Appendix B

Water Supply Technical Report Supplement

Water Supply Technical Report Supplement
MountainStar MPR and Cle Elum UGA

Trendwest Properties: Cle Elum UGA Final EIS

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Exhibits

1. INTRODUCTION

Trendwest Resorts, Inc. (Trendwest) owns approximately 7,400 acres of land between the cities of Cle Elum and Roslyn in unincorporated Kittitas County, Washington. Trendwest proposes to develop approximately 1,100 acres of the Trendwest property located in the City of Cle Elum's Urban Growth Area (UGA) as a master planned community, consistent with the goals and requirements for UGAs under the Washington State Growth Management Act (RCW 36.70A). Trendwest has received approval from Kittitas County to develop the remainder of the property, located outside the City of Cle Elum's UGA, as the MountainStar Master Planned Resort (MPR). Trendwest has developed a water supply strategy for the proposed development that relies on transfers of existing water rights. The Cle Elum UGA water supply strategy is similar in many respects to Trendwest's strategy to provide water for the MountainStar Master Planned Resort. The proposed MPR was the subject of a separate EIS published by Kittitas County in June 2000. The cumulative impacts of both projects are described in this report and in the UGA EIS for which this report was prepared. The water supply strategy for each project is described below.

Trendwest is proposing to develop property it owns within the City of Cle Elum's UGA, separate from the MPR. Trendwest's UGA proposal involves the development of a variety of single-family and multi-family residential units; a business campus; and community and recreation facilities. The UGA Draft Environmental Impact Statement (EIS) considered three development alternatives (referred to in the document as Alternatives 2, 3 and 4) and a no action alternative, referred to in the document as "Alternative 1." All three development alternatives included an 18-hole golf course and related facilities. Alternatives 2 and 4 also included development of the Washington State Horse Park, a multiple-use, national class equestrian facility. Trendwest agreed to set aside property under all three development alternatives for a Community Recreation Center, the City of Cle Elum's water treatment plant, and for future expansions of the School District No. 404 campus and Laurel Hill Memorial Park Cemetery.

Following publication of the Draft EIS in March 2001, Trendwest redesigned its proposal in response to public comment and submitted a Master Site Plan Application to the City of Cle Elum in August 2001 for a fourth development alternative (Alternative 5). Alternative 5 has been designed to result in a level of environmental impact that falls within the range of impacts evaluated in the Draft EIS; as such, no new significant impacts are anticipated and the analysis of Alternative 5 is evaluated in the Final EIS. The primary differences between Alternative 2 and Alternative 5 are that Alternative 5 does not include seasonal/visitor accommodations, a golf course, or the Washington State Horse Park. Alternative 5 features permanent residential housing, and expands the area of natural open space that would be dedicated as the Cle Elum River corridor.

1.1 PROJECT ENVIRONMENTAL REVIEW

The City of Cle Elum has assumed lead agency status for purposes of compliance with the State Environmental Policy Act (SEPA). Cle Elum is preparing an EIS on the Trendwest development proposal and for adoption of a Subarea Plan and zoning regulations for the UGA, as required under the SEPA and the City of Cle Elum's SEPA ordinance. The City published a Draft EIS in March 2001. The City invited public comment through May 7, 2001.

In December 2000 Trendwest entered a Cost Reimbursement Contract under RCW 90.03.265 with the Washington Department of Ecology (Ecology) for the purpose of conducting additional environmental review and processing of the Trendwest's water right transfer applications. In accordance with implementing regulations, Ecology retained the consultant team of Pacific Groundwater Group (PGG), Montgomery Water Group (MWG) and Parametrix as technical consultants under this Contract (collectively referred to as the Ecology Consultant Team, or ECT). Over the course of the last year, Trendwest and the City of Cle Elum have worked with Ecology and ECT to conduct additional environmental review of the Trendwest water transfer proposals. Initially, Ecology intended to produce and adopt a Supplemental EIS to the Kittitas County Final EIS for the MPR to evaluate the Trendwest water transfers. In November 2001, however, Ecology agreed instead to provide ECT's work product to the City to be incorporated into the City's Final EIS.

Trendwest is requesting that Kittitas County prepare an Addendum to the MPR Final EIS to disclose additional information on specific water-related aspects of the MPR proposal. Finally, Trendwest is requesting that Ecology and the Kittitas County Water Conservancy Board (KCWCB) use the City of Cle Elum's EIS and the Addendum to the Final EIS for purpose of SEPA compliance for water rights transfer applications Trendwest has filed in connection with both the UGA and MPR projects.

1.2 PURPOSE FOR TECHNICAL REPORT SUPPLEMENT

The purpose of this supplement is to respond to comments received on the UGA Draft EIS and to provide additional environmental review for Trendwest's proposed water rights transfers. This analysis reflects additional 2001 streamflow monitoring and detailed analysis of hydraulic and hydrogeologic conditions in the subbasins where Trendwest's tributary water rights are located.

1.3 STATUS OF WATER SUPPLY PERMITTING

At Ecology's direction, and as required under RCW 90.03.280, Trendwest published public notice of all of its water rights transfer applications in newspapers in Kittitas and Yakima counties. The public notices for the MPR were originally published in the Ellensburg Daily Record, the Northern Kittitas County Tribune and the Yakima Herald. The notices invited public comment on the applications through October 30, 2000

On October 8, 2001, Trendwest filed six separate water right transfer applications with the KCWCB, three to supply water for residential development within the UGA and three to supply water to the MPR. Public notices for the mainstem water rights were published by the KCWCB in the Ellensburg Daily Record and the Northern Kittitas County Tribune on November 8 and 15, 2001, and republished on December 20 and 27, 2001, inviting public comment through January 28, 2002. At Ecology's direction, Trendwest published public notices for 22 water right transfer applications for its tributary water rights, proposing to change the purpose of use of its tributary water rights from irrigation and stockwater to instream flows. The pubic notices invited public comment through December 17, 2001. Eleven of the tributary water right applications were made to offset consumptive uses within the UGA and eleven applications were made to offset consumptive uses within the MPR. The KCWCB will conduct a general investigation of the mainstem water rights transfer applications, creating a record for Ecology's review and approval. Ecology will conduct a general investigation of the tributary transfer applications. Both agencies will consider public comments prior to making any decisions on the applications.

2. PROPOSED ACTION AND ALTERNATIVES

2.1 DESCRIPTION OF DEVELOPMENT PROPOSALS

2.1.1 Urban Growth Area

This Water Supply Technical Report Supplement considers the impacts of Alternative 5 (reflecting the Master Site Plan Application). A summary of the dwelling units (d.u.) and other development activities is shown in Table 2-1.

Table 2-1: Cle Elum UGA Development Activities Summary

Land Use	Alternative 5[1]
Residential Uses	
Single Family Residential	810 d.u.
Multifamily Residential	524 d.u.
Subtotal, Residential Uses	1,334 d.u.
Commercial Uses	
Business Park	950,000 square feet
Irrigation Uses	
Miscellaneous irrigation	30.0 acres
Subtotal, Irrigation Uses	30.0 acres

1 Miscellaneous irrigation uses in Alternative 5 include public areas and residential irrigation.
Source: Trendwest 2001.

Water demands for the UGA are calculated in terms of total diversion requirements, total return flows, and net water requirements. The total annual diversion requirement for Alternative 5 is 500.1 acre-feet (ac-ft). Of this total diversion, approximately 370.9 ac-ft represents a return flow to the Cle Elum and Yakima Rivers, either as infiltration from irrigation practices, system losses, or as wastewater. The peak instantaneous demand is approximately 1.6 cubic feet per second (cfs) and occurs in July. Annual water demands for UGA Alternative 5 are summarized in Table 2-2.

2.1.2 MountainStar Master Planned Resort

Trendwest is proposing to develop the MountainStar MPR on 6,225 acres west of the Cle Elum UGA property, consistent with the Conceptual Master Plan submitted to Kittitas County in September 2000. The MPR will include a wide variety of visitor accommodations and resort amenities, located in a Resort Center and in satellite facilities located throughout the property. Trendwest's plans for the MountainStar Resort include development of two championship golf courses. Both will be located in the area east of the Cle Elum River. Both golf courses probably will include practice facilities, including putting greens and driving ranges.

Table 2-2: Cle Elum UGA Annual Water Requirements

Element	Alternative 5
Diversion Demands (ac-ft)	
Treated non-irrigation	358.7
Treated irrigation	70.6
Untreated irrigation	25.3
Misc. uses and losses	45.5
Total Diversion	500.1 ac-ft
Return Flows (ac-ft)	
Wastewater flows	301.1
Treated irrigation	24.7
Untreated irrigation	1.0
Irrigation, misc. uses and losses	44.1
Total Return Flows	370.9 ac-ft
Net Water Requirement (ac-ft)	129.2 ac-ft
Peak Instantaneous Demands (cfs) (July)	
Treated	1.4
Untreated	0.1
Total normal peak	1.6
Untreated emergency storage makeup	0.0
Total Normal + Makeup	1.6 cfs

Source: W&H Pacific 2001.

The MountainStar Resort will be opened for development in three primary phases, with each phase likely developed in sub-phases over a projected 30-year buildout period. The first year of buildout will correspond with development proposed for Phase 1, which includes the golf courses and Resort Center. The primary features of the Resort Center will be a 300-room overnight lodge, numerous shops and restaurants, a health spa, and a conference center. Construction in Phases 2 and 3 will be scheduled in response to market conditions. Each subsequent phase after Phase 1 may be started even though full buildout has not yet been completed in prior phases. Later resort phases will include overnight lodging, an equestrian center and other amenities.

MountainStar Resort will feature a variety of visitor accommodations, including timeshare and individually owned condominiums, clustered chalet home sites, and larger vacation lots. The Development Agreement and MPR Permit approved by the County for the MPR authorize Trendwest to develop 4,650 accommodation units. However, consistent with the terms of the recent settlement agreement with RIDGE (see discussion in Section 2.4), Trendwest has agreed to reduce the number of units constructed to 3,785. The dwelling units in the Reduced Density MPR are shown in Table 2-3.

Water demands for the MPR are calculated in terms of total diversion requirements, total return flows, and net water requirements (consumptive use). The Reduced Density MPR results in a total diversion requirement of approximately 2,472 ac-ft. Return flows to the Yakima River, either as infiltration from irrigation practices, system losses, or as wastewater from the planned Regional Wastewater Treatment Plant, are approximately 1,490 ac-ft. Consumptive use is approximately 982 ac-ft each year. The peak instantaneous diversion demand for the project is approximately 9.5 cfs. Annual water demands for the MountainStar Resort with reduced densities as agreed to by Trendwest, are shown in Table 2-4.

Table 2-3: MountainStar Resort Development Activities Summary

Land Use	Reduced Density
Domestic Uses	
Single-family resort residential	2,695 d.u.
Resort condominiums	790 d.u.
Subtotal/Domestic Uses	3,485 d.u.
Commercial Uses	
Hotel/Lodge Rooms	300 rooms
Retail & Commercial Building Area	100,000 square feet
Irrigation Uses	
Golf course	273 ac.
Miscellaneous irrigation[1]	74 ac.
Subtotal/Irrigation Uses	347 ac.

1 Miscellaneous irrigation uses include landscaping in residential and commercial areas.
Source: Trendwest 2001.

Table 2-4: MountainStar Resort Annual Water Requirements

Water Demand Element	Reduced Density
Diversion Demands (ac-ft)	
Treated non-irrigation	1,335.8
Treated irrigation	162.0
Untreated irrigation	749.4
Misc. uses and losses	224.7
Total Diversion	2,471.9 ac-ft
Return Flows (ac-ft)	
Wastewater flows	1,098.2
Treated irrigation	55.2
Untreated irrigation	118.8
Misc. uses and losses	218.0
Total Return Flows	1,490.1 ac-ft
Net Water Requirement (consumptive use) (ac-ft)	981.7 ac-ft
Peak Instantaneous Demands (cfs)	
Treated	4.4
Untreated	4.2
Total normal peak	8.6
Untreated emergency storage makeup	0.8
Total Normal + Makeup	9.5 cfs

Source: W&H Pacific 2001.

2.2 WATER SUPPLY AND FACILITIES FRAMEWORK

Trendwest proposes to transfer its Yakima River water rights so that they may be exercised for beneficial uses within the MPR and UGA. Trendwest has filed water transfer applications with Ecology andthe KCWCB. The applications filed with the KCWCB seek to transfer Trendwest's three mainstem Yakima River irrigation and stock water rights from their current place of use near Ellensburg to diversions year-around at the City of Cle Elum's Yakima and Cle Elum River water supply diversion works. The three mainstem water rights have six water rights transfer applications pending, three of which would serve the MPR and three would serve the UGA. A portion of each of Trendwest's three mainstem water rights would provide for recreation, irrigation, and domestic beneficial uses within the MPR and a portion of each of its three mainstem water rights would provide for municipal supply purposes within the City of Cle Elum. Trendwest has also filed applications with Ecology to transfer Trendwest's 11 tributary water rights to instream flows. These 11 rights have 22 water rights transfer applications pending, 11 of which would serve to offset consumptive uses on the MPR and 11 which would serve to offset consumptive uses within the UGA. The tributary water rights could be conveyed to Ecology under RCW 90.38, or could be retained by Trendwest as private instream flows. Nearly all of the mainstem and tributary water rights proposed for transfer are seasonal irrigation rights, although a portion of some water rights are authorized for use for year-around stock watering. All of the proposed transfers would require changes in purpose and place of use; additionally, transfer of the mainstem rights would also require a change in the season of use and points of diversion

At full buildout, the consumptive uses associated with Trendwest's tributary water rights and Trendwest's Yakima River water rights combined exceed the cumulative consumptive use from these two projects by approximately 541 to 684 ac-ft. A water balance comparing water supplies and consumptive uses for the two projects is shown in Table 2-5.

The City of Cle Elum is developing a regional water supply system to serve the needs for the City and its UGA and the Town of South Cle Elum, as well as provide water to the MPR. The City of Cle Elum is in the process of establishing new surface water supply diversion works at one location each on the Cle Elum River and the Yakima River. The new Yakima River intake will be the primary source of supply, with the new Cle Elum River intake also functioning as a source of supply. The Yakima and Cle Elum Rivers in the area of Cle Elum's existing diversion works were evaluated, and both require modifications to work satisfactorily under present standards (Geomax 2002 *Yakima/Cle Elum River Study Final Report*). The changes to the new diversion works include: (1) moving the Yakima River diversion works directly downstream of the existing intake, and utilizing the new pipelines located in the Yakima River bed that were installed during emergency stabilization work involving the South Cle Elum bridge over the Yakima River; and, (2) moving the Cle Elum River diversion works approximately 4.9 miles downstream to the vicinity of the Bullfrog Pond area. Both diversion works will include appropriate fish screens. The new Cle Elum River diversion works will function as a source of supply for Trendwest's water uses when Cle Elum River flows exceed a specified amount, to be determined annually by the USBR and the System Operations Advisory Committee (SOAC). Water transmission lines will connect the two intakes to a new water treatment facility located on property provided by Trendwest in the UGA. The City will own and operate the diversion works and the new water treatment facility.

