Prepared in cooperation with the Idaho Department of Water Resources and the Washington State Department of Ecology

Streamflow Trends in the Spokane River and Tributaries, Spokane Valley/Rathdrum Prairie, Idaho and Washington

Scientific Investigations Report 2005–5005

U.S. Department of the Interior
U.S. Geological Survey

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By Jon E. Hortness and John J. Covert

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Conversion Factors, Datums, and Acronymns

Conversion Factors

Multiply	By	To obtain
acre-foot (acre-ft)	1,233	cubic meter
cubic foot (ft^3)	0.02832	cubic meter
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
foot per second (ft/s)	0.3048	meter per second
gallon per minute	3.785	liter per minute
inch (in.)	2.54	centimeter
inch per year (in/yr)	25.4	millimter per year
mile (mi)	1.609	kilomter per hour
square mile (mi^2)	2.590	square kilometer

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

$$°F=(1.8\times°C)+32.$$

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

$$°C=(°F-32)/1.8.$$

Datums

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Altitude, as used in this report, refers to distance above the vertical datum.

Abbreviations

Abbreviation	Meaning
IDWR	Idaho Department of Water Resources
USGS	U.S. Geological Survey
WADOE	Washington State Department of Ecology

Streamflow Trends in the Spokane River and Tributaries, Spokane Valley/Rathdrum Prairie, Idaho and Washington

By Jon E. Hortness and John J. Covert

Abstract

A clear understanding of the aquifer and river dynamics within the Spokane Valley/Rathdrum Prairie is essential in making proper management decisions concerning ground-water and surface-water appropriations. Management of the Spokane Valley/Rathdrum Prairie aquifer is complicated because of interstate, multi-jurisdictional responsibilities, and by the interaction between ground water and surface water.

Kendall's *tau* trend analyses were completed on monthly mean (July through December) and annual 7-day low streamflow data for the period 1968–2002 from gaging stations located within the Spokane Valley/Rathdrum Prairie. The analyses detected trends of decreasing monthly mean streamflow at the following gaging stations: Spokane River near Post Falls, Idaho (August and September); Spokane River at Spokane, Washington (September); and Little Spokane River at Dartford, Washington (September and October); and decreasing annual 7-day low streamflows at the following gaging stations: Spokane River near Post Falls, Idaho and Spokane River at Spokane, Washington. Limited analyses of lake-level, precipitation, tributary inflow, temperature, and water-use data provided little insight as to the reason for the decreasing trends in streamflow.

A net gain in streamflow occurs between the gaging stations Spokane River near Post Falls, Idaho and Spokane River at Spokane, Washington. Significant streamflow losses occur between the gaging stations Spokane River near Post Falls, Idaho and Spokane River at Greenacres, Washington; most, if not all, of the gains occur downstream from the Greenacres gaging station. Trends of decreasing net streamflow gains in the Spokane River between the near Post Falls and at Spokane gaging stations were detected for the months of September, October, and November.

Introduction

The Spokane Valley/Rathdrum Prairie (SVRP) aquifer is the sole source of drinking water for more than 400,000 residents in Spokane County, Washington, and Kootenai County, Idaho. The area includes the rapidly growing cities of Spokane, Spokane Valley, and Liberty Lake, Washington, and Coeur d'Alene and Post Falls, Idaho. Recent and projected urban, suburban, industrial, and commercial growth has raised concerns about potential future impacts on water availability and water quality in the SVRP aquifer and the Spokane River and its tributaries. Water-resource concerns include growing demands on ground water, low streamflow in reaches of the Spokane River, a decrease in streamflows over time, and water-quality problems associated with changing land-use activities. Water-resource demands are increasing at a time when aquifer and river dynamics are not well understood. This understanding is essential in making proper management decisions concerning ground-water and surface-water appropriations in the SVRP area.

Management of the SVRP aquifer is complicated because of the interstate, multi-jurisdictional responsibilities for the aquifer. The states of Washington and Idaho have primary responsibility for water allocation and water quality. However, local governments are increasingly being called upon to consider water supply and quality implications in land-use planning. Aquifer management also is complicated by the interaction between ground water and surface water. Ground-water exchanges with surface water influence surface-water flow rates and water quality, and vice versa.

The Idaho and Washington Districts of the U.S. Geological Survey (USGS), in cooperation with the Washington Department of Ecology (WADOE) and the Idaho Department of Water Resources (IDWR), have begun work on several projects to assist local and State governments in understanding the complex issues associated with the SVRP aquifer. To this end, a numerical ground-water flow model will be developed to simulate the flow in the SVRP aquifer and its relation to surface water. The intended users are WADOE and IDWR. The intended use of the model is to test future management scenarios. The results of this report will be used by the modelers to help define specific characteristics of streamflow and scope of additional data needed for use in the model.

Purpose and Scope

This report documents the results of analysis of streamflow data obtained for streams located within the extent of the SVRP aquifer. Existing streamflow data for these streams were compiled and reviewed. Data from gaging stations with 10 or more years of record were analyzed for trends during the expected low-flow months of July through December. During periods for which statistically significant trends in streamflow were observed, other data sets, such as temperature and precipitation, were analyzed to look for relationships. Where possible, exchanges between ground water and surface water also were analyzed.

Description of Study Area

The study area is comprised of the Spokane River Valley, Rathdrum Prairie, and surrounding highlands included within the extent of the SVRP aquifer (fig. 1) and includes parts of eastern Washington and northern Idaho. The valley is relatively flat with altitudes ranging from about 1,500 to 2,600 ft. The valley floor is composed primarily of alluvial deposits, and the surrounding highlands primarily are composed of bedrock. Land use across the valley floor is mostly agricultural, while the highlands are covered primarily with coniferous forests and residential housing (Caldwell and Bowers, 2003). Development in the area increased rapidly between 1990 and 2000. During that period, population increased 16 percent in Spokane County, Washington, and almost 56 percent in Kootenai County, Idaho (U.S. Census Bureau, 2004).

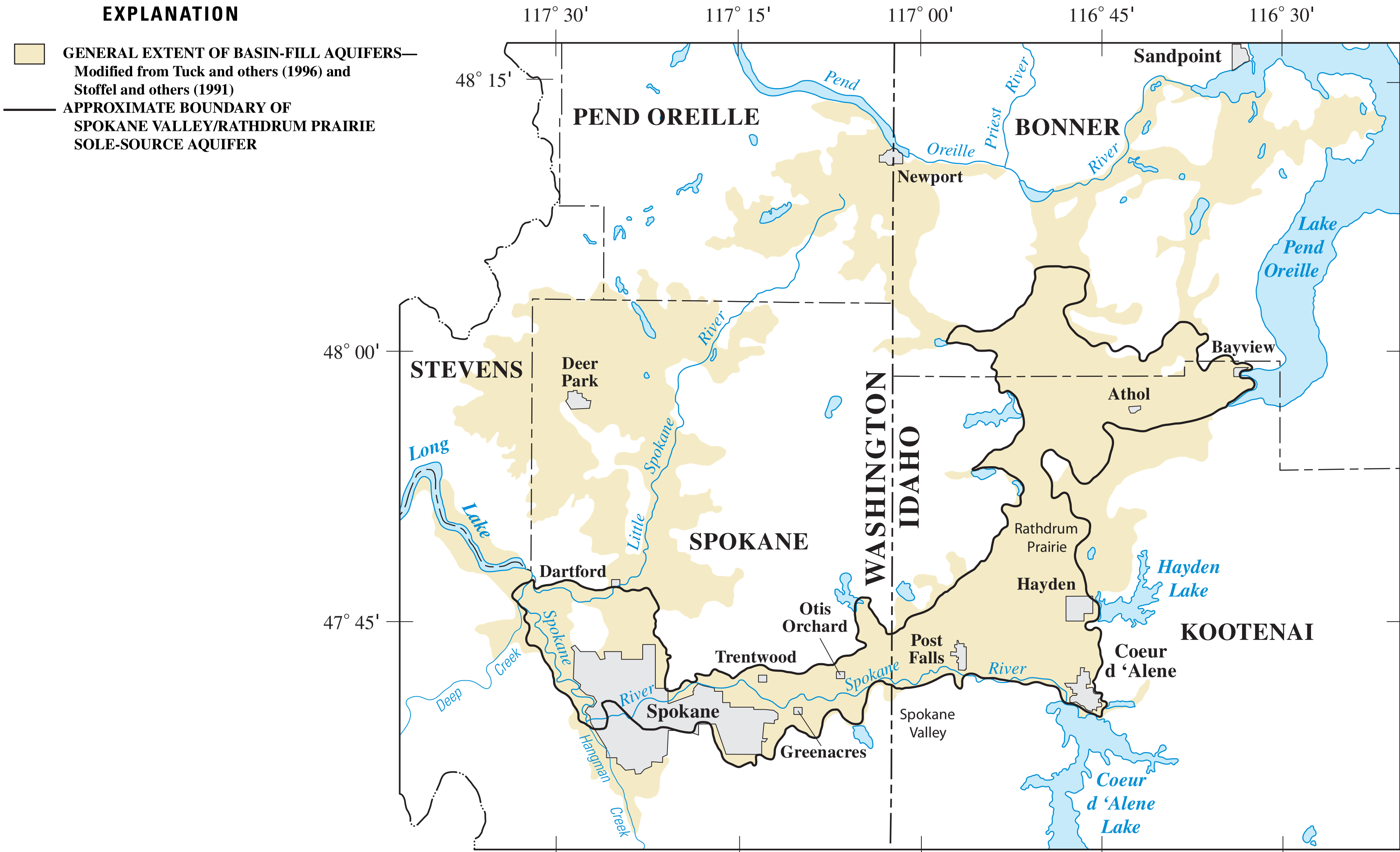
The climate ranges from semiarid to subhumid; summers are warm and dry; winters are cool and moist. Most of the precipitation falls as snow during the winter months of November through March (Molenaar, 1988). Mean annual precipitation (1971–2000) across the study area ranges from about 16.7 in/yr at the Spokane Airport to about 26.6 in/yr in Coeur d’Alene (Western Regional Climate Center, 2004).

