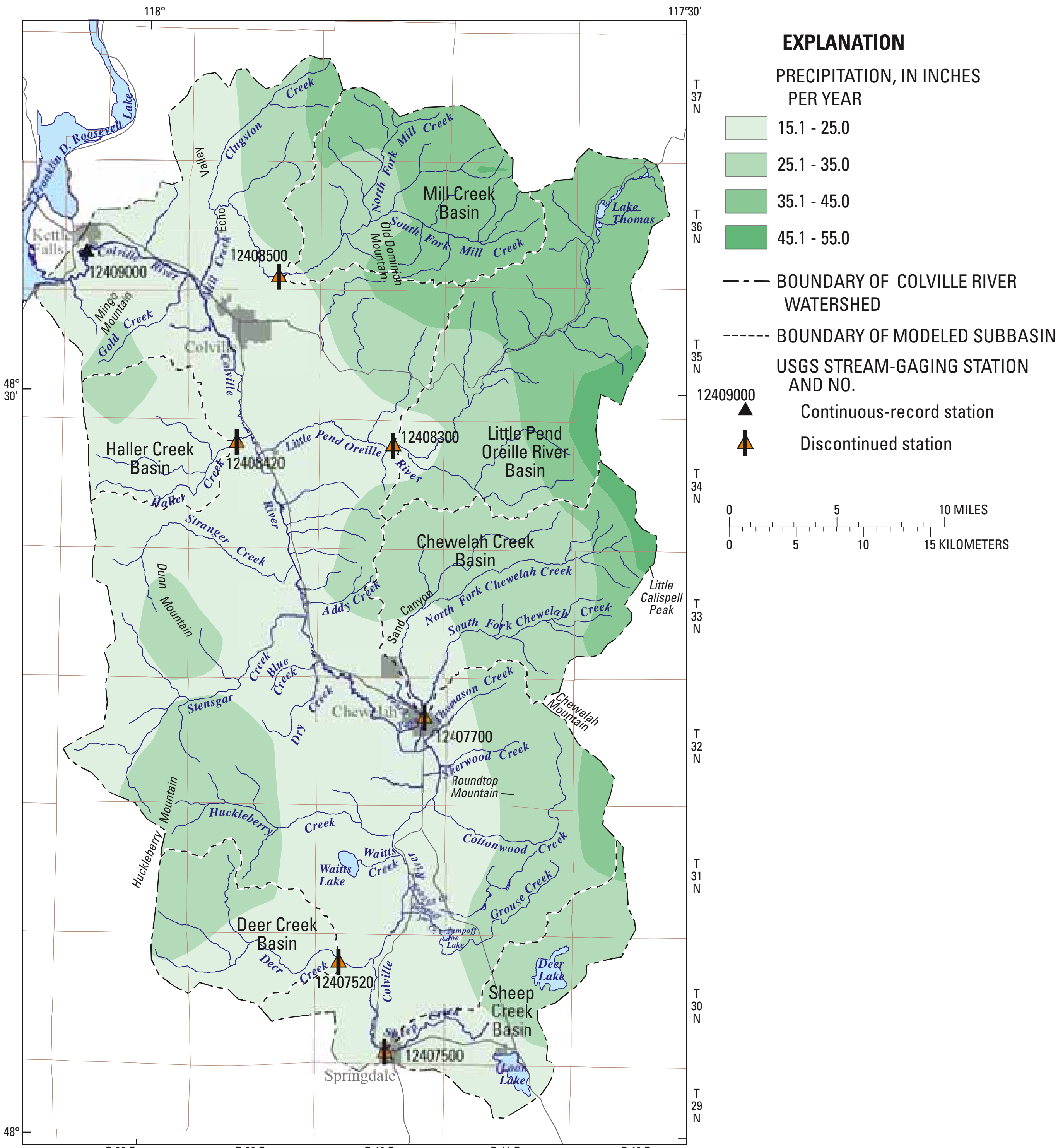


Figure 12. Modeled subbasins, distribution of long-term (1961-90) precipitation, and streamflow-gaging stations with data used to estimate recharge in the Colville River Watershed, Stevens County, Washington.

Drainage areas and streamflow records were downloaded from the USGS web page Water Resources Data for Washington (http://wa.water.usgs.gov/realtime/historical.html) for the period of record for the entire study area and for the six subbasins. Mean annual discharge was computed for the study area and for each of the subbasins, and the year with the annual discharge most closely matching the mean value was chosen for use with the PULSE model.

For the study area and each of the subbasins, the daily mean discharges were plotted on semi-log graphs and the recession indexes obtained from those plots. Input data files consisting of drainage area and the recession index were created, and model-generated daily streamflows were computed for each modeled basin. After the initial model runs, the hydrographs of model-generated ground-water discharge were plotted alongside the daily-values hydrograph. The two hydrographs were compared and new values of recharge were specified in the appropriate input data file to obtain additional model results. This process continued until the model-generated hydrograph matched, as closely as possible, the measured daily-values hydrograph for those days where streamflow was composed primarily of ground-water discharge (fig. 13).

Recharge estimates for the six subbasins were: Haller Creek Basin, 1.6 in./yr; Sheep Creek Basin, 2.3 in./yr; Chewelah Creek Basin, 4.2 in./yr; Deer Creek Basin, 4.5 in./yr; Little Pend Oreille River Basin, 4.2 in./yr; and Mill Creek Basin, 5.0 in./yr (table 9). In general, the higher recharge values are for basins with higher precipitation (fig. 12). However, other characteristics, such as land cover, soil type, subsurface geologic materials, or basin slope, may be as important as precipitation in determining the amount of recharge for a basin. For example, the estimated recharge in the Sheep Creek Basin, which has areas of relatively high precipitation, is lower than recharge estimated for Deer Creek, a basin with lower precipitation. Subsurface geologic material underlying the Sheep Creek drainage (station 12407500) is more permeable than subsurface geologic material underlying the Deer Creek gaging station (12407520). Because some of the water from precipitation likely bypasses the Sheep Creek gaging station as underflow, streamflow would be underestimated during low-flow periods, resulting in an underestimate of ground-water discharge to streams, which the model computes from recharge. The PULSE model does not directly use these characteristics, including precipitation, but these variables affect PULSE simulations by how they affect surface runoff and recharge and, subsequently, streamflow.

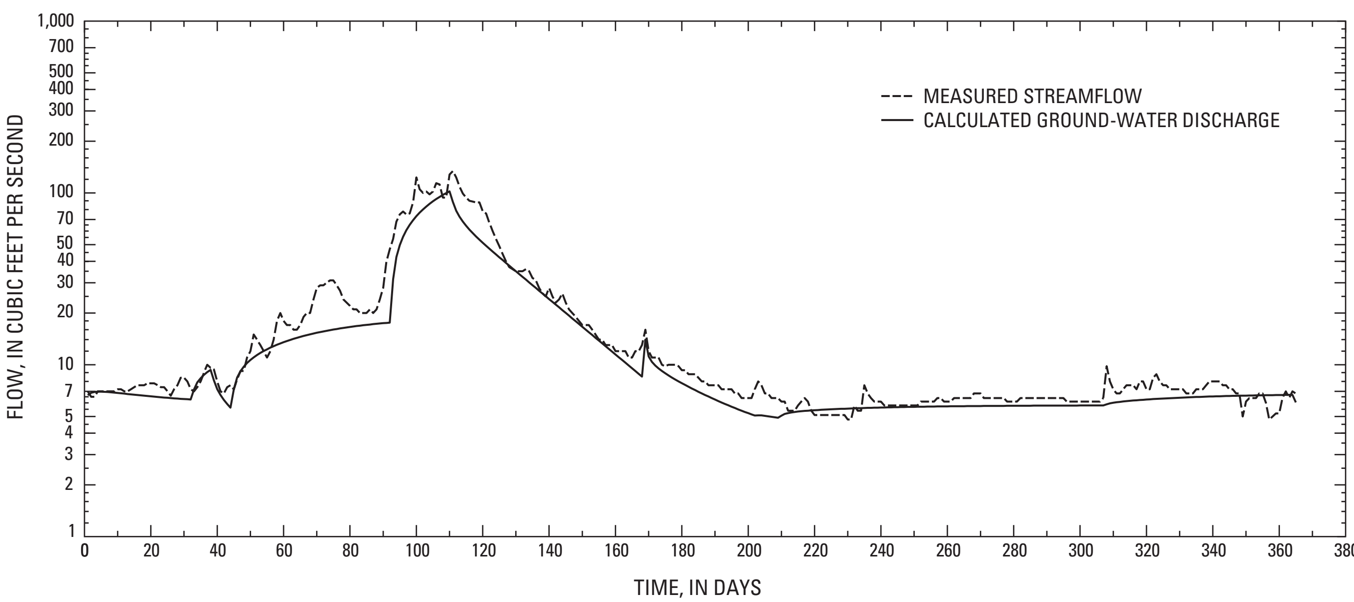


Figure 13. Comparison of measured streamflow and ground-water discharge calculated by the PULSE computer model for U.S. Geological Survey streamflow-gaging station 12407520, Deer Creek near Valley, Washington, from January 1, 1965, through December 31, 1965.

Table 9. Annual recharge estimated by the PULSE model for the Colville River Watershed and for selected subbasins, Washington

[**Station No.:** U.S. Geological Survey streamflow-gaging station No. **Water year:** Period from October 1 through September 30, designated by the year in which it ends. **Abbreviations**: mi^2, square mile; in., inch]

Stream	Station No.	Drainage area (mi^2)	Period of record (water years)	Estimated annual recharge (in.)
Subbasin				
Sheep Creek at Springdale	12407500	48.2	1950-59	2.3
Deer Creek near Valley	12407520	36.0	1959-72	4.5
Chewelah Creek at Chewelah	12407700	94.1	1957-74	4.2
Little Pend Oreille River near Colville	12408300	132.0	1958-75	4.2
Haller Creek near Arden	12408420	37.0	1959-70	1.6
Mill Creek near Colville	12408500	83.0	1939-72; 1977-86	5.0
Colville River Watershed				
Colville River at Kettle Falls	12409000	1,007	1923-present	1.5

The streamflow data from gaging station 12409000 on the Colville River near Kettle Falls were used in the PULSE model to obtain an estimate of the recharge for the entire study area of 1.5 in./yr. However, this value may not be reliable because of several factors. The contributing drainage area for station 12409000 is 1,007 mi^2, more than double the recommended maximum limit for use of the model. The variety and range of the subsurface geologic materials and precipitation in the study area (pl. 1 and fig. 12) almost certainly result in non-uniform recharge throughout the study area. Although some of the assumptions of the PULSE model are not stringently met, the results obtained provide a useful estimate of recharge. A fully calibrated ground-water flow model will likely give a more valid recharge estimate, and such a model is being developed for Phase II of this investigation.

A concurrent USGS study is using a precipitation-runoff model (Leavesley and others, 1983) to estimate ground-water recharge in the study area in support of the ground-water flow modeling that is underway (D.M. Ely, U.S. Geological Survey, written commun., 2002). Preliminary results of this work indicate that the recharge estimates produced by the PULSE model are reasonable. However, the rainfall-runoff model is uncalibrated, so any further comparisons cannot be made at this time. More refined basin-wide recharge estimates using the precipitation-runoff model are planned in Phase II.

Estimated Water Budget

On a long-term basis, a hydrologic system is usually in a state of dynamic equilibrium; that is, inflow to the system is equal to outflow from the system and there is little or no change in the quantity of water stored within the system. An estimated water budget, or distribution of precipitation, for a typical year in the Colville River Watershed is presented in table 10. It includes estimates of component values, and illustrates the fate of precipitation (inflow) by approximating the distribution of water in the basin's hydrologic system: precipitation (inflow) and evapotranspiration, streamflow, and ground-water discharge (outflow). It is assumed that, in the long term, inflow to the basin equals outflow and there is little or no change in the amount of water stored within the basin. The following equations illustrate this relation:

$$\text{Precipitation} = \text{Evapotranspiration} + \text{Streamflow at outlet} + \text{Ground-water discharge at outlet}; \quad (4)$$

and for the study area:

$$27 \text{ inches} = 22.5 \text{ inches} + 4.2 \text{ inches} + 0.3 \text{ inch}. \quad (5)$$

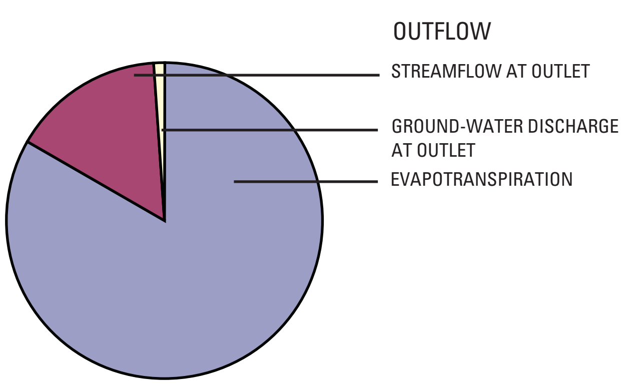
Equation 4 shows the water-budget components and equation 5 shows the estimated value for each component, in inches, derived for the study area. When converted to millions of gallons per year and acre-feet (table 10), the values of the components can be compared with water-use estimates provided in the section "Water Quantity" (table 8).

A statistical-topographic model for mapping climatological precipitation over mountainous terrain, PRISM (Daly and others, 1994), was used to derive an area-weighted average precipitation of 27 in. for the Colville River Watershed. The distribution of average annual precipitation (1961-90) for the watershed, contoured using data from NOAA weather stations and U.S. Department of Agriculture-Natural Resource Conservation Service snow-measurement stations, is shown in figure 12. Averaging the ranges of precipitation over the basin yielded the area-weighted average of 27 in. Discharge from the Colville River

Table 10. Estimated annual water budget for the Colville River Watershed, Stevens County, Washington

[Mgal/yr, million gallons per year]

Hydrologic component	Estimated quantity			Percentage of total precipitation
	Inches	Mgal/yr	Acre-feet	
Inflow:				
Precipitation	27	473,000	1,450,000	100
Outflow:				
Evapotranspiration (residual)	22.5	394,000	1,210,000	83
Streamflow at outlet	4.2	73,500	225,000	16
Ground-water discharge at outlet	.3	5,250	16,100	1



near Kettle Falls (4.2 in.) was based on the long-term average flow (309 ft^3/s) at gaging station 12409000 from 1923 to 2001. Ground-water discharge leaving the basin at depth was estimated to be 0.3 in. using a basic Darcy equation ($Q = -KA(dh/dl)$) and characteristics of the Lower aquifer in that area (K, hydraulic conductivity, 240 ft/d; A, area of Lower aquifer, 240,000 ft^2; dh/dl, change in hydraulic head, -200 ft/mi). Ground-water discharge is a gross estimate that could be refined in the future if the geometry of the Lower aquifer near the mouth of the basin is better understood. The value for evapotranspiration (22.5 in.) is a residual; that is, it represents the quantity that remains after Colville River and ground-water discharge are subtracted from precipitation. Preliminary results from a concurrent USGS study in the Colville River Basin using a precipitation-runoff model (Leavesley and others, 1983) include an estimated annual evapotranspiration of about 20 in. for the watershed (D.M. Ely, U.S. Geological Survey, written commun., 2002), which is in good agreement with the estimate for this study.

The predominant fate of precipitation in the basin (83 percent) is loss from the basin through evapotranspiration, a combination of evaporation from open bodies of water, evaporation from soil surfaces, and transpiration from the soil by plants. Evapotranspiration commonly accounts for the greatest loss from basins with similar hydrologic conditions. For comparison, evapotranspiration losses ranged from 74 percent to 89 percent of precipitation in hydrologically similar subbasins of the Yakima River Basin in central Washington (John Vaccaro, U.S. Geological Survey, written commun., February 2003). The estimates for the Yakima River subbasins were made with the assumptions that changes in ground-water storage over time and ground-water outflow are both negligible.

Streamflow leaving the basin, as measured at Kettle Falls, is 16 percent of precipitation. Ground-water discharge from the basin represents only 1 percent of precipitation. Actual total water use for 2001, an estimated 9,340 Mgal/yr or 28,700 acre-ft (table 8), is only 2 percent of total precipitation, whereas water rights and claims registered for the study basin are an estimated 36,680 Mgal/yr, about 8 percent of total precipitation (Appendix 1*A*). These simple comparisons indicate that actual water use and registered water use are relatively small compared to total precipitation.

An approximate water budget for the ground-water system is more difficult to estimate than the basin water budget presented above because of limited knowledge of component values. The total inflow to the ground-water system is unknown, but would include the 0.3 in. that leaves the basin at the lower end through subareal flow and 0.3 in. that leaves through pumping (gross withdrawals). More detailed water budgets will be estimated during Phase II using a calibrated ground-water flow model. The calibrated model will provide a more refined depiction of the ground-water and surface-water flow system where current observational data are lacking.

ADDITIONAL DATA NEEDS

Several primary data needs were noted during the course of this study that would aid in a more thorough understanding of the water resources of the Colville River Watershed.

- The most immediate need is for long-term ground-water level data. Monthly water-level data collected over many years of record would assist in detecting seasonal fluctuations and long-term trends in ground-water levels in the watershed. Water-level measurements from a representative mix of hydrogeologic units would be required to document fluctuations and trends throughout the entire hydrogeologic system of the watershed.
- Throughout much of the study area, the depth to bedrock, and therefore the thickness of the potential water-bearing sediments, is unknown. Geophysical studies and test drilling in the Colville River valley would help determine the geometry of the underlying bedrock. The geometry of the Lower aquifer near the mouth of the basin is also poorly understood, but could be better described with additional well and geophysical data.
- A better understanding of the relation between the shallow ground-water system and the Colville River is needed. Monitoring of river and nearby shallow ground-water levels over time would help address this issue.
- Accurate altitudes for selected wells on the valley floor would allow a more refined evaluation of vertical hydraulic head gradients between the shallow ground-water system and the river, and between the shallow and deep aquifers.
- There are few baseline and long-term ground-water chemistry data available within the watershed to document existing water quality and possible long-term changes in water quality. Initial water samples could be collected from selected wells and analyzed for concentrations of nitrate, bacteria, arsenic, and radionuclides. At the time of sampling, pH, specific conductance, dissolved-oxygen concentration, and temperature could be measured. From these baseline data, a water chemistry network could be designed to assess cyclic or long-term changes.
- The potential effects of ground-water development on the ground- and surface-water systems cannot be reasonably estimated or quantified at present. However, a ground-water flow model currently being developed by the USGS can help predict these effects and assist local watershed planners in evaluating various water-use alternatives.