At present, the City relies on two sources for its municipal supply: (1) a water right owned by the City with a priority date of June 30, 1896 (confirmed by a Conditional Final Order in State v. Acquavella, and thereafter modified by Ecology in 2001) in the amount of up to 1,100 ac-ft per year and 3 cfs from the Cle Elum and Yakima Rivers; and (2) a series of water supply agreements with the USBR, beginning in 1932, for a municipal supply derived from the Yakima River system of up to 2,170 ac-ft per year and 3 cfs (based on water rights of the United States). In conjunction with the processing its claims in the Acquavella water rights adjudication, the City is now negotiating the latest in the series of USBR water supply agreements. In the context of the Acquavella proceeding, the maximum to be withdrawn by the City pursuant to its 1896 priority right and the USBR agreement is 2,375 ac-ft per year. The yearly amounts of the City's water use have ranged between 3,100 ac-ft per year to 800 ac-ft per year. The latter amount is based on most recent withdrawal experience after the upgrading of the water supply facilities and has yet to be verified in light of longer-term experience.

Table 2-5: Trendwest's Average Annual Consumptive Use and Supply Balance for Direct Uses, in Ac-Ft

Net Consumptive Use[1]		Available Water Supply[2]		
Direct Consumptive Use		Water Rights	Most Probable Lower Range[3]	Most Probable Upper Range[3]
		Tributary Water Rights		
Reduced Density MPR	981.7	Big Creek	124.7	126.5
UGA Alt. 5 (Residential)	129.2	Teanaway River	349.9	351.8
Direct Subtotal	1,110.9	Swauk Creek	366.8	486.6
		Tributaries Subtotal	841.4	965.0
		Mainstem Water Rights		
		Yakima River	811.1	830.2
		Mainstem Subtotal	811.1	830.2
		Total Supply	1,652.5	1,795.2
Average Net Water Supply Likely Range			541.3	684.3

1 Net consumptive use is the difference between total diversions and total return flows per year. Refer to Section 3.16, Utilities, and to Appendix E of the Final EIS for a detailed discussion of the derivation of water demand. Total diversion requirements are summarized in Appendix B, Exhibit E.
The return flows are described in Section 3.16 and summarized in Exhibit E., However monthly return flows shown in Exhibit E that would travel subsurface back to the Cle Elum and Yakima Rivers were time delayed and "smoothed" (attenuated) through time. The methods for calculating the groundwater-routed return flows are described in Exhibit F.

2 Water supply under Trendwest water rights shown reflects water availability under long term average year conditions calculated as part of the water balance model described in Section 4.1.

3 Long-term, average year, water supply availability would most likely occur within the range shown in these two columns, calculated from data in Tables B.1 and B.3 in Exhibit B.

Source: Brown & Caldwell 2002; W&H Pacific 2001.

2.2.1 Urban Growth Area

The City of Cle Elum would supply water for the Business Park, the Community Recreation Center, and the the school and cemetary expansion areaswithin the UGA from its Yakima River system existing water rights or water supply bases. These UGA uses are hereafter referred to as "non-residential" UGA uses. These are distinguished from all other UGA uses, which are hereafter referred to as "residential." Water users within the UGA residential development would become customers of the City's water utility and receive water service from the City of Cle Elum. Property within the UGA would be included within the City's water supply service area. Under the terms of the City's recently adopted Water Supply Policy, Trendwest and the City have executed a water supply agreement under which Trendwest will convey water rights to the City associated with Trendwest's residential development activities in the UGA. Upon Ecology's final approval of the transfer applications, Trendwest would convey approximately one third of its mainstem water rights to the City of Cle Elum for municipal use within the UGA. The Trendwest water rights would be added to the City's existing municipal water supplies and would provide a year-round water supply for new customers within the UGA in an amount equal to the quantity of the Trendwest water rights that were conveyed to Cle Elum for municipal use applied to the residential portion of the UGA, pursuant to the aforementioned agreement.

In accordance with the City of Cle Elum's adopted water policy for the UGA, the City would initially issue certificates of water availability for the project based on the water use rate set forth in the City's Comprehensive Water Plan (October 1997), which is currently 610 gallons per ERU. Cle Elum would monitor the use of both the City's current water customers and new UGA customers so that, when appropriate, adjustments may be made to the ERU average daily demand in the future. The Washington State Department of Health (DOH) design criteria require a minimum of three years of historical consumption data be used to establish ERU average demand. Consequently, the intent of the City would be to re-examine Trendwest's estimated demands once units are constructed and water meter records reflecting water use are available. Following the three-year data collection period, updated ERU water demands would be incorporated into future required updates of the City's Water Comprehensive Plan. These updated ERU demands may result in the City issuing additional water availability certificates for the UGA from the water initially required by the City for each ERU beyond Trendwest's estimated demands. Alternatively, if the calculated ERU value for development within the UGA underestimates water demand, additional water rights would need to be provided to the City by Trendwest before full buildout of the UGA could be achieved.

2.2.2 MountainStar Master Planned Resort

The MPR will have its own water supply utility. MountainStar Resort Resources, Inc. (MountainStar Resources) is a private, for-profit corporation organized by Trendwest to provide utility services for the MPR. MountainStar Resources has received approval from the Washington Department of Health (WDOH) for a water system comprehensive plan to operate as a privately-owned public water system.[1] The City of Cle Elum will provide water treatment services for MountainStar Resources, Inc.; however, water users in the MPR would be customers

1 The Washington Utilities and Transportation Commission (WUTC) will regulate MountainStar Resort Resources' water rates.

of MountainStar Resources, Inc., not the City of Cle Elum. Water demand calculations for the MPR and UGA are shown in Exhibit E of this report.

2.3 DESCRIPTION OF AVAILABLE WATER SUPPLIES

Trendwest currently owns three surface water rights on the Yakima River and 11 surface water rights on three tributaries between Easton and Ellensburg. Trendwest's surface water rights entitle the company to divert up to 40.7 cfs of water, not to exceed 8,075 ac-ft of water each year. These water rights were used historically for irrigation and stock water. Since being acquired by Trendwest, these water rights have either remained in use for irrigation or have been temporarily approved for instream flow purposes by the Yakima County Superior Court. The water rights currently are appurtenant to approximately 888 acres of land, the net irrigation requirements of which total about 2,065 ac-ft each year. Trendwest's surface water rights are summarized in Table 2-6.

Table 2-6: Trendwest Surface Water Rights

Source	Annual Water Quantity[1,2] (ac-ft)	Instantaneous Quantity (cfs)
Yakima River	4,783 ac-ft	23.4 cfs
Big Creek	390 ac-ft	1.5 cfs
Teanaway River	1,016 ac-ft	3.8 cfs
Swauk Creek	1,886 ac-ft	12.0 cfs
Total	8,075 ac-ft	40.7 cfs

1 Annual water quantity represents the total volume of diversion specified under the water rights.
2 Figures are rounded to the nearest acre-foot.
Source: Trendwest 2001.

2.3.1 Mainstem Yakima River Water Rights

Trendwest owns water rights that are appurtenant to three parcels of land formerly owned by Pautzke Bait Company, Inc. located in Ellensburg, about 20 miles downstream from the City of Cle Elum. The former Pautzke Bait Company water rights currently are appurtenant to three separate parcels that together comprise approximately 291 acres of land and entitle Trendwest to divert up to about 23.4 cfs, not to exceed about 4,783 ac-ft each year from the Yakima River and up to 4.0 cfs, not to exceed 1,270 ac-ft each year from Reecer Creek. Since the place of use under the Reecer Creek water right is identical to one of the Yakima River water rights, Trendwest considers this water right a supplemental water right. The Reecer Creek water right is not included in the water balance analysis.

2.3.2 Tributary Water Rights

Big Creek Water Rights

Trendwest purchased water rights appurtenant to approximately 81.5 acres of land in the Big Creek watershed, between Easton and Cle Elum. Trendwest's Big Creek water rights total approximately 1.53 cfs, not to exceed 390.1 ac-ft of water each year. The Big Creek water rights formerly were used for irrigation purposes. Figure 2.1 shows the location of Big Creek within the Easton subbasin.

Teanaway River Water Rights

Trendwest owns water rights appurtenant to approximately 188 acres of land formerly irrigated from the Masterson-Walker Diversion on the Teanaway River. Trendwest's Teanaway River water rights entitle Trendwest to divert approximately 3.76 cfs, not to exceed 1,014.12 ac-ft for irrigation and 2 ac-ft for stockwater each year. The Teanaway River water rights formerly were used for irrigation and stock watering purposes. Figure 2.2 shows the Teanaway River subbasin.

Swauk Creek Water Rights

Trendwest owns water rights appurtenant to approximately 95 acres of land formerly owned by Kenneth J. Hartman, et al. Trendwest purchased water rights appurtenant to 75 acres of the former Hartman property prior to completion of the Draft EIS. Trendwest purchased water rights appurtenant to the remaining 20 acres in June 2001. The Hartman water rights entitle Trendwest to divert approximately 4.23 cfs, not to exceed 712.5 ac-ft each year directly from Swauk Creek.

Trendwest owns water rights from two separate parcels of land in the Reecer Creek Basin that receive water from a diversion on First Creek, a tributary to Swauk Creek. Trendwest owns water rights appurtenant to approximately 150 acres of land owned by J.P. Roan and formerly delivered by the First Creek Water Users Association (FCWUA) diversion from First Creek. The former Roan water rights entitle Trendwest to divert approximately 5 cfs, not to exceed 756.7 ac-ft each year. Trendwest also owns water rights for approximately 83 acres of land owned by E. James Nelson, et al., again delivered by FCWUA from First Creek. The former Nelson water rights entitle Trendwest to divert approximately 2.8 cfs, not to exceed 420.4 ac-ft each year. Together, Trendwest's FCWUA water rights comprise rights for 7.8 cfs, not to exceed 1,173.2 ac-ft each year. Figure 2.3 shows Subbasin No. 4 (Swauk Creek).

2.4 ENVIRONMENTAL STEWARDSHIP AGREEMENTS

2.4.1 WDFW/Yakama Nation Cooperative Agreement

Trendwest has entered into a Cooperative Agreement with the Washington Department of Fish and Wildlife (WDFW) and the Yakama Nation to address agency and tribal concerns about environmental impacts from Trendwest's development proposals for the MountainStar Resort and the Cle Elum UGA. The parties have agreed to work toward the goal of no net loss of fish and wildlife habitat, as well as the protection of the environmental, scenic, historical, cultural, and recreational values associated with the Trendwest property through the creation of a non-profit organization known as the MountainStar Conservation Trust. The Cooperative Agreement provides a mechanism to protect open space areas on Trendwest property, to acquire off-site conservation easements and water rights for instream flow purposes, and to provide other measures to protect against environmental impacts off the Trendwest property.

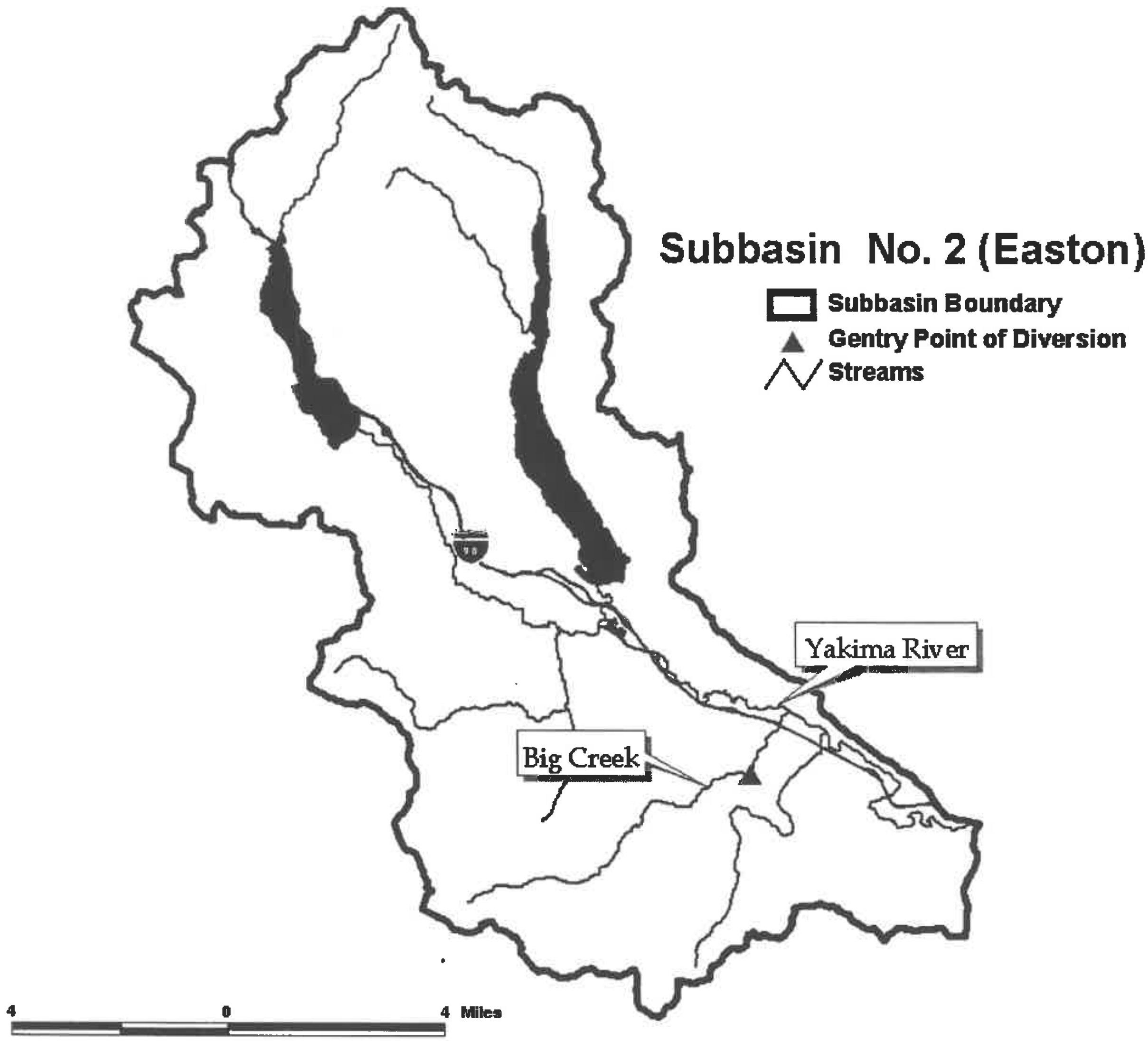

Figure 2.1. Subbasin No. 2 (Easton).

