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INITIAL WATERSHED ASSESSMENT
WATER RESOURCES INVENTORY AREA 22
WALLA WALLA RIVER WATERSHED

Open-File Technical Report 95-11

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1 Introduction

1.1 Background

Population growth within the past several decades has imposed significant pressure upon Washington State's limited water resources. Ecology is charged with protecting and managing these resources for the greatest public benefit. Currently, Ecology receives almost 2,000 applications per year for new water use permits. Almost two third of these applications are for ground water withdrawals. Historically, Ecology has evaluated most of these water right applications on an individual basis. This case-by-case approach requires a substantial amount of time and often lends itself to duplication of effort. In addition, this process may result in inconsistent and less defensible conclusions because the evaluation is often unable to provide a regional or long-term perspective on the natural hydrogeologic system.

It has become apparent to most resource planners that water rights decisions are often best evaluated from the context of a basin-wide analysis of the hydrologic system. Ecology, in order to increase the efficiency of the water rights permitting process, intends to base future permit decisions on hydrologic surveys of entire watersheds. Permits are granted on the condition that: 1) the use will be beneficial; 2) the use will be in the public interest; 3) the water is available; and 4) the use will not impair senior users. Determination of conditions 3 and 4 depends on whether the hydrologic system can sustain the new withdrawal without undesirable reductions in streamflow or ground water level declines.

As a first attempt to answer these questions, Ecology is working with teams of consultants on initial watershed assessments for 16 of the State's 62 Water Resource Inventory Areas (WRIAs). The assessments are considered "initial" because they are based on readily available, existing information and do not include collection or assessment of new or unanalyzed data. This watershed assessment includes development of a conceptual and quantitative hydrologic understanding of the interaction between climate, surface water and ground water. The assessment also considers existing allocations, withdrawals, water quality, and fisheries values. The "health" of the hydrologic system is assessed by focusing on critical indicators – hydrologic parameters which reflect the impacts of water withdrawals. Other environmental health parameters, notably surface water quality and fish stocks, are evaluated and compared to critical indicators.

The Walla Walla WRIA, not unlike many WRIAs in the State, is facing potentially conflicting pressures from water withdrawal requests and efforts to protect senior rights, fish stocks, and required minimum instream flows. It is hoped that the information presented in this initial assessment assists Ecology to develop conclusions regarding the potential availability of water within the WRIA, to seek resources for long-term approaches to water allocation, and (where information is lacking) to develop the necessary hydrologic monitoring programs.

1.2 Major Findings

Water Rights / Water Use:

- Water right allocations in the Walla Walla WRIA, reported as maximum allowable annual withdrawals (Qa's), are on the order of 513,200 acre-feet per year. Ground water permits and certificates comprise 51% of these allocations.

- Ecology currently has applications for 62 ground water and 7 surface water rights. Ground water applications request a total of 36,500 gallons per minute (86 cfs) of maximum instantaneous withdrawal (Qi). Surface water applications request almost 20 cfs of Qi. *(Note: Requested Qi's are sometimes for a greater amount than issued by Ecology. Annual quantities (Qa's) are typically less than annualized Qi's and are assigned once Ecology has completed its investigation of the application.)*

- Surface water permits and certificates (for consumptive use) are almost entirely allocated for irrigation use (99% of Qa). Surface water applications are similar, with over 99% of the application quantity (by Qi) requested for irrigation.

- Ground water permits and certificates are primarily allocated for irrigation and municipal uses (62% and 13% of Qa, respectively). Ground water applications request water primarily for irrigation (58% of Qi) and frost protection/heart control (17% of Qi).

- Water right claims in the WRIA are on the order of 37,400 acre-feet per year. Ground water claims comprise 74% of the total annual volume. Surface water claims were adjudicated in the Walla Walla River and some of its tributaries after 1920. As a result of the adjudications, claims on these water bodies may no longer be valid. Claims are registered largely for irrigation, and to a lesser degree domestic and stock watering purposes.

- Water use estimates are available for the WRIA, although actual water use is not well quantified. Estimated ground water withdrawals (38,000 to 68,000 af/yr) are about 15% to 26% of the currently allocated ground water permits and certificates. Estimated surface water diversions (46,000 af/yr) are about 18% of the currently allocated surface water permits and certificates. Improved documentation and quantification of water use would be valuable in assessing the dynamics of the hydrologic system.

Surface Water Hydrology:

- Analysis of average annual streamflow trends at four gages within the WRIA (on Mill Creek, Touchet River, and Walla Walla River) suggested below average flows beginning in the mid 1980s. The streamflow data, which begins in the 1940s and 1950s, did not strongly suggest long-term declining trends. The effects of climatic variation were not assessed, but may play a significant role in understanding the implications of streamflow trends.

- Analysis of minimum streamflow trends at the same four gages showed reduced flows (a progressive increase in zero-flow days) for Mill Creek at Walla Walla. The reduced minimum flows are associated with a diversion to Yellowhawk Creek, immediately upstream of the gage. Similarly obvious changes in zero-flow days or minimum flows were not found at the three other stream gages which were assessed. Minimum streamflows at these gages, in general, appeared to be stable.

- The suggested recent declines in average annual streamflow, without corresponding declines in minimum streamflow, illustrates that different hydrologic processes support total annual streamflow and summer low (minimum) flows. Minimum flows are strongly influenced by stream diversions, however the relative influence of mechanisms which support minimum flows (e.g. ground water seepage and irrigation return flows) are not well understood.

Ground Water Hydrology:

- Major aquifers occur within an alluvial gravel deposit (gravel aquifer) in the approximate center of the basin and within tertiary basalt flows (basalt aquifer system) which underlie the entire basin. The basalt aquifer system is comprised by a number of relatively thin tabular water bearing zones found at the contacts between adjacent basalt flows. In most places, these two major aquifer (systems) are separated by a thick low-permeability clay layer which overlies the basalt.

- A high degree of hydraulic continuity exists between the gravel aquifer and local rivers and streams. The basalt aquifer system is connected on a more regional scale to the major drainages (Columbia and Snake Rivers). Additional development from the gravel aquifer will serve to further reduce flows in local rivers and streams. Additional development from the basalt aquifer system will reduce ground water discharge to the Columbia and Snake River, and will likely result in continued ground water level declines.

- An analysis of water budget components estimated for the Walla Walla WRIA suggests that about 20% of precipitation goes to ground water recharge. In addition, about 16%-20% of recharge goes to ground water development. The remaining recharge exits the WRIA as ground water subflow or discharges to springs, rivers and streams. Although water budgets may quantify flow through various components of the hydrologic cycle, they cannot be rigorously used to assess resource availability because they do not allow prediction of system response to additional withdrawals.

- Water level trends were assessed to determine if long-term declines (critical indicators of ground water over-extraction) were evident. Significant declines have been observed in wells completed in the basalt aquifer system. These declines have been evident since pumping began in the 1940's, however declines have reduced starting in the early 1970's. Data for the gravel aquifer are quite limited for the Washington portion of the basin. Most of the gravel wells in Oregon, for which adequate records exist, indicate stable water level trends.

Stream Water Quality and Fisheries:

- High summer temperatures and high sediment delivery to streams in lower reaches of the basin are the largest water quality concerns identified in the WRIA. High temperatures are a result of natural low flow conditions, water withdrawals and removal of riparian vegetation. Summer high temperatures that can be lethal to fish have been recorded. Soil erosion as a result of agricultural activities has been noted as a major cause of sedimentation. Other factors potentially affecting water quality in the WRIA have not been extensively investigated.

- The most recent 303(d) water quality limited list submitted to EPA by Ecology includes a portion of the Walla Walla River for temperature, pH, fecal coliform and heptachlor violations; a portion of the Touchet River for temperature, pH and fecal coliform violations; a portion of the North Fork Touchet River for temperature violations; and portions of Mill Creek for phosphorus, nitrogen, temperature and fecal coliform violations.

- Both of the summer steelhead stocks utilizing habitat in the WRIA are chronically depressed, meaning they are close to or below the population size where permanent loss of distinct genetic material is a risk. These stocks include the Touchet and Walla Walla River wild summer steelhead stocks. Critical steelhead habitat is found in the North Fork Touchet River, upper Robinson Creek and tributaries, in tributaries to the upper South Fork Touchet River and in upper portions of Mill Creek.

- Stream habitat in the lower reaches of the WRIA is degraded. Irrigation depleted streamflow is the major factor limiting production of anadromous fish within the WRIA. Intensive agriculture uses most of the available surface water, and low to no-flow conditions have been documented throughout the WRIA. Irrigation diversions also present significant barriers to fish passage. Continued habitat degradation, along with low flows that are aggravated by water withdrawals from drainages in the basin, may lead to declines in water quality and/or fish stocks in the future.

- Low flow or no-flow conditions have been reported on the Walla Walla River, Mill Creek, Dry Creek, Blue Creek and Touchet River. Some reaches where low flows have been reported also provide spawning habitat for steelhead stocks in the WRIA. Most of the information reviewed for this report did not identify specific stream reaches. Low-flow conditions may be substantially degrading spawning habitat, blocking fish passage and contributing to high water temperatures.

- Runs of spring and fall chinook, chum, coho and sockeye salmon are believed to have inhabited the WRIA at one time, but they are no longer present. Dam construction and low summer flows are believed to have contributed to the disappearance of these species from the WRIA.

- The watershed also supports fish species of special concern including bull trout, Olympic mudminnow, pygmy whitefish and/or sea-run cutthroat. Major reaches where these species are present include North Fork Mill Creek, South Fork Touchet River and tributaries, North Fork Touchet River, Robinson Fork and Wolf Fork and tributaries.

1.3 Recommendations

Monitoring & Data Collection:

- Establish a network of wells for long-term monitoring of regional water level trends within all of the principal aquifer systems. The network of public water supply wells established by the Walla Walla County Health Department would provide a framework for monitoring the basalt aquifer system. Basalt aquifer monitoring should be expanded beyond the area of existing municipal withdrawal. Monitoring of the gravel aquifer should be achieved with a network of existing private domestic wells, old unused wells, and/or new wells specifically installed for ground water monitoring. Data collection efforts should strive for monthly measurements.

- Water use data would aid in the causal analysis of streamflow and ground water level trends. Quantification of water use should be performed to provide better definition of actual water withdrawals from the system.

- The three remaining stream gages in the Walla Walla WRIA (two on Mill Creek and one on the Walla Walla River) should be continued to provide the data which will be necessary to conduct a more detailed assessment of the impacts of ground water withdrawals on streamflows, and to monitor the effects of improved (more efficient) irrigation practices on minimum streamflows.

- Collection of additional water quality information is recommended, particularly for water bodies where data were not identified. Future water quality data collection and monitoring efforts should be focused on areas where water withdrawals occur and where agricultural operations are resulting in sediment inputs to streams, as water quality problems identified in the WRIA to date have primarily been associated with these activities.

- Class A temperature violations and other temperature concern areas have been reported in the WRIA. Some temperatures were sufficiently high to be lethal to fish. Additional temperature data should be collected, particularly in agricultural areas where shading riparian vegetation has been removed and in low flow areas.

- Continued monitoring of the Walla Walla and Touchet River summer steelhead stocks should occur, as both of these stocks are reported to be chronically depressed.

- Additional and updated information on the location and extent of chronic and periodic low flow conditions should be collected to verify these conditions and to more accurately assess effects on fish stocks.

Additional Analyses:

- Perform a more detailed analysis of seasonal low flows in the Walla Walla River and tributaries which overly the gravel aquifer. The analysis should attempt to ascertain the primary source(s) of baseflow during the irrigation season (ground water seepage, irrigation return flows) and assess the degree to which hydraulic continuity is maintained during the heavy pumping season.

- Updated analysis of ground water level trends should be performed every five years based on additional water level and water use data (see monitoring recommendations above).

- Some of the hydrogeologic assumptions of the Water Resources Program for the Walla Walla River Basin (Chapter 173-532 WAC) should be re-evaluated. Specifically, the basis (and application) of the regulatory limit on basalt aquifer allocations (WAC 173-532-070) should be better defined.

- More detailed streamflow analysis should be performed where fisheries are shown to be specifically affected by low flows over significant portions of a stream. The analysis should focus on periods of low flow that are critical to fish. Characterization of instream flow requirements of fish species which inhabit these water bodies may require improvement.

2 Watershed Description

The Walla Walla WRIA is located in south-eastern Washington, east of the confluence between the Columbia and Snake Rivers and north of the Oregon border. The Walla Walla River is the principal drainage in the WRIA, flowing north from its origin in the Blue Mountains and draining into the Columbia River at Lake Wallula. The river's watershed is bounded by the Blue Mountains to the south and east, the Columbia River to the west, and the Snake River Basin to the north. Major tributaries include the Touchet River, Dry Creek, and Mill Creek. The watershed includes portions of Walla Walla and Columbia Counties in Washington and Umatilla County in Oregon. The area of the watershed is 1,758 square miles, of which approximately 73 percent occurs in Washington State. The Walla Walla WRIA is limited to those portions of the watershed within Washington State. Major communities in the WRIA include Walla Walla, College Place, Dayton and Waitsburg. A basemap of the Walla Walla watershed is presented on Figure 2-1.

There are two major physiographic provinces in the Walla Walla WRIA: the valley lowland and the Blue Mountains. The valley lowland extends from the center of the basin north to the Touchet River – Snake River divide and south to the Horse Heaven Hills. Land surface elevations of the lowland province range from less than 1,000 feet at the west end to nearly 2,500 feet at the foot of the Blue Mountains (just east of Walla Walla). The Touchet Slope covers a large portion of the valley lowland and extends from the lowland of the Walla Walla River to just south of the Touchet River. The topography consists of rolling hills underlain by wind-born silt deposits.

The Blue Mountains rise to an average elevation of about 5,000 feet along the drainage divide. The highest point is Table Mountain at just over 6,000 feet. Topography is characterized by flat topped ridges and steep stair-stepped valley walls. The stair-stepped valley walls are formed by the layered basalt which underlies the Blue Mountains.

The climate is considered continental, although some oceanic storms occur during the winter months. Summers are typically hot and dry, while winters are typically cold with varying precipitation. Precipitation within the basin ranges from 5 to 45 inches/year, and is described in greater detail in Section 4. The climate varies with altitude: warm semi-arid conditions occur in the western, low elevation region while cool and relatively moist conditions occur in the eastern, high elevation region.

Land cover in the WRIA ranges from coniferous forest in the upper basin to rangeland, dry cropland and irrigated cropland in the lower basin. The largest land use is by far agriculture, which makes up about 75% of the WRIA. Rangeland covers about 11% and forest covers about 10%. The rest of the land use (4%) is miscellaneous, which includes urban areas. The proportions of land use in the entire basin (including Oregon) are similar to those described for the WRIA.

Land cover and use affects the quantity and quality of water resources in the WRIA. Surface water can be affected by land use from both quantity and quality standpoints. Natural vegetation and forest land provide the optimal biological and physical characteristics for maintaining healthy stream habitats. Agricultural diversions may profoundly affect streamflows, and agricultural practices can impact surface water quality – especially with respect to sediment loading. Agricultural use of chemicals for fertilizers, herbicides, and insecticides can impact ground water quality, as some chemicals are transported downward through the soil with infiltrated rainfall and irrigation applications.

Land use practices can alter quantities of ground water recharge. Recharge is reduced in municipal and industrial areas where significant portions of the land surface are covered with impermeable pavement. Agricultural irrigation can substantially increase ground water recharge depending upon application practices, soil types, and evapotranspiration rates.

3 Water Allocation and Use

The State of Washington regulates ground-water and surface-water withdrawals through a legal system of water allocations. Water withdrawals for all but limited small ground water uses must be approved by Ecology. Upon receiving an application for a water right, Ecology may issue a permit to develop the water resource. Water right certificates are issued after the water withdrawal has been perfected (actually put to beneficial use). In this report, permits and certificates are collectively referred to as water rights. Water rights have been issued under existing water laws since 1917 (for surface water) and 1945 (for ground water). Not all uses of water developed before these dates were registered as part of the water rights process. In order to protect active withdrawals developed prior to these two dates, the State allowed individuals to register withdrawals during a “claims period” between 1969 and 1974. A water right claim is not an authorization to use water, but rather a statement in claim to a water withdrawal developed prior to 1917 or 1945. Surface water claims were adjudicated during the general surface water adjudication for Doan Creek (1923), Dry Creek (1952), the Touchet River (1929), Upper Stone Creek (1923) and the Walla Walla River (1928). As a result of these adjudications, claims on these water bodies may no longer be valid. The validity of other surface water claims and all ground water claims has yet to be determined.

Quantities of water allocations are not necessarily equal to quantities of water use. Allocations state legally permissible quantities of withdrawal. Experience has shown that these permissible quantities are not always achieved, and a significant discrepancy can exist between allocations and use. A distinction between allocation and use must be drawn in assessing stress on the hydrologic system due to withdrawals Actual use cannot be enumerated through water allocation statistics, but must be arrived upon by surveying major water users and estimating the sum of minor uses. Although total allocation may differ from actual use, total allocation is a significant figure because it represents the maximum legally permissible withdrawal from the hydrologic system.

This section addresses both water allocations and water use. Section 3.1 describes a unique and specific regulatory allocation designed to protect water resources in the Walla Walla WRIA. Sections 3.2 through 3.4 provide information regarding public water allocations, applications for water rights, and estimates of actual water use. The implications of these rates and quantities, as well as their relation to observed hydrologic trends, will be explored later in the report.

3.1 Water Resources Program – Walla Walla River Basin

The Water Resources Program for the Walla Walla River Basin (Chapter 173-532 WAC) was promulgated in 1977 to protect and manage the basin’s water resources. This regulation asserts a profound influence on water resource allocations in the WRIA. The regulation addresses both surface water and ground water components of the basin hydrology. A copy of Chapter 173-532 WAC is included as Appendix A of this report.

The Water Resources Program establishes seasonal closures for all major and some minor drainages within the basin (not including the Columbia River). Water in these rivers and creeks is considered “totally appropriated” during the irrigation season (WAC 173-532-030). The closures typically occur between late spring (April-June) and late fall (October-November) Minimum instream flow requirements have not been established, but have been deferred until storage projects are constructed to bolster summer flows. The surface water elements of the Program are discussed in greater detail in Section 5.2 of this report.

The Water Resources Program contains three provisions which affect ground water appropriations within the WRIA. Understanding these provisions requires some advance knowledge of the basin hydrogeology (discussed in Section 6). Two primary ground water sources are identified within the basin. The "basalt aquifer" comprises a system of water bearing zones that is present beneath most of the basin. The "gravel aquifer" is a single water bearing body that occupies a large portion of the valley lowland along the Walla Walla River. Based on these definitions, the provisions are summarized below:

- The potential for hydraulic continuity between ground water and surface water is recognized. New appropriators of ground water will be required to locate wells outside of the "zone of direct hydraulic continuity between the surface water stream and the ground water aquifer". The limits of this zone will be determined by Ecology.

- The Program designates ground water from the Walla Walla/College Place vicinity for specific uses. Water in the basalt aquifer was reserved for municipal withdrawals until October 1, 1986. After that time, any remaining ground water is open to appropriation as determined by Ecology. (Note: this regulation is no longer valid since water was not reserved before the set date (pers. comm. Bill Neve, 1995)). Water in the gravel aquifer was reserved for uses other than municipal supply.

- Water in the basalt aquifer will be closed to further appropriation when withdrawals reach 125,000 acre-feet/year. According to WAC 173-532-070, this value is considered to be approximately 95 percent of the average annual recharge to the basalt aquifer. *(Note: the WAC does not specify whether the 125,000 acre-feet/year limit pertains to the WRIA or the entire basin, including Oregon).*

3.2 Water Rights and Claims

Water right permits, certificates and applications within the Walla Walla WRIA are recorded in the WRIS (Water Rights Information System) database. The database contains specific information for each entry, including: date of application and approval, location of diversion or withdrawal, maximum allowable diversion or withdrawal, purpose(s) of use, and irrigated acreages where applicable. There are 12,500 surface water permits/certificates which were issued statewide that have no annual withdrawal quantity specified on the document. For this reason, discussion of surface-water permits and certificates as annual withdrawals may involve some underestimation. Withdrawal quantities are also often unspecified for a large number of claims. Estimation techniques (described below) were used to approximate total annual quantities associated with claims.

Water right permits and certificates are issued with both annual and instantaneous permissible withdrawal quantities. The annual allocation (expressed in acre-feet/year) represents the maximum amount of water allowed over a year's time for a specified use(s). The instantaneous allocation (measured in cubic feet per second for surface water and gallons per minute for ground water) represents the capacity of the system to divert/withdraw water from the source. Research of water right records indicates that for most permits/certificates, the annual allocation is not withdrawn continuously over time but is taken seasonally or sporadically at rates approaching the instantaneous allocation.

Water rights may also be issued with a "supplemental" status. Supplemental water rights are common in agricultural areas, and can be put to use only when a primary water right is unavailable. A supplemental ground water right, for example, could be used in years when low streamflows make a surface water allocation unavailable. Supplemental water rights can be differentiated in the WRIS database, however distinguishing supplemental rights must be performed manually and was beyond the scope of this assessment.

3.2.1 Water Rights and Claims Over Time

The cumulative increase in water permits and certificates over time in the Walla Walla WRIA is shown in Figure 3-1. This cumulative increase reflects growing stress on the hydrologic system due to withdrawals. Quantities are reported as maximum allowable annual withdrawals (Qa) in acre-feet/year (af/yr). As previously mentioned, surface-water allocations may be somewhat underestimated due to database entries without registered Qa values. The number of ground water withdrawals increased significantly in the early 1940's along with the advances in pump technology. As of 1994, reported Qa's for surface-water permits/certificates in the Walla Walla WRIA amount to 253,020 af/yr. Total Qa's for ground-water permits/certificates as of 1994 amount to 260,173 af/yr.

Claims to a water right generally do not specify quantities of water claimed, so for the purpose of this watershed assessment instantaneous (Qi) and annual (Qa) quantities were estimated based on stated purpose of use. For single domestic supply and/or stock watering, values of 0.02 cfs and 2 af/yr were assigned. Claims for irrigation were assigned 0.02 cfs and 4 af/yr per acre. Based on these water duty assignments, claims within the WRIA are summarized in the following table. *(Note: as discussed above, remaining surface water claims have questionable validity.)* Comparisons between claims and permits/certificates are also summarized in this table and presented graphically on figure 3.2a.

	PERMITS AND CERTIFICATES			CLAIMS			TOTALS
	Qi (cfs)	Qa (af/yr)	Irrigated Acres	Qi (cfs)	Qa (af/yr)	Irrigated Acres	Qa (af/yr)
Surface Water	2,637	253,020	55,422	54	9,680	2,136	262,700
Ground Water	1,075 (482,500 gpm)	260,173	52,555	159 (71,370 gpm)	27,696	5,918	287,869
TOTAL	3,712	513,193	107,977	213	37,376	8,054	550,569

The majority of administered water resources in the WRIA is held as permits and certificates, The total allocation for permits/certificates is near evenly divided between surface water and ground water withdrawals. The bulk of water right claims is held for ground water withdrawals according to the estimation formulas discussed above.

3.2.2 Water Rights and Claims by Use

Water rights and claims are registered by purpose of use. The WRIS database typically lists one, if not several, stated purposes per water right. Examining the distribution of water rights and claims by purpose provides understanding of how water is used within the WRIA. Discerning the major uses can assist in formulating policy for water conservation or water rights administration.

In order to present water rights by use, permits and certificates were classified according to the larger of their first two stated purposes. The relative distribution of surface water permits/ certificates by use is presented on Figure 3.2b. Percentages of total use were calculated in terms of maximum allowable annual withdrawals (Qa's) for water rights as of 1994. Surface water rights in the Walla Walla WRIA are dominated by irrigation uses, which comprise 99% of the total allocated volume. The relative distribution of ground water permits/certificates by use is presented on Figure 3.2c. Ground water resources in the Walla Walla WRIA are largely allocated for irrigation use (62% of Qa) Municipal use accounts for 13% of the allocations, and domestic single, commercial & industrial, and domestic multiple uses all account for 5%-7% of total allocations.

Water claims are primarily registered for irrigation use. This dominant purpose reflects the historical circumstances of claims registration. Within the Walla Walla WRIA (based on the Qa formulas for water duty assignments discussed above), 88% of the claimed surface water and 88% of the claimed ground water are registered with irrigation as their primary purpose. The remainder of water rights claims are allocated to domestic single or stock uses.

3.2.3 Spatial Distribution of Rights and Claims

The spatial distribution of water permits/certificates and claims (by Qa as of 1994) is depicted in Figures 3-3 through 3-6. (Water rights are not shown outside the State of Washington.) The spatial distribution of water rights generally reflects the availability and ease of withdrawal of water resources. Surface water permits and certificates are shown in Figure 3-3 to be primarily distributed along the Touchet River, with lesser occurrences along the Walla Walla River and Dry Creek. This presentation, however, involves considerable inaccuracy associated with surface water right records where Qa values were not reported. Inspection of surface water rights by Qi (not shown in this report) indicates that considerably more diversion occurs along the Walla Walla River and adjacent tributaries than is shown on Figure 3-3. The distribution of surface water claims (Figure 3-4) differs significantly from permits/certificates. Claims are concentrated in the eastern half of the WRIA, and are less limited to locations along the major drainages. In contrast to water rights, very few claims occur on the lower reaches of the Touchet River.

Ground water permits/certificates (Figure 3-5) are concentrated along the major drainages where the bulk of irrigated agriculture and human settlement occurs. Figure 3-5 shows high densities of large (>500 af/yr) ground water rights along the Walla Walla and Columbia Rivers. Water rights are concentrated along the Walla Walla River, in part, due to the occurrence of a highly productive ground water aquifer within the river's coarse alluvial deposits. Ground water claims (Figure 3-6) are distributed throughout the WRIA.

3.3 Water Right Applications

There are currently 69 applications for new water rights within the Walla Walla WRIA on file with Ecology. Maximum withdrawal information for water right applications is generally limited to instantaneous extraction rates (Qi), largely because Ecology has not made final decisions as to maximum allowable annual withdrawals. The table presented below provides a summary of water right applications in the Walla Walla WRIA, expressed as Qi. Applications cannot be directly compared to allocations where allocations are reported as Qa. Values of Qi requested in the applications are typically higher than the values of Qa granted by Ecology when projected over an annual period.

Source	Number of Applications	Total Qi (cfs)
Surface Water	7	19.6
Ground Water	62	85.8
Total	69	105.4

Applications for ground water rights comprise the largest component of potential future water allocations (81% of Qi). Figure 3.2d presents water rights applications by requested purpose of withdrawal. The majority of requested ground water resources, and essentially all of requested surface water resources, are associated with irrigation. The remainder of requested ground water resources are distributed primarily between frost protection & heat control, commercial & industrial, and domestic single uses.

The geographic distributions of surface water and ground water right applications are presented in Figure 3-7 and 3-8, respectively. The largest surface water request(s) occurs from the Columbia River along the western WRIA boundary. Other surface water applications occur from the Walla Walla River in the western half of the WRIA. Ground water applications are also concentrated along the Columbia River and Walla Walla River (including tributaries).

3.4 Estimates of Actual Use and Comparison with Allocations

Estimates of water use are important

3.4.1 Ground Water Use

Ground water withdrawals in the Walla Walla WRIA are not well documented or quantified, especially for the gravel aquifer. Metered pumping data are limited to the public water supply systems which typically report pumped volumes once every two months. Irrigation use is typically not metered. Investigators have often relied on indirect methods to obtain ground water pumpage estimates. Power consumption records have been used to estimate pumping volumes based on knowledge of pump type and required lifts. Crop distributions have also been used to estimate agricultural applications based on assumptions of crop requirements. Crop types and acreages are typically determined from Landsat imagery. Estimates of ground water withdrawal are usually oriented to the entire Walla Walla basin, and are often unavailable for the WRIA alone.

As mentioned earlier, ground water resources in the WRIA generally occur in either of two aquifers (see Section 6.1 for detailed aquifer descriptions). The “basalt aquifer” comprises a system of water bearing zones that is present beneath most of the basin. The “gravel aquifer” is a single water bearing body that occupies a large portion of the valley lowland along the Walla Walla River. In general, it is estimated that about 50% of ground water pumpage in the WRIA is from the gravel aquifer and 50% is from the basalt aquifer system. The following table presents a summary of historical and current ground water pumpage estimates for the gravel and basalt aquifers.

Record Year	Gravel Aquifer Pumpage	Basalt Aquifer Pumpage	Total Pumpage	Reference
Estimates for Entire Walla Walla Basin:				
1958	16,050 af/yr	14,800 af/yr	30,850 af/yr	Newcomb, 1965
1969	25,000 af/yr	27,000 af/yr	52,000 af/yr	MacNish et al, 1973
1984	23,210 af/yr	27,290 af/yr	50,500 af/yr	Cline & Knadle, 1990 and Collins, 1987
1989	66,496 af/yr	25,031 af/yr	91,527 af/yr	James et al, 1991
Estimates for Walla Walla WRIA:				
1984	15,560 af/yr	21,940 af/yr	37,500 af/yr	Cline & Knadle, 1990 and Collins, 1987
1989	46,277 af/yr	21,986 af/yr	68,263 af/yr	James et al, 1991

Gravel Aquifer

Estimates of basin-wide pumping from the gravel aquifer appear reasonable for 1958 and 1969, however the disparity between 1984 and 1989 suggests significant error in one of these values. Newcomb (1965) analyzed 2 to 3 years of pumpage data to estimate basin-wide pumpage for both the gravel and basalt aquifer systems. He also estimated utilization from springflow from the gravel aquifer to be 30,450 acre-ft/yr. MacNish et al (1973) used electrical records and measured pumping lifts in estimating basin-wide pumpage. Their work, in general, made extensive use of original field work for baseline characterization. The RASA study (Collins, 1987 and Cline & Knadle, 1990) relied heavily on the work by MacNish et al (pers. comm., D. Cline, 1992). The RASA study evaluated the geographic distribution of pumping from the gravel aquifer. Figure 3-9 presents the 1984 RASA pumping estimates per ¼ township area, as well as the areal boundary of the gravel aquifer. The 1989 estimate by James et al relied on electrical consumption records from metered pumps obtained from the two main power distributors. Their study divided the basin into 20 "farm regions", 19 of which comprise the Walla Walla WRIA. Questions remain as to the accuracy of the study, and members of its review committee reportedly had limited confidence in the study's water use estimates (pers. comm., Bill Neve, 1995). Many pumps were not field checked to determine source of supply, nor were pump lifts measured in the field.

Estimates for gravel aquifer pumpage limited to the Walla Walla WRIA were derived from the Cline & Knadle and James et al studies. Pumpage estimates differ significantly between the two studies. The Cline & Knadle estimate was derived by summing specific values of pumpage provided by 1/4 township area in their report (note that Figure 3-9 classifies specific values into data ranges). The James et al value was derived by summing pumpage estimates for the 19 "farm regions" within the WRIA.

The ground water pumped from the gravel aquifer is used predominantly for irrigation applications. According to Newcomb (1965), 97% of basin-wide gravel aquifer pumpage is used for irrigation, about 2% used for domestic supply, and the rest is divided between public water supply systems and industrial users. More recent investigations have indicated approximately the same distribution of gravel aquifer pumpage among these four categories of use. MacNish et al (1973) concluded that all of the travel aquifer pumpage is for irrigation use, and the RASA study concluded that the majority of gravel aquifer pumping is for irrigation use.

Basalt aquifer system

The basin-wide estimates of pumpage from the basalt aquifer system appear to be reasonable, especially in light of the consistency between the four values. Basin-wide pumpage has reportedly increased from about 14,800 af/yr in 1958 to between 25,000-27,300 af/yr in the 20-year period preceding 1989. Available pumping estimates for the WRIA show close agreement, and comprise about 80% to 88% of associated basin-wide estimates. Figure 3-10 presents (by value ranges) the areal distribution of ground water pumpage from the basalt aquifer system for 1984 per 1/4 township (Collins, 1987 and Cline & Knadle, 1990).

The ground water pumped from the basalt aquifer system is used predominantly for irrigation and municipal (public supply) purposes. Newcomb (1965) estimated that 39% is used for irrigation, 44% is used for municipal (public supply), and 15% is used for industrial needs. A very small quantity is used for individual domestic supply. A more recent estimate of the distribution of pumpage from the basalt aquifer system was derived on Figure 3-11. The plot shows historic trends of total, municipal, and combined irrigation/industrial pumpage compiled by MacNish & Barker (1976). Municipal pumpage has increased along a fairly linear trend since

1950. Municipal pumping for 1984 was approximately by projecting this observed linear trend. Combined irrigation/industrial pumpage was approximated by subtracting the projected 1984 value of municipal pumping from the RASA 1984 total pumping estimate (see table). Based on this approximation, 36% of 1984 pumping from the basalt aquifer system was used for municipal supply while the remaining 65% was used for combined irrigation/industrial use.

3.4.2 Surface Water Use

Stream diversions were estimated for irrigation diversions in the Walla Walla Basin by James, et al (1991). Their report presents detailed regional breakdowns of each source of irrigation water in both the basin and the WRIA. Considering that approximately 99% of surface water rights in the WRIA are for irrigation (Section 3.1.3), estimated stream diversions for irrigation are likely representative of total stream diversions in the WRIA, regardless of purpose.

The report by James et al states that "just under 40 percent of the water used for irrigation in the Washington portion of the basin is diverted from streams". Total 1989 stream diversions in the WRIA were estimated to be 46,212 af/yr, of which 17,1763 af/yr are attributed to direct diversions and 29,039 af/yr are attributed to ditch diversions (derived from streams). Total 1989 stream diversions for the entire basin were estimated to be 63,086 af/yr, of which 17,173 af/yr are attributed to direct diversions and 45,913 af/yr are attributed to ditch diversions. As mentioned in the previous section, questions remain as to the accuracy of the James et al study. Specifically, errors were noted regarding correct identification of the source of water attributed to irrigation pumps (e.g gravel aquifer, basalt aquifers, surface water) (pers. comm., B. Neve, 1995).

3.4.3 Comparison of Water Allocation and Water Use

Recent estimates of ground water withdrawal in the WRIA range from approximately 37,500 to 68,300 af/yr. In comparison, ground water rights within the WRIA amount to approximately 260,200 af/yr. Thus, estimated withdrawals comprise between 14% and 26% of allocations. Recent estimates of surface water diversions in the WRIA are on the order of 46,200 af/yr, yet total surface water rights amount to 253,000. The ratio of surface water rights to diversions (18%) is within the range of ratios estimated for ground water.

The ratio of actual use estimates to allocated water rights is important because current withdrawals and diversions could conceivably increase to allocated amounts within existing legal constraints. To address this potential, water resource planning must allow for potential increases in water use unrelated to allocation of new water rights.

4 Precipitation

Quantification of precipitation is an important component of the watershed assessment process. Precipitation provides the input that supplies stream runoff and recharge to the gravel aquifer. Variation in precipitation must be taken into account when assessing trends in streamflow and ground water levels. *(Note: In most places, recent precipitation will not directly impact water levels in the basalt aquifers, as recent dating of water in this aquifer indicates an age on the order of 20,000 years (Pacific Groundwater Group, 1994).)* A long-term value for precipitation, averaged over the WRIA, is necessary for performing a basin-wide water budget analysis. A discussion of the spatial distribution and temporal trends of precipitation in the Walla Walla WRIA is presented below.

4.1 Spatial Distribution

Precipitation varies spatially within the Walla Walla basin from about 5 inches in the west to about 45 inches in the east (in the Blue Mountains). Figure 4-1 is an isohyetal map of the basin based on 1930-1957 data and empirical topographic adjustments (USDA, 1965). The mean annual precipitation of the basin, based on integration of the isohyetal map, is 14.7 inches. Weather stations are non-existent within the Blue Mountains, where relatively high precipitation contours are based on topography adjustments. Precipitation in the Blue Mountains may fall as snow during the winter months, and accumulations of several feet are not uncommon.

Site-specific climatic data are available from twelve weather stations on a year-to-year basis. Relative variability between stations may be due, in part, to the localized nature of rainfall events during parts of the year. Figure 4-3 compares precipitation records at Walla Walla FAA and Dayton weather stations. The plot shows that, while many years are similarly above or below average at both stations, there is considerable variability in the degree of departure from average. In addition, some years show contradicting (above versus below average) rainfall between the two gages. Differences in temporal trends between the gages are addressed below.

4.2 Precipitation Trends

Temporal variation and trends in precipitation occur on seasonal, short-term, and long-term scales. On a seasonal basis, 64% of the precipitation at Walla Walla occurs in the 6-month period from October though March (based on data from the Mill Creek Dam climate station). Additionally, total rainfall for the driest months of July, August, and September is 12% of the annual total. Departures from these seasonal statistics, such as “dry winters” or “wet summers” occur.

Long-term precipitation trends are demonstrated on Figure 4-3, which presents annual precipitation at Dayton (1931-1993) and Walla Walla FAA (1950-1993). A 10-year moving average of annual precipitation is also presented to help identify long-term cycles in weather patterns. In general, high variability can be seen throughout the period of record. At the Dayton station, the record shows generally above average precipitation between 1940-1958, below average precipitation between 1958-1970, and above average precipitation between 1980-1985. At Walla Walla FAA, below average precipitation generally occurs between 1960-1980, and above average precipitation dominates between 1980-1993. It should be noted that this recent above average period is not strongly evident in the Dayton data after 1985. Differences between the two records imply that precipitation trends noted at any particular station cannot be extensively applied to the entire WRIA.

5 Surface Water Hydrology

5.1 Description of Drainage Network

The Walla Walla River basin is the only significant drainage network in the Walla Walla WRIA. The main stem of the Walla Walla River begins in Oregon at the confluence of the North Fork Walla Walla River and the South Fork Walla Walla River. The Walla Walla River drains in a generally westerly direction and discharges into the Columbia River about 25 miles west of the City of Walla Walla. The major tributaries to the Walla Walla River which originate in the State of Washington are the Touchet River, Dry Creek, and Mill Creek. The WRIA also includes a relatively small area adjacent to the Columbia River which drains directly to the Columbia River. The major tributaries which originate in the State of Oregon are Pine Creek and the North and South Forks of the Walla Walla River.

During the irrigation season, all of the Walla Walla River flow is diverted for irrigation in Oregon upstream of the Washington-Oregon state line. A 1936 Supreme Court decision allows Oregon users to divert the entire flow of the Walla Walla River before it enters Washington. There is no compact or agreement between Washington and Oregon for sharing or managing the water resources. The summer baseflow entering Washington across the Oregon border is composed primarily of irrigation return flows and ground water seepage.

5.2 Established Regulatory Instream Flows

Instream flow regulations, and other rules which limit surface-water withdrawals in the Walla Walla WRIA, are published in Chapter 173-532 Washington Administrative Code (WAC), titled “Water Resources Program for the Walla Walla River Basin, WRIA 32.” These rules were promulgated in 1977 pursuant to Chapter 90.54 Revised Code of Washington (RCW) (Water Resources Management Act of 1971). The pertinent portions of the WAC are reproduced in Appendix A of this report.

No specific instream flows have been established for any streams within the Walla Walla WRIA. WAC 173-532-030 states, “At present, all surface streams are totally appropriated during the irrigation season and water is not available for protection of instream values.”

Presently, the Walla Walla River from the mouth to the Washington-Oregon state line is closed to further consumptive appropriations for the period May 1 to November 30 of each year. Principal tributaries to the Walla Walla River, including the Touchet River, Dry Creek, Mill Creek and six smaller streams, are also closed to further consumptive appropriations for at least five consecutive months during the irrigation season. The closed reaches of rivers and streams are shown in Figure 4-2.

An instream flow protection program was established in 1983 by the Oregon Water Resources Commission for a portion of the Walla Walla River (in Oregon). As of 1986, the Walla Walla River and its tributaries in Oregon had been closed to further appropriation in Oregon, and minimum perennial streamflows had been established for the Walla Walla River from its origin at the confluence of the North and South Forks to the city of Milton-Freewater in Oregon.

5.3 Quantification of Streamflow

Streamflow data considered in this preliminary assessment comprised all continuous streamflow records recorded and published for the Walla Walla WRIA by the U.S. Geological Survey (USGS). Gages located in the State of Oregon, and hence outside the Walla Walla WRIA, were not considered. In total, 12 continuous recording stream gages have been established by the USGS in the Walla Walla WRIA, as listed in Table 5-1. Of the 12 gages, only three are presently active.

Several gages within the WRIA were selected for analysis. Gages were selected for analysis on the basis of two criteria: that data were available through at least year 1985 to provide an indication of current conditions, and that at least 10 years of record were available to conduct an assessment of streamflow trends. By these criteria, the four gages listed below were selected for analysis.

Gage ID	Name	Basin Area	Years of Record
14013000	Mill Creek near Walla Walla	60 sq. mi.	1913-1917; 1938-1976; 1979-1993
14015000	Mill Creek at Walla Walla	96 sq. mi.	1941-1993
14017400	Touchet River at Bolles	361 sq. mi.	1924-1929; 1951-1989
14018500	Walla Walla River near Touchet	1,657 sq. mi.	1951-1993

The main objective in reviewing and quantifying the streamflow data was to assess whether there is any obvious trend in the streamflow data.

Streamflow data are published by the USGS following a "water year" convention where water year 1990, for example, begins on (calendar year) October 1, 1989 and ends September 31, 1990. The water year convention is useful to many aspects of hydrologic analysis, but may confuse readers not familiar with the convention. To minimize confusion, all data presented in this report are expressed with calendar year dates.

The streamflow data were processed to determine annual average and minimum flows for the period of record, and then analyzed for time-series trends and variations. The average and minimum streamflow data are presented graphically in Figures 5-1 through 5-8. The streamflow data for these figures, together with summary statistics, are listed in tables in Appendix B of this report.

Figures 5-9 through 5-20 present flow hydrographs and exceedance statistics for the four gages, together with the long-term median flows at each gage.

Our interpretation of these data is presented in the following report section.

5.4 Streamflow Trends and Critical Indicators

5.4.1 Average Flows and Trends Analysis

An analysis was conducted to assess whether there are any obvious trends in average annual flows over time. The analysis initially attempted to use annual precipitation data from the Walla Walla FAA rain gage to correct (normalize) average annual streamflows for natural climatic variations. Unfortunately, a major finding from that initial analysis was that data from the Walla Walla FAA rain gage may be an unreliable indicator of basin-wide precipitation due to spatial variability between gages. Rainfall trends are discussed further in Section 4. In the absence of precipitation records readily applicable to normalization of streamflow data, a trend analysis was performed directly on the mean annual flow data. Because these data are not corrected for natural climatic variations, the trend analysis results should be treated with some caution.