SUMMARY AND CONCLUSIONS

The Colville River Watershed is a 1,007-square-mile area located mostly in Stevens County, northeastern Washington. The Colville River begins at the south end of the basin, then flows generally north and north-northwest for about 43 mi to where it empties into Franklin D. Roosevelt Lake. Presently, surface water is available for further appropriation only from the mainstem of the Colville River from October 1 through July 15, and all streams tributary to the Colville are considered to be fully appropriated by the Washington Department of Ecology under existing water rights. Issuance of new ground-water rights has been halted by the Washington Department of Ecology because of possible hydraulic continuity between the ground and surface waters. These closures put limits on economic growth within the Colville River Watershed. The WRIA 59 Colville River Watershed Planning Team asked the U.S. Geological Survey to conduct a study with the primary goal being to investigate the ground-water system of the valley-fill deposits of the Colville River Watershed.

The objectives of this study were to:

- Define the hydrogeologic framework including mapping the extent and thickness of aquifers and confining units in the unconsolidated ground-water system;
- Make a preliminary determination of how the shallow and deeper parts of the ground-water system interact with each other and the surface-water system;
- Address water quantity issues including estimating a water budget for the Colville River Watershed; and
- Evaluate the need for additional data required for the construction of a ground-water flow model.

Geologically, the basin can be grouped into three types of formations: bedrock, glacial drift, and valley alluvium. The bedrock, including mostly sedimentary, metamorphic, and intrusive igneous rocks, forms the hills and mountains of the basin and underlies the lowland areas at generally unknown depths. Glacial and alluvial deposits, including silt, sand, gravel, clay, and till, mantle much of the lowland areas and lower reaches of the hills and mountains. Sands and gravels deposited by outwash streams are significant sources of ground water in the basin.

Between August and November 2001, 362 wells were inventoried. Information gathered at all sites included site location, land-surface altitude, and well-construction details. Depth to water was measured in most of the inventoried wells. Water levels were measured again in May 2002 in about one-third of the inventoried wells.

Twenty-six hydrogeologic sections were constructed in order to identify and correlate hydrogeologic units based primarily on grain size and stratigraphic position. From the hydrogeologic sections, seven hydrogeologic units were identified in the study area:

- Upper outwash aquifer (UA);
- Till confining unit (TC);
- Older outwash aquifer (OA);
- Colville Valley confining unit (VC);
- Lower aquifer (LA);
- Lower confining unit (LC); and
- Bedrock (BR)

The Upper outwash aquifer is a discontinuous but productive and widely used aquifer composed mostly of glacial outwash. It exists in the stream valleys and terraces that are tributary to the Colville River and has an average thickness of 100 ft. The Till confining unit is a low-permeability unit consisting of glacial till that mantles much of the mountainous areas of the study area. It has an estimated average thickness of 70 ft. The Older outwash aquifer is a very discontinuous confined aquifer consisting of sand and gravel outwash underlying till and overlying bedrock. Its estimated average thickness is 20 ft. The Colville Valley confining unit is a thick and generally low-permeability unit consisting mostly of glaciolacustrine silt and clay. It occurs throughout the Colville and Echo Valleys and has an average thickness of 150 ft. Discontinuous lenses of sand and gravel within the unit contribute usable quantities of water to some wells. The Lower aquifer consists of sand and some gravel and is likely continuous along the length of the Colville and Echo Valleys. It occurs beneath the Colville Valley confining unit and above bedrock. Thickness of the unit is about 60 ft. The Lower confining unit is a low-permeability unit consisting of glaciolacustrine silt and clay that underlies the Lower aquifer in places. The Bedrock unit underlies all of the previously described units. Although a low-permeability unit, bedrock supplies water to numerous wells at generally low yields. The median values of horizontal hydraulic conductivity for the Upper outwash, Older outwash, and Lower aquifers are 84, 270, and 49 ft/d, respectively.

Horizontal ground-water flow in the Upper outwash aquifer generally mimics the surface-water drainage pattern of the watershed where the unit occurs. Horizontal ground-water flow in the Lower aquifer from near Springdale to Chewelah is toward the north, from Chewelah to Colville it is north-northwest, and from Colville to Kettle Falls it is to the northwest. In Echo Valley, ground-water flow is south toward the Colville Valley. At the outlet of the basin, near Kettle Falls, ground-water flow directions are less certain, but likely diverge around a bedrock high near Meyers Falls.

Synoptic discharge measurements were made to quantify the surface water reaching the Colville Valley floor, and to identify gaining and losing reaches over the unconsolidated valley deposits. A total of 52.9 ft^3/s of tributary flow was measured at 21 sites at or near the sides of the Colville Valley during the September-October 2001 low-flow seepage measurement. The average discharge leaving the valley, as measured at U.S. Geological Survey streamflow gaging station 12409000, from September 4 to 13, 2001, was 47.2 ft^3/s. The difference, 5.7 ft^3/s or 11.3 acre-ft/d, represents the loss of 10.8 percent of the flow reaching the valley floor.

Low-flow measurements indicate that during September 2001, the Colville River gained flow from the shallow ground-water system near its headwaters to Valley and lost flow to the shallow ground-water system from Valley to Chewelah. Downstream from Chewelah, the river generally lost flow, but amounts were small and possibly within measurement error. The results of the September-October 2001 low-flow seepage run represent conditions at only one point in time, therefore they should not be assumed to be representative of other periods. In September of 1960 and 1961, for example, most reaches measured on the Colville River gained flow from the shallow system. Ground water/surface water interactions are not well understood over time and distance along the Colville River.

The Lower aquifer and the shallow ground-water system of the Colville Valley floor may act as fairly independent systems. Ground-water levels indicate that there are upward head gradients in the Lower aquifer. However, most reaches on the Colville River lost water to the ground-water system in September 2001. There may be some connection with the losing stream reaches and the Lower aquifer near the edges of the valley where the Valley confining unit is thinner or possibly absent.

Total surface- and ground-water withdrawals during 2001 were estimated to be 9,340 Mgal or 28,700 acre-ft. Surface water supplied 65 percent of the total estimated withdrawals for the study basin, and ground water supplied 35 percent. Water use for 2001, as a percentage of the total, was 75.3 percent for irrigation, 16.3 percent for public supply, 6.5 percent for private wells, and about 1 percent each for industrial and livestock use.

An approximate water budget, or distribution of precipitation, for a typical year in the Colville River Watershed shows that there are 27 in. of precipitation balanced by 4.2 in. of streamflow discharge from the basin, 0.3 in. of ground-water discharge from the basin, and 22.5 in. of evapotranspiration.

Primary data needs noted during this study are for long-term ground-water level data, information on the depth to bedrock, a better understanding of the relation between the shallow ground-water system and the Colville River, baseline and long-term ground-water chemistry data, and the potential effects of ground-water development on the ground- and surface-water systems.

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GLOSSARY

Acre-foot (acre-ft): The volume of water needed to cover an acre of land to a depth of 1 foot; equivalent to 43,560 cubic feet or 325,851 gallons.
Alluvium: General term for sediments of gravel, sand, silt, clay, or other particulate rock material deposited by flowing water, usually in the beds of rivers and streams, on a flood plain, on a delta, or at the base of a mountain.
Aquifer: A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to springs and wells.
Bedrock: A general term used for solid rock that underlies soils or other unconsolidated material.
Confined aquifer (artesian aquifer): An aquifer that is completely filled with water under pressure and that is overlain by material that restricts the movement of water.
Confining layer: A body of impermeable or distinctly less permeable (see permeability) material stratigraphically adjacent to one or more aquifers that restricts the movement of water into and out of the aquifers.
Cubic foot per second (ft^3/s, or cfs): Rate of water discharge representing a volume of 1 cubic foot passing a given point during 1 second, equivalent to approximately 7.48 gallons per second or 448.8 gallons per minute or 0.02832 cubic meter per second. In a stream channel, a discharge of 1 cubic foot per second is equal to the discharge at a rectangular cross section, 1 foot wide and 1 foot deep, flowing at an average velocity of 1 foot per second.
Direct runoff: The runoff entering stream channels promptly after rainfall or snowmelt.
Discharge: The volume of fluid passing a point per unit of time, commonly expressed in cubic feet per second, million gallons per day, gallons per minute, or seconds per minute per day.
Diversion: A turning aside or alteration of the natural course of a flow of water, normally considered physically to leave the natural channel.
Drainage area: The drainage area of a stream at a specified location is that area, measured in a horizontal plane, which is enclosed by a drainage divide.
Drainage basin: The land area drained by a river or stream.
Drainage divide: The boundary between adjoining drainage basins.
Drawdown: The difference between the water level in a well before pumping and the water level in the well during pumping. Also, for flowing wells, the reduction of the pressure head as a result of the discharge of water.
Drought: A prolonged period of less-than-normal precipitation such that the lack of water causes a serious hydrologic imbalance.
Effluent: Outflow from a particular source, such as a stream that flows from a lake or liquid waste that flows from a factory or sewage-treatment plant.
Evaporation: The process by which water is changed to gas or vapor; occurs directly from water surfaces and from the soil.
Evapotranspiration: The process by which water is discharged to the atmosphere as a result of evaporation from the soil and surface-water bodies and transpiration by plants.
Flood: Any relatively high streamflow that overflows the natural or artificial banks of a stream.
Flood plain: A strip of relatively flat land bordering a stream channel that is inundated at times of high water.
Fluvial deposit: A sedimentary deposit consisting of material transported by suspension or laid down by a river or stream.
Freshet: A sudden overflow of a stream resulting from a heavy rain or a thaw.
Gaging station: A particular site on a stream, canal, lake, or reservoir where systematic observations of hydrologic data are obtained.
Glacial: Of or relating to the presence and activities of ice or glaciers.
Glacial drift: A general term for rock material transported by glaciers or icebergs and deposited directly on land or in the sea.
Glacial lake: A lake that derives its water, or much of its water, from the melting of glacial ice; also a lake that occupies a basin produced by glacial erosion.
Glacial outwash: Stratified detritus (chiefly sand and gravel) "washed out" from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of an active glacier.
Granite/Granitic rock: A coarse-grained igneous rock.
Ground water: In the broadest sense, all subsurface water; more commonly that part of the subsurface water in the saturated zone.
Ground-water flow system: The underground pathway by which ground water moves from areas of recharge to areas of discharge.
Headwaters: The source and upper part of a stream.
Hydraulic conductivity: The capacity of a rock to transmit water. It is expressed as the volume of water that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow.
Hydraulic gradient: The change of hydraulic head per unit of distance in a given direction.
Hydraulic head: The height of the free surface of a body of water above a given point beneath the surface.
Hydrograph: Graph showing variation of water elevation, velocity, streamflow, or other property of water with respect to time.
Igneous rocks: Rocks that have solidified from molten or partly molten material.

Infiltration: The downward movement of water from the atmosphere into soil or porous rock.
Instantaneous discharge: The volume of water that passes a point at a particular instant of time.
Intermittent stream: A stream that flows only when it receives water from rainfall runoff or springs, or from some surface source such as melting snow.
Lacustrine: Pertaining to, produced by, or formed in a lake.
Lake stand: Temporary level of glacial lake lasting over a period of years.
Loess: Fine-grained deposit of wind-blown and wind-deposited silt and fine sand.
Long-term monitoring: The collection of data over a period of years or decades to assess changes in selected hydrologic conditions.
Main stem: The principal trunk of a river or a stream.
Median: The middle or central value in a distribution of data ranked in order of magnitude. The median is also known as the 50th percentile.
Metamorphic rocks: Rocks derived from preexisting rocks by mineralogical, chemical, or structural changes (essentially in a solid state) in response to marked changes in temperature, pressure, shearing stress, and chemical environment at depth in the Earth's crust.
Monitoring: Repeated observation, measurement, or sampling at a site, on a scheduled or event basis, for a particular purpose.
Moraine: A mound, ridge, or other distinct accumulation of unsorted, unstratified glacial drift, predominantly till, deposited chiefly by direct action of glacier ice.
Mouth: The place where a stream discharges to a larger stream, a lake, or the sea.
Permeability: The capacity of a rock for transmitting a fluid; a measure of the relative ease with which a porous medium can transmit a liquid.
Potentiometric surface: An imaginary surface that represents the total head in an aquifer. It represents the height above a datum plane at which the water level stands in tightly cased wells that penetrate the aquifer.
Precipitation: Any or all forms of water particles that fall from the atmosphere, such as rain, snow, hail, and sleet.
Reach: A continuous part of a stream between two specified points.
Recharge (ground water): The process involved in the absorption and addition of water to the zone of saturation; also, the amount of water added.
Runoff: That part of precipitation or snowmelt that appears in streams or surface-water bodies.
Sedimentary rocks: Rocks formed by the consolidation of loose sediment that has accumulated in layers.
Shale: A fine-grained sedimentary rock formed by the consolidation of clay, silt, or mud.
Siltstone: An indurated silt having the texture and composition of shale but lacking its fine lamination.
Spring: Place where a concentrated discharge of ground water flows at the ground surface.
Streamflow: The discharge of water in a natural channel.
Surface runoff: Runoff that travels over the land surface to the nearest stream channel.
Surface water: An open body of water such as a lake, river, or stream.
Terminal moraine: The end moraine extending across a glacial plain or valley as an arcuate or crescent ridge that marks the farthest advance or maximum extent of a glacier.
Till: Predominantly unsorted and unstratified drift, deposited directly by and underneath a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, and boulders.
Transmissivity: The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. It equals the hydraulic conductivity multiplied by the aquifer thickness.
Transpiration: The process by which water passes through living organisms, primarily plants, into the atmosphere.
Tributary: A river or stream flowing into a larger river, stream or lake.
Unconfined aquifer: An aquifer whose upper surface is a water table free to fluctuate under atmospheric pressure.
Unconsolidated deposit: Deposit of loosely bound sediment that typically fills topographically low areas.
Watershed: See drainage basin.
Water table: The top water surface of an unconfined aquifer at atmospheric pressure.
Water year: A continuous 12-month period selected to present data relative to hydrologic or meteorological phenomena during which a complete annual hydrologic cycle normally occurs. The water year used by the U.S. Geological Survey runs from October 1 through September 30, and is designated by the year in which it ends.
Withdrawal: Water removed from the ground or diverted from a surface-water source for use.

Table 11. Physical and hydrologic data for the inventoried wells in the Colville River Watershed, Stevens County, Washington

[**Well No.**: See figure 2 for explanation of well-numbering system. **WDOE tag**: Washington Department of Ecology**. Latitude and Longitude** are given in degrees, minutes, seconds. **Hydrogeologic unit**: UA, Upper outwash aquifer; TC, Till confining unit; OA, Older outwash aquifer; VC, Colville Valley confining unit, LA, Lower aquifer; LC, Lower confining unit; BR, Bedrock. **Water level**: Minus sign (-) indicates water level above land surface; F, flowing; P, pumping; R, recently pumped; S, nearby pumping; T, nearby recently pumped. **Type of log available**: DR, driller; DG, geologist. **Abbreviations**: ft/d, foot per day; –, no data available]

Well No.	WDOE tag	Latitude	Longitude	Hydro-geologic unit	Land-surface altitude (feet above NGVD29)	Depth, in feet		Estimated horizontal hydraulic conductivity (ft/d)	Date	Water level (feet below land surface)	Type of log available
						Hole	Well				
29N/41E- 02M01	AGG 500	480223	1173622	UA	2,390	58	58	–	10-02-01	10.53R	DR
									05-13-02	7.92	
02M02	ABT 272	480218	1173613	UA	2,400	46	44	–	–	–	DR
02M03	AGG 021	480223	1173618	UA	2,390	50	47	–	10-02-01	30	DR
02M04	–	480218	1173613	BR	2,400	117	117	–	–	–	DR
04C03	–	480246	1173837	BR	2,440	125	125	–	10-03-01	30.45	DR
									05-13-02	71.79R	
04F01	ACV 998	480231	1173856	BR	2,680	400	400	–	10-03-01	56.60R	DR
10C01	ACW 891	480150	1173712	UA/BR	2,400	91	77	–	09-19-01	16.29	DR
10C02	ACW 892	480150	1173713	UA	2,400	105	100	–	09-19-01	15.03	DR
30N/39E- 01G01	–	480754	1174954	UA	2,220	40	40	–	11-13-01	-.65F	DR
01G02	–	480747	1174940	TC	2,200	160	156	6.2	11-13-01	2.68	DR
									05-14-02	1.24	
01L01	AEJ 504	480733	1175000	BR	2,160	120	120	–	11-13-01	-5F	DR
13F01	ACM 481	480604	1175009	BR	2,440	70	70	–	10-15-01	42.55	DR
14G01	–	480610	1175109	LA	2,415	180	173	–	10-15-01	16.93	DR
14G02	–	480604	1175102	UA	2,400	16	16	–	10-15-01	11.70	–
24D02	–	480522	1175020	OA	2,460	60	59	–	10-15-01	41.50	DR
24L01	–	480504	1175008	–	2,460	–	70	–	10-15-01	46.15	–
30N/40E- 04R01	–	480727	1174539	LA	1,690	198	198	–	09-24-01	-15F	DR
10N02	–	480628	1174514	LA	1,800	130	129	–	09-26-01	46.19	–
									05-14-02	44.89	DR
12A01	ACV 806	480715	1174142	LA	2,180	196	195	91	–	–	DR
14M01	ACV 876	480556	1174349	BR	2,320	520	520	–	09-24-01	293.19R	DR
15E01	–	480600	1174523	LA	1,810	240	240	–	–	–	DR
15E02	–	480600	1174523	LA	1,810	258	248	–	09-26-01	14.83R	DR
									05-14-02	12.12R	
15Q01	ABM 770	480542	1174445	BR	1,980	225	225	–	10-16-01	91.45	DR
									05-14-02	84.76	
16G01	–	480601	1174601	LA	1,800	293	293	–	09-24-01	15.58R	DR
16L01	–	480557	1174607	LA	1,800	300	300	–	09-24-01	4.76R	DR
16L02D1	AAL 643	480549	1174605	LA	1,800	310	305	11	09-24-01	-.07F	DR
									05-14-02	–F	
20B01	–	480528	1174715	VC	2,060	255	235	–	–	–	DR
20F01	ACC 894	480518	1174724	VC	2,100	160	159	–	09-24-01	38.00R	DR
									05-14-02	10.1	
21H01	–	480515	1174529	LA	1,900	240.5	239	–	09-24-01	51.20	DR
									05-15-02	48.81	
21J02	ABI 928	480506	1174526	LA	1,900	160	159	–	10-01-01	36.38	DR
									05-14-02	34.38	
28A01D1	–	480434	1174537	LA	1,945	240	240	24	09-24-01	50.05	DR
									05-14-02	49.11	