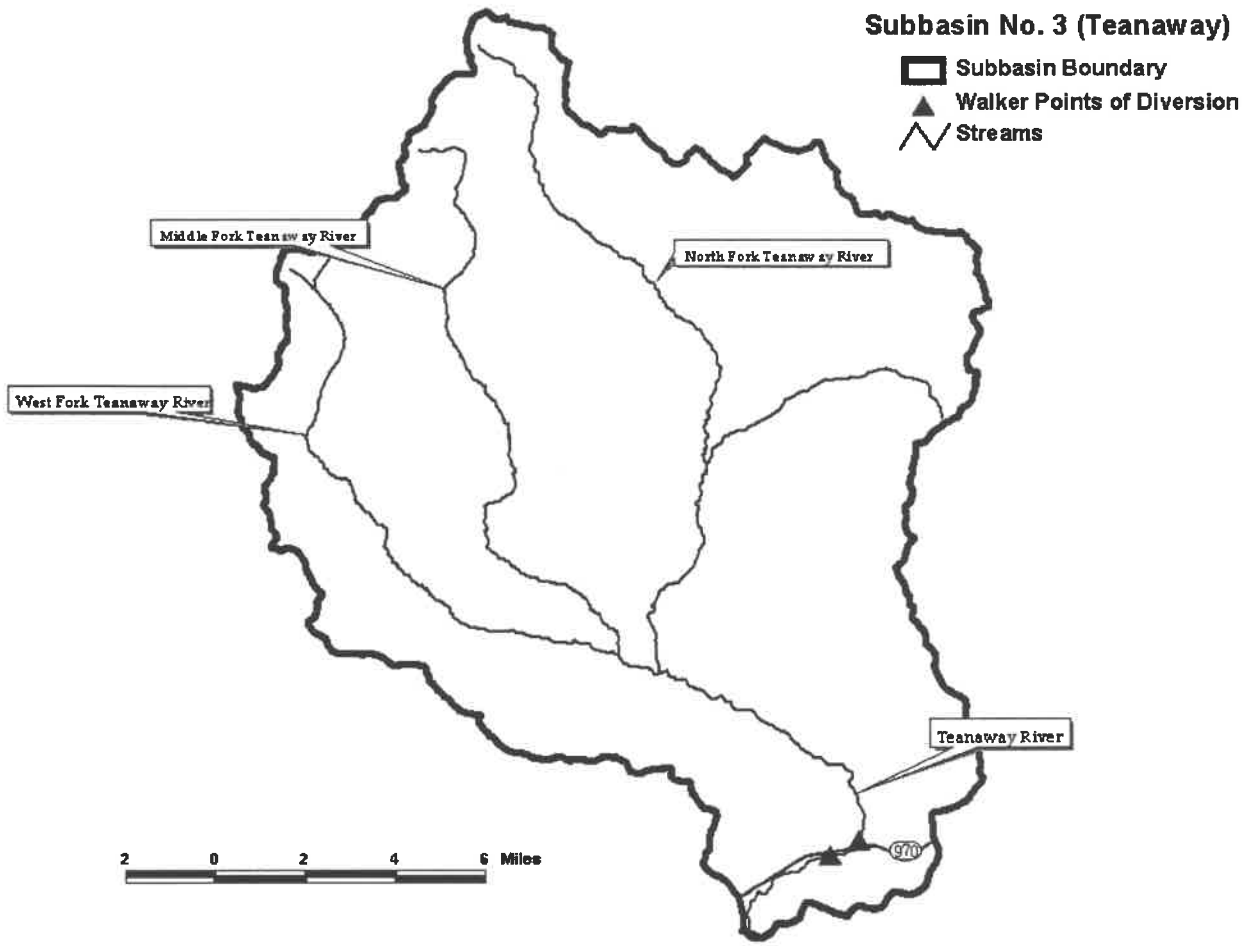

Figure 2.2. Subbasin No. 3 (Teanaway River).

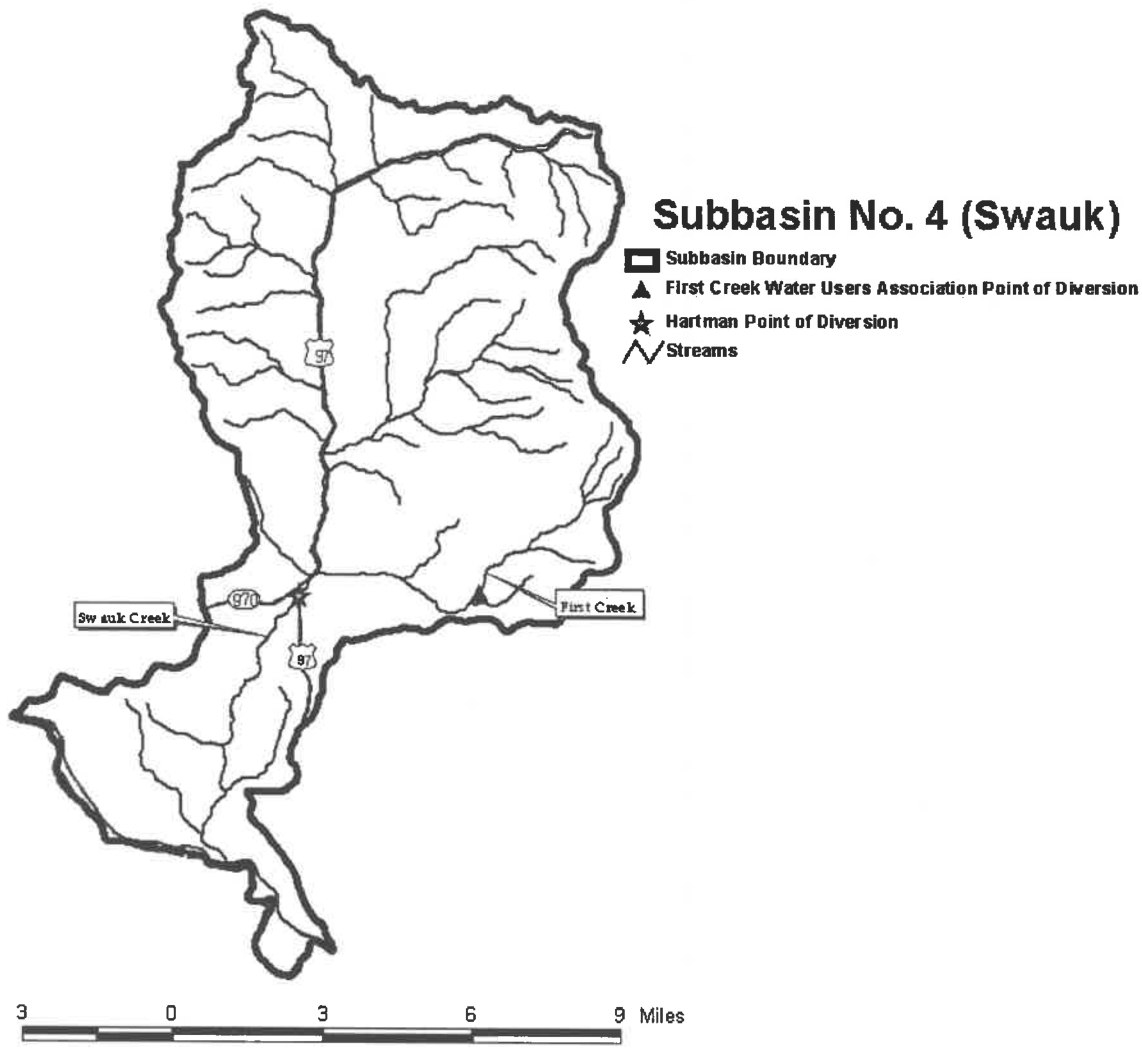

Figure 2.3. Subbasin No. 4 (Swauk Creek).

Implementation of the Cooperative Agreement is contingent on approval by Kittitas County of all permits and approvals necessary to develop the MountainStar Resort. The provisions of the Cooperative Agreement also are contingent on final approval by Ecology of transfer applications for each of the Trendwest Yakima River and tributary water rights, authorizing use of the water in connection with the Trendwest property.

Conservation Easements

Under the Cooperative Agreement, Trendwest has agreed to donate a conservation easement over most of the Cle Elum River geomorphic floodplain, thus securing permanent protection of the floodplain and its aquatic resources, to the extent owned by Trendwest, from the Cle Elum Dam to Interstate 90. A total of 1,071 acres of the Cle Elum River floodplain are within the MPR and 144 acres are within the Cle Elum UGA. Conveyance of the MPR portion of the easement is contingent upon MPR approval. Conveyance of the UGA portion is contingent upon approval of the UGA project.

The Cooperative Agreement establishes a number of restrictions within the Cle Elum River Corridor. First, residential units are prohibited in the corridor. Motorized vehicle use, for recreation or other purposes unrelated to governmental or property management functions, is not allowed. Trendwest is prohibited from riprapping the river banks, except to the extent necessary for bridge and utility river crossings. Trendwest has agreed not to construct impermeable trails or ground surfaces unless agreed to by the Trust. Trendwest has agreed not to extract gravel or conduct other mining. Finally, Trendwest has agreed not to undertake any forest management activity, firewood harvest, or other tree removal, except for purposes of fire protection, public health, or safety, or other purpose approved by the Conservation Trust Board consisting of one member each appointed by Trendwest, WDFW, and the Yakama Nation (for example, habitat restoration or enhancement).

The Cooperative Agreement includes provisions to manage a minimum of 1,171 acres on the west side of the MountainStar Resort property as open space. As permanent west side open space areas are identified during resort development, Trendwest will convey Conservation Easements to the MountainStar Conservation Trust.

In addition to protecting and managing the two on-site conservation easements, the Cooperative Agreement establishes a goal of acquiring ownership or conservation easements to at least 1,500 acres of land outside the Trendwest property. The MountainStar Conservation Trust is empowered to monitor and enforce the Conservation Easements and take other actions as necessary to protect open space areas the Trust has acquired. If satisfactory progress is not made toward off-site acquisition targets, Trendwest will increase its funding obligations to the MountainStar Conservation Trust in order to ensure that sufficient off-site properties are acquired to support the goal of no net-loss of wildlife habitat. The Agreement contains additional restrictions aimed at protecting other Yakima River floodplain areas from development and from gravel product production.

Acquisition of Water Rights for Instream Flows

Under the Agreement, Trendwest also will provide funding for the MountainStar Conservation Trust to acquire water rights from the upper Yakima River and its tributaries, to increase instream flows and to reduce consumptive uses of water within the upper basin. The purpose for this funding is to protect aquatic resources and downstream water users from impacts resulting from activities that are indirectly related to Trendwest's development activities. The water rights to be purchased under the Agreement are in addition to the water rights Trendwest has purchased to serve the projected water demand for the MPR and UGA development projects.

2.4.2 RIDGE Settlement Agreement

In September 2001, Trendwest entered into a settlement agreement with RIDGE, a non-profit conservation organization. In return for RIDGE's commitment to withdraw outstanding appeals and refrain from legal challenges to future MPR and UGA approvals, Trendwest agreed to a number of project modifications. First, Trendwest agreed to reduce the number of MPR units, as shown in Table 2.7, below. Second, Trendwest agreed to add an additional 550 acres of open space to the UGA and MPR projects. The new open space in the UGA and MPR will be protected by conservation easement. Third, Trendwest agreed to provide a comprehensive package of economic and environmental benefits for the local community. These include, in part, a commitment to transfer water rights to the City of Roslyn to provide water for indirect growth within Roslyn's municipal service area, and to provide water for expansion of the Cle Elum-Roslyn School District #404. The MPR approved units, and the unit reductions agreed to by Trendwest for a Reduced Density MPR, are shown in Table 2-7.

Table 2-7: MountainStar Unit Reductions

Type of Unit	County Approved	Settlement Terms	Unit Reduction	Percent Reduction
Single Family Units	3250	2695	555	17%
Condominiums	850	790	60	7%
Hotel Units	550	300	250	45%
Totals	4650	3785	865	18.6%

Source: Trendwest 2001.

3. AFFECTED ENVIRONMENT

3.1 INTRODUCTION

The Water Supply Technical Report prepared to accompany the Cle Elum Draft EIS contains a description of the affected environment for the proposed transfers. This supplement adds a description of existing conditions and water uses in the affected tributaries and the mainstem reach between Cle Elum and Ellensburg. This supplement also describes stream measuring activities undertaken by Trendwest and Ecology's consultants[2] during the summer 2001

2 Montgomery Water Group, Inc. 2002. *Streamflow Monitoring Report, Yakima River Tributaries.*

irrigation season. The Water Supply Technical Report in the Draft EIS contains the following information about the affected environment:

- Characterization of basin hydrology—meteorological parameters, such as air temperature, precipitation, and snowfall; streamflows of the mainstem Yakima River and tributaries; and groundwater levels.
- Water resource development—water resources plans implemented and infrastructure constructed in the study area.
- Water use—the purpose and place of use of water rights, the administrative system of water allocation, and historical consumption.
- Stream channels—physical characteristics of the tributary streams affected by the proposed water supply exchange contract.

3.2 TRIBUTARY SUBBASINS

Existing conditions in tributaries to the upper Yakima River are described in *Yakima / Klickitat Production, Project Preliminary Design Report, Appendix B* (Bureau of Reclamation, U.S. Department of the Interior 1990). Existing conditions in each tributary are summarized below. A list of diversions from the affected tributaries is provided in Table B.3.a. in Appendix D in the Draft EIS. Figure 3.1 shows a vicinity map of Kittitas County.