Several lakes are located along the edges of the study area. The largest of these are Coeur d’Alene Lake and Lake Pend Oreille in Idaho. Two perennial streams—the Spokane River, which drains Coeur d’Alene Lake and flows westerly, and the Little Spokane River. which originates in the highlands north of Spokane—flow across the study area. Streamflow in the Spokane River is regulated by Post Falls Dam. During most years, the dam gates are left open during the months of December through June, and streamflow often mimics inflows into the lake from snowmelt runoff. During most of the summer, however, the gates are set to maintain specific water levels in Coeur d’Alene Lake (Gary Stockinger, Avista Corporation, oral commun., 2004).

The SVRP aquifer is a basin-fill aquifer composed of unconsolidated coarse-grained sands, gravels, cobbles, and boulders primarily deposited by a series of catastrophic glacial outburst floods during the Pleistocene Epoch (Molenaar, 1988). Because the sediment is coarser grained than that of most basin-fill aquifers, the aquifer is one of the most productive, in terms of total withdrawals relative to the size of the aquifer, in the United States. Wells located with in the aquifer typically yield several thousand gallons per minute (Bolke and Vaccaro, 1979). More detailed information on the SVRP aquifer can be found in the report by Caldwell and Bowers (2003).

Available Data

Ten USGS continuous-record gaging stations either are operated currently or were operated previously on streams located within the study area (table 1; fig. 2). These include seven gaging stations on the Spokane River, one on Hangman Creek, and two on the Little Spokane River. The seven gaging stations that are currently in operation have at least 10 years of record are available for statistical analyses. Many of these gaging stations, however, were not operated continuously (fig. 3); thus, trend analyses and streamflow comparisons were not always possible.



Base from U.S. Geological Survey digital data; 1:2,000,000, 1999; Decimal Degree projection
Lakes; 1:100,000, 1995; Rivers; 1:100,000, 1985; Cities; 1:100,000, 1998
North American Datum 1927 (NAD 27)

Figure 1. Location of study area, general extent of basin-fill aquifers and Spokane Valley/Rathdrum Prairie sole-source aquifer, Idaho and Washington.

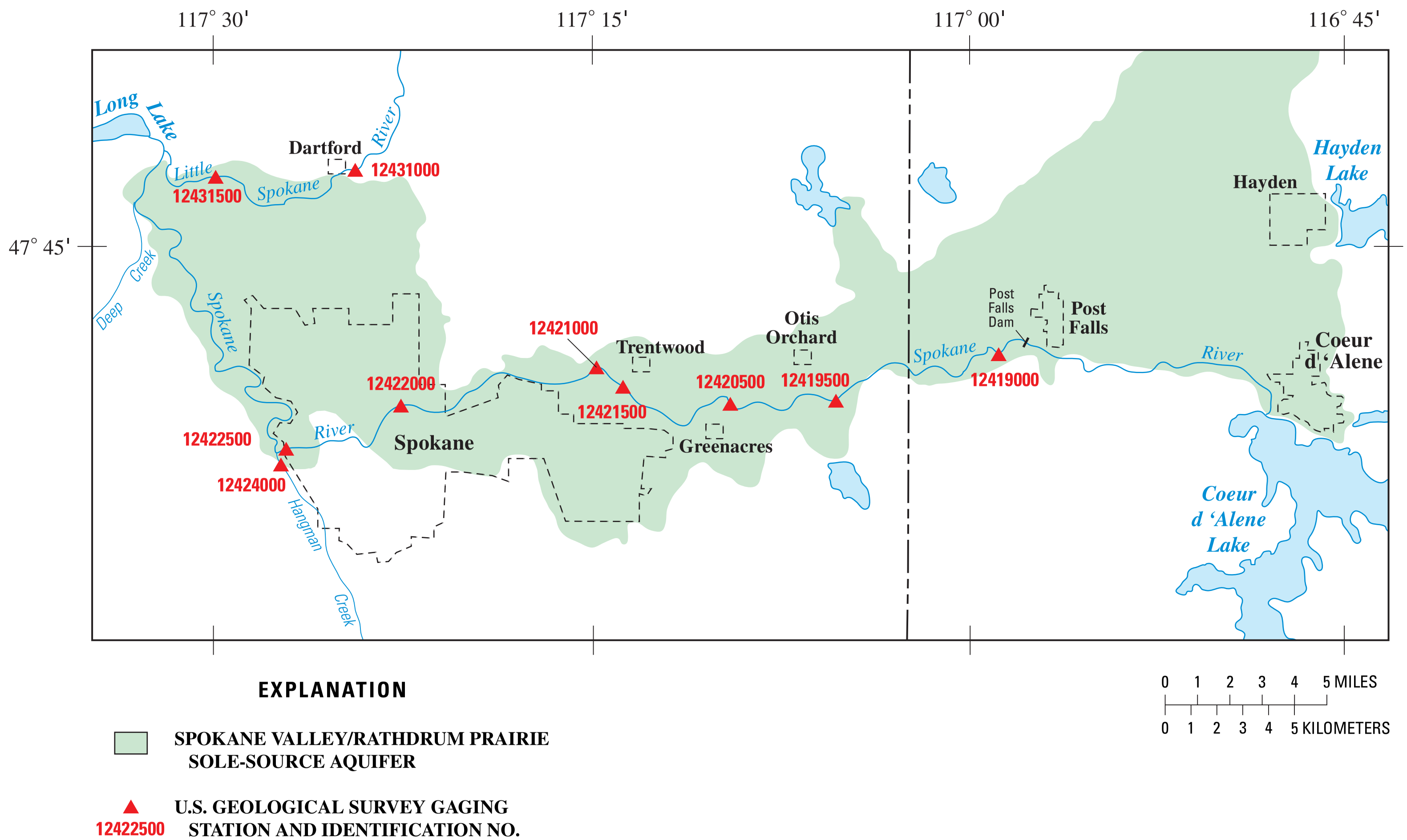


Figure 2. Location of gaging stations in the Spokane Valley/Rathdrum Prairie, Idaho and Washington.

Table 1. Summary of existing continuous streamflow records for gaging stations located within the extent of the Spokane Valley/Rathdrum Prairie aquifer.

[Locations of gaging stations shown in figure 2. **Abbreviations:** ID, Idaho; WA, Washington]

Gaging station name	Gaging station No.	Period of record (water years)	Total years of record
Spokane River near Post Falls, ID	12419000	1913–present	92
Spokane River above Liberty Bridge, near Otis Orchard, WA	12419500	1929–83, 1999–present	61
Spokane River at Greenacres, WA	12420500	1948–52, 1999–present	11
Spokane River at Trent, WA[1]	12421000	1912–13	2
Spokane River below Trent Bridge, near Spokane, WA	12421500	1948–54	7
Spokane River below Green Street at Spokane, WA	12422000	1949–52	4
Spokane River at Spokane, WA	12422500	1891–present	114
Hangman Creek at Spokane, WA	12424000	1948–present	57
Little Spokane River at Dartford, WA	12431000	1929–32, 1947–present	62
Little Spokane River near Dartford, WA	12431500	1948–52, 1998–present	12

[1] Trentwood was known as Trent when the gaging station was established.