Table 11. Physical and hydrologic data for the inventoried wells in the Colville River Watershed, Stevens County, Washington —*Continued*

[**Well No.**: See figure 2 for explanation of well-numbering system. **WDOE tag**: Washington Department of Ecology**. Latitude and Longitude** are given in degrees, minutes, seconds. **Hydrogeologic unit**: UA, Upper outwash aquifer; TC, Till confining unit; OA, Older outwash aquifer; VC, Colville Valley confining unit, LA, Lower aquifer; LC, Lower confining unit; BR, Bedrock. **Water level**: Minus sign (-) indicates water level above land surface; F, flowing; P, pumping; R, recently pumped; S, nearby pumping; T, nearby recently pumped. **Type of log available**: DR, driller; DG, geologist. **Abbreviations**: ft/d, foot per day; –, no data available]

Well No.		WDOE tag	Latitude	Longitude	Hydro-geologic unit	Land-surface altitude (feet above NGVD29)	Depth, in feet		Estimated horizontal hydraulic conductivity (ft/d)	Date	Water level (feet below land surface)	Type of log available
							Hole	Well				
30N/40E-	33R01R1	AFF310	480305	1174532	VC	2,020	195	190	–	–	–	DR
	33R02	AFR966	480305	1174533	VC	2,020	340	340	–	–	–	DR
	34A01	–	480341	1174421	UA	2,080	17	17	–	–	–	–
	34G01	–	480328	1174435	UA	2,040	150	150	2,400	10-26-01 05-15-02	73.18 67.78R	DR
	35C01	AFN 049	480346	1174326	UA	2,160	98	97	–	11-13-01 05-13-02	61.00 58.77	DR
30N/41E-	04G02	ACV 943	480747	1173812	UA	2,540	199	198	–	10-16-01 05-13-02	178.68 173.45	DR
	04N01	ACV 944	480730	1173853	UA	2,480	143	143	–	10-16-01	124.60	DR
	04P01	–	480727	1173839	UA	2,480	95	64	–	–	–	DR
	04P02	ACN 585	480727	1173839	UA	2,480	180	178	–	10-02-01 05-13-02	153.73R 152.22R	DR
	10R02	–	480628	1173627	UA	2,500	245	185	–	09-19-01	102.35	DR
	12R01	–	480634	1173403	BR	2,660	297	–	–	–	–	DR
	12R02	–	480634	1173403	BR	2,660	247	–	–	–	–	DR
	12R03	–	480634	1173403	BR	2,660	197	–	–	–	–	DR
	12R04	–	480634	1173403	UA	2,660	67	–	–	–	–	DR
	12R05	–	480634	1173403	UA	2,660	59	59	–	–	–	DR
	13H01	ABR 773	480608	1173358	UA/BR	2,500	60	59	–	09-19-01	20.34	DR
	13H02	AFB 493	480604	1173401	BR	2,500	120	119	–	09-19-01	21.90	DR
	13H03	–	480607	1173359	–	2,500	–	–	–	–	–	–
	15B04	AAL 029	480617	1173654	UA	2,510	242	241	–	09-28-01 05-13-02	140.00R 122.71R	DR
	15B05	AAK 940	480615	1173704	UA	2,510	165	161	–	10-16-01 05-13-02	134.49 122.56	DR
	15L04	–	480555	1173720	UA	2,500	300	300	–	10-02-01 05-13-02	130.52R 125.82R	DR
	15M01	–	480548	1173744	UA	2,460	171	171	–	10-17-01	97.34	DR
	18L01	AEJ O37	480557	1174109	UA	2,290	480	480	–	09-18-01	52.39R	DR
	28J01	–	480408	1173748	UA	2,420	120	119	–	09-28-01 05-13-02	78.18R 79.90	DR
	28Q02	–	480358	1173809	UA	2,420	140	138	–	09-28-01 05-13-02	68.29R 68.26	DR
	33H01	–	480328	1173746	UA	2,410	66	66	77	–	–	DR
	34C02	ACW 893	480342	1173723	UA	2,410	198	198	–	09-19-01 05-13-02	58.50R 47.51	DR
	34D01	AAK 927	480342	1173726	UA	2,410	104	104	–	09-21-01	53.37	DR
	34Q03	ABR 226	480304	1173655	UA	2,400	36	36	–	09-19-01	14.46T	DR
	34Q04	ABR 227	480304	1173655	UA/BR	2,400	50	50	–	09-19-01	14.28R	DR

Table 11. Physical and hydrologic data for the inventoried wells in the Colville River Watershed, Stevens County, Washington —*Continued*

[**Well No.**: See figure 2 for explanation of well-numbering system. **WDOE tag**: Washington Department of Ecology**. Latitude and Longitude** are given in degrees, minutes, seconds. **Hydrogeologic unit**: UA, Upper outwash aquifer; TC, Till confining unit; OA, Older outwash aquifer; VC, Colville Valley confining unit, LA, Lower aquifer; LC, Lower confining unit; BR, Bedrock. **Water level**: Minus sign (-) indicates water level above land surface; F, flowing; P, pumping; R, recently pumped; S, nearby pumping; T, nearby recently pumped. **Type of log available**: DR, driller; DG, geologist. **Abbreviations**: ft/d, foot per day; –, no data available]

Well No.		WDOE tag	Latitude	Longitude	Hydro-geologic unit	Land-surface altitude (feet above NGVD29)	Depth, in feet		Estimated horizontal hydraulic conductivity (ft/d)	Date	Water level (feet below land surface)	Type of log available
							Hole	Well				
31N/39E-	03A04	AEJ 596	481316	1175157	BR	2,540	260	260	–	09-18-01	15.53	DR
	13A02	–	481137	1174935	BR	2,200	–	98	–	09-18-01	10.25	–
	13A03	–	481137	1174934	BR	2,200	260	260	–	09-18-01	9.44R	DR
31N/40E-	02A01	–	481315	1174252	n/a	1,645	121	–	–	–	–	DR
	02P01	–	481233	1174350	LA	1,660	270	270	–	–	–	DR
	03C01	ACG 420	481319	1174506	BR	1,800	220	205	–	11-07-01	132.71	DR
	16L02	–	481111	1174620	VC	2,000	237	235	–	10-03-01	159.90R	DR
	16L04	–	481106	1174614	VC	1,970	221	221	14	09-21-01	141.65	DR
										05-14-02	141.32R	
	17A01	AGG 001	481131	1174648	VC	2,070	257	257	930	10-09-01	216.15	DR
	17A02	–	481134	1174648	VC	2,070	302	302	150	10-09-01	213.48	DR
	20F02	–	481029	1174735	BR	2,030	180	180	–	11-13-01	19.53	DR
										05-14-02	16.30	
	22B02	–	481037	1174432	LA	1,670	205	205	38	10-26-01	–F	DR
	22F02	ACV 878	481026	1174501	BR	1,690	423	423	–	10-16-01	44.01R	DR
										05-13-02	96.90R	
	23K01	ABT 268	481018	1174316	UA	1,760	195	195	–	10-19-01	68.08	DR
										05-13-02	66.38	
	23K02	ACG 570	481018	1174316	UA	1,760	198	189	–	10-09-01	68.86	DR
	25P01	–	480908	1174218	UA	2,030	–	60	–	10-09-01	41.56	
	25Q01	ACL 281	480903	1174204	UA	2,040	98	98	–	09-18-01	40.83	DR
										05-14-02	34.01	
	26K01	–	480926	1174325	UA	1,740	125	110	–	–	–	DR
	26K03	–	480926	1174321	UA	1,760	100	100	78	10-26-01	45.94	DR
										05-14-02	44.80	
	26K04	–	480912	1174317	UA	1,760	100	97.5	–	10-26-01	64.39	DR
	26Q01	–	480903	1174321	UA	1,760	100	95	–	10-26-01	41.86	DR
										05-14-02	40.56	
	26R02	–	480908	1174317	UA	1,760	100	100	–	–	–	DR
31N/41E-	05N03	AAK 108	481240	1174006	UA	2,080	900	580	–	09-18-01	263.24	DR
	07B01	AEP 957	481219	1174035	BR	1,810	200	195	–	10-01-01	25.46R	DR
										05-15-02	20.46R	
	08B01	–	481226	1173930	UA	2,050	300	297.5	–	–	–	DR
	11A01	ABQ 878	481211	1173516	LA	2,580	270	270	–	10-01-01	36.82R	DR
	30P01	–	480901	1174054	UA/VC	2,060	225	200	–	09-17-01	11.16	DR
										05-15-02	7.61	
	31E02	–	480843	1174121	UA	2,060	80	80	–	10-09-01	46.36	DR
										05-13-02	37.83	
	31M02	–	480837	1174121	UA/LA	2,045	297	251	–	10-09-01	31.18	DR
										05-13-02	20.71	
	31M03	–	480837	1174122	UA	2,045	68	59	–	–	–	DR

Table 11. Physical and hydrologic data for the inventoried wells in the Colville River Watershed, Stevens County, Washington —*Continued*

[**Well No.**: See figure 2 for explanation of well-numbering system. **WDOE tag**: Washington Department of Ecology**. Latitude and Longitude** are given in degrees, minutes, seconds. **Hydrogeologic unit**: UA, Upper outwash aquifer; TC, Till confining unit; OA, Older outwash aquifer; VC, Colville Valley confining unit, LA, Lower aquifer; LC, Lower confining unit; BR, Bedrock. **Water level**: Minus sign (-) indicates water level above land surface; F, flowing; P, pumping; R, recently pumped; S, nearby pumping; T, nearby recently pumped. **Type of log available**: DR, driller; DG, geologist. **Abbreviations**: ft/d, foot per day; –, no data available]

Well No.		WDOE tag	Latitude	Longitude	Hydro-geologic unit	Land-surface altitude (feet above NGVD29)	Depth, in feet		Estimated horizontal hydraulic conductivity (ft/d)	Date	Water level (feet below land surface)	Type of log available
							Hole	Well				
31N/41E-	32B01	ABQ 922	480860	1173929.4	UA	2,210	140	140	–	09-18-01 05-15-02	61.94R 63.35R	DR
	32F01	–	480839	1173943	UA	2,240	180	180	–	–	–	DR
	32F02		480841	1173941.9	BR	2,240	400	400	–	09-17-01 05-14-02	114.29 122.76R	DR
	32H01	–	480842	1173916	BR	2,300	340	340	–	10-01-01 05-15-02	65.60R 51.24R	DR
32N/38E-	15A01	–	481652	1175959	BR	2,550	78	78	4.4	09-17-01	2.48	DR
	21C01	ACM 903	481553	1180143	BR	3,000	160	160	–	09-17-01	33.44	DR
32N/39E-	04D01	–	481829	1175423	UA	2,100	70	53	–	10-02-01 05-16-02	24.26R 15.06	DR
	05A01	ABQ 867	481819	1175439	LA	2,250	257	257	–	09-25-01 05-16-02	201.93R 201.42	DR
	12D01	ACQ 182	481729	1175035	BR	2,210	440	440	.0011	–	–	DR
32N/40E-	01B01	–	481821	1174208	BR	2,060	400	360	–	–	–	DR
	01G01	–	481812	1174202	BR	2,040	340	340	– –	09-26-01 05-13-02	148.48R 148.21	DR
	02P01	ABJ 655	481752	1174339	UA	1,735	40	40	–	10-01-01 05-13-02	4.13 3.03	DR
	03G01	–	481814	1174435	UA	1,790	30	30	–	–	–	DR
	03G02	BGG 485	481818	1174440	UA	1,800	30	30	–	–	–	–
	03H01	–	481820	1174423	UA	1,790	–	24	–	–	–	DR
	03H02	–	481816	1174430	UA	1,800	35	35	–	–	–	–
	03H03	–	481817	1174426	–	1,790	–	–	–	–	–	–
	03K01	AFA 294 –	481759	1174450	UA	1,760	125	125	180	09-25-01 05-13-02	90.02 87.85	DR
	04R01	–	481744	1174534	BR	1,670	245	245	–	09-25-01	19.68	DR
	05K01	AAK 103	481759	1174716	LA	1,640	292	292	–	09-25-01	–F	DR
	10A01	–	481723	1174419	n/a	1,770	2471	–	–	–	–	DR
	11F04	AAK 102	481723	1174340	UA	1,710	118	118	–	10-10-01 05-14-02	27.47 25.25	DR
	12N01	–	481653	1174245	–	1,675	–	380	–	–	–	–
	14H01	–	481625	1174311	LA	1,660	175	175	–	08-29-01 05-15-02	5.37 –F	DR
	15F01	AAJ 898	481636	1174508	VC	1,700	78	78	80	09-25-01	36.50R	DR
	15G02	–	481636	1174442	LA	1,630	250	250	–	09-25-01	–F	DR
	15M02	ACM 923	481614	1174517	UA	1,900	165	165	–	09-17-01 05-13-02	94.64 94.97	DR
	15R01	–	481600	1174414	LA	1,630	362	362	15,000	–	–	DR
	15R02	AGG 484	481600	1174414	LA	1,630	–	350	–	–	–	–
	15R03	–	481600	1174414	LA	1,630	390	390	–	08-29-01	-3.39S	DR
	22G01	–	481535	1174441	UA	1,820	220	219	–	09-25-01	145.82	DR

Table 11. Physical and hydrologic data for the inventoried wells in the Colville River Watershed, Stevens County, Washington —*Continued*

[**Well No.**: See figure 2 for explanation of well-numbering system. **WDOE tag**: Washington Department of Ecology**. Latitude and Longitude** are given in degrees, minutes, seconds. **Hydrogeologic unit**: UA, Upper outwash aquifer; TC, Till confining unit; OA, Older outwash aquifer; VC, Colville Valley confining unit, LA, Lower aquifer; LC, Lower confining unit; BR, Bedrock. **Water level**: Minus sign (-) indicates water level above land surface; F, flowing; P, pumping; R, recently pumped; S, nearby pumping; T, nearby recently pumped. **Type of log available**: DR, driller; DG, geologist. **Abbreviations**: ft/d, foot per day; –, no data available]

Well No.		WDOE tag	Latitude	Longitude	Hydro-geologic unit	Land-surface altitude (feet above NGVD29)	Depth, in feet		Estimated horizontal hydraulic conductivity (ft/d)	Date	Water level (feet below land surface)	Type of log available
							Hole	Well				
32N/40E-	23J01	–	481524	1174254	–	1,630	80	80	–	–	–	–
	24E01	–	481539	1174250	n/a	1,635	60	–	–	–	–	DR
	24F01	AAJ 876	481531	1174222	TC	1,660	119	118	5.1	–	–	DR
	24N01	ACF 576	481510	1174249	LA	1,650	100	100	–	10-10-01	–F	DR
	25N01	AEB 821	481421	1174239	LA	1,650	168	160	–	10-16-01	13.79	DR
										05-14-02	6.36	
	26A01	–	481504	1174256	LA	1,660	198	198	3.8	10-01-01	–F	DR
	27E02	–	481453	1174512	BR	1,880	600	600	–	–	–	DR
	27R01	–	481415	1174416	BR	1,690	–	200	–	11-07-01	36.60	–
										05-13-02	31.11R	
	28G01D1	–	481452	1174605	VC	2,100	345	345	–	10-16-01	127.38	DR
									–	05-14-02	115.07R	
	28H01	–	481454	1174540	UA	2,000	205	205	–	10-17-01	47.84R	DR
									–	05-15-02	38.23	
	28L01	–	481433	1174622	UA/VC	2,070	260	259	–	10-16-01	95.66	DR
									–	05-14-02	93.38	
	28L02	AAL 649	481427	1174620	VC	2,060	160	158	–	–	–	DR
	28R01	–	481422	1174535	LA	1,900	120	120	–	10-16-01	10.13	DR
										05-14-02	7.63	
	29C01	–	481454	1174732	UA	2,110	190	190	–	10-02-01	48.18	DR
	33B01D1	–	481412	1174553	BR	1,990	180	180	–	10-16-01	60.85	DR
										05-14-02	60.05	
	35M01	–	481342	1174356	–	1,700	–	96	–	11-07-01	32.49	–
										05-13-02	28.02R	
	35N01	AEJ 597	481334	1174400	BR	1,680	420	420	–	11-07-01	37.42	DR
										05-13-02	32.03	
32N/41E-	05P01	ACV 822	481752	1173936	BR	2,440	200	200	–	10-01-01	12.44	DR
	07N01	AAJ 884	481702	1174133	BR	1,880	186	174	1.3	10-10-01	71.03	DR
										05-15-02	76.43R	
	19E01	–	481531	1174125	BR	1,680	280	280	–	10-01-01	43.00R	DR
33N/38E-	03F01	ABP 471	482315	1180034	BR	2,860	100	100	–	10-11-01	19.50	DR
33N/39E-	02E01	–	482323	1175152	VC	1,610	37	35	–	08-28-01	9.27	–
	03P01D1	–	482257	1175256	BR	1,760	150	150	–	–	–	DR
	05L01	AFF 382	482314	1175523	BR	2,140	320	320	–	10-11-01	47.80	DR
	10R02	–	482210	1175211	LA	1,640	240	240	–	–	–	DR
	10R03	–	482211	1175212	LA	1,640	250	250	180	10-11-01	0.65	DR
										05-14-02	–F	
	11L01	–	482219	1175133	–	1,620	–	90	–	11-14-01	15.47	–
										05-14-02	13.23R	
	13C01	–	482150	1175017	LA	1,610	523	520	34	–	–	DR