3.2.1 Big Creek

Big Creek is approximately 12 miles long and enters the Yakima River from the south near Easton. Big Creek has been heavily channelized in its lower reaches and in the lower-most quarter mile suffers from channel instability and bedload deposition. It has two diversions. A small (2 to 3 cfs) bermed diversion exists about 0.7 miles from the mouth, which has a flat screen across the ditch. The Lund/Darling diversion dam, located about 2.1 miles above the mouth, has an impassable 5-foot head and two unscreened diversion ditches. Upstream of the Lund/Darling diversion dam, Big Creek flows through exposed bedrock. Just upstream of the dam, the stream flows through schist bedrock and alpine glacial drift deposits. At an elevation of about 2,240 feet, from just above the dam, Big Creek encounters the Yakima River alluvium. Flow continues downstream over the alluvium at a gradual slope towards the stream's confluence with the Yakima River at elevation 2,060 feet. Well driller's logs indicate there is clean sand and gravel below ground in the vicinity of Big Creek, which ECT named the Big Creek Alluvium[3]. Further from the creek, well logs indicate a higher incidence of silt and clay near the surface, underlain by sands and gravels that are part of the Yakima River alluvium. Depths to groundwater in the alluvial aquifer under the Big Creek basin below the Lund/Darling diversion dam are approximately 10 to 30 feet below the land surface. Data from three deep wells ranging from about 120 to 200 feet below the land surface have more shallow or artesian static water levels, indicating there is regional upward flow from a deeper confined aquifer into the shallow unconfined alluvial aquifer. Water level data collected by ECT show that Big Creek loses flow to the alluvial aquifer over much of its course below the Lund/Darling diversion dam down to the Yakima River. Seepage into the alluvial aquifer from Big Creek and from irrigated areas

3 Big Creek Basin Hydrologic Analysis (Pacific Groundwater Group 2002).

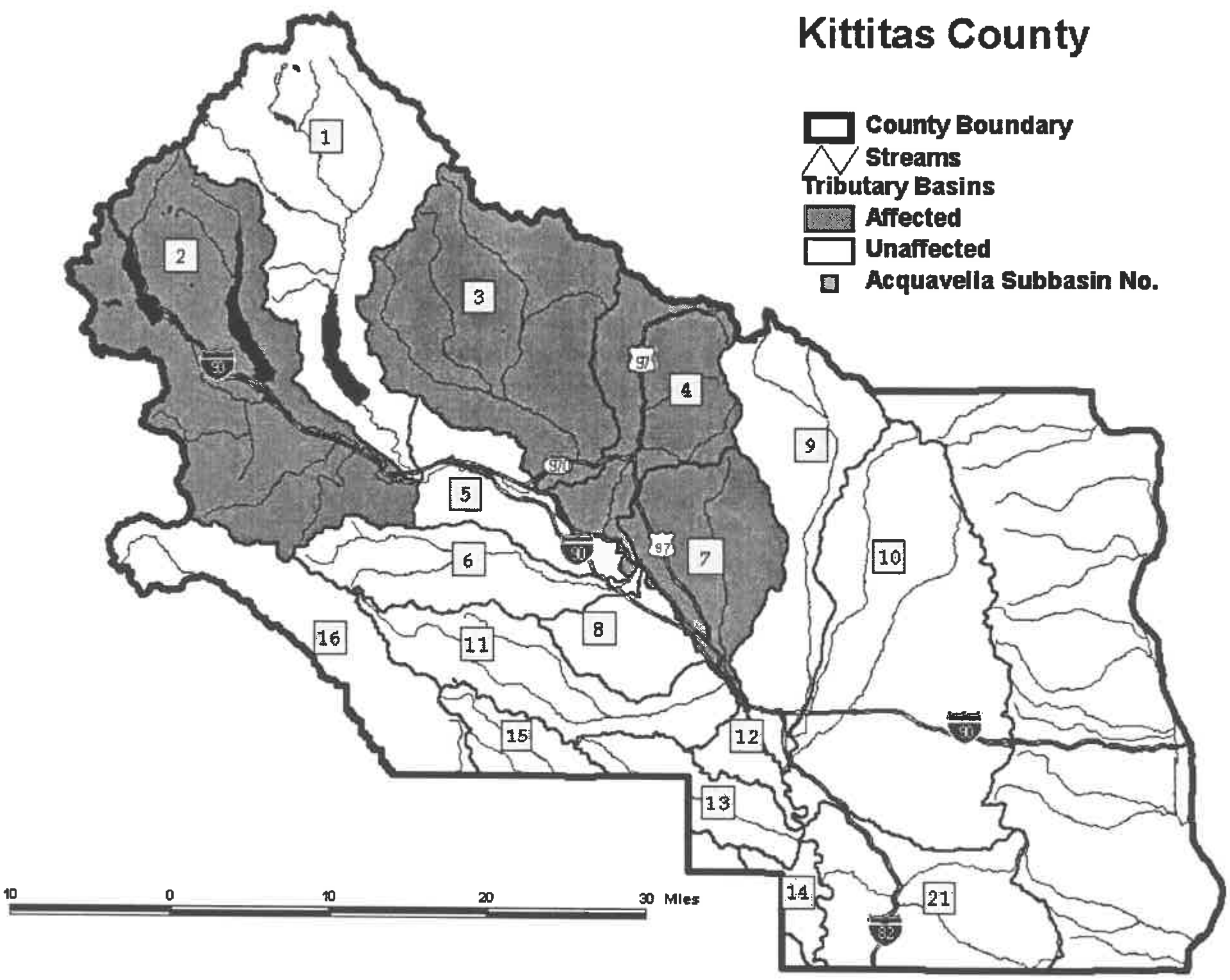

Figure 3.1. Vicinity Map of Kittitas County.

adjacent to the creek ultimately discharges to the Yakima River, and does not return to Big Creek downstream.

Big Creek has substantial summer flows above the Lund/Darling dam, but below this point, the creek carries very low flows allowed to pass through the upper diversion. Most of the creek's flow is removed at the lower diversion and the stream is nearly dry during the summer irrigation season from this point to the mouth. Big Creek produced steelhead historically and appears to still have potential for producing steelhead, coho, and to a lesser degree, spring chinook. Spring chinook juveniles rear in the lower reaches. The major factors limiting production on Big Creek, however, are the impassable Lund/Darling dam and unscreened diversion located at RM 2.1, and the lack of instream flows from this point to the mouth (USBR 1990).

3.2.2 Teanaway River

The Teanaway River is the second largest tributary to the Yakima River. The Teanaway River is approximately 61 miles long and has a drainage area of about 200 square miles. Based on its broad, flat floodplain and minimal channel incision, the Teanaway River is actively migrating across its floodplain. The lower river downstream of Red Bridge Road is underlain by soils ranging in composition from cobbles and gravel to fine-grained clay. In general, coarser materials are present nearer the surface, likely as a result of historic Teanaway River channel migration. These variably textured soils comprise the river's alluvial deposition within the floodplain. Near Red Bridge, driller's well logs indicate the alluvium is variable in depth above bedrock, ranging from zero to over 70 feet in thickness. Well logs along the Teanaway River near SR 970 in Section 26 indicate the alluvium may be several hundred feet thick[4]. Most of the wells located on the floodplain are completed into bedrock below the alluvial sediments; depths of 100 to 400 feet in these wells is common. Some of these wells have static water levels above the surface (artesian flow), while others have static water levels 200 feet or more below the surface. The floodplain alluvial aquifer under the Teanaway River at its mouth is part of an ongoing groundwater study conducted by the University of Montana and sponsored by the USBR. Data from the study show that groundwater conditions vary throughout the year without a discernable, direct correlation to streamflow. Just upstream of Highway 10, the University of Montana study team has installed a series of shallow wells in the alluvium, and has found historic stream migration pathways (paleochannels) with higher permeability than the surrounding finer-grained alluvium. Groundwater flow rates are likely higher through these paleochannels than through the surrounding alluvium.

The lower ten miles of the valley consists mainly of hay fields and is heavily irrigated where the Teanaway River flows through a broad valley. As natural runoff declines during summer and fall, the flows through this reach drop dramatically, and by September and October the lower river may be dry or nearly dry. The major riparian problems in this lower reach are seasonal lack of overhanging vegetation and lack of woody debris. The instream habitat also suffers from the disturbances caused by construction of berms associated with irrigation intakes.

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4 Teanaway River Basin Hydrologic Analysis (Pacific Groundwater Group 2002).

Ecology has proposed a Teanaway Temperature Total Maximum Daily Load (TMDL) to the U.S. Environmental Protection Agency for approval[5]. This TMDL proposes to improve temperatures in the Teanaway River by establishing shade to the site potential levels, largely through landowner cooperation, incentives, and voluntary effort. Site potential shade is lowered in many parts of the Teanaway basin by bedrock in the riparian zone. A maximum temperature of 28.5°C was measured in the mainstem Teanaway River during Ecology's TMDL monitoring in the summer of 1998 (July 1 to October 6), during which the mainstem Teanaway temperatures exceeded the 18°C standard 85 percent of the time. Local landowners planted over 5,000 trees along 2.7 miles of the Teanaway River in early 2001. The USBR and the National Resources Conservation Service have implemented water conservation measures for irrigation and will transfer the consumptive use portion of those savings to the State Trust Water Rights Program once the Yakima River Adjudication is completed. In addition, the Bonneville Power Administration funded moving some diversions downstream, leaving 13 cfs of irrigation flow in the Teanaway River for an additional 3 miles. The Yakima River Basin Water Enhancement Project is funding the USBR to work with landowners interested in selling conservation easements, land, or water rights, to provide additional riparian shade and instream flow.

3.2.3 Swauk Creek

Swauk Creek is approximately 24 miles long and enters the Yakima River from the north between Cle Elum and Thorp. The drainage area is fairly large (100 square miles), but precipitation is minimal and natural summer stream flows are very low. Upper Swauk Creek flows through a narrow alluvial valley underlain by sandstone and conglomerates until approximately 1.5 miles above its confluence with First Creek[6]. Below this point and down to First Creek, the stream's alluvium is underlain by basalts. Below the First Creek confluence, Swauk Creek is no longer confined by bedrock, and opens onto a wide alluvial floodplain named Hidden Valley. At the lower end of Hidden Valley, the creek is again confined within a narrow bedrock canyon about 4 miles in length, opening just above the stream's confluence with the Yakima River. At this location the stream flows over fractured bedrock and onto Yakima River alluvial deposits.

Upper Hidden Valley contains coarse alluvial sediments at the First Creek confluence, likely a result of a local alluvial fan immediately downstream of the emergence of Swauk Creek from the bedrock constricting valley above First Creek. The lower portion of Hidden Valley is comprised of various alluvial materials, underlain by glacial deposits and sandstone and basaltic bedrock. The alluvial aquifer beneath Swauk Creek in Hidden Valley is likely in hydraulic continuity with Swauk Creek in the lower portions of the valley, where the valley is constricted causing groundwater elevations to rise relative to the land surface, and flow into the stream.

First Creek water entering Swauk Creek in the upper Hidden Valley recharges the alluvial deposits as it approaches the Creek, but that water likely recharges Swauk Creek further downstream in Hidden Valley. In the final mile upstream of its confluence, the First Creek valley widens and the creek flows over alluvial sediments deposited by both First Creek and Swauk

5 Draft Teanaway Temperature Total Maximum Daily Load Submittal Report, Publication No. 01-10-019 (Washington State Department of Ecology 2001).

6 First and Swauk Creek Basin Hydrologic Analysis (Pacific Groundwater Group 2002).

Creek. Further upstream, First Creek predominantly flows through a narrow, bedrock-confined valley. This narrow valley limits the amount of water that can be lost from First Creek to alluvial subflow, all the way down to the basalt upstream of the alluvium in the lower mile of the creek.

Above First Creek, Swauk Creek has been generally characterized as follows by USBR (1990). Swauk Creek's lower bedrock canyon is arid and the gradient is relatively steep. The streambed in this location consists of large rock and boulders. This reach is characterized by USBR as having very low or intermittent summer flow as far upstream as RM 5.0. The stream enters a forested zone at RM 8.0 and above this point flows are marginally adequate during the summer. The riparian corridor is generally good above RM 3.0 and the streambed appears stable throughout (USBR 1990).

There are five irrigation diversions on Swauk Creek below the First Creek confluence, and one irrigation diversion on First Creek. Trendwest purchased water rights from the First Creek diversion and from one of the Swauk Creek diversions.

3.3 YAKIMA RIVER MAINSTEM

Trendwest's water transfer proposals call for diverting water from the Yakima River at a location upstream of the historic point of diversion of the acquired water rights. The proposed transfers potentially affect the Yakima River reach between Cle Elum (the proposed new diversion location) and Ellensburg (the historic diversion location). Existing conditions in the mainstem upper Yakima River are described in *Review of Yakima River Diversion Intakes—Cle Elum to Ellensburg Reach* (Northwest Hydraulic Consultants, Inc. 2002), *Yakima River Basin Water Enhancement Project, Washington, Final Environmental Impact Statement* (Bureau of Reclamation, U.S. Department of the Interior 1999), *Draft Report on Biologically-Based Flows for the Upper Yakima River Basin* (Systems Operations Advisory Committee 1998), and in *Effects of Hydraulic and Geologic Factors on Streamflow of the Yakima River Basin, Washington: Geological Survey Water Supply Paper 1595* (U.S. Geological Survey, U.S. Department of the Interior 1963).

3.3.1 Setting

The Yakima River crosses four large structural basins, which are separated from one another by one or more large anticlinal or monoclinal ridges. The river transects these ridges through deep narrow canyons, the largest and longest of which is the Yakima Canyon between Ellensburg and Yakima. Named in downstream order, these basins are the Roslyn, Kittitas, Upper Yakima and Lower Yakima basins.

The Roslyn basin is typical of the geology of the western edge of the Columbia Plateau. Located high on the eastern slopes of the Cascade Mountains, the Roslyn basin includes a drainage area of about 800 square miles. Some of the highest mountains in the Yakima River basin border this basin. A broad dissected synclinal valley, whose axis extends for 20 miles in an east-southeast direction, forms the central part of the Roslyn basin. At the eastern end, about six miles east of the City of Cle Elum, it is ended abruptly by the cross-valley monoclinal structure that forms Lookout Mountain. Drainage into the Roslyn Valley is in part regulated by the outflow of Lake

Keechelus, Lake Kachess and Lake Cle Elum. The Teanaway River, Swauk Creek, Big Creek and Cabin Creek are important tributary streams that drain small mountainous areas in this basin. The Yakima River leaves the Roslyn basin through a narrow canyon eroded through the basalt a few miles south of Lookout Mountain.

The Kittitas basin consists for the most part of the Kittitas Valley, a long broad synclinal valley lying just southeast of the Roslyn basin. The valley has a southeast trend and a length of about 30 miles. Manastash Ridge, a long anticlinal ridge, forms the southern boundary of the valley, and the Wenatchee Mountains, a low east-trending range that attains a maximum altitude of about 6,000 feet, form the northern boundary. The Yakima River enters the Kittitas basin at the northwestern end of the Kittitas Valley and flows along the southwestern edge of the valley to Yakima Canyon, a few miles south of Ellensburg. Numerous tributary streams enter the Yakima River before it leaves the Kittitas basin. Manastash Creek and Taneum Creek drain an upland area west of the Kittitas Valley. Reecer Creek and numerous smaller tributary streams drain the south slope of the Wenatchee Mountains north of the valley.

The Yakima River extends for approximately 175 miles from its headwaters in the Cascade Mountain range to its confluence with the Columbia River near Richland. The upper Yakima River reach potentially affected by Trendwest's proposed transfers extends for approximately 28 miles from Cle Elum to the Mill Ditch Diversion in Ellensburg. There are six irrigation diversions in the potentially affected mainstem reach.

3.3.2 Yakima Project Operations

The Yakima River's streamflow is regulated by the operation of Keechelus, Kachess, and Cle Elum dams. USBR has operated these dams since the early 20th century. Target flows have been established by USBR for several points on the Yakima River in the past. The USBR describes its flow management strategy for the upper Yakima River as follows:

> Releases from the storage reservoirs of the Yakima River system are made for three purposes: (1) irrigation demand, (2) flood control, and (3) instream flows. Throughout the irrigation season, late March through October, release of water from the six Yakima Project reservoirs is made to meet diversion demands. In the fall, winter, and spring months, releases are made in conjunction with system flood control guidelines, and as the reservoirs are filled, the spring freshet is significantly modified.
>
> Each year, as unregulated runoff recedes and irrigation demand increases, a point is reached where irrigation demand exceeds unregulated flow (usually late June or early July), and the system is put on storage control. During storage control, the flow passing Sunnyside Diversion Dam is controlled to a target level to minimize spill. Generally, the return flows and unregulated flow are sufficient downstream from this point to meet diversion demands. During the period of storage control before September, emphasis is placed on meeting lower basin demands from Cle Elum Lake, and most of the demands above the Cle Elum River are met from Keechelus Lake.