Figures 5-1 through 5-4 present time-series plots of the mean annual flows recorded at each of the four gages. Included on each plot are the results of linear regression analyses made using time as the independent variable to describe variations in the annual flows.

Inspection of Figures 5-1 through 5-4 suggests increasing losses with time at three of the four gages. The regression analysis results on the full periods of record show that there is no trend of either increasing or decreasing mean annual flows for Mill Creek at Walla Walla. Results on the full periods of record for the other three gages all show trends of declining mean annual flows. The largest apparent decline is at the Walla Walla River near Touchet, for which the regression suggests a 20% total decline in average annual flows since 1952.

In interpreting the regression analyses results, it is very important to consider the "fit" of the data to the regression line. In general, there is a considerable amount of scatter in the plotted points, and the R-Squared values (a statistical measure of the goodness of fit) are in all cases very low. From a statistical perspective, the fits are extremely poor and the linear regression results are not significant.

A check was made on the robustness of the long-term trends suggested by the regressions using the full periods of streamflow record. This check consisted of a second regression made on data through year 1985 only. The purpose of this check was to explore the sensitivity of the regression results to the recent years of below-average flows (particularly years 1987 and 1992). If the long-term trends suggested by the regressions on the full periods of record (typically 40 to 50 years of data) are indicative of actual trends, then we would expect to see similar trends in the first 35 or more years of these data sets. However, the results of the second sets of regressions suggest trends for increasing flows at all gages through year 1985. Regression results for the full periods of record are clearly quite sensitive to recent low flow years. As the two sets of regressions analysis give contradictory results, we are unable to draw any conclusions on long-term trends in flows at the gages.

In summary, there is some indication that flows since year 1985 may be lower than average, but the regression analysis results are inadequate to either confirm or quantify any long-term trends of either increasing or declining flows. Additional analyses which includes adjustment of streamflows for natural climatic variations would be required to assess the significance of the recent low flow years.

5.4.2 Minimum Flows and Trends Analysis

An assessment was also made on trends in the minimum annual streamflows recorded at each of the four gages. The minimum flow trend assessment was conducted by a simple visual analysis. Annual precipitation alone is generally not a good indicator of minimum flows for the year due to timing effects. It would be possible to develop synthetic minimum flows as a function of weighted antecedent precipitation in a simple hydrologic model and then to use the synthetic values to correct for climatic variability. However, this level of detailed minimum flow analysis was beyond the scope of this study.

Figures 5-5 through 5-8 each show two graphs to analyze minimum streamflow trends at the four gages. The lower graph shows the minimum flow recorded during each year of record, and the upper graph shows the departure of flow from the average of all minimum flows at each gage, or where applicable, the number of zero-flow days.

Inspection of Figures 5-5 through 5-8 shows an obvious trend in minimum flows for only one gage: Mill Creek at Walla Walla (Figure 5-6). At this gage, the first zero (daily average) flow day was recorded in 1954 and the number of zero-flow days each year has since dramatically increased to more than 140 zero-flow days in 1992. The Mill Creek at Walla Walla gage is immediately downstream of a controlled diversion from Mill Creek to Yellowhawk Creek. The increases in the number of zero-flow days at this location is believed to be the direct result of operating practices at the diversion.

At the Touchet River near Bolles gage (Figure 5-7), there is an apparent upward shift in minimum flows which occurred sometime between 1930 and 1951 while the stream gage was not in use. Interpretation of this shift is speculative. Because the gage was abandoned for over 20 years, it is possible that the early data are somehow in error or that some other change was incurred with reestablishment of the gage, such as being located immediately upstream rather than downstream from a diversion. Alternatively, an upstream diversion which existed prior to 1930 might have been discontinued sometime between 1930 and 1951.

Except for Mill Creek at Walla Walla, for which the number of zero-flow days has dramatically increased since 1950 due to upstream diversion practices, there are no obvious trends of declining minimum streamflows. Minimum flows on the Touchet River may have actually increased since the 1930s. It is important to note, however, that the trends or lack of trends in minimum streamflows are based on a streamflow record which begins at a time when the surface-water systems were already being heavily utilized for irrigation and other withdrawals.

5.4.3 Long-term Median Flows and Actual Flows

Finally, an assessment was made of flow hydrographs and flow statistics for each of the four stream gage stations presented above.

Figures 5-9 through 5-20 present actual flow hydrographs and flow statistics as a set of three figures for each gage. The first figure presents actual daily flow hydrographs for the earliest six years of record, together with median streamflows computed from the full period of record. The third figure presents the same median streamflows together with additional flow exceedence statistics.

Different years are presented for different gages due to differences in the periods of record available for each gage. The selection of six years of hydrographs per figure was, although somewhat arbitrary, made to provide a visual overview of the natural flow variability without excessive clutter or numbers of graphs.

Comparison of the early and recent hydrograph sets yields findings consistent with those presented in the previous sections. Flows at both the Mill Creek gages appear somewhat lower now than in the 1940s, with the most dramatic change occurring in summer flows at the Mill Creek at Walla Walla gage (Figures 5-12 and 5-13) below the diversion to Yellowhawk Creek. Minimum flows at the Touchet River gage are higher in the 1980s than in the 1920s; and the very low flows in the 1920s (Figure 5-15) show a very unsteady pattern which may reflect a (since-discontinued or reduced) upstream diversion. Walla Walla River flows appear generally lower now than in the 1950s.

6 Ground Water Hydrology

6.1 Aquifer Descriptions

6.1.1 Geologic Framework

The hydrogeology of the Walla Walla WRIA is controlled by the occurrence of three main geologic units: the Pleistocene gravel, the Pleistocene clay, and the Miocene Columbia River Basalt (CRB). Surficial deposits, such as the Palouse Formation and the Touchet Beds, form a thin veneer on the land surface and are unimportant from the standpoint of water supply. The subsurface geology of the Walla Walla basin is depicted in the east-west trending cross-section shown in Figure 6-1. Figure 6-2 is a base map which shows the cross-section location. The cross-section shows the subsurface structure and the stratigraphic relationship of the three main subsurface units. The units are described below.

The Pleistocene gravel was deposited as coalescent alluvial fans filling in the structural basin of the underlying bedrock. The sediments were transported from upland sources by Mill Creek (in the Walla Walla area) and by the Walla Walla River (in the Milton-Freewater area). The gravel exhibits variable cementation and is often described as “cemented gravel” by local well drillers. The gravel is commonly interbedded with clay, which represents a fine-grained facies of the same alluvial fan deposits.

The Pleistocene clay is a widespread unit which underlies the Pleistocene gravel in most places. It has a low hydraulic conductivity (permeability) and is an important aquitard (confining unit) in the area, limiting the vertical movement of water in the subsurface. Some wells in the cross-sections (i.e. 6/34-5F2) are shown to be completed within the clay. In reality, the contact between the gravel and the clay is a complex interfingering, resulting in many thin stringers of gravel within the clay. These stringers are often too thin to depict on the cross-section. Many well logs indicate large thicknesses of “gravel and clay”.

The Miocene Columbia River Basalt (CRB) is an extensive deposit of 10 to 17 million year old lava which covers all of southeastern Washington. The CRB is subdivided into three formations: the Saddle Mountains; the Wanapum; and the Grande Ronde. The Saddle Mountains Basalt is the uppermost unit and is relatively thin to non-existent in the Walla Walla area. The Wanapum Basalt occurs stratigraphically below the Saddle Mountains Basalt and is the most important unit from a water supply standpoint. Based on the available well logs, it appears that most of the public supply wells tap the Wanapum Basalt. The Grande Ronde Basalt occurs below the Wanapum Basalt. Very few wells are drilled deep enough to encounter the Grande Ronde Basalt, especially west of Walla Walla.

Each basalt formation is an aggradation of individual lava flows which may range in thickness from a few tens of feet to as much as 300 feet. Each flow generally contains three distinct zones: a vesicular, sometimes fractured flow top; a massive, hard, vertically fractured, low permeability flow interior; and a thin, vesicular, highly fractured flow bottom. The relatively permeable flow tops and bottoms, collectively or individually referred to as interflow zones, may provide conduits for significant ground water movement.

Sedimentary interbeds of the Ellensburg Formation are sometimes interfingered with the CRB within the Saddle Mountains and Wanapum Basalts. The interbeds were deposited between flow events (i.e. between flow tops and flow bottoms), and thus comprise portions of the interflow zones. One of these, the Mabton interbed, is depicted in Figure 6-1. Typically, these interbeds are composed of sand to clay size material and do not yield large quantities of water to wells. Thicknesses generally range from a few inches to a few tens of feet. The interbeds provide important marker beds within the CRB which enable identification of structural deformation and location within the stratigraphic sequence.

Regional structures play an important role in the occurrence of ground water within the basalt. The Walla Walla syncline is a large, generally east-west trending, trough-shaped feature which accounts for the basin topography. Ground water flows down-dip in basalt interflow zones and accumulates in this trough. Faults in the basalt may locally serve as natural underground dams which create large differences in hydraulic head over distances of several hundred feet. Abundant fold and fault structures emanate from the Horse Heaven Hills escarpment southwest of the Walla Walla Basin (Tolan and Reidel, 1989) and likely contribute to a low transmissivity zone within the basalt aquifer system west of Milton-Freewater. Above the basalts, significant clay and gravel units have been deposited into the synclinal trough.

6.1.2 Principal Aquifers

Two principal aquifers (or aquifer systems) occur within the Walla Walla WRIA. Saturated portions of the Pleistocene gravel unit contain the highly productive “gravel aquifer”, and saturated interflows in the Columbia River Basalt comprise the “basalt aquifer system”. The gravel aquifer is generally encountered close to the land surface, while the basalt aquifer system is encountered at varying depths. These two water bearing units are more fully described in the paragraphs below.

Gravel Aquifer

The gravel aquifer generally ranges in thickness from 0 to about 200 feet (Barker and MacNish, 1976). The aquifer is typically unconfined, and the water table is often encountered within 50 feet of the land surface. Locally, semiconfined to confined conditions may occur where layers of clay overlie a permeable gravel lens. The areal occurrence of the aquifer is shown on Figure 6-2. Relatively thick portions of the aquifer (up to 500 feet) are known to occur beneath the cities of Walla Walla and Milton-Freewater. Water level elevations are shown in Figure 6-3 to range from over 1200 feet above mean sea level (msl) east of Walla Walla to less than 500 feet msl toward the western portion of the aquifer near Touchet.

Most of what is known about the gravel aquifer in Washington has been summarized in several publications of the USGS RASA study and by Barker & MacNish (1976) as part of USGS numerical modeling. The exact number of wells completed in the gravel aquifer is not well known, however at least 2,000 wells are estimated to tap the aquifer. Most of these “gravel wells” are apparently used for domestic supply, however domestic withdrawals comprise only a small percentage of total gravel aquifer pumpage (see Section 3.4.1). Available data from these wells are quite limited and provide little useful information for regional characterization.

The hydraulic conductivity of the gravel aquifer is estimated to range from 1.5×10^{-4} ft/sec (5×10^{-3} cm/sec) to 7.6×10^{-3} ft/sec (8×10^{-2} cm/sec), with most of the aquifer at the lower end of this range. Barker & MacNish (1976) developed these estimates from specific capacity data as input parameters for their calibrated numerical model. Associated transmissivity values range from less than 10,000 ft^2/day to about 60,000 ft^2/day. In general, transmissivities are highest in the thickest portions of the aquifer near Walla Walla and Milton-Freewater. Storage coefficients reflect the unconfined nature of the aquifer, and are estimated to range from 0.1 to 0.25 (Barker and MacNish, 1976).

Basalt Aquifer System

The basalt aquifer system includes a number of water bearing zones which occur at interflows where the combination of a flow bottom and an underlying flow top (from a previous lava flow) creates a zone of higher hydraulic conductivity. These interflow zones are separated by the lower permeability flow interiors. The total basalt thickness beneath the WRIA is around 2,500 feet. However, the flow interiors comprise the bulk of an individual flow with the combined thickness of interflow zones (aquifers) comprising only about 10% of the total basalt thickness (Newcomb, 1965). Unfortunately, typical well log information is not detailed enough to correlate individual aquifers within the basalt.

The basalt aquifer system is ubiquitous beneath the Walla Walla WRIA. As previously noted, the Saddle Mountains, Wanapum, and Grande Ronde Basalts are part of the Columbia River Basalt which covers all of southeastern Washington. The Wanapum Basalt is extensively developed for water supply in the Walla Walla vicinity.

The depth to water bearing zones within the basalts varies widely in the Walla Walla area. The depth to a basalt aquifer depends not only on the thickness of overlying gravel and clay, but on the thickness of basalt flow which must be penetrated before a water bearing interflow is encountered. Wells which tap the basalt generally range from 500 to 1300 feet deep. These depths, however, are not indicative of the uppermost saturation since many wells are completed in multiple interflow zones. In addition, the occurrence of saturation in the interflows can be complex, thus resulting in high variability of well depths.

Ground water in the basalt interflow zones occurs under confined conditions. Water levels in wells which tap basalt interflows have been noted to rise 500 to 1,000 feet above the well intake, and several wells (when first drilled) exhibited flowing conditions. Current water level depths in basalt wells typically range from 50 to 250 feet below the land surface. Average depth to ground water in the City of Walla Walla municipal wells is about 150 feet below land surface. Water level elevations within the basin are shown on Figure 6-4 to range from 1100 feet msl east of Walla Walla to less than 500 feet msl in the western portions of the basin.

Transmissivity values within the basalt are estimated to range from below 2000 ft^2/day to a high of about 10000 ft^2/day, based on specific capacity data from over 100 wells (MacNish & Barker, 1976). A zone of higher transmissivity is approximately coincident with the trough of the Walla Walla syncline. A zone of lower transmissivity exists in an area of abundant faulting southwest of Milton-Freewater. Storage coefficient values are estimated to range from $9x10^{-5}$ to $4.7x10^{-4}$ (MacNish & Barker, 1976).

6.1.3 Hydraulic Continuity

Hydraulic continuity means the interconnection between water bearing units, both ground water and surface water. An aquifer is typically in hydraulic continuity with rivers, streams, or other surface water bodies where saturation is continuous to the edge of these water bodies. Hydraulic continuity can occur where ground water discharges to surface water, such as in spring-fed (gaining) rivers; or where surface water discharges to ground water, such as from riverbed seepage to an adjacent alluvial aquifer. Where hydraulic continuity exists, changing hydraulic conditions in a ground water body will result in changes to connected surface water bodies. For instance, pumping a well may result in reduced ground water discharge to adjacent surface water or increased seepage from surface water. Similarly, lowering the water level in a river or lake may result in decreased seepage to ground water or increased discharge from adjacent aquifers. Hydraulic continuity is not indicated *only* when ground water is trapped in a closed structural basin and is not connected to surface water bodies via saturation.

Determining or predicting cause-and-effect stream/aquifer relations can be simple or complex depending on hydrogeologic conditions. In the case of ground water withdrawals, potentially impacted surface water bodies must first be identified. Because shallow aquifers are generally dominated by local ground water flow systems, withdrawals from shallow wells are most likely to influence local surface water bodies. For instance, a shallow well in the (alluvial) gravel aquifer is likely to affect flow in an adjacent river or stream. Deeper aquifers are typically part of regional flow systems. Pumping from a deep confined aquifer is therefore more likely to reduce ground water discharge to a major drainage or to marginally impact many surface water bodies spread out over a large area. The timing and magnitude of stream/aquifer interactions depends on many factors, including: the distance between the well and the surface water body, the geometry and hydraulic properties of aquifers, aquitards and fault zones between the well and the surface water body, patterns of ground water flow and recharge, and the hydraulic “skin” effects of riverbeds and lakebeds. Based on these factors, ground water withdrawals may affect surface water bodies almost instantaneously or may be delayed by months or years. Similar delays can be expected in the effects of reduced or discontinued pumping.

Characterization of hydraulic continuity in the Walla Walla WRIA ranges in complexity based on the variables described above. Hydraulic continuity between the gravel aquifer and adjacent streams or rivers is typically high. Newcomb (1965) indicates that the gravel aquifer is “intimately coupled with the network of streams, canals, and ditches that web its surface”. Barker and MacNish (1976) differentiate gaining and losing reaches of streams in continuity with the gravel aquifer based on streambed elevation. A portion of the gravel aquifer flow discharges to surface springs (e.g. at Walla Walla and northwest of Milton-Freewater) which supply flow to various streams and ditches. Although the gravel aquifer receives recharge from losing stretches of streams and ditches, hydraulic continuity occurs on losing stretches only where the water table is in direct (saturated) contact with the channel bed. Seepage losses through channel beds which overly unsaturated soils will not be affected by ground water pumping. However, the effects of pumping may extend from points of withdrawal to areas along rivers and streams where direct hydraulic continuity occurs.

Hydraulic continuity between the basalt aquifer system and local streams (the Walla Walla River and its tributaries) is typically low; however, continuity with the Columbia and Snake Rivers may be high. The low-permeability Pleistocene clay unit and the massive basalt flow interiors serve to restrict hydraulic coupling between local surface water bodies and the underlying basalt aquifer system. This conclusion is supported by numerical modeling studies (MacNish & Barker, 1976) and by recent Carbon-14 dating which indicates that ground water in three basalt wells ranges from 18,000 to 22,000 years old (Pacific Groundwater Group, 1994). The Columbia and Snake Rivers are considered to be the major discharge areas for the basalt aquifer system.

6.1.4 Ground Water Flow

Ground water flow patterns within the WRIA reflect local and regional flow systems. Local flow systems typically occur within shallow aquifers, and regional flow systems occur within deep aquifers. Ground water flow occurs from areas of recharge to areas of discharge. The more regional the flow system, the longer the flowpath between recharge areas and discharge areas.

Ground water flow has both horizontal and vertical components. Horizontal flow is generally dominant within aquifers, whereas vertical flow dominates between aquifers. Flow within aquifers may exhibit prominent vertical flow components near recharge or discharge areas, or where stratigraphic units are significantly tilted. This section summarizes ground water flow in the two major aquifers by discussing recharge, discharge and movement.

Gravel Aquifer

Recharge to the gravel aquifer is derived from leakage from streams and ditches, direct precipitation, irrigation, and localized upward leakage from the underlying basalt. Recharge from streambed leakage is considered to be a point (or line) source, and is limited to the immediate vicinity of streams and ditches. Recharge from the other sources is considered non-point, and occurs over the areal extent of the aquifer. Water budget analyses (see following section) indicates that the dominant sources of recharge are direct precipitation and irrigation. Bauer and Vaccaro (1990) estimated the distribution of recharge to the gravel aquifer using a deep percolation model for the entire basin. They calculated that recharge has increased from 56,100 af/yr during pre-development conditions to 128,900 af/yr under current irrigation applications, not including recharge from underlying basalt aquifers (pers. comm., H. Bauer, 1993). Recharge from the basalt aquifers is not well understood, but is known to be limited by the low-permeability Pleistocene clay and basalt flow interiors. Upward gradients from the basalt to the gravel aquifer likely dominated in pre-development times, however recent ground water declines in the basalt aquifer system have reversed these gradients in places.

Discharge from the gravel aquifer occurs directly to springs, as seepage into local rivers and streams, as localized leakage to underlying basalt aquifers, and to pumping wells. The most notable springs occur in Walla Walla and northwest of Milton-Freewater. Total spring discharge from the gravel aquifer has been estimated to be on the order of 56,000 af/yr (Barker & MacNish, 1976). Figure 6-3, a water level contour map for the gravel aquifer, suggests that ground water discharge to rivers and streams is most prominent in the western (downgradient) portions of the aquifer. Based on these contours, the Walla Walla River appears to gain the most ground water below its confluence with Birch Creek. Ground water discharge to the Walla Walla River downstream of the Touchet River confluence is relatively unimportant due to low aquifer transmissivities. Discharge to the underlying basalts is localized, limited, and variably distributed (as discussed above). Pumping wells are prevalent throughout the gravel aquifer.

Ground water movement in the gravel aquifer follows the pattern of surface water drainage, as shown on Figure 6-3. Locally this flow pattern is rendered more complex due to pumping, spring discharge, gaining and losing interactions with streams, and to a lesser degree, variable recharge from (and discharge to) the underlying basalt aquifer system.

Basalt Aquifer System

Recharge to the basalt aquifer system occurs primarily within the Blue Mountains that lie near the southern and eastern portions of the Walla Walla basin. In addition, the basalt aquifers may be locally recharged from the gravel aquifer where basalt aquifer pumping has caused downward vertical gradients. The gravel aquifer, however, does not appear to be a major source of recharge. Historic ground water gradients (and likely existing gradients at locations removed from major pumping centers) are vertically upward from the basalt to the gravel aquifer. Recent carbon-14 dating indicates the age of ground water from three basalt wells to range from 18,000 to 22,000 years before present (Pacific Groundwater Group, 1994). These dates represent laboratory results, and have not been "corrected" for effects due to geochemical reactions. The laboratory results are considered representative due to the geochemistry of the basalt. In contrast, Carbon-14 dating of three samples from the gravel aquifer ranged from recent (post-atomic-bomb) to 4,000 years before present (Pacific Groundwater Group, 1994). The older ages are likely the result of mixing between water recently recharged to the gravel aquifer and older water introduced by upward leakage from the basalt aquifer.

The basalt aquifer system discharges primarily to the Columbia and Snake Rivers. The Wanapum Formation, which contains the most important basalt aquifers from a water supply standpoint, crops out along the Snake River (above the Columbia River confluence) and along the Columbia River at Wallula Gap. Ground water flow in the Wanapum Formation is depicted in Figure 6-4. Ground water flow is shown to occur from east to west, towards the Columbia River. Ground water also flows towards the center of the basin where relatively high transmissivities occur along the axis of the Walla Walla syncline. Ground water flow in the Grande Ronde Formation (not shown) is primarily to the north, toward discharge areas where the Basalt crops out along the Snake River (Lane and Whiteman, 1989). Horizontal (or lateral) movement of ground water occurs within the tabular interflow zones, which are relatively permeable. Vertical movement of ground water is dominant within the low-permeability flow interiors.

6.2 Quantification of Water Budget Components

Water budget analysis is a useful tool to relate natural components of the hydrologic system to existing withdrawals and/or allocations. Balancing the water budget may allow estimation of system components which could otherwise not be quantified. Although water budgets can be used to estimate the volume of water flowing through a hydrologic system they cannot be used to assess water resource development potential. Acceptable levels of water resource development must be determined based on acceptable levels of impact to the hydrologic system, and water budgets often cannot accurately predict system response to additional withdrawals. The hydraulic effects of additional development must be estimated by predictive models or long-term testing or monitoring.

Water budgets are balanced on the assumption of dynamic equilibrium: that hydrologic systems can be viewed as being in a quasi-steady state. In steady state, inflows are equivalent to outflows with negligible changes in system storage. Balancing the water budget is beyond the scope of this study because many water budget components within the WRIA are not estimated or sufficiently characterized in the available literature. Nevertheless, existing estimates and measurements are presented and discussed in this section.

The water budget can be divided into three elements: climatic, surface water, and ground water. Each of these elements are linked to the others through shared water-budget components. For instance, the climatic element is linked to the surface water element through runoff from precipitation and is linked to the ground water element through recharge. This section presents a water budget analysis for the ground water element only. Separate water budgets are performed for the gravel aquifer and the basalt aquifer system. Inputs to the ground water budget estimated by other investigators may have been derived based on a water budget approach.

The tables below present estimates of water budget components for the gravel aquifer and basalt aquifer system, respectively. These estimates are compiled from a number of studies. Newcomb (1965) and MacNish (1973) estimated pumping from both aquifers. Additionally, Newcomb estimated springflow from the gravel aquifer. Numerical ground water flow models were prepared by the USGS for both the gravel aquifer (Barker & MacNish, 1976) and the basalt aquifer system (MacNish & Barker, 1976). Input and output from these models provide the first detailed quantitative analysis of water budget components. Estimates of water budget components were also published by Ecology (1977) as part of a general water resource allocation policy which was later incorporated into administrative code (Chapter 173-592 WAC). These estimates draw largely on results of the prior four studies. More recent studies by the USGS include the Walla Walla WRIA in their Regional Aquifer-System Analysis (RASA) Program for the Columbia Plateau. The results of the RASA study, however, are inappropriate for application to the Walla Walla water budget due to differences in the scale and area of analysis.

Gravel Aquifer:

Component	Newcomb, 1965	Bauer & Vaccaro, 1990	Barker & MacNish, 1976	Ecology, 1977
Recharge to gravel aquifer (via precipitation and irrigation sources)	not estimated	128,900 af/yr	177,000 af/yr	177,000 af/yr
Recharge from basalt aquifer	not estimated	not estimated	11,000 af/yr	12,000 af/yr
Recharge from streams	not estimated	not estimated	not estimated	not estimated
Discharge to basalt aquifer	not estimated	not estimated	1,000 af/yr	not estimated
Discharge to streams and springs	50,000 af/yr (springs)	not estimated	56,000 af/yr (springs) 76,000 af/yr (streams)	113,000 af/yr (streams)
Discharge from pumping	16,050 af/yr	not estimated	25,000 af/yr	25,000 af/yr
Discharge from evapotranspiration	not estimated	not estimated	not estimated	not estimated

Basalt Aquifer System:

Component	Newcomb, 1965	MacNish, 1973	MacNish & Barker, 1976	Ecology, 1977
Total recharge to basalt (including subflow from Oregon recharge)	not estimated	not estimated	132,000 af/yr (steady state) 138,500 af/yr (transient, 1972)	132,000 af/yr
Discharge to gravel aquifer	not estimated	not estimated	34,500 af/yr (steady state) 22,000 af/yr (transient, 1972)	12,000 af/yr
Discharge to Columbia and Snake Rivers	not estimated	not estimated	97,500 af/yr (steady state) 89,000 af/yr (transient, 1972)	97,500 af/yr
Discharge from pumping	14,800 af/yr	27,000 af/yr	28,000 af/yr (transient, 1972)	22,500 af/yr (1975)

Gravel Aquifer

Surficial infiltration (combined incident precipitation and irrigation applications) was estimated to be the largest source of recharge to the gravel aquifer, totalling between 128,900 and 177,000 af/yr.

In contrast, estimates for recharge from the basalt aquifer system range from 11,000 af/yr to 12,000 af/yr. Estimates of recharge from streambed seepage to the gravel aquifer were not attempted, and would be difficult to address. The largest component of discharge from the gravel aquifer goes to springs and streams. The 50,000 af/yr spring discharge estimate (Newcomb, 1965) is based on field and reported observations, whereas the 132,000 af/yr combined (springs and streams) estimate was derived from numerical modeling (Barker & MacNish, 1976). The validity of this combined estimate has not been determined by field confirmation. Discharge to the basalt aquifer system was also estimated through numerical modeling. Discharge to pumping was generally considered to be about 25,000 af/yr based on more recent estimates of ground water withdrawal. Discharge to evapotranspiration by phreatophytes was not estimated.

Basalt Aquifer System

Available water budget estimates for the basalt aquifer system are dominated by the numerical modeling results of MacNish & Barker (1976). Their model was calibrated for two conditions: a steady state run was performed to simulate pre-development (1900) conditions and a transient run was performed to simulate pumping conditions between 1900 and 1972. Water budget estimates from the basalt aquifer model should be taken with some caution, as MacNish & Barker note that both vertical leakage and the "changing flux of water entering the modeled area from the Blue Mountains" were not treated to their satisfaction. Values for vertical leakage between the two aquifer (systems) differ between the gravel aquifer model and the basalt system model. The reference to "changing flux" probably relates to the difference in recharge values between steady state and transient conditions.

Recharge was estimated for the entire Walla Walla River drainage, and thus includes water recharged in the Oregon portion of the basin. Based on ground water flow patterns (Figure 6-4), recharge from Oregon enters the WRIA as subflow across the Oregon-Washington border. Recharge during the steady state condition (132,000 af/yr) is similar to recharge during transient conditions (138,500 af/yr), although the causes for the change are unclear. The majority (64%-74%) of ground water recharge is estimated to discharge to the Columbia and Snake Rivers. Approximately 26% and 16% of recharge is estimated to discharge to the gravel aquifer during steady state and transient conditions respectively. Pumping from the basalt aquifer system causes post-development reductions in discharge to the Columbia and Snake Rivers and to the gravel aquifer. Recent pumping estimates are on the order of 28,000 af/yr. Relatively low estimates of pumping and discharge to the gravel aquifer are found in a water resources assessment document published by Ecology (Washington Department of Ecology, 1977).

Recharge Comparisons

Although a climatic water budget was not performed for the Walla Walla WRIA, basin-wide estimates of both recharge and precipitation have both been discussed in the body of this report. Comparison of these values is useful to estimate the percentage of precipitation entering the ground water flow system. Total precipitation to the basin is on the order of 1,380,000 af/yr, based on an average precipitation value of 14.7 in/yr applied over the basin area (1,758 sq. miles). Total recharge to the gravel and basalt aquifers ranges from 260,900 to 315,500 af/yr (see discussion above). It can therefore be estimated that about 19 to 23 percent of precipitation recharges the ground water system, with the remainder going to surface runoff and evapotranspiration.

Ground water recharge can also be compared to ground water development. The majority of the ground water recharge not withdrawn by wells supports flows in the rivers and streams of the Walla Walla watershed and in the Columbia and Snake Rivers. Estimates of ground water withdrawal (from both the gravel aquifer and the basalt aquifer system) are on the order of 52,000 af/yr (see Section 3.4). This annual volume represents approximately 16 to 20 percent of estimated total ground water recharge. Estimates of ground water withdrawal from the basalt aquifer system are on the order of 28,000 af/yr, which is approximately 20 percent of estimated basalt recharge.

Comparison of ground water development to recharge in the basalt aquifer system should receive special attention due to a regulatory withdrawal limit specified in WAC 173-532. The regulation states that water in the basalt aquifer will be closed to further appropriation when withdrawals reach 125,000 af/yr (which is considered to be 95% of recharge). The regulation does not specify whether ground water withdrawal in the Oregon portion of the basin will be considered in the 125,000 af/yr cutoff. This regulatory limit appears to be excessive (too high) for a number of reasons. First, because water budget estimates have inherent inaccuracies (often ±20%), and the margin of error associated with allocating 95% of *estimated* recharge may lead to overdraft. Second, because removal of 95% of the recharge to any aquifer system requires a sophisticated configuration of pumping locations. The current configuration (several major pumping centers) could not withdraw 95% of recharge without causing significant ground water level declines (which continue to occur at existing pumping centers – see following section). Third, because a significant portion of pumping from the basalt aquifer system occurs in Oregon – where Ecology has no control of present or future ground water withdrawals. Finally, it should also be noted that because a portion of ground water in the basalt aquifer system discharges to the Snake and Columbia Rivers, increased pumpage will result in decreased baseflow in these rivers.

6.3 Critical Indicators: Ground Water Level Trends

Long-term ground water level records from multiple locations in a basin are useful for understanding the timing and effects of recharge and withdrawals from monitored aquifer(s). From the perspective of ground water quantity management, practical reasons for ground water level monitoring include: 1) ensuring a reliable source of supply, and 2) maintaining adequate streamflow where aquifers discharge to streams. Ground water levels in selected wells have been monitored over varying time periods by the USGS. Water level data in the Walla Walla/College Place urban area are collected by local public water system administrators and compiled by the Walla Walla County Health Department. A discussion of water level trends in the gravel and basalt aquifers is included in this section based on available data.

Gravel Aquifer

In general, water level trends in the gravel aquifer have been relatively stable over the past 30 to 40 years. Water level trend data for the gravel aquifer within Washington are quite limited. Recorded water levels for only one gravel aquifer well were encountered in readily available data for the WRIA. Sixteen long-term records were available for gravel aquifer wells in Oregon, of which only four have shown declines over the period of record. These declines amount to a total of about 5 feet over a thirty year period, an average decline rate of about 0.2 feet per year.

Figure 6-5 presents hydrographs for four gravel aquifer wells, including the single well in Washington State. The locations of these wells are shown on Figure 4-2. The longest record (51 years) is available for Oregon well 06N/35E-24DC0. This well showed stable water levels between 1934 and 1960, followed by a minimal (3-foot) decline between 1960 and 1985. Oregon wells 06N/35-34BA3 and Washington well 06N/35ED-14AC7 show slight and gradual declines totaling about 4 feet over their period of record (50 years). Washington well 06N/35E-18A01 is a Department of Ecology monitoring well which shows a gentle (0.02 feet/year) rising trend since the mid 1970's.

Basalt Aquifer System

Water level trend data for the basalt aquifer system indicate that significant declines have occurred in some areas. Figures 6-6 and 6-7 present water level trend plots for six basalt wells in the Walla Walla basin. The locations of these wells are shown on Figure 4-2. Figure 6-6 shows hydrographs for wells located near the pumping centers of Walla Walla and College Place. Figure 6-7 shows hydrographs for wells located in outlying areas. Water levels near the major pumping centers declined at rates between 4 and 6 feet/year prior to the early 1970's. Rates of decline in these wells decreased after the early to mid 1970's. Well 07N/36-13F01 (Walla Walla Well #1) shows a water level recovery between 1975 and 1985, followed by a suggested gradual water level decline. Well 07N/36ED-33D02 (Walla Walla Well #7) shows a decline of 2 to 3 feet per year between 1983 and 1992.

Water levels in outlying areas show variable rates of decline. Well 07N/34E-29C01 shows a decline rate of about 3 feet/year, with reduced decline starting in the mid-1970's. This well is located 10 miles west of College Place. Wells 09N/37E-11G01 and 06N/35E-18A03 show rising and stable water levels (respectively). Well 09N/37E-11G01 is Waitsburg's Well #2. It is located far from Walla Walla/College Place. Well 06N/35E-18A03 is one of Ecology's basalt aquifer monitoring wells located 5 miles southwest of College Place.

The rate of water level decline since the early 1970's is graphically presented in Figure 6-8, a water level decline contour map for the basalt aquifer system. This map was produced by detailed analysis of water level trend data presented in this and other reports (Pacific Groundwater Group, 1994). Decline rates of 2 to 3 feet/year are coincident with the major municipal pumping centers (Walla Walla, College Place and Milton Freewater). Post-1972 rates of decline are considered to be reasonable estimates of current decline rates, based on available data.

A comparison of total basalt aquifer pumpage and water level decline for well 07N/36E-13F01 (City of Walla Walla Well #1) is shown of Figure 6-9. The total pumpage trend is based on MacNish & Barker (1976), and other estimates discussed in Section 3.4. Significant water level declines are observed before the early 1970's, and stabilization is noted between the early 1970's and mid 1980's. This trend is similar to other wells in the Walla Walla vicinity. An inverse correlation exists between total pumpage and depth to water. The period of increasing pumpage is reflected by relatively steep water level declines. When total basalt pumpage stabilized in the early 1970's, water level stabilization and decreasing rates of declines are observed.

7 Stream Water Quality and Fisheries Habitat

7.1 Water Quality Assessment

A water quality assessment of the WRIA was completed to summarize existing water quality data and to provide an overview of water quality conditions. Data sources used to complete this water quality assessment include the Washington Department of Fish and Wildlife's Washington Rivers Information System (WARIS) database, the U.S. Environmental Protection Agency (EPA) STORET database and water quality data from the U.S. Geological Survey (USGS) (1994). Surface water quality classifications and water bodies listed on Ecology's "303d" water quality limited list are also indicated.

7.1.1 Water Quality Classifications

Surface waters in the WRIA are classified in Chapter 173-201A WAC to establish water quality standards for various parameters. The State of Washington classifies surface water by characteristic use and quality. Class AA is considered of extraordinary quality which markedly and uniformly exceeds the requirements for all uses. Class AA water is typically used for public water supplies, salmonid rearing, recreation, as well as other uses. Class A water is deemed of excellent quality and meets or exceeds the requirements for all or substantially all uses. Class A water is used for the same purposes as Class AA but does not meet the same stringent standards. Class B water is considered good quality water which meets or exceeds the requirements of most uses. Characteristic uses are similar to Class AA and Class A, with the exception of domestic water supplies.

Surface water classifications represent compliance standards which should be maintained for the benefit of public health and the protection of fish and wildlife. All waters in the WRIA are designated as Class A, with special exceptions noted for the following segments:

- Mill Creek from mouth to 13th Street Bridge in Walla Walla – B
- Mill Creek from Waterworks Dam to headwaters – AA
  (special condition – no waste discharge will be permitted)
- Touchet River, north fork from Dayton water intake to headwaters – AA
- Walla Walla River from mouth to Lowden (Dry Creek) – B
- Walla Walla River from Lowden to Oregon border – A (with a special condition that temperatures should not exceed 20° C due to human activities (WAC 173-201A-130)).

7.1.2 Water Quality Limited Water Bodies

Ecology periodically submits a list of "water quality limited" water bodies of the state to EPA as required by Section 303(d) of the federal Clean Water Act. This 303(d) list contains water body segments where existing management practices have not been adequate to maintain water quality standards. The state is then required to establish maximum daily limits on pollutant discharge to these areas. Fecal coliform and temperature violations caused the greatest number of listings for streams in the state in 1994. Water body segments located in the Walla Walla WRIA and contained in Ecology's May 13, 1994 303(d) list submitted to the EPA are included in this report (Table 7-1, Figure 7-1).

7.1.3 Water Quality Assessment

A search of the EPA STORET database was conducted for this report. Search results included a summary of all available water quality data recorded at stations throughout the Walla Walla basin and reported to EPA. The STORET results show that over the periods of record, Class A water quality violations have occurred with respect to water temperature, dissolved oxygen, pH and fecal coliform (U.S. Environmental Protection Agency, 1994). These results, along with state water quality criteria, are shown in Table 7-2.

A review of water quality data provided by the USGS showed several reports of low flow conditions and violations of Class A water temperature standards throughout the WRIA. Some temperature readings were sufficiently high to be lethal to fish (greater than 25° C), including maximum temperatures of 28.2° C on the Touchet River, 25.6° C on Dry Creek and 29.9° C on the Touchet River near Touchet. These data also showed that many reaches experience extreme low flow to no flow conditions (see fisheries assessment below).

Water quality in high-elevations, forested headwaters of the basin is generally cool, clear, low in pollutants and high in dissolved oxygen (Confederated Tribes of the Umatilla Indian Reservation et al., 1990). The mid- and lower reaches of the watershed have been developed for dryland and irrigated agriculture. Dryland farms can produce large quantities of sediments (Confederated Tribes of the Umatilla Indian Reservation et al., 1990). Large amounts of sediment are delivered to basin streams annually, predominantly due to soil erosion caused by agricultural activities. In 1981, an estimated 421,000 tons of sediment was delivered to the Touchet River, 291,000 tons was delivered to Dry Creek and 90,000 tons was delivered to the Walla Walla River (U.S. Department of Agriculture, 1984). Other factors potentially affecting water quality in the WRIA, such as high nutrients and toxic substances, have not been extensively investigated (U.S. Army Corps of Engineers, 1992).

Walla Walla River

Upstream of the Milton-Freewater diversion, high water temperatures do not appear to be a problem, although data is limited. The average temperature for the month of August, recorded at this location between 1987 and 1991, was 17.8° C. Downstream of this diversion, water temperatures in the mainstem Walla Walla are most likely too high for summer rearing of salmon or trout because of the greatly reduced or nonexistent flow and large open channel (U.S. Army Corps of Engineers, 1992). Summer temperatures often exceeded 28° C at a USGS site downstream of the confluence with the Touchet River (U.S., Army Corps of Engineers, 1992).

Mill Creek and Touchet River

High water temperatures are considered a major water quality concern in the middle and lower sections of Mill Creek. A summer temperature of 26° C was recorded just upstream of the Corps of Engineers diversion dam. It is likely that these high temperatures continue downstream as the creek passes through a concrete-lined channel and areas frequently confined by levees (U.S. Army Corps of Engineers, 1992). The Touchet also has high summer temperatures; temperatures recorded in areas downstream of Dayton peak at 26° to 28° C (Hunter and Cropp, 1975). The cause of these high temperatures was not discussed in the report.

7.2 Fisheries Assessment

The following fisheries assessment of the Walla Walla WRIA summarizes existing information on fish abundance and distribution and fish habitat conditions. Data sources used to complete this assessment include the State Salmon and Steelhead Stock Inventory (SASSI) (1994), consultation with a Washington Department of Fish and Wildlife habitat biologist (pers. comm., Wilms, 1995) and the WARIS database.

7.2.1 Salmon Distribution, Abundance and Stock Status

The SASSI is part of a statewide effort to identify distinct salmon and steelhead stocks and determine their status. A review of the SASSI was made to determine the abundance and distribution of genetically distinct salmon stocks in the Walla Walla WRIA (SASSI, 1994). Stocks identified as depressed or critical are close to or below the population size where permanent loss of distinct genetic material is a risk. The SASSI report defines a stock by the following criteria:

- distinct spawning distribution
- distinct run-timing distribution
- distinct biological characteristics (genetics, size, age structure, etc.)

Chinook, Chum, Coho and Sockeye Salmon

Runs of spring and fall chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), coho (*O. kisutch*) and sockeye (*O. nerka*) salmon are believed to have inhabited the WRIA at one time, but they are no longer present (Van Cleve and Ting, 1960; Wilms, pers. comm., 7 February 1995). Swindell (1942) and Lane and Lane (1979) described fishing sites in the Walla Walla River where chum, coho and steelhead were harvested; the last notable chinook run was in 1925 (Van Cleve and Ting, 1960). Chapman (1981) reported that the total undisturbed basin production of chinook may have been 5,000 fish.

Nine Mile Dam, built in 1905 on the mainstem Walla Walla River, is believed to be the main cause of the disappearance of salmon from the Walla Walla and Touchet Rivers (Confederated Tribes of the Umatilla Indian Reservation et al., 1990). This dam is no longer in place. Chinook, chum, coho and sockeye also typically migrate to spawning grounds during times of the year when streamflows are low. As summer low flows in the lower reaches of the Walla Walla basin decreased over time, it is believed that these runs were no longer able to access good spawning habitat in the upper basin (Wilms, pers. comm., 7 February 1995). There are currently an estimated 61 stream miles of habitat suitable for spring chinook spawning and rearing in the Walla Walla basin (Northwest Power Planning Council, 1988).

Plans have been proposed to reintroduce chinook to the Walla Walla basin using fish from the Carson Hatchery or from the Tucannon River. Upstream migration of Carson stock would likely occur in the Walla Walla River from April to June, with a peak in May. Spawning would occur from late August through early September. Most juveniles would rear in the basin for one year before migrating downstream from April through June. They would likely migrate upstream after one to three years in the ocean (U.S. Army Corps of Engineers, 1992).

