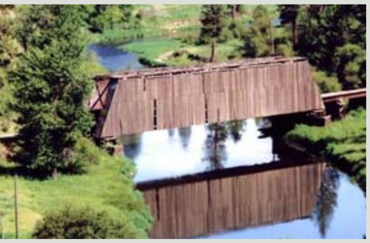
Final Draft

Phase II - Level 1 Technical Assessment

For the Palouse Basin (WRIA 34)




Submitted to: Palouse (WRIA 34) Planning Unit

December 8, 2004

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FINAL DRAFT

PHASE II – LEVEL 1 TECHNICAL ASSESSMENT

FOR THE PALOUSE BASIN (WRIA 34)

Submitted to:

Palouse Watershed
(WRIA 34) Planning Unit

Submitted by:

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1.0 INTRODUCTION

This section presents the objective and purpose of this study, the location of the study area, the scope of work for this project and a review of the watershed planning process.

1.1 Objective

This report presents the findings of the Final Phase II Technical Assessment for Water Resource Inventory Area 34 (WRIA 34). This report is the culmination of all Phase II findings and includes the information presented in the Phase II, Level 1 Technical Memoranda (Golder, 2004) as well as the additional technical analysis requested by the Planning Unit. The objectives of the Level 1 technical assessment are to compile, characterize and provide an initial assessment of existing technical information for Water WRIA 34.

This Phase II Technical Assessment fulfills many of the technical requirements of the Watershed Planning Act (RCW 90.82). The Phase III Watershed Plan must fulfill all requirements of the act, and may include additional technical analysis not completed in Phase II but necessary to support planning recommendations. As stated in RCW 90.82:

(1) The assessment shall include:

- (a) An estimate of the surface and ground water present in the management area;
- (b) An estimate of the surface and ground water available in the management area, taking into account seasonal and other variations;
- (c) An estimate of the water in the management area represented by claims in the water rights claims registry, water use permits, certificated rights, existing minimum instream flow rules, federally reserved rights, and any other rights to water;
- (d) An estimate of the surface and ground water actually being used in the management area;
- (e) An estimate of the water needed in the future for use in the management area;
- (f) An identification of the location of areas where aquifers are known to recharge surface bodies of water and areas known to provide for the recharge of aquifers from the surface; and,
- (g) An estimate of the surface and ground water available for further appropriation, taking into account the minimum instream flows adopted by rule or to be adopted by rule under this chapter for streams in the management area including the data necessary to evaluate necessary flows for fish.

(2) Strategies for increasing water supplies in the management area, which may include, but are not limited to, increasing water supplies through water conservation, water reuse, the use of reclaimed water, voluntary water transfers, aquifer recharge and recovery, additional water allocations, or additional water storage and water storage enhancements. The objective of these strategies is to supply water in sufficient quantities to satisfy the minimum instream flows for fish and to provide water for future out-of-stream uses for water identified in subsection (1)(e) and (g) of this section and to ensure that adequate water supplies are available for agriculture, energy production, and population and economic growth under the requirements of the state's growth management act, Chapter 36.70A RCW. These strategies, in and of themselves, shall not be construed to

confer new water rights. The watershed plan must address the strategies required under this subsection.

(3) The assessment may include the identification of potential site locations for water storage projects. The potential site locations may be for either large or small projects and cover the full range of possible alternatives. The possible alternatives include off-channel storage, underground storage, the enlargement or enhancement of existing storage, and on-channel storage.

1.2 Purpose

Watershed planning is funded by the State of Washington under the direction of the Department of Ecology (Ecology). Watershed planning is a tool for developing water resources management strategies in the context of current laws and policies. As the human population increases and land use activities change, so may the demands for water. Watershed planning incorporates the knowledge of those who live within a watershed with technical professionals to develop an inventory of water quantity information in the watershed. A wide variety of local interest groups have an opportunity to voice their needs and concerns. Watershed planning attempts to incorporate the perspectives of these groups into a framework for water resource allocation within the watersheds.

1.3 Background

The current WRIA 34 watershed planning effort was initiated in 2002 when funding was made available from the Washington Department of Ecology. The Palouse Conservation District is the lead agency. In April 2004, Golder Associates completed a series of Draft Phase II – Level 1 Technical Memoranda as an initial compilation and characterization of existing technical information. The technical memoranda were presented and discussed at a 1-day workshop with the WRIA 34 Planning Unit. After review and discussion of these memoranda, Golder and the Planning Unit agreed on the format and content for the Phase II technical assessment report that will allow the Planning Unit to proceed into Phase III of the planning process. In completion of Phase II, the Planning Unit chose to focus on additional technical analyses to better characterize hydraulic continuity and water rights in the Cow Creek and Palouse River Sub-basins.

1.4 Report Organization

This report is organized into two main sections: the main text, tables and figures that are organized by chapter and the appendices that follow the main text.

The main text is organized in to ten sections as follows:

- Section 1: Objectives, Background, Organization and Watershed Planning.
- Section 2: Climate
- Section 3: Surface Water
- Section 4: Groundwater
- Section 5: Land and Water Use
- Section 6: Water Rights
- Section 7: Water Quality

- Section 8: Cow Creek Sub-Basin Summary
- Section 9: Palouse Sub-Basin Summary
- Section 10: Bibliography

1.5 Watershed planning

Watershed planning within Watershed Resource Inventory Areas (WRIAs) recognizes the large scale and complexity of water resources and the wide variety of factors that influence the amount of water available for use. Although the geographic area contained in a WRIA rarely corresponds with political/jurisdictional boundaries, water resource issues such as water supply, water quality, and habitat for fish and wildlife are closely linked together within watersheds.

From an assessment perspective, the watershed (or basin) scale is appropriate because the hydrologic processes that occur within WRIA boundaries can be approximated using basin scale conceptual and quantitative tools that describe the hydrologic cycle. With a conceptual understanding the hydrologic cycle within a basin, planners can gain an intuition on how future actions within the watershed may impact water resources.

1.6 Washington State Watershed Planning Process

The 1998 Washington State legislature passed House Bill 2514, codified into **RCW 90.82**, to set a framework for addressing the State's water resources issues. RCW 90.82 states:

> *"The legislature finds that the local development of watershed plans for managing water resources and for protecting existing water rights is vital to both state and local interests. The local development of these plans serves vital local interests by placing it in the hands of people: Who have the greatest knowledge of both the resources and the aspirations of those who live and work in the watershed; and who have the greatest stake in the proper, long-term management resources. The development of such plans serves the state's vital interests by ensuring that the state's water resources are used wisely, by protecting existing water rights, by protecting instream flows for fish and by providing for the economic well-being of the state's citizenry and communities. Therefore the legislature believes it necessary for units of local government throughout the state to engage in orderly development of these watershed plans."*

Twelve State agencies signed a Memorandum of Understanding in 1998 identifying roles and responsibilities for coordination under the Watershed Planning Act. This memorandum commits these agencies to work through issues in order to speak with one governmental voice when sitting at local planning unit tables. The following agencies signed this document:

- The Department of Agriculture.
- The Conservation Commission.
- The Department of Community, Trade and Economic Development.
- The Department of Ecology.
- The Department of Fish and Wildlife.
- The Department of Health.

- The Department of Natural Resources.
- The Department of Transportation.
- The Interagency Committee for Outdoor Recreation.
- The Puget Sound Water Quality Action Team.
- The Salmon Recovery Office, within the Governor's Office.
- The State Parks and Recreation Commission.

The purpose of RCW 90.82 is to provide a framework for local government, interest groups and citizens to collaboratively identify and solve water related issues in each of the 62 Water Resource Inventory Areas (WRIAs) of Washington State.

RCW 90.82 does not require watershed planning but instead enables a group of initiating agencies to:

- Select a lead agency;
- Apply for grant funding;
- Define the scope of the planning; and,
- Convene a local group called a planning unit for the purpose of conducting watershed planning.

The initiating agencies include all the counties within the WRIA, the largest city and water purveyor within the WRIA. Indian tribes with reservation lands within the watershed must be given the option to participate as an initiating government, but their participation is not mandatory. Although all initiating entities must agree that they want Watershed Planning to occur in the basin, participation is not required for watershed planning to proceed.

The law also includes constraints on the activities of planning units. For example, the PU does not have the authority to change existing laws, alter water rights or treaty rights, change treaties, or require any party to take an action unless that party agrees.

Four phases of watershed planning are identified in RCW 90.82:

- Phase I - Organization
- Phase II - Assessment
  - Level 1 Assessment: A compilation and review of existing data (within time and budget limitations) relevant to defined objectives. If the Planning Unit decides that the existing data is sufficient to support the management requirements of all or some of the issues, the Planning Unit may choose to skip Level 2 and move on to Level 3 for these issues.
  - Level 2 Assessment: Collection of new data or conduct additional analysis of existing data within the time frame of the planning process to fill data gaps and to support decision needs.
  - Level 3 Assessment: Long term monitoring of selected parameters following completion of the initial watershed plan to improve management strategies.

Supplemental assessments may be conducted in the following focused areas:

  - Multipurpose Storage: To conduct a detailed assessment of multipurpose water storage opportunities or studies of specific multipurpose storage projects that are consistent with and support the other elements of the planning unit's watershed plan developed under RCW 90.82.
  - Instream Flow Assessment: To establish new minimum instream flow regulations, or amend existing regulations; and,
  - Water Quality Assessment: To conduct water quality assessment in fulfillment of RCW 90.82.090 and to support development of watershed plan.

- Phase III – Planning

RCW 90.82.130(1)(a) calls for a consensus approval of the watershed plan by all members of the Planning Unit (PU), or a consensus among the members of the PU appointed to represent units of government. Once the PU has accepted the plan by one of these methods it is referred to the County legislative body for approval. The County legislative body may veto the plan but must refer it back to the PU with recommended revisions. Once the plan has been approved by the county legislative bodies and the PU, the county and state agencies are required to implement the plan.

Furthermore, RCW 90.82.130 (3) addresses the obligation to implement elements of the watershed plan. It states that the PU can only add an element to its watershed plan that creates an obligation if each of the governments to be obligated has at least one representative on the PU and those members agree to add the element.

- Phase IV – Implementation

The Planning Unit must provide a detailed implementation plan to provide water for agriculture, commercial, industrial and residential use, and instream flows, including timelines and milestones. The plan must clearly define coordination, oversight responsibilities, needed regulations (ordinances, inter-local agreements or rules), and funding sources. The funds are distributed over an implementation period of up to five years and require 10% matching funds, which may consist of in-kind goods and services.

1.7 The WRIA 34 Planning Unit

The WRIA 34 planning effort was initiated in 2002 by Whitman County, Spokane County, Lincoln County, Adams County, the City of Pullman and the Steptoe Water and Sewer District. A limited portion of WRIA 34 falls within Franklin County and therefore, they decided not to participate in as an initiating government in the WRIA 34 planning process and deferred all decision making to the other initiating governments. These initiating governments began the planning process by identifying the Palouse Conservation District as the lead agency for this effort. The initiating governments formed a Planning Unit by asking various agencies, organizations and businesses to appoint a member. In addition, interested members of the public were invited to join. Members of the watershed Planning Unit include broad representation of interests within the basin and hold monthly meetings that are open to the public. The State of Idaho is also represented within the WRIA 34 Planning Unit as a voting member.

In November 2004, the planning unit was made up of the following members:

Initiating Governments:

- Whitman County
- Spokane County
- Adams County
- Lincoln County
- City of Pullman (largest city in the WRIA)
- Steptoe Water and Sewer District (largest water purveyor)

State Agencies:

- Washington Department of Ecology (represents all Washington State agencies)
- Idaho Department of Environmental Quality (IDEQ)

Federal Agencies:

- United States Forest Service (USFS)

Idaho Counties:

- Latah County, Idaho

Other Towns and Cities:

- City of Colfax, WA
- City of Medical Lake, WA - resigned
- Town of Farmington, WA
- City of Moscow, ID

Agriculture

- Whitman County Farm Bureau
- Washington State University Cooperative Extension

Recreational Interests:

- Sprague Lake Users Group

Environmental Groups:

- Palouse-Clearwater Environmental Institute

Technical Support Agencies:

- Adams Conservation District
- Whitman Conservation District
- Washington State Department of Ecology

- Washington State Department of Fish and Wildlife
- Washington State Department of Health
- Washington State Department of Natural Resources
- U.S. Geological Survey
- United States Forest Service (USFS)
- Washington State Conservation Commission
- University of Idaho
- Washington State University

1.7.1 Phase II Watershed Planning Optional Components

RCW 90.82 requires that the initiating agencies use Phase II grant monies to address water quantity issues. The law provides that grant money may be requested to address water quality, fish habitat, and instream flows, at the option of the initiating governments. There is a potential for additional grant funding, established under ESHB 1832, of $100,000 each for minimum instream flows, storage and water quality assessments.

The initiating governments for WRIA 34 chose to address instream flows, water quality, and multi-purpose storage supplemental components in addition to addressing quantity issues for the HB 2514 process. This report addresses only the water quantity component of Phase II Watershed Planning. The Planning Unit applied for and received funding to support all three Phase II optional components. The Planning Unit is in the process of developing their Instream Flow Step B scope of work and is in the process of developing the storage and water quality assessments.

1.7.2 Palouse Basin Planning Unit Mission Statement and Goals

The WRIA 34 Planning Unit identified a number of goals for their watershed planning process. It is important to appreciate that these goals may be modified in the future and that the list below represents the objectives as of February 2003. The scope of work for this report (Phase II of Watershed Planning) is to compile the information that will be used in Phase III to address these objectives. The WRIA 34 Planning Unit Goals are as follows:

- Protect existing water rights and private property rights;
- Emphasize incentive-based management solutions;
- Maintain the existing economy associated with the watershed hydrology, including but not limited to potable water, agriculture, industry, recreation and tourism;
- Establish and maintain ongoing educational and public involvement programs;
- Establish a detailed funding plan for implementation, including: projects, programs, long-term monitoring and evaluation of watershed plan implementation;
- Ensure fairness in distributing costs and burdens of water resource management actions;
- Address differences in local and state water resources regulatory and management approaches, and obtain local, state, federal and tribal buy-in and cooperation for recommended management strategies;

- Provide long-term reliable and predictable water supplies for human uses;
- Protect surface and groundwater quality needed for public drinking water supplies and other uses (recreation, fish etc.);
- Improve consistency, certainty, timeliness and efficiency across state lines in addressing water right decisions, and in regulatory approaches for improving water quality conditions;
- Improve scientific basis for understanding baseline conditions; and
- Identify and implement water conservation and efficiency strategies.

1.7.3 Phase II, Level 1 Assessment Process

The assessment activities described in this document were defined and overseen by the WRIA 34 Planning Unit. Members of the PU assisted in providing relevant information to assist in the Level 1 Technical Assessment process. Decisions on the information to be assessed were made by the PU members during scheduled meetings. A listing of the information compiled for the Level 1 assessment is included in as a bibliography, and a directory of Geographic Information System (GIS) files is included in Appendix H. Draft materials produced by Golder were provided to the PU for review. Review comments were discussed and incorporated prior to preparation of the final document.

2.0 CLIMATE

This section describes climate conditions in WRIA 34. The accepted definition of climate is it "represents the average state of the atmosphere during a period of time" (Maidment, 1993). Climate is influenced by the combined response of the earth's water storage, land mass and atmosphere to solar radiation, and is the driving force in a hydrologic system.

The main climatic input to a watershed's water cycle is precipitation, in the form of rain and snowfall. The amount of precipitation is the primary control on the amount of water that may be available within the watershed. Other climatic factors also influence the hydrologic system including temperature and evaporation/evapotranspiration. To fully understand a watershed's water cycle it is important to understand climate and its variability. Climate varies within a watershed from day to day as well as over many years. Climate also varies spatially, from town to town and sub-basin to sub-basin.

Climate variables discussed in this section include precipitation, temperature, Snow Water Equivalent (SWE), evapotranspiration and snow depth. The review is based on continuous (historical) as well as non-continuous data that are made available by several agencies.

2.1 Background Issues

Technical issues related to climate include:

- Climate variability – Seasonal, year-to-year and spatial variability in climate will ultimately determine future water availability in WRIA 34.
- Runoff - Agricultural land use in combination with seasonal climate conditions (e.g. frozen ground and high rainfall) may influence water availability in WRIA 34.

Management challenges:

- Watershed managers cannot control climate. Management decisions must therefore be based on a variable system, and uncertainty must be factored into predictions.
- Droughts occur in a natural system, adversely affecting the environment regardless of whether it is inhabited. In developed watersheds, the effects of drought are magnified, resulting in additional economic impacts to the residents of the area. Limited or lack of regulated storage coupled with natural hydrologic variability make it difficult to manage drought conditions.
- Global climate patterns appear to be changing. While their general effects are understood, their localized effects at a watershed level are somewhat uncertain.

2.2 Overview

The objective of this section is to describe climate data available for the Palouse Basin water cycle. Since climate varies both spatially and temporally.

The Palouse Basin is divided geographically into 8 sub-basins for data analysis and reporting purposes. These basins vary in size, location and elevation and provide adequate detail to capture variations across the basin. The size of these basins is summarized in Table 2-1; the basins are displayed in Figure 2-1. The temporal resolution of analysis varies from monthly to inter-annually.

Climate in the WRIA 34 varies over four distinct seasons, characterized by cool, wet winters and hot, dry summers with temperatures ranging from 36 °F below zero to 110 °F (Cook, 2001). Mean annual temperature is 48.8 °F, with seasonal means of 70 °F in July and 27 °F in January, (Mountain Resource Group, 1993; RPU, 2002a). In general, mean temperature decreases from west to east, whereas precipitation increases with increasing elevation moving east into the Idaho mountains.

During the fall, winter and spring months, cyclonic storms produce low intensity, long duration precipitation accounting for most of the annual precipitation (Henderson, 2003). Average annual precipitation ranges from 12 inches in the west; to 25 inches at low elevations in the east; to almost 50 inches in the Idaho Mountains (Cook, 2001 and RPU, 2002a). Most of the precipitation occurs between October and May and consists of a mix of rainfall and snowfall.

Snow contributes approximately 60-70% of the total annual precipitation at higher elevations and approximately 40% at lower elevations in the headwaters and middle reaches in the eastern portion of the watershed (RPU, 2002a). Annual snowfall ranges from less than 5 inches to more than 50 inches. Snow depths are typically 6-20 inches during winter and depths ranging from 20-28 inches have been recorded during periods of heavy snowfall in eastern Whitman County. Soils in the Palouse Sub-basin can freeze to a depth of 30 inches during extreme winter seasons (Cook, 2001).

2.3 Available Data

A variety of climate data are available, including long-term and short-term climate stations, snowpack stations and snow course surveys, regional climate model outputs, and miscellaneous climate measurements.

- The National Oceanic and Atmospheric Association (NOAA) and National Weather Service (NWS) co-operative (NOAA/NWS COOP) maintain several continuous climate stations within the basin. These stations record a number of climate variables and are summarized in Table 2-2 and displayed in Figure 2-1. Climate data was available through the WRCC and the University of Idaho Climate Data Center. Monthly and annual data for stations with adequate periods of record are presented in the tables and figures in this report. Data for some stations was not readily available. Additional efforts to obtain data for these stations as well as other specific types of climate data may be made for use in future analysis.
- The Natural Resource Conservation Service (NRCS) operates one Snowpack Telemetry (SNOTEL) station in the Palouse Basin. This station records continuous snow accumulation, precipitation, and temperature. Data are only available from 2002-2003 for the Moscow Mountain Snotel Station. Data from this SNOTEL station are summarized in Table 2-2 and the location is displayed in Figure 2-1.
- The Parameter-elevation Regressions on Independent Slopes Model (PRISM) provides an integrated basin-scale analysis of climate for the basin. PRISM is used to estimate mean annual, mean monthly and event-based precipitation, temperature, and other variables. PRISM is a model developed by Oregon State University that uses point data and a digital elevation model (DEM) to generate gridded estimates of climate parameters (Daly et al., 1994). Unlike other statistical methods in use today, PRISM was written by a meteorologist specifically to address climate. The effects of terrain on climate play a central role in the model's conceptual framework. Data input to the model consists of 1962-1990 mean monthly precipitation from over 8,000 National Oceanic and Atmospheric Administration (NOAA) Cooperative sites, Snowpack Telemetry

(SNOTEL) sites, and selected state network stations. The model grid resolution is 4-km (latitude and longitude). The outputs used in this study are re-sampled to 2-km resolution using mathematical filtering procedures (Daly et al., 1994). Figure 2-2 displays data obtained from PRISM model output.

2.4 Presentation of Data

2.4.1 Annual and Monthly Aggregate

Annual averages are commonly used to evaluate inter-year trends. A total yearly volume plot can be useful in determining if there has been an overall decline in precipitation or snowpack within the period of record. Monthly averages can be used to evaluate inter-year trends on a monthly basis as well as intra-year trends. Monthly averages aid in visualizing how individual months contribute to total annual precipitation volumes. In addition, monthly averages can indicate how monthly values vary with annual increases or declines in precipitation or snowpack.

Annual and monthly data include:

- Spatial presentation of PRISM annual precipitation (Figure 2-2);
- Annual and mean monthly precipitation for available stations (Table 2-3);
- Aerial averaging of PRISM precipitation in each sub-basin (Table 2-4);
- Comparisons of annual observed precipitation and PRISM precipitation (Table 2-5);
- Monthly and annual temperature summary (Table 2-6);
- Monthly and annual pan evaporation (Table 2-7); and
- Annual evapotranspiration at select climate stations (Table 2-8).

2.4.2 Time-Series Hydrograph

Time series plots display climatic parameters, such as temperature, precipitation or evaporation versus time. These plots are useful in understanding the actual variability of the system (as opposed to statistical comparison) and how they vary over the basin. Time series plots utilize different time intervals to understand different processes. Time step should be chosen based on the process that is being analyzed. Single storm events or diurnal variations are best viewed on a smaller time step, such as hourly or less. Long-term variations such as seasonal or annual variations are best viewed using longer time steps such as daily, weekly or monthly.

Time series plots include:

- Total annual precipitation plots of gage data (Figures 2-3(a-k));
- Mean monthly precipitation plots (Figure 2-4);
- Mean monthly temperature plots (Figure 2-5);
- Average monthly snowfall (Figure 2-6);
- Snow Water Equivalent (SWE) and precipitation (Figures 2-7 (a-c)); and
- Snow Water Equivalent (SWE) and accumulated precipitation (Figure 2-8).

2.4.3 Cumulative Departure Analysis

Cumulative departure plots provide a concise view of climate variability while also taking into account the longer term trends in the climate cycle. A Rescaled Cumulative Departure (RCD) plot displays whether a system is exhibiting above or below average precipitation, how severe conditions are (i.e. how far from average conditions) and the duration of the wet or dry period. A declining slope in a RCD plot indicates that precipitation was below average during much of the interval (a dry or drought period) while an increasing slope indicates that precipitation was above average during much of the interval. The slope of the RCD plot and duration of the cycle indicate the relative severity a trend. For example a high rate of decline on a RCD plot that persists for a long period of time indicates a severe drought.

In order to calculate the cumulative departure it is necessary to first determine a base period. A base period should be a period of record, which is representative of a normal cycle of wet and dry seasons. The base period can be the entire period of record or a shorter representative period. In a study completed by the USGS (Kresch, 1994) it was determined that a base period of 1937-1976 accurately reflected long-term average conditions in Washington (mean-monthly values and standard deviations of the base period accurately represent long-term average conditions).

Cumulative Departure analysis was completed using these long data sets that encompass an even balance of wet and dry years. The Colfax, Lacrosse and Rosalia NOAA/NWS COOP stations have periods of record of adequate length, and are presented in Figures 2-9 through 2-11.

2.4.4 Pacific Decadal Oscillation (PDO)

The Pacific Decadal Oscillation (PDO) was recognized initially in the early 1990s and describes warm and cool phases of climate that affect the Inland Northwest over 20 to 30 year cycles. A warm phase PDO, which occurs as a result of warming of sea surface temperatures in the central north Pacific, brings cooler sea surface temperatures to the coast of the Pacific Northwest. A cool phase PDO, which occurs as a result of cooling of sea surface temperatures in the central north Pacific, brings warmer sea surface temperatures to the coast of the Pacific Northwest. A warm PDO cycle generally increases temperature and total precipitation, but decreases snow depth and streamflow. A cool PDO cycle decreases temperature and total precipitation, but increases snow depth and streamflow. Because the PDO triggers are not well understood, they cannot be predicted at this time. Based on the climatic record of the Pacific Northwest, cool, wet PDO regimes are predicted to have lasted from 1890-1924 and again from 1947-1976. Warm, dry PDO regimes have spanned 1925-1946 and from 1977-1995 (JISAO and SMA, 1999). It is believed that the PDO phase may have shifted to a cool period in the late 1990s. The estimated PDO changes in the climate of the Pacific Northwest as a percentage of average (except for temperature) are presented in Table 2-9 (JISAO and SMA, 1999).

2.5 Data Quality

This section briefly describes the sources of data presented in Section 2.4.

2.5.1 NOAA/NWS COOP

A cooperative (COOP) station is a site at which observations are taken by volunteers or contractors who are not National Weather Service (NWS) employees and who are not required to take or pass observation certification examinations. Automatic observation stations are considered cooperative stations if their observed data are used for services which otherwise would be provided by cooperative observers. Many types of data may be collected at a COOP station including precipitation, temperature, wind, evaporation and snowfall and various parameters relating to these fields.

NWS personnel review all incoming data for correct station information and other supporting data. As the data are being key entered, data entry software checks for and resolves basic internal inconsistencies by deleting or rearranging observational elements. Finally data are checked using interactive aerial edits where stations are compared with nearest neighbor stations, manual outlier review and resolution of internal data inconsistencies.

2.5.2 Snow Accumulation (SNOTEL)

The Natural Resources Conservation Service (NRCS) installs, operates, and maintains an extensive, automated system to collect snowpack and related climatic data in the Western United States called SNOTEL (for SNOwpack TELemetry). The sites are generally located in remote high-mountain watersheds and are designed to operate unattended for up to one year in severe climates. Basic SNOTEL sites have a pressure sensing snow pillow, storage precipitation gage, and air temperature sensor. Preventative maintenance and sensor adjustments are made on an annual basis and individual site performance is compared against established performance standards. Ground truth measurements are collected on a regular basis and compared with telemetered data for quality control purposes. Any site that does not meet quality control standards undergoes a detailed site evaluation and any deficiencies are corrected.

2.5.3 PRISM

The PRISM model uses point climate data, a digital elevation model, and other spatial datasets to generate gridded, GIS-compatible estimates of annual, monthly, and event-based climatic elements to develop high quality maps (Daly et al. 1994, 1997). PRISM modeling results are the result of collaboration between Oregon State University, USDA-NRCS, and other agencies.

The PRISM modeling system and the climate maps it produces are routinely evaluated for climatological and statistical accuracy using statistical parameterization to achieve to lowest possible prediction error and peer review by a group composed of State and Regional Climatologists, a National Climatic Data Center representative, a National Weather Service representative, and engineers, hydrologists, GIS experts and a meteorologist from the NRCS. Due to the vast amount of data used in the analysis and the high degree of peer review since publication, PRISM precipitation data are considered high quality.

Within the Palouse Basin, PRISM outputs correlate well with annual precipitation measured by both the NOAA/NWS COOP and the SnoTel stations (see Table 2-5).

3.0 HYDROLOGY - STREAMFLOW

This section describes streamflow conditions in WRIA 34. Streamflow represents the final output of water in the hydrologic cycle as it moves in the watershed. It is the most visible component of the hydrologic cycle and a key component of many ecological systems within a watershed. Streamflow is influenced primarily by climatic factors, but is also influenced by land-use and groundwater. Like climate, streamflow varies from day to day and over many years. It also varies spatially, both between sub-basins and within a single sub-basin.

3.1 Background Issues

Characterization and interpretation of streamflow data must acknowledge a number of different factors, including:

- Natural variability: Natural variability of streamflow occurs both spatially and temporally. The precipitation pattern in the Palouse Basin is characterized by greater precipitation on the east side of the basin and decreasing precipitation levels to the west. In addition, climate variability causes the hydrologic regime to change from year to year. The volume of water held in snow storage and the timing of its release varies annually, affecting streamflow levels throughout the year.
- Hydraulic continuity: Hydraulic continuity between groundwater and surface water can play an important role in sustaining flow levels, particularly during dryer periods. An understanding of the specifics of hydraulic continuity is often difficult. Few specific data exist that characterize hydraulic continuity between surface water and groundwater and between aquifers.
- Accuracy and precision of measurements: Stream gaging sites are typically located to provide precise and accurate results. However, measurement errors are inherently introduced when collecting streamflow data. Flow is calculated based on the measurement of the level and velocity of water in the stream, coupled with measurements of channel geometry and streambed conditions. Inaccuracies are introduced through changing technology, geomorphic variability, human error, and machine error. These errors typically range from 5% to 20%, depending on site conditions. In effect, no streamflow measurement is 100% accurate.
- Timing and location of water use: The timing and location of water use can influence streamflow and baseflow levels through almost every aspect of the hydrologic cycle. The affects of these withdrawals vary with the location and magnitude of use.
- Land cover and land use: Land use and land cover can affect interception and evapotranspiration timing and rates, as well as how much and how quickly water infiltrates or runs-off to streams.

Ultimately, each of these physical factors must be balanced with study or planning objectives. The importance of the factors will vary depending on the planning issue being considered.

3.2 WRIA 34 Topics of Concern

Changing land use patterns over the last century have changed the hydrology of the Palouse to varying degrees. Streams in the Palouse Basin have a pattern of late summer and early fall low flows and spring and early summer high flows (Henderson, 2003). In general, hydrology in the forested upper Palouse Basin is snowmelt and groundwater dominated, whereas hydrology in the lower watershed on the agricultural lands is driven by snowmelt and precipitation events (Henderson, 2003).

Changes in hydrology in the Palouse Basin that may have watershed management implications:

- Peak Flows: Rain on snow and/or frozen ground can result in rapid snowmelt, flooding and severe erosion. Although flooding has always occurred in the Palouse Basin the effect of land use practices over the past century on peak flows is a concern.
- Low baseflows: The climate in WRIA 34 has always caused lower streamflows during the summer, and it is likely that many small streams have always been ephemeral. However, exaggerated peak flow events and rapid runoff may exacerbate low late summer baseflows by reducing infiltration to groundwater and subsequent discharge to streams.
- Reduced storage potential: Agricultural and forest practices as well as urbanization may have affected storage capacity in riparian and wetland areas throughout the Palouse Basin.
- Soil characteristics: Frozen soils and agricultural practices may affect infiltration rates and surface runoff in the Palouse Basin. However, typical assessment methods, such as the USDA SCS curve number technique, performs poorly in estimating surface runoff in the Palouse Basin because the technique was developed for large events and under non-winter conditions.
- Significance of Cow Creek: The USGS Palouse River at Hooper gage accounts for streamflow from all major tributaries in the basin with the exception of Cow Creek. Cow Creek contributes an estimated 7% of the total flow of the Palouse River but accounts for approximately 20% of the land mass of the Palouse Basin.

3.3 Objective and Level of Detail

Water quantity is a required component of Watershed Planning. The basic planning requirements under the watershed planning act (RCW 90.82) require an assessment of:

- Surface and groundwater present in the basin;
- Water rights, in the form of claims, permits, certificates and regulatory baseflows;
- Water use estimates for historic, current and future conditions;
- Hydraulic continuity between surface water and groundwater;
- Water availability, based on a comparison of appropriation and presence; and
- Potential strategies for increasing or better managing water resources in the basin.

The basin has been divided geographically into 8 sub-basins. The size of these sub-basins is summarized in Table 2-1. The sub-basins are displayed in Figure 3-1 along with the location of streamflow monitoring stations.

3.4 Previous Studies and Available Data

There are abundant streamflow records throughout the Palouse Basin. Several continuous recording streamflow gages have been in place in various sub-basins for roughly the last decade or longer.

Figure 3-2 (a-c) presents USGS Gage periods of record as well as the timing of the Pacific Decadal Oscillation (PDO) discussed in Section 2. Weather patterns affected by the Pacific Decadal Oscillation (PDO) are believed to be a dominant influence affecting streamflows. The PDO is a pattern of warm and cool phases that reverses on a 20-30 year time scale. Streamflows can decline as much as 10% during warm periods and can increase as much as 6 % during cool periods (JISAO and SMA, 2001).

Continuous gages are operated by the US Geological Survey (USGS) at a number of locations along the Palouse mainstem and its major tributaries. The longest period of record exists at the Palouse River gage at Hooper. It has been in operation since 1897. Continuous gage summaries are displayed in Table 3-1. The locations of these gages are depicted in Figure 3-1.

In addition to these continuous records, individual streamflow measurements have been collected by local, state, and federal agencies. Figure 3-1 presents the locations of various historically documented streamflow gages.

Other available USGS streamflow related data are included as part of the following studies:

- USGS Water Resources Investigations Report 88-4105 "Surface-water resources of the Columbia Plateau in Parts of Washington, Oregon, and Idaho."
- USGS Open-File Report 84-145B, "Streamflow Statistics, and Drainage-Basin Characteristics for the Southwestern and Eastern Regions, Washington."
- USGS Open-File Report 89-380, "Miscellaneous Streamflow Measurements in the State of Washington, January 1961 to September 1985."

The US Forest Service collects flow measurements on the Palouse River in the Clearwater National Forest, Idaho at one location above Laird Park, shown in Figure 3-1. Data collection at Laird Park began in 1997. Between 1986-1996, Palouse streamflow data were collected just above Little Sand Creek, also shown in Figure 3-1. Mean monthly streamflow data for both stations are presented in Figure 3-3.

The Idaho Department of Environmental Quality (IDEQ) collected bi-weekly streamflow measurements for seventeen 303(d) listed Palouse River tributaries between November 2001 and November 2002. These streamflow data are presented in Figures 3-4 (a-h).

The Adams County Conservation District collects continuous stage (water surface elevation) data using ISCO recorders at three Cow Creek locations, including Sprague Lake Outlet, Cow Creek at Harder Bridge and Cow Creek at Hooper, these locations are shown in Figure 3-1. Although rating curves have not been developed for these three locations, preliminary estimates of streamflow have been calculated using stage data. Instantaneous streamflow measurements were collected at these locations during 2003 and will be used along with 1997-2002 data in the development of stage-discharge relationships (i.e., rating curves) at these three locations (Gary DeVore, personal communication). Available streamflow estimates for these three locations are presented in Figures 3-5 (a-c). Relative stream stage for 2003 at Cow Creek at Harder Bridge and Cow Creek at Hooper as well as two additional locations (Cow Creek at Danekas Road and Lower Palouse River at old Highway 26 Bridge) are presented in Figures 3-5 (d-g).

Annual water levels at Sprague Lake Outlet for 1998-2002 are presented in Figure 3-5h.

Additional Sprague Lake water level data was collected by the USGS on a monthly basis between 1958-1980. In 2002, WDOE conducted limited field and modeling analysis of flows out of Sprague Lake (Martin Walther, Personal Communication). The analysis included development of rating curve for the outlet of Sprague Lake. This information is discussed further in Section 8.

Instantaneous flow measurements were collected on Airport Road Creek as part of the Washington State University Airport Road Creek Sampling Study, a study designed to determine sources of pollution impacting Airport Road Creek.

A number of previous assessments address WRIA 34 surface water issues including:

- Resource Planning Unlimited, Inc. (RPU), 2004 Draft Palouse Sub-basin Management Plan.
- Taylor Engineering, 2003. Comprehensive Flood Hazard Management Plan for the City of Pullman.
- Henderson, Robert, 2003. Palouse River Tributaries Sub-basin Assessment and TMDL. Prepared for the Idaho Department of Environmental Quality (IDEQ).
- Resource Planning Unlimited, Inc. (RPU), 2002a. North Fork Palouse River Watershed Characterization. Prepared for the Palouse Conservation District.
- Resource Planning Unlimited, Inc. (RPU), 2002b. South Fork Palouse River Watershed Characterization and Implementation Plan. Prepared for the Palouse Conservation District.
- Clark, Ken, 2002. Tributaries of the Palouse River Monitoring Report. Technical Results Summary KPC-PR-02. Prepared for the Idaho Association of Soil Conservation Districts.
- Cook, Trevor, 2001. Draft Palouse Sub-basin Summary.
- Resource Planning Unlimited Inc. (RPU), 2000. Cow Creek Watershed Management Plan. Prepared for the Adams County Conservation District.
- Palouse Conservation District and the Paradise Creek Management Committee, 1997. Paradise Creek Watershed Water Quality Management Plan.
- Hashmi, Gibran S., 1995. Four Mile Creek Watershed Characterization.
- Washington State University, 1985. Paradise Creek Watershed Ecological Inventory, Suitability Analysis and Landscape Plan.
- USDA, 1978. Palouse Co-Operative River Basin Study.
- U.S. Army Corps of Engineers Walla Walla District, 1998. Section 205 Flood Control Feasibility Study City of Pullman, Washington.

3.5 Data Representation

Hydrologic datasets are complex, highly variable, and cannot be represented by a single method of characterization. It is necessary to utilize several methods to represent each aspect of a system. This section describes and presents data using several methods to characterize the hydrologic regime.

3.5.1 Annual Aggregate

Annual averages (or means) are commonly used to evaluate inter-year trends. A total monthly or yearly flow volume plot can be useful in determining if there has been a change in streamflow levels over the long term.

Mean annual flows for continuous USGS gages within the basin are presented in Table 3-1. Mean Annual Flows occurring at each gage over the available period of record are displayed in Figures 3-6 (a-v). These plots can provide an indication of inter-annual (between year) flow variations.

3.5.2 Monthly Aggregate

Monthly averages (or means) can be used to evaluate inter-year trends on a monthly basis as well as intra-year trends. Monthly averages aid in visualizing the relative contribution of monthly flows to total annual flows as well as how these monthly flows relate to each other. In addition, monthly averages can indicate how monthly values vary with annual increases or declines in precipitation, snowpack and flow.

Mean monthly flows for continuous gages are displayed in Figures 3-7 (a-v). Peak flows at Palouse Basin gages generally occur in March or sometimes February or April, low flow months occur from July to December.

3.5.3 Time-Series Hydrographs

A hydrograph presents streamflow in a basic form - streamflow (or stage) versus time. A hydrograph can provide very detailed information when completed on a daily or hourly time step. Actual hydrographs, as opposed to aggregates, are used to describe the elements, or phases of the hydrologic cycle and provide the best insights into specific hydrologic responses. Unfortunately, because of the complexity of hydrograph response, it is difficult to automate or numerically analyze individual hydrographs. Therefore, analysis is often best completed through observation.

The basic elements of a hydrograph are shown on Figure 3-8 include the following:

- Baseflow (fall/winter);
- Rising limb (spring);
- Peak flow (spring);
- Peak flow recession (summer); and
- Baseflow recession (summer/fall).

In the Palouse Basin, the baseflow recession, baseflow and peak flow periods are all of importance. A description of each element is discussed in the paragraphs below.

- The technical definition of baseflow is defined as the "component of streamflow derived from groundwater inflow or discharge" (Ecology, 1999). The technical definition should not be confused with the regulatory use of the term "baseflow," and the terms have different meanings. This section uses the technical definition for baseflow exclusively. Baseflow represents streamflow, or runoff, which results from precipitation that infiltrates into the soil and eventually moves through the soil and underlying aquifers to the stream channel. It is often the primary source of water during dry periods when there is little or no surface water run-off.

- The rising limb is the period of time (usually spring) when run-off from both small (rain) and large (snowmelt) events begins to reach the stream. The shape and rate of streamflow increase on rising limb is affected by the size and shape of the watershed, as well as snow storage, temperature, land cover, and infiltration capacity.
- Peak streamflow represents the largest rate of streamflow during a year. Annual averages of streamflow are often greatly influenced by peak flow, because peak flows represent the greatest volume of water, being 1 or 2 orders of magnitude greater that normal and low flow conditions during the rest of the year.
- Peak flow recession follows the peak flow period. The recession limb occurs when run-off begins to decrease (usually summer). The slope and length of this recession period is affected by snow storage volume, temperature, land cover, and infiltration capacity.
- Baseflow recession represents a transition period when streamflows become increasingly supported by groundwater baseflow. The slope of this recession is typically lower than during peakflow, but is greater than during true baseflow.

Example daily hydrographs and baseflow for select continuous USGS gages are presented in Figures 3-9 (a-o). Each figure displays representative hydrographs for wet, dry and average years. Monthly average baseflow conditions are presented where available. Wet, dry and average years were selected using total annual precipitation data from nearby climate stations. Representative years were selected by sorting total annual precipitation data by deviation from total average precipitation at the climate station located closest to each USGS gage. Baseflow is shown as the shaded portion of the hydrograph and is based on analysis conducted by WDOE (1999). The methods for calculating baseflow included utilization of automated hydrograph separation software called HYSEP (Sloto and Crouse, 1996) to estimate monthly and annual baseflow statistics and are described in detail in WDOE (1999). Hydrograph separation divides a stream hydrograph into two major components: baseflow and surface runoff to evaluate the groundwater contribution to total streamflow. This process involved compilation of station characteristics for each gage, including period of streamflow record, type and degree of regulation affecting the gage, watershed drainage area, USGS station number, station name, and gage location.

Baseflow information was not available for the Palouse River at Potlatch Gage (Stn 13345000). From these graphs the baseflow period is seen extending from August through October or November. The rising limb typically begins in December and reaches peak levels in March; recession from the peak extends from approximately March through June. Baseflow recession is visible from the decline in the slope that occurs in July and early August. Baseflow is typically reached by early-August. Table 3-2 presents August and September monthly baseflow values for at each gage.

3.5.4 Range of Variability Statistics

Richter et al. (1996 and 1997) have used what is termed threshold analysis in an attempt to characterize streamflow and habitat parameters in a manner that describes periods of streamflow record. The method developed by Richter et al. (1996) is termed Range of Variability Analysis (RVA), which identifies a suite of 32 “biologically relevant” hydrologic parameters. The method is similar to an assessment of inter-annual (between year) variability. Parameters include standard hydrologic statistics, but also include threshold-type parameters that relate to specific events in the streamflow record. RVA can be applied to historical streamflow records, or synthetic naturalized records developed through modeling. The various parameters can be differentially weighted or used "as-is" to quantitatively define the current hydrologic regime and potential future hydrologic regimes and conduct sensitivity analysis. These RVA parameters are summarized below:

1. Monthly flow magnitudes,
2. Magnitude and duration of annual extremes,
3. Timing of annual extremes,
4. Frequency and duration of high and low pulses, and
5. Rate and frequency of hydrograph changes.

One use of these variability statistics for watershed planning purposes is to assess the statistical significance of changes in streamflow that might result from changes in water use, relative to historical year-to-year variability caused by climate and snowpack. In order for changes in water use patterns to have a statistically measurable effect on observed streamflow, the changes in streamflow have to be greater than the historical variability in the dataset. Otherwise, it would not be possible to distinguish between "naturally occurring" variability, and a change resulting from changes in water use practices. This should not be construed as an "excuse" for not considering ways to improve streamflow, but should be considered in designing monitoring programs.

Range of Variability statistics (RVA) are presented for stream gages having ten or more years of continuous data in Tables 3-3 through 3-10. The statistics were derived from historical streamflow records for gages having ten or more years of data.

3.5.5 Exceedance Probability Analysis

Exceedance probability plots are used to understand how often, or how probable, it is that that a certain flow will be equaled or exceeded in a specified time frame. Exceedance probabilities are also called recurrence intervals, or, more generally, frequency analysis. Frequency analysis techniques were primarily developed by civil engineers, who needed to determine design criteria for hydrologic structures, particularly during hydrologic extremes (e.g. floods and droughts). The source of data for these types of analysis is purely historical. Therefore, the "reliability" of frequency analysis increases with the length of the historical period of record. One of the most difficult problems faced by hydrologists relate to extrapolating the "tails" of frequency distributions to represent extreme events, and extrapolating frequency analyses at one location to other locations. Also, the occurrence of a certain exceedance probability flow in one month does not mean that the same exceedance probability will occur in the next month. Therefore, frequency analysis is useful in setting design criteria, but less useful for deciding how to respond to observed conditions.

Table 3-11 summarizes flows for the 10%, 50%, and 90% exceedance probability levels for flows at the various stream gages and Figures 3-10 (a-h) present the 10%, 50% and 90% exceedance curves at USGS stream gages having ten or more years of continuous streamflow data.

3.5.6 Peak Flow Recurrence Intervals

Peak flow recurrence intervals were plotted for stations having ten or more years of peak flow data and are presented in Figures 3-11(a-m). Peak flow frequency analysis provides the probability of occurrence for each annual peak flow at a particular station. At least ten years of USGS peak streamflow data were available for 9 of the stations presented in Table 3-1 as well as 4 additional stations (shown in Figure 3-1), including:

- 13348400 Missouri Flat Creek Tributary near Pullman
- 13349300 Palouse River Tributary at Colfax
- 13352200 Cow Creek Tributary near Ritzville
- 13352550 Stewart Canyon Tributary near Riparia

Several significant flood events have been documented in the City of Pullman, the most recent of which occurred in 1996. This event was triggered by heavy snowfall on frozen ground followed by warming temperatures and an extreme rainfall event (Taylor Engineering, 2003). The City of Pullman Comprehensive Flood Management Plan outlines problem areas and flood reduction alternatives for the City of Pullman. Severe flooding has also occurred in the City of Sprague and Colfax (see Appendix B).

3.5.7 Lakes, Dams and Wetlands

There are 42 lakes in the Palouse Basin that contain water year-round (RPU, 2004). Table 3-12 lists the area of each WRIA 34 lake. Figure 3-12 presents the locations of WRIA 34 dams and Table 3-13 presents basic characteristics of each WRIA 34 dam.

An estimated 98% of Palouse Basin wetlands have been destroyed as a result of development and agricultural practices (Cook, 2001). Figure 3-13 shows the current distribution of wetlands in WRIA 34, based on a National Wetland Inventory (NWI) coverage from 1971-1997. This map coverage was developed from satellite imagery at a 24 km resolution. Further discussion of wetlands in the Cow Creek sub-basin is provided in Section 8.

3.5.8 Soils

Cultivation practices, crop type and tillage patterns can also affect infiltration and run-off by disturbing soil structure and land surface contours. Studies by Williams and Allman (1969) and Alberta Environment (2004) address the issues of run-off and infiltration.

Soil hydrologic unit classifications are presented in Figure 3-14. The National Resource Conservation Service (NRCS) define a soil hydrologic group as a group of soils having similar runoff potential under similar storm and vegetative cover conditions. Runoff potential is a function of infiltration rate and transmission rate. The infiltration rate is the rate at which water enters the soil at the surface and is controlled by surface conditions. The transmission rate is the rate at which water moves in the soil and is controlled by soil properties. The NRCS classification system is based on the use of rainfall-runoff data from small watersheds and infiltrometer plots. From these data, the NRCS established relationships between soil properties and hydrologic group. Wetness characteristics, permeability after prolonged wetting, and depth to very low permeability layers are properties that assist in estimating hydrologic groups. These hydrologic classifications are used in equations that estimate runoff from rainfall, for example the Soil Conservation Service (SCS) runoff method. However, according to McCool et al. (1995), the SCS curve number method performs poorly in the Palouse Basin because the technique was developed for large events under unfrozen soil conditions.

The hydrologic groups defined by NRCS soil scientists for the Palouse Basin are as follows (NRCS, 1996):

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist mainly of sands and gravels that are deep, well drained to excessively drained, and have a high rate of water transmission (greater than 0.30 inches / hour).

Group B soils have moderate infiltration rates when thoroughly wetted. They consist mainly of soils that are moderately deep to deep, moderately well drained to well drained, and have moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15 to 0.30 inches / hour).

Group C soils have low infiltration rates when thoroughly wetted and consist mainly of soils having a layer that impedes downward movement of water and soils of moderately fine to fine texture. These soils have a slow rate of water transmission (0.05 to 0.15 inches / hour).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist mainly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay pan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0 to 0.05 inches / hour).

The soils of the Palouse Basin provide a highly productive agricultural soil that has been farmed over the past 120 years, predominantly for winter wheat.

3.6 Data Quality

The U.S. Geological Survey (USGS) stream-gaging program provides streamflow data for a variety of purposes that range from current needs, such as flood forecasting, to future or long-term needs, and allows for detection of changes in streamflow due to human activities or global warming. The reliability and accuracy of USGS data are considered high, based on the internal quality control used by the USGS in recording and maintaining the gages.

Adams County Conservation District (ACCD) streamflow data are estimated using continuous stage data. Rating curves have not yet been developed for these gaging locations, and therefore the streamflow estimates are not calculated on the basis of an established stage-discharge relationship. A rating curve expresses the relationship between observed water depth at a staff gage (stage) and measured stream discharge. A minimum of five (preferably ten) discharge and stage measurements are desired to produce a rating curve. The rating curve is then used to predict discharge at a given stage as recorded by a staff gage or transducer. The stage-discharge relationship at a site may change over time due to changes in channel configuration. For that reason, stream flow must be measured periodically and the results incorporated into the rating curve, to ensure that the rating curve remains accurate.

4.0 GROUNDWATER

Groundwater is an important resource in WRIA 34 and supplies nearly all of the drinking water for the area. This section includes an evaluation of groundwater resources, including:

- An estimate of ground water present in the management area;
- An estimate of the ground water available in the management area, taking into account seasonal and other variations; and
- An identification of the location of areas where aquifers are known to recharge surface bodies of water and areas known to provide for the recharge of aquifers from the surface.

An assessment of groundwater surface water interaction in the Cow Creek and Palouse sub-basins is provided in Section 8.

4.1 Background Issues

Background technical issues related to groundwater include:

- Groundwater levels in many area wells have been declining, leading to concerns about sustainability of the groundwater resource.
- The aquifer systems in WRIA 34 are complex and costly to investigate and characterize. Decisions may be necessary with incomplete data or uncertainty regarding all aspects of this complexity.
- The relationship between recharge, groundwater levels and summer baseflows to streams is affected by both natural complexity and changes to land cover and water use in the basin. Isolating relative components of these relationships can be difficult.
- The Palouse Basin is a bi-state watershed with a shared source of groundwater in the Palouse Basin Aquifer.

4.2 Available Data

There are many geological and hydrogeological references for WRIA 34. Many of these references are summarized in the Palouse Basin Aquifer Committees. *Summary of research completed in the Moscow-Pullman Basin Hydrology* (Belknap, 1999). Data examined for this report included the following sources:

State of Washington

- Department of Water Resources - *Reconnaissance of Geology and Ground-Water Occurrence in Whitman County*, 1969, discusses the geology and hydrogeology of Whitman County as well as groundwater occurrence, fluctuations, quality, development, usage, and trends.
- Department of Ecology (WDOE) – WDOE data includes data from the well log database (http://apps.ecy.wa.gov/welllog/). Well logs provide information relating to the subsurface geology and aquifer capacity within the watershed.

State of Idaho

- Idaho Department of Water Resources (IDWR) – IDWR data includes well log data from their well log database (http://www.idwr.state.id.us/water/well/search.htm).

United States Geological Survey (USGS)

- Water level data are available through the USGS. The USGS lists 930 sites with groundwater data on their database located at http://waterdata.usgs.gov/nwis/gw. Of the 930 locations, 870 of these locations had less than 20 data points; and 113 locations listed water quality data with only 6 of those locations containing more than 10 data sets for the location.

- *The Hydrogeologic Framework and Geochemistry of the Columbia Plateau Aquifer System, Washington, Oregon, and Idaho*, USGS Professional Paper 1413-B provides regional aquifer system analysis and was the primary reference for much of the geologic and hydrogeologic data presented herein.

- *Geohydrology and Numerical Model Analysis of Groundwater Flow in the Pullman-Moscow Area, Washington and Idaho (1989).* USGS Water Resources Investigation Report 89-4103 provides a good background on the hydrogeology of the area and one of the first numerical modeling analyses of the aquifer system.

- *The Summary of the Columbia Plateau Regional Aquifer-System Analysis, Washington, Oregon, and Idaho* (1999), provides additional information on recharge and discharge of groundwater in the Palouse, as well as groundwater flow directions and hydraulic conductivity values.

Data from cities within the watershed

- Pullman – *Well No. 3 Replacement Data Review and Well Siting Report*, 2004. Selected tables and figures from this document are also presented in Appendix C.

- Colfax – *City of Colfax Wellhead Protection Plan* provides data on Colfax municipal wells, as well as groundwater quality, management, usage, and groundwater flow maps.

- Moscow – Moscow well data was provided by the City of Moscow.

- Palouse – *Analysis of Ground Water Development Potential For the City of Palouse*, 1996. Provides an analysis of groundwater conditions in and around the City of Palouse and recommends new municipal well locations.

- LaCrosse – Municipal well data was provided by John Pearson.

- Steptoe – Water quality data and well information from the City of Steptoe.

- Cow Creek/Sprague Lake – *The Cow Creek Watershed Management Plan* (Resource Planning Unlimited 2000) discusses groundwater occurrence and well yields unique to the Cow Creek sub-basin.

Washington State University (WSU)

- *WSU wells – Construction Report for the W.S.U. Well No. 7 Production / Test Well* by Wyatt-Jaykim Engineers and Dr. Dale Ralston, 1987, provides data for Pullman and WSU wells in addition to interpretations of hydraulic gradients, borehole and geophysical logs, and aquifer pump test data for this well.

- *Stable isotope evidence for low recharge rate to a confined basalt aquifer: Implication for water resource development* by K.R Lawrence, K.C.. Keller, P.B. Larson, and R. Allen-King, 2000, provided recharge rate information for the Grande Ronde aquifer in the eastern portion of the watershed.

University of Idaho

- *Characterization of Grande Ronde Aquifers in the Palouse Basin Using Large Scale Aquifer Tests*. A Thesis presented in partial fulfillment of the requirements for the degree of Master of Science with and major in Hydrology in the College of Graduate Studies, University of Idaho. Dennis Owsley, 2003.

- *The relationship between streams and groundwater flow systems within the Pullman-Moscow area of Washington and Idaho,* U of I Master of Science thesis by R. Heinemann, 1994

- *Hydrogeology of the upper aquifer of the Pullman-Moscow basin and the University of Idaho aquaculture site*. U of I Master of Science thesis by William Paul Kopp, 1994.

- *Summary of Research completed on the Moscow-Pullman Basin Hydrology*, compilation by Bill Belknap, 1999.

Other Sources-

- *The Combined 1999 and 2000 Annual Reports* Palouse Basin Aquifer Committee (PBAC, 1999 and 2000) – Provides well and pumping data for wells in the Pullman/Moscow area as well as information on usage, recharge and usage.

- *The Eastern Columbia Plateau Aquifer System Sole Source Aquifer Investigation* (Mountain Resource Group 1993). Provides groundwater and aquifer information for the eastern Columbia Plateau as a single source aquifer.

- *Geohydrologic Assessment Report for Proposed Municipal Solid Waste Landfill, Washtucna, Adam County, Washington*, (Golder Associates, 1992). Contains extensive hydrogeologic testing data.

- *The Hydrogeological Characterization Report of the Columbia Basin Groundwater Management Report (Review Draft)*, 1999. Provides additional information on the hydrogeologic setting, flow rates and directions, and groundwater use in Adams County.

- *Hydrologic conditions of the Palouse Aquifer* (Dr. Dale Ralston, 2004). This presentation to the Expanded Natural Resource Interim Committee (formed by the Idaho Legislature) provides an excellent overview of the Palouse Aquifer and associated data.

On-going studies at the University of Idaho (U of I) and Washington State University (WSU) include:

- Groundwater age dating and correlation of groundwater ages and groundwater movement. Research being conducted by Alyssa Douglas with supervision from Dr. Jim Osiensky (U of I) and Dr. Kent Keller (WSU).

- Groundwater level monitoring to assess groundwater flow directions and connectivity within the Grande Ronde by monitoring an established network of wells and changes in groundwater levels during pumping tests. Research being conducted by Eric Stern with supervision form Dr. Jim Osiensky (U of I).

- Geologic mapping in Whitman County, WA. This work is being completed by Dr. John Bush (U of I).

- Characterization of subsurface geology in the Palouse Basin with a focus on the Moscow area. Work being completed by Dr. John Bush (U of I).

- Development of an annotated bibliography and hydrogeological database for the Palouse Basin. Research being conducted by Frieda Leek with supervision from Dr. Joan Wu (WSU).

- Design and cost estimate for recharge of the Grande Ronde aquifer via a well connecting the Wanapum and Grande Ronde aquifers. Work being conducted by Dr. Dale Ralston of Ralston Hydrologic Services, Inc.

Future work planned by PBAC includes:

- Groundwater level monitoring of the Wanapum Aquifer;

- Infiltration of captured precipitation from Moscow Mountain into the Wanapum aquifer; and,

- Drilling of monitoring wells to the north and west of Moscow to improve the understanding of hydrogeology in this area.

4.3 Presentation of Current Conditions

4.3.1 Geology/Stratigraphy

Figure 4-1 shows the regional geologic setting of WRIA 34. The Palouse Basin is located in the eastern portion of the massive Columbia River Basalt Group. This sequence of basalt flows provides the fundamental framework for most of the groundwater flow relationships in the area. The Columbia Plateau is underlain by the Columbia River basalts, which cover a total of approximately 25,000 square miles in Washington. The geologic setting of the Columbia Plateau was created by the outpourings of flood basalts; volcanic events that deposited volcanic and flood debris in the region; compressional tectonic events that caused folding and faulting of the flood deposits; deposition of windblown silts called loess; and glacial flooding that formed the Channeled Scablands. Figure 4-2 shows the surficial geology of WRIA 34. The surficial geology map of WRIA 34 is (Figure 4-2) comprised of data from three agencies, which have mapped the area at various scales. The sources used by Golder for this phase of work include:

- Washington State Department of Natural Resources (Pullman Quadrangle, Washington, 1:100,000) - http://www.dnr.wa.gov/geology/dig100k.htm
- United States Geological Survey (Pullman Quadrangle, Idaho, 1:250:000) – http://geopubs.wr.usgs.gov/open-file/of01-262/
- Idaho Geological Survey (St. Maries Quadrangle, 1:100,000) – http://inside.uidaho.edu/aspx/metadata/metadata.aspx?ResourceID=16&XSL=FGDCClassic.xsl

The geology of WRIA 34 is comprised of a wide variety of lithologic types. In order to simplify the complex geology and correlate nomenclature from three separate initiating agencies, each geologic unit was reclassified into a more general category (e.g. garnet-mica schist was reclassified to Metasedimentary/Metamorphic). The six categories selected by Golder include:

- Alluvium
- Outburst Flood Deposits
- Loess
- Basalt
- Plutonic
- Metasedimentary/Metamorphic

This reclassification scheme preserves the general lithologic distribution of the WRIA, while eliminating the arcane detail of the original maps. Interested parties desiring a higher level of lithologic detail should refer to the original maps.

Figure 4-3 shows a schematic cross-section of sub-surface geology across the watershed. Descriptions of the principal formations are provided below, from oldest to youngest.

- Crystalline Rocks – Principally metamorphic quartzite, phyllite, schist, and granite gneiss; and igneous granite pegmatite, and granitic rocks. The metamorphic rocks, probably metasediments, are generally chemically altered, in many places extensively. This unit locally protrudes above all basalt flows in the eastern part of the WRIA and thickness is unknown. Crystalline rocks are generally thought to underlie all other units within the Palouse.

- Grand Ronde Formation – The Grand Ronde basalt underlies the younger formations and is estimated to exceed a thickness of 10,000 feet in the central part of the Columbia Plateau. It is composed of a few hundred individual flows, most of which are fine-grained. Sedimentary interbeds within the Grande Ronde are rare, generally only a few feet thick and of small lateral extent.

- Sedimentary Interbeds – Sedimentary deposits of the Latah Formation are associated with the emplacement of successive basalt flows. The Latah Formation sediments exist in the form of interbeds between various individual basalt flows and as sediment deposits adjacent to basalt flows. The interbeds were deposited primarily as river and lake-bed sediments. The lithology of sedimentary interbeds between and within basalt flows varies from shales to sands and gravels. Most interbeds within the basalt formation are very limited in their extent. These interbeds may be locally transmissive and function as aquifers but, in general, they probably impede the vertical movement of water. The most notable sedimentary unit is the Vantage Member, an interbed that separates the Grande Ronde Formation from the Wanapum

Formation. The Vantage Member exists throughout most of the region and is a unique marker unit separating the two main basalt formations of the region.

- Wanapum Formation – The Wanapum basalt is thinner and less extensive than the Grande Ronde. The Wanapum is covered by a veneer of sedimentary deposits throughout most of the Palouse, but it can be viewed in outcrops throughout the region. The Wanapum hydrogeologic unit, which includes the Wanapum basalt and the underlying Vantage sedimentary unit, averages about 600 feet in thickness. The Wanapum contains more than 10 separate basalt flows, generally consisting of medium-grained basalt. Sedimentary interbeds are more common in the Wanapum hydrogeologic unit than in the Grande Ronde hydrogeologic unit but are generally thin and local in their extent.

- The Palouse Formation – Almost all of the upland areas of the Palouse Basin in Washington State are mantled by a windblown or eolian silt called loess, known locally as the Palouse Formation. These deposits range from a few feet to about 300 feet in thickness. The loess probably accumulated with an irregular upper surface, and the greatest thicknesses probably accumulated in lee areas as drifts. A drainage pattern was established on the basalt surface before deposition of the loess and the rolling Palouse topography may, in part, reflect the existence of the buried basalt hills. However, the unusual appearance of this topography is believed to be primarily related to the erosional characteristics of the loess.

- Scabland Deposits – The western portion of Whitman County is within the geographic extent of the Pleistocene era floods caused by drainage of the ancient Lake Missoula. The floods locally removed the loess cover (Palouse Formation) and scoured the basalts, leaving large areas of nearly bare, channeled basalts known as scablands or coulees. In the Palouse, many northeast-trending ridges or islands of loess, which were geographic high points during the floods, project above these coulees. The scabland deposits within the Palouse are extensive but thin, and do not provide the vertically extensive gravel deposits that were deposited by the floods to the north.

The regional geologic history of the Palouse Region is reasonably well defined. A series of maps showing the sequential emplacement of lava flows and a geologic cross-section is included in Appendix C.

4.3.2 Aquifer Extent and Properties

All of the geologic units described above have water-bearing potential, but they do not necessarily contain enough water to make them a viable source for drinking water needs. There are three types of aquifers: confined, leaky or semiconfined, and unconfined.

- A confined or semi-confined aquifer is sandwiched between confining beds or layers of less permeable materials that impede the movement of water into and out of the aquifer. The groundwater in these aquifers is often under pressure so the water level in a well will rise to a level higher than the top of the aquifer. Confined and semi-confined aquifers are often extensive, deep geologic formations. Water enters the aquifer via downward leakage from overlying materials or from direct recharge where the formation is exposed at the ground surface. These recharge zone can be many miles away from where wells are located within the aquifer. In reality, there are very few perfectly confined aquifers, and most deep aquifers are semi-confined or leaky.

- An unconfined aquifer is generally a shallow or "water table" aquifer where the groundwater only partially fills the aquifer and the water table rises and falls in response to surface recharge.

Table 4-1 summarizes the hydraulic characteristics of aquifer units in the Palouse Basin. Appendix C contains additional information and data.

The groundwater characteristics of geologic units is WRIA 34 are summarized below:

- Scabland Deposits – The gravels that were deposited in the western portion of the Palouse Basin are limited in extent and do not appear to constitute major regional aquifers. The gravels may be locally important in transmitting shallow groundwater in continuity with surface water, particularly in the Cow Creek Sub-basin. Springs have been noted at locations where the gravel deposits are saturated and contact the basalts.

- The Palouse Formation – The loess has high porosity (the amount of pore space available to hold water) but low permeability (the ability of water to move from one pore space to another). It is not generally used for water supply, but where saturated, the loess contains large volumes of unconfined water. The effect of loess on the infiltration of precipitation and subsequent recharge of underlying basalt or maintenance of streamflows may be significant. Precipitation that enters the loess is absorbed into the soils; used by plants (evapotranspiration); and percolates into the deeper layers of the soil toward the contact between the loess and underlying basalt. However, local soil structure may also prevent downward infiltration through the loess.

- Basalts – The movement of water through basalts is governed by numerous factors relating to the nature of individual flows. These factors include the topographic surfaces over which the basalts flowed; the internal structures formed as the lava cooled; the erosional processes that occurred after extrusion; the deposition of sedimentary interbeds; tectonic activity; and compaction. Figure 4-4 shows an idealized section of a basalt flow and describes various features. The lateral continuity, thickness, and composition of individual basalt flows are highly varied. As lava cools, structural changes occur that cause cracks and joints in the cooled rock (entablature and colonnade) further complicating water movement in the basalts. Subsequent tectonic activity or basin subsidence can further alter the distribution and properties of emplaced lava flows. As shown in Figure 4-4, basalt forms an extremely heterogeneous aquifer unit that transmits water most readily through the broken vesicular and scoriaceous interflow zones that commonly constitute 5 to 10 percent of the thickness of an individual basalt flow. The fractures are typically vertical. Lateral groundwater movement in the dense entablature and colonnade (main body of the flow) is typically negligible when compared with the volume of water that moves laterally through the interflow or fractured zones. Vertical movement of groundwater varies depending on the structure of individual flows and the hydraulic characteristics of the interbeds. Aquifers in the basalts are generally productive. Well yields of more than 150 gallons per minute (gpm) are common throughout the region and wells that penetrate multiple water-bearing zones can yield from 1,000 to 3,000 gpm.

  - Wanapum Basalt Aquifer. The Wanapum aquifer is an important water source for domestic and irrigation wells and in the past was an important municipal water source. The Wanapum is generally considered to be an unconfined aquifer and wells completed in this aquifer typically produce at less than 1,500 gpm. Hydraulic conductivities for the Wanapum are reported to range from 10^{-2} to 10^{4} feet per day (ft/day). Most municipal water supply in the Pullman-Moscow area is now pumped from the confined Grande Ronde basalt.

- Grande Ronde Basalt Aquifer. The Grande Ronde aquifer is the primary water supply aquifer in WRIA 34. Production rates from some Grande Ronde wells exceed 3,000 gpm. The Grande Ronde supplies drinking water to all of the municipalities in WRIA 34 and many irrigation wells. Conductivity ranges for the Grande Ronde are reported from 10^{-4} to 10^{-1} ft/day.

- Crystalline Rocks – Groundwater occurrence within the crystalline rocks is limited to areas where the rocks have been altered or fractured, and yields water to wells at only a few gallons per minute or less.

4.3.3 Groundwater Flow

Groundwater flow in the uppermost aquifer units tends to parallel the land surface and generally moves from topographic highs to topographic lows. Flow in the uppermost zones of the groundwater system can therefore be highly localized.

Groundwater flow within the deeper basalts is confined and generally flows from the peripheral boundaries of the basalts toward regional surface water bodies, principally the Snake and Columbia Rivers. Geologic structures such as faults and folds can significantly affect flow patterns, and "compartmentalize" the flow field. Geologic structures that may affect groundwater flow in the Palouse Basin include a northeast-trending series of faults and folds that become more east-west oriented at the eastern border of Whitman County. The faults are located east of Steptoe Canyon and south of Colton. These structures may limit southward and southeastward movement of groundwater locally.

The regional groundwater flow in both the Wanapum and Grande Ronde units within the Palouse Basin approximately parallels the southwest regional dip slope of the basalt. Appendix C contains maps of expected regional groundwater flow directions for the Grande Ronde basalt in the Palouse. The flow direction in the Grande Ronde aquifer in the Pullman-Moscow Basin is estimated to be to the southwest, toward the Snake River. However, data on groundwater levels is limited. Recent unpublished work by Dr. John Bush (presentation to PBAC, January 2004) suggests that a topographic high caused by basalt flow emplacement and/or uplift in the Pullman area may have resulted in a slope in the basalt flows from Pullman, in an easterly direction towards Moscow and from Pullman and Moscow, in a northerly direction towards Palouse. Dr. Bush suggests that if groundwater in the Palouse Basin Grande Ronde may flow along this slope from Pullman, in an easterly direction towards Moscow and from Pullman and Moscow, in a northerly direction towards Palouse. This would be consistent with general groundwater theory which would suggest that groundwater flow approximately parallels the dip slope of the basalt. Figure 4-5 shows the most recent geologic cross-section of the Pullman Moscow Basin.

4.3.4 Groundwater Level Fluctuations

Groundwater flow patterns are influenced by recharge/discharge patterns and by natural pumping wells. Groundwater fluctuations can provide an indication of groundwater availability, seasonality and long-term trends. The Pullman-Moscow Basin aquifer is used as the primary discussion on water level fluctuations because it has been the most thoroughly studied. Other portions of the Palouse Basin are discussed as appropriate and based on the availability of data.

The USGS has monitored water-levels in over 800 wells throughout WRIA 34. The well inventory is provided in Appendix C. Selected USGS hydrographs are presented on Figure 4-6a-c. Most of the wells within the USGS program have a limited data record. Less than 10% of the wells have more than 20 data points.

Figure 4-6a shows the selected hydrographs for Pullman area wells. All of the hydrographs for wells within the City of Pullman show declines of up to 65 feet between 1940 and 1980, with an average rate of decline equal to 1 to 1.5 feet per year. Shallow wells just outside of the municipal center do not indicate this same level of decline. Changes in the slope of the hydrograph in Pullman wells around the late 1940's and mid 1960's may indicate changes in pumping rates, changes in recharge conditions, or other boundary conditions within the aquifer. Wells for the City of Palouse show a similar relatively constant rate of decline of approximately one foot per year, even though there has been a reported decrease in the rate of pumpage (Ralston, 1996).

Figure 4-7 shows the long-term water level decline in Grande Ronde aquifer levels as measured at the WSU test well. This well is 144 feet deep.

Figure 4-8 show long-term water levels in the Wanapum basalt in Moscow, Idaho. The hydrograph shows declining water levels into the mid-1960's with a rebound in water levels since that time. This response is the result of the City of Moscow's shift from the shallow Wanapum aquifer to the deeper Grande Ronde aquifer for water supply.

Tables 4-2, 4-3, and 4-4 summarize well characteristics and static water levels for major water supply wells in WRIA 34.

Figure 4-6b shows hydrographs for selected wells in other parts of the watershed. These hydrographs do not appear to show a regional trend, as these wells all show different responses to pumping, climatic conditions, and seasonal changes in recharge.

4.4 Groundwater Recharge and Discharge

In most parts of Whitman County, water-level fluctuations in wells result from drawdown and recovery from pumping or from natural annual or seasonal imbalances of recharge and discharge. The relationship between recharge and discharge, in terms of spatial locations of recharge/discharge areas and the timing between recharge and subsequent discharge, has a significant influence on groundwater dynamics and the long-term availability of groundwater resources. However the local influences of pumping can complicate estimation of recharge based on water level fluctuation. There have been numerous estimates of groundwater recharge within WRIA 34. The methods for estimating recharge have varied from simple to complex and have involved both physical testing and modeling. As shown in Table 4-6, recharge estimates are quite variable. Because recharge varies over a very large area, and is distributed among shallow, intermediate and deep aquifer systems, the actual number assigned to the recharge rate is highly dependent on assumptions made in the analysis.

4.4.1 Total Aerial Recharge

The USGS evaluated total recharge in the Columbia Plateau area, indicating that recharge to the aquifer system is primarily from precipitation and applied irrigation water, and secondarily from surface-water bodies such as rivers, lakes, and reservoirs. Recharge modeling by the USGS (Bauer and Vaccarro, 1990) was conducted to evaluate groundwater recharge for pre-development and current land use conditions, using an energy-soil-water balance model to compute deep percolation of water. In WRIA 34, the recharge estimates are as follows:

- Pullman-Moscow – 4.13 inches per year pre-development and 2.8 inches per year current;
- Cow Creek – 2.3 inches per year pre-development and 2.1 inches per year current; and,
- Union Flat Creek – 2.98 inches per year pre-development and 3.7 inches per year current.

The decrease in recharge was generally attributed to cropping patterns, where, year-after-year, crops that have higher evapotranspiration rates are grown where native grasses once grew. The increase in recharge in Union Flat Creek was attributed to alternating fallow and crop years.

4.4.2 Recharge to Basalt Aquifers

Of the total aerial recharge, only a portion reaches the deeper Wanapum and Grand Ronde Aquifers Estimated recharge varies widely, as shown on Table 4-6.

Continually declining water levels in the Grand Ronde, in spite of nearly constant annual pumping rates suggest that, at least locally, the amount pumped is more than the amount that is being recharged or naturally replaced. Water isotope analyses by Dr. Kent Keller of WSU indicate that the isotopic signature of groundwater in the Grande Ronde is consistent with water that is 10,000 years old indicating a very slow rate of groundwater recharge. The recovery of water levels in wells completed in the Wanapum after reductions in pumping indicates that recharge is greater than pumping.

4.4.3 Discharge

Groundwater discharge is increasingly important for watershed management because it often represents a significant portion of streamflow during dry periods. Therefore, watershed actions that reduce groundwater discharge to streams may have management consequences. Discharge from the groundwater system in WRIA 34 includes pumpage from wells and discharge to streams. There are hundreds of water supply wells in WRIA 34. Figure 4-9 shows the location and depth of wells on-file with WDOE and IDWR and designated as water wells (i.e. not resource protection wells). The volume of groundwater pumpage is described in Section 5, but is approaching 3 billion gallons per year. Groundwater discharge to streams (baseflow) is discussed in Section 3 and includes baseflow estimates for several streams in WRIA 34.

Although estimates of groundwater discharge quantities are available, the location of aquifer discharge areas and the associated aquifer unit that produces the discharge (loess, Wanapum, Grande Ronde) is not well documented.

4.5 Hydraulic Continuity

The relationships between groundwater recharge, discharge, and stream flows are addressed in an assessment of hydraulic continuity. Hydraulic continuity is the interconnection of surface water and groundwater. Along any stream, some reaches may characteristically gain or lose water due to hydraulic interactions with the groundwater system. Hydraulic continuity studies can be useful in determining the relative impact of groundwater withdrawals on streamflows or to identify portions of the groundwater system that are significant to the maintenance of stream baseflows.

At a large enough spatial and temporal scale (basin scale or larger over many decades), all groundwater is in hydraulic continuity with surface water. This is a fundamental assumption based on conservation of mass. This assumption has become a default position in groundwater resource allocation and has legal standing in the water rights permitting process. At a more local scale, hydraulic continuity is more complex. Hydraulic continuity in the Cow Creek and Palouse Sub-basins is discussed in Section 8.

4.6 Groundwater Quality

The quality of groundwater is discussed in Section 7. Table 4-7 summarizes selected water quality information for the Wanapum and Grande Ronde basalts. In general, groundwater quality is acceptable for domestic, agricultural, and industrial purposes. Most of the groundwater in the WRIA can be classified as a silica-calcium-bicarbonate type. The dissolved solids content ranges from 135 to 311 milligrams per liter (mg/L), well below the established 500 mg/L upper level recommendation for drinking water. Higher concentrations of iron occur locally, mostly in the eastern one-third of the WRIA. The nitrate content of water samples collected from some wells within the WRIA is relatively high, but does not generally exceed the established recommendations. Chloride concentrations are generally low. Hardness of water, expressed as $CaCO_3$, ranges from 75 to 243 mg/L. Water harder than 180 mg/L is considered very hard for domestic consumption and may require chemical treatment to improve quality.

Pullman municipal supply wells and WSU wells have had exceedances of iron, manganese, and turbidity in water quality samples. Pullman municipal wells have only had one exceedance of iron since 1996 in these wells.

5.0 LAND AND WATER USE

Water use estimates for historic, current, and future conditions are required elements of watershed planning under RCW 90.82. Types of water use to be characterized include:

- Agricultural;
- Municipal (including commercial and residential);
- Rural residential (e.g. exempt wells); and,
- Non-irrigated lands.

Water use is an integral part of a water balance for the watershed, and is related to both natural and human related resources.

5.1 Land Cover and Land Use

Technical issues related to land and water use are centered on the WRIA 34 water balance (at a basin or sub-basin scale), including instream flows. The categories of land use that can influence a water balance include:

- Agricultural patterns, cropping trends, and irrigation technologies used;
- Rural developments patterns (e.g. exempt wells);
- Municipal and urban development patterns; and,
- Forest management patterns.

Land Use and land cover information is discussed below.

5.1.1 Current Land Cover

National Land Cover Data (NLCD) developed by the USGS and based on 1995 LANDSAT satellite imagery was used to classify land cover in WRIA 34. WRIA 34 encompasses over 2.1 million acres of land, making it the largest watershed (by area) in Washington State. Land cover provides an indication of actual conditions "on the ground" and is useful for determining current water use in a watershed. The NLCD coverages include multiple classifications of land-cover:

- Low Intensity Residential
- High Intensity Residential
- Commercial/Industrial/Transportation
- Bare Rock/Sand/Clay
- Transitional
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrubland

- Orchards/Vineyards/Other
- Grasslands/Herbaceous
- Pasture/Hay
- Row Crops
- Small Grains
- Fallow
- Urban/Recreational Grasses
- Woody Wetlands
- Emergent Herbaceous Wetlands
- Open Water

Figure 5-1 shows land cover in WRIA 34. Table 5-1 summarizes the breakdown of land cover type within WRIA 34, by sub-basin.

5.1.2 Agricultural Census

The U.S. Department of Agriculture (USDA) produces a census of agriculture at a county level every 5 years, which includes a variety of agricultural statistics. The most recent available census is for 1997. Results for the 2002 census became available in the summer of 2004. Based on the 1997 census, Table 5-2 summarizes farm acreage statistics, including livestock and crop types for 1992 and 1997. Appendix D contains the 2002 census and also summarizes cropland and irrigated areas based on previous agricultural census.

5.1.3 Historical Land Cover

A comprehensive assessment of historical land cover in the Palouse bioregion has been conducted through the Biological Resources Division (BRD) of the U. S. Geological Survey (USGS). The first phase of this new program, LUHNA, the Land Use History of North America project, focused on ten projects with historical vegetation and land cover patterns, as well as the anthropogenic factors driving those changes. The projects present spatial, map-based data on land cover and land use, and integrate historical information drawn from diverse sources, including paleoecological records, historical narratives, early land surveys, aerial photography, and satellite imagery. The work is published in a paper entitled "Biodiversity and Land Use History of the Palouse Bioregion: Pre-European to Present" (Black and others, 1997). The significant conclusions of the study related to watershed planning efforts were that, since 1870, 94% of the grasslands and 97% of the wetlands in the Palouse bioregion have been converted to agricultural uses. Although the watershed planning process may not address the biological and ecological consequences of this change, the Planning Unit may wish to evaluate the changes in hydrology and water quantity in order to establish long-term planning benchmarks. Electronic datasets for the LUHNA project were not obtained for this effort.

5.2 "Natural" Water Use

The term "water use" is typically associated with water that is used or managed by people. However, water leaves the landscape naturally through evapotranspiration, in proportion to the type of land cover. This section describes water use from forested areas and natural grasslands.

5.2.1 Forested Lands

Water use from forestlands can be an integral part of the basin's water budget. The headwaters of the Palouse River (in Idaho) are predominantly forested. Determining forest water use and the potential effects on water availability is a complicated problem. It is a controversial issue among land managers and various interest groups (Keppeler, 1998). Stream flows from forested ecosystems are dependent upon multiple factors. The relative magnitudes, timings, and significance of these factors are dependent on the natural forest regime and forest management practices.

Watershed studies have been conducted in areas outside of WRIA 34 to estimate the effect of logging on the water yield of a basin. However, conclusive generalized statements regarding these effects cannot be made. Some studies have found that annual stream flow yields have been altered by stand density reduction (Fritschen, 1997), while others have found that this is not always the case (Rhodes, 1998). However, if there has been (or will be) significant change in forest density or species type over time, differences in streamflow could be attributed, in part, to the altered species distribution.

The two principle variables controlling consumptive water use by forests are the basal area of the stand and the species type:

- The basal area of a single tree is the surface area of a tree as if it were cut at a height of 4 or 5 feet above ground. The total surface area of all trees represents the basal area of a forest stand, expressed in units of square feet per acre. Basal areas are commonly used in forest management since they describe the density of harvestable timber. Basal areas also affect water use: forest stands with higher basal areas use more water.
- Tree species type could have a positive, negative, or neutral effect on stream flows relative to an undisturbed forest. As with agricultural crops, water use between tree species also differs. Some tree species use water conservatively while others are more liberal water users. For example, Lodgepole Pine transpires 40% less water than an Englemman Spruce at the same basal area. Table 5-3 summarizes transpiration rates for selected species studies at the Rocky Mountain Forest Research Station in Colorado (Alexander, R.R., et al, 1985).

No data on basal area or species type was obtained for this phase of work. However, the U.S. Forest Service (USFS) maintains a comprehensive GIS database with many data types, some of which could be used in a water use analysis of forested lands. Appendix D provides a listing of available coverages.

5.2.2 Non-Irrigated Grassland

Similar to forested lands, lands in the lower portion of the watershed that are either natural grassland or modified dryland agriculture can be an integral part of the basin's water budget. The majority of the precipitation falling on natural grasslands is returned to the atmosphere as evapotranspiration (ET), an important component of the hydrologic cycle for Eastern Washington. ET is the quantity of water evaporated from soil and other surfaces together with the quantity of water transpired by plants. Changes in vegetation types can significantly affect ET rates and the hydrologic cycle. ET estimates, combined with precipitation and surface water discharge information are often used to estimate groundwater recharge. ET is among the most difficult elements of the hydrologic cycle to calculate due to its complexity and the level of effort involved to measure it directly.

A study was conducted by the USGS in 1995 to evaluate ET rates for natural grasslands in Eastern Washington that included analysis of four sites, including one within WRIA 34 (Turnbull Refuge), and one in Benton County. The study found that most of the precipitation that falls on natural grasslands is lost to ET (approximately 85-118%) and that grass-covered areas are likely to have more groundwater recharge than areas covered with deeper-rooted species, such as sagebrush. The consumptive use of water by these grasslands using ET estimates at the four USGS study sites is summarized in Table 5-4. At the Turnbull site, located in WRIA 34, low ET rates during the winter allow for refilling of lakes and wetlands and high summer ET rates contribute to lower water levels and in some cases wetlands and lakes become dry.

5.3 Water Use on Irrigated Agricultural Lands

The components affecting water use resulting from irrigated agriculture are discussed below.

5.3.1 Crop Irrigation Requirement

Crop Irrigation Requirement (CIR) is water "lost" to the atmosphere from evapotranspiration (ET) through a plant minus precipitation. It is the optimum consumptive use of water for cultivated crop. Multiplying irrigated acreage by consumptive use or CIR results in a total volume of water consumed by the irrigated crop. Although much of WRIA 34 is "dryland" agriculture, CIR is still a valid way to describe water use. CIR is calculated using the following equation:

$$CIR = ET_{crop} - \text{precipitation}$$

ET is a measurement of the total amount of water needed to grow a crop. Since different plants have different water requirements, they have different ET rates. CIR is usually expressed as a total value (in inches) over the growing season. However, crops do not use water at a constant rate during a growing season. It is dependent on the crop growth cycle, climatic and soil conditions, and varies over the growing season. Monthly CIR is often used to represent crop needs during the growing season. The total CIR is equal to the sum of the monthly CIR.

CIR calculations at multiple locations across Washington State are available in a publication prepared by Washington State University Cooperative Extension Bulletin 1513 (James and others, 1989). CIR estimates for crops grown in WRIA 34 are shown on Table 5-5. These data are expressed using return periods. A return period describes the level of irrigation that would be adequate based on historical climate data. For example, a return period of 5 years corresponds to the CIR necessary for irrigation to be adequate for crops for 4 out of 5 years.

5.3.2 On-Farm Irrigation Efficiencies

For irrigated lands, consumptive water use from agricultural lands is not only attributed to the CIR of a crop. An additional consumptive component of irrigation is water lost as a result of on-farm irrigation system technology. The total quantity of on-farm irrigation water use accounts for irrigation system "efficiency" losses such as evaporation, spillage, sprinkler set-times, wind drift from sprinkler irrigation, surface runoff and excessive subsurface drainage.

The on-farm efficiency of an irrigation system is the combination of two efficiencies:

- **Application efficiency** is most often associated with sprinkler irrigation. However it is applicable to multiple methods of irrigation. It can be viewed as a measurement of the water losses from the time water leaves the nozzle, until it infiltrates into the soil. The principle component is "spray drift" lost due to evaporation of the water droplets in the air. Application losses also include evaporation from ponding water or the wet soil surface, and runoff, which results from applying water faster than the infiltration rate of the soil. Runoff is common with surface irrigation unless agronomic or water management practices are used (Fipps, 1995).

- **Distribution efficiency** is a measurement of how uniform the water is applied over the area or field. With poor uniformity, some areas receive too much water and others too little. To compensate for poor distribution efficiency, an irrigator may apply excessive amounts of water to ensure that all areas receive enough. Uniformity is not only a potential problem in sprinkler and surface systems. Drip irrigation systems, if not designed properly, can also have very poor distribution efficiencies as well (Fipps, 1995).

Table 5-6 summarizes typical irrigation application efficiencies. For non-irrigated, dryland agriculture, run-off and sub-surface drainage could be considered a surrogate assessment of on-farm “efficiency”. The “efficiency” is related to the ability of the underlying soil to store water during a dormant period for use during a growing period. Farm practices that reduce the ability to store soil moisture are less efficient.

<u>Irrigation Transportation Losses</u>

Although uncommon in WRIA 34, conveyance of irrigation water via canals is common in the western portions of the Columbia Plateau, and is summarized here for completeness. The magnitude and seasonal pattern of conveyance losses are dependent on the saturated and unsaturated soil properties beneath the canal, the presence or absence of liner material which would reduce the permeability of the canal bottom (this would include natural materials such as organic debris or silt), the elevation of the water surface in the canal, the elevation of the underlying groundwater table, and the elevation of adjacent discharge boundaries such as streams or wetlands. There are many different settings and combinations of these parameters. Infiltration and resulting changes to groundwater elevations can be significant from canal leakage, but is dependent on the scale of irrigation leakage relative to groundwater flow volumes and associated water levels.

Irrigation transportation losses in the Central Columbia Plateau (west of WRIA 34) via canals of the Columbia Basin Project have caused significant changes in shallow groundwater levels. The extent to which canal leakage may contribute water to the far eastern margins of the Columbia Basin Project (i.e. toward the Cow Creek drainage) is not known.

<u>Return Flow</u>

Land cover and land management practices determine how much and when water that is not used by crops or natural vegetation will return to the hydrologic system. In WRIA 34, current land cover may exaggerate run-off during high precipitation events in localized areas, which causes erosion and water quality problems. Excess run-off can be further magnified by natural climatic conditions (such as frozen ground) or from specific land management practices that concentrate run-off. Changes in infiltration characteristics of soils can result from tillage practices, crop rotation practices, crop types, or grazing practices. The inter-relationship between precipitation, soil moisture, run-off, crop or land-cover and streamflow generation is complex and highly site-specific.

Screening methods can provide a GIS-based tool to identify areas most prone to run-off problems associated with agriculture. More site specific analytical methods to predict rainfall run-off relationships (such as the SCS Curve Method) can be very accurate but may not work well in agricultural settings with frozen ground. A cold region's hydrologic model has been developed in Canada (Hedstrom and others, 2001) that addresses the complexities of frozen ground.

5.3.3 Irrigation Withdrawals

Accurate measurements of actual irrigation withdrawal from wells or surface water are not available in WRIA 34. As shown on Table 5-1, about 14,600 acres of pasture and hay were present in WRIA 34 during 1995. Assuming that all of this land is irrigated at a duty of 3.6 feet per year, approximately 52,750 AF of water is withdrawn for irrigation purposes. An application rate of 3.6 feet equates to an irrigation efficiency of about 70% for an alfalfa/hay crop irrigation requirement of 28 inches. This is a typical efficiency for sprinkler irrigation.

5.4 Water Use on Non-Irrigated Agricultural Lands

The majority of agricultural land in WRIA 34 is not irrigated. However, dryland agricultural practices do have a water use component to them.

5.4.1 Crop Irrigation Requirements

The water needs for crops summarized in Table 5-5 are similar for both non-irrigated and irrigated lands when the effects of application efficiency factors are taken out. In a non-irrigated setting, the "efficiency" factors included in CIR could be equated with residual soil moisture needs. Common farming practice is to alternate fallow and crop growing years in order to increase moisture store in the soil zone during a growing year. This is in many ways equivalent to an "irrigation requirement" where precipitation is less than the ET requirement for the crop, but the water is essentially stored in the soil.

5.4.2 No Till / Direct Seed

The terms "zero-till" and "no-till" have been used to identify production systems where the crop is seeded into standing stubble without any prior tillage. Winter wheat lead the way in providing farmers with experience in low-disturbance direct seeding in western Canada in the 1980's. The term "stubbling-in" was coined to emphasize the importance of using low-disturbance, direct-seeding equipment to ensure that stubble remained standing to act as a snow trap in winter wheat production systems. The early 1990's saw a large increase in the acreage of direct-seeded spring-sown crops. Improvements in the design of seeding equipment, lower cost, more effective herbicides, a better understanding of the role of tillage in crop production systems, and increased emphasis on residue management were the key factors responsible for the success of this shift to direct seeding.

There are a number of potential benefits to direct seeding, including more efficient water use. Fields that are cultivated using direct seed trap soil moisture and snow, thus improving water availability. The surface mulch typical of minimum-till fields acts as a protective skin to the soil. This soil skin reduces the impact of raindrops and buffers the soil from temperature extremes as well as reducing water evaporation. In addition, residue slows runoff and increases the opportunity for water to soak into the soil. Another way infiltration increases is by the channels created by earthworms and old plant roots.

Additional benefits from direct seeding (STEEP, 2004) include:

- Reduces labor, saves time – As little as one trip for planting compared to two or more tillage operations means fewer hours on a tractor and fewer labor hours to pay, or more acres to farm.
- Saves fuel – Save an average 3.5 gallons per acre or 1,750 gallons on a 500-acre farm.
- Improves soil fertility and may increase yield – A continuous minimum-till system increases soil particle aggregation making it easier for plants to establish roots. Improved soil fertility also can minimize compaction. Worm numbers can be reduced by as much as 90 percent by deep and frequent tillage; and the tillage done by earthworms can replace some expensive tillage work done by machinery.
- Increases organic matter – The latest research shows that the more soil is tilled, the more carbon is released to the air and the less carbon is available to build organic matter for future crops. In fact, carbon accounts for about half of organic matter.
- Reduces soil erosion – Crop residues on the soil surface reduce erosion by water and wind. Depending on the amount of residues present, soil erosion can be reduced by up to 90 percent compared to an unprotected, intensively tilled field.
- Improves water quality – Crop residue helps hold soil along with associated nutrients (particularly phosphorous) and pesticides on the field to reduce runoff into surface water. In fact, residue can cut herbicide runoff rates in half. Additionally, microbes that live in carbon-rich soils may quickly degrade some pesticides and use nutrients to protect groundwater quality.
- Improves air quality – Crop residue left on the surface improves air quality because it: reduces wind erosion and the amount of dust in the air; reduces fossil fuel emissions from tractors by making fewer trips across the field; and, reduces the release of carbon dioxide into the atmosphere by tying up more carbon in organic matter.
- Increases wildlife – Crop residues provide shelter and food for wildlife, such as game birds and small animals.

5.5 Municipal and Domestic Water Use

Municipal water use is a significant portion of total water use in WRIA 34 and is a very important issue in the Pullman/Moscow area because of declining groundwater levels. Like agricultural use, a comparison of consumptive use to total water withdrawal is important. Larger municipal systems typically maintain more complete records of pumping rates, metered water deliveries, and wastewater return flows, so it is possible to conduct a in-depth evaluation of water usage patterns. Smaller public water systems often do not maintain records of pumping rates and it is more difficult to determine water usage patterns.

Table 5-7 summarizes Group A and Group B water systems on file with Washington Department of Health (WDOH). There are over 120 registered water systems in WRIA 34. Table 5-8 summarizes the primary city water systems by sub-basin. Table 5-9 (a-f) summarizes recent water production data for various municipalities in WRIA 34 that provided data for this assessment. Figure 5-2 shows the combined pumping from the deep aquifer in the Moscow/Pullman area. A discussion of the various components of water use is provided below, and focuses primarily on the eastern portion of WRIA 34, where most of the larger water systems are located.

5.5.1 Current Deep Aquifer Pumpage

Based on pumping records for 2002, about 8,000 acre-feet of water is pumped for municipal purposes from the basalt aquifer systems of the Palouse. This amount of water is equivalent to a continuous pumping rate of about 5,000 gallons per minute (gpm); or a continuous flow rate of about 12 cubic feet per second (cfs). Compared to estimated agricultural groundwater pumping (86,725 AF), municipal pumpage represents about 10% of the total groundwater withdrawal. This pumping, in addition to other pumping for agricultural purposes, contributes to the declining water levels in the basalt aquifers. Some of this water is used consumptively and does not return to the watershed. However, some of this water is returned to the watershed via wastewater return flows. The proportion of this water that is used consumptively is a potential water management issue, and requires a more refined assessment of consumptive water use.

Base use is a term that is generally applied to the year-round indoor component of water usage, such as cooking or laundry. Base use is often characterized on "per capita" basis. A large portion of this water use is returned to the watershed via a wastewater treatment plant or septic system. In most communities, base use is relatively constant and may grow annually depending on population growth. In communities such as Moscow and Pullman, the seasonal influx of students to the universities increases the base use. This complicates both the per capita and the year-round basis for evaluating base water use.

Peak use is a term that is generally applied to the summer component of water use when outdoor watering increases. Municipal water managers use "peaking factors" to design systems to handle peak usage on a daily, weekly, and monthly basis. On a monthly basis, peaking factors or 2 to 4 times the base usage rate are common. For the City of Pullman, summer pumping is typically about 2.3 times pumpage during the winter months, consistent with typical peaking factors.

Municipal wastewater is returned to the watershed via wastewater treatment facilities. Both Pullman and Moscow return their wastewater directly to surface water. Other wastewater return methods include land application and injection wells, but these methods are not used in WRIA 34. Wastewater discharge records can be used to estimate actual consumptive use. In some cases, a simple difference between pumpage and wastewater discharge can give an indication of consumptive use. For many systems however, including Moscow and Pullman, infiltration and inflow ("I and I") contributions from stormwater runoff make this calculation problematic. Table 5-10 summarizes pumpage, monthly wastewater return flows, and precipitation for the City of Pullman.

5.5.2 Current Municipal Consumptive Use and Return Flow

A simple and accurate determination of actual consumptive use for the Cities of Moscow and Pullman is complicated by the seasonal component of base use (students), the summer peaking component (outdoor watering), and the influence of I&I flows on the observed wastewater return flows. However, the following generalities are probably valid:

- About 50% of the total annual pumpage occurs during the fall and winter (September-March), and the majority of this amount is returned to the watershed. The relative amount of winter pumpage is likely higher than typical municipalities because of the high transient student population during the school year;
- The other 50% of annual pumpage occurs during the spring and summer, but a larger proportion of this pumpage not returned to the watershed because of outdoor watering and higher evapotranspiration. A rough estimate is that about 25% of the total annual

pumpage is lost to evapotranspiration and the other 25% consists of base usage from a lower population during the summer months.

- The rough proportions of usage are that 75% of the total pumpage is probably used by people, routed through the wastewater treatment systems and returned to the watershed, with the remaining 25% of use "lost" to the atmosphere and transpired by the landscape.
- Using an equivalent flow rate of 12 cfs (from the total 2002 pumpage from basalt aquifers), up to 9 cfs of net streamflow augmentation (75% of 12 cfs) may be occurring in streams in WRIA 34. This represents an upper limit for the amount of streamflow augmentation in WRIA 34 that may be occurring from pumping of deep aquifers. The net amount of stream augmentation needs to be balanced by possible reductions in streamflows caused by pumping, or other losses to groundwater that may be occurring. Additional analysis of this issue is necessary for further quantification.

5.5.3 Storage and Unaccounted Water

There are minimum storage requirements defined by DOH for public water systems, and additional guidelines are available from professional organizations (e.g., the American Public Works Association). Storage is needed for reliability of water supply and for public safety such as fire protection. Less than 10% unaccounted water is considered acceptable. Municipal storage capacity will be addressed in the storage supplemental assessment.

5.5.4 Municipal Water Bill

The Municipal Water Supply - Efficiency Requirements Act Chapter 5, Laws of 2003 provides greater certainty and flexibility for water rights held by public water systems, and more closely ties water system planning and engineering approvals by the State Department of Health (DOH) to water rights administered by the state Department of Ecology (Ecology). Commonly called the "Municipal Water Law," the act requires the Department of Health to change many of the processes and procedures it uses to approve water system plans. DOH developed an interim guidance document that explains the interim requirements purveyors must meet to gain approval for a water system plan (WSP). These requirements will remain in effect until DOH establishes long-term processes that will be phased in over the next three years. The guidance was first issued November 6, 2003. These changes affect the Department of Health's water system planning process and provide some unique benefits (including greater water right flexibility and certainty) to many water systems. There are several areas where the Municipal Water Bill may affect water supply plans:

- RCW 90.03.015(3) and (4) - Municipal water supplier definition. Provides the definition of a municipal water supplier and establishes municipal water supply purposes.
- RCW 90.03.260(4) and (5) - Water right connection/population limitations. Clarifies the state's Water Code by stating that the number of water service connections and population are not limiting attributes of water rights for water systems that have a DOH approved water system plan (WSP) or other approval that specifies the number of connections.
- RCW 90.03.386(1) - Plan Review Coordination between DOH and Ecology. Amends the state's Water Code directing DOH and Ecology to coordinate WSP approval procedures with water right determination procedures for both WSP and small water system management programs (SWSMP).

- RCW 90.03.386(2) - Service Area Consistency. Allows a municipal water supplier to expand the place of use on its water right to all areas included within the service area described in their approved WSP or SWSMP. This benefit is provided if the water right holder is in compliance with the terms of its WSP and the service area is consistent with applicable approved comprehensive plans, land use plans, development regulations, coordinated water system plans, and watershed plans. A utility's place of use is not reduced if the service area identified in an approved WSP or SWSMP is smaller than the place of use identified in the water right.
- RCW 90.03.386(3) - Conservation requirements for systems with 1,000 or more connections. Provides direction on conservation to water systems with 1,000 or more connections. This includes reporting the conservation measures the utility has put into practice in the past and how those measures have increased their water use efficiency. It also directs water systems that are using inchoate portions of a water right certificate to describe how they could delay the use of the inchoate water rights through additional cost-effective conservation measures.
- RCW 70.119A.180 - Current conservation programs and the conservation rule. Directs DOH to develop water conservation rules by the end of 2005 and to involve key stakeholders in the process. It also directs municipal water suppliers to continue to meet current conservation planning requirements and continue implementing their current programs.
- RCW 43.20.260 - Local government consistency and duty to serve. Requires new services within a water system's service area to be consistent with applicable approved local land use plans, comprehensive plans, and development regulations. Water utilities must delineate retail service areas in their WSP. Water systems with DOH approved WSPs now have a duty to provide service to new connections within their retail service area.
- RCW 90.46.120(3) - Reclaimed Water. Requires systems serving 1,000 connections or more to evaluate reclaimed water opportunities.

5.5.5 Exempt Domestic Wells

Exempt wells are a concern in watershed planning because the total number of wells and quantity of water withdrawn is not usually well known. Exempt wells are permitted to use up to 5,000 gallons per day for multiple purposes (maximum annual use of 5.6 AF/yr). The actual use is dependent on specific conditions, but is usually less for a "typical" residence.

The methods used to estimate the number of exempt wells and their quantity of water used typically assume that the population outside of the service areas of purveyors is served by exempt wells. Exempt well water use patterns typically mirror that of the municipal system. However, higher or lower use patterns are possible from exempt wells.

Variables contributing to higher water use from exempt wells include:

- There is no meter charge for exempt wells as there is for water supplied by municipal purveyors, therefore there is less incentive to conserve water (other than the electrical bill associated with pump operation).
- Exempt wells occur in rural areas with larger lot sizes. Therefore landscaping and garden use can be higher than in more developed areas;

- Exempt wells occur in rural areas that commonly support livestock with wells.

Variables contributing to lower water use from exempt wells include:

- Exempt wells may be installed in less productive aquifers which limit the volumes of water that can be withdrawn.
- Exempt wells may support homes in rural areas that do not have any landscape water needs.
- Properties with irrigation rights may only use their exempt wells for indoor use, resulting in lower consumptive use of the exempt well.

Exempt well distribution in WRIA 34 has not been accurately determined. Based on population statistics, and estimated 22,800 people reside in unincorporated rural areas not served by municipal water supply. Using an estimated 2.5 person per household, this suggests a total exempt well count on the order of 9,000. Some of these unincorporated areas are served by small water systems. Figure 4-9 shows the distribution of well logs on file with WDOE. Table 5-11 summarize the number of wells per sub-basin and indicates a significantly lower number of wells. Per capita, water use from exempt wells cannot be measured directly in WRIA 34 since there is no metering data available. This is a common circumstance. Other WRIA watershed plans have developed per capita water use estimates based on city water usage, as shown on Table 5-12.

5.6 Future Water Use

Changes in future water use in WRIA 34 will be predominantly the result of population increase.

Population and water demand projections for WRIA 34 are shown on Table 5-13. The table shows population for the year 2000 and 2025. Larger municipalities are designated as incorporated populations and rural areas are designated as unincorporated population, consistent with terminology used in Growth Management Area (GMA) terminology used by the State Office of Fiscal Management (OFM) documents.

Assumptions and methods used in the population forecasts are as follows:

- Forecasts for the Cities of Medical Lake, Colfax, Pullman, Moscow and WSU were derived from water supply plans or provided directly by City staff.
- Forecasts for unincorporated areas of Adams, Spokane and Whitman Counties were developed using 2000 census tract data, which was overlain with WRIA 34 watershed boundaries to determine the actual population in these counties within WRIA 34. Growth rates were calculated using 2025 GMA intermediate projections of population for each county and applied to the population within WRIA 34 determined by the 2000 census data.
- Forecasts for unincorporated areas of Benewah, Latah, and Nez Perce County were developed using 2003 population data provided by County staff and the 1990-2000 growth rate based on census data for rural areas of the county.

Table 5-13 shows that total current population in WRIA 34 is on the order of 80,000 people, with nearly 70% of the population residing in larger incorporated areas and about 30% residing in rural unincorporated areas. Future population is projected to exceed 100,000 people by 2025, with the majority of the new population occurring in incorporated areas.

In terms of water use, a per person annual average water usage rate of 116 gallons per day per person was applied to the population projections. This is consistent with City of Pullman average usage and is similar to water usage rates determined in other areas of Eastern Washington. Based on this usage rate, Table 5-13 shows that municipal and domestic water demand is expected in increase from a current level of 10,081 AF per year to about 13,400 AF per year. Current municipal water rights on file with WDOE and IDWR (see Section 6) in WRIA 34 exceed the projected demand for water in both the incorporated and unincorporated areas of WRIA 34.

No significant changes in agricultural water use are projected. The total acreage of irrigated and non-irrigated agriculture land is not expected to increase. The current estimated irrigated agricultural water demand of 52,750 AF per year is expected to stay constant. Current agricultural water rights on file with WDOE and IDWR (see Section 6) in WRIA 34 exceed the projected demand for irrigation water WRIA 34. The current estimated non-irrigated agricultural water demand is also expected to stay constant. No comparison with water rights is made for this type of water use.

6.0 WATER ALLOCATION

This section presents a summary of water rights by sub-basin within WRIA 34 estimated from claims and administratively issued water rights. In Washington, the Department of Ecology (Ecology) maintains a database to track and store water rights information, called the Water Rights Application Tracking System (WRATS) database. An abbreviated version of the WRATS database, called "**W**RATS-**O**n-a-**B**un," or WOB, that is current as of August 2001 was used for the assessment of allocation in the Palouse Basin. However, because WRATS is the more common reference to the WOB database, all references in this report to WRATS is actually to the WOB database. Current information on applications for new water rights and change applications was also obtained from Ecology to assess the current degree of water rights activity in the basin. Finally, instream flow regulations are reviewed.

Idaho maintains a GIS database of water right documents. A GIS database of water right documents in the Palouse Basin in Idaho was obtained from the Idaho Department of Water Resources.

The purpose of this assessment is to provide information that can be used to compare water rights allocation on a sub-basin basis with other sub-basin issues such as predicted development and surface water flows to provide more detailed information on water availability.

6.1 Background

6.1.1 Water Rights in Washington

Administrative water rights issued by Ecology have existed in Washington State since 1917 for surface water and 1945 for groundwater. These take the form of permits and certificates and are collectively referred to as administratively issued water rights. Legal water use since these dates requires application to, and approval from, Ecology. Water rights are valid only as long as they are used, and except under specific conditions, cease to exist if they are not used for a continuous period of five years (i.e., they are relinquished). A description of claims is presented below because of the uncertainty associated with the status of claims in the assessment of allocation.

Claims Registry

Water use before 1917 (for surface water) or 1945 (for groundwater) is "grandfathered" and establishes a water right, subject to conditions (e.g., the water must be applied to beneficial use, must not have been relinquished, etc.). Such rights are referred to as claims and must have been registered with Ecology. Since the establishment of the surface code (1917) and groundwater code (1945), there have been four claim registration periods. Claims for water use may have been registered multiple times resulting in duplicate, triplicate, or possibly quadruplicate records in Ecology's database for what is intended to be a single water right claim. Claims do not necessarily represent a valid water right and Ecology does not have the authority to determine their validity. Validity of claims are determined through a water rights adjudication.

Approximately 177,000 claims were filed statewide in the initial opening to the water right claims registry (July 1, 1969 through June 30, 1974) in response to Ch. 90.14.041 RCW. A list of the information that the claimant had to provide was specified in Ch. 90.14.041 RCW. In 1973, Ch. 90.14.041 RCW was amended to allow a less extensive list of information – a "short form" filing. The short form only requires inclusion of sufficient data to identify the claimant, source of water, purpose of use and legal description of the land upon which the water is used and is of limited evidentiary value in adjudications. With the amendment to RCW 90.14.051 in 1973, there are long forms (exclusively used prior to 1973, and selectively used after 1973) and short forms.

The intent was that short forms were to be used only by those who were withdrawing water pursuant to Ch. 90.44.050 RCW (exempt wells), but, in reality, that is not what happened. The language in Ch. 90.14.051 RCW is as follows: "Except, however, that any claim for diversion or withdrawal of surface or ground water for those uses described in the exemption from the permit requirements of Ch. 90.44.050 RCW may be filed on a short form to be provided by the department." This language is confusing because there is no exemption for the diversion of surface water under Ch. 90.44.050 RCW.

The second opening was from July 1, 1979 through December 31, 1979, and was created by Ch. 90.14.043 RCW.

Ch. 90.14.043 RCW was amended in 1985 to allow a third opening in July 1, 1985 through September 1, 1985. In those cases the claimant first had to petition the Pollution Control Hearings Board (PCHB) for a certificate and make a showing to the PCHB regarding their water use. A certification was issued by the PCHB if, upon petition to the board, it was shown to the satisfaction of the board that:

(a) Waters of the state have been applied to beneficial use continuously (with no period of nonuse exceeding five consecutive years) in the case of surface water beginning not later than June 7, 1917, and in the case of ground water beginning not later than June 7, 1945; or,

(b) Waters of the state have been applied to beneficial use continuously (with no period of nonuse exceeding five consecutive years) from the date of entry of a court decree confirming a water right and any failure to register a claim resulted from a reasonable misinterpretation of the requirements as they related to such court decreed rights.

If the claimant received a certificate from the Board, then Ecology accepted the filing of the claim and entered it into the claims registry.

The fourth opening from September 1, 1997 through June 30, 1998 was created by a new section of the code, Ch. 90.14.068 RCW. These claims are commonly entered into the WRATS database without designation as to whether they are long or short form claims.

Each of the openings came with limitations and differences from the other claim openings and most of that information can only be evaluated by reading the various laws that created or limited the openings. For example, filings in the September 1, 1997 through June 30, 1998 opening have a water right priority date of as of the date the statement of claim is filed with Ecology – even though to be a valid claim the water use needed to start prior to 1917 for surface water and 1945 for ground water.

<u>Adjudications</u>

Adjudication is generally required to legally establish the validity of claims, and to resolve conflicts between water rights holders. An adjudication is a court process that may be initiated by petition by a person claiming a right to water, by Ecology, or by planning units. Surface water claims in the Cow Creek sub-basin were adjudicated in 1986 (State of Washington v. Bar U Ranch).

Instream Flows

Water rights may be established for instream flow values under the Water Resources Act of 1971 (Ch. 173-500 WAC). Regulated instream flow quantity is a water right with a corresponding priority date and period of use. The purpose of establishing such flows is typically for the maintenance and/or protection of aquatic biota/fish, although other values may also be considered, such as water quality and recreational uses. Water may also be reserved or set aside for future use. Ecology must initiate a review of such regulations whenever new information, changing conditions, or statutory modifications make it necessary. Instream flows have not been set in WRIA 34.

Groundwater Subareas

Ecology has delineated a groundwater management subarea that extends into the eastern portion of WRIA 34 (the Odessa Ground Water Management Subarea [GWMS]) in response to severe declines in groundwater levels because of irrigation pumping (WAC 173-128A). The groundwater management policy for the Odessa GWMS (WAC 173-130A) includes the following provisions that affect groundwater rights:

- The rate of groundwater level decline is limited to a total of 30 feet in three consecutive years;
- The maximum lowering of the water table is 300 feet below the altitude of the static water level as it existed in the Spring of 1967;
- The duty for agricultural water rights shall not exceed 2.5 AF/yr; and
- The irrigation season shall extend from February 1 through November 30 each year, but permission to irrigate in December and January may be granted upon showing of need.

WAC 173-128A and WAC 173-130A are included in Appendix E.

Exempt Status

No other forms of water rights are addressed in this chapter including, but not limited to, tribal rights or exempt wells. A groundwater right for the withdrawal of up to 5,000 gallons per day of groundwater for prescribed uses may be established without application to Ecology, and are referred to as “exempt wells.” Exempt well use is addressed in the chapter assessing actual use.

6.1.2 Water Rights in Idaho

Administrative rights issued by the Idaho Department of Water Resources (IDWR) have existed in Idaho since 1971 for surface water and since 1963 for groundwater. These administrative rights take the form of permits and licenses. Legal water use after these dates requires application to IDWR. IDWR reviews the application, and, if the application meets the requirements of applicable statutes, rules, and regulations, a permit is issued. Proof of beneficial use must be documented before a field examination is performed. Following completion of the field evaluation and verification of beneficial use, a license is issued.

Prior to May 20, 1971 (for surface water) or March 25, 1963 (for groundwater), there were two ways in which a right to surface water could be established. The first way was to simply divert water and apply it to beneficial use. These water rights are called “beneficial use”, “historic use” or "constitutional" water rights. The priority date for a water right established by this method is the date water was first put to beneficial use.

The second way to establish a right to surface water was to comply with the statutory method in effect at the time the water right was established. The current statutory method is an application/permit/license procedure that is described further below. The priority date for a water right established by this method is the date of filing the application with IDWR, and this priority date is shown on the license that is issued when the process is completed. Prior to 1903, Idaho had a "posted notice" statute, which provided for posting of a notice at the point of diversion and recording the notice at the county recorder's office, followed by actual diversion and beneficial use of water, among other things. If the statutory requirements were met, then the priority date for a water right established under the posted notice statute was the date of posting the notice. Water rights established under the old statutory method are called "Posted Notice" water rights, but are considered beneficial use rights because they are not confirmed by a license or decree. The one exception to this rule is for water rights used solely for instream watering of livestock.

A "beneficial use" right to ground water may still be established for domestic purposes. "Domestic purposes" is defined by statute as "(a) the use of water for homes, organization camps, public campgrounds, livestock and for any other purpose in connection therewith, including irrigation of up to one-half (1/2) acre of land, if the total use is not in excess of thirteen thousand (13,000) gallons per day, or (b) any other uses, if the total use does not exceed a diversion rate of four one-hundredths (0.04) cubic feet per second and a diversion volume of twenty-five hundred (2,500) gallons per day." The exception to domestic purposes does not include "water for multiple ownership subdivisions, mobile home parks, commercial or business establishments" unless the use does not exceed a diversion rate of four one-hundredths (0.04) cubic feet per second and a diversion volume of twenty-five hundred (2,500) gallons per day.

Idaho also has a water claim system. There are two different types of filings that are often called "claims". The first is a "statutory claim" that was filed with IDWR to make a record of an existing beneficial use right. In 1978, a statute was enacted requiring persons with beneficial use rights (other than water rights used solely for domestic purposes as defined above) to record their water rights with IDWR. The purpose of the statute was to provide some means to make records of water rights for which there were previously no records. However, these records are merely affidavits of the water users, and do not result in a license, decree, or other confirmation of the water right.

The other type of claim is a "notice of claim" to a water right that is filed with IDWR in water rights adjudications. An adjudication is a court action for the determination of existing water rights, which results in a decree that confirms and defines each water right. The application/permit/and license procedure described above is for purposes of establishing new water rights. When an adjudication of a particular source is commenced, IDWR is required to notify the water users of the commencement of the adjudication, and notify the water users that they are required to file notices of claims for their water rights with IDWR. IDWR then investigates the notices of claims and prepares a report that is filed with the court. Claimants of water rights are notified of the filing of the report, and objections to the report may be filed with the court by anyone who disagrees with the findings in the report. If no objection is filed to a water right described in the report, then the court decrees the water right as described in the report. If an objection is filed to a water right described in the report, then the court determines the water right after a hearing and decrees the water right.

Adjudication is currently underway in the Snake River Basin in Idaho. IDWR is in the process of investigating claims and making recommendations on how the claims should be decreed by the Court.

6.2 Assessment of Allocation

This section describes water rights allocated by (Ecology) and IDWR in the WRIA 34 and by sub-basin. The characterization of water rights was based on:

- Source type (groundwater or surface water);
- Document type (certificate, permit, claim, etc.);
- Purpose of use (irrigation, domestic, municipal, etc.); and,
- Sub-basin.

The WRATS and IDWR databases were initially queried to exclude those documents listed in the database as relinquished, rejected, cancelled, or otherwise listed as not being in good standing. The extracted data were placed in a new database for further analysis. A total of approximately 5,769 records were extracted from the WRATS database for WRIA 34, and 795 documents were extracted from the IDWR database. The documents in the WRATS and IDWR databases for groundwater and surface water in WRIA 62 are summarized in Table 6.1.

Also included in the WRATS database is one long form claim (Claim/L) for combined groundwater and surface water, or uncertain source (document number starts with "B") and twenty documents for reservoirs (one application, and nineteen certificates).

6.2.1 Characterization by Purpose of Use

For each sub-basin, the WRATS and IDWR databases were queried to extract the distribution of documents by purpose of use for both groundwater and surface water. The order of extraction was as follows:

1. All documents including the "MU" (municipal) purpose of use and the "DG", "DS", and "DM" (domestic) purposes of use;
2. Remaining documents including the "IR" (irrigation) purpose of use;
3. Remaining documents including the "CI" (commercial-industrial and mining) purposes of use;
4. Remaining documents with non-consumptive or infrequently used purposes of use (power, fish propagation, cooling, and fire);
5. Remaining documents including the "ST" designation, and,
6. All other documents including all other purposes of use (mining, recreation, etc).
7. For the IDWR database, some documents did not have a purpose of use assigned in the database and were assigned a separate category designated "no purpose". These included rights designated as "reserved".

After each query, the records are removed from the database before applying the next query. This characterization is based solely on the number of records. The results of the analysis by purpose of use are summarized on Table 6.2.

Non-consumptive (e.g., wildlife, enhancement, fish hatchery, cooling, or hydropower production) or infrequently used (e.g., fire suppression) water rights contributed less than one percent of all documents. Because annual quantities are usually not listed in the WRATS database for these types of water rights, they are not further characterized with respect to associated annual quantities following initial extraction from the database. The surface water diversions for non-consumptive or infrequently used purposes of use are summarized as follows:

- Four certificates totaling 1.09 cubic foot per second (cfs) for wildlife; and
- One certificate for 0.3 cfs for enhancement.

The quantities described above do not include adjudicated rights for Turnbull Wildlife Refuge, which includes wildlife or a purpose of use. There are also four applications for non-consumptive or infrequently used purposes of use. Three are for enhancement and one is for wildlife. There are no groundwater withdrawals for non-consumptive or infrequently used purposes of use in Washington.

In Idaho, there are eight claims or licenses for a total of 0.15 cfs of groundwater for non-consumptive use, and 29 licenses, permits, or recommendations for a total of 950 cfs of surface water for non-consumptive use. This total includes 940 acre-feet per year for one license for aesthetic and recreation use.

The remaining water rights, including municipal, irrigation, commercial / industrial and other uses (recreation, mining and stock watering) are considered consumptive uses (return from wastewater or septic is not considered). As shown on Table 6-2, water rights including the municipal and irrigation purposes of use make up about 20% and 31% of the total number of records in Washington, respectively. Other uses (including recreation, mining and stock watering) make up about 48% of the total number of records. Much of this is for stock watering. Commercial / industrial water rights make up about 1% of the total number of records.

In Idaho, municipal and irrigation rights make up about 29% and 20% of the consumptive use records, respectively. Other uses make up 27% of the consumptive use records, primarily for stock watering. Commercial-industrial records make up about 4% of the total records. About 16% of the records do not have a purpose of use assigned.

6.2.2 Assignment of Annual Withdrawals or Diversions for Consumptive Uses

Water rights are assigned with a variety of properties among which are an instantaneous withdrawal/diversion rate (Qi; in gallons per minute [gpm] for groundwater and cubic feet per second [cfs] for surface water), and an annual withdrawal/diversion rate (Qa; acre feet per year for both surface and groundwater). Groundwater is typically described with the term "withdrawal" while surface water is generally described with the term "diversion." The terms withdrawal and diversion may be used interchangeably in this report. Assessment of allocation on a watershed scale is appropriately considered by examination of the annual permitted quantities, which may then be seasonally distributed.

In Washington, the annual quantity in the WRATS database includes instantaneous withdrawal rates (Qi) for almost all administratively issued rights (permits and certificates). However, annual withdrawal rates (Qa) are missing for many administratively issued rights and almost all claims. Surface water permits and certificates generally have a higher percentage of records with missing Qa than groundwater permits and certificates (Table 6-3a). In Idaho, many records do not have a Qa assigned. Regulation of water rights is generally based on diversion or withdrawal rates. Some groundwater or surface water irrigation rights are assigned an annual quantity.

For records that do not include Qa in the database, a value has been assigned to allow an assessment of allocation. The method of estimating assigned Qa is described below.

Certificates and Permits

For certificates and permits within each purpose of use, the ratio of Qi/Qa was calculated for surface water and groundwater rights for which both Qi and Qa parameters are defined. The Qi/Qa ratios for the purposes of use (municipal / domestic, irrigation, commercial / industrial and other) are summarized on Table 6.3a (Washington) and 6-3b (Idaho).

A summary of the number and percentage of each of each certificate and permit in the WRATS database without Qa is also presented on Table 6.3a and Table 6-3b. The methods of estimating Qa for those certificates and permits without Qa are described below.

Irrigation Use

- For Washington irrigation certificates and permits without Qa but with irrigated acreage information, the Qa was calculated by multiplying the irrigated acres for that record by a duty (annual water use per acre). The duty was estimated by dividing the Qa for certificates and permits by the number of irrigated acres for both groundwater and surface water. The median duty for surface water and groundwater was 3.6 feet per acre. Therefore, for those records without Qa but with irrigated acreage information, Qa was estimated by multiplying the number of irrigated acres by the median duty for groundwater or surface water (based on use as indicated on records with Qa).
- For the Idaho water rights, irrigated acreage information was not available in the database. Therefore, a duty could not be calculated for the Idaho rights. To estimate Qa for Idaho irrigation rights, the Qi/Qa ratio was calculated for all Licenses that had Qi and Qa information and used to estimate Qa for those records in the database without Qa (Table 6-3b).

Other Uses

- For municipal/domestic, commercial/industrial and other certificates and permits without Qa, the Qa was estimated by multiplying the Qi by the median Qi/Qa ratio for rights that were assigned both Qi and Qa. All certificates and permits had either Qa or Qi information. The median Qi/Qa is considered most representative, as it is not skewed by outliers in the Qi/Qa ratio.

Assignment of Qa to Claims in Washington

Long and short form claims generally do not contain complete information on Qa, Qi, or irrigated acres, and therefore require an estimation of Qa. New claims filed during the last claim registration period (September 1, 1997 through June 30, 1998) have Qa and Qi information.

Short form claims are generally equivalent to exempt well as defined in Ch. 90.44.050 RCW, such as for domestic water use and limited irrigation (i.e. less than 0.5 acre). Short form claims were assigned a Qa of 0.5 AF/yr, regardless of purpose of use, consistent with domestic, stock, and limited irrigation use. Long form claims that had a purpose of use of general domestic were also assigned a Qa of 0.5 AF/yr.

For long form claims with irrigated acreage information, the 3.6 ft/acre duty calculated from certificates and permits was applied. Long form claims for irrigation use without a defined number of irrigated acres were assigned a Qa based on the median number of irrigated acres for groundwater or surface water rights, and a corresponding duty calculated from water rights.

For the remaining long form claims, the purpose of use includes stock, or no purpose of use is listed. A Qa of 2 AF/yr was assigned to all of these remaining long form claims. 2 AF/yr is the maximum quantity assigned for domestic use claims in the Cow Creek adjudication (see Section 6.5).

6.3 Results

A total of 882,309 AF/yr is allocated for consumptive use in WRIA 34. The distribution of surface water allocations is shown on Figure 6-1, and the distribution of groundwater allocations is shown on Figure 6-2. A number of water rights and claims have a place of use that covers multiple sections. For these documents, the Qa was allocated between sections by dividing the total Qa by the number of sections. This total includes 868,718 AF/yr in Washington and 13,591 AF/yr in Idaho. The total for Washington includes 585,097 AF/yr from three surface water claims. These three claims represent over 50% of the total allocated water in WRIA 34, and about 67% of the allocated water in Washington. These claims are summarized as follows:

Document Number	Qa (AF/yr)	Purpose of Use
S3-302255CL	390,697	Irrigation, Stock
S3-300543CL	135,000	Stock
S3-300542CL	59,400	Stock

It is likely that the Qa associated with these claims in the WRATS database is erroneous. The actual claim documents have not been evaluated. Without these claims included in the total, the total allocation for WRIA 34 is 297,212 AF/yr, and the allocation in Washington is 283,621 AF/yr.

About 25 percent of the total allocation (212,824 AF/yr) is groundwater. The remaining 655,833 AF/yr (75 percent) is surface water. If the three claims discussed above are excluded, groundwater comprises about 76 percent of the allocated water, and surface water the remaining 24 percent (70,736 AF/yr).

Groundwater certificates and permits account for 143,341 AF/yr, or 67 percent of the allocated groundwater in Washington. Claims account for the remaining 33 percent, or 69,543 AF/yr, of allocated groundwater in Washington (Table 6.4). In Washington, surface water certificates and permits account for 37,544 AF/yr, or six percent of the allocated surface water, when the three claims are included. Claims make up the remaining 94 percent (618,290 AF/yr) of allocated surface water, including the potentially erroneous claims. Without the three surface water claims, surface water certificates and permits comprise about 53 percent of the allocated total, and claims comprise the remaining 47 percent (33,193 AF/yr).

In Idaho, groundwater licenses account for over 99 percent of the total of 10,747 AF/yr of allocated groundwater (10,773 AF/yr). Recommendations make up less than one percent (26 AF/yr) of the allocated groundwater. Surface water licenses account for 95 percent (2,818 AF/yr) of the allocated surface water. The remaining five percent (31 AF/yr) includes claims and recommendations.

The largest allocation of water in WRIA 34 is for irrigation use. A total of 612,008 AF/yr is allocated for irrigation use, accounting for 70 percent of the total allocated water in WRIA 34. This total includes 567,967 AF/yr in Washington and 7,021 AF/yr in Idaho. Without the one potentially erroneous claim for irrigation use, irrigation is still the largest use of water in WRIA 34, with a total of 184,286 AF/yr, or about 62 percent of the allocated water. Surface water accounts for 452,227 AF/yr of irrigation allocation (61,530 without the one potentially erroneous claim). Groundwater accounts for the remaining 159,783 AF/yr of irrigation allocation. The distribution of surface water and groundwater for irrigation use is shown on Figures 6-3 and 6-4, respectively.

Stock watering, which is included in the "other" purpose of use, is the second greatest allocated use of water in WRIA34. A total of 235,340 AF/yr is allocated in WRIA 34 for other uses. This total includes 194,400 AF/yr for two potentially erroneous claims for stockwatering. Without these claims, the total allocated water for the other purpose of use is 40,940 AF/yr.

Municipal and domestic use accounts for a total of 33,294 AF/yr, with 32,495 AF/yr of the total allocation from groundwater (Table 6.4). Municipal use is the largest use of groundwater with a municipal or domestic purpose of use. The largest municipal water rights in WRIA 34 are held by Cities of Pullman, Moscow, and Medical Lake, and Washington State University. The distribution of municipal and domestic water rights is shown on Figure 6-5 (groundwater) and 6-6 (surface water).

There are a total of 15 applications for new water rights in WRIA 34, including three in Idaho and 43 in Washington. The applications are as follows:

- Two applications for reservoir rights to store 8,340 AF/yr;
- 29 applications for new groundwater rights totaling 42,597 gpm, including 27 in Washington (36,168 gpm) and two in Idaho (6,429 gpm); and
- 15 applications for new surface water rights totaling 14.99 cfs, including 14 in Washington (14.89 cfs) and one in Idaho from the Palouse River (0.1 cfs).

The applications for new water rights and water right changes in Washington are summarized on Table 6-5. The distribution of surface water right applications is shown on Figure 6-8, and the distribution of groundwater applications is shown on Figure 6-9.

There are a total of seven applications for change in WRIA 34 (one for surface water and six for groundwater).

6.4 Administrative Status of Instream Flows

Water rights may be established for instream flow values under the Water Resources Act of 1971 (Ch. 173-500 WAC). Water rights for instream flows in WRIA 34 have not been established at this time.

6.5 Water Rights by Sub-basin

Water rights were totaled for each of the 8 sub-basins. Table 6-6 presents total Qa for both groundwater and surface water applications, and rights and claims for each sub-basin. The Cow Creek Sub-basin has the highest Qa for both groundwater and surface water applications, totaling 20,835 AF/year and 8,352 AF/year, respectively. The surface water Qa for Cow Creek includes storage applications, totaling 8,340 AF/year. The Palouse River Sub-basin has the highest total Qa for both groundwater and surface water rights and claims, totaling 68,242 AF/yr and 408,185 AF/yr, respectively.

6.6 Cow Creek Adjudication

Surface water claims in the Cow Creek sub-basin were adjudicated in 1986 (State of Washington v. Bar U Ranch). The findings of the referee in the adjudication concerning water allocation are summarized as follows:

- 1 AF/yr was allocated for domestic and domestic stockwater use;
- 1 AF/yr was allocated for domestic supply and a lawn and garden;
- 2 AF/yr was allocated for domestic supply and a large lawn and garden;
- 0.5 AF/yr for stock watering;
- A duty of 3.6 AF/yr was used for crop irrigation; and
- 1 cfs was allocated for each 50 acres of irrigated land.