After September 10 and into early October, most of the demand of the lower basin is met by releases from Rimrock Lake below Tieton Dam, and most of the upper basin demand is met from Kachess Lake. The objective of these releases, beyond continued diversion delivery, is to restrict the flow to target levels during September at Martin, Easton, and Roslyn. The reason for this "flip-flop" of releases is to keep spring chinook spawning as low as possible in the channel at this time. If the spring chinook deposit their eggs low in the river channel, incubation flows can be kept low as well the following winter, which minimizes the impact on irrigation water supplies. "Reduced" spawning flows with "flip-flop" are generally at or above the historic flow levels.

After mid-October, natural runoff is usually sufficient to meet any diversion demands without storage release. During mid-October through March, a portion of reservoir inflow is allowed to pass through to avoid dewatering salmon redds (nests of fish eggs)." [7]

Since 1995, targets for instream flows during the irrigation season have been set annually by SOAC at Parker and Prosser based on prevailing conditions. The goal of target flows is to maintain the wetted perimeter of the Yakima River at a minimum during the so-called "flip-flop" period. Irrigation season target flows at Parker and Prosser are shown in Table 3-1.

Table 3-1: YRBWEP Target Parker and Prosser Flows

Total Water Supply Available (million acre-ft)				Parker and Prosser Flows (cfs)
Apr-Sept	May-Sept	Jun-Sept	Jul-Sept	
3.2	2.9	2.4	1.9	600
2.9	2.65	2.2	1.7	500
2.65	2.4	2.0	1.5	400
Less than above TWSA				300

3.3.3 Fall and Winter Yakima River Streamflow

The YRBWEP Act requires USBR to meet flow targets at Parker and Prosser, but only from April through October. Since 1995, a reduction in Yakima River streamflow at Parker or Prosser from November through March would not have resulted in stream flows being less than Title XII target flows. However, pre-Title XII instream flow targets were specified year-round, at locations farther upstream than Parker (Cle Elum, Easton, and Martin), and on the Cle Elum River. Other flow targets may exist, but these are not formally stipulated in state or federal laws. Since 1981, SOAC has assisted USBR on fish-related issues associated with the operations of the YRBWEP. Flows for maintaining fish life in the Yakima Basin are determined by the USBR Field Office Manager, according to the annual prevailing conditions, and in consultation with SOAC, irrigation district managers, and others (USBR, 1999). Furthermore, according to the partial summary judgment regarding the rights of the Yakama Nation entered by the Superior

7 *Yakima River Basin Water Enhancement Project, Washington: Final Programmatic Environmental Impact Statement* 53 (Bureau of Reclamation, U.S. Department of the Interior 1999).

Court on July 17, 1990, the Yakima Field Office Manager is responsible for providing minimum instream flows to maintain all life stages of anadromous fish in the Yakima River Basin.

Fall and winter flow targets that are set annually or seasonally by SOAC and the Yakima Field Office Manager are not listed in Title XII instream flow criteria. Some low flows that cause biological problems are common and well known. For instance, after irrigation season ends, when releases are cut back to refill reservoirs, flows in most mainstem reaches become sub-optimal or critically low for fish. Problems related to fall spawning and winter incubation have been successfully managed in the Yakima River.

3.3.4 Yakima River Mainstem Diversions

All major irrigation entities in the Yakima Basin receive water under the terms of a 1945 federal court consent decree. The decree states the quantities of water to which all major water users are entitled (maximum monthly and annual diversions limits) and defines a method of prioritization to be used during water-short years. Water entitlements for proratable water users are based on the total water supply available (TWSA). TWSA represents the combined quantity of unregulated flow, return flow, and stored water available for the period April through September upstream from the Parker gauge at Sunnyside Diversion Dam on the Yakima River. USBR prepares forecasts of the TWSA beginning each March and continuing through the irrigation season. These forecasts are the basis for determining the adequacy of the TWSA to meet irrigation water entitlements stipulated in the 1945 consent decree. (USBR 1999). Figure 3.2 shows the location of the eight diversions in the affected reach between the City of Cle Elum's diversion works and Ellensburg. In addition, the City of Roslyn diverts water from Domerie Creek, a tributary to the Cle Elum River downstream of Cle Elum Dam. Roslyn's water right has a 1908 priority date.

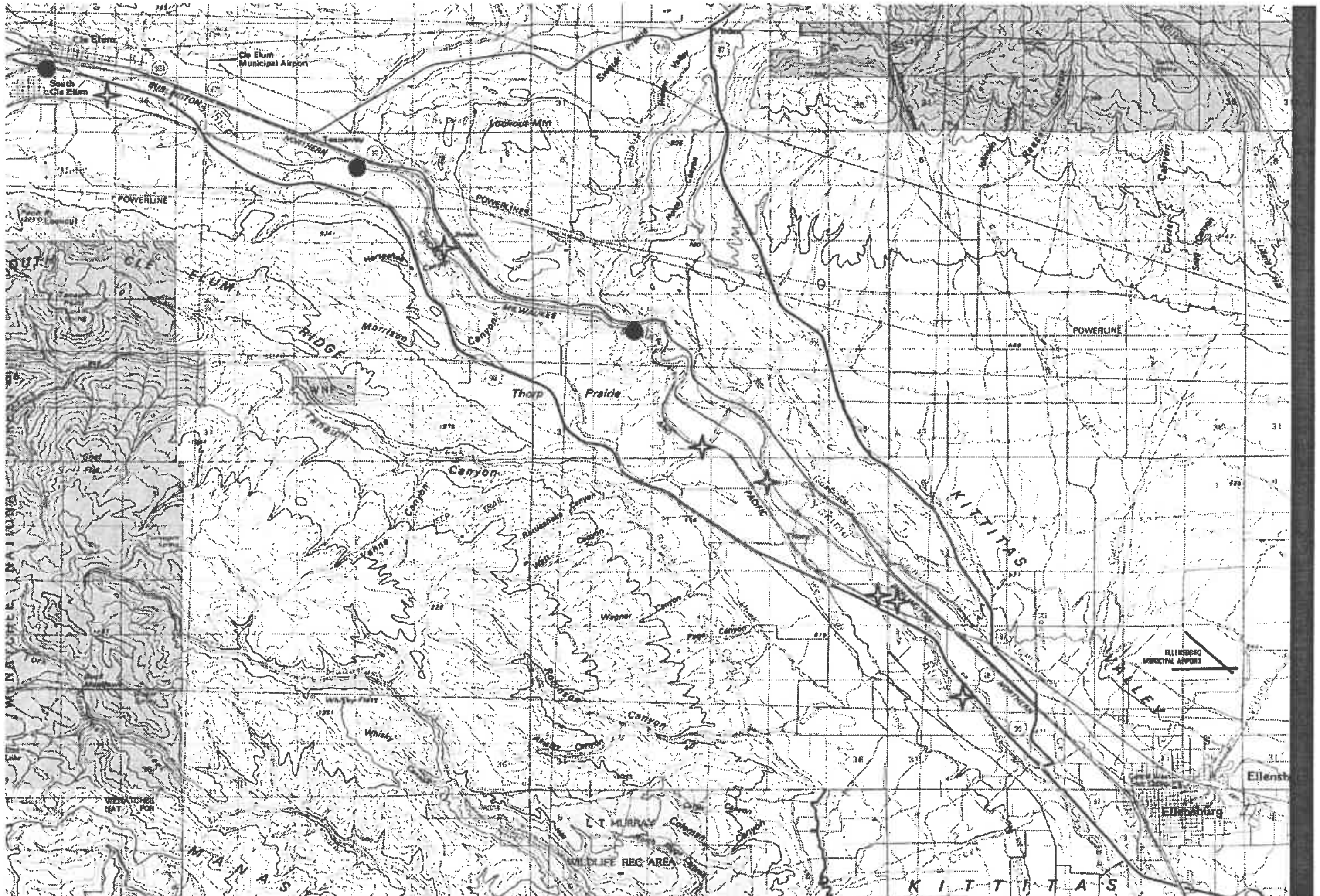
City of Cle Elum Diversions

The City of Cle Elum diverts water from the Yakima River for its municipal water system at an intake structure on the south bank of the river just east of the South Cle Elum Bridge, at Yakima River Mile 183. The City also maintains an intake structure on the Cle Elum River at about Cle Elum River Mile 7. The City is in the process of developing new water intake structures, as described above in Section 2.2.

Younger Ditch Diversion

The Younger Ditch Diversion is located on the left (north) bank of the Yakima River, just over one mile downstream of South Cle Elum at about River Mile 182. The diversion consists of a side channel diversion from the Yakima River, which directs flow into a 15-foot wide channel leading approximately 200 feet to an intake structure. The intake includes a rolling drum fish screen, several gated diversion openings, and a return flow bypass to the Yakima River. Diverted flows pass over a measurement weir and enter the Younger Ditch irrigation canal downstream of the intake structure.

Figure 3.2. Mainstem Yakima River Diversions



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The Younger Ditch diversion channel sits on the left bank of the Yakima River on the outside of a large meander bend. Because of the meander bend the river is deepest and flows are swift along the left bank near the diversion channel. The higher flow along the left bank carries more entrained sediments. During the irrigation season, flow is relatively uniform across the river upstream of the diversion. Yakima River flows tend to form an eddy at the diversion channel as the river expands at the channel opening. The eddy results in the deposition and accumulation of fine-grained sediments in the diversion channel.

Wallace Pump Diversion

The Wallace Ranch (Bristol Flats) diversion is located on the left (northeast) bank of the Yakima River approximately 7.5 miles downstream from the City of Cle Elum at about River Mile 174. The diversion consists of a backwater channel off the Yakima River, which allows flow into a pump intake. The diversion channel is approximately 20 feet wide and 80 feet long.

The Wallace Ranch (Bristol Flats) diversion channel sits on the left bank of the Yakima River on a relatively straight reach of the river. The diversion is located approximately 100 feet downstream of a small constriction and riffle in the river. The river width at the inlet to the diversion channel is approximately 210 feet. The flow depth in the main channel near the diversion site is relatively shallow at low flows. There is considerable sedimentation in the backwater channel leading from the Yakima River to the pump intake. Diversions at this site could be precluded altogether if Yakima River water levels drop below the level of the sediment deposits.

West Side Irrigating Company Diversion

The Westside Irrigation Company diversion is located on the right (south) bank of the Yakima River upstream of the Burlington Northern Railroad Bridge and the Thorp Highway Bridge, north of Thorp, Washington at about River Mile 166. The Westside diversion consists of a gated intake structure on the right bank of the Yakima River which directs flow into a 20 foot wide trapezoidal channel leading approximately 1,500 feet to a second hydraulic structure. The second facility includes a rolling drum fish screen with a return flow bypass to the Yakima River and several gated openings leading to irrigation canals.

The Westside diversion intake structure is located on the right bank of the Yakima River on the outside of a large meander bend. The Yakima River is approximately 160 feet wide near the location of the diversion. As a result of the meander bend, channel is deeper along the right bank than at other points across this section. Thus, the siting of this diversion structure is appropriate from a hydraulic standpoint. Although the diversion structure is located appropriately, flow depths in this wide reach of the river are typically too low for the Westside Irrigation Company to make its full diversion during the low flow season. Westside annually places ecology blocks part way across the Yakima River downstream from the diversion site to raise the backwater into the intake structure.

Thorp Mill Ditch Diversion

The Thorp Diversion is located on the right (south) bank of the Yakima River approximately 2.8 miles downstream of the Thorp Highway Bridge north of the town of Thorp, Washington at about River Mile 163. The diversion consists of an ungated side channel diversion from the Yakima River, which directs flow into a 3 to 5 foot wide diversion channel. The diversion structure consists of 4 side-by-side box culverts that pass under the Burlington Northern railroad track.

The Thorp diversion channel sits on the right bank of the Yakima River in a relatively straight reach of the river, which is constrained from lateral movement by the Burlington Northern Railroad fill. Flows in this section of the river often are shallow and swift moving. Until recently, much of the diversion structure was blocked with fine-grained sediments.

Ellensburg Water Company Diversion

The Ellensburg Water Company (EWC) diversion structure consists of a diversion dam extending completely across the Yakima River. This structure has the capacity to divert EWC's full water entitlement (which ranges from 63 cfs to 125 cfs), regardless of Yakima River streamflow conditions. The structure also includes large head gates and fish screens. It is located immediately west of Highway 10, just below Yakima River Mile 162.

Packwood Canal Company Diversion

The Packwood Diversion is located on the right (west) bank of the Yakima River approximately 2000 feet downstream of the Burlington Northern Railroad Bridge near Thorp, Washington, at about River Mile 161. The diversion consists of an ungated side channel diversion from the Yakima River that directs flow into the Ellensburg canal. The Packwood Diversion structure protrudes out from the right bank of the Yakima River on the outside of a large meander bend. As a result of this meander, flow depths are likely to be deeper along the right channel bank than at other points across this section.

The Packwood Diversion structure protrudes out from the right bank of the Yakima River on the outside of a large meander bend. As a result of this meander, flow depths are likely to be deeper along the right channel bank than at other points across this section.

There is extensive erosion and deposition occurring near the diversion and significant human induced modifications have occurred over the last 40 years. The river has eroded the right bank upstream of the diversion, and bank protection measures (armoring and barbs) have been installed to constrain additional channel migration. Without the bank protection measures it is likely that the meander would continue to move downstream and could create problems for the Packwood diversion. Wood debris can accumulate in the Packwood diversion structure and impair operation of the diversion.

Cascade Irrigation Company Diversion

The Cascade Irrigation Company diversion is located on the left (north) bank of the Yakima River approximately 4,000 feet downstream of the Burlington Northern Railroad Bridge near Thorp, Washington, just above River Mile 160. The Cascade diversion consists of an intake structure on the left bank of a side channel of the Yakima River. The intake structure comprises 4 independently operable gates that direct flow into a large irrigation canal. Approximately 100 feet along the irrigation canal is another hydraulic structure and a measurement flume. A pump station is also located at this point.

The Cascade Irrigation diversion intake sits on the left bank of a side channel of the Yakima River downstream of a complex flow split. Upstream of the diversion flow is divided among the following four routes: 1) the Packwood diversion, 2) the Gladmar channel, 3) the main stem Yakima River, and 4) the Cascade side channel. The hydraulic complexities upstream of the Cascade irrigation diversion are a result of ongoing natural geomorphic processes and human river modifications. Hydraulic conditions continually change as a result of extensive sediment movement and deposition by the river. The Cascade side channel has been transformed from the primary flow path to a small side channel that likely requires extensive sediment removal to keep flowing. Human modifications to this stretch of the river over the last 40 years include levee building, bank armoring, barb construction, channel dredging, and opening the Gladmar channel. Each of these modifications has an effect on sediment deposition, and by extension, flows in the Cascade side channel.