Table 11. Physical and hydrologic data for the inventoried wells in the Colville River Watershed, Stevens County, Washington —*Continued*

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Well No.		WDOE tag	Latitude	Longitude	Hydro-geologic unit	Land-surface altitude (feet above NGVD29)	Depth, in feet		Estimated horizontal hydraulic conductivity (ft/d)	Date	Water level (feet below land surface)	Type of log available
							Hole	Well				
33N/39E-	13C02	AGG 004	482150	1175017	LA	1,610	489	488	28	08-28-01	10.97R	DR
										05-14-02	3.20	
	13F01	–	482149	1175017	LA	1,610	668	639	530	–	–	DR
	15J01	–	482122	1175210	LA/BR	1,660	329	313	–	08-28-01	40.68R	DR
										05-14-02	15.91	
	23A01	–	482100	1175101	UA	1,650	–	17.1	–	08-28-01	8.48	–
									–	05-14-02	7.14	
	23A02	–	482101	1175102	UA	1,650	400	379	40	08-28-01	8.76	DR
										05-14-02	7.30	
	23J01	–	482035	1175049	LA	1,636	340	340	–	10-04-01	34.57	DR
									–	05-13-02	18.28	
	24E01	–	482055	1175037	VC	1,630	230	220	86	08-28-01	15.76P	DR
	24G01	–	482055	1174955	n/a	1,611	92	–	–	–	–	DG
	24K01	–	482034	1174955	VC/LA	1,680	315	310	–	–	–	DR
	25D01	–	482010	1175028	LA	1,630	345	340	1.1	08-28-01	2.65	DR
										05-13-02	–F	
	33N01	ABP 470	481840	1175436	BR	2,340	600	600	–	10-04-01	116.48	DR
33N/40E-	25E01	AAJ 980	481958	1174258	BR	2,690	600	600	–	–	–	DR
	27J01	–	481946	1174432	UA	2,090	200	200	–	10-15-01	159.00	DR
										05-13-02	159.60	
	27K01	ACA 309	481945	1174452	–	2,110	300	300	–	10-15-01	167.28	DR
										05-15-02	167.78	
	27Q01	–	481930	1174442	UA	2,100	210	210	270	10-15-01	181.87	DR
										05-14-02	182.46	
	31F01	AAJ 988	481901	1174851	LA	1,680	178	178	–	10-09-01	58.87	DR
										05-16-02	56.87	
	34G01D1	–	481910	1174444	UA	2,090	375	373	60	08-29-01	224P	DR
	34G02	AGG 488	481910	1174444	UA	2,090	300	300	85	08-29-01	187.46S	DR
										05-15-02	188.83S	
	34H01D1	ABR 520	481909	1174431	UA	2,080	240	240	95	08-09-01	184.86R	DR
	34H02	AGG 486	481908	1174430	UA	2,080	250	250	210	–	–	DR
	34J01R2	AGG 487	481855	1174430	UA	2,075	301	270	22	–	–	DR
	34L01	ACV 801	481853	1174511	UA	2,080	312	310	7.5	10-17-01	195.41	DR
										05-15-02	197.31R	
	35P01	–	481834	1174345	UA	1,860	185	179	–	05-13-02	86.81	DR
										10-18-01	91.41	
	35P02	AEP 704	481833	1174345	UA	1,860	120	120	–	05-13-02	84.00	DR
										10-18-01	88.37	
	36H01	–	481909	1174152	BR	2,200	380	380	–	–	–	DR
33N/41E-	28A01	AAL 638	482010	1173746	LA	2,690	165	163	–	10-10-01	39.67	DR
										05-15-02	37.91R	
	30B01	–	482013	1174045	VC	2,300	197	191	–	10-09-01	–F	DR

Table 11. Physical and hydrologic data for the inventoried wells in the Colville River Watershed, Stevens County, Washington —*Continued*

[**Well No.**: See figure 2 for explanation of well-numbering system. **WDOE tag**: Washington Department of Ecology**. Latitude and Longitude** are given in degrees, minutes, seconds. **Hydrogeologic unit**: UA, Upper outwash aquifer; TC, Till confining unit; OA, Older outwash aquifer; VC, Colville Valley confining unit, LA, Lower aquifer; LC, Lower confining unit; BR, Bedrock. **Water level**: Minus sign (-) indicates water level above land surface; F, flowing; P, pumping; R, recently pumped; S, nearby pumping; T, nearby recently pumped. **Type of log available**: DR, driller; DG, geologist. **Abbreviations**: ft/d, foot per day; –, no data available]

Well No.		WDOE tag	Latitude	Longitude	Hydro-geologic unit	Land-surface altitude (feet above NGVD29)	Depth, in feet		Estimated horizontal hydraulic conductivity (ft/d)	Date	Water level (feet below land surface)	Type of log available
							Hole	Well				
34N/38E-	03B01	–	482850	1180032	OA	2,740	80	79	–	10-17-01	-1.31F	DR
	04A01	AEJ 543	482854	1180108	TC/BR	2,880	120	120	–	–	–	DR
	12G01	–	482737	1175754	BR	2,240	320	320	–	09-20-01	61.68	DR
										05-16-02	62.03	
	13E01	ABP 463	482649	1175814	UA	2,180	79	79	–	10-18-01	14.94	DR
										05-14-02	7.53	
	13M01	AFN 011	482639	1175828	BR	2,190	300	300	–	10-17-01	40.95	DR
										05-14-02	35.34	
	14J01	–	482631	1175836	BR	2,250	122	122	–	10-18-01	80.81	DR
	21R01	–	482535	1180129	UA	2,900	40	28	–	09-25-01	9.91R	DR
	23D01	–	482604	1175939	OA	2,420	107	107	–	–	–	DR
34N/39E-	02C01	–	482844	1175134	BR	2,000	260	260	–	09-26-01	109.64	DR
	02H01	ABV 436	482832	1175058	BR	1,860	420	420	–	09-27-01	103.69	DR
										05-14-02	106.92	
	03R01	–	482814	1175213	BR	1,780	300	300	–	09-26-01	53.10R	DR
										05-14-02	68.59P	
	04P02	–	482804	1175403	LA	1,600	65	64	–	09-26-01	–F	DR
	09C01	–	482760	1175410	UA/BR	1,605	100	100	–	–	–	DR
	09J01	–	482724	1175322	LA	1,720	280	278	–	–	–	DR
	09P01	–	482717	1175407	VC/BR	1,820	180	180	–	–	–	DR
	09R01	–	482718	1175323	BR	1,720	460	460	–	09-26-01	117.65	DR
										05-15-02	117.53R	
	10H02	–	482739	1175204	UA	1,625	–	15.8	–	10-10-01	12.70	–
	10J03	–	482728	1175209	VC	1,625	120	115	–	10-09-01	1.45	DR
										05-15-02	.32	
	10M01	ACC 875	482734	1175311	UA	1,580	35	35	–	–	–	DR
	10M02	AAK 222	482731	1175307	UA	1,580	40	34	–	10-09-01	6.18	DR
										05-15-02	4.69	
	10N03	–	482711	1175318	LA	1,680	215	212	–	09-20-01	54.59R	DR
										05-16-02	52.72R	
	10P01	AGG 009	482723	1175247	VC	1,590	38	38	–	10-11-01	12.82R	DR
										05-14-02	11.25R	
	10P02	AGG 010	482714	1175249	VC	1,590	60	50	–	10-11-01	8.18R	DR
										05-14-02	10.60R	
	11C01	–	482753	1175138	UA	1,820	225	225	–	09-26-01	191.65	DR
										05-14-02	192.13	
	11G02	ACF 504	482741	1175119	UA	1,885	292	292	–	09-27-01	173.62	DR
										05-14-02	173.12	
	16C01	–	482709	1175359	LA/BR	1,835	123	123	–	–	–	DR
	22G01	–	482602	1175237	LA	1,600	151	151	–	–	–	DR
	22R01	ACT 458	482537	1175211	LA	1,620	185	160	–	09-27-01	26.12R	DR
										05-15-02	24.28	

Table 11. Physical and hydrologic data for the inventoried wells in the Colville River Watershed, Stevens County, Washington —*Continued*

[**Well No.**: See figure 2 for explanation of well-numbering system. **WDOE tag**: Washington Department of Ecology**. Latitude and Longitude** are given in degrees, minutes, seconds. **Hydrogeologic unit**: UA, Upper outwash aquifer; TC, Till confining unit; OA, Older outwash aquifer; VC, Colville Valley confining unit, LA, Lower aquifer; LC, Lower confining unit; BR, Bedrock. **Water level**: Minus sign (-) indicates water level above land surface; F, flowing; P, pumping; R, recently pumped; S, nearby pumping; T, nearby recently pumped. **Type of log available**: DR, driller; DG, geologist. **Abbreviations**: ft/d, foot per day; –, no data available]

Well No.		WDOE tag	Latitude	Longitude	Hydro-geologic unit	Land-surface altitude (feet above NGVD29)	Depth, in feet		Estimated horizontal hydraulic conductivity (ft/d)	Date	Water level (feet below land surface)	Type of log available
							Hole	Well				
34N/39E-	23M01	AAL 631	482541	1175159	LA	1,611	140	140	56	10-10-01	17.82	DR
										05-15-02	16.14	
	23Q01	–	482539	1175109	VC	1,685	131	131	–	–	–	DR
	23Q02D1	–	482536	1175103	LA	1,666	179	–	–	10-10-01	64.38	DR
	23Q03	–	482532	1175113	n/a	1,640	46	–	–	–	–	DR
	25M01	–	482451	1175025	BR	1,740	305	305	–	10-23-01	134.05R	DR
									–	05-14-02	85.87	
	25M02	–	482450	1175028	UA	1,720	100	100	–	10-12-01	2.93	DR
									–	05-14-02	2.94	
	26B01	–	482522	1175108	n/a	1,642	54.5	54.5	–	–	–	DR
	26K01	–	482458	1175105	n/a	1,640	42	42	–	–	–	DR
	26N01	–	482445	1175160	BR	1,720	300	300	–	–	–	DR
	26P01	–	482442	1175130	LA	1,600	140	139	–	10-12-01	3.19	DR
									–	05-14-02	1.45	
	26Q01	–	482444	1175113	LA	1,630	240	239	–	–	–	DR
	26R01	–	482439	1175059	n/a	1,660	44.5	–	–	–	–	DR
	35A01D1	–	482424	1175050	VC	1,660	150	148	–	09-27-01	67.76	DR
										05-14-02	66.81R	
	35A02	–	482422	1175102	LA	1,640	140	140	–	09-27-01	36.06	DR
										05-14-02	34.29R	
	35H01	–	482413	1175048	UA	1,715	210	210	–	09-20-01	109.38	DR
									–	05-16-02	108.38	
	35P01	–	482352	1175126	UA	1,780	177	177	–	09-27-01	147.42	DR
									–	05-14-02	145.93	
	36P01	ACT 868	482428	1174952	BR	1,880	400	400	–	–	–	DR
34N/40E-	11D01	AGG 665	482756	1174415	BR	2,120	600	600	–	10-15-01	86.7	DR
	11F01	ACV 889	482741	1174349	LA	2,030	145	144	–	10-17-01	36.57	DR
										05-14-02	35.51	
	19M01	ACF 570	482547	1174919	BR	2,360	700	700	–	10-09-01	–F	DR
	30M01	–	482449	1174907	UA/BR	2,180	200	200	–	10-17-01	12.66	DR
										05-14-02	9.78	
35N/38E-	01E01	–	483348	1175840	UA	1,950	60	60	1,200	10-18-01	41.32	DR
										05-15-02	32.24	
	11A01	ACV 855	483305	1175851	TC	2,080	124	124	2.5	10-11-01	30.84	DR
	11A02	AEJ 006	483303	1175854	BR	2,090	540	540	–	10-11-01	43.3	DR
										05-15-02	39.24	
	11M01	AEP 732	483241	1175945	TC	2,320	90	90	28	10-12-01	14.72	DR
	12R01	ABP 496	483226	1175732	BR	1,960	440	440	–	–	–	DR
	27P01		482951	1180051	BR	3,020	160	160	–	10-13-01	12.11R	DR

Table 11. Physical and hydrologic data for the inventoried wells in the Colville River Watershed, Stevens County, Washington —*Continued*

[**Well No.**: See figure 2 for explanation of well-numbering system. **WDOE tag**: Washington Department of Ecology**. Latitude and Longitude** are given in degrees, minutes, seconds. **Hydrogeologic unit**: UA, Upper outwash aquifer; TC, Till confining unit; OA, Older outwash aquifer; VC, Colville Valley confining unit, LA, Lower aquifer; LC, Lower confining unit; BR, Bedrock. **Water level**: Minus sign (-) indicates water level above land surface; F, flowing; P, pumping; R, recently pumped; S, nearby pumping; T, nearby recently pumped. **Type of log available**: DR, driller; DG, geologist. **Abbreviations**: ft/d, foot per day; –, no data available]

Well No.	WDOE tag	Latitude	Longitude	Hydro-geologic unit	Land-surface altitude (feet above NGVD29)	Depth, in feet		Estimated horizontal hydraulic conductivity (ft/d)	Date	Water level (feet below land surface)	Type of log available
						Hole	Well				
35N/39E- 01D01	AEH 427	483405	1175040	TC	2,210	125	125	–	09-26-01	67.48R	DR
02B01		483405	1175119	VC	2,040	147	146	–	10-16-01	2.47R	DR
02C01D2	ABV 413	483404	1175132	LA	2,010	218	210	–	09-26-01	–F	DR
05F01	–	483347	1175541	LA	1,555	80	80	–	10-16-01	–F	DR
05F02	–	483345	1175535	LA/BR	1,550	505	505	–	10-16-01	25.65R	DR
06D01	ABV 327	483356	1175709	TC/BR	1,575	300	300	–	09-24-01 05-15-02	29.99 26.49	DR
06K01	AAK 204	483332	1175642	LA	1,540	255	250	–	09-24-01	-12F	DR
07K01	AEQ 452	483247	1175626	LA	1,560	200	200	–	–	–	DR
09J01	–	483250	1175327	UA	1,760	90	90	–	–	–	DR
10B02B	–	483313	1175225	OA	1,890	212	210	–	–	–	DR
	AGG 490	483313	1175226	OA	1,890	254	254	270	09-25-01	25.50R	DR
10B03	AGG 492	483317	1175227	OA	1,890	236	235	–	–	–	DR
10B04	AGG 491	483314	1175226	UA	1,890	200	200	240	09-25-01	26.95R	DR
10N01	–	483231	1175324	UA	1,740	48	48	81	–	–	DR
11A01	–	483316	1175053	OA	2,190	188	188	–	–	–	DR
11A02	–	483315	1175045	BR	2,190	100	100	–	–	–	DR
11Q03	AGG 493	483237	1175120	UA	2,000	50	50	–	09-25-01	1.35	DR
11R01	ABR 829	483235	1175100	UA	2,060	121	118	–	09-25-01	13.32R	DR
11R02A	–	483235	1175104	UA	2,030	198	198	–	–	–	DR
11R02B	AGG 494	483235	1175103	UA	2,030	100	100	83	09-25-01	3.24	DR
11R03	ABV 350	483235	1175121	UA	2,000	113	113	1.9	–	–	DR
11R04	–	483236	1175047	UA	2,180	120	120	–	10-16-01	76.98	DR
11R05	ABV 338	483237	1175120	UA	2,000	70	62	140	09-25-01	-1.58F	DR
12H01	–	483253	1174927	BR	2,255	78	78	–	09-27-01	41.43	DR
12Q01	ACF 558	483233	1175002	UA	2,210	180	180	–	09-26-01	85.53R	DR
12R02	ABR 231	483226	1174934	UA	2,210	146	146	190	09-25-01	71.04R	DR
14E02	ABQ 928	483201	1175157	BR	1,960	306	306	–	–	–	DR
16F01	–	483203	1175406	BR	1,590	196	196	–	–	–	DR
18A01	–	483215	1175624	UA	1,580	40	38	–	11-06-01 05-15-02	11.07 -1.24F	DR
18B01D1	ABJ 029	483222	1175636	BR	1,630	540	540	–	–	–	DR
20K01	–	483056	1175524	VC	1,555	110	110	–	09-24-01	–F	DR
21E01	AAK 224	483107	1175429	LA	1,550	262	262	–	09-25-01	–F	DR
23B01	–	483130	1175120	BR	2,280	280	280	–	09-27-01 05-14-02	262.45 266.85	DR
23F01	–	483117	1175124	BR	2,160	328	328	–	–	–	DR
23F02	–	483116	1175133	BR	2,080	320	320	–	09-27-01	113.5P	DR
27C01	–	483026	1175249	OA/BR	2,110	123	103	–	10-14-01	11.57	DR
27C02	–	483028	1175260	OA/BR	2,160	123	98	–	–	–	DR