A total of 8,456 AF/yr was allocated in the Cow Creek adjudication. The distribution of water allocated in the Cow Creek adjudication is shown on Figure 6-7.

7.0 WATER QUALITY DATA

7.1 Background Issues

The water quality component of Watershed Planning within Washington State (RCW 90.82.090) is an optional component of the watershed planning process. The WRIA 34 Planning Unit decided that water quality considerations are important, thus this water quality component has been incorporated into the level 1 watershed assessment. The decision to incorporate water quality information into the WRIA 34 assessment was based on the opinion that water quality applies a direct and significant influence on the current and future availability of water in the Palouse Basin. Water of poor quality potentially constrains the availability of water for various designated uses throughout the watershed. For example:

- Total Maximum Daily Load (TMDL) efforts on the Palouse River system may affect future water availability if flows are currently insufficient to maintain water quality under current loading conditions. Figure 7-1 shows TMDL activity in WRIA 34.
- Water Quality impairments documented through the 303(d) listing under the Clean Water Act could affect water availability if further uses are shown to impair water quality. Figure 7-2 shows the location of 303(d) listed waterbodies in WRIA 34. The figure displays 303(d) listed waters[1]—polluted waters that require a TMDL (these water bodies are also known as Category 5 water bodies within the water quality assessment categories).

7.2 Objective and Level of Detail

Remaining consistent with the Watershed Planning guidelines for examining water quality, examination of available data was based on existing studies conducted by federal, state, and local entities. The review was focused on the degree to which legally established water quality standards are being met, including both Washington and Idaho portions of the watershed. The level of detail dedicated to this initial assessment was a compilation and review of existing data from selected parameters. Data gaps were also identified.

7.2.1 Parameter Selection

The predominant land use across the Palouse Basin is agriculture, and the urban landscape is relatively rural. Therefore, the parameters selected for review focused on key indicate parameters including water temperature, bacteria, nutrients and turbidity. These four parameters are most closely linked to water quality issues across the watershed that could be affected by agricultural practices and rural development. There are many additional parameters which evaluate surface water quality. However, by evaluating the four selected parameters, we can make inferences to their relationship with other parameters. For example, water temperature typically exhibits a negative correlation with dissolved oxygen—the higher the water temperature, the lower the instream dissolved oxygen. Another example may include the interdependent relationship of water temperature, nutrient inputs and pH levels. As water temperature accelerates in summer months with a corresponding accelerated level of nutrient input into the water body, algae and macrophyte growth accelerates. The process of

[1] The water quality standard is not attained. The waterbody is impaired or threatened for one or more designated uses by a pollutant(s), and requires a TMDL. This category constitutes the section 303(d) list of waters impaired or threatened by a pollutant(s) for which one or more TMDL(s) are needed.

excess algal and instream plant growth die-off and decay may contribute to elevated pH levels and decrease dissolved oxygen levels.

Using the same parameter selection rationale, the selection of ground water quality parameters included the review of nitrates and to a limited degree, pesticides.

7.3 Existing Data

Water quality data has been collected by numerous entities across the Palouse Basin. These agencies include:

- United States Geological Survey (USGS)
- United States Department of Agriculture Forest Service (USFS)
- Washington Department of Ecology (Ecology)
- Idaho Department of Environmental Quality (DEQ)
- Idaho Association of Conservation Districts (IASCD)
- Washington State University (WSU)
- University of Idaho (UI)
- City of Colfax, WA
- City of Pullman, WA
- City of Moscow, Idaho
- Adams Conservation District (CD)
- Palouse Conservation District (PCD)
- Palouse Rock Lake Conservation District (PRLCD)
- Latah Soil and Water Conservation District (LSWCD)

The listed entities typically follow standardized collection, analytical, and quality assurance/quality control protocols. The data is therefore considered relatively reliable. Many other entities than seen listed above have been involved in water quality data collection and analysis, including area schools and citizen groups. Although the data was insightful, the data sets were not used in this review unless their protocols were shown to be consistent with the agencies listed above.

7.3.1 Surface Water Quality

Water Temperature

Water temperature affects many aspects of aquatic ecology. Cold water fish species (both anadramous and resident) are particularly sensitive to increased temperature. Water quality temperature standards in the western states have been undergoing review and changes over the last several years. A recent guidance document issued by EPA Region 10 (2003) provides temperature criteria intended to protect bull trout, salmon, steelhead, and resident nonmigratory trouts. The EPA 2003 guidance document recommends the following criteria:

- 20°C (68°F) for migration protection of trout (applies to the summer maximum temperature). This criteria is for waters used almost exclusively for salmonid migration only during the summer and for waters that would naturally not be able to meet the 18 or 16°C rearing use goals.

- 13°C (55°F) for trout spawning, egg incubation, and fry emergence (applies, generally during the fall-winter-spring period). Dates are set to match the spawning through emergence window in each watershed; whereas the average window could be used to set the dates.

In Washington, water quality standards[2] are based on aquatic life uses that are designated categories of key species. The standards that all indigenous fish and nonfish aquatic species be protected in waters of the state in addition to the key species described in the standards. Where the dominant species under natural conditions would be temperature tolerant indigenous nonsalmonid species (for example dace, redside shiner, chiselmouth, sucker, and northern pikeminnow) the 7-day average of the daily maximum temperatures (7-DADMax)[3] is also set at 20°C (68°F). For trout rearing and migration, the 7-DADMax should not exceed 17.5°C (63.5°F).

In Idaho, water quality standards[4] for maximum water temperatures of cold water aquatic life are set at 22°C, with a maximum daily average of no greater than 19°C. Seasonal cold water standards (between the summer solstice and autumn equinox) are offset at 26°C or less as a daily maximum with a daily average of no greater than 23°C. Waters designated for warm water aquatic life have maximum temperature criteria of 33°C, with a maximum daily average not greater than 29°C.

Some long-term data are available for major tributaries across the watershed. In the North Fork Palouse River system, water temperature data sets collected by USGS and Ecology are available for the North Fork near Potlatch and at Palouse, respectively (Figures 7-3 and 7-5). Water temperatures exceeded 20°C during the summer months in nearly every year sampled.

The Palouse Conservation District (PCD) collected continuous water temperature data in 2001-2003 on the North Fork Palouse River mainstem and main tributaries. Water temperatures exceed the state standard for that system (20°C) during each year at all 6 mainstem stations and tributary stations of Clear, Cedar, and lower Silver Creeks. Upper Silver Creek was the only exception with temperatures below the standard throughout the summer months.

Several data sets exist for the South Fork Palouse River and Paradise Creek, gathered by Ecology, USGS, DEQ, IASCD, City of Moscow, and private individuals. All stations show water temperatures each summer above the state standards set for that system (20°C). Continuous recording stations are available for the Cow Creek system (Washington), monitored by the Adams Conservation District, and also show elevated summer water temperatures. The Rock Creek system and Cottonwood Creek system also have recent data sets gathered by PRLCD with results showing water temperatures over standards in summer months. Long-term data sets from USGS and Ecology (Figure 7-5) at the Palouse River station near Hooper confirm water temperature standards are exceeded in summer months, usually by late May through mid-September.

Little water temperature information is available from the Union Flat, Pine and Cottonwood Creek systems. And, very few data sets exist on the Palouse River mainstem between Colfax and Hooper, as well as in the Palouse River downstream of the Cow Creek confluence.

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[2] Water Quality Standards for Surface Waters of the State of Washington Chapter 173-201A WAC Amended July 1, 2003. Washington State Department of Ecology.

[3] The 7-DADMax is the arithmetic average of seven consecutive measures of daily maximum temperatures. The 7-DADMax for any individual day is calculated by averaging that day's daily maximum temperature with daily maximum temperatures of the three days prior and the three days after that date.

[4] IDAPA 58 Title 01 Chapter 02, 58.01.02–Water Quality Standards and Wastewater Treatment Requirements. 250 Surface Water Quality Criteria For Aquatic Life Use Designations.

Bacteria

Fecal coliform bacteria presence in significant numbers is indicative of possible human health risk due to fecal contamination by warm blooded animals. In Washington, fresh water quality standards for bacteria (surface water) are based on the designated use of the water body. Two categories of uses apply in the Palouse Basin and include primary and secondary contact recreation. Primary contact recreation means activities where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and water skiing. Secondary contact recreation means activities where a person's water contact would be limited (e.g. wading or fishing) to the extent that bacterial infections of eyes, ears, respiratory or digestive systems, or urogenital areas would normally be avoided.

The water quality standards in Washington are determined by the numerical evaluation of fecal coliform bacteria levels as follows:

- For primary contact recreation, fecal coliform organism levels must not exceed a geometric mean value of 100 colonies /100 mL, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 colonies /100 mL.
- For secondary contact recreation, fecal coliform organism levels must not exceed a geometric mean value of 200 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 400 colonies /100 mL.

Any stream that flows into a lake or into another class AA stream is classified as a AA (extraordinary waters) and therefore has a standard of 50 colonies /100 mL with not more than 10% exceeding 100 colonies /100 mL.

In Idaho, water quality standards are also based on the designated uses of primary and secondary contact recreation. The indicator organism used to measure fecal contamination presence is E.coli.

- For primary contact recreation, exceedances are measured by a single sample of 406 E.coli organisms per 100 mL, or a geometric mean of 126 E.coli organisms 100 mL based on a minimum of 5 samples taken every 3 to 5 days over a 30 day period.
- For secondary contact recreation, exceedances are measured by a single sample of 576 E.coli organisms per 100 mL, or a geometric mean of 126 E.coli organisms per 100 mL based on a minimum of 5 samples taken every 3 to 5 days over a 30 day period.

The Idaho portion of the North Fork Palouse River tributaries showed bacteria levels exceeding Idaho state standards at each of the stations sampled in the 2002 water year survey. Data collected by USGS from the North Fork near Potlatch from 1989-1993 and 1997 -2002 indicate Washington state standards are exceeded at sampling points throughout the monitoring years. Data collected by Ecology from 1974-1975 and 1992-2003 in the North Fork Palouse River at Palouse shows fecal coliform bacteria standards (100 colonies/100 mL) were exceeded in every sampled water year.

Several data sets also exist for the South Fork Palouse River system and major tributary of Paradise Creek. The long-term data set of Ecology of the South Fork at Pullman shows standards exceeded in each water year sampled (200 colonies/100 mL), including 1974-1975, 1978-1993, and 1995-2003.

The Cow Creek data sets include 1997 through 2003 and indicate bacteria exceedances throughout each of the years throughout the watershed. The data were collected by ACD. Limited bacteria information is available from the Union Flat, Pine and Cottonwood Creek systems. The Palouse River mainstem between Colfax and Hooper, as well as in the Palouse River downstream of the Cow Creek confluence, also have limited data sets. The Ecology data set of the Palouse River near Hooper (Figure 7-4), is similar to the other monitoring results throughout the watershed—fecal coliform results exceed state standards in the majority of the sampled years. Exceedances appear at nearly any month, without a specific pattern showing seasonality.

Nutrients

Nutrient levels specifically nitrate nitrogen and phosphorus levels, are not listed in either the Washington or Idaho surface water quality standards. Instead, it is customary to default to the federal standards set by United States Environmental Protection Agency (EPA). The standards, currently under revision, were established in a 1976 publication of EPA's Quality Criteria for Water. Nitrogen, and associated compounds, act like fertilizer in the garden—high levels in the water body can result in aggressive and excessive plant and algae growth. The process of growth, die-off and decomposition can in turn cause wide fluctuations in dissolved oxygen and pH levels. The nutrient most often limiting production in freshwater aquatic systems is phosphorus. In other words, when there is a very limited amount of phosphorus in the water body, plant growth is limited.

Nutrients come from a variety of sources. Most commonly, nitrogen compounds can originate from fertilizer in the urban, rural and agricultural settings. Fertilizers not utilized by crop and plant uptake can leach, or move downward, within the soil profile. They also run off the land with overland flows. Nitrogen is utilized by plant life during the growing season. Therefore, nitrogen levels in the water can be elevated in winter months when little plant growth occurs.

Phosphorus also may originate from fertilizer. Although not as free to leach, it can travel to a surface water supply by attachment to soil particles that erode from the uplands. Phosphorus is also found in human and animal waste, and can be present in the background geology of the area. The federal surface water standards for these commonly measured nutrients are:

- Nitrate nitrogen <0.30 mg/L.
- Total Phosphorus <0.10 mg/L (for streams or rivers not discharging directly into lakes or reservoirs).

Nitrogen

Long-term and complete data sets were available for the North Fork Palouse River, South Fork Palouse River, Palouse River near Hooper and Cow Creek. Cow Creek (Idaho), Union Flat, Pine, Cottonwood, and Rock Creeks (Washington), Cow Creek (Washington) above the Sprague Lake, the Palouse River between Colfax and Hooper, and the Palouse River below the Cow Creek confluence had incomplete data sets, or no test results were available.

The Idaho portion of the North Fork Palouse River tributaries showed elevated nitrate-nitrite levels in December through March at each of the stations sampled in the 2002 water year survey. Data collected by Ecology from 1991 through 2003 in the North Fork Palouse River at Palouse showed elevated nitrate-nitrite levels (>.30 mg/L) occurring primarily in the months of February (Figure 7-5). Another long-term set of data (1977-1980 and 1988 -2002) collected by Ecology from the South Fork of the Palouse River at Pullman also shows concentrations exceeding standards throughout the year, with highest concentrations occurring in the winter and late spring months (Figure 7-6).

Data collected by the Adams CD in Cow Creek (Washington) at multiple stations throughout the sub-basin below Sprague Lake station since 1997 shows nitrate standards (.30 mg/L) exceeded at all stations across the watershed. Most stations in most years exhibit the highest concentrations in the early winter months.

The long-term set of data (1978-1980 and 1988-2003) collected by Ecology from the Palouse River near Hooper (above the confluence of Cow Creek) shows elevations in nitrate-nitrite levels across the months, with highest concentrations occurring in the winter months (Figure 7-7). The National Water Quality Assessment (NAQWA) encompassing the central Columbia Plateau area, (USGS, 1994) claims, “Sites with the highest summertime concentrations (of nitrate) include the wastewater-dominated South Fork of the Palouse River in the Palouse subunit and several irrigated streams in the Quincy-Pasco subunit.” Figure 7-8 is one of several illustrative figures that show where elevated nitrogen levels were detected in the Palouse Basin portion Appendix F contains others. Note that inorganic nitrogen includes nitrate-nitrite and ammonia compounds and is the nitrogen form available for plant uptake.

The USGS NAWQA’s analysis of 25 years of data (beginning in 1965) of the Palouse River near Hooper claims, “Concentrations of nitrate in the Palouse River have not changed significantly since 1965, which reflects the consistent land use (dryland agriculture) over time.” In test results collected and reviewed, nitrate concentrations throughout the sampling areas show the standard of .30 mg/L is exceed throughout the course of the year with the highest concentrations occurring in the winter and early spring months.

Phosphorus

Long-term and complete data sets for phosphorous were available from the North Fork Palouse River, South Fork Palouse River, Palouse River near Hooper and Cow Creek. Cow Creek (Idaho), Union Flat, Pine, Cottonwood, and Rock Creeks (Washington), Cow Creek (Washington) above the Sprague Lake, the Palouse River between Colfax and Hooper, and the Palouse River below the Cow Creek confluence had incomplete data sets, or no test results were available.

Total phosphorus, a measure of all the forms of phosphorus including dissolved or particulate, is often the chemical form reported. The Idaho portion of the North Fork Palouse River (NFPR) tributaries showed elevated total phosphorus levels at each of the stations sampled in the 2002 water year survey. Long-term data sets from the NFPR near Potlatch (Figure 7-11) and the North Fork Palouse River at Palouse (Figure 7-12) show total phosphorus concentrations exceeding standards (10 mg/L).

In comparison, Ecology monitoring in the South Fork Palouse River from 1970 through 2000 (Figure 7-11) shows total phosphorus standards exceeded many fold with concentrations staying elevated throughout the seasons.

Data collected by the Adams CD in Cow Creek (Washington) since 1997 shows total phosphorus standards (10 mg/L) exceeded at all stations across the watershed (data collected from the Sprague Lake outlet to the mouth at the Palouse River).

The long-term set of data (1970-1972 and 1973-2000) collected by Ecology from the Palouse River near Hooper (above the confluence of Cow Creek) shows total phosphorus levels exceed standards across all months (Figure 7-12).

The USGS NAQWA Study (USGS 1994) of the Palouse River system, claimed that, “Discharge of treated wastewater during summer low flow elevates concentrations of phosphorus. During the summer, plants in the South Fork (Palouse River) increase to excessive amounts. Nitrogen is reduced in the lower river because of uptake by these aquatic plants whereas phosphorus concentrations are greater than what is required by plants, so concentrations in water remain high. The high phosphorus can be due to low oxygen conditions during the summer, which cause sediments to release phosphorus.”

Several lakes within the sub-basin are listed as Category 2 (waters of concern)[5] on the Washington Water Quality Assessment. Washington’s water quality standards for surface waters cites recommended nutrient criteria for lakes found in the According to data collected by Sumioka and Dion (1985)[6] water quality standards for the nutrient criterion was exceeded in the following lakes: Alkali (Miller), Alkali (Pines), Alkali, Ames, Bonnie, Cow, Crooked Knee, Downs, Feustal, Finnel, Fishtrap, Folsom, Fourth of July, Granite, Green, Hallin, Hog (Hog Canyon), Lavista, Mason, Medical, Negro, Otter, Palm, Philleo, Ring, Rock, Sheep, Sprague, Stevens, Texas, Twelve Mile, Twelve-Mile Slough, and Willow Lakes.

Turbidity

Turbidity is a measure of the clarity of the water. High turbidities can affect sight-feeding organisms, including fish, and may be indicative of watershed disturbance. High concentrations of particulate matter can cause increased sedimentation and siltation in a stream, which in turn can ruin important habitat areas for fish and other aquatic life. Suspended particles also provide attachment places for other pollutants, such as metals and bacteria. Turbidity standards have replaced total suspended solids—the weight to volume measurement often used in watershed monitoring. Both states set surface water quality standards for turbidity which is measure and recorded in nephelometric[7] turbidity units, or NTUs.

- In Washington, the aquatic life turbidity criteria for trout spawning is <5 NTU over background when the background is 50 NTU or less; or a 10% increase in turbidity when the background turbidity is more than 50 NTU.
- The aquatic life turbidity criteria for indigenous warm water species is <10 NTU over background when the background is 50 NTU or less; or a 20% increase in turbidity when the background turbidity is more than 50 NTU.
- In Idaho for cold water aquatic life (and other aquatic life designations), turbidity shall not exceed background turbidity by more than 50 NTU instantaneously or more than 25 NTU for more than 10 consecutive days.

The available monitoring data includes instantaneous sampling from areas across the watershed. The North Fork Palouse River tributaries in Idaho show average turbidity levels below 50 NTU in the 2002 water year, with the exception of Deep Creek, which shows average turbidity greater than

5 Category 2 - Attaining some of the designated uses; no use is threatened; and insufficient or no data and information is available to determine if the remaining uses are attained or threatened.

6 Sumioka, S. S., and N. P. Dion. 1985. Trophic classification of Washington lakes using reconnaissance data. Washington State Department of Ecology Water-Supply Bulliten 57.

7 A nephelometer is an apparatus for measuring the size and concentrations of particles in a liquid by analysis of light transmitted through or reflected by the liquid.

100 NTU. Turbidity levels in the long-term data sets from the North Fork Palouse River (USGS) near Potlatch and at Palouse (Ecology) yield average turbidity of less than 50 NTU.

The South Fork Palouse River in Idaho and the South Fork at Pullman (USGS) data shows turbidity levels around 50 NTU across the monitoring periods. Cow Creek (Washington) was sampled by ACD and also show 50 NTU as an approximate average throughout the monitoring periods and throughout the watershed. USGS data from the Palouse River near Hooper shows the majority of the turbidity readings below 100 NTU, illustrated in Figure 7-15.

The USGS data sets from the South Fork Palouse River near Pullman and the Palouse River near Hooper are the longest duration sampling periods for turbidity compared to other monitoring sets across the Palouse Basin. Other areas contain either little data, short-term sampling durations, or no data available.

Background turbidity for the stations monitored has not been determined. Therefore, because turbidity standard violations are evaluated in comparison to background information, it is not possible to determine whether results are high, low, or average.

7.3.2 Ground Water Quality

Ground water quality, for the purpose of this segment, is referring to the quality of drinking water from a public health perspective. A common measurement made in ground water is the nitrate nitrogen parameter. Many other inorganic chemicals, organic compounds, and other parameters are sampled, analyzed and studied for site specific studies. Nitrates may reach ground water supplies from fertilizer use, leaching from septic tanks, sewage, and erosion of natural deposits. High nitrate concentrations may be indicators of other potential ground water contamination. Infants below the age of six months who drink water containing nitrate in excess of the maximum contaminant level (MCL) could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome. A ground water quality standard for drinking water is set by EPA as a MCL of 10 mg/L nitrate.

Most of the long-term nutrient data found in and to the west of the Palouse Basin was generated by USGS NAQWA efforts. A report, *Nitrate Concentrations in Ground Water of the Central Columbia Plateau* (1997) by USGS, is an overview of nitrate concentrations in the Central Columbia Plateau. The sampling of 573 wells included 30 on the Palouse. Results indicated that land practices are the dominant influence over the distribution and concentration of nitrate in ground water. In the Palouse samples, nitrate concentrations were as follows: 46% of wells had concentrations less than 1.0 mg/L; 19% had concentrations from 1.1 to 3.0 mg/L; 29% had concentrations from 3.1 to 9.9 mg/L; and 6% had concentrations over 10 mg/L (i.e. above the MCL).

Water Quality in the Central Columbia Plateau, Washington and Idaho (1992-95) by USGS discusses the major issues—nitrates, pesticides, sediment, nutrients—related to water quality in the Central Columbia Plateau. Overall, about 20% of wells in this study unit exceed the EPA MCL for nitrate in drinking water. However, the Palouse sub-unit, which is dominated by non-irrigated agriculture, has generally lower nitrate concentrations than the rest of the study unit. The percentage of drinking water wells with nitrate concentrations exceeding the MCL of 10 mg/L is as follows: Adams County, 3% of Class A public supply wells; 25% of Class B public supply wells and insufficient data on shallow domestic wells; Whitman County, 7% Class A public supply wells; 4% Class B public supply wells and 6% shallow domestic wells. The report concludes that nitrate concentrations in groundwater have generally increased since 1950s and continue to increase in most areas. Regarding pesticides, none of the commonly used pesticides were detected in groundwater in wells in the Palouse subunit.

A *Report on Nitrate Contamination of Ground Water in the mid-Columbia Basin* (1996) by the Washington State Interagency Ground Water Committee describes findings of an assessment of nitrate contamination of ground water in Adams, Benton, Franklin, Grant, Lincoln and Whitman counties. Conducted by Washington Departments of Agriculture, Ecology and Health, findings suggest that of the 76 wells sampled in Whitman County, 29 (63%) had average nitrate-nitrogen concentrations at or below 5 mg/L; 14 (30%) had concentrations below 10 mg/L; and 3 (7%) had concentrations over 10 mg/L. Only 2 wells from the Adams County area were within the Palouse Basin.

The *Analysis of Nitrate Concentration Trends in 25 Ground Water Quality Management Areas, Idaho 1961-2001*, conducted by the USGS in cooperation with IDEQ, summarizes nitrate trends based on data compiled and assessed from 2,931 wells in 25 priority areas. Analyses dates ranged from June 1961 to Feb 2001. The Genesee/Cow Creek area was included as a priority area. Eleven analyses were conducted from 3 wells and nitrate concentrations were under 10 mg/L. The report notes insufficient data to determine long-term trends (decades) or short-term trends (selected years) for the Genesee/Cow Creek area.

Water-Quality Assessment of the Central Columbia Plateau in Washington and Idaho--Analysis of Available Nutrient and Pesticide Data for Ground Water, 1942-92, conducted by USGS, included 89 wells sampled in the Palouse subunit, with a median nitrate concentration of 1.2 mg/L. Only 6% of samples exceeded 10 mg/L. Pesticides were detected in two wells in Whitman County.

Moscow Basin Ground Water Quality Study, North Central Idaho (1995), conducted by IDEQ, evaluated ground water quality in the shallow and deep ground water systems of the Moscow basin. There were 28 wells of different depths sampled with detections of pesticides in the samples. Elevated nitrates were detected in some wells, and 4 sites had nitrate concentrations in excess of 5 mg/L. The highest concentration of nitrate (16 mg/L) occurred in the shallowest well (16 feet depth). Background nitrate concentrations were determined to be 0.005 mg/L.

Nitrate Loading of Underground Water: A Time Based Evaluation of Nitrate Concentration Changes in Private Wells of Whitman County, Washington (1993) is a study conducted by WSU Cooperative Extension. The objective of the study was to evaluate changes in nitrate concentration levels over time in private ground water sources in Whitman County. Included in the study were 110 wells. Nitrate levels declined over the mean sampling period of 14.72 years with a drop of 1.86 mg/L nitrate concentrations. Most of the wells with elevated nitrate levels (23 wells, or 21% containing nitrate levels at 10 mg/L or higher) lacked well-head protection practices.

A *Reconnaissance of Ground Water Nitrite/Nitrate in the Cow Creek Watershed, Latah & Nez Perce County, Idaho* (2001) was conducted by IDEQ. The goal of this study was to assess ground water nitrate concentrations in the Cow Creek watershed. Of the 38 sample sites, 66% had concentrations lower than 2 mg/L; 5% had concentrations of 2 –5 mg/L; 18% had concentrations of 5-10 mg/L; and 11 % had concentrations greater than the MCL of 10 mg/L. Of the 4 sites that exceeded the MCL, one was from a well and the other 3 were from springs. The 18% with concentrations of 5-10 are a concern since these sites may be at risk.

The Genesee/Cow Creek area is included in the top 25-nitrate degraded areas in the state and is ranked as the 23rd priority area (*State of Idaho, Nitrate Priority Ranking*). The ranking is based on three wells, which were sampled 1999/2000; two (67%) had nitrate concentrations between 5-9.99 mg/L and 1 had concentrations less than 2 mg/L. No samples exceeded the MCL of 10 mg/L.

Pesticides and Volatile Organic Compounds in Ground and Surface Water of the Palouse Subunit, Washington and Idaho (1996) conducted by USGS, investigated the potential effects of dryland farming of wheat and small grains on water quality (surface and ground water). For the ground water analysis, samples were taken from 53 wells (15 shallow monitoring wells and 38 public supply/domestic wells) between 1993 and 1995 and analyzed for 84 pesticides. Pesticides were detected in 25% of the groundwater samples, but did not exceed drinking water standards or guidelines. None of the pesticides analyzed for and commonly used in the area were detected in ground water.

The USGS fact sheet, *Pesticides in Public Supply Wells of the Central Columbia Plateau*, (1996), summarizes results from USGS sampling of wells in the Central Columbia Plateau, 302 wells were analyzed in 1994 in conjunction with Washington Department of Health. This included wells in Whitman and Adams counties. Seventeen wells (10 in Adams, 7 in Whitman) were sampled with no pesticides detected; 14 wells (4 in Adams, 10 in Whitman) were sampled with pesticides detected. No pesticides were detected at concentrations exceeding EPA drinking water standards. Shallow wells had the highest rate of detections and elevated nitrate levels.

City of Moscow collected well water data from several years and included results from many parameters including: polychlorinated biphenyl's (PCBs), herbicides, organochlorine insecticides, organo phosphates, water chemistry (inorganics including iron, manganese, zinc, etc.), radiological, trihalomethanes, and volatile organic chemicals (VOCs).

8.0 COW CREEK SUB-BASIN

Cow Creek encompasses about 473,000 acres and includes the entire western boundary between WRIA 34 and WRIA 43 (Crab Creek). The upper Cow Creek Sub-basin includes a confined "finger" of the watershed between Medical Lake and Cheney. This portion of the watershed shares a watershed boundary with the Latah (Hangman) Watershed (WRIA 56).

Over 50% of the land-cover in the sub-basin is designated as "shrubland". However, this sub-basin contains the largest acreage of "open-water" (over 7,000 acres) and the largest acreage of commercial/industrial (over 6,000 acres) in WRIA 34.

A description of the watershed is provided below, organized into Upper, Middle, and Lower classifications.

8.1 Upper Cow Creek Sub-Basin

The uppermost portion of the Cow Creek sub-basin includes the relatively developed area along the I-90 Corridor near Cheney, and a mostly undeveloped area surrounding Turnbull Wildlife Refuge. The City of Cheney itself is not part of WRIA 34, but developed areas associated with Cheney do extend into WRIA 34. A portion of Fairchild Airforce Base also extends into WRIA 34.

8.1.1 Hydraulic Continuity

The upper Cow Creek sub-basin contains an extensive and complex series of drained and active wetlands. Based on the National Wetland Inventory (NWI) database, a total of 22,377 acres of active wetlands and 2,925 acres of drained wetlands exist in the upper Cow Creek sub-basin. The location and total area of drained wetlands in the upper Cow Creek sub-basin were determined using qualifiers assigned to the wetland types in the NWI database. All other wetlands were considered active for the purposes of this assessment. Drained wetlands are assigned a "d" qualifier in the NWI database. The database includes a variety of qualifiers that were not included as part of this assessment. Figure 8-1 shows the extent of mapped active and drained wetlands based on the NWI inventory.

The US Fish and Wildlife Service manages the Turnbull National Wildlife Refuge, which encompasses over 20 square miles of wetland habitat, and was established in the early 1930's as a "refuge and breeding ground for migratory birds and other wildlife." (Executive Order 7681 July 30, 1937) and "...for use as an inviolate sanctuary, or for any other purpose for migratory birds" (Migratory Bird Conservation Act). Private (predominantly agricultural) lands were acquired within the approved refuge boundary and over 65 homesteads were removed, including over 100 structures and hundreds of miles of fences. To restore the wetlands, drainages ditches were plugged with water control structures and farm fields and pastures were re-seeded. Enhancement of wetlands has occurred by deepening (by excavation), ditch cleaning, water control structure replacement, and nesting island construction. A total of 22 wetlands are managed with water control structures at various "objective levels" to sustain and enhance the wetlands in the refuge. Water levels in managed wetlands are monitored throughout the year. Detailed contour maps of these wetlands are proposed so that models can be developed to predict wetland vegetation growth to determine optimum water management levels over the long-term. Figures 8-2 is a map of the Turnbull wetland complex, showing the names and locations of the various wetland lakes and the location of control structures used to manage water levels. Figure 8-3 contains example photos of wetland areas and control structures.

Drainage patterns in the upper sub-basin converge to the southwest, toward the town of Sprague. These drainage patterns are partly related to geologic conditions, which allowed a large "floodway" to exist between the Spokane and Columbia River drainages, via the western portion of the Palouse Basin. This converging drainage pattern contributes to recurring flooding problems in the Town of Sprague. The U.S. Army Corps of Engineers conducted a study of flooding in the Town of Sprague (Rex Harder, 10/11/2004, personal communication). However, useful technical information related to this work could not be obtained, despite repeated contact with the USACOE and a consultant associated the work.

Hydraulic continuity in the upper portion of the sub-basin is significant in that the extensive wetland areas are highly interconnected with shallow groundwater regime:

- The visible "surface waters" of the wetlands essentially provide a widely dispersed but interconnected natural water storage area. As shown on Figure 8-2, channels between the wetlands connect these water features over many miles. Water is stored in the surface depressions and slowly released into the underlying groundwater and to downstream areas of Cow Creek.
- Beneath these wetlands, sub-surface shallow groundwater undoubtedly connects the wetlands to each other and to deeper portions of the groundwater flow system.

Hydraulic continuity is generally approached from both a sub-surface/hydrogeologic perspective and a surface/streamflow perspective. Each is discussed below.

8.1.2 Upper Cow Creek Hydrogeologic Cross Sections

Figures 8-4 and 8-5 show the associated wells on file with WDOE. Well logs were reviewed and portrayed on two cross-sections to show the sub-surface geologic conditions. The cross-sections are provided in Appendix G.

8.1.3 Upper Cow Creek Streamflow Patterns

The cumulative effect of hydraulic continuity (infiltration, run-off, storage, and release) patterns in the upper watershed would be reflected in streamflow patterns on Cow Creek above Sprague Lake. However, there are no continuous flow records for Cow Creek above Sprague Lake. Therefore it is not possible to evaluate baseflow recession characteristics or other data that would describe groundwater interactions. Water-level monitoring at Turnbull Wildlife Refuge provides some limited insight into conditions, but actual water level data was not available for this assessment. Figure 8-6 shows a record of summer water-levels in the wetlands since 1994 provided by Turnbull Wildlife Refuge (Mike Rule, 10/27/2004, personal communication). It is a 3-dimensional plot showing, for the month of May in each year, the percentage of wetlands achieving various water depths, ranging from "full" to "dry". In 1994 (a drought year), water-depths were generally low, trending toward the "dry" end of the axis. Between 1995 and 1999, water-depths were generally higher, trending toward the "full" end of the axis. Since 1999, water-depths have been more varied, staying in the middle regions between "full" and "dry". This plot indicates that the wetlands respond to annual climate. The years with the lowest (driest) water levels in the wetlands are 1994, 2001, and 2004, which also correspond to the lowest precipitation years and the lowest mean annual flows for the Palouse River at Hooper. The relationship between early summer storage (May) and late season storage (August/September) cannot be determined with the available data. This type of information might provide some insight into groundwater infiltration rates. The extent of any connections between groundwater and surface water is therefore likely both complex and very site specific. However, storage and hydraulic continuity processes that are taking place in these wetlands, will likely be highly seasonal in nature. The available data do not suggest that there is significant "carry over" storage in the wetlands that would offset drought conditions.

Since the available data are portrayed as a single "snapshot" in the summer, the potential effects of wetland storage on seasonal fluctuations in groundwater level or surface water flow cannot be examined. This may be an area of investigation for the supplemental storage assessment.

8.2 Middle Cow Creek Sub-Basin

The middle portion of the Cow Creek sub-basin includes Sprague Lake and several small tributaries that enter from the western edge of the watershed. For this discussion, the middle segment of the Cow Creek sub-basin extends from Sprague Lake south to below the Cow Creek dam.

8.2.1 Hydraulic Continuity

The topography of the Sprague Lake area is broad and relatively flat. Sprague Lake covers about 1,900 acres and has a control structure that consists of flashboards that provide some ability to manage lake levels.

Below Sprague Lake, flows move into Cow Lake and several other small pond features. Also, an important spring (Loganville Spring) is located below Sprague Lake, which provides additional flow to this segment of Cow Creek.

Hydraulic continuity in the middle portion of the sub-basin is potentially significant. Seepage from Sprague Lake, combined with inflows and outflows of water between Cow Creek and the underlying basalts and flood gravels provides a high degree of interconnection between surface water and shallow groundwater regime. Sprague Lake is a relatively constant water feature, but surface flows elsewhere in this segment of the sub-basin are quite variable. Flows from springs, and impoundment of water at Sheep Springs and Hog Canyon dams creates a variety of surface water regimes which are interconnected along Cow Creek over many miles. Figures 8-7a-e show photographs of various features in Middle Cow Creek. The presence of flood gravels in this portion of the sub-basin suggests that, where present, the underlying shallow aquifer would be highly permeable and expected to fluctuate closely with surface water fluctuation.

Similar to the upper portion of the sub-basin, hydraulic continuity is described from both a sub-surface/hydrogeologic perspective and a surface/streamflow perspective below.

8.2.2 Middle Cow Creek Hydrogeologic Cross Sections

Figures 8-4 and 8-5 show the middle portion of Cow Creek and associated wells on file with WDOE. Well logs were reviewed and portrayed on cross-sections to show the sub-surface geologic conditions. The cross-sections are provided in Appendix G.

8.2.3 Middle Cow Creek Streamflow Patterns

As described in Section 2, long-term water-level fluctuations on Sprague Lake are available, but not in an electronic format, so a detailed quantitative analysis of the data was not conducted. Similarly, streamflows on Cow Creek in this area are not well documented. The most complete record of stream levels only covers two years (during 2001-2002) and has not been translated into a flow record by a rating curve. Handwritten records of lake levels were obtained from the USGS for the period 1960-1979.

The Washington Department of Ecology conducted some limited investigations of the control structure at Sprague Lake in 2003. Some basic topographic data was collected, including a profile of the stream channel below the flashboards and several stream cross-sections. This information was used in a preliminary modeling assessment using HEC-RAS to investigate how the outflow from the lake moves through the channel below the lake. A rating curve that relates lake level to outflow was also developed from the model (Figure 8-8). For this assessment this information was combined with the handwritten USGS lake level data from 1960 to 1979 to examine relationships between Sprague Lake Levels and stream flows below Sprague Lake.

Seepage for Sprague Lake is a potentially significant component of hydraulic continuity in this portion of the sub-basin. Seepage of water out of the lower section of the lake into the groundwater is likely, but not documented in existing studies. As a preliminary assessment of the contribution of Sprague Lake to downstream flows in the summer, data from the first day of April, August and October was taken from the handwritten records between 1960 and 1979 provided by the USGS. Figure 8-9 shows the recorded lake levels over this period. Maximum lake level in the spring varies from elevation 1877 to 1881. Minimum lake level during October ranges from 1875 to 1878. Lake levels reflect climate patterns, with the lowest levels recorded during 1966, 1973 and 1977, all very dry years.

Between 1960 and 1979, the average drop in lake level between August and October is about 0.7 feet. The average August lake elevation over this period is 1,877.4 feet. Assuming a lake surface area of 1,900 acres, this amount of water level drop is equivalent to about 1,350 acre-feet of water. As a flow rate, this is equivalent to about 11 cfs over 60 days (August through October). Based on the rating curve for the lake developed recently by WDOE, a lake level of 1877.4 would produce 6 cfs over the flashboards. The difference between the equivalent flow rate based on water-level drop of 0.7 feet (11 cfs) and the expected flow rate out of the lake at the 1877.4 elevation (6 cfs) equal 5 cfs, and represents an estimate of groundwater seepage which does not pass over the flashboards. Therefore, lake seepage appears to be significant and possibly worthy of further investigation. This seepage could be, at least in part, contributing to flows from springs below Sprague Lake. However, additional investigation would be necessary to determine this.

8.3 Lower Cow Creek

The lower portion of the sub-basin consists of mostly dry "scabland" terrain. The section of the sub-basin includes a portion of the Odessa Groundwater Sub-Area, which is a heavily managed portion of the Columbia Plateau Basalt Aquifer system. Issues related to this deeper groundwater system include how well the Odessa Aquifer is mapped into this area of the aquifer and whether it is affected by the regional water-level declines. Additionally, there are known deep wells that are not cased and therefore exposed to both the shallow and deep aquifer systems.

8.3.1 Hydraulic Continuity

Hydraulic continuity in the middle portion of the sub-basin may be significant. Inflows and outflows of water between Cow Creek and the underlying flood gravels could provide a high degree of interconnection between surface water and shallow groundwater regime. In addition, the influence of regional flow patterns in the Columbia River Basalt system could be more significant as groundwater flows toward the more regional discharge boundaries along the Snake and Columbia Rivers

Similar to the upper portion of the sub-basin, hydraulic continuity is described from both a sub-surface/hydrogeologic perspective and a surface/streamflow perspective below.

8.3.2 Hydrogeologic Cross Sections

Figures 8-4 and 8-5 shows the lower portion of Cow Creek and associated wells on file with WDOE. Well logs were reviewed and portrayed on cross-sections to show the sub-surface geologic conditions. The cross-sections are provided in Appendix G.

8.3.3 Streamflow Patterns

The cumulative effect of hydraulic continuity (infiltration, run-off, storage, and release) patterns in the middle and lower watershed (between Sprague Lake and Hooper) should be reflected in streamflow patterns on Cow Creek at Hooper. USGS Streamflow data in Cow Creek at Hooper is available for the period 1965-1970. Figure 8-10 shows streamflow in Cow Creek at Hooper between 1965 and 1970, along with selected flows out of Sprague Lake estimated using the WDOE rating curve and 1960-1980 USGS lake levels. Although the period of record is limited, the following observations may provide some initial insight into surface water groundwater interactions in the lower Cow Creek sub-basin.

1. Peak flows at Hooper do appear to correlate with April flows out of Sprague Lake. Although the available data set only spans 6 years, flows of 40 cfs or more out of Sprague Lake appear to produce flows in excess of 100 cfs at Hooper, while flows of less than 20 cfs produce flows of 30-40 cfs.
2. August flows at Hooper do not appear to show a strong correlation with flows out of the Sprague Lake outlet channel. Zero flow conditions at Hooper are observed in 1966, 1967, and 1968, when flows out of Sprague Lake flows were between 2.3 and 7.9 cfs. Flows of 3 to 10 cfs were observed at Hooper in 1965, 1969, and 1970, when flows out of Sprague Lake flows were between 5 and 10 cfs.
3. The rate of decline in the hydrograph during the initial peak flow recession is very similar for all years of record. However, when flow reach a level of about 10 cfs (usually in early August) flows decline at a greater rate, and commonly decrease to zero.

8.3.4 Groundwater Levels

Three groundwater wells in the lower Cow Creek sub-basin have water-level records extending over a period of years in the 1960-1970 era. The location of these wells is shown on Figure 8-5. Figure 8-11 shows the groundwater level fluctuations for these wells. Similar to the streamflow analysis, the period of record is limited, but the following observations may provide some initial insight into groundwater conditions in the lower Cow Creek sub-basin:

- The well near Cow Lake is a relatively shallow well (88 feet), completed in Wanapum basalt. Summer water levels appear to progressively decline between 1965 and 1968. 1965 was a relatively wet year, and Cow Creek flowed all year. 1966 – 1968 were relatively dry (lower peak flows and zero late summer flows). In this case, the groundwater appears to mirror surface climate conditions.
- The well near Sheep Spring is also a relatively shallow well (102 feet), completed in Wanapum basalt. Groundwater levels are relatively constant between 1965 and 1968 and

then increase significantly during the winter of 1968. This shift cannot be explained and may be a data error. However, the lack of seasonal fluctuation in this well suggests that the groundwater in this area is not significantly affected by climate or streamflow conditions.

- The well near Hooper is a deep well (473 feet) completed in Grand Ronde basalt. Water levels in this well are near ground surface, indicating upward hydraulic gradients, consistent with an increasing influence of a regional discharge boundary (Snake or Columbia River) for the Grand Ronde aquifer. Summer water levels progressively decline between 1965 and 1968, increase in 1969 and progressively decline until 1973. 1969 was a wet year, which could partially explain the rebound in groundwater levels. In 1969, a year in which Cow Creek flowed at 10 cfs during August, relatively high groundwater levels were observed all year. The magnitude of seasonal fluctuation also decreased in 1969 from about 15 feet during 1965-1968 to about 5 feet. This seasonal fluctuation likely represents changes in irrigation pumping amounts in the vicinity of the well. While it is possible that higher groundwater levels and less pumpage in 1969 contributed to higher summer streamflows in Cow Creek that year, additional analysis or modeling would be necessary to substantiate this.

8.4 Cow Creek Water Rights

Table 8-1 summarizes water rights in the Cow Creek sub-basin

The Turnbull Wildlife Refuge has individual water right claims for all major wetlands, which were acquired when the properties were purchased. Five water right claims in the Cow Creek Drainage were confirmed with a June 30, 1914 priority date during a 1988 adjudication in Adams County. The purpose of use for these claims includes "wildlife refuge management", irrigation, stock watering, and recreational purposes. In analyzing the WRATs database, most of these water rights are classified with an irrigation purpose of use.

Cow Creek accounts for over 40% of the total groundwater irrigation rights in WRIA 34 (excluding claims), and about 13% of the total groundwater municipal/domestic rights. As a portion of total surface water rights in WRIA 34, Cow Creek has virtually no surface water allocation that has not been adjudicated.

As an equivalent flow rate, adjudicated surface water irrigation rights in the Cow Creek sub-basin exceed 15 cfs. Groundwater certificates and permits exceed 70 cfs as an equivalent flow rate. The proportion of these flow rates that could be directly attributable to lower stream flows in Cow Creek cannot be determined with existing data, but clearly some reduction in stream flows can be attributed to existing water rights. Given the large allocation of water rights in comparison to flows in Cow Creek it is likely that setting instream flows on Cow Creek would limit, and possibly eliminate, future additional consumptive use in the watershed. Water storage is probably the only means to support future consumptive use, and may be useful to better manage existing consumptive uses.

Key issues related to the adjudication of rights in Cow Creek and the regulation of Sprague Lake are described in a summary prepared by Scott Haugen (12/15/02) and a response by WDOE (1/14/02). This information is provided in Appendix G. This correspondence was in regard to storage rights in Sprague Lake, and describes two important flow related conditions in the adjudication. According to WDOE, *"the presiding superior right to waters of the lake is the stockwater flow established as 0.5 cubic feet per second at the old US Highway No. 10, now known as Wellsandt Road and the flow of 1.0 cfs at the outlet of Cow Lake. Water must flow into Cow Lake in a sufficient quantity to allow* *filling of the lake to provide the 1.0 cfs flow."* These are in effect, default in-stream flow requirements specified in the adjudication. However, there is some ambiguity in how lake levels may or may not support those flows during drought periods and how WDOE regulates lake levels when necessary to provide for the senior stock watering flows at Cow Lake. Lake levels themselves were not established by decree and do not have priority date, but there are agreements to communicate between affected parties when lake levels are adjusted.

Issues related to the adjudication of rights in Cow Creek and the regulation of flows in Turnbull Wildlife Refuge are described in the Report of Referee (No. 13538). The adjudication resulted in the following allocations:

1. Upper Turnbull East Tritt Lake : 1,571 AF, 8.6 cfs
2. Lower Turnbull Lake and Ballinger Meadow: 2,446 AF, 13.4 cfs
3. Long Lake : Not considered (outside of Cow Creek drainage)
4. Hales Lake, Shafer Marsh and Wade Meadow: 948 AF, 5.2 cfs
5. Campbell Lake and Lasher Lake, and Cossalman Lake:
6. West Tritt Lake, and Findley Lake: 1,292 AF, 7.1 cfs

The referee acknowledges that while water rights for wildlife refuge purposes exist, quantification of those rights "does pose somewhat of a problem since it depends largely on the amount of water actually put to beneficial use". No testimony with respect to flow was considered, but the Referee allocated both a volumetric quantity (classified as a storage right) and a rate of flow to each confirmed claim. The rate of flow was calculated based on a formula that allocates the equivalent storage capacity of the lakes and associated wetlands over a six month period. This rate of flow "should more than compensate for the effects of evapotranspiration and whatever seepage losses, if any, that occur. The rights were considered non-consumptive in that no water is artificially diverted from the drainage and the only losses that occur are through natural processes.

9.0 SOUTH FORK PALOUSE SUB-BASIN

The South Fork Palouse encompasses about 190,000 acres and includes the urban center for WRIA 34 (Moscow/Pullman/Colfax). Trans-boundary water management issues between Washington and Idaho are significant in this sub-watershed. Over 70% of the land-cover in the sub-basin is designated as "small grains". This sub-basin contains significant acreage (over 7,000 acres) of residential, commercial and industrial land cover. A description of the watershed is provided below.

The two key water quantity-related issues in the South Fork Palouse drainage include:

- Physical availability of groundwater in the deep basalt aquifer system underlying the Moscow/Pullman urban area.
- The effects (both physical and jurisdictional) of water management proposals currently being discussed to reduce demand on the deep basalt aquifer system.

Significant sub-issues to the fundamental issue of groundwater availability revolve around surface water quality and quantity in the South Fork Palouse River and its tributaries.

9.1 Hydraulic Continuity

Hydraulic continuity in the Moscow/Pullman area is complex for a number of reasons:

- The area lies along the eastern margin of the Columbia Plateau basalt flows, and is therefore geologically complex;
- The aquifers have been utilized for water supply for many years, and water-level records are therefore "imprinted" with the regional effects of pumping; and,
- Summer streamflows, which are generally characteristic of groundwater discharge to streams, are very low in the area (e.g. South Fork Palouse, Paradise Creek, Missouri Flat Creek and Fourmile Creek), and therefore subject to measurement uncertainty and statistical difficulties in analyzing flow data.

In order to understand hydraulic continuity between groundwater and surface water, the complexities and interconnections between deep and shallow aquifers and then to streams needs to be characterized. Periods of record for streamflow in the area rarely overlap, which prevents a viable statistical analysis that could compare streamflows between stations or between streamflows and groundwater levels. Similarly, this also limits a simple overlay of daily flow or water-level records to look for relationships between observed streamflows and groundwater levels.

Initial groundwater modeling by Lum and others (1990), which was subsequently refined by Johnson and others (1996) attempted to integrate and quantify these various interconnections. Figure 9-1 shows the extent of the model area and a schematic of the inflows and outflows to the three aquifer units simulated in the model. This model predicted about over 70 cfs total groundwater discharge to streams including discharge to the Snake River (outside of WRIA 34). This is about 50% of the estimated 135 cfs of total precipitation recharge).

Similar to the analysis presented for Cow Creek, hydraulic continuity is described from both a sub-surface/hydrogeologic perspective and a surface/streamflow perspective below.

9.1.1 Streamflow Patterns

Streamflows have been monitored at numerous locations in this area since the 1930's, but a continuous streamflow monitoring record is not available for any of the locations monitored by the USGS. This complicates an analysis of hydraulic continuity from a surface water perspective since the flow records often cannot be compared directly since there are multiple influences on the observed streamflow data. However, several observations are notable:

- Streamflows in the South Fork Palouse River at Pullman have shown a steady increase in summer baseflow since 1960 (Figure 9-2). This gage is located above the Pullman WWTP but below the Moscow WWTP. This trend is not the result of increased groundwater discharge, but is directly attributable to wastewater discharge by the City of Moscow. As population has increased, wastewater flows have increased. Prior to 1960, the South Fork would commonly drop to less than 1 cfs;
- Streamflows in Paradise Creek above the Moscow are flashy and commonly less than 1 cfs for 150 days per year (1979-2003);
- Streamflows in other tributaries above the confluence with the mainstem at Colfax (Missouri Flat, Fourmile) are also characteristically perennial;
- The amount of flow provided by the South Fork to the mainstem and reaches of the Palouse River below Colfax is often significant.
- Between 1960 and 1980, about 20-25% of the summer flow below Colfax was provided by the South Fork. On some years, this percentage exceeded 50%.

For the South Fork Palouse, the various influences of wastewater discharge, ephemeral discharge from tributary streams, and the lack of a strong baseflow component make it very difficult to characterize the contribution of groundwater to streamflows in the South Fork using current data. Further characterization will require a fairly complex streamflow monitoring plan, using both hydraulic and geochemical methods, to account for inflows and outflows from multiple sources.

9.1.2 Hydrogeologic Cross-Sections

Figure 9-4 shows the South Fork Palouse sub-basin and associated wells on file with WDOE and IDEQ. Well logs were reviewed and portrayed on cross-sections to show the sub-surface geologic conditions. In addition, cross-sections from a WSU Masters Thesis study in 1994 (Heinneman, 1994) are shown. This document describes surface water groundwater interactions in the vicinity of the South Fork Palouse River in the Pullman-Moscow area of the Palouse Basin. Regional and local hydrogeology were reviewed and stratigraphic cross sections were constructed using well logs for groundwater wells located in the vicinity of the streams of interest. Figures showing the cross-section locations and the geologic profiles of each are presented in Appendix G. This information as well as data collected during a field reconnaissance was used to identify areas in which groundwater recharge or discharge is believed to occur. According to Heinemann, the South Fork Palouse River does not receive significant groundwater discharge.

Data complied as part of Heinemann's thesis suggest that wells completed in the upper aquifer along the South Fork Palouse River exhibit static water levels near stream elevation. There are two areas in which static water levels are above stream elevations including Stratton Hollow (Cross-section E-F), exhibiting static water levels between 20-40 feet above stream elevation and Albion (Cross-section F-G) with static water levels between 50-120 feet above stream elevation. Wells completed in the lower aquifer between Pullman and Moscow generally exhibit water levels that are below stream elevations. West of Pullman, water levels are generally near stream elevations.

9.1.3 Hydraulic Continuity with Basalt Aquifers

Since 1976, groundwater levels in both the shallow and deep aquifers in the Moscow/Pullman area have been relatively well documented. Water-levels in the Moscow and Pullman area are summarized on Figure 9-3. Several observations are notable:

- Deep wells in the Pullman Palouse area show a steady and fairly uniform decline in groundwater levels, while deep wells in the Moscow area respond more erratically, though they are generally declining. The steady decline is indicative of continued withdrawal of groundwater storage, possibly compounded by structural boundaries in the aquifer itself. This trend has been evident for many years, but an ultimate steady state condition has not been well defined because of uncertainty regarding boundary conditions for the aquifer. The higher degree of variability in water-level trends in the Moscow area suggests that the wells in this area are more responsive to recharge. This could indicate higher connectivity between the deep and shallow aquifer in the Moscow area. This has recently been postulated based on geologic structure and the identification of interconnections between shallow and deeper aquifer zones via wells themselves.
- Deep wells in the Pullman/Palouse area generally have higher average groundwater elevations compared to deep wells in the Moscow area. The WDOE test well is an exception. However, this would suggest that there may be a component of groundwater flow from Pullman/Palouse toward Moscow. This has recently been postulated based on testing and geologic structure. Groundwater elevations are about 10 feet higher in the Pullman area compared to the Moscow area. Significant direct hydraulic continuity with surface waters would be unlikely in this scenario because the hydraulic gradient of the groundwater system would be opposite to the surface water gradient.
- Shallow wells in the Moscow area have significantly higher groundwater elevations than the deeper wells in both the Moscow and Pullman/Palouse areas. Also, shallow wells in the Moscow area have very different trends compared to deeper wells in the Moscow area, showing increases during the late 1970's and 1980's, presumably in response to a shift in water supply from the shallow aquifer to the deep aquifer. This could indicate higher continuity between surface water in Moscow and the shallow basalt aquifer but, again, separating direct continuity to surface water from other shallow groundwater recharge would be very difficult using hydraulic data alone. There are insufficient long-term water-level data for shallow wells in the Pullman/Palouse area.

Modeling of the aquifer system suggests that uncertainty associated with the boundary fluxes within each aquifer unit and localized flow patterns near wells is much greater than the magnitude of streamflow that might be considered "significant". Characterizing hydraulic continuity between aquifers will probably require a well-coordinated and fairly complex testing and monitoring program using a combination of geochemical and hydraulic studies that can isolate groundwater systems and identify multiple water sources. As shown on Figure 9-1, significant discharge to the Snake River (outside of WRIA 34) from the Palouse Basin Aquifer may be occurring.

9.1.4 Hydraulic Continuity with Palouse Soils

There is also hydraulic continuity with the shallower Palouse Formation soils. Unlike groundwater discharge from basalt aquifers, discharge from shallower Palouse soils is much more dynamic and responsive to seasonal climate patterns and land use practices. There is very little data relating to patterns of groundwater discharge from Palouse soils. Modeling of the aquifer system (Lum, 1990) suggests high discharge from the loess to streams (37 cfs). This is considered with the observed media summer baseflow of around 30 cfs in the Palouse River at Hooper. Palouse soils have a high storage capacity but a relatively low hydraulic conductivity. Since they are underlain by relatively impermeable basalts, the majority of water that enters these soils is either taken up by crops or discharges to small streams and drainages.

- The structure of soils also plays a role in how water infiltrates and is either stored in the soil or moves towards streams. In deep uniform soils, infiltration is well distributed and remains in storage within the soil. In shallower soils or soils that have been compacted, altered, or have complex structure, it is possible that infiltration is able to move along preferential pathways into shallow drainages and is not stored. In a deep uniform soil where two-year crop rotations are used, the effect would likely be a physical increase the water storage capacity of the soil that would not likely increase or decrease discharge to streams. In a shallower more complex soil where two year crop rotations are used, the effect could be to decrease shallow discharge during the growing year and increase discharge during the fallow year. No-till types of agricultural management tools have been reported to be successful in restoring local spring flows and maintaining better infiltration characteristics during wetter periods. The net result may be a better degree of hydraulic continuity between managed farm lands and adjacent streams.
- Vegetative cover also affects how water is infiltrated or runs-off into streams. As described in previous sections, the evapotranspiration from the natural grasslands that once dominated the Palouse is thought to differ from the current crops grown in the region. Predictions of pre-development recharge are about 2 inches greater than current recharge. It is therefore likely that, prior to development, there was a higher degree of hydraulic continuity between the shallow soil-water system and smaller streams and drainages. It is not clear whether a continuous cover of perennial grasses, similar to pre-developed conditions on the Palouse, would have significant effects on shallow groundwater discharge. However, the trends toward no-till practices and research on perennial types of crops could, over time, improve hydraulic continuity between the shallow soil-water system and smaller streams and drainages.

9.2 Water Quality

Water quality is an important issue facing the Cities of Pullman and Moscow (and Washington State University). The primary water rights issue is the result of wastewater discharge to the South Fork Palouse River and the subsequent allocation of that water to downstream water rights. These wastewater discharges sustain flows in the South Fork Palouse and sustain water rights and claims between Pullman and Colfax. The desire to minimize demand on the deep aquifer by using reclaimed water for a variety of non-potable irrigation needs therefore has a potentially negative effect on downstream water rights, since reducing wastewater discharges would also reduce streamflows. An analysis of the potential effects from reduced WWTP discharge to downstream water right holders was conducted by Ecology in 2002. The analysis estimated the streamflow effect of a reduced WWTP inflow to the South Fork Palouse River. Based on Ecology's analysis, reducing WWTP flows by 1.05 MGD would:

"have no significant effect on either water quantity or quality, while a 1.35 MGD project would increase the risk of impairing existing water rights and would raise the uncertainty of meeting future water quality TMDL's that will be established in the river. A 2.0 MGD project would almost certainly impair water quality."

Ecology's analysis indicates a total instantaneous water right requirement of about 3.65 cfs exists for surface water allocated among 15 water right holders between Pullman and Colfax. This allocation was made between 1949 and 1992; includes certificates only; and is for irrigation of about 300 acres in total. About 85% of this allocation occurred prior to 1960, the year that stream gaging on the South Fork was restarted by the USGS (see Figure 9-3). Flow records between 1935 and 1942 indicated flows of less that 1 cfs in the South Fork during the summer. It is not clear what on what basis the allocation was made, since the data available would suggest that there was no water in the South Fork during the summer until the 1960's. The report of examination for one of the certificates issued in 1952 noted that:

"The Palouse River is heavily appropriated at the present time. Measurements taken in past years during periods of minimum flow would indicate that water will not be available throughout the season to supply the presently authorized diversions. Although no critical shortage has yet occurred, it may be necessary to curtail or cease entirely diversion under this permit in order to satisfy prior rights".

The Qi allocated in these rights is equivalent to an irrigation requirement of about 0.015 cfs per acre. Over a 180-day irrigation season, this is equivalent to about 1,470 AF of water, or a crop irrigation requirement of nearly 5 feet. This amount of water would irrigate 300 acres of a high water need crop such as hay or pasture at a fairly poor irrigation efficiency.

Ecology's analysis of the effect of reduced wastewater discharge to the South Fork is based on an analysis of the lowest mean monthly summer streamflows between 1971 and 1981, and the lowest mean discharge from Pullman's WWTP between 1971 and 1981. Flows between Pullman and Colfax were estimated by adding the WWTP flows to the observed flows at the USGS gage. The analysis indicated that less than 4 cfs would be produced during one or more summer months downstream from Pullman if WWTP flows were reduced by 1.35 MGD (2.1 cfs) or more.

Because the analysis is based on data from 1971-1981, and does not include a "calibration" of the estimated flows below the WWTP to actual data downstream of Pullman, further analysis of the effect of WWTP discharge on flows using more recent data would be appropriate. In particular, the current effect of the City of Moscow's WWTP discharge on flows in the South Fork may indicate higher flows entering above Pullman's WWTP and therefore more flexibility in reducing flows. In addition, the actual irrigation needs for the 300 acres of land associated with the 4 cfs of allocated water should be investigated since the implied irrigation efficiency in the allocation is low. If the 1,470 AF of water allocated in the water rights is actually applied to the designated 300 acres of land, then improved efficiency alone could reduce the irrigation requirement.

This situation is further complicated by:

- The municipal water bill, which provides explicit requirements for Washington municipalities to try and develop reclaimed water opportunities;

- Washington wastewater reuse regulations, which indicate that the treatment plant operator (i.e. the City of Pullman and WSU) "owns" the wastewater, which is derived from a valid water right senior to downstream rights;
- Trans-boundary issues that will necessitate the development of a TMDL in Washington, which will necessarily have to incorporate assumptions on flows in the South Fork Palouse. Assumptions regarding flows and nutrient loads coming across the Idaho/Washington state line. Idaho's regulatory framework allows the City of Moscow to eliminate wastewater discharge to the Paradise Creek entirely, which could reduce flows in the South Fork; and,
- The potential development of an instream flow requirement, which could place further obligations to maintain flows in the South Fork.

There is not a simple technical or regulatory pathway through these issues, and, in many ways, the structure and objective of watershed planning under RCW 90.82 is not adequate for solving this problem. Further technical assessment of the issues surrounding the relationship between water quantity and water quality would be best attempted after a policy framework has been developed that lays out the scope of assumptions or scenarios that could be accommodated and defended under current regulatory constraints. This could be an area for further discussion under Phase III planning and the water quality supplemental assessment.

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TABLES

TABLE 2-1

WRIA 34 Subbasins

Subbasin	Acreage	Percent in WRIA 34
Cow Creek	473,410	22.4%
Palouse River	363,503	17.2%
North Fork Palouse	316,008	14.9%
Rock Creek	255,256	12.1%
Pine Creek	228,044	10.8%
Union Flat Creek	203,483	9.6%
South Fork Palouse	188,737	8.9%
Cottonwood Creek	88,323	4.2%
TOTAL	**2,116,764.2**	**100.0%**

TABLE 2-2

Climate Station Summary
NOAA/NWS COOP

Station Name	Station Number	Lat.	Long.	Elevation.	Period of Record
Colfax	451586	46.53	117.21	1979.5 ft	2/1892 – 5/1994
Ewan	452706	47.07	117.44	1721.7 ft	12/1939 – 12/1973
Farmington	452769	47.03	117.03	2903.1 ft	8/1929 – 3/1937
La Crosse	454343	46.49	117.53	1482.6 ft	1/1948 – 9/1948
Lacrosse 3 ESE	454338	46.49	117.53	1449.8 ft	3/1908 – 11/2003
Lamont 4 SSW	454470	47.09	117.57	1951.6 ft	6/1/48 – 7/31/48
Moscow 5NE	106148	46.47	116.55	2999.2 ft	7/1/72 – Present
Moscow U of I	106152	46.43	116.58	2659.4 ft	11/1893 – 11/2003
Potlatch 3 NNE	107301	46.57	116.53	2599.4 ft	3/1915 – 9/2002
Princeton 5 SE	107402	46.52	116.49	2601.4 ft	8/1948 – 7/1949
Princeton Ranger Station	107406 (no online data)	46.55	116.51	2502.3 ft	7/1/53 – Present
Pullman 2 E	456788	46.43	117.09	769 ft	11/1951 – 11/1951
Pullman 2 NW	456789	46.45	117.11	2544.3 ft	10/1940 – 11/2003
Pullman Exp Station	456784	46.44	117.10	2581.4 ft	1/1893 – 2/1954
Pullman Moscow Regional Airport	94129	46.45	117.07	2550.2 ft	6/1/47 – Present
Pullman USGS	456787 (no data online)	46.44	117.11	2332.4 ft	12/1/71 – 4/1/82
Ritzville 1 SSE	457059	47.07	118.23	1829.6 ft	3/1899 – 11/2003
Rosalia	457180	47.14	117.22	2399.3 ft	1/1893 – 11/2003
Saint John	457267	47.05	117.36	1944.4 ft	8/1963 – 11/2003
Sprague	457956	47.18	117.59	1969.6 ft	4/1899 – 8/1982
Tekoa	458348	47.13	117.05	2494.4 ft	6/1905 – 9/1980
Moscow Mountain Snotel		46.80	116.85	4,700 ft	2001-present

TABLE 2-3

Mean Monthly and Annual Precipitation
Derived from NOAA/NWS COOP Meteorological Gaging Stations
(All units in inches)

NOAA/NWS COOP Station	Annual	O	N	D	J	F	M	A	M	J	J	A	S
Colfax	19.70	1.40	2.35	2.85	2.51	1.85	1.99	1.57	1.53	1.36	0.65	0.76	0.88
Ewan	15.03	1.32	1.90	2.17	1.99	1.40	1.19	0.97	1.13	1.19	0.40	0.61	0.75
Lacrosse (3SSE)	14.09	1.10	1.78	2.13	1.78	1.41	1.38	1.10	1.03	0.98	0.36	0.41	0.63
Moscow U of I	23.54	1.85	3.03	2.93	2.96	2.20	2.26	1.90	2.00	1.65	0.73	0.78	1.23
Potlatch (3 NNE)	24.78	1.92	2.97	3.11	2.88	2.48	2.38	2.06	2.11	1.88	0.82	0.81	1.35
Pullman 2 NW	21.38	1.71	2.86	2.87	2.79	2.09	2.01	1.62	1.64	1.44	0.59	0.78	0.99
Ritzville 1 SSE	11.86	0.95	1.59	1.69	1.41	1.12	1.08	0.86	0.91	0.83	0.46	0.41	0.55
Rosalia	17.74	1.37	2.21	2.38	2.25	1.60	1.58	1.35	1.53	1.35	0.62	0.68	0.82
Saint John	16.85	1.19	2.18	2.35	2.05	1.46	1.52	1.41	1.46	1.17	0.66	0.62	0.77
Sprague	14.59	1.12	1.90	2.15	1.97	1.36	1.26	0.98	1.10	0.92	0.54	0.62	0.66
Tekoa	20.24	1.56	2.36	2.79	2.60	1.68	1.79	1.41	1.65	1.79	0.72	0.84	1.04

Note: Data derived from NOAA/NWS COOP gage data for the period of record available (see Table 2-2).

TABLE 2-4

Mean Monthly and Annual Precipitation
Estimated from PRISM Outputs for the State of Washington
(All units in inches)

Sub-Basin	Annual	O	N	D	J	F	M	A	M	J	J	A	S
North Fork Palouse	30.1	1.9	3.7	4.0	3.9	3.0	2.9	2.3	2.4	2.1	1.1	1.3	1.5
Pine Creek	19.0	1.3	2.4	2.5	2.2	1.7	1.9	1.5	1.7	1.4	0.8	0.8	0.9
Cottonwood Creek	17.5	1.2	2.2	2.4	2.1	1.6	1.7	1.3	1.5	1.2	0.7	0.7	0.9
Rock Creek	15.9	1.1	2.1	2.3	1.9	1.5	1.5	1.1	1.3	1.1	0.6	0.6	0.8
South Fork Palouse	24.2	1.6	3.1	3.1	3.1	2.3	2.4	1.9	2.0	1.7	0.9	1.1	1.2
Union Flat Creek	20.6	1.4	2.6	2.7	2.6	2.0	2.0	1.6	1.7	1.4	0.7	0.9	1.0
Palouse River	15.2	1.0	1.9	2.2	1.9	1.5	1.5	1.2	1.2	1.0	0.5	0.6	0.7
Cow Creek	13.9	1.0	1.9	2.0	1.6	1.3	1.3	1.0	1.1	0.9	0.5	0.6	0.7
BASIN-SCALE	**19.6**	**1.3**	**2.5**	**2.7**	**2.4**	**1.9**	**1.9**	**1.5**	**1.6**	**1.4**	**0.7**	**0.8**	**1.0**

Note: Numbers derived from outputs of the PRISM Model developed by the Oregon Climate Service–August 1998

TABLE 2-5

Comparison of Annual Observed Precipitation and PRISM Model Output

Station Name	PRISM Annual Precipitation	Measured Annual Precipitation	Percent Error
Colfax	18.2	19.7	8%
Ewan	15.4	15.0	2%
Lacrosse (3SSE)	14.9	14.1	6%
Moscow U of I	25.7	23.5	9%
Potlatch (3 NNE)	25.2	24.8	2%
Pullman 2 NW	22.6	21.4	6%
Ritzville 1 SSE	11.1	11.9	6%
Rosalia	17.7	17.7	0%
Saint John	16.5	16.9	2%
Sprague	14.8	14.6	1%
Tekoa	19.9	20.2	2%

TABLE 2-6

Summary of Monthly and Annual Temperatures

Station Name		January	February	March	April	May	June	July	August	September	October
Colfax	Max.	36.5	43.3	50.3	59.1	67.5	74.9	83.9	83.6	75.4	62.9
	Mean	29.5	35.3	40.4	47.2	54.4	61	66.8	66.2	58.5	48.6
	Min.	22.4	27.4	30.6	35.4	41.3	47.1	49.8	48.9	41.6	34.3
La Crosse	Max.	37.3	44.3	53.2	62.1	71	78.8	88.6	87.1	77.7	64.1
	Mean	30.5	36	42.3	49	56.1	63.1	70.1	68.8	60.6	49.9
	Min.	23.7	27.7	31.5	35.8	41.1	47.3	51.7	50.5	43.6	35.6
Moscow University of Idaho	Max.	34.7	40.1	47.4	56.9	65.4	72.6	82.8	82.4	72.9	59.9
	Mean	28.6	33	39	46.3	53.3	59.5	66.6	66.1	58.5	48.6
	Min.	22.5	26	30.6	35.7	41.2	46.3	50.3	49.7	44.1	37.3
Potlatch	Max.	35.8	41.6	48.3	57.3	66.2	73	82.7	82.9	73.3	60.5
	Mean	28.3	33.1	38.3	45	52	58	64.1	63.5	56	46.8
	Min.	20.8	24.7	28.3	32.8	37.8	43.1	45.6	44.1	38.7	33.1
Pullman 2 NW	Max.	34.6	40.5	47	55.9	64.4	71.3	81.7	81.9	72.8	59.8
	Mean	28.6	33.8	38.8	45.7	52.8	58.8	65.7	65.8	58.6	48.5
	Min.	22.6	27.1	30.7	35.5	41.3	46.3	49.7	49.7	44.3	37.2
Ritzville 1 SSE	Max.	34	41.7	50.8	60.4	69.3	77.6	86.6	85.6	76.7	62.2
	Mean	27.5	33.7	40.1	47	54.7	62.2	69.4	68.7	60.9	48.8
	Min.	21	25.7	29.4	33.7	40.2	46.7	52.2	51.7	45	35.5
Rosalia	Max.	34.6	40.5	47.8	57.1	65.4	72.4	82.1	82.3	73.5	60.2
	Mean	28.4	33.4	39	45.9	53.1	59.4	66.2	66.2	58.3	47.4
	Min.	22.3	26.3	30.1	34.7	40.9	46.3	50.3	50.1	43.1	34.7
Saint John	Max.	37.5	44	51.9	60	68.9	76.4	85.1	85	76.2	62.8
	Mean	30.9	35.8	41.3	47.3	54.5	61.1	67.3	67	59.4	48.2
	Min.	24.2	27.6	30.7	34.5	40.1	45.8	49.5	49	42.3	33.5
Sprague	Max.	33.4	41.9	50.4	60.1	69.5	77.6	86.5	85.3	75.8	61.7
	Mean	25.6	33.4	39.5	46.8	55	62.2	68.7	67.4	58.9	47.5
	Min.	17.8	25.1	28.6	33.6	40.5	46.8	50.9	49.4	41.9	33.3
Note: Temperature data not available for Ewan and Tekoa											

TABLE 2-6

Summary of Monthly and Annual Temperatures

Station Name		November	December	Annual	Winter	Spring	Summer	Fall
Colfax	Max.	46.6	38.4	60.2	39.4	59	80.8	61.6
	Mean	38.2	31.8	48.2	32.2	47.4	64.7	48.4
	Min.	29.9	25.3	36.2	25.1	35.8	48.6	35.3
La Crosse	Max.	47.1	38.8	62.5	40.1	62.1	84.8	63
	Mean	38.7	32.5	49.8	33	49.1	67.3	49.7
	Min.	30.2	26.2	37.1	25.8	36.1	49.8	36.5
Moscow University of Idaho	Max.	44.4	36.3	58	37	56.6	79.3	59.1
	Mean	37.5	30.6	47.3	30.7	46.2	64	48.2
	Min.	30.6	25	36.6	24.5	35.8	48.8	37.4
Potlatch	Max.	45.3	37.4	58.7	38.3	57.3	79.5	59.7
	Mean	36.9	30.3	46	30.6	45.1	61.9	46.6
	Min.	28.5	23.2	33.4	22.9	33	44.2	33.4
Pullman 2 NW	Max.	43.7	35.9	57.5	37	55.8	78.3	58.8
	Mean	37.1	30.4	47.1	30.9	45.8	63.4	48
	Min.	30.4	25	36.6	24.9	35.8	48.5	37.3
Ritzville 1 SSE	Max.	45.1	35.7	60.5	37.1	60.1	83.3	61.3
	Mean	36.8	29.4	48.3	30.2	47.3	66.7	48.8
	Min.	28.5	23	36.1	23.2	34.5	50.2	36.3
Rosalia	Max.	44.2	35.9	58	37	56.8	78.9	59.3
	Mean	36.6	29.9	47	30.6	46	63.9	47.5
	Min.	29.1	23.9	36	24.2	35.2	48.9	35.6
Saint John	Max.	46.2	37.3	60.9	39.6	60.3	82.2	61.7
	Mean	38.1	30.8	48.5	32.5	47.7	65.1	48.5
	Min.	30	24.3	36	25.4	35.1	48.1	35.3
Sprague	Max.	45	37.1	60.4	37.5	60	83.1	60.8
	Mean	36.1	29.9	47.6	29.7	47.1	66.1	47.5
	Min.	27.1	22.7	34.8	21.9	34.2	49	34.1
Note: Temperature data not ava								

Mean Pan Evapotranspiration for Spokane WB Airport (Stn 7938) 1956-1970

Month	Mean Evapotranspiration
January	0.61
February	1.11
March	2.28
April	4.04
May	6.28
June	7.82
July	10.66
August	8.63
September	5.37
October	2.58
November	0.92
December	0.51
*May - Oct	41.36
*Nov - Apr	9.47
*Annual	50.83

* Sum of Monthly Means

Mean Annual Evapotranspiration for Select WRIA 34 Climate Stations

Climate Station	Mean Evapotranspiration [1]
LaCrosse (454338)	-33.8
Ritzville (457059)	-32.0
Sprague (456956)	-38.5

(1) Based on the Blaney Criddle calculation method (USDA, 1993) with a crop coefficient of 1.0.

(2) From Kennedy/Jenks Consultants & Daniel B. Stephens & Associates, 1999.

TABLE 2-9

Climatic Changes related to PDO Phases
(adapted from Figure 4, JISAO and SMA, 2001)

Climatic Factors	WARM PDO (1925-46 and 1977-1995)	COOL PDO (1890-1924, 1946-1976 and 1996-?)
Temperature	+ 0.3 °F	- 0.2 °F
Precipitation	+ 2%	- 4%
Snow Depth	- 15%	+ 17%
Streamflow	- 10%	+6%
Forest Fires	+65%	-49%

Notes: 1) Temperature averaged over the Pacific Northwest for October – March.
2) Total annual precipitation averaged over the Pacific Northwest.
3) Snow depth averaged from Jan 15 to Apr 15 at Snoqualmie Pass.
4) Streamflow based on Columbia River at The Dalles (corrected for dam regulation).
5) Areas burned by forest fires in Washington and Oregon.

TABLE 3-1

USGS Streamflow Gages for the Palouse River and Major Tributaries

Gage #	Description	Sub-basin	Period of Record Available	Mean Annual Flow (cfs)	Max Annual Flow (cfs)	Minimum Annual Flow (cfs)
13352500	Cow Creek at Hooper	Cow Creek	2/1/51 – 11/30/53 4/1/62 – 9/30/70	25.1	47.0	4.3
*13349210	Palouse River below S.F. at Colfax	Palouse River	10/1/63 – 6/30/73 9/29/75 – 9/30/95	349.0	726.2	69.1
13349320	Rebel Flat Creek at Winona	Palouse River	10/1/92 – 9/30/95	7.0	10.2	3.4
13350000	Palouse River near Winona	Palouse River	1/1/15 – 9/30/15 10/1/16 – 9/30/17	**894.0	**894.0	**894.0
*13351000	Palouse River at Hooper	Palouse River	10/1/1897 – 12/31/1899 4/1/1900 – 4/17/07 6/14/08 – 7/31/12 3/31/13 – 3/31/16 2/8/51 – 9/30/02	610.8	1595.3	105.8
*13345000	Palouse River near Potlatch	North Fork Palouse	10/1/15 – 9/30/19 11/11/66 – 9/30/02	269.5	633.9	38.8
13345300	Palouse River at Palouse	North Fork Palouse	4/19/73 -10/2/80	269.1	591.2	42.0
13346000	Palouse River near Colfax	North Fork Palouse	10/1/55 – 9/30/64 10/1/93 – 9/30/94	309.6	457.9	174.6
13346100	Palouse River at Colfax	North Fork Palouse	10/1/63 – 7/13/73 10/1/75 – 5/31/79	299.0	542.9	47.9
13346500	S.F. Palouse River above Paradise Creek, near Pullman	South Fork Palouse	6/1/34 – 9/30/40	16.5	21.1	11.4
*13346800	Paradise Creek at University of Idaho at Moscow, ID	South Fork Palouse	10/1/78 – 9/30/03	7.5	16.8	1.4
13347000	Paradise Creek near Pullman	South Fork Palouse	5/1/34 – 9/30/38	9.5	11.7	7.3
13347500	Dry Fork of S.F. Palouse River at Pullman	South Fork Palouse	12/1/34 – 9/30/38	1.5	1.5	1.4

TABLE 3-1

USGS Streamflow Gages for the Palouse River and Major Tributaries

Gage #	Description	Sub-basin	Period of Record Available	Mean Annual Flow (cfs)	Max Annual Flow (cfs)	Minimum Annual Flow (cfs)
*13348000	S.F. Palouse River at Pullman	South Fork Palouse	2/1/34 – 9/30/42 1/1/60 – 9/30/81 5/25/01 – 9/30/02	39.2	111.3	7.7
*13348500	Missouri Flat Creek at Pullman	South Fork Palouse	2/1/34 – 9/30/40 1/1/60 – 10/3/79	8.5	21.4	0.8
13349000	Fourmile Creek at Shawnee	South Fork Palouse	4/1/34 – 9/30/40	14.9	21.3	10.2
13349200	S.F. Palouse River at Colfax	South Fork Palouse	4/15/93 – 9/30/95	53.6	90.3	16.8
*13349400	Pine Creek at Pine City	Pine Creek	9/1/61 – 9/30/75	60.6	134.4	22.4
13349410	Pine Creek at Pine City Rd. at Pine City	Pine Creek	4/14/93 – 10/6/94	**8.0	**8.0	**8.0
13349325	Philleo Ditch near Cheney	Rock Creek	3/1/93 – 6/15/93 10/1/93 – 1/10/96	1.2	2.3	0.1
13349500	Rock Creek at Ewan	Rock Creek	4/1/14 – 9/30/15 10/1/16 – 9/30/17	92.6	148.6	36.5
*13350500	Union Flat Creek near Colfax	Union Flat Creek	8/1/53 – 10/14/71	37.1	83.0	14.6

*Years with 10 or more years of continuous streamflow data.
**Due to data availability, mean annual flows calculated for one water year only.

Summary of August and September Monthly Baseflow

Station Number	Station Name	August Baseflow (cfs)	September Baseflow (cfs)
13345300	Palouse River at Palouse, WA.	7.8	8.7
13346000	Palouse River near Colfax, WA.	6.8	7.9
13346100	Palouse River at Colfax, WA.	6.5	7.6
13346500	South Fork Palouse R. Above Paradise Creek Near Pullman, WA.	0	0
13347000	Paradise Creek near Pullman, WA	0.39	0.56
13348000	South Fork Palouse River at Pullman, WA.	2.3	2.6
13348500	Missouri Flat Creek at Pullman, WA.	0.21	0.17
13349000	Fourmile Creek at Shawnee, WA.	0	0
13349210	Palouse River below South Fork at Colfax, WA.	14	17
13349400	Pine Creek at Pine City, WA.	2.1	2.2
13350500	Union Flat Creek near Colfax, WA.	0.66	1.2
13351000	Palouse River at Hooper, WA.	28	31
13352500	Cow Creek at Hooper, WA.	2.9	3

Source: Washington Department of Ecology, 1999. Estimated Baseflow Characteristics of Selected Washington Rivers and Streams

Range of Variablity Outputs, Palouse at Potlatch
(Stn. 13345000)

Period of Record: 1915-1919 & 1966-2002

Monthly Magnitude				
	Mean Discharge (cfs)	**Standard Deviation (cfs)**	**Mean + 1 Std Dev (cfs)**	**Mean - 1 Std Dev (cfs)**
January	358.1	390.6	748.7	-32.5
Febuary	608.0	521.0	1129.0	87.0
March	759.4	459.2	1218.6	300.2
April	731.4	490.2	1221.6	241.2
May	373.3	317.1	690.4	56.2
June	121.1	123.4	244.5	-2.3
July	27.9	14.1	42.0	13.8
August	11.9	6.5	18.4	5.4
September	11.3	5.6	16.9	5.7
October	18.1	8.6	26.7	9.5
November	56.1	44.0	100.1	12.1
December	167.8	196.6	364.4	-28.8
Magnitude and Duration of Annual Extremes				
	Mean Discharge (cfs)	**Standard Deviation (cfs)**	**Mean + 1 Std Dev (cfs)**	**Mean - 1 Std Dev (cfs)**
1 day minimum	4.8	3.0	7.8	1.8
3 day minimum	5.3	3.0	8.3	2.3
7 day minimum	5.8	3.2	9.0	2.6
30 day minimum	7.0	3.7	10.7	3.3
90 day minimum	11.2	6.0	17.2	5.2
1 day maximum	3723.7	2464.6	6188.3	1259.1
3 day maximum	2972.8	2014.9	4987.7	957.9
7 day maximum	2214.8	1344.0	3558.8	870.8
30 day maximum	1252.9	656.5	1909.4	596.4
90 day maximum	787.9	384.3	1172.2	403.6
Timing of annual Extremes				
	Mean (Julian Day)[1]	**Standard Deviation (Julian Day)[1]**	**Mean + 1 Std Dev (Julian Day)[1]**	**Mean - 1 Std Dev (Julian Day)[1]**
Annual Maximum	260.7	30.1	290.8	230.7
Annual Minimum	73.9	59.3	133.2	14.6
Frequency and Duration of High and Low Pulses				
	Mean	**Standard Deviation**	**Mean + 1 Std Dev**	**Mean - 1 Std Dev**
Count (number)				
Low Pulses	6.8	4.4	11.2	2.4
High Pulses	7.5	2.3	9.8	5.2
Duration (days)				
Low Pulses	18.6	9.7	28.3	8.9
High Pulses	13.7	5.9	19.6	7.8
Rate and Frequency of Hydrograph Changes				
	Mean	**Standard Deviation**	**Mean + 1 Std Dev**	**Mean - 1 Std Dev**
Count (number)				
Fall	61.2	9.5	70.7	51.6
Rise	55.6	12.2	67.8	43.3
Rate (cfs/day)				
Fall	-59.6	34.5	-25.1	-94.1
Rise	106.9	69.1	176.0	37.8

NOTES:
1. A count of the days, starting from 12 noon on 1 January 4713 BC.

Range of Variablity Outputs, Paradise Creek (at U of I) at Moscow, ID
(Stn. 13346800)

Period of Record: 10/1/1978- - 9/30/2003

Monthly Magnitude				
	Mean Discharge (cfs)	**Standard Deviation (cfs)**	**Mean + 1 Std Dev (cfs)**	**Mean - 1 Std Dev (cfs)**
January	14.2	12.1	26.3	2.1
Febuary	27.1	24.2	51.3	2.9
March	21.0	15.0	36.0	6.0
April	9.4	6.2	15.6	3.2
May	4.9	3.7	8.6	1.2
June	2.3	1.3	3.6	1.0
July	1.0	0.5	1.5	0.5
August	1.0	0.8	1.8	0.2
September	0.8	0.5	1.3	0.3
October	1.2	0.8	2.0	0.4
November	2.4	1.5	3.9	0.9
December	5.5	6.3	11.8	-0.8
Magnitude and Duration of Annual Extremes				
	Mean Discharge (cfs)	**Standard Deviation (cfs)**	**Mean + 1 Std Dev (cfs)**	**Mean - 1 Std Dev (cfs)**
1 day minimum	0.1	0.1	0.2	0.0
3 day minimum	0.2	0.1	0.3	0.1
7 day minimum	0.2	0.1	0.3	0.1
30 day minimum	0.3	0.1	0.4	0.2
90 day minimum	0.6	0.2	0.8	0.4
1 day maximum	219.2	156.8	376.0	62.4
3 day maximum	148.3	128.1	276.4	20.2
7 day maximum	90.8	68.7	159.5	22.1
30 day maximum	39.3	24.5	63.8	14.8
90 day maximum	22.5	12.0	34.5	10.5
Timing of annual Extremes				
	Mean (Julian Day)[1]	**Standard Deviation (Julian Day)[1]**	**Mean + 1 Std Dev (Julian Day)[1]**	**Mean - 1 Std Dev (Julian Day)[1]**
Annual Maximum	285.9	26.5	312.4	259.4
Annual Minimum	57.3	70.6	127.9	351.8
Frequency and Duration of High and Low Pulses				
	Mean	**Standard Deviation**	**Mean + 1 Std Dev**	**Mean - 1 Std Dev**
Count (number)				
Low Pulses	17.6	4.6	22.2	13.0
High Pulses	15.3	5.4	20.7	9.9
Duration (days)				
Low Pulses	5.7	1.4	7.1	4.3
High Pulses	6.9	2.7	9.6	4.2
Rate and Frequency of Hydrograph Changes				
	Mean	**Standard Deviation**	**Mean + 1 Std Dev**	**Mean - 1 Std Dev**
Count (number)				
Fall	83.1	5.4	88.5	77.7
Rise	78.9	6.5	85.4	72.4
Rate (cfs/day)				
Fall	-3.5	1.7	-1.8	-5.2
Rise	6.0	3.2	9.2	2.8

NOTES:
1. A count of the days, starting from 12 noon on 1 January 4713 BC.

Range of Variability Outputs, S.F. Palouse at Pullman
(Stn. 13348000)
Period of Record: 1934-1942, 1960-1981 & 2001-2002

Monthly Magnitude				
	Mean Discharge (cfs)	**Standard Deviation (cfs)**	**Mean + 1 Std Dev (cfs)**	**Mean - 1 Std Dev (cfs)**
January	84.9	91.1	176.0	-6.2
Febuary	111.2	89.4	200.6	21.8
March	117.7	77.5	195.2	40.2
April	58.4	36.8	95.2	21.6
May	23.0	14.7	37.7	8.3
June	10.3	7.8	18.1	2.5
July	3.7	2.1	5.8	1.6
August	2.9	2.1	5.0	0.8
September	3.2	1.8	5.0	1.4
October	4.3	2.2	6.5	2.1
November	9.2	7.7	16.9	1.5
December	36.0	44.1	80.1	-8.1
Magnitude and Duration of Annual Extremes				
	Mean Discharge (cfs)	**Standard Deviation (cfs)**	**Mean + 1 Std Dev (cfs)**	**Mean - 1 Std Dev (cfs)**
1 day minimum	1.9	1.3	3.2	0.6
3 day minimum	2.0	1.3	3.3	0.7
7 day minimum	2.1	1.3	3.4	0.8
30 day minimum	2.4	1.4	3.8	1.0
90 day minimum	2.8	1.6	4.4	1.2
1 day maximum	799.7	638.9	1438.6	160.8
3 day maximum	571.4	430.2	1001.6	141.2
7 day maximum	380.6	253.0	633.6	127.6
30 day maximum	184.9	121.7	306.6	63.2
90 day maximum	111.8	71.8	183.6	40.0
Timing of annual Extremes				
	Mean (Julian Day)[1]	**Standard Deviation (Julian Day)[1]**	**Mean + 1 Std Dev (Julian Day)[1]**	**Mean - 1 Std Dev (Julian Day)[1]**
Annual Maximum	234.8	33.2	268.0	201.6
Annual Minimum	55.2	64.5	119.7	355.7
Frequency and Duration of High and Low Pulses				
	Mean	**Standard Deviation**	**Mean + 1 Std Dev**	**Mean - 1 Std Dev**
Count (number)				
Low Pulses	7.9	3.1	11.0	4.8
High Pulses	7.7	3.3	11.0	4.4
Duration (days)				
Low Pulses	15.7	15.4	31.1	0.3
High Pulses	13.7	7.5	21.2	6.2
Rate and Frequency of Hydrograph Changes				
	Mean	**Standard Deviation**	**Mean + 1 Std Dev**	**Mean - 1 Std Dev**
Count (number)				
Fall	71.7	10.9	82.6	60.8
Rise	64.2	10.9	75.0	53.3
Rate (cfs/day)				
Fall	-12.4	8.2	-4.2	-20.6
Rise	21.6	15.1	36.7	6.6

NOTES:
1. A count of the days, starting from 12 noon on 1 January 4713 BC.

Range of Variability Outputs, Missouri Flat Creek at Pullman
(Stn. 13348500)

Period of Record: 1934-1940 & 1960-1979

Monthly Magnitude				
	Mean Discharge (cfs)	**Standard Deviation (cfs)**	**Mean + 1 Std Dev (cfs)**	**Mean - 1 Std Dev (cfs)**
January	21.6	23.2	44.8	-1.6
Febuary	27.2	24.9	52.1	2.3
March	28.6	21.7	50.3	6.9
April	8.9	6.9	15.8	2.0
May	2.4	2.1	4.5	0.3
June	1.0	1.7	2.7	-0.7
July	0.4	0.3	0.7	0.1
August	0.4	0.5	0.9	-0.1
September	0.2	0.2	0.4	0.0
October	0.4	0.3	0.7	0.1
November	1.2	1.8	3.0	-0.6
December	7.5	11.0	18.5	-3.5
Magnitude and Duration of Annual Extremes				
	Mean Discharge (cfs)	**Standard Deviation (cfs)**	**Mean + 1 Std Dev (cfs)**	**Mean - 1 Std Dev (cfs)**
1 day minimum	0.1	0.1	0.2	0.0
3 day minimum	0.1	0.1	0.2	0.0
7 day minimum	0.1	0.1	0.2	0.0
30 day minimum	0.2	0.1	0.3	0.1
90 day minimum	0.2	0.2	0.4	0.0
1 day maximum	244.5	187.3	431.8	57.2
3 day maximum	170.9	122.7	293.6	48.2
7 day maximum	110.3	69.4	179.7	40.9
30 day maximum	48.3	31.2	79.5	17.1
90 day maximum	26.8	17.9	44.7	8.9
Timing of annual Extremes				
	Mean (Julian Day)[1]	**Standard Deviation (Julian Day)[1]**	**Mean + 1 Std Dev (Julian Day)[1]**	**Mean - 1 Std Dev (Julian Day)[1]**
Annual Maximum	270.4	33.9	304.3	236.4
Annual Minimum	88.4	106.4	194.8	347.0
Frequency and Duration of High and Low Pulses				
	Mean	**Standard Deviation**	**Mean + 1 Std Dev**	**Mean - 1 Std Dev**
Count (number)				
Low Pulses	12.3	6.5	18.8	5.8
High Pulses	8.6	3.9	12.5	4.7
Duration (days)				
Low Pulses	11.9	10.3	22.2	1.6
High Pulses	N/A	N/A	N/A	N/A
Rate and Frequency of Hydrograph Changes				
	Mean	**Standard Deviation**	**Mean + 1 Std Dev**	**Mean - 1 Std Dev**
Count (number)				
Fall	64.6	19.1	83.8	45.5
Rise	57.2	18.6	75.8	38.6
Rate (cfs/day)				
Fall	-4.3	2.7	-1.6	-7.0
Rise	7.5	4.8	12.3	2.8

NOTES:
1. A count of the days, starting from 12 noon on 1 January 4713 BC.

TABLE 3-7

Range of Variability Outputs, Palouse below S.F. at Colfax
(Stn. 13349210)

Period of Record: 1963-1973 & 1975-1995

Monthly Magnitude	Mean Discharge (cfs)	Standard Deviation (cfs)	Mean + 1 Std Dev (cfs)	Mean - 1 Std Dev (cfs)
January	562.3	428.7	991.0	133.6
Febuary	894.8	677.0	1571.8	217.8
March	1006.6	637.9	1644.5	368.7
April	736.1	471.9	1208.0	264.2
May	364.6	231.8	596.4	132.8
June	154.4	165.2	319.6	-10.8
July	39.3	18.9	58.2	20.4
August	20.0	9.8	29.8	10.2
September	25.2	15.4	40.6	9.8
October	32.8	10.8	43.6	22.0
November	81.4	45.9	127.3	35.5
December	241.9	274.3	516.2	-32.4
Magnitude and Duration of Annual Extremes				
	Mean Discharge (cfs)	**Standard Deviation (cfs)**	**Mean + 1 Std Dev (cfs)**	**Mean - 1 Std Dev (cfs)**
1 day minimum	13.1	15.3	28.4	-2.2
3 day minimum	10.6	5.9	16.5	4.7
7 day minimum	11.4	6.2	17.6	5.2
30 day minimum	14.5	8.0	22.5	6.5
90 day minimum	19.4	9.1	28.5	10.3
1 day maximum	4606.5	2907.2	7513.7	1699.3
3 day maximum	3660.5	2300.6	5961.1	1359.9
7 day maximum	2684.8	1643.5	4328.3	1041.3
30 day maximum	1485.6	879.9	2365.5	605.7
90 day maximum	952.2	538.8	1491.0	413.4
Timing of annual Extremes				
	Mean (Julian Day)[1]	**Standard Deviation (Julian Day)[1]**	**Mean + 1 Std Dev (Julian Day)[1]**	**Mean - 1 Std Dev (Julian Day)[1]**
Annual Maximum	247.6	26.5	274.1	221.1
Annual Minimum	71.4	73.7	145.1	362.7
Frequency and Duration of High and Low Pulses				
	Mean	**Standard Deviation**	**Mean + 1 Std Dev**	**Mean - 1 Std Dev**
Count (number)				
Low Pulses	5.9	3.0	8.9	2.9
High Pulses	7.0	2.3	9.3	4.7
Duration (days)				
Low Pulses	N/A	N/A	N/A	N/A
High Pulses	N/A	N/A	N/A	N/A
Rate and Frequency of Hydrograph Changes				
	Mean	**Standard Deviation**	**Mean + 1 Std Dev**	**Mean - 1 Std Dev**
Count (number)				
Fall	61.8	6.4	68.2	55.5
Rise	57.5	12.0	69.5	45.4
Rate (cfs/day)				
Fall	-74.7	37.6	-37.1	-112.3
Rise	118.6	64.9	183.5	53.8

NOTES:

1. A count of the days, starting from 12 noon on 1 January 4713 BC.

TABLE 3-8

Range of Variability Outputs, Pine Creek at Pine City
(Stn. 13349400)

Period of Record: 1961-1994

Monthly Magnitude				
	Mean Discharge (cfs)	**Standard Deviation (cfs)**	**Mean + 1 Std Dev (cfs)**	**Mean - 1 Std Dev (cfs)**
January	164.6	149.2	313.8	15.4
Febuary	193.9	155.2	349.1	38.7
March	185.5	167.6	353.1	17.9
April	81.6	81.0	162.6	0.6
May	34.8	28.0	62.8	6.8
June	13.7	11.7	25.4	2.0
July	4.5	3.7	8.2	0.8
August	2.6	1.4	4.0	1.2
September	2.3	0.9	3.2	1.4
October	3.0	1.4	4.4	1.6
November	6.3	2.3	8.6	4.0
December	41.6	60.0	101.6	-18.4
Magnitude and Duration of Annual Extremes				
	Mean Discharge (cfs)	**Standard Deviation (cfs)**	**Mean + 1 Std Dev (cfs)**	**Mean - 1 Std Dev (cfs)**
1 day minimum	1.4	0.6	2.0	0.8
3 day minimum	1.5	0.6	2.1	0.9
7 day minimum	1.5	0.6	2.1	0.9
30 day minimum	1.7	0.8	2.5	0.9
90 day minimum	2.1	1.0	3.1	1.1
1 day maximum	1682.9	1197.9	2880.8	485.0
3 day maximum	1182.9	832.4	2015.3	350.5
7 day maximum	737.8	464.6	1202.4	273.2
30 day maximum	339.4	224.2	563.6	115.2
90 day maximum	198.9	117.9	316.8	81.0
Timing of annual Extremes				
	Mean (Julian Day)[1]	**Standard Deviation (Julian Day)[1]**	**Mean + 1 Std Dev (Julian Day)[1]**	**Mean - 1 Std Dev (Julian Day)[1]**
Annual Maximum	254.3	26.2	280.4	228.1
Annual Minimum	81.8	99.3	181.1	347.5
Frequency and Duration of High and Low Pulses				
	Mean	**Standard Deviation**	**Mean + 1 Std Dev**	**Mean - 1 Std Dev**
Count (number)				
Low Pulses	3.9	2.2	6.1	1.7
High Pulses	5.8	2.8	8.6	3.0
Duration (days)				
Low Pulses	N/A	N/A	N/A	N/A
High Pulses	16.9	6.9	23.8	10.0
Rate and Frequency of Hydrograph Changes				
	Mean	**Standard Deviation**	**Mean + 1 Std Dev**	**Mean - 1 Std Dev**
Count (number)				
Fall	57.2	15.1	72.3	42.1
Rise	50.1	14.0	64.1	36.1
Rate (cfs/day)				
Fall	-23.2	16.5	-6.7	-39.8
Rise	39.3	29.0	68.3	10.2

NOTES:
1. A count of the days, starting from 12 noon on 1 January 4713 BC.

Range of Variability Outputs, Union Flat Creek at Colfax
(Stn. 13350500)
Period of Record: 1953-1971

Monthly Magnitude				
	Mean Discharge (cfs)	**Standard Deviation (cfs)**	**Mean + 1 Std Dev (cfs)**	**Mean - 1 Std Dev (cfs)**
January	82.7	77.5	160.2	5.2
Febuary	104.6	58.0	162.6	46.6
March	121.8	108.2	230.0	13.6
April	58.1	38.6	96.7	19.5
May	23.7	12.5	36.2	11.2
June	9.4	5.8	15.2	3.6
July	2.6	1.8	4.4	0.8
August	1.0	0.7	1.7	0.3
September	1.5	1.1	2.6	0.4
October	2.9	1.5	4.4	1.4
November	9.2	6.5	15.7	2.7
December	31.7	32.9	64.6	-1.2
Magnitude and Duration of Annual Extremes				
	Mean Discharge (cfs)	**Standard Deviation (cfs)**	**Mean + 1 Std Dev (cfs)**	**Mean - 1 Std Dev (cfs)**
1 day minimum	0.5	0.7	1.2	-0.2
3 day minimum	0.5	0.7	1.2	-0.2
7 day minimum	0.6	0.7	1.3	-0.1
30 day minimum	0.7	0.7	1.4	0.0
90 day minimum	1.2	0.8	2.0	0.4
1 day maximum	606.3	548.2	1154.5	58.1
3 day maximum	479.3	417.6	896.9	61.7
7 day maximum	348.3	275.6	623.9	72.7
30 day maximum	176.0	126.4	302.4	49.6
90 day maximum	106.1	62.2	168.3	43.9
Timing of annual Extremes				
	Mean (Julian Day)[1]	**Standard Deviation (Julian Day)[1]**	**Mean + 1 Std Dev (Julian Day)[1]**	**Mean - 1 Std Dev (Julian Day)[1]**
Annual Maximum	243.4	18.2	261.6	225.2
Annual Minimum	71.0	70.5	141.4	365.5
Frequency and Duration of High and Low Pulses				
	Mean	**Standard Deviation**	**Mean + 1 Std Dev**	**Mean - 1 Std Dev**
Count (number)				
Low Pulses	3.6	2.2	5.8	1.4
High Pulses	7.3	3.4	10.7	3.9
Duration (days)				
Low Pulses	34.5	27.9	62.4	6.6
High Pulses	13.0	7.1	20.1	5.9
Rate and Frequency of Hydrograph Changes				
	Mean	**Standard Deviation**	**Mean + 1 Std Dev**	**Mean - 1 Std Dev**
Count (number)				
Fall	56.8	18.0	74.8	38.8
Rise	49.0	16.6	65.6	32.4
Rate (cfs/day)				
Fall	-10.4	7.6	-2.8	-18.0
Rise	17.8	14.5	32.3	3.3

NOTES:
1. A count of the days, starting from 12 noon on 1 January 4713 BC.

Range of Variability Outputs, Palouse River at Hooper
(Stn. 13351000)
POR: 1897-1916 1951-2002

Monthly Magnitude				
	Mean Discharge (cfs)	**Standard Deviation (cfs)**	**Mean + 1 Std Dev (cfs)**	**Mean - 1 Std Dev (cfs)**
January	1038.4	986.3	2024.7	52.1
Febuary	1718.9	1214.5	2933.4	504.4
March	1840.1	1260.9	3101.0	579.2
April	1287.7	803.9	2091.6	483.8
May	630.3	345.0	975.3	285.3
June	254.4	154.7	409.1	99.7
July	83.7	53.8	137.5	29.9
August	33.6	22.2	55.8	11.4
September	38.7	22.2	60.9	16.5
October	68.5	29.9	98.4	38.6
November	146.2	74.6	220.8	71.6
December	443.5	487.8	931.3	-44.3
Magnitude and Duration of Annual Extremes				
	Mean Discharge (cfs)	**Standard Deviation (cfs)**	**Mean + 1 Std Dev (cfs)**	**Mean - 1 Std Dev (cfs)**
1 day minimum	20.0	14.7	34.7	5.3
3 day minimum	20.7	14.7	35.4	6.0
7 day minimum	21.9	14.7	36.6	7.2
30 day minimum	23.8	15.0	38.8	8.8
90 day minimum	34.3	18.8	53.1	15.5
1 day maximum	7966.9	6102.0	14068.9	1864.9
3 day maximum	6639.0	4947.8	11586.8	1691.2
7 day maximum	4879.6	3377.4	8257.0	1502.2
30 day maximum	2651.2	1594.5	4245.7	1056.7
90 day maximum	1730.2	956.0	2686.2	774.2
Timing of annual Extremes				
	Mean (Julian Day)[1]	**Standard Deviation (Julian Day)[1]**	**Mean + 1 Std Dev (Julian Day)[1]**	**Mean - 1 Std Dev (Julian Day)[1]**
Annual Maximum	243.8	29.9	273.7	213.9
Annual Minimum	61.3	61.9	123.2	364.5
Frequency and Duration of High and Low Pulses				
	Mean	**Standard Deviation**	**Mean + 1 Std Dev**	**Mean - 1 Std Dev**
Count (number)				
Low Pulses	3.4	2.3	5.7	1.1
High Pulses	5.8	2.6	8.4	3.2
Duration (days)				
Low Pulses	N/A	N/A	N/A	N/A
High Pulses	18.0	8.3	26.3	9.7
Rate and Frequenct of Hydrograph Changes				
	Mean	**Standard Deviation**	**Mean + 1 Std Dev**	**Mean - 1 Std Dev**
Count (number)				
Fall	54.6	12.1	66.7	42.5
Rise	50.7	12.2	63.0	38.5
Rate (cfs/day)				
Fall	-119.9	89.9	-30.0	-209.8
Rise	201.8	166.8	368.6	35.0

NOTES:
1. A count of the days, starting from 12 noon on 1 January 4713 BC.

TABLE 3-11

Summary of Exceedance Flow Probability for USGS Gages

	Palouse near Potlatch (Stn. 13345000)			Paradise at Moscow (Stn. 13346800)			SF. Palouse at Pullman (Stn. 13348000)			Missouri Flat at Pullman (Stn. 13348500)			Palouse below SF at Colfax (Stn. 13349210)		
Month	10%	50%	90%	10%	50%	90%	10%	50%	90%	10%	50%	90%	10%	50%	90%
January	681.8	252.9	41.1	58.8	19.5	6.3	231.0	49.7	6.9	61.2	12.6	0.9	1157.0	501.1	123.1
February	1240.6	520.8	84.1	44.4	18.5	3.5	295.4	89.8	33.7	82.3	22.5	4.6	1798.7	728.5	203.8
March	1177.5	670.0	220.2	16.6	8.0	2.4	229.1	98.5	26.0	58.4	24.3	3.0	1904.2	857.2	245.4
April	1445.5	595.1	159.3	12.2	3.3	1.8	123.5	45.1	20.4	20.9	7.4	1.4	1313.9	600.2	175.7
May	667.2	290.9	68.2	3.7	2.2	0.8	49.4	20.6	6.3	6.1	1.7	0.5	739.5	322.0	87.8
June	280.6	84.6	31.7	1.8	0.9	0.5	19.0	8.3	3.1	2.0	0.7	0.1	338.5	97.7	35.9
July	52.2	26.7	8.3	2.0	0.6	0.3	7.1	3.2	1.2	0.8	0.3	0.006	69.2	37.8	12.6
August	20.0	11.6	4.2	1.6	0.7	0.3	6.4	2.5	0.6	0.9	0.3	0.003	32.8	22.6	5.9
September	17.8	11.1	3.3	2.7	1.0	0.4	5.6	2.8	0.8	0.5	0.3	0.003	36.9	24.5	8.6
October	29.4	15.6	9.9	4.3	2.2	0.6	7.1	4.3	1.4	0.7	0.3	0.010	48.7	34.8	17.6
November	128.7	46.2	14.0	17.1	2.7	1.2	16.7	7.4	2.1	2.8	0.8	0.1	163.7	74.9	32.7
December	425.8	88.8	23.0	29.4	16.0	2.2	83.4	17.2	4.1	23.9	2.5	0.2	578.1	154.2	49.3

Note: Refer to Table 3-1 for period of record.

TABLE 3-11

Summary of Exceedance Flow Probability for USGS Gages

	Pine Creek at Pine City (Stn. 13349400)			Union Flat near Colfax (Stn. 13350500)			Palouse at Hooper (Stn. 13351000)		
Month	10%	50%	90%	10%	50%	90%	10%	50%	90%
January	456.1	131.1	18.5	233.8	47.6	14.7	2231.7	835.4	210.7
February	448.1	130.6	45.3	191.9	82.0	36.7	3557.0	1324.5	437.0
March	539.8	155.3	38.0	341.1	98.6	29.9	3682.3	1471.8	504.8
April	242.1	52.1	13.6	113.0	50.6	22.3	2297.9	1145.9	377.6
May	82.4	24.4	5.2	44.9	24.9	8.0	1112.1	582.3	173.5
June	33.8	11.0	2.6	15.8	8.4	3.6	463.4	237.9	85.8
July	11.4	3.1	1.1	5.3	2.1	0.8	143.0	74.8	28.7
August	5.5	2.3	1.1	2.1	1.0	0.1	64.5	31.0	6.4
September	3.7	2.5	1.0	3.1	1.4	0.1	70.9	34.6	13.7
October	5.1	2.9	1.4	5.5	2.5	1.4	103.7	63.8	31.6
November	10.0	6.2	3.0	18.7	6.2	3.2	246.7	123.9	68.4
December	180.6	18.9	6.8	83.0	24.1	5.9	1324.4	262.5	113.7

Note: Refer tc

TABLE 3-12

Summary of WRIA 34 Lakes

Lake Name	Acreage	Perimeter (ft)
Adams Lake	18.5	6,385
Alkali Lake	95.9	11,418
Alkali Lake	118.8	17,459
Alkali Lake	25.9	5,255
Amber Lake	92.6	16,449
Ames Lake	23.5	5,549
Badger Lake	218.4	33,165
Ballinger Lake	41.0	11,275
Berry Lake	12.0	3,758
Big Lake	7.1	2,821
Big Swamp	8.8	3,213
Bonnie Lake	335.1	55,042
Browns Lake	37.6	8,369
Campbell Lake	34.5	9,929
Chapman Lake	125.8	19,850
Cherry Cove Lake	8.9	2,704
Clear Lake	9.6	3,023
Cow Lake	279.7	39,446
Crane Lake	18.1	5,297
Crooked Knee Lake	81.4	13,238
Deep Lake	13.3	3,241
Devils Lake	2.6	1,285
Dixons Pond	32.0	10,125
Downs Lake	317.1	34,252
Duck Lake	9.0	2,728
Duck Lake	23.2	5,297
East Tritt Lake	19.2	3,614
Feustal Lake	31.7	9,426
Findley Lake	11.9	3,737
Finnell Lake	42.3	8,827
Fishtrap Lake	190.1	34,419
Folsom Lake	76.3	19,794
Fourth of July Lake	98.9	23,236
Granite Lake	96.1	9,845
Green Lake	114.8	21,017
Green Lake	9.6	3,625
Groves Lake	17.4	4,047
Hale Lakes	17.4	3,727
Hale Lakes	6.2	2,488
Hale Lakes	7.7	2,501
Herbert G West, Lake	17.9	4,811
Hergert Lake	11.2	3,441
Hog Lake	49.6	8,483
Honn Lakes	26.2	7,697
Hooper Lake	4.4	2,085
Horseshoe Lake	13.0	3,619

TABLE 3-12

Summary of WRIA 34 Lakes

Lake Name	Acreage	Perimeter (ft)
Isaacson Lake	16.2	4,444
Johnson Lake	15.7	4,250
Johnson Lake	9.5	2,678
Kennedy Lake	11.8	4,097
Kepple Lake	74.9	15,787
Lasher Lake	22.3	7,245
Lavista Lake	20.6	4,276
Long Lake	20.0	6,778
Lost Lake	6.7	2,528
Lye Lake	7.6	2,408
Mason Lake	54.4	10,143
McDowell Lake	54.3	12,438
Medical Lake	122.7	12,860
Mule Lake	11.4	3,514
Negro Lake	18.5	5,432
Otter Lake	23.8	6,872
Page Pond	12.9	2,884
Palm Lake	100.2	13,915
Palouse River	627.9	62,034
Philleo Lake	92.8	11,136
Pine Lakes	5.9	2,491
Pine Lakes	12.9	5,248
Pine Lakes	42.5	8,211
Reeves Lake	188.6	19,064
Ring Lake	21.0	4,042
Ringwood Lake	20.4	5,845
Robinson Lake	7.3	2,324
Rock Lake	2,188.6	97,271
Sheep Lake	54.0	8,768
Silver Lake	418.1	36,273
Silver Lake	11.8	3,583
Sims Lake	23.5	4,690
Sixteen, Lake	15.5	3,991
Spider Lake	4.5	1,953
Sprague Lake	1,842.8	77,349
Stevens Lake	27.0	8,185
Stubblefield Lake	63.9	7,921
Swanee Lake	8.9	2,510
Texas Lake	21.6	5,195
Tule Lake	21.4	5,293
Tule Pond	5.1	1,816
Twelvemile Lake	41.7	7,809
Twelvemile Lake	71.5	9,274
Twelvemile Lake	173.5	25,009
Twin Lakes	5.9	2,061
Twin Lakes	11.3	3,454

Summary of WRIA 34 Lakes

Lake Name		Acreage	Perimeter (ft)
Wall Lake		15.6	6,459
West Tritt Lake		47.9	8,125
Widgeon Lake		5.8	2,299
Wildcat Lake		5.6	2,050
Williams Lake		317.9	27,441
Willow Lake		41.6	6,781
Winn Lake		8.2	3,442
Winn Lakes		17.4	5,328
Unnamed Lakes - Washington			
X-Coordinate[1]	**Y-Coordinate[1]**	**Acreage**	**Perimeter (ft)**
2343244.819	831479.0403	71.4	10,582
2341288.355	830118.0575	21.7	3,832
2336994.304	825068.9667	11.3	3,317
2335301.418	824837.0599	7.1	2,309
2334565.799	823871.1246	6.5	2,519
2337269.838	820160.329	18.4	6,776
2343037.312	812581.2743	33.7	5,363
2341564.392	808907.085	22.2	6,110
2339732.093	804916.6246	15.0	3,201
2364505.051	787010.8197	2.9	1,651
2361137.169	780723.5926	18.4	4,532
2366113.145	780348.1287	37.1	5,925
2362317.343	777614.0623	152.6	34,679
2364006.987	779457.8542	9.4	3,366
2359457.131	776478.446	145.3	29,181
2396169.768	777200.4476	121.7	12,889
2356440.741	774869.3193	148.4	27,443
2357123.507	774970.0423	40.2	9,357
2365610.3	775911.8453	4.9	2,068
2358633.786	775230.4837	35.2	5,439
2371298.681	774755.8972	8.2	2,759
2353945.71	772273.6906	51.7	13,323
2391782.636	771818.4094	48.7	6,552
2351736.674	770626.7332	124.1	14,273
2428196.675	757568.0676	26.1	5,115
2356529.642	755151.5023	22.4	4,396
2275569.94	753273.753	25.6	4,742
2279264.034	748425.7291	27.3	5,156
2296360	746500.3664	45.5	7,608
2278101.109	746015.8917	27.2	4,002
2265128.422	745790.3292	8.7	3,363
2327158.854	744224.9532	19.5	6,853
2347881.483	744486.4282	21.7	3,832
2344129.013	743278.8586	21.0	4,076

Summary of WRIA 34 Lakes

Lake Name		Acreage	Perimeter (ft)
2292791.781	738179.1091	16.5	4,101
2289656.657	726571.4271	59.3	7,788
2319070.387	726318.0698	17.5	3,950
2317111.164	724724.8732	17.8	3,644
2311944.782	722232.5185	60.8	9,021
2313022.086	722631.9486	12.2	2,909
2301138.499	719993.6428	14.4	3,655
2297479.819	718782.6145	87.9	10,900
2291723.411	718401.1468	69.9	9,295
2298970.162	710277.6093	9.0	3,399
2254543.279	709538.2796	5.7	2,110
2298215.12	709011.3963	2.0	1,700
2254330.013	706214.8759	4.6	2,249
2234915.178	704417.0437	201.0	23,521
2283202.964	701503.5389	18.8	3,853
2257185.731	700534.6021	15.0	3,871
2258239.517	698653.7513	18.7	4,162
2280728.997	689305.3938	39.7	6,431
2248668.885	682831.7816	4.2	1,603
2273130.589	682231.4733	1.0	1,143
2256772.542	672100.9195	43.2	9,601
2327052.373	667285.8358	30.4	10,013

Summary of WRIA 34 Lakes

Lake Name		Acreage	Perimeter (ft)
2323453.081	663588.8352	11.6	6,185
2218382.799	662714.5926	11.5	3,574
2321844.326	661351.3207	8.7	5,539
2321552.074	660227.4363	0.5	703
2330192.387	657790.0159	11.1	3,247
2264549.003	652398.9574	72.6	11,227
2258437.789	650970.6899	24.6	6,780
2265209.381	650022.2936	8.4	2,916
2261770.718	647618.2846	6.5	2,553
2257601.667	644792.2973	4.7	1,836
2262825.233	622753.7752	10.5	2,865
2273273.616	617142.013	3.7	1,921
2273582.858	615646.3016	5.8	2,326
2209806.486	614620.3612	29.2	5,627
2205666.369	615438.1278	4.1	1,592
2294075.32	613668.5698	1.8	1,126
2258184.702	612000.5074	8.0	2,636
2210229.053	609042.267	23.5	7,169
2283269.976	606633.1276	15.7	4,612
2251530.791	602193.3815	10.9	2,891
2538023.941	598689.0634	29.8	8,099
2240081.37	590000.7242	2.7	1,308
2267889.252	588928.799	11.6	3,162
2238730.046	523333.5092	6.0	2,587
2237132.204	521703.3637	4.0	2,029
2219698.35	512396.6579	2.5	1,298
2224153.949	510341.0628	2.6	1,299
2214156.036	509600.6375	2.2	1,173
2224015.545	506735.7012	2.2	1,169
2223728.517	504903.937	1.6	951
2222856.043	496714.9893	4.8	2,109
2217640.366	475730.0942	6.6	2,644
2494618.812	473882.012	1.9	1,170
Unnamed Lakes - Idaho			
X-Coordinate[1]	**Y-Coordinate[1]**	**Acreage**	**Perimeter (ft)**
2538023.99402	598689.08281	29.8	8,102
2540044.71781	539003.39771	7.3	2,325

Notes:

1) Washington State Plane, South Zone, NAD 83, Feet.

Data Sources:

WDOE, 1997. Washington Hydrology Framework 100k Water Bodies &
IDWR, 1990. Idaho GIS Lakes Coverage.

WRIA 34 Dam Summary

Dam Name	Alternate Name	Federal NID ID	County	Stream	Owner Name	Owner Type	Type of Dam	Dam Purpose	Date Built	Crest Length (ft)	Height (ft)	Max Discharge Capacity (cfs)	Max Storage (acre-ft)	Normal Storage (acre-ft)	Surface Area (acres)	Drainage Area (mi2)	Downstream Hazard	Regulating Authority
Hog Lake Dam	Deep Lake Dam	WA00056	SPOKANE	Fishtrap Creek	Washington Dept. of Wildlife	State	Rockfill	Recreation	1957	330	19	770	540	280	40	48	High	Washington, Dept of Ecology
Chapman Lake Dam		WA00303	SPOKANE	Rock Creek	Chapman Lake Resort, Inc.	Private	Concrete Gravity	Recreation	1940	75	17	5000	8000	7500	150	49	Low	Washington, Dept of Ecology
Sprague Lake Dam		WA00313	ADAMS	Cow Creek		Private	Concrete Gravity	Recreation	1920	75	2	450	15000	3600	1800	290	Low	Washington, Dept of Ecology
Lower Pine Lake Dam	Turnbull National Wildlife Refuge	WA00317	SPOKANE	Rock Creek	Dept. of Interior, Fish & Wildlife	Federal	Rockfill	Recreation	1940	450	8	45	498	332	75	23	Low	Federally Owned and Regulated
Winslow Dike	Turnbull National Wildlife Refuge	WA00318	SPOKANE	Pine Creek Tr-Rock Creek	Dept. of Interior, Fish & Wildlife	Federal	Earth	Recreation	1939	425	6	45	52	39	14	193	Low	Federally Owned and Regulat
Sheep Springs Dam		WA00440	ADAMS	Cow Creek		Private	Concrete Gravity	Recreation	1906	94	30	0	150	120	7	342	Significant	Washington, Dept of Ecology
Brown Dam	Russell Brown Dam	WA00532	LINCOLN	Tr-Ringwood Lake		Private	Earth	Recreation	1965	200	17	160	80	64	23	133	Low	Washington, Dept of Ecology
Emtman Dam No. 2		WA01026	SPOKANE	Tr-Minnie Creek		Private	Earth	Irrigation	1968	192	13	0	24	18	18	0	Low	Washington, Dept of Ecology
Fishtrap Lake		WA01035	LINCOLN	Fishtrap Creek		Private	Concrete Gravity	Irrigation	1929	150	3	0	4483	4087	373	0	Low	Washington, Dept of Ecology
Middle Pine Dike	Turnbull National Wildlife Refuge	WA01253	SPOKANE	Pine Creek Tr-Rock Creek	Dept. of Interior, Fish & Wildlife	Federal	Earth	Recreation	1939	760	6	45	48	36	20	0	Low	Federally Owned and Regulat
Harder Dam		WA01256	ADAMS	Cow Creek		Private	Concrete Gravity	Recreation	1930	50	6	165	25	14	10	280	Low	Washington, Dept of Ecology
Cow Lake Dam	Harder Dam	WA01267	ADAMS	Cow Creek		Private	Earth	Recreation	1935	600	4	95	900	500	240	315	Low	Washington, Dept of Ecology
Chapman Lake Saddle Dam		WA01362	SPOKANE	Rock Creek	Chapman Lake Resort, Inc.	Private	Earth	Recreation	1940	30	5	0	8000	7500	150	49	Low	Washington, Dept of Ecology
Bennett Pond Dam		WA01557	WHITMAN	Pine Creek		Private	Earth	Irrigation	1960	500	7	4	10	4	4	0	Low	Washington, Dept of Ecology

Source: Washington Department of Ecology, Dam Safety Section, 1998. Dams of Washington State.

Hydraulic Characteristics of Units in the Palouse Watershed
WRIA 34 - Palouse

	Lateral Hydraulic conductance, in feet per second (as derived from specific-capacity data)			
Hydrologic Unit	**median**	**mean**	**minimum**	**maximum**
Overburden Aquifer	2.78E-04	9.53E-02	2.86E-07	1.73E+00
Wanapum Unit	6.02E-05	7.60E-04	8.12E-08	6.07E-02
Upper Grande Ronde Unit	5.70E-05	5.77E-04	5.78E-08	2.92E-02
Lower Grande Ronde Unit*	1.45E-05	2.30E-05	1.10E-07	7.44E-05
	Transmissitvity, in feet squared per second			
Hydrologic Unit	**median**	**mean**	**minimum**	**maximum**
Overburden Aquifer	5.79E-02	2.13E-01	2.60E-05	3.12E+00
Wanapum Unit	8.45E-03	1.55E-02	5.00E-05	1.08E-01
Upper Grande Ronde Unit	1.97E-02	4.25E-02	4.80E-04	1.84E-01
Lower Grande Ronde Unit*	3.11E-02	8.51E-02	5.52E-04	4.80E-01
	Vertical Hydraulic Conductance, in feet per second per foot			
Hydrologic Unit	**median**	**mean**	**minimum**	**maximum**
Overburden Aquifer	2.63E-08	1.25E-06	2.00E-12	1.01E-05
Wanapum Unit	6.02E-12	3.66E-10	5.00E-13	2.70E-08
Upper Grande Ronde Unit	4.98E-11	4.10E-11	4.50E-13	4.98E-11

* values derived from regional groundwater flow model

TABLE 4-2

Pullman Area Supply Well Inventory
WRIA 34 - Palouse

Well ID	Approx. Ground Surface Elevation (ft)	Bottom of Well		Average Pumping Rate			Average Specific Capacity		Average Pumping Water Level				Average Static Water Level			
				1991 [4]	2002	2002	1991 [4]	2002	1991 [4]		2002		1991 [4]		2002	
		Depth (ft)	Elev (ft)	(gpm)	(gpm)	(ft)	(gpm/ft)	(gpm/ft)	Depth (ft)	Elev (ft)	Depth (ft)	Elev (ft)	Depth (ft)	Elev (ft)	Depth (ft)	Elev (ft)
Pullman No. 3	2340.31	165.3	2175.0	488	306	40.6	8.76	7.54	135.0	2205.3	130.0	2210.3	79.3	2261.0	89.4	2250.9
Pullman No. 4	2342.18	954.0	1388.2	230	469	112.4	2.17	4.17	189.5	2152.7	216.6	2125.6	83.4	2258.8	104.2	2238.0
Pullman No. 5	2446.69	712.0	1734.7	240	620	13.6	21.64	45.59	196.2	2250.5	212.5	2234.2	185.1	2261.6	198.9	2247.8
Pullman No. 6	2424.12	560.0	1864.1	640	230	67.6	7.09	3.40	252.9	2171.2	253.7	2170.4	162.7	2261.4	186.1	2238.0
Pullman No. 7	2342.00	718.0	1624.0	3,267 [1]	880 [2]	2.9 [2]	478 [1]	303.4 [2]	101 [1]	2241 [1]	130 [2]	2212.0	93.5 [1]	2248.5 [1]	89.4 [2]	2252.6 [2]
WSU Well No. 1 test	2364	144	2220	0	0	-	-	-	-	-	-	-	106	2258	113	2251
WSU Well No. 1	2364	247	2117	221	0											
WSU Well No. 3	2365	223	2142	287	0								108	2257	112	2253
WSU Well No. 4	2363	275	2088	431	245											
WSU Well No. 5	2507	396	2111	0	0											
WSU Well No. 6	2535	702	1833	172	287								277	2228	287	2218
WSU Well No. 7	2416	2224	192	0	521								153	2263	182	2235
WSU Well No. 8	2580 [3]	812	1768	-	-											

Notes:
Pullman Well No. 1 abandoned March, 1995. Pullman Well No. 2 abandoned March 2001.
WSU Well No. 2 was abandoned August 2003.
1 = Data at time of initial well testing - February 2001.
2 = Data from Summer 2003.
3 = Elevation is approximate
4 = WSU Data is from 1995 and is a mix of pumping and static water levels
Blank cells indicate no data
- = parameter does not apply to well
all depths below ground surface (bgs)
information from City of Pullman Well data files, 3/5/98; Golder, 2001: and Golder 2004
All Pullman and WSU wells are reported to be completed in the Grande Ronde aquifer

TABLE 4-3

Other Municipal System Well Data
WRIA 34 - Palouse

Well ID	Approx. Ground Surface Elevation (ft)	Bottom of Well Depth (ft)	Bottom of Well Elev. (ft)	Date Well Completed	Static Water Level Depth (ft)	Static Water Level Elev. (ft)	Static Water Level Date	Average Yield (gpm)	Aquifer
LaCross Wells									
LaCrosse #1		210		Pre 1920	42		1960		
					43		2000		
LaCrosse #2		272		Pre 1920	147		1939		
					147		2003		
LaCrosse #3		261		Pre 1920	146		1969		
					146		2003		
Steptoe Wells									
#1		510		1983				450	GR
Colfax Wells									
Glenwood #1		110		1915	artesian		1915	106.4	
Glenwood #2		105		1927	artesian		1927	1554	
Clay Street		595		1949	180		1949	711	
Fairview		723		1954	90		1954		GR
Palouse Wells									
Wells 1 & 2	2433	297	2136	Circa 1903	160	2273	7/26/1994	800	GR
					179	2254	12/1/1999		
Well 3		170			9.9		7/26/1994		GR
Well 4		460			250		1/13/2000	800+	

Notes: Blank cells indicate no data compiled
all depths below ground surface (bgs)
GR Grande Ronde

Moscow Area Supply Well Inventory
WRIA 34 - Palouse

Well Identification	Date Well Completed	Approx. Ground Surface Elevation (ft)	Bottom of Well		Aquifer	Static Water Level			Average Pumping Water Level		Average Pumping Rate (gpm)
			Depth (ft)	Elev (ft)		Depth (ft)	Elev (ft)	Year	Depth (ft)	Elev (ft)	
U of I #3	1963	2567	1337	1230	GR	317	2250	1999			2185
U of I #4	1976	2552	747	1805	GR	290	2262	1999			1935
U of I #5	1991	2617	247	2370	WP	130	2487	1999			70
U of I #6	1993	2619	351	2268	WP	140	2479	1999			75
U of I #7	1993	2617	350	2267	WP	137	2480	1999			
Moscow #2*	1925	2568	240	2328	WP	57	2511	1988	73	2495	1150
Moscow #3	1930	2569	569	2000	WP	81	2488	1988	90	2479	1250
Moscow #6	1959	2586	1305	1281	GR	341	2245	1988	389	2197	1350
Moscow #7	1978	2604	508	2096	GR	139	2465	1988	198	2406	700
Moscow #8	1964	2618	1458	1160	GR	366	2252	1988	392	2226	1250
Moscow #9	1982	2557	1242	1315	GR	286	2271	1988	312	2245	2350

Notes: Blank cells indicate no data compiled
GR (Grande Ronde)
WP (Wanapum)
all depths below ground surface (bgs)
*Moscow #2 is no longer active

TABLE 4-5

Water Quality Parameters for the Wanapum and Grande Ronde Aquifers
WRIA 34 - Palouse

Parameter	Unit	Maximum		Minimum		Mean	
		Wanapum	Grande Ronde	Wanapum	Grande Ronde	Wanapum	Grande Ronde
Specific Conductance	μS/cm @ 25 °C	1,970	830	85	85	385.6	311.8
Calculated dissolved solids	mg/L	1,100	510	69	94	243	234.1
Sodium	mg/L	130	90	2.4	4	40.4	24.9
Chloride	mg/L	300	45	0.5	0.5	14.9	7.1
Nitrate + Nitrite	mg/L	54	15	0.1	0.1	2.9	0.96
Silica	mg/L	110	110	10	29	52.3	56.5
Sulfate	mg/L	490	100	0.2	0.2	30.1	21.8
Temperature	°C	43.4	36.7	6.2	7.6	16.7	18
Disolved Oxygen	mg/L	10.6	10.2	0.1	0.1	4.5	3.3
Calcium	mg/L	180	88	0.8	0.95	30.8	24.5
Magnesium	mg/L	75	38	0.01	0.13	14.1	10.7
Fluoride	mg/L	4.9	4.9	0.1	0.1	0.53	0.6
Bicarbonate	mg/L	455	455	43	43	166.2	170.3
Iron	mg/L	10	10	0.003	0.003	0.05	0.098
Potassium	mg/L	22.0	13	0.9	1.1	5.1	4.7
pH	pH units	9.4	9.4	6.1	6.7	7.5	7.6

Notes:

Source: Summary of the Columbia Plateau Regional Aquifer-System Analysis, USGS Professional Paper 1413-A
Wanapum values based on 410 water analyses
Grande Ronde values based on 283 water analyses

TABLE 4-6

Reported Groundwater Recharge Estimates – WRIA 34
(from Larson, 1997 and Belknap, 1999)

Recharge Estimate	Source	Notes
3.0 cm/year	Stevens, 1960	Estimated discharge through loess to the basalt.
1.6 cm/year	Foxworthy and Washburn, 1963	Estimated for the Wanapum.
Negligible	Crosby and Chatters, 1965	Estimated for the Grande Ronde during the Pleistoene using radiocarbon dating.
19.7[(a)] cm/year 1.70[(b)] cm/year	Barker, 1979	Estimated using groundwater flow model (a) Wanapum Recharge (b) Grande Ronde Recharge
3.6[(a)] inches/year 1.9[(b)] inches/year 0.9[(c)] inches/year	Smoot, 1987	Estimated using groundwater flow model Total Recharge (a) Wanapum Recharge (b) Grande Ronde Recharge
2.8[(a)] inches/year 4.1[(b)] inches/year	Bauer and Vaccaro, 1989	Estimated using drop infiltration model (a) Total Recharge (current) (b) Total Recharge (pre-development)
2.8[(a)] inches/year 2.0[(b)] inches/year	Lum and others, 1990	Estimated using groundwater flow model (a) Total (b) Grande Ronde
10.5 cm/year	Johnson, 1991	Estimated for loess using 1-D unsaturated flow model using in situ conductivity measurements.
2.5 – 10.3 cm/year	Muniz, 1991	Estimated for loess using 1-D unsaturated flow model based on textural characteristics.
0.2 – 2 cm/year	O'Brien and others, 1997	Estimated for loess using chloride and tritium profiles.