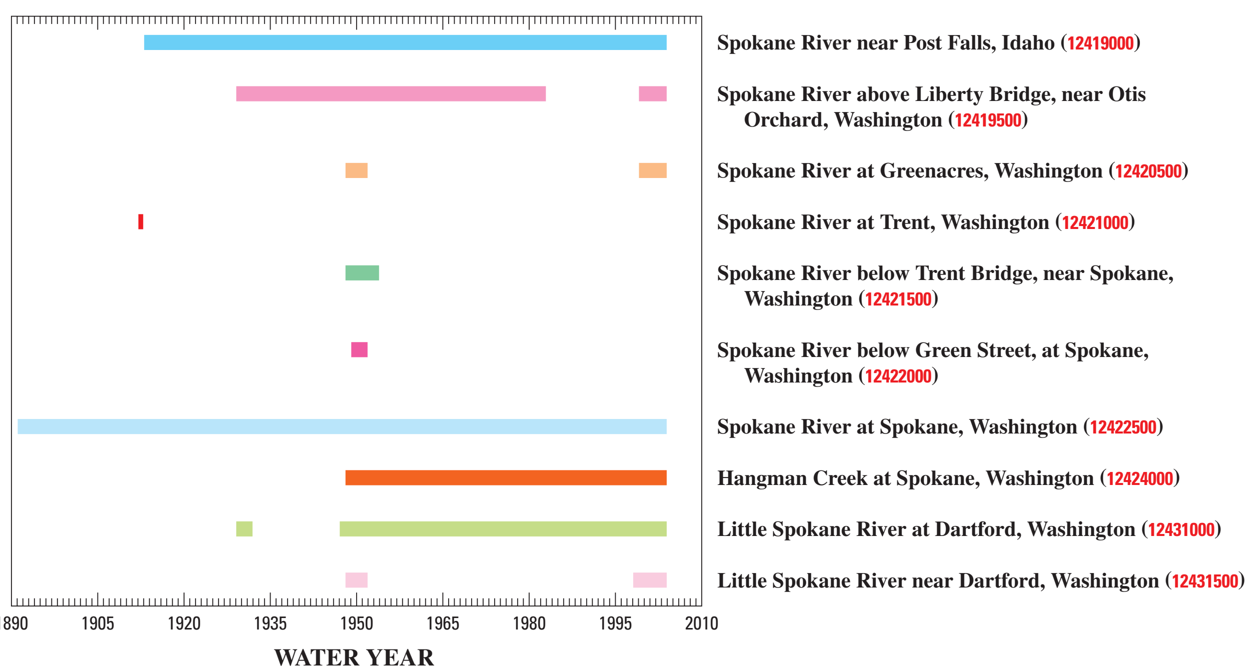


Figure 3. Period of records for gaging stations located within the extent of the Spokane Valley/Rathdrum Prairie Aquifer, Idaho and Washington.
(Locations of sites shown in figure 2.)

Trend Analysis

The purpose of the data analyses was to identify any long-term trends in streamflows, primarily during baseflow periods. Streamflow data for the months of July through December were used in each of the analyses. The Kendall's *tau* hypothesis test was used to test for the presence of trends in the data. This test measures the strength of the monotonic relation between two data sets (Helsel and Hirsch, 1992). In this study, a strong monotonic relation would indicate an increase or decrease in streamflow with respect to time. The null hypothesis for each test was that no trends existed in the data. The significance level (α) defines the acceptable error in determining if a trend actually does exist and the *p*-value is the probability that the computed *tau* value could be obtained when the null hypothesis is true (no trend). The acceptable error was limited to 5 percent ($\alpha = 0.05$) for this study. Thus, for data sets in which trends were detected, there is less than a 5-percent chance that the test was wrong and trends do not exist.

Four significant events in the basin that affected streamflows during the periods of data collection were noted during the analyses. These included (1) the completion of Post Falls Dam in 1906; (2) the operation of the Spokane Valley Farms Canal, which began in 1924 and diverted water from the Spokane River upstream of the Post Falls gaging station; (3) the change in operating practices of Post Falls Dam in 1941 to raise the summer levels of Coeur d'Alene Lake; and (4) the discontinuation of irrigation withdrawals through the Spokane Valley Farms Canal in 1967.

The trend analyses were completed using data from four gaging stations: Spokane River near Post Falls, Spokane River at Spokane, Hangman Creek at Spokane, and Little Spokane River at Dartford. Data from the other three gaging stations with 10 or more years of record (table 1) were not analyzed for trends because most of the data were not collected during continuous years (fig. 3). Data for the period 1968–2002 from the Spokane River gaging stations were used because operation of the Spokane Valley Farms Canal had ceased and these data likely represent the most current conditions for the Spokane River.

Spokane River near Post Falls, Idaho (12419000)

Statistically significant decreasing trends in monthly mean streamflow were detected for August and September (fig. 4). Analyses of data for other months revealed no statistically significant trends.

Because of the proximity of this gaging station to Post Falls Dam, and the lack of any significant inflows or outflows between the gaging station and the dam (Rick Backsen, USGS, oral commun., 2004), any trends in the streamflow data from the gaging station essentially represent trends in releases from the dam. Woods and Beckwith (1997) also determined that inflow or outflows within this reach were negligible during their hydrologic budget analysis for water years 1991 and 1992.

It is normal operating procedure to keep lake levels steady between late May and early September for recreational purposes (Gary Stockinger, Avista Corporation, oral commun., 2004). August and September monthly mean stage of Coeur d'Alene Lake for the post-canal period is shown in figure 5. Lake levels were relatively consistent during August throughout the entire period. Lake levels during September, however, were more variable; mean lake levels increase during September throughout the period of interest. This increase could be partly the reason for the trends in the September data for the Post Falls gaging station.

Given that mean August lake levels have been relatively consistent during the post-canal period, the decreasing trends in streamflow in August could be related to decreases in inflows to or increases in outflows from the system upstream of Post Falls Dam (for example, water balance). Inflows result primarily from precipitation over the lake, surface-water inflows to the lake, or ground-water inflows to the entire system. A Kendall's *tau* analysis of total monthly precipitation data (Western Regional Climate Center, 2004) for Coeur d'Alene, Idaho, from 1968 to 2002 indicated a slight downward trend for both August and September, but neither trend was statistically significant based on the criteria used in this study ($\alpha = 0.05$).

Streamflow data from gaging stations on the major rivers flowing into Coeur d'Alene Lake (Coeur d'Alene River at Cataldo, 12413500, and St. Joe River at Calder, 12414500) also were analyzed for trends. Data from these two gaging stations indicate that these rivers account for about 92 percent of the total inflows to Coeur d'Alene Lake (Woods and Beckwith, 1997). No trends were found in the data for either of these gaging stations for water years 1968 through 2002 based on the criteria used in this study ($\alpha = 0.05$). Any changes in ground-water influences upstream of the lake likely would be seen in the streamflow data for the Coeur d'Alene River. Lack of trends in these data during the study period likely proves that ground-water conditions upstream of the lake also were essentially unchanged. Ground-water levels between Post Falls Dam and the Post Falls gaging station are, for the most part, as much as 100 ft below land surface, and there is believed to be little if any interaction between the aquifer and the river in this area (MacInnis and others, 2000).