Steelhead

Fifteen summer steelhead stocks and three winter steelhead stocks have been identified in the upper Columbia River. These stocks are treated separately due to geographic isolation of spawning populations. There is little or no information available to indicate these are genetically distinct stocks. Two of the summer steelhead stocks, the Touchet and Walla Walla River stocks, utilize habitat in the Walla Walla WRIA.

Steelhead historically spawned and reared throughout a large area of the middle and upper reaches of the mainstem Walla Walla and Touchet Rivers and tributaries. Annual runs are believed to have contained 4,000 to 5,000 fish (Oregon Department of Fish and Wildlife, 1987). An estimated 1,090 to 1,817 native summer steelhead returned to the basin annually between 1977 and 1987.

Steelhead enter the basin from December through March, and peak spawning occurs from April through May. Adult fish remain in the Columbia River until flows increase in the Walla Walla from December through March (U.S. Army Corps of Engineers, 1992). Most juveniles rear for two years prior to migration, emigrating out of the basin from April through May (Confederated Tribes of the Umatilla Indian Reservation et al., 1990).

Wild summer steelhead in the Walla Walla River, Mill Creek, Dry Creek and tributaries are defined as distinct based on the geographical isolation of the spawning population (SASSI, 1994). Many smaller tributaries contain unknown populations of steelhead which are presumed to contribute to the Walla Walla stock. Most of the better spawning habitat in the Walla Walla River is located in Oregon in the upper watershed. The origin of the stock is mixed. Hybridization with hatchery-reared returning adults has probably occurred since 1984, but the degree of hybridization is unknown. Runs generally occur from mid-October through March, and spawning takes place from early March through mid-May (SASSI, 1994).

The Walla Walla River wild summer steelhead stock is chronically depressed, and the presence of the four downstream Columbia River hydroelectric dams, long-term habitat degradation and extreme low flow conditions in the Washington portion of the river keep population levels below potential. Short-term population declines also occur in drought or other severe climatic events.

Spawning ground survey results have not been reported, and no escapement estimates are available (SASSI, 1994).

Wild summer steelhead in the Touchet River, Coppei Creek, Robinson Creek, Wolf Creek and tributaries are a distinct stock based on the geographical isolation of the spawning population. The Touchet River is a major tributary to the Walla Walla River (SASSI, 1994). Fish enter the Touchet River in early December depending on flow conditions. Much of the lower river is impassable for much of the year, but fish are believed to overwinter throughout the entire river. Fish begin actively moving again in late February and spawn from March through early May. The origin of the stock is mixed. Hybridization with hatchery fish is likely to have occurred since 1984. Predominantly Wells and Lyons Ferry hatchery stocks have been used in these releases.

The status of the Touchet River stock is chronically depressed, as the four Columbia River hydroelectric dams, long-term habitat degradation and water withdrawal keep population levels below potential. Drought and dramatic climatic events can also cause short-term severe population declines. Estimates of escapement are highly variable due to weather and driver flow conditions but have ranged between 44 and 221 fish since 1989 (SASSI, 1994).

In recent years the Washington Department of Wildlife released hatchery reared summer steelhead in the basin. The Oregon Department of Fish and Wildlife (ODFW) and confederated tribes of the Umatilla Reservation are planning a hatchery steelhead and spring chinook supplementation program for the basin. The Tribes may also be investigating the feasibility of fall chinook, coho and chum salmon (Confederated Tribes of the Umatilla Indian Reservation et al., 1990). The Umatilla Tribes and the Oregon Department of Fish and Wildlife have also developed cooperative plans to enhance steelhead habitat and reintroduce spring chinook in the Walla Walla basin (Oregon Department of Fish and Wildlife, 1987). The Washington Department of Wildlife placed restrictions on recreational steelhead fishing beginning in 1986, limiting sport harvest to fin-clipped fish of hatchery origin (Northwest Power Planning Council, 1986).

Resident Fish Species

In addition to fresh water fish species typically inhabiting eastern Washington streams, species of concern found in the WRIA include Dolly Varden/bull trout, pygmy whitefish and sea-run cutthroat. These species are present in suitable habitat in stream systems in upper portions of the basin. Major reaches where these species are reported present include North Fork Mill Creek, South Fork Touchet River and tributaries, North Fork Touchet River, Robinson Fork and Wolf Fork and tributaries (Washington Department of Fish and Wildlife, 1994) (Figure 7-2).

Critical Spawning Habitat

Critical steelhead spawning habitat occurs in the upper basin along the North Fork Touchet River, along upper Robinson Creek and tributaries, in tributaries to the upper South Fork Touchet River and in the upper reaches of Mill Creek (Washington Department of Fish and Wildlife, 1994). Critical spawning habitat includes areas which provide habitat necessary for the perpetuation of regional fish populations (Figure 7-2).

7.2.2 General Habitat Description and Limiting Factors

Stream habitat in the lower reaches of the WRIA is generally in a degraded condition. Fine sediment deposition from erosion of upland areas is high in nearly all streams, and pool-to-riffle ratios are generally low. Much of the riparian vegetation has been lost to livestock grazing, cultivation and stream channelization (U.S. Department of Agriculture, 1984).

The Walla Walla River is characterized by low-gradient valleys with highly erodible fine soils intermixed with medium to large gravels. Intensive agriculture in the lower reaches of the WRIA uses most of the available surface water and a substantial amount of ground water (SASSI, 1994). The stream channel is unstable and receives a large quantity of fine sediment and gravels. These factors, in combination with very warm summer temperatures, greatly limit the available steelhead habitat in the Walla Walla River and upstream migration through this area. Juvenile and adult mortality, associated with the lower four Columbia River dams, are significant at both life stages of both stocks and will continue to negate small habitat improvements in the basin unless migration survival can be improved (SASSI, 1994).

Fish habitat in the mainstem Walla Walla River varies by locations, species and life stage. Changes to gravel quantity and quality, riparian vegetation, bank stability and streamflow from increased land use all affect habitat quality in the Walla Walla WRIA. Abundant alluvium in the mainstem and tributaries provide extensive spawning gravel availability. The deep gravels also contribute to migration problems where low streamflows are inadequate to fill the porous substrate and still maintain sufficient surface flow for fish passage. A major alluvial deposit in the Milton-Freewater area acts as a sink which, in combination with irrigation depleted streamflows, seasonally dewaters the mainstem Walla Walla River. Adult spawners may not be able to access spawning habitat upstream due to shallow stream depths, inadequate holding pools, high stream temperatures or in some places, poorly constructed or maintained irrigation diversions. There have been efforts in recent years to improve passage past the diversions (SASSI, 1994).

Riparian conditions are generally good in the high elevation headwaters, but grazing and flood control activities in the lower reaches have seriously reduced riparian vegetation (Confederated Tribes of the Umatilla Indian Reservation et al, 1990). Decreased streamside shading may contribute to elevated water temperatures and reduced juvenile rearing suitability. In the Touchet River, logging, road building, agricultural practices and cattle grazing continue to negatively impact streambank stability. As streambanks are disturbed, the quality of available fish habitat may decline as a result of increased sedimentation and decreased large woody debris. Stream channel diking, channelizing and straightening reduce habitat complexity and can result in decreased fish habitat quality.

Basin-wide, irrigation diversions present significant barriers to fish passage. Four major diversions – three permanent structures and one seasonal gravel dam – exist on the mainstem Walla Walla River. These diversions impede and may block upstream migration. The Little Walla Walla diversion at river mile 47 completely dewaters the river during the summer and during the spring in years of low streamflow (Oregon Department of Fish and Wildlife, 1987).

The lower 4 miles of the Touchet River and the lower 10 miles of Mill Creek may also be entirely dry due to naturally low flows combined with irrigation withdrawals (U.S. Army Corps of Engineers, 1992). Numerous small irrigation diversions on Walla Walla River tributaries impede adult and juvenile passage. Two major diversions on the lower mainstem Touchet partially block adult fish passage (U.S. Fish and Wildlife Service, 1982). All irrigation diversions in the Washington portion of the basin were screened to protect fish from intakes (Northwest Power Planning Council, 1986), although many of the screens are now missing or no longer functional (pers. comm., B. Neve, 1995).

Low streamflow is considered to be the major factor limiting production of anadromous fish in the Walla Walla basin (Confederated Tribes of the Umatilla Indian Reservation et al., 1990). Streamflows and fish production are highly dependent on annual high-elevation snowpack. By May or early June, the mainstem Walla Walla is dry near the state line due to irrigation withdrawals and naturally low summer flows. Depleted streamflows and high summer temperatures elevate water temperatures to lethal levels for salmonids in July and August (Northwest Power Planning Council, 1986). Low flows in the summer and fall restrict steelhead from entering the river until November or December in many years. This condition persists from July until the end of the irrigation season. Data from the USGS indicate that extreme low flow conditions have been documented throughout the WRIA. Flows on Mill Creek have been recorded as low as 29 cubic feet per second (cfs), on Blue and Dry Creeks less than 2 cfs and on the Touchet 6 cfs. Periods of no flow have been recorded on the Walla Walla River (U.S. Geological Survey, 1994).

8 References and Bibliography

Barker, R.A., and Mac Nish, R.D., 1976, Digital Model of the Gravel Aquifer, Walla Walla River Basin, Washington and Oregon: Water-Supply Bulletin 45, Washington State Dept. of Ecology, Olympia, WA, 49p.

Bauer, H.H., Vaccaro, J.J., 1990, Estimates of Ground Water Recharge to the Columbia Plateau Regional Aquifer System, Washington, Oregon, and Idaho, for Predevelopment and Current Land-Use Conditions, USGS Water Resources Investigations Report 88-4108, 37p.

Bauer, H.H., Vaccaro, J.J., and Lane, R.C., 1985, Maps Showing Ground water Levels in the Columbia River Basalt and Overlying Materials, Spring 1983, Southeastern Washington: Water-Resources Investigations Report, 84-4360, 4 sheets.

Bauer, H.H., 1993, Personal Communication, Recharge Data from Deep Percolation Model for Walla Walla Basin (subarea 49).

Bush, J.H., Morton, J.A., Anderson, J.V., Crosby, J.W. III, and Siems, B.A., 1973, Test-Observation Well near Walla Walla, Washington: Description, Stratigraphic Relationships, and Preliminary Results, WSU, College of Engineering, Research Report 73-15-66, Project No. 3811-1184.

Chapman, D.W., 1981, Pristine production of anadromous salmonids-Walla Walla River. Prepared for the Bureau of Indian Affairs, Portland, OR. 55 pp.

Cline, D.R., 1992, U.S. Geological Survey. Personal Communication, telephone conversation with Russ Prior (Pacific Groundwater Group).

Cline, D.R., and Knadle, M.E., 1990, Ground water Pumpage from the Columbia Plateau regional aquifer system, Washington: USGS Water-Resources Investigations Report 87-4135, 32 p.

Confederated Tribes of the Umatilla Indian Reservation, Oregon Department of Fish and Wildlife, Washington Department of Fisheries and Washington Department of Wildlife. 1990. Walla Walla River subbasin salmon and steelhead production plan. Confederated Tribes of the Umatilla Indian Reservation, Pendelton, OR.

Collins, C.A., 1987, Groundwater Pumpage from the Columbia Plateau Regional Aquifer System, Oregon, 1984: A Contribution of the Regional Aquifer-System Analysis Program, USGS Water Resources Investigations Report 86-4211.

Drost B.W., and Whiteman, K.J., 1986, Surficial Geology, Structure, and Thickness of Selected Geohydrologic units in the Columbia Plateau, Washington: USGS Water-Resources Investigations Report 84-4326, 10 sheets.

EES (Economic and Environmental Services) and Pacific Groundwater Group, 1995, Draft pre-ground water management area study. Prepared for the Walla Walla Urban Area Water User Coordinating Committee.

James, L.G., Whittlesey, N.K., Butcher, W.R., Willis, D.B., Sonnichsen, R.P., and Reilly, E.A., 1991, Irrigation Water Use Efficiency Demonstration Project. Phase II: Conservation Assessment, State of Washington Dept. of Ecology, Agreement No. C0090109.

Hansen, A.L., and Mitchell, S., 1977, Basin Program Series No. 6, Water Resources Management Program, Walla Walla River Basin (Water Resources Inventory Area No. 32, State of Washington Dept. of Ecology, Olympia, WA.

Hearn, PP., Steinkampf, W.C., Bortelson, G.C., and Drost, B.W., 1985, Geochemical controls on dissolved sodium in basalt aquifers of the Columbia Plateau. USGS WRI-84-4304.

Hunter, J.W., and Cropp, T.D., 1975, Touchet River study, part II, fisheries. Bulletin number 5. Washington Game Department, Olympia, WA.

IAEA, 1990, Environmental Isotope Data, 9. World Survey of Isotope Concentration in Precipitation (1984 – 1987). IAEA Tech. Rep. Ser.

Lane, R.B., and Lane, B., 1979, Traditional fisheries of the Walla Walla, Cayuse and Umatilla. Confederated Tribes of the Umatilla Indian Reservation, Pendelton, OR.

Lane, R.C., and Whiteman, K.J., 1989, Ground water Levels Spring 1985, and Ground water level changes spring 1983 to Spring 1985, in Three Basalt Units Underlying the Columbia Plateau, Washington and Oregon: USGS Water-Resources Investigations Report 88-4018, 4 sheets.

Mac Nish, R.D., and Barker, R.A., 1976, Digital Simulation of a Basalt Aquifer System, Walla Walla River Basin, Washington and Oregon: Water-Supply Bulletin 44, Washington State Dept. of Ecology, 51p.

Mac Nish, R.D., Myers, D.A., and Barker, R.A., 1973, Appraisal of Groundwater Availability and Management Projections, Walla Walla River Basin, Washington and Oregon: Water-Supply Bulletin 37, Washington State Dept. of Ecology, Olympia, WA, 25p.

Newcomb, R.C., 1965, Geology and Ground water Resources of the Walla Walla River Basin, Washington-Oregon: Water-Supply Bulletin 21, Washington State Dept. of Conservation, Olympia, WA, 151p.

Neve, Bill, April 1995, Washington Department of Ecology, Walla Walla Field Station. Personal Communication, telephone conversation with Peter Schwartzman (Pacific Groundwater Group), April, 1995.

Northwest Power Planning Council, 1986, Application for amendment, Columbia River basin fish and wildlife program; Walla Walla River basin flow augmentation, Submitted by the Washington Department of Game and Oregon Department of Fish and Wildlife.

Northwest Power Planning Council, 1988, Anadromous species presence/absence files for the Walla Walla basin, Portland, OR.

Oregon Department of Fish and Wildlife, 1987, United States v. Oregon subbasin production reports. Portland, OR.

Pacific Groundwater Group, 1994, Section IV – hydrogeologic characterization, Report section provided to Economic and Environmental Services, Inc. as a portion of: EES and Pacific Groundwater Group, 195 (see previous reference).

Price, C.E., 1960, Artificial Recharge of a Well Tapping Basalt Aquifers, Walla Walla Area, Washington Water-Supply Bulletin 7, Washington State Dept. of Conservation, Olympia, WA, 50p.

Reidel, S., and Hooper, P., 1989, Columbia River Basalts, preliminary citation, Geological Society of America, Special Paper 239.

Swanson, D.A., Wright, T.L., Camp, V.E., Gardner, J.N., Helz, R.T., Price, S.M., Reidel, S.P., and Ross, M.E., 1980, Reconnaissance Geologic Map of the Columbia River Basalt Group, Pullman and Walla Walla Quadrangles, Southeast Washington and Adjacent Idaho: USGS Miscellaneous Geologic Investigations Report I-1139, scale 1:250,000, 2 sheets.

Swindell, E.G. 1942. Report on source, nature and extent of the fishing, hunting and miscellaneous rights of certain Indian Tribes in Washington and Oregon together with affidavits showing location of a number of usual and accustomed fishing grounds and stations. Office of Indian Affairs, Division of Forestry and Grazing, Los Angeles, CA.

Tolan, T.L., and Reidel, S.P., 1989, Structure map of a portion on the Columbia River flood-basalt Province in Reidel and Hooper, 1989.

U.S. Army Corps of Engineers, 1992, Walla Walla River Basin fisheries enhancement potential reconnaissance investigations, Prepared by Ebasco Services, Bellevue, WA.

U.S. Army Corps of Engineers, Seattle District, 1980, Geologic Reconnaissance of Parts of the Walla Walla and Pullman, Washington and Pendleton, Oregon 1° x 2° AMS Quadrangles Foundation Sciences, Inc., Portland, OR., Contract No. DACW67-80-C-0125.

U.S. Army Corps of Engineers, Walla Walla District, 1992, Walla Walla River Basin, Oregon and Washington: Reconnaissance Report.

U.S. Environmental Protection Agency, 1994, STORET database search results prepared for Pacific Groundwater Group, Prepared by U.S. Environmental Protection Agency, Seattle, WA.

U.S. Department of Agriculture (USDA) Soil Conservation Service, 1965, Mean annual precipitation 1930-1957 state of Washington, Prepared in cooperation with the U.S. Weather Bureau (U.S. Department of Commerce).

U.S. Department of Agriculture, 1984, Southwest Washington cooperative river basin study, U.S. Department of Agriculture, Soil Conservation Service, Forest Service and Economic Research Service.

U.S. Fish and Wildlife Service, 1982, Lower Snake River enhancement study, Unpublished report. Ecological Services Office, Boise, ID.

U.S. Geological Survey, 1994, Database search results prepared for Washington Department of Ecology, 9 January 1995, U.S. Geological Survey, Tacoma, WA.

Vaccaro, J.J., and Bauer, H.H., 1990, Archiving of Deep Percolation Models, Data Files, and Calculated Recharge Estimates for the Columbia Plateau Regional Aquifer System, Washington, Oregon, and Idaho USGS Open File Report, 88-186, 13p.

Van Cleave, R., and Ting, R., 1960, The condition of salmon stocks in the John Day, Umatilla, Walla Walla, Grande Ronde and Imnaha Rivers as reported by various fisheries agencies, Publishers unknown.

Washington Department of Ecology, December, 1977, Basin program series no. 6, water resources management program, Walla Walla River Basin (Water Resources Inventory Area Number 32), Prepared by the Policy Development Section of the Water Resources Management Division.

Washington Department of Fisheries and Western Washington Treaty Indian Tribes (SASSI), 1994, 1992 Washington State salmon and steelhead stock inventory.

Washington Department of Fish and Wildlife, 1994, Walla Walla WRIA: Map products produced from the WARIS database, Prepared by Marshall and Associates.

Williams, J.R., and Pearson, H.E., 1985, Streamflow Statistics and Drainage-basin Characteristics for the Southwestern and Eastern Regions, Washington, Volume II. Eastern Washington: USGS Open-File Report 84-145-B, 662.

Wilms, Roger, 7 February, 1995, Habitat Biologist, Washington Department of Fish and Wildlife. Personal communication, telephone conversation with Carl Hadley (Beak Consultants).

Tabled 4-1 Summary of Weather Stations
Walla Walla WRIA

Station Name	Station ID	Latitude	Longitude	Elevation (ft-MSL)	Period of Record Begin	End	Years of Record
DAYTON 5 NW	2035	46:22:00	118:04:00	1710	1950	1951	2
DAYTON 1 WSW	2030	46:19:00	118:00:00	1560	1931	1993	63
DAYTON 9 SE	2037	46:13:00	117:51:00	2340	1950	1951	2
WALLA WALLA 14 ENE	8927	46:06:00	118:10:00	3560	1972	1972	1
WALLA WALLA FAA AIRPORT	8928	46:06:00	118:17:00	1170	1949	1993	45
DIXIE 4 SE	2197	46:06:00	118:05:00	2340	1950	1951	2
MILL CREEK DAM	5387	46:05:00	118:16:00	1180	1948	1993	46
GARDEN CITY HEIGHTS	3050	46:05:00	118:19:00	1050	1916	1942	27
WALLA WALLA 3 W ENT LA	8926	46:03:00	118:24:00	800	1931	1962	32
WHITMAN MISSION	9200	46:03:00	118:27:00	630	1962	1993	32
WALLA WALLA WB CITY	8931	46:02:00	118:20:00	950	1948	1987	40
MILL CREEK	5377	46:01:00	118:07:00	2000	1948	1973	26

Notes:
1) Data source is National Climate Data Center.

Tabled 5-1 Summary of USGS Stream-Flow Gaging Stations Walla Walla WRIA

Station Name	Station ID	Latitude	Longitude	Period of Record	Length of Record (yrs)
EAST FK TOUCHET R NR DAYTON, WASH.	14016500	46 16 45	117 54 05	1941 1968	24
EF TOUCHET R BL HATLEY CR NR DAYTON, WASH	14016610	46 16 45	117 54 05	1965 1966	2
TOUCHET RIVER AT BOLLES, WASH.	12017000	46 16 28	118 13 15	1924 1989	43
DRY CREEK NEAR WALLA WALLA, WASH.	14016000	46 07 20	118 14 10	1949 1967	19
MILL CR BLW BLUE CR NR WALLA WALLA, WA.	14013600	46 04 55	118 11 25	1969 1970	2
MILL CREEK AT WALLA WALLA, WASH.	14015000	46 04 35	118 16 21	1941 1994	56
GARRISON CR AT WALLA WALLA, WASH.	14014500	46 04 25	118 17 10	1941 1952	12
YELLOWHAWK CR AT WALL A WALLA, WASH.	14014000	46 04 20	118 16 55	1941 1952	12
BLUE CREEK NEAR WALLA WALLA, WASH.	14013500	46 03 30	118 08 10	1940 1971	32
TOUCHET R NR TOUCHET, WASH.	14017500	46 02 30	118 41 00	1941 1955	15
WALLA WALLA RIVER NEAR TOUCHET, WASH.	14018500	46 02 15	118 45 55	1952 1994	43
MILL CREEK NEAR WALLA WALLA, WASH.	14013000	46 00 29	118 07 03	1914 1994	56

Notes:
1) Data sources include Washington State Department of Ecology, Water Resources Division and the US Geological Survey.

Table 7-1. Water quality limited water body segments in the Walla Walla WRIA

Water Body Segment Number	Water Body	Segment in Violation
WA 32-1010	Walla Walla River	Temperature
		pH
		Fecal Coliform
		Heptachlor
WA 32-1020	Touchet River	Temperature
		pH
		Fecal Coliform
WA 32-1025	Touchet River, N.F. (E.F.)	Temperature
WA 32-1060	Mill Creek	Total Phosphorus
		Total Nitrogen
WA 32-1070	Mill Creek	Temperature
		Fecal Coliform

Table 7-2. EPA STORET water quality database search results for the Walla Walla River Basin (HUC 17070102).

Parameter	Number of Samples	Mean	Maximum	Minimum	Beginning/End Date OF Collection	WAC 246-290-310 Drinking Water Standards	WAC 173-201A Water Quality Standards	
							Class AA	Class A
Water Temp. (°C)	3549	9.9	33.3	-.6	7/59 to 3/94	None	16	18
Turbidity (NTU)†	169	24.4	2000	0.8	8/86 to 9/93	< 1 unit chg.	<5 unit chg.	<5 unit chg.
Diss. Oxygen (mg/l)	1814	10.8	21.8	0	7/59 to 9/93	None	<9.5	<8
pH	1849	7.8	9.8	4.0	7/59 to 9/93	None	6.5-8.5	6.5-8.5
Fecal Coliform (/100ml)	31	443.4	7000	6	12/67 to 11/75	0	50	100
NO_2 and NO_3 (mg/l)	448	0.72	0	5.6	10/74 to 9/93	None	None	None
Ammonia (mg/l)	30	0.05	.2	0	4/67 to o9/93	None	24‡	
Copper (ug/l)	1	6	6	6	7/80	1000	10.6*	
Lead (ug/l)	9	9.4	10	5	4/79 to 12/81	50	34.2*	
Zinc (ug/l)	1	20	20	20	7/80	5000	75.0*	
Mercury (ug/l)	141	0.3	1	0	10/73 to 12/81	2	2.4	
Cadmium (ug/l)	9	1.8	2	0	4/79 to 12/81	10	2.2*	
Chromium (ug/l)	14	6.4	10	0	8/67 to 12/81	50	1263.2*	

† Nephelometric Turbidity Units
* Acute standards based on a recorded hardness of 67.8.
‡ Total ammonia criteria for 15 C and a pH of 7.0. For the same conditions, the unionized standard is 0.0066mg/l.

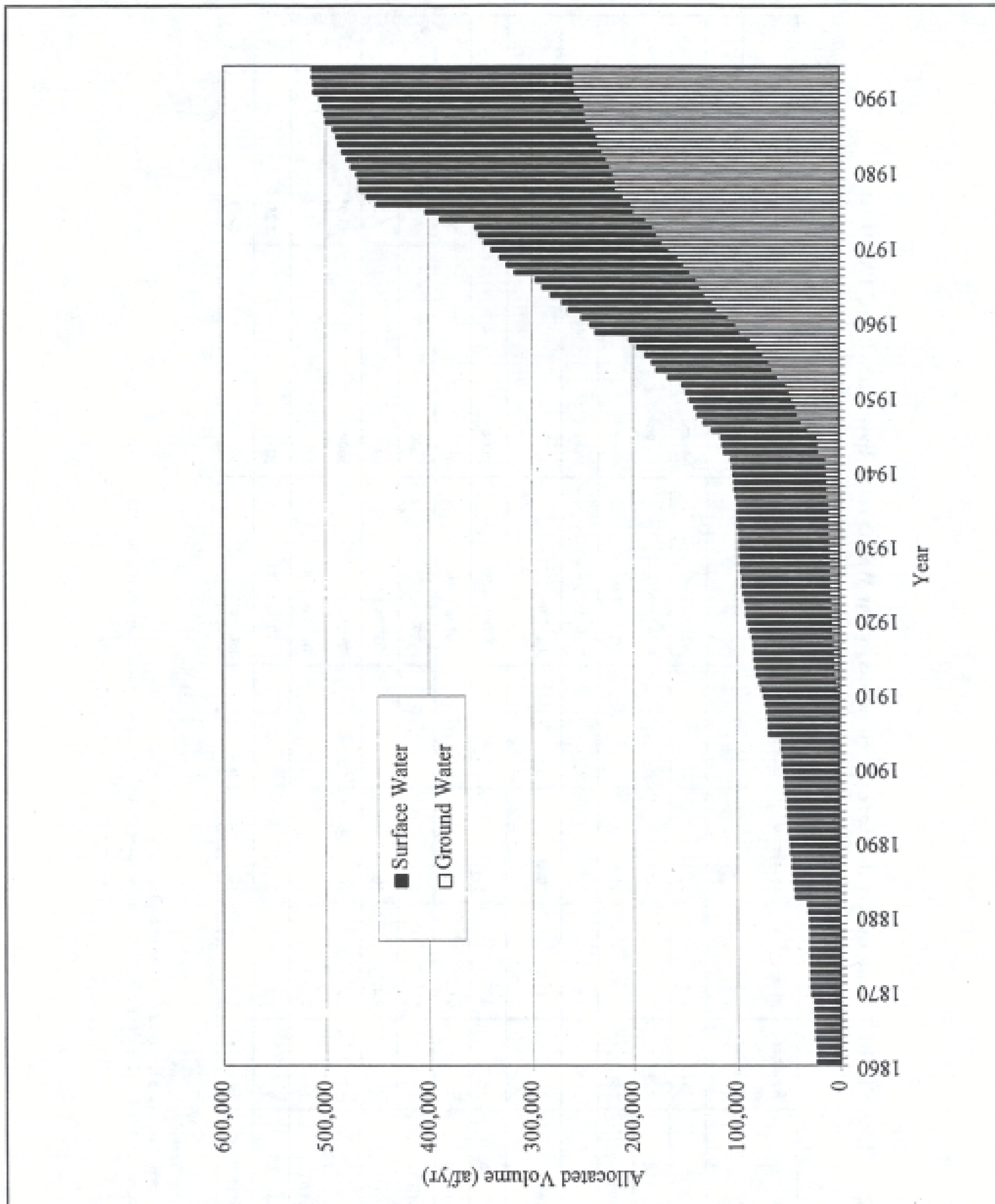


FIGURE 3-1

Water Rights Versus Time

Initial Watershed Assessment Program
Walla Walla Basin

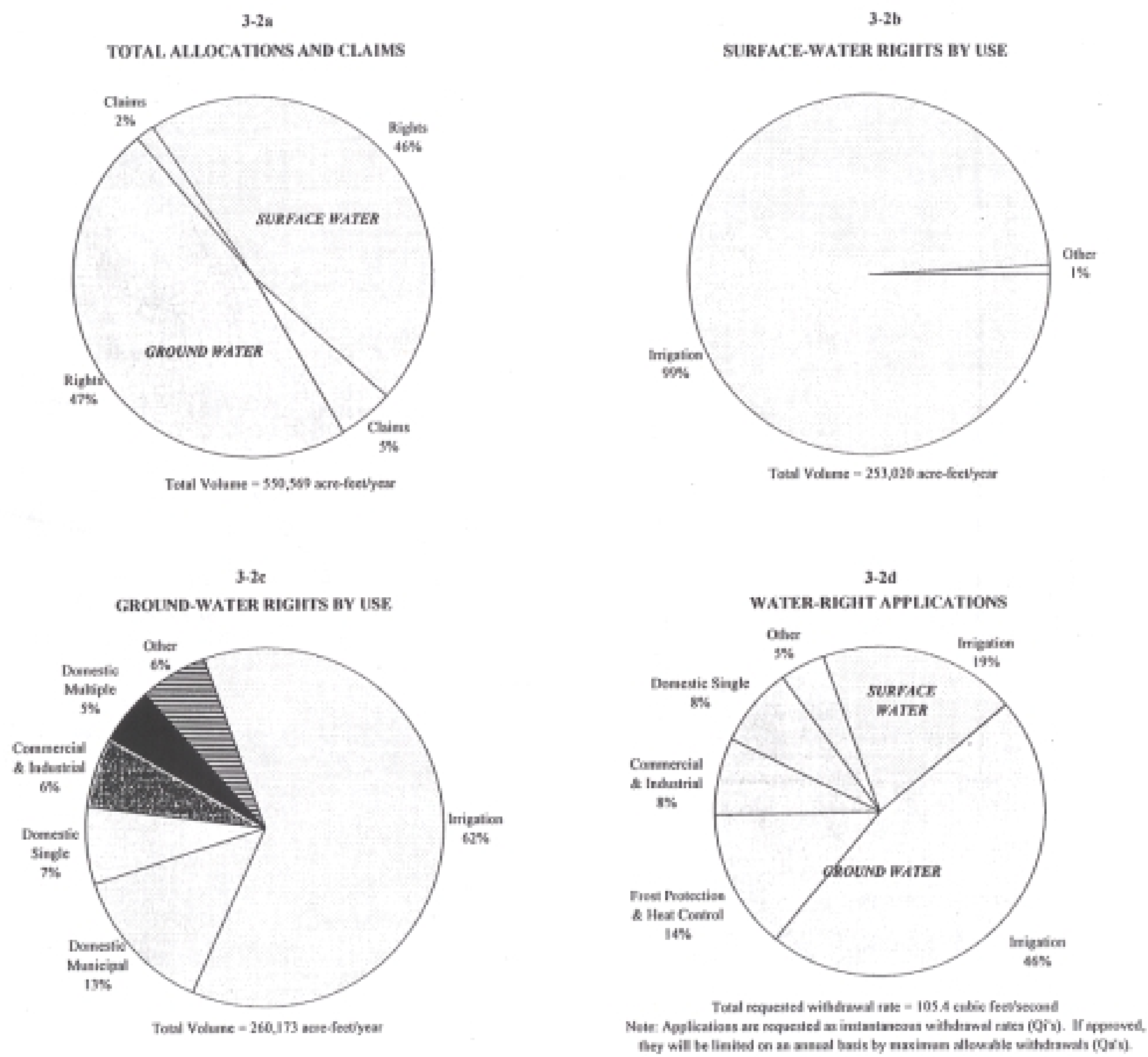
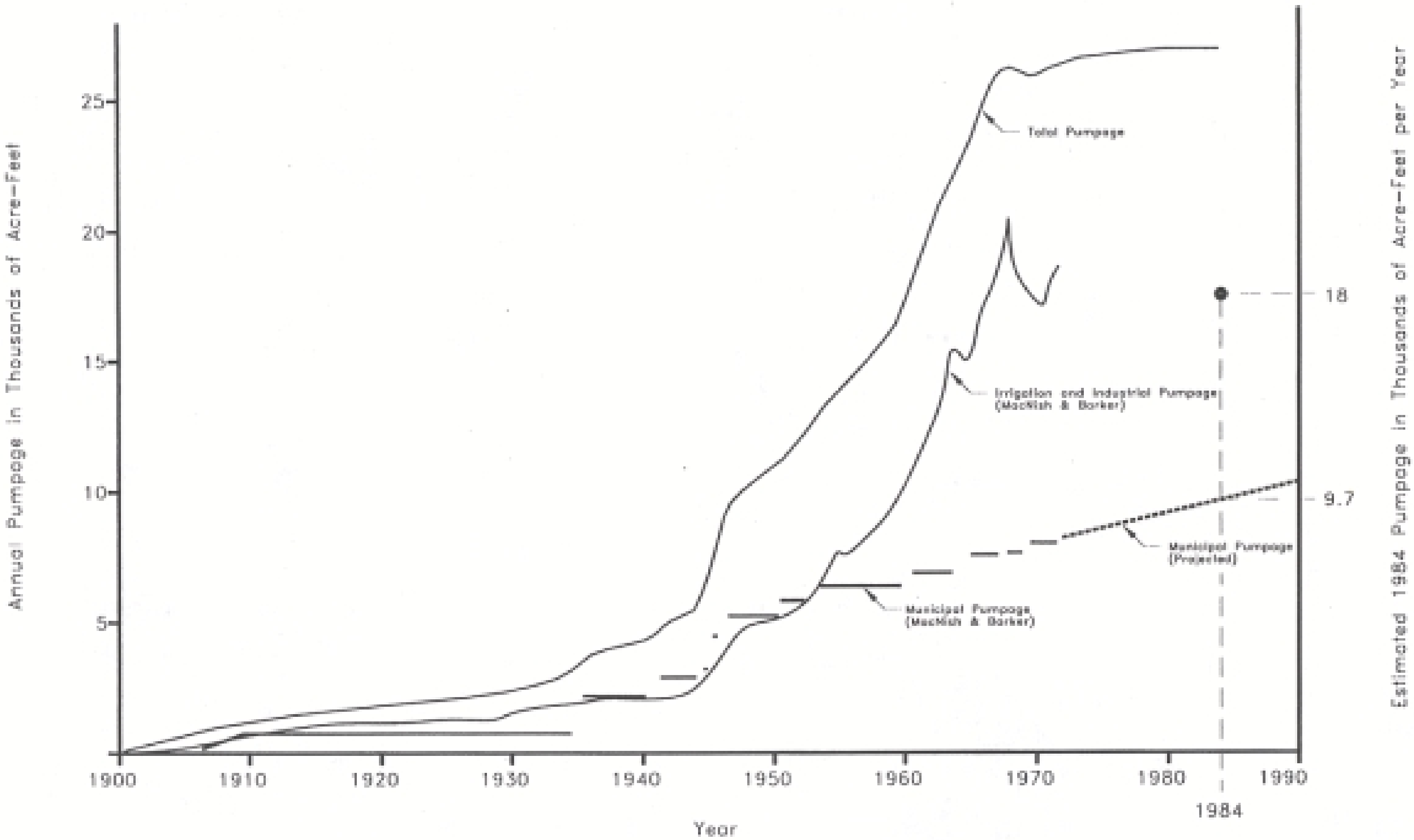


FIGURE 3-2(a-d)

Total Allocations and Claims, Surface-Water Rights, Ground-Water Rights, and Water-Right Applications

Initial Waterhed Assessment Program
Walla Walla WRIA



DATA SOURCES

Trend Plots
MacNish and Barker, 1976

EXPLANATION

● Estimated irrigation and industrial pumpage for 1984 based on total RASA pumpage estimate for basalt aquifer minus projected municipal pumpage of 9,700 acre-ft/yr

FIGURE 3-11

Basalt Aquifer Pumping vs. Time

Initial Watershed Assessment Program
Walla Walla Basin

Pacific Groundwater Group

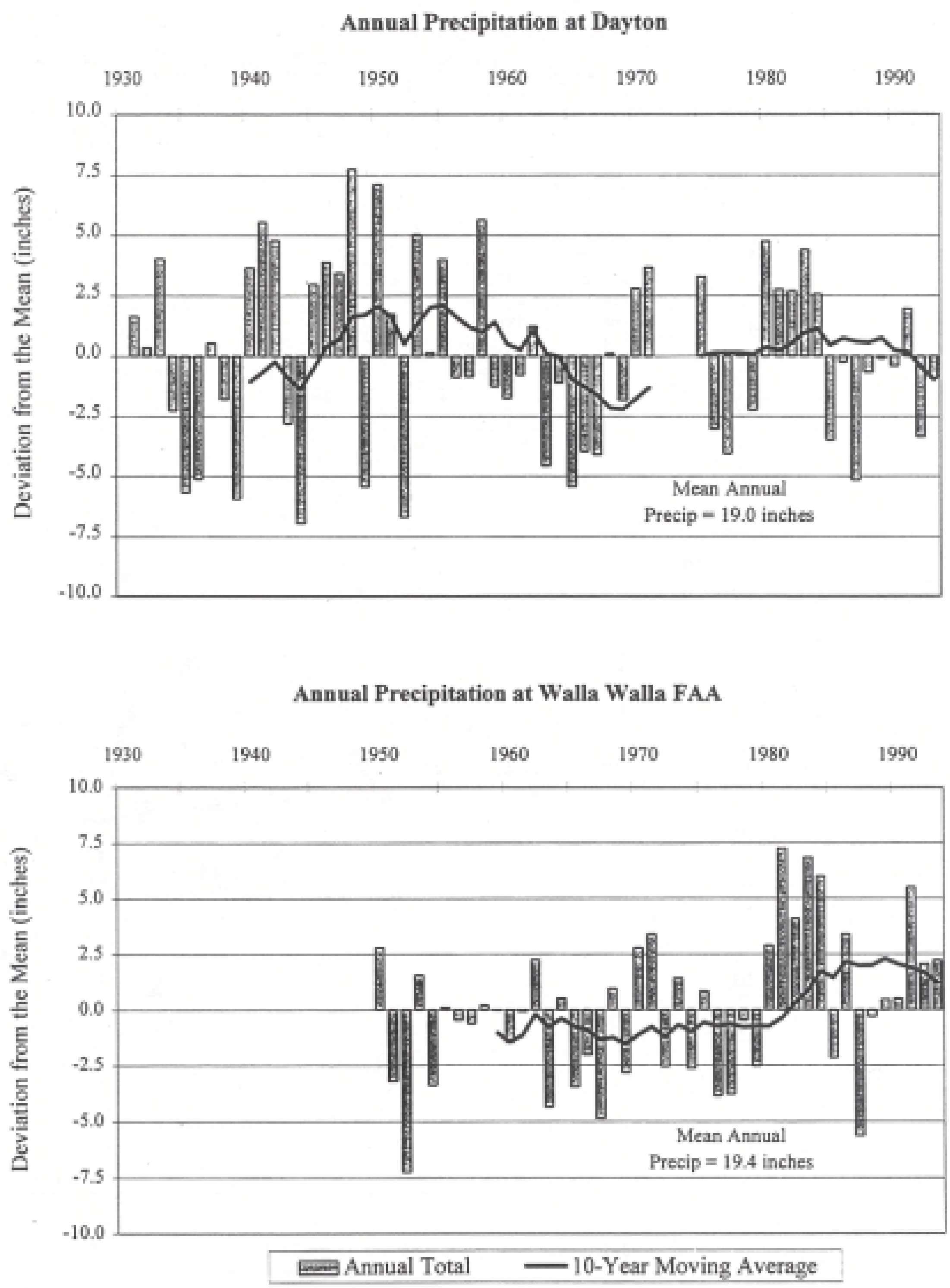


FIGURE 4-3

Annual Precipitation in the Walla Walla WRIA

Initial Watershed Assessment Program
Walla Walla Basin

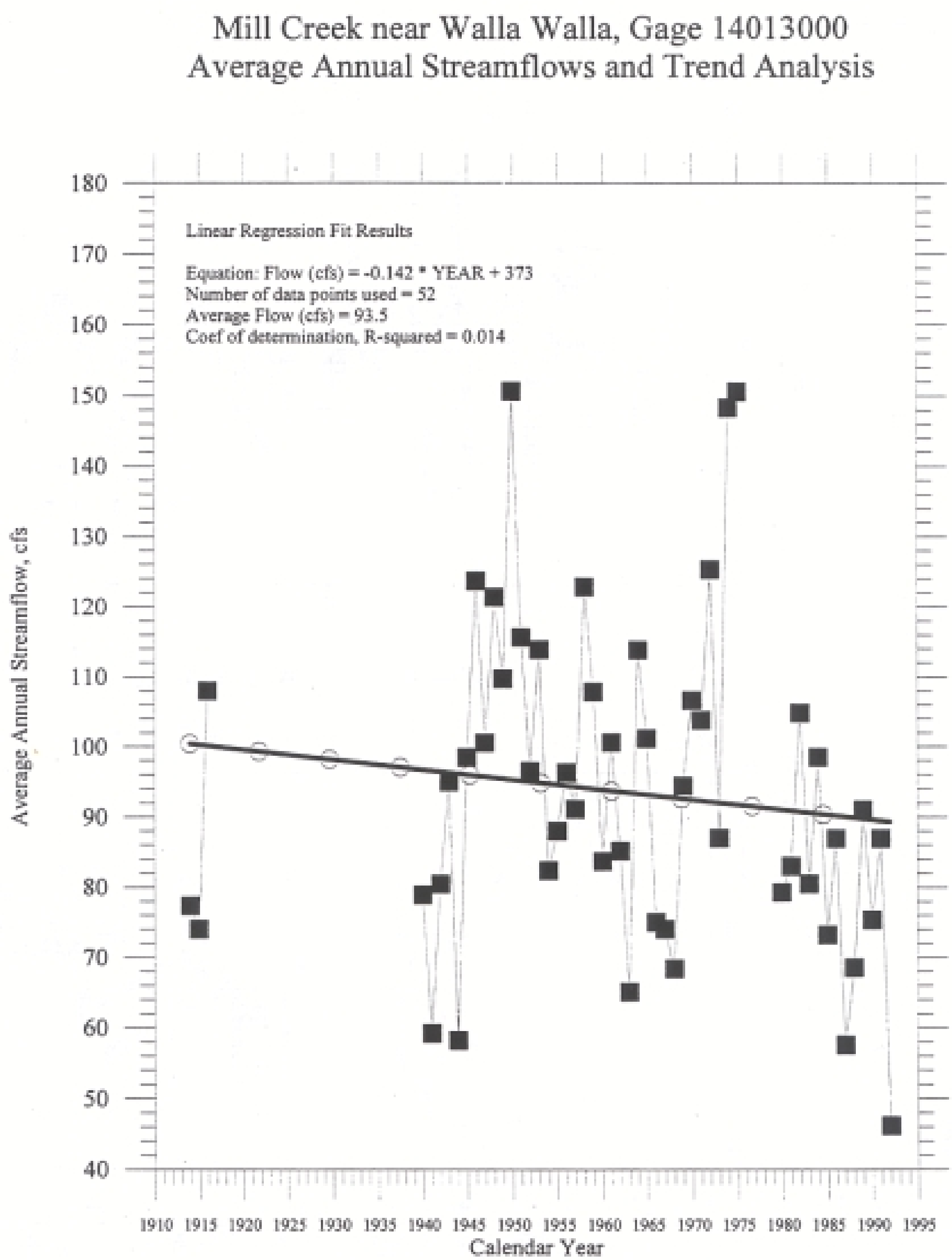


FIGURE 5-1
Average Flows and Trend Analysis
Mill Creek near Walla Walla
Basin Area 60 sq. mi.