Land Cover Type in WRIA 34

Type	South Fork Palouse	Cow Creek	Rock Creek	Palouse	Pine Creek	North Fork Palouse	Cottonwood	Union Flat	TOTAL	Percent in watershed
Low Intensity Residential	4,087	1,946	239	313	695	1,446	185	325	**9,236**	0.44%
High Intensity Residential	128	3	-	-	-	-	-	-	**132**	0.01%
Commercial/Industrial/Transportation	3,349	6,118	1,350	1,986	2,575	2,118	698	1,045	**19,240**	0.91%
Bare Rock/Sand/Clay	1	294	32	68	3	486	0	1	**885**	0.04%
Transitional	30	26	1	3	-	15,109	-	1	**15,170**	0.72%
Deciduous Forest	12	540	275	281	18	123	49	38	**1,336**	0.06%
Evergreen Forest	6,321	30,156	8,169	13	2,668	125,621	2	30	**172,981**	8.17%
Mixed Forest	1,163	1,196	256	29	360	5,224	3	5	**8,235**	0.39%
Shrubland	5,881	265,358	84,142	115,732	7,823	10,992	2,075	16,197	**508,201**	24.01%
Orchards/Vineyards/Other	-	0.2	-	-	-	-	-	-	**0**	0.00%
Grasslands/Herbaceous	421	26,631	13,045	13,100	3,055	992	402	1,362	**59,008**	2.79%
Pasture/Hay	10	6,675	2,170	5,144	47	153	361	96	**14,655**	0.69%
Row Crops	-	5	-	-	-	-	-	-	**5**	0.00%
Small Grains	138,972	54,157	53,696	157,774	141,886	113,880	54,389	140,608	**855,363**	40.41%
Fallow	28,214	67,747	55,010	98,027	68,801	39,364	30,153	43,566	**430,883**	20.36%
Urban/Recreational Grasses	87	364	-	28	-	-	-	70	**549**	0.03%
Woody Wetlands	2	769	192	43	3	4	1	2	**1,015**	0.05%
Emergent Herbaceous Wetlands	2	3,694	1,132	266	5	7	-	0	**5,107**	0.24%
Open Water	59	7,638	4,431	1,784	81	471	5	119	**14,589**	0.69%
TOTAL	**188,739**	**473,318**	**224,141**	**394,592**	**228,020**	**315,990**	**88,324**	**203,466**	**2,116,590**	**100.00%**

Summary of Agricultural Census Data (1992, 1997)

	Whitman		Lincoln		Adams		Spokane		Latah	
	1997	**1992**	**1997**	**1992**	**1997**	**1992**	**1997**	**1992**	**1997**	**1992**
Farm Acreage	1,301,265	1,404,289	1,375,869	1,465,788	1,096,447	996,742	589,843	625,769	325,484	347,293
Total Cropland	1,066,676	1,132,001	876,196	888,059	808,651	781,122	398,064	397,644	237,543	246,148
Harvested Cropland	801,501	802,486	489,505	469,660	413,299	387,500	280,969	293,248	188,086	200,033
Irrigated Lands	5,469	6,622	47,984	55,679	148,018	141,852	10,711	14,755	266	2,060
LIVESTOCK (numbers)										
Cattle & Calves	25,379	28,343	32,302	34,610	29,276	77,976	28,596	32,879	10,301	12,415
Beef Cows	12,921	16,151	Withheld	20,924	11,603	10,358	12,083	12,860	5497	6458
Milk Cows	437	229	Withheld	115	3,211	2,641	2,570	4,011	141	174
Hogs and Pigs	9,446	14,908	947	1,118	4,147	6,001	1,294	3,428	371	3,841
Sheep and Lambs	2,329	1,341	1,072	724	1,027	1,419	2,259	2,297	978	3,377
CROPS HARVESTED										
Corn	101	0	564	Withheld	5,388	4,611	Withheld	Withheld	NA	NA
Spring Wheat	478,098	473,128	355,317	360,331	303,813	304,932	155,324	124,571	90,706	97,212
Winter Wheat										
Barley	160,110	167,579	102,415	86,309	10,022	11,079	43,927	48,621	18,615	26,135
Potatoes	0	75	771	Withheld	27,914	17,167	Withheld	Withheld	Withheld	Withheld
Hay-alfalfa, other, wild silage	12,637	11,678	24,902	18,319	27,252	23,730	52,901	52,403	17,540	15,176
Vegetables	5,792	5,822	Withheld	Withheld	3,793	1,395	449	433	NA	NA
Land in Orchards	25	23	85	61	3,597	2,343	367	567	NA	NA

Note: All units in acres unless noted otherwise

TABLE 5-3

Consumptive Use of Tree Species in the Rocky Mountains, Colorado

Tree Species	Estimated Consumptive Use (in/Yr)			Length of Transpiration Season (days)
	Basal Area 10 (m2/ha)	Basal Area 20 (m2/ha)	Basal Area 30 (m2/ha)	
Engelmann Spruce	4.9	9.8	14.7	227
Sub-Alpine Fir	3.4	---	---	227
Lodgepole Pine	2.9	5.7	8.7	227
Aspen	4 to 12			110

Source: Alexander, R.R., et al, 1985 *The Fraser Experimental Forest, Colorado: Research Program and Published Research 1937-1985*, USDA Forest Service, General Technical Report RM-119.

TABLE 5-4

Consumptive Use of Grasslands, Washington

Species/Location	ET Method[6]	June 1990	July 1990	August 1990	September 1990	October 1990	November 1990
Snively Basin Site[1]	BR (inches)	1.08	0.43	--	--	--	--
	PM (inches)	1.09	0.46	0.63	0.21	0.39	0.32
Turnbull Marsh Site[2]	PM (inches)	--	--	--	--	--	--
Turnbull Meadow Site[3]	BR (inches)	--	--	--	--	--	--
	PM (inches)	--	--	--	--	--	--
Grass Lysimeter Site[4]	BR (inches)	--	--	--	--	--	--
	WL (inches)	--	--	--	--	--	--

Species/Location	ET Method[6]	December 1990	January 1991	February 1991	March 1991	April 1991	May 1991
Snively Basin Site[1]	BR (inches)	--	--	--	--	2.63	1.53
	PM (inches)	0.19	0.23	0.52	1.16	2.62	1.58
Turnbull Marsh Site[2]	PM (inches)	--	--	--	--	--	--
Turnbull Meadow Site[3]	BR (inches)	--	--	--	--	--	1.45
	PM (inches)	--	--	--	--	--	1.51
Grass Lysimeter Site[4]	BR (inches)[5]	--	--	--	--	0.51	0.17
	WL (inches)[5]	--	--	--	--	1.27	0.33

Species/Location	ET Method[6]	June 1991	July 1991	August 1991	September 1991
Snively Basin Site[1]	BR (inches)	1.46	--	--	--
	PM (inches)	1.43	0.94	0.23	0.06
Turnbull Marsh Site[2]	PM (inches)	--	--	3.01	1.67
Turnbull Meadow Site[3]	BR (inches)	3.49	3.30	--	--
	PM (inches)	3.57	3.46	--	--
Grass Lysimeter Site[4]	BR (inches)	--	--	--	--
	WL (inches)	--	--	--	--

Source: Tomlinson, Stewart A., 1995. Evaluating Evapotranspiration for Grasslands on the Arid Lands Ecology Reserve, Benton County, and Turnbull National Wildlife Refuge, Spokane County, Washington, May 1990 to September 1991: U.S. Geologic Survey Water-Resources Investigations Report 95-4069.

Notes:
[1] Dominant vegetation types include: cheatgrass
[2] Dominant vegetation types include: wheatgrass, ryegrass, bulrush, sedges, common rush, common cat-tail and common thistle.
[3] Dominant vegetation types include: Idaho fescure, bluebunch wheatgrass, Merrills bluegrass, Sandsbergs bluegrass and Kentucky bluegrass
[4] Dominant vegetation types include: bluebunch wheatgrass and Sandbergs bluegrass
[5] Partial Month of Data
[6] BR = Bowen-Ratio Method, PM = Penman-Montheith & WL = Weighing Lysimeters Method

TABLE 5-5

Estimated Crop Water Requirements
for Crops Grown in the Palouse Basin

Crop	Estimated CIR (CU-EPg -EPd) (inches/yr.)[4]			
	2 Year Return Period	5 Year Return Period	10 Year Return Period	20 Year Return Period
Hay[2]	24-25	26-27	26-28	27-28
Winter Wheat	20	21	22	23
Spring Grain (Barley)	21	23	23	24
Vegetables[3]	14	18	19	20

[1]All data based on Pullman Station
[2]Based on Alfalfa and Pasture
[3]Based on dry beans
4 CIR = CU-EPg-EPd
CIR = Crop Irrigation Requirement
CU = Consumptive Use
EPg = Effective Precipitation (Growing Season)
EPd = Effective Precipitation (Dormant Season)

Source: James and others, 1989. Irrigation requirements for Washington - Estimates and methodology. WSU Agricultural Research Center, EB 1513

TABLE 5-6

Typical Overall On-farm Efficiencies (Including Application and Distribution Efficiency) for Various Irrigation Systems[1]

System type	Overall efficiency (%)
Surface:	
a). Average	50
b). Land leveling, pipe water delivery meeting design standards	70
c). Tailwater recovery with (b)	80
d). Cut-back irrigation	80
e). Surge	70 - 90[2]
Sprinkler	50 - 75[3]
Center Pivot - equipped with:	
a). Impact sprinklers	50 - 60
b). Low pressure drops	75 - 85[3]
c). LESA (low elevation spray application)	85 - 95
d). LEPA (low energy precision application)	85 - 95
Drip	80 - 90[4]

[1] Fipps 1998-freely adapted from James, 1988.
[2] surge increases efficiencies from 8 - 28% over non-surge furrow systems
[3] under low wind weather conditions
[4] drip systems are typically designed at these efficiencies. However, short laterals and/or pressure compensating emitters may have higher efficiencies, and excessively long lateralswill have lower efficiencies.

Example: 100 acres of hay with a crop irrigation requirement (CIR) of 28 inches requires 233 acre-feet of water. If the crop obtains that CIR via an impact sprinkler irrigation system with a 60% efficiency, it takes an additional 93 AF of withdrawal to compensate for system inefficiency, or a total water withdrawal of 326 AF.

WRIA 34 Group A and Group B Water Systems

Pws_Id	Pws_Grp_Code	Pws_Type_Code	Pws_Effec_Date	Pws_Name	Pws_City_Name
09277	A	TNC	1/1/1970	BUNKERS RESORT 1	CHENEY
09280	A	TNC	1/1/1970	WILLIAMS LAKE BEACH CLUB	CHENEY
45622	A	TNC	1/1/1970	WILLIAMS LAKE RESORT	CHENEY
46985	A	COMM	1/1/1970	LEWIS BROTHERS INC	CHENEY
66633	A	TNC	1/1/1970	PEACEFUL PINES TRAILER COURT	CHENEY
89725	A	TNC	7/1/1978	TURNBULL WILDLIFE REFUGE SYSTEM 1	CHENEY
08015	A	TNC	1/1/1970	BOYER PARK & MARINA	COLFAX
14000	A	COMM	1/1/1970	COLFAX WATER DEPARTMENT, CITY OF	COLFAX
37580	A	TNC	1/1/1970	KAMIAK BUTTE COUNTY PARK	COLFAX
42775	A	TNC	1/1/1970	KLEMGARD COUNTY PARK	COLFAX
48625	A	TNC	1/1/1970	PORT CENTRAL FERRY DWELLING	COLFAX
63917	A	TNC	1/1/1970	ONECHO BIBLE CHURCH	COLFAX
65785	A	TNC	1/1/1970	PALOUSE EMPIRE FAIRGROUNDS	COLFAX
93860	A	TNC	6/1/1979	WAWAWAI COUNTY PARK	COLFAX
HD300	A	TNC	1/1/1970	HORN SCHOOL REST AREA	COLFAX
11010	A	COMM	1/1/1970	CANYON CREEK COURT	COLTON
14100	A	COMM	1/1/1970	COLTON WATER DEPARTMENT	COLTON
HD749	A	TNC	1/1/1970	SPRAGUE LAKE EB REST AREA	DAVENPORT
HD750	A	TNC	1/1/1970	SPRAGUE LK WB REST AREA	DAVENPORT
23400	A	COMM	1/1/1970	ENDICOTT WATER DEPT	ENDICOTT
24700	A	COMM	1/1/1970	FARMINGTON WATER DEPT	FARMINGTON
27200	A	COMM	1/1/1970	GARFIELD WATER DEPARTMENT	GARFIELD
15477	A	TNC	1/1/1970	COUNTRY BIBLE CHURCH	LACROSSE
43400	A	COMM	1/1/1970	LACROSSE, TOWN OF	LACROSSE
77420	A	TNC	1/1/1970	SELBU LUTHERAN CHURCH	LACROSSE
45647	A	NTNC	1/1/1970	LAMONT SCHOOL DISTRICT 264	LAMONT
45650	A	COMM	1/1/1970	LAMONT WATER SYSTEM	LAMONT
50550	A	COMM	1/1/1970	MALDEN WATER DEPT	MALDEN
51845	A	COMM	1/1/1970	MARSHALL COMMUNITY WATER ASSN	MARSHALL
13525	A	COMM	1/1/1970	CLEAR LAKE WATER USERS ASSN	MEDICAL LAKE
34374	A	NTNC	6/1/1985	WEST PLAINS FARM SUPPLY	MEDICAL LAKE

WRIA 34 Group A and Group B Water Systems

Pws_Id	Pws_Grp_Code	Pws_Type_Code	Pws_Effec_Date	Pws_Name	Pws_City_Name
45086	A	COMM	1/1/1970	EASTERN WASHINGTON BIBLE CAMP	MEDICAL LAKE
67295	A	COMM	1/1/1970	PICNIC PINES TRAILER COURT	MEDICAL LAKE
84620	A	COMM	1/1/1970	STRATHVIEW WATER DISTRICT 16	MEDICAL LAKE
62700	A	COMM	1/1/1970	OAKESDALE, TOWN OF	OAKESDALE
65800	A	COMM	1/1/1970	PALOUSE WATER DEPT, CITY OF	PALOUSE
49375	A	TNC	1/1/1970	LYONS FERRY CORPS OF ENG	POMEROY
SP150	A	TNC	1/1/1970	CENTRAL FERRY STATE PARK	POMEROY
SP630	A	TNC	1/1/1970	PALOUSE FALLS STATE PARK	POMEROY
SP870	A	TNC	1/1/1970	STEPTOE BUTTE STATE PARK	POMEROY
00710	A	COMM	7/8/1991	SNAKE RIVER HOUSING WATER SYSTEM	PRESCOTT
05425	A	COMM	5/1/1979	BELLEVUE DUPLEXES	PULLMAN
24150	A	COMM	1/1/1970	EVERGREEN HOMEOWNERS ASSOCIATION	PULLMAN
69880	A	COMM	1/1/1970	PULLMAN WATER DEPARTMENT, CITY OF	PULLMAN
86130	A	COMM	1/1/1970	SUNSET MOBILE COURT	PULLMAN
89520	A	NTNC	1/1/1970	TULA YOUNG HASTINGS FARM - WSU	PULLMAN
93200	A	COMM	1/1/1970	WASHINGTON STATE UNIVERSITY	PULLMAN
07297	A	NTNC	6/1/1981	BRIARWOOD-VALLEY FARMS	ROCHESTER
74250	A	COMM	1/1/1970	ROSALIA, TOWN OF	ROSALIA
32688	A	COMM	1/1/1970	HIGH SCHOOL STUDENT AMB PROGRAM	SPOKANE
34199	A	TNC	7/1/1986	RUBY'S ON SILVER LAKE	SPOKANE
25555	A	TNC	1/1/1970	FISHTRAP LAKE RESORT	SPRAGUE
83140	A	TNC	1/1/1970	SPRAGUE LAKE RESORT	SPRAGUE
83150	A	COMM	1/1/1970	SPRAGUE, CITY OF	SPRAGUE
75300	A	COMM	1/1/1970	ST JOHN, TOWN OF	ST JOHN
24881	A	COMM	5/1/1984	STEPTOE WATER/SEWER DISTRICT	STEPTOE
30801	A	TNC	6/1/1985	SYSTEM #2 - KINSINGER	STEPTOE
84075	A	TNC	1/1/1970	STEPTOE SCHOOL DISTRICT #304	STEPTOE
87300	A	COMM	1/1/1970	TEKOA, CITY OF	TEKOA
88100	A	TNC	1/1/1970	THORNTON W SUPPLY	THORNTON
90400	A	COMM	1/1/1970	UNIONTOWN WATER WORKS	UNIONTOWN
00278	B		1/1/1970	ADAMS CO FIRE DIST #6	BENGE

WRIA 34 Group A and Group B Water Systems

Pws_Id	Pws_Grp_Code	Pws_Type_Code	Pws_Effec_Date	Pws_Name	Pws_City_Name
05660	B		11/1/1979	BENGE SCHOOL DISTRICT	BENGE
00106	B		10/10/1990	J & J WELL WATER SYSTEM	CHENEY
00545	B		5/10/1991	FOUR LAKES ANG WATER SYSTEM	CHENEY
01539	B		7/7/1992	BETZ WATER SYSTEM	CHENEY
01965	B		1/1/1970	AMBER LAKE RESORT	CHENEY
02410	B		7/1/1978	ANDERSON TRAILER COURT	CHENEY
02483	B		6/11/1993	TURNBULL NWR HELM BUNKHOUSE	CHENEY
09278	B		1/1/1970	BUNKERS RESORT 2	CHENEY
13514	B		5/1/1982	BUNKERS RESORT SYSTEM 3	CHENEY
18367	B		1/1/1970	DECKERS RESORT	CHENEY
19911	B		1/1/1970	DOWNS LAKE RESORT	CHENEY
21905	B		1/1/1970	EASTERN WASH. UNIV.-BADGER LAKE	CHENEY
25764	B		1/1/1979	FOLAND WATER SYSTEM	CHENEY
26865	B		1/1/1970	FULLERS RESORT	CHENEY
51144	B		9/1/1988	HUNT-MAYFIELD	CHENEY
55991	B		5/1/1989	OLD LLAMA WATERING HOLE	CHENEY
56151	B		6/1/1989	GROGAN WATER SYSTEM	CHENEY
56242	B		7/1/1989	JEAN'S CAKES & CATERING	CHENEY
89727	B		7/1/1978	TURNBULL WILDLIFE REFUGE SYSTEM 2	CHENEY
00198	B		1/3/1991	MCGREGOR OFFICE COMPLEX	COLFAX
00236	B		1/1/1980	COLFAX MEAT PACKING CO	COLFAX
00727	B		6/17/1991	STEWART WATER SYSTEM	COLFAX
01725	B		1/1/1970	ALMOTA ELEVATOR COMPANY	COLFAX
01729	B		9/17/1992	SWALLEY WATER SYSTEM	COLFAX
02995	B		1/1/1970	ARROW MACHINERY	COLFAX
05529	B		12/1/1980	GRANDVIEW WATER SYSTEM	COLFAX
06326	B		12/11/1997	WHITMAN CO PORT OF INDUSTRIAL PARK	COLFAX
07616	B		1/31/2000	HUBER WELL	COLFAX
08382	B		12/13/2001	COLFAX COUNTY SHOP	COLFAX
33591	B		8/1/1986	MCGREGOR COMPANY	COLFAX
84078	B		1/1/1970	STEPTOE WATER SYSTEM	COLFAX

WRIA 34 Group A and Group B Water Systems

Pws_Id	Pws_Grp_Code	Pws_Type_Code	Pws_Effec_Date	Pws_Name	Pws_City_Name
86758	B		1/1/1970	SYSTEM 1 KINSINGER	COLFAX
86759	B		1/1/1970	SYSTEM #2 KINSINGER	COLFAX
96526	B		1/1/1970	WHITMAN COUNTY MEMORIAL AIRPORT	COLFAX
HD117	B		8/1/1985	COLFAX MAINTENANCE - DOT	COLFAX
01283	B		3/20/1992	RUSSELL WATER SYSTEM	COLTON
02509	B		6/29/1993	ROSGEN WATER SYSTEM	COLTON
12600	B		7/1/1982	FREI, TONY MEAT PROCESSING	COLTON
HD740	B		1/1/1970	SPRAGUE MAINTENANCE SHED	DAVENPORT
BP340	B		1/1/1970	LITTLE GOOSE SUBSTATION	DAYTON
FW013	B		3/11/1991	FORD HATCHERY WATER SYSTEM	FORD
34149	B		1/1/1970	HOOPER WATER	HOOPER
20610	B		1/1/1970	DUSTY FARM CO-OP INC	LACROSSE
32014	B		3/1/1986	POE ASPHALT PAVING INC	LEWISTON
01772	B		10/9/1992	LEFEVRE'S TRACTS 3 & 4	MEDICAL LAKE
17616	B		3/1/1983	STALEY RESIDENTIAL WATER SYSTEM	MEDICAL LAKE
41535	B		11/1/1987	FUHRMAN WATER SYSTEM	MEDICAL LAKE
51061	B		8/1/1988	COLES WATER SYSTEM	MEDICAL LAKE
56274	B		7/1/1989	DENEMRAC	MEDICAL LAKE
79248	B		1/1/1970	SILVER LAKE RESORT	MEDICAL LAKE
90971	B		1/1/1970	VALLEY CEMENT	MOSCOW
00488	B		5/6/1991	HANFORD CASTLE WATER SYSTEM	OAKSDALE
01998	B		9/1/1980	BYRD WATER SYSTEM	OLYMPIA
15626	B		12/1/1982	TECUMSEH WATER SYSTEM	OLYMPIA
37221	B		12/1/1986	WHISKERS	OLYMPIA
HD615	B		1/1/1970	ROSALIA MAINTENANCE SITE	OLYMPIA
SP880	B		1/1/1970	STEPTOE MEMORIAL STATE PARK	OLYMPIA
18796	B		8/1/1983	DENTON WATER SYSTEM	ORANGE
07539	B		11/24/1999	POTHOLEVIEW ESTATES	OTHELLO
02523	B		7/1/1993	DALE'S FLYING SERVICE	PALOUSE
03680	B		6/24/1994	WEST, LYLE WATER SYSTEM	PALOUSE
04414	B		4/7/1995	RIOJAS-RISK	PROSSER

WRIA 34 Group A and Group B Water Systems

Pws_Id	Pws_Grp_Code	Pws_Type_Code	Pws_Effec_Date	Pws_Name	Pws_City_Name
00156	B		7/25/1990	PALOUSE PRODUCERS SUBDIVISION	PULLMAN
00319	B		2/28/1991	CRYSTAL COMMUNITY DISTRICT WS	PULLMAN
02134	B		2/1/1993	BENSCOTER WATER SYSTEM	PULLMAN
02488	B		6/17/1993	PAC WEST PRE-MIX WATER SYSTEM	PULLMAN
02489	B		6/16/1993	U-CITIES SUPPLY WATER SYSTEM	PULLMAN
03664	B		7/29/1994	C & B READY MIX CO INC	PULLMAN
05003	B		12/22/1995	MCGREGOR COMPANY - PULLMAN	PULLMAN
05190	B		4/29/1996	BRUCE/TENWICK WATER SYSTEM	PULLMAN
05438	B		10/4/1996	CARSTENS, LLOYD	PULLMAN
05695	B		3/13/1997	CROSSROADS NURSERY & GARDEN GIFTS	PULLMAN
05944	B		2/1/1981	MEADOW LARK WELL ASSN	PULLMAN
06064	B		2/1/1981	WHITMAN COUNTY LANDFILL	PULLMAN
06881	B		11/30/1998	MCKEIRNAN BROS	PULLMAN
07025	B		3/24/1999	SEL HANGER WATER SYSTEM	PULLMAN
12781	B		9/1/1982	EXECUTRANS	PULLMAN
28995	B		1/1/1970	GRANGE 118	PULLMAN
33465	B		1/1/1970	HINRICHS FARM WATER SYSTEM	PULLMAN
36875	B		10/1/1979	JOHNSON ROAD WATER FUND	PULLMAN
39055	B		4/1/1987	PALOUSE CONSERVATION FIELD STATION	PULLMAN
69877	B		1/1/1970	PULLMAN MOSCOW REGIONAL AIRPORT	PULLMAN
80795	B		1/1/1970	SMOOT HILL BIOL FIELD STUDY AREA	PULLMAN
82981	B		1/1/1970	SPILLMAN FARM	PULLMAN
90425	B		1/1/1970	USDA-WSU-PLANT MATERIALS CENTER	PULLMAN
93349	B		1/1/1970	AVISTA UTILITIES	PULLMAN
93995	B		1/1/1970	WEGNER FARM	PULLMAN
95200	B		1/1/1970	WESTHILL ACRES HOMEOWNERS ASSN	PULLMAN
03490	B		6/14/1994	GELHAUS, DON WATER SYSTEM	ROSALIA
03624	B		5/1/1994	CACHE CREEK RANCH WATER SYSTEM	ROSALIA
65452	B		1/1/1970	PG&E GT-NW #6	ROSALIA
67755	B		1/1/1970	PLAZA GRANGE SUPPLY	ROSALIA
10813	B		2/1/1982	CHAPMAN LAKE RESORT #3	SPANGLE

WRIA 34 Group A and Group B Water Systems

Pws_Id	Pws_Grp_Code	Pws_Type_Code	Pws_Effec_Date	Pws_Name	Pws_City_Name
12241	B		1/1/1970	CHAPMAN LAKE RESORT SYSTEM 1	SPANGLE
12242	B		1/1/1970	CHAPMAN LAKE RESORT SYSTEM #2	SPANGLE
03554	B		7/1/1994	UNION GOSPEL MISSION SHANKRILA CAMP	SPOKANE
24250	B		1/1/1970	EWAN WATER ASSOCIATION	ST. JOHN
01225	B		1/1/1970	ALDERMAN, BOB WATER	STEPTOE
86760	B		1/1/1970	SYSTEM #3 KINSINGER	STEPTOE
02746	B		10/21/1993	WYNN WATER SYSTEM	THORNTON
24265	B		1/1/1970	TYLER STORE AND CAMPGROUND	TYLER

Code Definitions:

TNC = Transient Non Commercial

COMM = Commercial

NTNC = Non Transient Non Commercial

A = Group A System (greater than 25 permanent residents)

B = Group B System (serving less than 25 permanent residents)

City Water Systems by Subbasin

City Water Systems by Sub-Basin
North Fork Palouse
Town of Garfield, WA
City of Potlatch, ID
City of Palouse, WA
Pine Creek
Town of Farmington, WA
Town of Oakesdale, WA
Town of Rosalia, WA
Cottonwood Creek
Town of Saint John, WA
Rock Creek
Town of Lamont, WA
South Fork Palouse
City of Moscow, ID
City of Pullman, WA
Union Flat Creek
Town of Colton, WA
City of Genesee, ID
Palouse River
City Colfax, WA
Town of Endicott, WA
City of LaCrosse, WA
Cow Creek
City of Medical Lake, WA
City of Sprague, WA

Water Production - City of Pullman

	Water Production (M Gallons)			
	2000	**2001**	**2002**	**Average**
January	52.743	49.667	51.003	51.137667
February	54.949	51.492	52.795	53.078667
March	54.377	51.437	52.508	52.774
April	61.805	56.474	59.717	59.332
May	69.347	65.525	66.623	67.165
June	81.064	79.464	82.416	80.981333
July	121.115	100.73	117.042	112.96233
August	133.956	120.98	116.63	123.85533
September	80.518	105.148	95.224	93.63
October	63.992	68.466	65.907	66.121667
November	52.343	49.714	52.84	51.632333
December	52.1953	51.37	47.526	50.363767
TOTAL	**878.4043**	**850.467**	**860.231**	**863.0341**

	Metered Water (Sold) (M Gallons)			
	2000	**2001**	**2002**	**Average**
Single Family	302.27	296.3	295.73	298.1
Duplex	58.942	59.57	56.921	58.477667
Multifamily, M/H	185.433	192.347	188.864	188.88133
Business/Commercial	95.262	98.659	90.678	94.866333
Group Housing	45.869	43.574	42.501	43.981333
Schools	7.123	6.062	7.722	6.969
Irrigation	87.161	79.492	73.992	80.215
Mobile Homes	43.589	45.143	44.115	44.282333
Industrial	0.224	0.321	0.457	0.334
Hydrant Meters Billed	2.371	0.987	0.881	1.413
Adjustment	24.315	0.23		
TOTAL	**803.929**	**822.685**	**801.861**	**809.49167**

	Summary			
	2000	**2001**	**2002**	**Average**
Water, MG	878.404	850.467	860.231	863.034
Water Metered Sold, MG	803.933	822.688	801.863	809.49467
Annual Water (Not Billed)	4.962	4.273	5.445	4.8933333
% of Water Accounted for	92.09%	97.24%	93.85%	0.9439333
Daily Average, MG	2.216	2.266	2.212	2.2313333
Average Daily Use Per Capita	117.88	119.5	112.2	116.52667

Water Production - City of Palouse

City of Palouse Water Pumping Records - monthly average (Gallons per Day)

	2000	2001	2002	2003
January	81,532	74,658	73,665	99,603
February	81,997	67,600	80,689	89,689
March	79,090	74,006	75,887	91,558
April	96,233	85,337	77,908	91,220
May	146,300	143,516	125,895	118,490
June	238,070	218,097	221,127	311,727
July	404,377	293,316	442,674	457,219
August	403,219	377,048	317,077	342,187
September	103,887	250,497	210,707	209,633
October	87,842	94,819	110,587	121,955
November	86,680	84,503	104,410	87,293
December	77,235	80,803	84,165	92,850

Monthly WWTP Discharge to North Fork Palouse River (RM 120) - mgd

	2000	2001	2002	2003
January	0.107	0.06	0.103	0.076
February	0.155	0.073	0.103	0.105
March	0.14	0.053	0.128	0.113
April	0.083	0.051	0.065	0.066
May	0.06	0.056	0.045	0.051
June	0.059	0.041	0.037	0.042
July	0.051	0.042	0.042	0.037
August	0.053	0.035	0.035	0.039
September	0.05	0.035	0.04	0.041
October	0.047	0.04	0.04	0.041
November	0.051	0.58	0.054	0.044
December	0.055	0.098	0.058	--
ANNUAL				

Pumped vs. Metered Water (gallons)

	2000-2001	2001-2002	2002-2003
Pumped	17,101,400	14,323,500	13,881,000
Metered	14,275,991	13,438,351	13,348,157
%	83.5%	93.8%	96.2%

Water Production - Town of Farmington

	Current - 2002
Total Annual Use - 2002	19.5 Million Gallons
Residential Service Annual Use (150 People)	12.5 Million Gallons
Institutional/Commercial Annual Use	7.0 Million Gallons
Number of Current Active Connections	80
Residential Connections	71
Institutional/Commercial Connections	9
Existing Average Daily Usage per ERU	482 gpd/ERU
***Estimated Average Day Demand (ADD) per ERU**	520 gpd/ERU
****Number of ERUs Based on Annual Water Use**	111 ERU
Water Rights Certificate - Max Annual Volume (Qa)	150 AF/yr
****Number of Available ERUs based on Qa**	278
Number of Currently Approved DOH Connections	100
Meter Record Total	19.2 Million Gallons

ERU - Equivalent Residential Unit based on 71 residential connections

*Based on Water System Design Manual - Equation 1:
ADD = (8000/AAR) + 200, where average annual rainfall
= 25 inches/year
**Based on 482 gpd

Source: Town of Farmington, 2003

Water Production - City of Colfax

City of Colfax Total Gallons Pumped per Year

	2000 TOTAL	2001 TOTAL	2002 TOTAL	2003 TOTAL
January*	No Data	17,421,400	40,667,000	15,789,756
February	16,246,000	16,065,000	8,605,200	15,174,000
March	17,510,000	16,877,000	1,799,000	13,395,100
April**	15,882,000	16,071,000	770,600	15,395,400
May	25,462,900	25,149,700	22,746,300	20,927,877
June*	No Data	32,973,100	34,909,000	41,446,090
July	45,701,800	45,702,800	67,645,000	49,633,394
August	52,553,400	50,738,100	41,723,900	44,421,428
September	20,843,700	30,157,400	27,859,500	27,060,086
October	18,308,600	19,955,000	19,113,700	21,076,668
November	16,769,000	15,703,000	14,915,000	15,412,580
December	12,733,314	15,179,200	15,791,700	16,057,355
TOTAL	**242,010,714**	**301,992,700**	**296,545,900**	**295,789,734**

* No data collected in January and June 2000

**No data collected at Booster/Glenwood Wells due to meter repair in April 2002

City of Colfax Total Gallons Pumped per Well - 2000

	2000			
	Fairview Well	**Clay Street Well**	**Booster/ Glenwood Wells**	**2000 TOTAL**
January*	No Data	No Data	No Data	**No Data**
February	2,716,000	0	13,530,000	**16,246,000**
March	2,901,000	299,000	14,310,000	**17,510,000**
April	2,410,000	0	13,472,000	**15,882,000**
May	2,058,000	2,471,900	20,933,000	**25,462,900**
June*	No Data	No Data	No Data	**No Data**
July	10,858,000	15,062,800	19,781,000	**45,701,800**
August	11,623,000	18,412,400	22,518,000	**52,553,400**
September	3,633,000	419,700	16,791,000	**20,843,700**
October	3,108,000	2,600	15,198,000	**18,308,600**
November	4,614,000	0	12,155,000	**16,769,000**
December	4,314	0	12,729,000	**12,733,314**
TOTAL	**43,925,314**	**36,668,400**	**161,417,000**	**242,010,714**

* No data collected in January and June 2000

City of Colfax Total Gallons Pumped per Well - 2001

	2001			
	Fairview Well	**Clay Street Well**	**Booster/ Glenwood Wells**	**2001 TOTAL**
January	3,843,000	254,400	13,324,000	**17,421,400**
February	2,896,000	0	13,169,000	**16,065,000**
March	2,592,000	0	14,285,000	**16,877,000**
April	2,379,000	0	13,692,000	**16,071,000**
May	3,550,000	1,966,700	19,633,000	**25,149,700**
June	9,520,000	5,347,100	18,106,000	**32,973,100**
July	6,923,000	16,196,800	22,583,000	**45,702,800**
August	7,198,000	20,280,100	23,260,000	**50,738,100**
September	4,362,000	7,431,400	18,364,000	**30,157,400**
October	2,682,000	308,000	16,965,000	**19,955,000**
November	2,838,000	0	12,865,000	**15,703,000**
December	2,479,000	110,200	12,590,000	**15,179,200**
TOTAL	**51,262,000**	**51,894,700**	**198,836,000**	**301,992,700**

Water Production - City of Colfax

City of Colfax Total Gallons Pumped per Well - 2002

	2002			
	Fairview Well	**Clay Street Well**	**Booster/ Glenwood Wells**	**2002 TOTAL**
January	27,718,000	0	12,949,000	**40,667,000**
February	2,576,000	124,200	5,905,000	**8,605,200**
March	1,142,000	143,000	514,000	**1,799,000**
April*	361,000	409,600	No Data	**770,600**
May	0	2,526,300	20,220,000	**22,746,300**
June	2,305,000	12,898,000	19,706,000	**34,909,000**
July	16,574,000	29,589,000	21,482,000	**67,645,000**
August	10,990,000	9,296,900	21,437,000	**41,723,900**
September	3,364,000	5,470,500	19,025,000	**27,859,500**
October	1,026,000	256,700	17,831,000	**19,113,700**
November	103,000	0	14,812,000	**14,915,000**
December	0	42,700	15,749,000	**15,791,700**
TOTAL	**66,159,000**	**60,756,900**	**169,630,000**	**296,545,900**

*No data collected at Booster/Glenwood Wells due to meter repair in April 2002

City of Colfax Total Gallons Pumped per Well - 2003

	2003			
	Fairview Well	**Clay Street Well**	**Booster/ Glenwood Wells**	**2003 TOTAL**
January	0	399,500	15,390,256	**15,789,756**
February	589,000	0	14,585,000	**15,174,000**
March	4,000	356,100	13,035,000	**13,395,100**
April	0	159,400	15,236,000	**15,395,400**
May	37,377	2,161,500	18,729,000	**20,927,877**
June	12,110,190	9,849,900	19,486,000	**41,446,090**
July	28,245,994	728,400	20,659,000	**49,633,394**
August	25,249,428	2,495,000	16,677,000	**44,421,428**
September	8,224,386	4,403,700	14,432,000	**27,060,086**
October	109,068	2,034,600	18,933,000	**21,076,668**
November	298,400	245,700	14,868,480	**15,412,580**
December	0	15,660	16,041,695	**16,057,355**
TOTAL	**74,867,843**	**22,849,460**	**198,072,431**	**295,789,734**

Water Production - Washington State University (WSU)

WSU Monthly Water Usage (Millions of Gallons)

	2000 TOTAL	2001 TOTAL	2002 TOTAL	2003 TOTAL
January	34.53	36.74	29.70	32.00
February	34.46	35.22	29.43	35.25
March	39.85	39.38	34.87	36.48
April	39.31	43.22	40.96	41.13
May	37.86	46.50	46.93	42.00
June	47.36	55.59	55.59	64.80
July	72.30	71.64	73.56	84.89
August	83.39	85.43	77.17	81.58
September	57.27	80.67	70.35	65.03
October	47.58	50.52	51.22	56.05
November	37.43	46.51	40.19	36.27
December	45.21	36.45	35.87	32.69
TOTAL	**576,552,625**	**627,876,660**	**585,853,585**	**608,157,031**

Running Totals in Millions of Gallons Used

	2001 TOTAL	2002 TOTAL	2003 TOTAL
January	36.739	29.698	31.998
February	71.956	59.130	67.243
March	111.337	93.995	103.722
April	154.552	134.956	144.852
May	201.055	181.887	186.854
June	256.647	237.480	251.657
July	328.291	311.039	336.544
August	413.716	388.213	418.126
September	494.390	458.566	483.153
October	544.914	509.786	539.203
November	591.428	549.980	575.471
December	627.877	585.854	608.157

City of Pullman Wastewater Treatment Plant Flow Summary

Month	2000		2001		2002	
	Total Influent (million gallons)	Total Effluent (million gallons)	Total Influent (million gallons)	Total Effluent (million gallons)	Total Influent (million gallons)	Total Effluent (million gallons)
JANUARY	102.02	96.33	85.38	79.83	96.92	93.14
FEBRUARY	115.65	110.77	96.01	90.39	100.37	96.42
MARCH	109.56	104.25	91.76	85.86	111.90	107.23
APRIL	102.02	96.51	101.07	95.81	102.73	98.08
MAY	82.26	77.27	91.86	86.92	86.97	84.22
JUNE	71.64	65.35	70.98	66.05	75.41	71.24
JULY	67.54	62.06	70.62	64.53	75.45	70.23
AUGUST	76.54	68.55	78.31	72.88	79.26	74.78
SEPTEMBER	92.81	89.23	92.06	88.84	91.98	87.61
OCTOBER	94.30	90.03	96.31	93.15	94.71	89.92
NOVEMBER	86.59	81.30	87.51	83.13	89.20	84.90
DECEMBER	89.01	83.81	100.76	96.68	81.12	77.36
Total	1089.94	1025.47	1062.62	1004.07	1086.02	1035.14
Maximum	115.65	110.77	101.07	96.68	111.90	107.23
Minimum	67.54	62.06	70.62	64.53	75.41	70.23
Average	90.83	85.46	88.55	83.67	90.50	86.26

TABLE 5-11

Summary of Well Logs by Sub-basin

Sub-Basin	Washington Wells	Idaho Wells	Total Wells
Cottonwood Creek	59		**59**
Cow Creek	1049		**1049**
North Fork Palouse River	51	400	**451**
Palouse River	157		**157**
Pine Creek	150	4	**154**
Rock Creek	163		**163**
South Fork Palouse River	215	536	**751**
Unionflat Creek	77	66	**143**
TOTAL	**1921**	**1006**	**2927**

TABLE 5-12

Comparison of Per Residence Water Use in
Eastern Washington Watershed Assessments

Location	Source	Water use per residence (gallons per day)
Town of Twisp	WRIA 48	1,200
City of Spokane	WRIA 55/57	490-980
City of Waterville	WRIA 44/50	367
City of Mansfield	WRIA 44/50	670
City of Newport	WRIA 62	242
Town of Ione	WRIA 62	557
City of Yakima	WRIA 37/38/39	900
City of Pullman	WRIA 34	116[1]
Town of Farmington	WRIA 34	482-520

[1]Per person water use

Notes: Water use for other WRIAs reported as total use (i.e. including consumptive and non-consumptive use).

TABLE 5-13

Projected Population and Water Use

	Population		Annual Water Demand (MG)		Annual Water Demand (AF)	
	2000	2025	2000	2025	2000	2025
Incorporated Population						
Medical Lake	3,815	4,608	162	195	496	599
Pullman	10,101	14,692	428	622	1,313	1,909
WSU	15,672	21,506	664	911	2,037	2,795
Colfax	2,844	3,414	120	145	370	444
Palouse	1,011	1,213	43	51	131	158
Moscow	21,291	28,676	901	1,214	2,767	3,726
Total Incorporated	**54,734**	**74,109**	**2,317**	**3,138**	**7,112**	**9,630**
Municipal Water Rights					**33,294**	
Unincorporated Population						
Adams County	512	688	22	29	67	89
Lincoln County	663	833	28	35	86	108
Spokane County	4,409	5,925	187	251	573	770
Whitman County	9,075	11,416	384	483	1,179	1,483
Benewah County	223	223	9	9	29	29
Latah County	7,950	9,781	337	414	1,033	1,271
Nez Perce County	12	22	1	1	2	3
Total Unincorporated	**22,844**	**28,887**	**967**	**1,223**	**2,968**	**3,754**
Grand Total	**77,578**	**102,996**	**3,285**	**4,361**	**10,081**	**13,384**

NOTES:

Per capita Use (incorporated) 116 gpd per person

Per capita Use (unincorporated) 116 gpd per person

TABLE 6-1

Summary of Water Rights Documents

Number of Documents (WRATS)			Number of Documents (IDWR)		
Document Type	**Groundwater**	**Surface Water**	**Document Type**	**Groundwater**	**Surface Water**
Application	25	15	Application	2	1
Certificate	335	354	License	435	178
Change Application	27	7	na		
Claim/	16	155			
Claim/L	1,910	1,054			
Claim/S	1,332	515	Claim	3	0
Permit	10	14	Permit	37	109
na			Recommendation	3	27
Subtotal	**3,655**	**2,114**	**Subtotal**	**480**	**315**
Total	**5,769**		**Total**	**795**	

Note:
Data from WRATS database, August 2001, and IDWR database, January 2004. WRATS does not include reservoir documents (13 documents) or documents with "B" document numbers (three documents).

WRIA 34 Water Right Breakdown by Purpose of Use and Docuent Type-Washington

	Document Type									
	Application	Certificate	Change/ Application	Change/ Certificate	Change/ Permit	Claim/	Claim/L	Claim/S	Permit	Total
Municipal+Domestic	7	112				1	724	317	19	1,180
Commercial-Industrial	6	43				6			1	56
Irrigation	20	453				31	699	581	4	1,788
Other	7	81	25	5	4	133	1,542	949		2,746
Total	40	689	25	5	4	171	2,965	1,847	24	5,770

Note:
Municipal+Domestic includes all documents with MU as one of the purposes of use and all douments with the DG, DM, or DS purposes of use only.
Commercial-Industrial includes all documents with CI, MI, or RW as one of the puproses of use, excluding any documents with the Municipal purpose of use.
Irrigation includes all douments with the IR purpose of use, excluding any documents with the MU, CI, MI, or RW purposes of use.
Other includes all other purposes of use, including stock, domestic+stock, or documents with no purpose of use listed.
Does not include reservoir documents (19 certificates and one application)

WRIA 34 Water Right Breakdown by Purpose of Use and Document Type-Idaho

Process	Municipal+Domestic	Commercial-Industrial	Irrigation	Non-Consumptive	Other	No Purpose	Total
Application	0	2	1	0	0	0	3
Claim	0	0	0	2	1	0	3
License	214	18	131	32	210	8	613
Permit	10	8	20	8	0	100	146
Recommendation	5	0	4	2	1	18	30
Total	229	28	156	44	212	126	795

Note:
Municipal+Domestic includes all documents with MU as one of the purposes of use and all douments with the DG, DM, or DS purposes of use only.
Commercial-Industrial includes all documents with CI, MI, or RW as one of the puproses of use, excluding any documents with the Municipal purpose of use.
Irrigation includes all douments with the IR purpose of use, excluding any documents with the MU, CI, MI, or RW purposes of use.
Other includes all other purposes of use, including stock, domestic+stock, or documents with no purpose of use listed.
No purpose inlcudes all documents with no purpose of use listed.

WRIA 34 Water Right Analysis-Washington

	Groundwater Certificates and Permits				Surface Water Certificates and Permits			
	Purpose of Use				Purpose of Use			
	MU+DOM	IRR	CI	Other	MU+DOM	IRR	CI	Other
Number of Documents	66	216	41	22	65	241	3	59
Percent without Qa	0%	0%	0%	0%	3%	29%	33%	8%
Mean Qa (AF/yr)	420	402	69	1,184	2	157	5	5
Median Qa (AF/yr)	112	100	24	4	1	80	5	0
Mean Qi/Qa (cfs/AF/yr)	0.006	0.005	0.014	0.093	0.014	0.007	0.009	0.011
Median Qi/Qa (cfs/AF/yr)	0.004	0.004	0.007	0.018	0.010	0.005	0.009	0.010
Mean Irrigated Acres	-	110	-	-	-	52	-	-
Median Irrigated Acres	-	35	-	-	-	30	-	-
Mean Duty (ft)	-	3.4	-	-	-	3.3	-	-
Median Duty (ft)	-	3.6	-	-	-	3.6	-	-

Does not include reservoirs or documents with a document number starting with "B"
Purposes of Use:
MU+DOM: Municipal+Doemstic
IRR: Irrigation
CI: Commercial-Industrial
Other: Includes stockwatering, recreation, etc.

TABLE 6-3b

WRIA 34 Water Rights Analysis-Idaho

	Groundwater					
	Purpose of Use					
	Municipal+Domestic	Commercial-Industrial	Irrigation	Non-Consumptive	Other	No Purpose
Number of Documents	214	24	92	11	121	18
Percent without Qa	73%	47%	45%	25%	71%	100%
Mean Qa (AF/yr)	21	12	96	3	3	-
Median Qa (AF/yr)	1.2	6.4	9.0	3.5	1.4	-
Percent without Qi	100%	0%	0%	25%	2%	95%
Mean Qi (cfs)	-	0.98	0.48	0.03	0.05	0.07
Median Qi (cfs)	-	0.10	0.08	0.02	0.04	0.04
Mean Qi/Qa (cfs/AF/yr)	-	0.039	0.008	0.021	0.031	-
Median Qi/Qa (cfs/AF/yr)	-	0.008	0.007	0.009	0.029	-

	Surface Water					
	Purpose of Use					
	Municipal+Domestic	Commercial-Industrial	Irrigation	Non-Consumptive	Other	No Purpose
Number of Documents	15	4	64	33	91	108
Percent without Qa	40%	75%	50%	14%	59%	56%
Mean Qa (AF/yr)	45	0.25	62	10,861	7.4	5.6
Median Qa (AF/yr)	1.2	0.25	6.0	2.5	1.5	3.0
Percent without Qi	100%	0%	9%	79%	16%	76%
Mean Qi (cfs)	-	0.37	0.32	158	0.18	0.64
Median Qi (cfs)	-	0.34	0.14	2.1	0.02	0.02
Mean Qi/Qa (cfs/AF/yr)	-	0.368	0.316	158	0.177	0.637
Median Qi/Qa (cfs/AF/yr)	-	0.335	0.140	2.1	0.020	0.020

TABLE 6-4

Summary of Allocated Water Rights (acre-feet/year)

		Washington			Idaho		
	Document Type	**Municipal Domestic**	**Irrigation**	**Other**	**Municipal Domestic**	**Irrigation**	**Other**
Groundwater	Adjudicated	-	-	-	16	-	270
	Certificate and Permit	27,753	86,725	28,864	4,278	5,411	773
	Claim	449	67,648	1,447	0	0	26
	Total Groundwater[a]	28,202	154,372	30,310	4,293	5,411	1,069
	Total Groundwater[b]	27,753	86,725	28,864	4,293	5,411	1,043
Surface Water	Adjudicated	46	8,456	214	200	-	83
	Certificate and Permit	72	28,568	187	410	1,610	485
	Claim	71	413,590	204,628	0	0	31
	Total Surface Water[a]	189	450,615	205,030	610	1,610	598
	Total Surface Water[b]	118	37,024	401	610	1,610	568
Totals	Total [a]	28,391	604,987	235,340	4,903	7,021	1,667
	Total [b]	27,870	123,749	29,265	4,903	7,021	1,610
	Grand Total [a]	868,718			13,591		
	Grand Total [b]	324,226			13,535		

Notes

a. Total of adjudicated certificates, certificates, permits, and claims

b. Total of adjudicated certificates, certificates and permits.

Other includes stock watering, domestic+stock watering, commercial-industrial, and doscuments with no purpose of use listed.

TABLE 6-5

WRIA 34 Water Right Applications and Change Applications in Washington

Document Number	Purpose of Use	Qa (AF/yr)	Qi (gpm or cfs)	Priority Date	Name	TRS	Source
RESERVOIRS							
R3-29454	FS WL	2,340.00	0	4/22/1993	Hercules Ranch Limited Partner	T20N/R37E-14-	NEGRO CREEK
R3-30403	IR RE WL	6,000.00	0	1/27/2003	Sprague Lake Users Group (SLUG	T20N/R37E-14-NE/NE	SPRAGUE LAKE
GROUNDWATER							
CG3-*07126C		662	550	12/23/1998	Galbreath Land & Livestock Inc	T19N/R36E-21-NE/NW	WELL
						T19N/R36E-22-NE/SE	WELL
						T19N/R36E-20-W2/NE	WELL
CG3-01498C		716	1,500.00	12/23/1998	Galbreath Land & Livestock Inc	T19N/R36E-20-W2/NE	WELL
						T19N/R36E-21-NE/NW	WELL
						T19N/R36E-22-NE/SE	WELL
CG3-01435C		1,988.00	1,500.00	12/23/1998	Galbreath Land & Livestock Inc	T19N/R36E-22-NE/SE	WELL
						T19N/R36E-21-NE/NW	WELL
						T19N/R36E-20-W2/NE	WELL
CG3-*09126C		1,502.00	1,400.00	12/23/1998	Galbreath Land & Livestock Inc	T19N/R36E-21-NE/NW	WELL
						T19N/R36E-22-NE/SE	WELL
						T19N/R36E-20-SE/NE	WELL
G3-29859	IR		17,250.00	7/11/1995	Henley Farms	T16N/R36E-22-	WELL
					James Tribbett	T16N/R36E-26-	WELL
					Kinch Farms, Inc.	T16N/R36E-27-	WELL
						T16N/R36E-15-	WELL
						T16N/R36E-23-	WELL
						T16N/R36E-23-	WELL
						T16N/R36E-14-	WELL
						T16N/R36E-13-	WELL
						T16N/R36E-14-	WELL
G3-29620	IR	400	1,500.00	1/26/1994	Kinch Farms Inc.	T16N/R36E-23-	WELL
G3-29255	DS IR ST		40	8/3/1992	Frank Ruzicka	T19N/R36E-24-	WELL
G3-29055	DS IR ST		1,000.00	9/26/1991	W. Evans	T15N/R37E-22-	WELL
G3-29060	DS IR ST		35	8/22/1991	Jacob Harder II	T19N/R36E-34-	WELL
G3-29219	DM IR ST WL		775	6/3/1992	Thomas Blaine	T15N/R37E-26-	WELL
G3-29223	CI IR		650	6/8/1992	Waste Management Of Washington	T15N/R37E-21-	WELL
						T15N/R37E-21-	WELL
G3-30244	DM IR		750	11/10/1998	Hercules Ranch Limited Partner	T21N/R38E-23-	WELL
						T21N/R38E-23-	WELL
G3-30120	CI		100	11/14/1997	Gene Brown	T21N/R39E-03-	WELL
G3-29605	DM ST		100	1/10/1994	Teel Dairy Farms Inc	T21N/R38E-12-	WELL
G3-29918	DM		25	8/22/1995	USAFB Fairchild	T23N/R41E-06-	WELL

TABLE 6-5

WRIA 34 Water Right Applications and Change Applications in Washington

Document Number	Purpose of Use	Qa (AF/yr)	Qi (gpm or cfs)	Priority Date	Name	TRS	Source
G3-29561	HW		35	10/8/1993	WA Transportation Department	T23N/R40E-27-	WELL
CG3-29249		1,200.00	1,400.00	6/22/2001	Airway Heights City	T25N/R41E-26-SW/SE	WELL
						T25N/R41E-25-SE/NW	WELL
						T25N/R41E-26-SE/NE	WELL
						T25N/R41E-26-SE/SE	WELL
						T25N/R41E-26-SE/SW	WELL
						T25N/R41E-25-SE/SW	WELL
						T25N/R41E-36-NW/NW	WELL
						T24N/R41E-02-NE/SW	WELL
G3-30145	DS IR ST		60	2/27/1998	D Scott Adams	T14N/R44E-33-	WELL
G3-30200	DS IR ST		50	6/4/1998	Clarence Claypool	T16N/R43E-12-	WELL
						T16N/R43E-12-	WELL
G3-30246	IR		600	6/29/1998	J S B Ranch Inc	T19N/R40E-10-	WELL
G3-30070	MU		100	8/21/1997	Malden Town	T20N/R42E-13-	WELL
G3-30022	IR		960	2/18/1997	Judy Harder	T15N/R38E-15-	WELL
G3-29973	CI		150	6/17/1996	Whitman Cnty Port	T16N/R43E-21-	WELL
CG3-CL151672	CI			4/23/1996	Motley-Motley, Inc.	T15N/R38E-22-	WELL
G3-29589	MU		450	11/29/1993	Rosalia Town	T20N/R43E-10-	WELL
G3-29746	CI EN		30	9/29/1994	Cochran Partnership	T15N/R45E-29-	WELL
G3-29595	DM FR ST WL		2,250.00	12/21/1993	Miller Land Company	T20N/R41E-29-	WELL
G3-29664	FR MU		700	4/6/1994	Colton Town	T13N/R45E-34-	WELL
						T13N/R45E-34-	WELL
						T13N/R45E-34-	WELL
G3-30357	CI DM		2,000.00	1/31/2002	Billou River Ranch LLC	T17N/R44E-10-	WELL
						T17N/R44E-15-	WELL
G3-30345	CI		1,000.00	2/6/2002	Paul Hendrickson	T18N/R45E-33-	WELL
G3-30344	CI		1,000.00	2/6/2002	Paul Hendrickson	T18N/R45E-34-	WELL
G3-30346	CI DS		1,000.00	2/6/2002	Paul Hendrickson	T18N/R45E-33-	WELL
						T18N/R45E-33-	WELL
						T18N/R45E-33-	WELL
						T18N/R45E-33-	WELL
G3-30379	IR		1,200.00	11/20/2002	Peggy Wright	T19N/R40E-21-NW/SW	

TABLE 6-5

WRIA 34 Water Right Applications and Change Applications in Washington

Document Number	Purpose of Use	Qa (AF/yr)	Qi (gpm or cfs)	Priority Date	Name	TRS	Source
SURFACE WATER							
S3-28019	IR ST		2.67	5/23/1985	Bar U Ranch Co Inc	T16N/R37E-21-	COW CREEK
S3-28020	IR ST		1.11	5/23/1985	Bar U Ranch Co Inc	T16N/R37E-21-	BIG SPRING
						T16N/R37E-21-	COW CREEK
S3-28183	IR	1,080.00	3.11	6/27/1986	Harder Land Co Inc	T20N/R38E-08-	SPRAGUE LAKE
S3-28184	IR	540	1.78	6/27/1986	Harder Land Co Inc	T20N/R37E-14-	SPRAGUE LAKE
S3-30314	WL		3	2/26/2001	Jon Robson	T17N/R36E-12-	COW CREEK
CS3-78049J@2	IR	648	3.6	2/27/2003	Hercules Ranch Limited Partner	T21N/R38E-22-SE/NE	
S3-30269	CI DS		0.02	7/8/1999	Robert Hardesty	T22N/R43E-27-	UNNAMED SPRING
S3-30059	DS		0.02	6/6/1997	Pam Hostetter	T24N/R41E-17-	SILVER LAKE
S3-28990	EN		1	4/19/1991	Philleo Duck & Conservation Cl	T22N/R42E-14-	ROCK CREEK
S3-30279	DS		0.02	2/25/2000	Robert Rees	T24N/R41E-17-	SILVER LAKE
S3-30187	IR ST		0.07	5/28/1998	A Old	T15N/R44E-23-	UNNAMED POND
S3-30223	IR		0.06	6/29/1998	Robin Stobie	T17N/R41E-31-	REBEL FLAT CREEK
S3-28916	FS RE ST WL		1.8	11/6/1990	Edgar Smith	T18N/R40E-21-	CHERRY CREEK
						T18N/R40E-28-	CHERRY CREEK
S3-28960	IR ST WL	13.5	0.23	3/11/1991	J. Smith	T18N/R40E-15-	CHERRY CREEK
						T01N/R04-1-	CHERRY CREEK

WRIA 34 Water Rights by Sub-basin

Sub-Basin	Groundwater Qa (AF/yr)		Surface Water Qa (AF/yr)[1]	
	Applications	Rights and Claims	Applications	Rights and Claims
Cottonwood Creek	0	5,143	0	2,842
Cow Creek	20,835	48,357	8,352	11,632
North Fork Palouse	10,052	22,683	0	4,096
Palouse River	2,535	68,242	2	408,185
Pine Creek	550	7,805	0	7,391
Rock Creek	4,050	9,168	1	208,661
South Fork Palouse	30	51,629	0	7,541
Union Flat Creek	760	7,749	1	7,122
Total	**38,812**	**220,776**	**8,355**	**657,472**

1. Includes Storage

Summary of Allocated Water Rights in Cow Creek Sub-basin (acre-feet/year)

		Cow Creek Subbasin Water Rights					
		Annual Quantity (Acre-Feet)			Equivalent Flow Rates (cfs)		
	Document Type	Municipal Domestic	Irrigation	Other	Municipal Domestic	Irrigation[c]	Other
Groundwater	Adjudicated	-	-	-	-	-	-
	Certificate and Permit	3,592	37,281	1,800	5.0	69.6	2.5
	Claim	98	4,888	713	0.1	9.1	1.0
	Total Groundwater[a]	3,690	42,169	2,513	5.1	78.7	3.5
	Total Groundwater[b]	3,592	37,281	1,800	5.0	69.6	2.5
Surface Water	Adjudicated	46	8,456	214	0.06	15.8	0.30
	Certificate and Permit	21	1	0	0.03	0.0	0.00
	Claim	2	948	1,333	0.00	1.8	1.84
	Total Surface Water[a]	69	9,405	1,547	0.10	17.6	2.14
	Total Surface Water[b]	67	8,457	214	0.09	15.8	0.30
Totals	Total [a]	3,759	51,573	4,061	5.2	96.3	5.6
	Total [b]	3,659	45,737	2,014	5.1	85.4	2.8

Notes

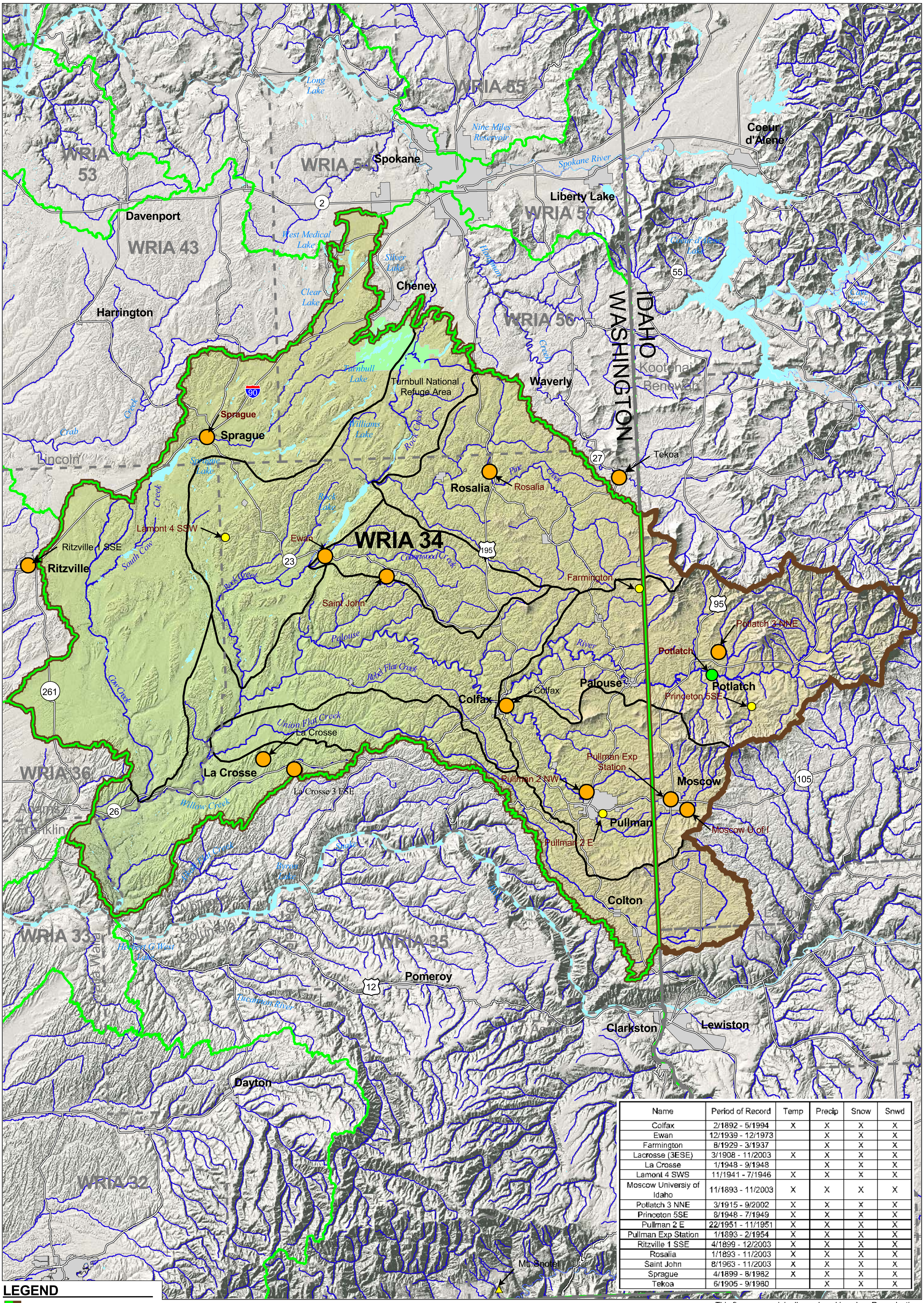
a. Total of adjudicated certificates, certificates, permits, and claims

b. Total of adjudicated certificates, certificates and permits.

c. Assumes 9-month irrigation season

Other includes stock watering, domestic+stock watering, commercial-industrial, and doscuments with no purpose of use listed.

FIGURES



Name	Period of Record	Temp	Precip	Snow	Snwd
Colfax	2/1892 - 5/1994	X	X	X	X
Ewan	12/1939 - 12/1973		X	X	X
Farmington	8/1929 - 3/1937		X	X	X
Lacrosse (3ESE)	3/1908 - 11/2003	X	X	X	X
La Crosse	1/1948 - 9/1948		X	X	X
Lamont 4 SWS	11/1941 - 7/1946	X	X	X	X
Moscow Universiy of Idaho	11/1893 - 11/2003	X	X	X	X
Potlatch 3 NNE	3/1915 - 9/2002	X	X	X	X
Princeton 5SE	8/1948 - 7/1949	X	X	X	X
Pullman 2 E	22/1951 - 11/1951	X	X	X	X
Pullman Exp Station	1/1893 - 2/1954	X	X	X	X
Ritzville 1 SSE	4/1899 - 12/2003	X	X	X	X
Rosalia	1/1893 - 11/2003	X	X	X	X
Saint John	8/1963 - 11/2003	X	X	X	X
Sprague	4/1899 - 8/1982	X	X	X	X
Tekoa	6/1905 - 9/1980		X	X	X

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

LEGEND

- Palouse Watershed Boundary
- WRIA Boundary
- Subbasin Boundary
- National Wildlife Refuge
- Community
- Waterbody
- Stream
- Road
- County Boundary

Weather Stations Period of Record

- <10
- >10
- >20

0 50,000
Scale 1" = 50,000 Feet

Map Projection: Washington State Plane South Zone, NAD 83, Feet

Source: WSDOE, WSDOT, USGS, INSIDE Idaho, GIS Data Depot, FWS

DRAFT

N

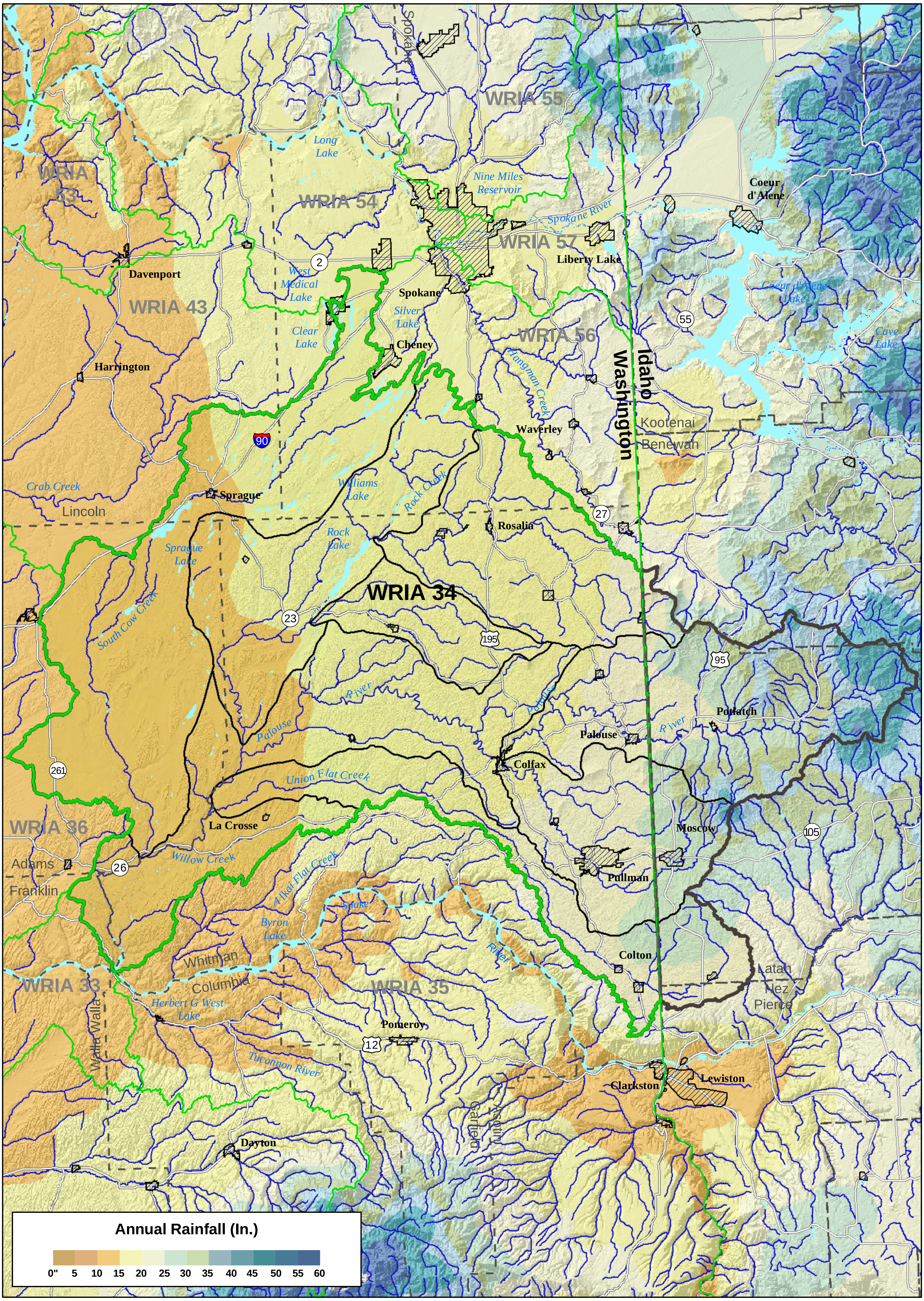
CLIMATE STATIONS

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: KAV | Revision: 3 | Date: Dec. 7, 2004 | Figure: 2-1

04310641010_012804.apr

Golder Associates



LEGEND

- Palouse Watershed Boundary
- WRIA Boundaries
- Lake
- River
- County Boundary
- Road
- Community
- Subbasin Boundary

0 50,000

Scale 1" = 50,000 Feet

Map Projection:
Washington State Plane
South Zone, NAD 83, Feet

Source: WSDOE, WSDOT, USGS, INSIDE Idaho, USDA GIS Data Depot, National Atlas, Climate Source LLC (PRISM)

N

DRAFT

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

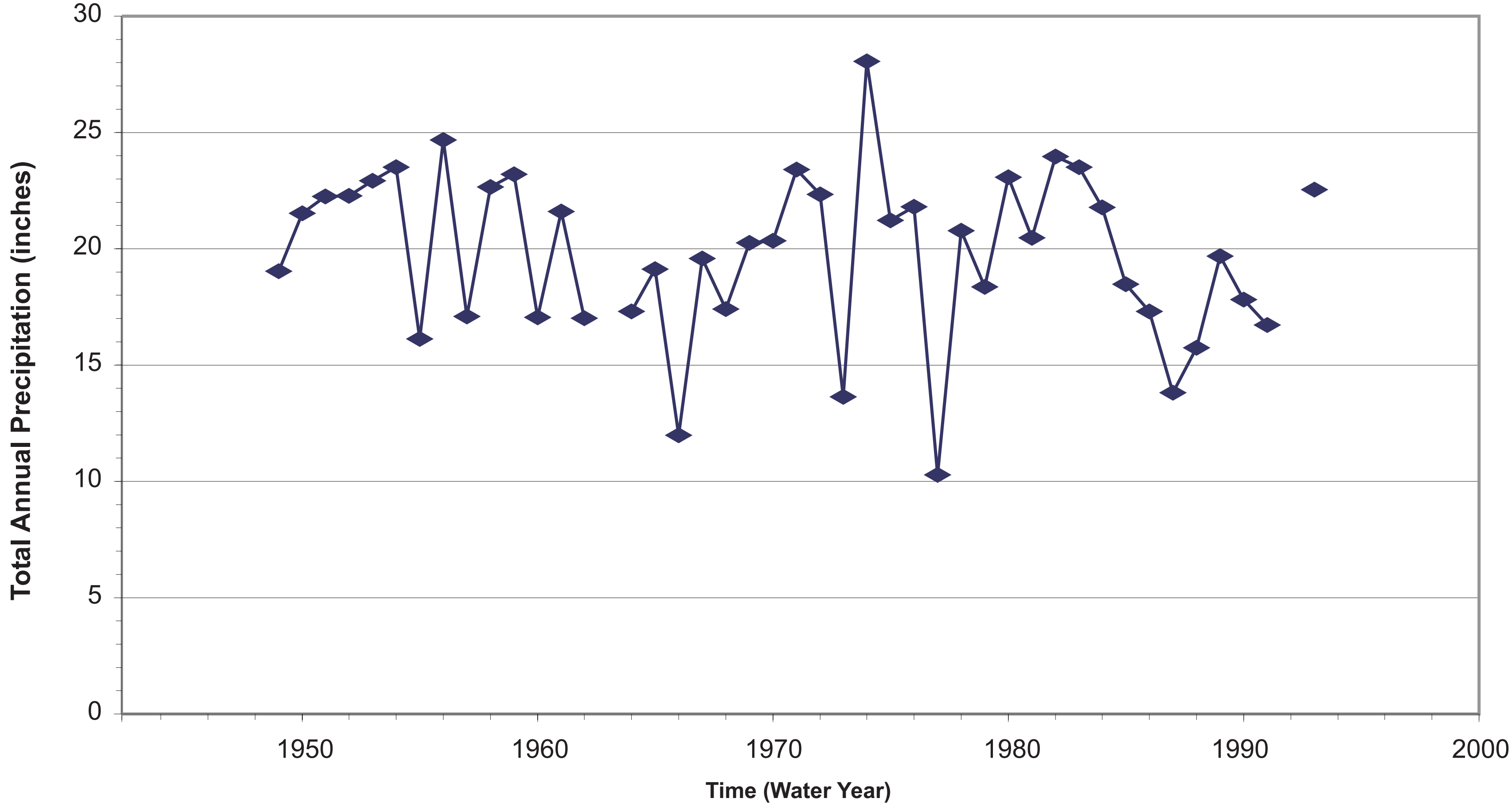
Mean Annual Rainfall (PRISM)

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: KAV	Revision: 3	Date: Dec. 7, 2004	Figure: 2-2

04310641010F02.mxd

Golder Associates



LEGEND

Total Annual Precipitation

Note: Water years missing one full month or more of precipitation data were omitted.

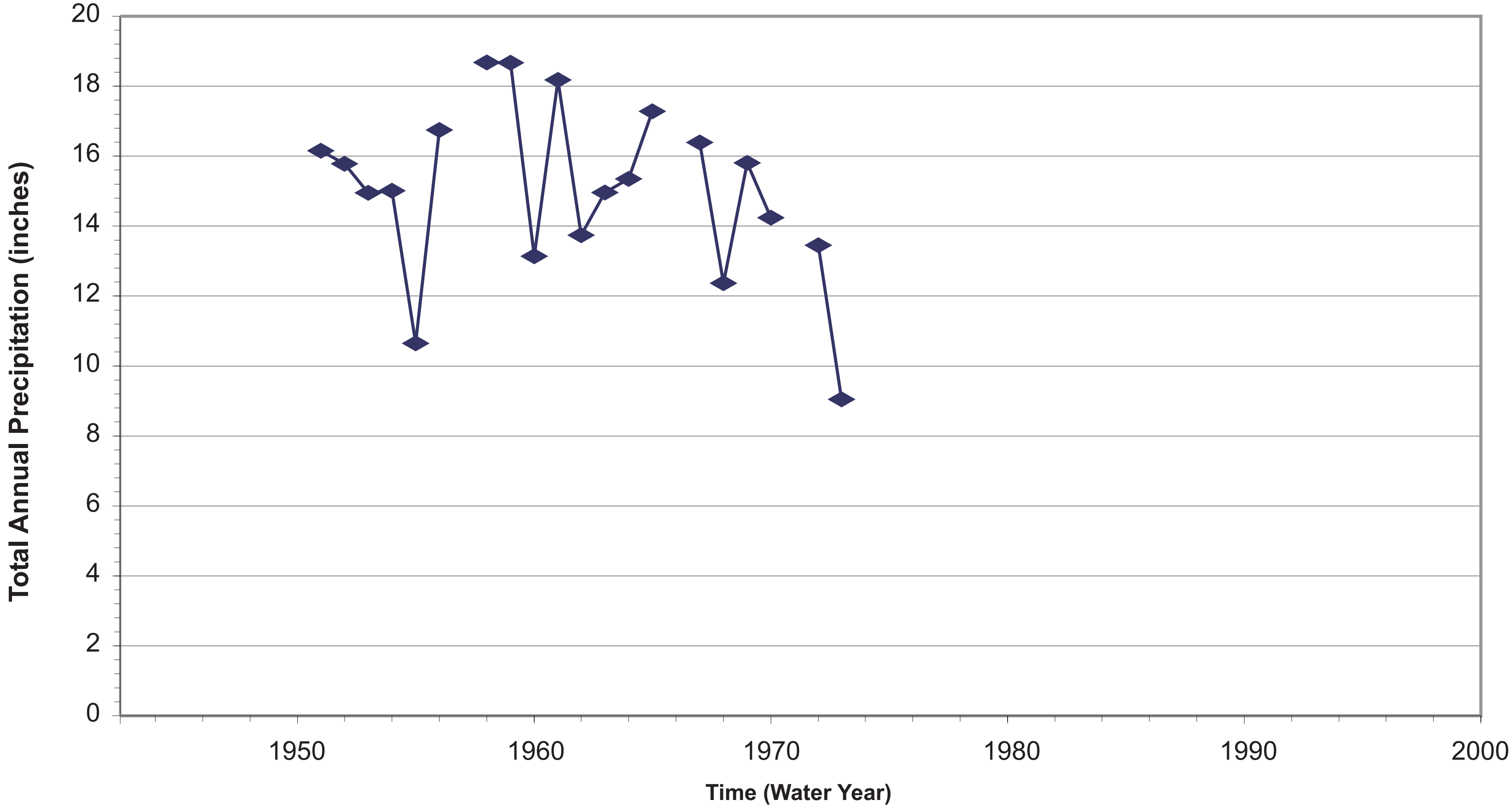
FIGURE **2-3a**

COLFAX, WA (STN 451586)
TOTAL ANNUAL PRECIPITATION

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg01.fh11 DATE 10/01/04 DRAWN BY EL

Golder Associates



LEGEND

Total Annual Precipitation

Note: Water years missing one full month or more of precipitation data were omitted.

FIGURE **2-3b**

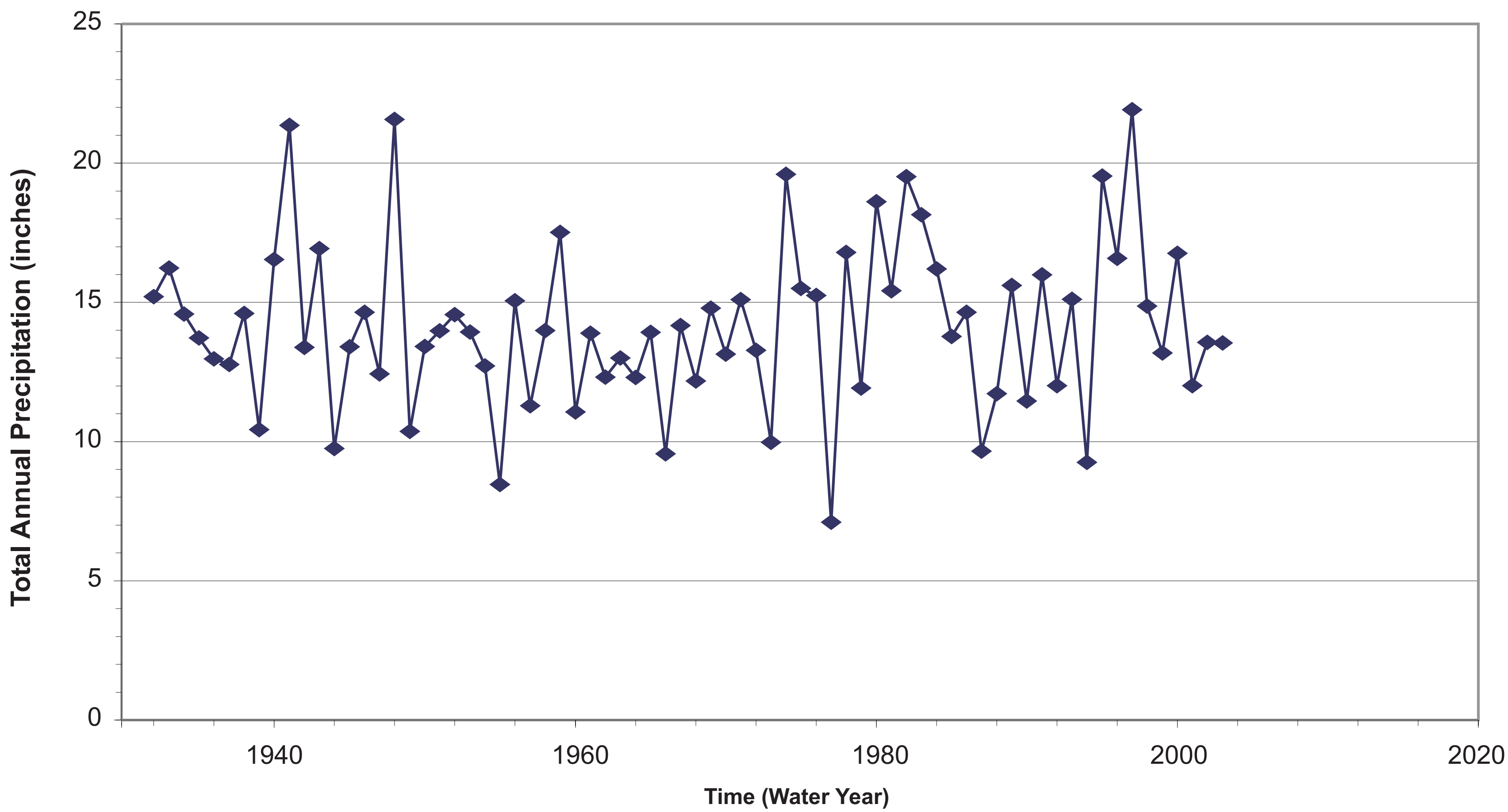
EWAN, WA (STN 452706)

TOTAL ANNUAL PRECIPITATION

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg02.fh11 DATE 11/01/04 DRAWN BY EL

Golder Associates



LEGEND

Total Annual Precipitation

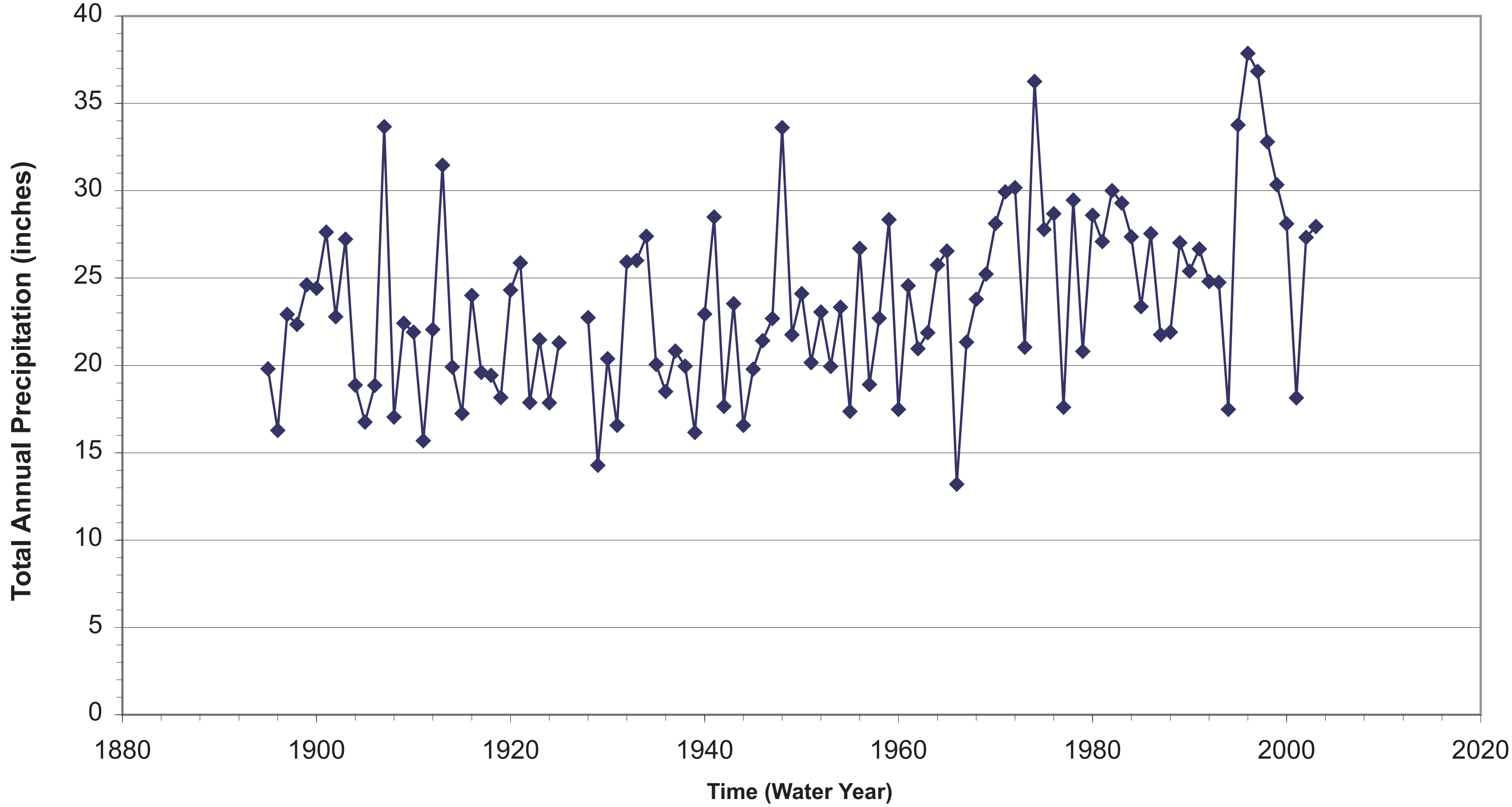
Note: Water years missing one full month or more of precipitation data were omitted.

FIGURE **2-3c**

LACROSSE 3 ESE, WA (STN 454338)
TOTAL ANNUAL PRECIPITATION
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg03.fh11 DATE 11/01/04 DRAWN BY EL

Golder Associates



LEGEND

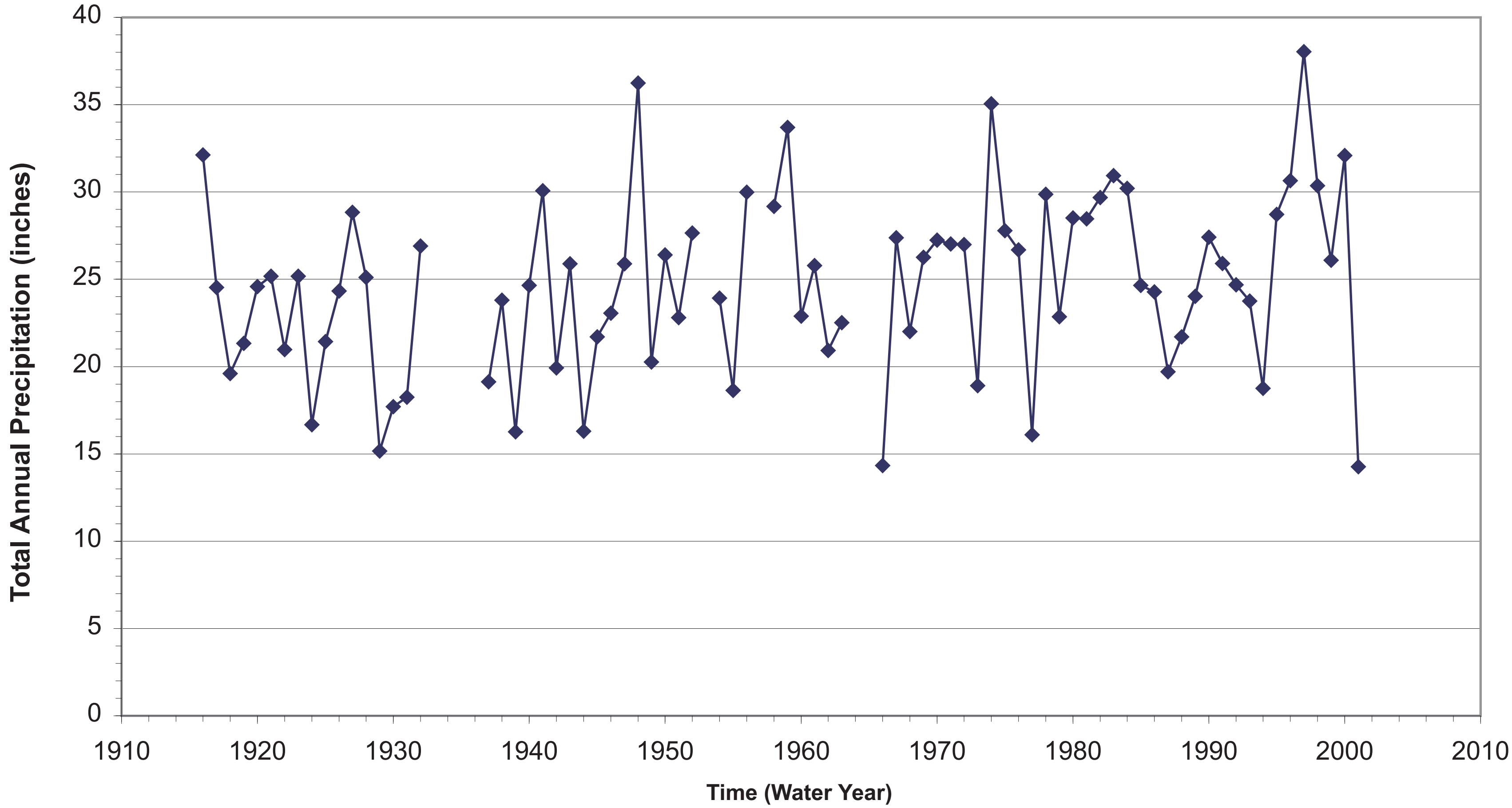
Total Annual Precipitation

Note: Water years missing one full month or more of precipitation data were omitted.

FIGURE **2-3d**

MOSCOW, UNIVERSITY OF IDAHO, ID (STN 106152)
TOTAL ANNUAL PRECIPITATION

PCD/WRIA 34 WATERSHED PLANNING/WA



LEGEND

Total Annual Precipitation

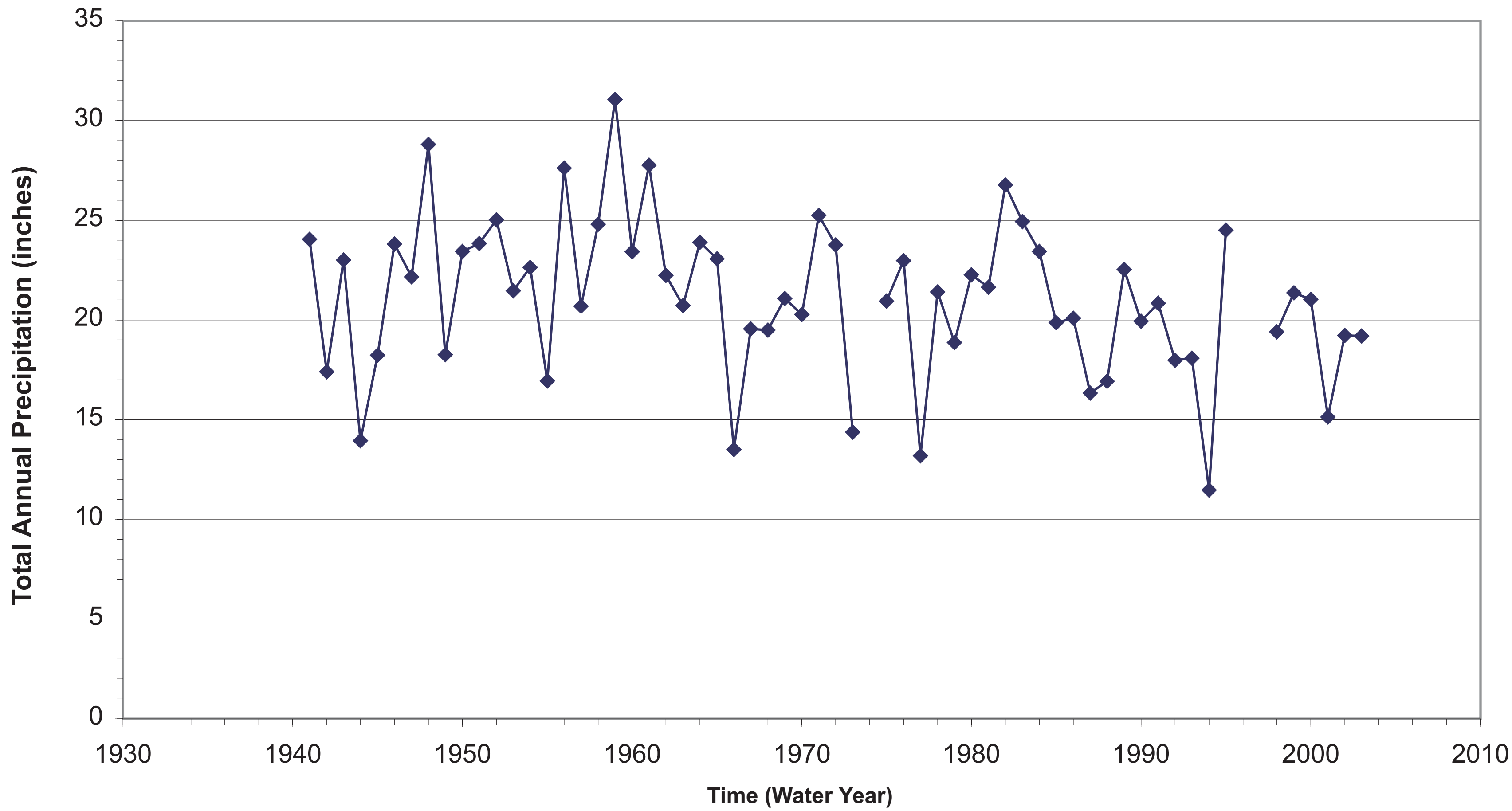
Note: Water years missing one full month or more of precipitation data were omitted.

FIGURE **2-3e**

POTLATCH 3 NNE, ID (STN 107301)
TOTAL ANNUAL PRECIPITATION
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg05.fh11 DATE 11/01/04 DRAWN BY EL

Golder Associates



LEGEND

Total Annual Precipitation

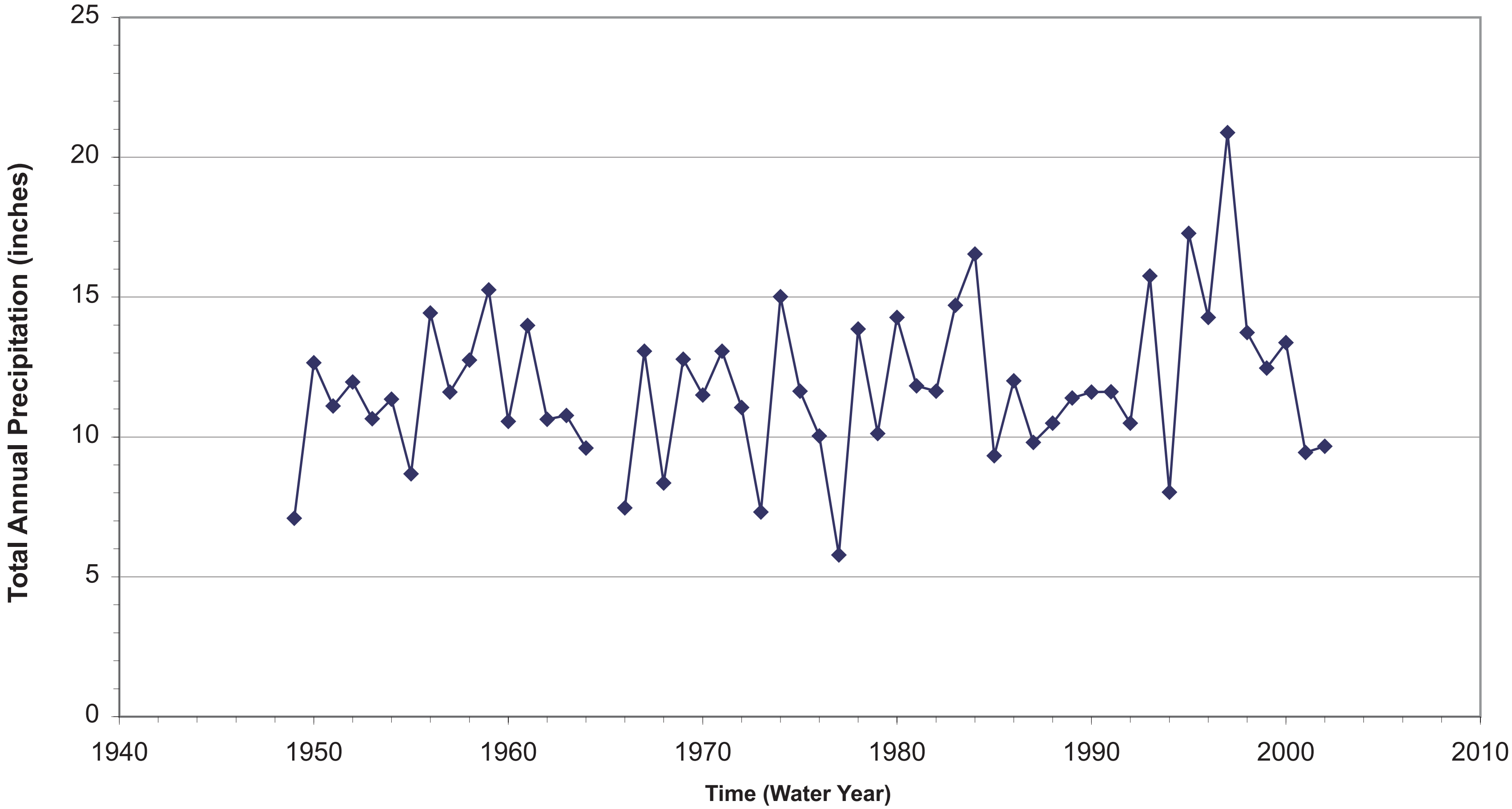
Note: Water years missing one full month or more of precipitation data were omitted.

FIGURE **2-3f**

PULLMAN 2 NW, WA (STN 456789)
TOTAL ANNUAL PRECIPITATION
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg06.fh11 DATE 11/01/04 DRAWN BY EL

Golder Associates



LEGEND

Total Annual Precipitation

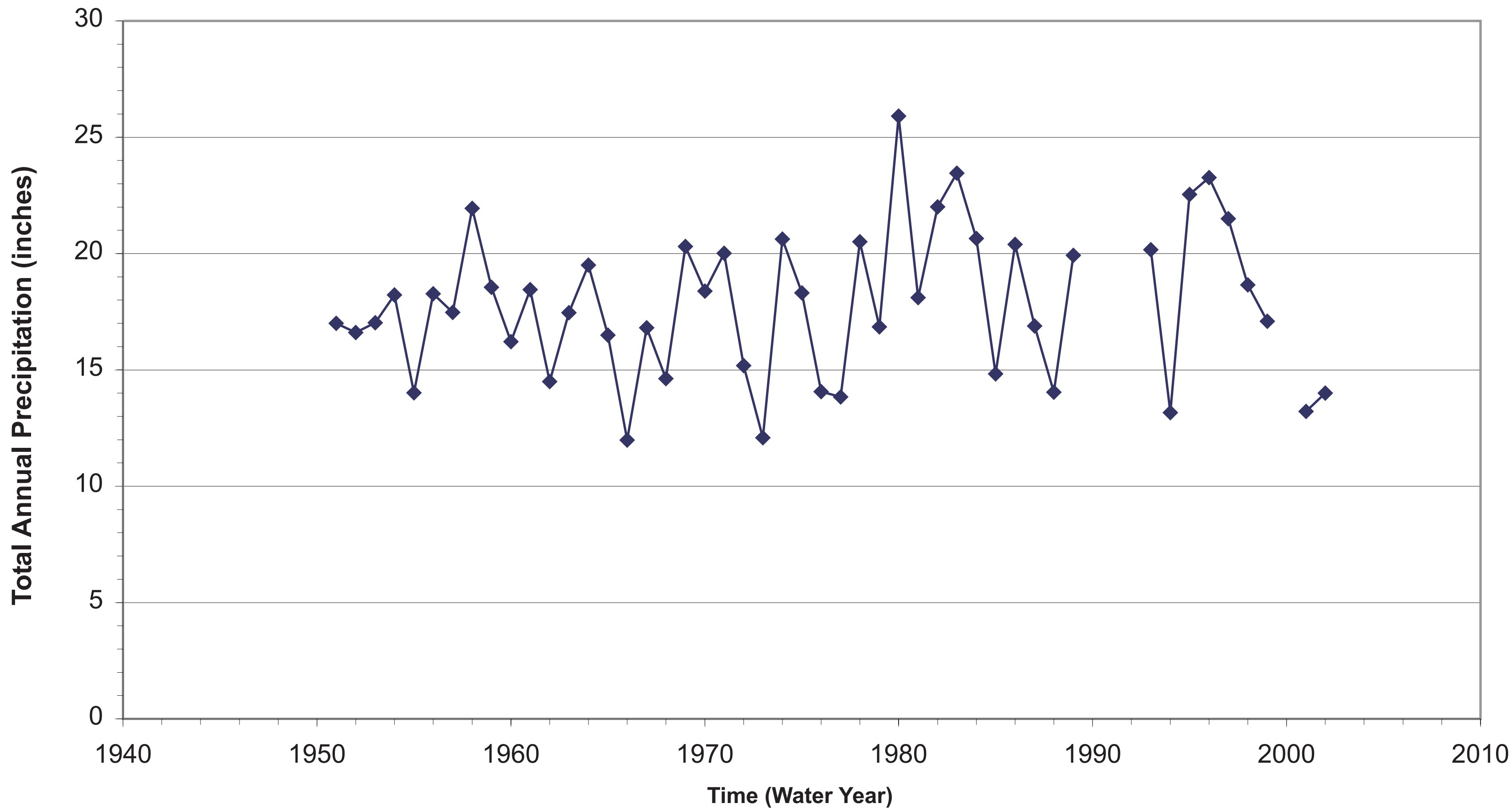
Note: Water years missing one full month or more of precipitation data were omitted.

FIGURE **2-3g**

RITZVILLE 1 SSE, WA (STN 457059)
TOTAL ANNUAL PRECIPITATION
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg07.fh11 DATE 11/01/04 DRAWN BY EL

Golder Associates



LEGEND

Total Annual Precipitation

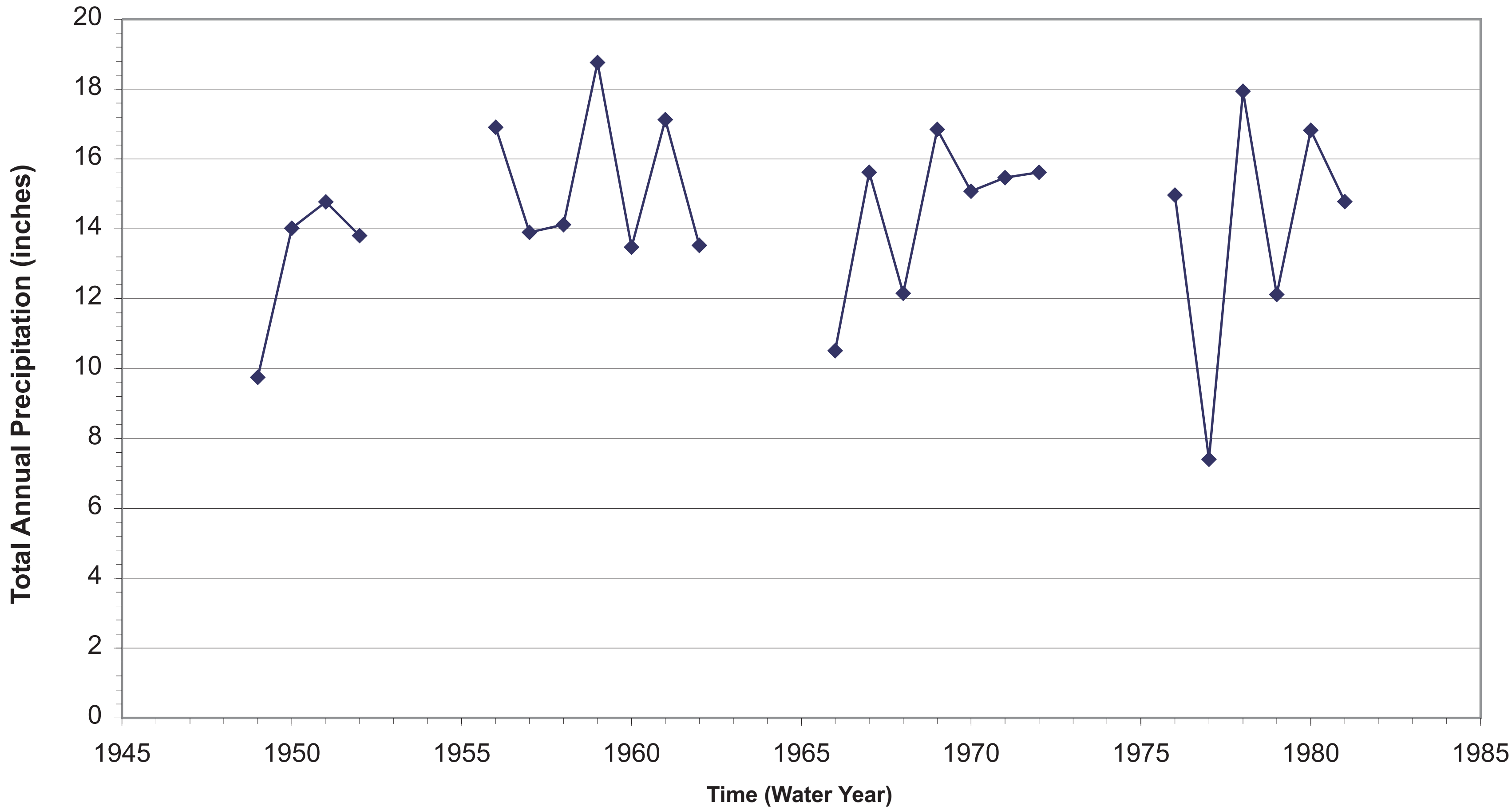
Note: Water years missing one full month or more of precipitation data were omitted.

FIGURE **2-3h**

ROSALIA, WA (STN 457180)
TOTAL ANNUAL PRECIPITATION
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg08.fh11 DATE 11/01/04 DRAWN BY EL

Golder Associates



LEGEND

Total Annual Precipitation

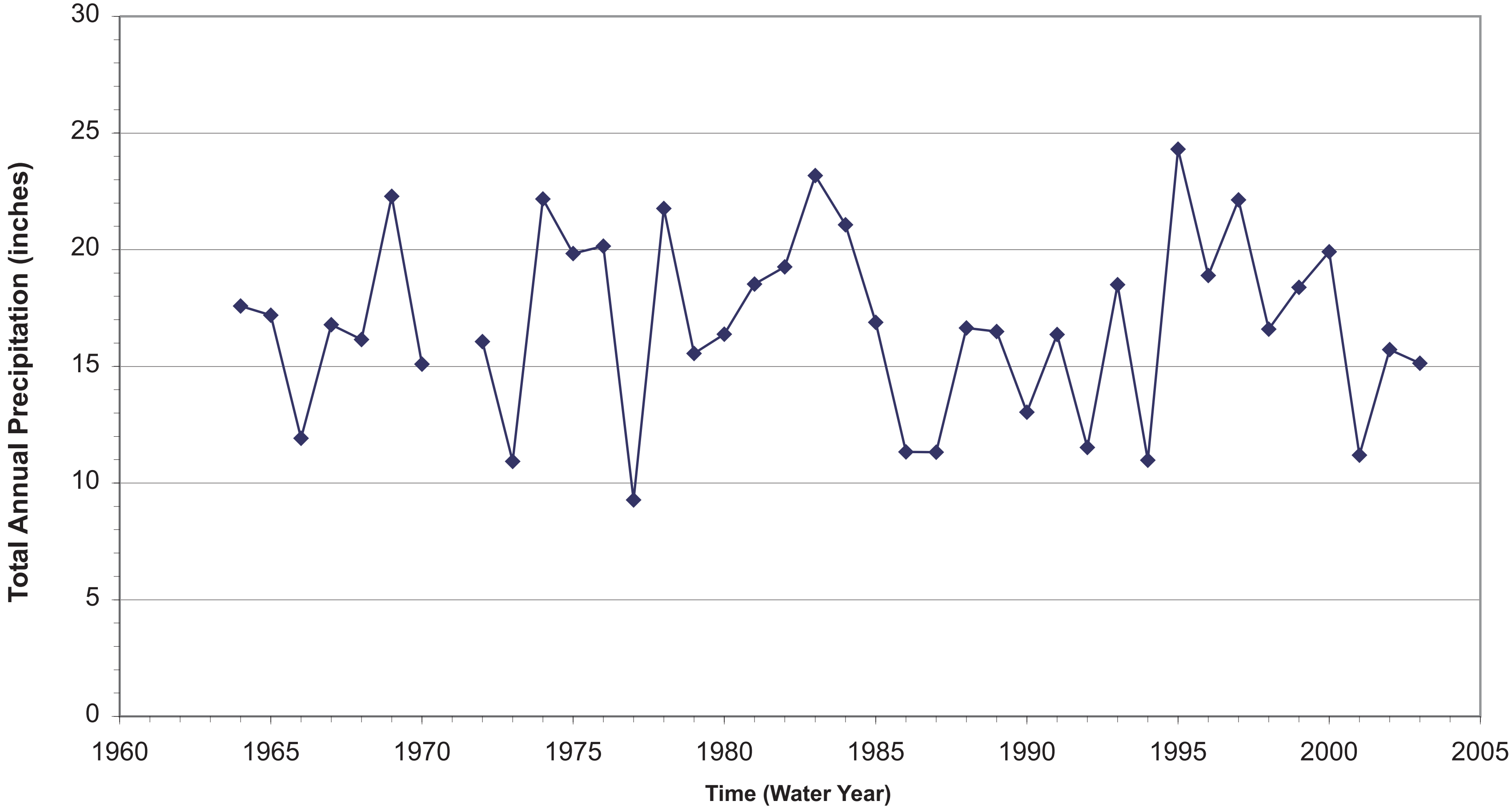
Note: Water years missing one full month or more of precipitation data were omitted.

FIGURE **2-3i**

SPRAGUE, WA (STN 457956)
TOTAL ANNUAL PRECIPITATION
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg09.fh11 DATE 11/01/04 DRAWN BY EL

Golder Associates



LEGEND

Total Annual Precipitation

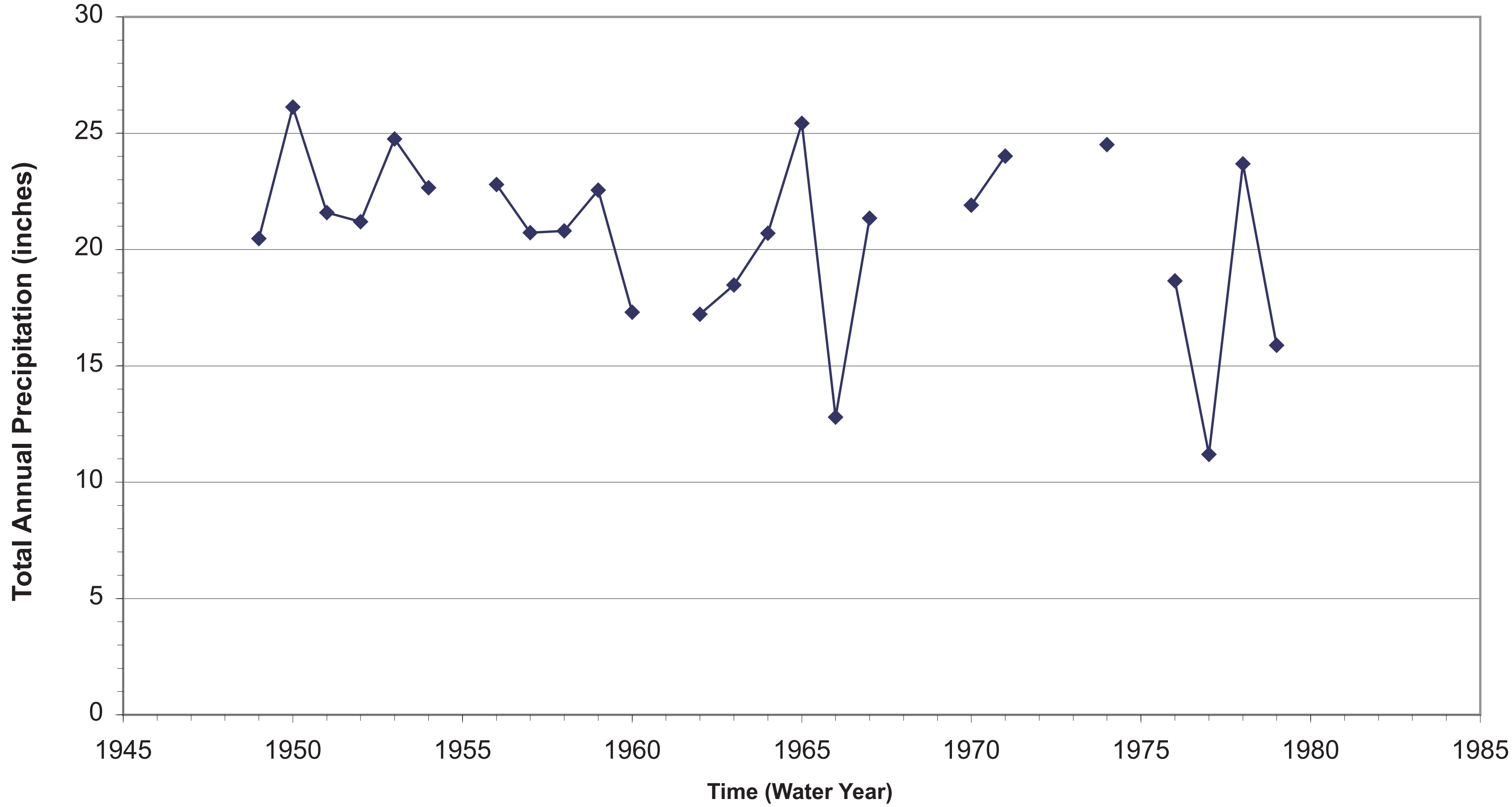
Note: Water years missing one full month or more of precipitation data were omitted.

FIGURE **2-3j**

SAINT JOHN, WA (STN 457267)
TOTAL ANNUAL PRECIPITATION
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg10.fh11 DATE 11/01/04 DRAWN BY EL

Golder Associates



LEGEND

Total Annual Precipitation

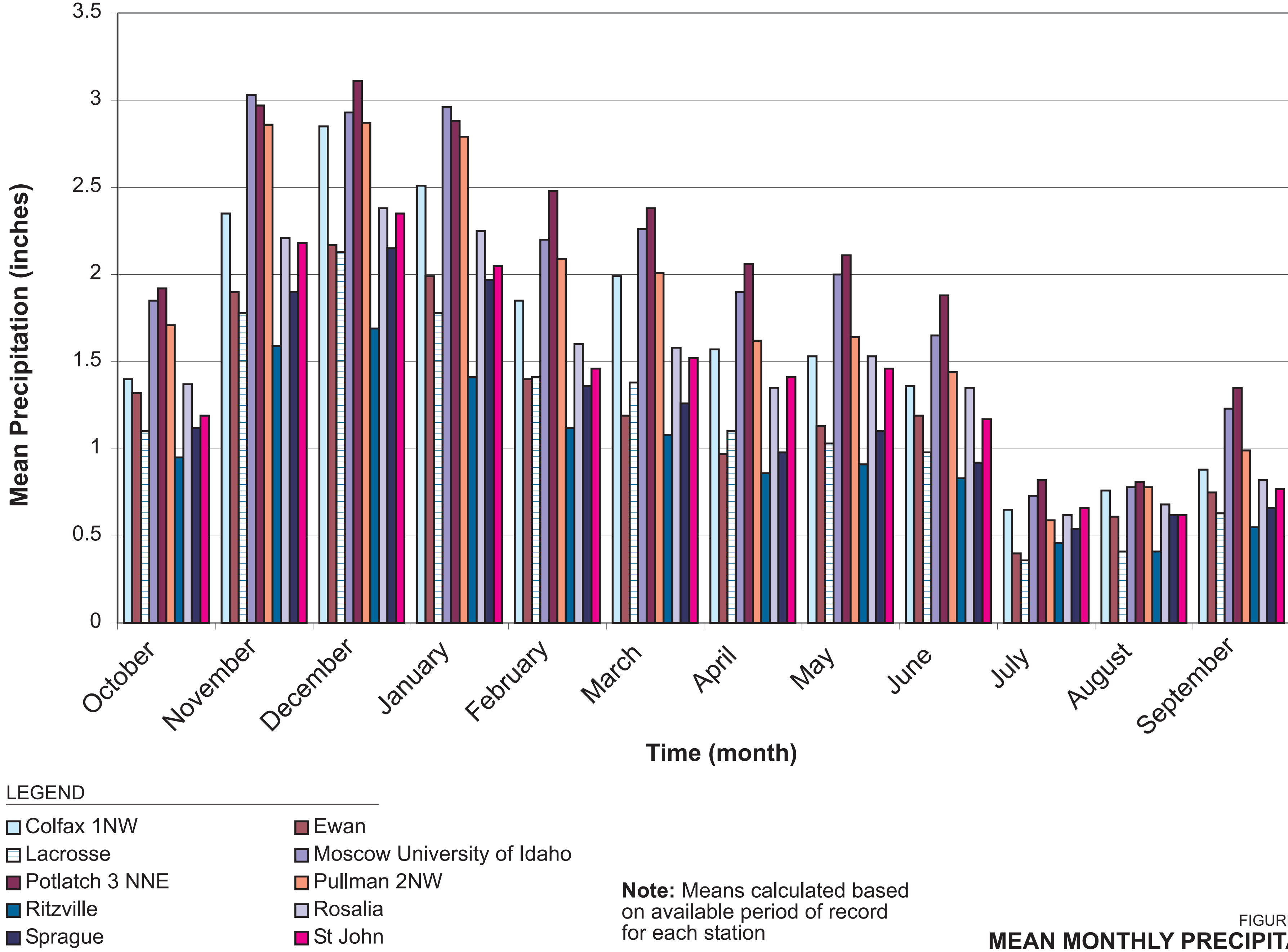
Note: Water years missing one full month or more of precipitation data were omitted.