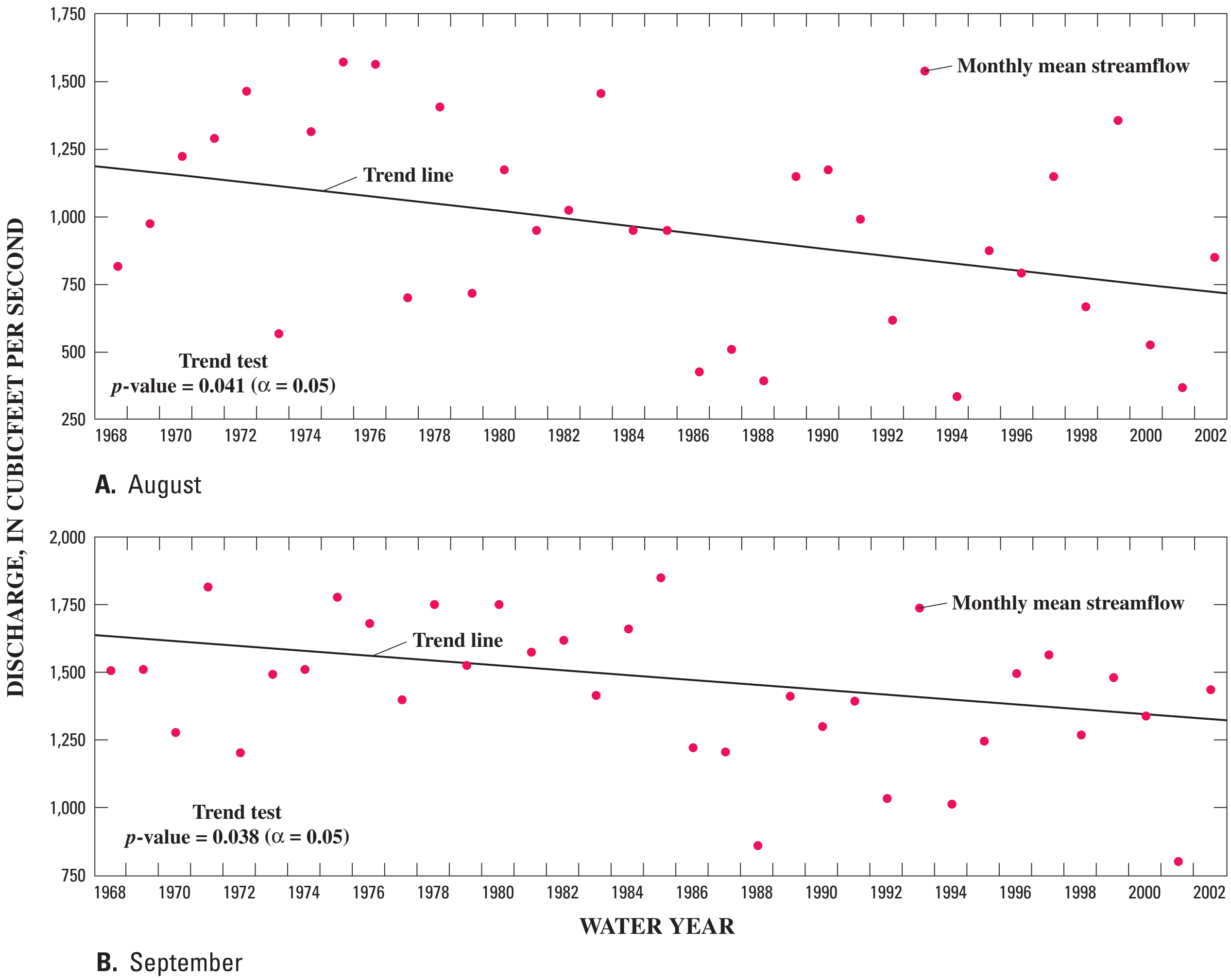


Figure 4. Trend analysis of August and September monthly mean streamflows for the Spokane River near Post Falls, Idaho, 1968 –2002.

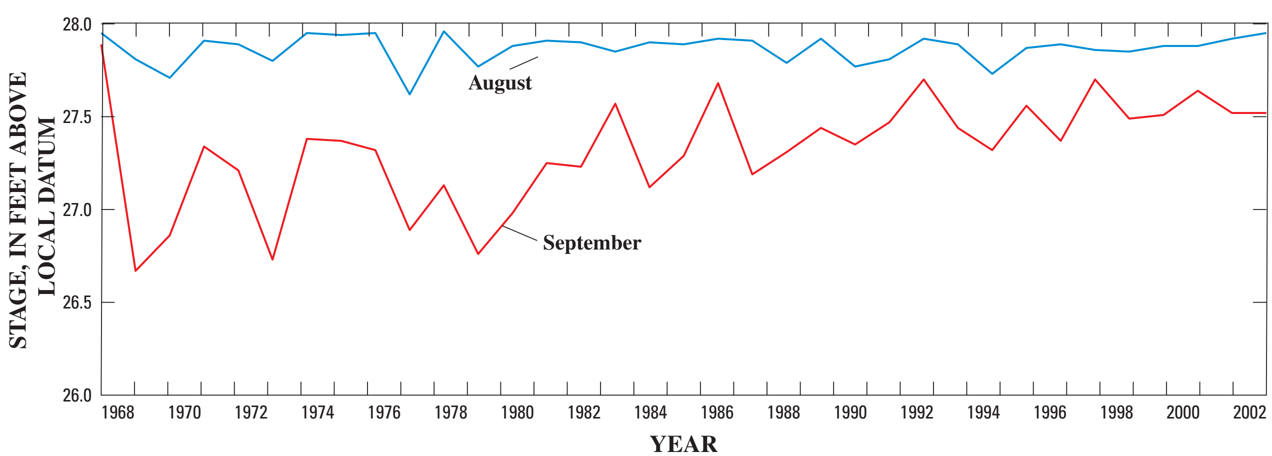


Figure 5. Monthly mean stage of Coeur d'Alene Lake, Idaho, August and September, 1968–2002.

Outflows from the system that could affect long-term trends include surface-water and ground-water withdrawals and evaporation. Detailed water-use data for the study area were available only for the period from about 1990 to 2004. Data before 1990 were compiled using different methods and comparisons of these data to current data are difficult (Molly Maupin, U.S. Geological Survey, oral commun., 2004). Thus, additional analyses, beyond the scope of this study, are needed to determine whether water-use changes are affecting long-term trends in streamflow.

Because of the size of Coeur d'Alene Lake and the lack of trees along long distances of the rivers that feed the lake, evaporation could be a significant cause of water losses. Woods and Beckwith (1997) estimated that evaporation losses from Coeur d'Alene Lake ranged from 1.5 to 2.8 percent of the total outflows from the lake during water years 1991 and 1992. Trend analyses of monthly August and September and annual temperature data (Western Regional Climate Center, 2004) for Spokane and Coeur d'Alene revealed no trends during the post-canal period, with the exception of the annual mean temperature at Spokane which increased slightly more than 1°F during that period. Additional analyses, beyond the scope of this study, are needed to determine whether small increases in temperature could increase evaporation to the extent that it would affect long-term trends in streamflow.

In addition to the monthly data, annual mean streamflow data for the Spokane River near Post Falls gaging station also were analyzed for the post-canal period. No statistically significant trends were found. This lack of trends, like the lack of trends in the analysis of system inflows and outflows, indicates that the total available water in the system upstream of the Post Falls gaging station has remained relatively constant during any given year since 1968. Therefore, the decreasing trends in monthly streamflow in August and September would be expected to be offset by increases in streamflow during other months. However, analyses of monthly mean streamflows for the other months, including those for January through June, revealed no statistically significant trends. This likely means that any changes in long-term streamflow during the other months were small enough that they were not found to be significant in the trend analyses, but the cumulative changes were enough to offset the decreases in August and September.

Finally, annual 7-day low streamflows for two different periods of record 1914–2002 and 1968–2002 at the Post Falls gaging station were analyzed. Analysis of the data for the period 1914–2002 (fig. 6) reveals "breaks" during years in which the previously mentioned significant changes in the basin occurred. These include a decreasing trend in annual low streamflow during the operation of the "Spokane Valley Farms Canal" in the 1920s and 1930s, which corresponds

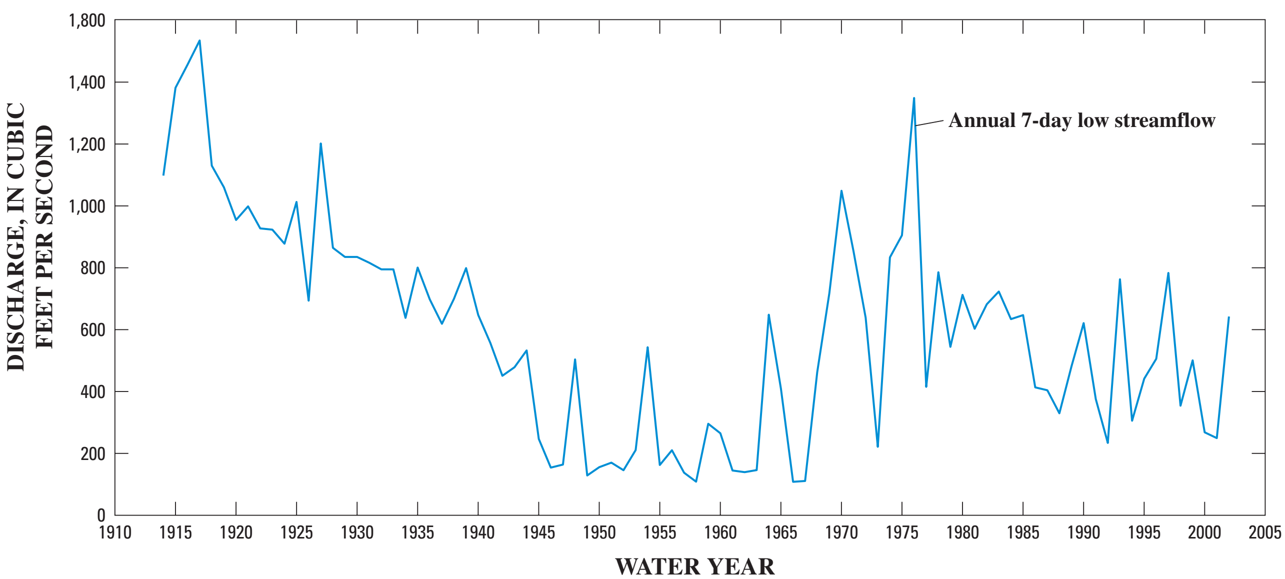


Figure 6. Annual 7-day low streamflows for the Spokane River near Post Falls, Idaho, 1914–2002.

to a general increase in summer streamflow being diverted into the canal until the late 1930s when the amount leveled off at about 260 ft^3/s (fig. 7); a significant decrease in annual low streamflows in the early 1940s when efforts were made to keep Coeur d'Alene Lake levels higher; and a significant increase in annual low streamflows in the late 1960s when the operation of the Spokane Valley Farms Canal was discontinued.

The trend analysis of the annual 7-day low streamflows for the post-canal period 1968–2002 (fig. 8) revealed a significant decrease in annual 7-day low streamflows. This would be expected because 7-day low streamflows often occur in the late summer months of August and September where the decreasing streamflow trends were found.