Table 11. Physical and hydrologic data for the inventoried wells in the Colville River Watershed, Stevens County, Washington —*Continued*

[**Well No.**: See figure 2 for explanation of well-numbering system. **WDOE tag**: Washington Department of Ecology**. Latitude and Longitude** are given in degrees, minutes, seconds. **Hydrogeologic unit**: UA, Upper outwash aquifer; TC, Till confining unit; OA, Older outwash aquifer; VC, Colville Valley confining unit, LA, Lower aquifer; LC, Lower confining unit; BR, Bedrock. **Water level**: Minus sign (-) indicates water level above land surface; F, flowing; P, pumping; R, recently pumped; S, nearby pumping; T, nearby recently pumped. **Type of log available**: DR, driller; DG, geologist. **Abbreviations**: ft/d, foot per day; –, no data available]

Well No.		WDOE tag	Latitude	Longitude	Hydro-geologic unit	Land-surface altitude (feet above NGVD29)	Depth, in feet		Estimated horizontal hydraulic conductivity (ft/d)	Date	Water level (feet below land surface)	Type of log available
							Hole	Well				
35N/39E-	32H01D1	AEP 702	482925	1175458	LA	1,575	310	310	–	10-11-01	–F	DR
	32L01	–	482917	1175538	VC	1,880	241	241	–	10-13-01 05-15-02	195.33 194.32	DR
	32N01	–	482857	1175601	BR	2,080	502	502	–	10-11-01	69.60	DR
	32P01D1	–	482857	1175536	LA	1,880	288	287	28	–	–	DR
	32P02	–	482857	1175537	LA/BR	1,880	290	290	–	–	–	DR
	33E01	ACV 856	482926	1175429	VC	1,570	73	73	130	10-06-01 05-15-02	8.32 5.45	DR
35N/40E-	06L01	ABV 306	483332	1174902	BR	2,550	400	400	–	–	–	DR
	19B01	ACC 919	483120	1174842	BR	2,220	420	420	–	09-25-01	173.22P	DR
	21L01	ABQ 897	483055	1174638	BR	2,415	380	380	–	–	–	DR
	27J01	–	482960	1174424	OA	2,460	105	104	–	09-20-01	83.04R	DR
	29N01	ACV 881	482951	1174805	OA	2,180	120	119	–	09-21-01	5.32	DR
	31G01	–	482928	1174832	UA	2,120	215	214	–	–	–	DR
	31G02	–	482926	1174836	UA	2,160	290	260	–	09-24-01	161.98	DR
	33J01	–	482916	1174554	BR	2,335	171	171	–	10-17-01 05-14-02	17.27 18.20	DR
	33R02	AAJ 986	482904	1174543	OA	2,260	72	72	–	–	–	DR
	36F01	AFF 391	482923	1174233	TC	2,380	98	98	–	09-25-01	8.76	DR
35N/41E-	08E01	AEJ 005	483259	1174027	UA	3,200	100	100	–	09-20-01	68.75	DR
	08M01	AEP 703	483248	1174023	UA	3,120	80	70	–	–	–	DR
	14C01	–	483210	1173616	UA	3,020	63	60	–	–	–	DR
	14E01	ACT 841	483201	1173621	UA	3,020	260	260	–	–	–	DR
	15E01	–	483200	1173749	BR	3,100	193	189	–	–	–	DR
	21F01	ABZ 960	483114	1173834	UA/BR	2,890	345	338	–	–	–	DR
	21P01	–	483042	1173835	BR	2,965	320	320	–	–	–	DR
	21P02	–	483044	1173841	UA	2,880	120	118	–	–	–	DR
36N/37E-	25R01	–	483458	1180456	LA	1,587	316	306	–	–	–	DG
	36A01	–	483444	1180456	LA	1,580	300	300	310	10-18-01	286.85	DR
	36B01	–	483447	1180533	LA	1,530	274	274	–	10-18-01	232.17	DR
	36G01	–	483442	1180517	LA	1,530	292	278	–	–	–	DG
	36H01	–	483442	1180502	LA	1,560	340	292	–	–	–	DR
	36H02	–	483440	1180513	LA	1,580	293	266	–	–	–	DR
36N/38E-	21C01	ACT 809	483641	1180201	BR	1,680	320	320	–	–	–	DR
	21J01	AAK 025	483607	1180127	LA	1,570	304	299	–	10-16-01	244.05	DR
	21J02	ABP 457	483607	1180119	LA	1,570	374	374	–	10-16-01 05-15-02	226.60R 226.82	DR
	26E01	–	483530	1175932	LA	1,565	280	279	–	05-15-02 10-18-01	18.28 20.60	DR

Table 11. Physical and hydrologic data for the inventoried wells in the Colville River Watershed, Stevens County, Washington —*Continued*

[**Well No.**: See figure 2 for explanation of well-numbering system. **WDOE tag**: Washington Department of Ecology**. Latitude and Longitude** are given in degrees, minutes, seconds. **Hydrogeologic unit**: UA, Upper outwash aquifer; TC, Till confining unit; OA, Older outwash aquifer; VC, Colville Valley confining unit, LA, Lower aquifer; LC, Lower confining unit; BR, Bedrock. **Water level**: Minus sign (-) indicates water level above land surface; F, flowing; P, pumping; R, recently pumped; S, nearby pumping; T, nearby recently pumped. **Type of log available**: DR, driller; DG, geologist. **Abbreviations**: ft/d, foot per day; –, no data available]

Well No.		WDOE tag	Latitude	Longitude	Hydro-geologic unit	Land-surface altitude (feet above NGVD29)	Depth, in feet		Estimated horizontal hydraulic conductivity (ft/d)	Date	Water level (feet below land surface)	Type of log available
							Hole	Well				
36N/38E-	26M01	–	483509	1175944	BR	1,530	340	340	–	11-07-01 05-16-02	34.65R 87.05R	DR
	26N01	–	483454	1175944	LA	1,565	170	169	–	11-07-01	–	DR
	27H01	AGH 581	483530	1180007	LA	1,540	585	584	–	11-06-01 05-16-02	142.42 142.91	DR
	29J01	ACF 580	483517	1180224	BR	1,615	780	780	–	10-16-01 05-16-02	312.15 324.94	DR
	30G01	–	483523	1180411	LA	1,389	215	215	–	09-25-01	100.71R	DR
	30K01	–	483513	1180403	LA	1,380	647	169	–	–	–	DR
	30K02	–	483523	1180411	LA	1,390	178	177	–	–	–	DR
	30K03	–	483513	1180404	LA	1,380.5	199	192	–	09-25-01	89.9R	DR
	30K04	–	483516	1180413	LA	1,410	226	226	130	09-25-01	115	DR
	30K05	–	483518	1180404	LA	1,400	258	258	–	–	–	DR
	30K06	–	483513	1180410	LA	1,400	185	185	–	09-25-01 05-15-02	106.46 100.09	DR
	30K07	AHC 045	483513	1180410	LA	1,410	157	155	290	09-25-01 05-15-02	109.54 103.15	DR
	30N01	–	483502	1180447	LA	1,625	350	350	–	10-18-01	322.06	DR
	30N02	–	483503	1180446	LA	1,620	345	329	–	–	–	DG
	30N03	–	483455	1180454	LA	1,595	327	302	–	–	–	DG
	31P01	–	483415	1180424	LA	1,640	512	506	–	–	–	DR
	31Q01	ABQ 865	483404	1180407	LA	1,730	499	499	–	10-18-01 05-16-02	451.10 446.20	DR
	32C01	–	483448	1180303	LA	1,600	360	319	–	10-18-01	298.42	DR
	32L01	AFN 036	483420	1180317	LA	1,660	415	414	–	10-16-01 05-16-02	372.25 368.75	DR
	32L02	AFI 096	483420	1180311	VC	1,680	102	102	14	–	–	DR
	32M01	–	483423	1180327	LA	1,625	390	390	– –	10-16-01 05-16-02	341.15 335.79	DR
	36A01D1	–	483459	1175733	LA	1,540	300	300	–	–	–	DR
	36H01D1	ABO 862	483434	1175738	LA	1,560	395	395	–	10-17-01 05-15-02	-1.1F –F	DR
36N/39E-	06R01	AAY 892	483839	1175609	UA	1,865	68	66	330	10-10-01	22.71	DR
	06R02	AEQ 467	483835	1175609	LA	1,855	380	372	–	–	–	DR
	08E01	–	483807	1175547	VC	1,820	237	228	160	10-10-01 05-15-02	70.82 71.16	DR
	08L01	ACM 906	483800	1175540	VC	1,810	240	240	–	10-11-01	65.05	DR
	19A01	–	483636	1175614	UA	1,670	117	117	–	10-17-01	57.3	DR

Table 11. Physical and hydrologic data for the inventoried wells in the Colville River Watershed, Stevens County, Washington —*Continued*

[**Well No.**: See figure 2 for explanation of well-numbering system. **WDOE tag**: Washington Department of Ecology**. Latitude and Longitude** are given in degrees, minutes, seconds. **Hydrogeologic unit**: UA, Upper outwash aquifer; TC, Till confining unit; OA, Older outwash aquifer; VC, Colville Valley confining unit, LA, Lower aquifer; LC, Lower confining unit; BR, Bedrock. **Water level**: Minus sign (-) indicates water level above land surface; F, flowing; P, pumping; R, recently pumped; S, nearby pumping; T, nearby recently pumped. **Type of log available**: DR, driller; DG, geologist. **Abbreviations**: ft/d, foot per day; –, no data available]

Well No.		WDOE tag	Latitude	Longitude	Hydro-geologic unit	Land-surface altitude (feet above NGVD29)	Depth, in feet		Estimated horizontal hydraulic conductivity (ft/d)	Date	Water level (feet below land surface)	Type of log available
							Hole	Well				
36N/39E-	19J01	–	483608	1175626	VC	1,640	60	60	–	10-11-01	16.45	DR
									–	05-15-02	13.85	
	22M01	–	483608	1175322	LA	1,890	140	139	–	10-11-01	7.14	DR
									–	05-15-02	3.31	
	24G01D1	–	483619	1174947	OA	2,450	148	148	–	–	–	DR
	24H01	–	483632	1174935	OA	2,520	140	140	–	10-10-01	-1.7F	DR
	25J01	–	483525	1174938	UA	2,100	120	109	–	–	–	DR
	25K01	–	483523	1174944	UA/BR	2,080	130	122	–	10-12-01	77.40	DR
									–	05-15-02	75.39	
	25N01	ABV 411	483504	1175035	UA	2,000	60	40	–	10-12-01	9.95	DR
										05-15-02	7.49R	
	28F01	–	483530	1175424	BR	2,480	300	300	–	10-11-01	51.51	DR
										05-16-02	73.7R	
	30B01	–	483547	1175641	LA	1,590	345	345	–	11-06-01	–F	DR
	30M01	ACV 816	483521	1175716	BR	1,570	136	135	–	10-11-01	–F	DR
	31M01	ABQ 406	483432	1175724	LA	1,560	400	400	49	–	–	DR
	32C01	AHC 086	483450	1175545	BR	1,860	200	200	–	–	–	DR
	32E01	AHC 085	483446	1175551	BR	1,850	225	225	–	–	–	DR
	34C01	–	483458	1175249	UA	1,915	60	59	–	–	–	DR
	34L01	–	483430	1175246	UA	1,940	80	80	–	10-13-01	34.63	DR
	35P01	–	483422	1175135	BR	2,060	300	300	–	–	–	DR
	35R01	–	483412	1175049	BR	2,200	220	220	–	–	–	DR
	36C01	–	483449	1175006	UA	2,035	80	80	–	10-11-01	34.05	DR
	36C02	–	483457	1175015	UA	2,005	40	39	–	10-15-01	11.11	DR
36N/40E-	17N01	–	483656	1174808	OA	2,450	213	213	–	09-18-01	–F	DR
	19P01	AEQ 410	483558	1174848	BR	2,150	418	418	–	–	–	DR
	20N01	–	483604	1174812	UA	2,105	37	35	–	09-18-01	5.62	DR
										05-16-02	4.24	
	20N02	–	483603	1174803	LA	2,180	140	139	–	09-18-01	112.44R	DR
										05-16-02	110.41	
	30D01	–	483540	1174912	UA	2,085	37	36	–	09-18-01	13.18	DR
	31R01	AAK 120	483415	1174827	TC	2,790	97	97	–	10-15-01	30.04R	DR
36N/42E-	19A01	AEP 737	483650	1173242	UA	3,160	46	46	220	09-19-01	14.35	DR
	19H01	ABZ 959	483630	1173250	UA	3,165	60	58	–	–	–	DR
	20C01	AGG 018	483643	1173208	UA	3,180	107	107	–	09-19-01	30.84	DR
	20E01	AFA 256	483633	1173224	UA	3,160	95	31	3	–	–	DR
37N/38E-	25B01	AEJ 014	484054	1175744	UA	1,960	98	98	–	09-18-01	66.22	DR
37N/39E-	30D01	–	484104	1175703	UA	1,900	72	72	–	09-18-01	25.18	DR
	31R01	ABO 442	483922	1175604	UA	1,890	78	74	12	–	–	DR

Table 12. Thickness of hydrogeologic units in inventoried wells in the Colville River Watershed, Stevens County, Washington

[**Well No.:** See figure 2 for explanation of well-numbering system in Washington. **Latitude and Longitude** are given in degrees, minutes, seconds. **Thickness of hydrogeologic unit:** –, well does not penetrate to stratigraphic position where unit may or may not be present; >, minimum thickness of unit where total thickness unknown; 0, unit not present]

Well No.	Latitude	Longitude	Land-surface altitude (feet above NGVD29)	Thickness of hydrogeologic unit (feet)						
				Upper outwash aquifer	Till confining unit	Older outwash aquifer	Colville Valley confining unit	Lower aquifer	Lower confining unit	Bedrock
29N/41E-02M01	480223	1173622	2,390	>58	–	–	–	–	–	–
02M02	480218	1173613	2,400	>46	–	–	–	–	–	–
02M03	480223	1173619	2,390	49	0	0	0	0	0	>1
02M04	480218	1173613	2,400	40	0	0	0	0	0	>77
04C03	480246	1173837	2,440	0	0	0	0	0	0	>125
04F01	480231	1173856	2,680	0	0	0	0	0	0	>400
10C01	480150	1173712	2,400	74	0	0	0	0	0	>17
10C02	480150	1173713	2,400	102	0	0	0	0	0	>3
30N/39E-01G01	480755	1174954	2,220	>40	–	–	–	–	–	–
01G02	480747	1174940	2,200	12	145	>3	–	–	–	–
01L01	480733	1175001	2,160	0	26	0	0	0	0	>94
13F01	480604	1175009	2,440	0	40	0	0	0	0	>30
14G01	480610	1175109	2,415	31	0	0	137	>12	–	–
14G02	480604	1175102	2,400	No log						
24D02	480523	1175020	2,460	0	50	>10	–	–	–	–
24L01	480504	1175008	2,460	No log						
30N/40E-04R01	480727	1174539	1,690	0	0	0	150	>48	–	–
10N02	480628	1174514	1,800	0	0	0	92	>38	–	–
12A01	480715	1174142	2,180	70	0	0	102	24	0	>1
14M01	480556	1174349	2,320	316	0	0	176	0	0	>28
15E01	480600	1174523	1,810	0	0	0	233	>7	–	–
15E02	480600	1174523	1,810	0	0	0	233	>25	–	–
15Q01	480542	1174445	1,980	47	0	0	53	0	0	>125
16G01	480601	1174601	1,800	0	0	0	260	>27	–	–
16L01	480557	1174607	1,800	0	0	0	210	>90	–	–
16L02D1	480549	1174605	1,800	0	0	0	280	>25	–	–
20B01	480528	1174715	2,060	150	0	0	>105	–	–	–
20F01	480518	1174725	2,100	115	0	0	>45	–	–	–
21H01	480515	1174529	1,900	0	0	0	148	>92	–	–
21J02	480506	1174527	1,900	0	0	0	135	>25	–	–
28A01D1	480434	1174537	1,945	23	0	0	150	>67	–	–
33R01R1	480305	1174532	2,020	32	0	0	>163	–	–	–
33R02	480305	1174533	2,020	25	0	0	>315	–	–	–
34A01	480341	1174421	2,080	No log						
34G01	480328	1174435	2,040	>150	–	–	–	–	–	–
35C01	480346	1174326	2,160	>98	–	–	–	–	–	–
30N/41E-04G02	480747	1173812	2,540	>199	–	–	–	–	–	–
04N01	480730	1173853	2,480	>143	–	–	–	–	–	–

Table 12. Thickness of hydrogeologic units in inventoried wells in the Colville River Watershed, Stevens County, Washington—*Continued*

[**Well No.:** See figure 2 for explanation of well-numbering system in Washington. **Latitude and Longitude** are given in degrees, minutes, seconds. **Thickness of hydrogeologic unit:** –, well does not penetrate to stratigraphic position where unit may or may not be present; >, minimum thickness of unit where total thickness unknown; 0, unit not present]