FIGURE **2-3k**

TEKOA, WA (STN 458348)
TOTAL ANNUAL PRECIPITATION
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg11.fh11 DATE 11/01/04 DRAWN BY EL

Golder Associates



Note: Means calculated based on available period of record for each station

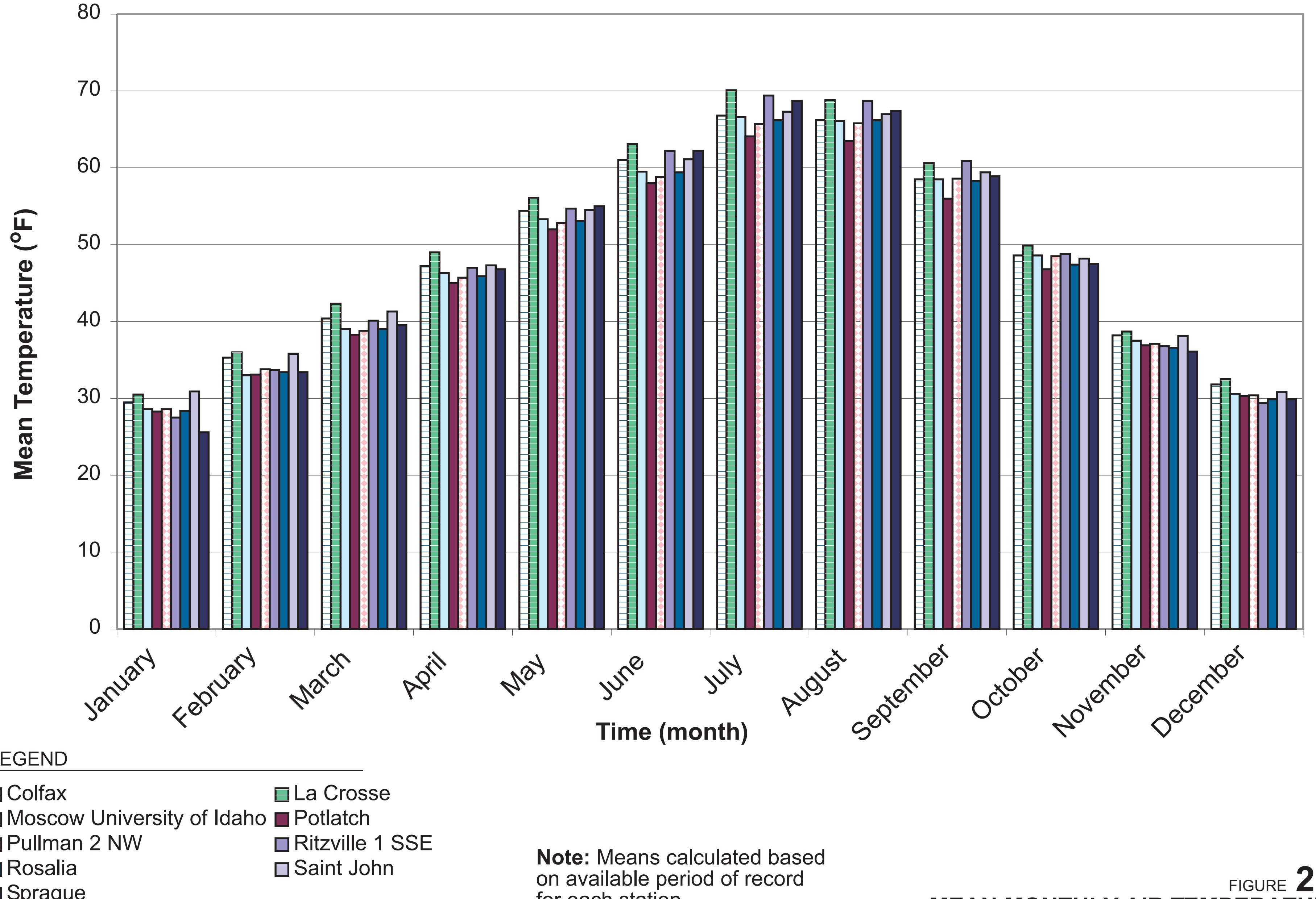
FIGURE **2-4**

MEAN MONTHLY PRECIPITATION

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg12.fh11 DATE 03/22/04 DRAWN BY AMP

Golder Associates



Note: Means calculated based on available period of record for each station

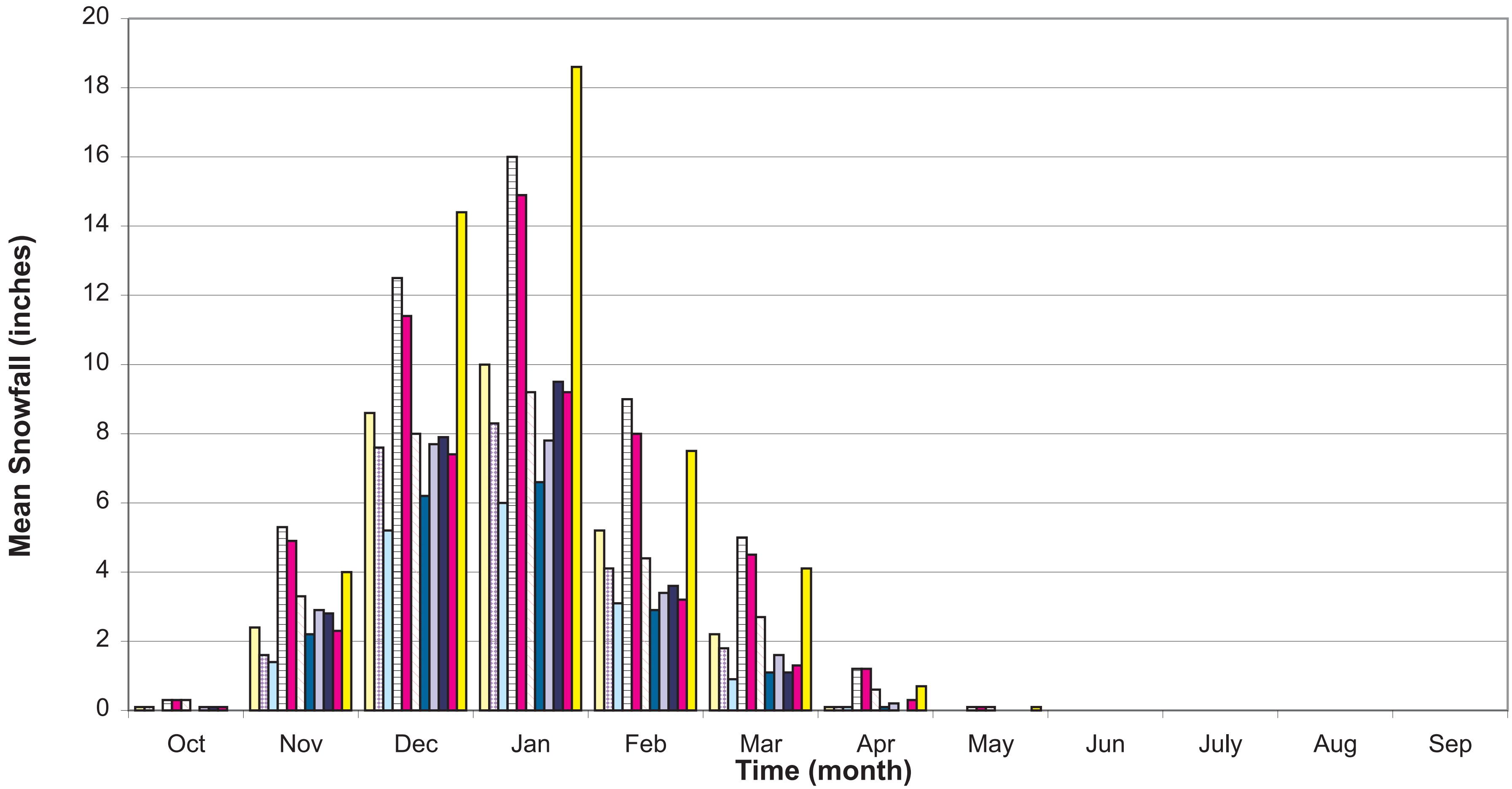
FIGURE **2-5**

MEAN MONTHLY AIR TEMPERATURE

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg13.fh11 DATE 11/01/04 DRAWN BY EL

Golder Associates



LEGEND

- Colfax 1NW
- Lacrosse
- Potlatch 3 NNE
- Ritzville
- Sprague
- Tekoa
- Ewan
- Moscow University of Idaho
- Pullman 2NW
- Rosalia
- St John

Note: Means calculated based on available period of record for each station

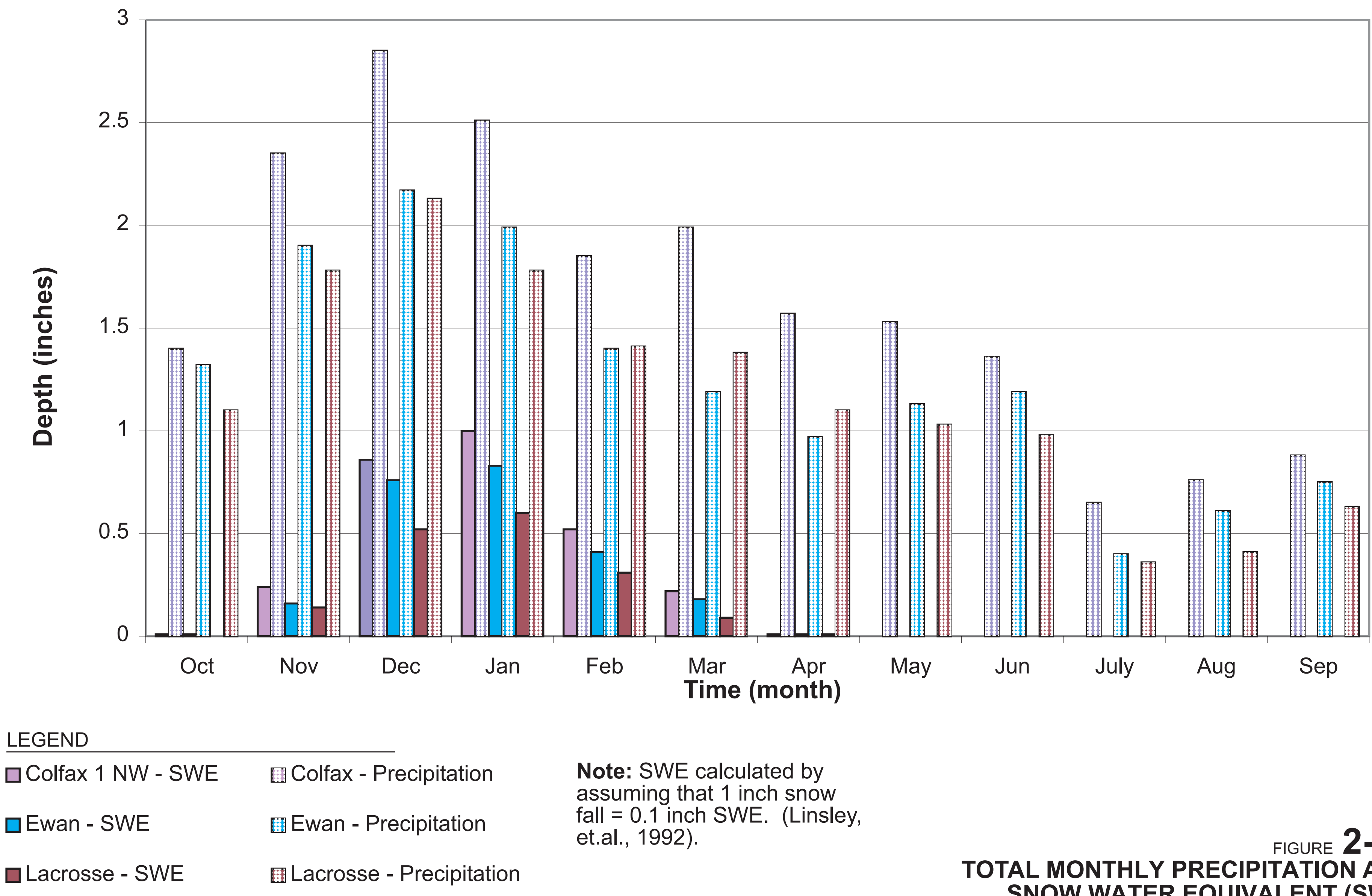
FIGURE **2-6**

MEAN MONTHLY SNOWFALL

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg14.fh11 DATE 11/01/04 DRAWN BY EL

Golder Associates



Note: SWE calculated by assuming that 1 inch snow fall = 0.1 inch SWE. (Linsley, et.al., 1992).

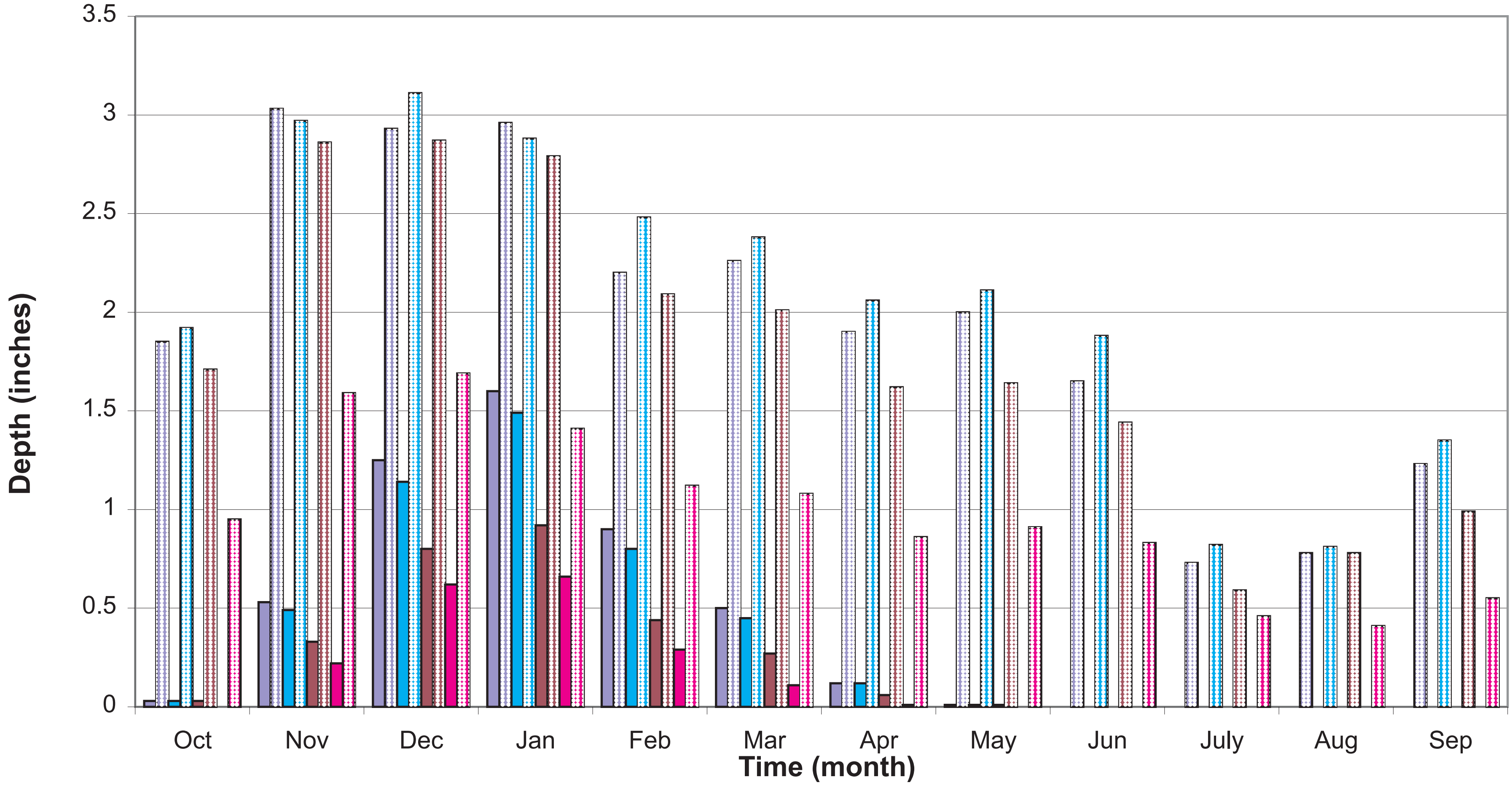
FIGURE **2-7a**

TOTAL MONTHLY PRECIPITATION AND SNOW WATER EQUIVALENT (SWE)

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg15.fh11 DATE 11/01/04 DRAWN BY EL

Golder Associates



LEGEND

- Moscow U of I - SWE
- Potlatch 3 NNE - SWE
- Pullman 2 NW - SWE
- Ritzville - SWE
- Moscow U of I - Precipitation
- Potlatch - Precipitation
- Pullman 2 NW - Precipitation
- Ritzeville - Precipitation

Note: SWE calculated by assuming that 1 inch snow fall = 0.1 inch SWE. (Linsley, et.al., 1992).

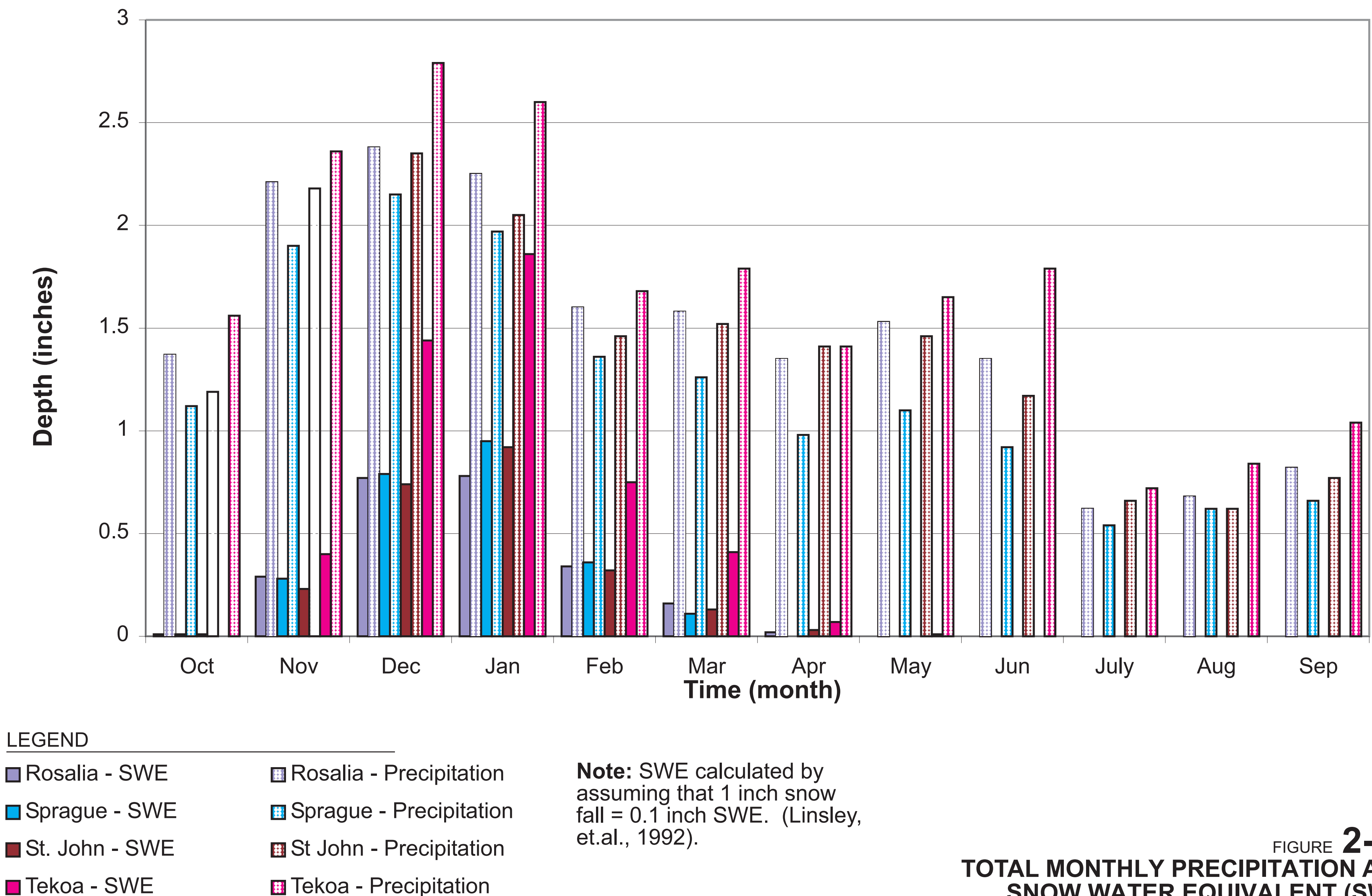
FIGURE **2-7b**

TOTAL MONTHLY PRECIPITATION AND SNOW WATER EQUIVALENT (SWE)

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg16.fh11 DATE 11/01/04 DRAWN BY EL

Golder Associates



Note: SWE calculated by assuming that 1 inch snow fall = 0.1 inch SWE. (Linsley, et.al., 1992).

FIGURE **2-7c**

TOTAL MONTHLY PRECIPITATION AND SNOW WATER EQUIVALENT (SWE)

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg17.fh11 DATE 11/01/04 DRAWN BY EL

Golder Associates

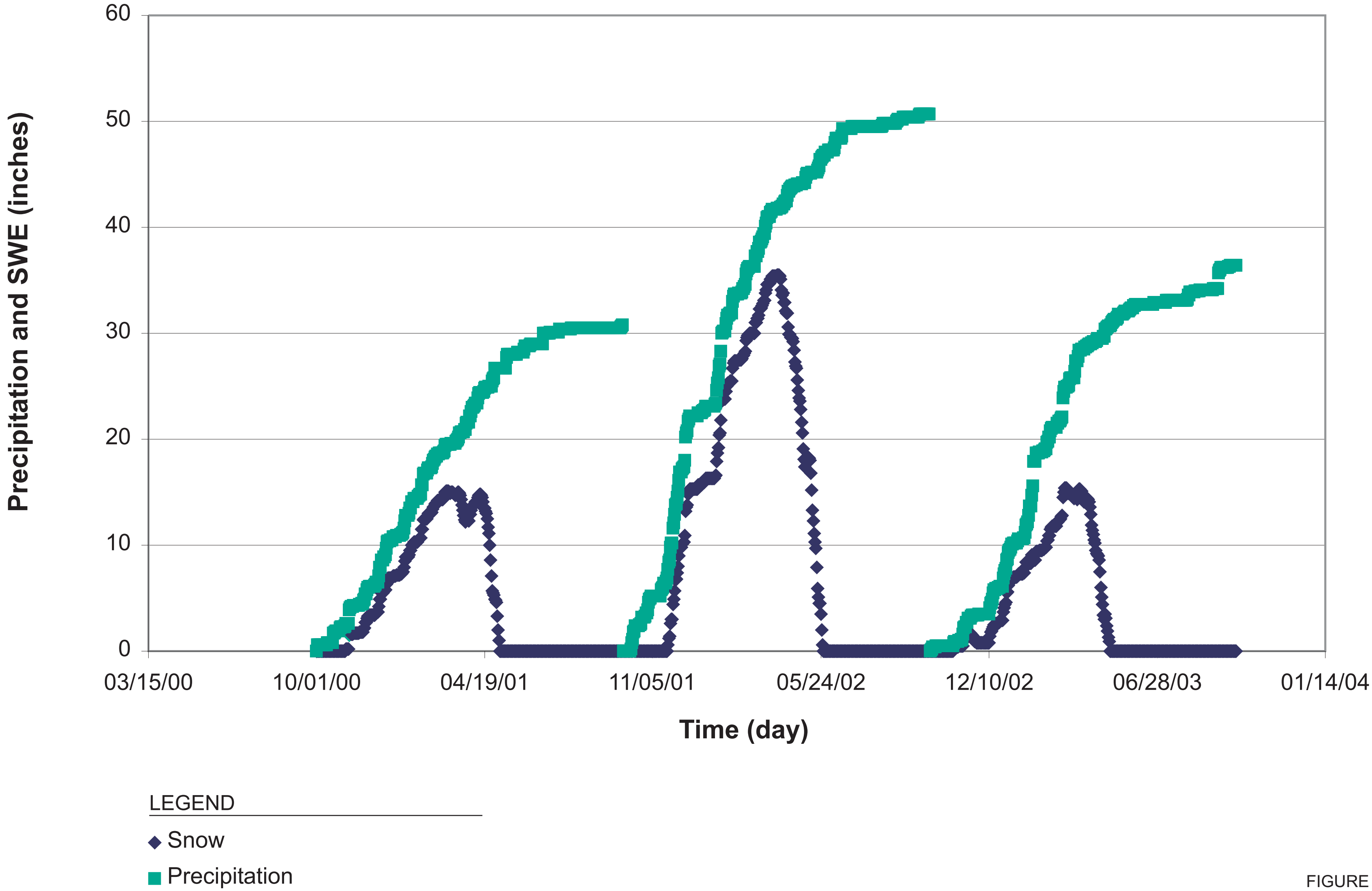


FIGURE **2-8**

ACCUMULATED DAILY PRECIPITATION AND SNOW WATER EQUIVALENT (SWE) - MOSCOW MOUNTAIN SNOTEL

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg18.fh11 DATE 11/01/04 DRAWN BY EL

Golder Associates

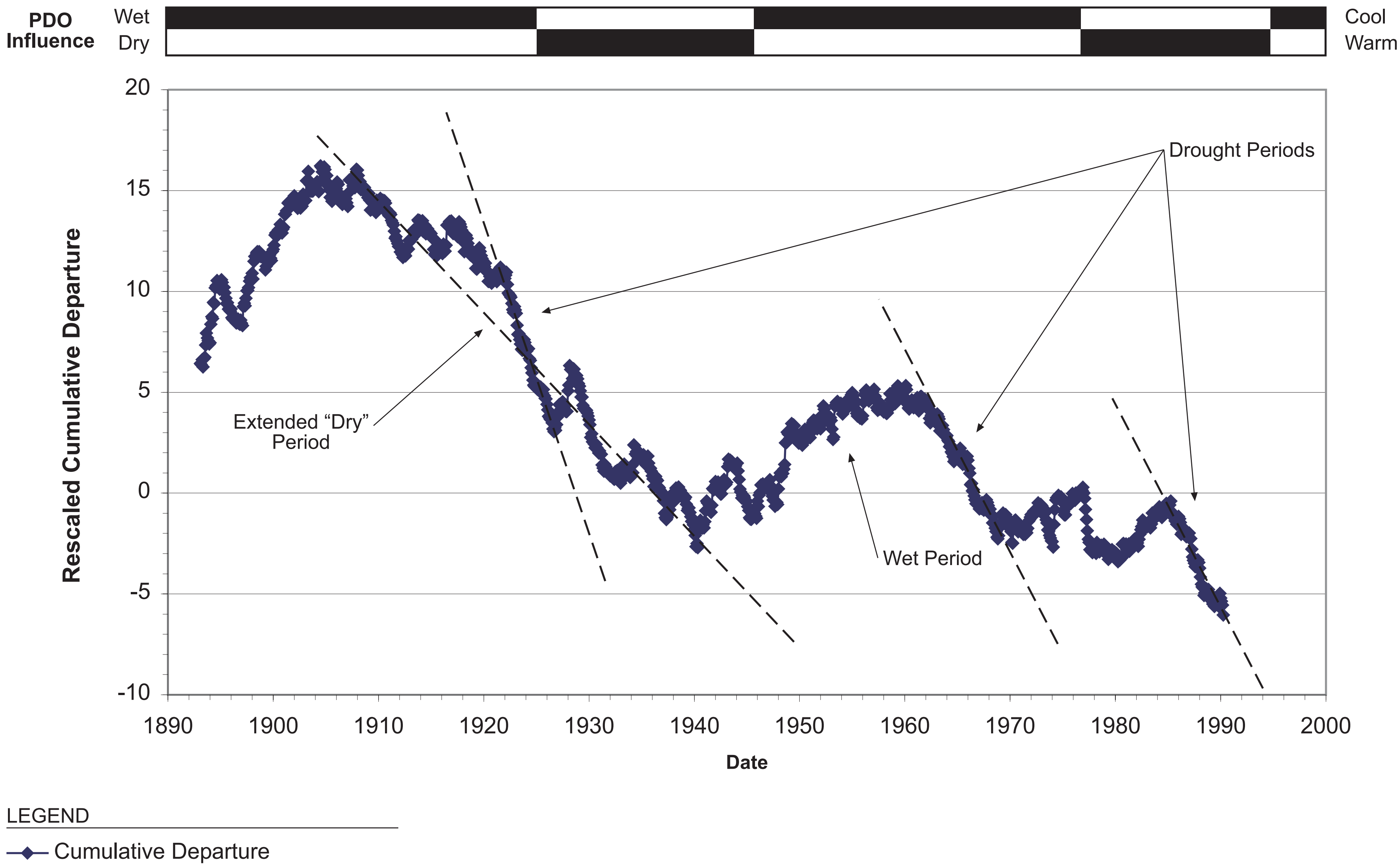


FIGURE **2-9**

COLFAX, WA CUMULATIVE DEPARTURE (STN 451586)

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg19.fh11 DATE 11/02/04 DRAWN BY EL

Golder Associates

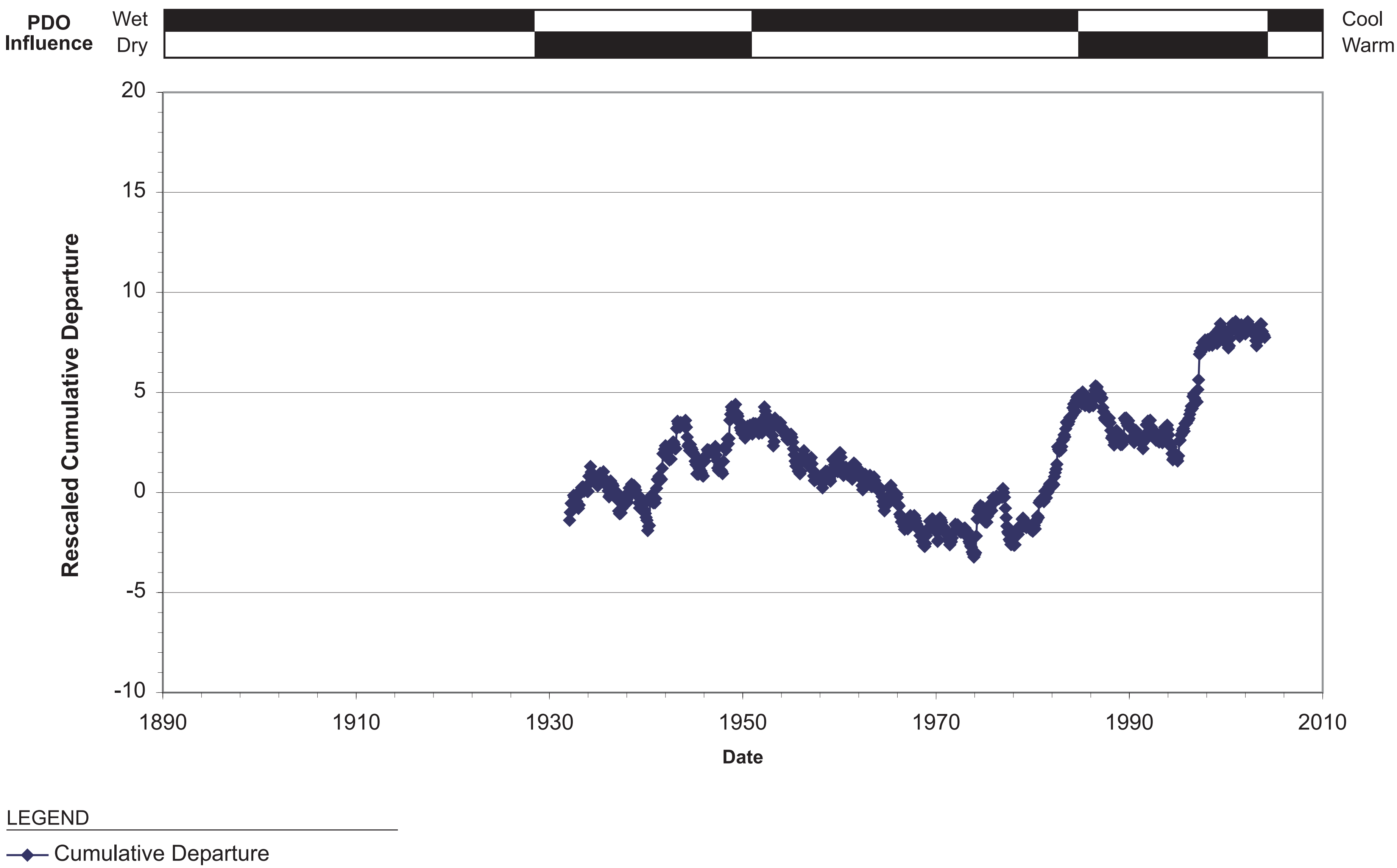


FIGURE **2-10**

LACROSSE, WA CUMULATIVE DEPARTURE (STN 454338)

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg20.fh11 DATE 11/02/04 DRAWN BY EL

Golder Associates

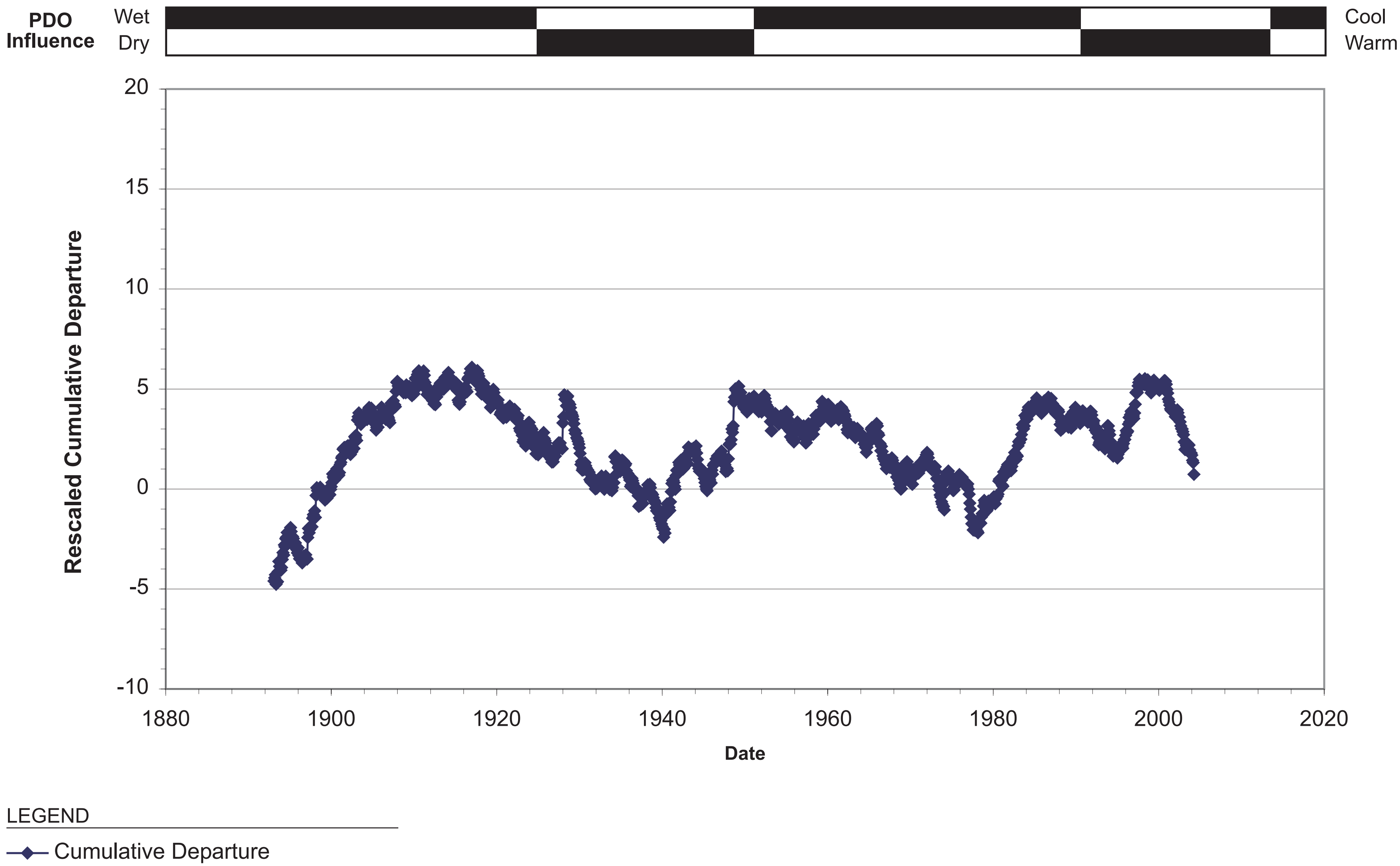


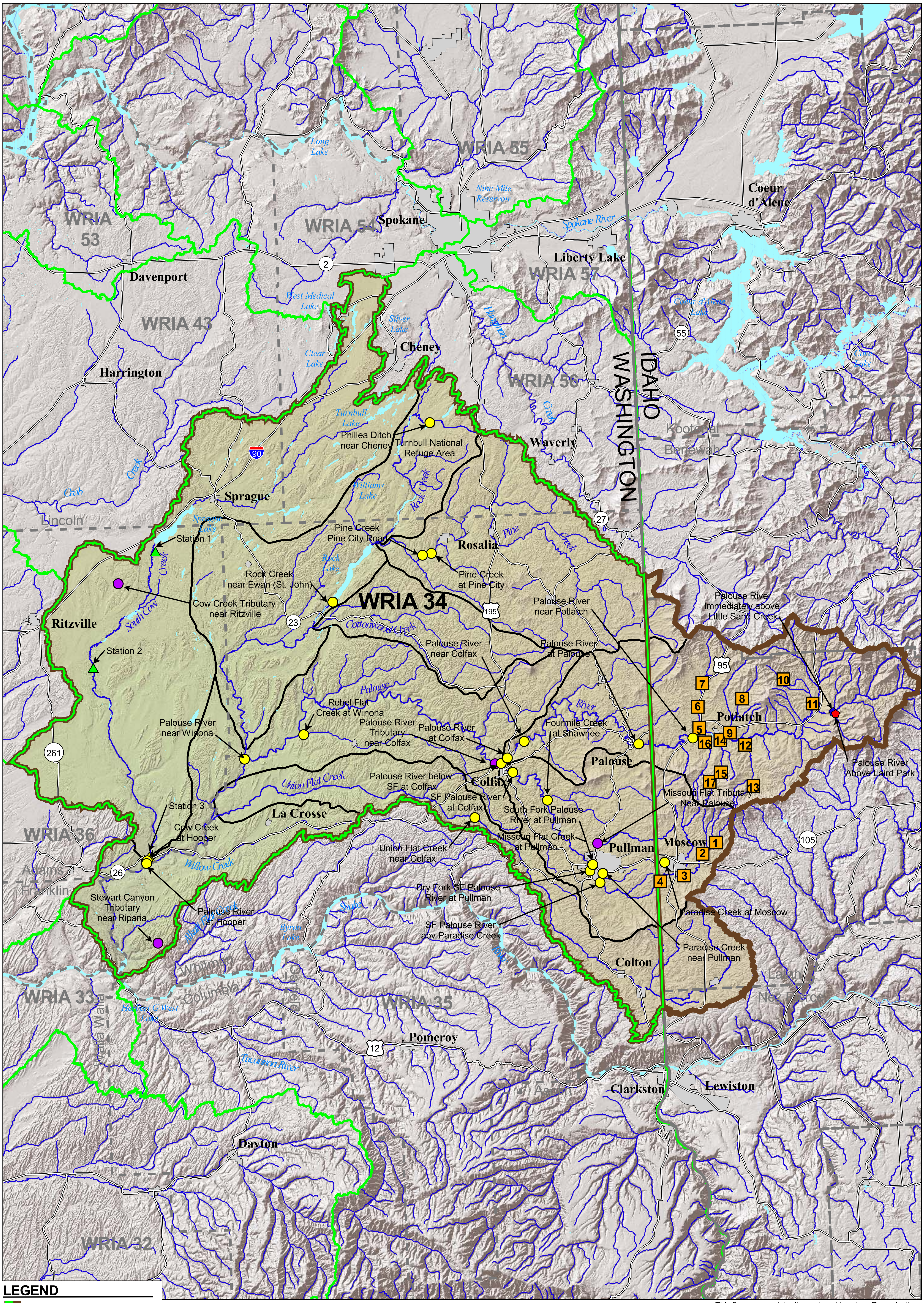
FIGURE **2-11**

ROSALIA, WA CUMULATIVE DEPARTURE (STN 457180)

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641010fg21.fh11 DATE 11/02/04 DRAWN BY EL

Golder Associates



LEGEND

- Palouse Watershed Boundary
- WRIA Boundary
- Subbasin Boundary
- National Wildlife Refuge
- Community
- Waterbody
- Stream
- Road
- County Boundary

Surface Water Monitoring Sites

- Adam County Conservation District
- USFS - Old
- USFS - New
- USGS
- USGS - Peakflow Only
- IDEQ

0 50,000
Scale 1" = 50,000 Feet

Map Projection:
Washington State Plane
South Zone, NAD 83, Feet

Source: WSDOE, WSDOT, USGS, INSIDE Idaho, GIS Data Depot,, Adams County, USFS, IDEQ

N

This figure was originally produced in color. Reproduction in black and white may result in loss of information.
Locations of Adams County Conservation sampling points are approximate.

SURFACE WATER MONITORING SITES

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: KAV	Revision: 6	Date: Dec. 7, 2004	Figure: 3-1

04310641030_012804.apr

Golder Associates

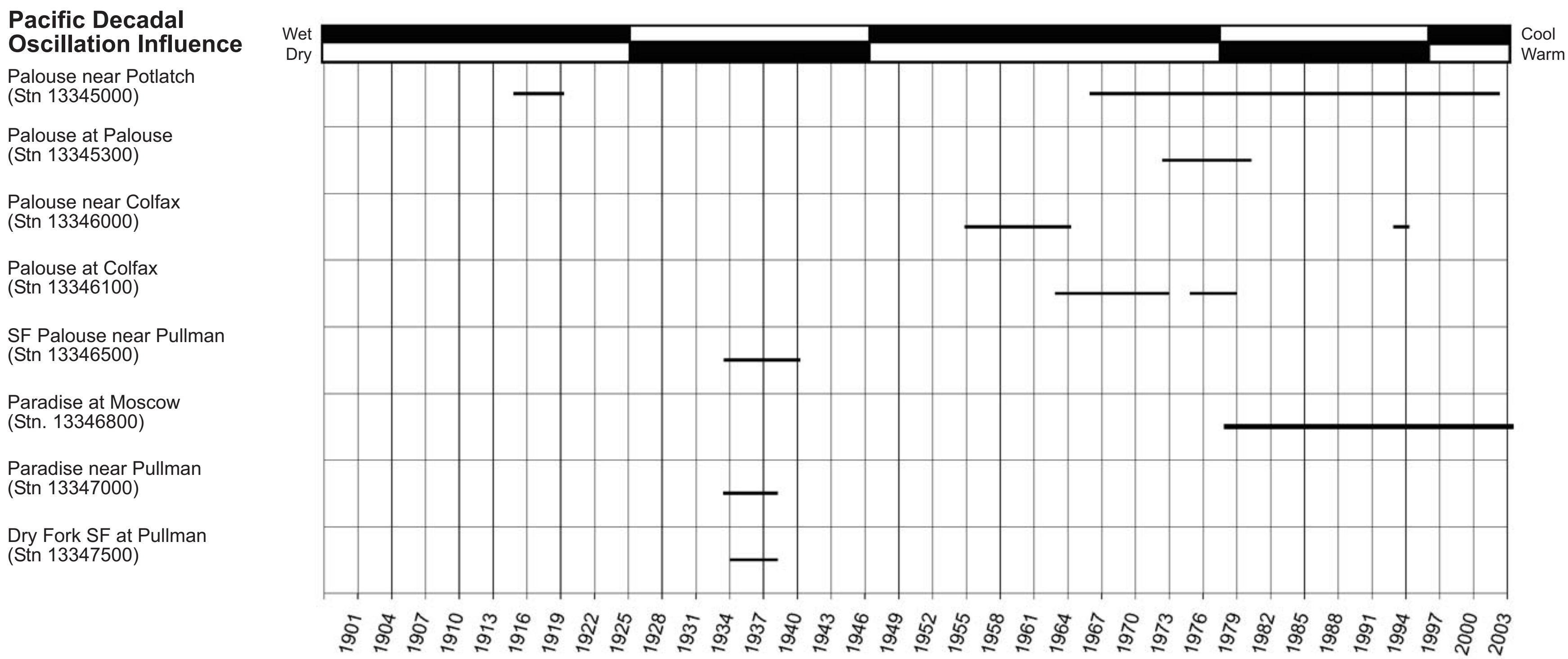


FIGURE **3-2a**

USGS STREAM GAGING PERIODS OF RECORDS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg56.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

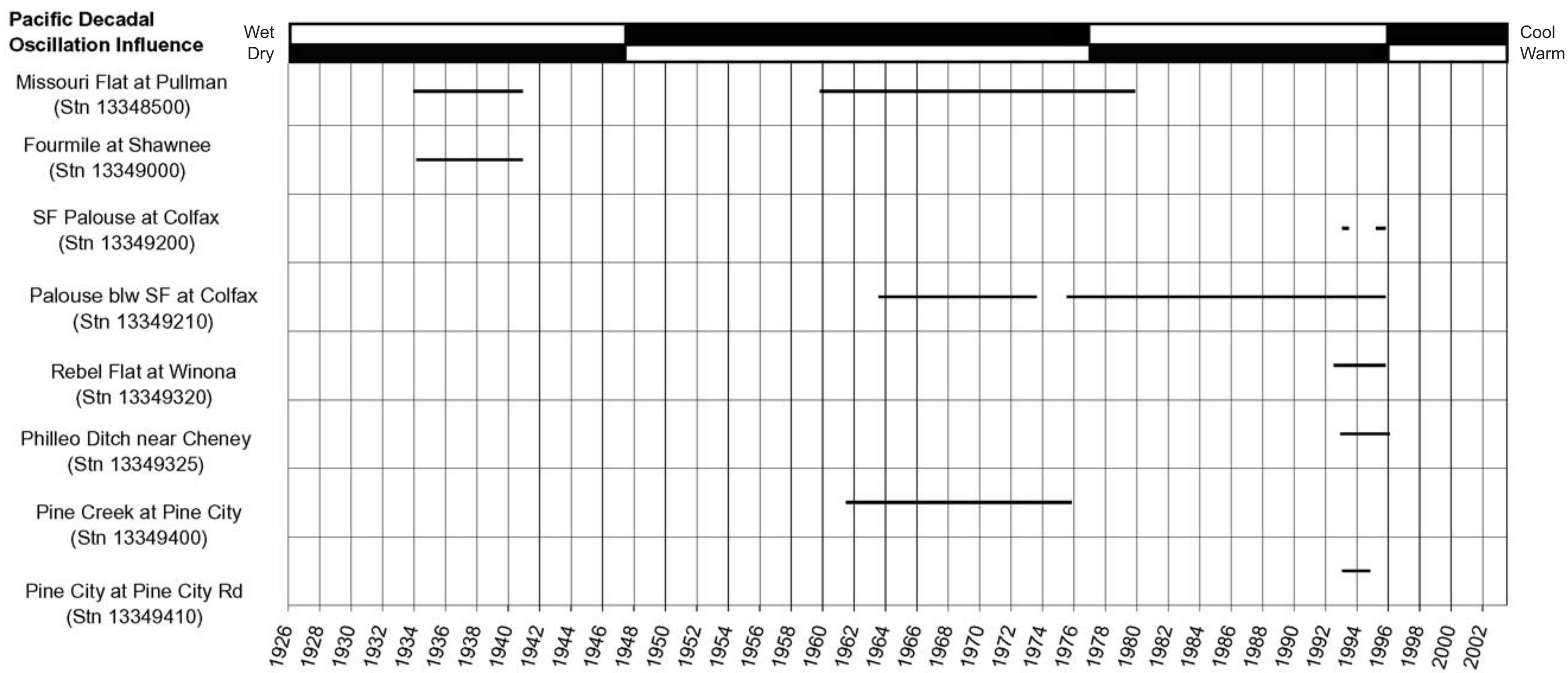
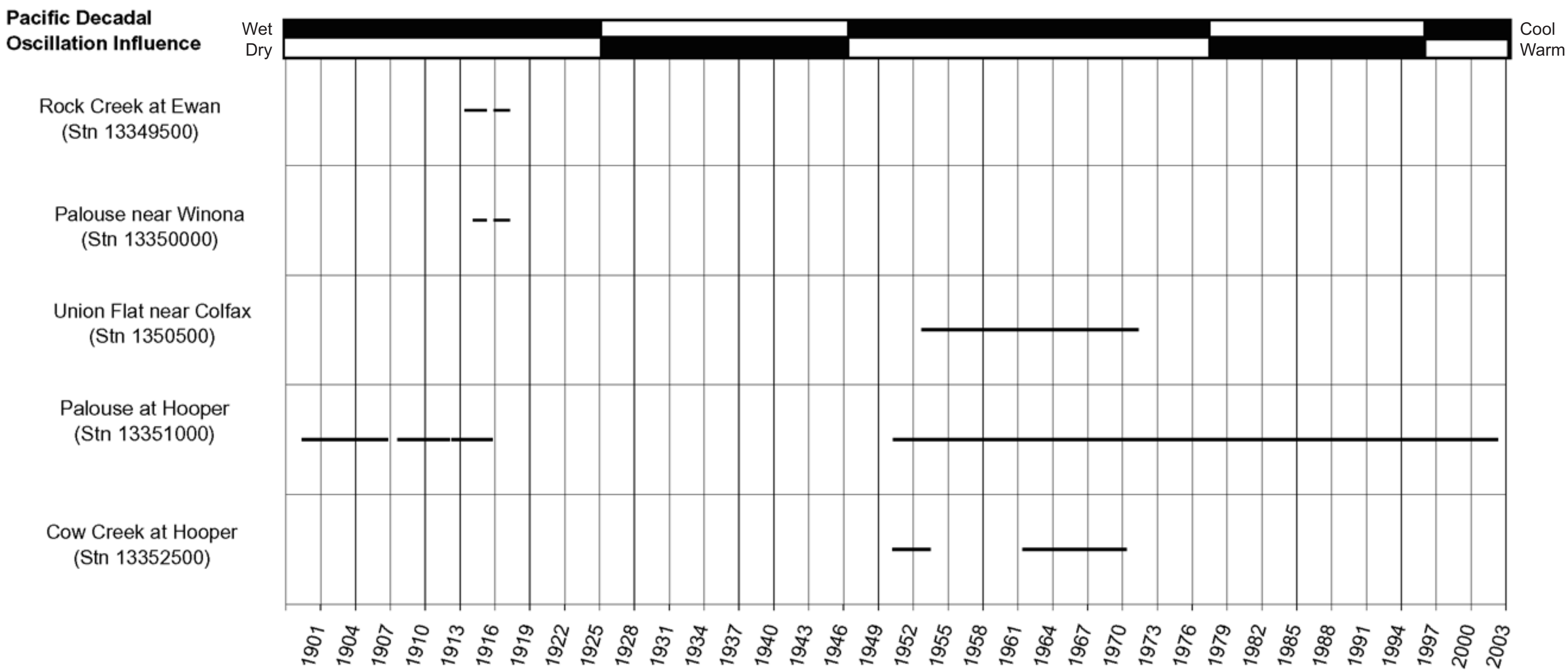


FIGURE **3-2b**
USGS STREAM GAGING PERIODS OF RECORD
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg57.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates



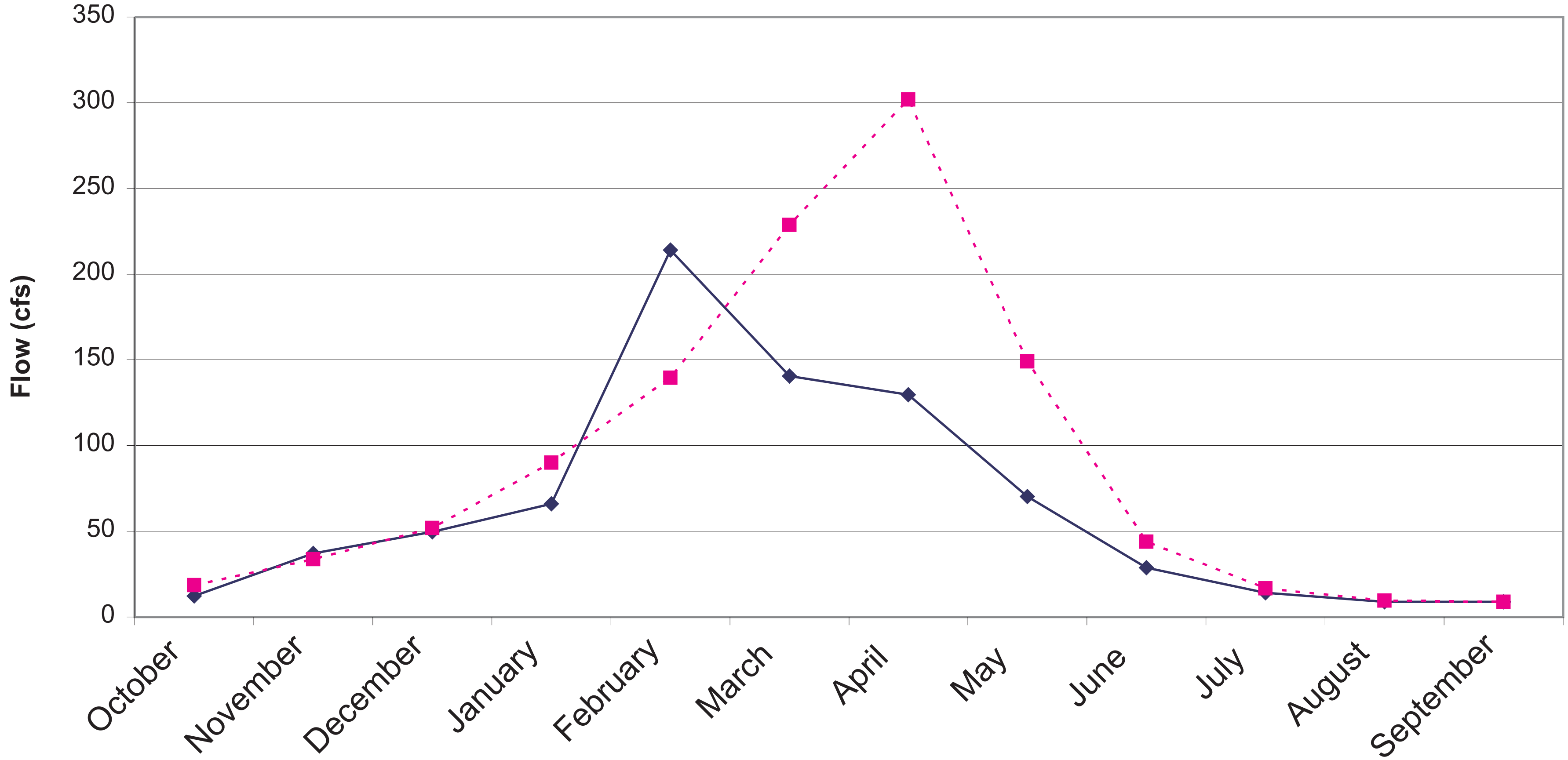
Note: Portion of Palouse at Hooper (Stn. 13351000) period of record not included: 1897-1899

FIGURE **3-2c**

USGS STREAM GAGING PERIODS OF RECORDS
PALOUSE PHASE II/LEVEL 1 ASSESSMENT
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg58.fh11 DATE 03/25/04 DRAWN BY AMP

Golder Associates



LEGEND

Old Gage above Little Sand Creek (1986-1996)

New Gage above Laird Park (1997-2003)

Source: Clearwater National Forest

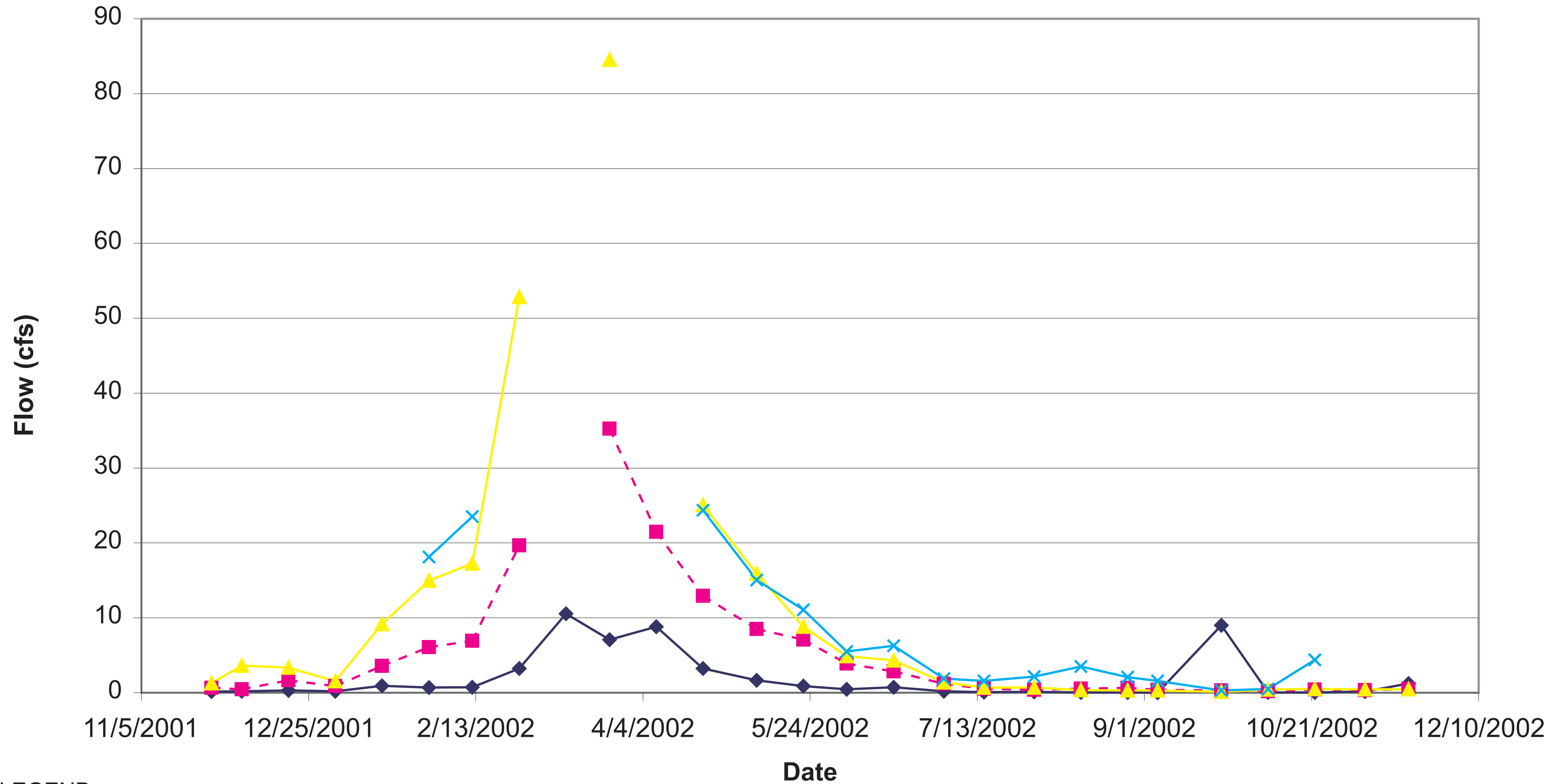
FIGURE **3-3**

USFS PALOUSE RIVER GAGING STATION MEAN MONTHLY STREAMFLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg01.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates



LEGEND

- PR-1 SF Palouse
- PR-2 SF Palouse
- PR-3 SF Palouse
- PR-4 SF Palouse

Note: See Figure 3-1 for station locations

Source: Idaho Department of Environmental Quality (IDEQ)

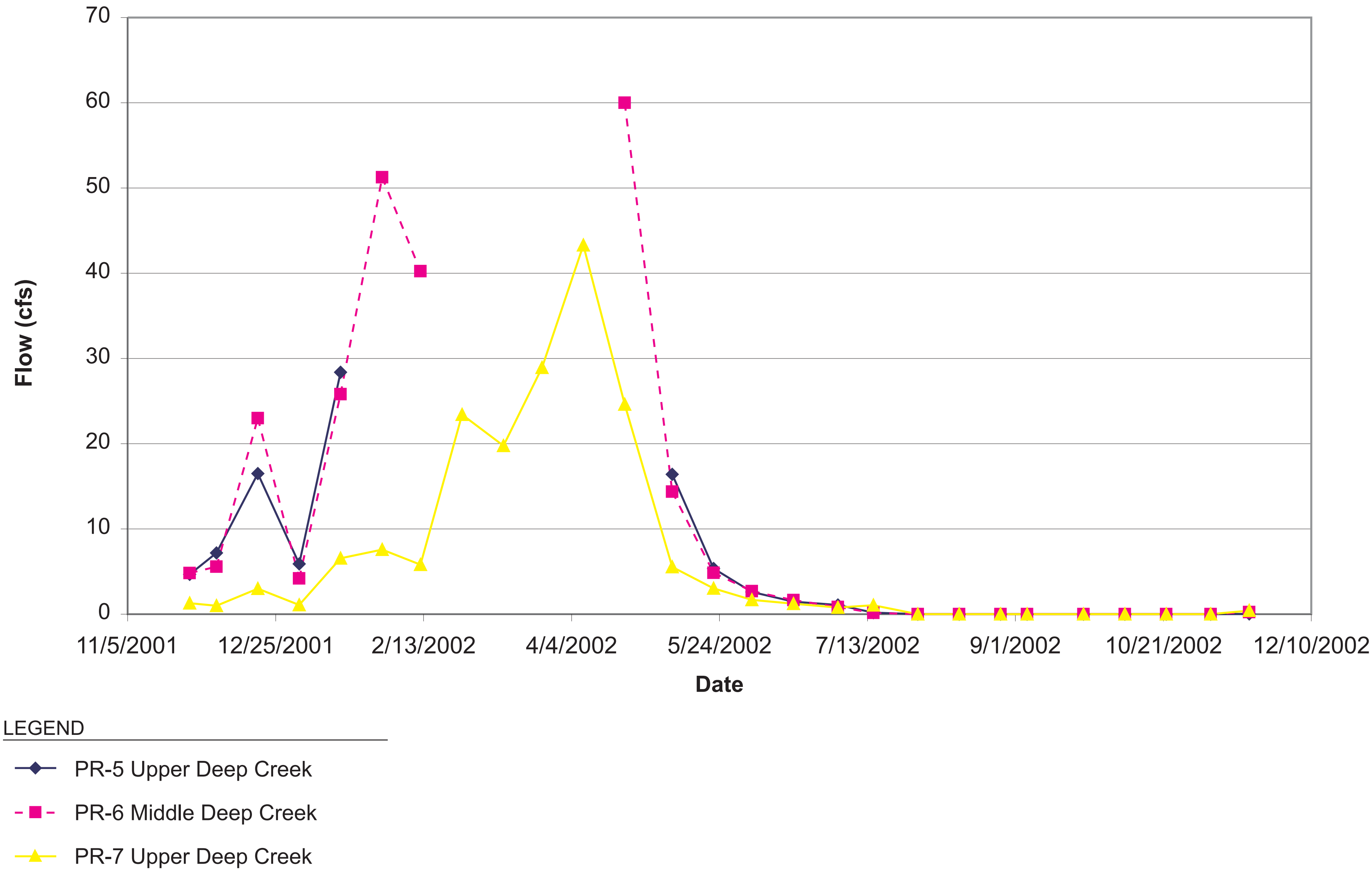
FIGURE **3-4a**

IDEQ SOUTH FORK PALOUSE RIVER FLOWS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg09.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates



Note: See Figure 3-1 for station locations

Source: Idaho Department of Environmental Quality (IDEQ)

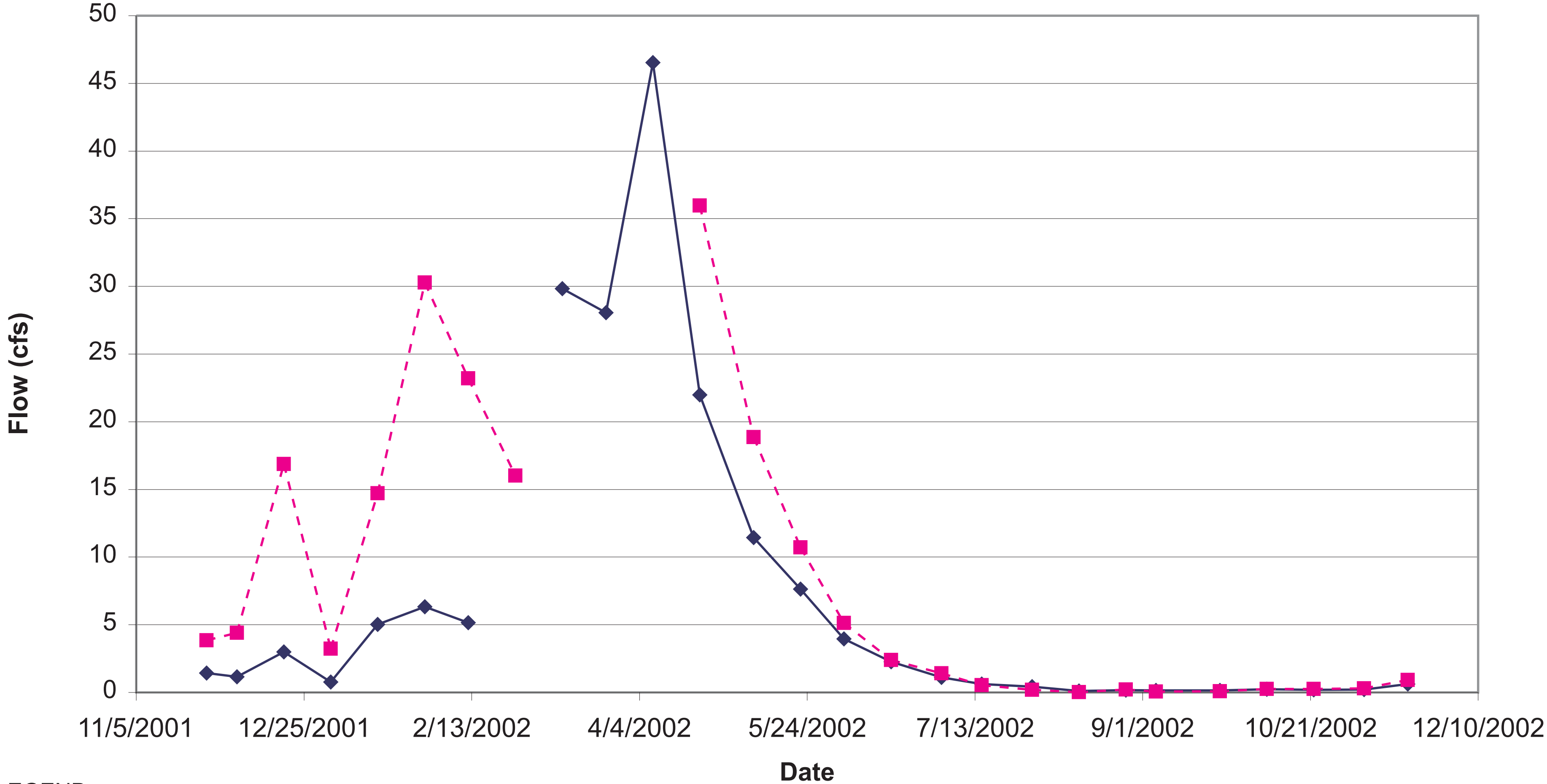
FIGURE **3-4b**

IDEQ DEEP CREEK FLOWS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg08.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates



LEGEND

- PR-8 Upper Gold Creek
- PR-9 Lower Gold Creek

Note: See Figure 3-1 for station locations

Source: Idaho Department of Environmental Quality (IDEQ)

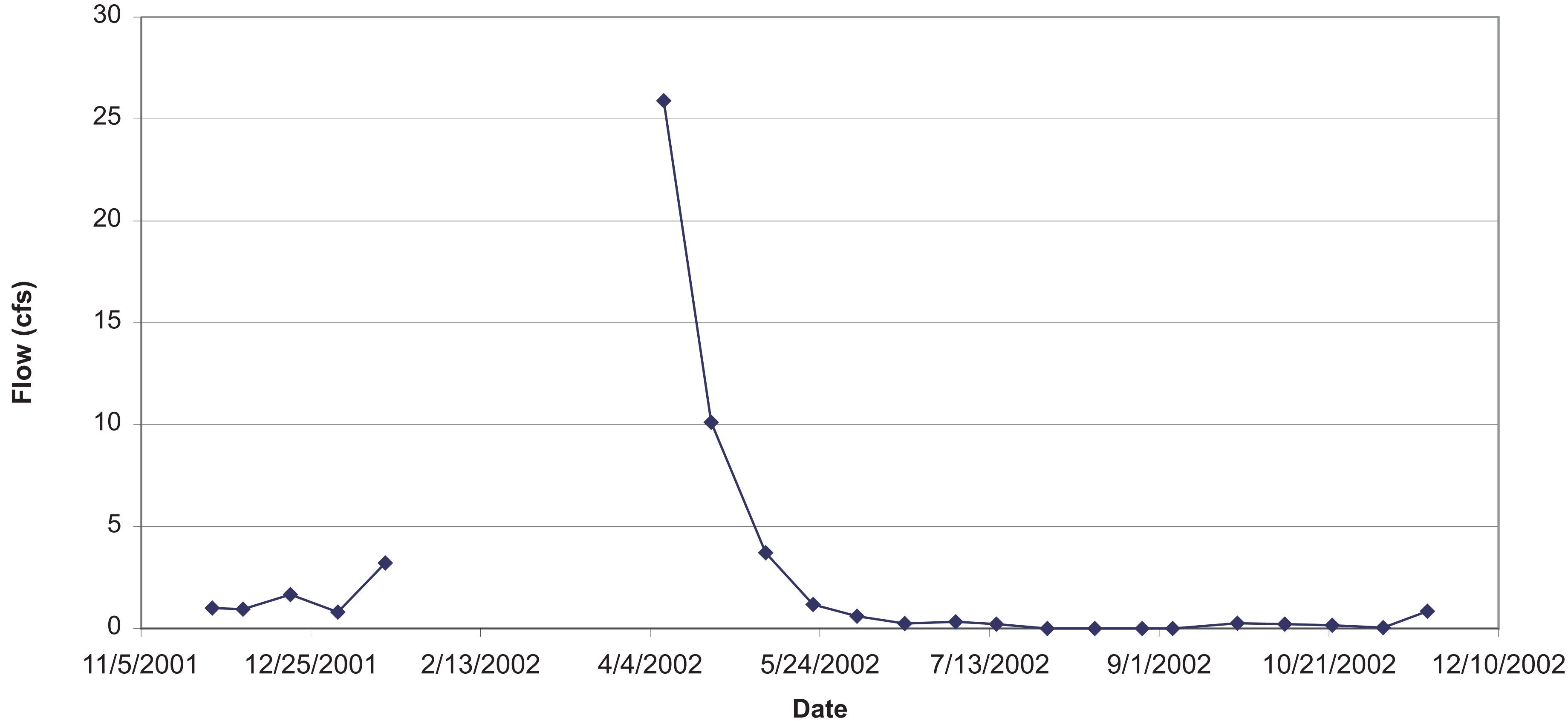
FIGURE **3-4c**

IDEQ GOLD CREEK FLOWS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg07.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates



LEGEND

PR-10 Last Chance Creek

Note: See Figure 3-1 for station locations

Source: Idaho Department of Environmental Quality (IDEQ)

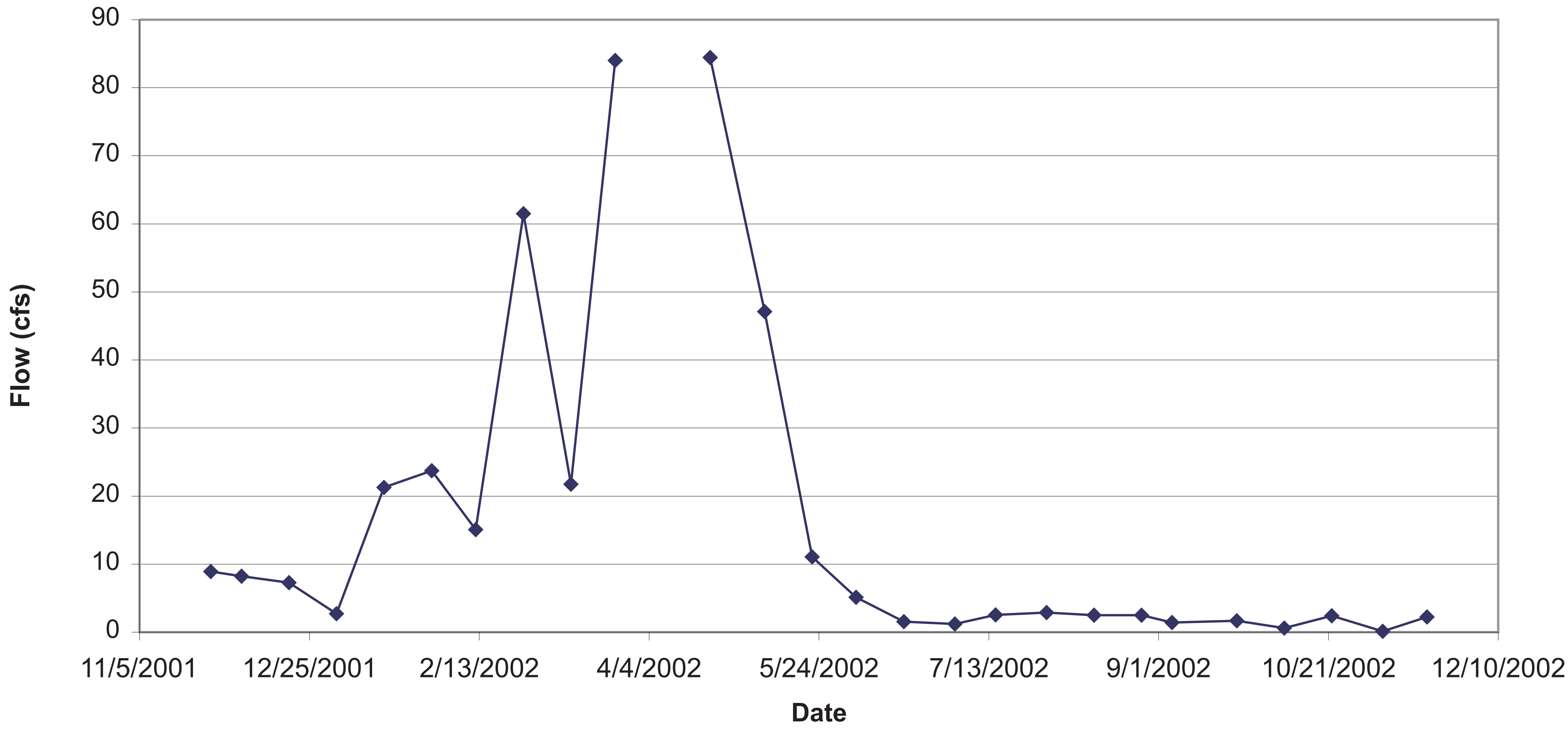
FIGURE **3-4d**

IDEQ LAST CHANCE CREEK FLOWS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg06.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates



LEGEND

PR-11 Lower Big Creek

Note: See Figure 3-1 for station locations

Source: Idaho Department of Environmental Quality (IDEQ)

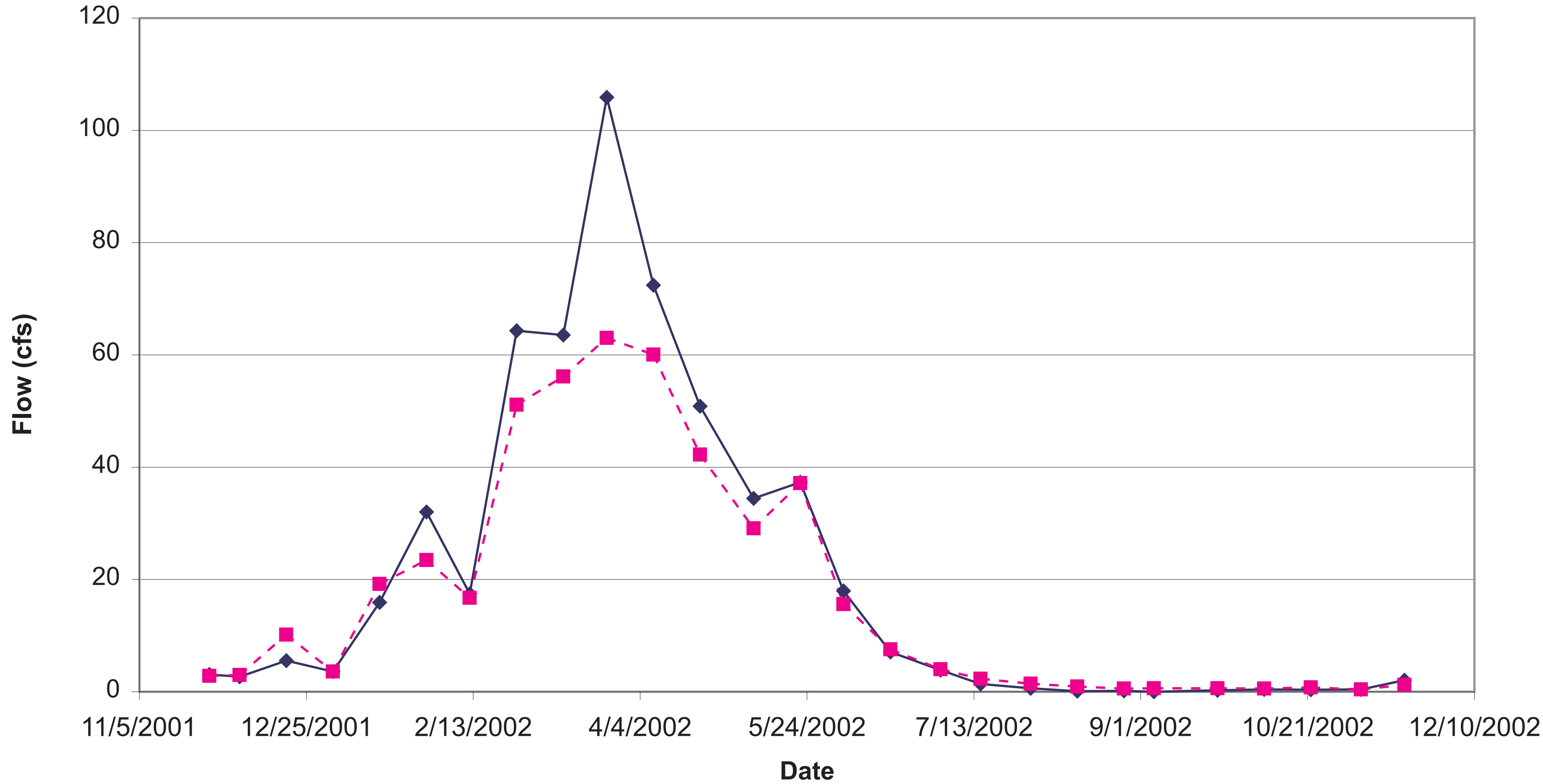
FIGURE **3-4e**

IDEQ BIG CREEK FLOWS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg05.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates



LEGEND

- PR-12 Lower Hatter Creek
- PR-13 Upper Hatter Creek

Note: See Figure 3-1 for station locations

Source: Idaho Department of Environmental Quality (IDEQ)

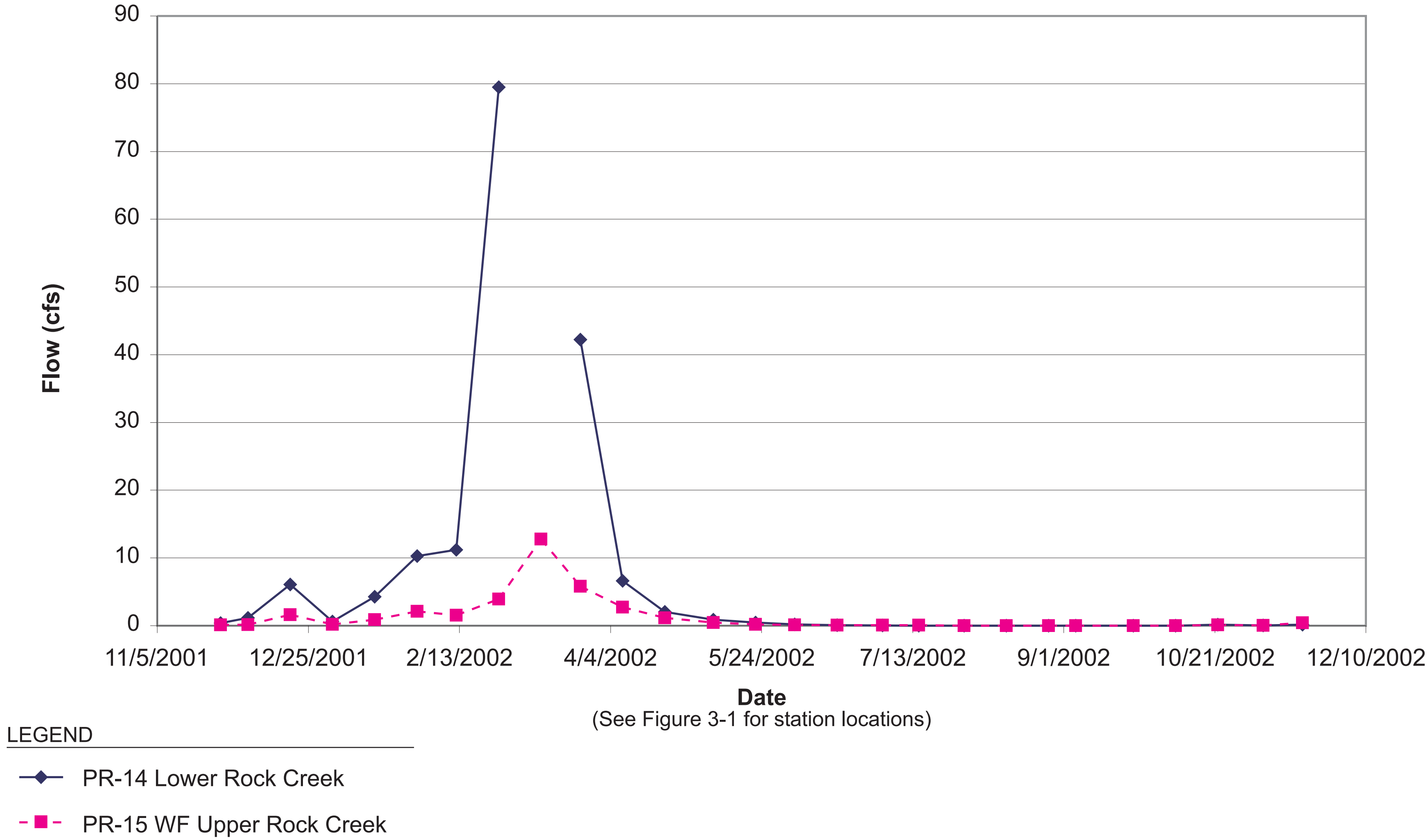
FIGURE **3-4f**

IDEQ HATTER CREEK FLOWS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg04.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates



Note: See Figure 3-1 for station locations

Source: Idaho Department of Environmental Quality (IDEQ)

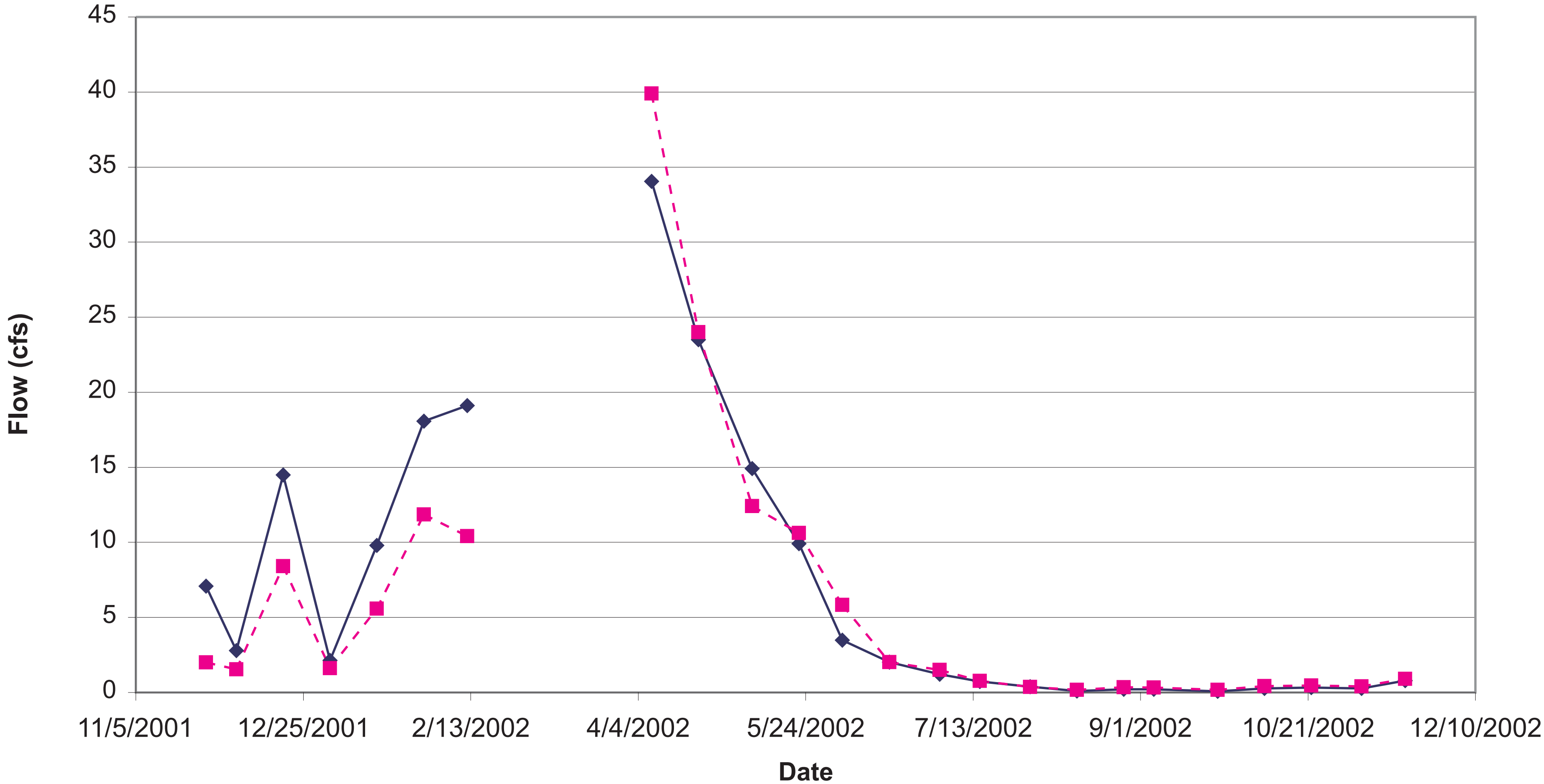
FIGURE **3-4g**

IDEQ ROCK CREEK & WEST FORK ROCK CREEK FLOWS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg03.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates



LEGEND

- PR-16 Lower Flannigan Creek
- PR-17 Upper Flannigan Creek

Note: See Figure 3-1 for station locations

Source: Idaho Department of Environmental Quality (IDEQ)

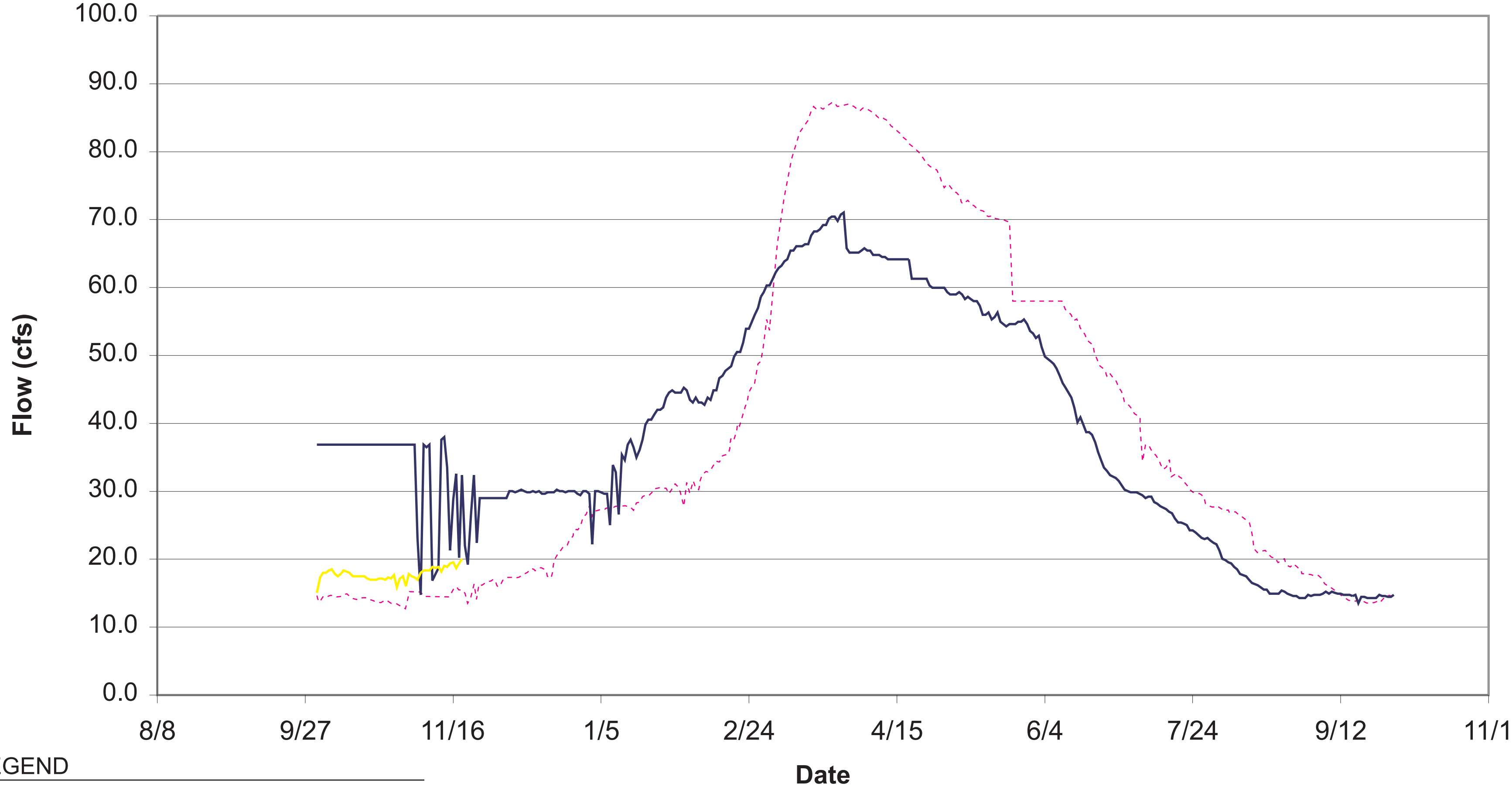
FIGURE **3-4h**

IDEQ FLANNIGAN CREEK FLOWS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg02.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates



LEGEND

- Station 1 - WY 1998
- Station 1 - WY 1999
- Station 1 - WY 2000

Note: Streamflow estimation based on analysis provided by ACCD using continuous stage data.
See Figure 3-1 for station locations

Source: Adams County Conservation District

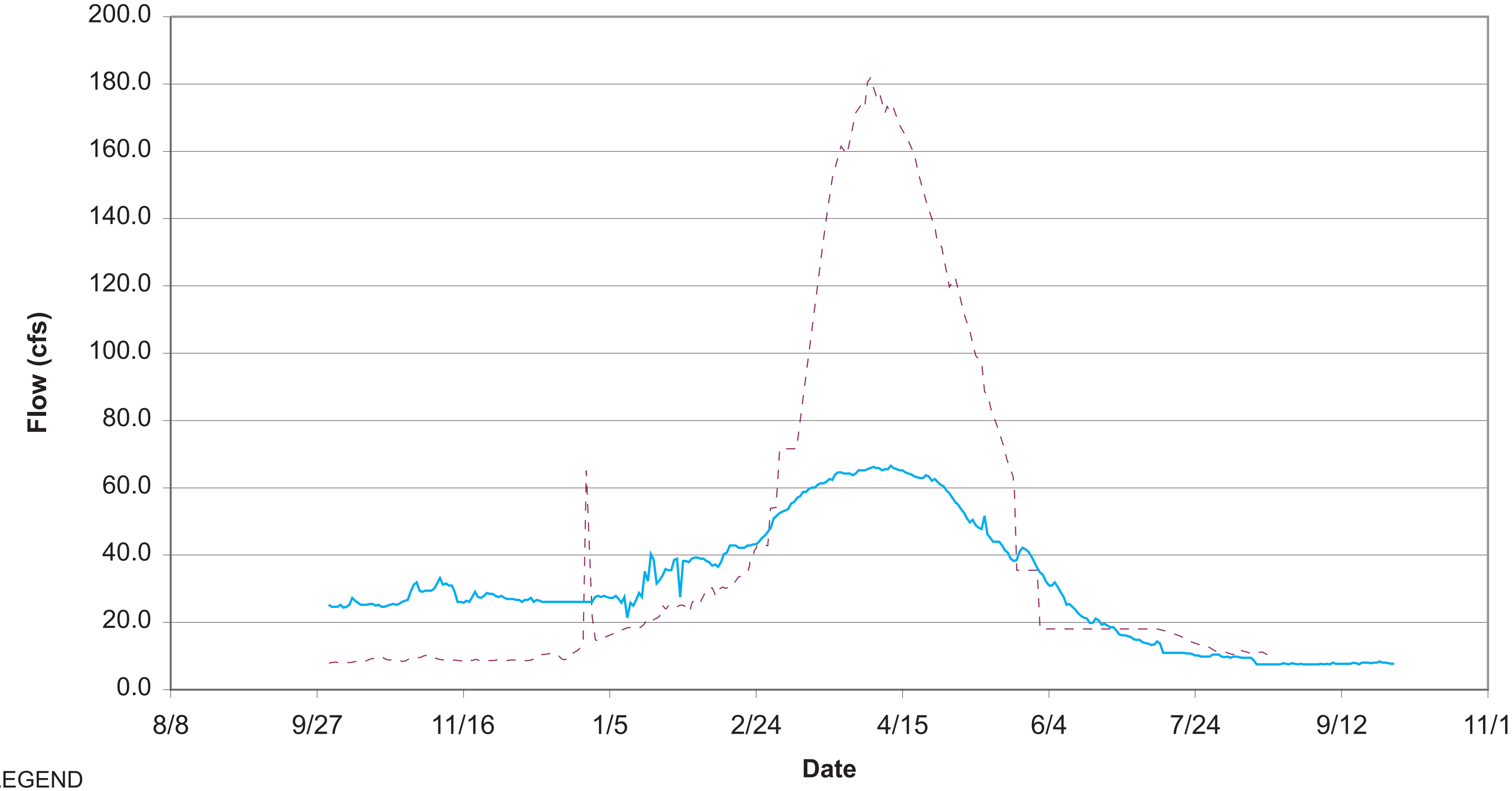
FIGURE **3-5a**

ESTIMATED DAILY HYDROGRAPHS
SPRAGUE LAKE OUTLET (STATION 1)

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg10.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



LEGEND

Station 2 - WY 1998

Station 2 - WY 1999

Note: Streamflow estimation based on analysis provided by ACCD using continuous stage data. See Figure 3-1 for station locations

Source: Adams County Conservation District

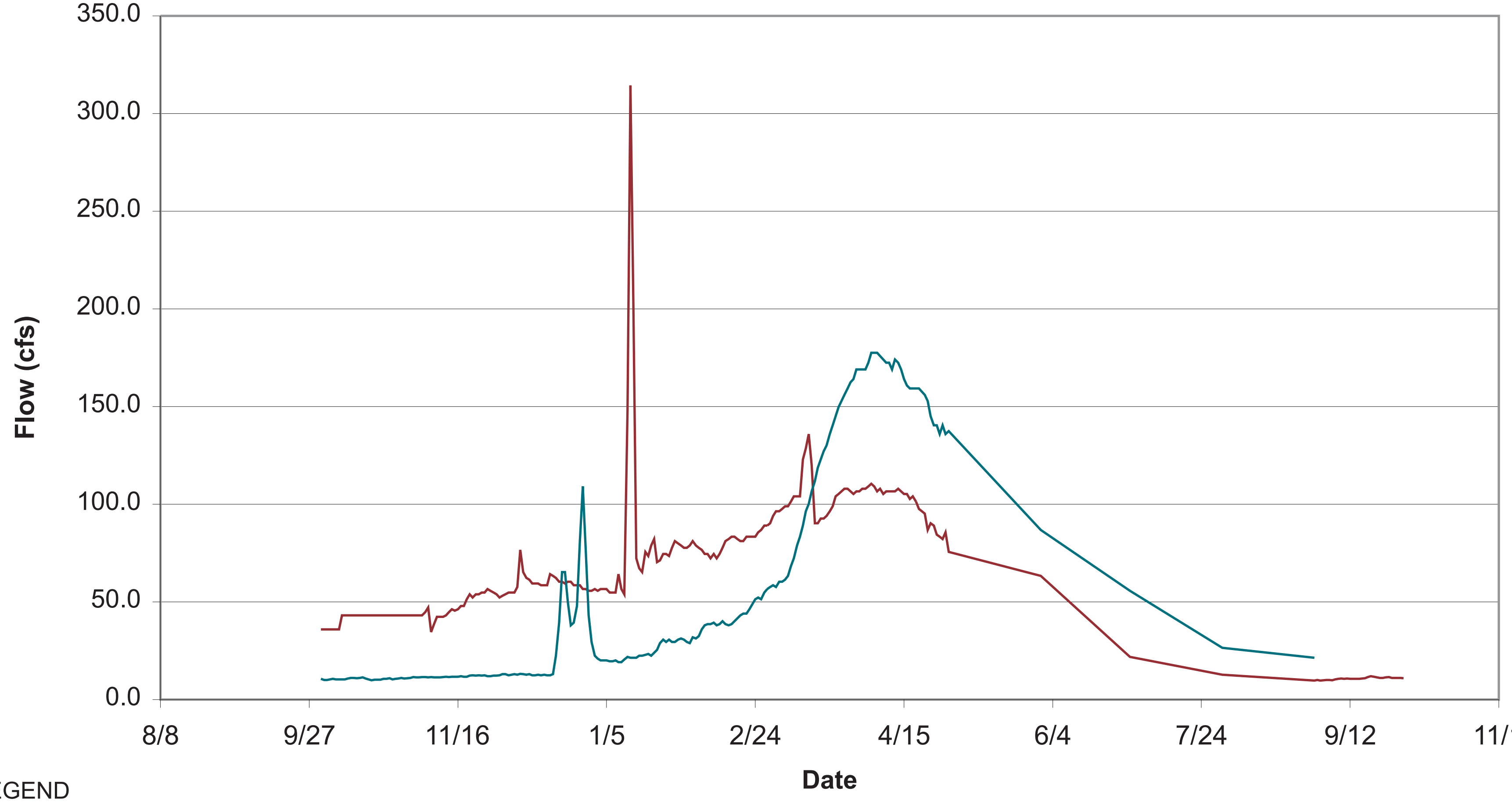
FIGURE **3-5b**

ESTIMATED DAILY HYDROGRAPHS
COW CREEK AT HARDER BRIDGE (STATION 2)

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg11.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



LEGEND

Station 3 - WY 1998

Station 3 - WY 1999

Note: Streamflow estimation based on analysis provided by ACCD using continuous stage data. See Figure 3-1 for station locations

Source: Adams County Conservation District

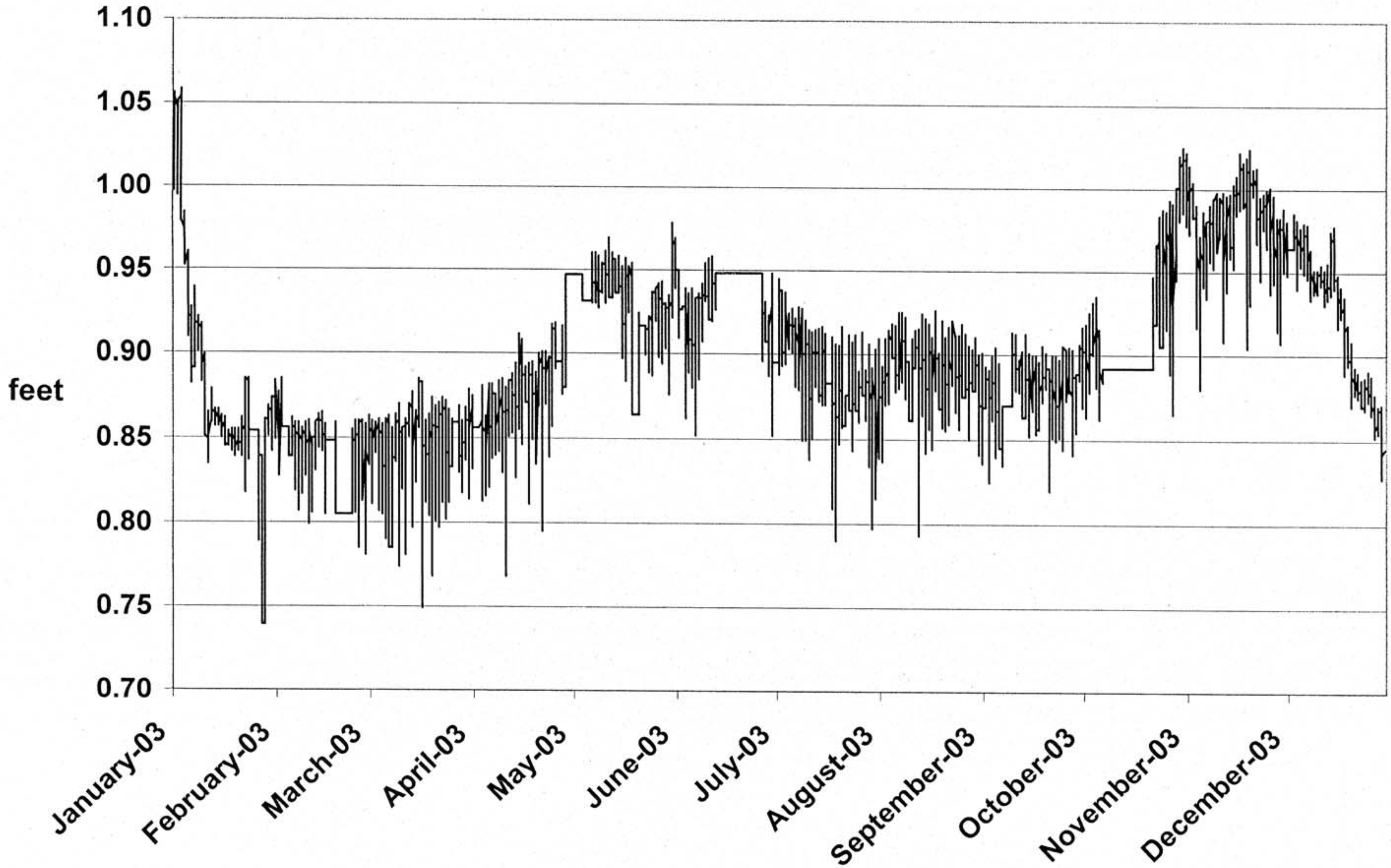
FIGURE **3-5c**

ESTIMATED DAILY HYDROGRAPHS
COW CREEK AT HOOPER (STATION 3)

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg12.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



Note: Streamflow estimation based on analysis provided by ACCD using continuous stage data. See Figure 3-1 for station locations

Source: Adams County Conservation District

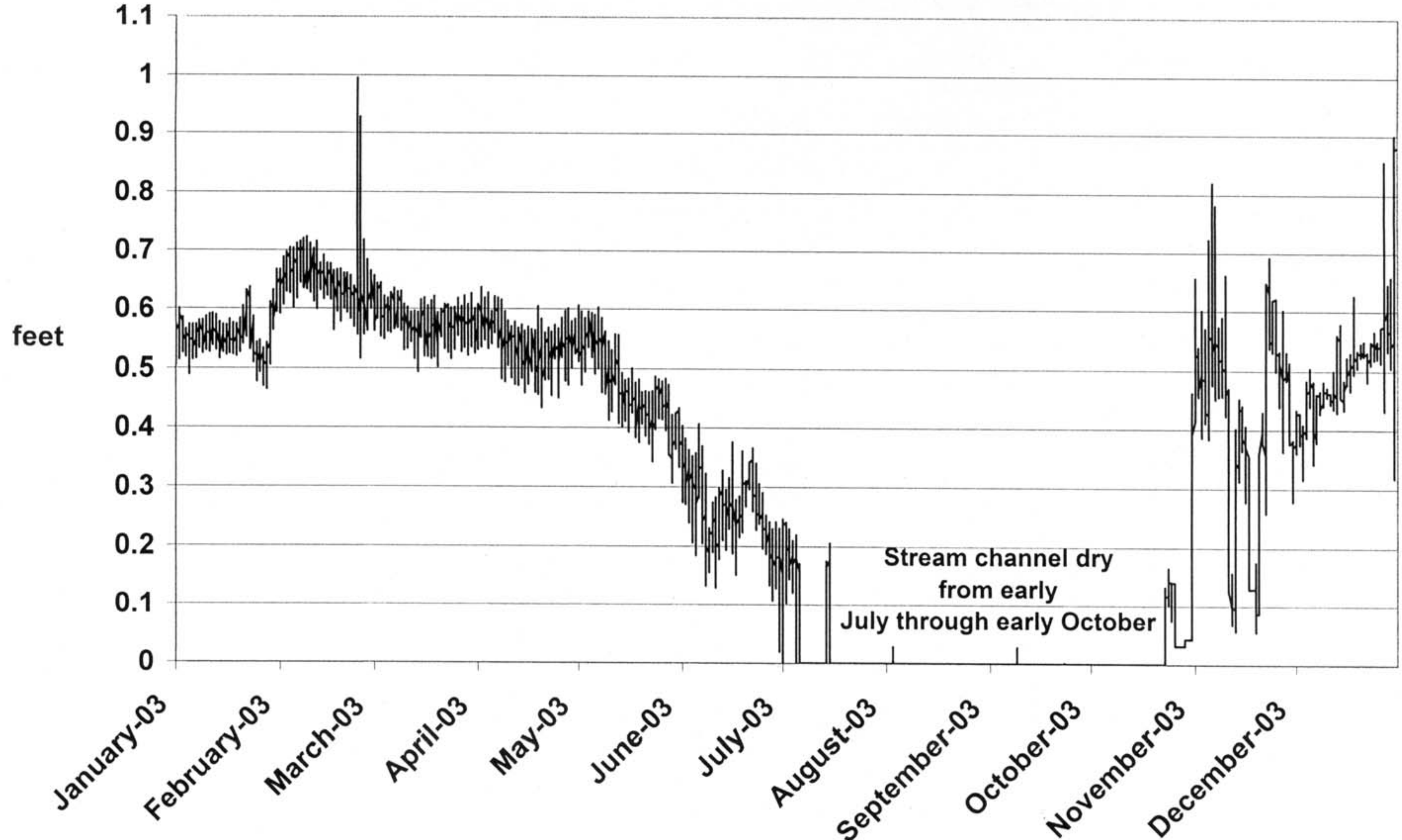
FIGURE **3-5d**

COW CREEK AT HARDER BRIDGE-RELATIVE STREAM STAGE IN 2003

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg92.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



Note: Streamflow estimation based on analysis provided by ACCD using continuous stage data. See Figure 3-1 for station locations

Source: Adams County Conservation District

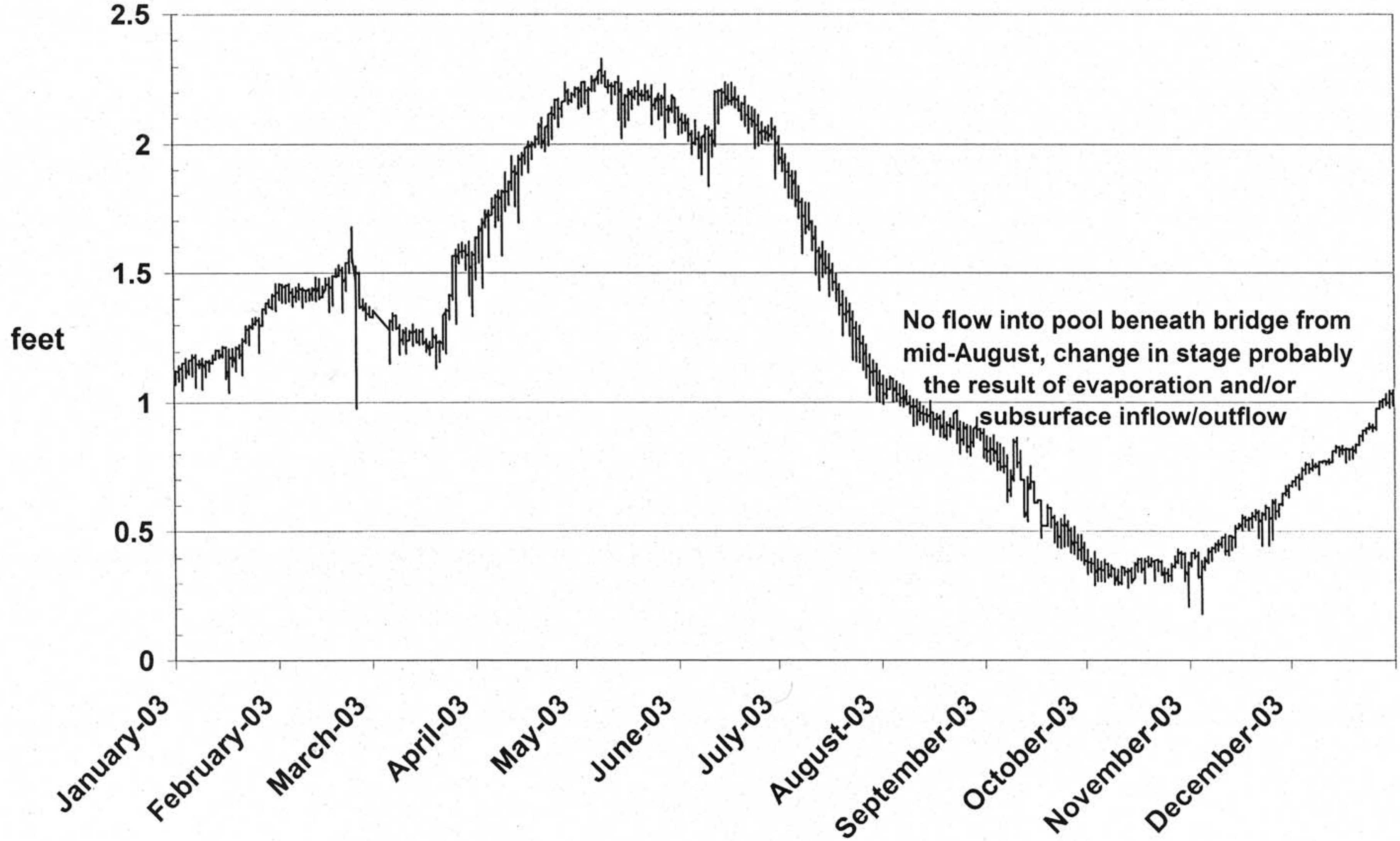
FIGURE **3-5e**

COW CREEK AT HOOPER-RELATIVE STREAM STAGE IN 2003

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg93.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



Note: Streamflow estimation based on analysis provided by ACCD using continuous stage data. See Figure 3-1 for station locations

Source: Adams County Conservation District

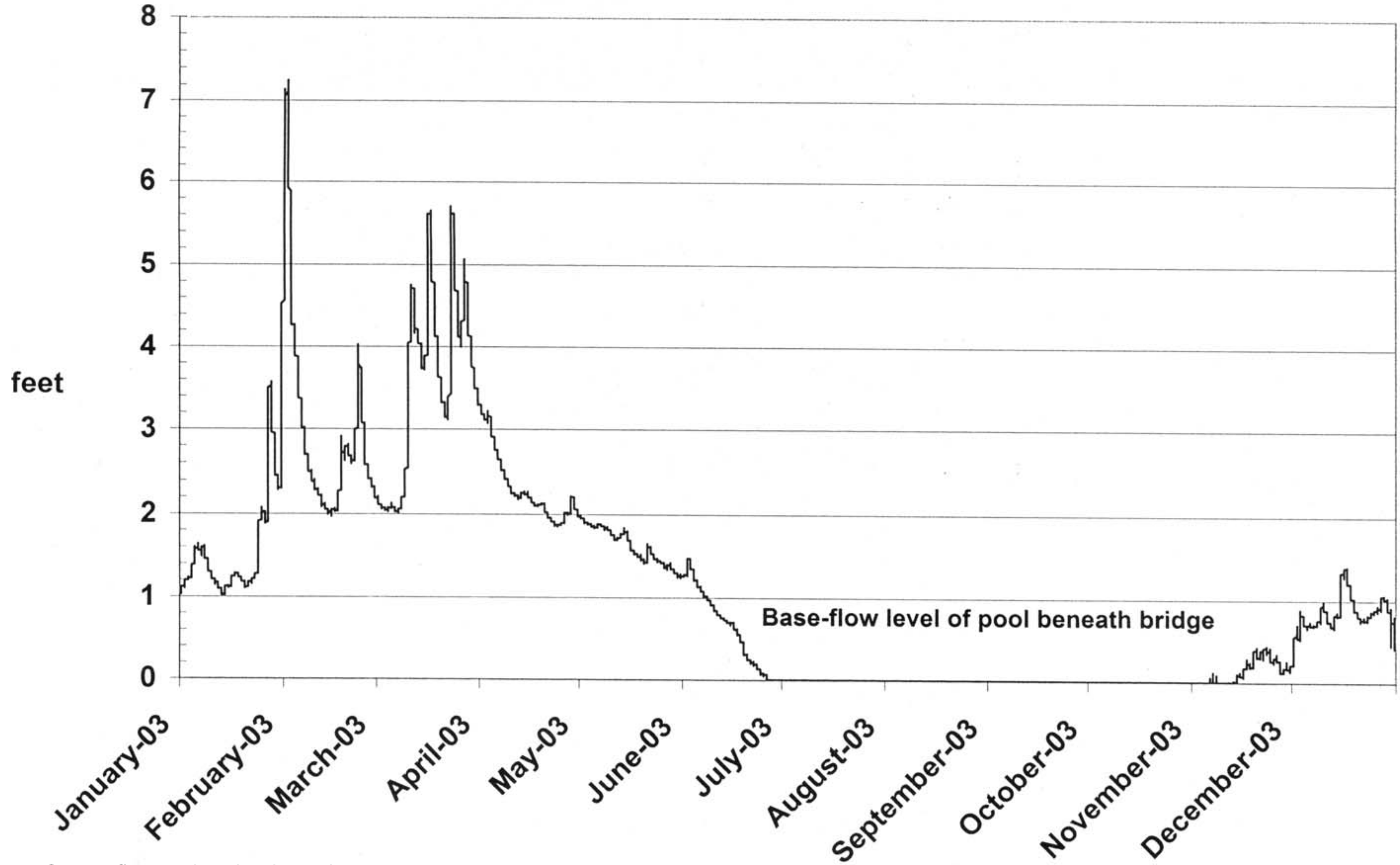
FIGURE **3-5f**

COW CREEK AT DANEKAS ROAD-RELATIVE STREAM STAGE IN 2003

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg94.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



Note: Streamflow estimation based on analysis provided by ACCD using continuous stage data. See Figure 3-1 for station locations

Source: Adams County Conservation District

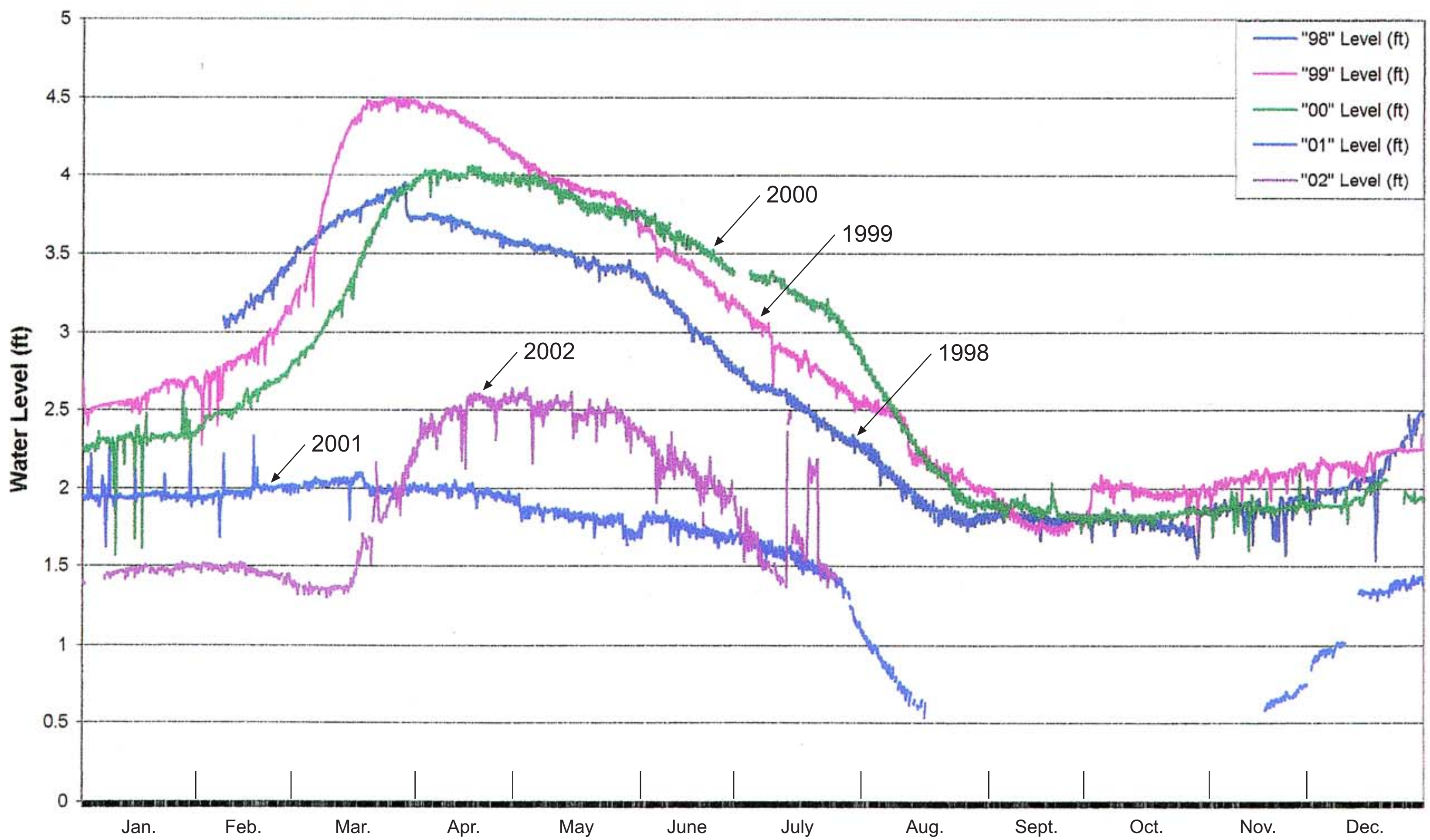
FIGURE **3-5g**

LOWER PALOUSE RIVER AT OLD HIGHWAY 26 BRIDGE
RELATIVE STREAM STAGE IN 2003

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg95.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



Note: Streamflow estimation based on analysis provided by ACCD using continuous stage data. See Figure 3-1 for station locations

Source: Adams County Conservation District

FIGURE **3-5h**

SPRAGUE OUTLET ANNUAL WATER LEVELS 1998- 2002

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg96.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates

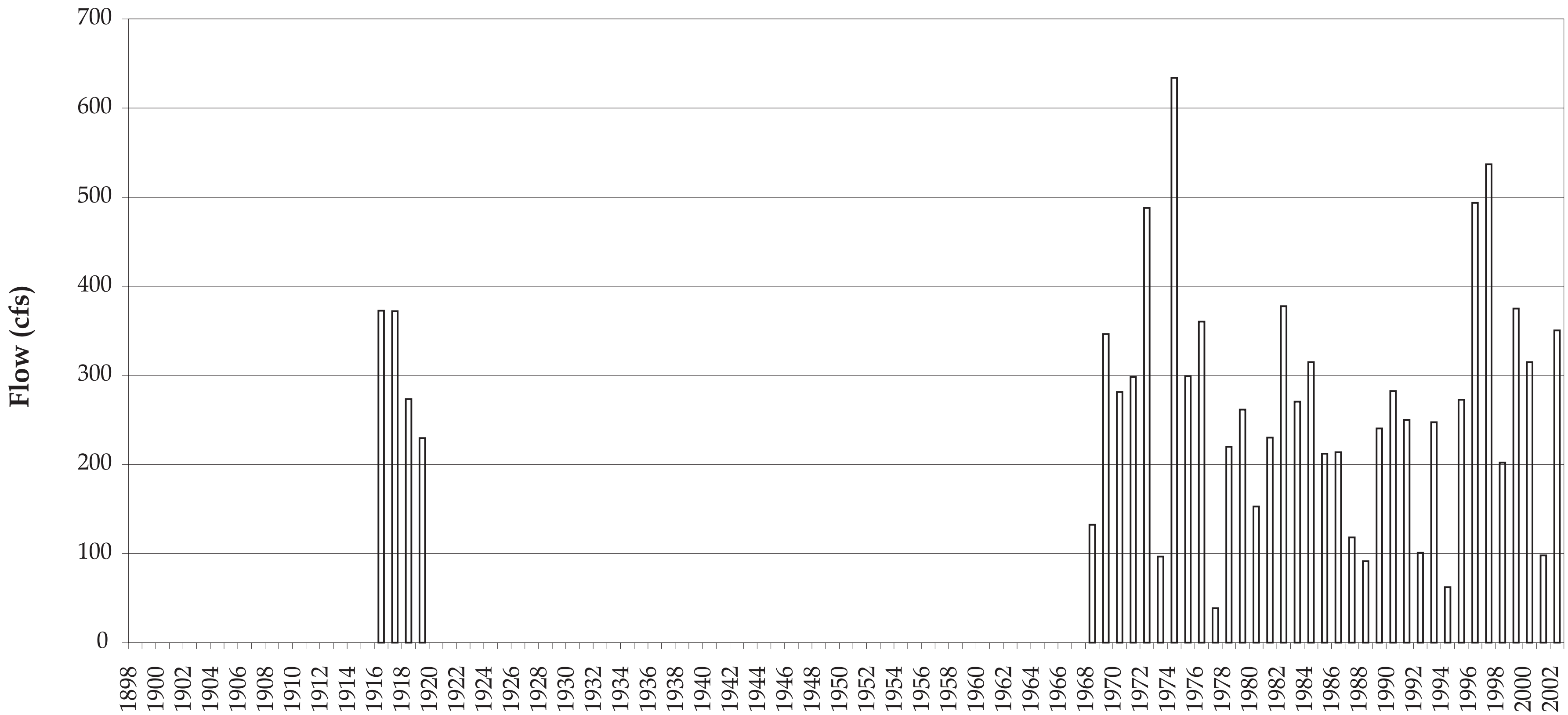


FIGURE **3-6a**

PALOUSE RIVER NEAR POTLATCH (USGS STN. 13345000)
MEAN ANNUAL FLOW
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg13.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

FIGURE **3-6b**

PALOUSE RIVER AT PALOUSE (USGS STN. 13345300)
MEAN ANNUAL FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg14.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

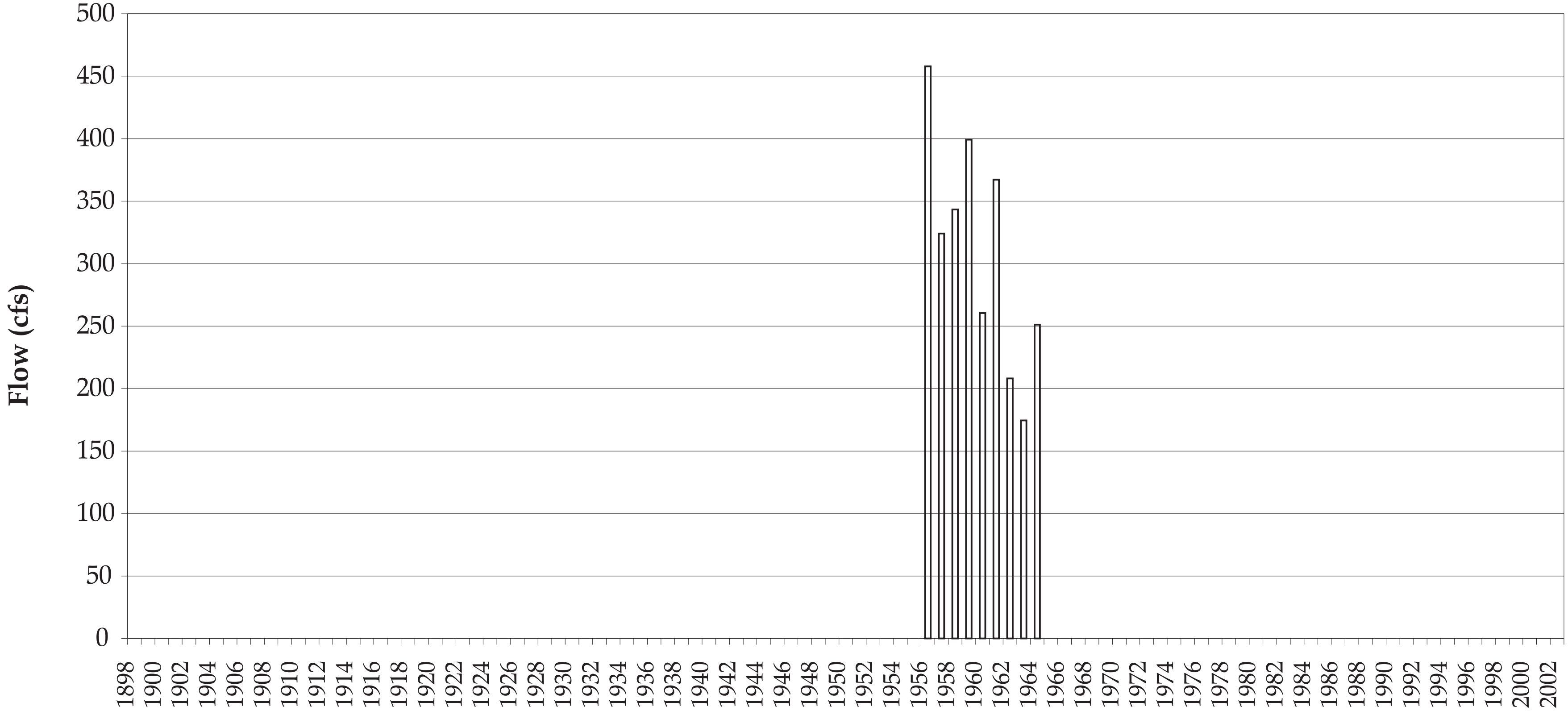


FIGURE **3-6c**

PALOUSE RIVER NEAR COLFAX (USGS STN. 13346000)
MEAN ANNUAL FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg15.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

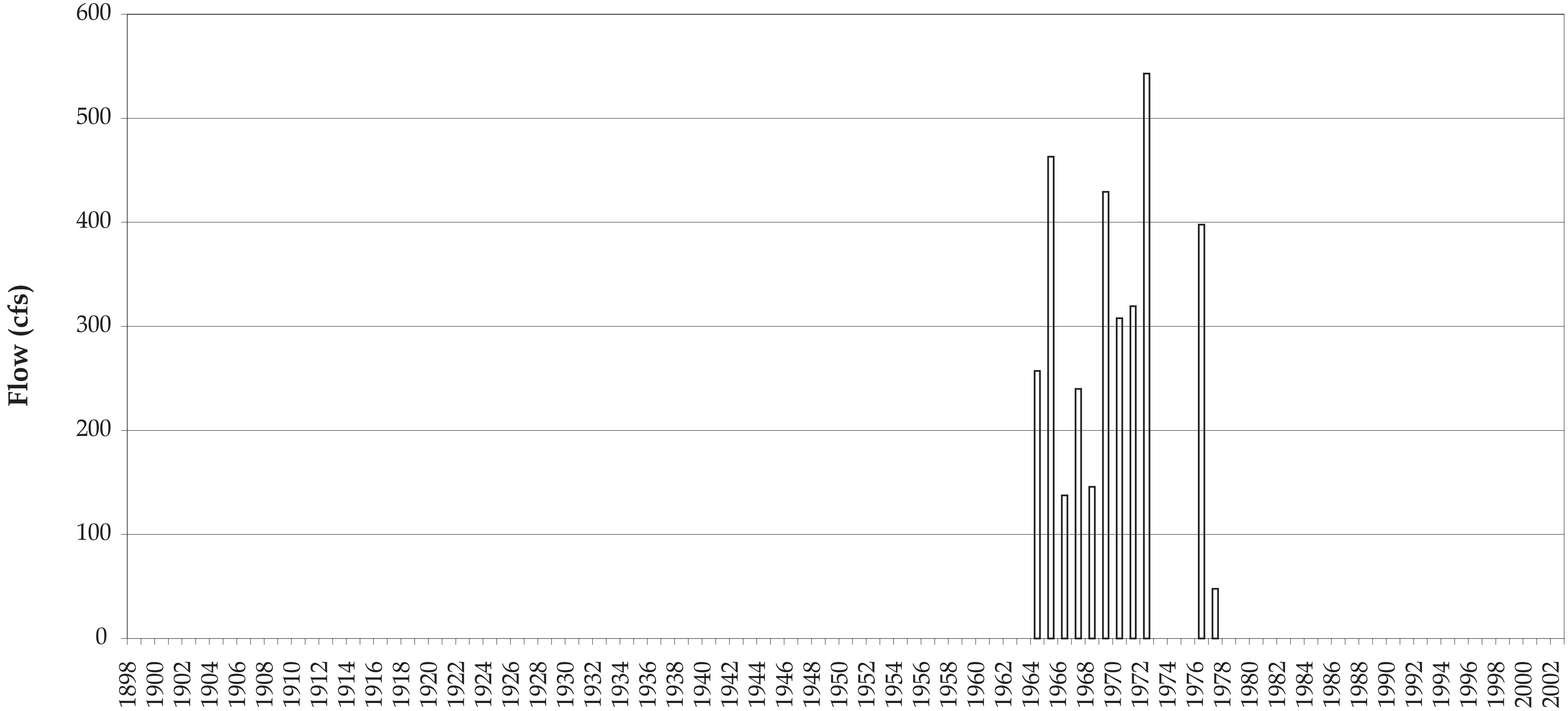


FIGURE **3-6d**
PALOUSE RIVER AT COLFAX (USGS STN. 13346100)
MEAN ANNUAL FLOW
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg16.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