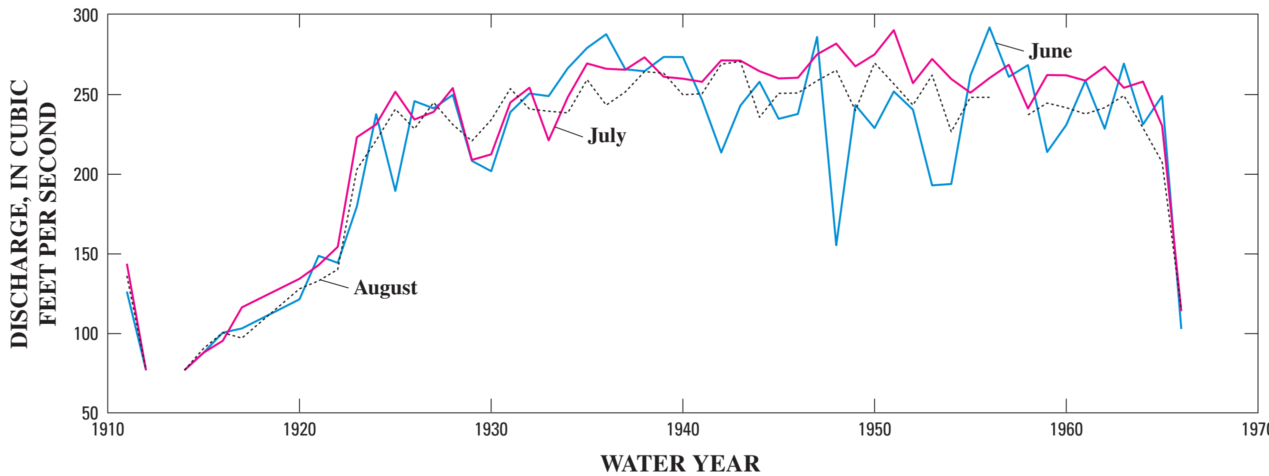


Figure 7. Monthly mean streamflows for the Spokane Valley Farms Canal at Post Falls, Idaho, June, July, and August, 1911–1966.

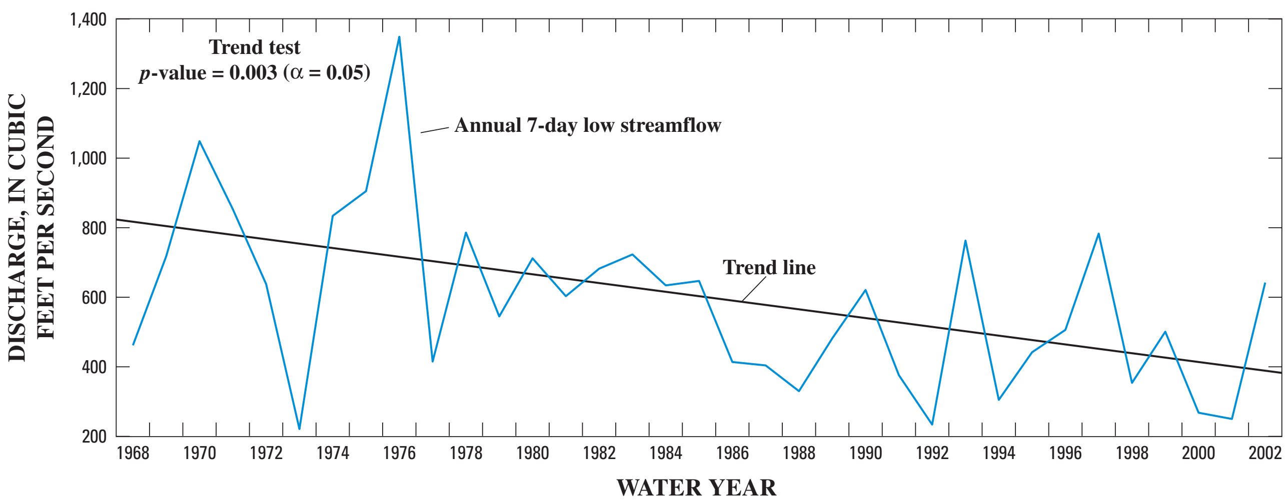


Figure 8. Trend analysis of annual 7-day low streamflows for the Spokane River near Post Falls, Idaho, 1968 –2002.

Spokane River at Spokane, Washington (12422500)

Monthly mean streamflow data for the Spokane River at Spokane gaging station for the months of July through December during the post-canal period, 1968–2002, were analyzed for trends. Statistically significant decreasing trends in monthly mean streamflow were detected for the month of September (fig. 9). Visual inspection of the August monthly mean streamflows at Spokane (fig. 9) also revealed a decreasing trend; however, this trend was not statistically significant based on the criteria used in this study ($\alpha = 0.05$).

A trend analysis of the annual 7-day low streamflow for the Spokane River at Spokane gaging station for the period of record 1891–2002 indicates an obvious decrease in the low-flow characteristics of the river (fig. 10). The annual 7-day low streamflows until about 1930 often exceeded 1,500 ft^3/s; annual 7-day low streamflows after about 1985 rarely exceeded 1,000 ft^3/s. Results of a trend analysis of the annual 7-day low streamflows at this gaging station for the post-canal period of 1968–2002 (fig. 11) were similar to those for the Post Falls gaging station: a significant decrease in annual 7-day low streamflows during the post-canal period.

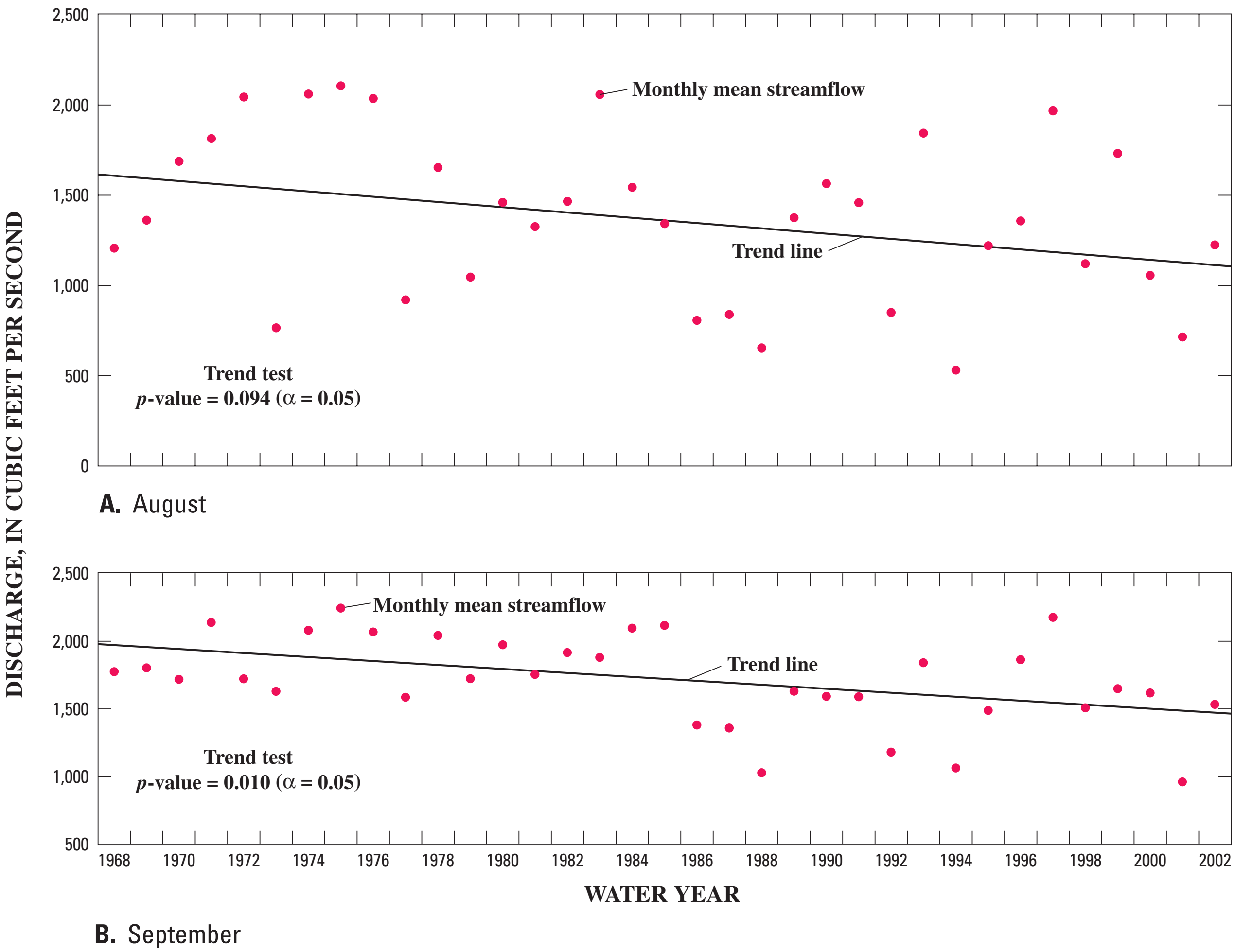


Figure 9. Trend analysis of August and September monthly mean streamflows for the Spokane River at Spokane, Washington, 1968–2002.