Well No.	Latitude	Longitude	Land-surface altitude (feet above NGVD29)	Thickness of hydrogeologic unit (feet)						
				Upper outwash aquifer	Till confining unit	Older outwash aquifer	Colville Valley confining unit	Lower aquifer	Lower confining unit	Bedrock
30N/41E-04P01	480727	1173839	2,480	>95	–	–	–	–	–	–
04P02	480727	1173839	2,480	>180	–	–	–	–	–	–
10R02	480628	1173627	2,500	>245	–	–	–	–	–	–
12R01	480634	1173403	2,660	0	0	0	0	0	0	>297
12R02	480634	1173403	2,660	0	0	0	0	0	0	>247
12R03	480634	1173403	2,660	0	0	0	0	0	0	>197
12R04	480634	1173403	2,660	>67	–	–	–	–	–	–
12R05	480634	1173403	2,660	53	0	0	0	0	0	>6
13H01	480608	1173358	2,500	56	0	0	0	0	0	>4
13H02	480604	1173401	2,500	31	0	0	0	0	0	>89
13H03	480607	1173359	2,500	No log						
15B04	480617	1173654	2,510	>242	–	–	–	–	–	–
15B05	480615	1173704	2,510	>165	–	–	–	–	–	–
15L04	480555	1173721	2,500	>300	–	–	–	–	–	–
15M01	480548	1173744	2,460	>171	–	–	–	–	–	–
18L01	480557	1174109	2,290	>480	–	–	–	–	–	–
28J01	480408	1173748	2,420	>120	–	–	–	–	–	–
28Q02	480358	1173809	2,420	>140	–	–	–	–	–	–
33H01	480328	1173746	2,410	>66	–	–	–	–	–	–
34C02	480342	1173723	2,410	>198	–	–	–	–	–	–
34D01	480342	1173726	2,410	>104	–	–	–	–	–	–
34Q03	480304	1173655	2,400	>36	–	–	–	–	–	–
34Q04	480304	1173655	2,400	38	0	0	0	0	0	>12
31N/39E-03A04	481316	1175157	2,540	0	22	0	0	0	0	>238
13A02	481137	1174935	2,200	No log						
13A03	481137	1174934	2,200	0	45	0	0	0	0	>215
31N/40E-02A01	481315	1174252	1,645	0	0	0	119	>2	-	-
02P01	481233	1174350	1,660	0	0	0	245	>25	–	–
03C01	481319	1174506	1,800	0	58	0	0	0	0	>162
16L02	481111	1174620	2,000	90	0	0	>147	–	–	–
16L04	481106	1174614	1,970	70	0	0	>151	–	–	–
17A01	481131	1174648	2,070	133	0	0	>124	–	–	–
17A02	481134	1174648	2,070	127	0	0	>175	–	–	–
20F02	481029	1174735	2,030	0	16	0	0	0	0	>164
22B02	481037	1174432	1,670	0	0	0	185	20	0	>1
22F02	481026	1174501	1,690	0	0	0	139	0	0	>284
23K01	481018	1174316	1,760	>195	–	–	–	–	–	–

Table 12. Thickness of hydrogeologic units in inventoried wells in the Colville River Watershed, Stevens County, Washington—*Continued*

[**Well No.:** See figure 2 for explanation of well-numbering system in Washington. **Latitude and Longitude** are given in degrees, minutes, seconds. **Thickness of hydrogeologic unit:** –, well does not penetrate to stratigraphic position where unit may or may not be present; >, minimum thickness of unit where total thickness unknown; 0, unit not present]

Well No.	Latitude	Longitude	Land-surface altitude (feet above NGVD29)	Thickness of hydrogeologic unit (feet)						
				Upper outwash aquifer	Till confining unit	Older outwash aquifer	Colville Valley confining unit	Lower aquifer	Lower confining unit	Bedrock
31N/40E-23K02	481018	1174316	1,760	196	0	0	>2	–	–	-
25P01	480908	1174218	2,030	No log						
25Q01	480903	1174204	2,040	>98	–	–	–	–	–	-
26K01	480926	1174325	1,740	>125	–	–	–	–	–	-
26K03	480926	1174321	1,760	>100	–	–	–	–	–	-
26K04	480912	1174317	1,760	>100	–	–	–	–	–	–
26Q01	480903	1174321	1,760	>100	–	–	–	–	–	–
26R02	480908	1174317	1,760	>100	–	–	–	–	–	–
05N03	481240	1174006	2,080	317	–	–	–	–	–	>583
07B01	481219	1174035	1,810	98	50	0	0	0	0	>52
08B01	481227	1173931	2,050	>300	–	–	–	–	–	–
11A01	481211	1173516	2,580	38	0	0	231	>5	–	–
30P01	480901	1174055	2,060	50	0	0	>175	–	–	–
31E02	480843	1174121	2,060	>80	–	–	–	–	–	–
31M02	480837	1174121	2,045	99	0	0	139	>59	–	–
31M03	480837	1174122	2,045	>68	–	–	–	–	–	–
32B01	480860	1173929	2,210	>140	–	–	–	–	–	–
32F01	480839	1173943	2,240	>180	–	–	–	–	–	–
32F02	480841	1173942	2,240	189	0	0	0	0	0	>211
32H01	480842	1173916	2,300	24	0	0	41	0	0	>275
32N/38E-15A01	481652	1175959	2,550	42	33	0	0	0	0	>3
21C01	481553	1180143	3,000	32	0	0	0	0	0	>128
32N/39E-04D01	481829	1175423	2,100	>70	–	–	–	–	–	–
05A01	481819	1175439	2,250	113	0	0	142	>2	–	–
12D01	481729	1175035	2,210	38	0	0	0	0	0	>402
32N/40E-01B01	481821	1174208	2,060	220	0	0	58	0	0	>122
01G01	481813	1174202	2,040	150	0	0	75	0	0	>115
02P01	481752	1174339	1,735	37	0	0	>3	–	–	–
03G01	481814	1174435	1,790	>30	–	–	–	–	–	–
03G02	481818	1174440	1,800	No log						
03H01	481820	1174423	1,790	>30	–	–	–	–	–	–
03H02	481817	1174430	1,800	No log						
03H03	481817	1174426	1,790	No log						
03K01	481759	1174450	1,760	>125	–	–	–	–	–	–
04R01	481744	1174534	1,670	0	0	0	216	0	0	>29
05K01	481759	1174716	1,640	0	0	0	280	>12	–	–
10A01	481723	1174419	1,770	180	0	0	138	0	0	>2,152

Table 12. Thickness of hydrogeologic units in inventoried wells in the Colville River Watershed, Stevens County, Washington—*Continued*

[**Well No.:** See figure 2 for explanation of well-numbering system in Washington. **Latitude and Longitude** are given in degrees, minutes, seconds. **Thickness of hydrogeologic unit:** –, well does not penetrate to stratigraphic position where unit may or may not be present; >, minimum thickness of unit where total thickness unknown; 0, unit not present]

Well No.	Latitude	Longitude	Land-surface altitude (feet above NGVD29)	Thickness of hydrogeologic unit (feet)						
				Upper outwash aquifer	Till confining unit	Older outwash aquifer	Colville Valley confining unit	Lower aquifer	Lower confining unit	Bedrock
32N/40E-11F04	481723	1174340	1,710	>118	–	–	–	–	–	–
12N01	481653	1174245	1,675	No log						
14H01	481625	1174311	1,660	0	0	0	140	>35	–	–
15F01	481636	1174508	1,700	0	0	0	>78	–	–	–
15G02	481636	1174443	1,630	0	0	0	183	>67	–	–
15M02	481614	1174517	1,900	>165	–	–	–	–	–	–
15R01	481600	1174414	1,630	0	0	0	325	>37	–	–
15R02	481600	1174414	1,630	No log						
15R03	481600	1174414	1,630	Incomplete log						
22G01	481535	1174441	1,820	>220	–	–	–	–	–	–
23J01	481524	1174254	1,630	No log						
24E01	481539	1174250	1,635	0	0	0	>60	–	–	–
24F01	481531	1174222	1,660	0	>119	–	–	–	–	–
24N01	481510	1174249	1,650	0	0	0	70	>30	–	–
25N01	481421	1174239	1,650	0	0	0	97	62	0	>9
26A01	481504	1174256	1,660	0	0	0	160	25	0	>3
27E02	481453	1174512	1,880	39	0	0	71	59	0	>431
27R01	481415	1174416	1,690	0	0	0	100	0	0	>100
28G01D1	481452	1174605	2,100	0	250	0	>95	–	–	–
28H01	481454	1174540	2,000	>205	–	–	–	–	–	–
28H02	481452	1174605	2,100	No log						
28L01	481433	1174622	2,070	120	0	0	60	0	0	>80
28L02	481427	1174620	2,060	90	0	0	>70	–	–	–
28R01	481422	1174535	1,900	39	0	0	72	>9	–	–
29C01	481454	1174732	2,110	100	0	0	80	0	0	>10
33B01D1	481412	1174553	1,990	0	10	0	0	0	0	>170
35M01	481343	1174356	1,700	No log						
35N01	481335	1174400	1,680	0	0	0	89	0	0	>331
32N/41E-05P01	481752	1173937	2,440	47	0	0	0	0	0	>153
07N01	481702	1174133	1,880	95	0	0	0	0	0	>91
19E01	481531	1174125	1,680	0	27	0	0	0	0	>253
33N/38E-03F01	482315	1180034	2,860	0	29	0	0	0	0	>71
33N/39E-02E01	482323	1175152	1,610	No log						
03P01D1	482257	1175257	1,760	0	0	0	60	0	0	>90
05L01	482314	1175523	2,140	0	48	0	0	0	0	>272
10R02	482210	1175211	1,640	0	0	0	169	>71	–	–
10R03	482211	1175212	1,640	0	0	0	215	21	14	>1
11L01	482219	1175133	1,620	No log						

Table 12. Thickness of hydrogeologic units in inventoried wells in the Colville River Watershed, Stevens County, Washington—*Continued*

[**Well No.:** See figure 2 for explanation of well-numbering system in Washington. **Latitude and Longitude** are given in degrees, minutes, seconds. **Thickness of hydrogeologic unit:** –, well does not penetrate to stratigraphic position where unit may or may not be present; >, minimum thickness of unit where total thickness unknown; 0, unit not present]

Well No.	Latitude	Longitude	Land-surface altitude (feet above NGVD29)	Thickness of hydrogeologic unit (feet)						
				Upper outwash aquifer	Till confining unit	Older outwash aquifer	Colville Valley confining unit	Lower aquifer	Lower confining unit	Bedrock
33N/39E-13C01	482150	1175017	1,610	0	0	0	480	>40	–	–
13C02	482151	1175017	1,610	0	0	0	403	>86	–	–
13F01	482149	1175017	1,610	0	0	0	478	158	27	>5
15J01	482122	1175211	1,660	0	0	0	298	12	0	>19
23A01	482101	1175101	1,650	No log						
23A02	482101	1175102	1,650	20	0	0	>380	–	–	–
23J01	482035	1175049	1,636	80	0	0	240	>20	–	–
24E01	482055	1175037	1,630	0	0	0	>230	–	–	–
24G01	482055	1174955	1,611	0	0	0	>92	–	–	–
24K01	482034	1174955	1,680	40	0	0	218	57	0	>1
25D01	482010	1175028	1,630	0	0	0	320	>25	–	–
33N01	481840	1175436	2,340	0	110	0	0	0	0	>490
33N/40E-25E01	481958	1174258	2,690	0	74	0	0	0	0	>526
27J01	481946	1174432	2,090	>200	–	–	–	–	–	–
27K01	481945	1174453	2,110	240	0	0	0	0	0	>60
27Q01	481931	1174442	2,100	>210	–	–	–	–	–	–
31F01	481901	1174851	1,680	0	0	0	135	>43	–	–
34G01D1	481910	1174444	2,090	>375	–	–	–	–	–	–
34G02	481910	1174444	2,090	>300	–	–	–	–	–	–
34H01D1	481909	1174431	2,080	>240	–	–	–	–	–	–
34H02	481908	1174430	2,080	>250	–	–	–	–	–	–
34J01R2	481855	1174430	2,075	>301	–	–	–	–	–	–
34L01	481853	1174511	2,080	310	0	0	0	0	0	>2
35P01	481834	1174345	1,860	>185	–	–	–	–	–	–
35P02	481833	1174345	1,860	>120	–	–	–	–	–	–
36H01	481909	1174152	2,200	85	110	0	30	0	0	>155
33N/41E-28A01	482010	1173746	2,690	43	0	0	115	>7	–	–
30B01	482013	1174045	2,300	15	86	0	>96	–	–	–
34N/38E-03B01	482850	1180032	2,740	0	70	>10	–	–	–	–
04A01	482854	1180108	2,880	14	16	0	0	0	0	>90
12G01	482737	1175754	2,240	95	43	0	0	0	0	>182
13E01	482649	1175814	2,180	69	0	0	0	0	0	>10
13M01	482639	1175828	2,190	63	0	0	0	0	0	>237
14J01	482631	1175836	2,250	50	71	0	0	0	0	>1
21R01	482535	1180129	2,900	>40	–	–	–	–	–	–
23D01	482604	1175939	2,420	75	30	>2	–	–	–	–
34N/39E-02C01	482844	1175134	2,000	63	0	0	0	0	0	>197
02H01	482832	1175058	1,860	155	0	0	0	0	0	>265

Table 12. Thickness of hydrogeologic units in inventoried wells in the Colville River Watershed, Stevens County, Washington—*Continued*

[**Well No.:** See figure 2 for explanation of well-numbering system in Washington. **Latitude and Longitude** are given in degrees, minutes, seconds. **Thickness of hydrogeologic unit:** –, well does not penetrate to stratigraphic position where unit may or may not be present; >, minimum thickness of unit where total thickness unknown; 0, unit not present]

Well No.	Latitude	Longitude	Land-surface altitude (feet above NGVD29)	Thickness of hydrogeologic unit (feet)						
				Upper outwash aquifer	Till confining unit	Older outwash aquifer	Colville Valley confining unit	Lower aquifer	Lower confining unit	Bedrock
34N/39E-03R01	482814	1175213	1,780	0	0	0	40	0	0	>260
04P02	482804	1175403	1,600	0	0	0	61	>4	–	–
09C01	482760	1175410	1,605	26	0	0	66	0	0	>8
09J01	482724	1175322	1,720	0	0	0	242	>38	–	–
09P01	482717	1175407	1,820	0	0	0	130	0	0	>50
09R01	482718	1175323	1,720	0	0	0	300	0	0	>160
10H02	482739	1175204	1,625	No log						
10J03	482729	1175209	1,625	27	0	0	>93	–	–	–
10M01	482734	1175311	1,580	35	0	0	>1	–	–	–
10M02	482731	1175307	1,580	28	0	0	>12	–	–	–
10N03	482711	1175318	1,680	0	0	0	195	>20	–	–
10P01	482723	1175247	1,590	0	0	0	>38	–	–	–
10P02	482714	1175249	1,590	0	0	0	>60	–	–	–
11C01	482753	1175138	1,820	210	>15	–	–	–	–	–
11G02	482741	1175119	1,885	>292	–	–	–	–	–	–
16C01	482709	1175359	1,835	0	0	0	88	20	0	>15
22G01	482602	1175237	1,600	0	0	0	111	>40	–	–
22R01	482537	1175211	1,620	0	0	0	140	>45	–	–
23M01	482541	1175159	1,611	0	0	0	130	>10	–	–
23Q01	482539	1175109	1,685	0	0	0	>131	–	–	–
23Q02D1	482536	1175103	1,666	25	0	0	145	>9	–	–
23Q03	482532	1175113	1,640	>46	–	–	–	–	–	–
25M01	482451	1175025	1,740	91	0	0	0	0	0	>214
25M02	482450	1175029	1,720	91	0	0	0	0	0	>9
26B01	482522	1175108	1,642	0	0	0	>54	–	–	–
26K01	482458	1175105	1,640	0	0	0	>42	–	–	–
26N01	482445	1175160	1,720	0	0	0	39	0	0	>261
26P01	482442	1175130	1,600	0	0	0	125	>15	–	–
26Q01	482444	1175113	1,630	0	0	0	215	>25	–	–
26R01	482439	1175059	1,660	0	0	0	>44.5	–	–	–
35A01D1	482424	1175050	1,660	32	0	0	>118	–	–	–
35A02	482422	1175102	1,640	0	0	0	92	>48	–	–
35H01	482413	1175048	1,715	>210	–	–	–	–	–	–
35P01	482352	1175126	1,780	>177	–	–	–	–	–	–
36B01	482428	1174952	1,880	12	0	0	0	0	0	>388
34N/40E-11D01	482756	1174415	2,120	36	0	0	0	0	0	>564
11F01	482741	1174349	2,030	0	0	0	138	6	0	>1
19M01	482547	1174919	2,360	0	0	0	0	0	0	>700
30M01	482449	1174907	2,180	48	0	0	0	0	0	>152

Table 12. Thickness of hydrogeologic units in inventoried wells in the Colville River Watershed, Stevens County, Washington—*Continued*

[**Well No.:** See figure 2 for explanation of well-numbering system in Washington. **Latitude and Longitude** are given in degrees, minutes, seconds. **Thickness of hydrogeologic unit:** –, well does not penetrate to stratigraphic position where unit may or may not be present; >, minimum thickness of unit where total thickness unknown; 0, unit not present]