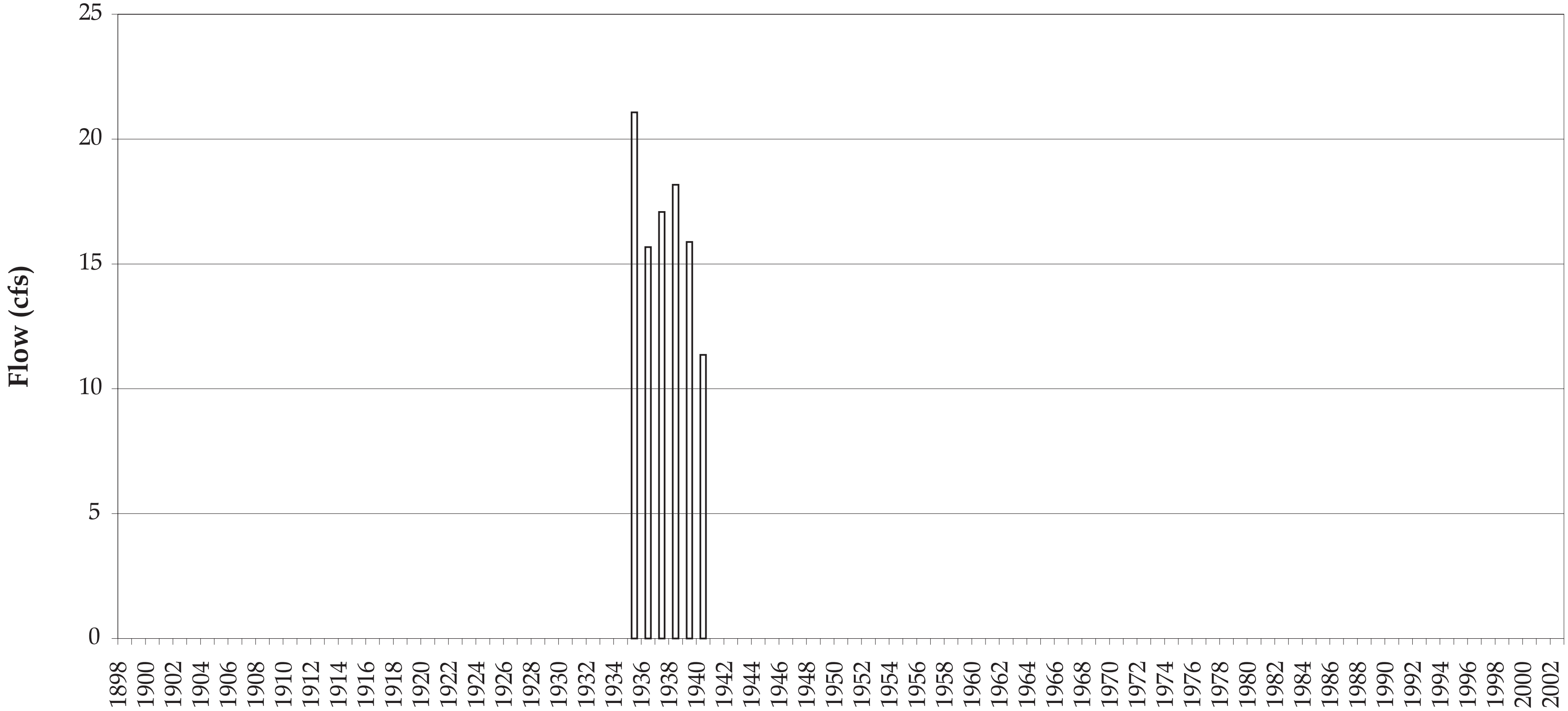


FIGURE **3-6e**

SOUTH FORK PALOUSE RIVER ABOVE PARADISE CREEK, NEAR PULLMAN (USGS STN. 13346500) MEAN ANNUAL FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg17.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

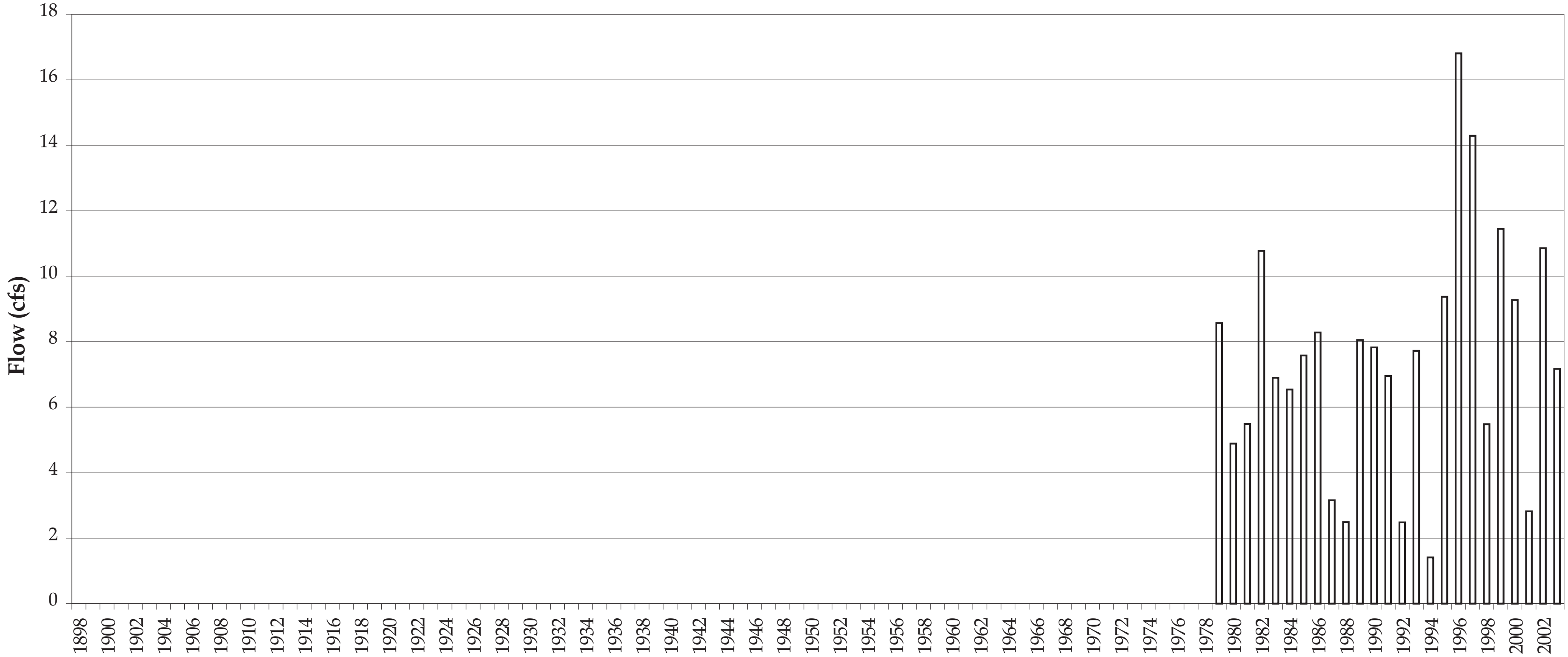


FIGURE **3-6f**

PARADISE CREEK AT UNIVERSITY OF IDAHO, MOSCOW, ID (USGS STN. 13346800)

MEAN ANNUAL FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg102.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

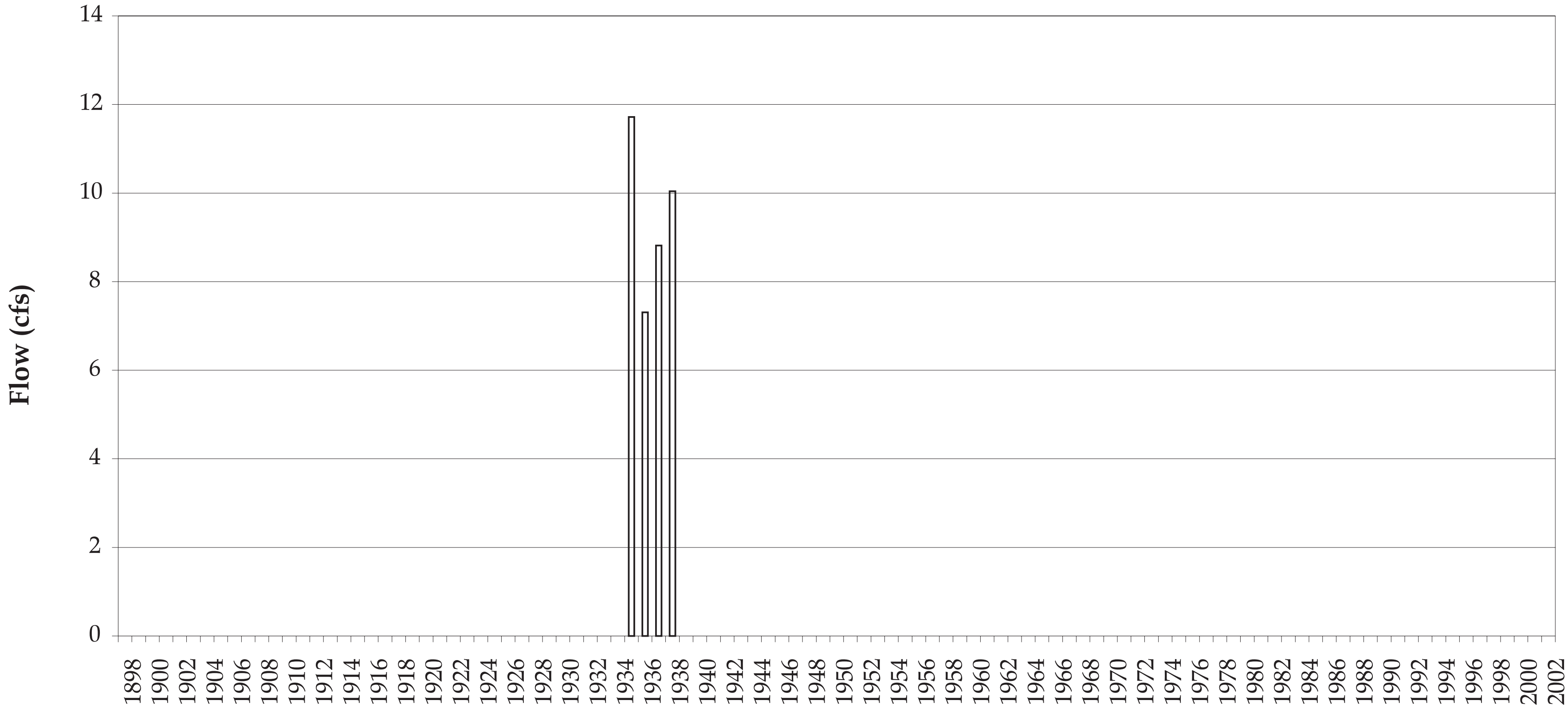


FIGURE **3-6g**

PARADISE CREEK NEAR PULLMAN (USGS STN. 13347000)

MEAN ANNUAL FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg18.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

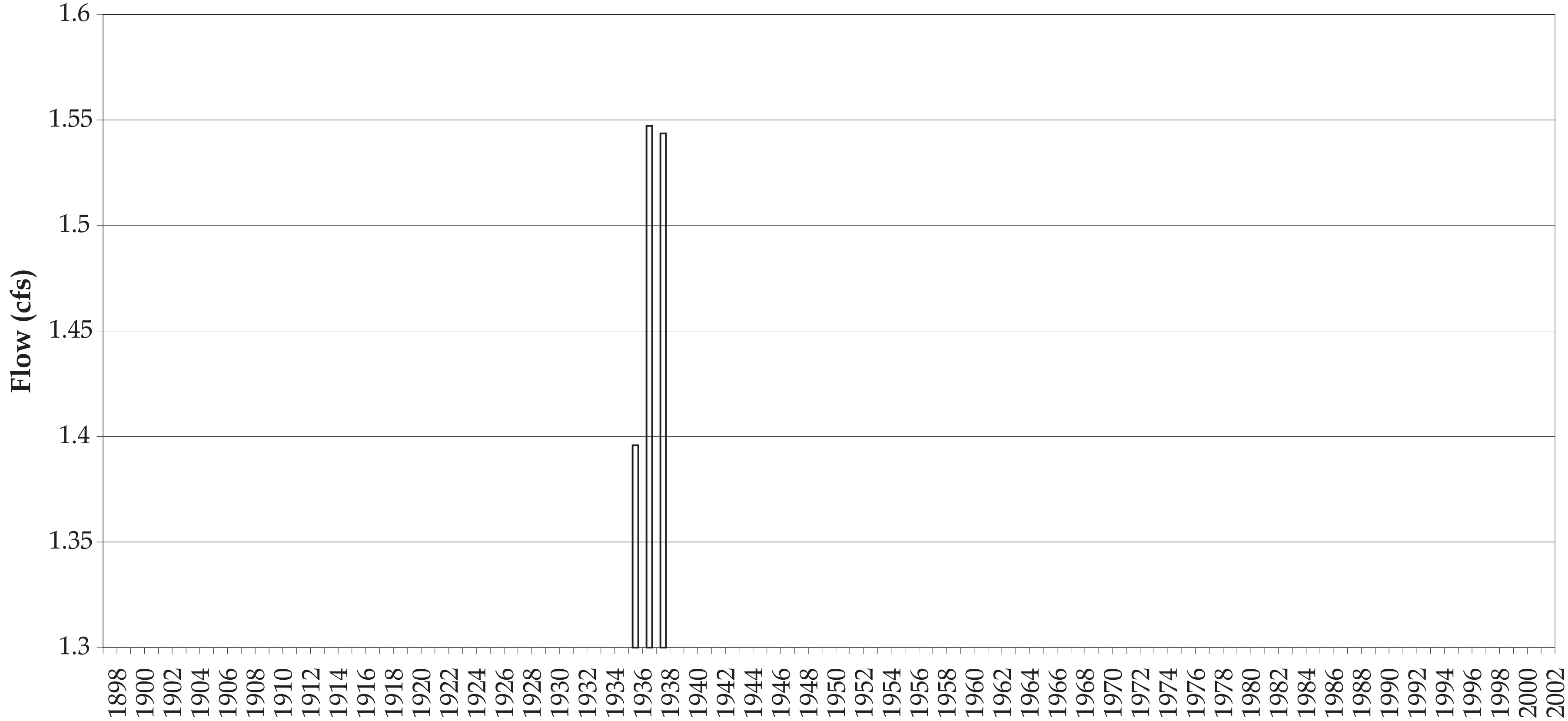


FIGURE **3-6h**

DRY FORK OF SOUTH FORK PALOUSE RIVER AT PULLMAN (USGS STN. 13347500)

MEAN ANNUAL FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg19.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

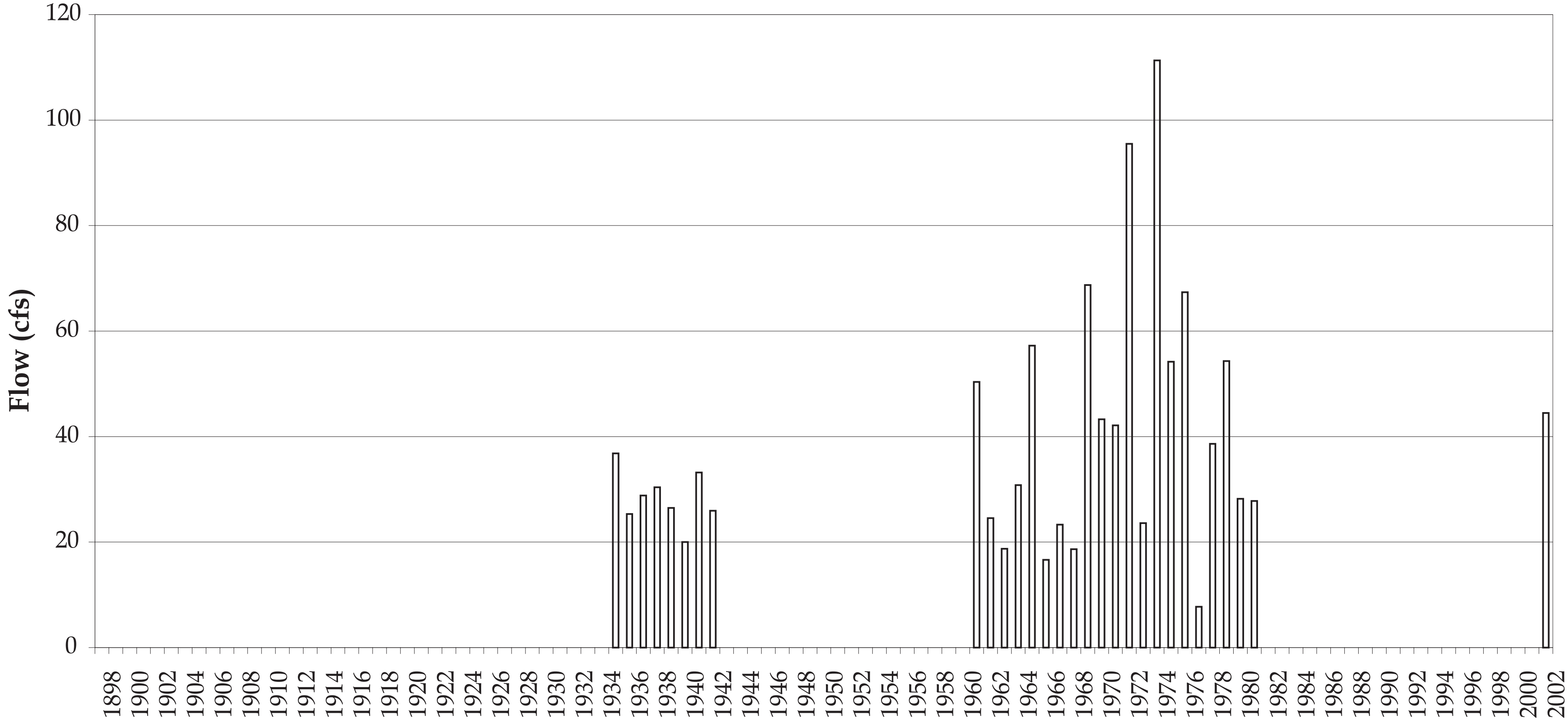


FIGURE **3-6i**

SOUTH FORK PALOUSE RIVER AT PULLMAN (USGS STN. 13348000)
MEAN ANNUAL FLOW
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg20.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

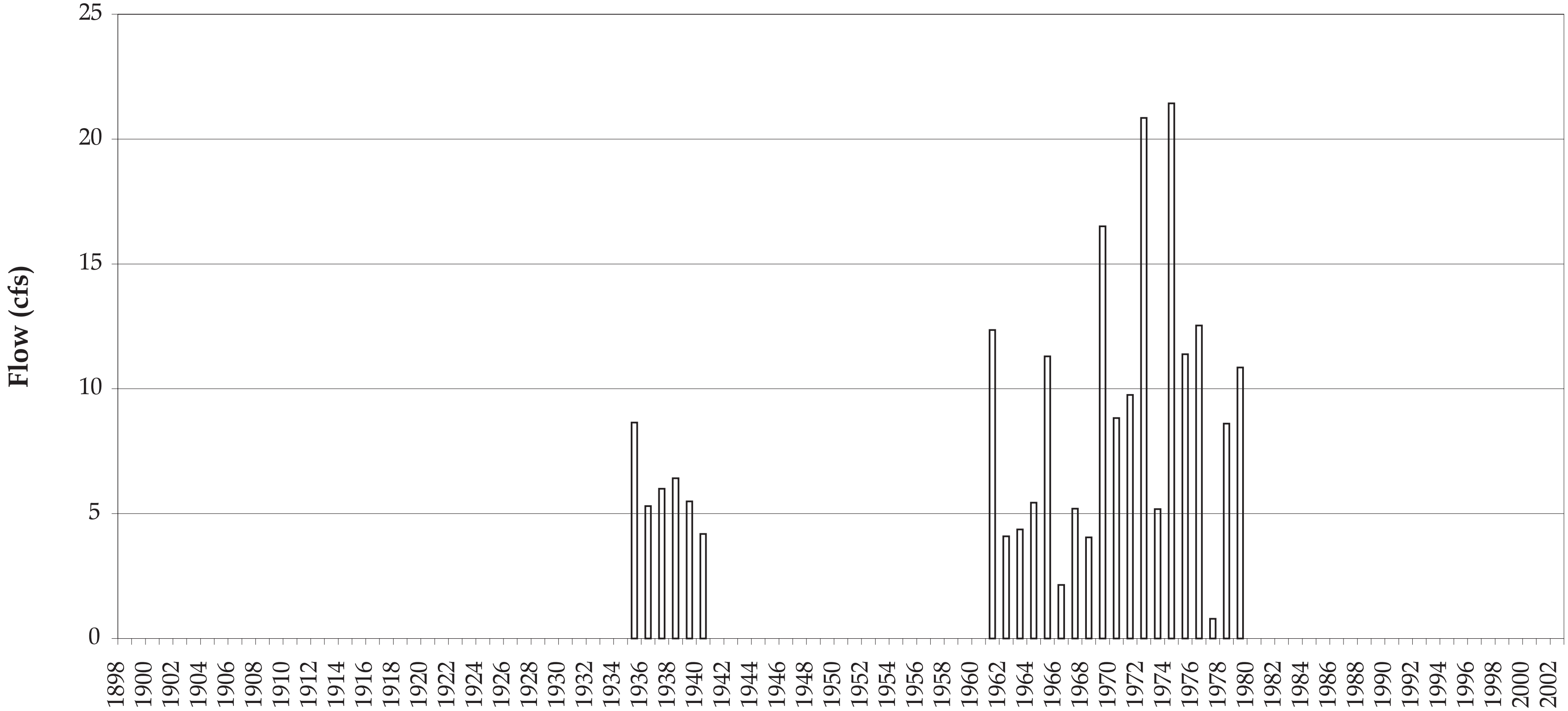


FIGURE **3-6j**

MISSOURI FLAT CREEK AT PULLMAN (USGS STN. 13348500)

MEAN ANNUAL FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg21.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

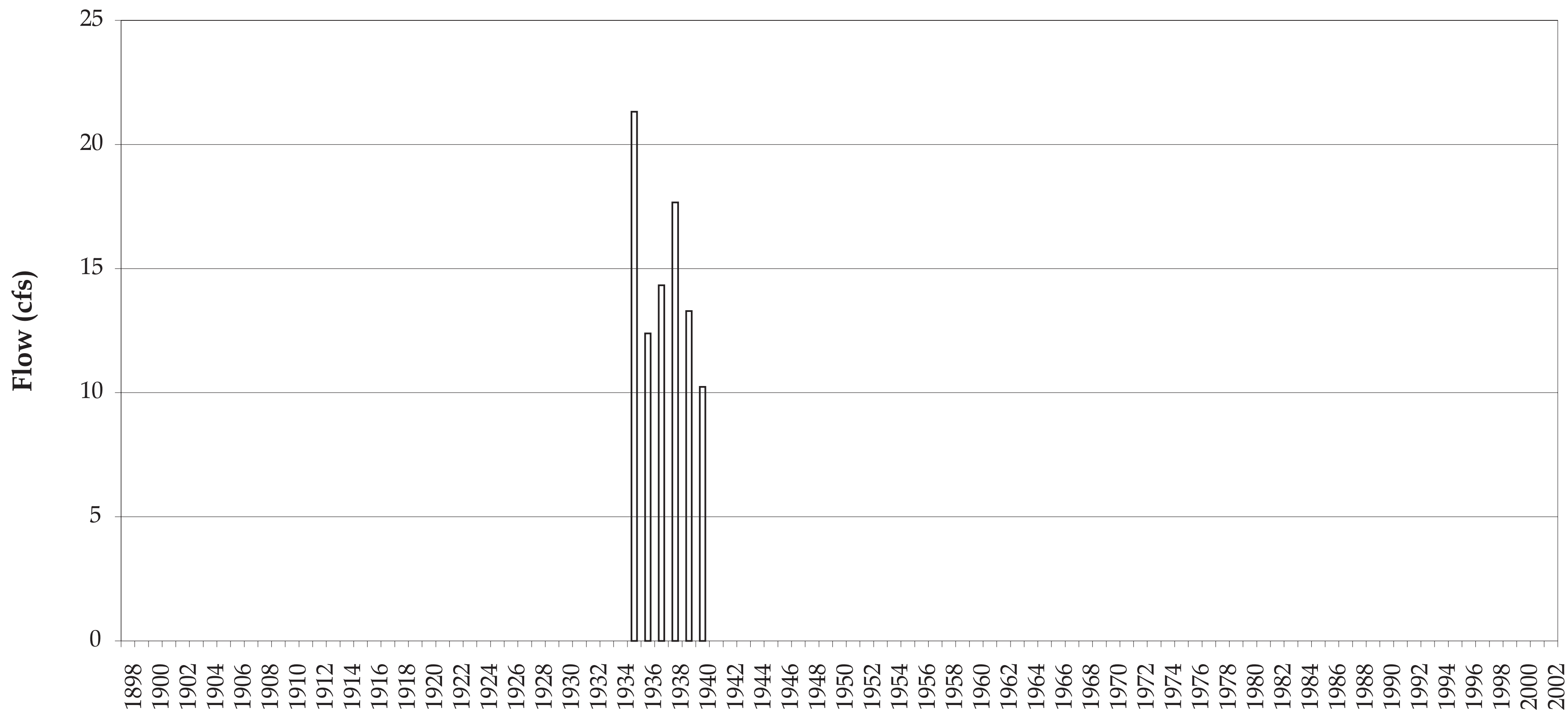


FIGURE **3-6k**

FOURMILE CREEK AT SHAWNEE (USGS STN. 13349000)

MEAN ANNUAL FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg22.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

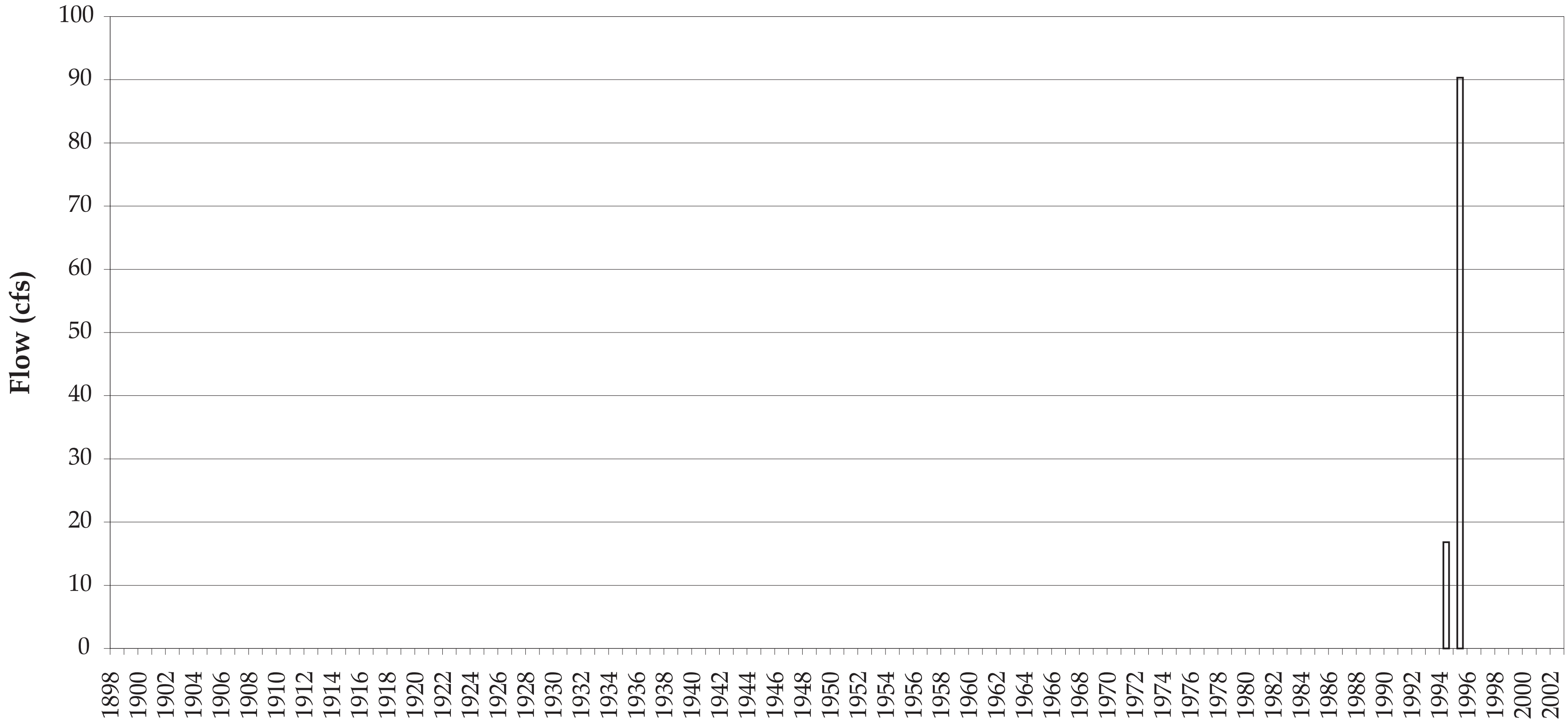


FIGURE **3-6I**

SOUTH FORK PALOUSE RIVER AT COLFAX (USGS STN. 13349200)

MEAN ANNUAL FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

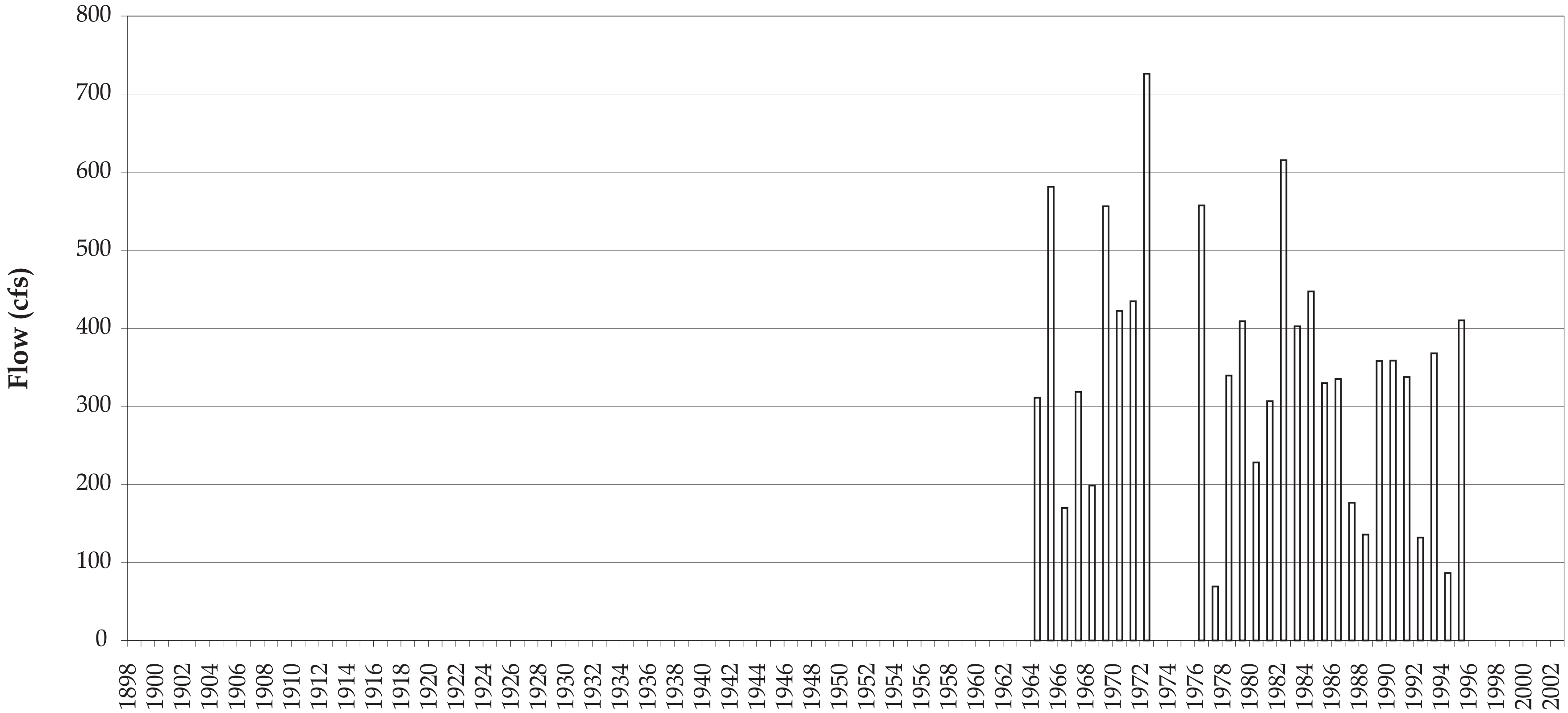


FIGURE **3-6m**

PALOUSE RIVER BELOW SOUTH FORK AT COLFAX (USGS STN. 13349210)
MEAN ANNUAL FLOW
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg24.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

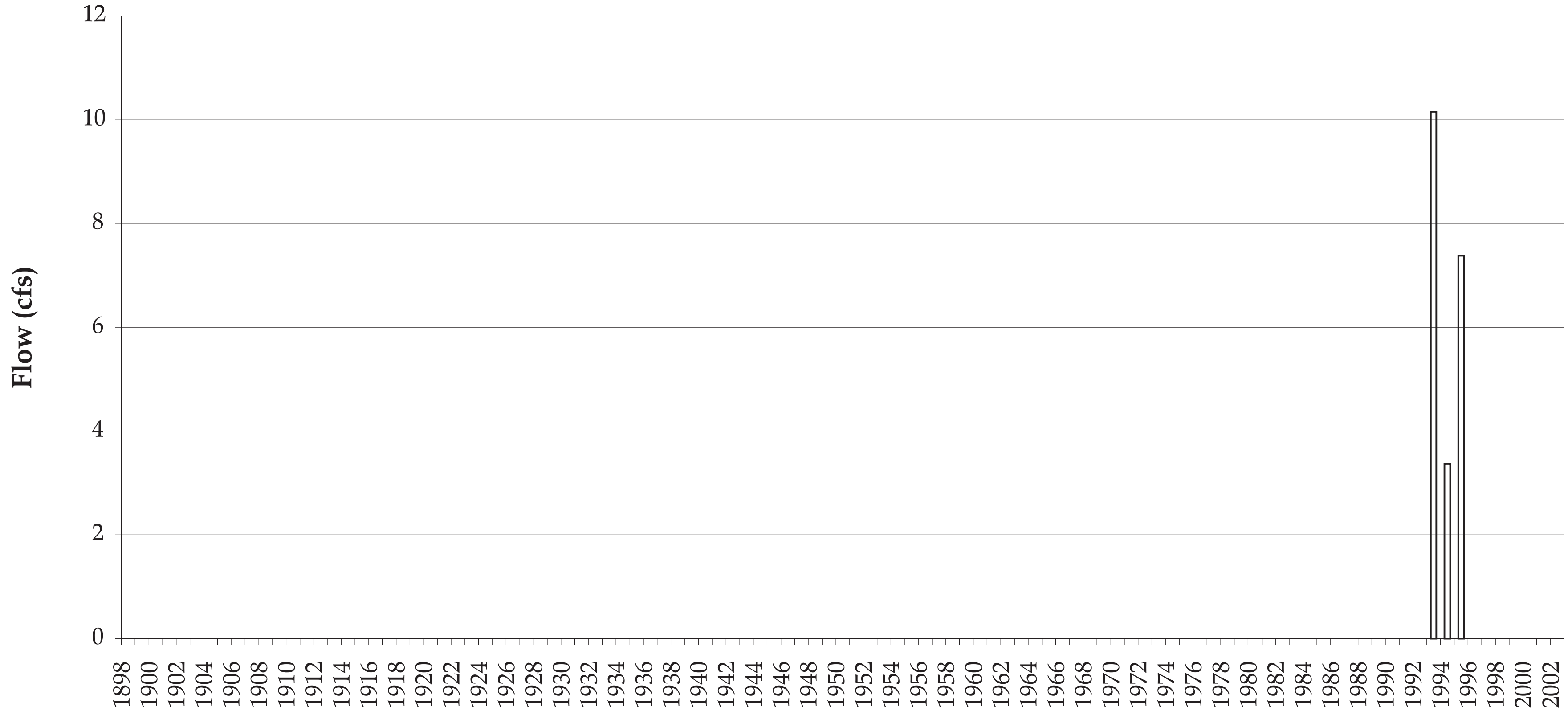


FIGURE **3-6n**

REBEL FLAT CREEK AT WINONA (USGS STN. 13349320)

MEAN ANNUAL FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg25.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

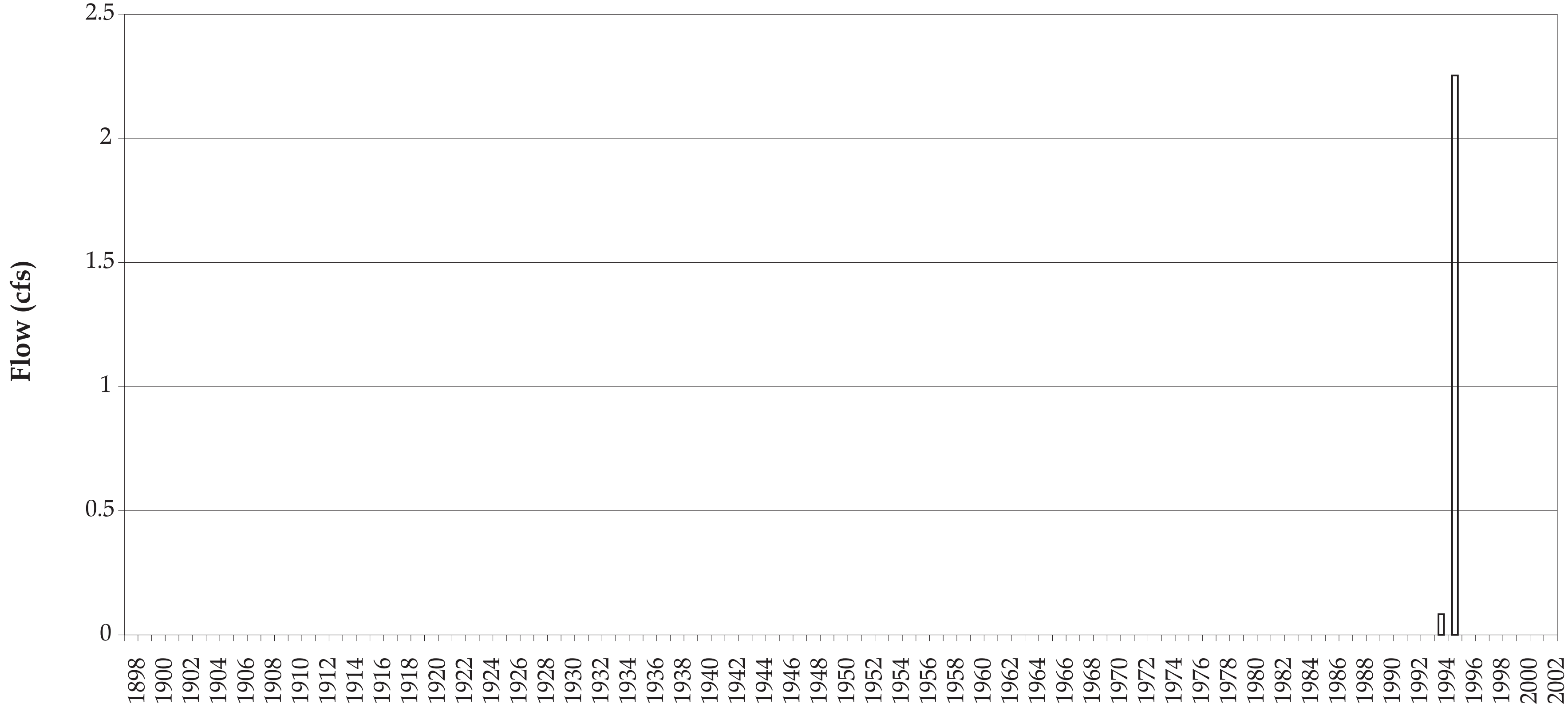


FIGURE **3-6o**

PHILLEO DITCH NEAR CHENEY (USGS STN. 13349325)

MEAN ANNUAL FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg26.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

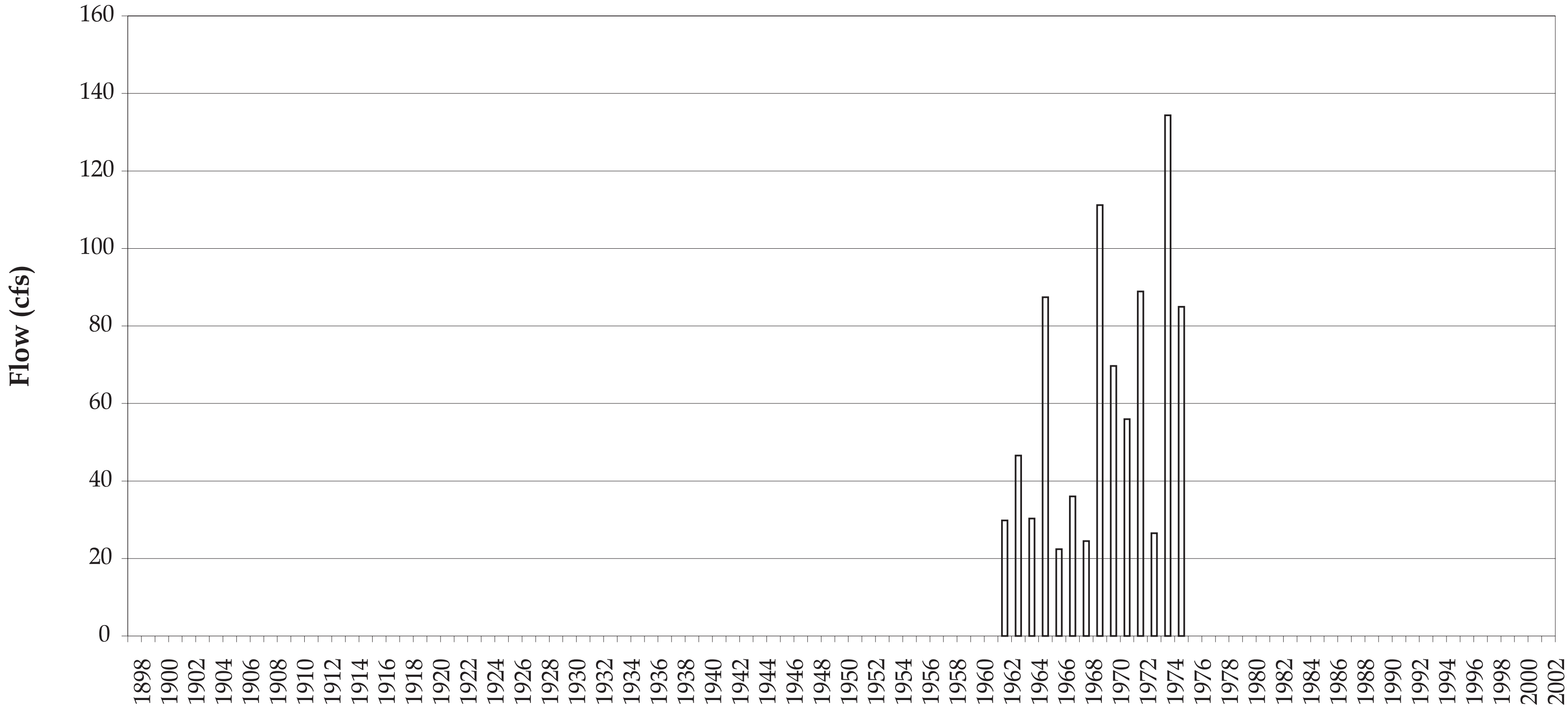


FIGURE **3-6p**

PINE CREEK AT PINE CITY (USGS STN. 13349400)

MEAN ANNUAL FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg27.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

FIGURE **3-6q**

PINE CREEK AT PINE CITY ROAD AT PINE CITY (USGS STN. 13349410)

MEAN ANNUAL FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg28.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

FIGURE **3-6r**

ROCK CREEK AT EWAN (USGS STN. 13349500)

MEAN ANNUAL FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg29.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

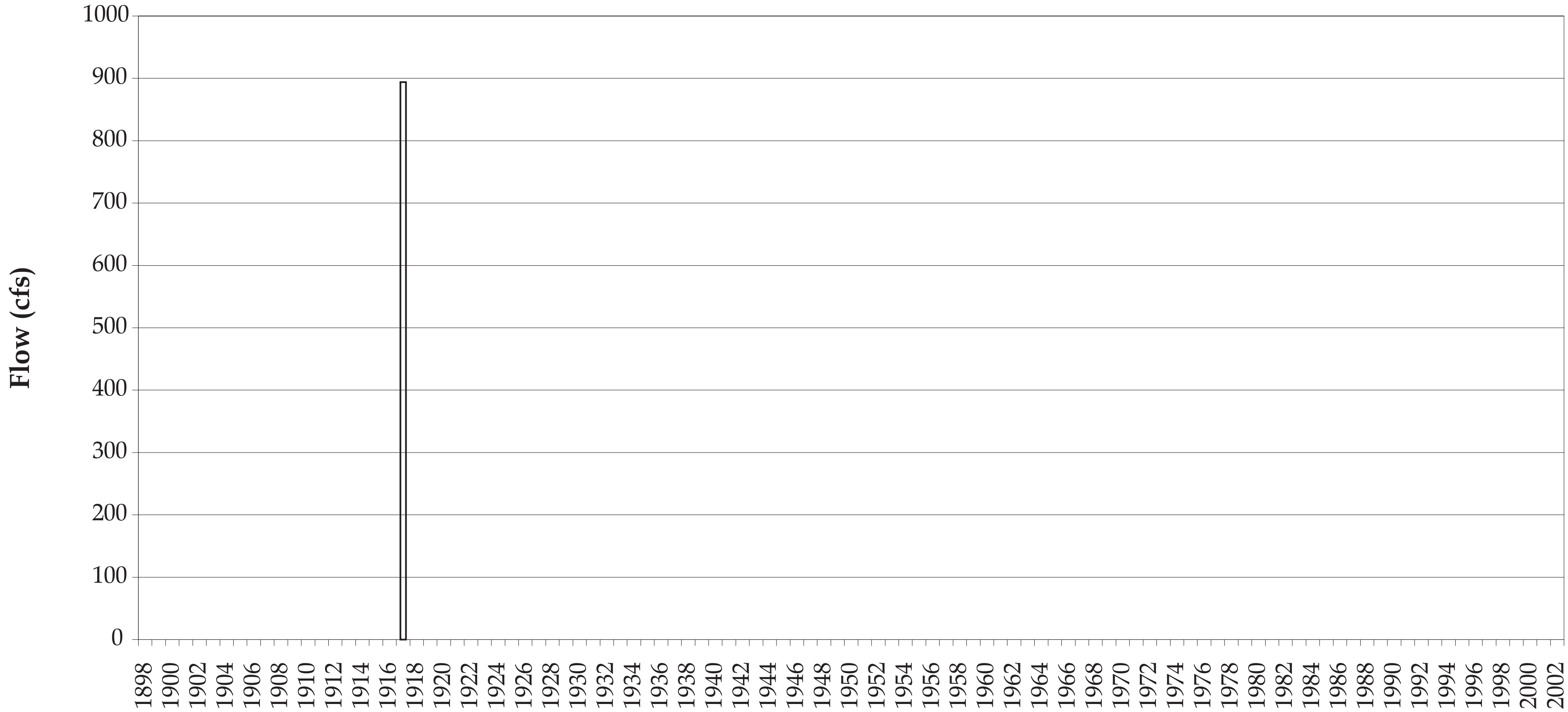


FIGURE **3-6s**

PALOUSE RIVER NEAR WINONA (USGS STN. 13350000)

MEAN ANNUAL FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg30.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

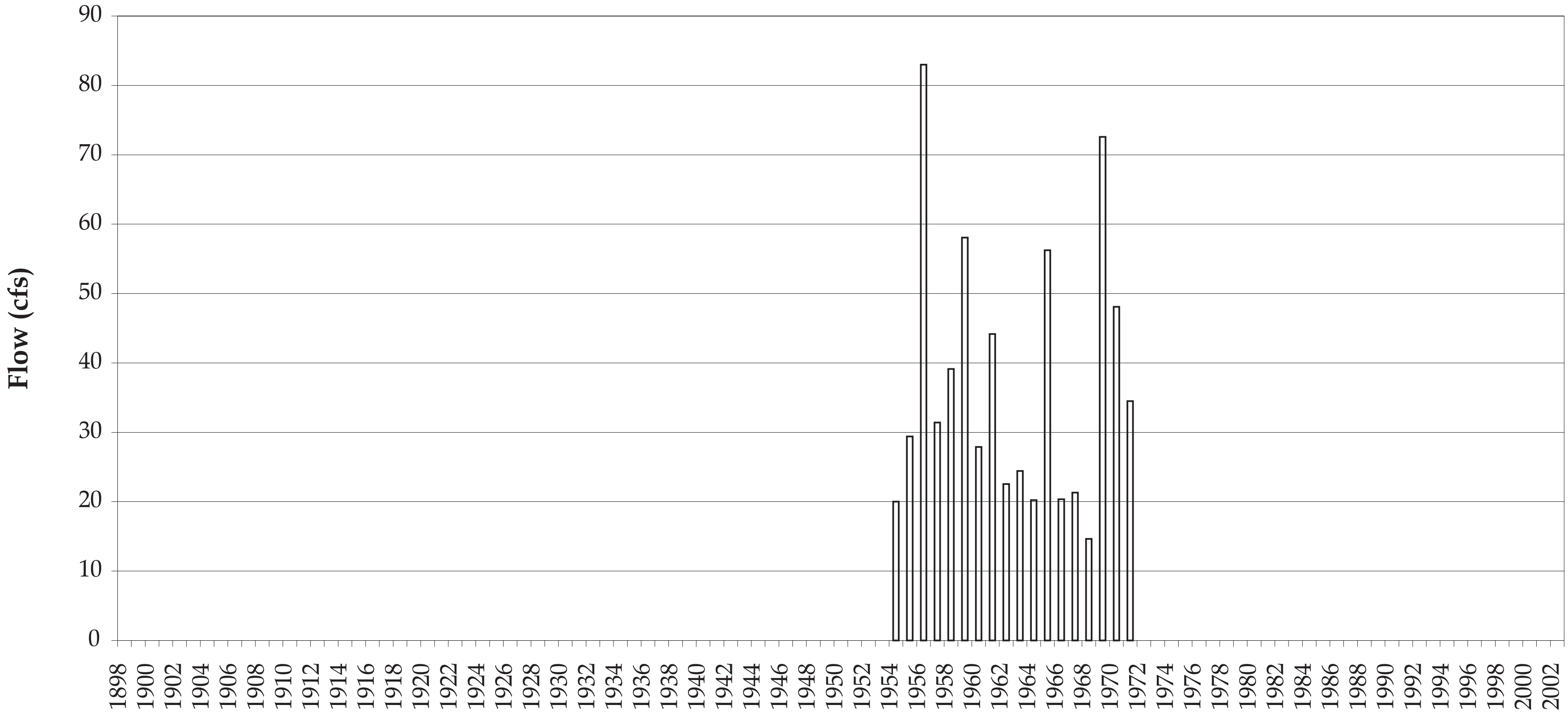


FIGURE **3-6t**

UNION FLAT CREEK NEAR COLFAX (USGS STN. 13350500)
MEAN ANNUAL FLOW
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg31.fh11 DATE 11/05/04 DRAWN BY EL

Golder Associates

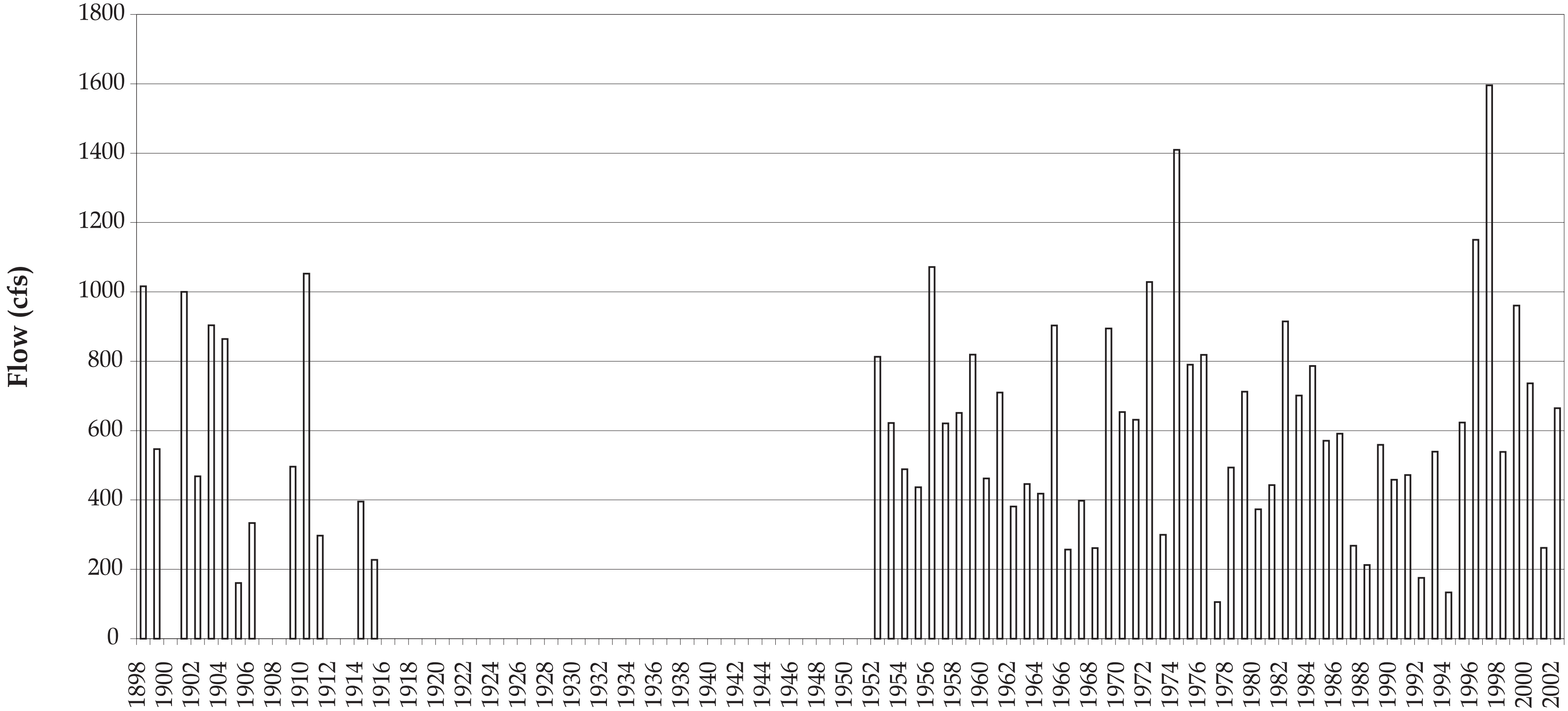


FIGURE **3-6u**

PALOUSE RIVER AT HOOPER (USGS STN. 13351000)
MEAN ANNUAL FLOW
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg32.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

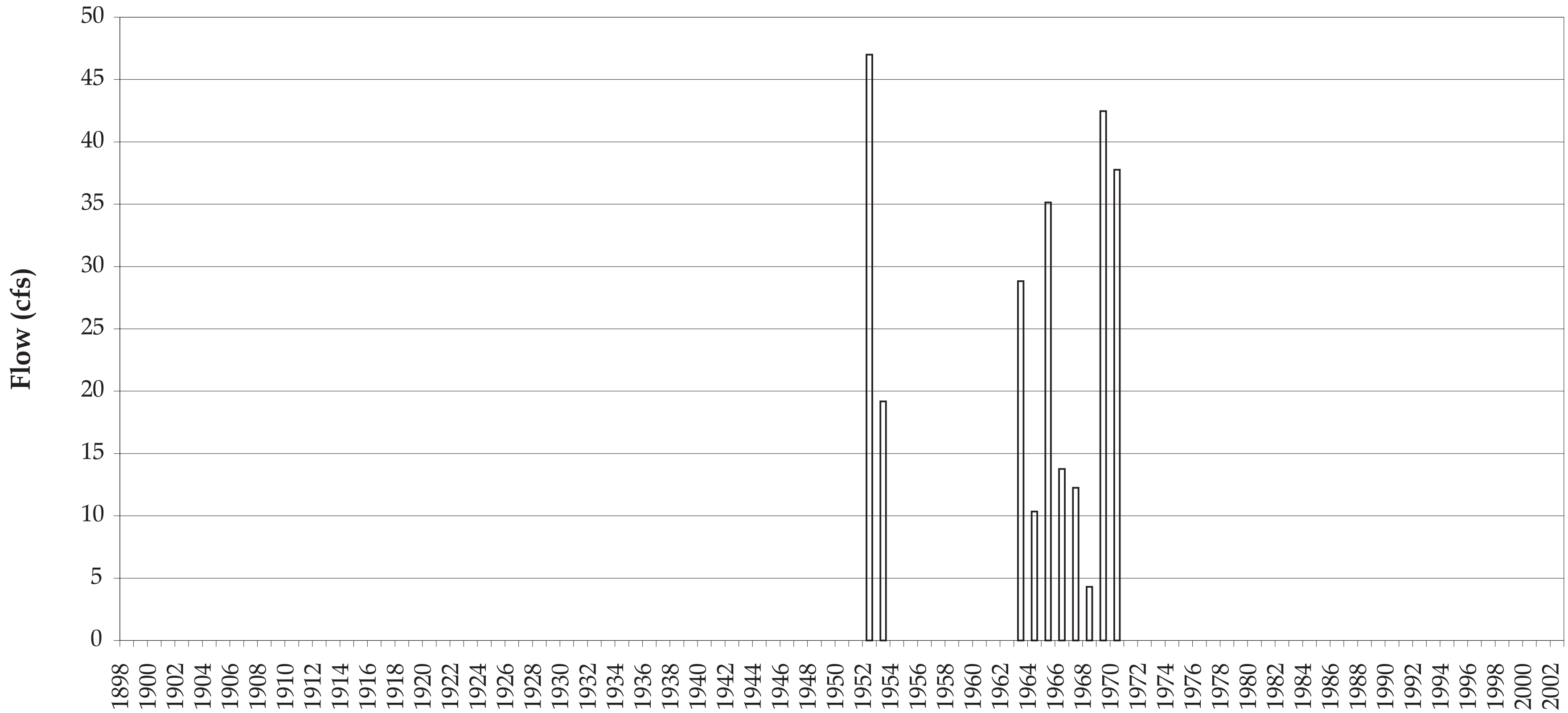


FIGURE **3-6v**

COW CREEK AT HOOPER (USGS STN. 13352500)
MEAN ANNUAL FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg33.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

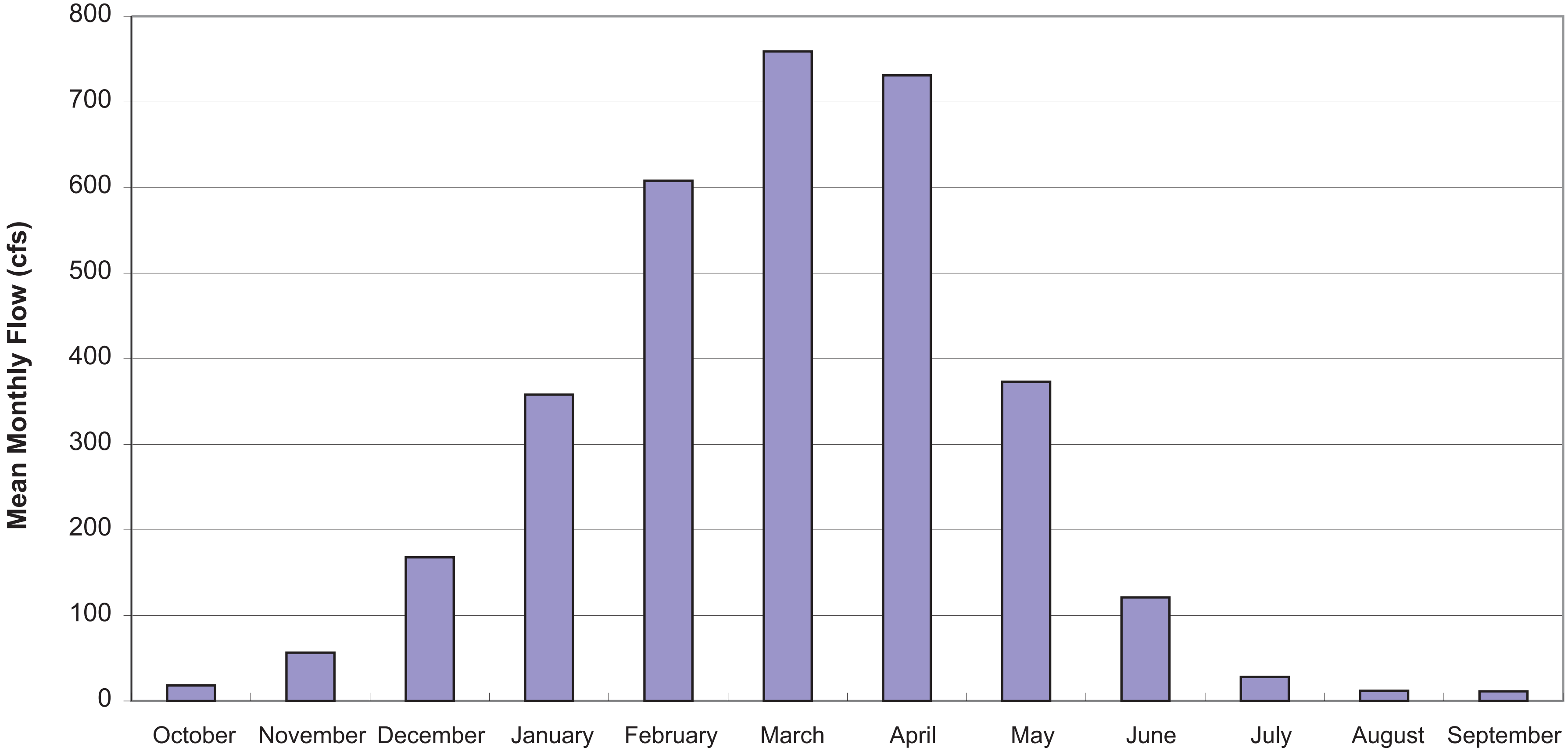


FIGURE **3-7a**

PALOUSE RIVER NEAR POTLATCH (USGS STN.13345000)

MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

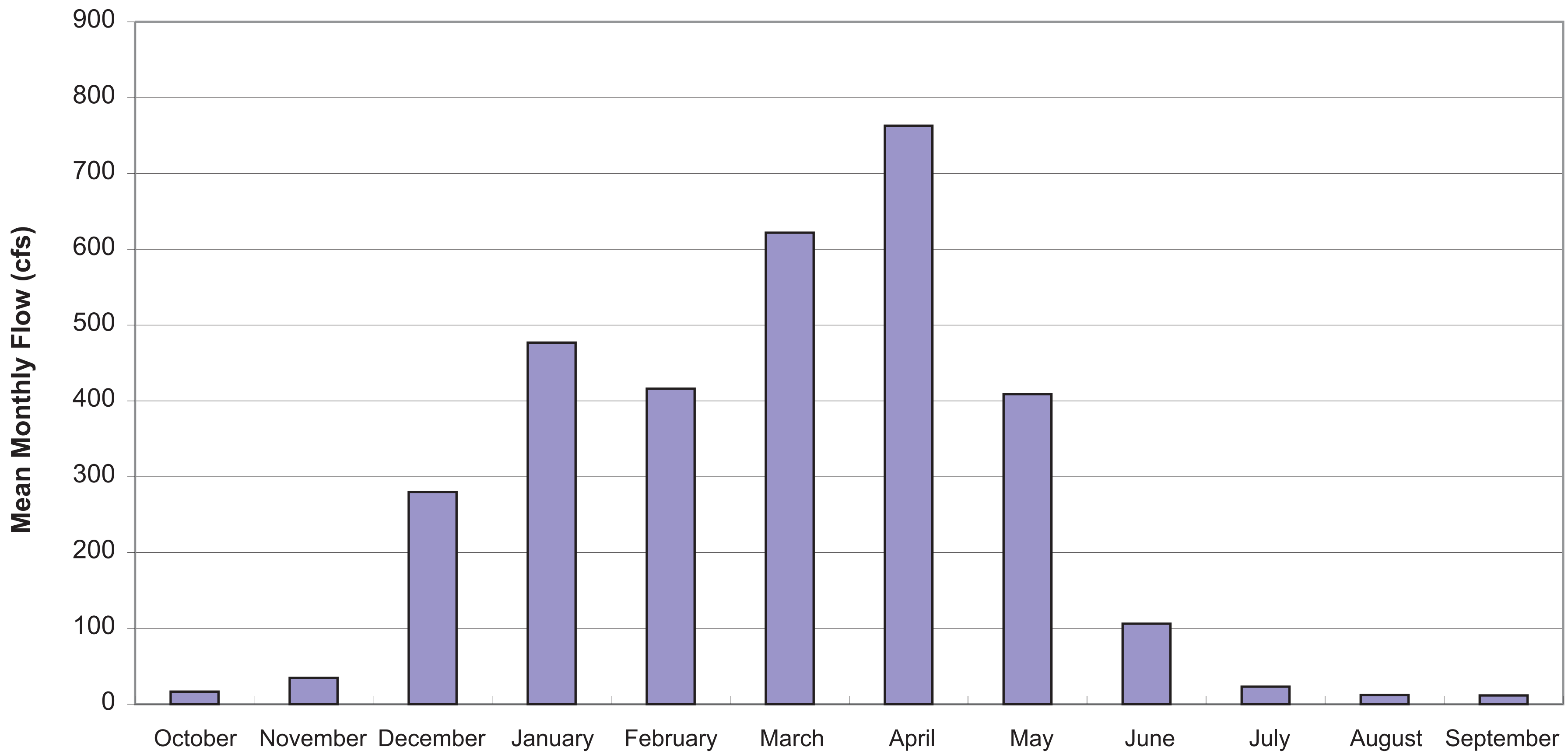


FIGURE **3-7b**

PALOUSE RIVER AT PALOUSE (USGS STN. 13345300)
MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg35.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

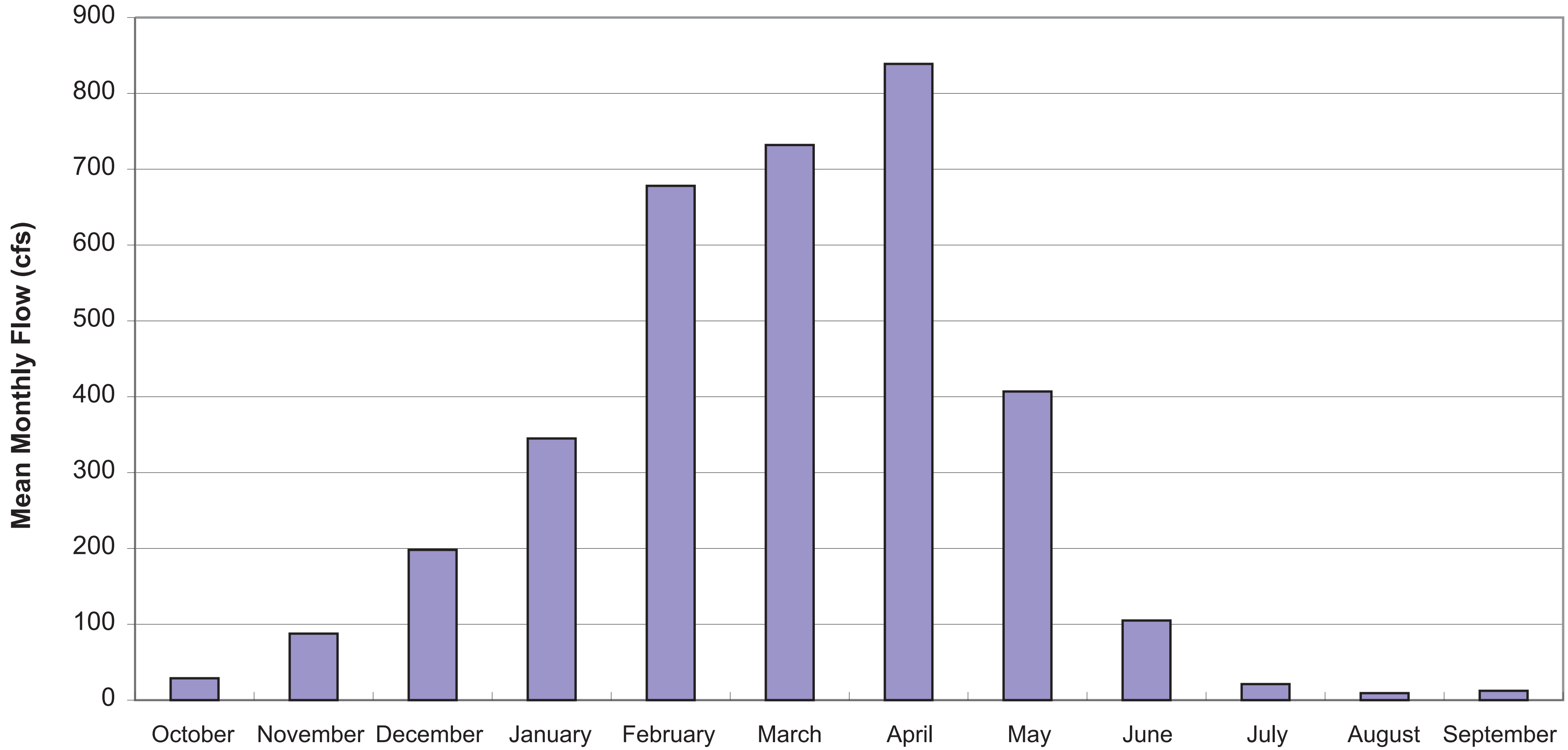


FIGURE **3-7c**

PALOUSE RIVER NEAR COLFAX (USGS STN. 13346000)

MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg36.fh11 DATE 12/03/04 DRAWN BY EL

Golder Associates

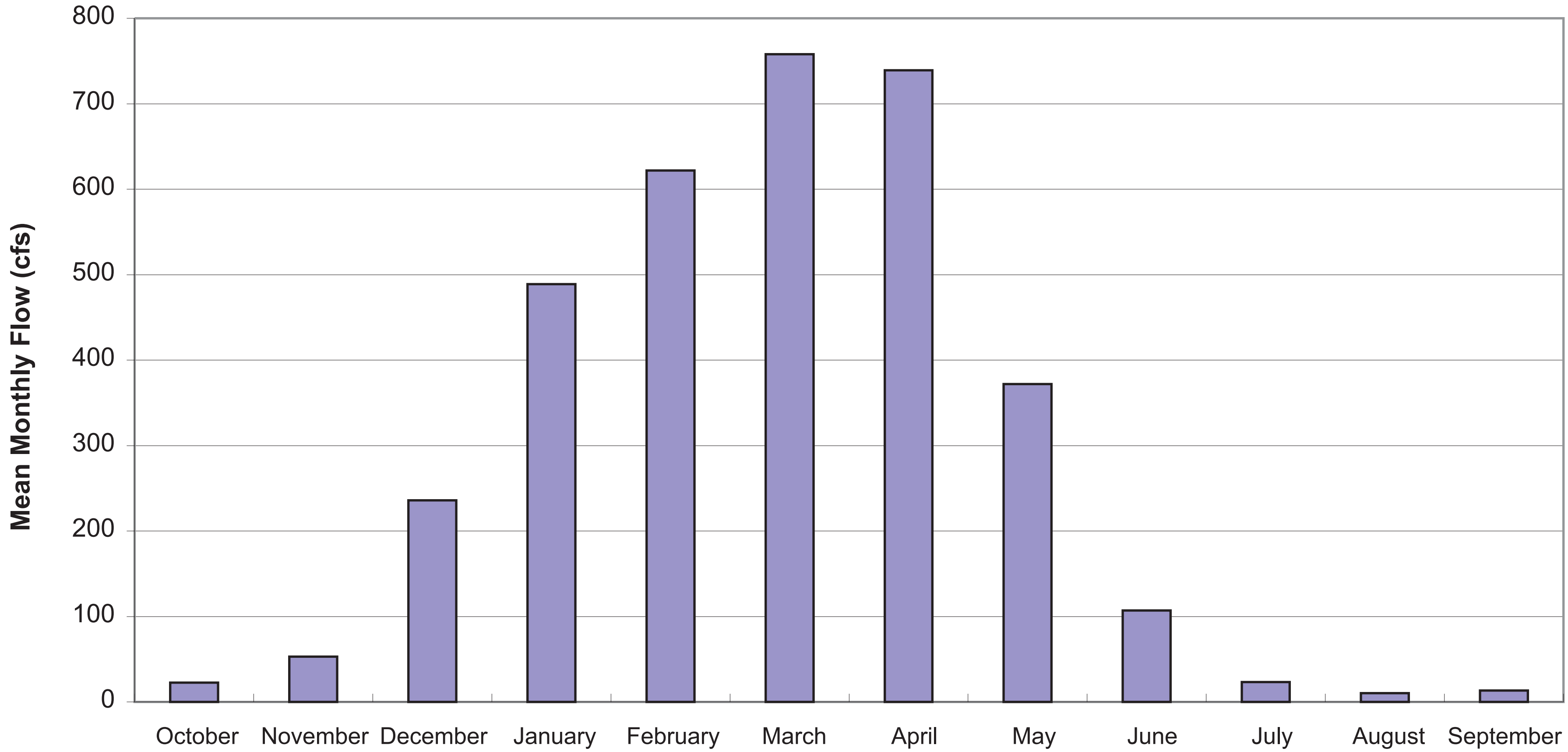


FIGURE **3-7d**

PALOUSE RIVER AT COLFAX (USGS STN. 13346100)
MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg37.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

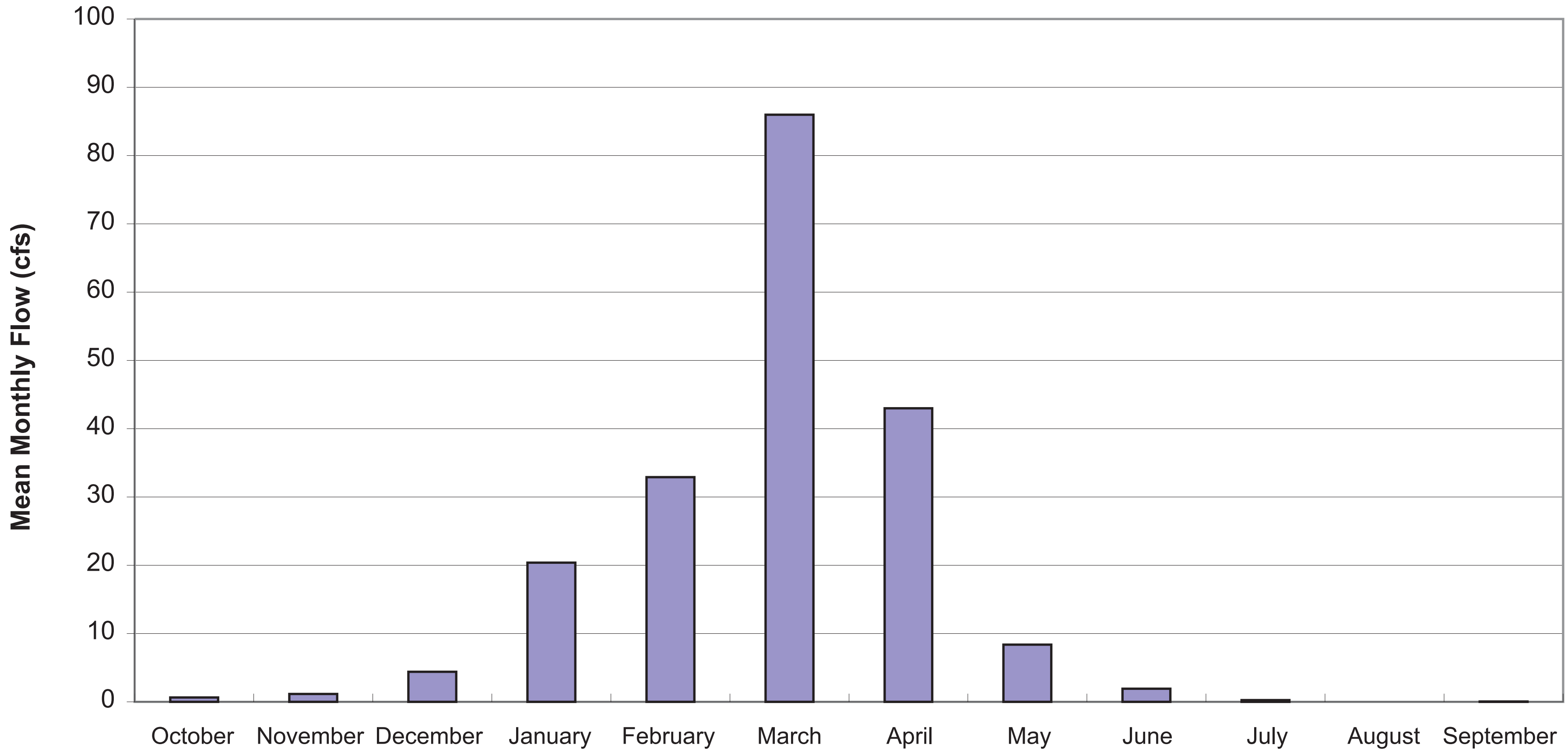


FIGURE **3-7e**

SOUTH FORK PALOUSE ABOVE PARADISE CREEK, NEAR PULLMAN (USGS STN. 13346500) MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg38.fh11 DATE 12/03/04 DRAWN BY EL

Golder Associates

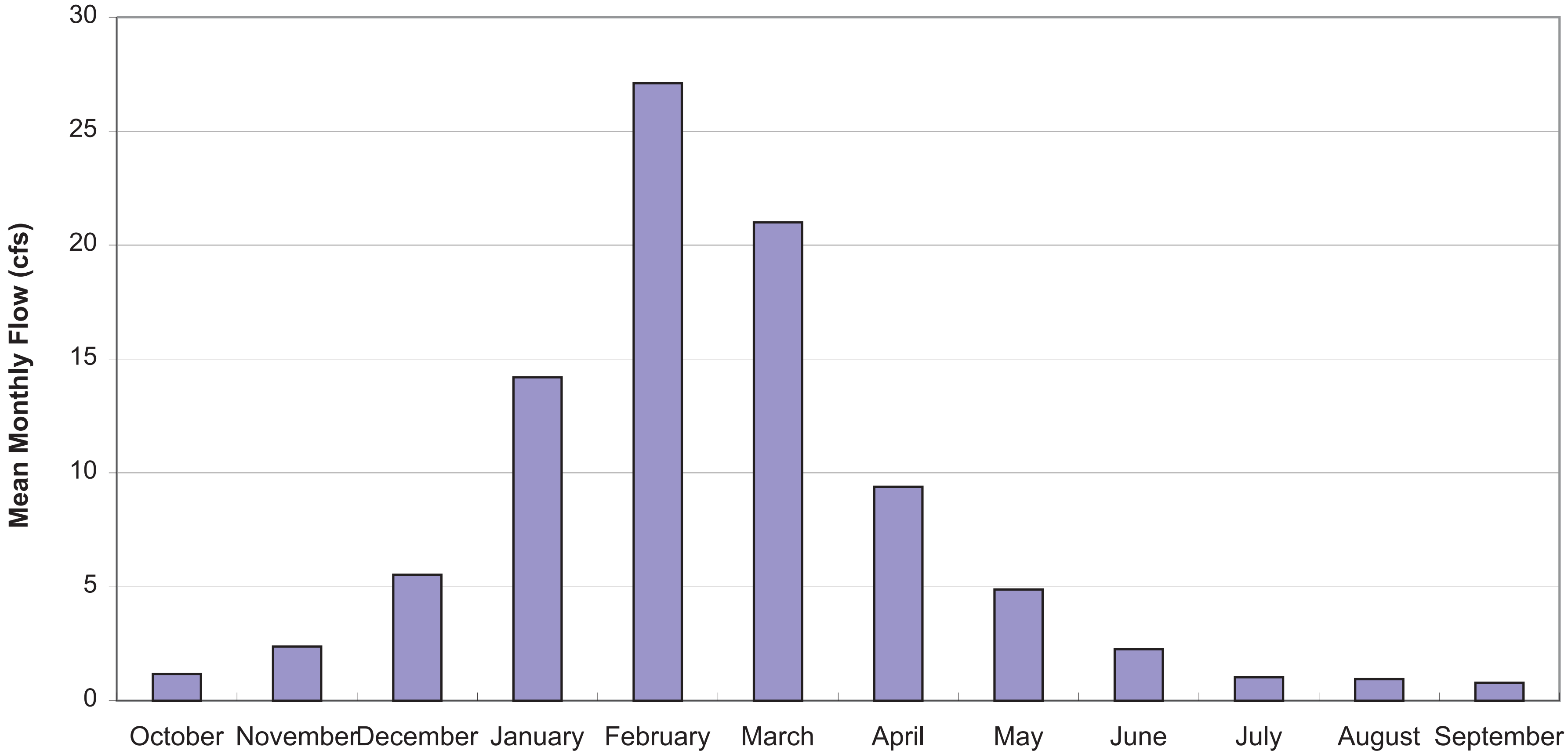


FIGURE **3-7f**

PARADISE CREEK AT UNIVERSITY OF IDAHO, MOSCOW, ID (USGS STN. 13346800) MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg103.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

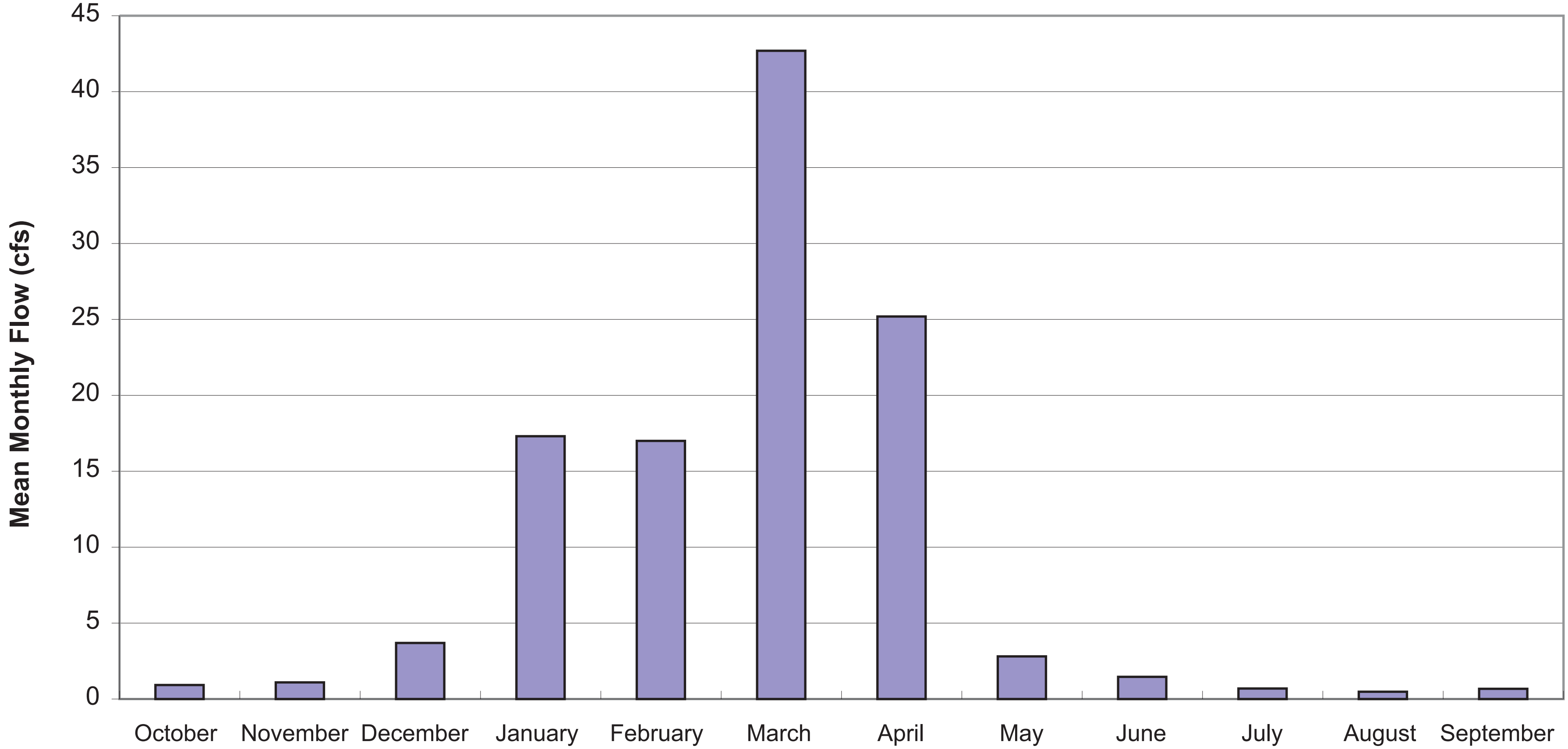


FIGURE 3-7g
PARADISE CREEK NEAR PULLMAN (USGS STN. 13347000)
MEAN MONTHLY FLOW
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg39.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

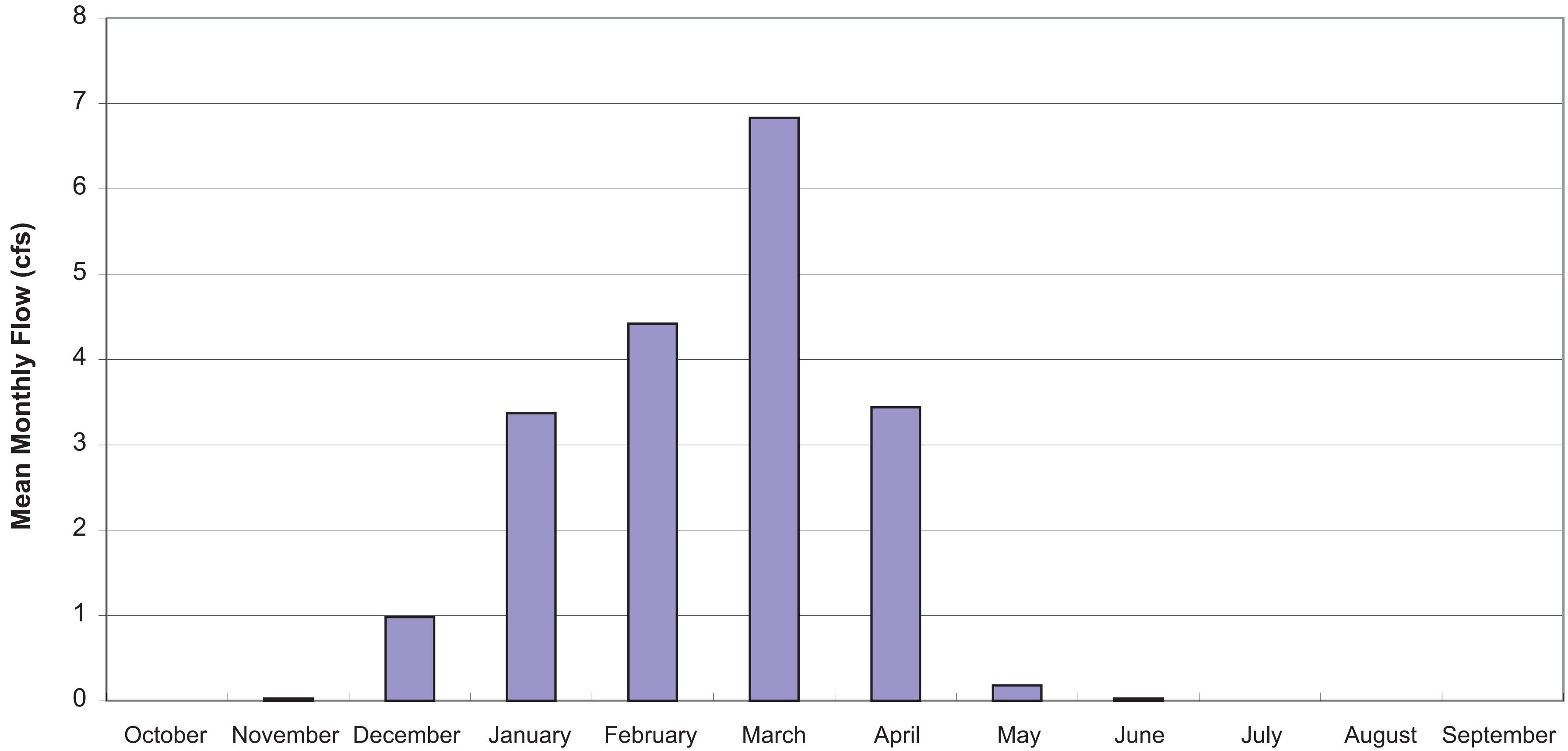


FIGURE **3-7h**

DRY FORK OF SOUTH FORK PALOUSE AT PULLMAN (USGS STN. 13347500)

MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg40.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

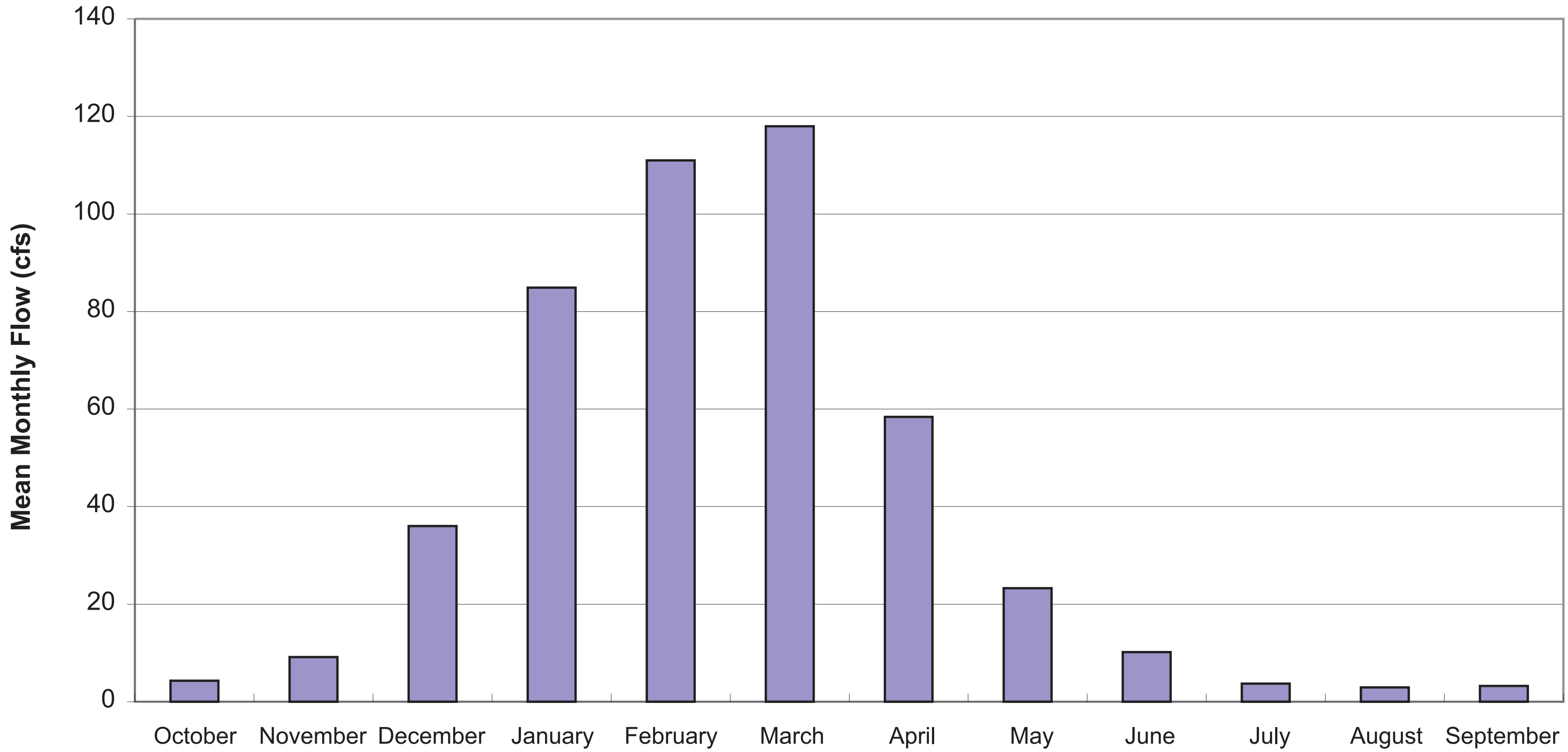


FIGURE **3-7i**

SOUTH FORK PALOUSE RIVER AT PULLMAN (USGS STN. 13348000)

MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg41.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

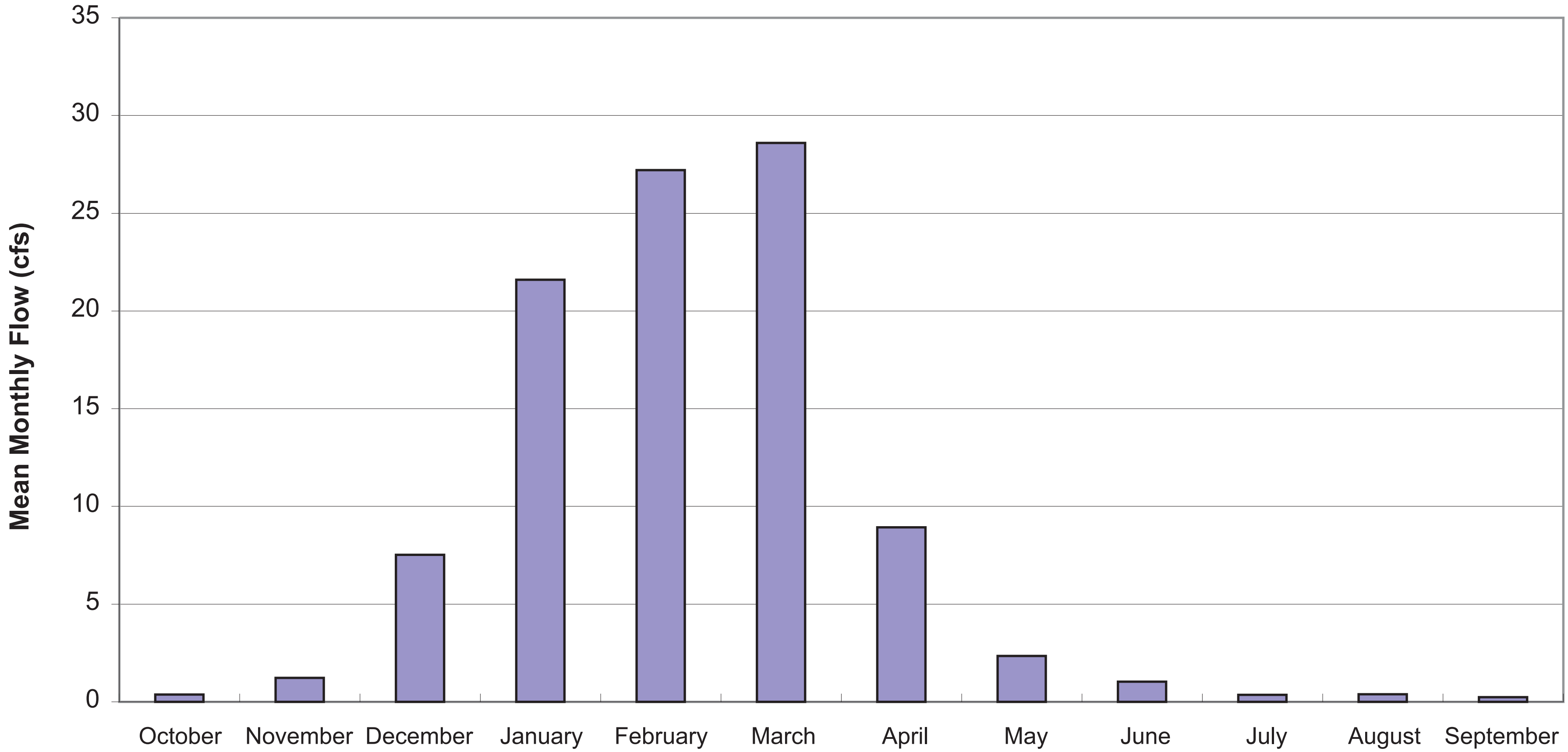


FIGURE **3-7j**

MISSOURI FLAT CREEK AT PULLMAN (USGS STN. 13348500)

MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg42.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

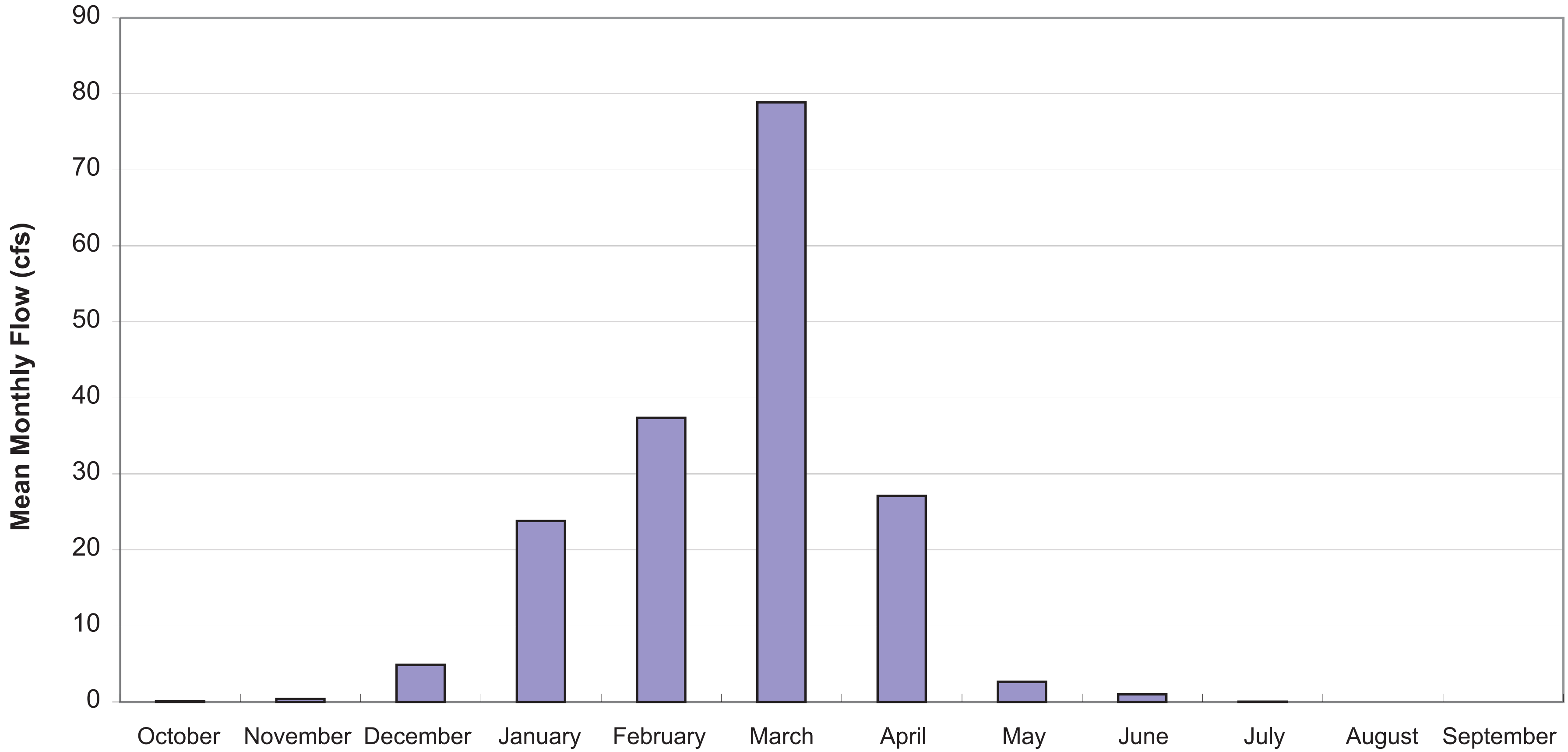


FIGURE **3-7k**

FOURMILE CREEK AT SHAWNEE (USGS STN. 13349000)

MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg43.fh11 DATE 12/03/04 DRAWN BY EL

Golder Associates

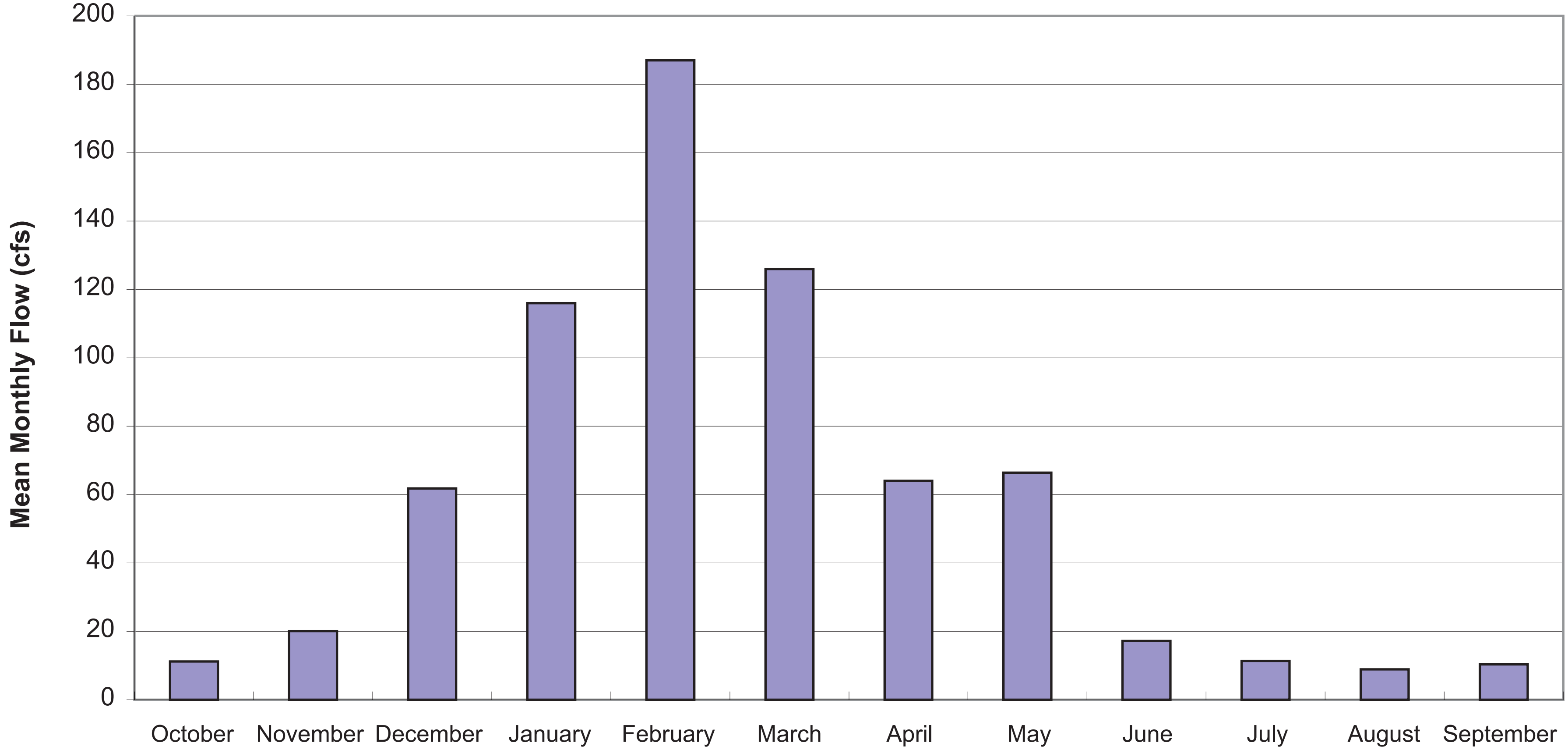


FIGURE **3-7I**

SOUTH FORK PALOUSE RIVER AT COLFAX (USGS STN. 13349200)

MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg44.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

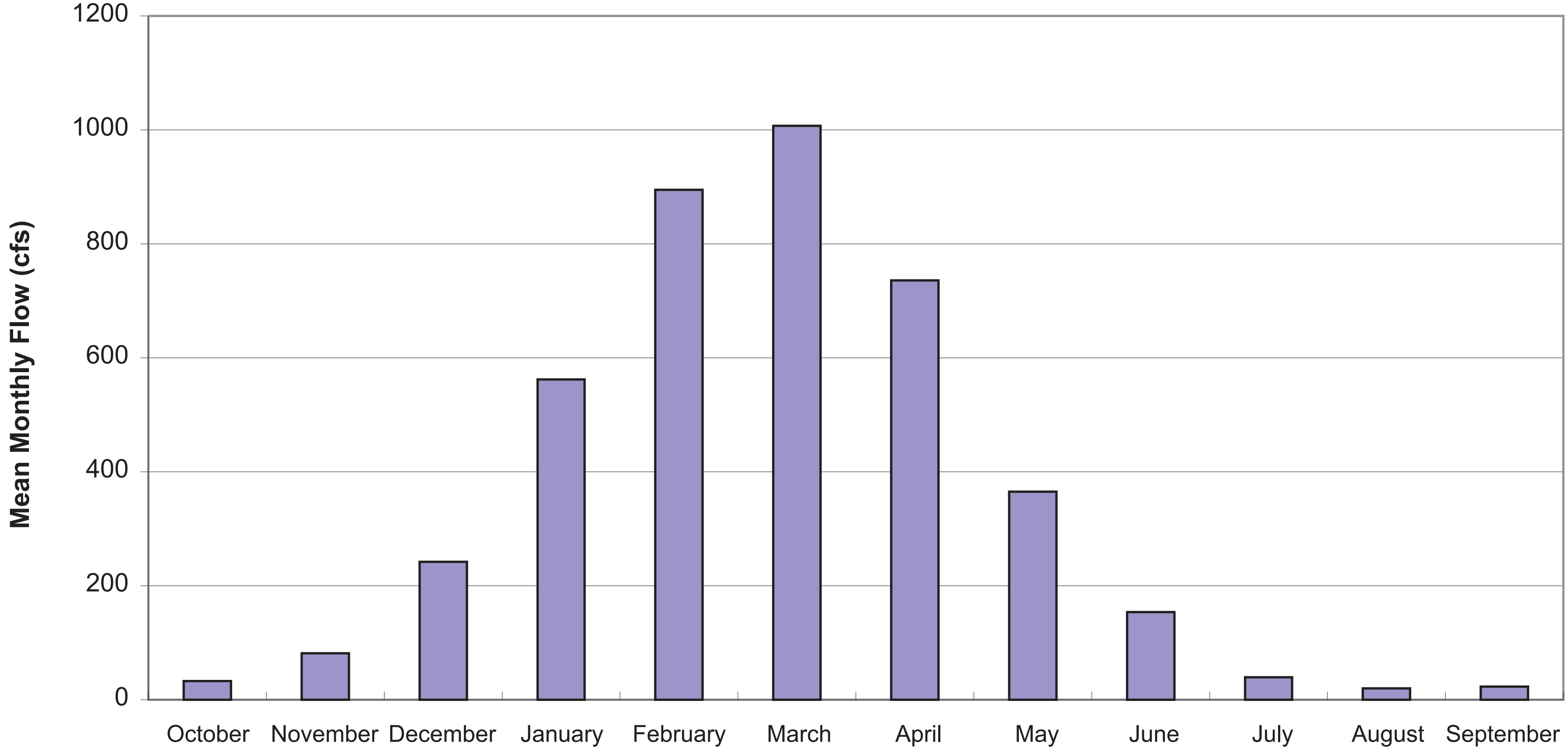


FIGURE **3-7m**

PALOUSE RIVER BELOW SOUTH FORK AT COLFAX (USGS STN. 13349210)

MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg45.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

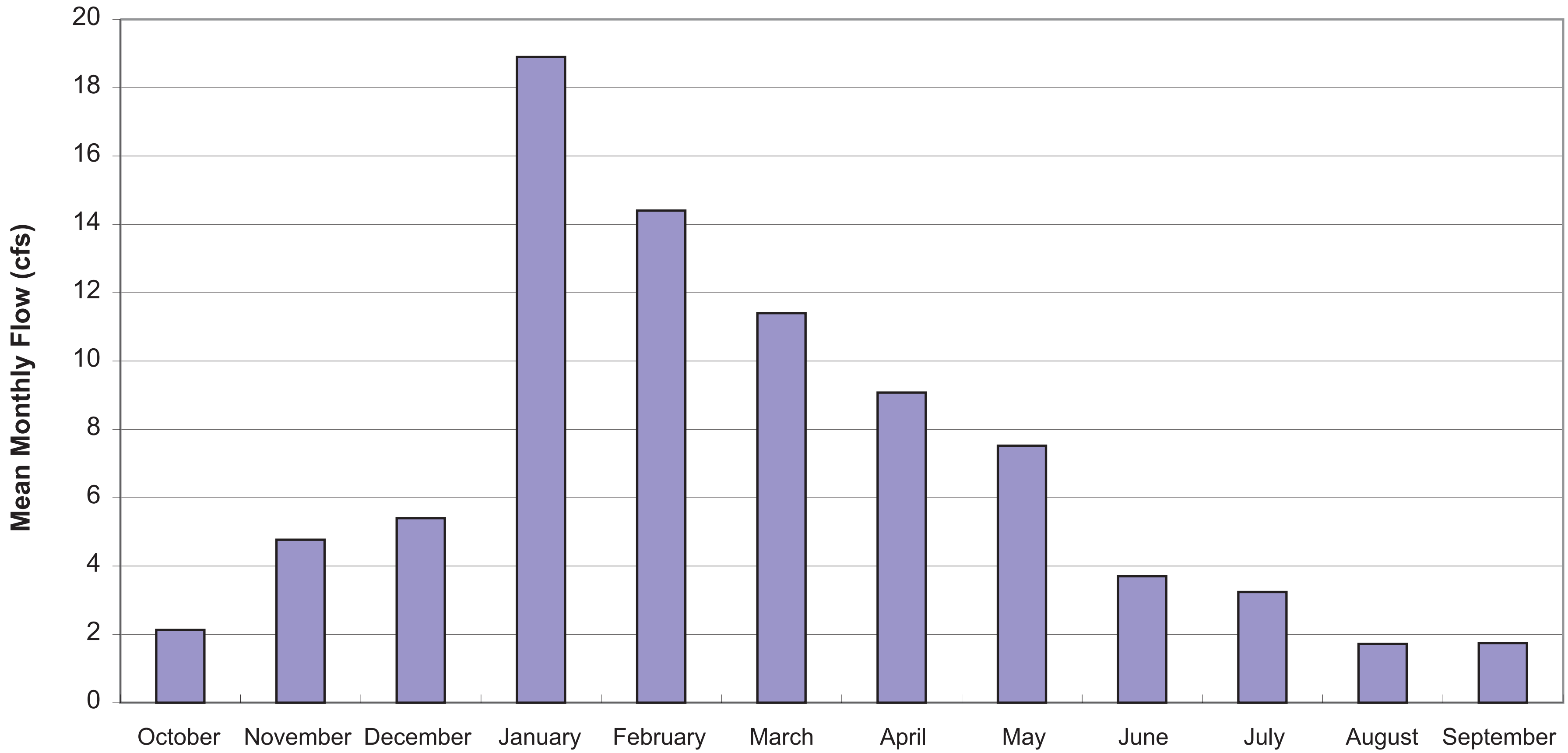


FIGURE **3-7n**

REBEL FLAT CREEK AT WINONA (USGS STN. 13349320)

MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg46.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

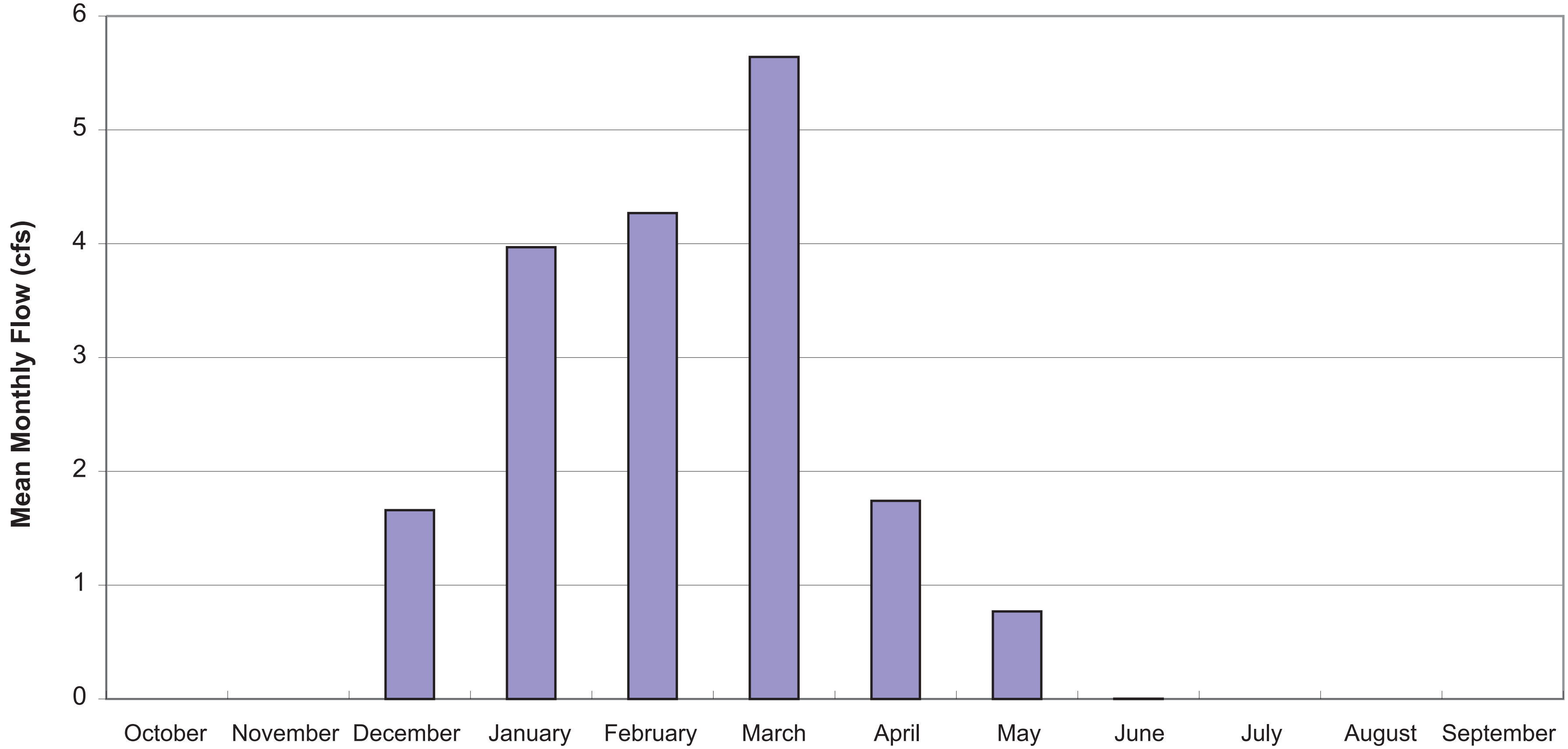


FIGURE **3-7o**

PHILLEO DITCH NEAR CHENEY (USGS STN. 13349325)

MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg47.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

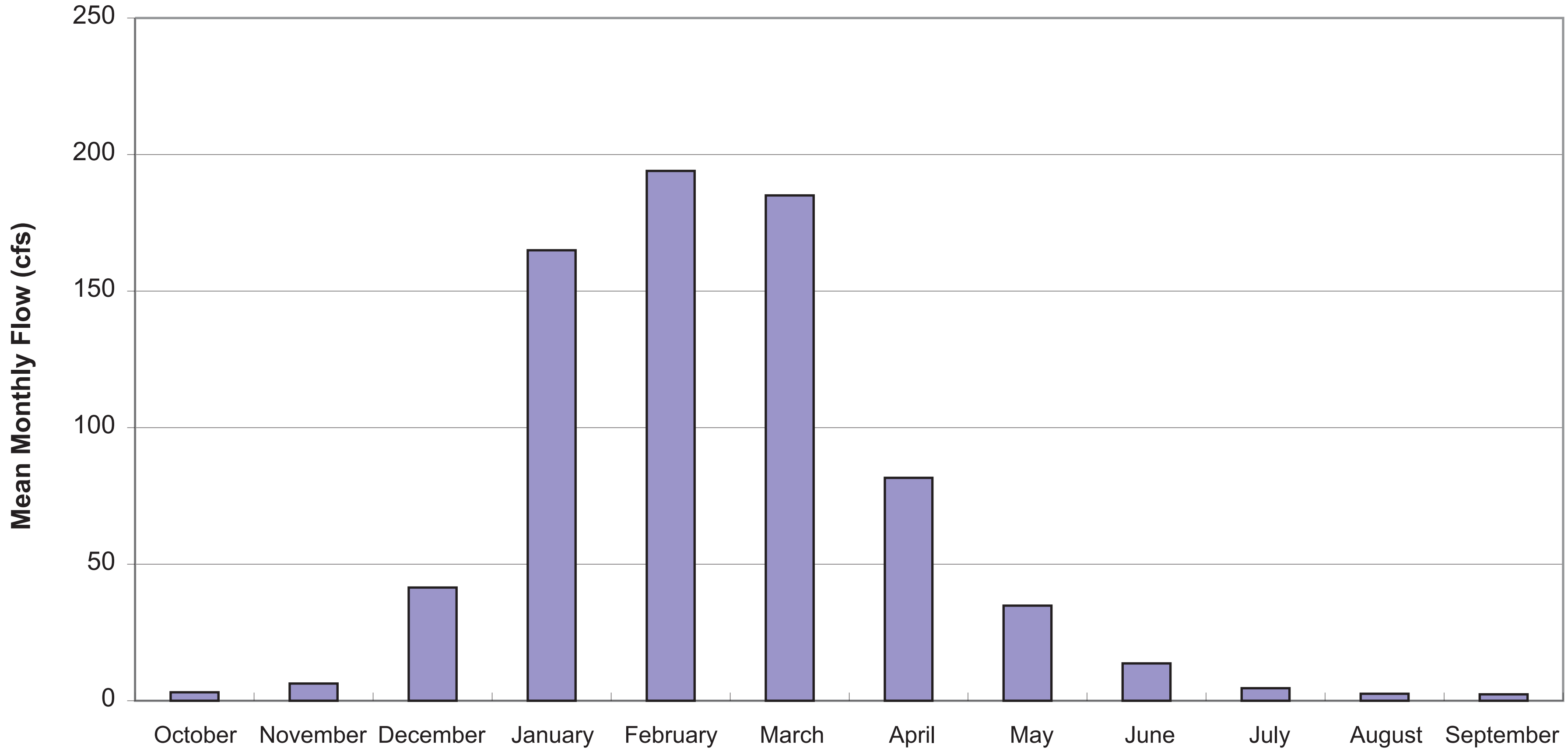


FIGURE **3-7p**

PINE CREEK AT PINE CITY (USGS STN.13349400)
MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg48.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

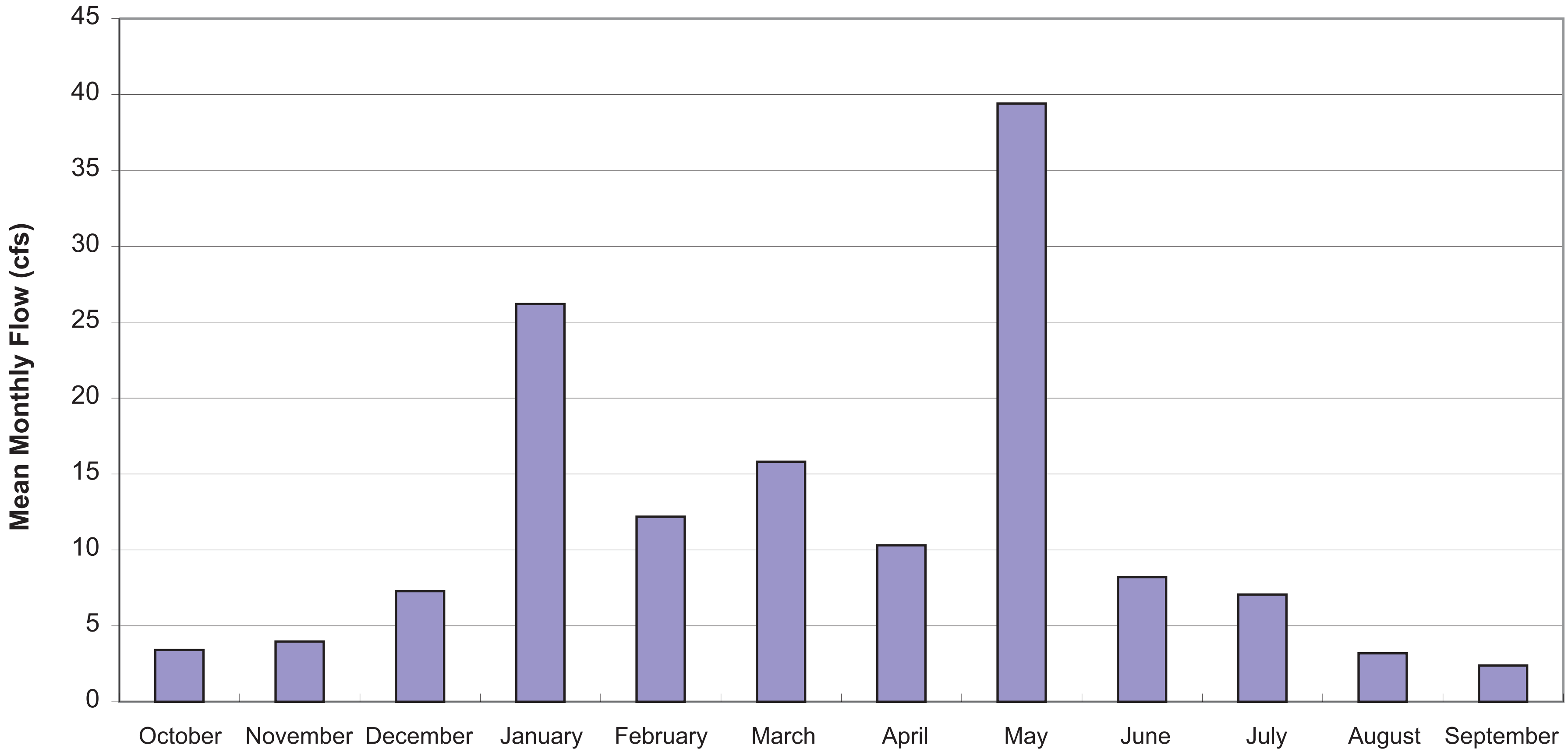


FIGURE **3-7q**

PINE CREEK AT PINE CITY ROAD AT PINE CITY (USGS STN. 13349410)

MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

Note: Plots use limited data.

DRAWING NO. 04310641030fg49.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

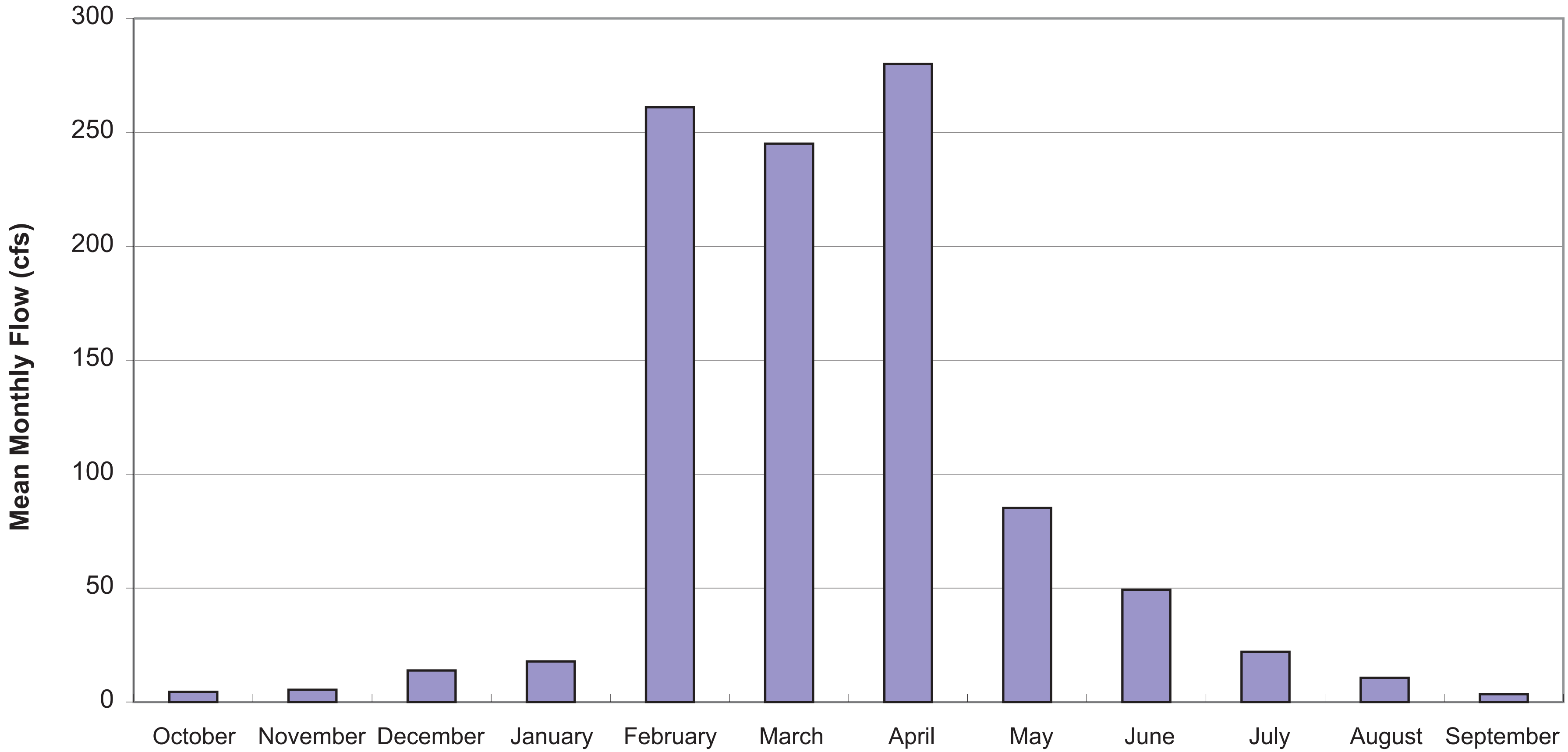


FIGURE **3-7r**

ROCK CREEK AT EWAN (USGS STN. 13349500)
MEAN MONTHLY FLOW
PCD/WRIA 34 WATERSHED PLANNING/WA

Note: Plots use limited data.