Initial Watershed Assessment Program
Walla Walla Basin

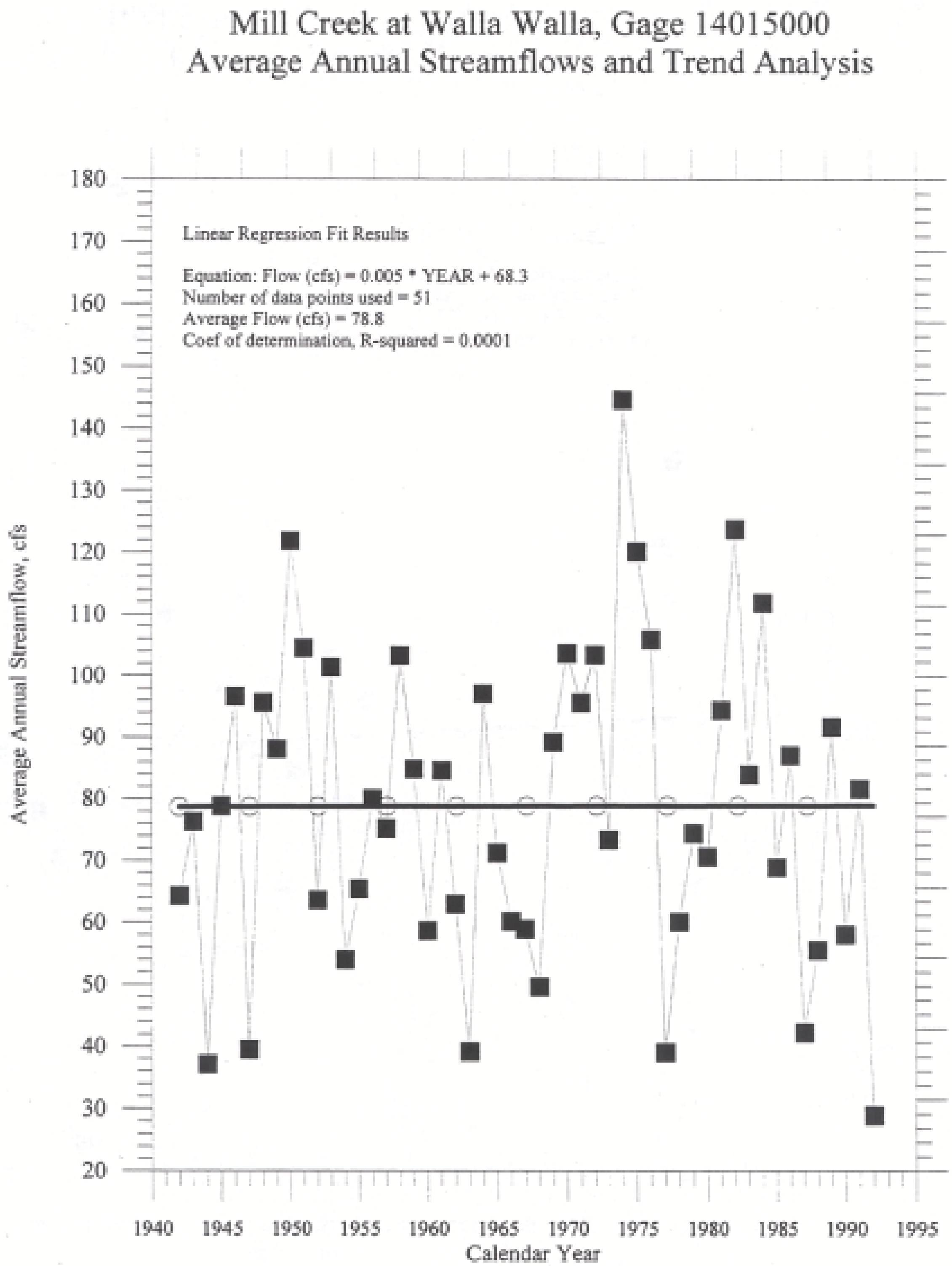


FIGURE 5-2
Average Flows and Trend Analysis
Mill Creek at Walla Walla
Basin Area 96 sq. mi.

Initial Watershed Assessment Program
Walla Walla Basin

Touchet River at Bolles, Gage 14017000
Average Annual Streamflows and Trend Analysis

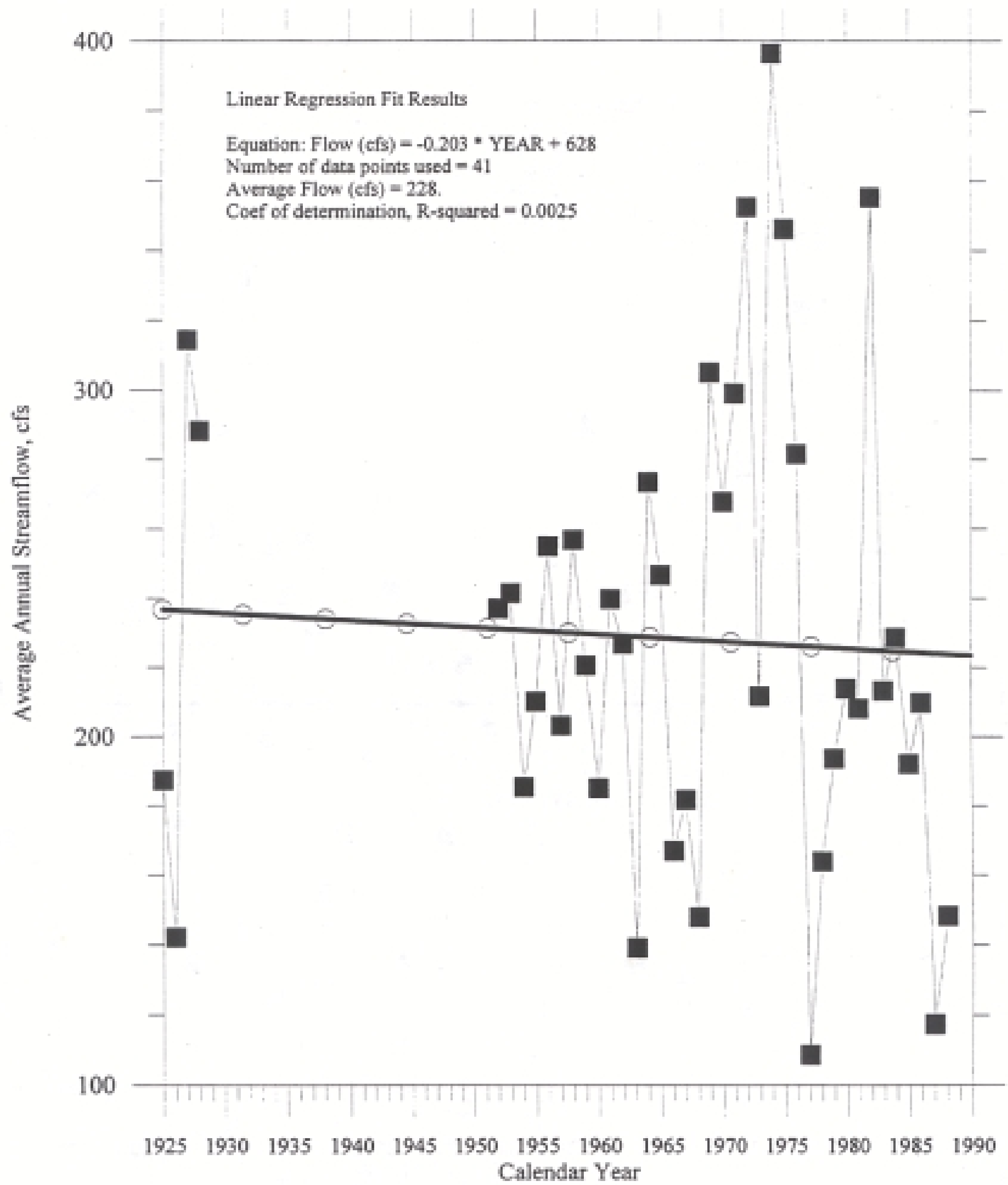


FIGURE 5-3
Average Flows and Trend Analysis
Touchet River at Bolles
Basin Area 381 sq. mi.

Initial Watershed Assessment Program
Walla Walla Basin

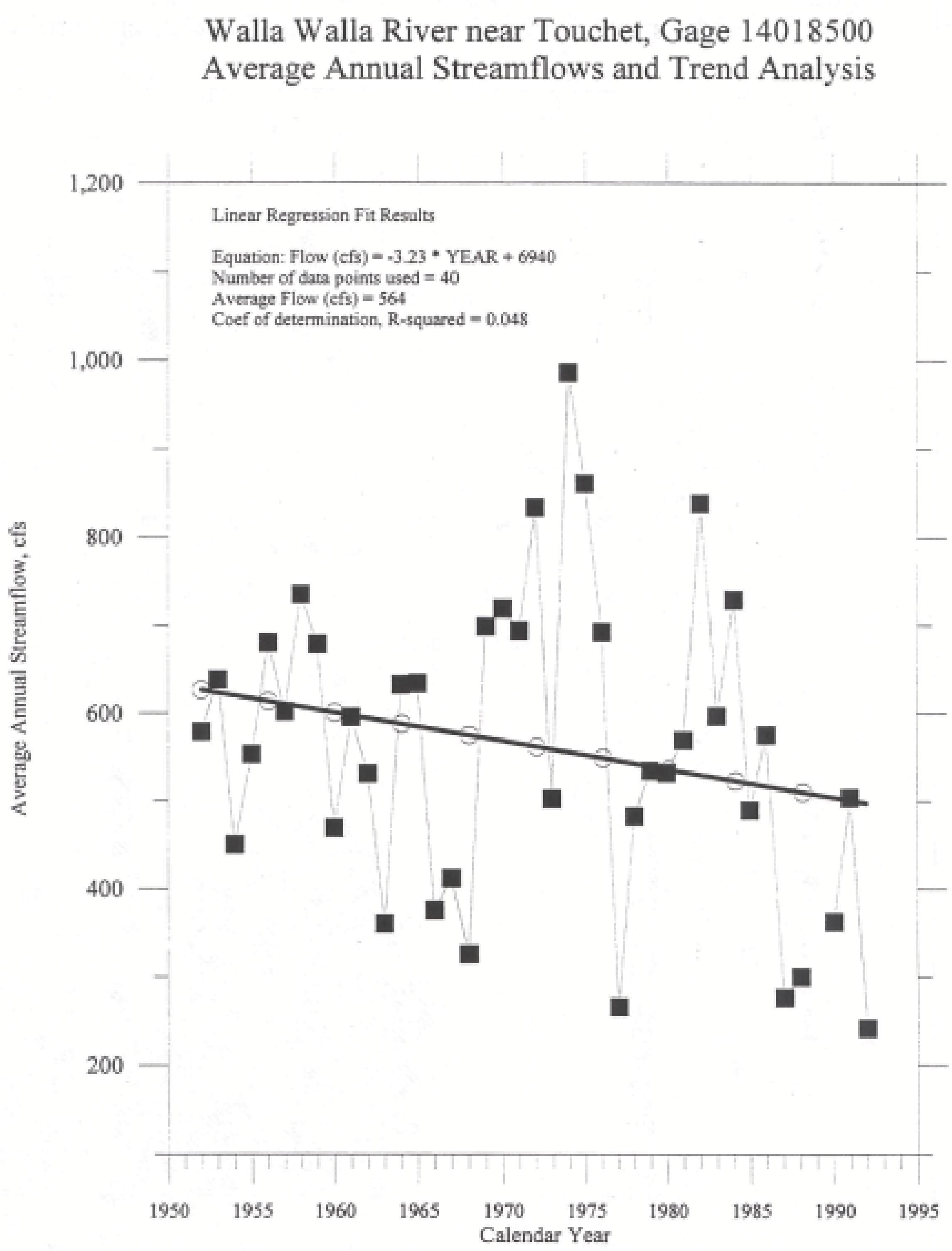


FIGURE 5-4
Average Flows and Trend Analysis
Walla Walla River near Touchet
Basin Area 1,657 sq. mi.

Initial Watershed Assessment Program
Walla Walla Basin

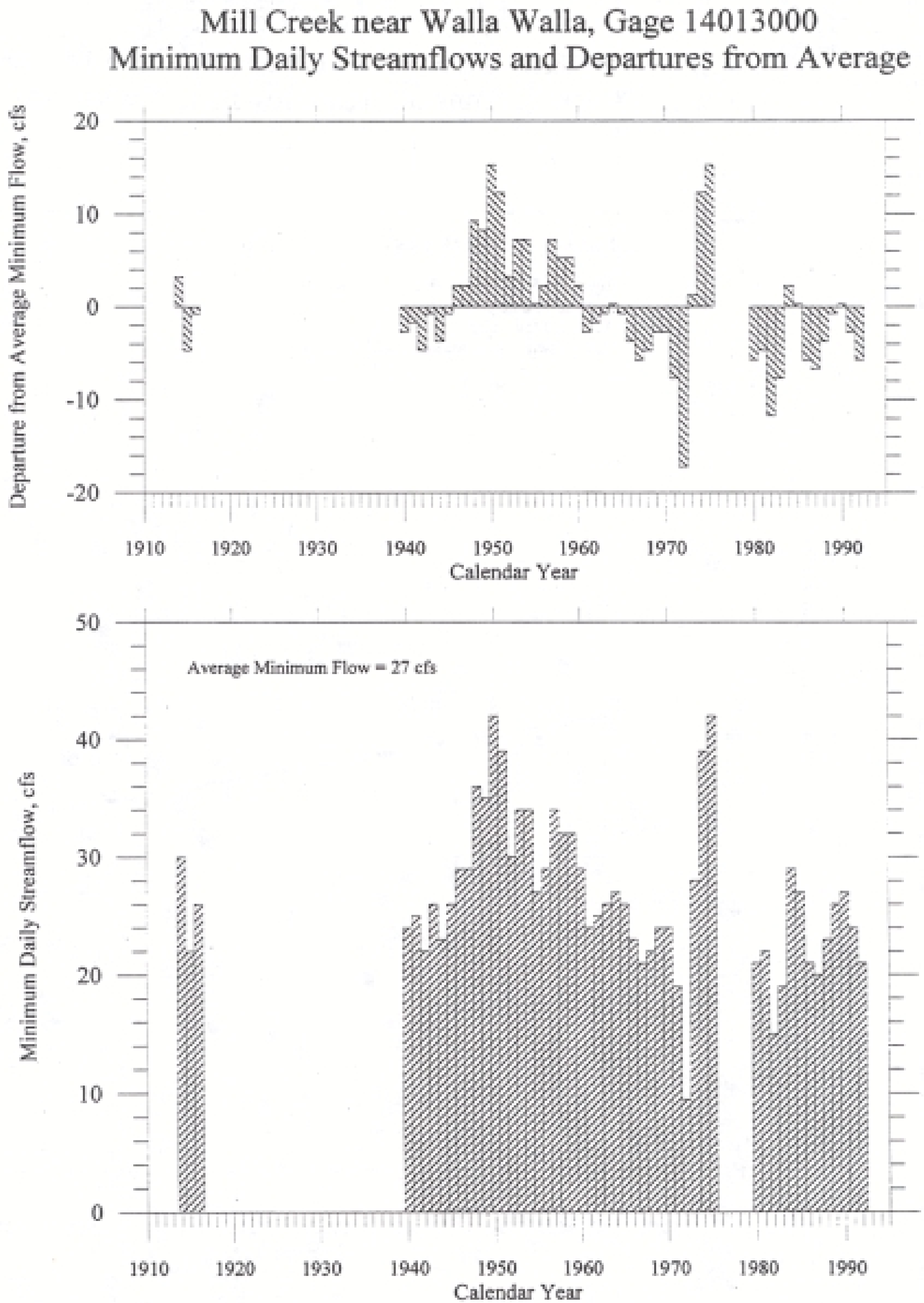


FIGURE 5-5
Minimum Flows and Trend Analysis
Mill Creek near Walla Walla
Basin Area 60 sq. mi.

Initial Watershed Assessment Program
Walla Walla Basin

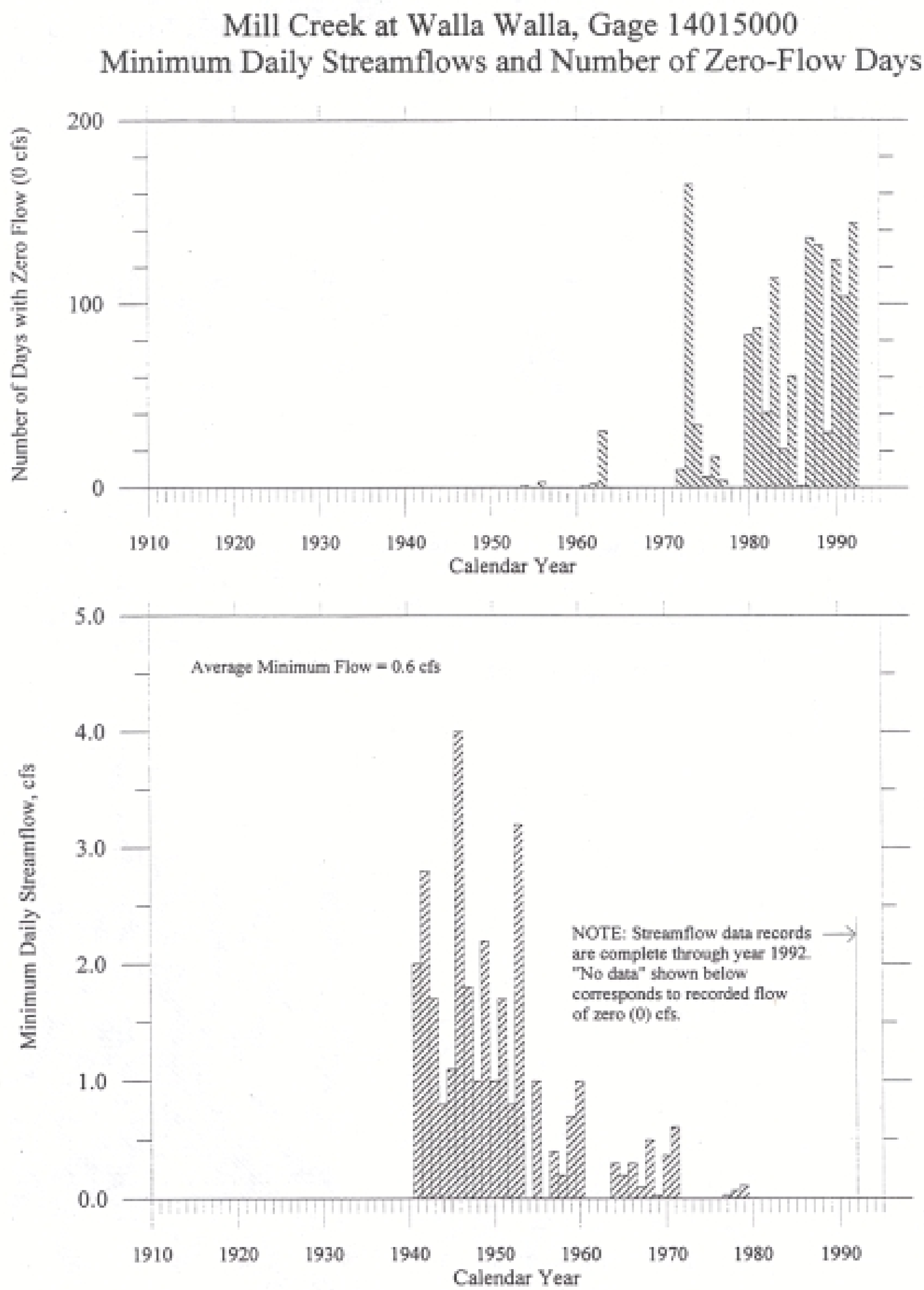


FIGURE 5-6
Minimum Flows and Trend Analysis
Mill Creek at Walla Walla
Basin Area 96 sq. mi.

Initial Watershed Assessment Program
Walla Walla Basin

Touchet River at Bolles, Gage 14017000
Minimum Daily Streamflows and Departures from Average

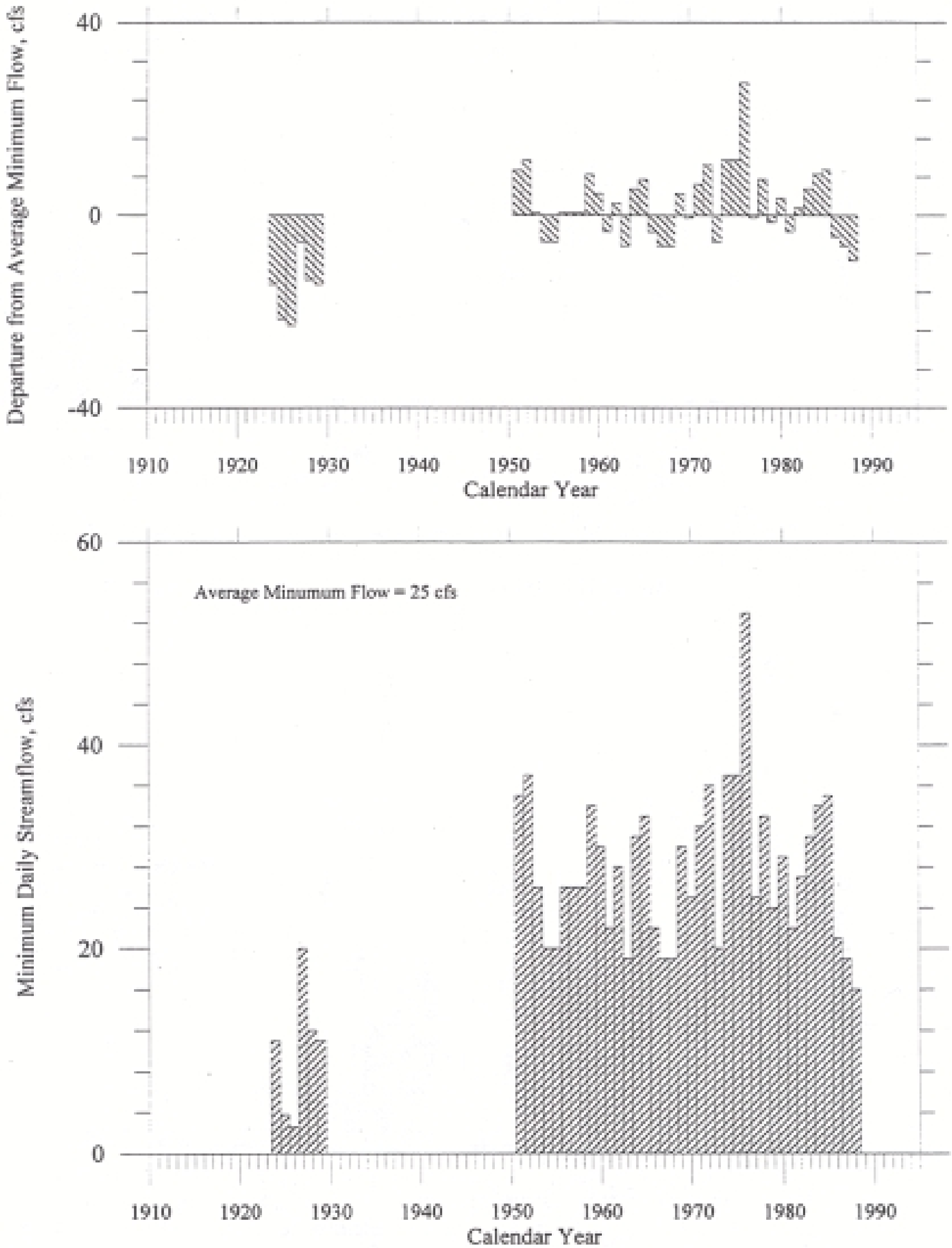


FIGURE 5-7
Minimum Flows and Trend Analysis
Touchet River at Bolles
Basin Area 361 sq. mi.

Initial Watershed Assessment Program
Walla Walla Basin

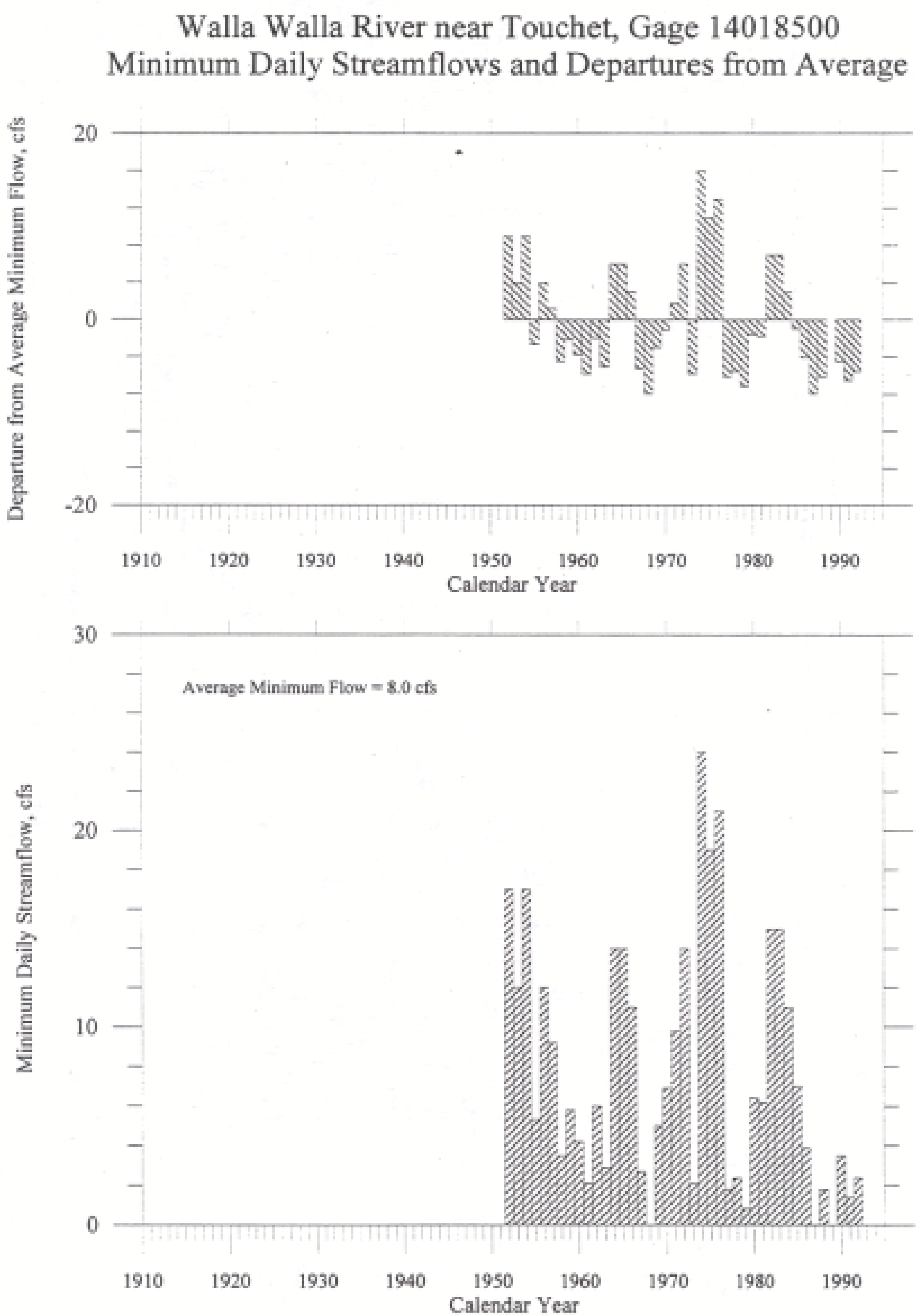


FIGURE 5-8
Minimum Flows and Trend Analysis
Walla Walla River near Touchet
Basin Area 1,657 sq. mi.

Initial Watershed Assessment Program
Walla Walla Basin

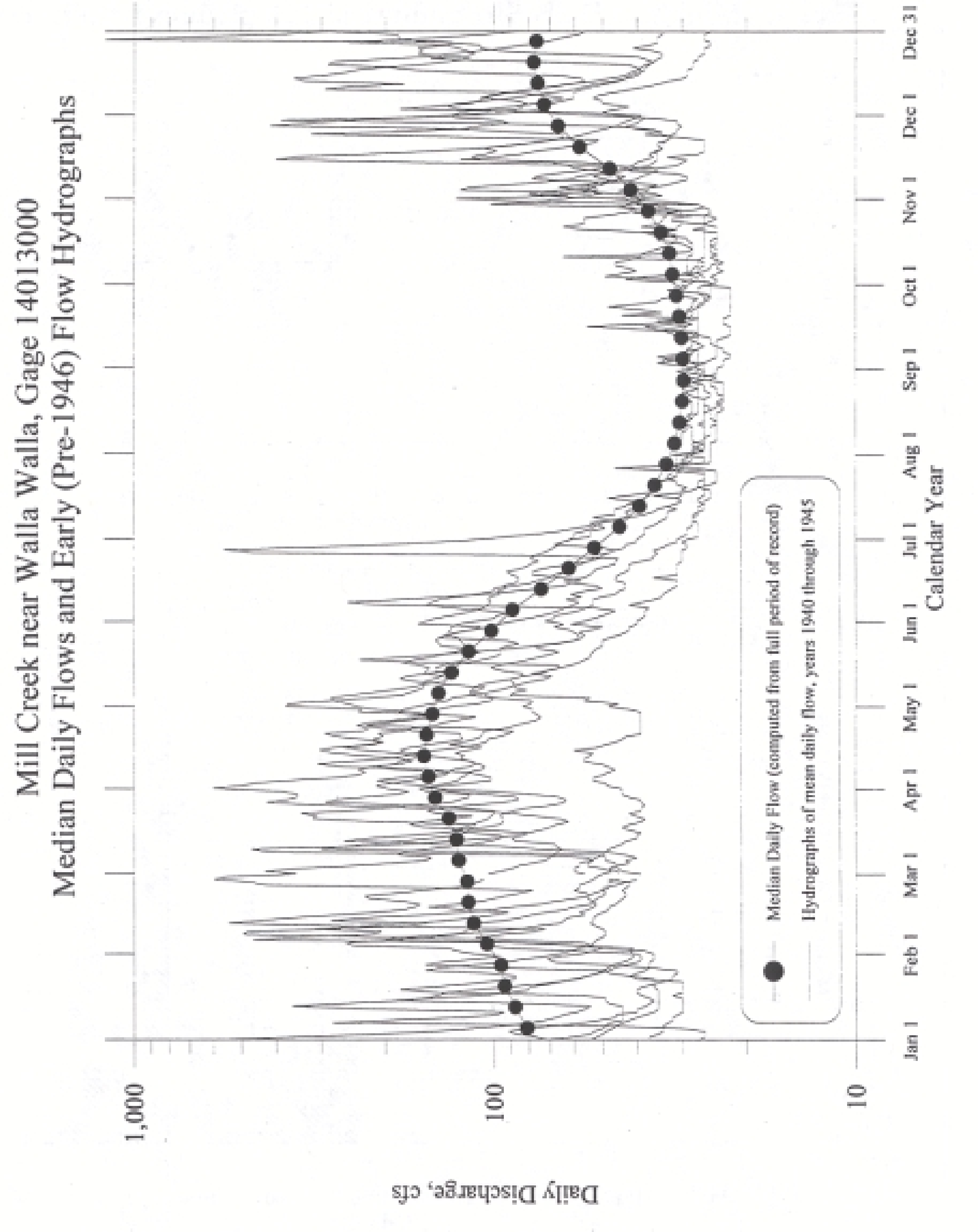


FIGURE 5-9

Median Flows and Actual Flows
Mill Creek near Walla Walla
Early Flow Hydrographs

Initial Watershed Assessment Program
Walla Walla Basin

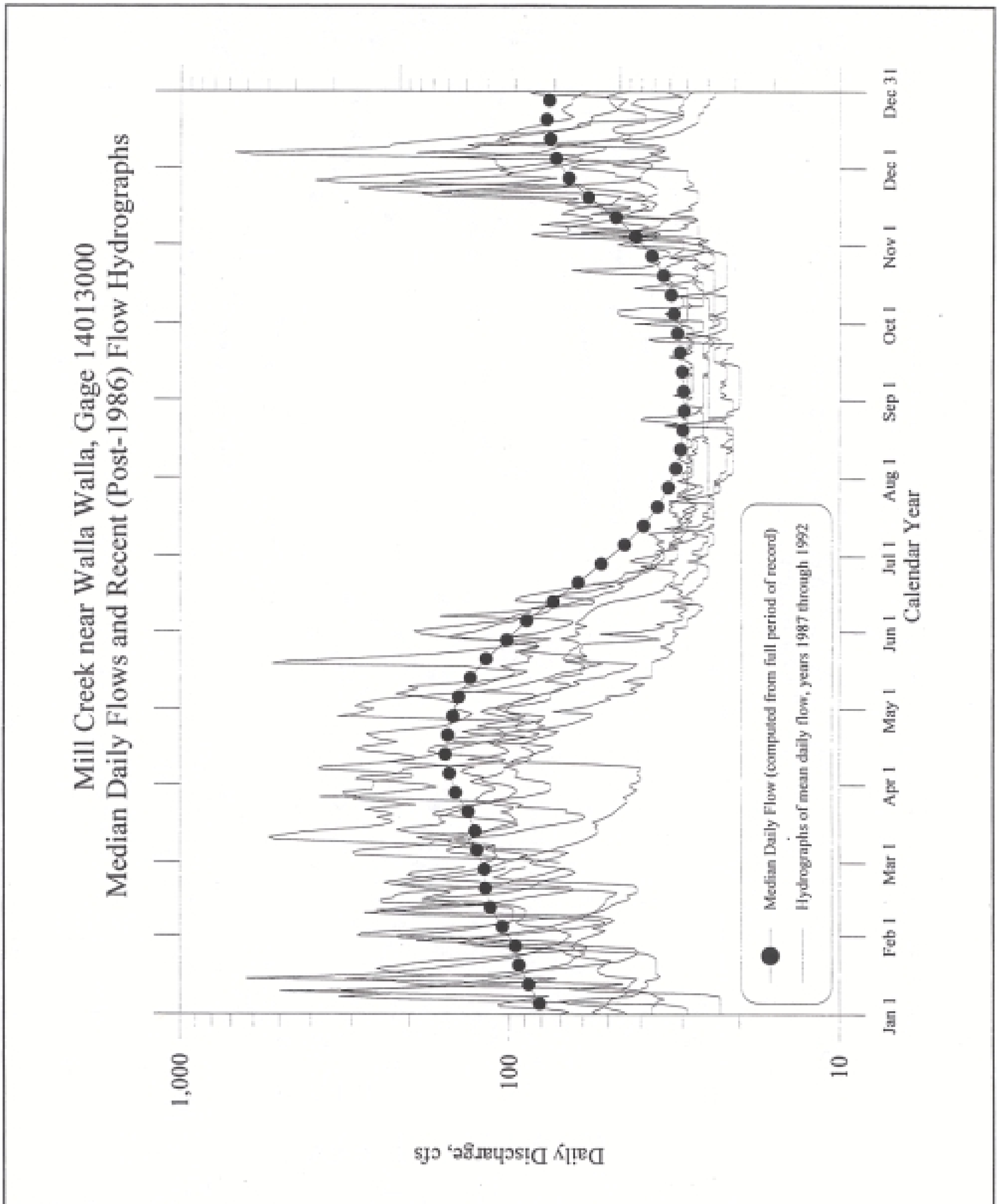


FIGURE 5-10
Median Flows and Actual Flows
Mill Creek near Walla Walla
Recent Flow Hydrographs

Initial Watershed Assessment Program
Walla Walla Basin

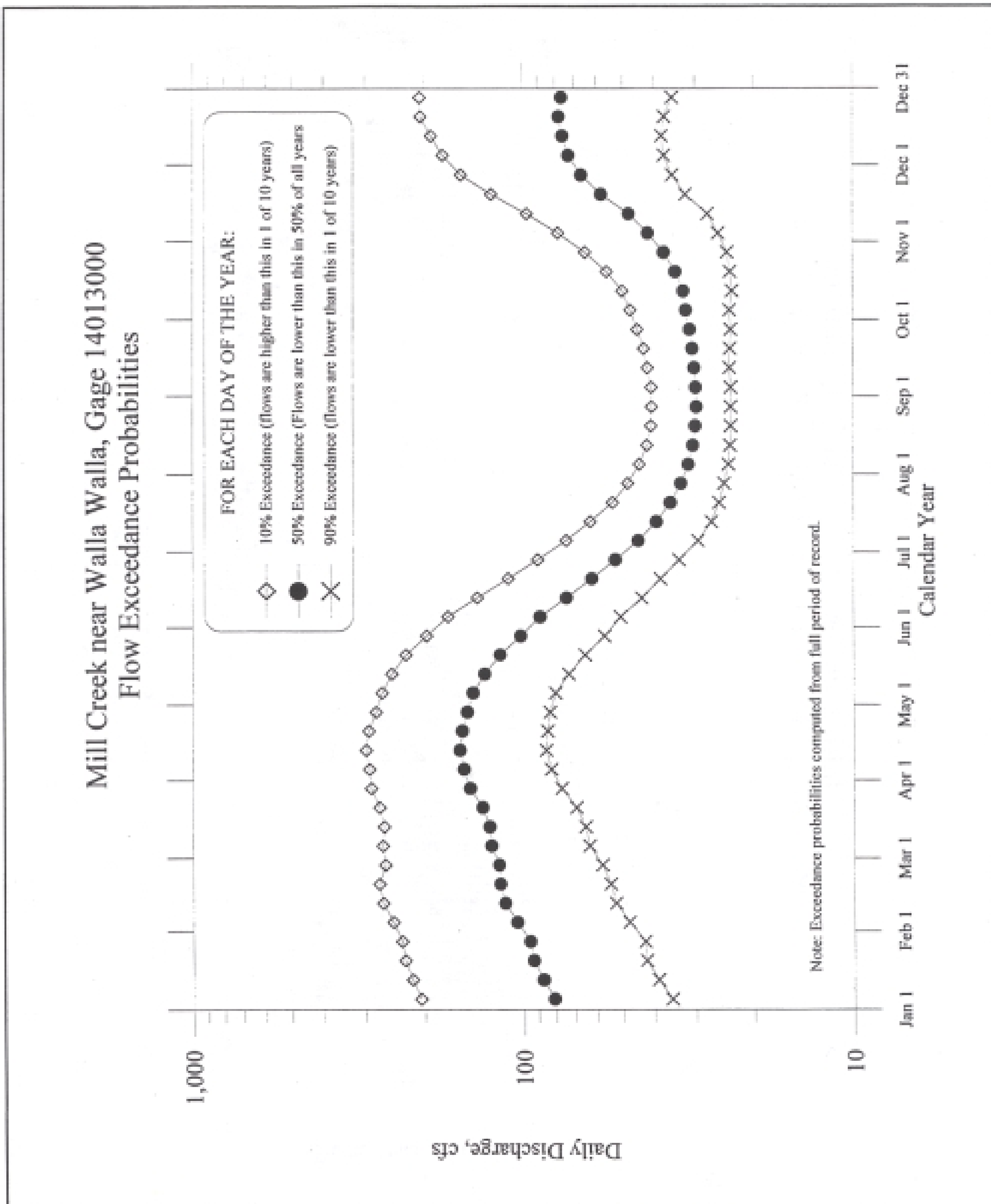


FIGURE 5-11
Flow Exceedance Probabilities
Mill Creek near Walla Walla
Full Period of Record