Well No.	Latitude	Longitude	Land-surface altitude (feet above NGVD29)	Thickness of hydrogeologic unit (feet)						
				Upper outwash aquifer	Till confining unit	Older outwash aquifer	Colville Valley confining unit	Lower aquifer	Lower confining unit	Bedrock
35N/38E-01E01	483348	1175840	1,950	>60	–	–	–	–	–	–
11A01	483305	1175851	2,080	0	>124	–	–	–	–	–
11A02	483303	1175854	2,090	25	95	0	0	0	0	>420
11M01	483241	1175945	2,320	50	>40	–	–	–	–	–
12R01	483227	1175732	1,960	0	4	0	0	0	0	>436
27P01	482951	1180051	3,020	0	91	0	0	0	0	>69
01D01	483405	1175040	2,210	42	>83	–	–	–	–	–
02B01	483405	1175119	2,040	23	0	0	>124	–	–	–
02C01D2	483404	1175132	2,010	25	0	0	168	>25	–	–
05F01	483347	1175541	1,555	0	0	0	55	>25	–	–
05F02	483345	1175535	1,550	0	0	0	45	18	0	>442
06D01	483356	1175709	1,575	0	88	0	0	0	0	>212
06K01	483332	1175642	1,540	0	0	0	240	>15	–	–
07K01	483247	1175626	1,560	0	0	0	193	7	0	>1
09J01	483250	1175327	1,760	>90	–	–	–	–	–	–
10B02A	483313	1175225	1,890	160	16	>36	–	–	–	–
10B02B	483313	1175226	1,890	160	38	>56	–	–	–	–
10B03	483317	1175227	1,890	155	27	>54	–	–	–	–
10B04	483314	1175226	1,890	180	>20	–	–	–	–	–
10N01	483231	1175324	1,740	48	0	0	>1	–	–	–
11A01	483316	1175053	2,190	21	159	>8	–	–	–	–
11A02	483315	1175045	2,190	22	41	0	0	0	0	>37
11Q03	483237	1175120	2,000	No log						
11R01	483235	1175101	2,060	No log						
11R02A	483235	1175104	2,030	144	52	0	0	0	0	>2
11R02B	483235	1175103	2,030	>100	–	–	–	–	–	–
11R03	483235	1175121	2,000	102	0	0	0	0	0	>11
11R04	483236	1175047	2,180	>120	–	–	–	–	–	–
11R05	483237	1175120	2,000	62	0	0	0	0	0	>8
12H01	483253	1174927	2,255	59	0	0	0	0	0	>19
12Q01	483233	1175002	2,210	>180	–	–	–	–	–	–
12R02	483226	1174934	2,210	144	0	0	0	0	0	>2
14E02	483201	1175157	1,960	52	0	0	0	0	0	>254
16F01	483203	1175406	1,590	0	0	0	185	9	–	>2
18A01	483215	1175624	1,580	>40	–	–	–	–	–	–
18B01D1	483222	1175636	1,630	70	0	0	0	0	0	>470
20K01	483056	1175524	1,555	0	0	0	>110	–	–	–
21E01	483107	1175429	1,550	0	0	0	245	>17	–	–
21M01R1	483106	1175425	1,550	No log						

Table 12. Thickness of hydrogeologic units in inventoried wells in the Colville River Watershed, Stevens County, Washington—*Continued*

[**Well No.:** See figure 2 for explanation of well-numbering system in Washington. **Latitude and Longitude** are given in degrees, minutes, seconds. **Thickness of hydrogeologic unit:** –, well does not penetrate to stratigraphic position where unit may or may not be present; >, minimum thickness of unit where total thickness unknown; 0, unit not present]

Well No.	Latitude	Longitude	Land-surface altitude (feet above NGVD29)	Thickness of hydrogeologic unit (feet)						
				Upper outwash aquifer	Till confining unit	Older outwash aquifer	Colville Valley confining unit	Lower aquifer	Lower confining unit	Bedrock
35N/39E-23B01	483130	1175120	2,280	30	235	0	0	0	0	>15
23F01	483117	1175125	2,160	85	29	0	0	0	0	>214
23F02	483117	1175133	2,080	27	145	–	–	0	0	>148
27C01	483026	1175249	2,110	0	90	4	0	0	0	>29
27C02	483028	1175260	2,160	0	90	4	0	0	0	>29
32H01D1	482925	1175458	1,575	0	0	0	305	>5	–	–
32L01	482917	1175538	1,880	78	77	0	85	0	0	>1
32N01	482857	1175601	2,080	0	193	0	0	0	0	>309
32P01D1	482857	1175536	1,880	0	175	0	105	>8	–	–
32P02	482857	1175537	1,880	0	75	0	190	15	0	>10
33E01	482926	1175429	1,570	0	0	0	>73	–	–	–
35N/40E-06L01	483332	1174902	2,550	0	12	0	0	0	0	>388
19B01	483120	1174842	2,220	0	68	0	0	0	0	>352
21L01	483055	1174638	2,415	80	0	0	0	0	0	>300
27J01	482960	1174425	2,460	32	66	>7	–	–	–	–
29N01	482951	1174805	2,180	35	70	>15	–	–	–	–
31G01	482928	1174832	2,120	>215	–	–	–	–	–	–
31G02	482926	1174836	2,160	>290	–	–	–	–	–	–
33J01	482916	1174554	2,335	76	22	0	0	0	0	>73
33R02	482904	1174543	2,260	28	35	>9	–	–	–	–
36F01	482923	1174233	2,380	0	>98	–	–	–	–	–
35N/41E-08E01	483259	1174027	3,200	>100	–	–	–	–	–	–
08M01	483248	1174023	3,120	70	0	0	0	0	0	>10
14C01	483211	1173616	3,020	>63	–	–	–	–	–	–
14E01	483201	1173621	3,020	>260	–	–	–	–	–	–
15E01	483200	1173749	3,100	189	0	0	0	0	0	>4
21F01	483114	1173834	2,890	338	0	0	0	0	0	>7
21P01	483042	1173835	2,965	80	80	0	0	0	0	>160
21P02	483044	1173841	2,880	120	0	0	–	–	–	–
36N/37E-25R01	483458	1180456	1,587	65	0	0	70	>181	–	–
36A01	483444	1180456	1,580	46	0	0	120	>134	–	–
36B01	483447	1180533	1,530	17	0	0	93	>164	–	–
36G01	483442	1180517	1,530	24	0	0	94	>174	–	–
36H01	483442	1180502	1,560	44	0	0	141	145	>10	–
36H02	483440	1180513	1,580	104	0	0	71	>118	–	–

Table 12. Thickness of hydrogeologic units in inventoried wells in the Colville River Watershed, Stevens County, Washington—*Continued*

[**Well No.:** See figure 2 for explanation of well-numbering system in Washington. **Latitude and Longitude** are given in degrees, minutes, seconds. **Thickness of hydrogeologic unit:** –, well does not penetrate to stratigraphic position where unit may or may not be present; >, minimum thickness of unit where total thickness unknown; 0, unit not present]

Well No.	Latitude	Longitude	Land-surface altitude (feet above NGVD29)	Thickness of hydrogeologic unit (feet)						
				Upper outwash aquifer	Till confining unit	Older outwash aquifer	Colville Valley confining unit	Lower aquifer	Lower confining unit	Bedrock
36N/38E-21C01	483641	1180201	1,680	45	0	0	130	0	0	>145
21J01	483607	1180127	1,570	0	0	0	275	>29	–	–
21J02	483607	1180119	1,570	0	0	0	258	>116	–	–
26E01	483530	1175933	1,565	0	0	0	275	>5	–	–
26M01	483509	1175944	1,530	0	0	0	77	0	0	>263
26N01	483454	1175944	1,565	0	0	0	147	>23	–	–
27H01	483530	1180007	1,540	0	0	0	570	>15	–	–
29J01	483517	1180224	1,615	0	0	0	195	126	0	>459
30G01	483523	1180411	1,389	0	0	0	0	194	4	>17
30K01	483513	1180403	1,380	0	0	0	0	169	454	>24
30K02	483523	1180411	1,390	0	0	0	0	177	>1	–
30K03	483513	1180404	1,380.5	0	0	0	0	179	>20	–
30K04	483516	1180419	1,560	0	0	0	0	205	>21	–
30K05	483518	1180404	1,400	0	0	0	0	220	>38	–
30K06	483513	1180410	1,400	0	0	0	0	160	>25	–
30K07	483513	1180410	1,410	0	0	0	0	>157	–	–
30N01	483502	1180447	1,625	53	0	0	103	>194	–	–
30N02	483503	1180446	1,620	75	0	0	97	>173	–	–
30N03	483455	1180454	1,595	10	0	0	100	>217	–	–
31P01	483415	1180424	1,640	310	0	0	55	133	>8	–
31Q01	483404	1180407	1,730	48	0	0	162	>289	–	–
32C01	483448	1180303	1,600	0	0	0	297	23	>40	–
32L01	483420	1180317	1,660	13	0	0	382	>20	–	–
32L02	483420	1180311	1,680	23	0	0	>80	-	–	–
32M01	483423	1180327	1,625	0	0	0	295	>95	–	–
36A01D1	483459	1175733	1,540	0	0	0	260	>40	–	–
36H01D1	483434	1175738	1,560	39	0	0	343	>13	–	–
36N/39E-06R01	483839	1175609	1,865	>68	–	–	–	–	–	–
06R02	483835	1175609	1,855	0	0	0	368	>12	–	–
08E01	483807	1175547	1,820	80	0	0	>157	–	–	–
08L01	483800	1175540	1,810	110	0	0	>130	–	–	–
19A01	483636	1175614	1,670	>117	–	–	–	–	–	–
19J01	483608	1175626	1,640	0	0	0	>60	–	–	–
22M01	483608	1175322	1,890	22	0	0	93	>25	–	–
24G01D1	483619	1174947	2,450	58	82	>8	–	–	–	–
24H01	483632	1174935	2,520	32	70	>38	–	–	–	–
25J01	483525	1174938	2,100	110	>10	–	–	–	–	–
25K01	483523	1174944	2,080	80	21	21	0	0	0	>8

Table 12. Thickness of hydrogeologic units in inventoried wells in the Colville River Watershed, Stevens County, Washington—*Continued*

[**Well No.:** See figure 2 for explanation of well-numbering system in Washington. **Latitude and Longitude** are given in degrees, minutes, seconds. **Thickness of hydrogeologic unit:** –, well does not penetrate to stratigraphic position where unit may or may not be present; >, minimum thickness of unit where total thickness unknown; 0, unit not present]

Well No.	Latitude	Longitude	Land-surface altitude (feet above NGVD29)	Thickness of hydrogeologic unit (feet)						
				Upper outwash aquifer	Till confining unit	Older outwash aquifer	Colville Valley confining unit	Lower aquifer	Lower confining unit	Bedrock
36N/39E-25N01	483504	1175035	2,000	40	0	0	>20	–	–	–
28F01	483530	1175424	2,480	0	105	0	0	0	–	>195
30B01	483547	1175641	1,590	0	0	0	340	>6	–	–
30M01	483521	1175716	1,570	0	0	0	134	2	–	>1
31M01	483432	1175724	1,560	22	0	0	370	>8	–	–
32C01	483450	1175545	1,860	0	23	0	0	0	0	>177
32E01	483446	1175551	1,850	0	12	0	0	0	0	>213
34C01	483458	1175249	1,915	>60	–	–	–	–	–	–
34L01	483430	1175247	1,940	>60	–	–	–	–	–	–
35P01	483422	1175135	2,060	14	0	0	170	0	-	>116
35R01	483413	1175049	2,200	43	115	0	0	0	0	>62
36C01	483449	1175007	2,035	70	0	0	>8	–	–	–
36C02	483457	1175015	2,005	>40	–	–	–	–	–	–
36N/40E-17N01	483656	1174808	2,450	45	158	>10	–	–	–	–
19P01	483558	1174848	2,150	0	48	0	0	0	0	>370
20N01	483605	1174812	2,105	>37	–	–	–	–	–	–
20N02	483603	1174803	2,180	0	80	-	50	>10	–	–
30D01	483540	1174912	2,085	>37	–	–	–	–	–	–
31R01	483415	1174827	2,790	0	97	0	0	0	0	>1
36N/42E-19A01	483650	1173242	3,160	>46	–	–	–	–	–	–
19H01	483630	1173250	3,165	>60	–	–	–	–	–	–
20C01	483643	1173208	3,180	105	0	0	0	0	0	>2
20E01	483633	1173224	3,160	60	>35	–	–	–	–	–
37N/38E-25B01	484054	1175744	1,960	>98	–	–	–	–	–	–
37N/39E-30D01	484104	1175703	1,900	>72	–	–	–	–	–	–
31R01	483922	1175604	1,890	>78	–	–	–	–	–	–

APPENDIX 1. WATER RIGHTS AND CLAIMS DATA, RETURN FLOW DATA, AND WATER-USE DATA COMPILED, REVIEWED, AND SUBMITTED BY THE WRIA 59 WATERSHED PLANNING TEAM

Appendix 1A. Surface- and ground-water rights and claims data, as reported by the WRIA 59 Colville River Watershed Planning Team, February 11, 2002

WRIA 59 Water Rights and Claims Registered with Washington Department of Ecology

Using the WDOE's Water Rights Application Tracking System (WRATS), the following totals were compiled from data that was input into that system as of December 12, 2001:

- 47 Water Right Applications (for new water rights)
- 25 Applications for Change (changes to current water rights or claims)
- 13 Water Right Permits
- 1,434 Water Right Certificates
- 2,724 Water Right Claims

4,243 TOTAL WATER RIGHTS AND CLAIMS IN WRIA 59

WRIA 59 Estimated Annual Quantity of Water Use Shown on Water Right Permits, Certificates, and Claims at Washington Department of Ecology

• Surface-Water Use per year for Permits and Certificates	36,498 acre-ft
• Ground-Water Use per year for Permits and Certificates	35,056 acre-ft
• Surface-Water Use per year for Claims	35,274 acre-ft
• Ground-Water Use per year for Claims	5,747 acre-ft
TOTAL 'PAPER RIGHTS AND CLAIMS':	112,575 acre-ft

That equals to 36,682,563,750 gallons of water claimed for use in WRIA 59 each year.

Footnote: The WRIA 59 Watershed Planning Team understands that the water-use figures above for water right claims has very marginal validity, until the claims have gone through a court adjudication process.

The Team also acknowledges that there is a large difference between the amounts of acres irrigated, and water use stated on the water rights and claims, as compared to the 'actual' irrigated acres and 'actual' water use. For example, in reviewing the Department of Ecology's WRATS system, the following numbers stand out in a comparison of 'paper' water rights irrigated acres, compared to 'actual' irrigated acres:

- Irrigated Acres: The WRATS data show 38,830 (±) acres within WRIA 59 that are designated as irrigated acres. However, in the WRIA 59 Irrigation Water-Use Report, only 7,190 (±) acres are in irrigation. The actual irrigated acres amount is only 18.5 percent of the claimed irrigated acres.
- Water Use: Once all the figures are compiled for 'actual water use', then a comparison can be made with the claimed water use to show the differences between the two.

Water Conversion Factors	
1 acre-foot = 325,850 gallons of water	1 million gallons = 3.0689 acre-feet
1 cubic foot of water = 7.4805 gallons	1 cubic foot per second (ft^3/s) = 448.83 gallons per minute (gal/min)

Appendix 1B. Return-flow data for the cities of Chewelah, Colville, and Kettle Falls; the Colville fish hatchery; and septic systems, as reported by the WRIA 59 Colville River Watershed Planning Team, April 22, 2002, and February 26, 2003

Return flows from Chewelah, Colville, and Kettle Falls

[**Chewelah**: Effluent is discharged from the City of Chewelah's Waste Water Treatment Plant to the Colville River. **Colville**: Effluent is discharged from the City of Colville's Waste Water Treatment Plant to the Colville River. **Kettle Falls**: Effluent is land applied through seasonal spray irrigation of about 6 acres near Kettle Falls. –, not reported]

Month (2001)	Chewelah	Colville	Kettle Falls
	(in million gallons per month)		
January	8.64	21.76	–
February	7.92	21.25	–
March	7.20	31.61	–
April	6.60	33.69	0.480
May	6.00	25.98	1.364
June	5.40	22.02	0.630
July	4.80	19.00	1.116
August	3.60	19.52	1.550
Septemer	4.80	20.03	0.750
October	7.20	30.06	–
November	8.40	33.87	–
December	10.2	26.82	–

Return flows for the Colville Fish Hatchery

[Effluent discharges to a small creek adjacent to the hatchery that in turn discharges to the Colville River about 1.5 miles to the west of the hatchery. Discharge is in gallons per minute (gal/min)]

December – January	(when they have very few fish)	**200 gal/min**
February	(increased production)	**300 gal/min**
March – June	(high peak use period)	**450 gal/min**
July – August	(low-use period, mostly fish eggs)	**200 gal/min**
September – November	(increased use for production)	**450 gal/min**

Estimated annual return flows from septic systems for households and businesses on public or private water systems

[Return flows were estimated using 200 gallons per day per household or business (Washington State Department of Health, 02-05-03)]

		Estimated annual return flows from septic systems	Gallons per year	Acre-feet per year
LOWER BASIN AREA	1,443	households served by private domestic wells	105,339,000	323.27
	296	households/businesses served by public water	21,608,000	66.31
MID-BASIN AREA	842	households served by private domestic wells	61,466,000	188.63
	137	households/businesses served by public water	10,001,000	30.69
UPPER BASIN AREA	684	households served by private domestic wells	49,932,000	153.24
	134	households/businesses served by public water	9,782,000	30.02
TOTAL BASIN		**Total estimated return flows from septic systems:**	**258,128,000**	**792.16**

Appendix 1C. Estimated irrigation water use, as reported by the WRIA 59 Colville River Watershed Planning Team and the Natural Resources Conservation Service, March 14, 2002

Total Estimated Irrigation Water Use: 21,570 acre-feet per year

Averaging three (3) acre-feet per year water-use for each acre irrigated (7,190 acres), the total estimated irrigation water-use within the Colville River Watershed is 21,570 acre-feet per year.

Source of Water Use: 86.6 percent surface water and 13.4 percent ground water

Of the total amount of water used to irrigate crops within the watershed, 86.6 percent is taken from surface water (SW) sources and 13.4 percent is taken from ground water (GW) sources.