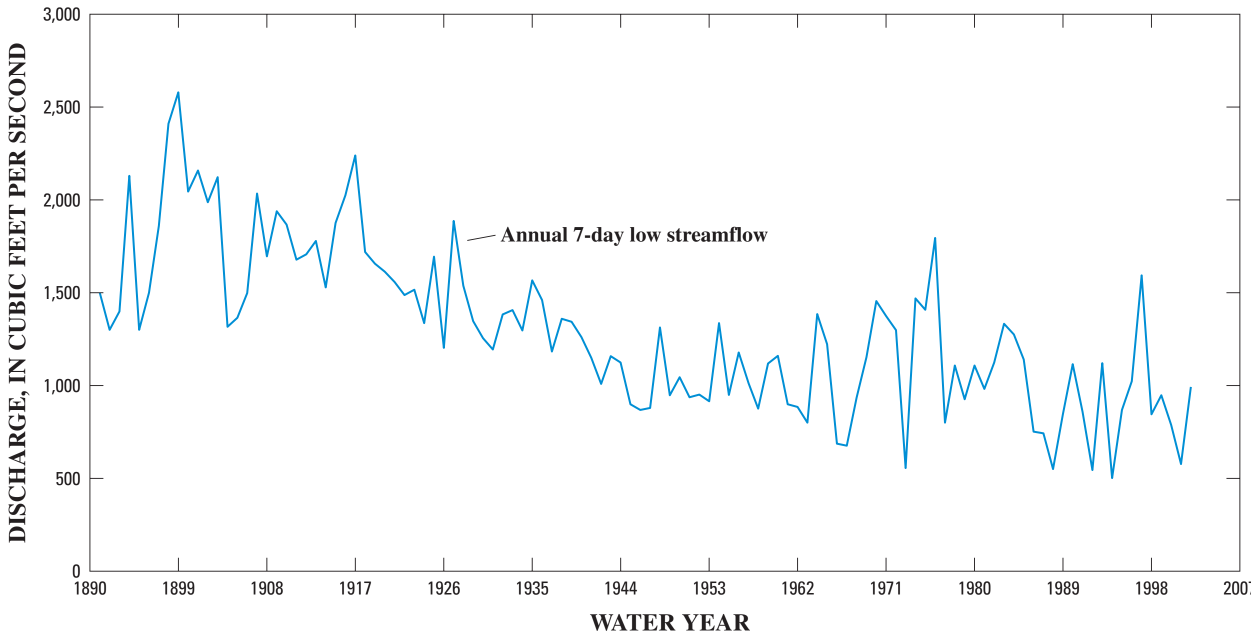


Figure 10. Annual 7-day low streamflows for the Spokane River at Spokane, Washington, 1891–2002.

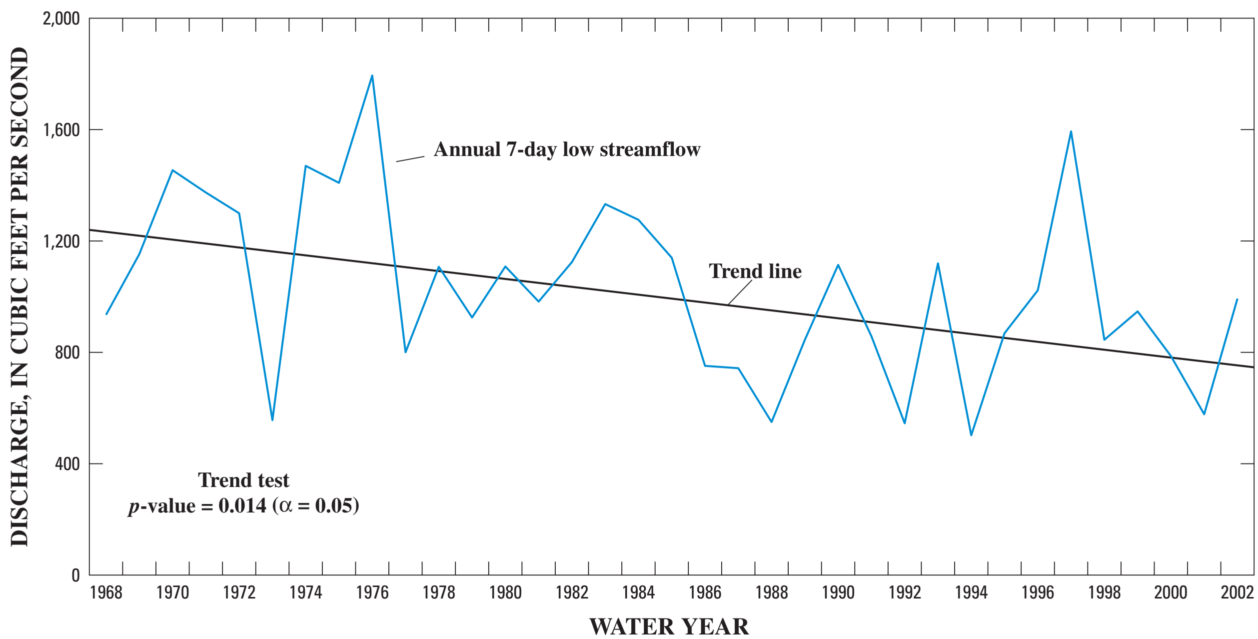


Figure 11. Trend analysis of annual 7-day low streamflows for the Spokane River at Spokane, Washington, 1968 –2002.

Hangman Creek at Spokane, Washington (12424000)

Monthly mean streamflow data for the Hangman Creek at Spokane gaging station, for the months of July through December during the periods 1949–2002 and 1968–2002, were analyzed for trends. No trends were found in the monthly mean data for any of the months that were analyzed. This would be expected because analyses of precipitation and temperature data revealed little if any changes that may have affected streamflow. Hangman Creek also is unaffected by human factors (regulation, diversions, water use, etc.) and typically is a good indicator of natural streamflow conditions within the lowland portions of the study area (Raymond Smith, USGS, oral commun., 2004).

Little Spokane River at Dartford, Washington (12431000)

Monthly mean streamflow data for the Little Spokane River at Dartford gaging station, for the months of July through December during the periods 1930–32 and 1947–2002, were analyzed for trends. Statistically significant decreasing trends in monthly mean streamflow were detected for the months of September and October (fig. 12). No trends were detected for the other months. Monthly precipitation data from the Spokane Airport (Western Regional Climate Center, 2004) for the period 1914–2002 were analyzed for trends. A Kendall's *tau* analysis indicated that there were no trends in monthly precipitation for the months of September and October during the period of record.

Annual 7-day low streamflow data for this gaging station for the periods 1930–32 and 1947–2002 (fig. 13) also were analyzed for trends. Although visual inspection of the data revealed a slight downward trend, the trend was not statistically significant. For comparisons with data from the Spokane River gaging stations, data from the period 1968–2002 also were analyzed. No statistically significant trends were detected in any of the monthly mean data or the 7-day low streamflow data for this period.

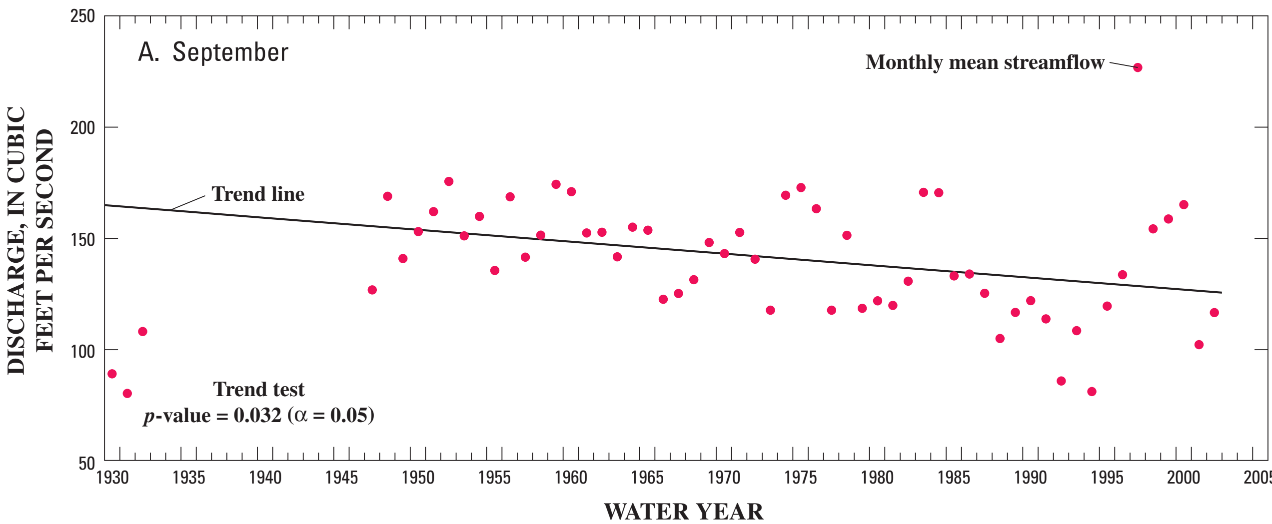


Figure 12. Trend analysis of September and October monthly mean streamflows for the Little Spokane River at Dartford, Washington, 1930–32, 1947–2002.