Some of these modifications, for instance the armoring of the left bank upstream of the Packwood diversion and the opening of the Gladmar channel, have likely had a significant effect on sediment deposition that affects operation of the Cascade Irrigation diversion. It appears that the head of the Cascade irrigation side channel is being filled with sediment as a result of deposition associated with the upstream point bar. Furthermore, the Yakima River may be shifting towards the south at the location of the Gladmar channel opening. If the revetment blocking the Gladmar channel opening is not maintained, it is possible that the Gladmar channel might become the main flow path for the Yakima River. If this were to occur, it is possible that the side channel leading to the Cascade Irrigation diversion could be cut off from the flow entirely.

The Cascade Irrigation Company annually installs temporary structures in the Yakima River in order to maintain flows to the diversion structure. (Tony Jantzer, Cascade Irrigation, Pers. Comm.). Ecology block dams are installed in the mainstem at the head of the island that divides the river, and in the Cascade side channel downstream of the diversion intake. These structures are necessary if full irrigation diversions are to be made during periods of low flow.

Mill Ditch System

The Mill Ditch diversion is located on the left (north) bank of the Yakima River near Ellensburg, Washington, at about River Mile 158. The diversion consists of a lateral diversion off a side channel of the Yakima River. Flow diverted from the Yakima River side channel is directed into a 15-foot wide ditch leading approximately 100 feet to a twin culvert crossing under I-90.

Approximately 500 feet downstream of the I-90 crossing the diversion ditch joins with flow from a small groundwater fed lake and discharges from Dry Creek. From there, flow passes approximately 1,750 feet before reaching the Mill Ditch diversion intake structure. A rock weir across the channel maintains water levels at the diversion structure with return flows bypassing to the Yakima River via another channel under I-90. The intake includes several gated diversion openings. Downstream of the intake structure diverted flows pass over a measurement weir and then enter the Mill Ditch irrigation system.

The Mill Ditch diversion channel sits on the left bank of a side channel of the Yakima River. Discharges to the diversion channel are controlled by the level of water in the side channel and the level of a gravel bar on the left bank of the side channel. Discharges (and by extension water levels) in the side channel are controlled by a flow split in the Yakima River. The Washington Department of Transportation periodically removes gravel from the side channel entrance to increase flows being directed towards the diversion channel. This can include maintenance dredging only at the main stem of the Yakima River, maintenance dredging only in the side channel, or both.

3.4 2001 MONITORING ACTIVITIES

This section describes 2001 USBR monitoring data and field monitoring by ECT during the 2001 water year that contributed to the analyses in this report.

Hydrologic data were obtained by BC from two existing gauges at Forks and at Lambert Road to estimate natural streamflows along the Teanaway River. Both gauges are operated by USBR. USBR temperature and precipitation data from the Forks gauge were also obtained by BC. Information on active water rights usage[8] and irrigation ditch/pump flow was also gathered from Ecology. Data were gathered from May to September, 2001.

Water year 2001 was the worst single year drought since 1977, which was the worst single year drought on record in the Yakima River Basin.

ECT member MWG, in cooperation with Trendwest, collected streamflow data during the 2001 irrigation season from Yakima River tributaries and irrigation ditches where Trendwest proposes the transfer of existing water rights to instream flows. The data were used to support surface water and groundwater hydrology analyses completed for the processing of Trendwest's water rights application through Ecology. The 2001 monitoring program administered by Ecology consisted of either continuous or non-continuous water level recording, depending upon the station. Where non-continuous, the monitoring occurred either weekly or bi-weekly. Monitoring stations were established on Big Creek, Swauk Creek, First Creek, Reecer Creek, and Mill Ditch. Seepage surveys and weekly monitoring of irrigation diversions were also performed on the Mill, FCWUA, and Lund irrigation ditches. Suitable site locations for the stations were selected in May and June 2001 in the stream reaches identified for monitoring by ECT.

8 Personal Communication with Stan Isley, Sept. 13, 2001 and Sept. 20, 2001; Stan Isley Field Notes Fax, Aug. 30, 2001.

A total of the eleven continuous water level recording stations and six non-continuous stations (irrigation diversions and temporary staff-gauge installations) were installed and monitored at key points along the tributaries and ditches from May to October 2001. Continuous monitoring stations were placed at the following locations: (1) Big Creek upstream of the Darling/Lund diversion; (2) Big Creek downstream of the Darling/Lund diversion; (3) Big Creek downstream of the West Nelson Siding Road Bridge; (4) Big Creek on the Ensign Ranch property; (5) Swauk Creek upstream of the confluence with First Creek; (6) Swauk Creek downstream of the Burke and Burke-Hartman diversions; (7) Swauk Creek upstream of the confluence of Swauk Creek and the Yakima River; (8) First Creek downstream of the FCWUA diversion; (9) First Creek upstream of the confluence with Swauk Creek; (10) Mill Ditch headworks; and (11) Reecer Creek between Pott Road and Dolarway Road. Figure 3.3 shows the location of the continuous monitoring stations. The date of installation of the stations varied from May to July as property owner permissions were obtained. In addition to the continuous monitoring stations, various locations were monitored weekly including the Darling, Lund, and Ensign Ranch diversions on Big Creek, the FCWUA diversion flume and the Roan/Olsen weirs on First Creek, and on Mill Ditch just upstream of the confluence with Reecer Creek.

A series of flow measurements were collected at each of the continuous monitoring sites for development of stage-discharge rating curves. Flow measurements were collected whenever a significant change in stage was noted so that a range of low to intermediate flows was available for construction of the rating curves. The continuous stations consisted of a data logger and water level sensor powered by a rechargeable battery that recorded water level data every 15 minutes. Manual readings of the staff gauges were collected weekly so that the continuous data could be correlated to the actual gauge height readings. The rating curves were applied to the 15-minute water level data to create continuous flow hydrographs for the monitoring period at each of the eleven stream gauging stations. The continuous 15-minute data were averaged for each day to develop average daily hydrographs for the monitoring stations that were used in the hydrologic and hydraulic analyses.

The stations were monitored after the April to May spring freshet had passed, so in most cases high flows were not available to include in the rating curves. Many of the stations could not be installed until midway through the irrigation season so only partial low flow hydrographs are available at these stations. In general, flows in the creeks declined steadily to their lowest base flows in August and September, until heavy rain in mid-October resulted in rising hydrographs at all of the monitoring stations.

In addition to the weekly to bi-weekly monitoring program on the tributaries and irrigation diversions, Trendwest and the ECT conducted seepage surveys on the Lund and FCWUA irrigation ditches in July, August, and September 2001. For each seepage survey, measurements of the flow and cross-sectional geometry were collected at a number of key points along the ditch. The data were used to estimate the losses and/or gains in selected reaches of the ditches and the depths at key turnouts.

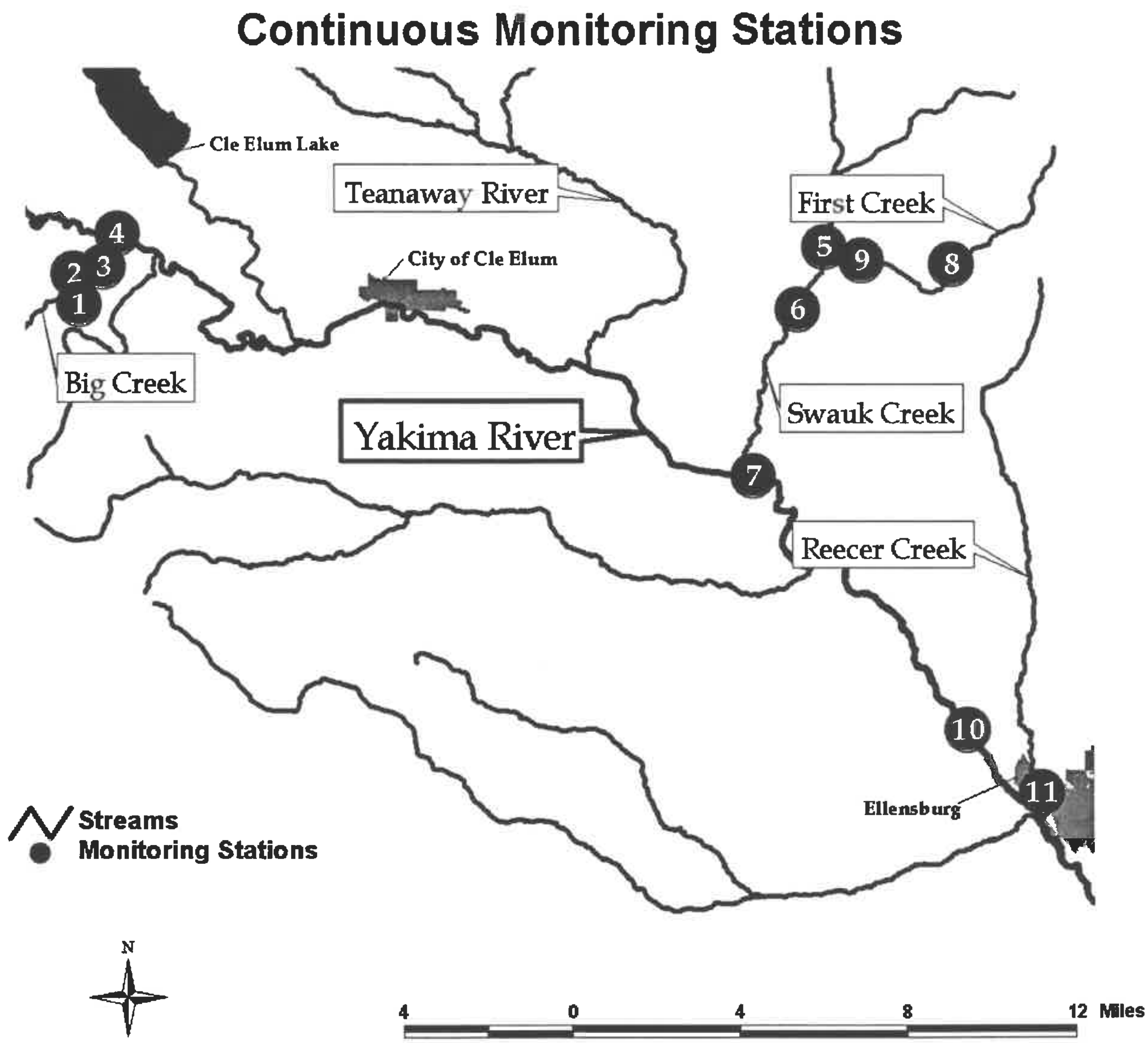

Figure 3.3. Location of 2001 Gauge Stations.

4. ENVIRONMENTAL IMPACTS

This section summarizes the potential water supply impacts resulting from implementation of all of Trendwest's proposed water rights transfers. Since publication of the Draft EIS, the water balance model was updated to reflect changes in the MPR and UGA proposals, recent monitoring data, additional information on onsite (MPR and UGA) irrigation return flow, and tributary irrigation and alluvial return flow information developed by Ecology. The water supply model changes are summarized below in Section 4.1.1. Potential direct impacts to tributary streamflows, tributary third party diverters, Yakima River streamflow and mainstem third party diverters are discussed below. This analysis supports the intent of Trendwest to supply water for both the MPR and UGA projects.

4.1 IMPACTS ON STREAMFLOWS

This section describes the balance of water between supply and demand and the effect on streamflow, summarized on a monthly basis, for both the UGA and Trendwest's proposed MountainStar MPR. A description of the water balance model for the upper Yakima River Basin (model), and how it was revised using new data collected cooperatively by ECT and the UGA consultant team, is contained in Section 4.1.1. Section 4.1.2 discusses model results, which show changes in Yakima River stream flows resulting from the transfer of Trendwest's mainstem Yakima River water rights, and from retiring consumptive uses of water resulting from irrigation use of Trendwest's tributary water rights. The proposed transfers would affect the lower Cle Elum River from about Bullfrog Road down to its confluence with the Yakima River, and a reach of the Yakima River between its confluence with Big Creek, near Easton (the vicinity of the uppermost proposed instream flow transfer) and Ellensburg (the most downstream historic diversion location).

The water balance model computes mean daily changes in Upper Yakima River basin streamflows due to the proposed transfers of, and changes in, Trendwest irrigation and stockwater water rights. On a daily basis, the model determines changes in Yakima River streamflow by accumulating changes in inflows and outflows, from upstream to downstream. These include changes from the transfer of Trendwest's mainstem Yakima River water rights, and from transferring Trendwest's tributary irrigation water rights to instream flows. The model results are evaluated as monthly average changes. The model was used to analyze and separate the effects of: (1) changes resulting from the shift of consumptive uses and return flows to the UGA and MPR sites (described below); and (2) changes resulting from converting former irrigation return flows to instream flows at the former points of diversion (these results are described in Exhibit A). These effects were evaluated under both "average" and "drought year" conditions, as explained in Section 4.1.1 below. The two conditions are relevant for purposes of evaluating potential mitigation and monitoring proposals, which is discussed in Section 7. For purposes of this analysis, a "drought year" is a year in which the USBR prorates water supplies to its contract water users because there are insufficient supplies to meet demands.

Related analyses are included as exhibits. Exhibit A includes a description of changes in streamflows that result from Trendwest's proposed transfer of tributary water rights into the Yakima Trust Water Program. Specifically, the model results contained in Exhibit A include the effects of cessation of irrigation return flow, which is a non-consumptive use component. The timing of former return flows was included in the impact assessment for mainstem diversions in the reach of the Yakima River affected by Trendwest's water rights transfers, since these model runs most accurately characterize the net flow changes expected to occur. Exhibit B discusses the sensitivity of the results to a reasonable range of model input parameter values. The sources of uncertainty are identified and the variability of results due to these uncertainties is presented.

4.1.1 Water Balance Model Construction

The model includes separate water availability modules for each of the Yakima River tributaries where Trendwest acquired water rights.[9] The results from ECT analyses of tributary irrigation and alluvial return flow were integrated into the tributary modules of the model. The tributary modules were all linked to the mainstem module of the upper Yakima River, which includes flow changes to the lower portion of the Cle Elum River from UGA and MPR return flows. The model calculates the overall water balance resulting from transfer of the Trendwest water rights.

Water availability for the consumptive portion of Trendwest's water rights is calculated on a daily basis and reported on a monthly basis by the model. Ultimately, water availability is compared with water consumptive use by the MPR and UGA. The model was run using observed and synthetic tributary streamflows generated for study years selected to exhibit a natural range of hydrologic conditions. For each of the water rights acquired by Trendwest, the water availability modules track natural streamflow at the former point of diversion, the diversion and return flows associated with former irrigation use and existing senior users on the same water course, and assesses the extent to which sufficient water is available for withdrawal under the water right each day during the irrigation season. The water availability modules assume any water that would have been withdrawn under a Trendwest water right is left instream to mitigate for withdrawals from the Yakima River to supply water demands at the Trendwest property.

Separate water availability modules were necessary for each tributary to account for differences in the timing and receiving water for return flows, and the range of gains and losses of flow through the streambeds to the underlying alluvial aquifers. However, each of the water availability modules contains a number of common elements. This section of the report contains a description of the basic elements and assumptions common to each of the tributary water availability modules, followed by a description of the particular method used for each tributary stream.