DRAWING NO. 04310641030fg50.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

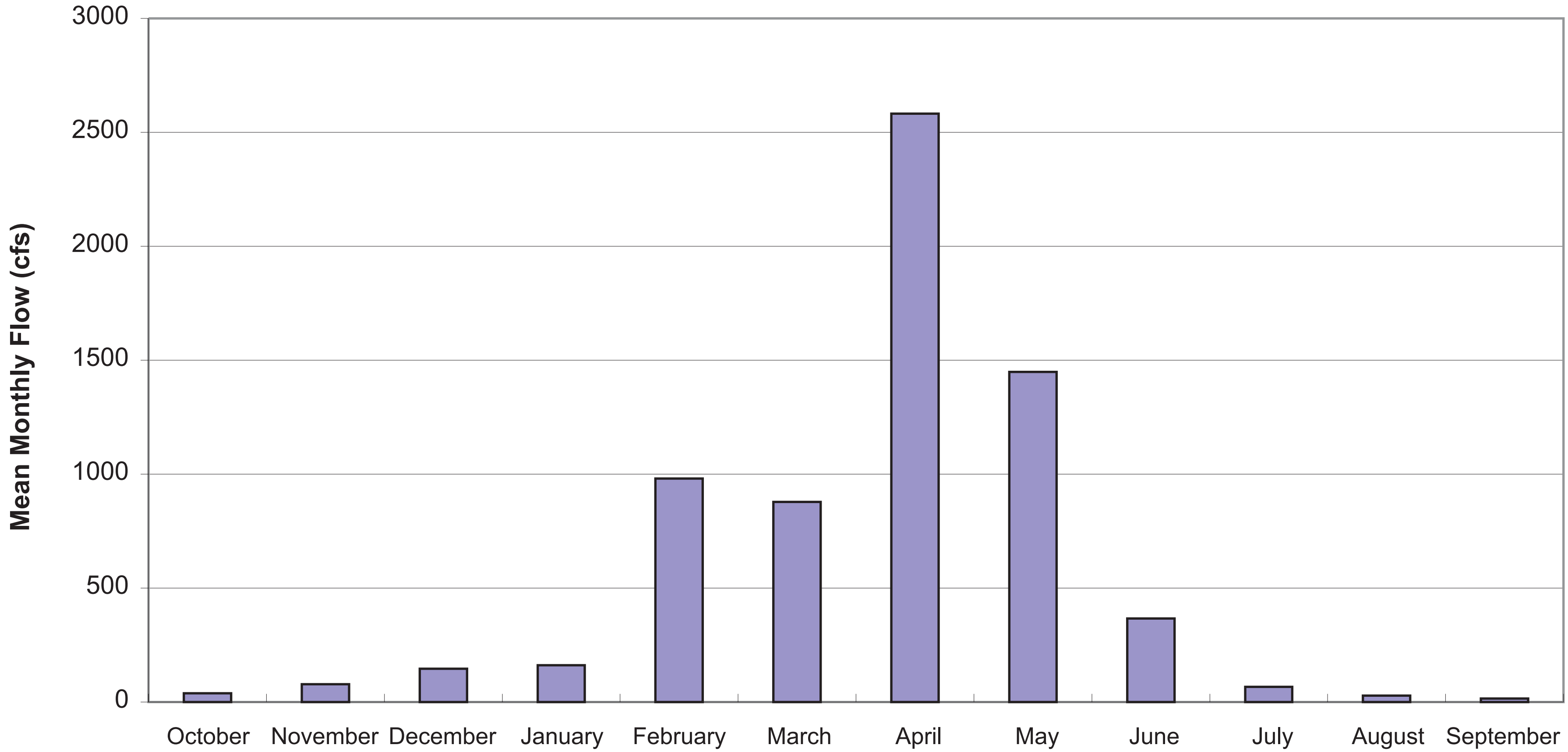


FIGURE **3-7s**

PALOUSE RIVER NEAR WINONA (USGS STN. 13350000)

MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg51.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

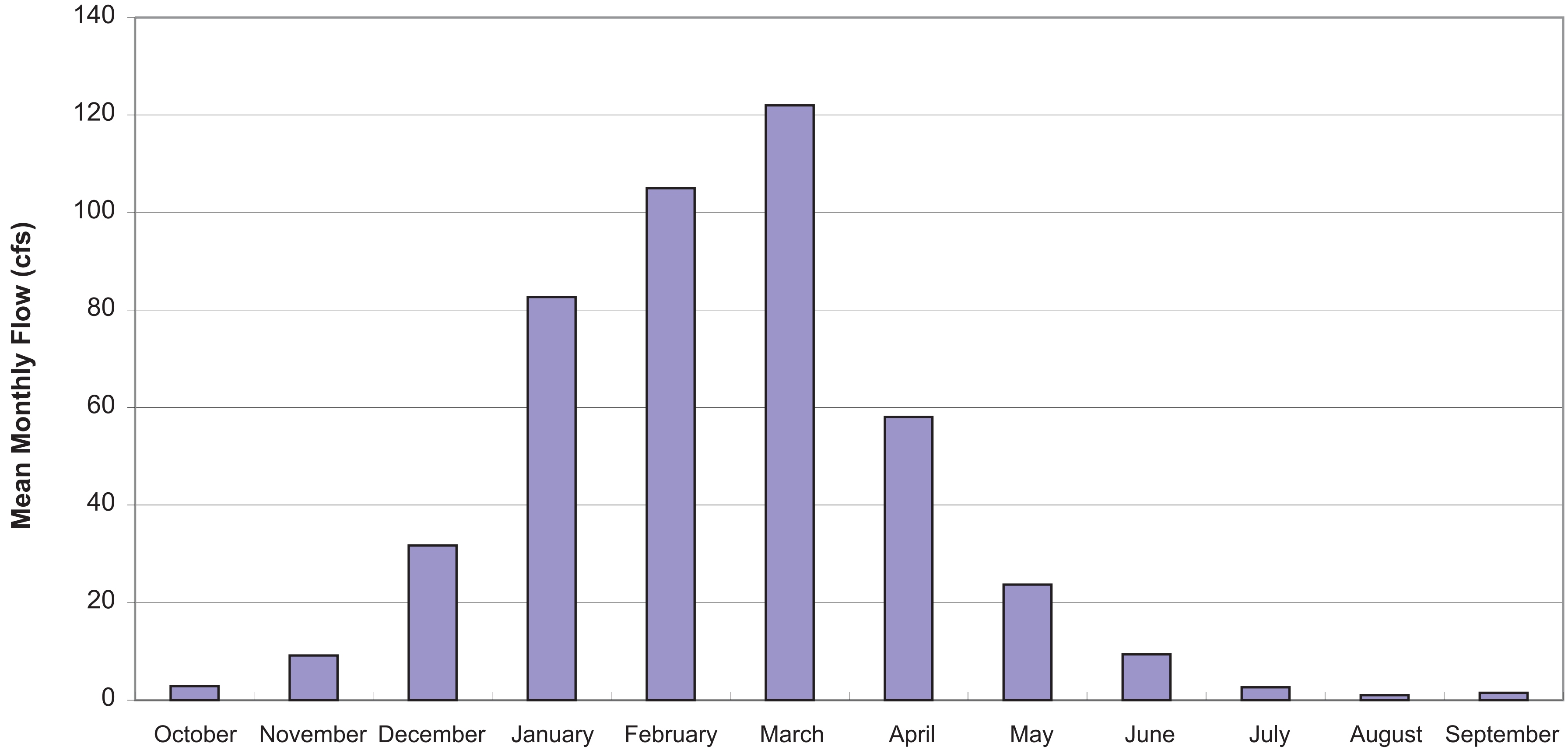


FIGURE **3-7t**

UNION FLAT CREEK NEAR COLFAX (USGS STN. 13350500)
MEAN MONTHLY FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg52.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

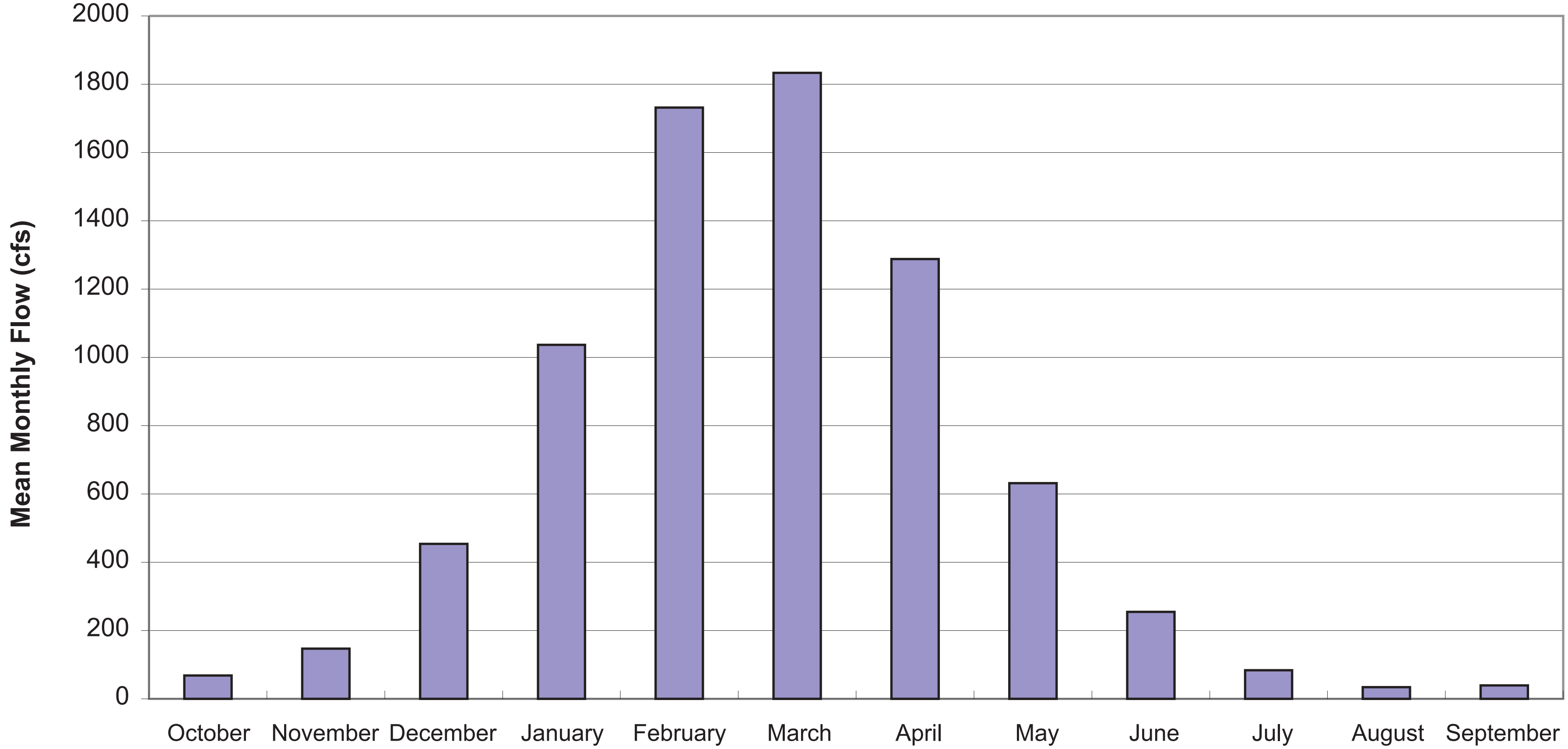


FIGURE **3-7u**

PALOUSE RIVER AT HOOPER (USGS STN. 13351000)
MEAN MONTHLY FLOW
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg53.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

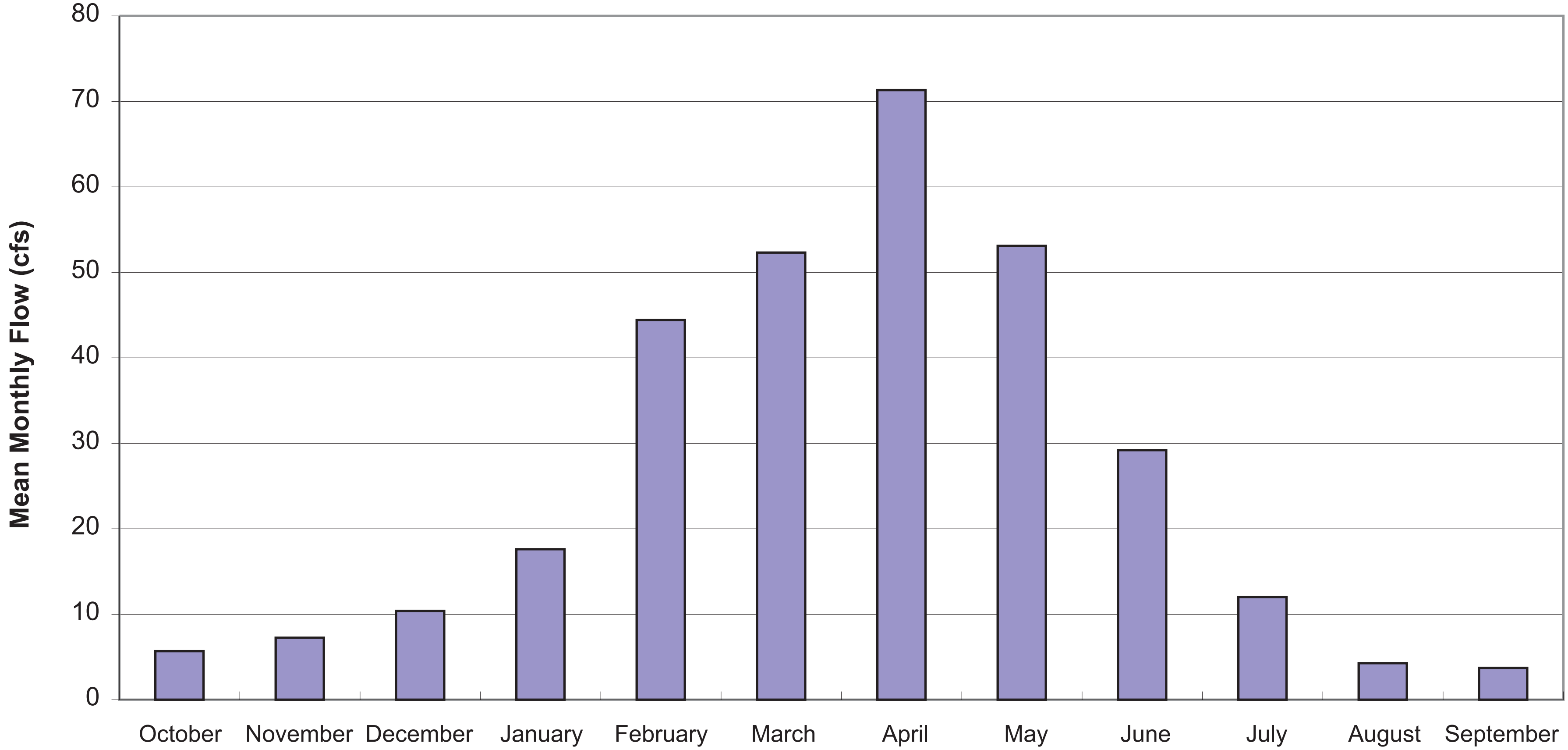


FIGURE **3-7v**

COW CREEK AT HOOPER (USGS STN. 13352500)
MEAN MONTHLY FLOW
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg54.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates

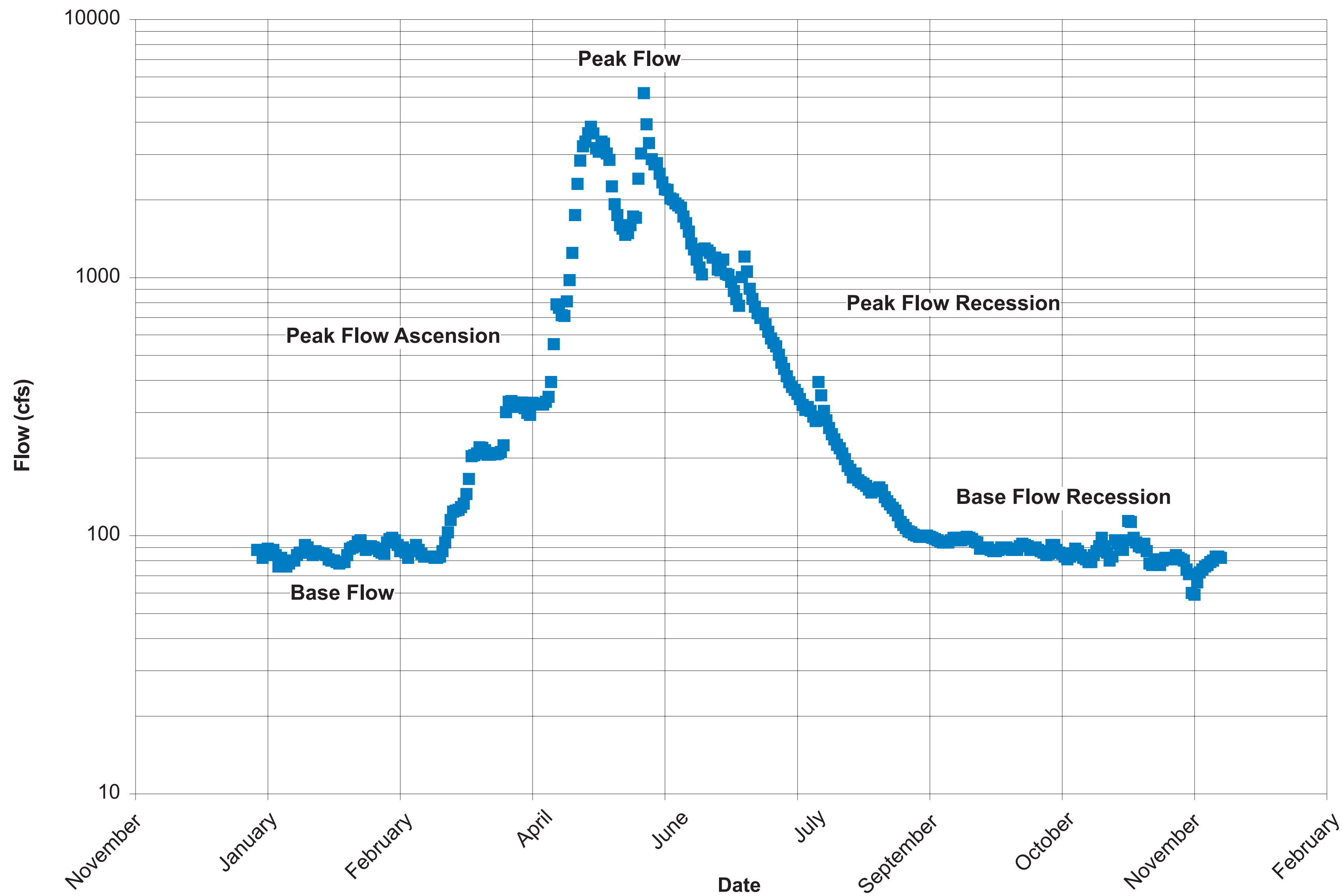


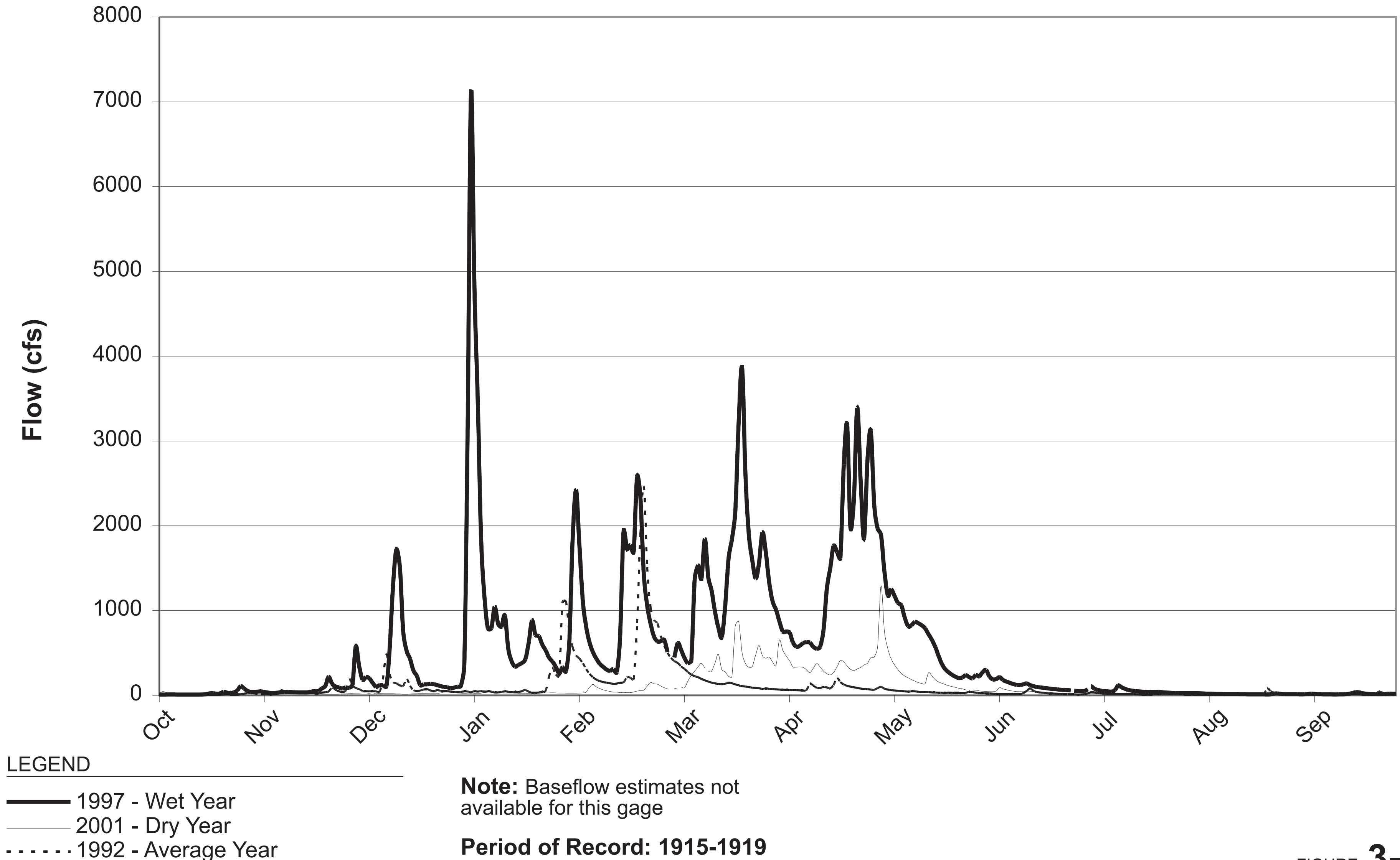
FIGURE **3-8**

EXAMPLE STREAMFLOW HYDROGRAPH FOR PALOUSE BASIN

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg55.fh11 DATE 11/03/04 DRAWN BY EL

Golder Associates



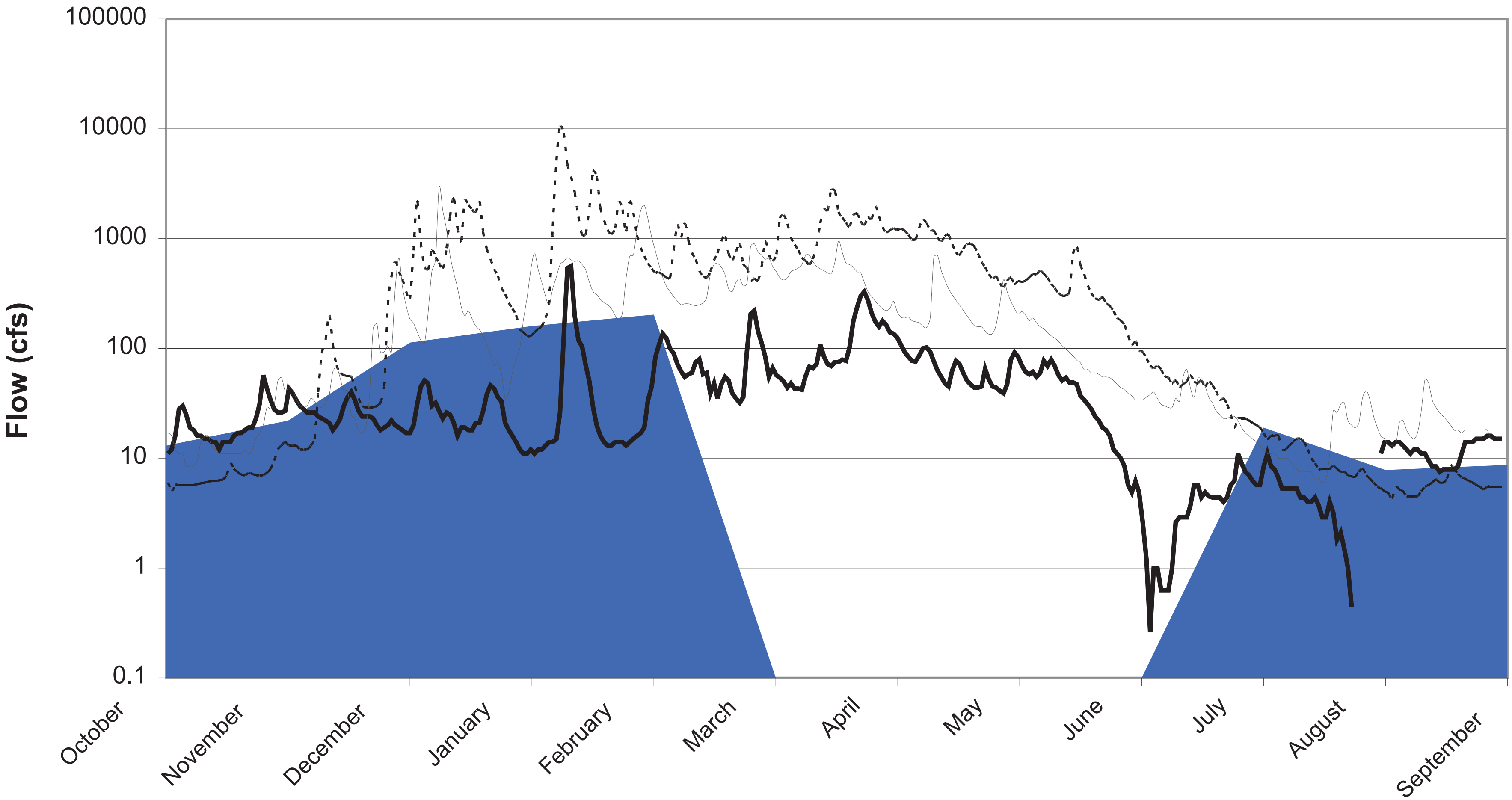
Note: Baseflow estimates not available for this gage

Period of Record: 1915-1919 & 1966-2002

FIGURE **3-9a**

PALOUSE RIVER NEAR POTLATCH (USGS STN. 13345000)
DAILY HYDROGRAPH

PCD/WRIA 34 WATERSHED PLANNING/WA



LEGEND

Average Baseflow (WDOE, 1999)

1974 - Wet Year

1977 - Dry Year

1978 - Average Year

Note: Baseflow data not available for March through June.

Period of Record: 1973-1980

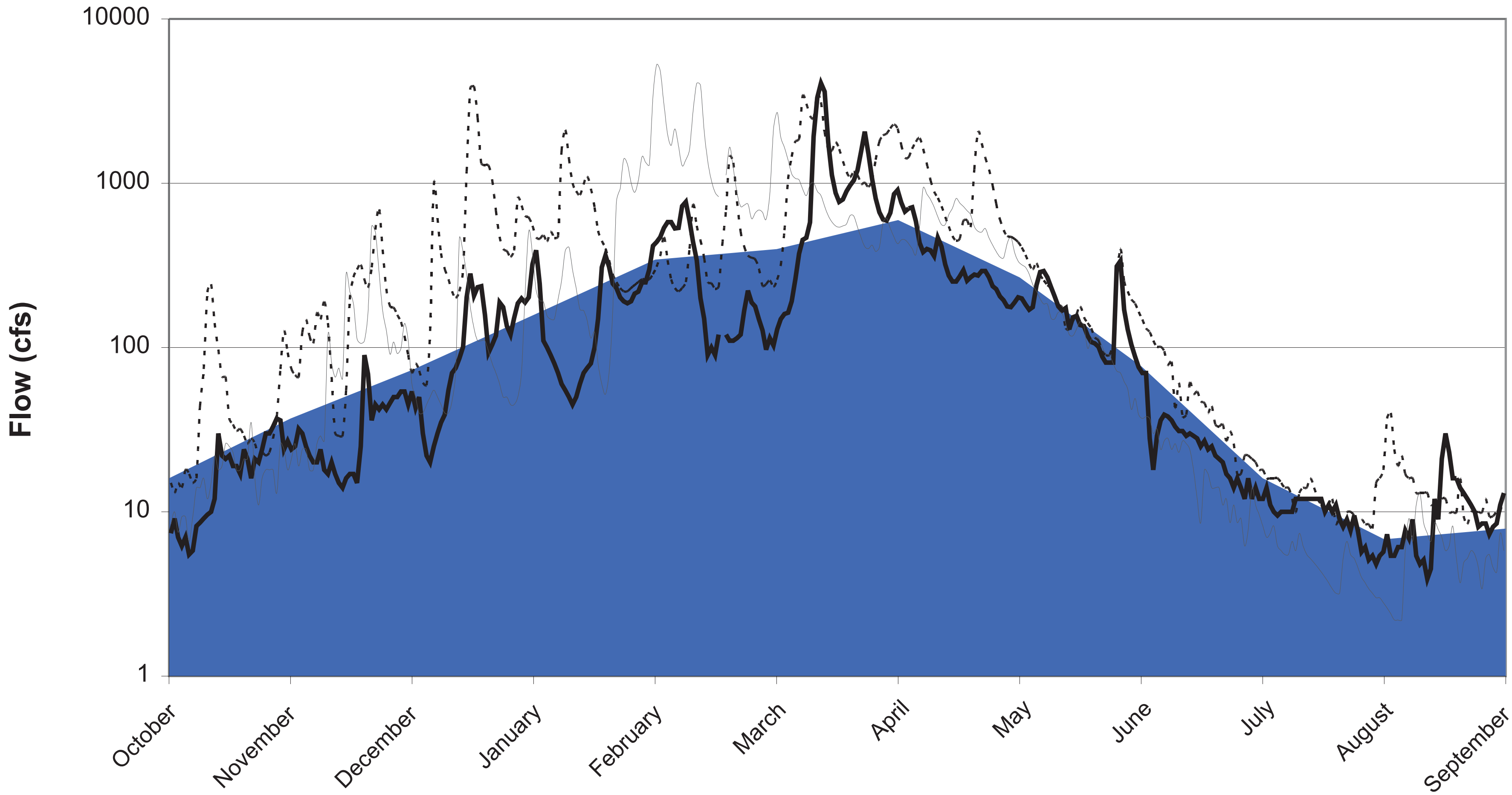
FIGURE **3-9b**

PALOUSE RIVER AT PALOUSE (USGS STN.13345300)
DAILY HYDROGRAPH

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg79.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



LEGEND

Average Baseflow (WDOE, 1999)

1956 - Wet Year

1962 - Dry Year

1961 - Average Year

Period of Record: 1955-1964 & 1993-1994

FIGURE **3-9c**

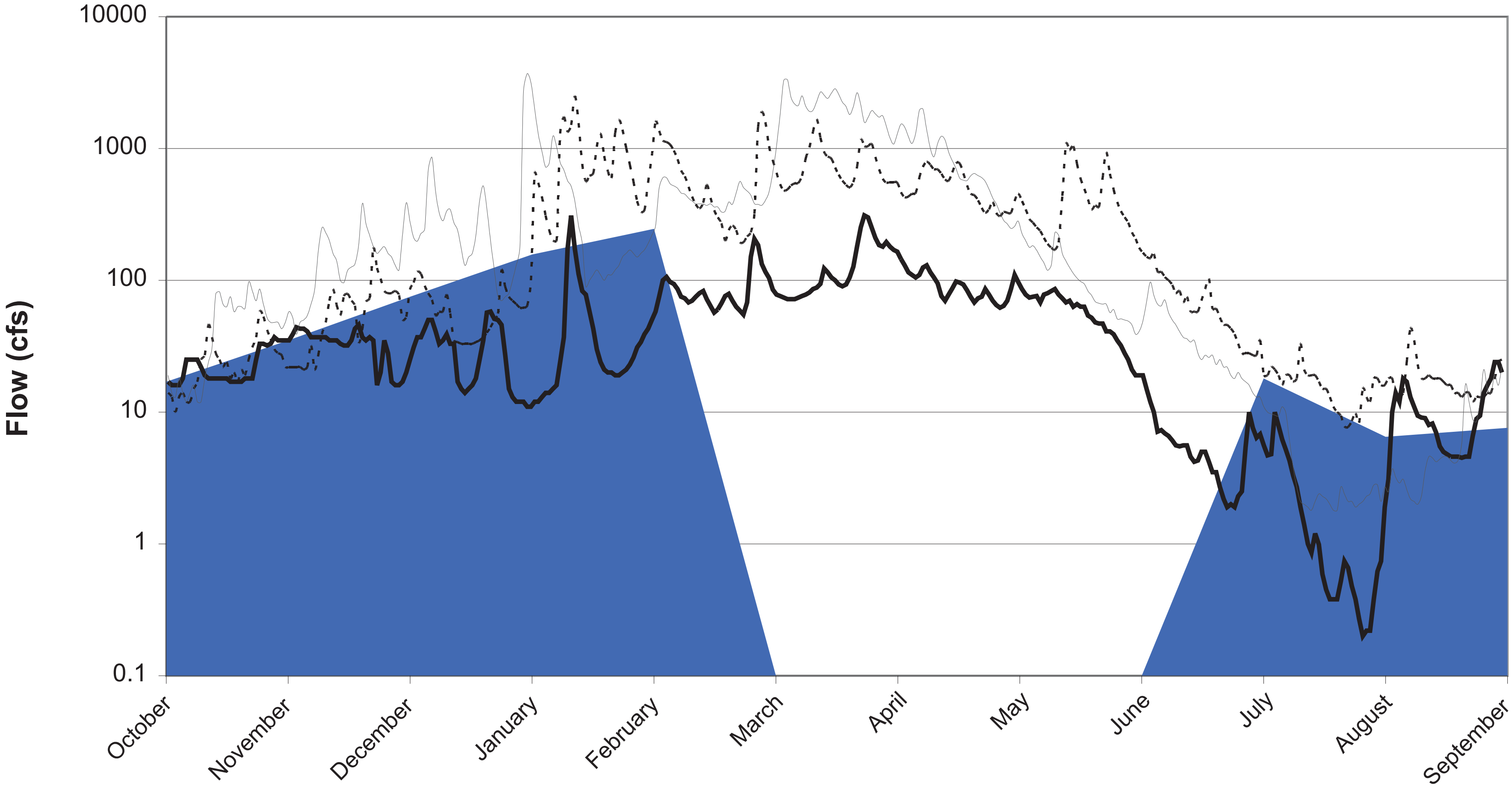
PALOUSE RIVER NEAR COLFAX (USGS STN.13346000)

DAILY HYDROGRAPH

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg80.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



LEGEND

Average Baseflow (WDOE, 1999)

- - - - - - 1971 - Wet Year

1977 - Dry Year

1969 - Average Year

Note: Baseflow data not available March through June.

Period of Record: 1963-1973 & 1975-1979

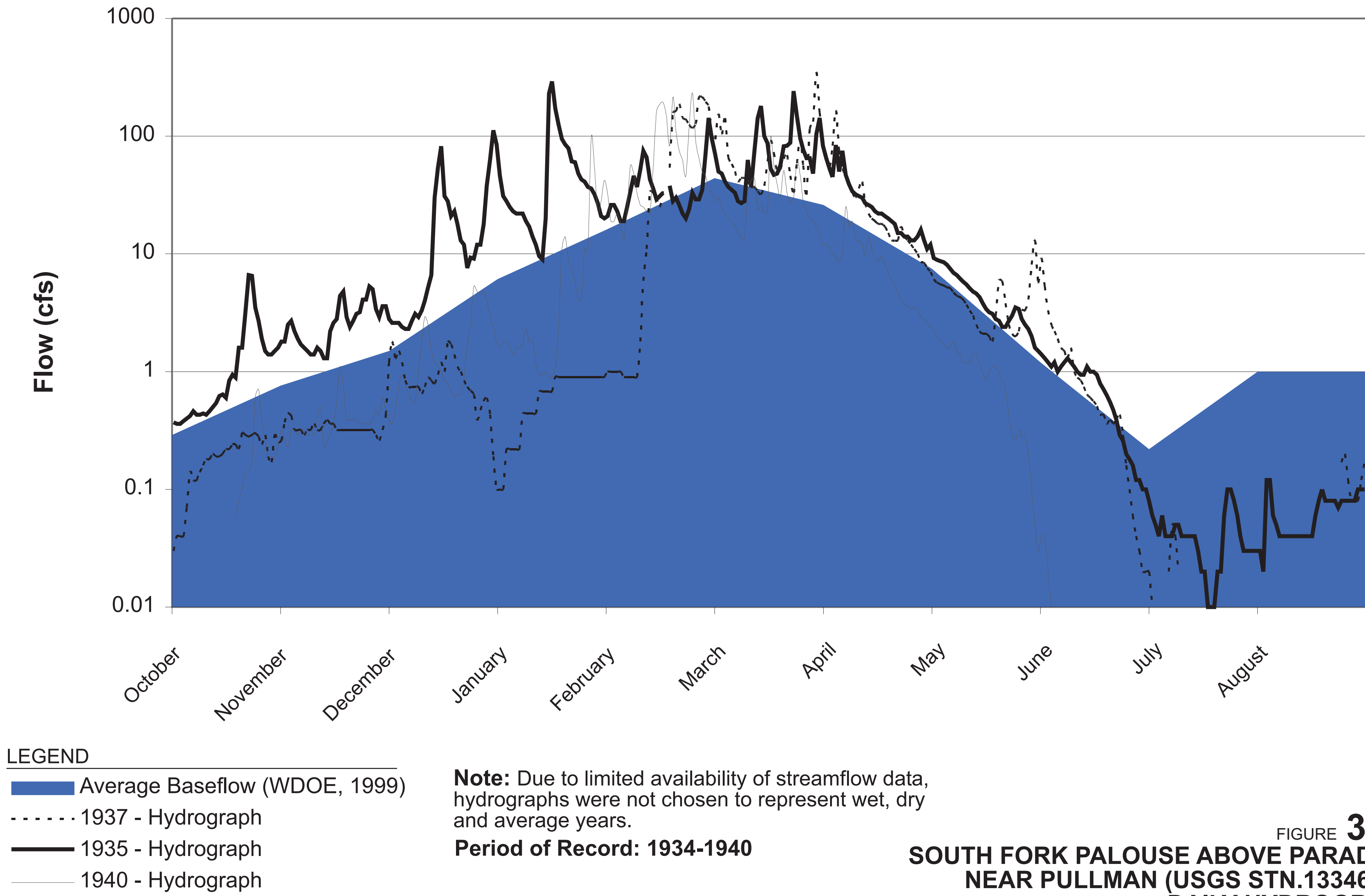
FIGURE **3-9d**

PALOUSE RIVER AT COLFAX (USGS STN.13346100)
DAILY HYDROGRAPH

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg81.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



Note: Due to limited availability of streamflow data, hydrographs were not chosen to represent wet, dry and average years.

Period of Record: 1934-1940

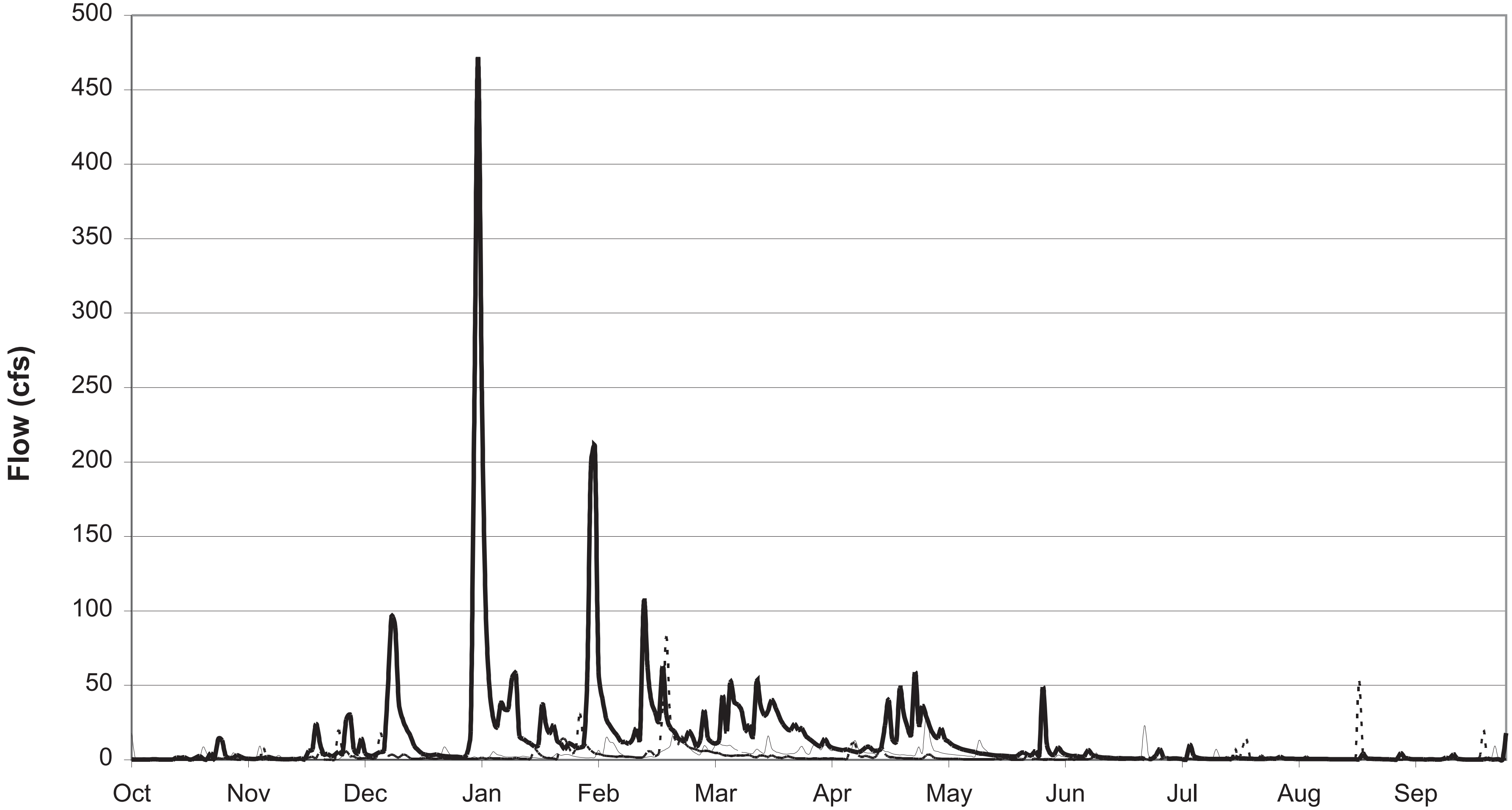
FIGURE **3-9e**

SOUTH FORK PALOUSE ABOVE PARADISE, NEAR PULLMAN (USGS STN.13346500) DAILY HYDROGRAPH

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg82.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



LEGEND

1997 - Wet Year
2001 - Dry Year
1992 - Average Year

Note: Baseflow estimates not available for this gage

Period of Record: 1978-2003

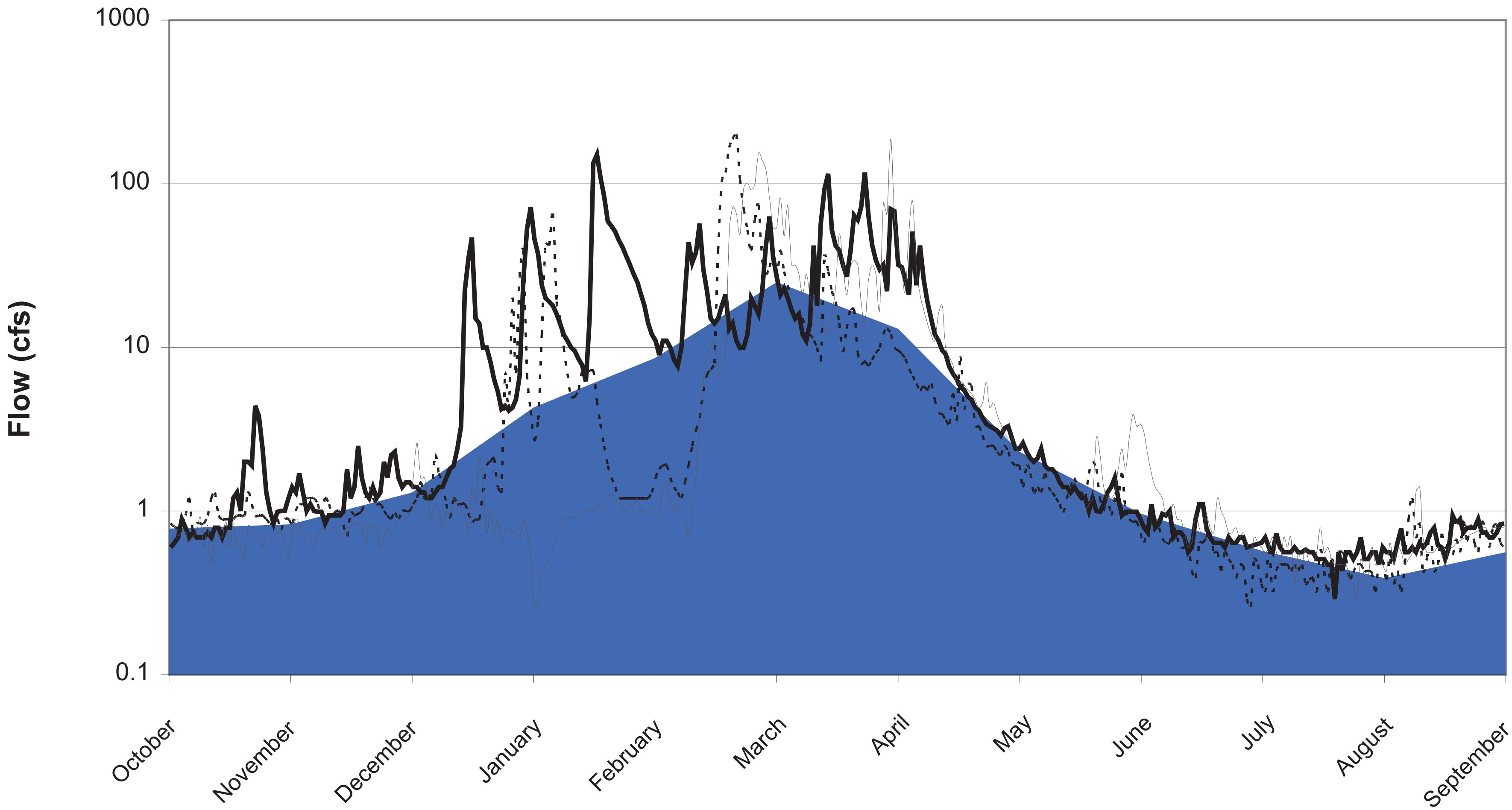
FIGURE **3-9f**

PARADISE CREEK AT UNIVERSITY OF IDAHO, MOSCOW, ID (USGS STN. 13346800) DAILY HYDROGRAPH

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg105.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



LEGEND

Average Baseflow (WDOE, 1999)
1936 - Hydrograph
1935 - Hydrograph
1937 - Hydrograph

Note: Due to limited availability of streamflow data, hydrographs were not chosen to represent wet, dry and average years.

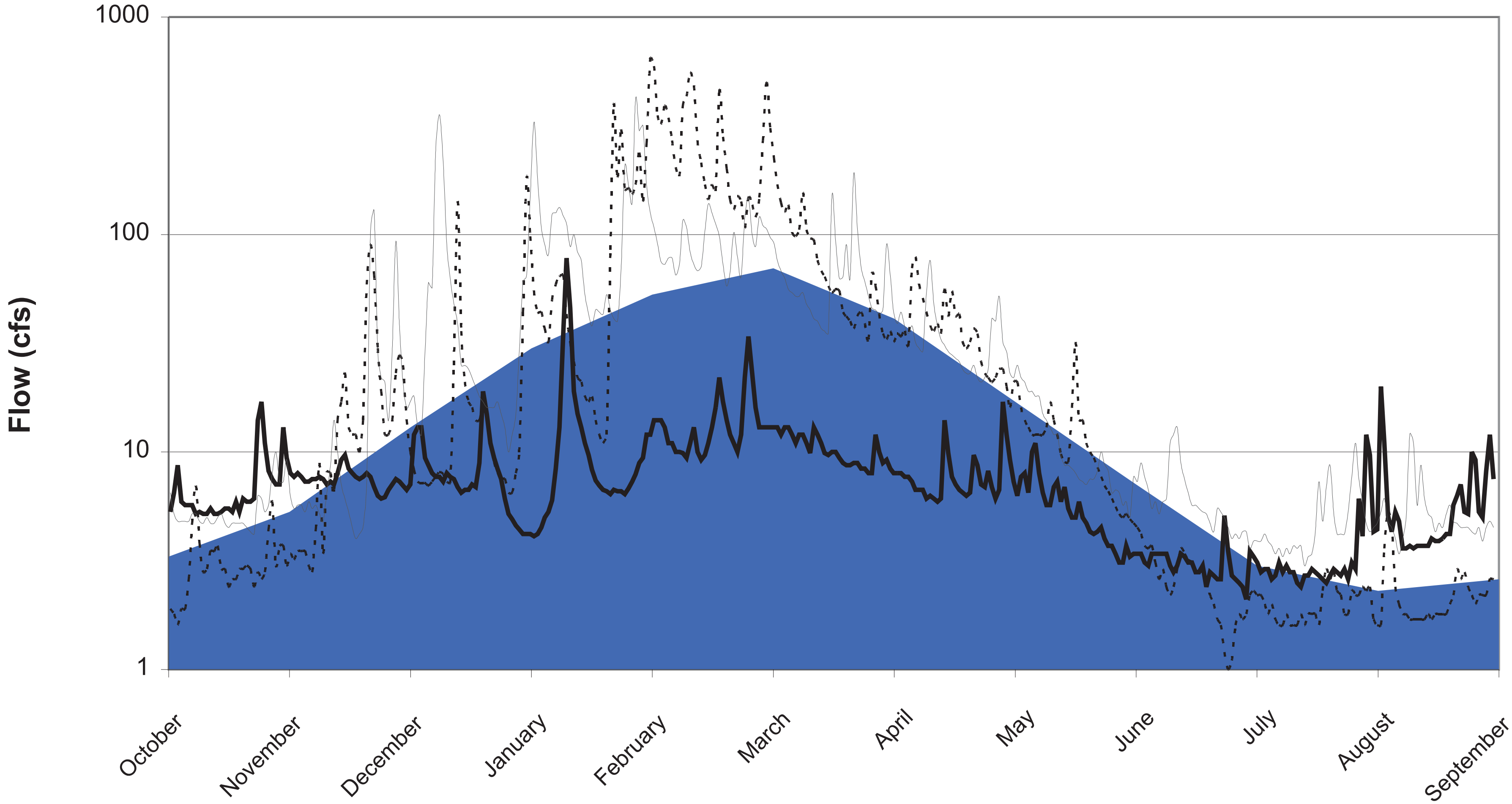
Period of Record: 1934-1938

FIGURE **3-9g**

PARADISE CREEK NEAR PULLMAN (USGS STN. 13347000)
DAILY HYDROGRAPH
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg83.fh11 DATE 12/03/04 DRAWN BY EL

Golder Associates



LEGEND

Average Baseflow (WDOE, 1999)

1961 - Wet Year

1977 - Dry Year

1978 - Average Year

Period of Record: 1934-1942, 1960-1981 & 2001-2002

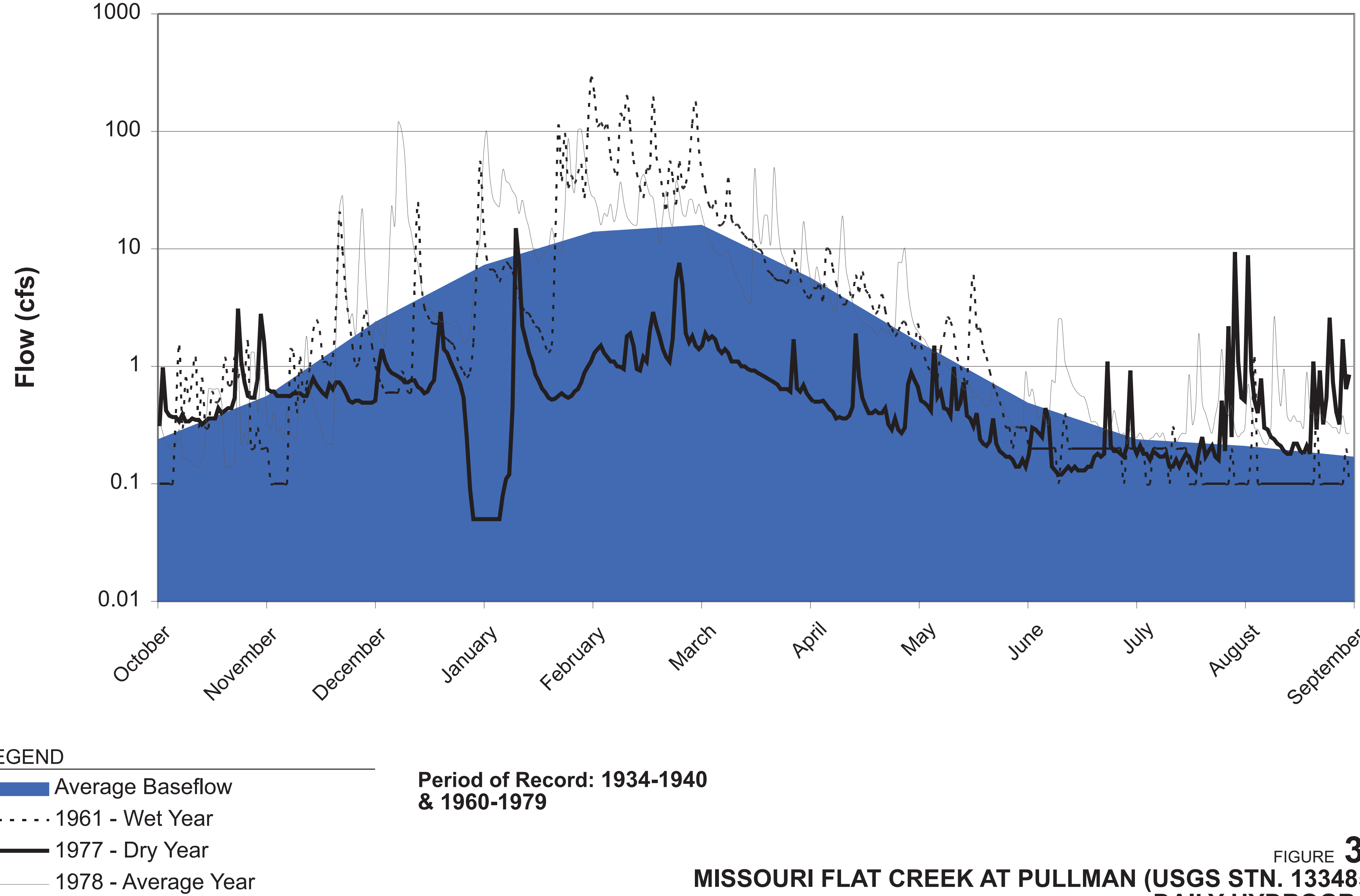
FIGURE **3-9h**

SOUTH FORK PALOUSE RIVER AT PULMAN (USGS STN. 13348000)
DAILY HYDROGRAPH

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg84.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



Period of Record: 1934-1940 & 1960-1979

FIGURE **3-9i**

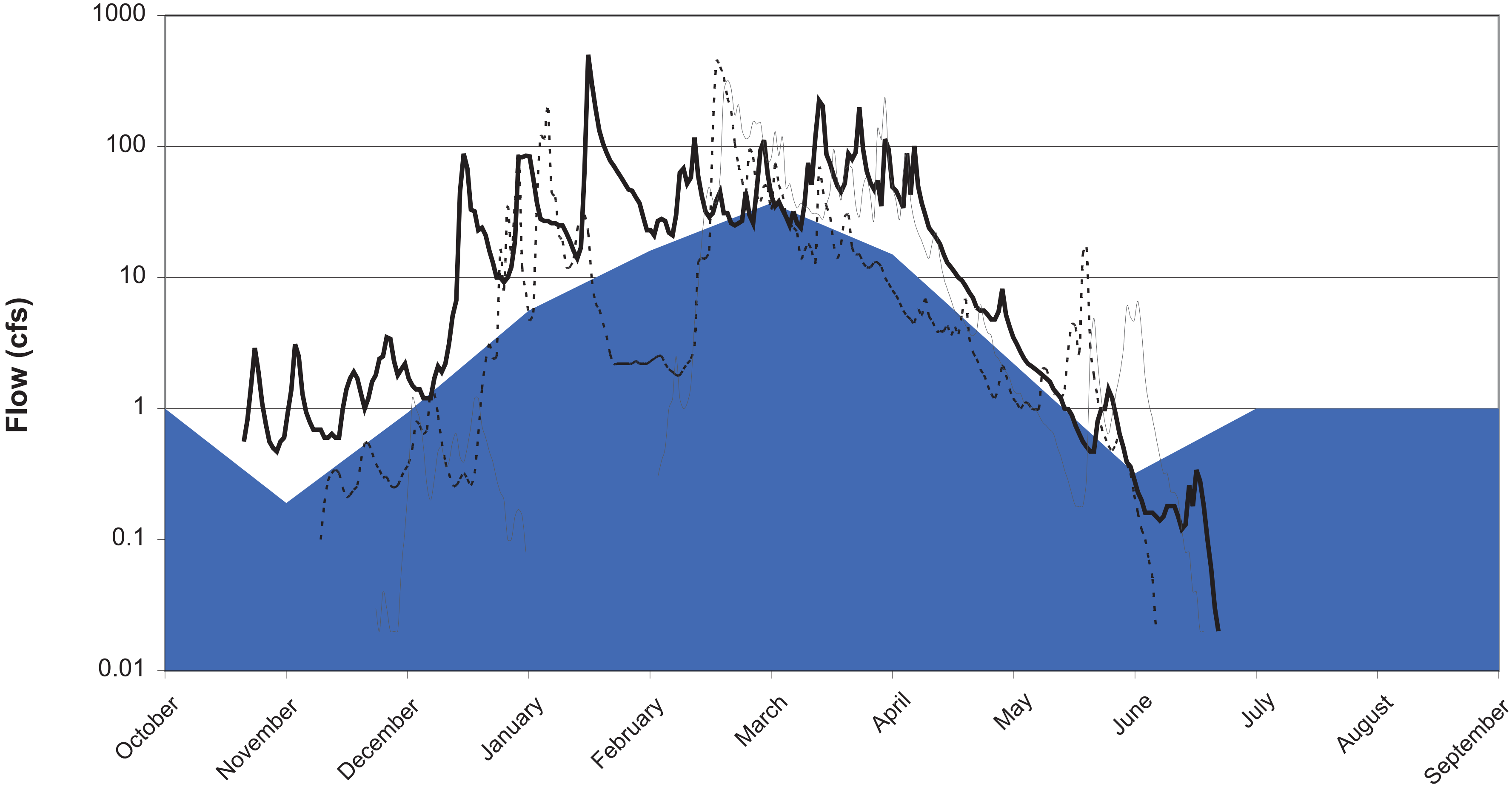
MISSOURI FLAT CREEK AT PULLMAN (USGS STN. 13348500)

DAILY HYDROGRAPH

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg85.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



LEGEND

Average Baseflow (WDOE, 1999)
1936 - Hydrograph
1935 - Hydrograph
1937 - Hydrograph

Note: Due to limited availability of streamflow data, hydrographs were not chosen to represent wet, dry and average years.

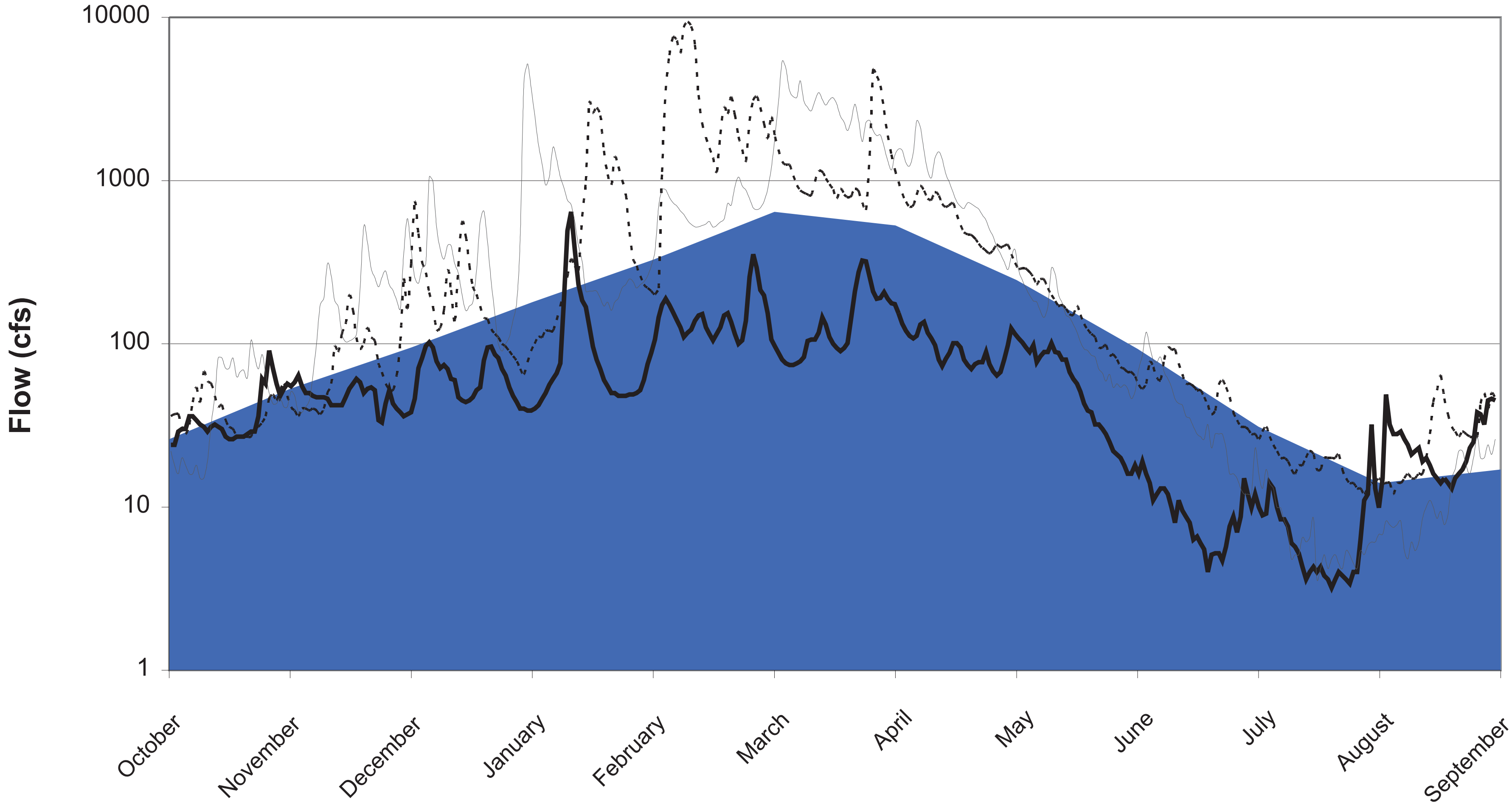
Period of Record: 1934-1940

FIGURE **3-9j**

FOURMILE CREEK AT SHAWNEE (USGS STN. 13349000)
DAILY HYDROGRAPH
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg86.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



LEGEND

Average Baseflow (WDOE, 1999)

1982 - Wet Year

1977 - Dry Year

1969 - Average Year

Period of Record: 1963-1973 & 1975-1995

FIGURE **3-9k**

PALOUSE RIVER BELOW SOUTH FORK AT COLFAX (USGS STN. 13349210)

DAILY HYDROGRAPH

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg87.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates

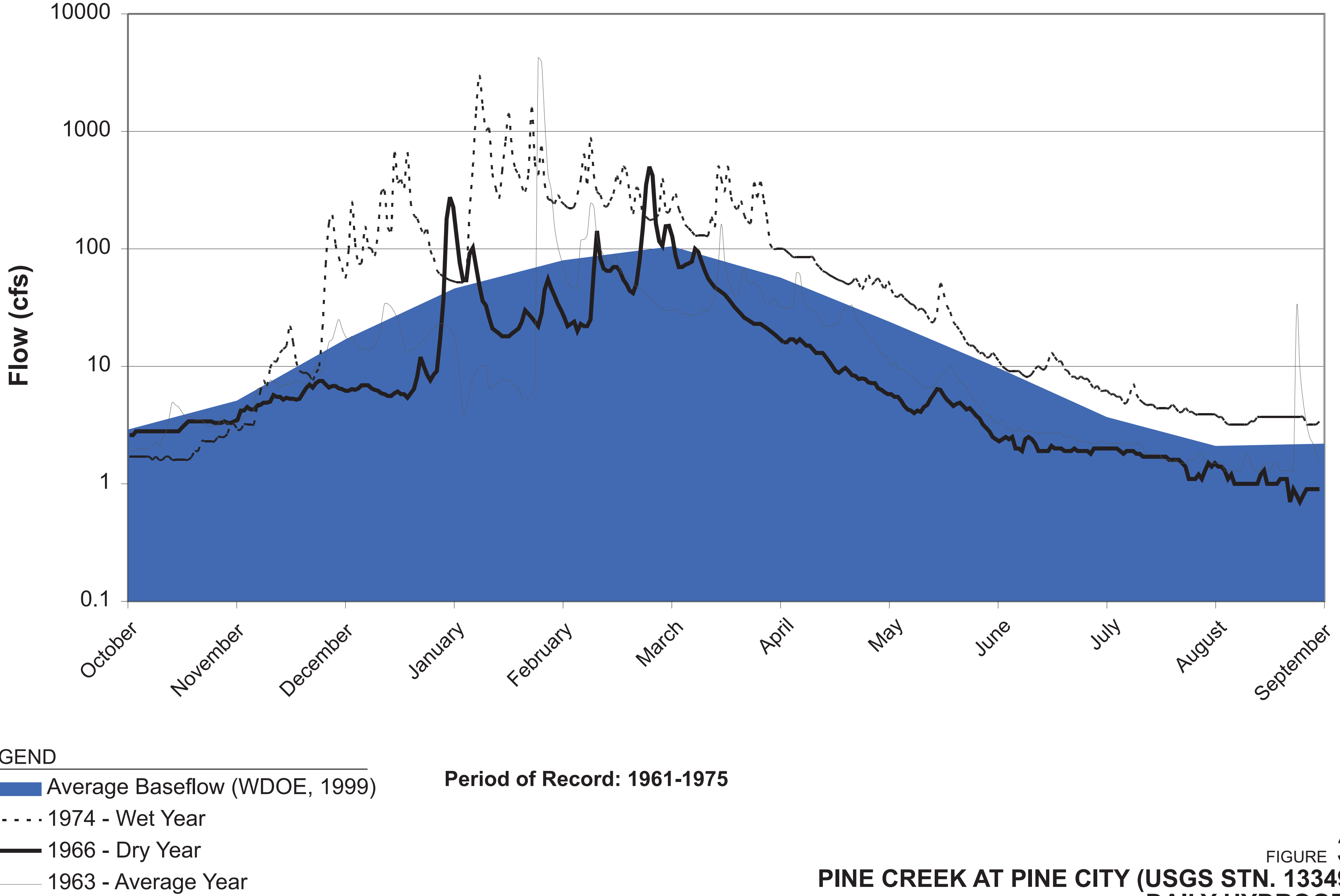


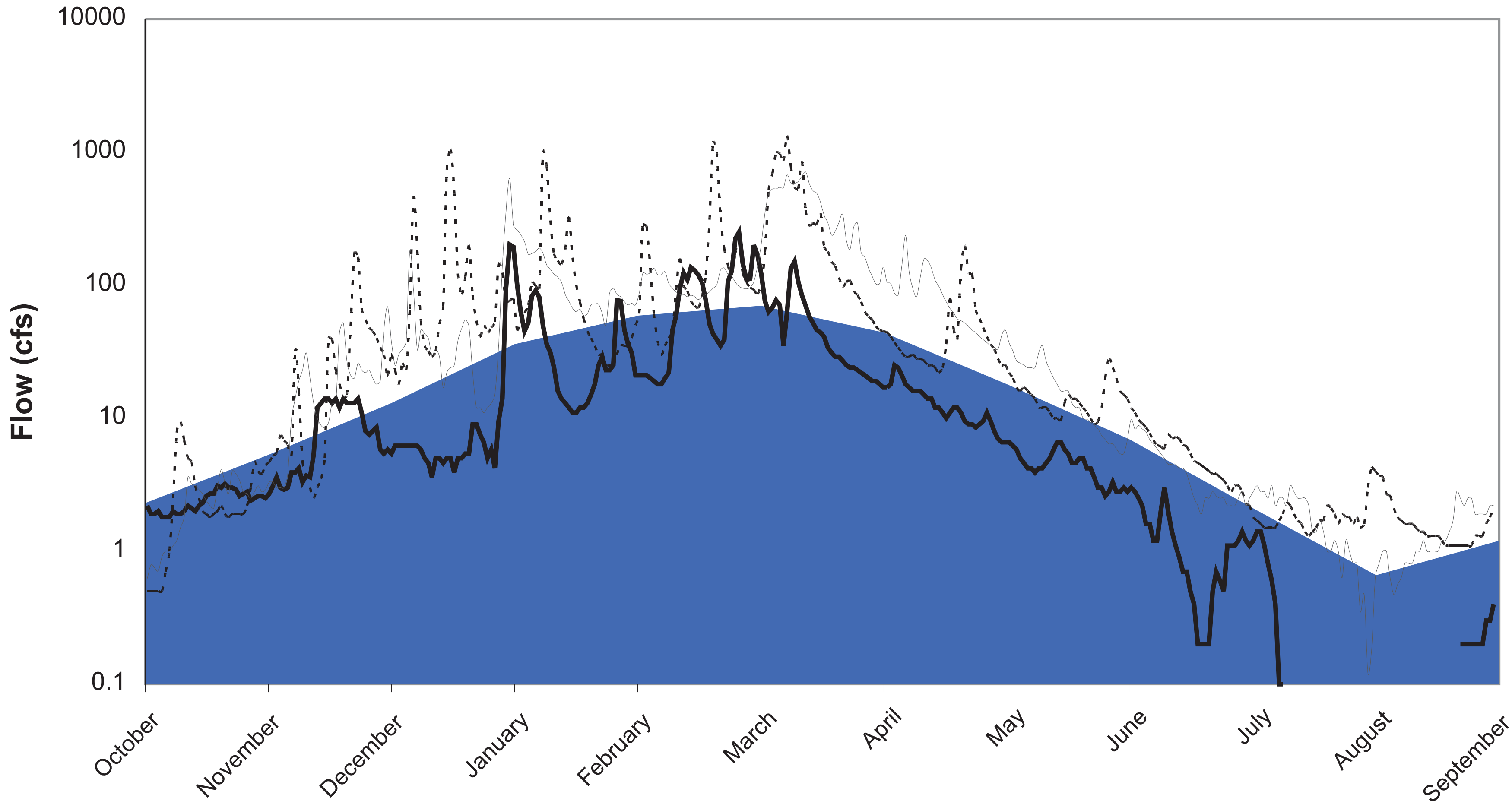
FIGURE **3-9I**

PINE CREEK AT PINE CITY (USGS STN. 13349400)
DAILY HYDROGRAPH

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg88.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



LEGEND

Average Baseflow (WDOE, 1999)

1956 - Wet Year

1966 - Dry Year

1969 - Average Year

Period of Record: 1953-1971

FIGURE **3-9m**

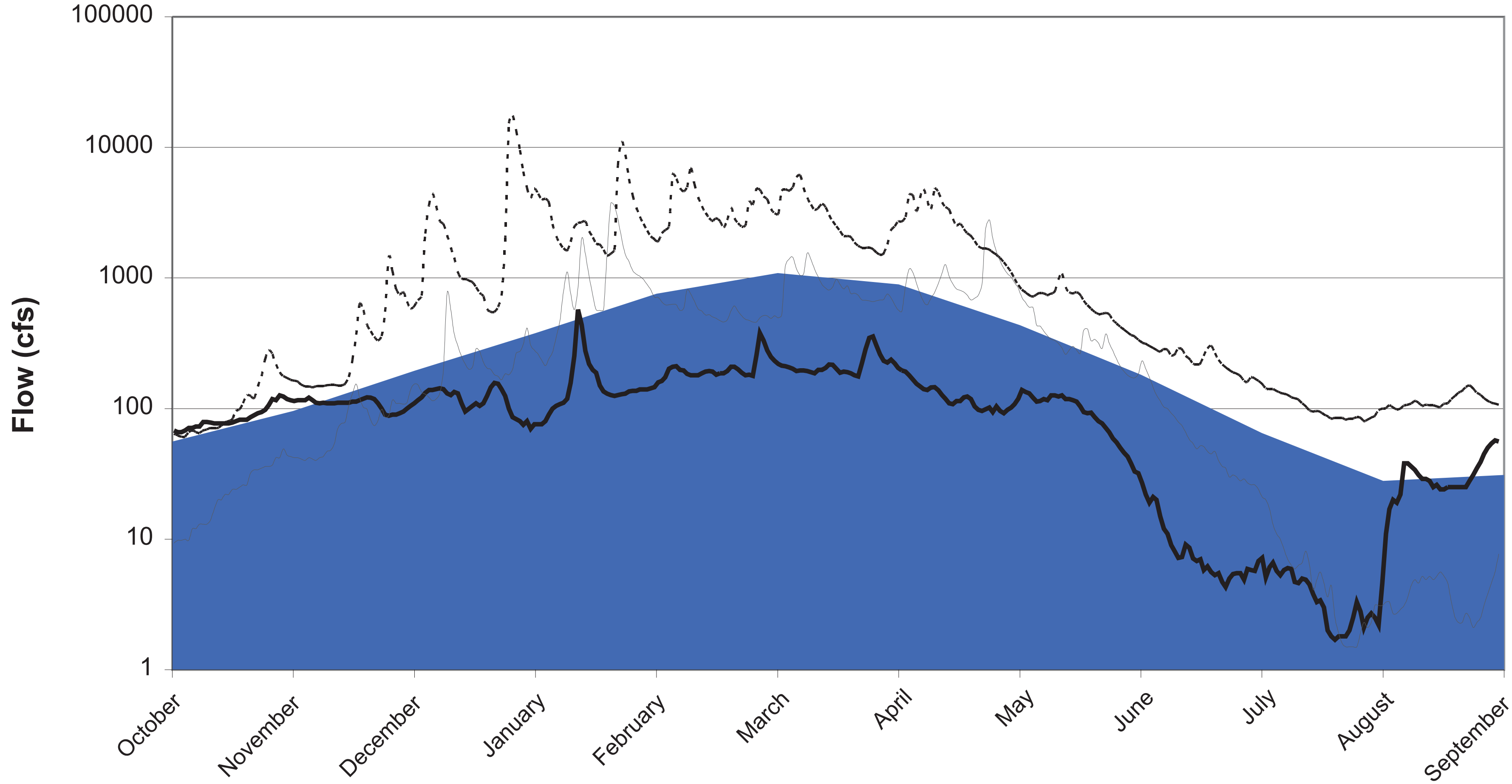
UNION FLAT CREEK NEAR COLFAX (USGS STN. 13350500)

DAILY HYDROGRAPH

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg89.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



LEGEND

Average Baseflow (WDOE, 1999)

1997 - Wet Year

1977 - Dry Year

1967 - Average Year

Note: Streamflow data not available for a representative wet year.

Period of Record: 1897-1916 & 1951-2002

FIGURE **3-9n**

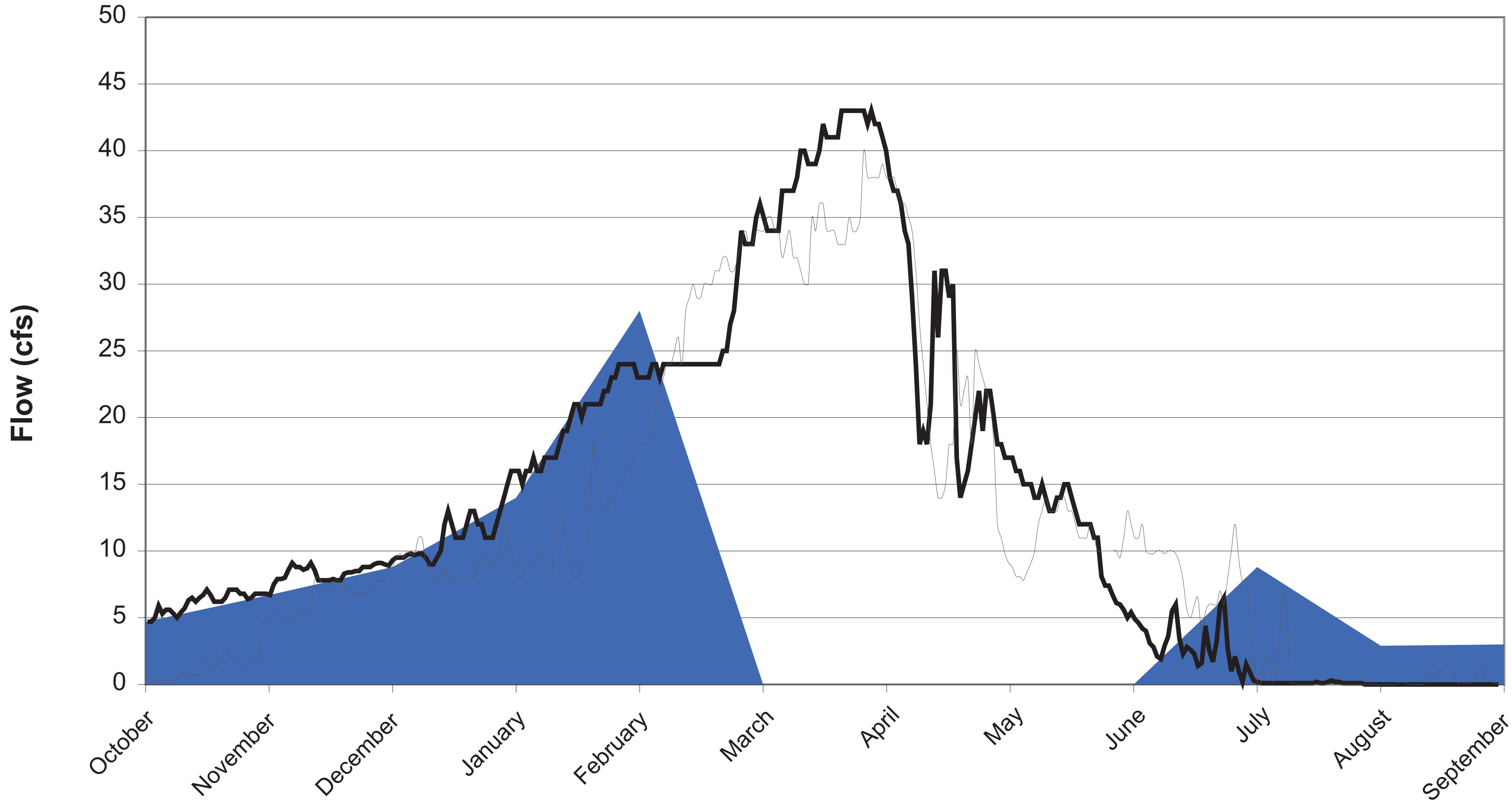
PALOUSE RIVER AT HOOPER (USGS STN.13351000)

DAILY HYDROGRAPH

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg90.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



LEGEND

Average Baseflow (WDOE, 1999)

1977 - Dry Year

1967 - Average Year

Note: Streamflow data not available for a representative wet year.

Period of Record: 1951-1953 & 1962-1970

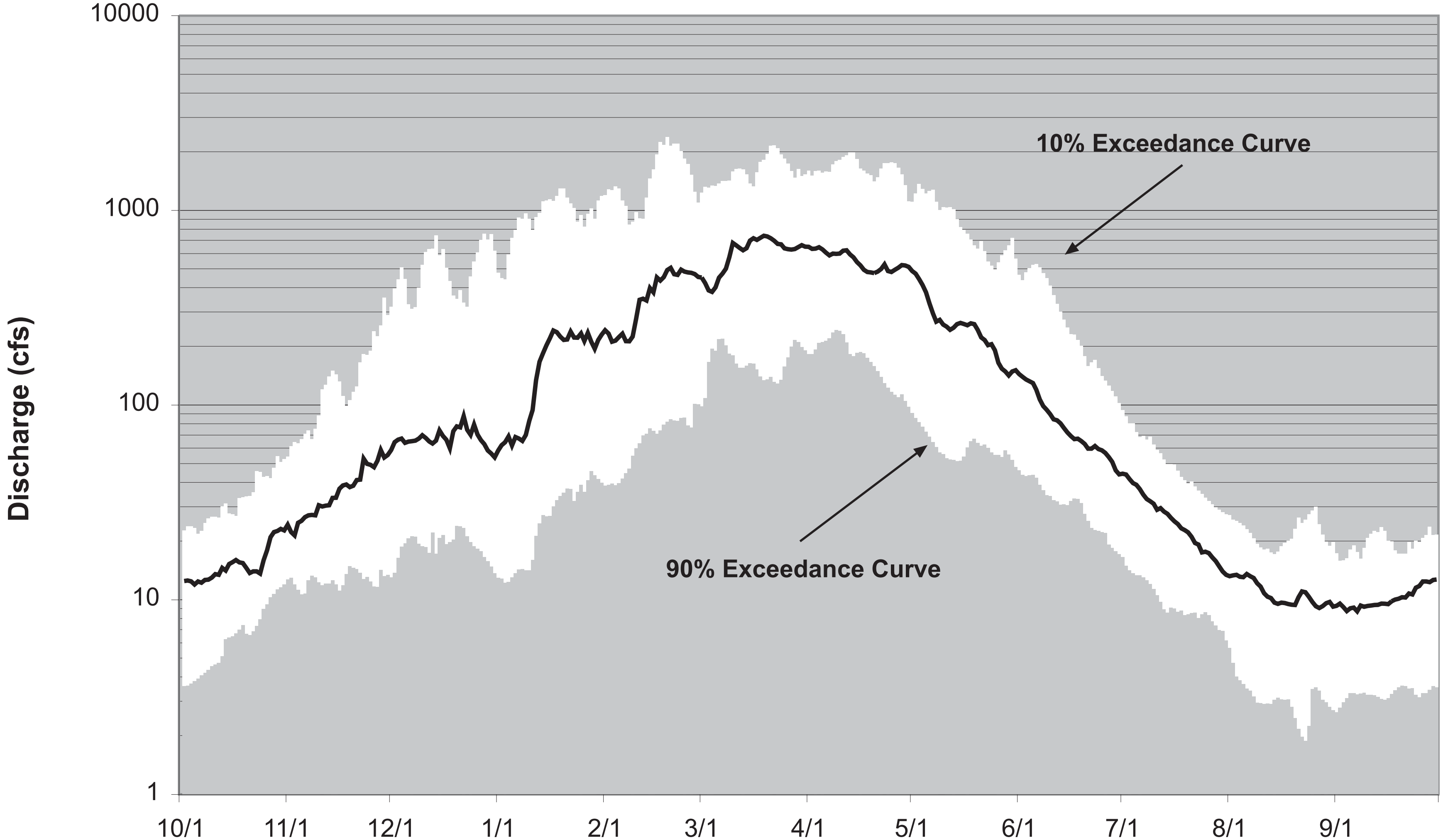
FIGURE **3-9o**

COW CREEK AT HOOPER (USGS STN. 13352500) DAILY HYDROGRAPH

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg91.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



LEGEND

10% Exceedance
50% Exceedance
90% Exceedance

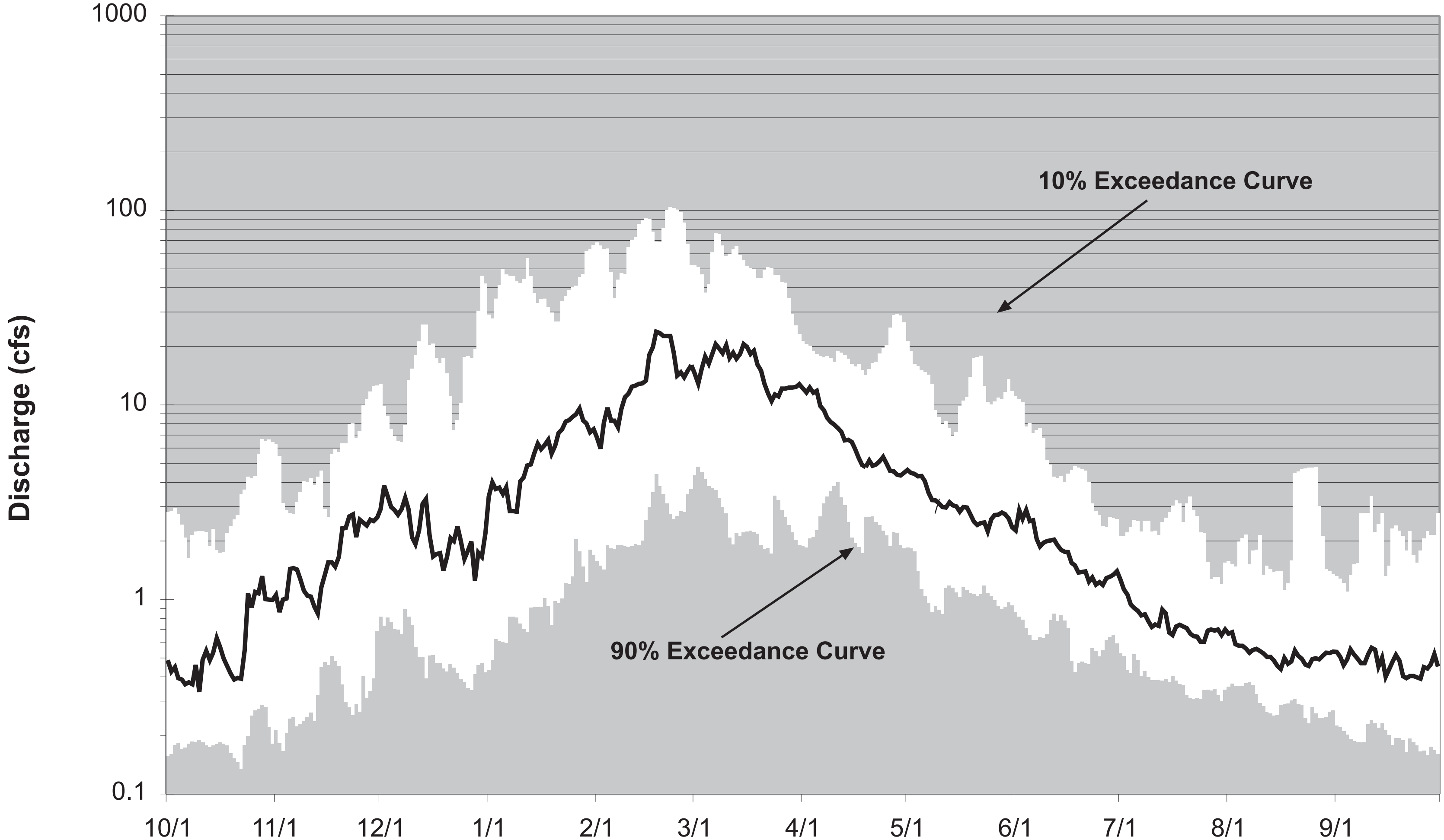
Exceedance Data Based on Running 7-Day Daily Average

Period of Record: 41 Years within 1915-1919 & 1966-2002

FIGURE **3-10a**
PALOUSE RIVER NEAR POTLATCH (USGS STN. 13345000) EXCEEDANCE CURVES
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg59.fh11 DATE 11/05/04 DRAWN BY AMP

Golder Associates



LEGEND

10% Exceedance

50% Exceedance

90% Exceedance

Exceedance Data Based on Running
7-Day Daily Average

Period of Record: 25 Years within 1978-2003

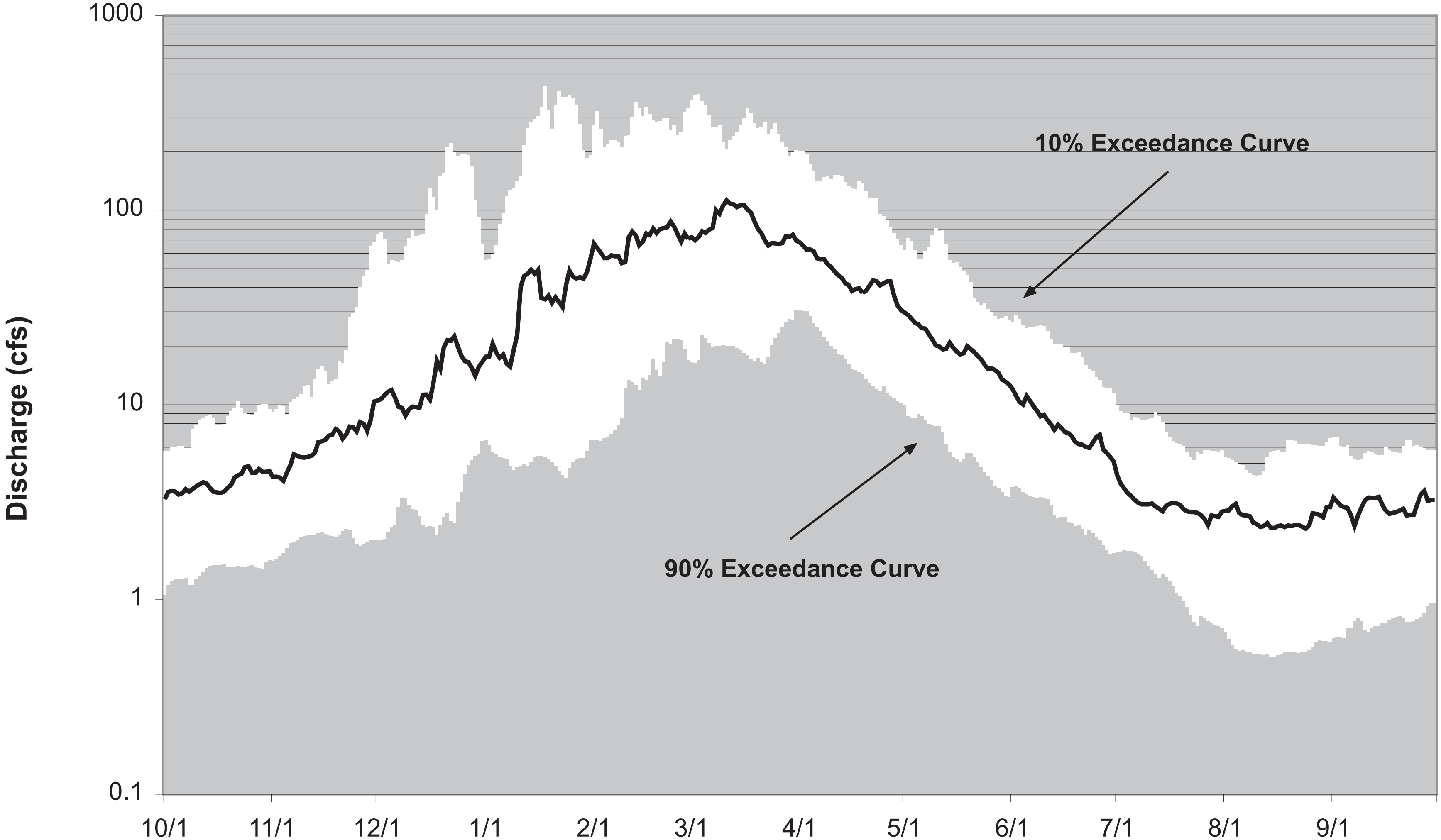
FIGURE **3-10b**

PARADISE CREEK AT UNIVERSITY OF IDAHO AT MOSCOW (USGS STN. 13346800)
EXCEEDANCE CURVES

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg106.fh11 DATE 11/05/04 DRAWN BY AMP

Golder Associates



LEGEND

10% Exceedance
50% Exceedance
90% Exceedance

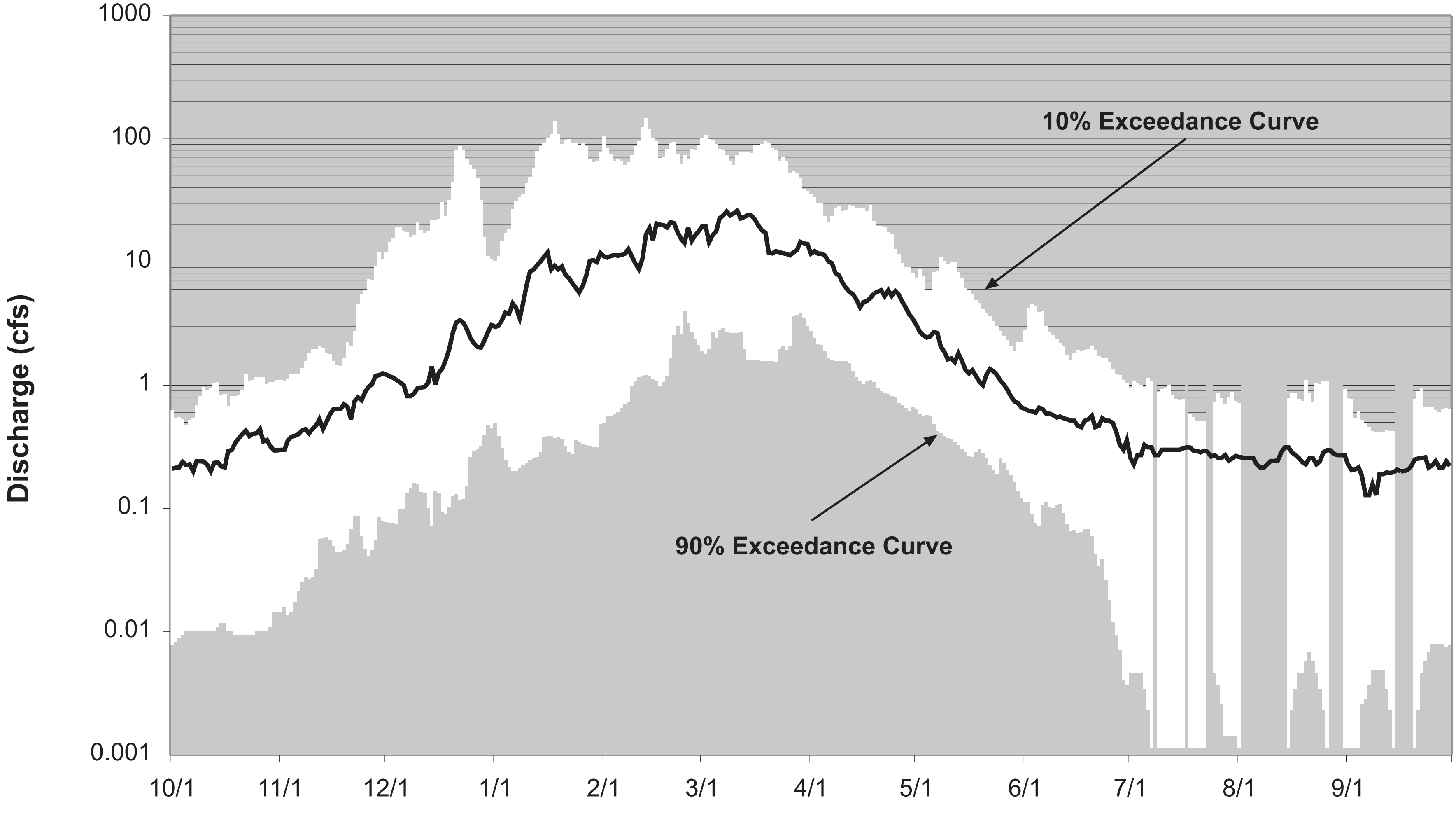
Exceedance Data Based on Running 7-Day Daily Average

Period of Record: 30 Years within 1934-1942, 1960-1981 & 2001-2002

FIGURE **3-10c**

SOUTH FORK PALOUSE RIVER AT PULLMAN (USGS STN. 13348000) EXCEEDANCE CURVES

PCD/WRIA 34 WATERSHED PLANNING/WA



LEGEND

10% Exceedance

50% Exceedance

90% Exceedance

Exceedance Data Based on Running 7-Day Daily Average

Period of Record: 17 Years within 1953-1971

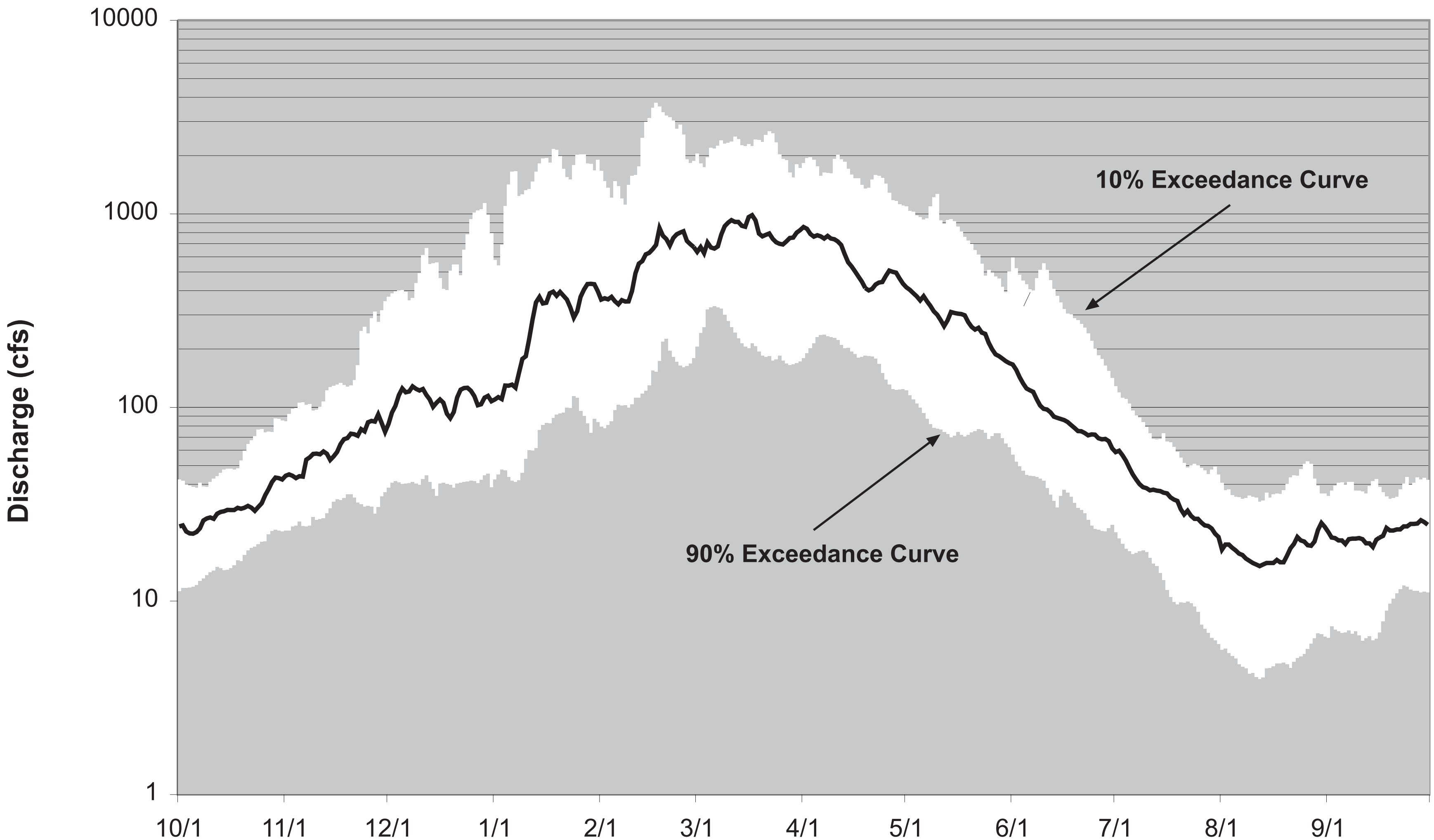
Note: Irregularities in July-September 90% exceedance due to zero flow values.

FIGURE **3-10d**

MISSOURI FLAT CREEK AT PULLMAN (USGS STN. 13348500)
EXCEEDANCE CURVES
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg61.fh11 DATE 11/05/04 DRAWN BY AMP

Golder Associates



LEGEND

10% Exceedance

50% Exceedance

90% Exceedance

Exceedance Data Based on Running 7-DayDaily Average

Period of Record: 29 Years within 1963-1973 & 1975-1995

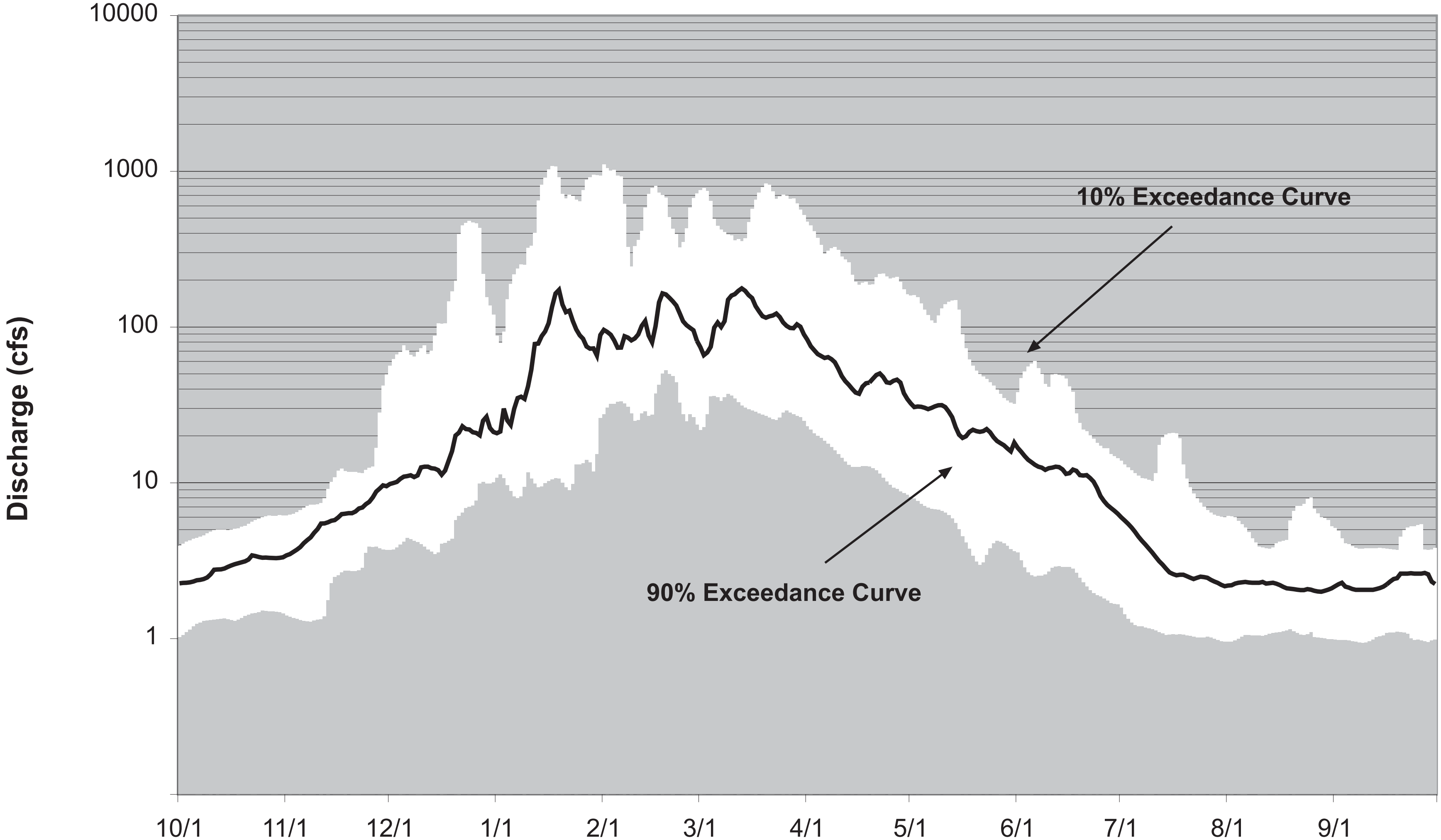
FIGURE **3-10e**

PALOUSE RIVER BELOW SOUTH FORK AT COLFAX (USGS STN. 13349210) EXCEEDANCE CURVES

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg62.fh11 DATE 11/05/04 DRAWN BY AMP

Golder Associates



LEGEND

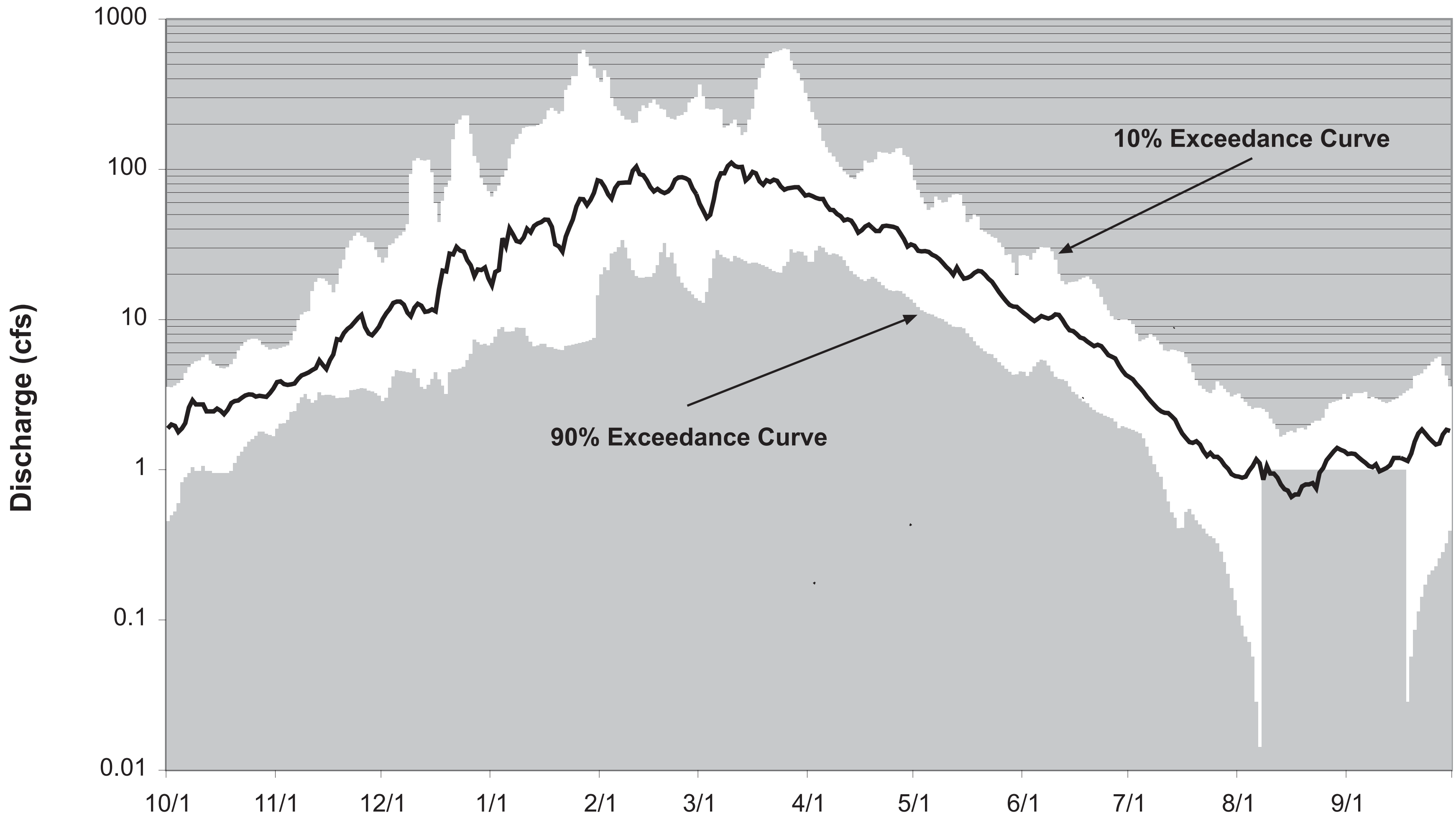
10% Exceedance
50% Exceedance
90% Exceedance
Exceedance Data Based on Running
7-DayDaily Average

Period of Record: 14 Years within 1961-1975

FIGURE **3-10f**
PINE CREEK AT PINE CITY (USGS STN. 13349400) EXCEEDANCE CURVES
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg63.fh11 DATE 11/05/04 DRAWN BY AMP

Golder Associates



LEGEND

10% Exceedance
50% Exceedance
90% Exceedance

Exceedance Data Based on Running 7-DayDaily Average

Period of Record: 17 Years within 1953-1971

Note: 90% exceedance values = 0 for August 8- September 17

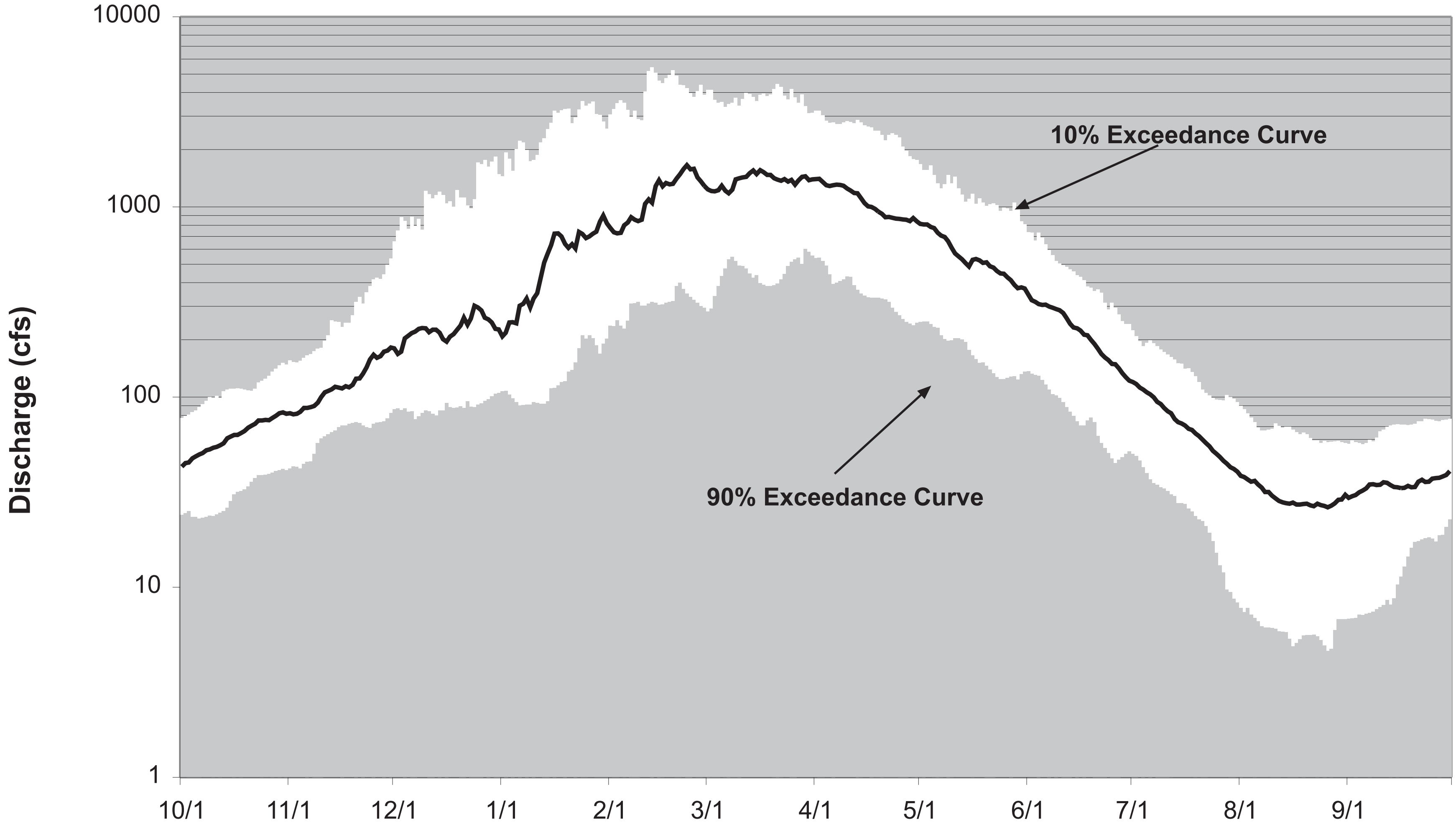
FIGURE **3-10g**

UNION FLAT CREEK NEAR COLFAX (USGS STN. 13350500) EXCEEDANCE CURVES

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg64.fh11 DATE 11/05/04 DRAWN BY AMP

Golder Associates



LEGEND

10% Exceedance

50% Exceedance

90% Exceedance

Exceedance Data Based on Running 7-DayDaily Average

Period of Record: 61 Years within 1897-1916 & 1951-2002

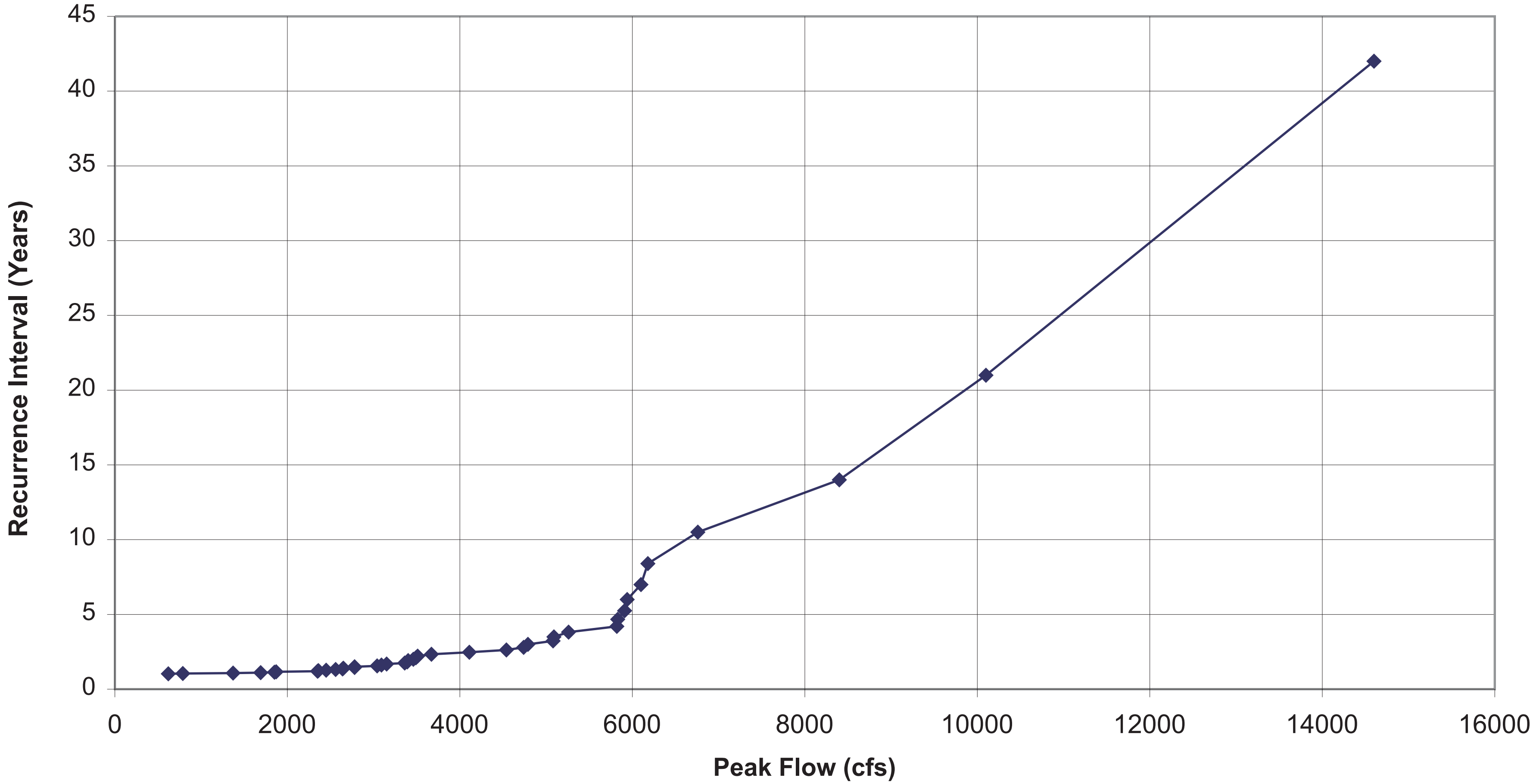
FIGURE **3-10h**

PALOUSE RIVER AT HOOPER (USGS STN. 13351000) EXCEEDANCE CURVES

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg65.fh11 DATE 11/07/04 DRAWN BY EL

Golder Associates



LEGEND

Recurrence Interval

Period of Record: 1915-1919 & 1966-2002

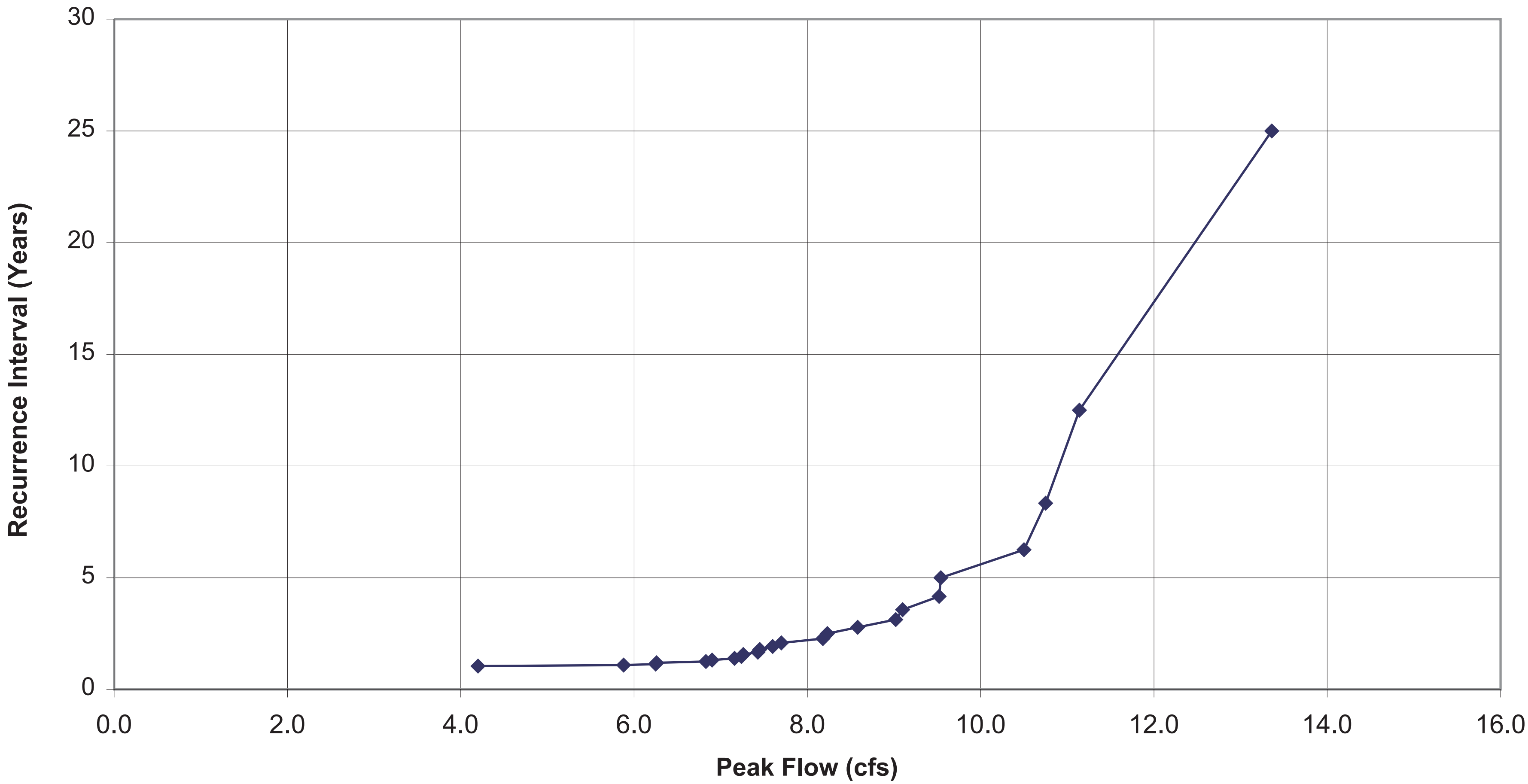
FIGURE **3-11a**

PALOUSE RIVER NEAR POTLATCH (USGS STN. 13345000)
PEAK FLOW RECURRENCE INTERVAL

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg66.fh11 DATE 11/05/04 DRAWN BY AMP

Golder Associates



LEGEND

Recurrence Interval

Period of Record: 1956-1979

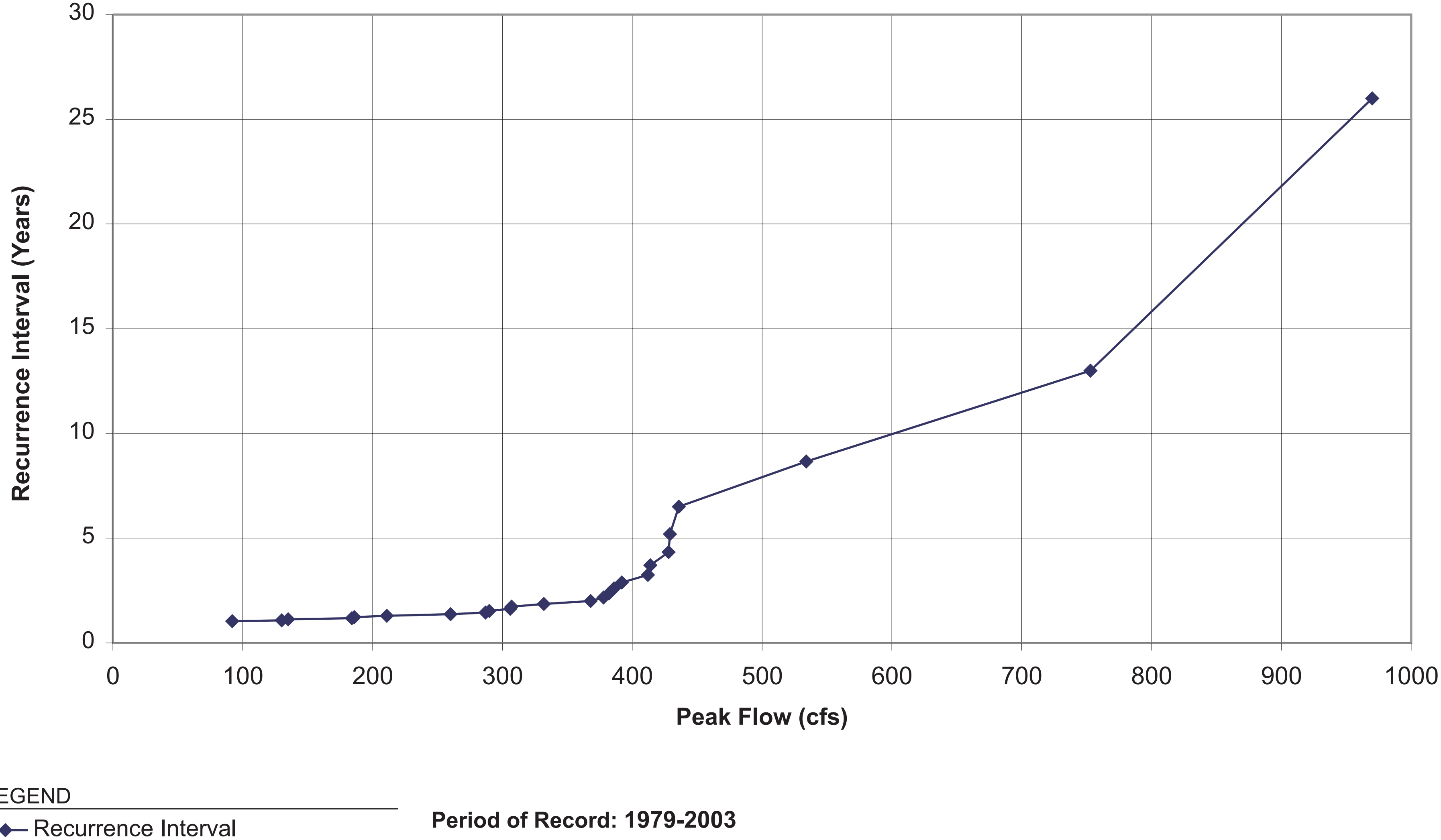
FIGURE **3-11b**

PALOUSE RIVER AT COLFAX (USGS STN. 13346100) PEAK FLOW RECURRENCE INTERVAL

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg67.fh11 DATE 11/05/04 DRAWN BY AMP

Golder Associates



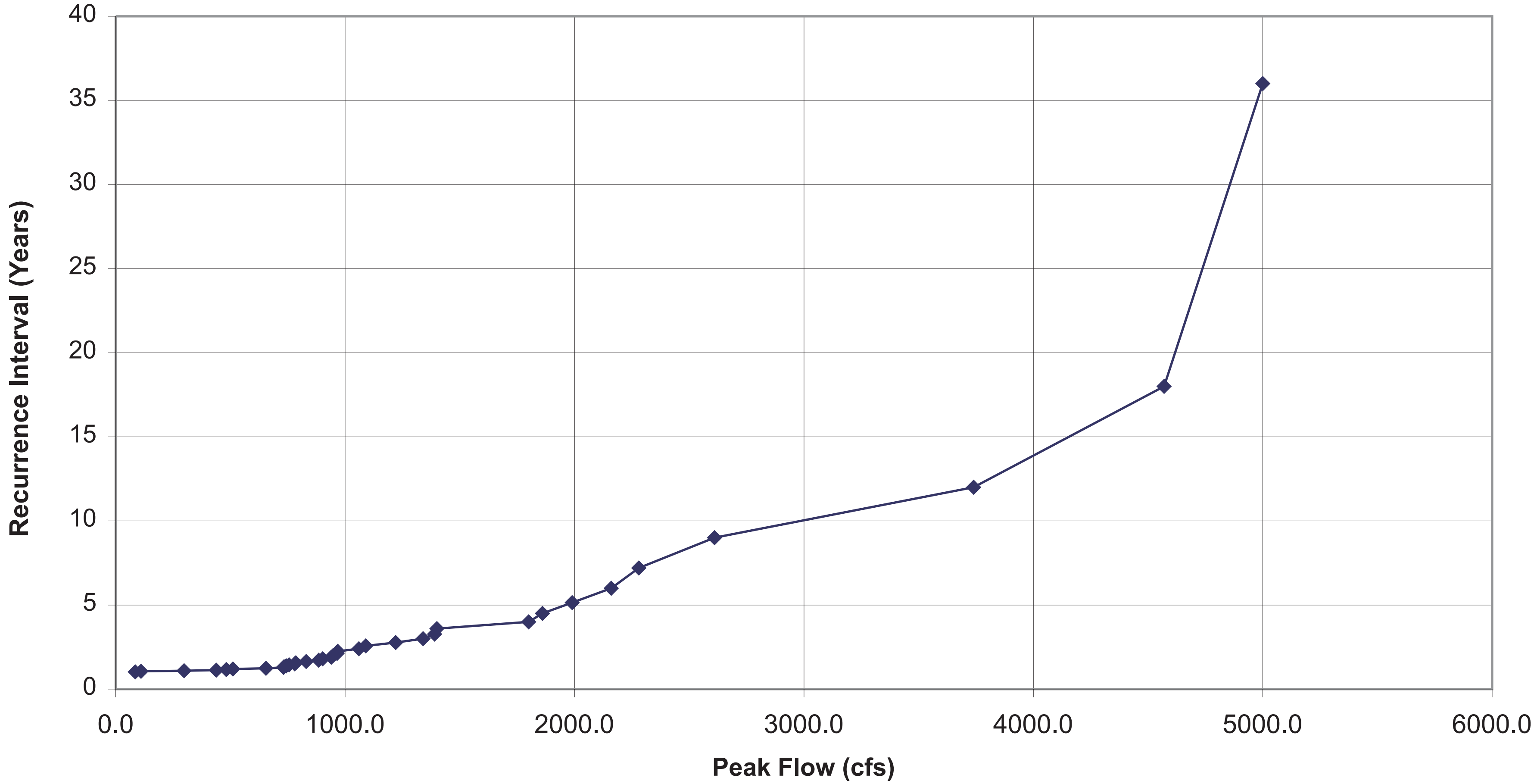
Period of Record: 1979-2003

FIGURE **3-11c**

PARADISE CREEK AT UNIVERSITY OF IDAHO AT MOSCOW (USGS STN. 13346800)
PEAK FLOW RECURRENCE INTERVAL
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg107.fh11 DATE 11/05/04 DRAWN BY AMP