Initial Watershed Assessment Program
Walla Walla Basin

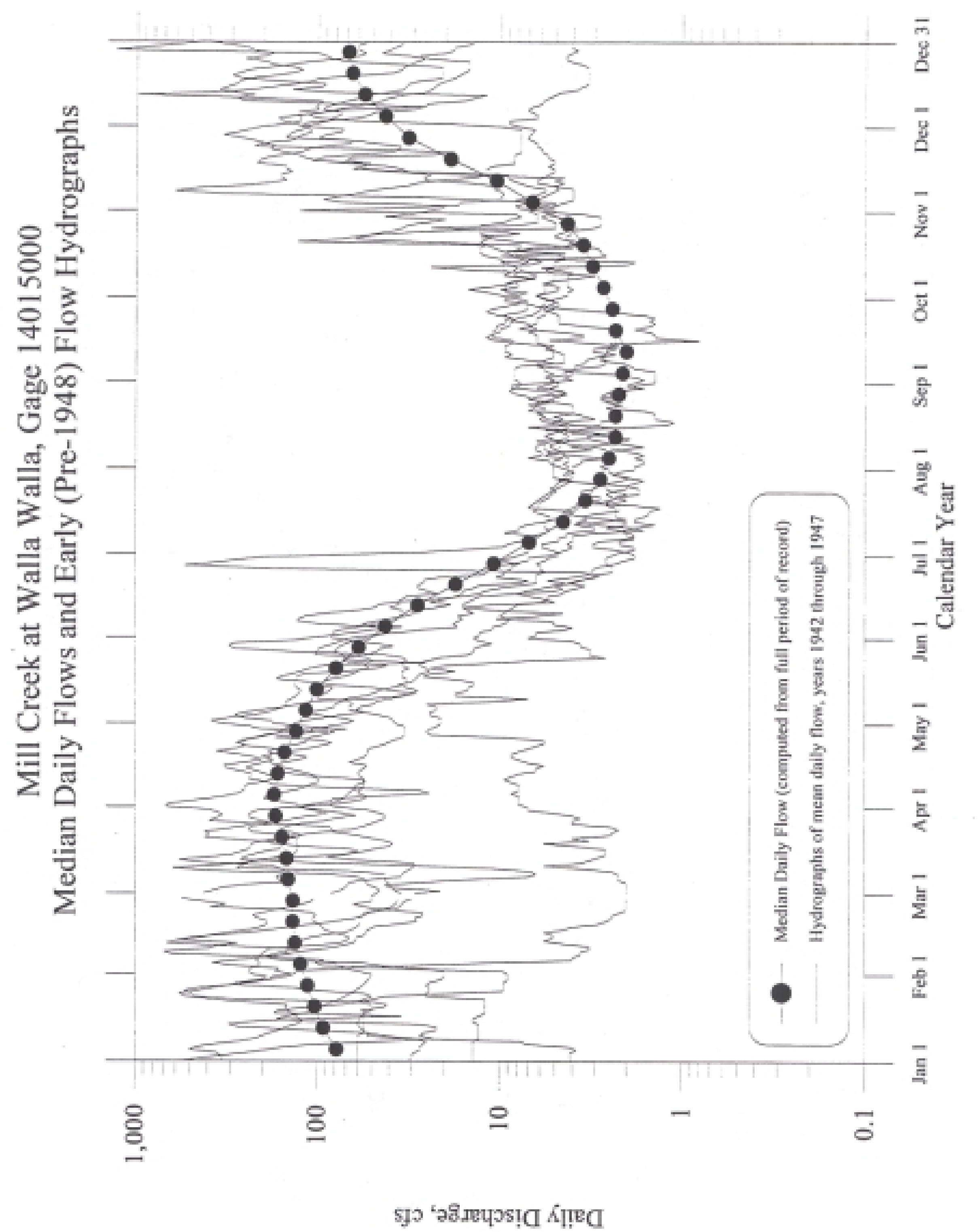


FIGURE 5-12

Median Flows and Actual Flows
Mill Creek at Walla Walla
Early Flow Hydrographs

Initial Watershed Assessment Program
Walla Walla Basin

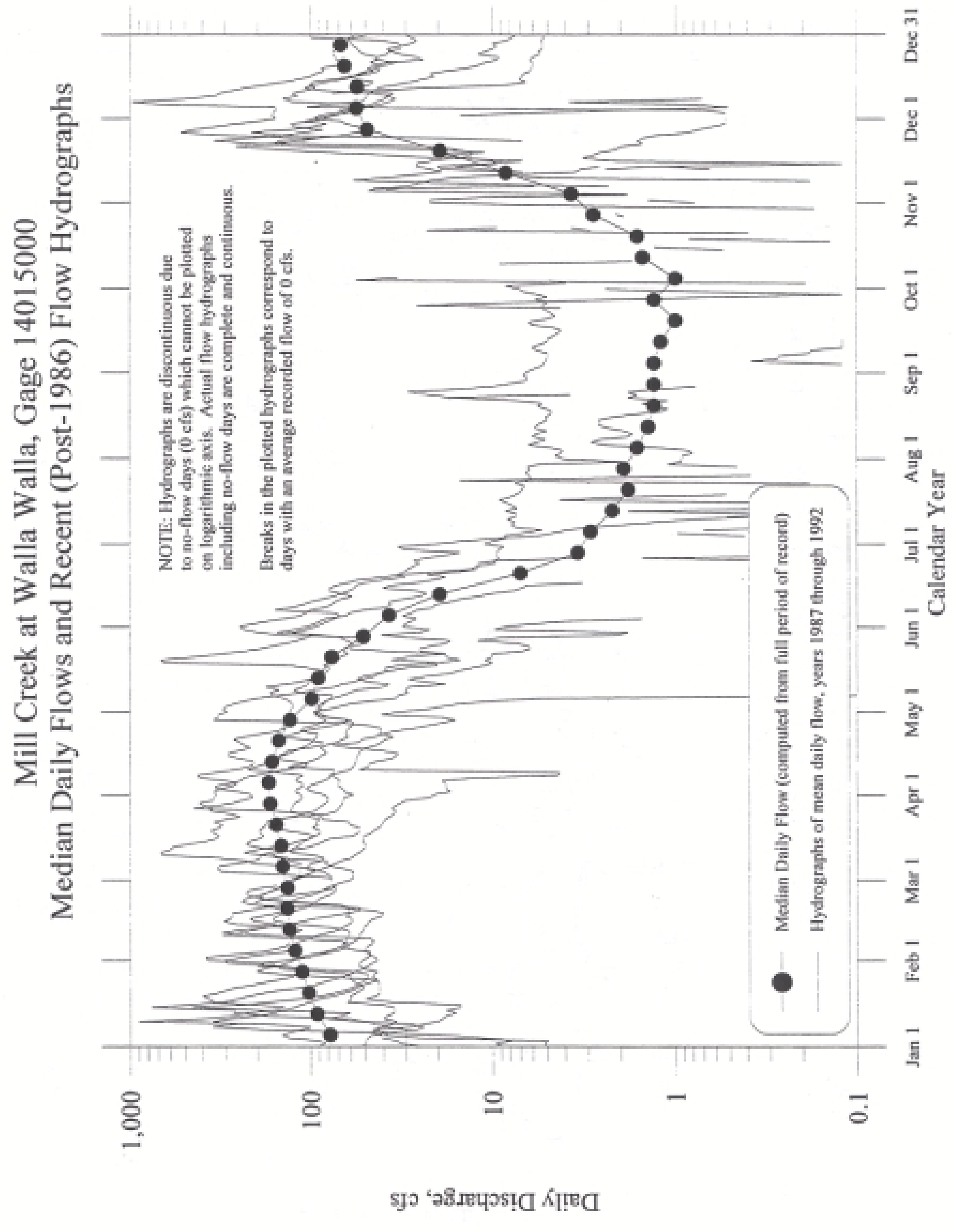


FIGURE 5-13

Median Flows and Actual Flows
Mill Creek at Walla Walla
Recent Flow Hydrographs

Initial Watershed Assessment Program
Walla Walla Basin

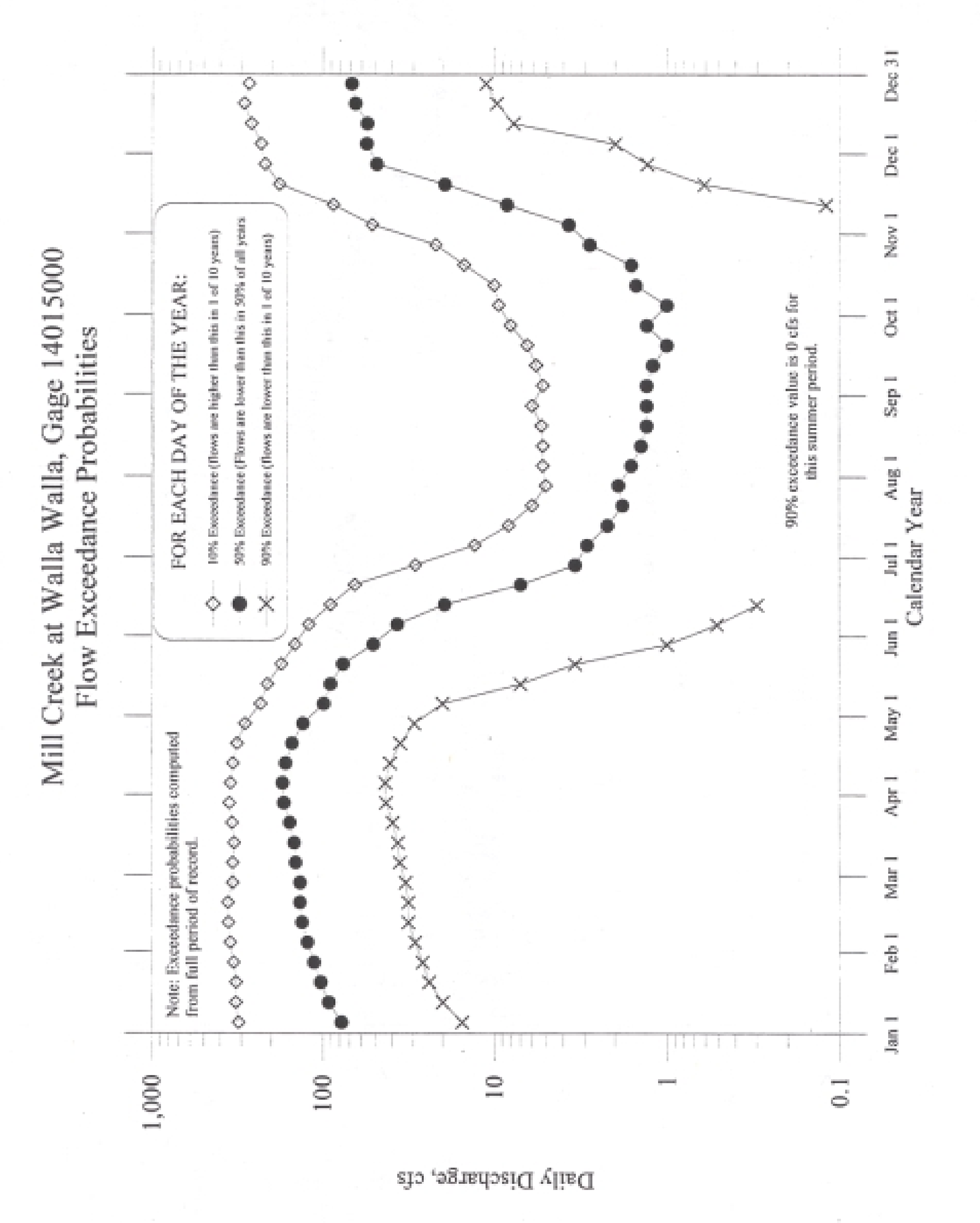


FIGURE 5-14
Flow Exceedance Probabilities
Mill Creek at Walla Walla
Full Period of Record

Initial Watershed Assessment Program
Walla Walla Basin

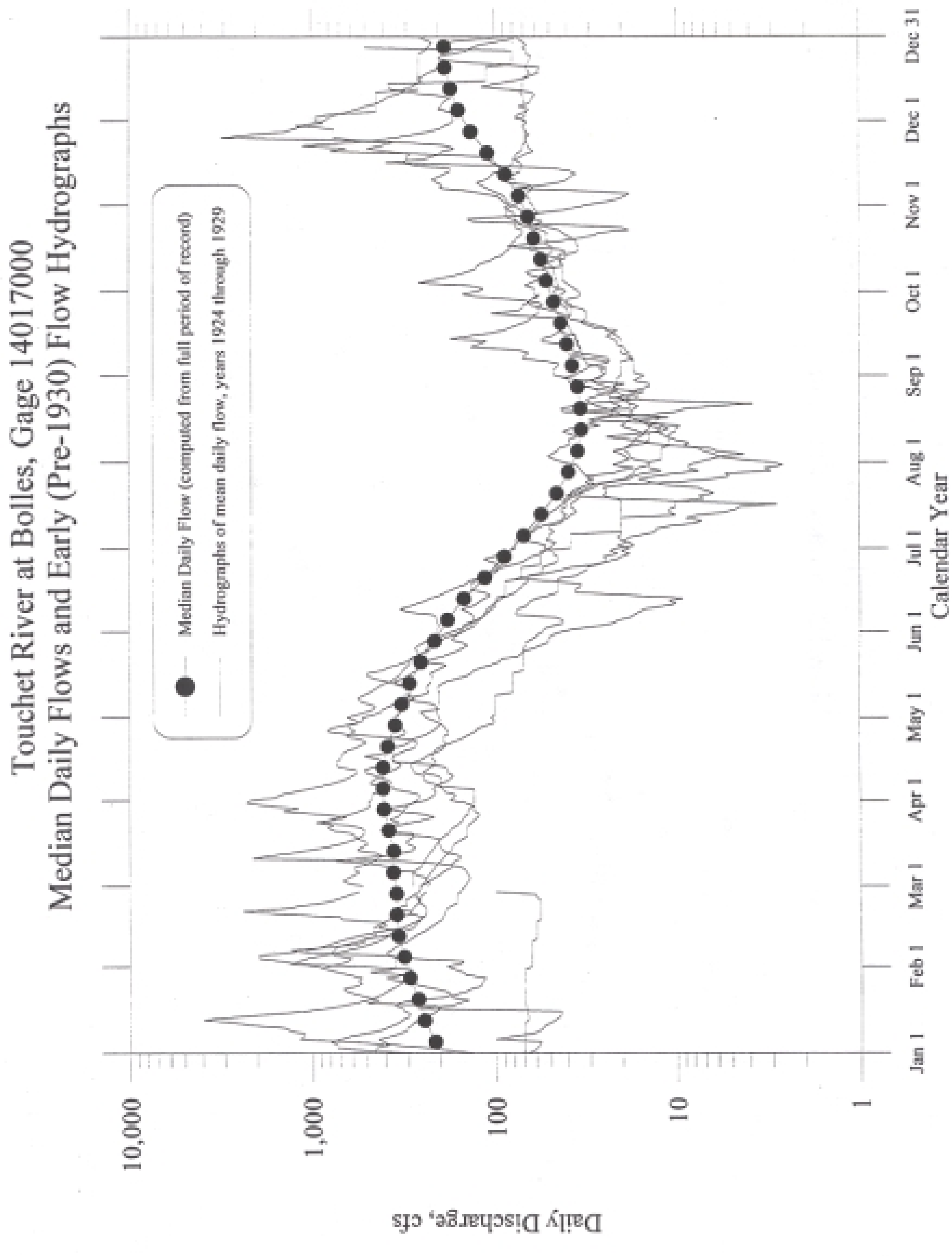


FIGURE 5-15

Median Flows and Actual Flows
Touchet River at Bolles
Early Flow Hydrographs

Initial Watershed Assessment Program
Walla Walla Basin

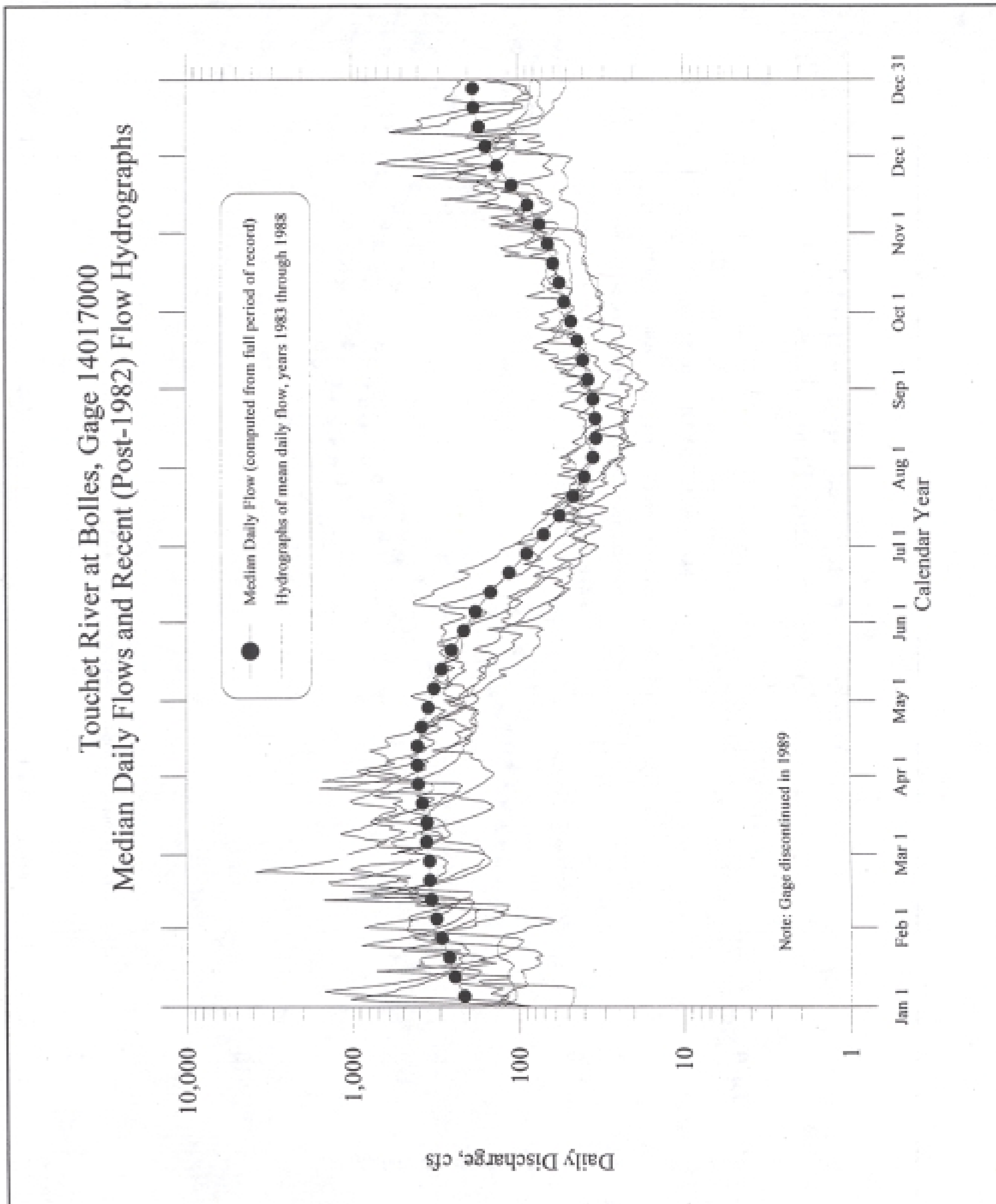


FIGURE 5-16

Median Flows and Actual Flows
Touchet River at Bolles
Recent Flow Hydrographs

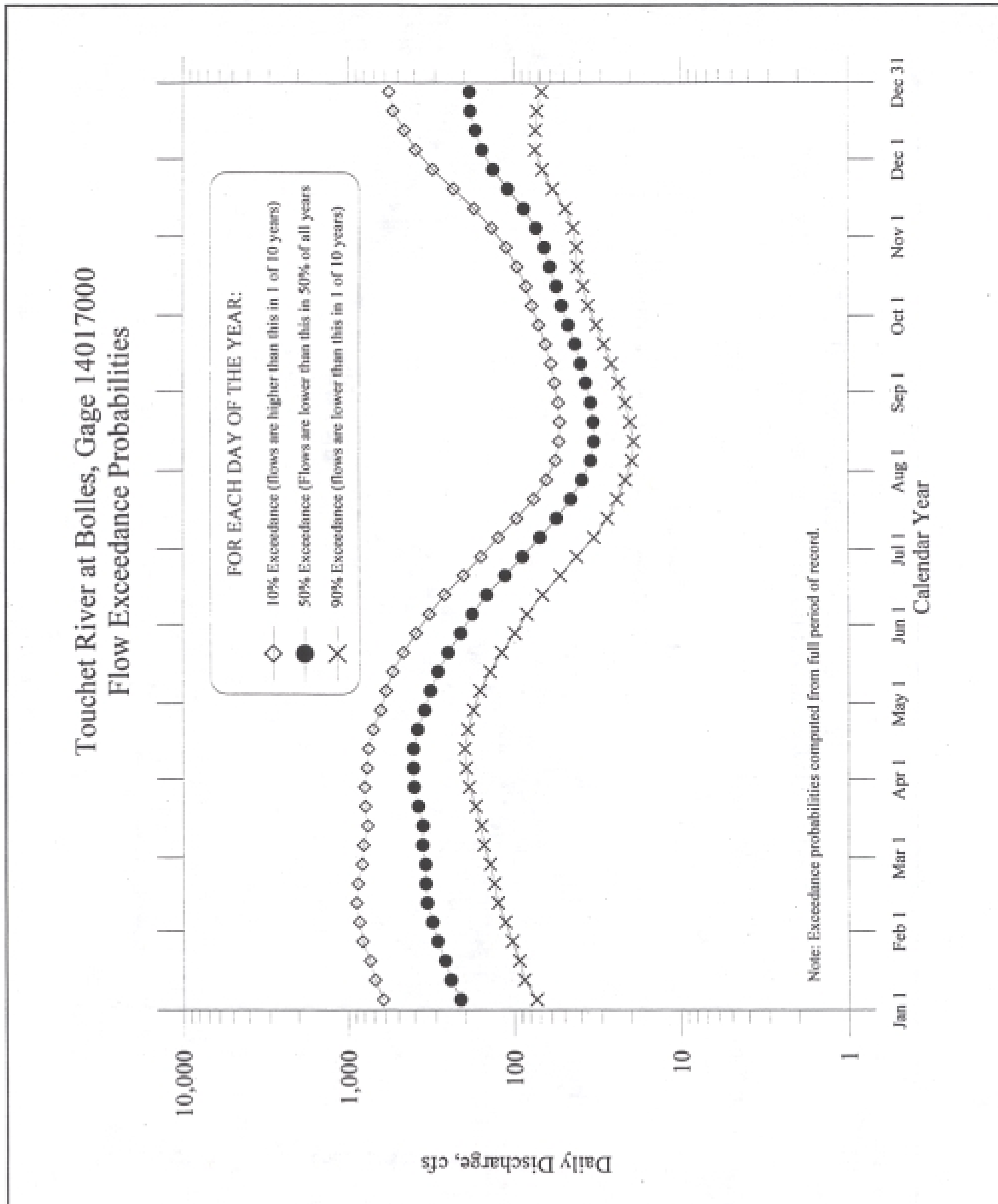


FIGURE 5-17
Flow Exceedance Probabilities
Touchet River at Bolles
Full Period of Record

Initial Watershed Assessment Program
Walla Walla Basin

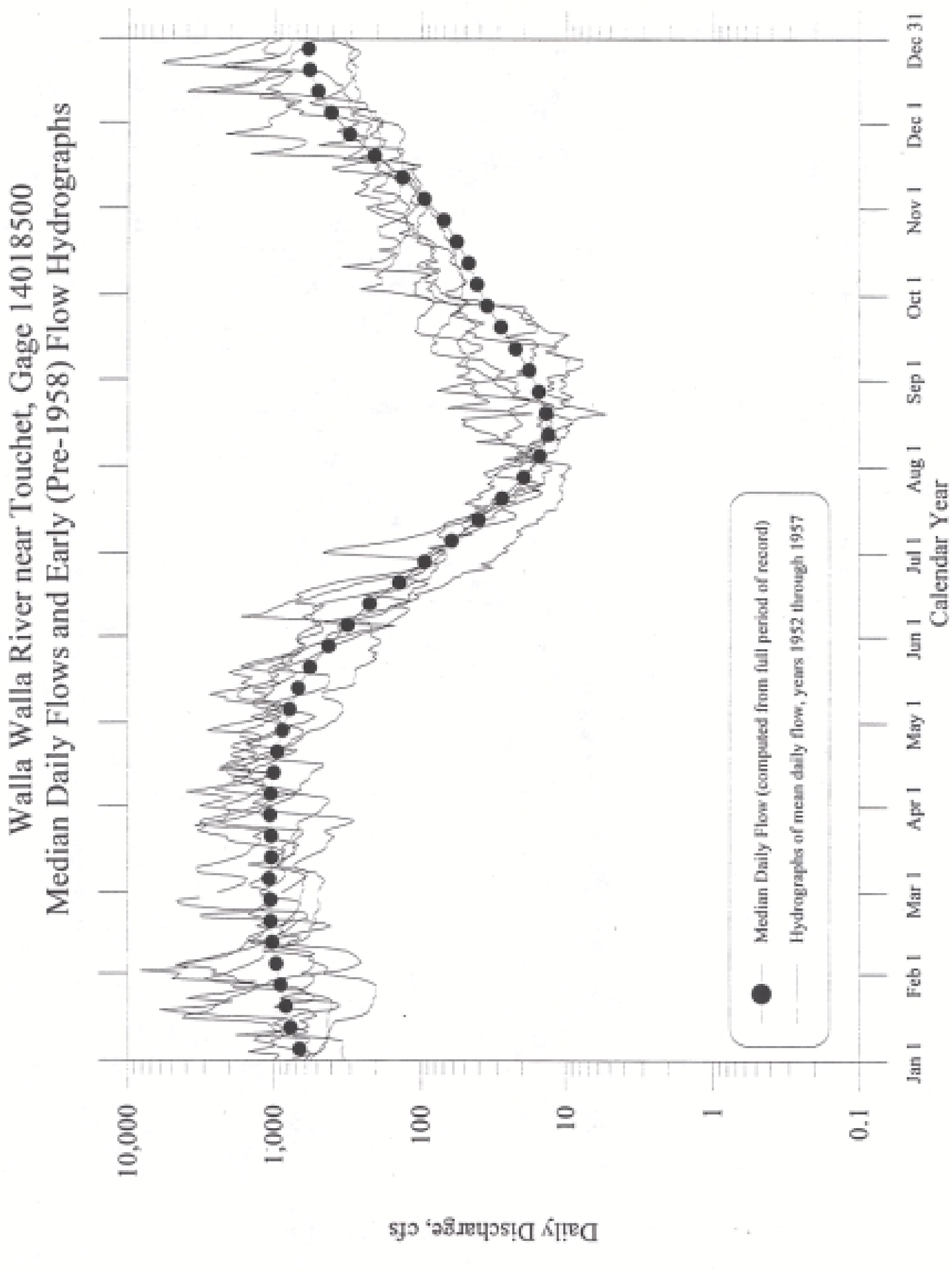


FIGURE 5-18
Median Flows and Actual Flows
Walla Walla River near Touchet
Early Flow Hydrographs

Initial Watershed Assessment Program
Walla Walla Basin

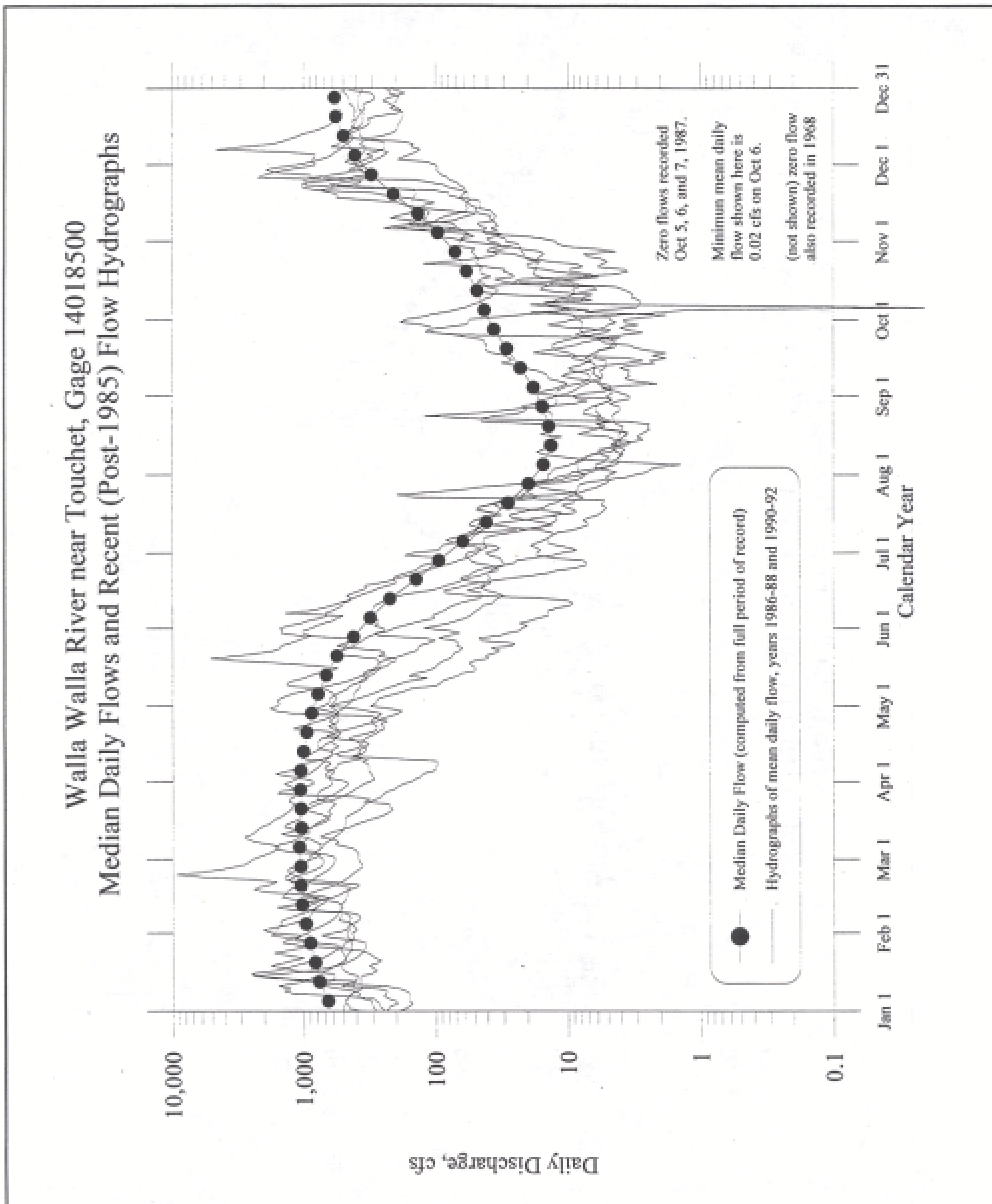


FIGURE 5-19
Median Flows and Actual Flows
Walla Walla River near Touchet
Recent Flow Hydrographs

Initial Watershed Assessment Program
Walla Walla Basin

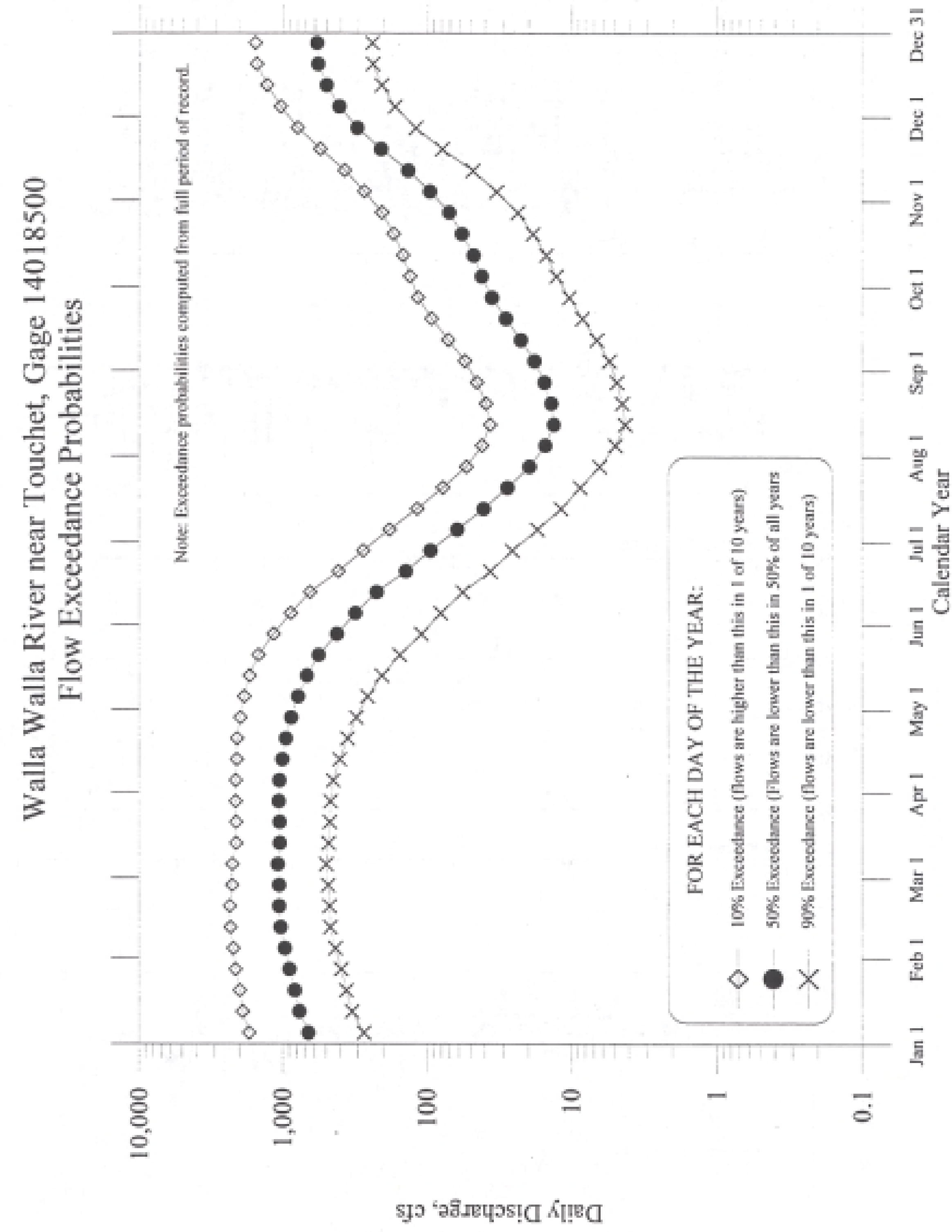
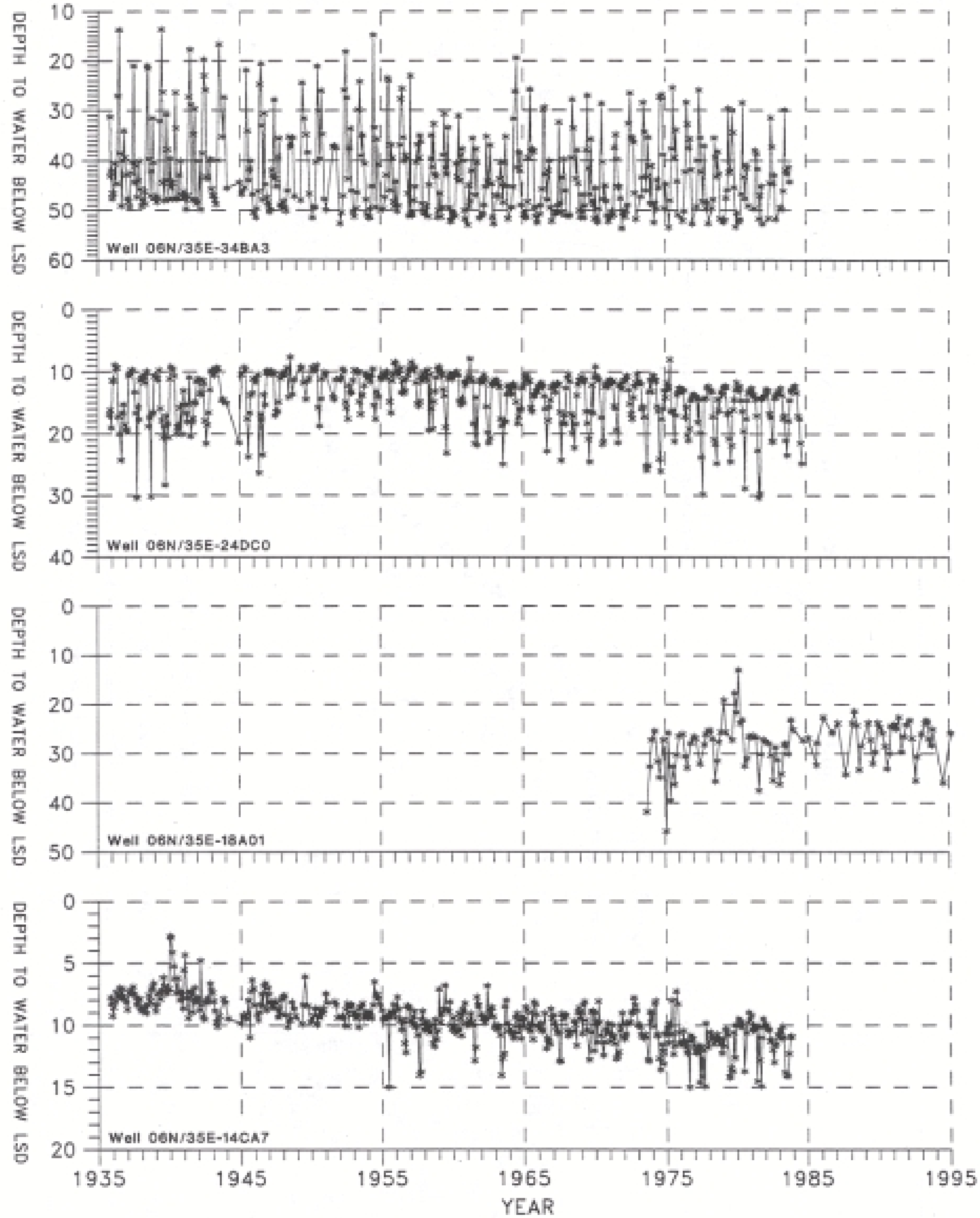


FIGURE 5-20

Flow Exceedancd Probabilities
Walla Walla River near Touchet
Full Period of Record

Initial Watershed Assessment Program
Walla Walla Basin



DATA SOURCES

Pacific Groundwater Group, 1994
USGS WATSTOR Database
Washington State Dept of Ecology
Walla Walla Co. Health Department

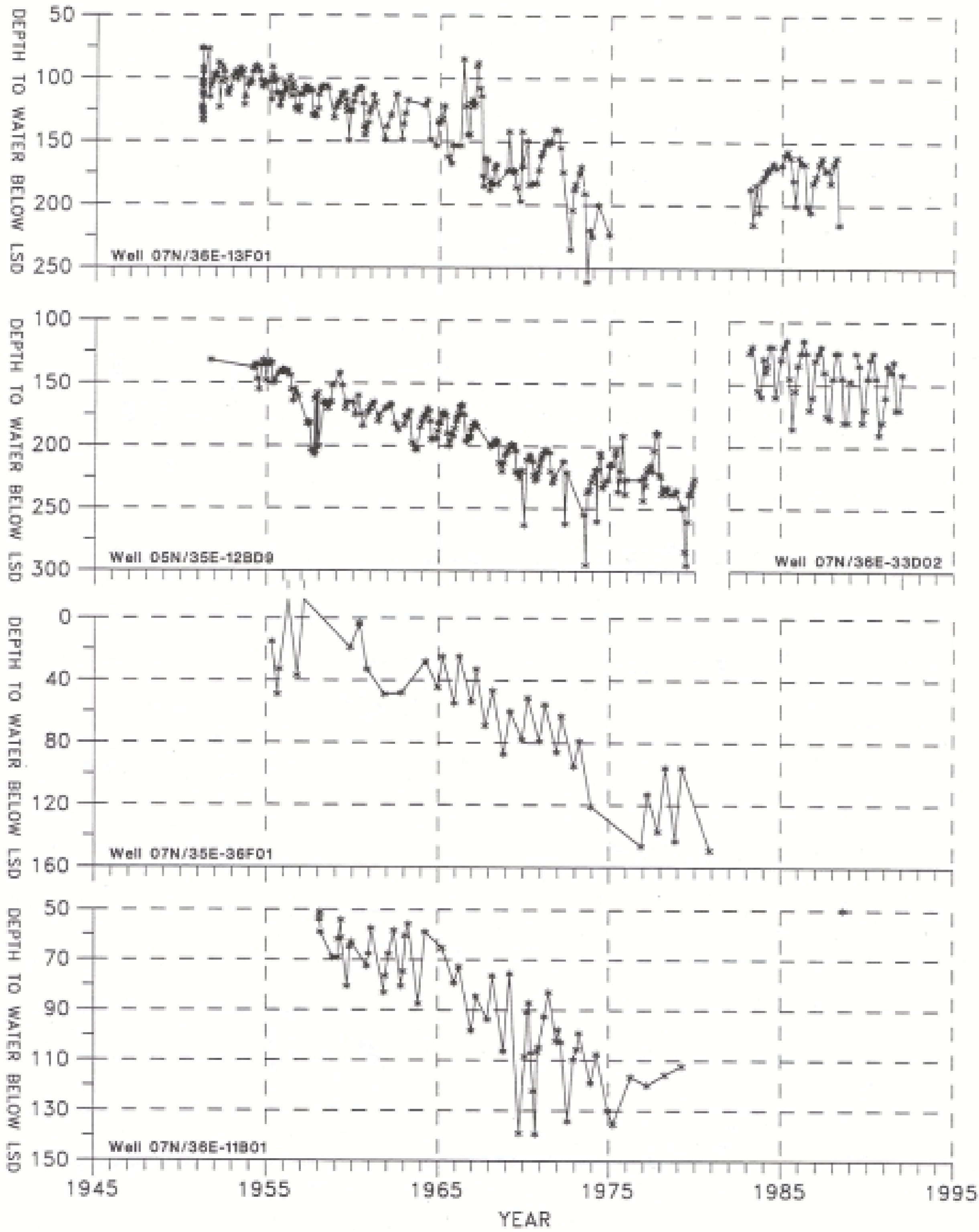
EXPLANATION

FIGURE 6-5

Water-Level Trends for the Gravel Aquifer

Initial Watershed Assessment Program
Walla Walla Basin

Pacific Groundwater Group



DATA SOURCES

Pacific Groundwater Group, 1994
USGS WATSTOR Database
Washington State Dept of Ecology
Walla Walla Co. Health Department