The model originally was constructed for the MPR EIS and updated for the UGA Draft EIS. Subsequent Ecology review of the model resulted in a recommendation to include irrigation return time lags, and to incorporate additional data collected by Ecology during 2001. Regression analyses were conducted to improve the accuracy of the UGA Draft EIS estimates for Big, First

9 The tributaries with Trendwest water rights are Big Creek, Teanaway River, First Creek and Swauk Creek. First Creek is a tributary of Swauk Creek. First Creek flow is diverted to irrigate crops in the Reecer Creek Sub-Basin, via the First Creek Water Users Association Ditch (formerly known as the Wold-Munson Ditch). First Creek irrigation return flows follow groundwater pathways under the Reecer Creek Sub-Basin and discharge into the Yakima River near Ellensburg.

and Swauk Creek streamflows. The Draft EIS streamflow predictions were based on a limited set of historical USGS measurements, and monthly monitoring from the period of 1999 through 2000. Data from ECT in 2001 provided continuous streamflow from late spring through summer, and thus enabled regressions with a much larger set of measurements. In August 2001, ECT and the UGA team met to discuss the water balance model and decide how to best apply the new 2001 data in combination with the 1999 to 2000 data that were available. The ECT and UGA teams decided that updating the regression analysis to include the relationship between data from the USBR Teanaway River at Forks gauge and the 2001 continuous gauge data would be the best way to improve the accuracy of the model's streamflow estimates. The UGA team also agreed to calculate the confidence bounds around the regression prediction to indicate uncertainty of the streamflow estimates. Adding the large number of 2001 data pairs to the prior 1999 to 2000 data in the regression greatly tightened the confidence bounds around the model prediction for each stream. The regressions and confidence bounds are shown and discussed in Exhibit B.

The regression equations in the revised model used: (1) data collected by the UGA team during the 1999 and 2000 irrigation seasons; and (2) the ECT data from 2001. These data were paired with concurrent flow data from the Teanaway River to estimate flows at the continuous gauge locations. The data pairs, regressions, and R-squared values are shown in Figures 4.1, 4.3, and 4.5. The regressions link natural streamflow in the tributaries to streamflow measured at the Forks gauge on the Teanaway River. Figures 4.2, 4.4 and 4.6 show the regression-estimated streamflow and the 90 percent confidence limits with the actual measured flows for the period of continuous monitoring during 2001. These figures show that the actual streamflows are greater or less than the regression-estimated streamflow by varying amounts. The regressions minimized the difference between the concurrent observed and predicted flow for the total data set for each predicted streamflow location. Each regression includes the basic assumption that the differences between concurrent observed and predicted flows occur randomly in a log-normal distribution. A logarithmic transformation was used to avoid predicting negative flows during the low-flow season. Much of the time, the regression analysis over-predicted flows during the mid- to late-summer low flow season, and under-predicted flows during the spring and early-summer season.

It is evident that as streamflows reduced through the 2001 irrigation season, the fit of the predicted streamflows to the actual observed data tightens along with the 90 percent confidence bounds. Outside of a single storm in August 2001, the regression-predicted flows were within the 90 percent confidence bounds during the lower-flow period of concern. The late August 2001 storm shows as a peak in the predicted tributary hydrographs because of the Teanaway River's response to the storm. However, during the lowest flow season in 2001, observed stream flows generally ranged between the middle and lower bound model simulations (see Exhibit B). The middle and lower bound simulations were therefore used to characterize a reasonable range of expected conditions for the average study years.

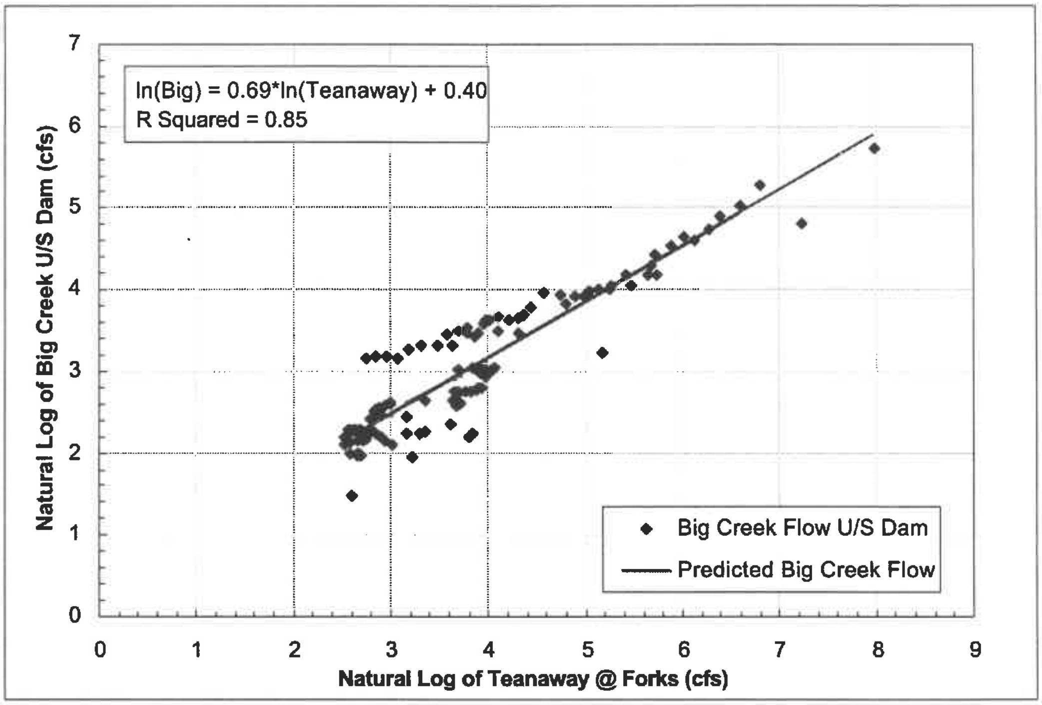

Figure 4.1. Log-Log Regression of Teanaway River at Forks and Big Creek (Upstream of Darling- Lund Diversion)

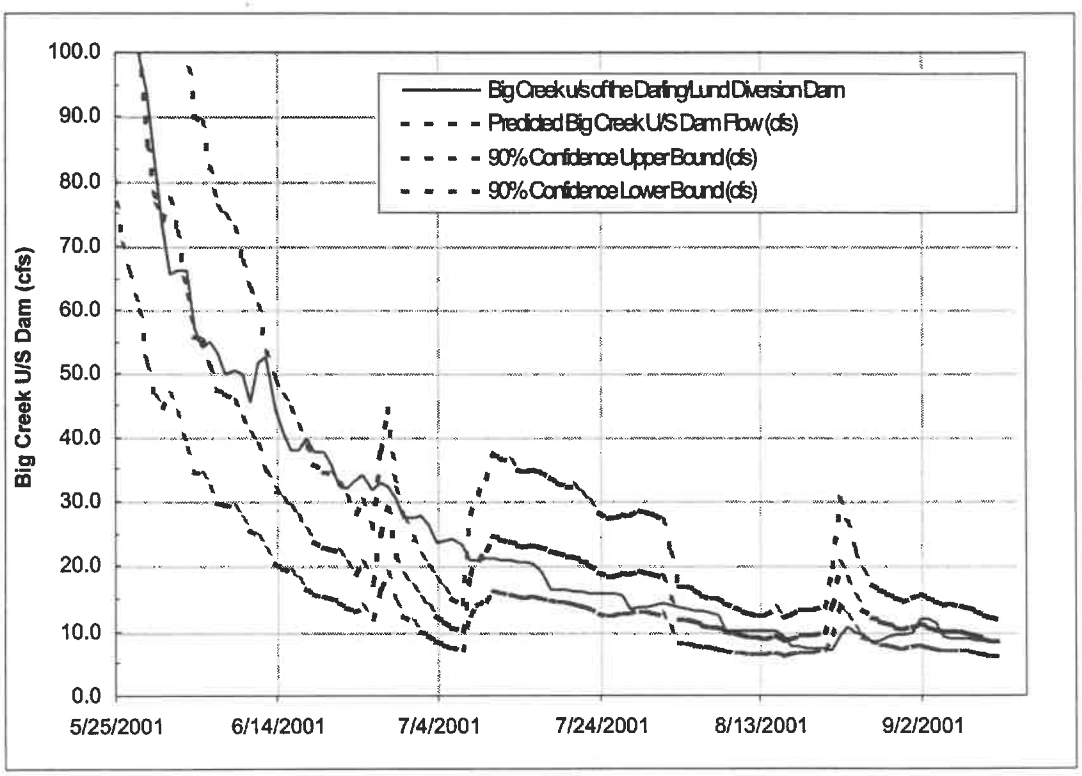

Figure 4.2. Predicted Versus Observed Big Creek Stream flow During 2001 Monitoring Period

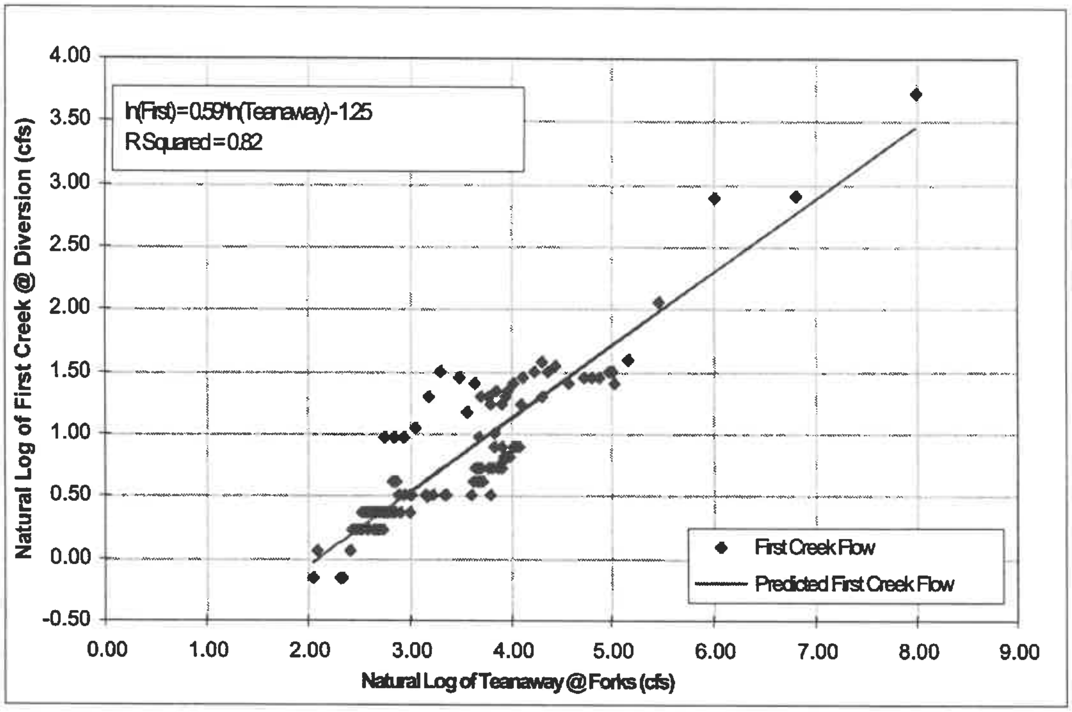

Figure 4.3. Log-Log Regression of Teanaway River at Forks And First Creek Upstream of the Diversion

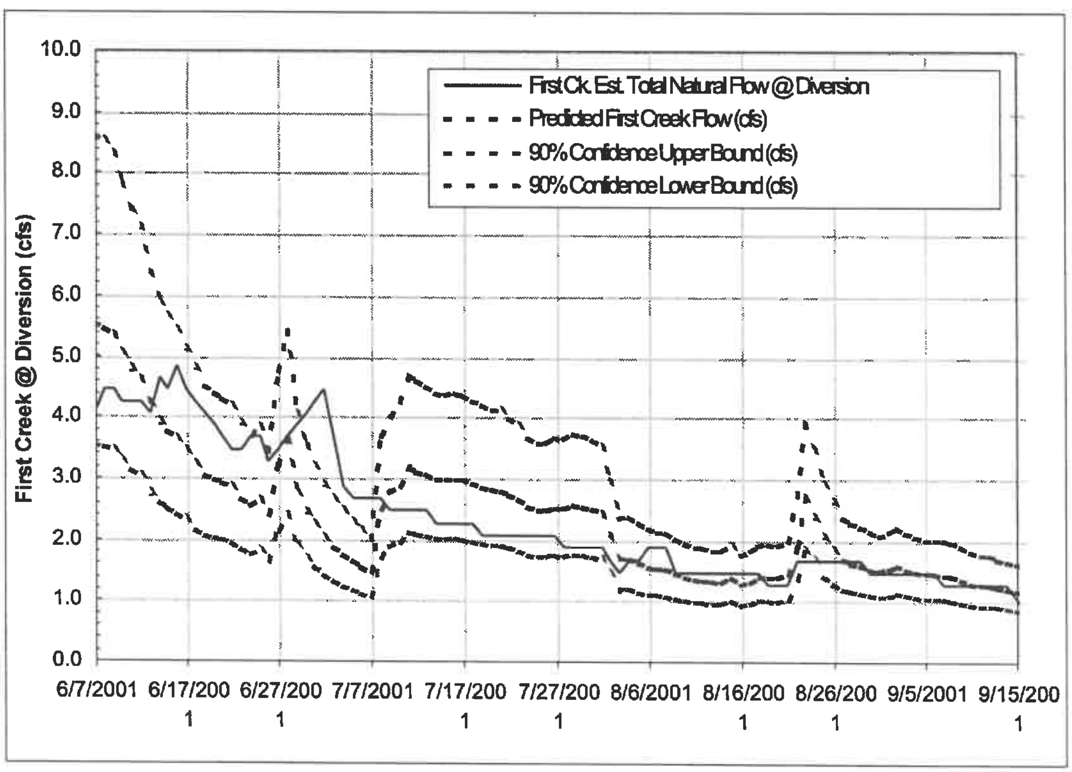

Figure 4.4. Predicted Versus Observed First Creek Streamflow During 2001 Monitoring Period