Golder Associates



LEGEND

Recurrence Interval

Period of Record: 1934-1942, 1948, 1959-1981 & 2002

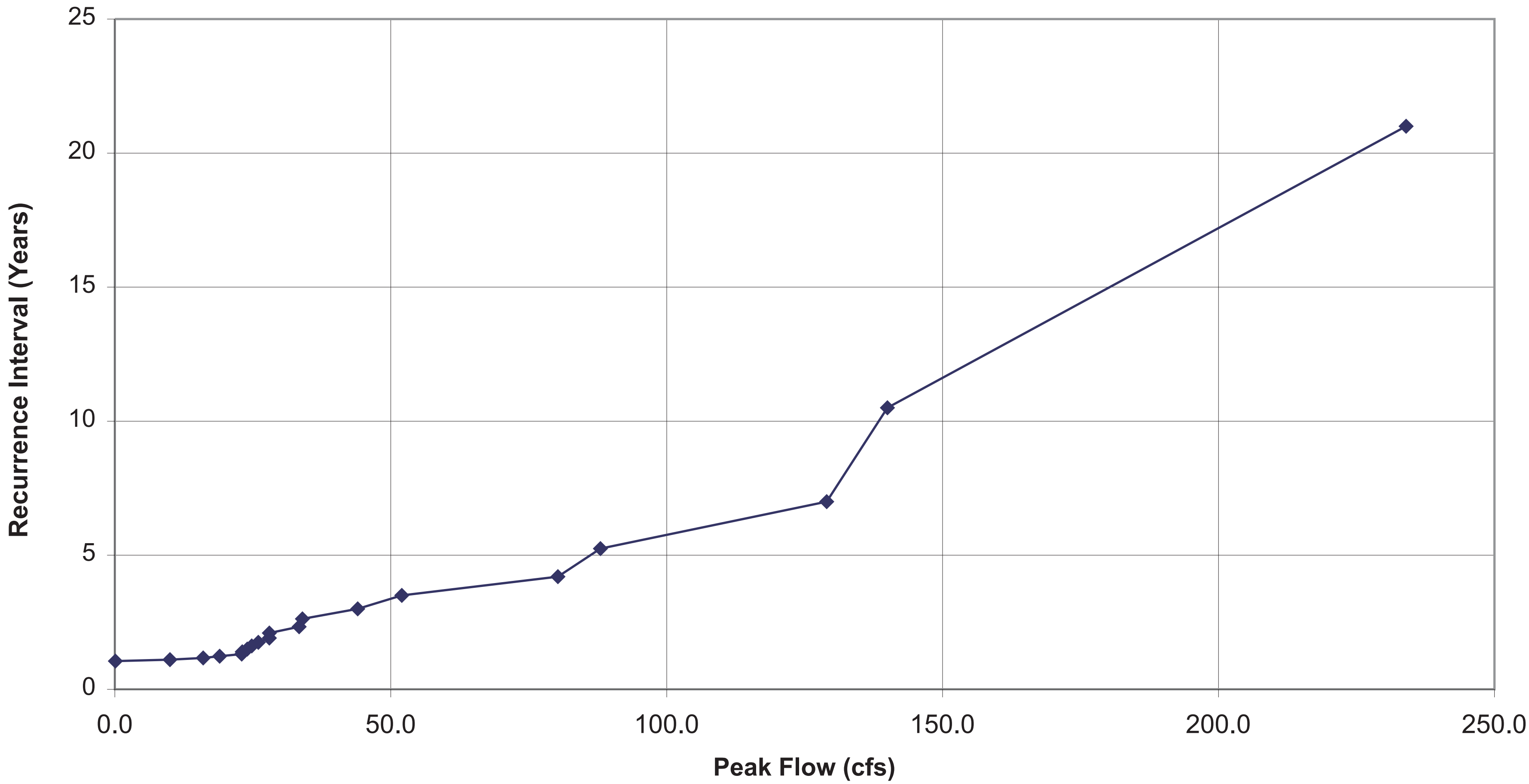
FIGURE **3-11d**

SOUTH FORK PALOUSE RIVER AT PULLMAN (USGS STN. 13348000)
PEAK FLOW RECURRENCE INTERVAL

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg68.fh11 DATE 11/05/04 DRAWN BY AMP

Golder Associates



LEGEND

Recurrence Interval

Period of Record: 1955-1974

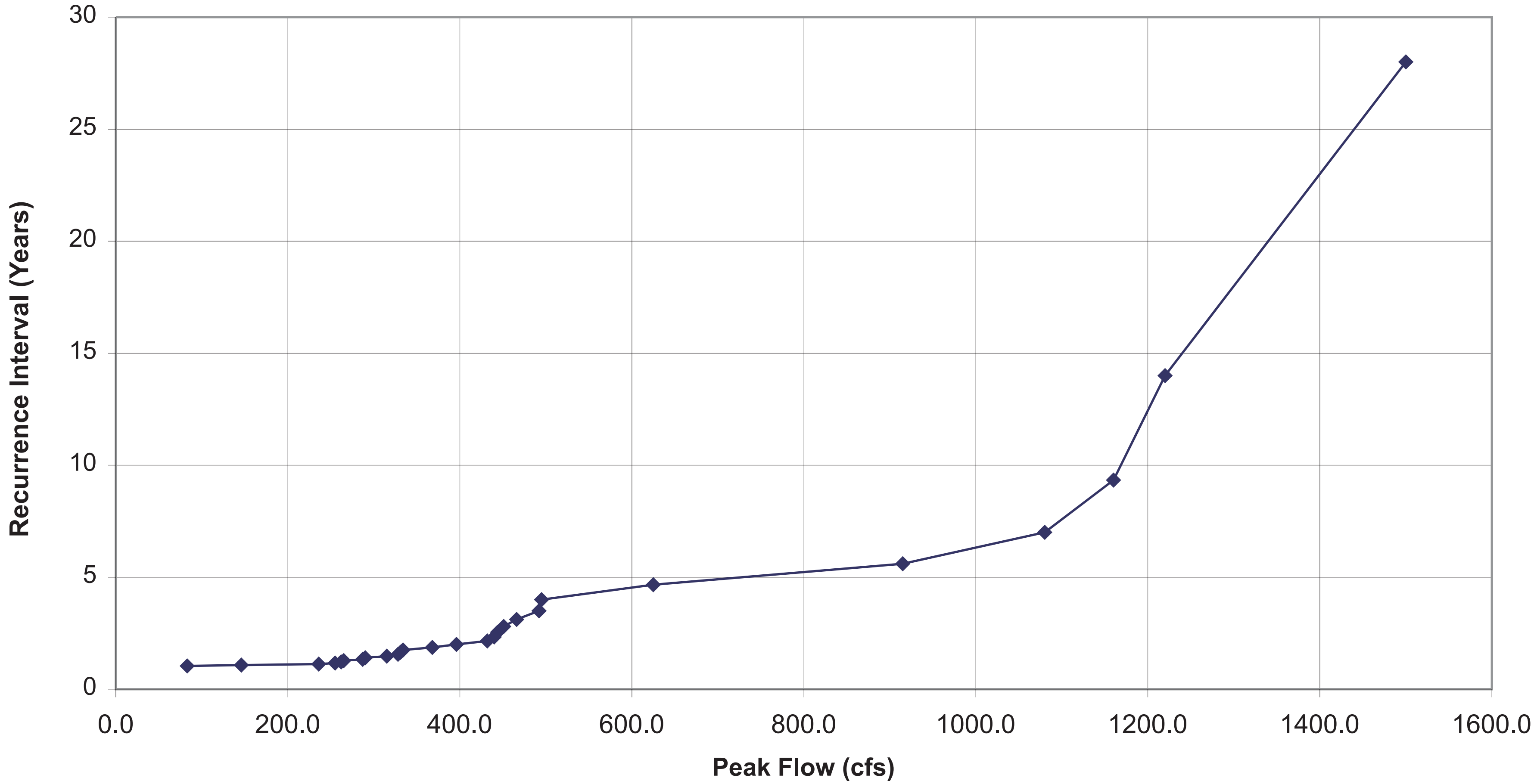
FIGURE **3-11e**

MISSOURI FLAT CREEK TRIBUTARY NEAR PULLMAN (USGS STN. 13348400)
PEAK FLOW RECURRENCE INTERVAL

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg69.fh11 DATE 03/25/04 DRAWN BY AMP

Golder Associates



LEGEND

Recurrence Interval

Period of Record: 1935-1940, 1948 & 1960-1979

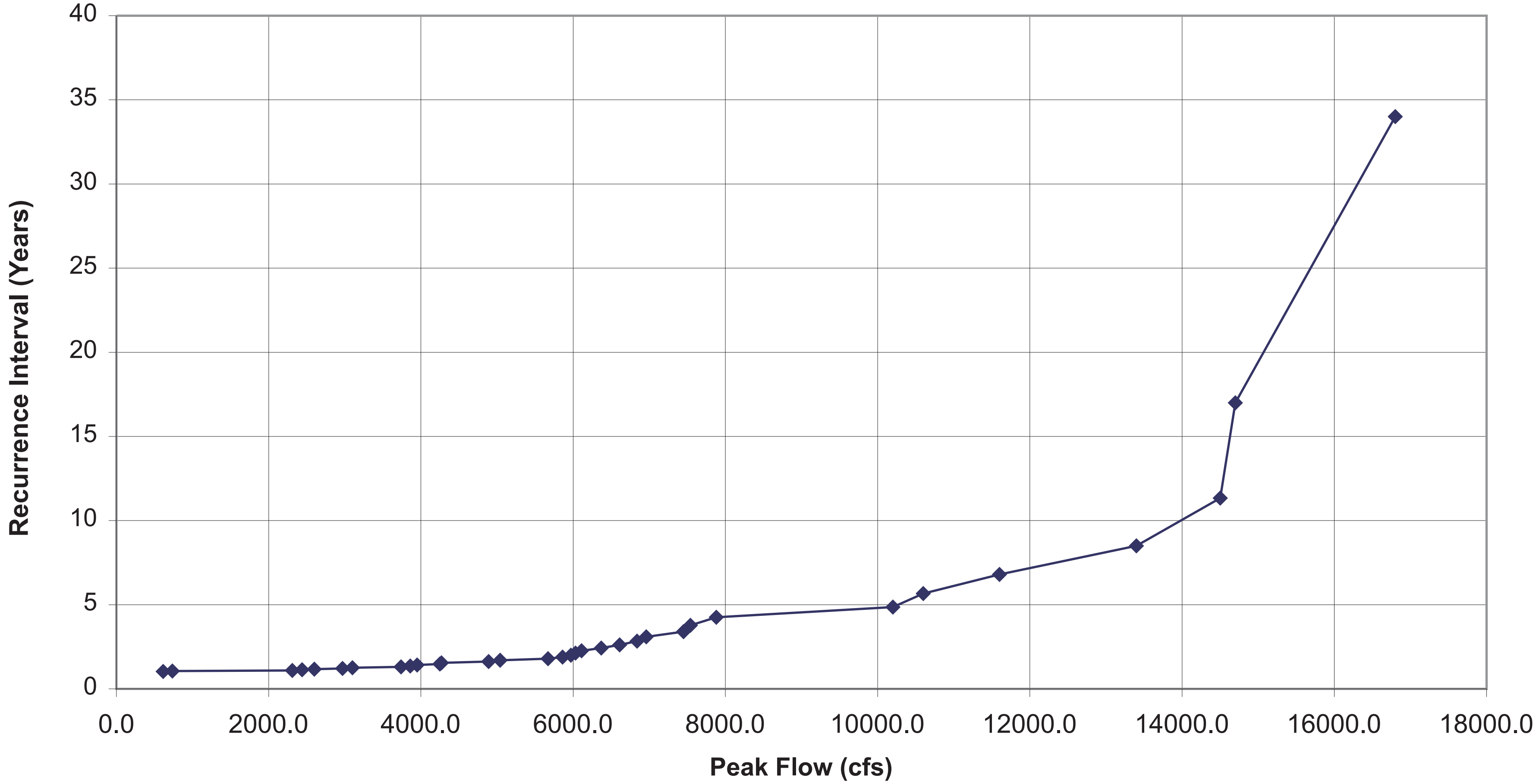
FIGURE **3-11f**

MISSOURI FLAT CREEK AT PULLMAN (USGS STN. 13348500)
PEAK FLOW RECURRENCE INTERVAL

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg70.fh11 DATE 11/05/04 DRAWN BY AMP

Golder Associates



LEGEND

Recurrence Interval

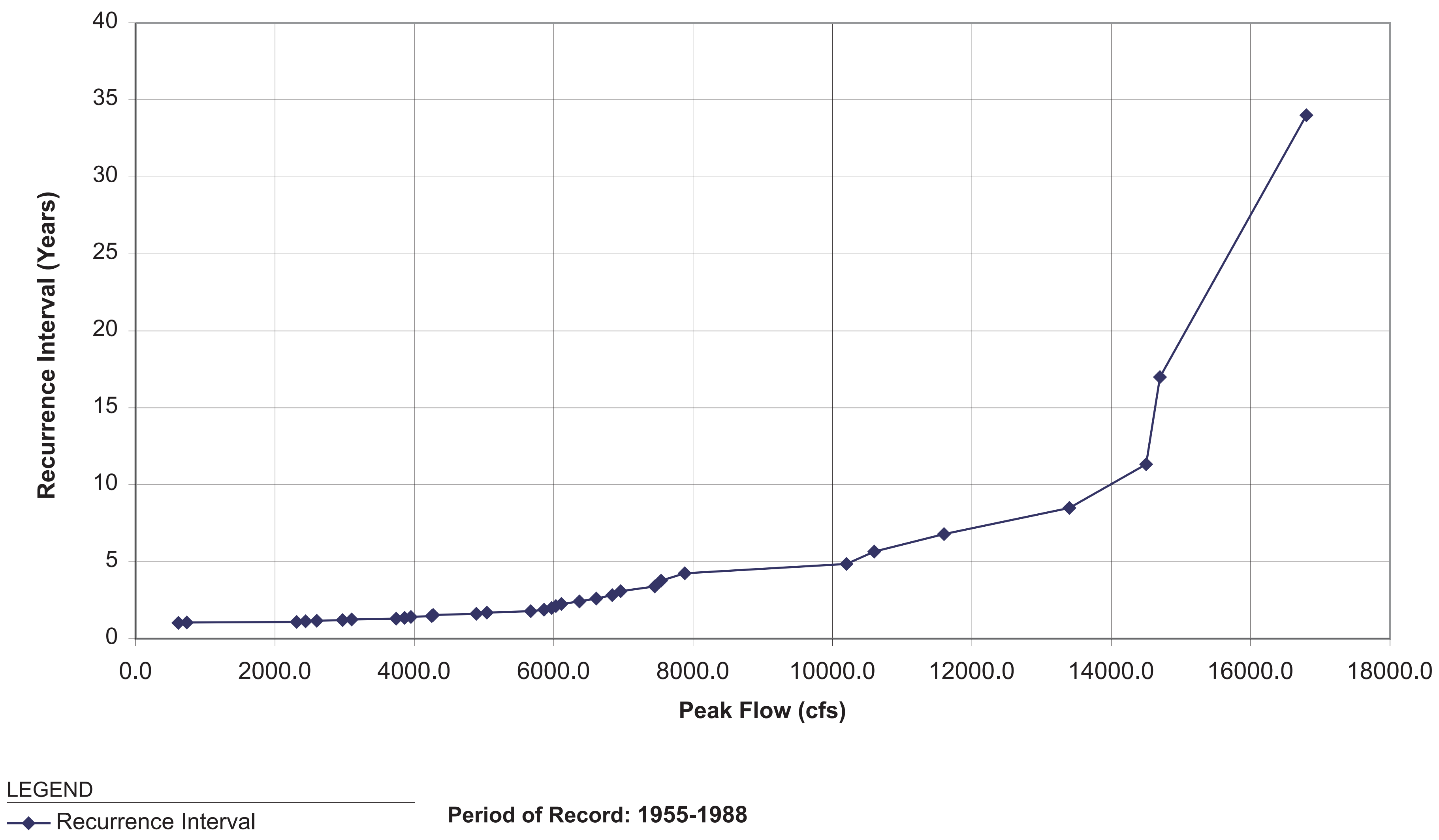
Period of Record: 1963-1995

FIGURE **3-11g**

PALOUSE RIVER BELOW SOUTH FORK AT COLFAX (USGS STN. 13349210)
PEAK FLOW RECURRENCE INTERVAL
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg71.fh11 DATE 11/05/04 DRAWN BY AMP

Golder Associates



Period of Record: 1955-1988

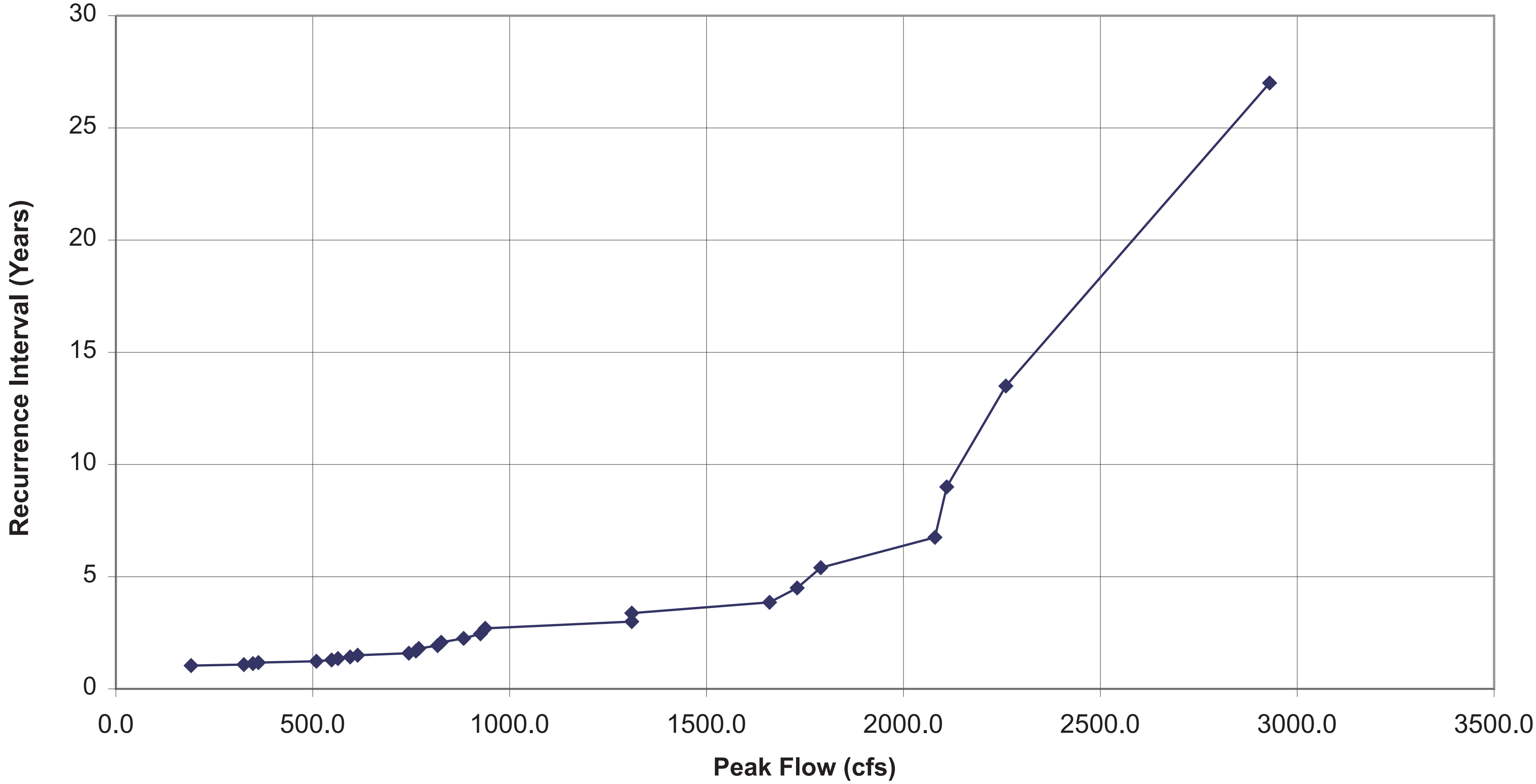
FIGURE **3-11h**

PALOUSE RIVER TRIBUTARY AT COLFAX (USGS STN. 13349300)
PEAK FLOW RECURRENCE INTERVAL

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg72.fh11 DATE 11/05/04 DRAWN BY AMP

Golder Associates



LEGEND

Recurrence Interval

Period of Record: 1954-1979

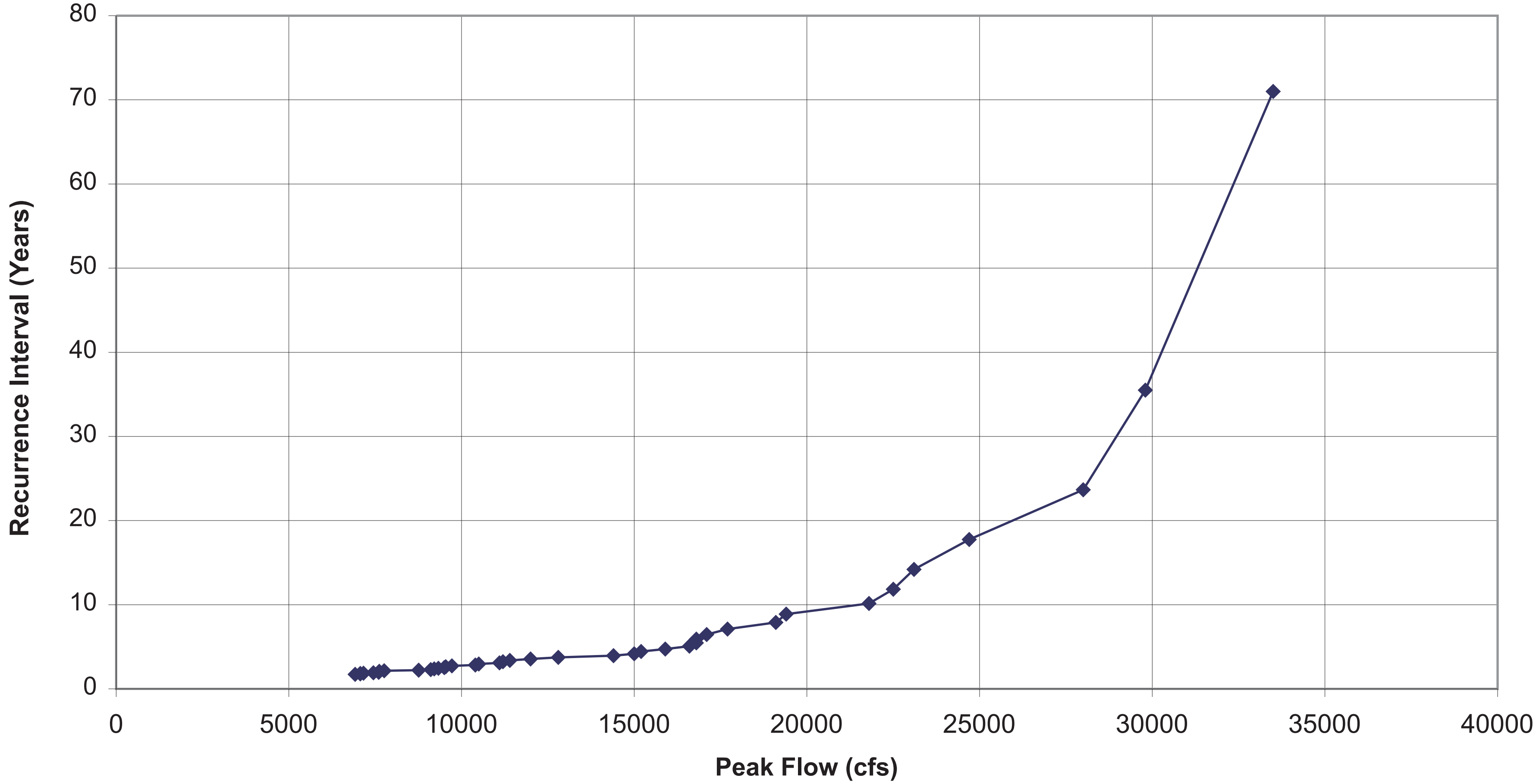
FIGURE **3-11i**

UNION FLAT CREEK NEAR COLFAX (USGS STN. 13350500)
PEAK FLOW RECURRENCE INTERVAL

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg73.fh11 DATE 11/05/04 DRAWN BY AMP

Golder Associates



LEGEND

Recurrence Interval

Period of Record: 1898-1899, 1901-1907, 1909-1916, 1948 & 1951-2002

FIGURE **3-11j**

PALOUSE RIVER AT HOOPER (USGS STN. 13351000)
PEAK FLOW RECURRENCE INTERVAL

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg74.fh11 DATE 12/03/04 DRAWN BY EL

Golder Associates

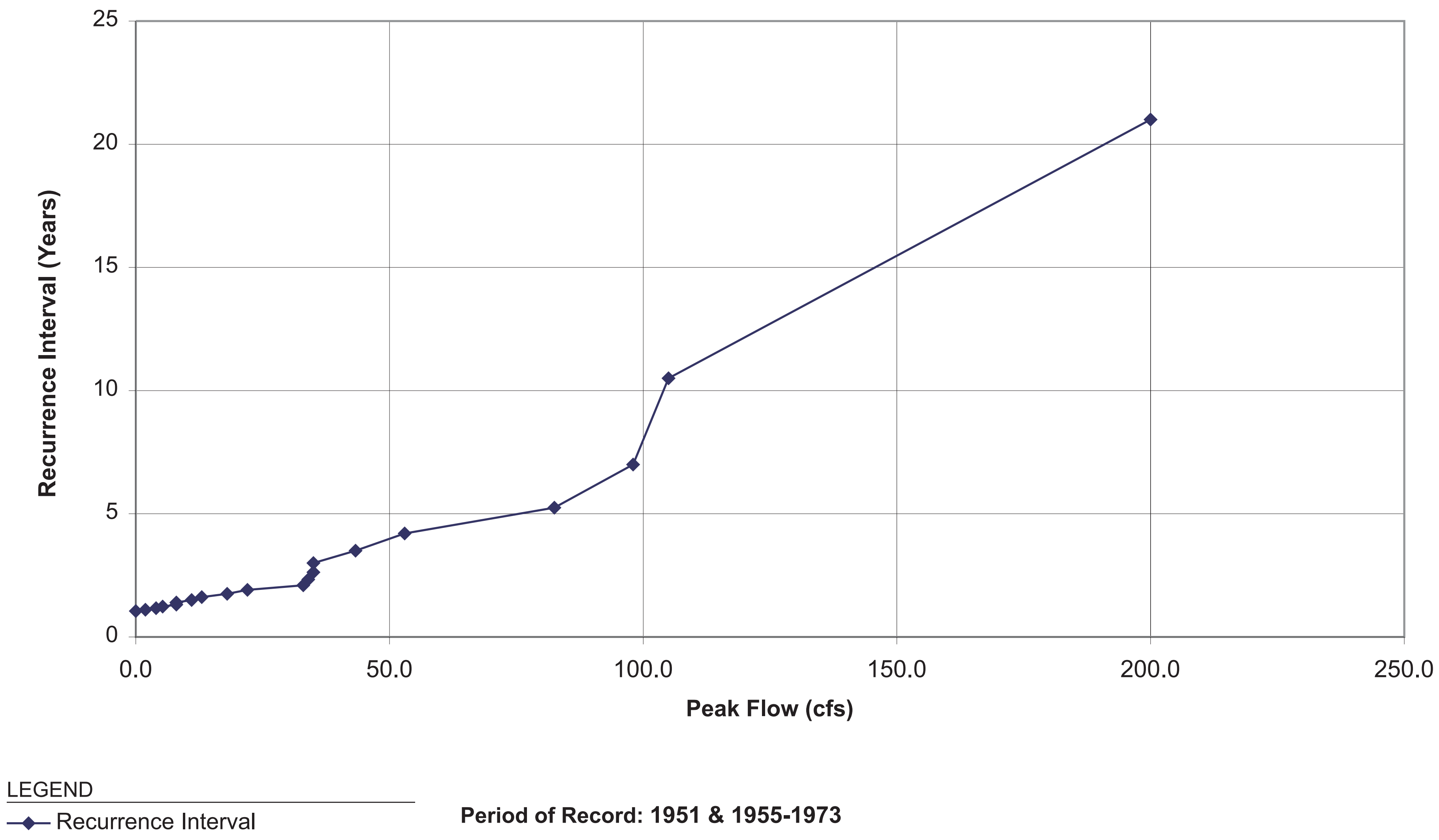
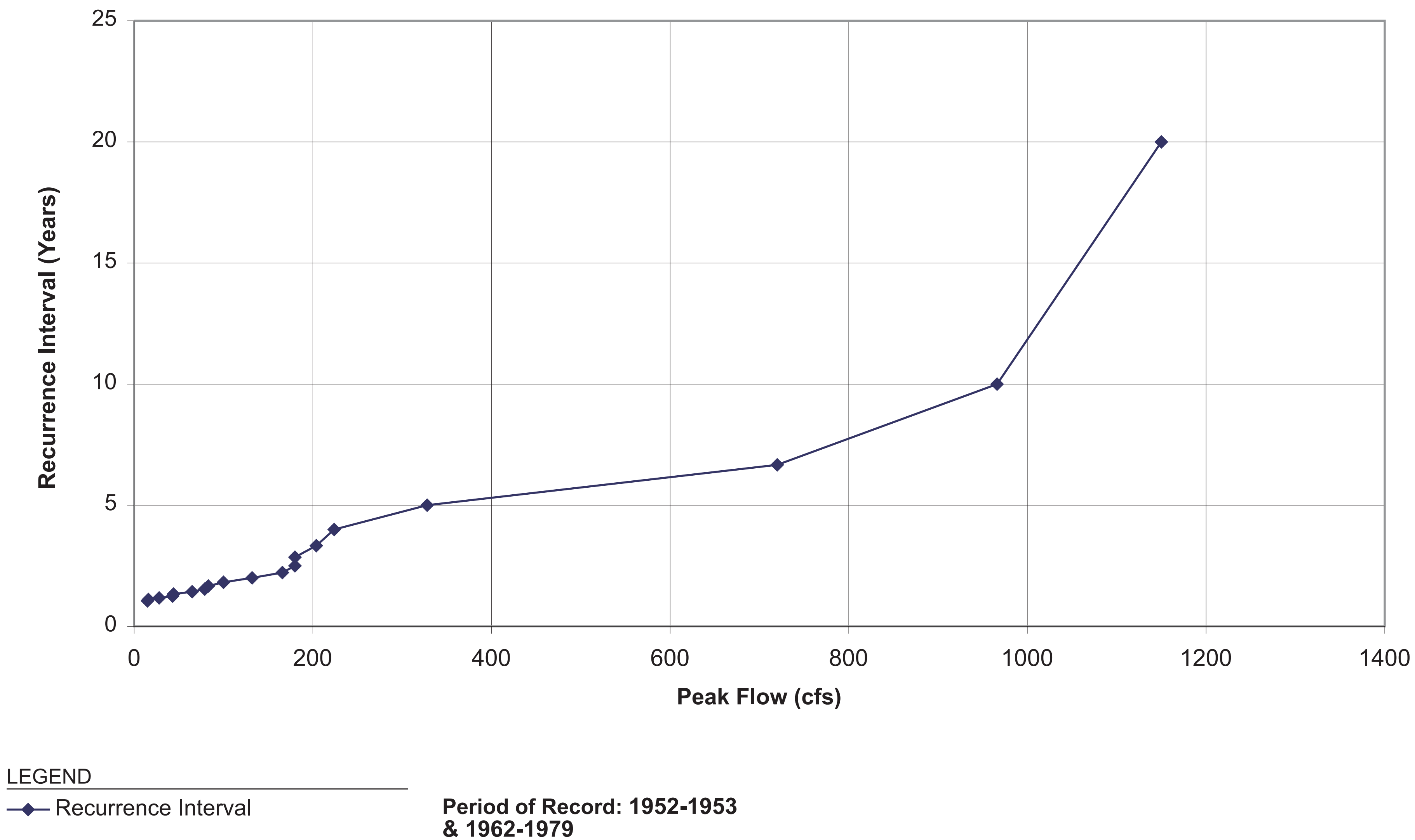


FIGURE **3-11k**

COW CREEK TRIBUTARY NEAR RITZVILLE (USGS STN. 13352200)
PEAK FLOW RECURRENCE INTERVAL
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg75.fh11 DATE 12/03/04 DRAWN BY EL

Golder Associates



Period of Record: 1952-1953 & 1962-1979

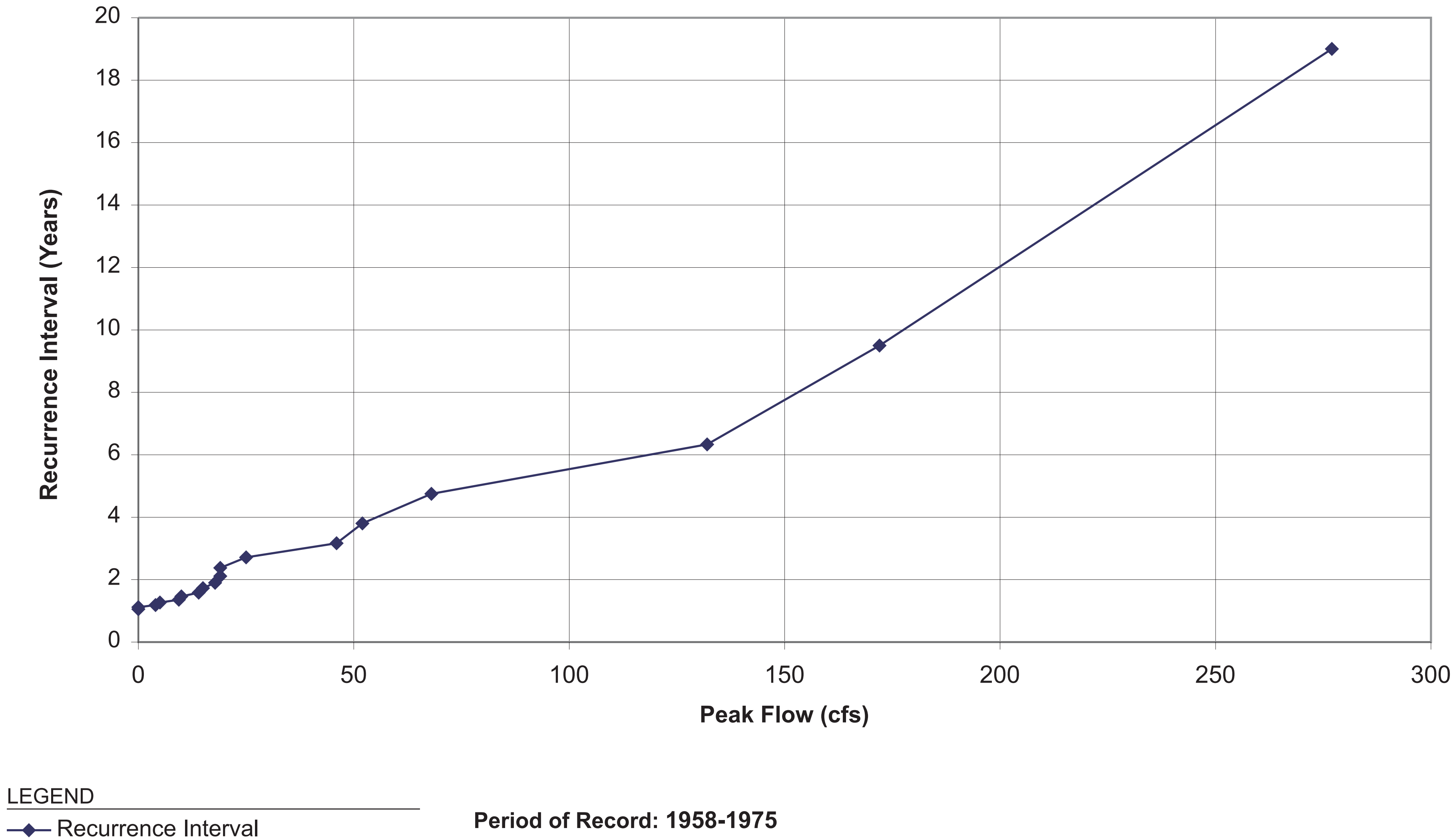
FIGURE **3-11I**

COW CREEK AT HOOPER (USGS STN. 13352500)
PEAK FLOW RECURRENCE INTERVAL

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg76.fh11 DATE 11/05/04 DRAWN BY AMP

Golder Associates



Period of Record: 1958-1975

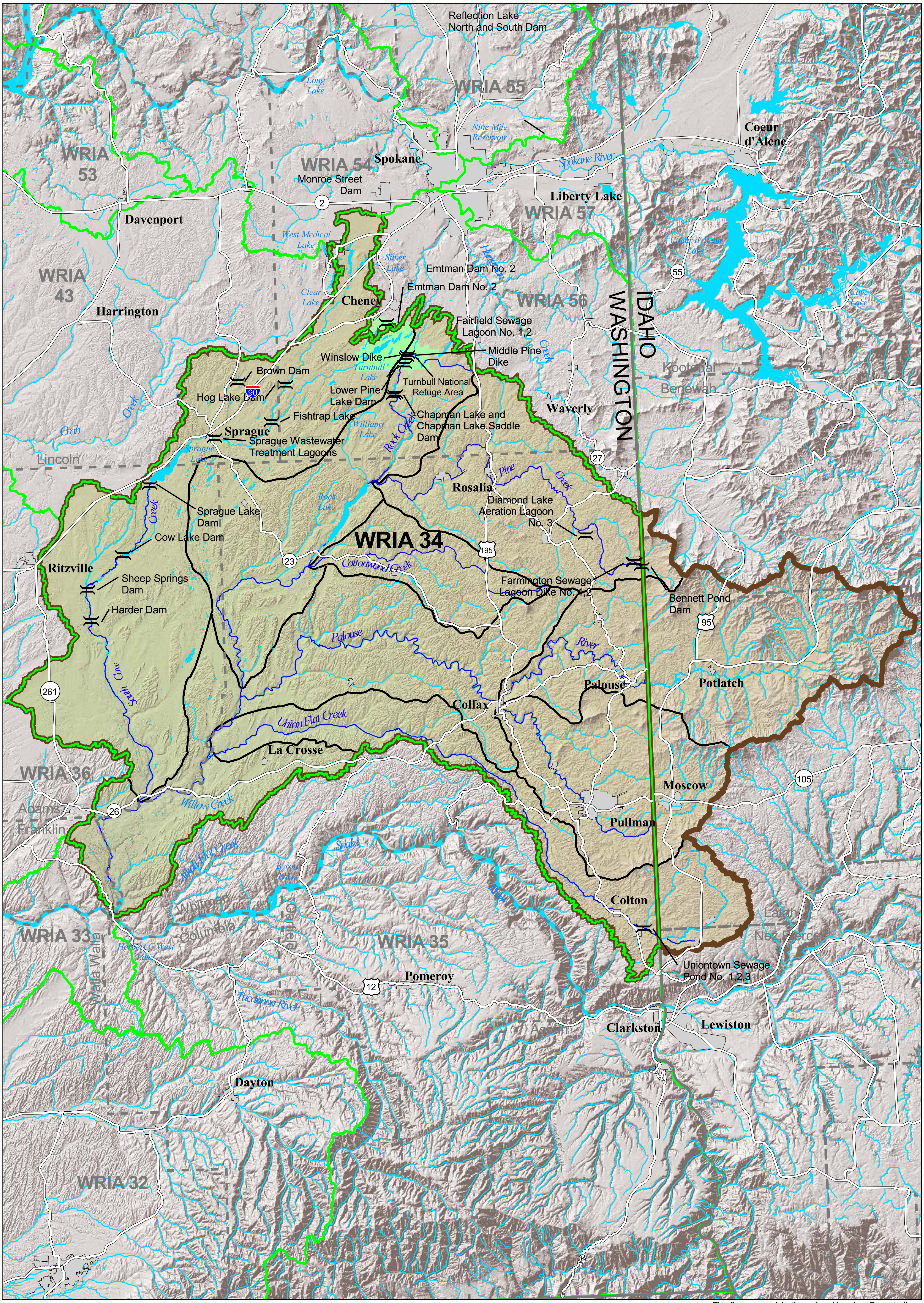
FIGURE **3-11m**

STEWART CANYON TRIBUTARY NEAR RIPARIA (USGS GAGE 13352550)
PEAK FLOW RECURRENCE INTERVAL

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg77.fh11 DATE 11/05/04 DRAWN BY AMP

Golder Associates



LEGEND

- Palouse Watershed Boundary
- WRIA Boundary
- Subbasin Boundary
- National Wildlife Refuge
- Community
- Waterbody
- County Boundary
- Dam
- Road
- Stream

0 50,000

Scale 1" = 50,000 Feet

Map Projection:
Washington State Plane
South Zone, NAD 83, Feet

Source: WSDOE, WSDOT,
USGS, INSIDE Idaho,
GIS Data Depot

N

DRAFT

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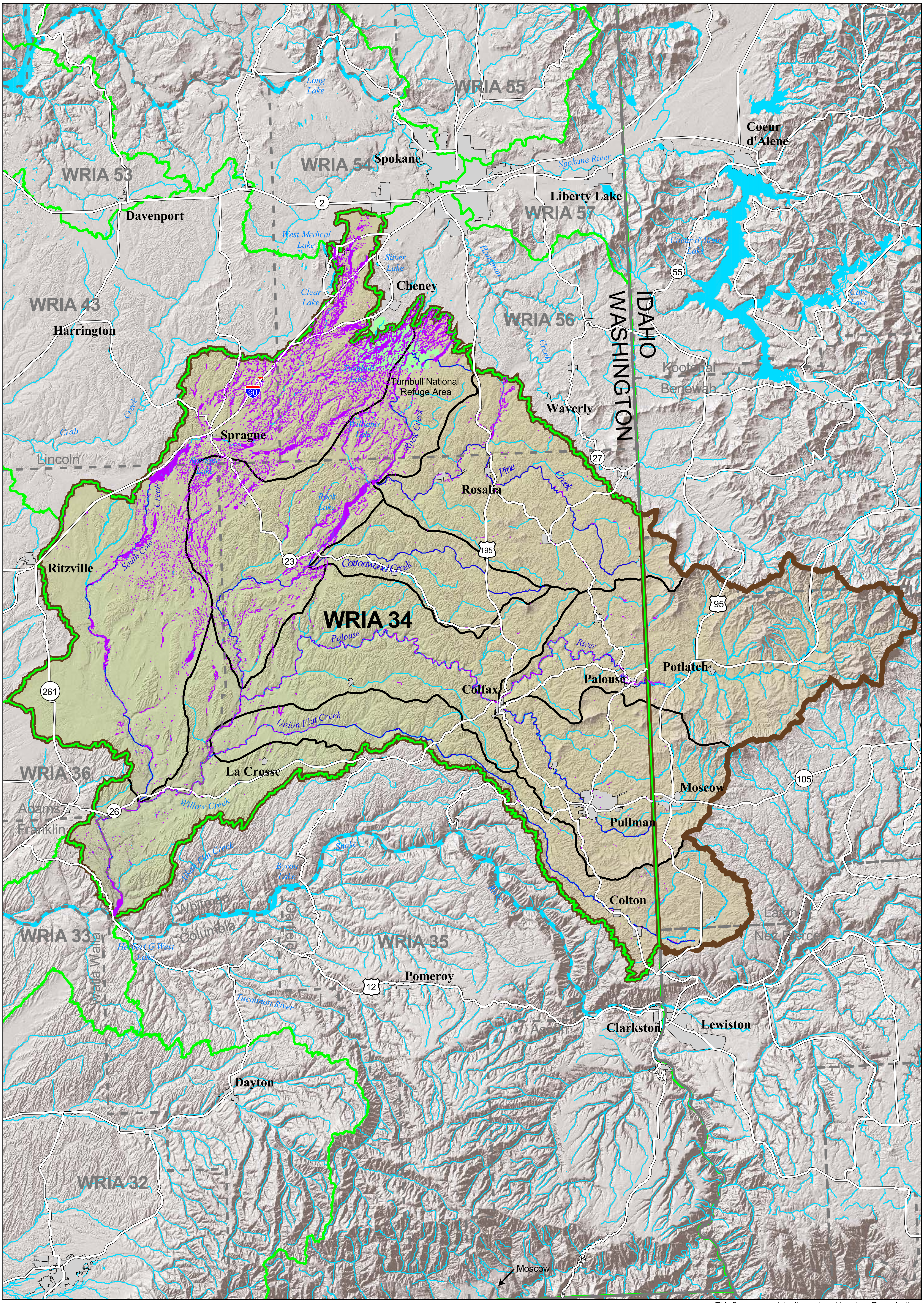
DAMS

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: KAV	Revision: 3	Date: Dec. 7, 2004	Figure: 3-12

04310641030_012804.apr

Golder Associates



LEGEND

- Palouse Watershed Boundary
- WRIA Boundary
- Subbasin Boundary
- National Wildlife Refuge
- Community
- Waterbody
- County Boundary
- Wetland Area
- Road
- Stream

0 50,000
Scale 1" = 50,000 Feet

Map Projection:
Washington State Plane
South Zone, NAD 83, Feet

Source: WSDOE, WSDOT,
USGS, INSIDE Idaho,
GIS Data Depot,
NWI 1:24K, (1971-1997)

DRAFT

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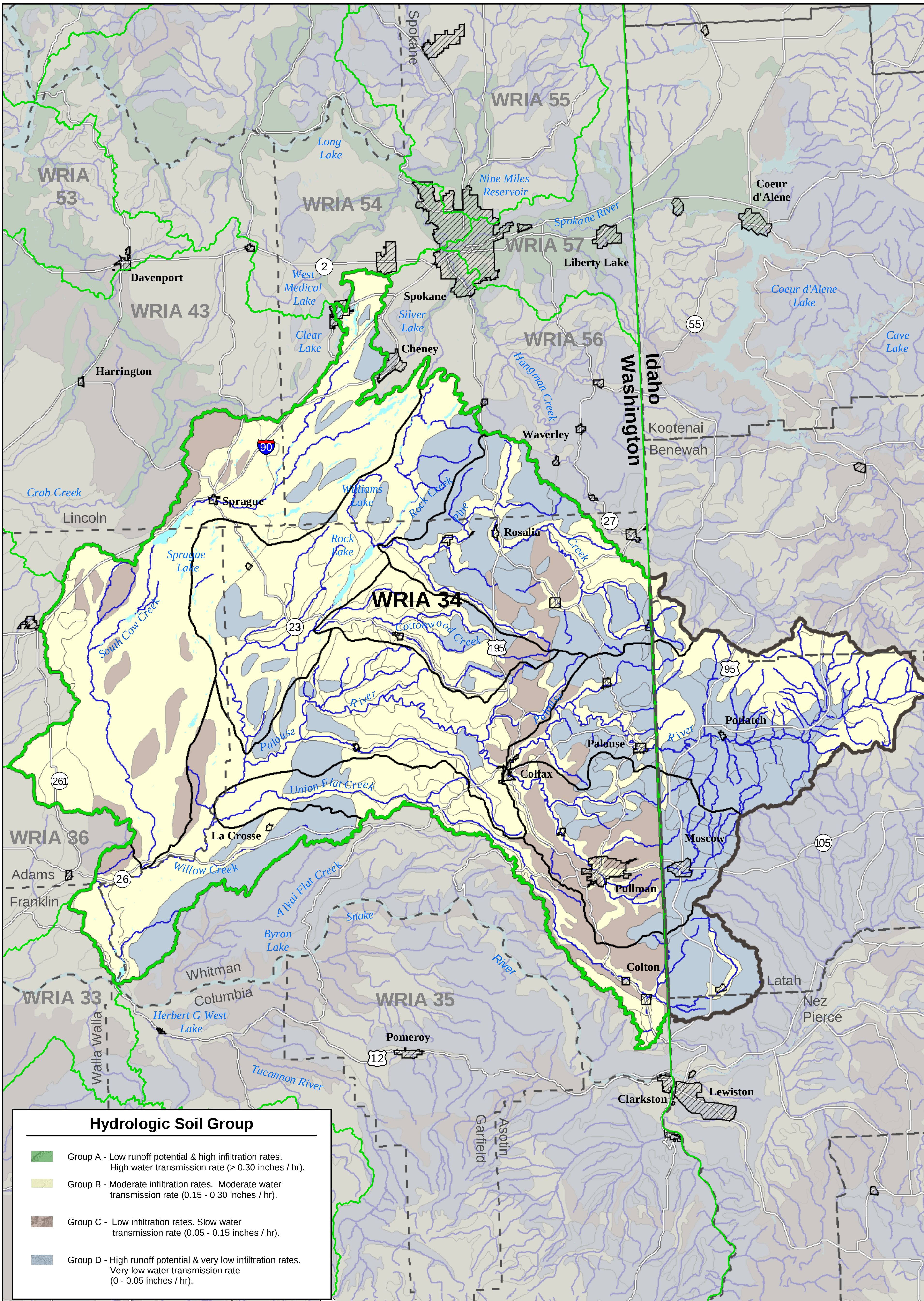
WETLAND AREAS

WRIA 34 WATERSHED PLANNING/WA

Drawn: KAV	Revision: 4	Date: Dec. 7, 2004	Figure: 3-13

04310641030_012804.apr

Golder Associates



LEGEND

- Palouse Watershed Boundary
- Subbasin Boundary
- WRIA Boundaries
- Lake
- River
- County Boundary
- Road
- Community

0 50,000

Scale 1" = 50,000 Feet

Map Projection:
Washington State Plane
South Zone, NAD 83, Feet

Source: WSDOE, WSDOT, USGS (STATSGO), INSIDE Idaho, USDA GIS Data Depot

N

DRAFT

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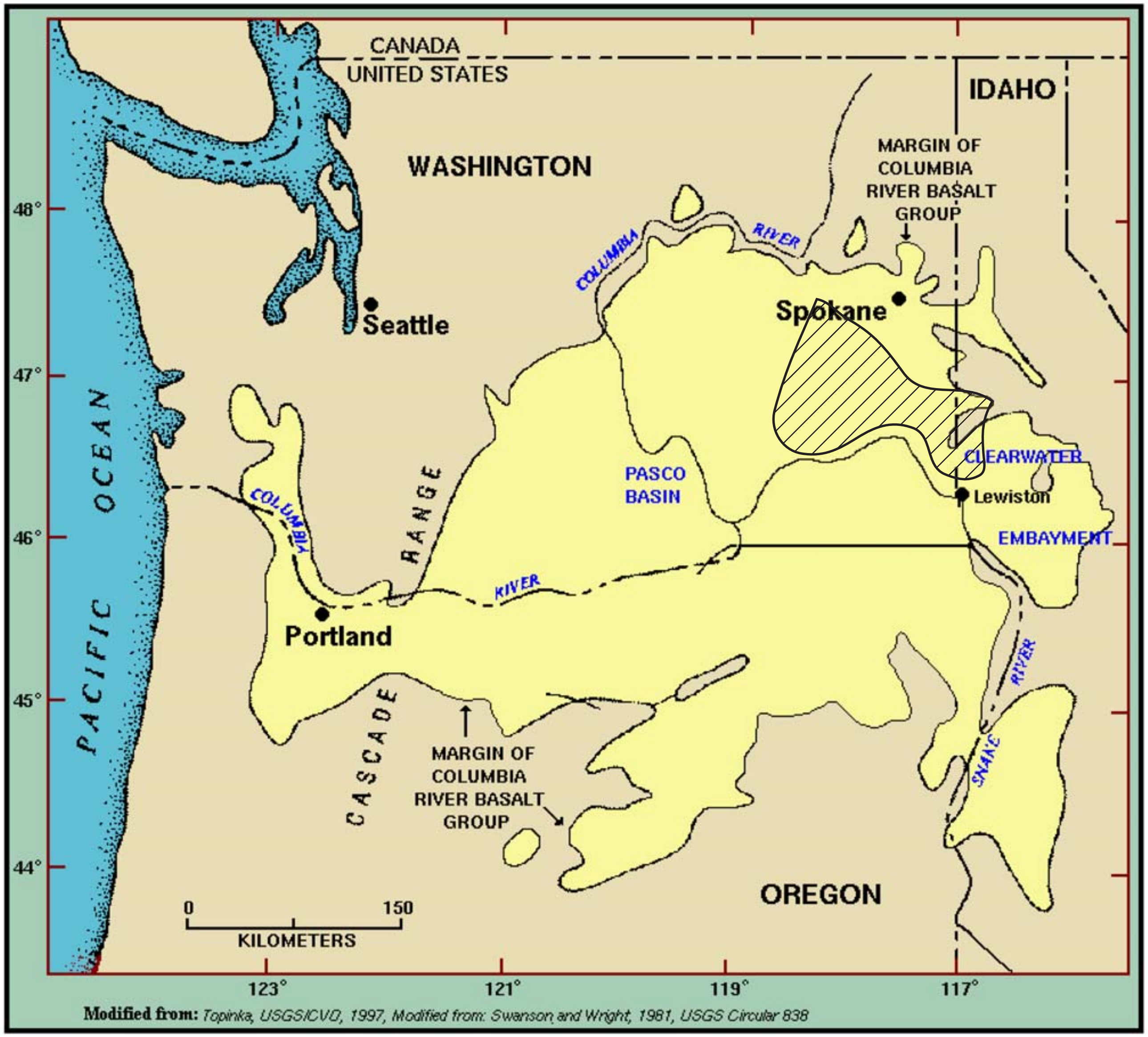
Hydrologic Soil Groups - STATSGO Database

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: KAV	Revision: 3	Date: Dec. 7, 2004	Figure: 3-14

04310641030_Soils_020804.mxd

Golder Associates



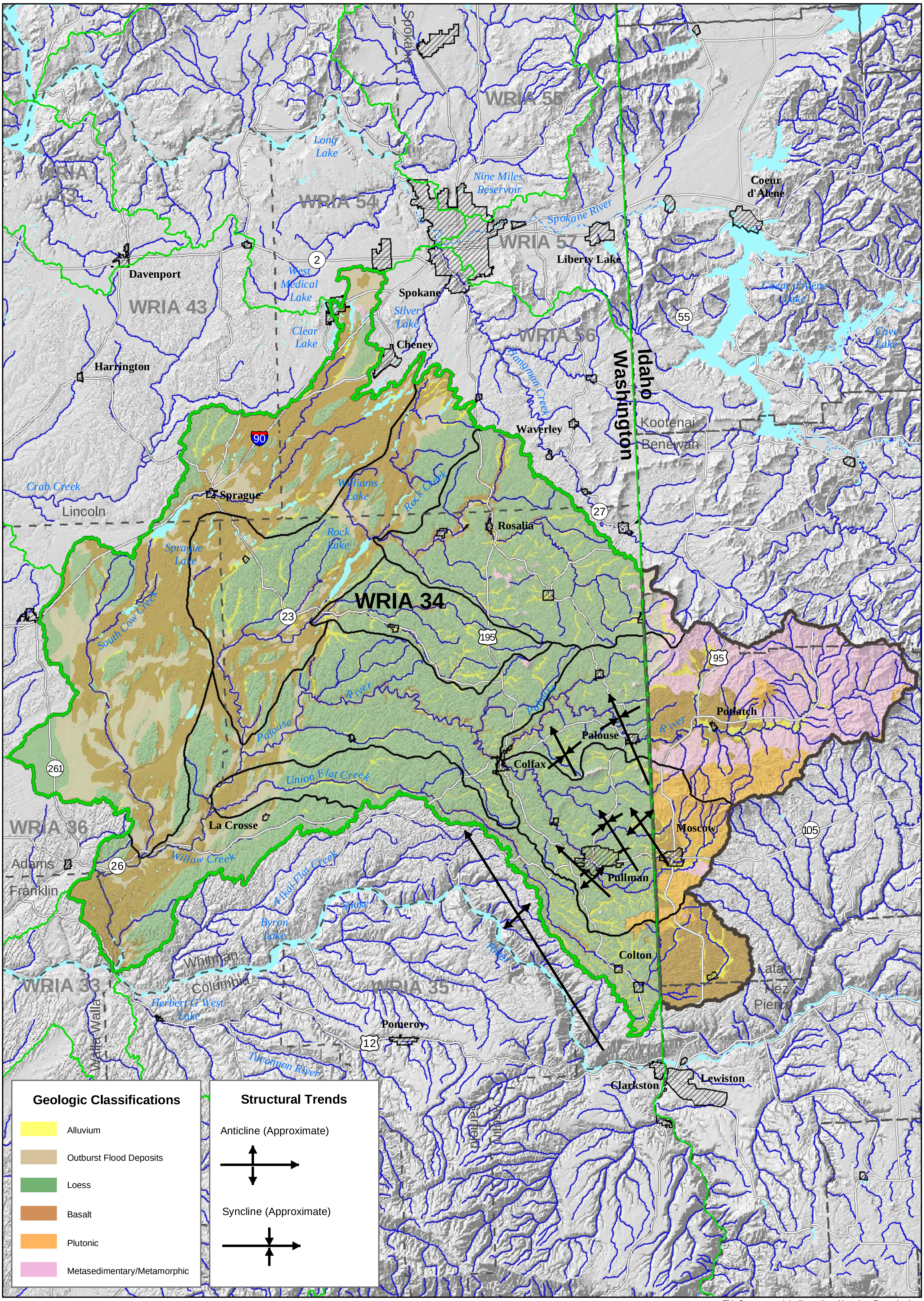
LEGEND

Generalized Extent of WRIA 34

FIGURE **4-1**
REGIONAL GEOLOGIC SETTING
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641020fg03.fh11 DATE 11/03/04 DRAWN BY AMP

Golder Associates



LEGEND

- Palouse Watershed Boundary
- Subbasin Boundary
- WRIA Boundaries
- Lake
- River
- County Boundary
- Road
- Community

0 50,000
Scale 1" = 50,000 Feet

Map Projection:
Washington State Plane
South Zone, NAD 83, Feet

Source: WSDOE, WSDOT, USGS
(Geology 1:250k), INSIDE Idaho (Geology 1:100k),
GIS Data Depot, WDNR (Geology 1:100k)

N

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

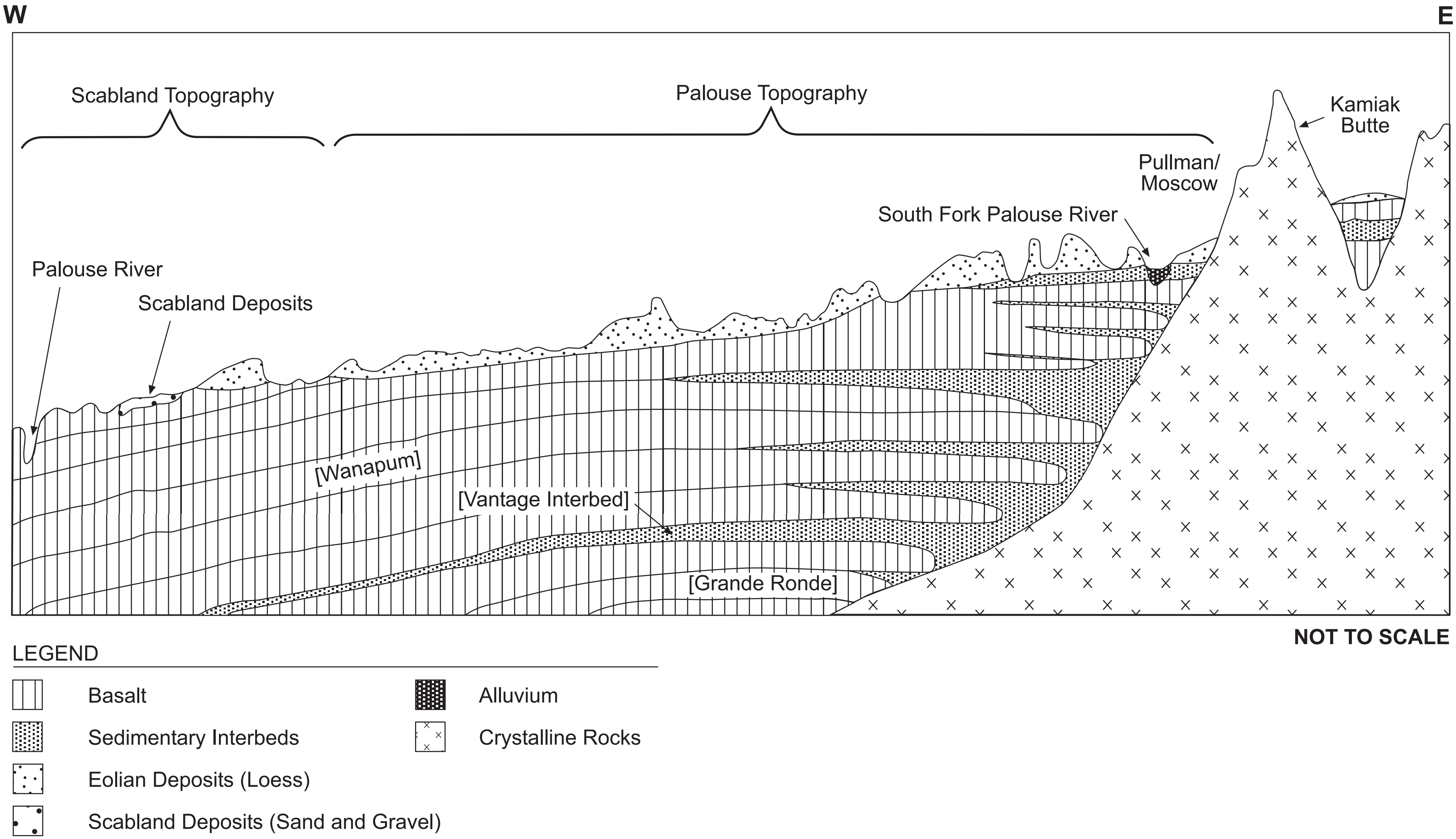
Geologic Map of the Palouse

WRIA 34 WATERSHED PLANNING

Drawn: GKL	Revision: 2	Date: Dec. 7, 2004	Figure: 4-2

04310641010F01.mxd

Golder Associates



Reconnaissance of Geology and of Groundwater Occurrence in Whitman County, Washington (Walthers & Glancy 1969)

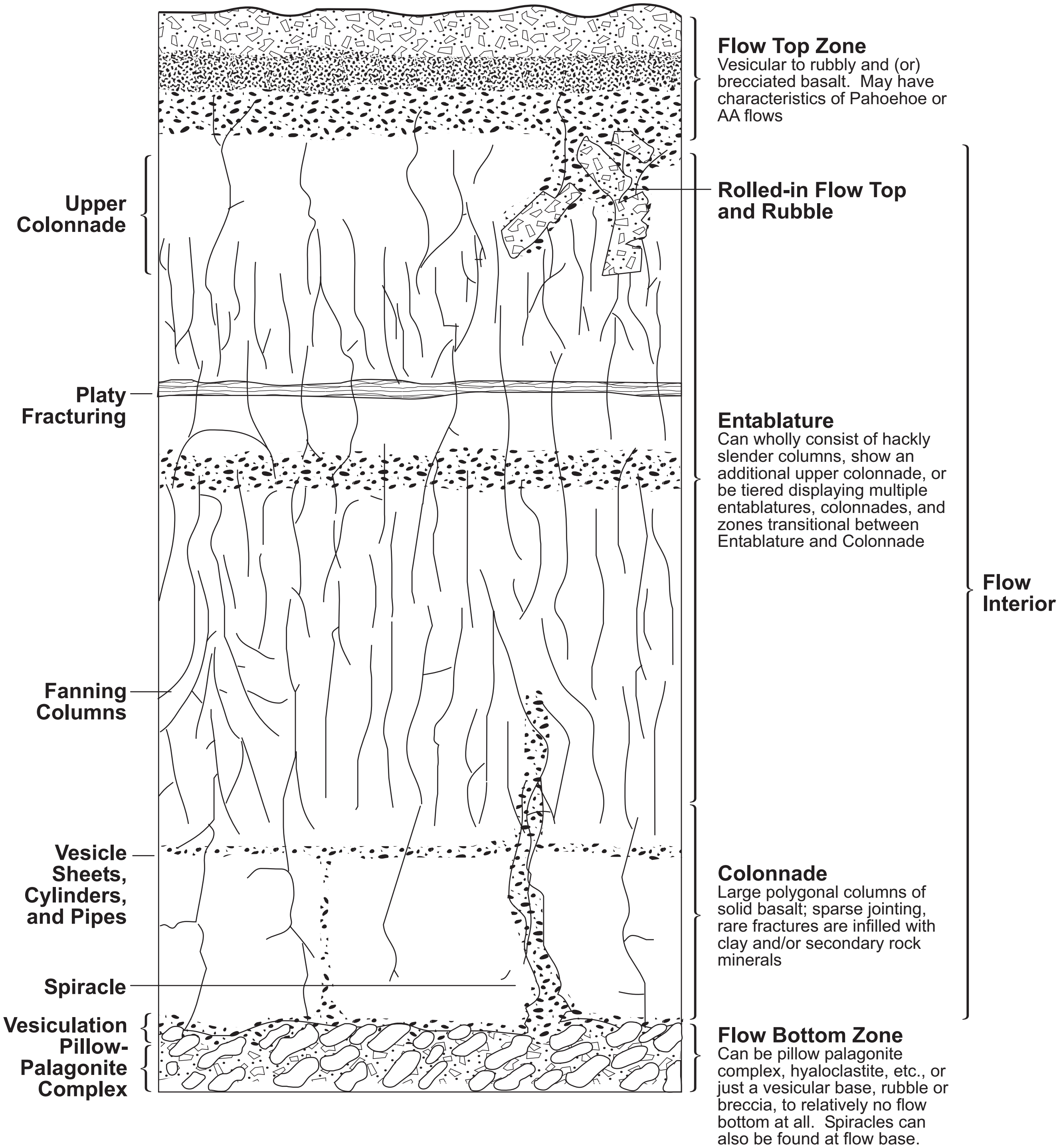
FIGURE **4-3**

WRIA 34 AND THE PALOUSE WATERSHED CONCEPTUAL CROSS-SECTION

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641020fg01.fh11 DATE 12/03/04 DRAWN BY EL

Golder Associates



Idealized section showing intraflow structures possible in Columbia River basalt flows. Flows do not necessarily exhibit all types of structures.

(Modified from USDOE, 1988)

FIGURE **4-4**

IDEALIZED SECTION OF BASALT FLOW

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641020fg02.fh11 DATE 11/03/04 DRAWN EFS

Golder Associates

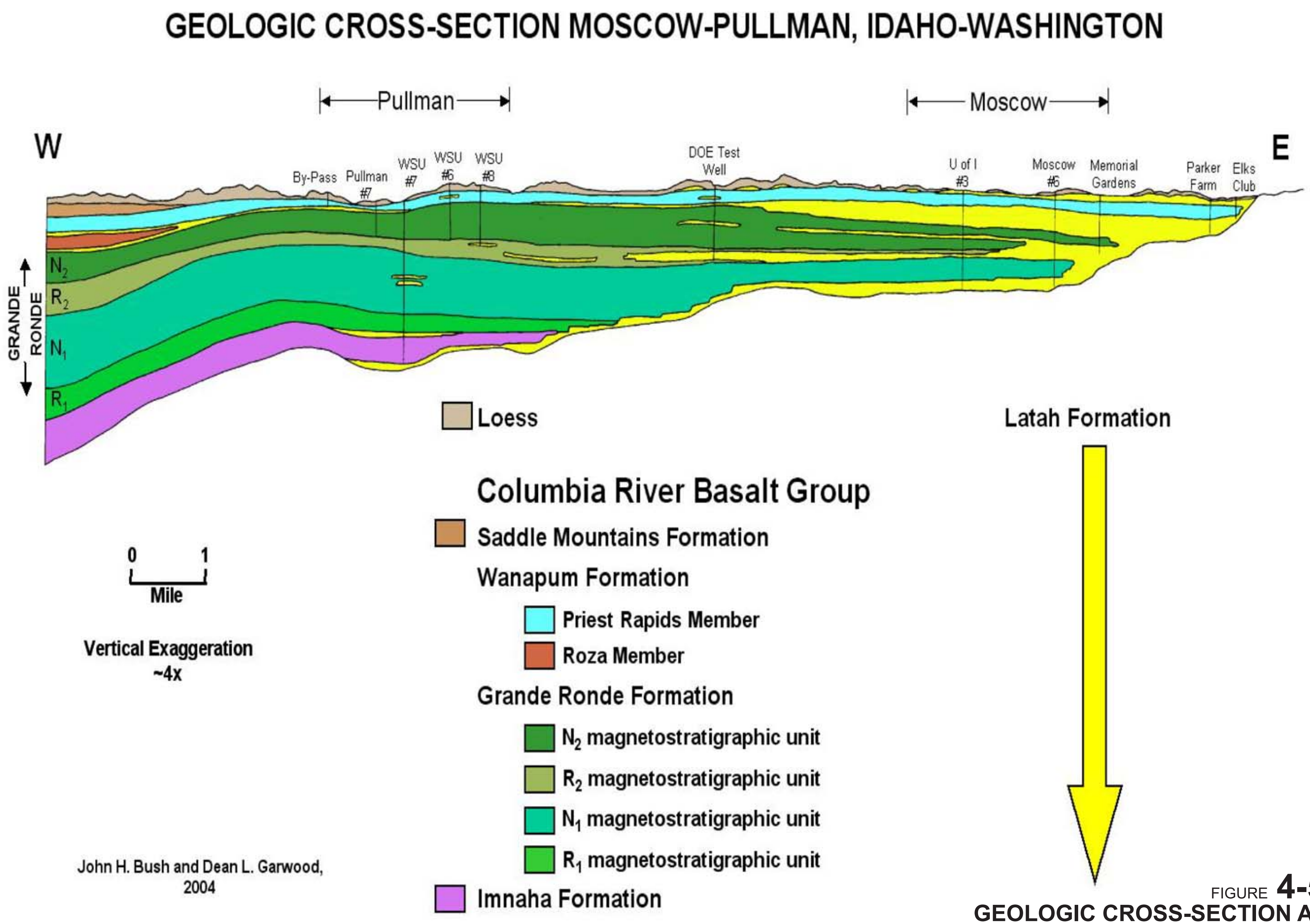


FIGURE **4-5**
GEOLOGIC CROSS-SECTION AT IDAHO-WASHINGTON STATE LINE
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641020fg04.fh11 DATE 11/03/04 DRAWN BY AMP

Golder Associates

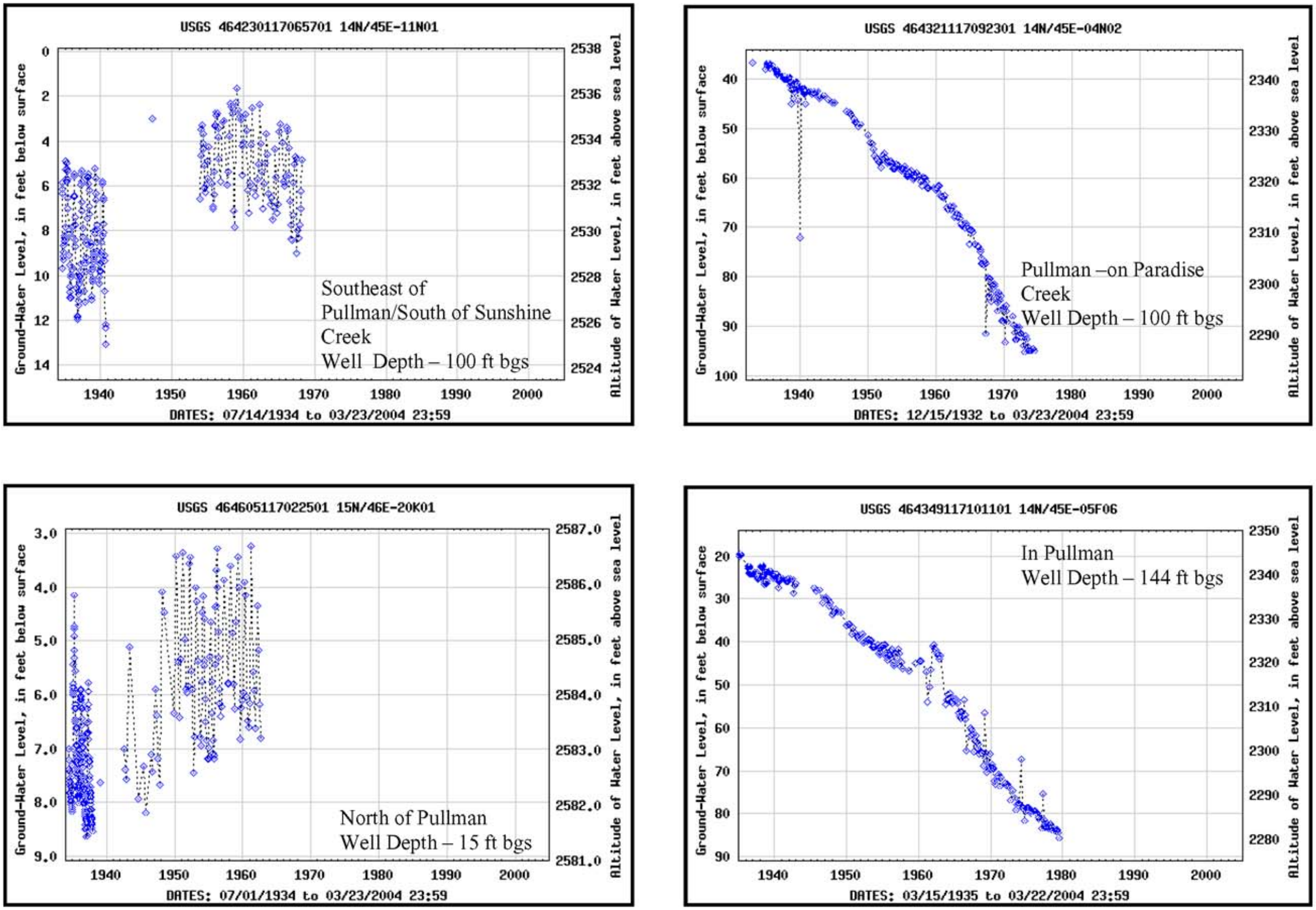


FIGURE **4-6a**

USGS HYDROGRAPHS FOR SELECTED WRIA 34 WELLS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg101.fh11 DATE 12/03/04 DRAWN BY EL

Golder Associates

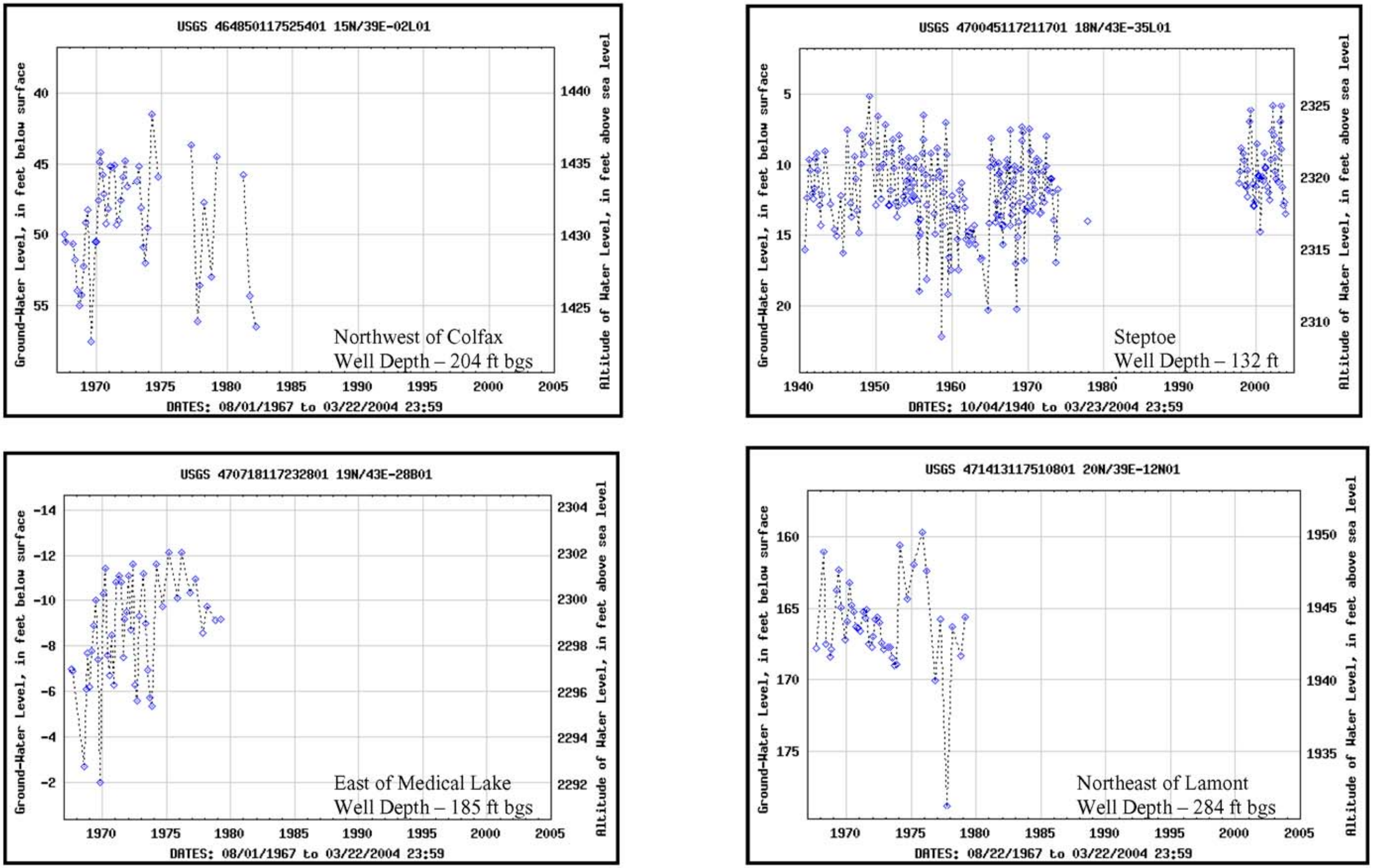
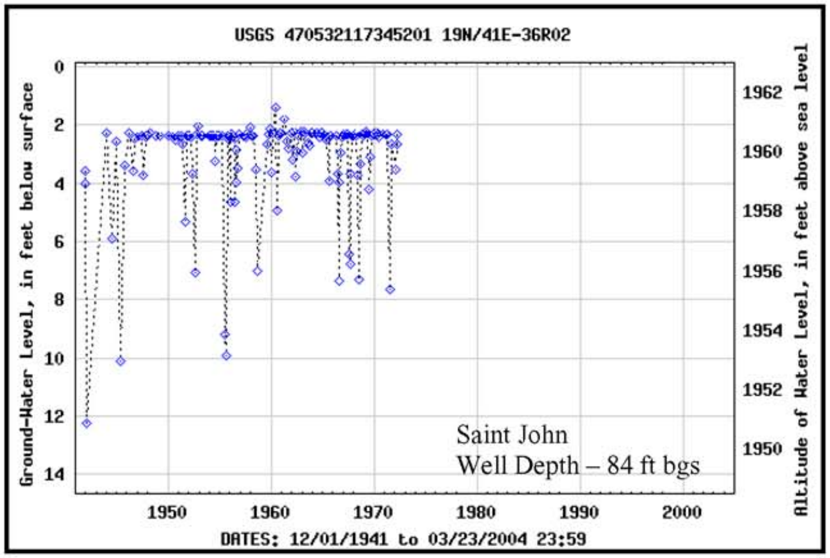
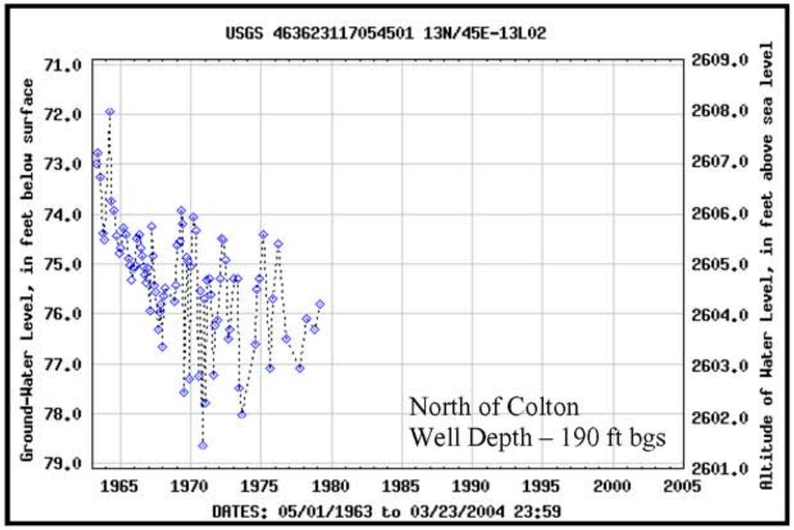


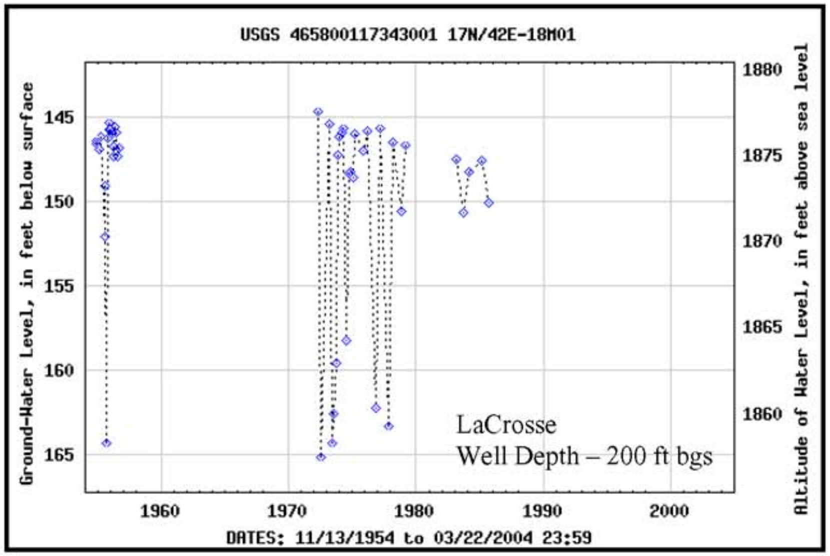
FIGURE **4-6b**

USGS HYDROGRAPHS FOR SELECTED WRIA 34 WELLS

PCD/WRIA 34 WATERSHED PLANNING/WA







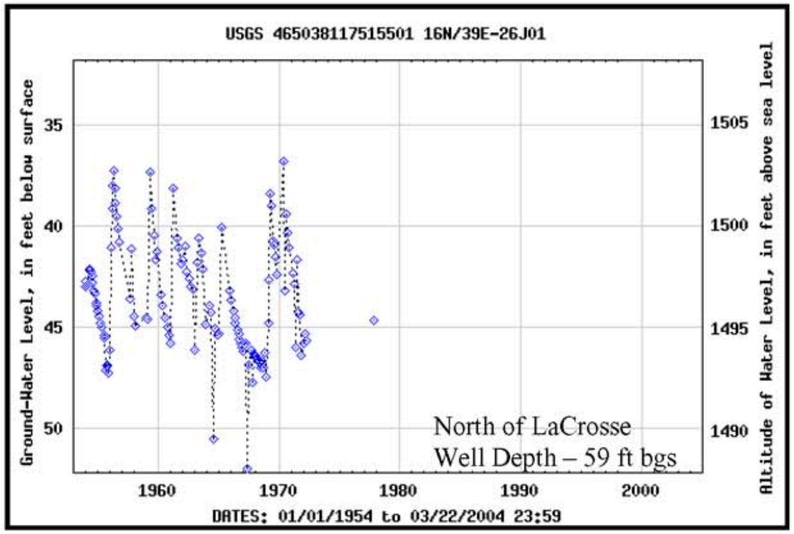


FIGURE **4-6c**

USGS HYDROGRAPHS FOR SELECTED WRIA 34 WELLS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641030fg99.fh11 DATE 12/03/04 DRAWN BY EL

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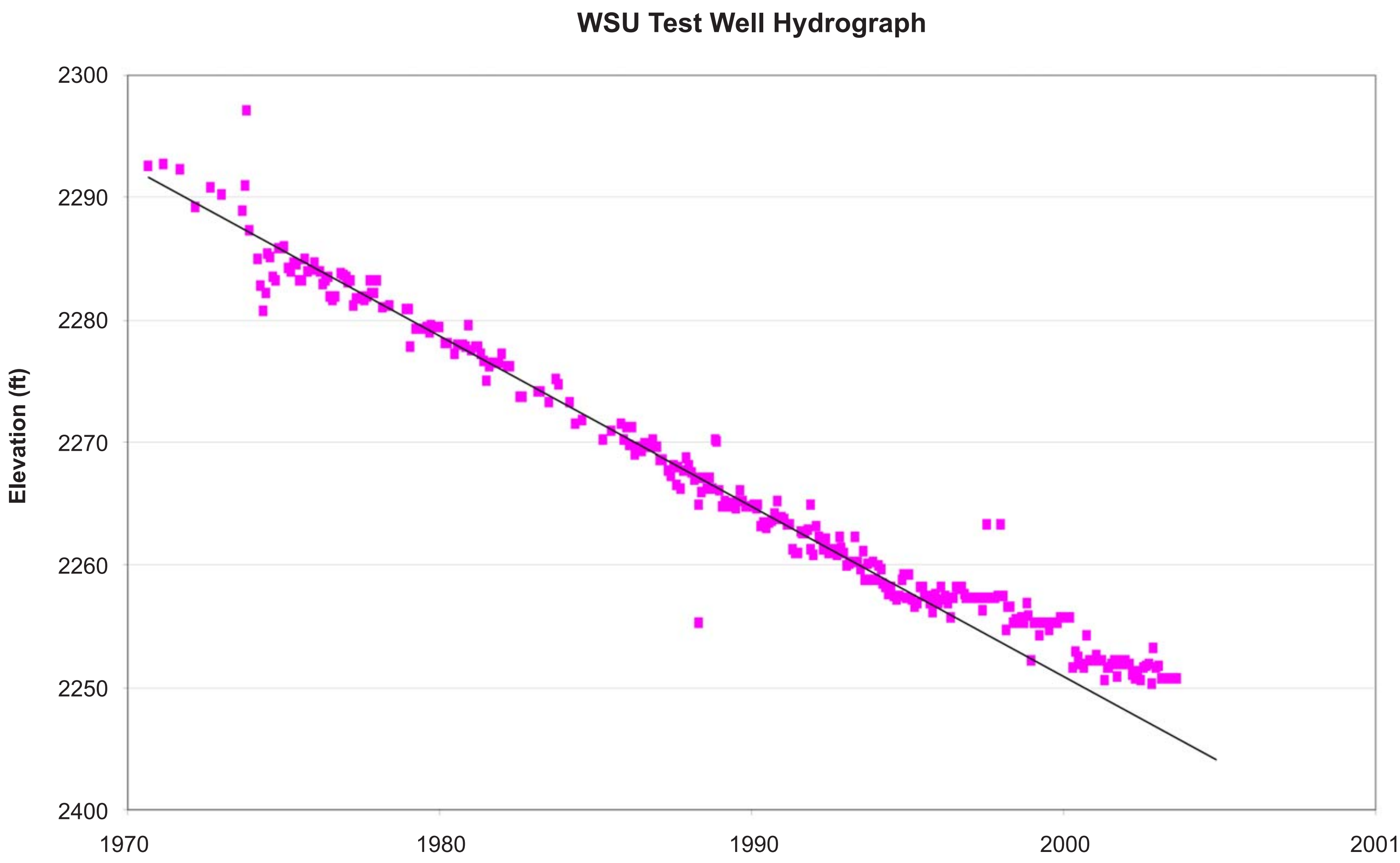


FIGURE **4-7**
OBSERVED WATER LEVEL
DECLINES IN GRANDE RONDE AQUIFER
PCD/WRIA 34 WATERSHED PLANNING/WA

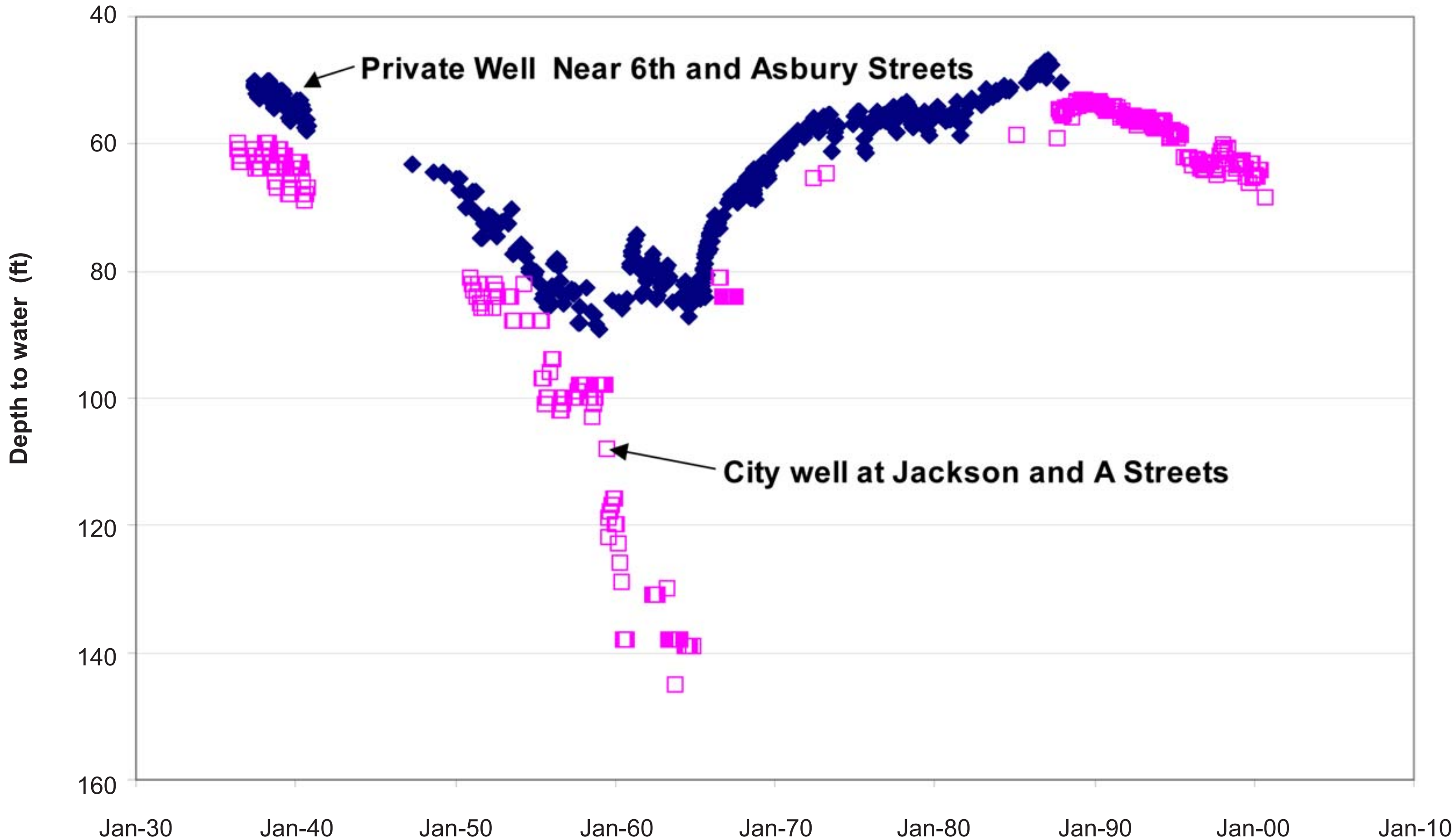
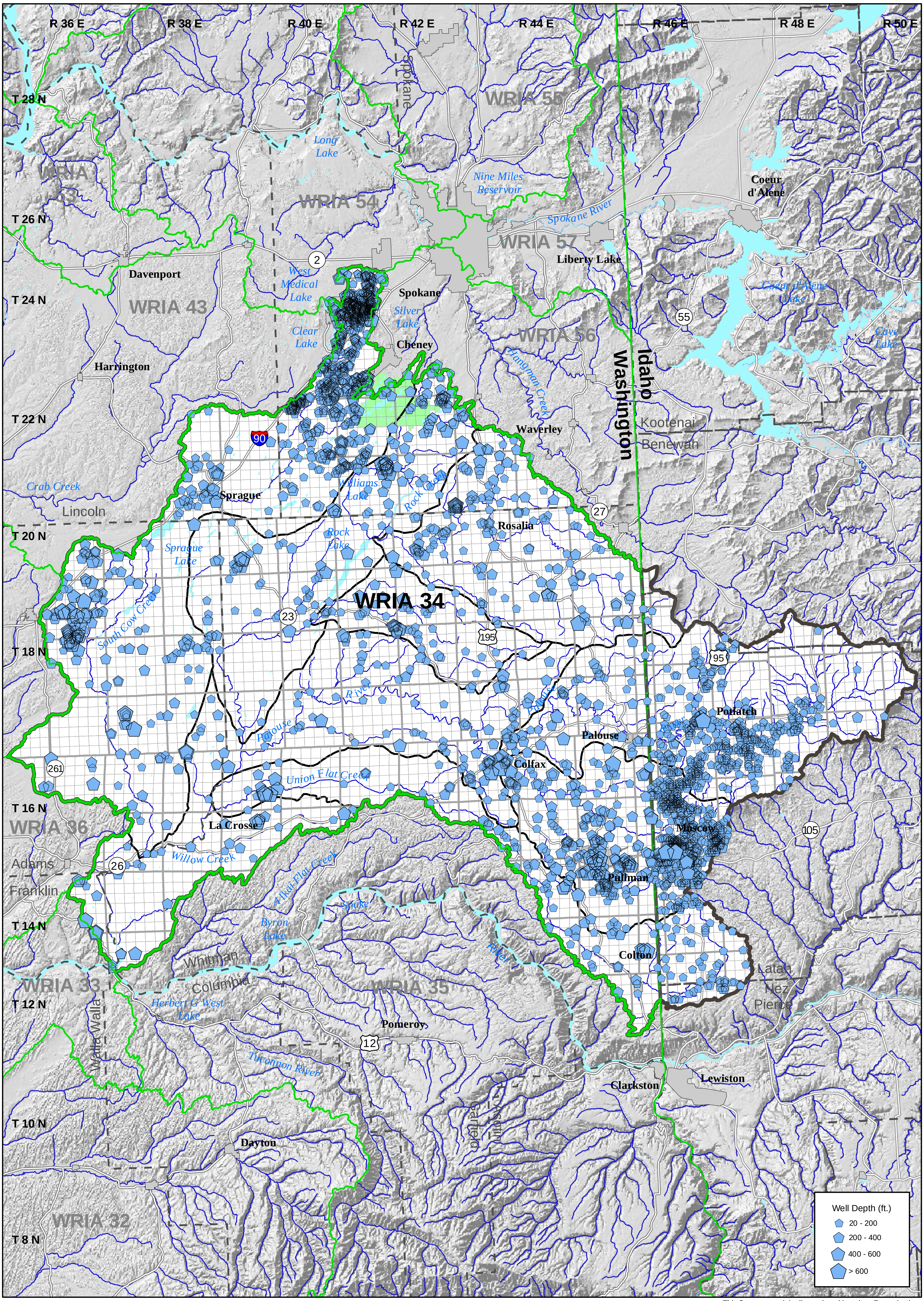


FIGURE **4-8**

OBSERVED WATER LEVEL DECLINES AND REBOUND IN WANAPUM AQUIFER MOSCOW, IDAHO

PCD/WRIA 34 WATERSHED PLANNING/WA



LEGEND

- Palouse Watershed Boundary
- Subbasin Boundary
- WRIA Boundaries
- National Wildlife Refuge
- Lake
- River
- County Boundary
- Road
- Community

Note: Well log database queried October 2004

0 50,000

Scale 1" = 50,000 Feet

Map Projection: Washington State Plane South Zone, NAD 83, Feet

Source: WSDOE, WSDOT, USGS, INSIDE Idaho, USGS, GIS Data Depot, WDNR, IDWR

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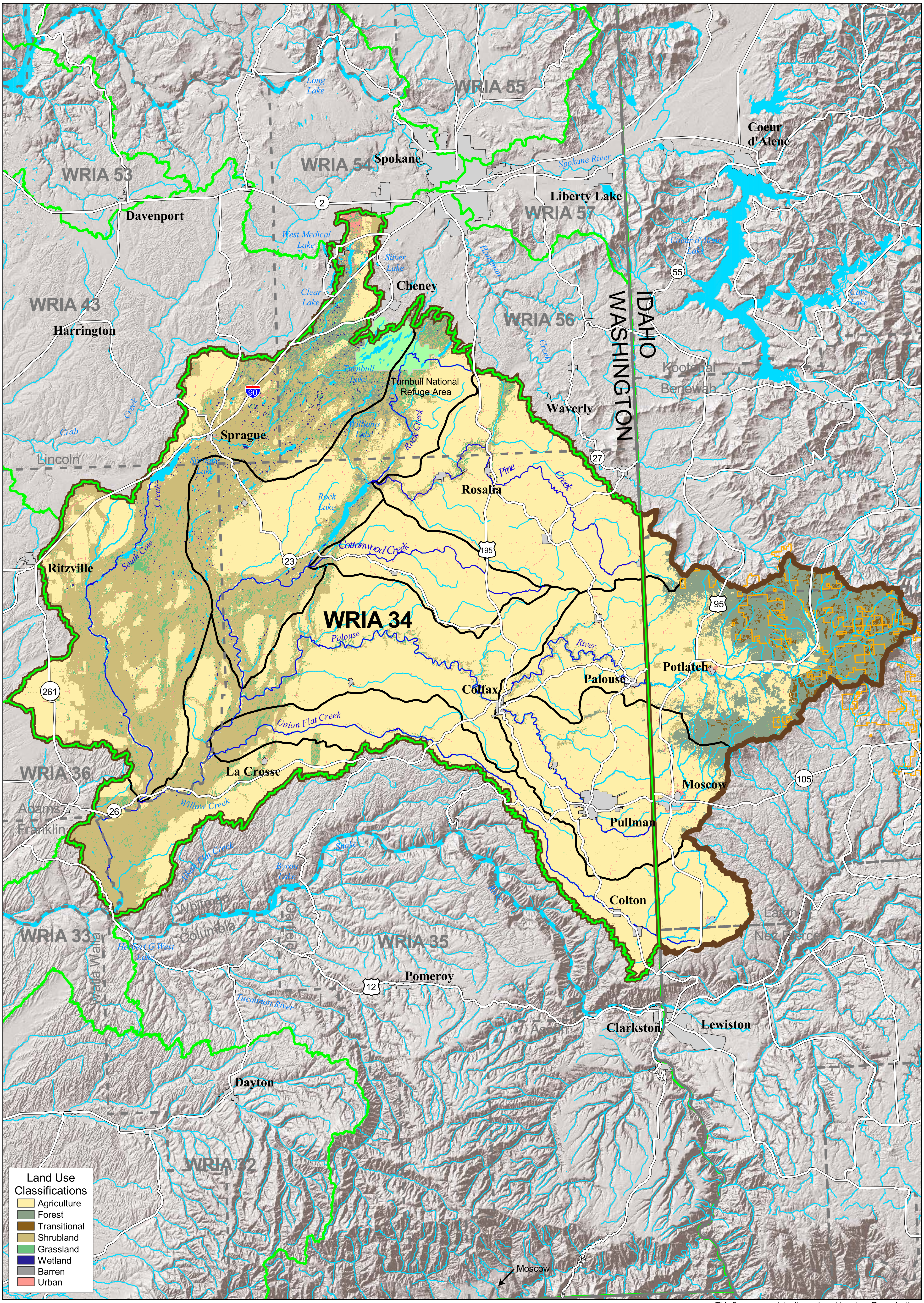
Groundwater Well Supply Depth and Source Type

WRIA 34 WATERSHED PLANNING

Drawn: GKL	Revision: 2	Date: Dec. 7, 2004	Figure: 4-9

04310641030F01R0.mxd

Golder Associates



This figure was originally produced in color. Reproduction in black and white may result in loss of information.

LEGEND

- Palouse Watershed Boundary
- WRIA Boundary
- Subbasin Boundary
- National Wildlife Refuge
- Community
- Waterbody
- Stream
- Road
- County Boundary
- Clearwater National Forest

0 50,000

Scale 1" = 50,000 Feet

Map Projection:
Washington State Plane
South Zone, NAD 83, Feet

Source: WSDOE, WSDOT, USGS, INSIDE Idaho, GIS Data Depot, NLCD (1993)

N

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NLCD LAND COVER

WRIA 34 WATERSHED PLANNING/WA

Drawn: KAV	Revision: 3	Date: Dec. 7, 2004	Figure: 5-1

04310641030_012804.apr

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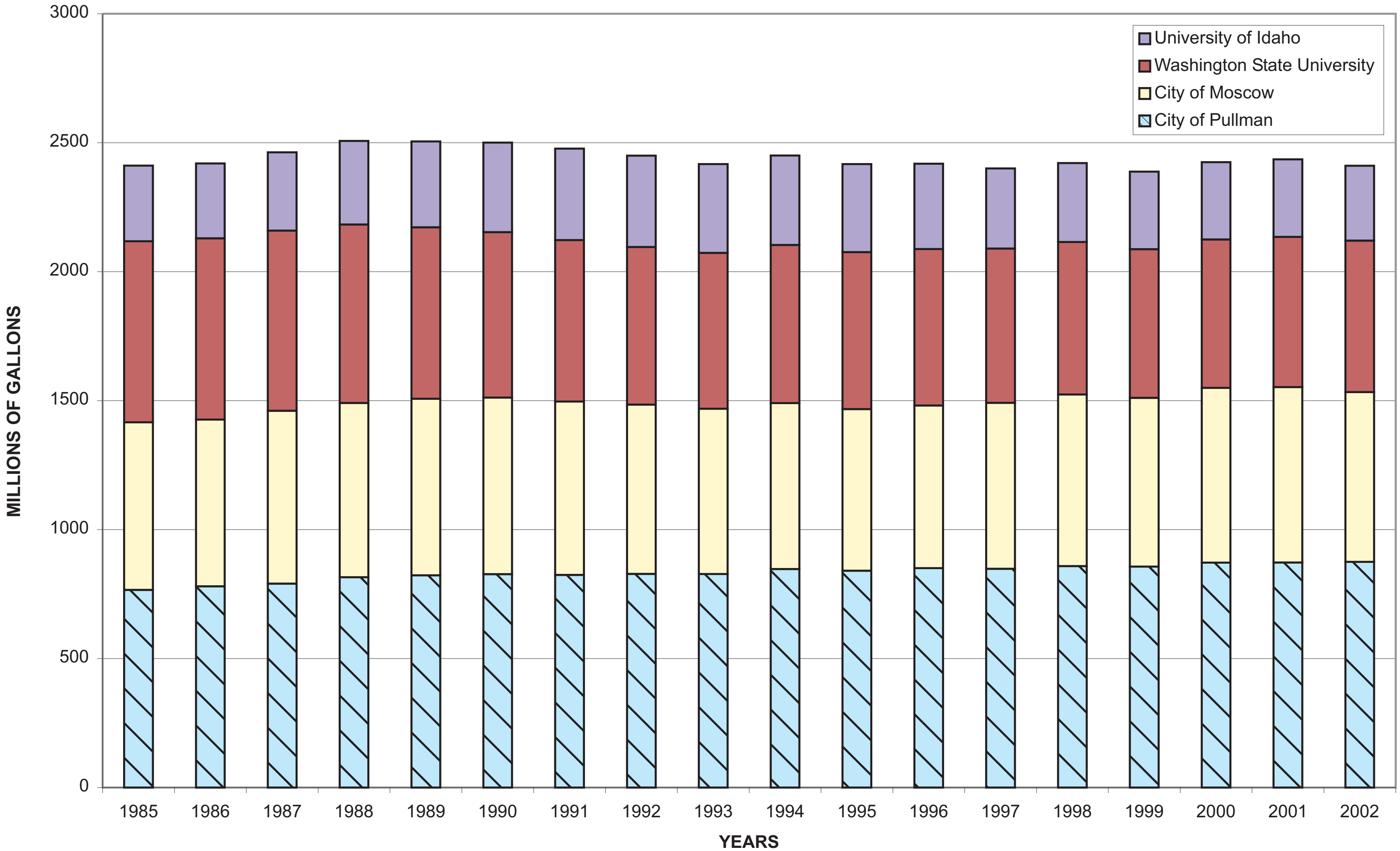


Note: Represents cumulative annual pumpage.

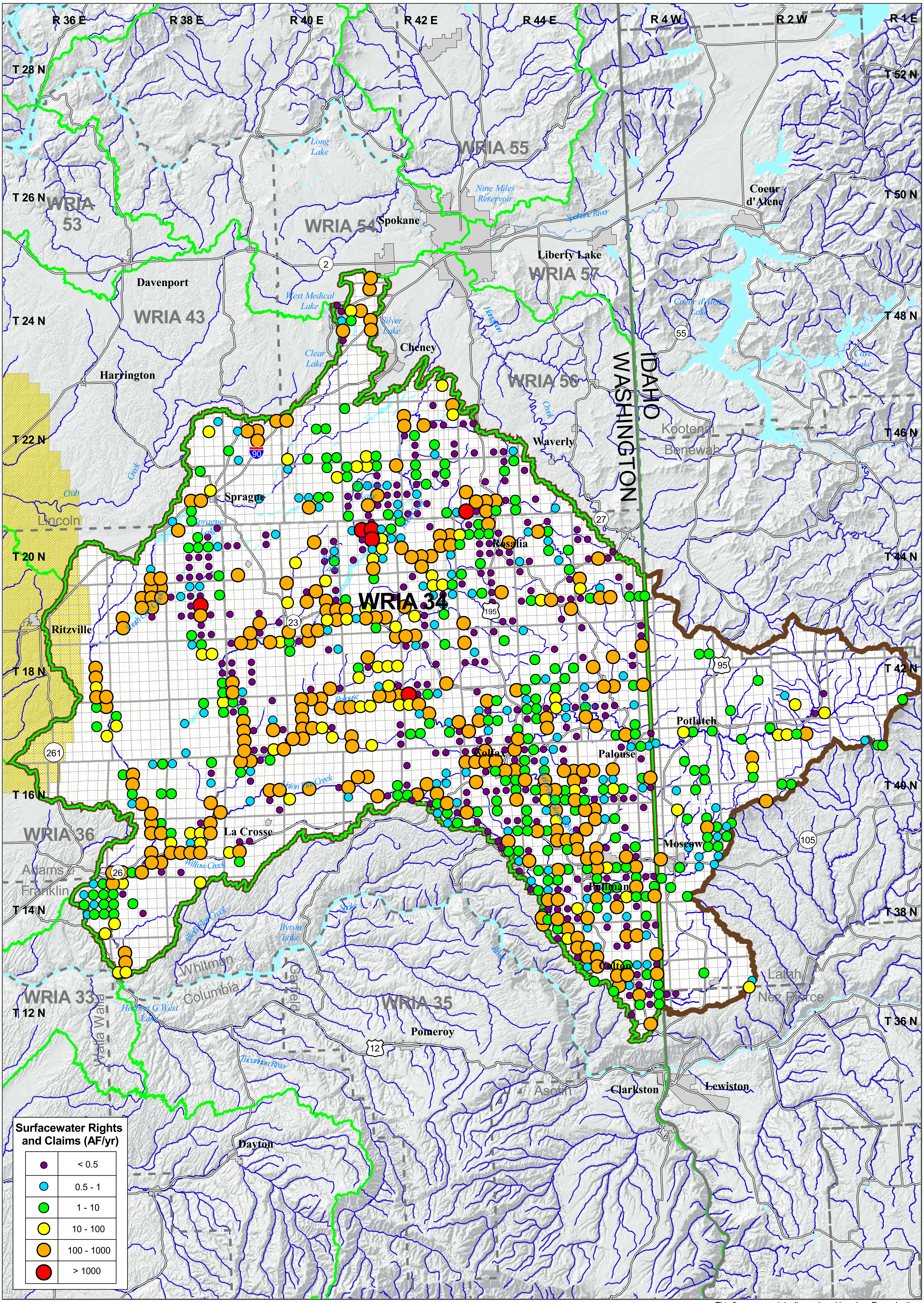
FIGURE **5-2**

GRANDE RONDE AQUIFER SYSTEM PUMPAGE BY PBAC ENTITIES

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641120fg11.fh11 DATE 11/02/04 DRAWN BY EL

Golder Associates



LEGEND

- Surface Water Changes
- Palouse Watershed Boundary
- WRIA Boundaries
- Waterbody
- Streams
- Roads
- County Boundary
- Communities
- Odessa Groundwater Management Subarea (173-128A WAC)

0 50,000

Scale 1" = 50,000 Feet

Map Projection: Washington State Plane South Zone, NAD 83, Feet

Source: WSDOE, WSDOT, USGS, INSIDE Idaho, GIS Data Depot, WRATS

N

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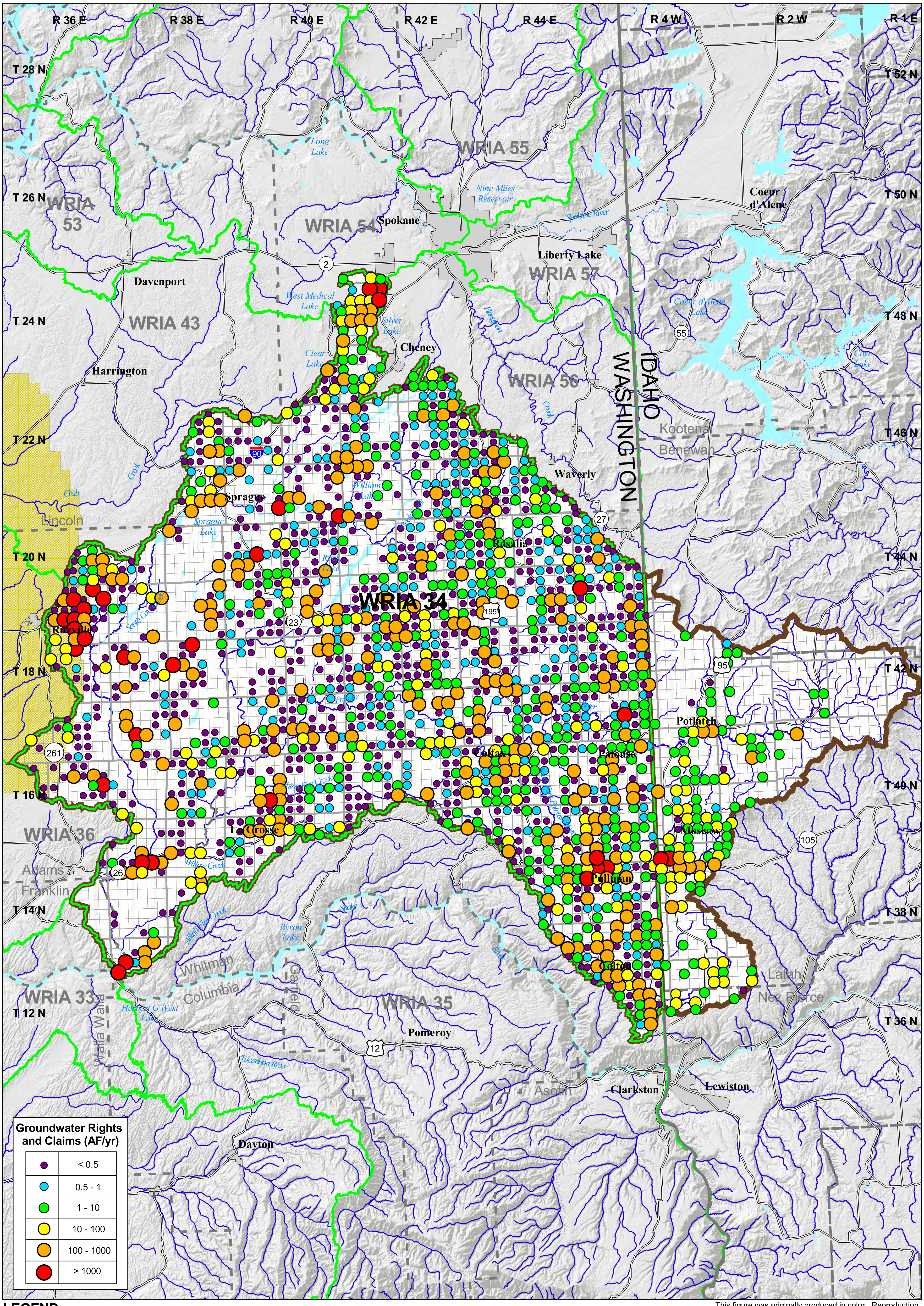
SURFACE WATER RIGHTS AND CLAIMS

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: RMT	Revision: 3	Date: Dec. 7, 2004	Figure: 6-1

04310641060_033004.apr

Golder Associates



This figure was originally produced in color. Reproduction in black and white may result in loss of information.

LEGEND

- Palouse Watershed Boundary
- WRIA Boundaries
- Waterbody
- Streams
- Roads
- County Boundary
- Communities
- Odessa Groundwater Management Subarea (173-128A WAC)

0 50,000

Scale 1" = 50,000 Feet

Map Projection: Washington State Plane South Zone, NAD 83, Feet

Source: WSDOE, WSDOT, USGS, INSIDE Idaho, GIS Data Depot, WRATS

N

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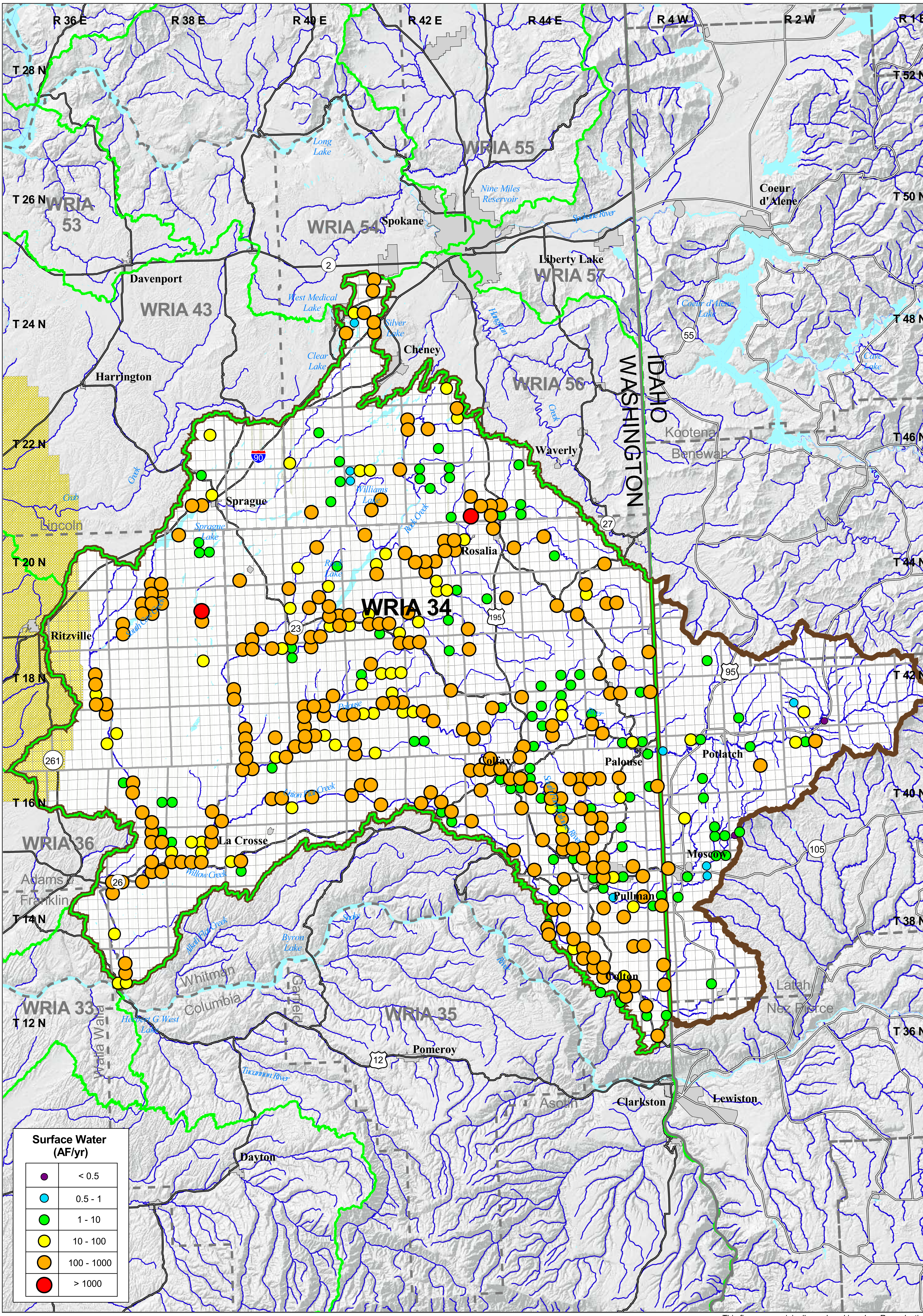
GROUNDWATER RIGHTS AND CLAIMS

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: RMT	Revision: 3	Date: Dec. 7, 2004	Figure: 6-2

04310641060_033004.apr

Golder Associates



This figure was originally produced in color. Reproduction in black and white may result in loss of information.