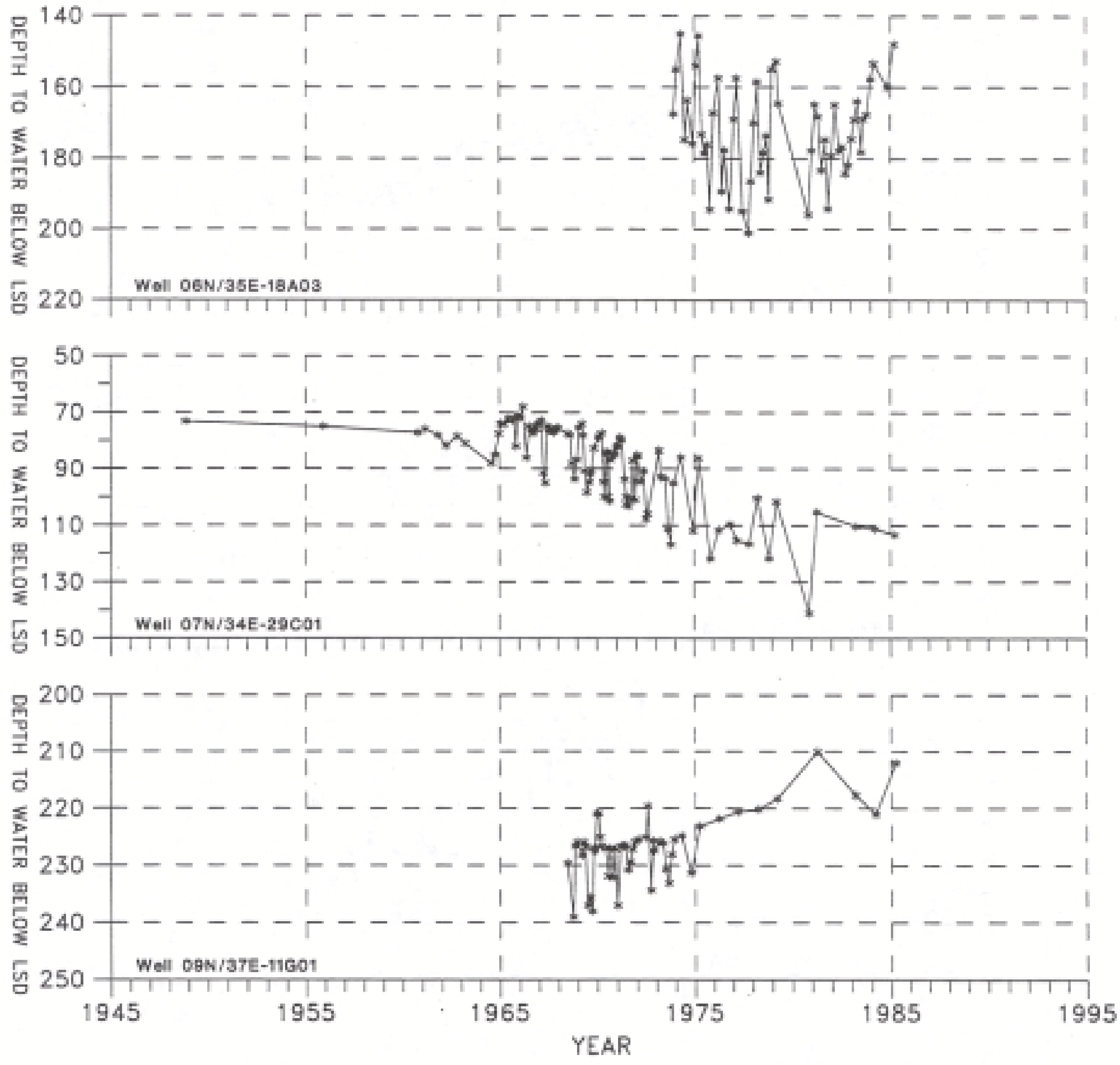
EXPLANATION

FIGURE 6-6

Water-Level Trends for the Basalt Aquifer at Pumping Centers

Initial Watershed Assessment Program
Walla Walla Basin

Pacific Groundwater Group



DATA SOURCES

Pacific Groundwater Group, 1994
USGS WATSTOR Database
Washington State Dept of Ecology
Walla Walla Co. Health Department

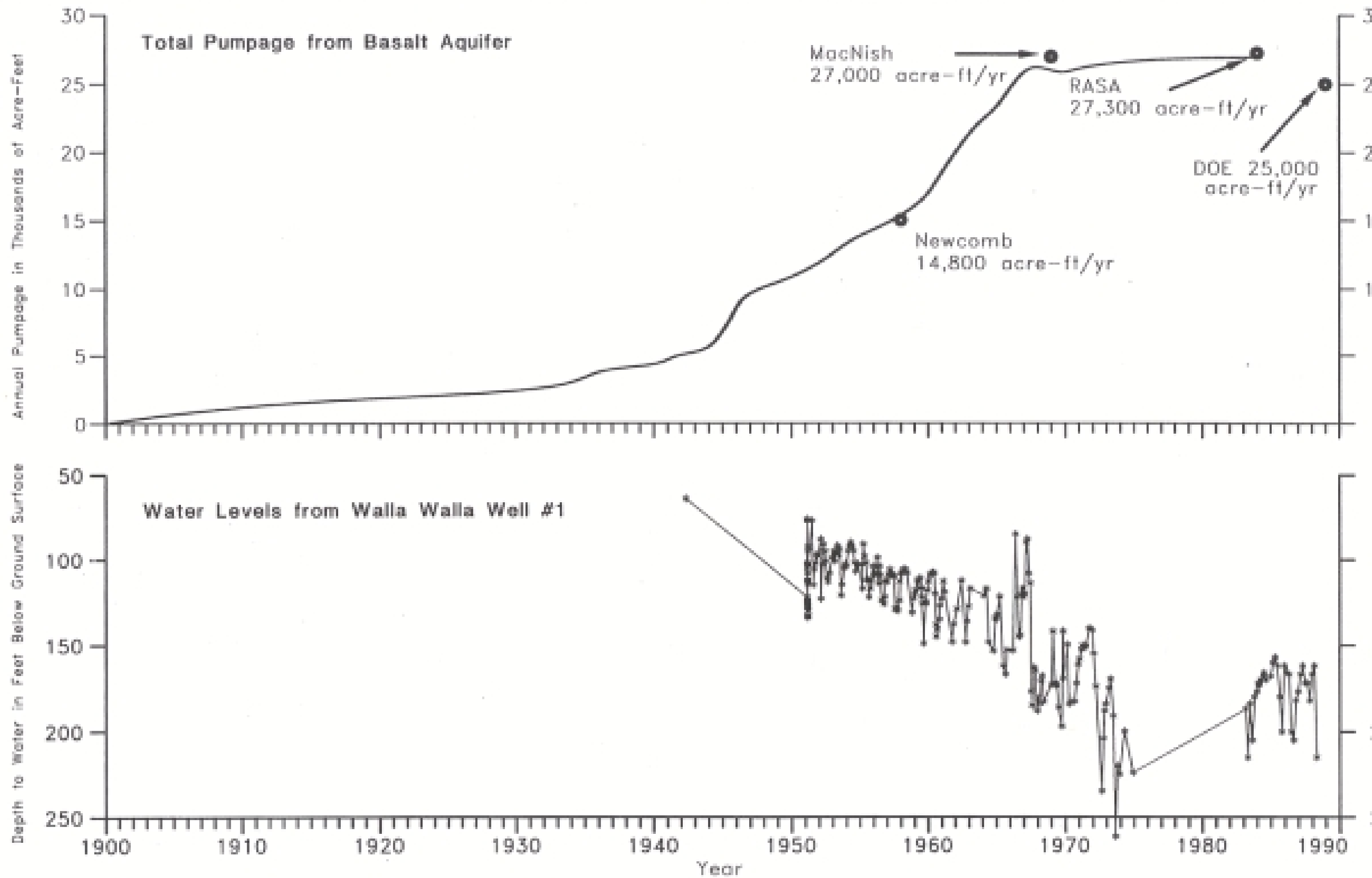
EXPLANATION

FIGURE 6-7

Water-Level Trends for the Basalt Aquifer in Outlying Areas

Initial Watershed Assessment Program
Walla Walla Basin

Pacific Groundwater Group



DATA SOURCES

Water Levels
Pacific Groundwater Group, 1994

Pumpage from Basalt Aquifer
after MacNish and Barker, 1976

EXPLANATION

FIGURE 6-9

Historical Pumpage From Basalt Aquifer and Water-Level Decline From Typical Basalt Well

Initial Watershed Assessment Program
Walla Walla Basin

Pacific Groundwater Group

APPENDIX A
RESOURCE PROTECTION AND MANAGEMENT REGULATIONS

Chapter 173-532 WAC
WATER RESOURCES PROGRAM FOR THE WALLA WALLA RIVER BASIN, WRIA 32

WAC 173-532-010 Purpose. This regulation is adopted in accordance with the water resources management regulation, chapter 173-500 WAC, which was promulgated under the authority of the Water Resources Act of 1971, chapter 90.54 RCW. This chapter, including any amendments, applies to all waters that lie within or contribute to the Walla Walla River drainage basin. This chapter sets forth the department's policies to manage the basin's water resources. [Order DE 77-30, § 173-532-010, filed 12/14/77.]

WAC 173-532-020 Definitions. For purposes of this chapter, the following definitions shall be used.

(1) "Allocation" means the designating of specific amounts of the water resource for specific beneficial uses.

(2) "Base flow" means a level of stream flow established in accordance with provisions of chapter 90.54 RCW required in perennial streams to preserve wildlife, fish, scenic, aesthetic, and other environmental and navigational values.

(3) "Consumptive use" means use of water whereby there is discernible diminishment of the water source.

(4) "Department" means the Washington state department of Ecology.

(5) "Director" means the director of the department of ecology.

(6) "Domestic use" means use of water associated with human health and welfare requirements, including water used for drinking, bathing, sanitary purposes, cooking, laundering, irrigation of not over one-half acre of lawn and garden per dwelling, and other incidental household uses.

(7) "In-house domestic use" means use of water for drinking, cleaning, sanitation, and other uses in a residence, excluding irrigation of lawn and garden.

(8) "Municipal water supply system" means a set of facilities including source, treatment, storage, transmission and distribution facilities whereby water is furnished for commercial and/or industrial uses, and public water supplies with 10 or more connections.

(9) "Nonconsumptive use" means a type of water use where either there is no diversion from a source body, or where there is no discernible diminishment of the source.

(10) "Perennial stream" means a stream with a natural flow which is normally continuous at any given location.

(11) "Public water supply" means any water supply intended or used for human consumption and community uses.

(12) "Water right" means a right to make beneficial use of public waters of the state.

(13) "Zone of direct hydraulic continuity" means that zone of inter action between the surface water stream and the adjacent ground water whereby a pumping well can effectively reduce the flow in the stream to the detriment of surface water users, as determined by the department. [Order DE 77-30, § 173-531-020, filed 12/14/77.]

WAC 173-532-030 Base flows. The establishment of base flows for surface streams will be deferred until such time as storage project or projects become a reality. At present, all surface streams are totally appropriated during the irrigation season and water is not available for protection of instream values. With the advent of future storage projects, the department may establish base flows which can be included as project benefits and maintained by storage releases. [Order DE 77-30, § 173-532-030, filed 12/14/77.]

WAC 173-532-040 Streams closed to further consumptive appropriations. The department has determined that no waters are available for consumptive appropriation through the establishment of water rights for the following streams for the periods indicated:

TABLE II-1
SURFACE WATER CLOSURES*

STREAM NAME	AFFECTED REACH	EFFECTIVE DATE OF CLOSURE	PERIOD OF CLOSURE
Blue Creek	Mouth to Headwaters	Date of Adoption	June 1 – Oct. 31
Mill Creek	Mouth to State Line	2-6-1957	May 1 – Oct. 1
Walla Walla River	Mouth to State Line	Date of Adoption	May 1 – Nov. 30

STREAM NAME	AFFECTED REACH	EFFECTIVE DATE OF CLOSURE	PERIOD OF CLOSURE
Dry Creek	Mouth to Headwaters	Date of Adoption	April 15 – Nov. 15 or whatever Walla Walla at USGS Gage 14.0185 drops below 91.0 cfs.
Touchet River	Mouth to Headwaters	Date of Adoption	June 1 – Oct. 31
Coppei Creek	Mouth to Headwaters	Date of Adoption	April 1 – Nov. 10
Dean Creek	Mouth to Headwaters	Date of Adoption	June 1 – Oct. 1
Mud Creek	Mouth to Headwaters	Date of Adoption	May 1 – Oct. 31 or whenever Walla Walla below confluence with Mud Creek falls below 50 cfs.
Pine Creek	Mouth to Headwaters	Date of Adoption	May 1 – Oct. 31 or whenever Walla Walla River at confluence with Pine Creek or below Touchet River drops below 50 cfs.
Stone Creek	Mouth to Headwaters	Date of Adoption	May 1 – Oct. 31

*Exception for single-domestic and stock water where no other practical source is available.

[Order DE 77-30, § 173-532-040, filed 12/14/77.]

WAC 173-532-050 Protection of surface water rights from new appropriators of ground water. New appropriators of ground water will be required to locate wells outside of the zone of direct hydraulic continuity between the surface water stream and the ground water aquifer. The actual limits of the zone of direct hydraulic continuity at a specific location will be determined by the department after an individual ground water application is received. The department will use accepted engineering methods for its determination. [Order DE 77-30, § 173-532-050, filed 12/14/77.]

WAC 173-532-060 Designation of ground water areas for specific uses. A portion of the ground water resource in the Walla Walla-College Place vicinity is designated for the anticipated growth of the community. Within the following area, ground water in the basalt aquifer is limited to appropriation for municipal water supply systems only, and ground water in the shallow gravel aquifer is limited to uses other than municipal water supply systems:

> All the area contained within the following listed sections: Sections 35 and 36, T8N, R35; sections 1, 2, 11, 12, 13, 14, 15, 23, 24, 25, 26, 27, 28, 34, 35, and 36, T7N, R35E; sections 1, 2, 3, 10, 11, 12, and all of 13, 14, and 15 lying within Washington state. T6N, R35E; sections 31, 32, 33, 34, 35, and 36, T7N, R36E; all the area within T7N, R36E; all the area within T6N, R36E lying within the state of Washington; section 31, T8N, R37E; sections 6, 7, 18, 19, 30, and 31, T7N, R37E; and sections 6, 7, and all of section 18 lying within Washington state, T6N, R37E.

The provisional designation of water in the basalt aquifer for municipal water supply systems shall be effective for a period from February 1, 1978 to October 1, 1984. After October 1, 1984, all designated waters not appropriated or reserved under chapter 173-590 WAC reservation of water for future public water supply, shall be open for appropriations by other users as determined by the department.

The designation of water in the gravel aquifer for users other than municipal water supply systems shall remain indefinitely until changed by the department. [Statutory Authority: RCW 90.54.050. 83-02-039 (Order DE 82-46), § 173-532-060, filed 12/30/82; Order DE 77-30, § 173-532-060, filed 12/14/77.]

WAC 173-532-070 Closure of ground water aquifer to further appropriation. When the department determines that annual ground water withdrawals from the basalt aquifer have reached 125,000 acre-feet, which is approximately 95 percent of the average annual recharge to that aquifer, the aquifer will be closed to further appropriation. [Order DE 77-30, § 173-532-070, filed 11/14/77.]

WAC 173-532-080 Evaluation of ground water applications. Each new application for ground water appropriation will be evaluated to minimize interference with existing wells and with adjacent surface water streams. The department will issue permits for ground water withdrawal in those cases where senior surface water and ground water rights will not be adversely affected as determined by the department. [Order DE 77-30, § 173-532-080, filed 12/14/77.]

WAC 173-532-090 Enforcement. In enforcement of this chapter, the department of ecology may impose such sanctions as are appropriate under authorities vested in it, including but not limited to the issuance of regulatory orders under RCW 43.27A.190 and civil penalties under RCW 90.03.600. [Statutory Authority: Chapters 43.27A, 90.22 and 90.54 RCW. 88-13-037 (Order 88-11), § 173-532-090, filed 6/9/88.]

WAC 173-532-100 Appeals. All final written decisions of the department of ecology pertaining to permits, regulatory orders, and related decisions made pursuant to this chapter shall be subject to review by the pollution control hearings board in accordance with chapter 43.21B RCW. [Statutory Authority: Chapters 43.27A, 90.22 and 90.54 RCW. 88-13-037 (Order 88-11), § 173-532-100, filed 6/9/88.]

WAC 173-532-110 Regulation review. The department of ecology shall initiate a review of the rules established in this chapter whenever new information, changing conditions, or statutory modifications make it necessary to consider revisions. [Statutory Authority: Chapters 43.27A, 90.22 and 90.54 RCW. 88-13-037 (Order 88-11), § 173-532-110, filed 6/9/88.]

APPENDIX B
STREAMFLOW DATA

Average Flows at Gage 14013000, Mill Creek near Walla Walla

Average Discharges in cfs for Calendar Year

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	Departure From Mean
1913														
1914	120	141	182	134	80	50	36	33	36	38	50	34	77	-16.2
1915	41	101	124	130	148	49	30	24	24	28	72	118	74	-19.6
1916	65	201	315	197	168	99	51	31	29	29	39	73	108	14.4
1917	81	116	71	420	495	214	61	31	31					
1938				156	96	45	26	24	24					
1939										19	24	38		
1940	50	199	173	165	75	33	28	27	29	29	57	87	79	-14.7
1941	80	50	45	47	83	80	36	26	29	36	86	112	59	-34.4
1942	54	99	101	110	116	105	44	25	23	27	90	173	80	-13.1
1943	105	168	137	242	160	94	42	29	27	41	48	56	95	1.4
1944	34	71	130	156	86	47	27	25	28	27	34	34	58	-35.4
1945	103	136	138	188	165	84	33	28	32	31	102	145	98	4.9
1946	166	143	202	190	153	85	53	34	33	49	137	240	124	30.2
1947	159	114	147	180	85	51	36	30	34	61	165	146	101	7.0
1948	158	195	110	205	308	119	54	42	41	39	81	105	121	27.8
1949	59	149	260	284	211	75	47	39	36	41	52	69	110	16.2
1950	91	267	317	226	226	164	60	47	44	58	144	174	151	57.1
1951	168	241	150	160	104	110	45	41	40	105	106	128	116	22.1
1952	80	175	140	277	163	77	62	38	37	38	36	39	97	3.0
1953	225	184	180	177	147	94	46	38	37	37	51	154	114	20.4
1954	136	148	94	165	88	123	42	38	37	39	42	45	82	-11.2
1955	58	70	81	170	177	89	39	29	30	35	79	198	88	-5.6
1956	147	80	174	222	156	59	36	32	30	38	50	127	96	2.7
1957	43	129	188	198	156	51	39	35	34	38	53	132	91	-2.4
1958	148	271	96	270	183	56	37	33	34	36	103	222	123	29.3
1959	256	135	150	167	131	72	41	36	48	70	115	75	108	14.3
1960	68	141	152	153	123	63	34	41	41	40	83	67	84	-9.9
1961	74	258	251	155	135	54	35	32	35	35	51	103	101	7.1
1962	109	78	149	187	115	54	31	28	31	57	80	102	85	-8.4
1963	53	134	100	138	75	36	33	29	29	29	60	71	65	-28.5
1964	104	87	112	206	183	82	35	30	30	30	84	376	114	20.3
1965	362	216	96	180	98	69	37	33	33	32	34	33	101	7.6
1966	83	76	189	164	94	43	32	25	24	30	45	93	75	-18.6
1967	178	85	99	103	142	52	25	23	27	32	35	85	74	-19.6
1968	79	200	68	82	51	34	23	25	30	47	87	99	68	-25.2
1969	250	80	148	233	161	56	34	26	28	30	28	55	94	0.9
1970	279	171	150	131	139	70	37	32	32	41	110	89	107	13.1
1971	221	149	147	149	137	108	41	29	34	32	76	124	104	10.2
1972	146	229	358	180	175	76	53	40	43	43	49	109	125	31.8
1973	126	72	100	77	61	43	37	32	33	36	149	273	87	-6.6
1974	275	182	215	301	218	260	70	49	42	41	49	83	148	54.8
1975	308	138	197	150	235	110	61	49	44	55	96	356	151	57.0
1976	246	166	170	276	170	91	53	48	45					
1977														
1978														
1979										31	31	71		
1980	119	100	122	141	93	69	32	24	26	26	40	157	79	-14.3
1981	58	212	84	171	75	135	36	25	23	28	43	119	83	-10.6
1982	141	343	163	155	132	61	34	21	26	34	66	102	105	113
1983	167	163	167	113	109	44	31	23	21	22	48	63	80	-13.1
1984	154	120	219	131	130	125	37	32	33	31	87	80	98	4.9
1985	43	63	125	237	133	71	33	29	31	34	41	40	73	-20.3
1986	96	264	185	95	97	41	30	23	28	29	117	52	87	-6.6
1987	54	140	154	99	62	30	25	21	22	25	28	35	58	-36.0
1988	72	104	121	146	71	45	27	25	25	30	80	77	69	-25.0
1989	139	83	248	224	128	65	31	30	29	31	38	48	91	-2.5
1990	104	110	122	115	123	79	31	29	29	35	69	60	75	-18.2
1991	120	124	117	131	143	61	30	27	25	25	99	144	87	-6.6
1992	62	98	58	74	40	28	25	22	23	23	58	45	46	-47.4
1993	54	63	217	203	216	46								
Min	34	50	45	47	40	28	23	21	21	19	24	33	46	-47.4
Avg	127	146	155	174	140	77	39	31	32	37	70	109	94	-0.0
Max	362	343	358	420	495	260	70	49	48	105	165	376	151	57.1

Average Flows at Gage 14015000, Mill Creek at Walla Walla

Average Discharges in cfs for Calendar Year

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	Departure From Mean
1941					49.1	34.4	5.9	3.2	9.6	6.3	43.6	90.9		
1942	81.5	118.3	97.9	55.0	71.3	65.0	9.0	5.5	7.8	10.7	61.7	190.4	64.2	-14.6
1943	116.0	209.1	111.3	239.2	129.1	33.9	3.4	5.2	3.8	18.2	24.0	34.9	76.3	-2.5
1944	15.8	62.3	139.6	157.1	39.6	7.0	2.3	2.7	2.5	6.3	5.8	4.9	37.1	-41.7
1945	63.8	188.2	147.5	189.1	112.9	37.1	3.1	2.2	4.4	4.2	45.1	157.1	78.8	-0.0
1946	273.2	183.0	244.2	108.5	82.9	27.0	6.0	5.2	5.8	7.0	88.6	130.7	96.6	17.8
1947	129.6	16.2	3.2	9.7	14.9	6.5	2.6	4.5	8.3	17.0	146.7	112.2	39.4	-39.4
1948	144.5	119.4	115.5	247.4	344.5	87.8	5.7	5.9	4.1	3.9	19.8	46.5	95.6	16.8
1949	52.7	206.1	319.2	248.2	153.5	20.7	4.4	4.9	5.0	7.0	11.3	32.7	88.0	9.2
1950	86.9	329.5	336.9	190.3	107.6	117.7	3.7	1.3	1.7	13.7	136.7	154.9	121.8	43.0
1951	211.3	332.4	167.2	134.0	71.5	87.9	5.0	5.1	3.4	96.0	46.6	111.6	104.5	25.7
1952	58.7	187.1	114.9	276.0	97.0	12.1	9.9	1.1	2.0	3.1	3.6	4.8	63.6	-15.2
1953	261.0	227.0	208.1	159.3	122.6	67.4	7.6	5.6	6.1	6.0	11.4	141.7	101.4	22.6
1954	121.5	152.6	60.4	142.7	32.7	113.5	4.5	4.3	3.8	2.3	6.9	12.9	53.9	-24.9
1955	25.6	30.0	45.5	178.6	160.3	26.0	6.4	2.3	3.4	3.6	51.2	247.3	65.3	-13.5
1956	180.3	83.5	234.5	192.9	107.4	23.2	6.7	1.2	0.7	5.2	8.4	110.3	80.0	1.2
1957	33.7	169.2	243.5	194.2	124.8	8.7	2.6	2.3	2.2	1.0	7.5	118.6	75.2	-3.6
1958	169.1	294.9	75.0	293.3	121.0	25.3	4.0	2.0	2.4	0.7	3.6	205.3	103.3	24.4
1959	276.6	151.5	180.1	167.1	97.2	17.4	1.3	1.2	8.1	21.8	56.2	42.2	84.8	6.0
1960	44.6	149.0	153.8	147.8	95.8	13.0	3.0	4.0	2.7	1.9	50.6	40.7	58.6	-20.2
1961	51.1	296.2	307.1	130.3	97.5	13.7	3.6	4.3	4.1	2.6	17.7	101.0	84.5	5.7
1962	89.7	48.7	172.1	179.4	71.5	8.2	2.0	1.8	1.7	28.2	53.9	96.4	62.9	-15.9
1963	39.7	158.8	83.0	127.7	26.0	0.5	0.4	0.5	0.5	0.3	9.8	33.0	39.1	-39.7
1964	107.2	80.9	113.5	202.6	118.9	34.1	1.9	1.1	1.0	1.0	62.9	432.8	97.1	18.3
1965	316.5	229.7	95.1	147.9	39.4	20.7	2.3	1.9	0.9	0.5	1.4	9.7	71.2	-7.6
1966	97.5	87.0	249.7	156.3	25.0	2.2	1.4	1.8	1.2	0.6	15.1	84.6	60.2	-18.7
1967	209.1	91.1	99.6	100.7	129.5	4.4	1.6	2.6	2.2	1.3	0.8	62.8	58.9	-19.9
1968	73.5	216.0	42.4	48.9	1.1	1.4	1.4	1.4	1.0	9.1	81.1	123.9	49.5	-29.3
1969	302.4	117.0	182.7	299.4	136.6	8.7	0.2	0.2	0.3	0.4	0.4	22.0	89.1	10.3
1970	369.1	221.5	186.4	140.9	100.6	26.5	1.3	1.1	2.2	6.4	97.6	96.1	103.6	24.8
1971	276.4	146.7	165.1	143.2	94.9	76.6	6.8	1.8	11.5	4.9	50.7	170.3	95.6	16.8
1972	165.0	262.7	391.5	173.8	125.7	17.7	2.3	1.2	0.3	0.1	2.7	97.5	103.4	24.6
1973	138.6	78.0	97.6	33.1	1.4	0.0	0.0	0.0	0.6	0.2	152.2	375.5	73.3	-5.5
1974	372.3	248.7	249.9	381.3	218.7	178.9	13.5	0.3	0.0	0.0	8.0	74.2	144.7	65.9
1975	328.5	147.8	202.3	136.4	182.6	48.7	8.2	0.5	0.3	2.6	34.8	343.2	120.1	41.3
1976	346.0	197.3	202.8	324.4	133.5	36.4	0.5	2.3	1.0	4.6	9.7	13.3	105.9	27.1
1977	31.0	12.0	71.8	62.4	8.3	0.5	0.6	2.3	0.6	0.8	43.1	230.3	39.0	-39.8
1978	171.4	162.3	111.0	126.9	70.6	0.3	1.3	1.2	0.6	0.2	4.8	76.9	60.1	-18.7
1979	43.7	231.4	197.1	223.3	138.4	5.8	1.7	1.1	0.9	2.3	5.1	54.9	74.4	-4.4
1980	162.9	135.4	154.6	127.4	38.9	28.0	0.1	0.0	0.0	0.7	24.3	173.6	70.6	-8.2
1981	55.5	296.7	122.4	240.8	68.4	147.8	18.4	0.0	0.0	3.6	35.0	165.1	94.4	15.6
1982	230.7	489.2	256.0	208.8	119.3	31.6	4.6	0.0	2.4	10.4	46.2	114.9	123.8	45.0
1983	197.0	220.1	222.4	127.7	88.2	5.8	0.5	0.0	1.1	0.6	47.2	105.1	83.9	5.1
1984	219.3	174.9	331.8	111.9	96.9	161.7	13.7	3.4	2.9	4.2	99.7	120.3	111.9	33.1
1985	61.9	107.8	152.0	262.9	110.6	33.1	0.3	0.1	0.0	12.1	41.3	49.9	68.9	-9.9
1986	139.7	361.1	242.0	79.3	68.6	16.0	5.5	2.0	5.9	9.2	98.6	37.8	87.0	8.2
1987	56.8	180.9	166.9	76.2	24.4	0.7	0.1	1.5	0.0	0.1	0.1	9.2	42.2	-36.6
1988	88.2	125.5	121.6	152.1	44.2	10.7	0.1	0.0	0.0	0.0	56.6	69.7	55.5	-23.3
1989	221.3	121.4	328.9	243.5	104.4	34.3	7.3	7.6	5.3	1.0	0.9	24.2	91.7	12.8
1990	102.0	119.8	128.2	89.4	108.7	66.5	0.0	0.0	0.0	1.5	33.6	50.7	58.0	-20.8
1991	136.0	103.8	102.9	122.2	163.9	59.3	2.4	0.0	0.0	0.2	104.9	18.2	81.6	2.8
1992	59.1	101.9	55.9	32.5	3.4	0.0	0.6	1.2	1.5	3.1	38.2	51.8	28.9	-49.9
1993	97.8	64.2	229.7											
Min	15.8	12.0	3.2	9.7	1.1	0.0	0.0	0.0	0.0	0.0	0.1	4.8	28.9	-49.9
Avg	148.1	170.1	169.9	163.6	94.2	36.8	3.9	2.2	2.6	6.7	41.7	108.6	78.8	0.0
Max	372.3	489.2	391.5	381.3	344.5	178.9	18.4	7.6	11.5	96.0	152.2	432.8	144.7	65.9.

Average Flows at Gage 14017000, Touchet River at Bolles

Average Discharges in cfs for Calendar Year

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	Departure From Mean
1924		471	174	206	145	46	22	18	26	45	232	221		
1925	437	646	276	339	206	91	17	14	35	57	75	93	187	-41
1926	105	397	179	181	78	29	12	16	46	55	271	359	142	-86
1927	383	780	590	435	337	173	48	33	80	107	530	322	314	86
1928	919	252	748	784	365	86	39	20	38	55	69	68	288	60
1929	70	62	335	282	275	115	39	19	31					
1951				453	274	212	63	41	48	124	147	292		
1952	333	664	386	657	333	137	71	50	54	53	55	70	237	9
1953	539	466	424	375	280	198	61	42	38	49	107	334	242	13
1954	377	476	237	408	192	201	58	46	54	58	69	76	185	-43
1955	105	137	190	454	376	163	53	29	39	70	209	690	210	-18
1956	545	181	600	626	418	158	61	46	47	70	83	210	255	27
1957	79	356	574	503	367	95	40	37	34	52	68	243	203	-25
1958	315	533	245	607	377	71	39	29	38	60	248	545	257	28
1959	595	419	391	350	231	130	46	41	64	98	167	129	221	-8
1960	107	310	406	457	327	133	44	40	38	60	159	144	185	-43
1961	204	800	678	345	283	128	38	26	40	62	93	223	240	11
1962	240	166	553	529	384	137	43	38	49	117	184	276	227	-2
1963	124	426	256	340	122	45	34	25	32	46	107	139	139	-89
1964	312	247	282	478	325	189	60	39	42	55	124	1,110	273	45
1965	997	655	248	395	223	121	58	50	49	62	68	63	247	18
1966	183	156	510	424	198	86	47	30	33	48	91	194	167	-61
1967	410	253	305	329	360	126	30	26	33	69	83	158	182	-47
1968	169	449	133	179	96	55	27	33	50	83	202	308	148	-81
1969	894	389	630	802	442	138	51	35	41	63	67	112	305	77
1970	758	610	478	343	313	146	51	34	50	74	170	209	268	39
1971	725	418	504	451	368	305	77	38	57	72	157	421	299	71
1972	556	777	1,257	458	401	179	70	49	56	69	81	271	352	124
1973	376	194	281	164	118	56	27	23	48	57	310	876	212	-17
1974	1,081	675	633	894	522	498	108	47	45	66	91	122	396	168
1975	736	493	572	422	516	264	89	57	54	81	177	693	346	118
1976	702	455	493	694	404	189	82	71	57	65	86	80	282	53
1977	86	77	128	145	105	59	33	35	53	60	111	409	109	-120
1978	336	355	293	302	197	66	53	44	55	50	68	161	164	-64
1979	63	522	477	470	334	85	41	32	34	58	68	167	194	-35
1980	433	321	444	369	260	161	59	38	48	55	83	291	214	-14
1981	137	628	260	419	203	253	56	28	32	63	114	346	208	-20
1982	621	1,262	615	684	372	176	76	37	48	75	124	247	355	127
1983	383	486	518	327	235	96	59	38	46	59	132	200	213	-15
1984	409	316	559	340	269	242	66	39	46	59	165	227	229	0
1985	120	462	419	531	269	140	45	42	56	75	87	90	192	-36
1986	261	822	604	219	154	58	39	24	44	50	173	116	210	-19
1987	145	339	325	199	119	58	36	24	24	36	48	73	117	-111
1988	158	251	360	408	152	82	35	22	26	35	212	134	148	-80
1989	365	272	585	453	224									
Min	63	62	128	145	78	29	12	14	24	35	48	63	109	-120
Avg	393	441	435	427	279	140	50	35	44	65	137	268	228	-0
Max	1,081	1,262	1,257	894	522	498	108	71	80	124	530	1,110	396	168

Average Flows at Gage 14018500, Touchet River at Bolles

Average Discharges in cfs for Calendar Year

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	Departure From Mean
1951										392	447	873		
1952	1,048	1,836	993	1,525	800	137	94	23	59	63	124	295	579	16
1953	1,555	1,509	1,173	1,076	766	385	35	18	22	78	173	924	638	75
1954	964	1,303	770	974	298	471	41	34	71	103	171	287	451	-113
1955	484	593	518	1,134	1,048	296	46	12	33	139	528	1,807	553	-10
1956	1,576	861	1,686	1,539	1,052	189	36	23	49	103	215	805	681	117
1957	334	1,177	1,730	1,559	1,217	142	16	13	20	164	184	711	602	39
1958	963	1,872	737	2,165	1,147	166	26	7	29	65	436	1,317	735	172
1959	1,888	1,389	1,287	1,154	687	207	28	16	181	336	531	490	679	115
1960	470	1,069	1,157	1,076	761	162	10	11	35	88	384	427	470	-94
1961	642	2,096	1,843	932	699	148	7	4	14	63	150	658	596	32
1962	782	590	1,224	1,217	845	190	20	10	30	226	416	820	531	-32
1963	435	1,411	662	912	309	26	18	9	13	20	156	442	360	-203
1964	794	722	633	1,015	736	359	41	21	25	50	262	2,890	633	69
1965	2,698	1,956	765	996	440	228	50	47	80	65	117	257	634	71
1966	628	545	1,266	944	265	60	48	12	14	32	150	547	375	-188
1967	1,152	752	719	688	966	113	22	6	14	30	76	415	412	-151
1968	586	1,287	408	268	61	21	6	4	33	76	460	730	325	-238
1969	2,264	1,131	1,438	2,061	936	135	27	8	18	57	61	272	698	135
1970	2,264	1,763	1,422	927	824	237	34	12	55	88	426	639	719	156
1971	1,907	1,146	1,096	917	724	693	62	14	87	96	353	1,254	694	131
1972	1,362	1,933	3,105	1,187	1,013	311	54	30	70	81	123	731	834	271
1973	963	618	689	243	87	24	6	3	18	29	971	2,364	502	-61
1974	2,567	1,856	1,652	2,437	1,372	1,130	139	33	43	66	160	463	987	423
1975	2,058	1,357	1,506	937	1,264	373	76	40	56	106	324	2,231	861	298
1976	2,085	1,285	1,268	1,745	947	275	60	83	54	71	152	283	692	129
1977	348	286	339	308	84	35	9	17	69	71	257	1,353	266	-298
1978	1,151	1,224	997	945	513	48	58	39	100	39	156	568	482	-81
1979	306	1,891	1,385	1,282	893	67	17	8	9	31	124	514	535	-29
1980	1,162	1,069	1,193	880	468	262	43	11	32	82	217	961	532	-31
1981	539	1,695	901	1,43	483	698	67	15	16	64	259	959	569	6
1982	1,568	2,819	1,684	1,501	880	243	99	30	51	106	340	896	839	275
1983	1,260	1,501	1,607	920	600	107	77	27	48	50	327	692	597	33
1984	1,401	1,117	1,874	1,095	836	825	86	25	49	77	505	848	729	166
1985	493	1,362	1,013	1,440	602	238	19	21	57	83	260	369	489	-74
1986	857	2,215	1,711	677	369	67	39	7	44	56	511	477	575	12
1987	512	1,059	935	350	176	48	18	6	8	12	55	190	276	-287
1988	538	582	538	850	338	160	21	5	3	6	193	373	300	-264
1989	1,011	589	1,743							19	84	260		
1990	633	770	798	517	700	446	23	12	6	26	157	288	362	-201
1991	685	748	795	653	1,271	413	44	11	8	19	434	969	504	-60
1992	548	770	496	289	98	26	27	13	23	18	199	410	242	-322
1993	561	545	1,434	1,311	1,542	243								
Min	306	286	339	243	61	21	6	3	3	6	55	190	242	-322
Avg	1096	1252	1171	1070	710	254	41	18	41	82	277	787	564	-0
Max	2698	2819	3105	2437	1542	1130	139	83	181	392	971	2890	987	423

Minimum Flows at Gage 14013000, Mill Creek near Walla Walla

Minimum Daily Discharges in cfs for Calendar Year

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	Departure From Mean
1913										29	38	36		
1914	49	50	83	83	60	40	32	32	32	34	35	30	30	3.3
1915	34	61	6	164	66	32	27	22	22	23	27	50	22	-4.7
1916	38	46	92	146	117	66	32	27	26	28	29	40	26	-0.7
1917	39	47	43	105	230	106	36	28	28					
1938				90	71	32	23	23	23					
1939										16	23	23		
1940	31	50	95	88	40	29	26	26	26	24	323	39	24	-2.7
1941	44	42	38	39	45	46	26	25	25	25	35	39	25	-1.7
1942	35	40	39	74	78	45	29	23	22	23	46	64	22	-4.7
1943	41	41	62	112	109	64	31	26	26	26	30	34	26	-0.7
1944	30	36	47	113	58	31	24	23	24	25	26	25	23	-3.7
1945	26	40	40	102	120	40	29	27	27	28	43	36	26	-0.7
1946	91	83	137	115	107	57	45	29	30	30	66	89	29	2.3
1947	37	80	76	16	52	42	32	29	29	34	62	84	29	2.3
1948	62	47	70	132	135	72	42	39	39	36	42	60	36	9.3
1949	45	45	125	125	125	57	42	36	35	35	39	48	35	8.3
1950	45	43	134	140	140	88	49	43	42	43	81	96	42	15.3
1951	96	92	72	101	70	54	40	39	39	46	67	65	39	12.3
1952	55	70	67	183	95	60	42	37	35	36	30	35	30	3.3
1953	39	86	101	92	116	56	40	35	35	34	35	68	34	7.3
1954	65	113	64	62	64	55	36	34	36	35	35	37	34	7.3
1955	40	48	41	112	123	48	34	28	28	27	35	73	27	0.3
1956	90	55	82	151	89	42	32	30	29	34	40	35	29	2.3
1957	34	39	101	115	72	43	37	34	34	36	36	50	34	7.3
1958	62	164	62	90	80	43	34	33	33	32	33	56	32	5.3
1959	100	92	107	94	84	49	37	32	34	47	66	64	32	5.3
1960	35	60	55	102	84	40	29	38	39	36	39	44	29	2.3
1961	53	104	144	124	78	36	32	28	32	24	35	30	24	-2.7
1962	47	50	55	118	73	36	28	25	25	30	35	56	25	-1.7
1963	40	53	77	109	46	28	30	26	26	26	28	41	26	-0.7
1964	51	64	56	146	131	43	29	27	28	28	30	100	27	0.3
1965	83	140	61	74	77	46	31	29	31	29	29	26	26	-0.7
1966	33	43	59	94	52	32	25	24	23	26	26	50	23	-3.7
1967	60	62	73	78	76	32	22	21	25	26	29	30	21	-5.7
1968	50	56	43	60	43	26	22	23	23	23	34	40	22	-4.7
1969	40	48	65	148	75	40	26	24	24	28	25	25	24	-2.7
1970	33	91	70	99	87	47	33	29	24	25	37	53	24	-2.7
1971	51	89	78	108	91	63	31	25	28	19	35	65	19	-7.7
1972	64	54	130	124	119	54	44	37	37	39	43	10	10	-17.2
1973	38	54	75	68	50	40	34	31	28	32	48	101	28	1.3
1974	56	105	112	195	120	97	55	44	41	39	42	47	39	12.3
1975	59	82	112	108	138	74	50	45	42	44	59	108	42	15.3
1976	120	89	112	163	99	66	45	44	44					
1977														
1978														
1979										26	26	30		
1980	24	24	89	86	56	42	24	21	23	22	27	46	21	-5.7
1981	38	43	36	104	59	55	28	23	22	25	25	48	22	-4.7
1982	40	47	93	76	75	42	26	15	15	26	43	47	15	-11.7
1983	44	59	83	61	78	33	25	20	19	20	22	28	19	-7.7
1984	30	64	102	79	82	52	32	31	30	29	29	48	29	2.3
1985	36	35	65	122	85	39	30	28	27	28	32	32	27	0.3
1986	34	62	114	77	79	30	28	21	23	25	27	38	21	-5.7
1987	35	68	70	75	35	27	23	20	20	23	26	24	20	-6.7
1988	23	51	59	78	52	31	25	25	25	26	26	44	23	-3.7
1989	62	41	66	129	81	34	29	26	28	28	30	28	26	-0.7
1990	29	48	94	71	58	36	27	28	28	30	36	30	27	0.3
1991	34	65	95	89	75	36	26	26	24	24	25	58	24	-2.7
1992	41	47	41	40	31	25	23	21	21	22	36	34	21	-5.7
1993	31	43	43	131	57	32								
Min	23	24	36	39	31	25	22	15	15	16	22	10	10	-17.2
Avg	48	63	78	103	84	47	32	29	29	29	37	48	27	-0.0
Max	120	164	144	195	230	106	55	45	44	47	81	108	42	15.3