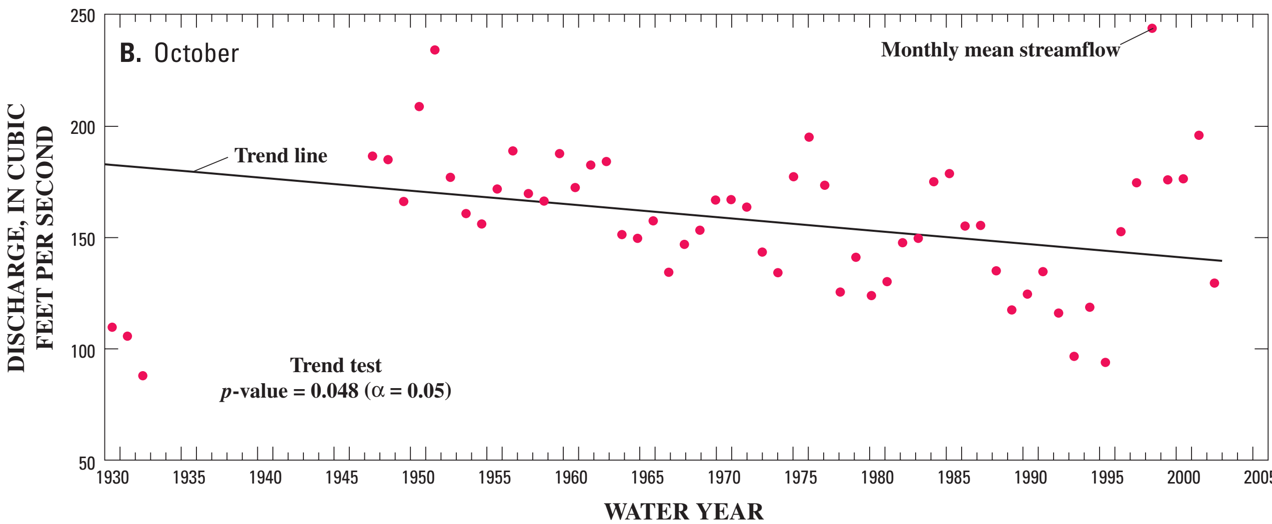


Figure 12. Continued.

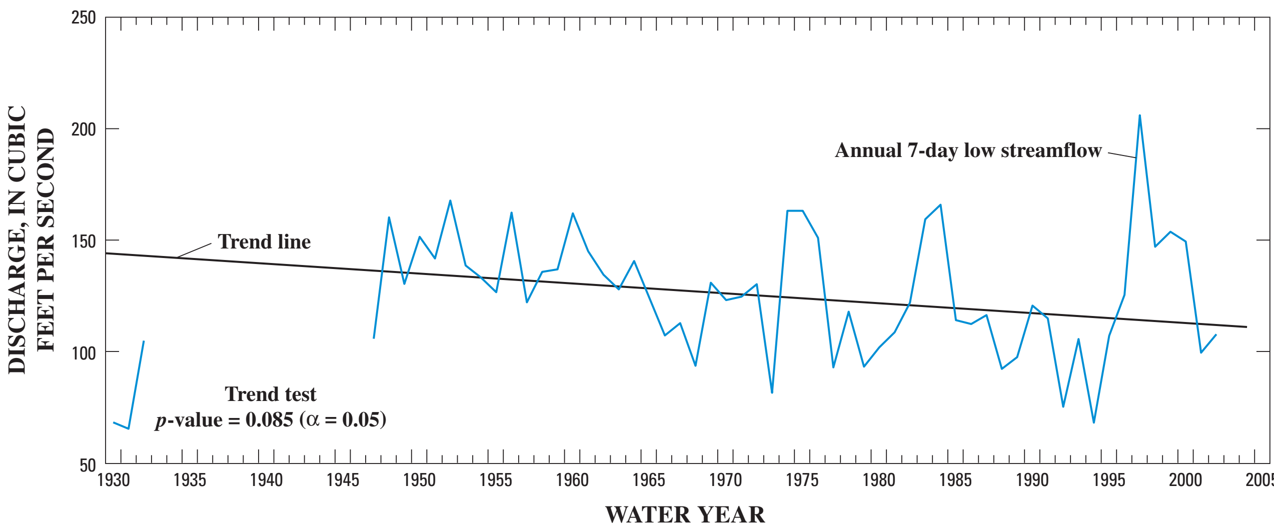


Figure 13. Trend analysis of annual 7-day low streamflows for the Little Spokane River at Dartford, Washington, 1930–32 and 1947 –2002.

Ground-Water / Surface-Water Exchanges

Results from previous studies and analyses of existing streamflow data were used to summarize ground-water/surface-water exchanges on both the Spokane and Little Spokane Rivers. As shown in figure 3, there are very few periods for which data for adjacent locations exist for use in estimating ground-water/surface-water exchanges. For example, estimates can be calculated for the overall reach from Post Falls to Spokane over an extended period; however, only limited data are available at intermediate locations for use in making more refined estimates within the reach.

Spokane River

Previous investigations of the interactions between the Spokane River and the SVRP aquifer have shown that the Spokane River consistently loses streamflow to the aquifer in the upstream reaches where ground-water levels are below that of the streambed. Conversely, the Spokane River gains streamflow from the aquifer in areas farther downstream near the city of Spokane, where ground-water levels intersect the streambed. Because of the presence of coarse-grained, highly transmissive deposits and the high productivity of the aquifer, these losses and gains are quite large (hundreds of cubic feet per second).

Caldwell and Bowers (2003) reported consistent and, in most cases, significant streamflow losses in the river reach between the Spokane River gaging stations (fig. 2) near Post Falls, Idaho, and near Otis Orchard, Washington, and in the longer reach between the Spokane River gaging stations near Post Falls, Idaho, and at Greenacres, Washington, during water years 2000 and 2001. Their estimates of differences in monthly mean streamflow between the Post Falls and Otis Orchard gaging stations ranged from a loss of 69 ft^3/s to a loss of 810 ft^3/s; the median loss was 255 ft^3/s. Their estimates of differences in monthly mean streamflows between the Post Falls and Greenacres gaging stations ranged from a gain of 42 ft^3/s to a loss of 858 ft^3/s; the median loss was 288 ft^3/s.

Differences similar to those reported by Caldwell and Bowers (2003) for water years 2000 and 2001 were computed following a seepage study completed by the USGS during September 2004. Losses between the Post Falls and Otis Orchard gaging stations averaged 177 ft^3/s and losses between the Post Falls and Greenacres gaging stations averaged 287 ft^3/s. In addition, gains computed for the reach between the Greenacres and Spokane gaging stations averaged about 557 ft^3/s (Raymond Smith, U.S. Geological Survey, written commun., 2004).

Gearhart and Buchanan (2000) estimated losses in the reach of the Spokane River between the Idaho-Washington State line and the Sullivan Road Bridge, which is about 2 mi downstream from the Greenacres gaging station (fig. 2). They used streambed areas and Darcy’s Law to estimate losses of 104 ft^3/s during low-flow conditions and 571 ft^3/s during high-flow conditions.

Streamflow data for various periods of record (fig. 3) at four gaging stations located between the long-term gaging stations Post Falls, Idaho, and Spokane, Washington, (fig. 2) were available for analysis. Differences in monthly mean streamflow values for July through December were analyzed for periods for which data comparisons were possible. Based on all available monthly mean data for the reach between the Post Falls and Otis Orchard gaging stations, the median July through December losses ranged from 37 ft^3/s in November to 78 ft^3/s in December. Data analyses indicated that for the reach between the Otis Orchard and Greenacres gaging stations no calculated gains or losses were outside the range of measurement error. The reaches between the Greenacres and the Spokane River below Trent Bridge gaging stations and between the Trent Bridge and Spokane River below Green Street gaging stations both generally gained streamflow during the periods of time data were collected. Based on all available monthly mean data, median July-through-December gains between the Greenacres and Trent Bridge gaging stations ranged from 330 ft^3/s in December to 754 ft^3/s in July; median July through December gains between the Trent Bridge and Green Street gaging stations ranged from 259 ft^3/s in November to 447 ft^3/s in July. Data analyses indicated that for the reach between the Green Street and Spokane gaging stations no calculated gains or losses were outside the range of measurement error.