LEGEND

- Surface Water Changes
- Palouse Watershed Boundary
- WRIA Boundaries
- Waterbody
- Streams
- Roads
- County Boundary
- Communities
- Odessa Groundwater Management Subarea (173-128A WAC)

0 50,000

Scale 1" = 50,000 Feet

N

Map Projection: Washington State Plane South Zone, NAD 83, Feet

Source: WSDOE, WSDOT, USGS, INSIDE Idaho, GIS Data Depot, WRATS

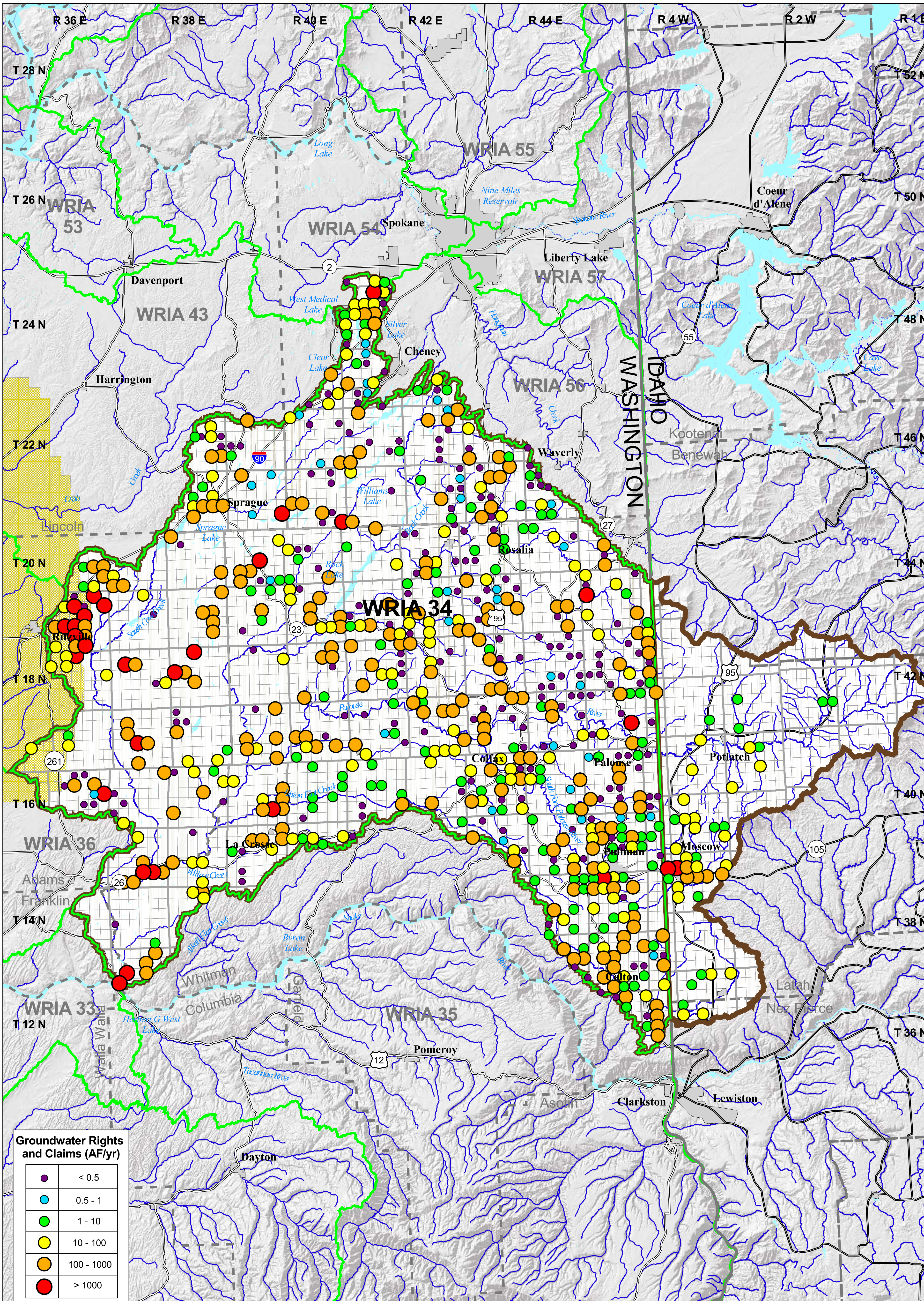
SURFACE WATER IRRIGATION RIGHTS AND CLAIMS

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: RMT	Revision: 3	Date: Dec. 7, 2004	Figure: 6-3

04310641060_033004.apr

Golder Associates



LEGEND

- Palouse Watershed Boundary
- WRIA Boundaries
- Waterbody
- Streams
- Roads
- County Boundary
- Communities
- Odessa Groundwater Management Subarea (173-128A WAC)

0 — 50,000
Scale 1" = 50,000 Feet

DRAFT

N

Map Projection: Washington State Plane South Zone, NAD 83, Feet

Source: WSDOE, WSDOT, USGS, INSIDE Idaho, GIS Data Depot, WRATS

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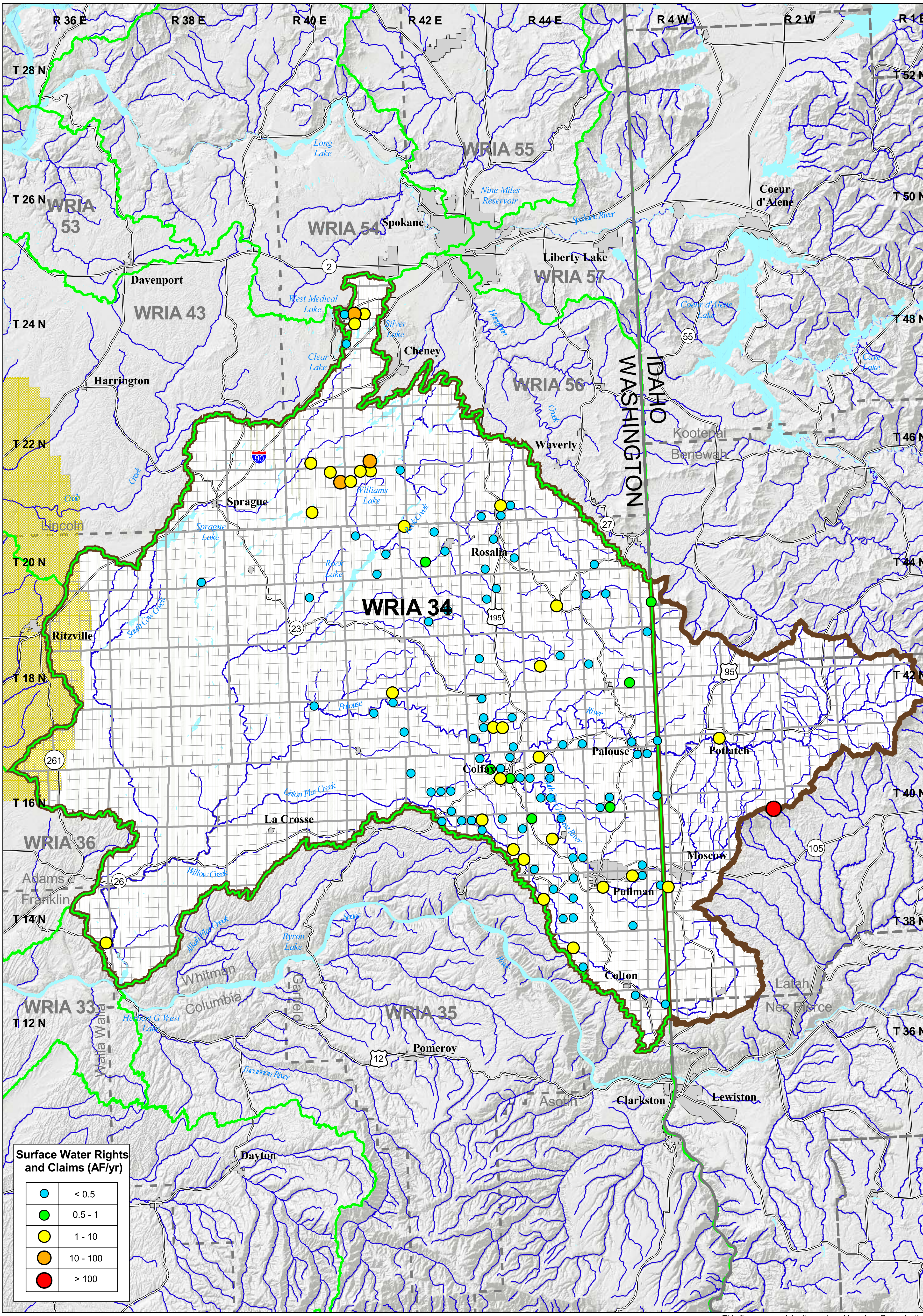
GROUNDWATER IRRIGATION RIGHTS AND CLAIMS

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: RMT	Revision: 3	Date: Dec. 7, 2004	Figure: 6-4

04310641060_033004.apr

Golder Associates



LEGEND

- Surface Water Changes
- Palouse Watershed Boundary
- WRIA Boundaries
- Waterbody
- Streams
- Roads
- County Boundary
- Communities
- Odessa Groundwater Management Subarea (173-128A WAC)

0 50,000

Scale 1" = 50,000 Feet

N

Map Projection: Washington State Plane South Zone, NAD 83, Feet

Source: WSDOE, WSDOT, USGS, INSIDE Idaho, GIS Data Depot, WRATS

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

SURFACE WATER DOMESTIC AND MUNICIPAL RIGHTS AND CLAIMS

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: RMT	Revision: 3	Date: Dec. 7, 2004	Figure: 6-5

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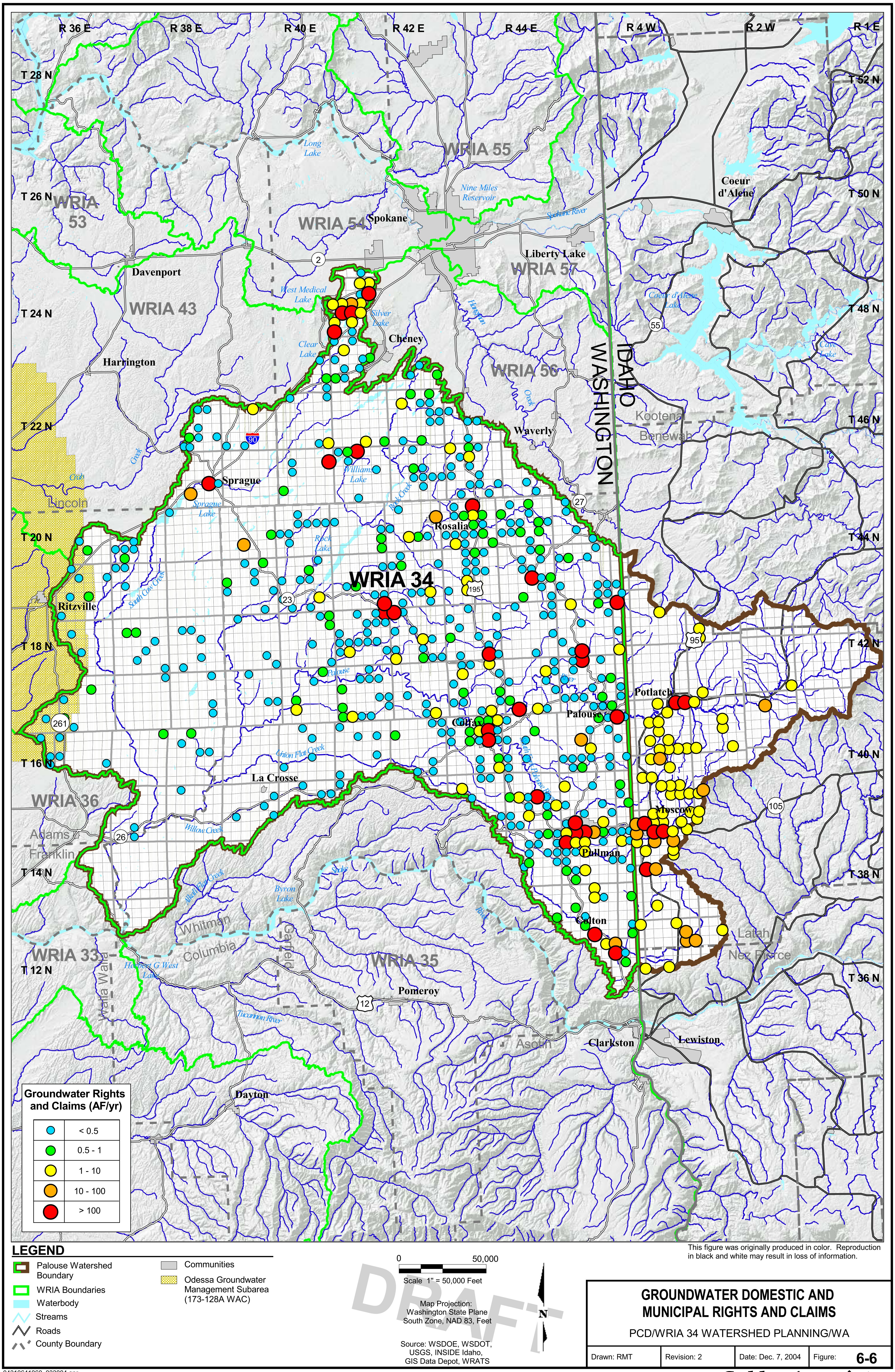

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

GROUNDWATER DOMESTIC AND MUNICIPAL RIGHTS AND CLAIMS

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: RMT	Revision: 2	Date: Dec. 7, 2004	Figure: 6-6

04310641060_033004.apr

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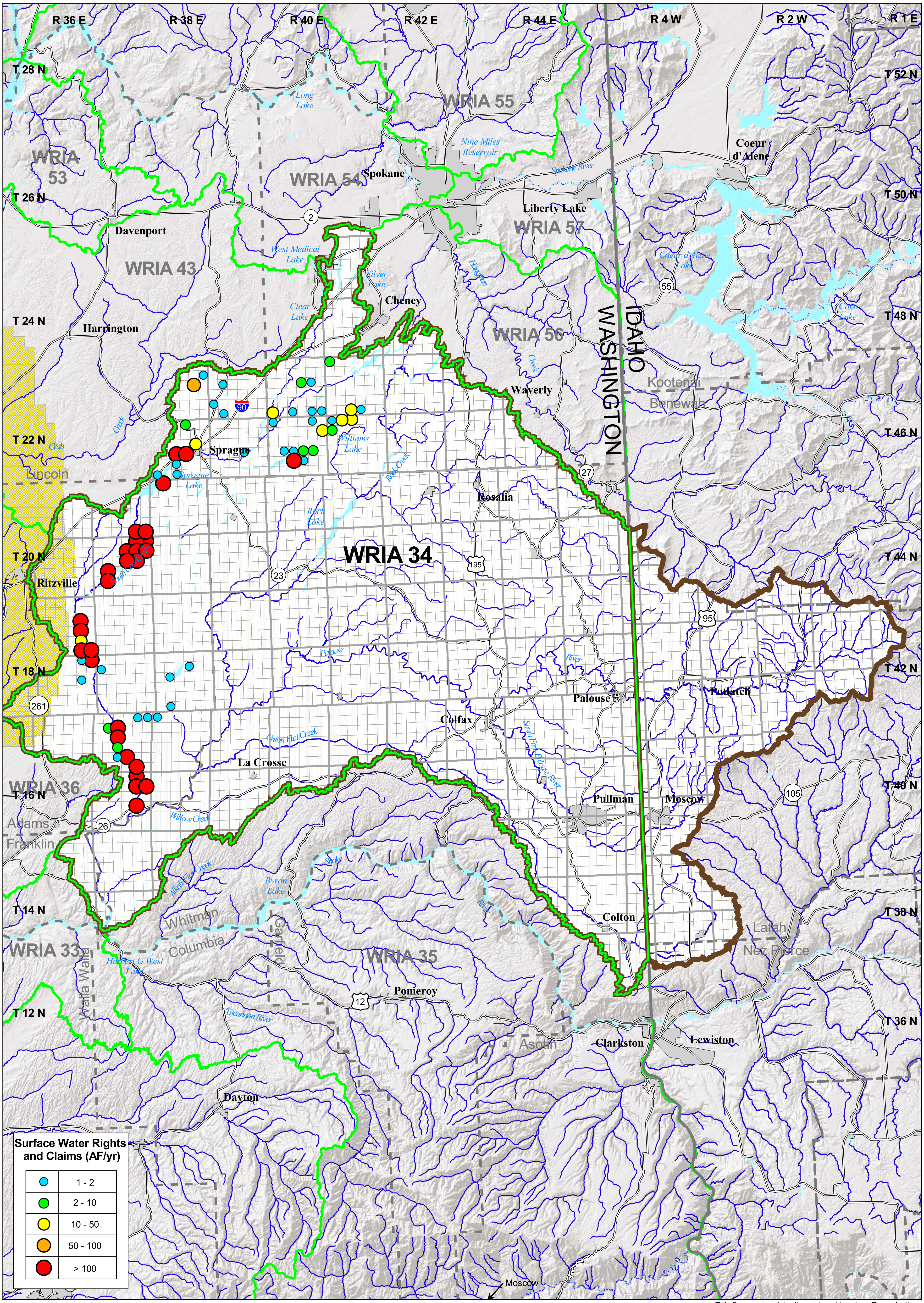

LEGEND

- Surface Water Changes
- Palouse Watershed Boundary
- WRIA Boundaries
- Waterbody
- Streams
- Roads
- County Boundary
- Communities
- Odessa Groundwater Management Subarea (173-128A WAC)

0 50,000
Scale 1" = 50,000 Feet

Map Projection:
Washington State Plane
South Zone, NAD 83, Feet

Source: WSDOE, WSDOT, USGS, INSIDE Idaho, GIS Data Depot, WRATS

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ADJUDICATED SURFACE WATER CLAIMS

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: RMT	Revision: 3	Date: Dec. 7, 2004	Figure: 6-7

04310641060_033004.apr

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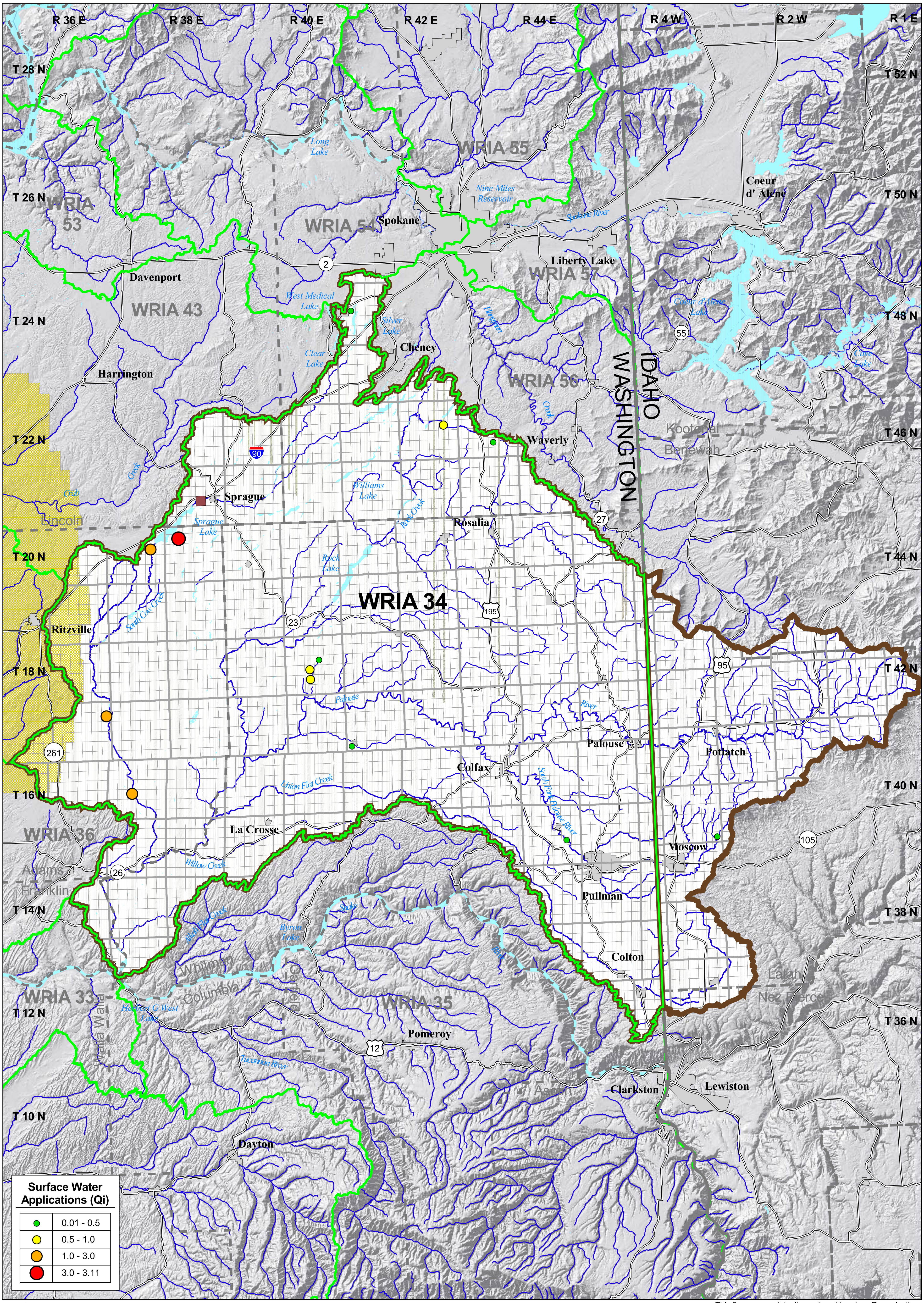

LEGEND

- Surface water changes
- Palouse Watershed Boundary
- WRIA Boundaries
- Waterbody
- Streams
- Roads
- County Boundary
- Communities
- Odessa Groundwater Management Subarea (173-128A WAC)

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

0 50,000
Scale 1" = 50,000 Feet

Map Projection: Washington State Plane South Zone, NAD 83, Feet

Source: WSDOE, WSDOT, USGS, INSIDE Idaho, GIS Data Depot, WRATS

N

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SURFACE WATER APPLICATIONS AND CHANGES

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: RMT	Revision: 3	Date: Dec. 7, 2004	Figure: 6-8

04310641060_012904.apr

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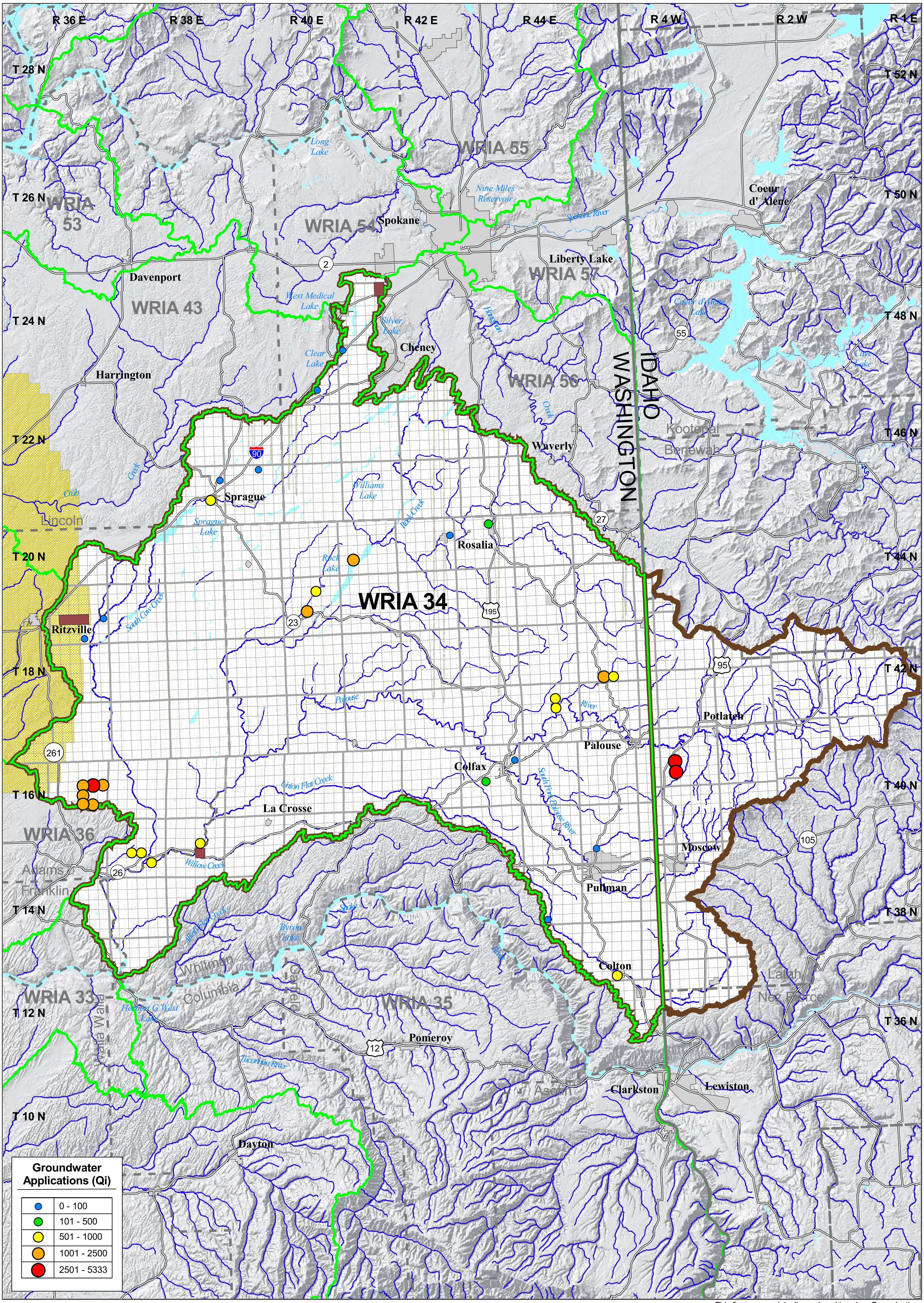

LEGEND

- Groundwater Changes
- Palouse Watershed Boundary
- WRIA Boundaries
- Waterbody
- Streams
- Roads
- County Boundary
- Communities
- Odessa Groundwater Management Subarea (173-128A WAC)

0 50,000

Scale 1" = 50,000 Feet

Map Projection: Washington State Plane South Zone, NAD 83, Feet

Source: WSDOE, WSDOT, USGS, INSIDE Idaho, GIS Data Depot, WRATS

N

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GOUNDWATER APPLICATIONS AND CHANGES

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: RMT	Revision: 3	Date: Dec. 7, 2004	Figure: 6-9

04310641060_012904.apr

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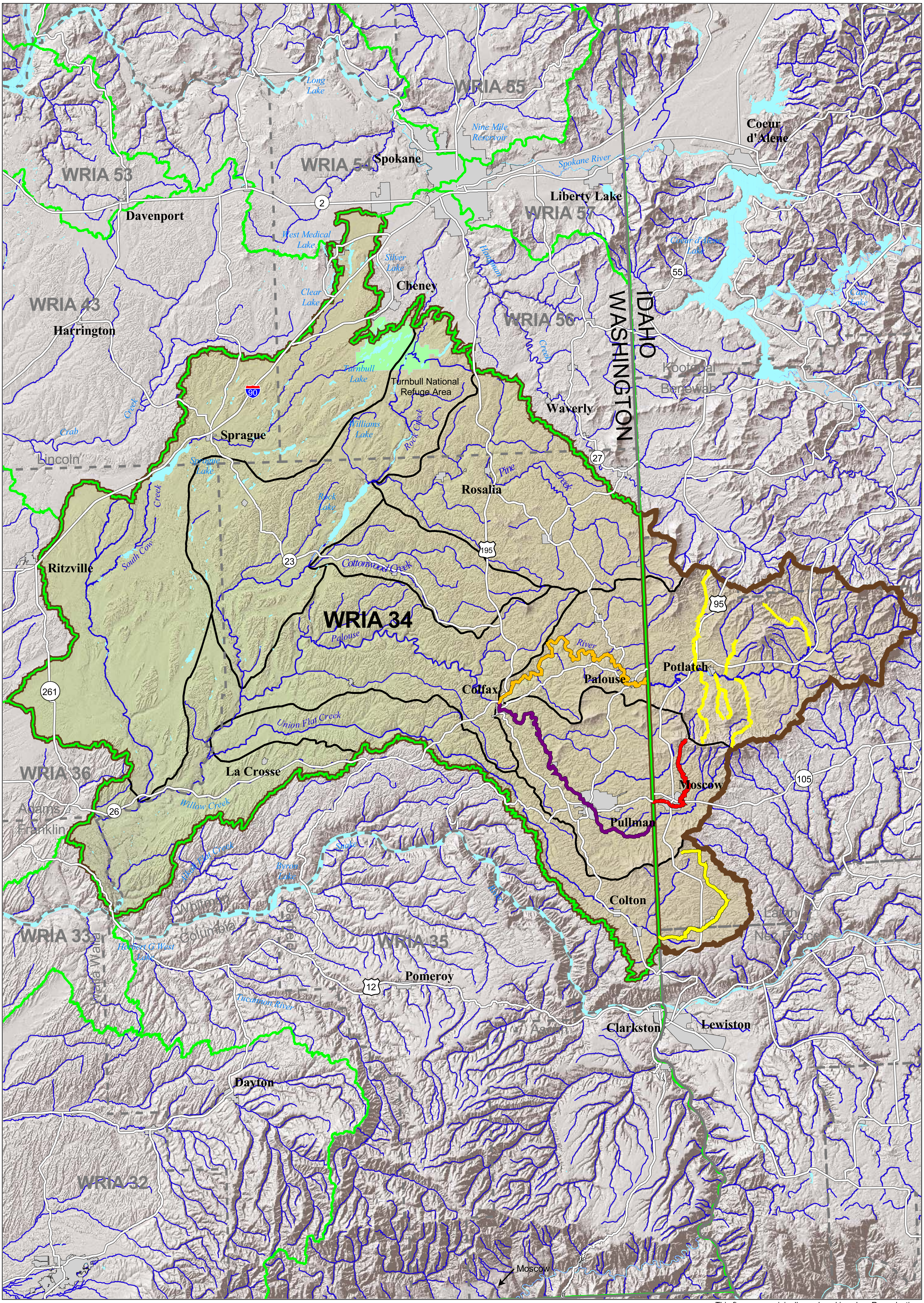

LEGEND

- Palouse Watershed Boundary
- WRIA Boundary
- Subbasin Boundary
- National Wildlife Refuge
- Community
- Waterbody
- TMDL - Ongoing
- TMDL - Written
- Written for Fecal Coliform
- Written for Ammonia
- County Boundary
- Road
- Stream

0 50,000

Scale 1" = 50,000 Feet

N

Map Projection:
Washington State Plane
South Zone, NAD 83, Feet

Source: WSDOE (3030(d) Database), WSDOT, USGS, INSIDE Idaho, GIS Data Depot

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

TMDL WATERBODIES

WRIA 34 WATERSHED PLANNING/WA

Drawn: KAV	Revision: 2	Date: Dec. 7, 2004	Figure: 7-1

04310641030_012804.apr

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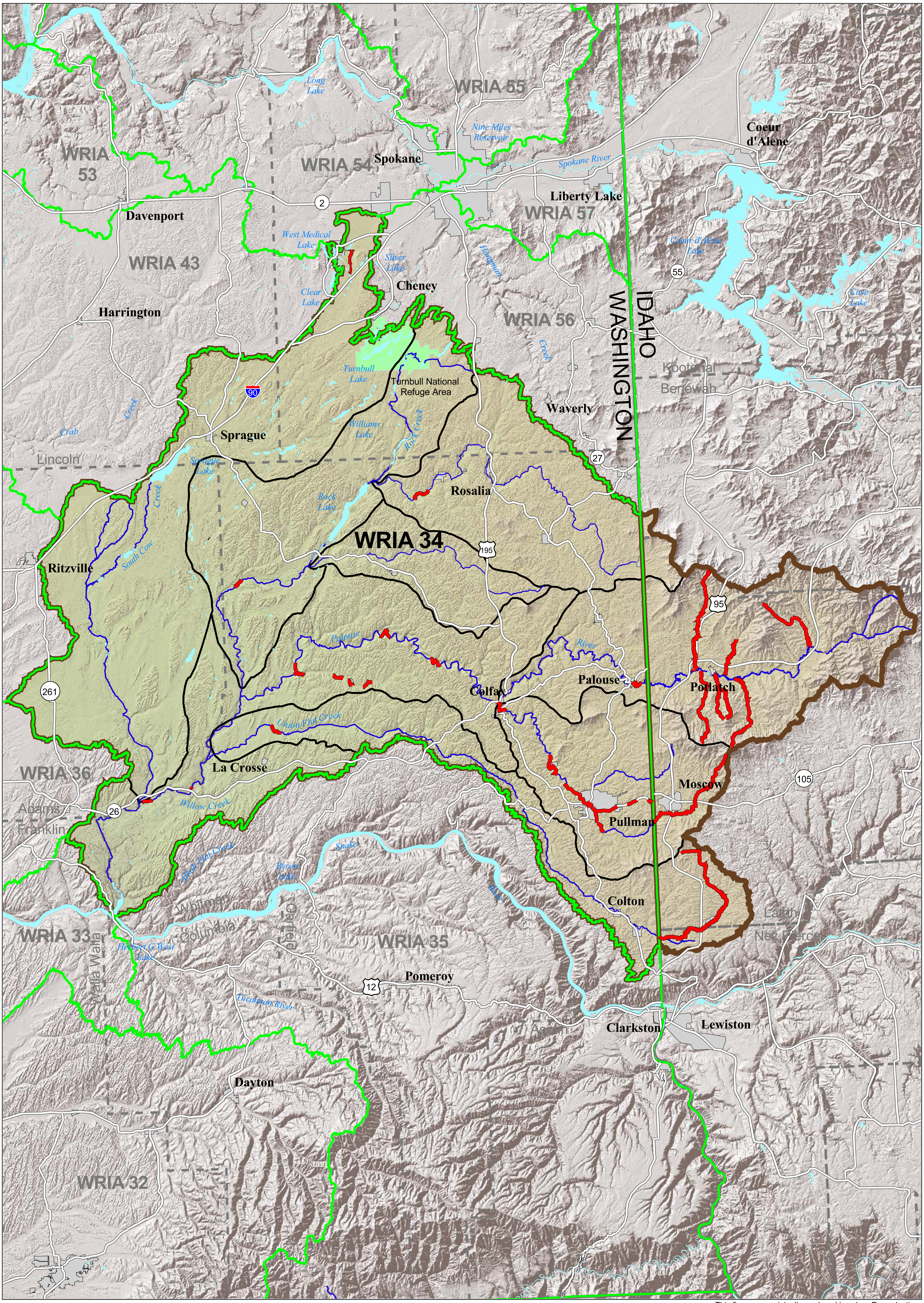

LEGEND

- Palouse Watershed Boundary
- WRIA Boundary
- Subbasin Boundary
- National Wildlife Refuge
- Community
- Waterbody
- 303(d) Listed Waterbody
- County Boundary
- Road
- Stream

0 50,000

Scale 1" = 50,000 Feet

Map Projection: Washington State Plane South Zone, NAD 83, Feet

Source: WSDOE (303(d), Database), WSDOT, USGS, INSIDE Idaho, GIS Data Depot

N

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303(d) LISTED WATERBODIES

WRIA 34 WATERSHED PLANNING/WA

Drawn: KAV	Revision: 1	Date: Dec 7, 2004	Figure: 7-2

04310641030_012804.apr

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Figure 7-3. Water Temperature of the North Fork Palouse River Near Potlatch (USGS data set)

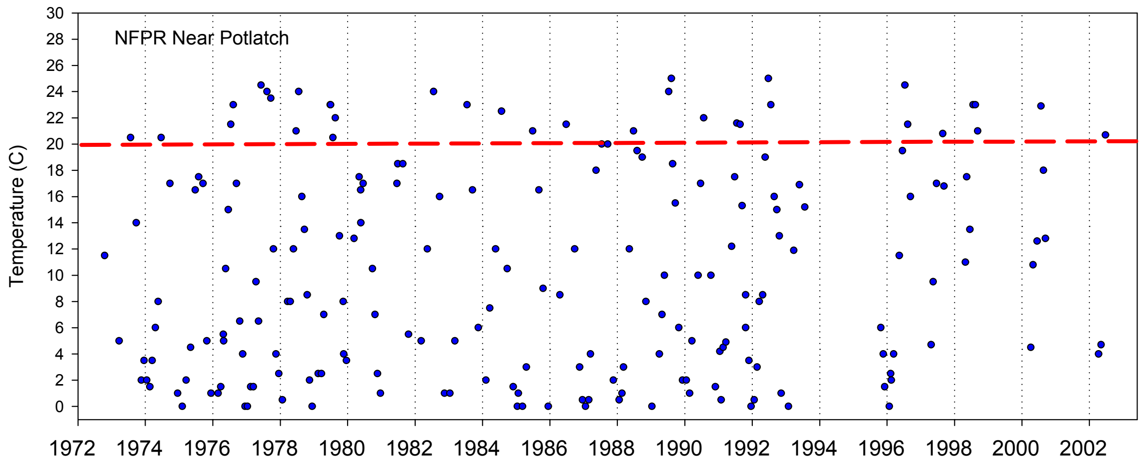


Figure 7-4. Water Temperature of the North Fork Palouse River at Palouse (Ecology data set)

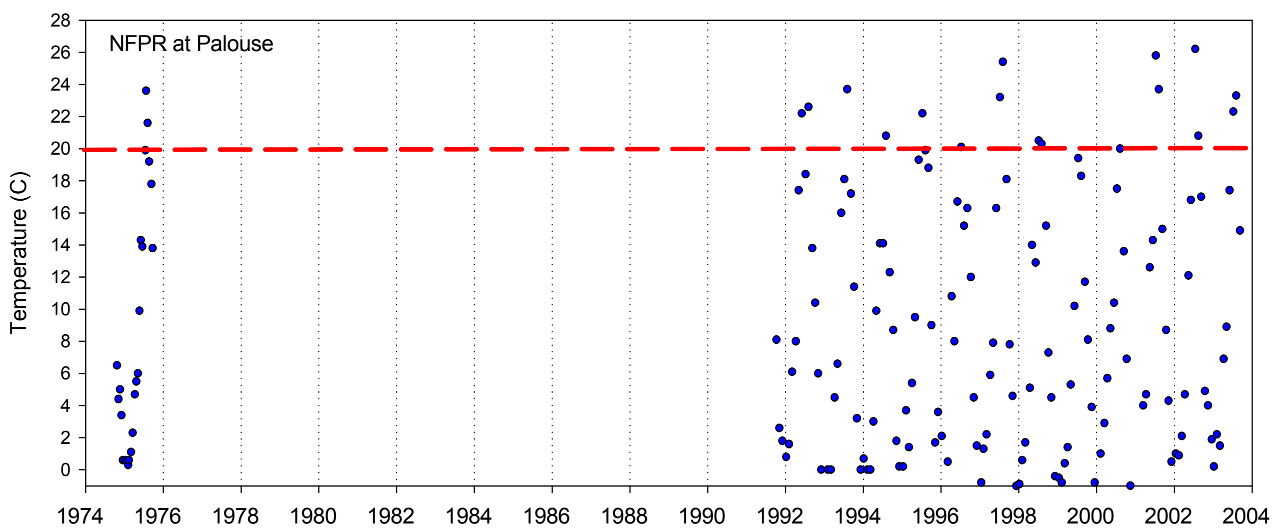


Figure 7-5. Water Temperature of Palouse River Near Hooper, Washington (Ecology data set)

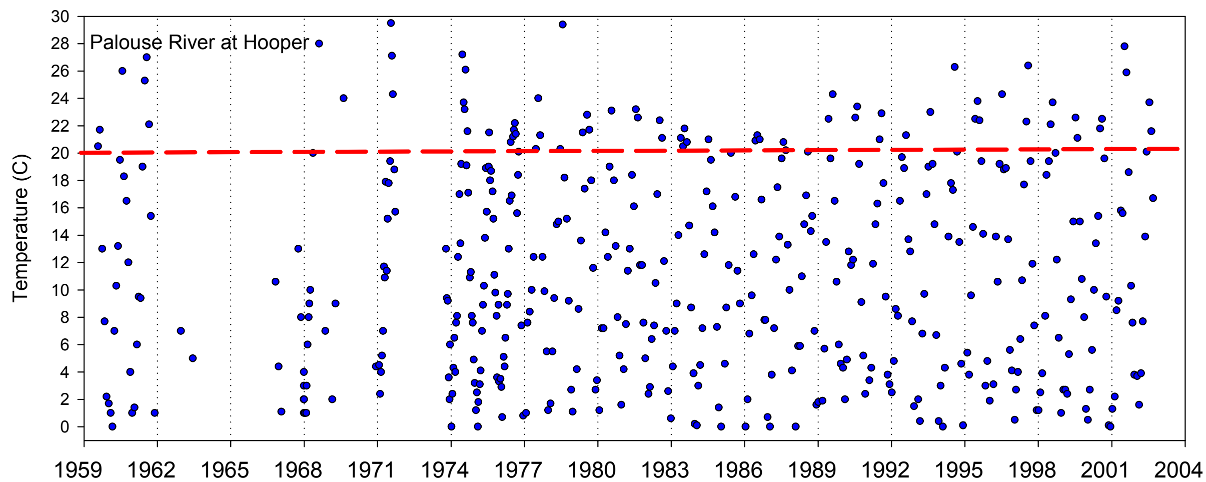


Figure 7-6. Fecal Coliform Results from Palouse River Near Hooper (Ecology data set)

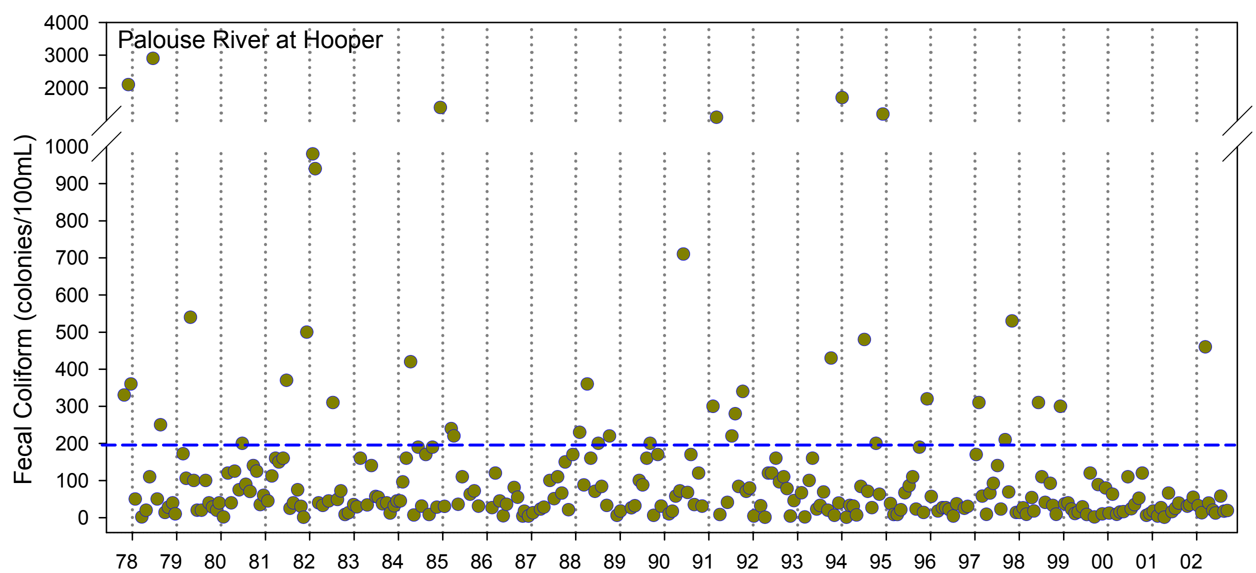


Figure 7-7. Nitrate-Nitrite Levels in North Fork Palouse River at Palouse (Ecology data set)

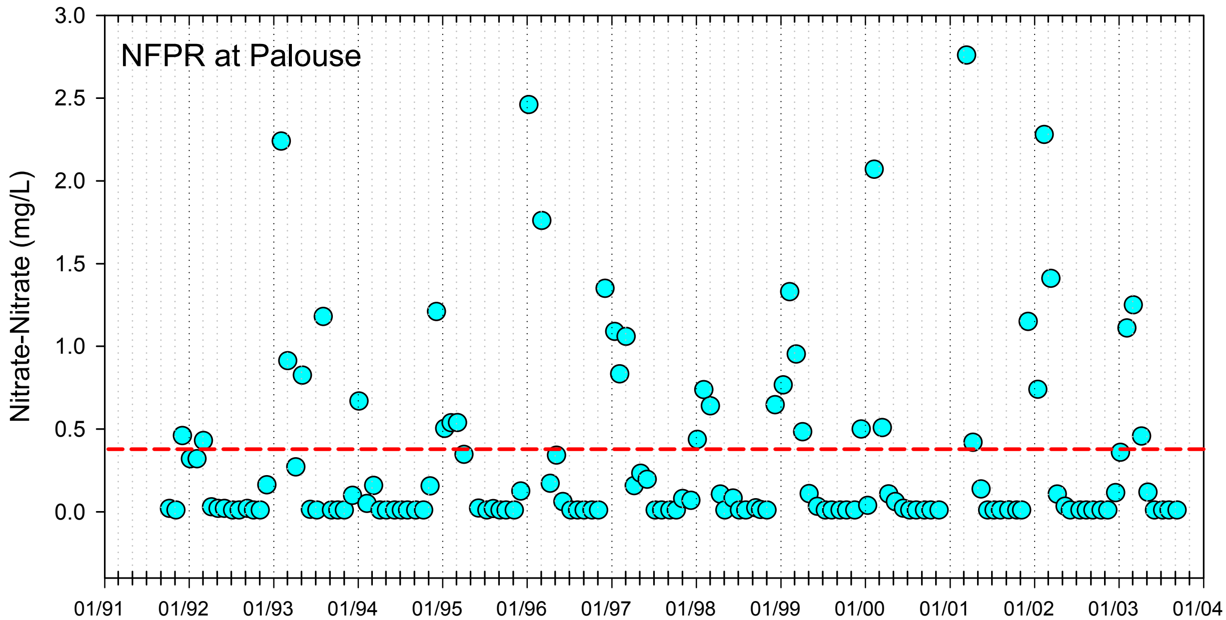


Figure 7-8. Nitrate-Nitrite Levels in South Fork Palouse River at Pullman (Ecology data set)

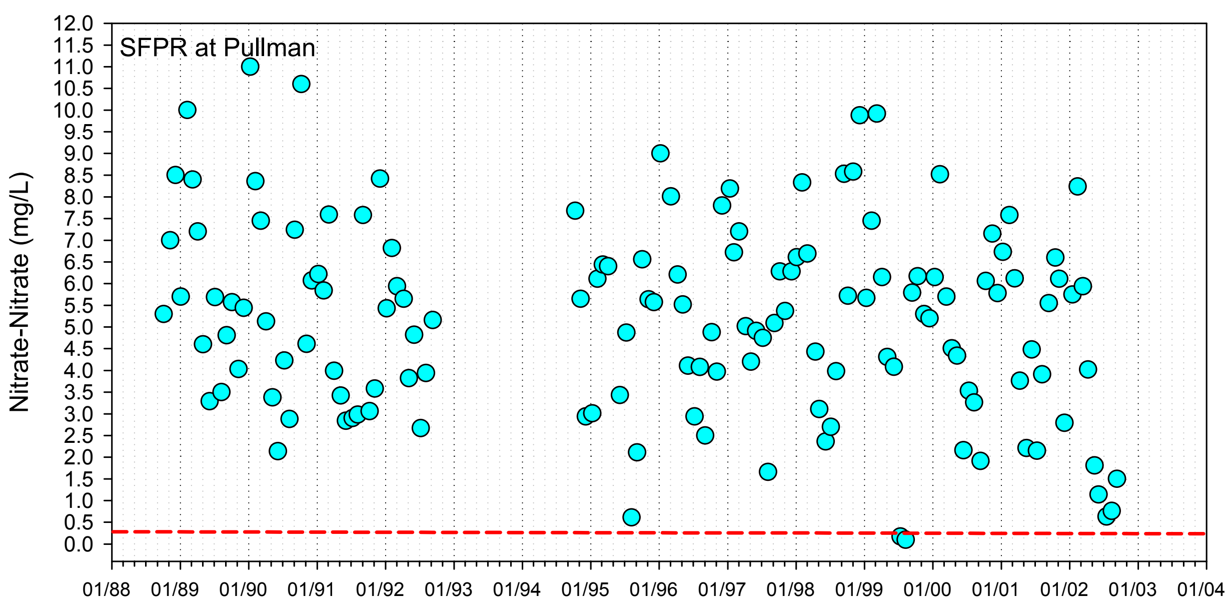


Figure 7-9. Nitrate-Nitrite Levels in Palouse River Near Hooper (Ecology data set)

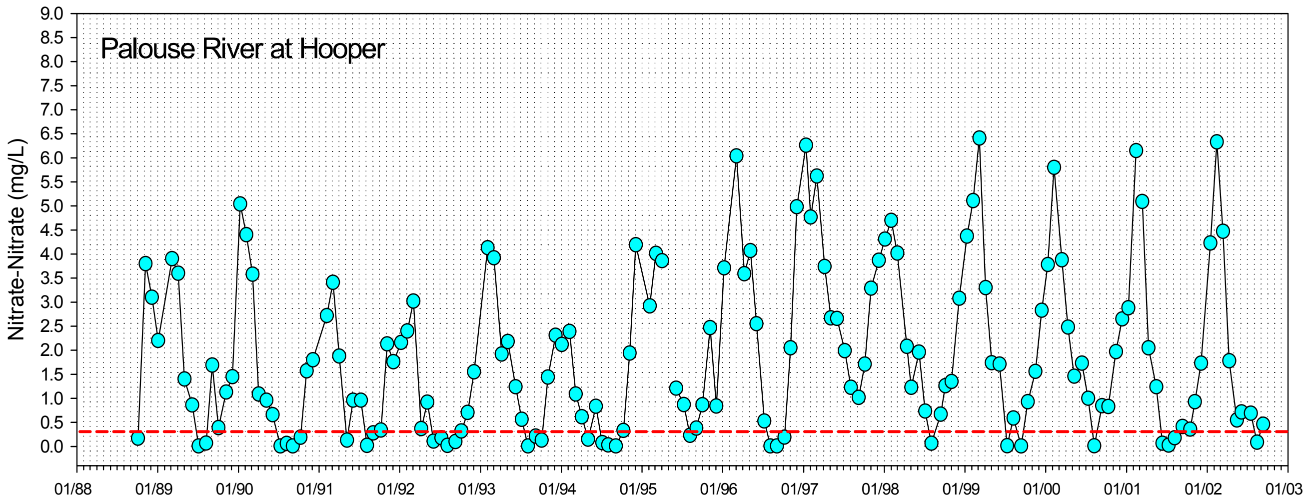


Figure 7-10. Inorganic Nitrogen Concentrations (USGS)

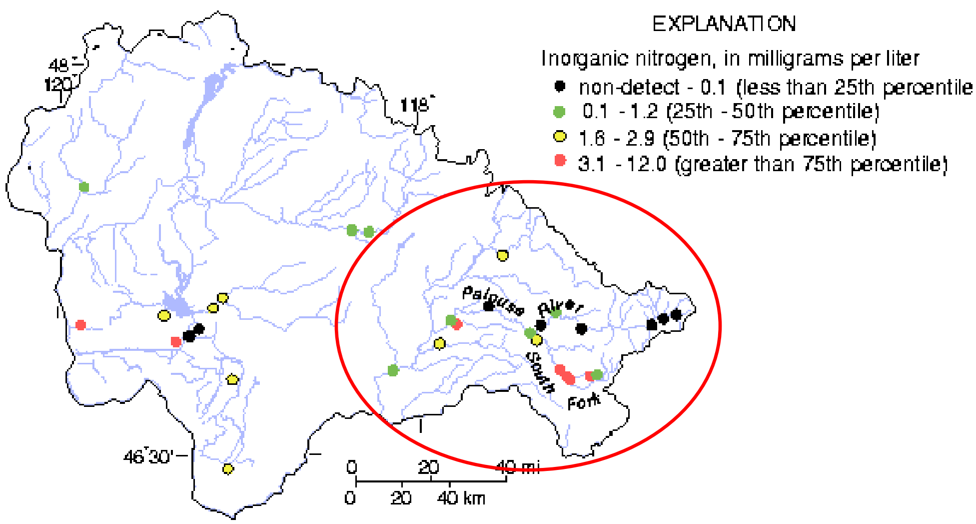


Figure 7-11. Total Phosphorus Concentrations in North Fork Palouse River Near Potlatch (USGS data set)

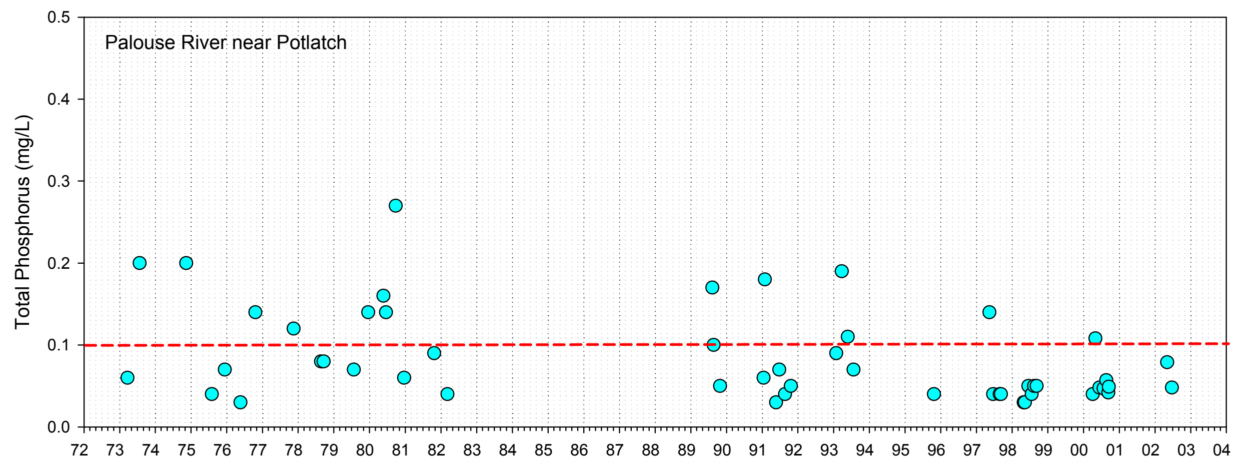


Figure 7-12. Total Phosphorus Concentrations in North Fork Palouse River at Palouse (Ecology data set)

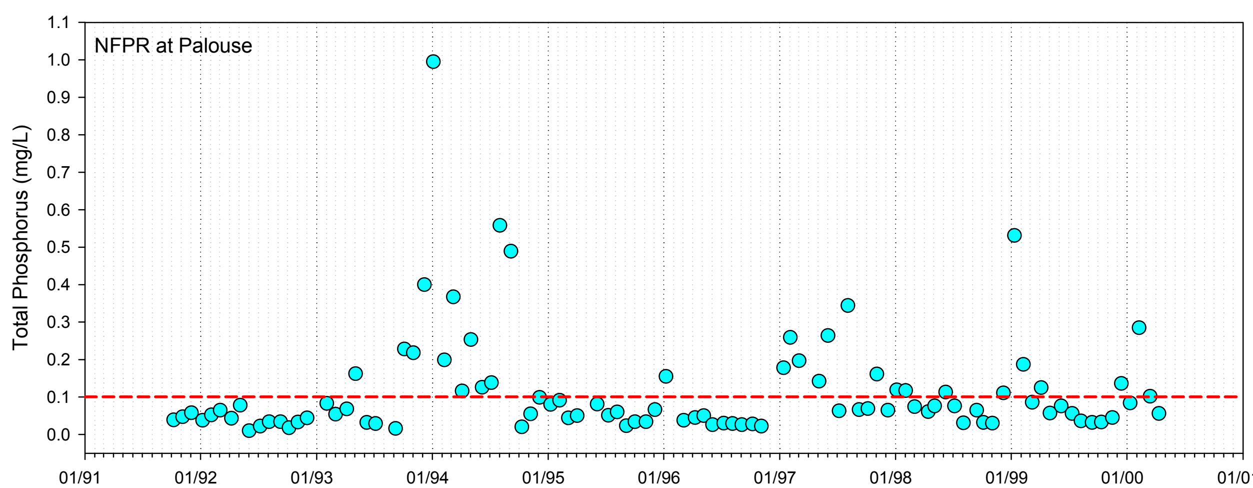


Figure 7-13. Total Phosphorus Concentrations in the South Fork Palouse River at Pullman (Ecology data set)

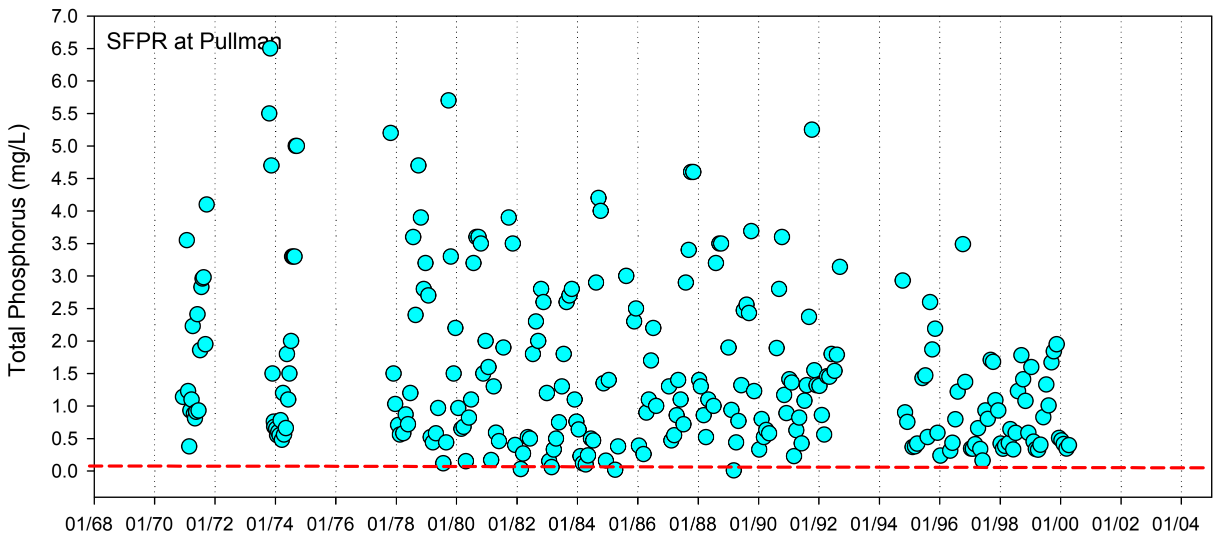


Figure 7-14. Total Phosphorus Concentrations in the Palouse River at Hooper (Ecology data set)

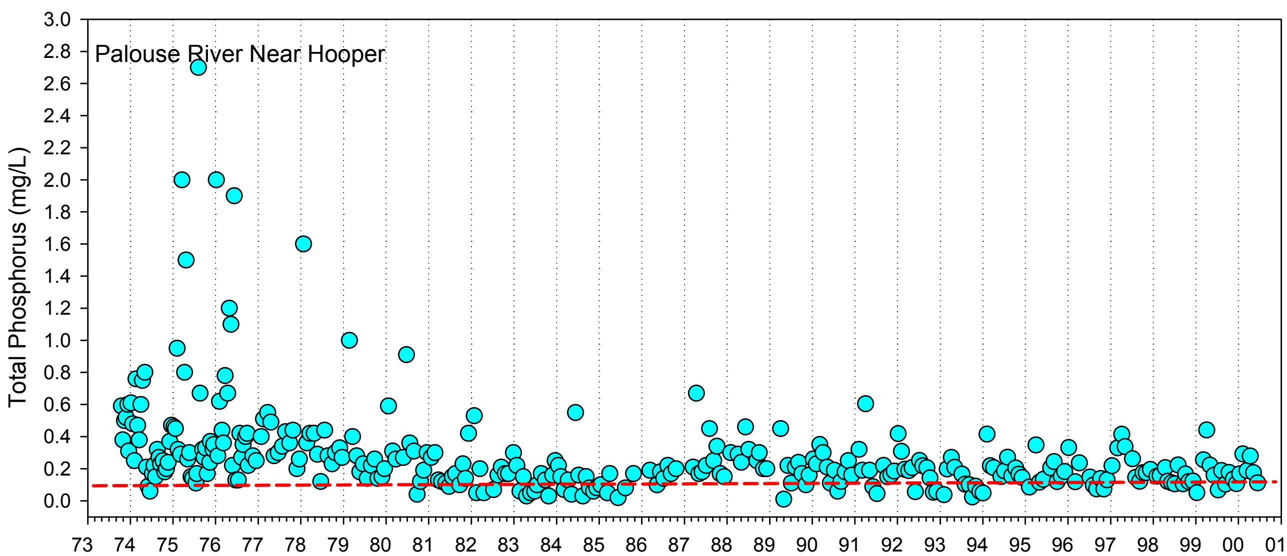
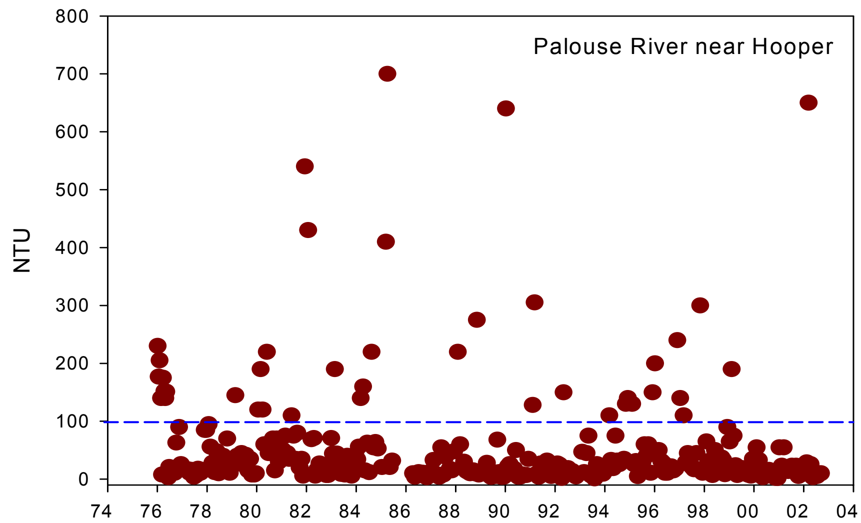
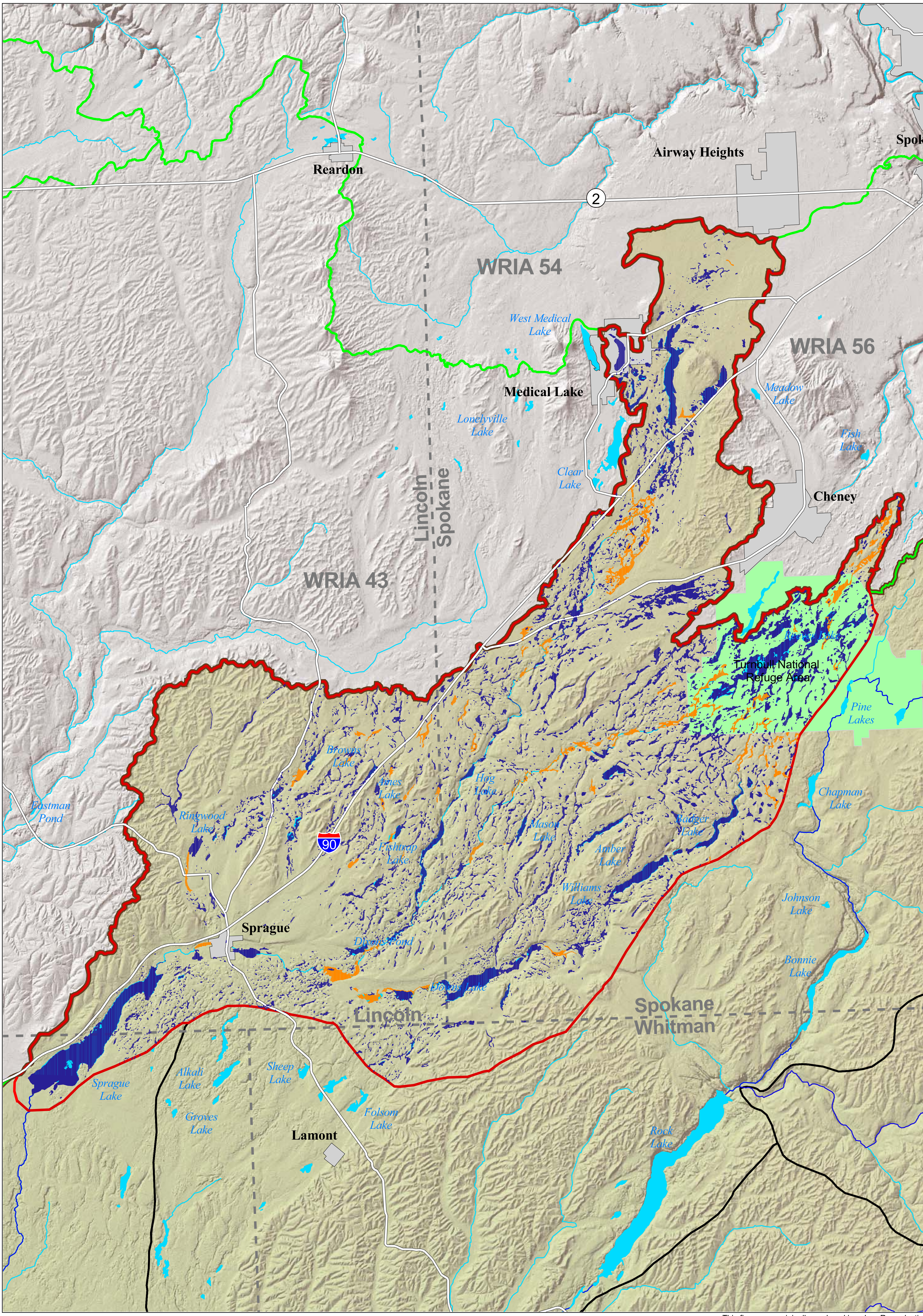


Figure 7-15. Turbidity Results in Palouse River Near Hooper (USGS data set)





LEGEND

- Palouse Watershed Boundary
- WRIA Boundary
- Subbasin Boundary
- National Wildlife Refuge
- Community
- Waterbody
- Drained Wetland Area
- Undrained Wetland Area
- Upper Cow Creek Subbasin Boundary
- County Boundary
- Road
- Stream

0 3
Scale 1" = 3 Miles

N

Map Projection: Washington State Plane South Zone, NAD 83, Feet

Source: WSDOE, WSDOT, USGS, INSIDE Idaho, GIS Data Depot, NWI 1:24K, (1971-1997)

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WETLAND AREAS: DRAINED AND UNDRAINED

WRIA 34 WATERSHED PLANNING/WA

Drawn: BBA	Revision: 1	Date: Dec. 7, 2004	Figure: 8-1

04310641030_012804.apr

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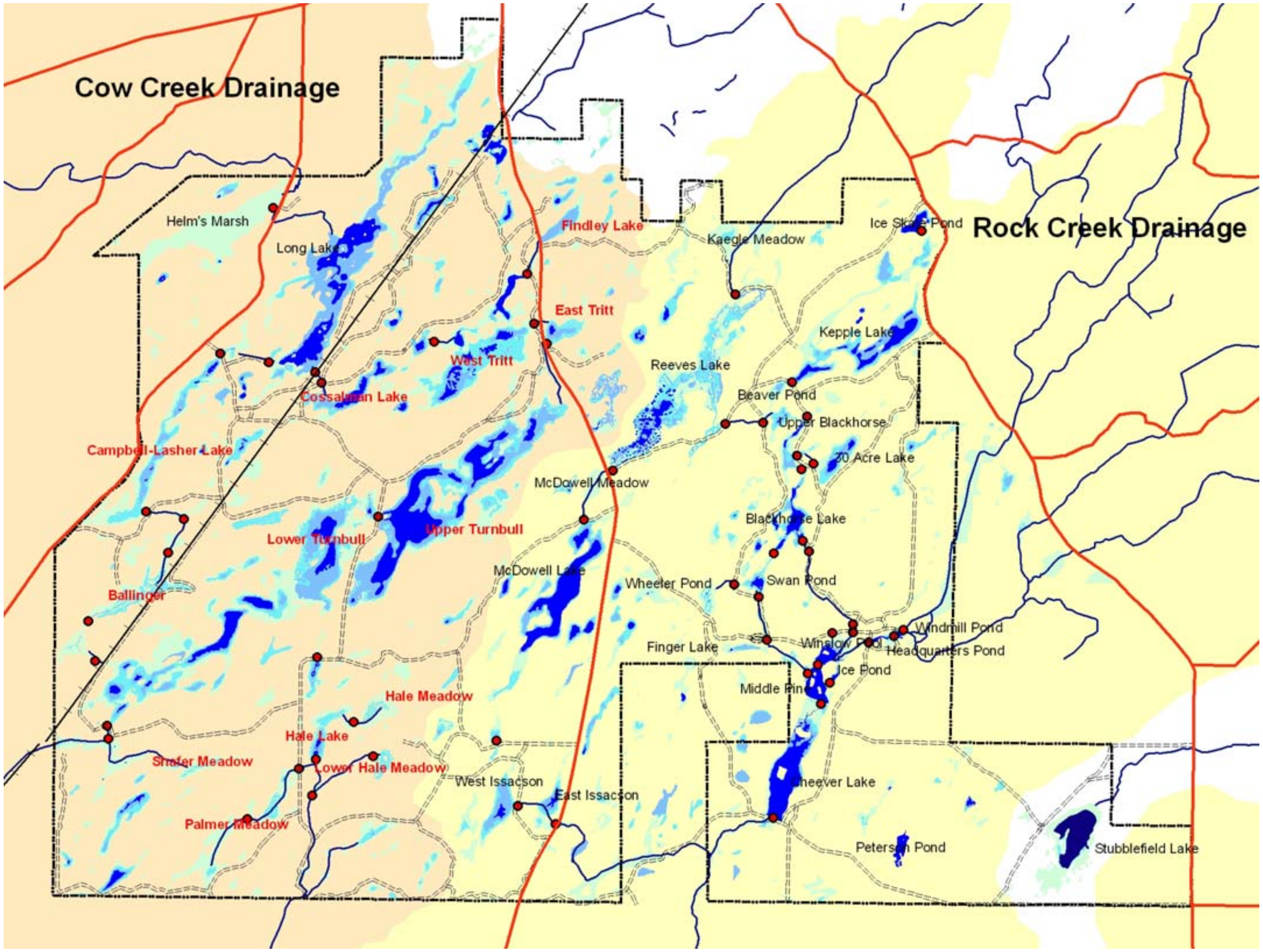


FIGURE **8-2**

MANAGED WETLANDS AT TURNBULL WILDLIFE REFUGE

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641120fg01.fh11 DATE 12/06/04 DRAWN BY EFS

Golder Associates

Long Lake water control structure
September 17, 2004

Cossalman Lake water control structure
September 17, 2004

Upper Turnbull Slough water control structure
September 17, 2004

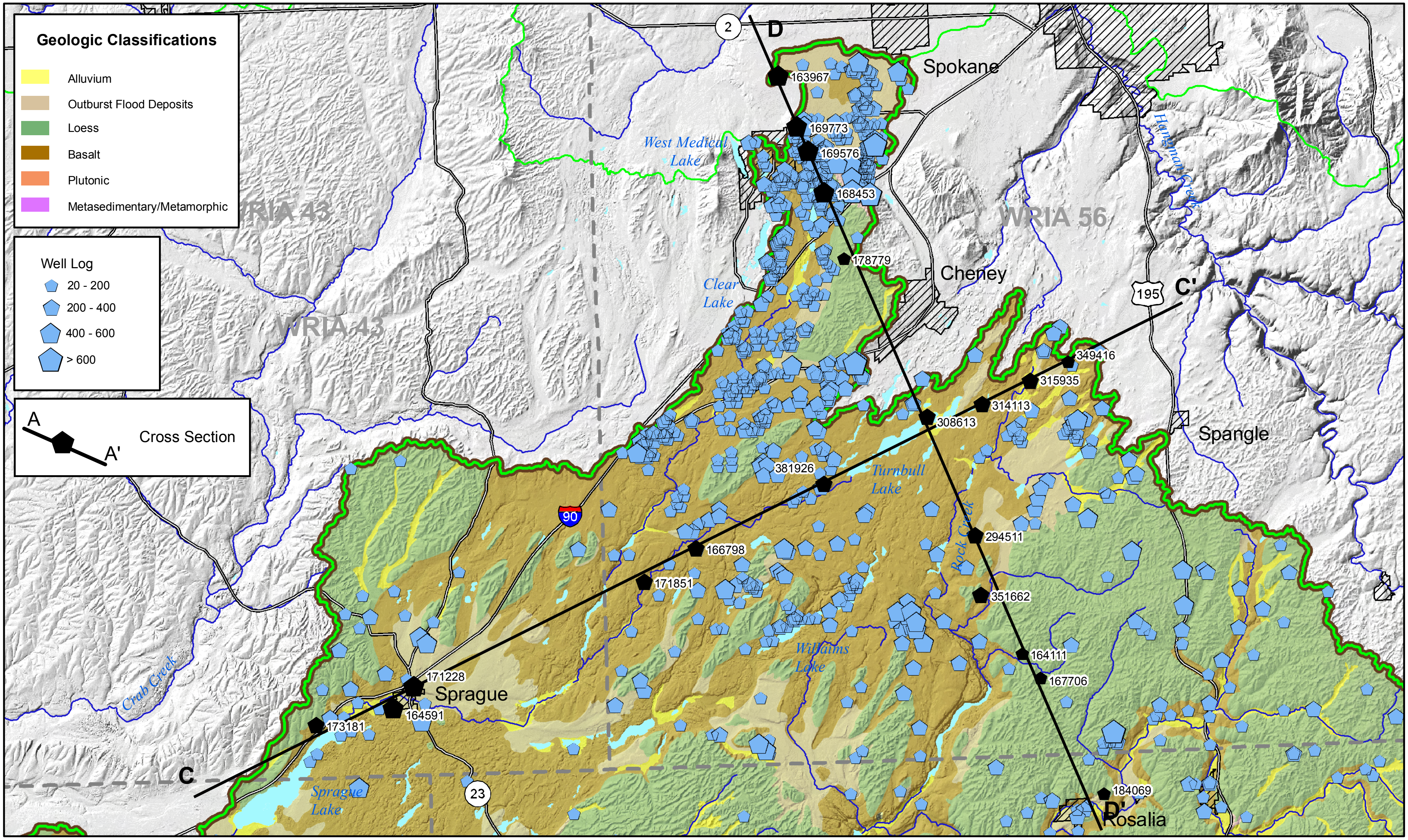
FIGURE **8-3**

EXAMPLE WATER CONTROL STRUCTURES AT TURNBULL WILDLIFE REFUGE

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641120fg02.fh11 DATE 12/06/04 DRAWN BY EFS

Golder Associates



LEGEND

- Palouse Watershed Boundary
- WRIA Boundary
- Waterbody
- Stream
- Road
- County Boundary
- Community

0 5 Miles

Scale 1" = 5 Miles

Map Projection:
Washington State Plane,
South Zone, NAD 83, Feet

Source: USGS (Geology 1:250k), WSDOE,
WDNR (Geology 1:100k), WSDOT, INSIDE
Idaho (Geology 1:100k), GIS Data Depot

DRAFT

N

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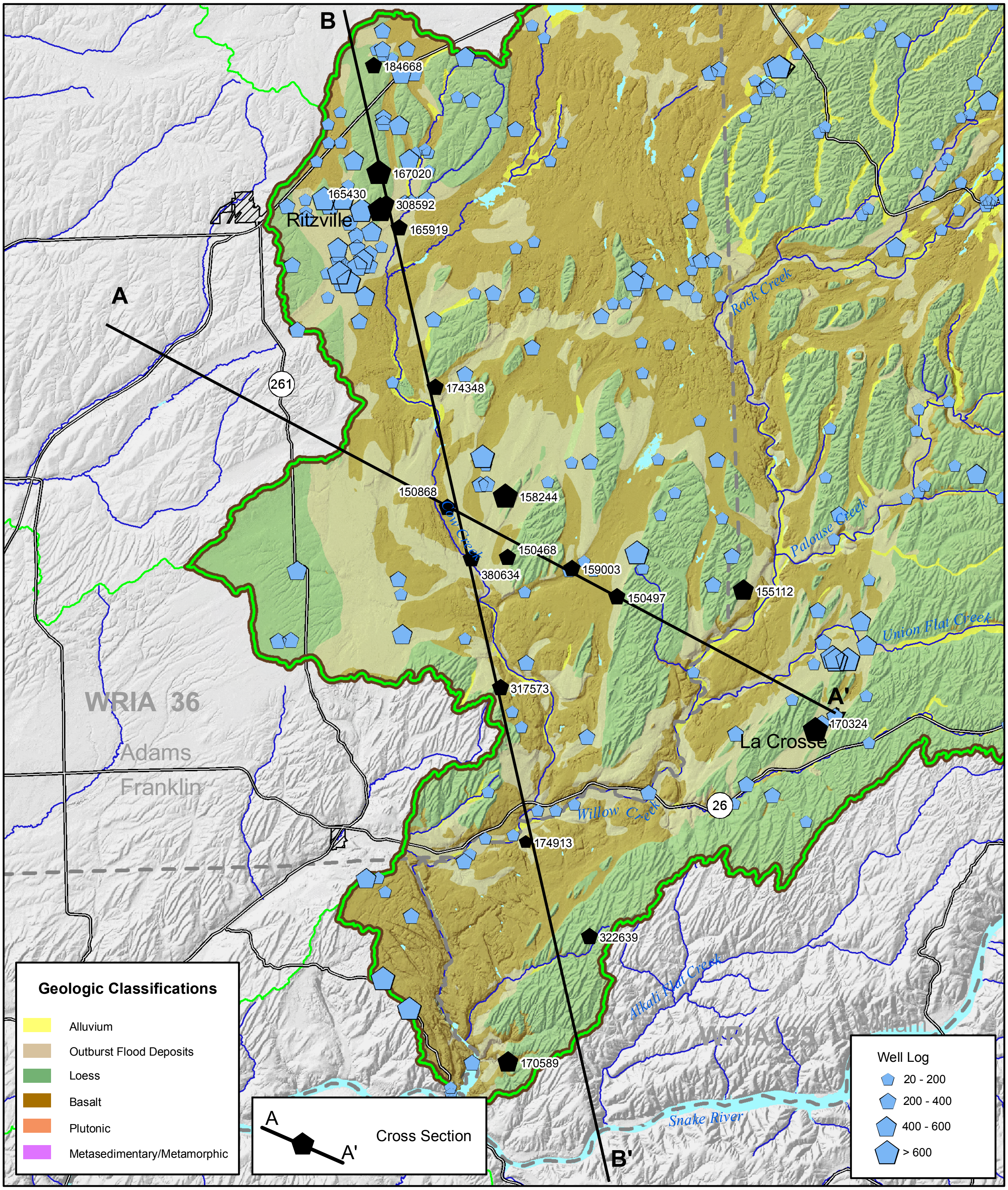
Upper Cox Creek / Sprague Lake

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: SJG	Revision: 2	Date: Dec. 7, 2004	Figure: 8-4

04310641080F16R0.mxd

Golder Associates



This figure was originally produced in color. Reproduction in black and white may result in loss of information.

LEGEND

- Palouse Watershed Boundary
- WRIA Boundary
- Waterbody
- Stream
- Road
- County Boundary
- Community

0 30,000

Scale 1" = 30000 Feet

N

Map Projection:
Washington State Plane,
South Zone, NAD 83, Feet
Source: USGS (Geology 1:250k), WSDOE, WDNR (Geology 1:100k), WSDOT, INSIDE Idaho (Geology 1:100k), GIS Data Depot

Lower Cow Creek

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: SJG	Revision: 2	Date: Dec. 7, 2004	Figure: 8-5

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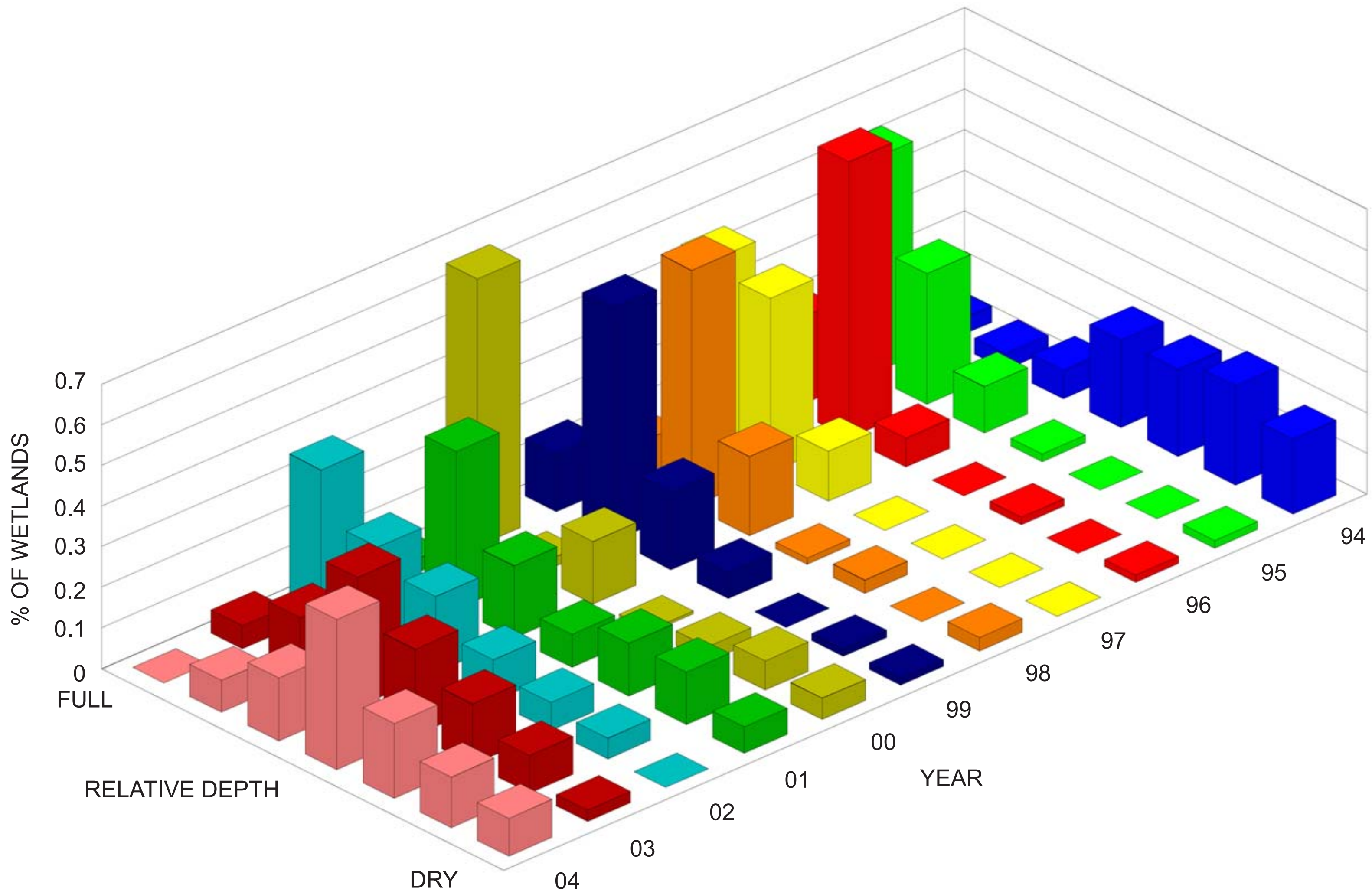

FIGURE **8-6**

WATER DEPTH IN TURNBULL WILDLIFE WETLANDS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641140fg06.fh11 DATE 12/03/04 DRAWN BY EFS

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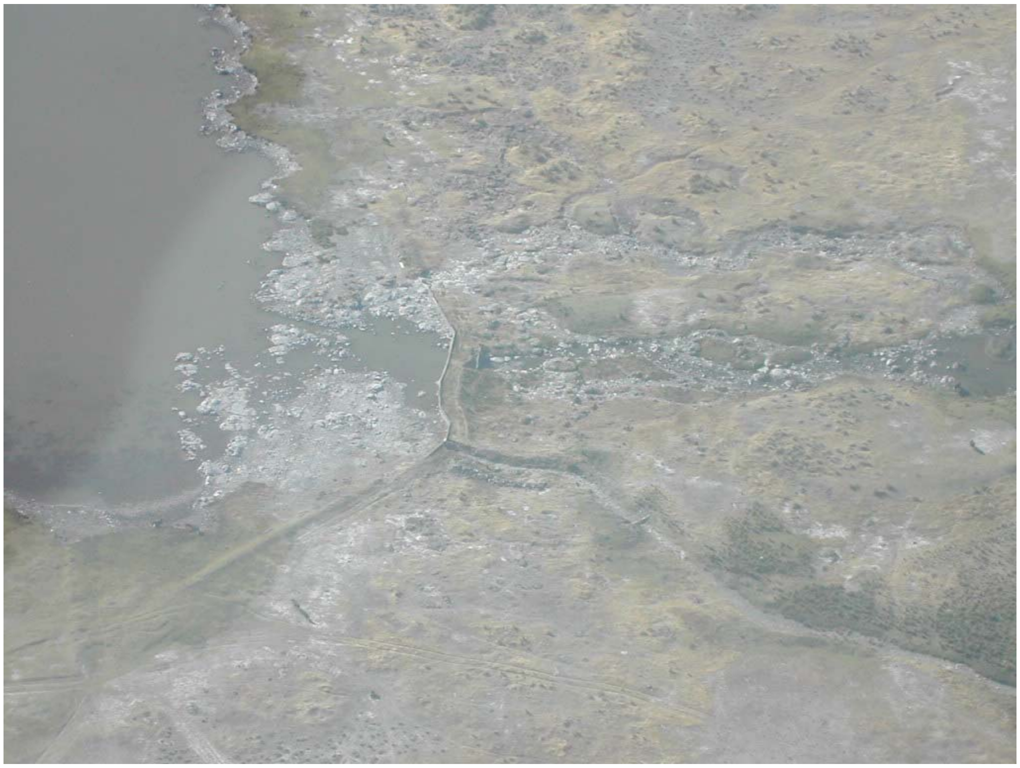
Sprague Lake outlet dam, May 19, 2002.

Sprague Lake outlet, October 27, 2003.

FIGURE **8-7a**

SPRAGUE LAKE SITE PHOTOGRAPHS

PCD/WRIA 34 WATERSHED PLANNING/WA



Cow Lake outlet, July, 2002.

Cow Lake outlet, June 5, 2003.

FIGURE **8-7b**

COW LAKE SITE PHOTOGRAPHS

PCD/WRIA 34 WATERSHED PLANNING/WA

Sheep Springs dam flood.

Sheep Springs dam, July, 2002.

FIGURE **8-7c**

SHEEP SPRINGS SITE PHOTOGRAPHS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641120fg06.fh11 DATE 12/06/04 DRAWN BY EFS

Golder Associates

Sheep Springs looking SW.

FIGURE **8-7d**
SHEEP SPRINGS SITE PHOTOGRAPHS
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641120fg07.fh11 DATE 12/06/04 DRAWN BY EFS

Golder Associates

Hog Canyon, February 22, 2002.

Hog Canyon, July, 2002.

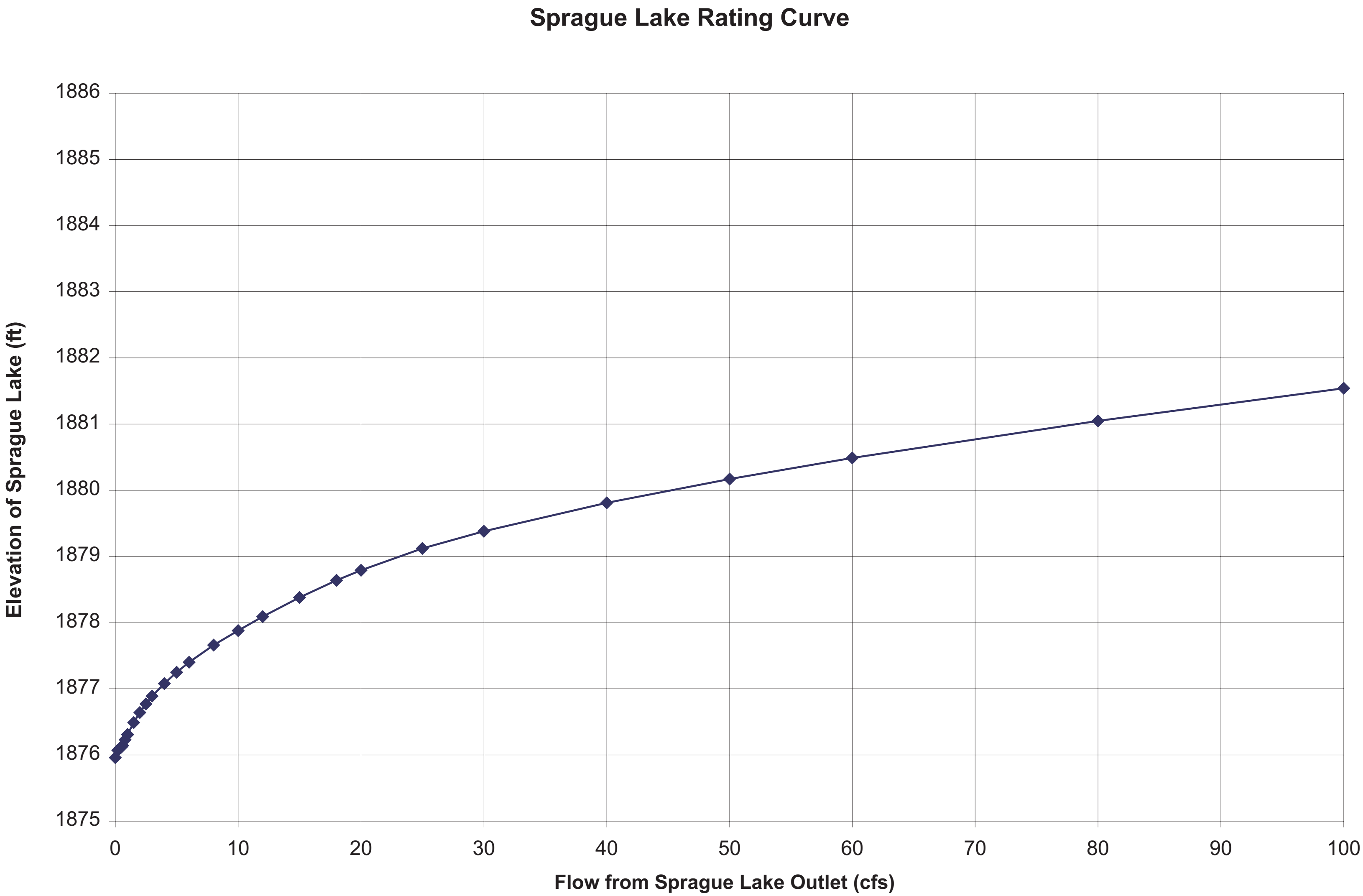
FIGURE **8-7e**

HOG CANYON SITE PHOTOGRAPHS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641120fg03.fh11 DATE 12/06/04 DRAWN BY EFS

Golder Associates



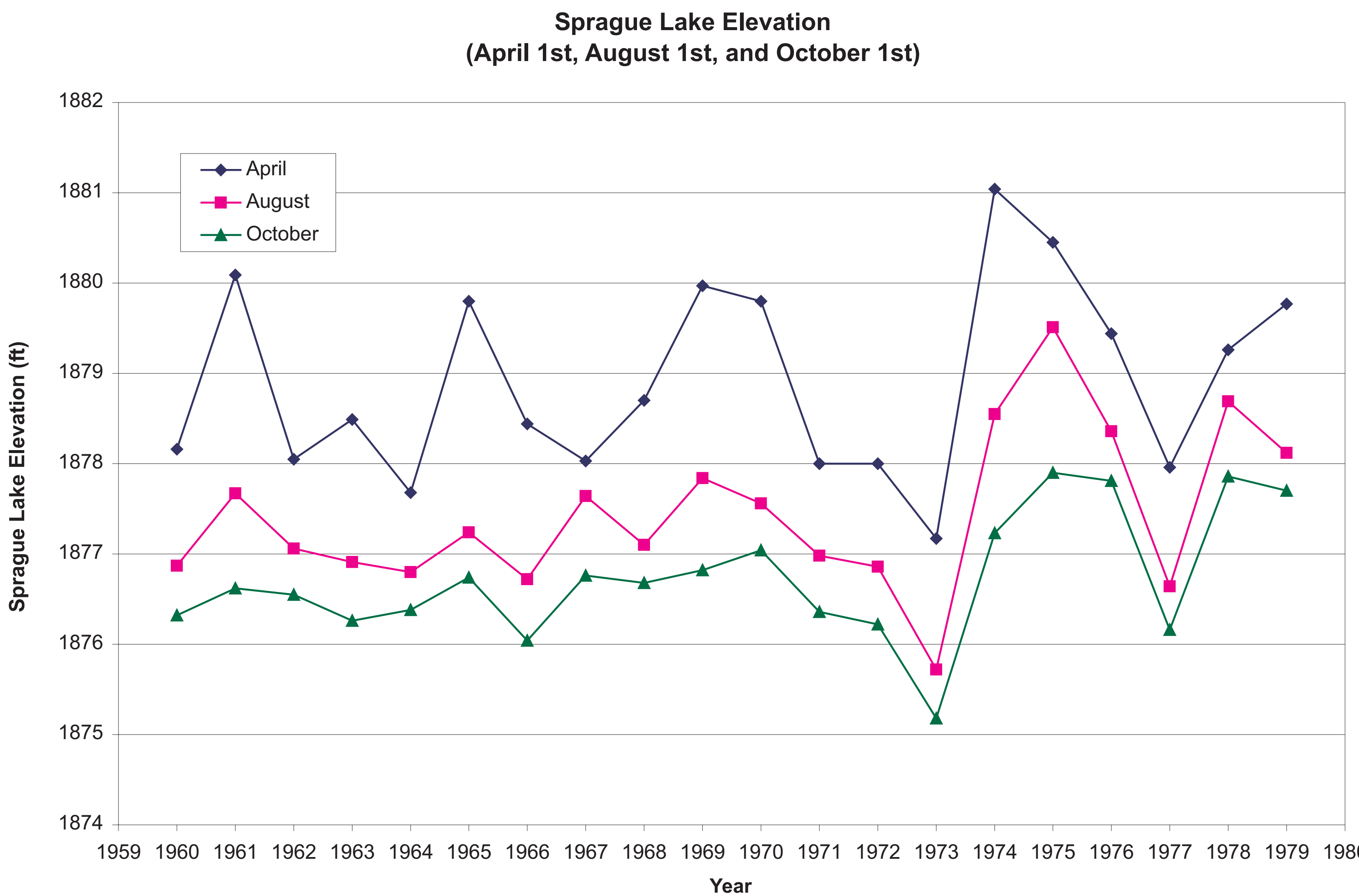
Note: Average Lake Level = 1877.4
Estimated Average Lake outflow = 6 cfs

Source: Provisional Data Provided by WDOE (Martin Walther, 2004)

FIGURE **8-8**
RATING CURVE FOR SPRAGUE LAKE
PCD/WRIA 34 WATERSHED PLANNING/WA

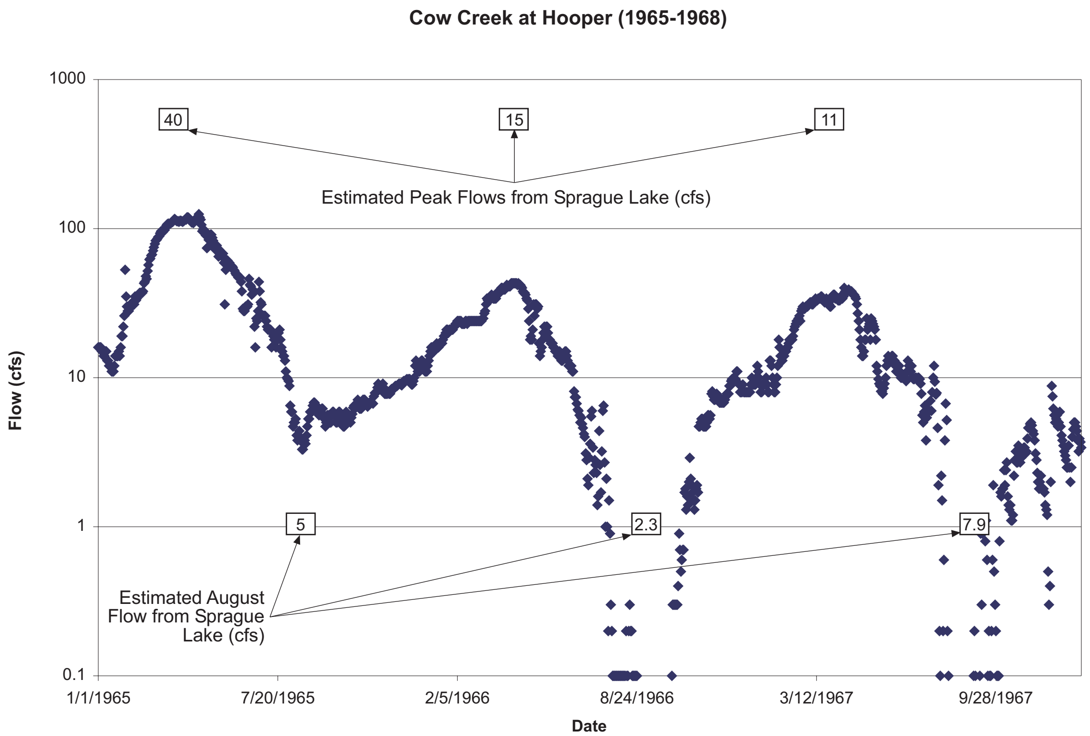
DRAWING NO. 04310641120fg09.fh11 DATE 12/06/04 DRAWN BY EFS

Golder Associates



Note: Based on Hand Written Records Provided by USGS Data from the First Day or Record in April, August and October was Selected for the Plot.

FIGURE **8-9**
WATER SURFACE ELEVATION AT SPRAGUE LAKE
PCD/WRIA 34 WATERSHED PLANNING/WA



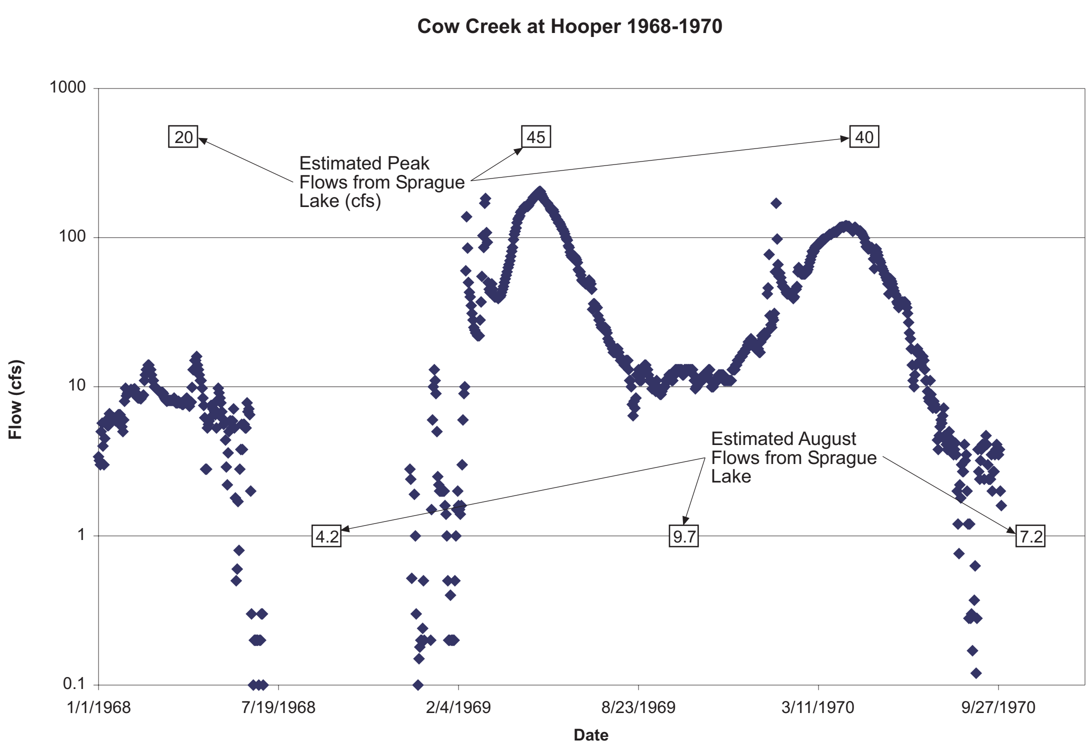
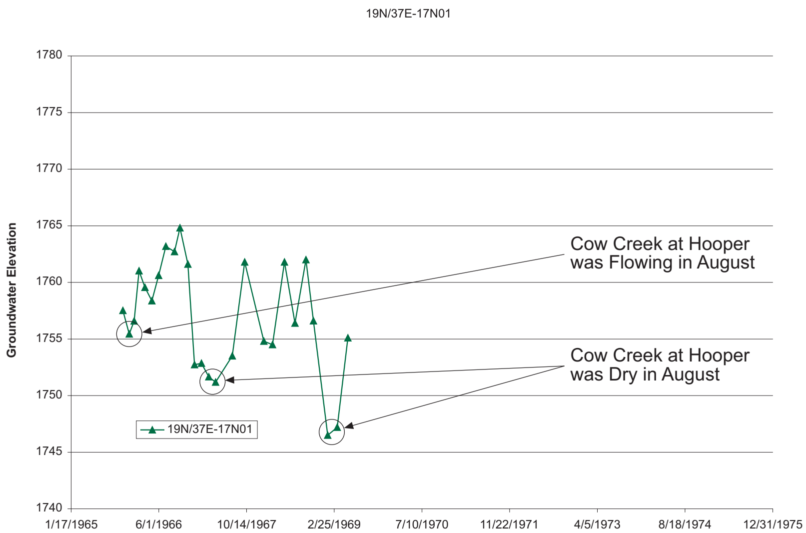


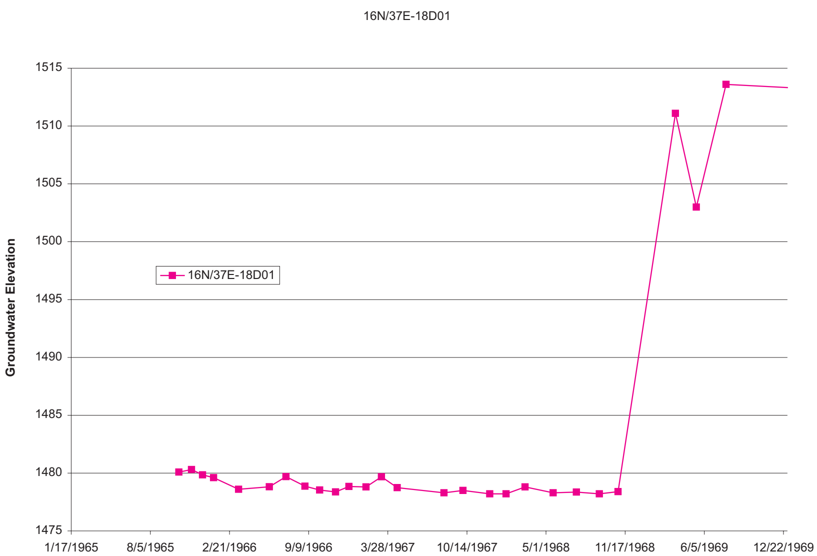
FIGURE **8-10**

STREAMFLOWS IN COW CREEK AT HOOPER

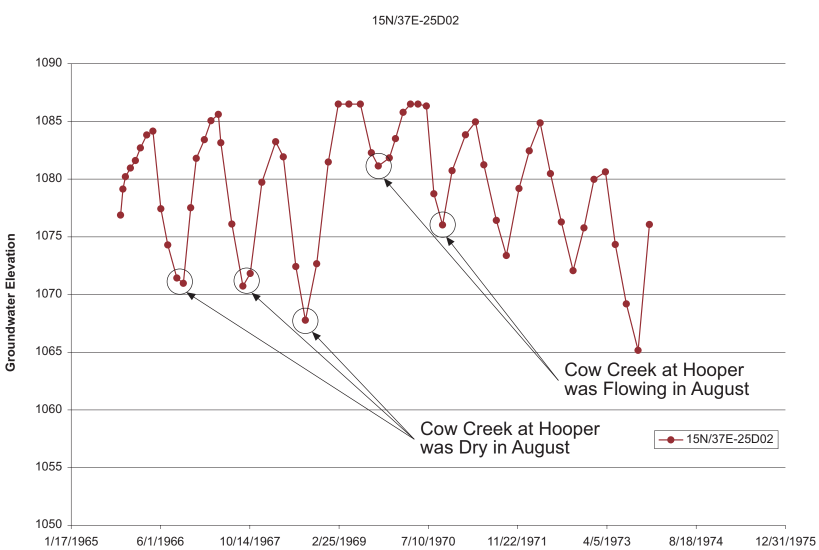
PCD/WRIA 34 WATERSHED PLANNING/WA



Note: Well Depth = 80’
Completion Elevation = 1,727
Location: Near Cow Lake



Note: Well Depth = 102’
Completion Elevation = 1,727
Location: Near Sheep Spring



Note: Well Depth = 473’
Completion Elevation = 612
Location: Near Hooper

FIGURE **8-11**
GROUNDWATER LEVEL FLUCTUATIONS COW CREEK
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641120fg14.fh11 DATE 12/06/04 DRAWN BY EFS

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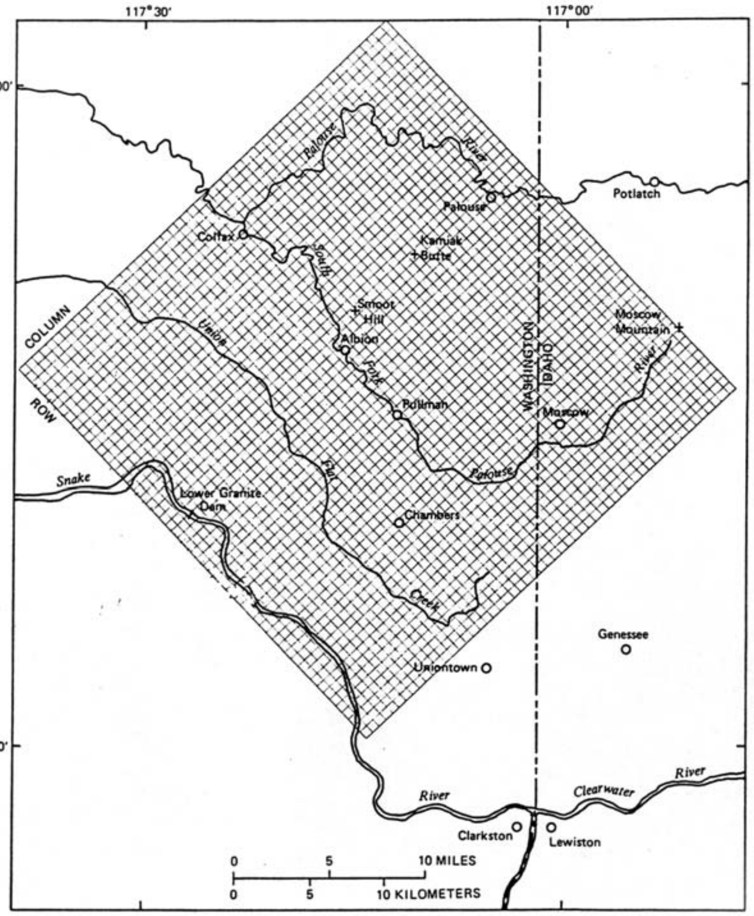
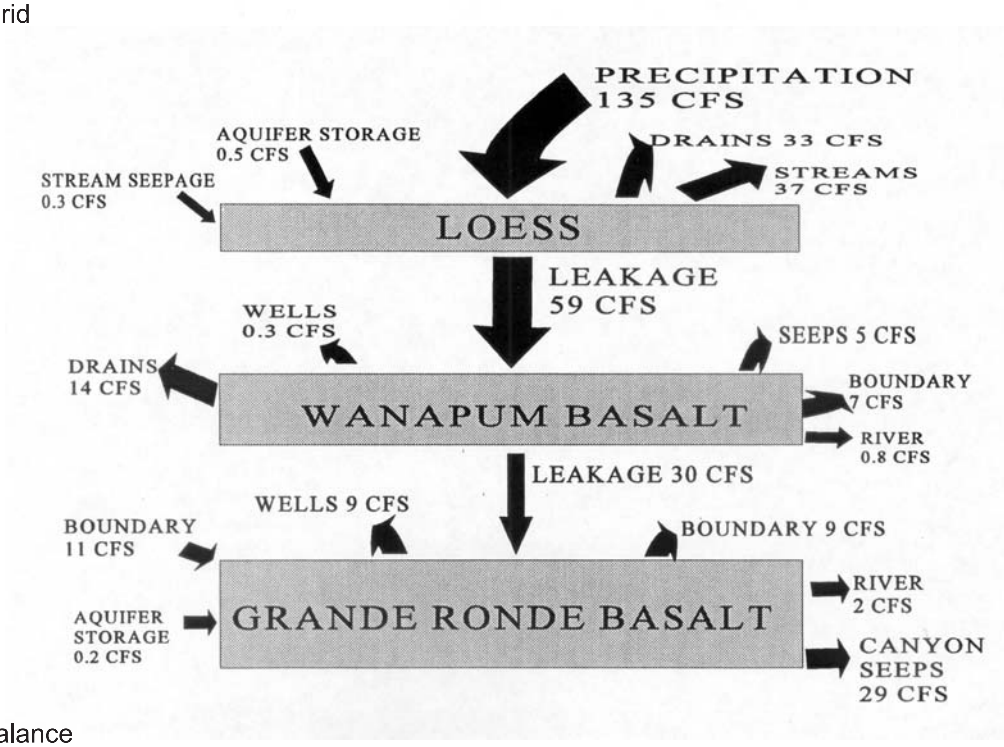


A. Model Grid



B. Water Balance

FIGURE **9-1**

SCHEMATIC OF GROUNDWATER MODEL FOR PALOUSE BASIN AQUIFER

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641140fg05.fh11 DATE 12/03/04 DRAWN BY EFS

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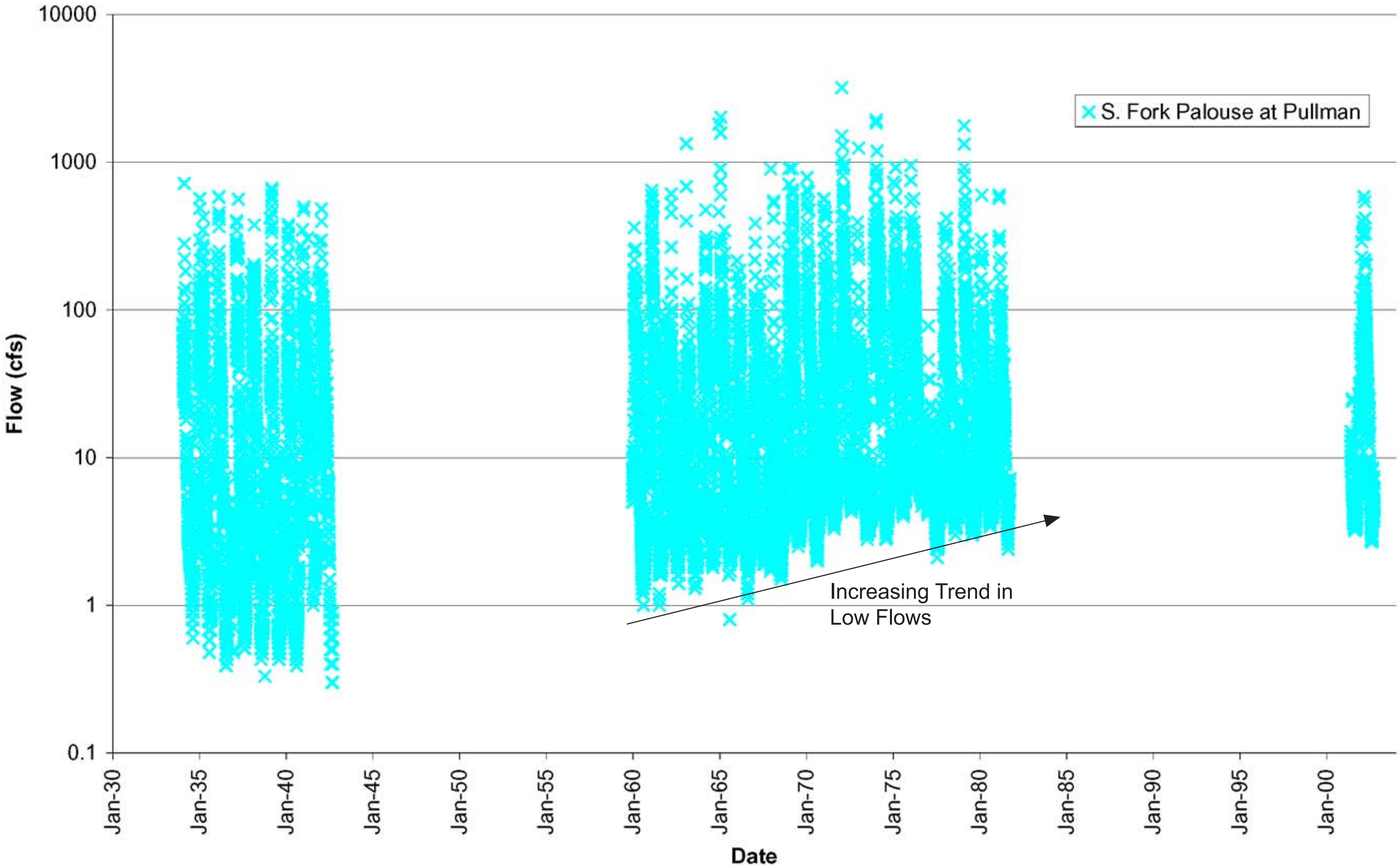

FIGURE **9-2**

SOUTH FORK PALOUSE STREAM FLOWS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641120fg10.fh11 DATE 11/02/04 DRAWN BY EL

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FIGURE **9-3**

MOSCOW/PULLMAN AREA GROUNDWATER LEVELS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641120fg13.fh11 DATE 11/02/04 DRAWN BY EL

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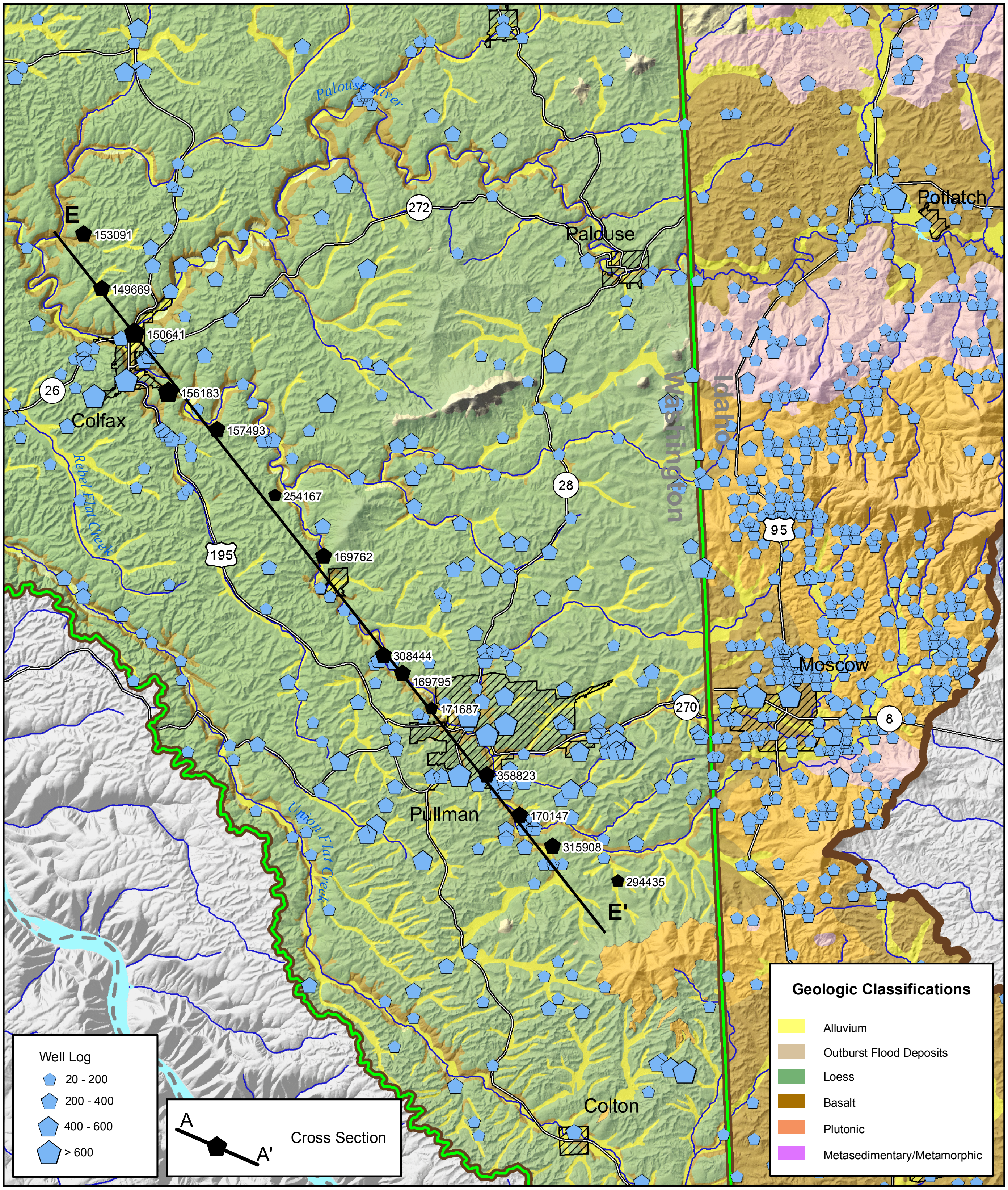

LEGEND

- Palouse Watershed Boundary
- WRIA Boundary
- Waterbody
- Stream
- Road
- County Boundary
- Community

0 3 Miles

Scale 1" = 3 Miles

Map Projection:
Washington State Plane,
South Zone, NAD 83, Feet

Source: USGS (Geology 1:250k), WSDOE, WDNR (Geology 1:100k), WSDOT, INSIDE Idaho (Geology 1:100k), GIS Data Depot

N

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Palouse Basin

PCD/WRIA 34 WATERSHED PLANNING/WA

Drawn: SJG	Revision: 1	Date: Dec. 7, 2004	Figure: 9-4

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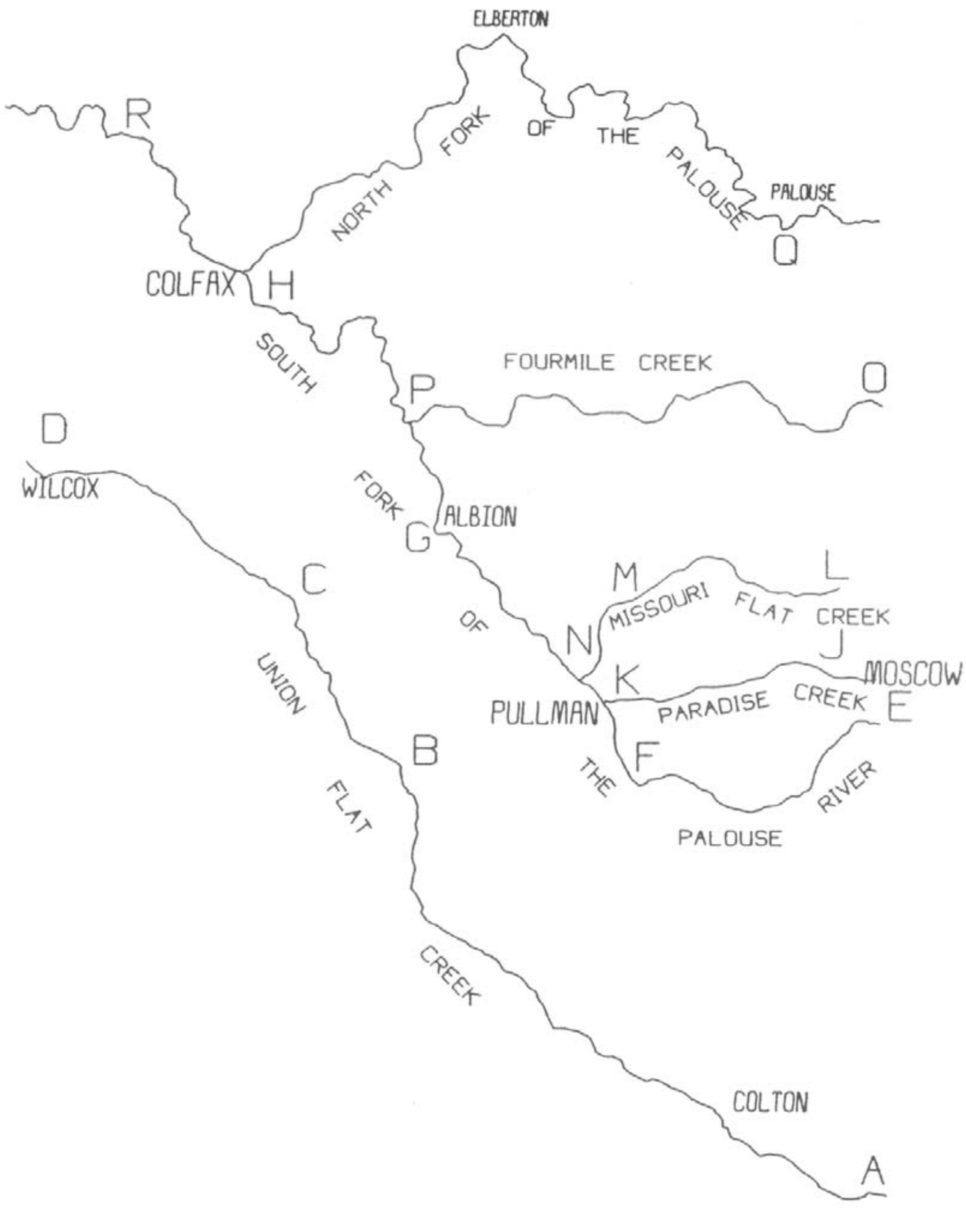
Golder Associates



Note: Adapted from Heinemann, 1994

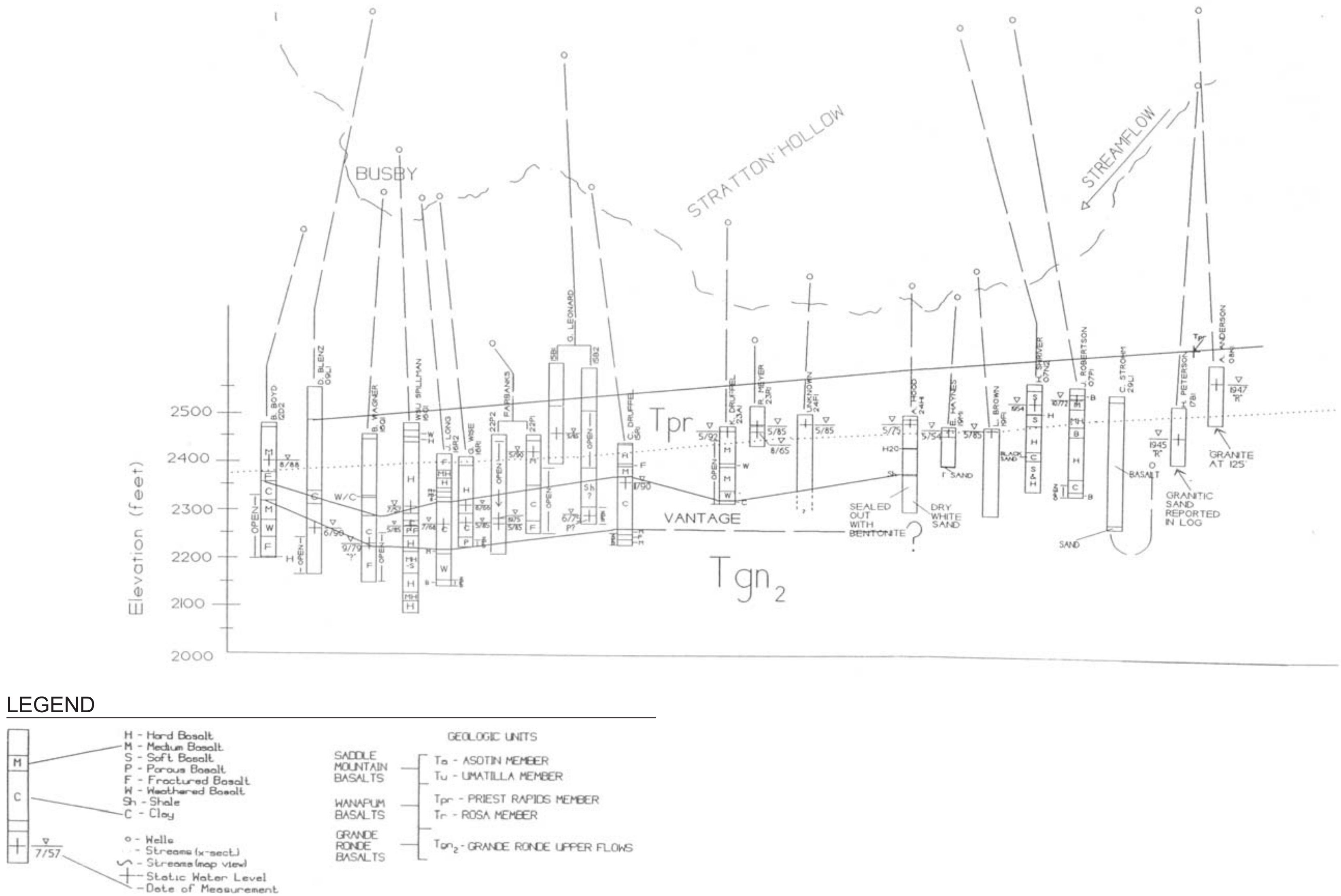
FIGURE **9-5**

LOCATION MAP FOR AREA STREAM CROSS SECTIONS

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641140fg04.fh11 DATE 11/23/04 DRAWN BY AMP

Golder Associates

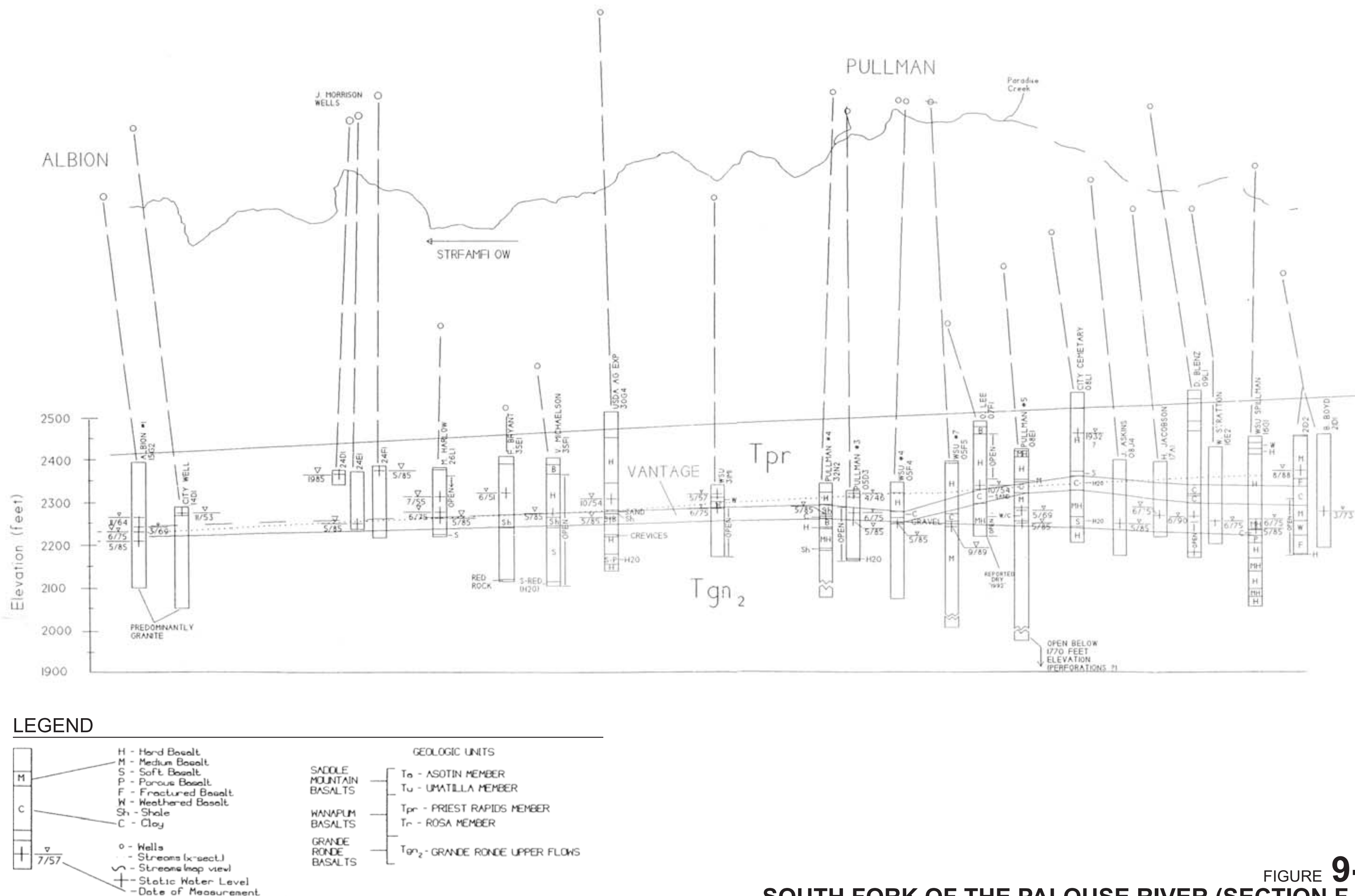


Note: Adapted from Heinemann, 1994

FIGURE **9-6**
SOUTH FORK OF THE PALOUSE RIVER (SECTION E-F)
PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641140fg01.fh11 DATE 11/23/04 DRAWN BY AMP

Golder Associates



Note: Adapted from Heinemann, 1994

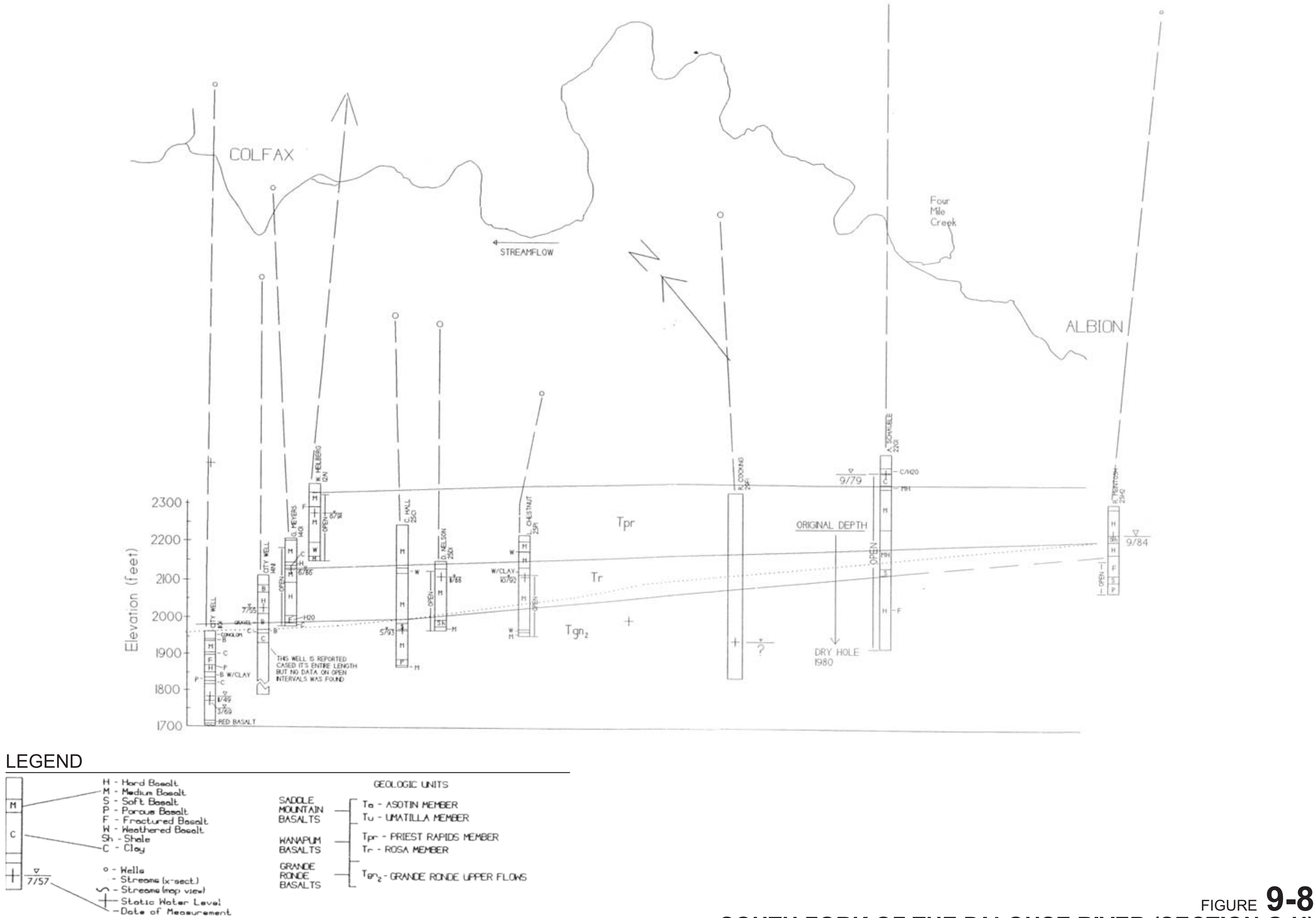
FIGURE **9-7**

SOUTH FORK OF THE PALOUSE RIVER (SECTION F-G)

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641140fg02.fh11 DATE 11/23/04 DRAWN BY AMP

Golder Associates



Note: Adapted from Heinemann, 1994

FIGURE **9-8**

SOUTH FORK OF THE PALOUSE RIVER (SECTION G-H)

PCD/WRIA 34 WATERSHED PLANNING/WA

DRAWING NO. 04310641140fg03.fh11 DATE 11/23/04 DRAWN BY AMP

Golder Associates