Minimum Flows at Gage 14015000, Mill Creek at Walla Walla

Minimum Daily Discharges in cfs for Calendar Year

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	Departure From Mean	Zero-Flow Days
1941					6.0	7.0	2.2	2.0	2.8	4.4	6.5	6.5	2.0	1.4	none
1942	50.0	36.0	34.0	33.0	37.0	2.8	4.2	4.2	4.5	6.6	9.6	26.0	2.8	2.2	none
1943	22.0	50.0	29.0	80.0	38.0	7.0	1.7	3.0	2.3	3.0	7.7	9.9	1.7	1.1	none
1944	12.0	20.0	45.0	97.0	11.0	1.8	1.3	1.8	0.8	2.8	4.8	3.3	0.8	0.2	none
1945	3.8	9.0	6.3	24.0	25.0	5.4	1.6	1.1	1.6	1.8	5.7	21.0	1.1	0.5	none
1946	120.0	66.0	129.0	54.0	31.0	7.0	4.0	4.0	5.1	4.0	4.0	26.0	4.0	3.4	none
1947	25.0	2.0	2.0	5.7	2.6	2.4	1.8	2.2	4.0	5.0	5.0	12.0	1.8	1.2	none
1948	15.0	6.1	64.0	140.0	140.0	16.0	1.0	1.0	1.0	2.2	3.5	15.0	1.0	0.4	none
1949	40.0	40.0	116.0	112.0	50.0	2.8	2.2	2.5	3.4	5.4	6.2	3.0	2.2	1.6	none
1950	20.0	20.0	80.0	16.0	18.0	16.0	2.0	1.0	1.0	3.6	27.0	56.0	1.0	0.4	none
1951	98.0	82.0	68.0	68.0	36.0	7.6	3.9	3.1	1.7	14.0	6.0	30.0	1.7	1.1	none
1952	17.0	40.0	39.0	151.0	37.0	6.0	1.0	0.8	1.1	2.3	2.8	3.6	0.8	0.2	none
1953	3.6	47.0	92.0	36.0	67.0	20.0	4.4	4.0	4.7	3.2	3.2	40.0	3.2	2.6	none
1954	45.0	77.0	31.0	31.0	10.0	8.2	2.7	2.6	3.2	1.0	0.0	3.7	0.0	-0.6	1
1955	5.2	8.7	4.5	65.0	91.0	5.9	2.6	1.3	1.3	1.6	1.0	65.0	1.0	0.4	none
1956	74.0	35.0	78.0	74.0	31.0	11.0	1.9	0.3	0.4	0.0	3.3	2.0	0.0	-0.6	3
1957	30.0	35.0	125.0	49.0	34.0	2.6	2.1	1.7	1.7	0.4	0.7	11.0	0.4	-0.2	none
1958	49.0	128.0	51.0	89.0	47.0	6.0	4.0	2.0	1.2	0.2	0.3	6.5	0.2	-0.4	none
1959	112.0	89.0	112.0	30.0	34.0	1.6	1.0	1.0	0.7	1.6	15.0	35.0	0.7	0.1	none
1960	20.0	40.0	40.0	70.0	21.0	2.4	2.4	2.9	2.4	1.2	1.0	23.0	1.0	0.4	none
1961	24.0	78.0	147.0	91.0	43.0	3.0	0.5	3.0	1.7	0.0	0.6	18.0	0.0	-0.6	1
1962	20.0	30.0	39.0	76.0	18.5	0.0	1.3	1.3	0.1	0.4	2.8	51.0	0.0	-0.6	2
1963	20.0	30.0	56.0	56.0	0.4	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0	-0.6	31
1964	43.0	51.0	47.0	115.0	23.0	2.8	1.0	0.8	0.6	0.3	0.4	105.0	0.3	-0.3	none
1965	70.0	128.0	49.0	26.0	4.0	2.2	1.3	1.3	0.4	0.2	0.2	0.6	0.2	-0.4	none
1966	17.0	43.0	66.0	49.0	2.8	1.3	0.8	1.0	0.4	0.3	0.4	5.1	0.3	-0.3	none
1967	47.0	56.0	56.0	56.0	37.0	1.0	1.3	1.3	1.0	0.7	0.3	0.1	0.1	-0.5	none
1968	27.0	22.0	4.5	1.2	0.7	0.9	0.9	0.9	0.5	0.7	0.7	50.0	0.5	-0.1	none
1969	50.0	62.0	78.0	193.0	35.0	0.1	0.0	0.0	0.2	0.1	0.1	0.1	0.0	-0.5	none
1970	2.3	99.0	63.0	76.0	43.0	1.8	0.9	0.6	0.6	0.4	1.3	37.0	0.4	-0.2	none
1971	35.0	81.0	53.0	84.0	49.0	21.0	2.3	0.6	0.9	0.6	4.5	68.0	0.6	0.0	none
1972	63.0	77.0	132.0	109.0	29.0	1.3	1.3	0.1	0.0	0.0	0.0	2.0	0.0	-0.6	10
1973	45.0	51.0	50.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	168.0	0.0	-0.6	165
1974	110.0	122.0	139.0	231.0	113.0	39.0	0.2	0.1	0.0	0.0	0.0	35.0	0.0	-0.6	34
1975	53.0	80.0	103.0	96.0	59.0	16.0	0.0	0.0	0.2	0.1	0.7	86.0	0.0	-0.6	6
1976	142.0	73.0	99.0	182.0	33.0	2.3	0.0	0.6	`0.8	0.1	0.0	4.6	0.0	-0.6	17
1977	7.1	0.7	41.0	13.0	0.1	0.2	0.4	0.5	0.2	0.0	0.5	54.0	0.0	-0.5	4
1978	38.0	82.0	81.0	75.0	0.5	0.1	0.2	0.7	0.2	0.1	0.1	25.0	0.1	-0.5	0
1979	27.0	30.0	12.0	86.0	26.0	0.6	0.6	0.4	0.4	0.1	1.0	3.3	0.1	-0.5	0
1980	22.0	35.0	90.0	67.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	27.0	0.0	-0.6	83
1981	25.0	26.0	42.0	142.0	47.0	41.0	0.0	0.0	0.0	0.0	0.0	55.0	0.0	-0.6	87
1982	31.0	61.0	137.0	100.0	66.0	12.0	0.0	0.0	0.0	0.0	13.0	47.0	0.0	-0.6	41
1983	38.0	50.0	90.0	41.0	46.0	0.0	0.0	0.0	0.0	0.0	0.0	41.0	0.0	-0.6	114
1984	62.0	77.0	147.0	74.0	58.0	45.0	3.7	0.6	0.0	0.0	8.2	55.0	0.0	-0.6	21
1985	35.0	32.0	89.0	65.0	54.0	0.0	0.0	0.0	0.0	0.1	1.4	36.0	0.0	-0.6	61
1986	38.0	89.0	153.0	53.0	43.0	2.0	0.0	1.3	1.4	2.8	1.5	14.0	0.0	-0.6	1
1987	15.0	77.0	65.0	58.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.6	136
1988	5.0	62.0	54.0	62.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	32.0	0.0	-0.6	132
1989	83.0	59.	94.0	122.0	59.0	8.6	1.9	4.1	4.2	0.0	0.0	0.5	0.0	-0.6	30
1990	7.8	45.0	80.0	35.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	24.0	0.0	-0.6	124
1991	30.0	43.0	76.0	81.0	75.0	15.0	0.0	0.0	0.0	0.0	0.0	57.0	0.0	-0.6	104
1992	34.0	40.0	22.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.0	0.0	-0.6	144
1993	16.0	34.0	35.0												
Min	2.3	0.7	2.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.6	none
Avg	39.3	53.0	69.9	73.5	34.0	6.9	1.3	1.2	1.1	1.4	2.9	29.5	0.6	0.0	n/a
Max	142.0	128.0	153.0	231.0	140.0	45.0	4.4	4.2	5.1	14.0	27.0	168.0	4.0	3.4	165

Minimum Flows at Gage 14017000, Touchet River at Bolles

Minimum Daily Discharges in cfs for Calendar Year

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	Departure From Mean
1924		255	122	130	58	21	14	11	17	34	80	80	11	-14
1925	201	239	201	196	140	56	6	4	24	44	67	56	4	-22
1926	44	150	131	101	47	9	3	3	23	18	18	216	3	-23
1927	175	344	414	264	207	83	28	20	44	70	83	85	20	-5
1928	130	152	137	498	161	45	12	14	23	40	61	63	12	-13
1929	67	57	214	168	184	53	17	11	15				11	-14
1951				254	153	88	44	35	39	63	85	171	35	10
1952	180	283	236	433	236	80	52	48	50	51	37	44	37	12
1953	68	206	315	198	198	94	42	28	26	34	57	90	26	1
1954	20	300	134	168	112	87	40	31	45	45	54	54	20	-5
1955	57	83	45	295	256	61	34	20	22	45	30	240	20	-5
1956	150	80	230	379	255	84	37	31	26	61	68	70	26	1
1957	44	100	368	293	173	54	30	30	26	39	39	66	26	1
1958	176	270	173	149	105	52	30	26	29	43	55	151	26	1
1959	230	296	264	171	138	69	34	34	42	67	60	90	34	9
1960	50	60	70	279	240	61	36	31	30	36	61	89	30	5
1961	90	280	383	296	209	48	27	22	28	45	65	56	22	-3
1962	90	90	176	302	247	57	31	28	30	54	73	170	28	3
1963	65	80	198	176	53	33	25	21	19	36	51	88	19	-6
1964	119	156	146	358	214	85	42	31	37	48	58	140	31	6
1965	281	402	163	214	177	61	44	33	37	50	59	50	33	8
1966	63	93	137	194	117	51	33	22	28	32	49	114	22	-3
1967	138	160	156	250	206	56	20	22	19	43	62	55	19	-6
1968	111	122	48	120	69	38	19	19	26	45	75	100	19	-6
1969	110	200	271	494	236	82	32	30	30	55	61	60	30	5
1970	62	343	284	267	208	80	40	25	27	44	71	90	25	-0
1971	100	247	189	298	310	143	51	32	47	53	96	200	32	7
1972	193	150	394	332	284	96	53	36	46	60	72	50	36	11
1973	110	126	171	141	78	43	20	20	30	48	65	438	20	-5
1974	170	399	399	665	313	183	45	37	37	48	76	76	37	12
1975	157	215	369	340	361	142	42	37	45	43	84	207	37	12
1976	320	150	291	476	237	107	57	53	53	55	71	71	53	28
1977	65	70	92	105	92	35	26	25	38	49	50	125	25	-0
1978	60	203	241	224	108	47	34	33	44	46	57	50	33	8
1979	28	50	264	296	140	57	27	24	30	37	58	70	24	-1
1980	90	110	308	261	160	91	37	29	34	39	53	81	29	4
1981	75	93	125	295	136	103	29	22	22	47	59	117	22	-3
1982	130	228	380	316	245	108	45	27	34	60	81	135	27	2
1983	117	174	218	191	188	69	41	31	35	45	79	80	31	6
1984	130	185	291	218	222	120	44	34	38	46	65	92	34	9
1985	92	60	257	273	194	66	37	35	36	52	60	64	35	10
1986	84	192	320	176	110	40	28	21	27	46	56	80	21	-4
1987	72	161	150	141	70	33	28	19	20	30	40	50	19	-6
1988	46	123	141	211	94	47	22	19	16	30	43	85	16	-9
1989	167	119	188	253	144									
Min	20	50	45	101	47	9	3	3	15	18	18	44	3	-23
Avg	115	179	223	264	175	71	33	26	32	46	61	106	25	-0
Max	320	402	414	665	361	183	57	53	53	70	96	438	53	28

Minimum Flows at Gage 14018500, Walla Walla River near Touchet

Minimum Daily Discharges in cfs for Calendar Year

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	Departure From Mean
1951										190	285	640		
1952	500	640	585	1,050	296	88	31	17	26	49	88	160	17.0	9.0
1953	324	660	660	448	407	87	17	12	16	51	89	262	12.0	4.0
1954	350	950	465	412	186	84	20	17	38	74	120	180	17.0	9.0
1955	392	480	282	686	600	76	14	5	8	83	100	730	5.3	2.7
1956	700	250	844	748	437	67	13	12	31	67	138	228	12.0	4.0
1957	200	420	1,020	620	393	30	10	9	10	114	104	187	9.2	1.2
1958	420	1,130	482	910	450	53	5	4	6	37	72	350	3.5	-4.5
1959	650	844	862	560	362	51	11	6	24	240	250	427	5.8	-2.2
1960	300	400	380	555	463	28	4	6	19	41	103	290	4.2	-3.8
1961	352	975	1,150	565	348	9	2	2	6	26	85	200	2.1	-5.9
1962	350	400	545	655	530	44	6	6	7	58	128	70	6.0	-2.0
1963	250	300	511	620	59	5	5	3	7	11	33	155	2.9	-5.1
1964	442	464	383	650	395	90	16	14	15	34	74	410	14.0	6.0
1965	918	1,120	415	451	270	69	33	14	41	45	54	178	14.0	6.0
1966	301	404	496	265	77	23	18	11	12	11	40	223	11.0	3.0
1967	385	560	496	399	382	37	6	4	3	5	43	90	2.7	-5.3
1968	360	392	117	99	37	6	0	0	7	23	74	300	0.0	-8.0
1969	350	500	800	1,170	329	50	10	5	7	41	45	84	5.0	-3.0
1970	210	1,010	824	576	399	73	15	7	10	49	60	392	6.9	-1.1
1971	388	718	528	674	404	181	16	10	16	64	107	630	9.8	1.8
1972	650	630	1,080	807	680	80	25	14	30	56	69	160	14.0	6.0
1973	340	444	359	130	56	10	2	2	3	9	60	1,110	2.1	-5.9
1974	540	1,200	1,100	1,650	665	271	41	27	24	53	66	202	24.0	16.0
1975	462	813	881	664	617	154	27	19	37	42	113	782	19.0	11.0
1976	1,120	715	833	1,090	364	102	21	25	39	48	112	215	21.0	13.0
1977	240	162	220	65	60	10	3	2	35	36	69	500	1.8	-6.2
1978	325	835	860	559	107	27	12	2	56	24	47	230	2.4	-5.6
1979	200	210	758	794	178	19	3	1	4	4	50	274	0.8	-7.2
1980	370	430	795	614	136	132	10	6	9	25	95	297	6.4	-1.6
1981	364	337	474	811	219	123	15	12	6	37	83	329	6.2	-1.8
1982	350	640	1,050	737	402	127	28	15	19	43	185	506	15.0	7.0
1983	443	599	756	481	265	71	35	15	26	25	103	350	15.0	7.0
1984	500	684	1,050	660	648	263	35	11	31	40	126	500	11.0	3.0
1985	399	310	704	641	351	50	7	9	9	36	106	250	7.0	-1.0
1986	286	662	1,140	500	228	30	14	4	10	33	55	351	3.9	-4.1
1987	260	601	350	257	62	13	8	3	5	0	29	100	0.0	-8.0
1988	195	361	211	563	100	33	5	3	2	2	12	228	1.8	-6.2
1989	423	466	650							3	39	106		
1990	247	380	460	231	199	51	8	4	4	5	50	170	3.5	-4.5
1991	150	397	575	540	550	91	4	1	4	6	31	506	1.4	-6.6
1992	390	448	173	96	23	7	5	2	3	8	57	336	2.4	-5.6
1993	280	333	347	799	254	84								
Min	150.0	162.0	117.0	65.0	23.0	4.9	0.0	0.0	1.8	0.0	12.0	84.0	0.0	--8.0
Avg	397.0	578.0	635.0	604.9	316.8	70.7	14.0	8.5	16.5	44.0	86.9	337.8	8.0	0.0
Max	1,120	1,200	1,150	1,650	680	271	41	27	56	240	285	1,110	24	16

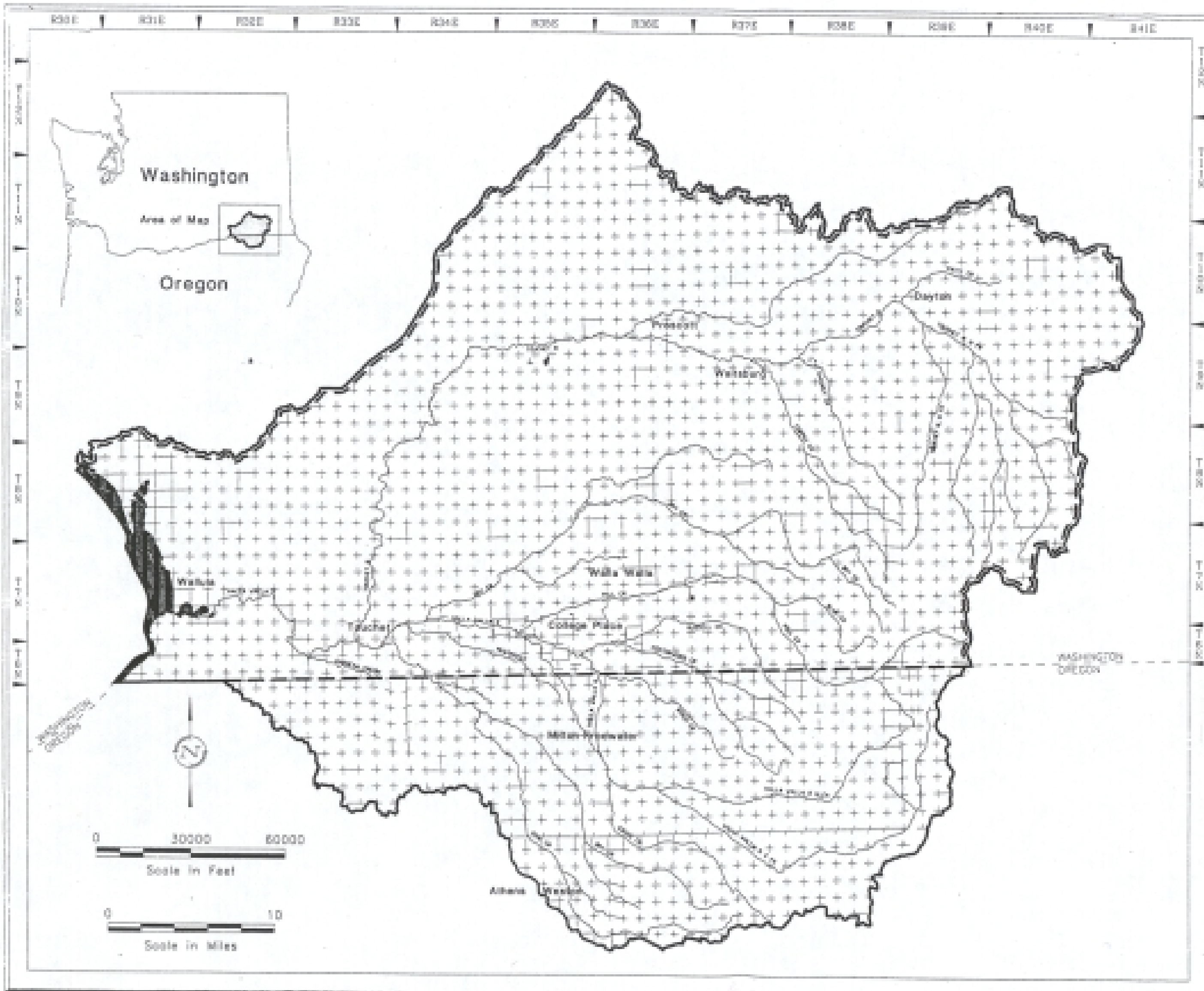


FIGURE 2-1

Location and Base Map of the Walla Walla River Basin

Initial Watershed Assessment Program
Walla Walla Basin

Pacific Groundwater Group

EXPLANATION

Walla Walla Basin Boundary

WRIA Boundary (note: WRIA Boundary is coincident with basin boundary and state line)

Streams

Section Lines

DATA SOURCES

Washington State Department of Ecology

Oregon State Service Center for GIS

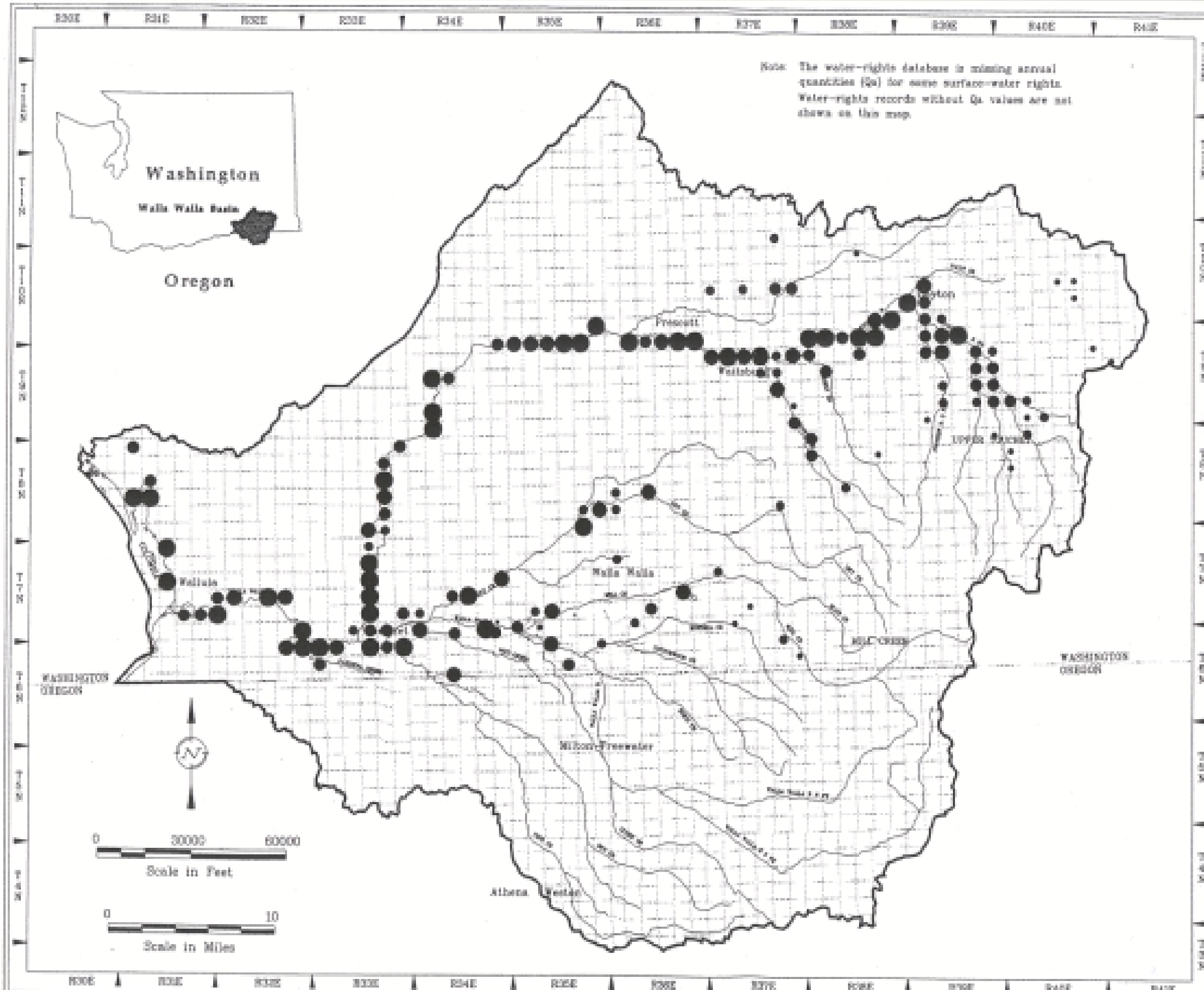


FIGURE 3-3

Distribution of Surface-Water Permits/Certificates

Initial Watershed Assessment Program
Walla Walla Basin

EXPLANATION

Aggregate Surface-Water Permits/Certificates Maximum Annual Quantities by Section

- 0 acre-ft/yr
- 0 to 10 acre-ft/yr
- 10 to 100 acre-ft/yr
- 100 to 500 acre-ft/yr
- 500 to 1000 acre-ft/yr
- Greater Than 1000 acre-ft/yr

- Stream, Major
- Section Lines
- Walla Walla Basin Boundary

DATA SOURCES

Washington State Department of Ecology, Water Resources Division

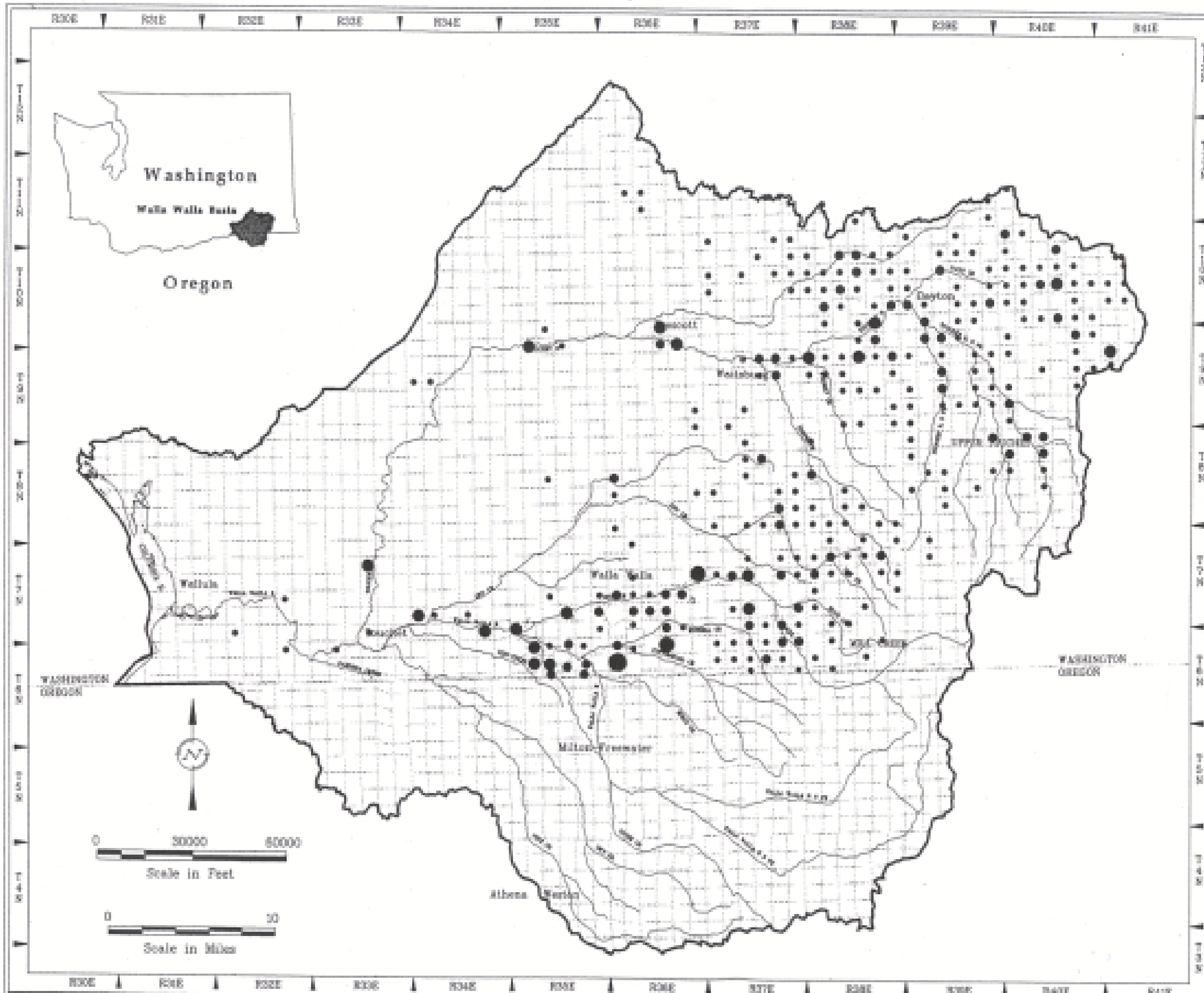


FIGURE 3-4

Distribution of Surface-Water Claims

Initial Watershed Assessment Program
Walla Walla Basin

EXPLANATION

Aggregate Surface-Water Claims
Maximum Annual Quantities by Section

- 0 acre-ft/yr
- 0 to 10 acre-ft/yr
- 10 to 100 acre-ft/yr
- 100 to 500 acre-ft/yr
- 500 to 1000 acre-ft/yr
- Greater Than 1000 acre-ft/yr

- Stream, Major
- Section Lines
- Walla Walla Basin Boundary

DATA SOURCES

Washington State Department of Ecology,
Water Resources Division

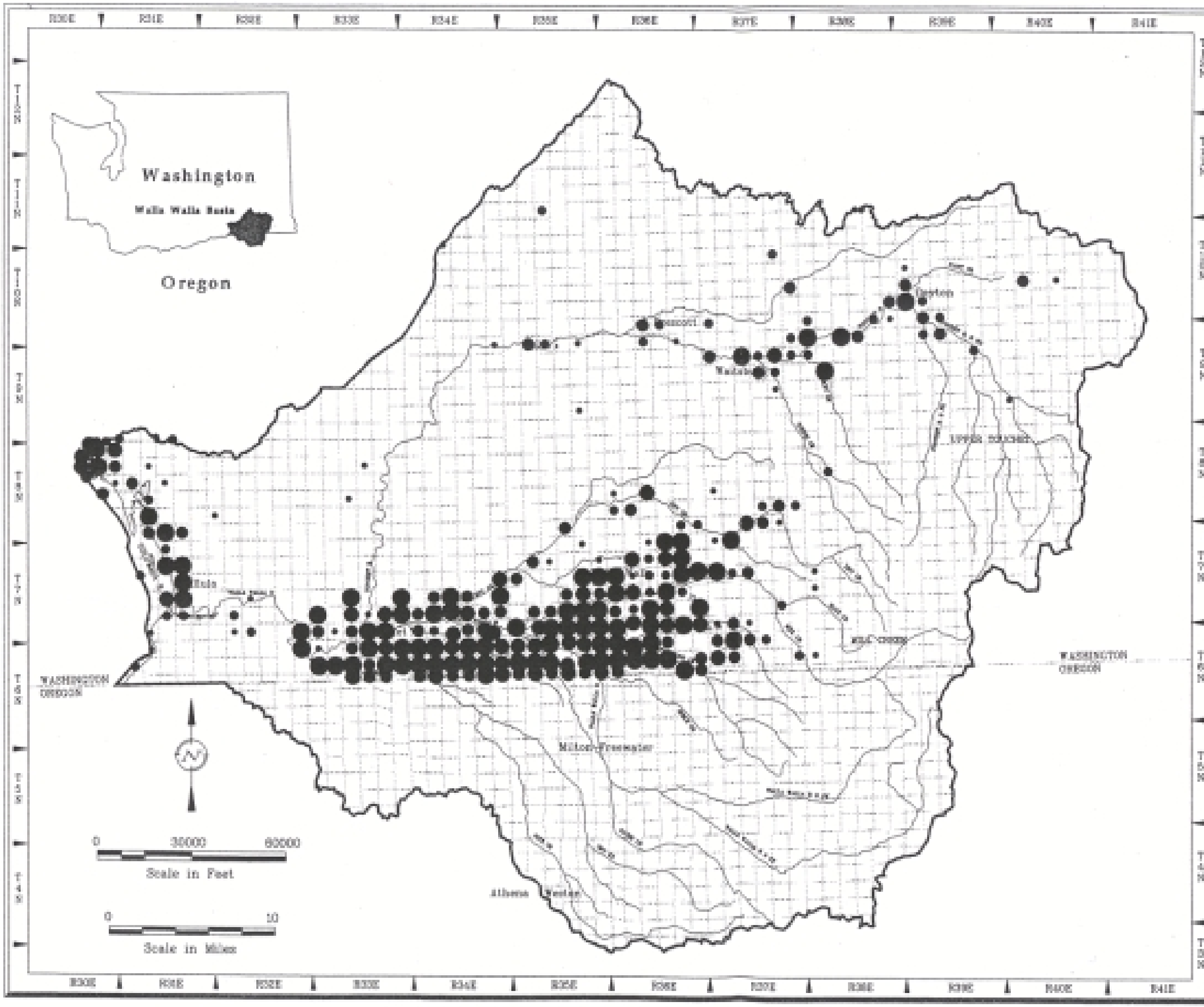


FIGURE 3-8

Distribution of Ground-Water Permits/Certificates

Initial Watershed Assessment Program
Walla Walla Basin

EXPLANATION

Aggregate Ground-Water Permits/Certificates
Maximum Annual Quantities by Section

- 0 acre-ft/yr
- 0 to 10 acre-ft/yr
- 10 to 100 acre-ft/yr
- 100 to 500 acre-ft/yr
- 500 to 1000 acre-ft/yr
- Greater Than 1000 acre-ft/yr

- Stream, Major
- Section Lines
- Walla Walla Basin Boundary

DATA SOURCES

Washington State Department of Ecology,
Water Resources Division

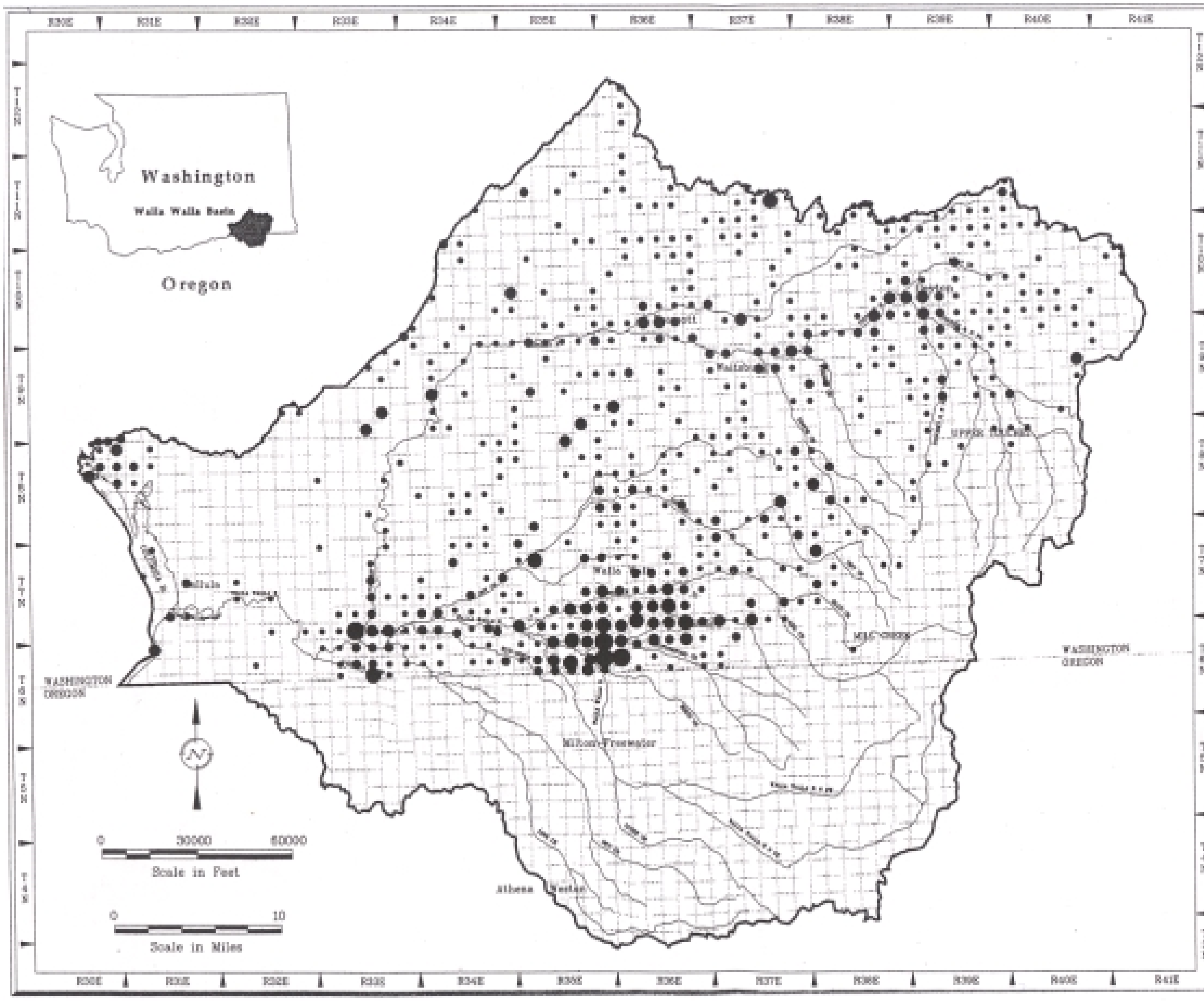


FIGURE 3-6

Distribution of Ground-Water Claims

Initial Watershed Assessment Program
Walla Walla Basin

EXPLANATION

Aggregate Ground-Water Claims
Maximum Annual Quantities by Section

- 0 acre-ft/yr
- 0 to 10 acre-ft/yr
- 10 to 100 acre-ft/yr
- 100 to 500 acre-ft/yr
- 500 to 1000 acre-ft/yr
- Greater Than 1000 acre-ft/yr

- Stream, Major
- Section Lines
- Walla Walla Basin Boundary

DATA SOURCES

Washington State Department of Ecology, Water Resources Division

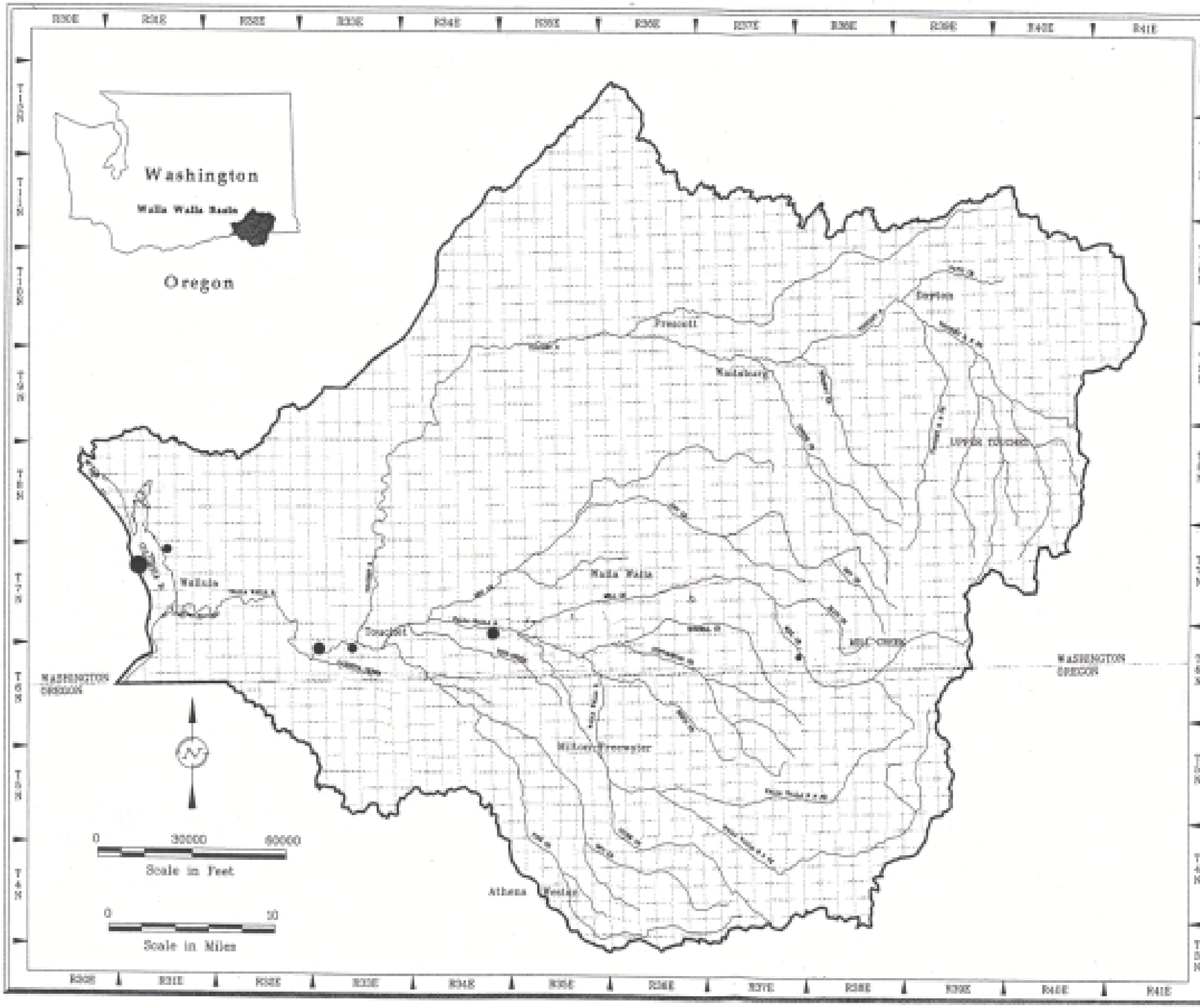


FIGURE 3-7

Distribution of Surface-Water Applications

Initial Watershed Assessment Program
Walla Walla Basin

EXPLANATION

Aggregate Surface-Water Applications
Instantaneous Quantities by Section

- 0 cfs
- 0 to 1 cfs
- 1 to 5 cfs
- 5 to 10 cfs
- 10 to 50 cfs
- Greater Than 50 cfs

- Stream, Major
- Section Lines
- Walla Walla Basin Boundary

DATA SOURCES

Washington State Department of Ecology,
Water Resources Division

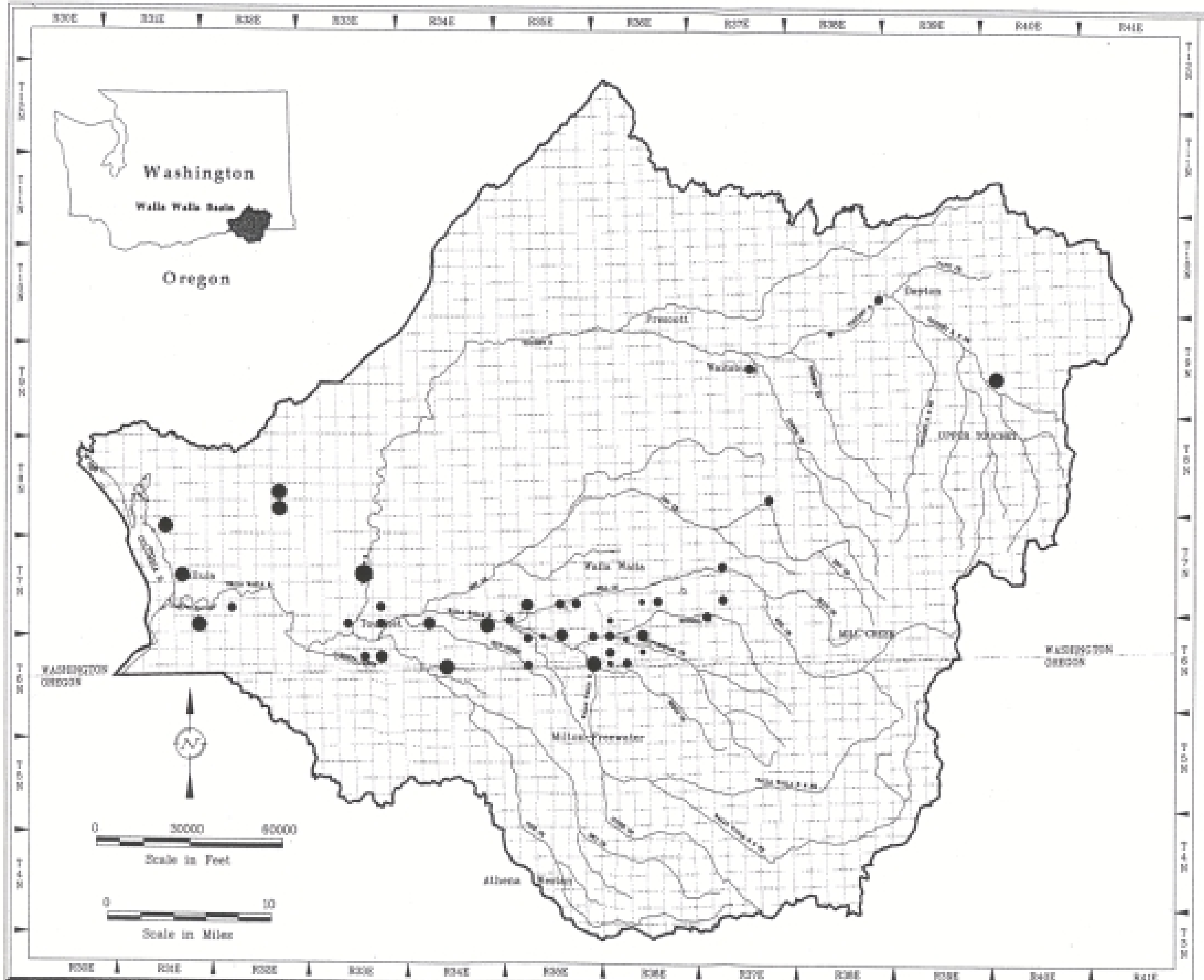


FIGURE 3-8

Distribution of Ground-Water Applications

Initial Watershed Assessment Program
Walla Walla Basin

EXPLANATION

Aggregate Ground-Water Applications
Instantaneous Quantities by Section

- 0 gpm
- 0 to 100 gpm
- 100 to 500 gpm
- 500 to 1000 gpm
- 1000 to 5000 gpm
- Greater Than 5000 gpm