Differences in monthly mean streamflow between the Post Falls and Spokane gaging stations for the months of July through December during 1968–2002 were analyzed for trends. Although the upper parts of this reach generally lose streamflow to the aquifer, the overall reach historically has gained streamflow. Trends detected for the months of September, October, and November were statistically significant. The analyses showed that streamflow gains within this reach decreased over time during the period 1968–2002 (fig. 14). This long-term decrease could indicate a decrease in ground-water inflows to the river channel within this reach; however, additional analyses of ground-water levels and the ground-water/surface-water interactions within this reach would be necessary to better understand the reason for the decrease in streamflow gains.

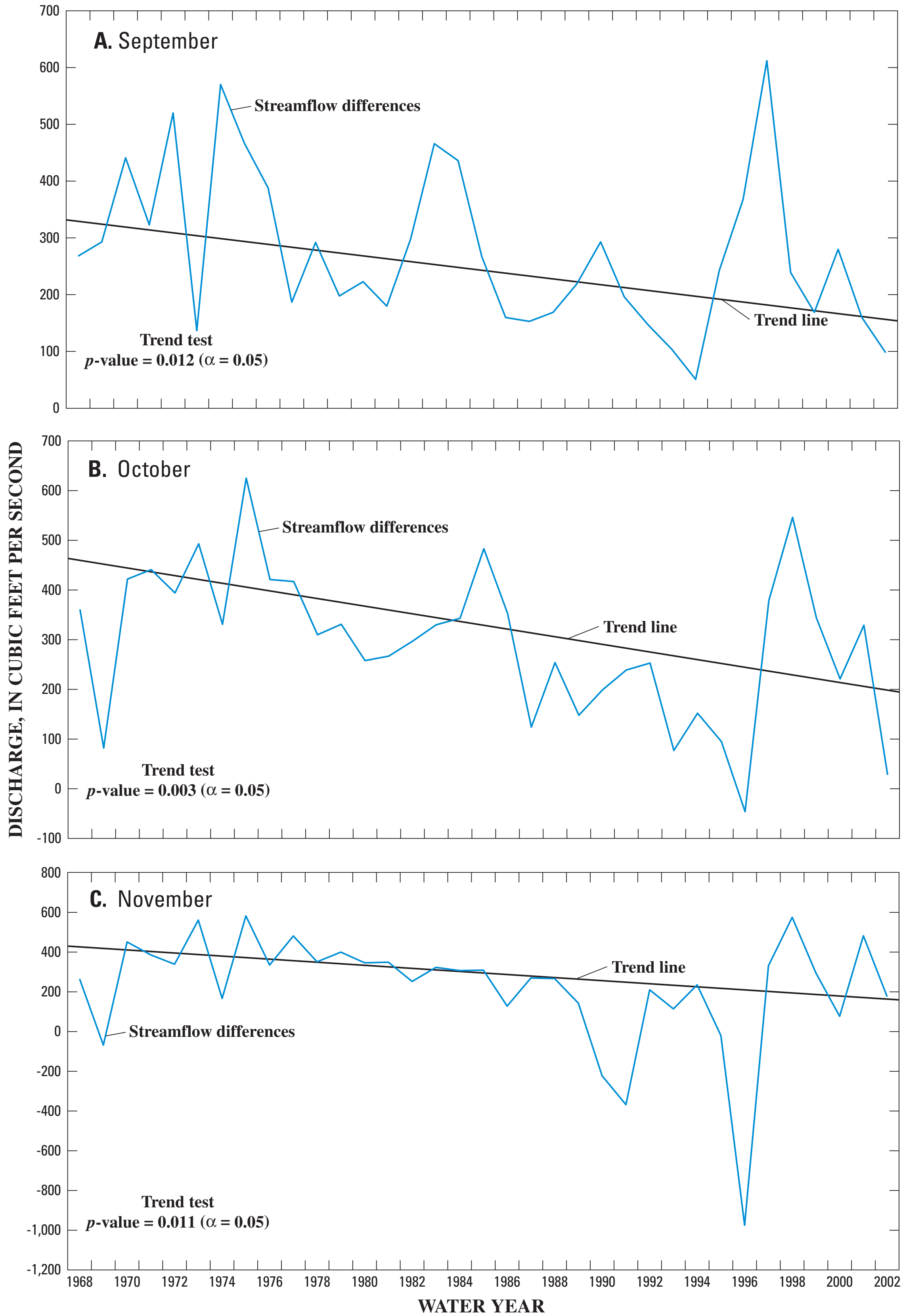


Figure 14. Trend analysis of differences in September, October, and November monthly mean streamflow between the gaging stations at Spokane River at Post Falls, Idaho, and Spokane River at Spokane, Washington, 1968–2002.

Little Spokane River

Nearly all streamflow in the Little Spokane River during the summer and autumn is from ground-water discharge from the SVRP aquifer (Cline, 1969). Cline (1969) also estimated the annual mean ground-water discharge to the Little Spokane River upstream of Dartford to be at least 160 ft^3/s. A seepage study completed by the USGS during September 2004 resulted in estimates of streamflow gains between the gaging stations at Dartford and near Dartford of about 255 ft^3/s (Raymond Smith, U.S. Geological Survey, oral commun., 2004).

Limited data are available to compare the data from the Little Spokane River at Dartford and the Little Spokane River near Dartford gaging stations. Differences in monthly mean streamflow values for the months of July through December were analyzed for periods for which data comparisons were possible (1947–52 and 1998–2003; table 1, fig. 3). The differences were very consistent and ranged from an average gain of 244 ft^3/s in July to an average gain of 249 ft^3/s in October and December. The consistent increase in streamflow along the lower part of the Little Spokane River also has been attributed to ground-water discharge from the SVRP aquifer (Cline, 1969). Close inspection of the differences in streamflow during 1998–2003 revealed a possible decreasing trend in streamflow gains between the two gaging stations. This was an observation based on 6 years of data, however, and no statistical analyses were completed.

Summary

The Spokane Valley/Rathdrum Prairie aquifer (SVRP) is the sole source of drinking water for more than 400,000 residents in Spokane County, Washington, and Kootenai County, Idaho. Recent and projected urban, suburban, industrial, and commercial growth has raised concerns about potential future impacts on water availability and water quality in the SVRP aquifer, and the Spokane River and its tributaries. Water resource demands are increasing at a time when aquifer and river dynamics are not well understood. This understanding is essential in making proper management decisions concerning ground water and surface water appropriations in the SVRP area.

Existing streamflow data for all streams located within the extent of the aquifer were compiled and reviewed. Trend analyses were performed on data from gaging stations with 10 or more years of record. During periods when statistically significant trends in streamflow were observed, trend analyses were completed on other data sets, such as temperature and precipitation. Where possible, exchanges between ground water and surface water also were analyzed.

Ten USGS continuous-record gaging stations either are operated currently or were operated previously on streams located within the study area. Seven of the ten gaging stations have at least 10 years of record available for statistical analyses. Many of these gaging stations, however, were not operated continuously over the years, making trend analyses and upstream to downstream data comparisons difficult.

Statistically significant decreasing trends in monthly mean streamflow between 1968 and 2002 were detected for the months of August and September at the Spokane River near Post Falls, Idaho gaging station. Because of the proximity of the gaging station to Post Falls Dam, and the lack of any significant inflows or outflows between the gaging station and the dam, the data essentially represent releases from the dam. Analyses of long-term lake-level, precipitation, tributary-inflow, temperature, and water-use data revealed no significant trends that would indicate a direct relation to the decreasing trends in streamflow at Post Falls. A significant decreasing trend in the annual 7-day low streamflow at the Post Falls gaging station also was observed.

A significant decreasing trend in monthly mean streamflow between 1968 and 2002 was detected for the month of September at the Spokane River at Spokane, Washington gaging station. A significant decreasing trend in the annual 7-day low streamflow at the Spokane gaging station also was observed.

Hangman Creek is unregulated, has only minor diversions for irrigation purposes, and is typically a good indicator of natural streamflow conditions in much of the study area. No trends were detected in the monthly mean data for any of the months that were analyzed.

Significant decreasing trends in monthly mean streamflow between 1968 and 2002 were detected for the months of September and October at the Little Spokane River at Dartford, Washington gaging station. No trends in monthly precipitation that might explain the decrease in streamflow were detected for these months.

A net gain in streamflow occurs in the reach of the Spokane River between the gaging stations near Post Falls and at Spokane. Significant losses do occur in the reach between Post Falls and Greenacres, Washington, while most, if not all, of the gains occur downstream from Greenacres. Statistically significant decreasing trends in the net gain between Post Falls and Spokane were detected for the months of September, October, and November, between 1968 and 2002.

Nearly all streamflow in the Little Spokane River during the summer and autumn is from ground-water discharge. Visual inspection of the limited data available revealed a possible decrease in ground-water discharge to the Little Spokane River between 1998 and 2003; however, no statistical analyses were completed to verify this observation.

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