Breakdown of Acres, Water Use, Crops and Water Source per Each Basin Area

Lower Basin Area (north end of the watershed, includes area where the Colville River flows into Lake Roosevelt. Includes Echo, Bon Ayer, Lakes, Haller Creek, Middle Colville, and Middle Little Pend Oreille River Watershed Administrative Units (WAUs):

- Irrigated Acres: 3,190 acres
- **Irrigation Water Use: 9,570 acre-feet per year (26 cubic feet per second/6 months)**
- Average Crops: 90 percent alfalfa grass and small grains, and 10 percent corn and potatoes
- Water-Use Source: 86.8 percent surface water, and 13.2 percent ground water

Mid-Basin Area (heart of the watershed, includes East Stranger Creek, Stensgar Creek, Iron Mountain, and Park Rapid WAUs):

- Irrigated Acres: 1,200 acres
- **Irrigation Water Use: 3,600 acre-feet per year (10 cubic feet per second/6 months)**
- Average Crops: 90 percent alfalfa grass, and 10 percent corn
- Water-Use Source: 96.3 percent surface water, and 3.7 percent ground water

Upper Basin Area (headwaters of the Colville River Watershed. Includes Huckleberry Creek, Cottonwood Creek, Grouse Creek, Deer Creek, and Loon-Deer Lakes WAUs):

- Irrigated Acres: 2,800 acres
- **Irrigation Water Use: 8,400 acre-feet per year (23 cubic feet per second/6 months)**
- Average Crops: 100 percent alfalfa grass and small grains
- Water-Use Source: 78.5 percent surface water, and 21.5 percent ground water

Note #1 Figures above are at 90-percent accuracy rate.

Note #2 The above data were figured on long-term averages and were based on peak water-use rates, which includes both drought and wetter years. July and August are the normal peak periods.

Appendix 1D. Group A public water systems water-use totals, WRIA 59, as reported by the WRIA 59 Colville River Watershed Planning Team, March 14, 2002

[–, not reported]

Annual total water usage		Gallons per year				Acre-feet per year			
No.	System name	2001	2000	1999	1998	2001	2000	1999	1998
LOWER BASIN AREA		**992,569,780**	**1,019,286,078**	**966,228,550**	**1,003,070,722**	**3,046**	**3,128**	**2,965**	**3,078**
1	Ardenbrook Water Assoc.[1]	2,441,600	2,611,472	2,605,520	2,908,208	7.5	8.0	8.0	8.9
2	Arden Hills Water System[1]	3,204,600	3,427,557	3,419,745	3,817,023	9.8	10.5	10.5	11.7
3	Colville, City of[2]	465,562,000	493,893,000	498,645,000	489,703,000	1,428.8	1,515.7	1,530.3	1,502.8
4	Corbett Creek Water System[1]	6,113,320	6,528,680	6,513,800	7,270,520	18.8	20.0	20.0	22.3
5	Country Villa Mobile Park[1]	6,867,000	7,344,765	7,328,025	8,179,335	21.1	22.5	22.5	25.1
6	Cross Roads Bar & Grill[1]	127,920	128,160	127,920	127,920	.4	.4	.4	.4
7	Dominion View Water Assn.[1]	2,746,800	2,937,906	2,931,210	3,271,734	8.4	9.0	9.0	10.0
8	Elm Tree Water & Sewer Assoc.	2,136,400	2,285,038	2,279,830	2,544,682	6.6	7.0	7.0	7.8
9	Echo Estates (PUD)[2]	550,140	–	–	–	1.7	–	–	–
10	Kettle Falls, City of[2]	485,808,000	482,051,000	424,341,000	465,320,000	1,490.9	1,479.4	1,302.3	1,428.0
11	Panorama Mobile Home Park[1]	7,324,800	7,834,416	7,816,560	8,724,624	22.5	24.0	24.0	26.8
12	Stimson Lumber Co.[3]	1,752,000	1,756,800	1,752,000	1,752,000	5.4	5.4	5.4	5.4
13	Tiger Tracts Water System[1]	5,188,400	5,549,378	5,536,730	6,179,942	15.9	17.0	17.0	19.0
14	Timothy Park Sub-Div.[1]	610,400	652,868	651,380	727,052	1.9	2.0	2.0	2.2
15	Williams Lake Rd. Sub-Div.[1]	2,136,400	2,285,038	2,279,830	2,544,682	6.6	7.0	7.0	7.8
MID-BASIN AREA		**310,801,990**	**318,971,540**	**325,017,790**	**275,073,150**	**953.8**	**978.9**	**997.4**	**844.2**
16	Addy, Town of (PUD)[2]	15,173,650	16,104,800	16,460,350	13,632,110	46.6	49.4	50.5	41.8
17	Chewelah, City of (PUD)[2]	251,318,000	262,246,000	275,543,000	231,970,000	771.3	804.8	845.6	711.9
18	Chewelah, City of, Golf Course (PUD)	23,698,000	19,334,000	18,421,000	16,329,000	72.7	59.3	56.5	50.1
19	Chewelah LDS Chapel[1]	138,240	138,240	138,240	138,240	.4	.4	.4	.4
20	N.W. Alloys, Inc.[3]	20,474,100	21,148,500	14,455,200	13,003,800	62.8	64.9	44.4	39.9
20.5	Flowery Trail Comm. Assoc.	822,400	826,050	822,400	822,400	2.5	2.5	2.5	2.5
UPPER BASIN AREA		**217,340,185**	**195,913,288**	**182,493,703**	**209,536,881**	**667.0**	**601.2**	**560.1**	**643.0**
21	Christian Water System[1]	2,594,200	2,774,689	2,768,365	3,089,971	8.0	8.5	8.5	9.5
22	Deer Lake (PUD)[2]	59,485,300	56,348,400	55,643,140	59,995,560	182.6	172.9	170.8	184.1
23	Granite Point Park[1]	667,700	699,551	698,435	755,189	2.0	2.1	2.1	2.3
24	Jumpoff Joe Lake (PUD)[2]	10,178,060	10,754,821	11,117,078	10,856,228	31.2	33.0	34.1	33.3
25	Loon Lake (PUD)[2]	65,584,550	48,062,970	30,597,490	46,619,610	201.3	147.5	93.9	143.1
26	Loon Lake Acres[1]	7,324,800	7,834,416	7,816,560	8,724,624	22.5	24.0	24.0	26.8
27	Loon Lake SW (PUD)[2]	16,354,300	13,445,300	14,055,800	14,142,200	50.2	41.3	43.1	43.4
28	Pine Grove Mennonite Church[2]	146,100	302,500	6,300	–	.4	.9	.0	–
29	Pine Low Park[1]	1,186,275	1,229,493	1,227,255	1,302,927	3.6	3.8	3.8	4.0
30	Springdale, Town of[1]	21,974,400	23,503,248	23,449,680	26,173,872	67.4	72.1	72.0	80.3
31	Valley, Town of (PUD)[2]	8,036,100	8,586,700	7,659,000	13,960,100	24.7	26.4	23.5	42.8
32	Waitts' Lake (PUD)[2]	23,808,400	22,371,200	27,454,600	23,916,600	73.1	68.7	84.3	73.4
	TOTAL	**1,520,711,955**	**1,534,170,906**	**1,473,740,043**	**1,487,680,753**	**4,666.9**	**4,708.2**	**4,522.8**	**4,565.5**

[1]Estimated water-use data.
[2]Actual water-use data.
[3]Water-use data for industrial use located in the industrial water-use charts.

Appendix 1E. Monthly and annual water-use totals for exempt wells, as reported by the WRIA 59 Colville River Watershed Planning Team, March 14, 2002

ESTIMATED AVERAGE DAILY WATER-USE PER HOME (Base amount) (gallons per home per day)

Year	January	February	March	April	May	June	July	August	September	October	November	December
2001	398	356	419	322	416	840	1,169	1,096	832	310	279	295
2000	431	442	452	629	466	772	939	1,652	374	329	329	312
1999	426	496	457	395	494	849	977	1,129	730	371	409	374
1998	376	307	351	354	445	669	1,512	1,506	1,450	326	393	400

ESTIMATED DAILY WATER-USE TOTALS FOR 2,969 HOMES WITHIN WRIA 59 (gallons per day)

Year	January	February	March	April	May	June	July	August	September	October	November	December
2001	1,181,662	1,056,964	1,244,011	956,018	1,235,104	2,493,960	3,470,761	3,254,024	2,470,208	920,390	828,351	875,855
2000	1,279,639	1,312,298	1,341,988	1,867,501	1,383,554	2,292,068	2,787,891	4,904,788	1,110,406	976,801	976,801	926,328
1999	1,264,794	1,472,624	1,356,833	1,172,755	1,466,686	2,520,681	2,900,713	3,352,001	2,167,370	1,101,499	1,214,321	1,110,406
1998	1,116,344	911,483	1,042,119	1,051,026	1,321,205	1,986,261	4,489,128	4,471,314	4,305,050	967,894	1,166,817	1,187,600

ESTIMATED MONTHLY WATER-USE TOTALS FOR 2,969 HOMES WITHIN WRIA 59 (gallons per month)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual Totals
2001	36,631,522	29,594,992	38,564,341	28,680,540	38,288,224	74,818,800	107,593,591	100,874,744	74,106,240	28,532,090	24,850,530	27,151,505	609,687,119
2000	39,668,809	38,056,642	41,601,628	56,025,030	42,890,174	68,762,040	86,424,621	152,048,428	33,312,180	30,280,831	29,304,030	28,716,168	647,090,581
1999	39,208,614	41,233,472	42,061,823	35,182,650	45,467,266	75,620,430	89,922,103	103,912,031	65,021,100	34,146,469	36,429,630	34,422,586	642,628,174
1998	34,606,664	25,521,524	32,305,689	31,530,780	40,957,355	59,587,830	139,162,968	138,610,734	129,151,500	30,004,714	35,004,510	36,815,600	733,259,868
4 years of monthly totals	150,115,609	134,406,630	154,533,481	151,419,000	167,603,019	278,789,100	423,103,283	495,445,937	301,591,020	122,964,104	125,588,700	127,105,859	2,632,665,742

ESTIMATED ANNUAL WATER-USE TOTALS FOR EXEMPT WELLS IN WRIA 59 (325,850 gallons = 1 acre-foot per year water use)

Year				
2001	609,687,119	water use in gallons equals	1,871.07	acre-feet per year water use
2000	647,090,581	water use in gallons equals	1,985.85	acre-feet per year water use
1999	642,628,174	water use in gallons equals	1,972.16	acre-feet per year water use
1998	733,259,868	water use in gallons equals	2,250.30	acre-feet per year water use

Appendix 1E. Annual water-use totals for exempt wells by area, as reported by the WRIA 59 Colville River Watershed Planning Team, March 14, 2002—*Continued*

WRIA 59 – COLVILLE RIVER BASIN ESTIMATED EXEMPT WELLS WATER-USE TOTALS					
		2001	**2000**	**1999**	**1998**
LOWER BASIN AREA	(1,443 exempt wells)				
	Gallons per year	296,321,493	314,500,407	312,331,578	356,380,596
	Acre-feet per year	909.38	965.17	958.51	1,093.70
MID BASIN AREA	(842 exempt wells)				
	Gallons per year	172,905,542	183,513,058	182,247,532	207,950,424
	Acre-feet per year	530.63	563.18	559.30	638.18
UPPER BASIN AREA	(684 exempt wells)				
	Gallons per year	140,460,084	149,077,116	148,046,064	168,928,848
	Acre-feet per year	431.06	457.50	454.34	518.43
TOTAL BASIN AREA	(2,969 exempt wells)				
	Gallons per year	609,687,119	647,090,581	642,625,174	733,259,868
	Acre-feet per year	1,871.07	1,985.85	1,972.16	2,250.30

Appendix 1F. Industrial water-use data, as reported by the WRIA 59 Colville River Watershed Planning Team, February 26, 2003

System No. 12-B - Estimated monthly and annual surface water-use totals for Stimson Lumber Company, Lower Basin Area

ESTIMATED MONTHLY SURFACE WATER USAGE FOR STIMSON LUMBER OUTSIDE WATERING (INDUSTRIAL USE) (gallons per month)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual totals
2001	–	–	–	3,393,360	4,675,296	4,524,480	4,675,296	4,675,296	4,524,480	3,506,472	–	–	29,974,680
Monthly Totals	–	–	–	3,393,360	4,675,296	4,524,480	4,675,296	4,675,296	4,524,480	3,506,472	–	–	29,974,680

ESTIMATED YEARLY SURFACE WATER USAGE FOR STIMSON LUMBER OUTSIDE WATERING (INDUSTRIAL USE) (gallons per year)

Year	
2001	29,974,680 **(29,974,680 gallons per year = an estimated 91.99 acre-feet per year of surface-water use for outside industrial watering)**

Note: Estimated daily surface-water usage was figured at 0.7 cubic foot per second or 314.2 gallons per minute (times) 60 minutes per hour (times) number of hours used per day (times) days used per month, as follows:

April: 314.2 gallons per minute × 60 minutes × 6 hours per day × 30 days use = 3,393,360 gallons per day
May: 314.2 gallons per minute × 60 minutes × 8 hours per day × 31 days use = 4,675,296 gallons per day
June: 314.2 gallons per minute × 60 minutes × 8 hours per day × 30 days use = 4,524,480 gallons per day
July 314.2 gallons per minute × 60 minutes × 8 hours per day × 31 days use = 4,675,296 gallons per day
August 314.2 gallons per minute × 60 minutes × 8 hours per day × 31 days use = 4,675,296 gallons per day
September: 314.2 gallons per minute × 60 minutes × 8 hours per day × 30 days use = 4,524,480 gallons per day
October: 314.2 gallons per minute × 60 minutes × 6 hours per day × 31 days use = 3,506,472 gallons per day

Note: 1 million gallons = 3.0689 acre-feet

Appendix 1F. Industrial water-use data, as reported by the WRIA 59 Colville River Watershed Planning Team, February 26, 2003—*Continued*

System No. 20A - Monthly and annual water-use totals for N.W. Alloys, Inc., Mid-Basin: SHOWS PERCENT OF INDUSTRIAL WATER USE (70 PERCENT)

Note: The actual water use report submitted by N.W. Alloys, Inc. stated that 70 percent of the water used by N.W. Alloys, Inc. was for industrial use, and 30 percent municipal use. The first chart shows the actual total water use for the plant. The second chart has calculated out the 70 percent industrial use. The municipal water use (30 percent) is shown on the public-water supply charts.

ACTUAL AVERAGE DAILY WATER USAGE - S03 WELL FIELD COMPRISED OF S01/S02 (BASE AMOUNT ACTUALS) (monthly withdrawals in gallons)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual totals
2001	4,695,000	4,728,000	8,006,000	7,344,000	6,006,000	9,594,000	12,002,000	4,090,000	5,270,000	5,729,000	190,000	593,000	68,247,000
2000	2,496,000	2,417,000	3,544,000	6,167,000	8,793,000	9,712,000	7,627,000	7,064,000	5,803,000	6,398,000	5,151,000	5,323,000	70,495,000
1999	3,126,000	1,976,000	2,736,000	3,313,000	4,035,000	4,650,000	5,151,000	4,657,000	7,009,000	6,145,000	2,924,000	2,462,000	48,184,000
1998	2,210,000	2,437,000	2,455,000	2,469,000	3,242,000	2,830,000	3,050,000	3,388,000	4,768,000	5,451,000	5,523,000	5,219,000	43,042,000
4 years of monthly totals	12,527,000	11,558,000	16,741,000	19,293,000	22,076,000	26,786,000	27,830,000	19,199,000	22,850,000	23,723,000	13,788,000	13,597,000	186,926,000

ESTIMATED MONTHLY WATER-USE TOTALS FOR INDUSTRIAL WATER-USE WITHIN THE PLANT: 70 PERCENT OF REPORTED TOTALS (monthly withdrawals in gallons)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual totals
2001	3,286,500	3,309,600	5,604,200	5,140,800	4,204,200	6,715,800	8,401,400	2,863,000	3,689,000	4,010,300	133,000	415,100	47,772,900
2000	1,747,200	1,691,900	2,480,800	4,316,900	6,155,100	6,798,400	5,338,900	4,944,800	4,062,100	4,478,600	3,605,700	3,726,100	49,346,500
1999	2,188,200	1,383,200	1,915,200	2,319,100	2,824,500	3,255,000	3,605,700	3,259,900	4,906,300	4,301,500	2,046,800	1,723,400	33,728,800
1998	1,547,000	1,705,900	1,718,500	1,728,300	2,269,400	1,981,000	2,135,000	2,371,600	3,337,600	3,815,700	3,866,100	3,653,300	30,129,400
4 years of monthly totals	8,768,900	8,090,600	11,718,700	13,505,100	15,453,200	18,750,200	19,481,000	13,439,300	15,995,000	16,606,100	9,651,600	9,517,900	130,848,200

ACTUAL TOTAL WATER USAGE FOR N.W. ALLOYS, INC., FOR INDUSTRIAL WATER USE WITHIN THE PLANT: 70 PERCENT OF TOTAL WATER USE

Year	Gallons per year	Acre-feet per year
2001	47,772,900	146.61
2000	49,346,500	151.44
1999	33,728,800	103.51
1998	30,129,400	92.46

Note: As of November 2001, N.W. Alloys, Inc. began the process of closing down the plant. For the next 2+ years, it will be working on the cleanup prior to closure, so the water-use amounts will be decreased during the closure process.

Appendix 1G. Estimated livestock water use, as reported by the WRIA 59 Colville River Watershed Planning Team and the Natural Resources Conservation Service, March 14, 2002

[Water-use figures below were figured in gallons per day (gal/d)]

WRIA 59 — LIVESTOCK ESTIMATED WATER-USE FIGURES			
Type of livestock	**How many**	**Average water use per day**	
Dairy cows	2,754	at 30 gal/d each =	82,620 gal/d
All other cattle/calves	12,800	at 15 gal/d each =	192,000 gal/d
Hogs and pigs	440	at 2 gal/d each =	880 gal/d
Sheep and lambs	520	at 2 gal/d each =	1,040 gal/d
TOTAL ESTIMATED LIVESTOCK WATER USE FOR WRIA 59 =			**276,540 gal/d**

Note: The above livestock water-use figures do not include water-use amounts for horses, or smaller domestic animals and foul. Those figures are estimated into the WRIA 59 Domestic Exempt Well Water-Use Report.

USGS

Kahle and others

Water Resources of the Ground-Water System in the Unconsolidated Deposits of the Colville River Watershed, Stevens County, Washington

WRIR 03-4128

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