- Stream, Major
- Section Lines
- Walla Walla Basin Boundary

DATA SOURCES

Washington State Department of Ecology,
Water Resources Division

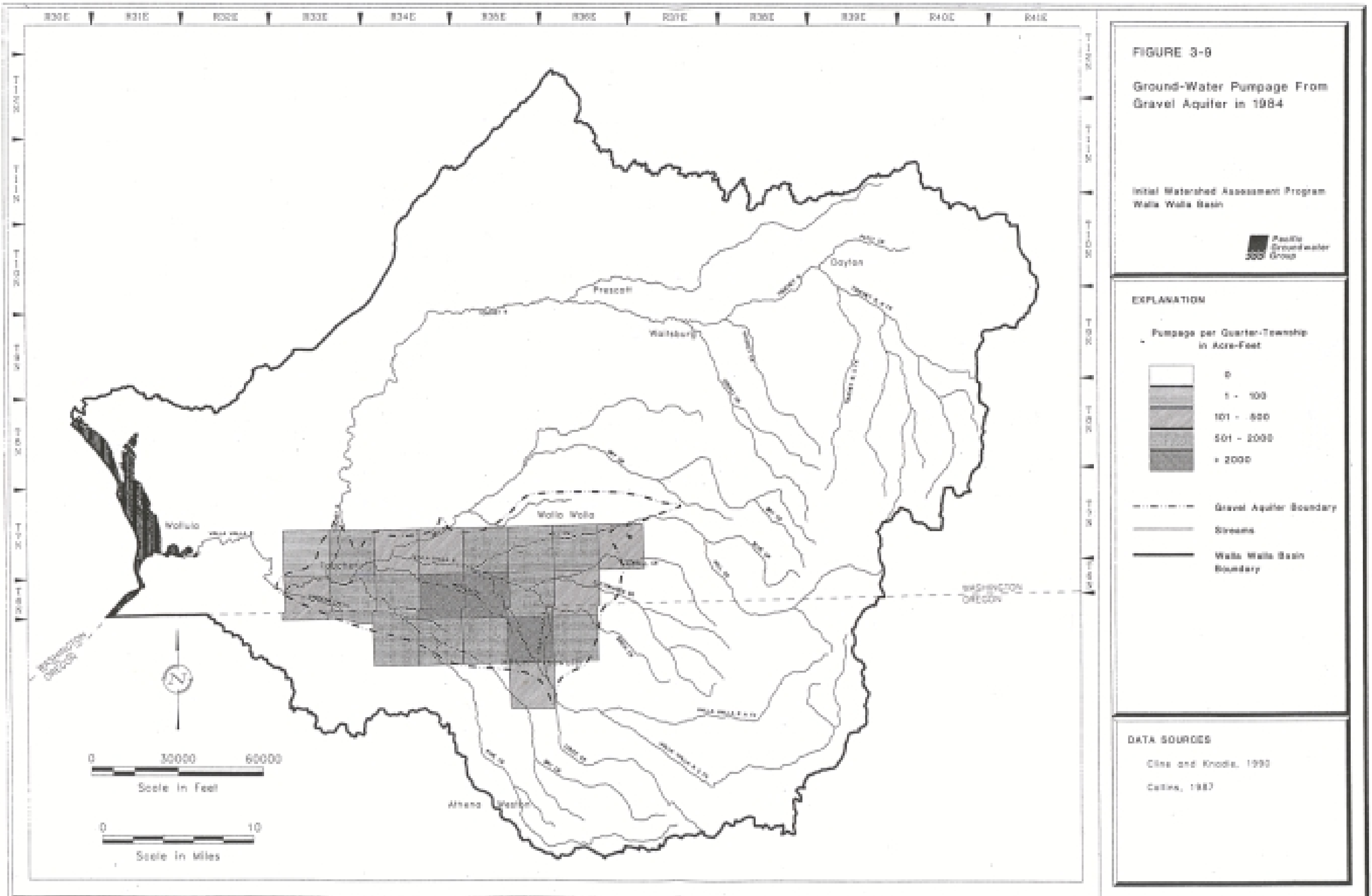


FIGURE 3-8

Ground-Water Pumpage From Gravel Aquifer in 1984

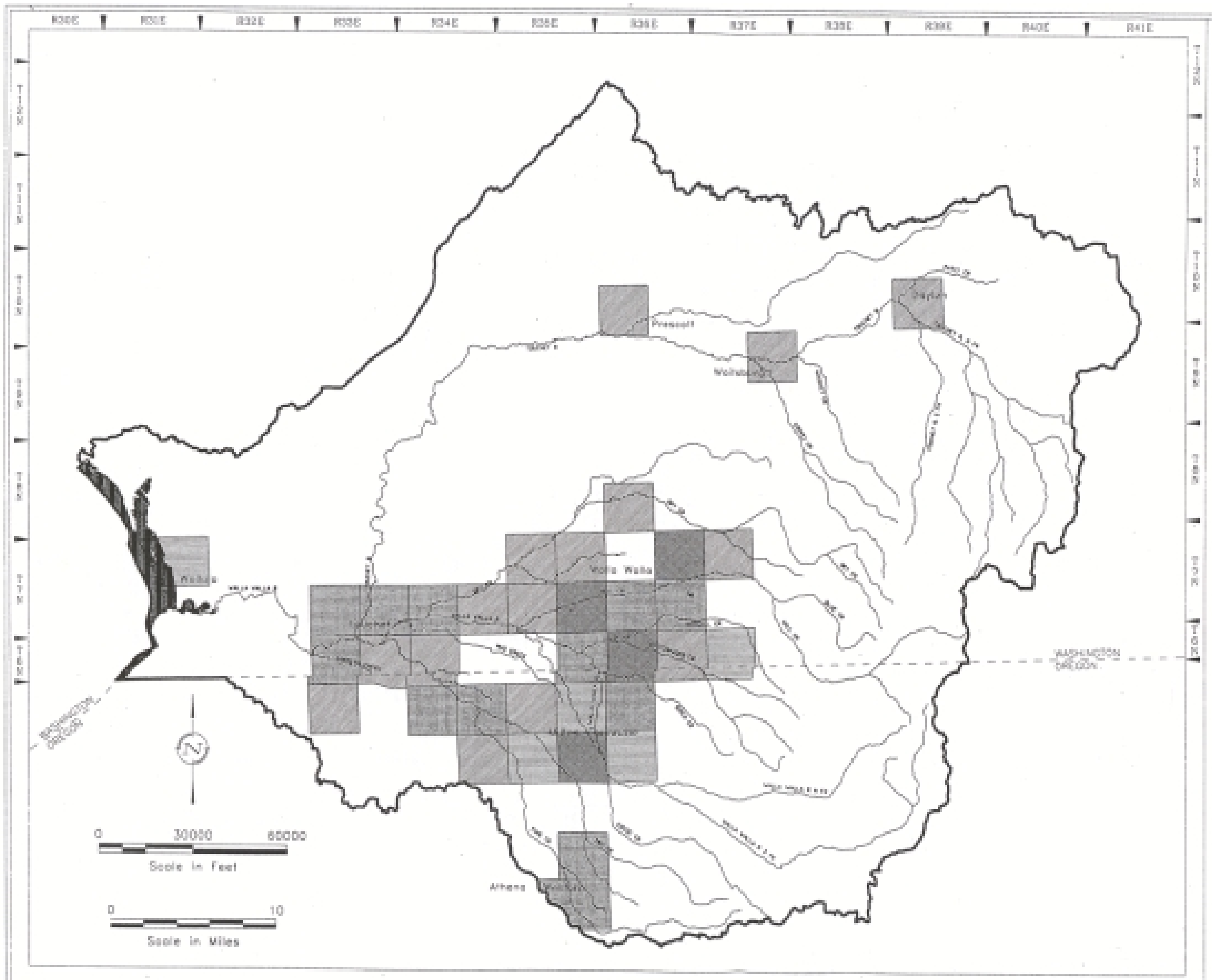


FIGURE 3-10

Ground-Water Pumpage From Basalt Aquifer in 1984

Initial Watershed Assessment Program
Walla Walla Basin

Pacific Groundwater Group

EXPLANATION

Pumpage per Quarter-Township in Acre-Feet

- 0
- 1 - 100
- 101 - 500
- 501 - 2000
- > 2000

Streams

Walla Walla Basin Boundary

DATA SOURCES

Cline and Knadle, 1990

Collins, 1987

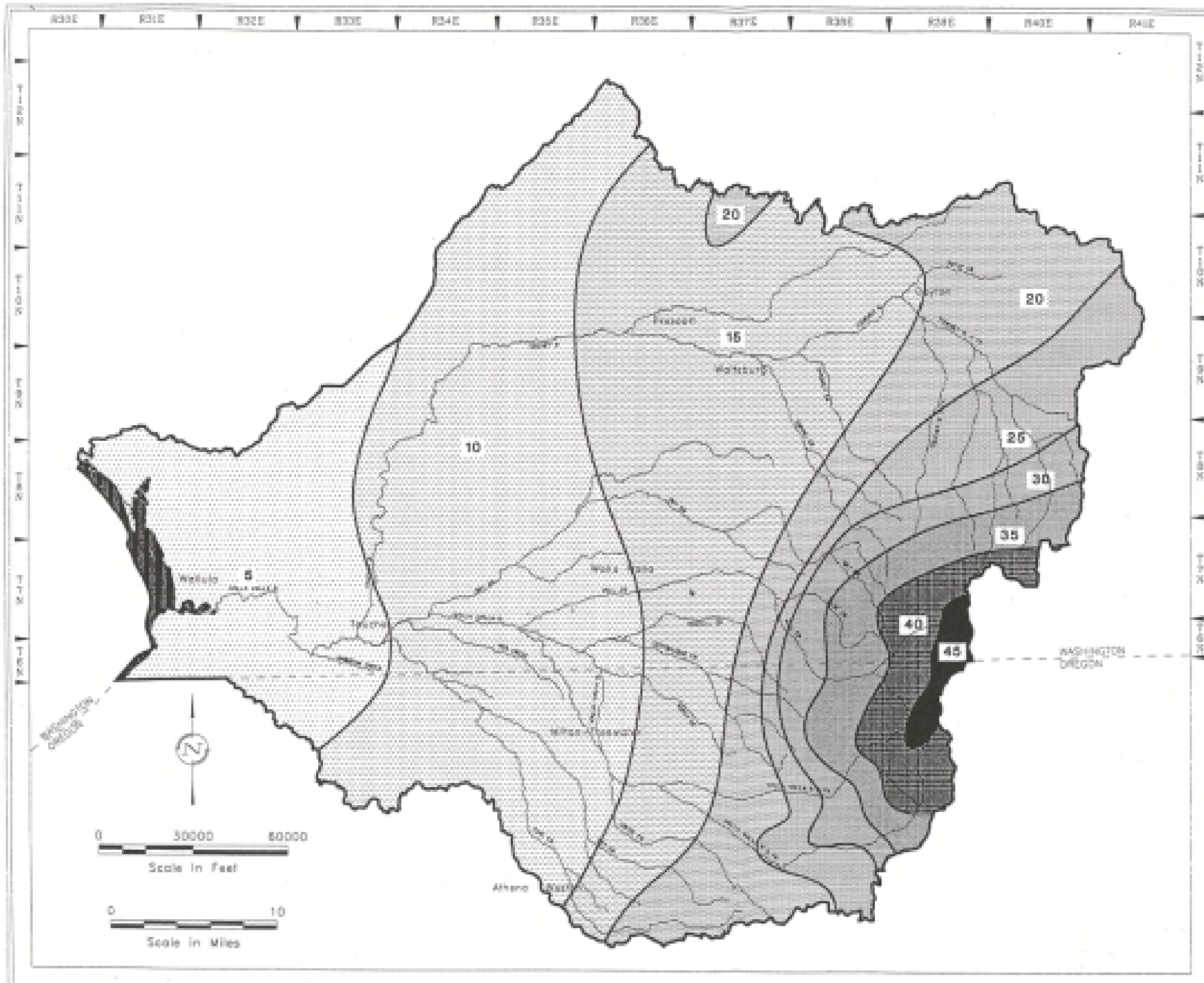


FIGURE 4-1

Spatial Distribution of Precipitation

Initial Watershed Assessment Program
Walla Walla Basin

Pacific Groundwater Group

EXPLANATION

Precipitation (inches)

5
10
15
20
25
30
35
40
45

Streams

Walla Walla Basin Boundary

DATA SOURCES

Washington State Department of Ecology

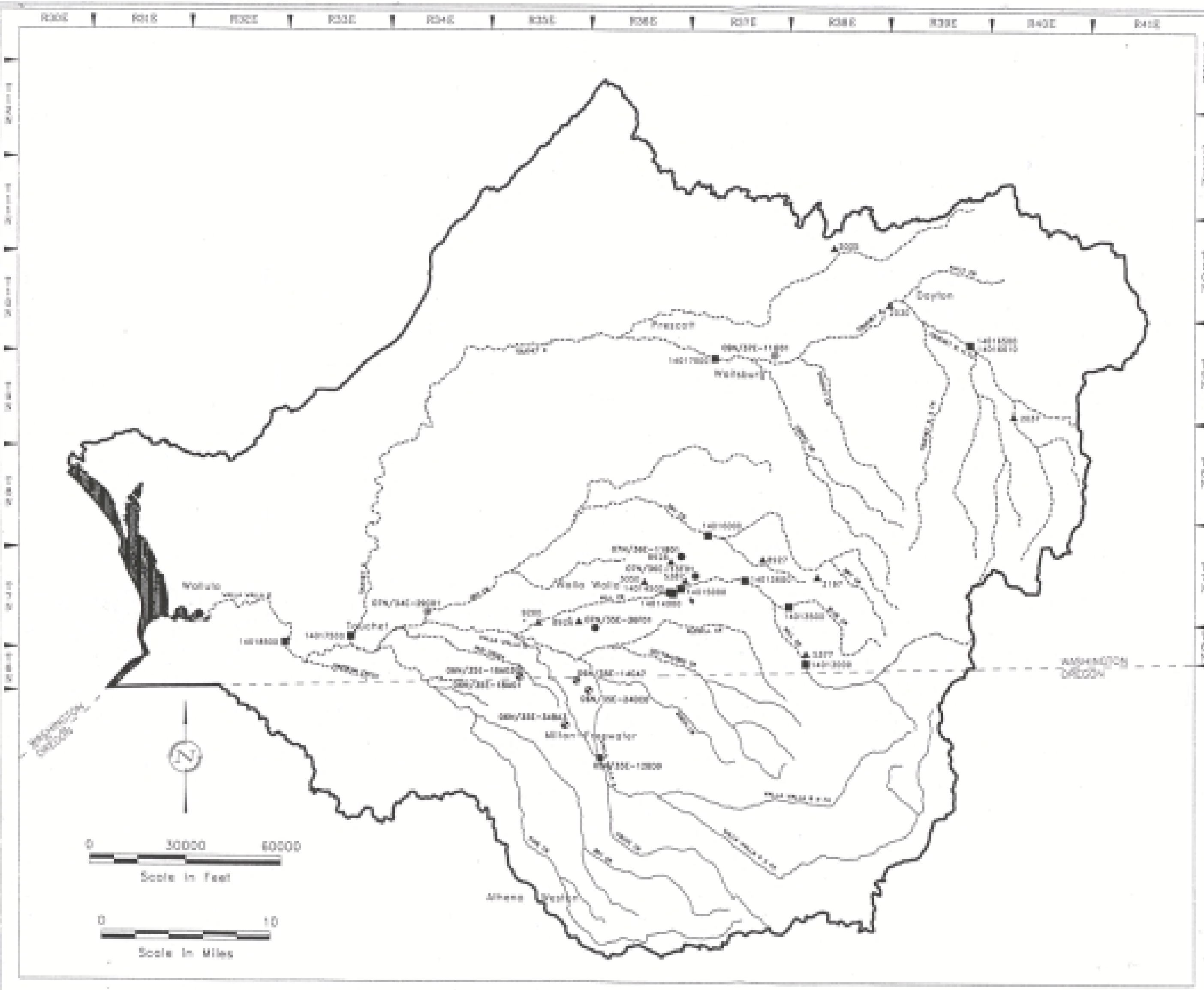


FIGURE 4-2

Monitoring Stations and Surface-Water Restrictions

Initial Watershed Assessment Program
Walla Walla Basin

Pacific Groundwater Group

EXPLANATION

Water-Level-Trend Locations

Gravel Aquifer

Basalt Aquifer - Pumping Centers

Basalt Aquifer - Outlying Areas

Stream Gages

Weather Stations

Stream Restrictions

Stream - No Restrictions

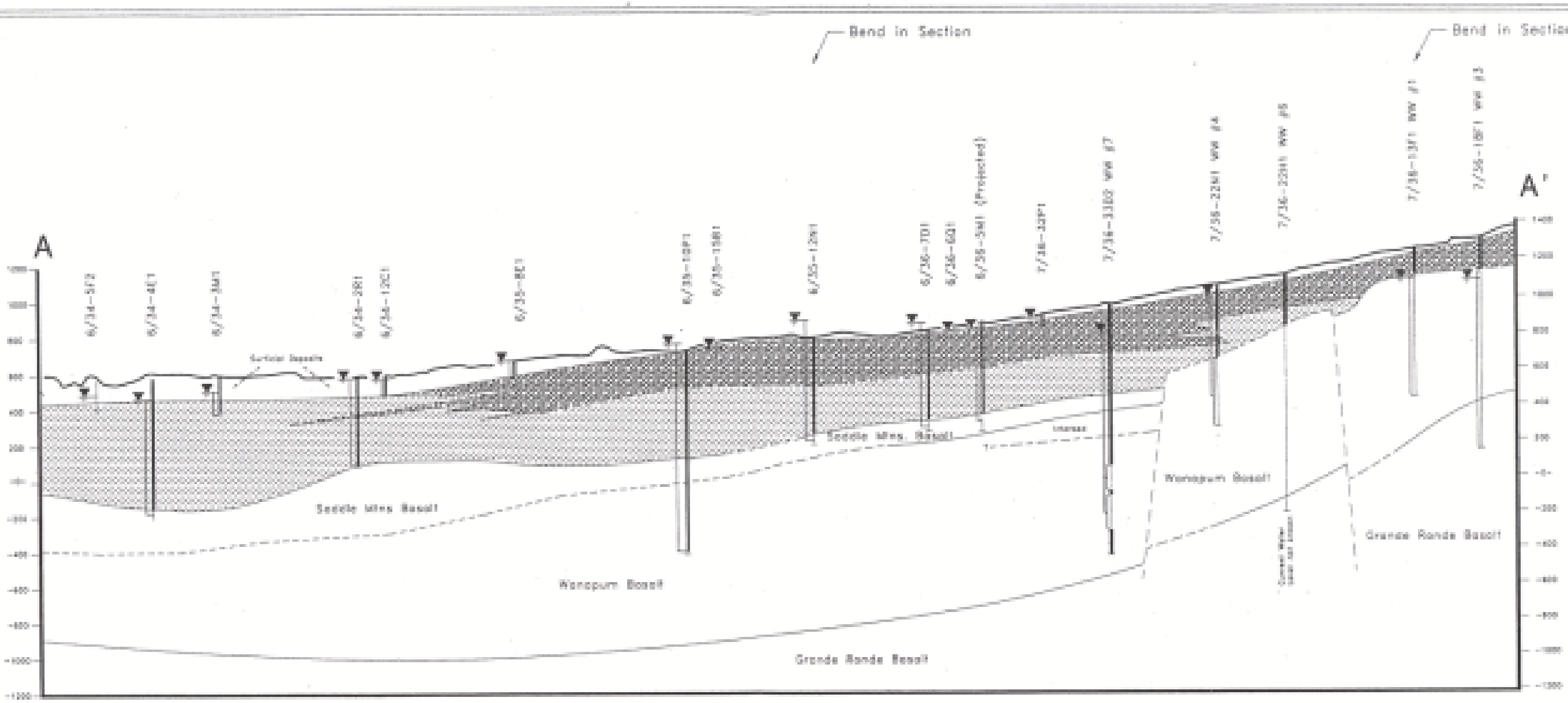
Surface Water Closure

Walla Walla Basin Boundary

DATA SOURCES

Washington State Department of Ecology

Pacific Groundwater Group, 1994



DATA SOURCES

Cross-Section
after Newcomb, 1965

Contacts within Basalt
after Drost and Whiteman, 1985

EXPLANATION

Surficial Deposits
Touchet Beds
Palouse Formation

Pleistocene Gravel

Pleistocene Clay

Miocene Basalt (with Interbeds)
Saddle Mountains Basalt
Wanapum Basalt
Grande Ronde Basalt

HORIZONTAL SCALE IN MILES

VERTICAL SCALE IN FEET

Local Well Number

Water Level (Current Data used for Walla Walla Wells)

Casing

Open Area

FIGURE 6-1

Hydrogeologic Cross-Section
A - A'

Initial Watershed Assessment Program
Walla Walla Basin

Pacific Groundwater Group

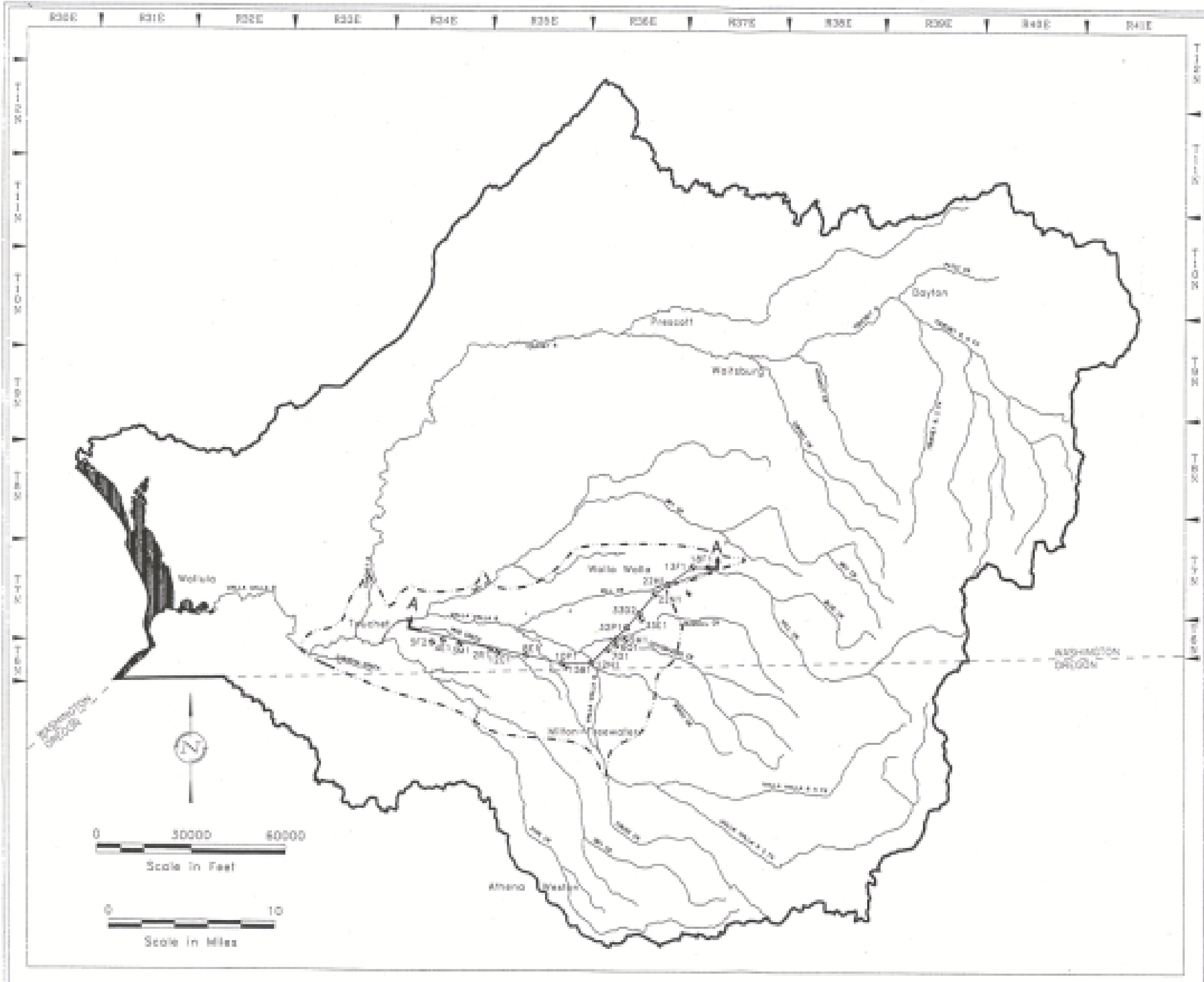


FIGURE 6-2

Cross-Section Location Map

Initial Watershed Assessment Program
Walla Walla Basin

Pacific Groundwater Group

EXPLANATION

Cross-Section Location
Wells Used in Cross-Section

Gravel Aquifer Boundary

Streams

Walla Walla Basin Boundary

DATA SOURCES

Pacific Groundwater Group, 1994

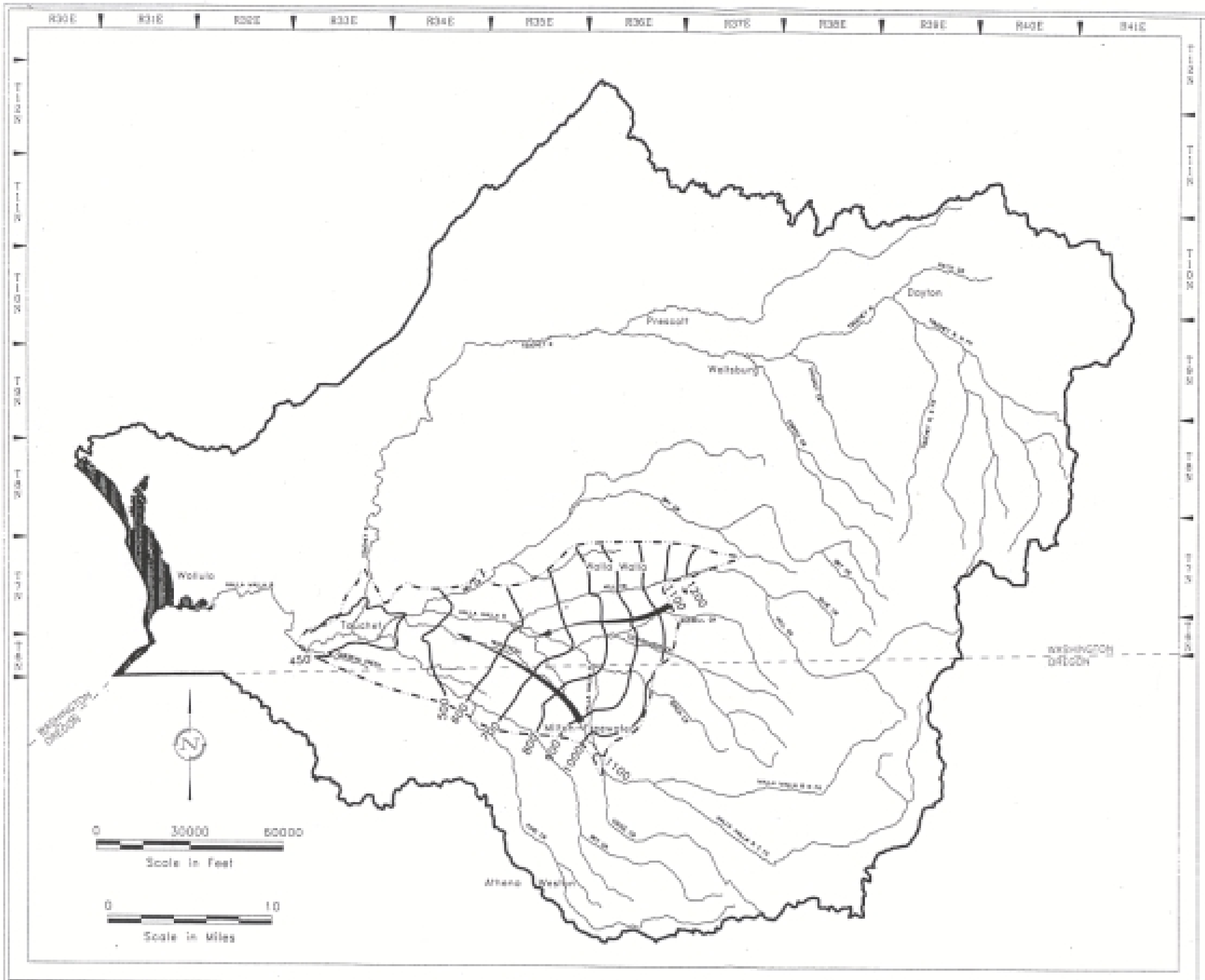


FIGURE 6-3

Ground-Water Level Contours For Gravel Aquifer

Initial Watershed Assessment Program
Walla Walla Basin

Pacific Groundwater Group

EXPLANATION

- 1000 — Water Table Elevation Contour Based on Average Conditions for Jan. 1969 - 1973
- Groundwater Flow Direction
- Gravel Aquifer Boundary
- Streams
- Walla Walla Basin Boundary

DATA SOURCES

Barker and MacNish, 1976

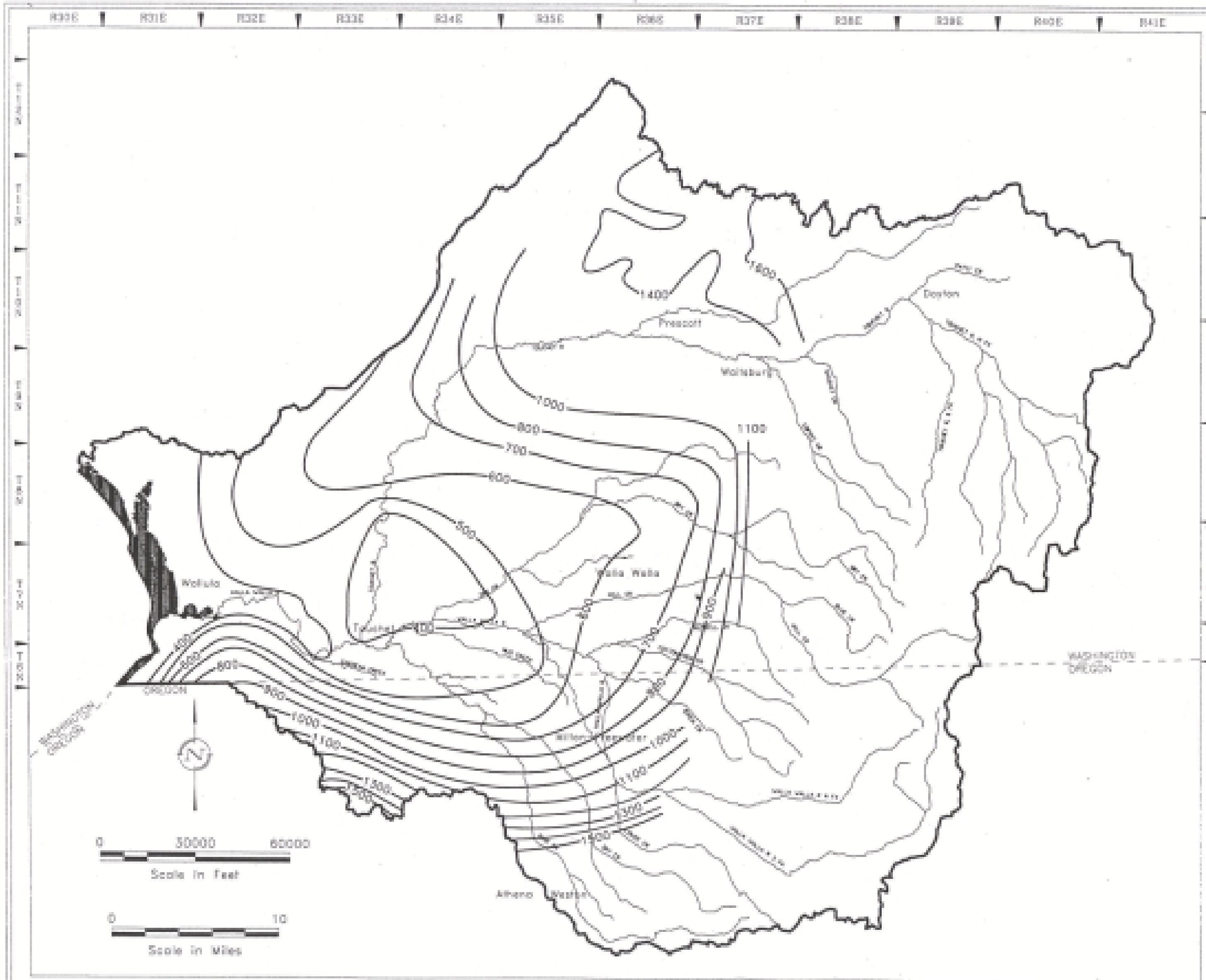


FIGURE 6-4

Ground-Water Level Contours for Basalt Aquifer

Initial Watershed Assessment Program
Walla Walla Basin

Pacific Groundwater Group

EXPLANATION

1000 — Water Table Elevation Contour Based on Average Conditions for Spring 1985

Groundwater Flow Direction

Streams

Walla Walla Basin Boundary

DATA SOURCES

Ground Water Levels, Spring 1985..., Sheet 3 of 4, R.C. Lane and J. Whiteman, U.S. Geological Survey, 1989

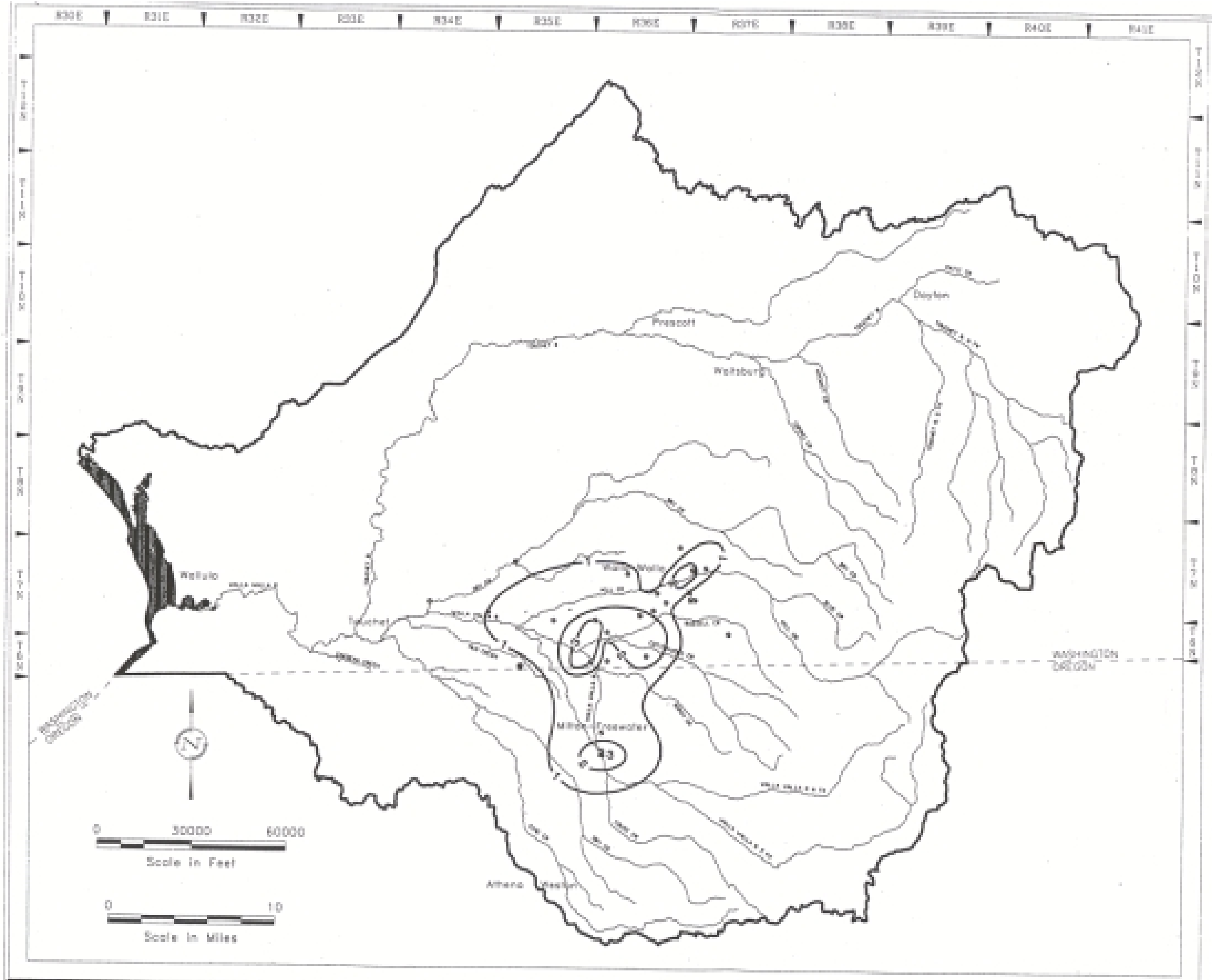


FIGURE 6-8

Rate of Water-Level Decline Contour Map for Basalt Aquifer Since 1972

Initial Watershed Assessment Program
Walla Walla Basin

Pacific Groundwater Group

EXPLANATION

Rate of Water-Level Decline (ft/yr)

Well Used for Contouring

Streams

Walla Walla Basin Boundary

DATA SOURCES

Pacific Groundwater Group, 1994
U.S. Geological Survey
Washington State Department of Ecology
Walla Walla County Health Department

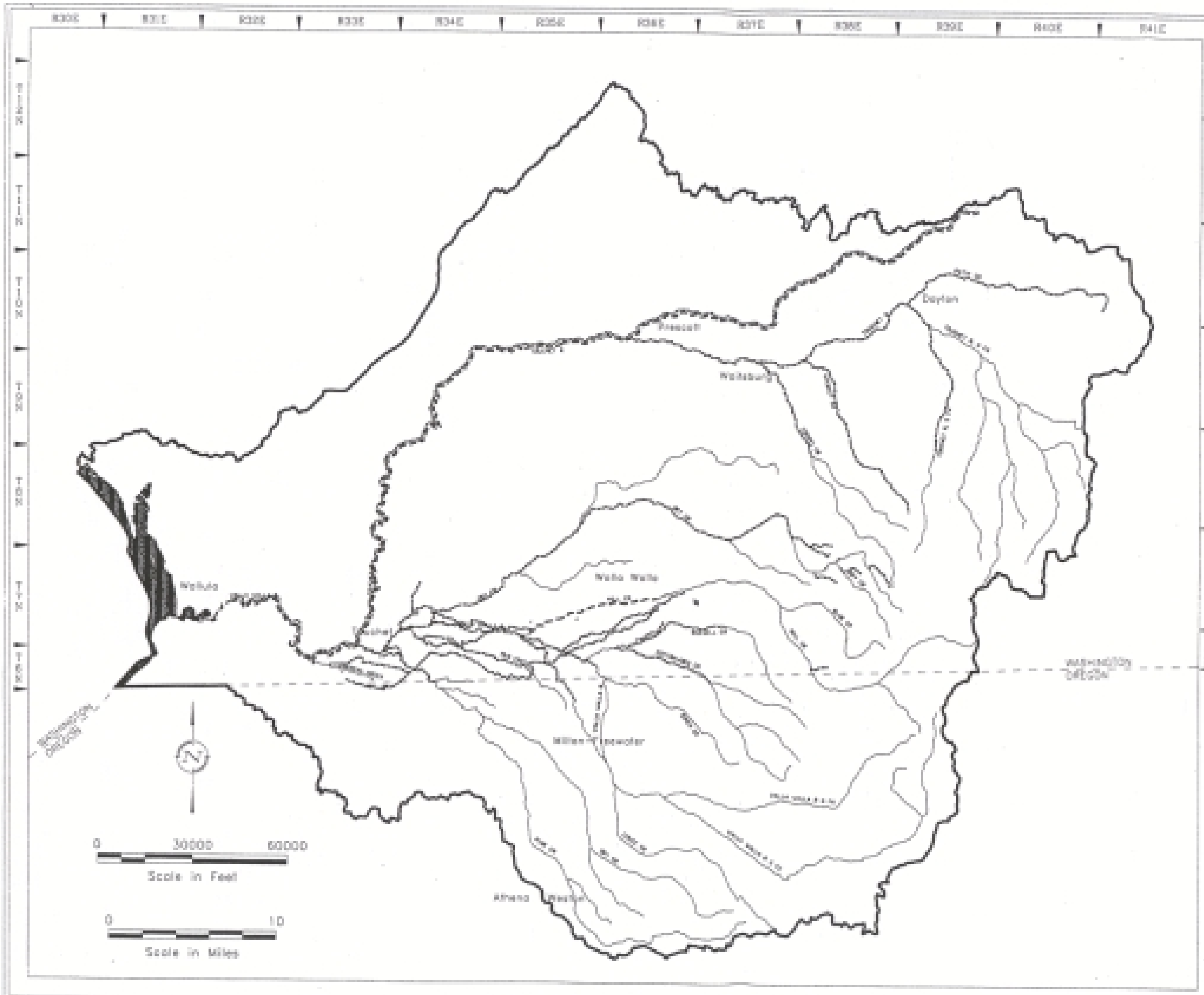


FIGURE 7-1

Water-Quality Limited Segments of the Walla Walla Basin

Initial Watershed Assessment Program
Walla Walla Basin

Pacific Groundwater Group

EXPLANATION

303(d) Water Quality Limited Water Bodies

Factors Present and are Annually Impacting Fish Populations

Streams

Walla Walla Basin Boundary

DATA SOURCES

Washington State Department of Ecology, Water Resources Division, 303(d) List