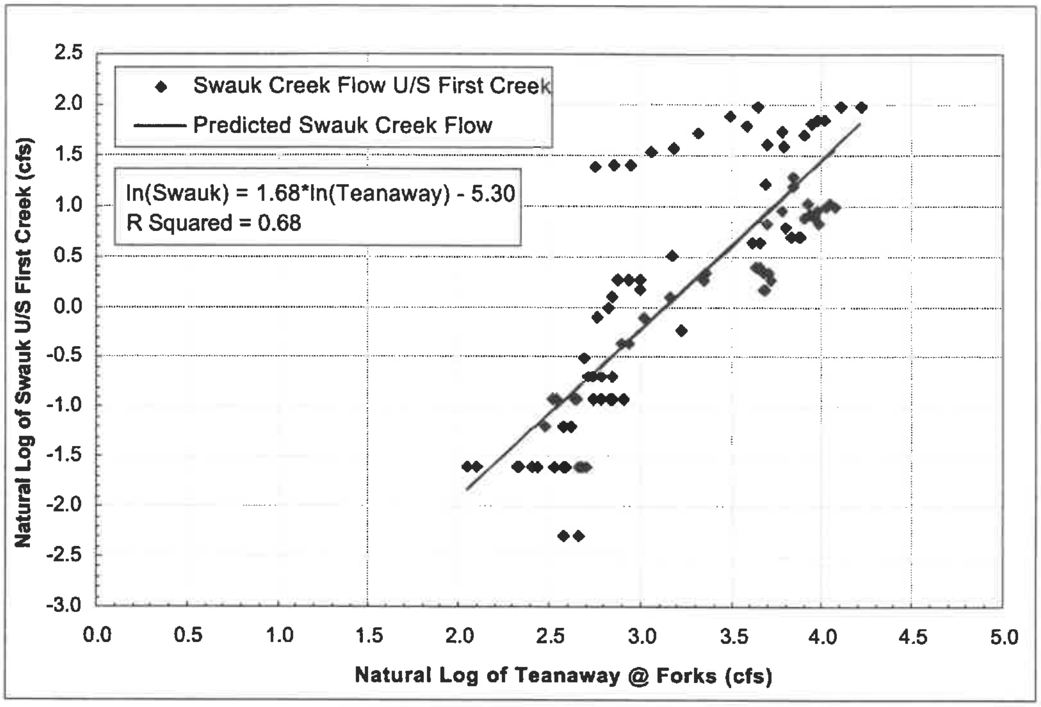

Figure 4.5. Log-Log Regression of Teanaway River at Forks and Swauk Creek (Upstream of First Creek)

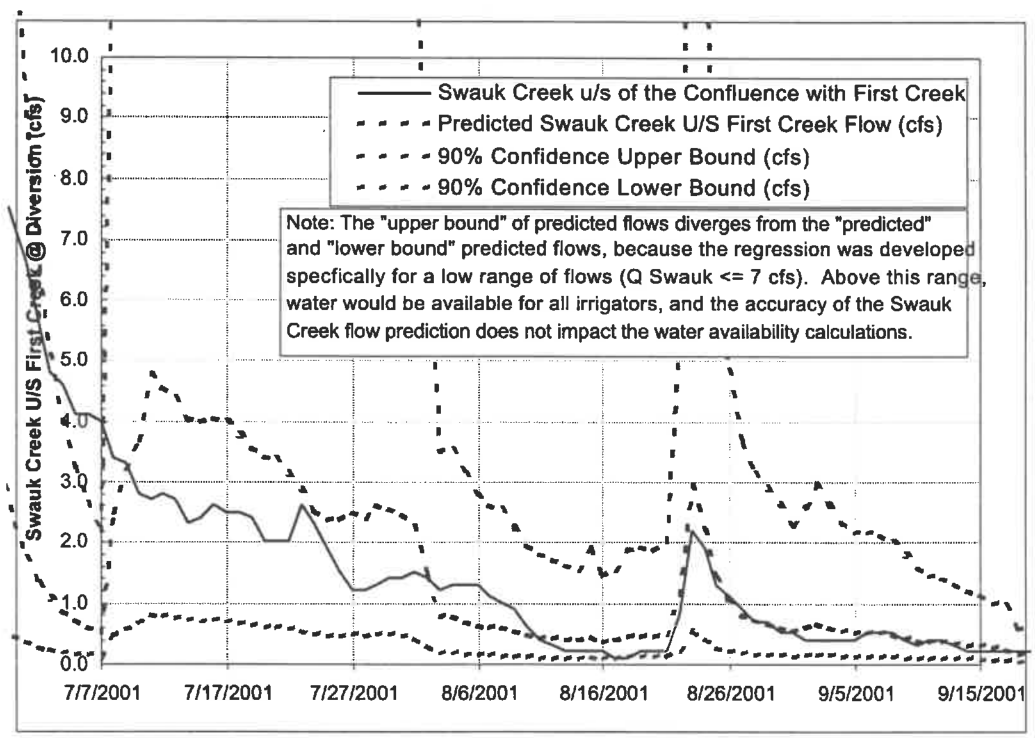

Figure 4.6. Predicted Versus Observed Swauk Creek Streamflow (Upstream of First Creek) During 2001 Summer Low Flow Season

Work by ECT in 2001 included not only continuous and non-continuous streamflow gauging on the tributaries and diversions, but also seepage studies, modeling of irrigation return flows, evaluation of alluvial subsurface flows, and review of the consumptive inputs and MPR and UGA return flow inputs to the models. Brown and Caldwell incorporated the new data and recalibrated the streamflow estimates of the water availability using the regressions described above. Consistent with the previous MPR and UGA EIS model analyses, water years 1991 through 1995 were simulated. Water year 2001 was added for this analysis to represent a drought year condition.

The water supply technical report prepared for the UGA Draft EIS used water years 1990 through 1995 as a study period. The study period for the revised model for the UGA Final EIS also includes water years 1991 through 1995 and 2001. The period of water years 1992 through 1994 was the worst continuous drought on record for the Yakima River basin. Water availability in 1994 was the worst of these three continuous drought years. Model results from four of the six water years are averaged on a monthly basis to represent long-term, average conditions. Those four years include the relatively average years of 1991 and 1995, and the dry years of 1992 and 1993, so the representation of the long term average by the model is likely conservatively dry. The worst simulated drought years (1994 and 2001) were removed when computing the long-term, average conditions. Mean monthly changes in Yakima River streamflow are computed for water year 2001 to exemplify drought condition results. Water year 2001 was the worst single year drought since 1977. 1977 was the worst single year drought on record in the Yakima River basin. The characterizations of "average" and "drought" conditions are defined by the years chosen to represent them in the study period. It should be noted that even between "drought" years, the dry conditions can manifest in different ways at different times of the year. In 2001, for example, October precipitation was greater than the October average.

Natural Streamflow

The USBR operates and maintains several streamflow monitoring stations in the Upper Yakima River basin. Prior to summer 2001, there were few flow data available for the tributary streams. USBR has continuous monitoring gauge gauges on the Teanaway River at the Forks and above Lambert Road, but Big Creek, First Creek, and Swauk Creek were not continuously monitored until Ecology's work in summer 2001.

Determining the natural streamflow for the study period was a key first element to the water availability modeling that involved intensive flow monitoring, statistical analyses and extensive collaboration with ECT. As described above, during the summer of 2001 Trendwest, in cooperation with ECT, installed continuous flow monitoring gauge gauges on Big Creek, First Creek, and Swauk Creek.[10] ECT recorded streamflow at each monitoring gauge, and Brown and Caldwell used the natural streamflow at the Teanaway River at Forks gauge as a reference to establish a set of regression equations linking streamflow in the Teanaway River and the other tributaries. The regression equations predict flow in the tributary streams based on the natural streamflow at Teanaway at Forks.

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10 The ECT gauges recorded water level. Spot streamflow measurements collected by ECT were used to develop a relationship between flow depth and flow rate (i.e. a rating curve) that allowed for the conversion of water level to streamflow rate.

The log-log regressions for Big Creek and First Creek had R-square values above 0.80, and thus data from the entire monitoring period were used to define the relationship between the Teanaway and these two tributaries' flows. On the other hand, data for the entire Swauk Creek monitoring period resulted in a poor regression fit. Therefore, only the low flow range (less than 7.0 cfs occurring after July 1st) of the Swauk Creek monitoring data were used to obtain the best possible estimates of Swauk Creek flow from Teanaway data for the critical low flow period of interest.

Measurement or estimation of natural streamflows is made more complicated when diversions occur upstream of gauge locations. This occurred for the USBR Teanaway gauge at Forks and at the gauge ECT installed on First Creek below the FCWUA diversion. Estimations of natural flow at the Teanaway Forks gauge required correction for upstream diversions and return flows. Diversions were estimated using the Blaney-Criddle method to calculate crop consumption. Return flow quantities were estimated from crop consumption and irrigation efficiencies. Return flow routing and delays in timing were assessed by ECT (see Appendix B, which also provided estimates of reasonable confidence bounds for the sensitivity analysis shown in Appendix B. Total natural flow on First Creek was calculated directly by summing gauge data from the First Creek gauge below the diversion and measurements taken at the First Creek Water Users ditch just below the diversion.

Consumptive Use Calculations

Irrigation consumptive use was defined as the volume of water consumed through plant evapotranspiration. The calculations, based on the Blanney-Criddle formula, used the same conceptual method as described in the Washington State Irrigation Guide to estimate crop net consumptive use. The Blanney-Criddle method incorporates, at minimum, precipitation, temperature and crop types (in this case, pasture grass was used to represent the crop mix for the areas historically irrigated by Trendwest's water rights). The Washington State Irrigation Guide also included averaged relative humidity and wind data, however the Guide does not include sufficient data to estimate relative humidity at the places of use of the Trendwest water rights. Therefore, the version of the Blanney-Criddle equation used in the Guide could not be incorporated into the model. The Blanney-Criddle equation incorporated into the model included temperature and precipitation inputs for which spatial and temporal distributions could be determined to estimate location-specific and time-specific net consumptive use. The irrigation consumptive use in this report describes the total consumptive use for each predominate crop type, less effective rainfall.

Applicable proceedings in Ecology v. Acquavella were used to estimate the amount of land to be irrigated under each water right. For the Big Creek (Easton), Teanaway River and Reecer Creek subbasins, these consist of Conditional Final Orders entered by the Court. The Court has not yet entered a Conditional Final Order for the Swauk Creek subbasin. Consequently, the Supplemental Report of Referee for Swauk Creek was used to describe the number of irrigated acres for each Swauk Creek water right.

Water Availability Determination

The diversion and return flow calculations for the water rights Trendwest seeks to transfer determine when and how much water would have been available for the Trendwest acquired water rights. While each of the tributaries has its own combination of controlling factors, such as the relative location of junior and senior water users, the basic determination of water availability is the same for all tributaries. The model used the following steps to compute water availability and net consumptive use:

- Natural mean daily streamflow is estimated upstream of the point of diversion for Trendwest water rights.
- Mean monthly net consumptive use is calculated for Trendwest water rights and all senior water rights in the same tributary using the Blanney-Criddle equation. The equation inputs include actual mean monthly temperature and precipitation for the study period.
- Irrigation efficiency for surface diversions is established as a range of values (0.32 to 0.45) based on three sources of information, including rulings in the Acquavella adjudication, as described below.
- The irrigation diversion requirement is calculated by multiplying the net consumptive use by irrigated area and dividing by irrigation efficiency.
- Senior water right diversions are subtracted from the natural flows to determine water availability for Trendwest diversions and for all other water rights with the same priority.
- Time lagged irrigation return flows from upstream diversions are added back into the water availability.
- The Trendwest net consumptive use is determined based on the water available for diversion. If insufficient flow is available to meet the diversion requirement, then the crop consumption is calculated from available flow divided by the irrigation efficiency. Otherwise, the net consumptive use is calculated using Blanney-Criddle.

The prioritization of water rights is very important because, in some tributaries, there would not have been sufficient water for all irrigators throughout the summer season. In the water availability model, the location of a diversion is less important than its priority date, although location is important in situations where return flows are a significant percentage of total flow. For example, the model assumes junior rights holders must not divert if the water flowing past the diversion is less than sufficient to serve all downstream senior rights holders. Table 4-1 lists the tributary and mainstem water rights acquired by Trendwest. Exhibit C contains the list of all water rights included in the model for which priorities were assigned and consumptive uses calculated.

The diversion requirement for water at each irrigation site is computed as the consumptive use divided by the irrigation efficiency. The range of irrigation efficiency values (0.32 to 0.45) was based on three sources of information. First, the Washington State Irrigation Guide provides on-farm irrigation efficiencies. The furrow irrigation efficiency of 60 percent was multiplied by a conveyance efficiency of 75 percent to obtain the upper end of the efficiency range. Second, the Acquavella adjudication provides the total volume of diversion allowed for the irrigation season (Qa) in each irrigation water right. The Qa was divided by the net consumptive use estimated by the Blanney-Criddle equation using mean monthly temperature and precipitation input values for the period of 1989 to 1995. Third, Ecology provided their measurements of diversions into the 3M Ditch and the Ballard Ditch during 2001. These two ditches are near each other, and divert water from the Teanaway River between the Forks and Lambert gauges. Independently, for both ditches, the daily net consumptive use was estimated for the day of the measurements using the Blanney-Criddle equation with actual mean monthly temperature and precipitation measured during 2001. The irrigation efficiencies of the areas served by 3M and Ballard Ditches were estimated from net consumptive use divided by the measured diversion. Irrigation efficiency does not change the maximum potential consumptive use by crops, but does affect the amount of water necessary to supply the diversion requirement. The diversion requirement is the crop consumption, plus the non-consumptive irrigation return flow from the irrigated acres, plus return flow derived from seepage from diversion ditches.

The amount of water not consumed by evapotranspiration (crop consumptive use) was assumed to infiltrate to the groundwater table and flow to a surface water body. The subsurface flow path and irrigation return flow timing was a complex issue investigated by Brown and Caldwell and ECT, using streamflow measurements, field test pits, geological inference, and computer groundwater model simulations. The methods used to route irrigation return flow were specific to each tributary water availability model. See the following section for a detailed description of the method used for each stream.

Table 4-1: Tributary Water Rights Acquired by Trendwest

Tributary Water Rights	Acres	Qa (ac-ft)	Qi (cfs)	CU (ac-ft)	CU (cfs)
Big Creek (Gentry 1887)	81.51	390.1	1.53	127.22	0.50
Big Creek Subtotal[1]	81.51	390.1	1.53	127.22	0.50
Teanaway (Walker 1883)	63.00	341.20	1.26	121.75	0.45
Teanaway (Walker 1883)	70.00	379.00	1.40	135.28	0.50
Teanaway (Walker 1883)	4.00	21.60	0.08	7.73	0.03
Teanaway (Walker 1890)	34.00	183.60	0.68	65.71	0.24
Teanaway (Walker 1898)	12.80	69.12	0.26	24.74	0.09
Teanaway (Walker 1898)	4.00	21.60	0.08	7.73	0.03
Teanaway Subtotal[2]	187.80	1,016.12	3.76	362.92	1.34
First Creek (1877)	69.9	359.80	2.8	166.65	1.30
First Creek (1881)	163.1	813.40	5.00	388.86	2.39
First Creek Subtotal[3]	233.00	1,173.20	7.8	555.51	3.70
Swauk Creek (Hartman 1889)	75.00	562.50	3.34	179.31	1.06
Swauk Creek (Hartman 1878)	20.00	150.00	0.89	47.82	0.28
Swauk Subtotal[c]	95.00	712.50	4.23	227.13	1.35

1 Conditional Final Order Re Subbasin No. 2 (Easton) (Feb. 13, 1997).
2 Conditional Final Order Re Subbasin No. 3 (Teanaway River) (Feb. 8, 2001).
3 Supplemental Report of Referee Re Subbasin No. 4 (Swauk Creek) (July 6, 1998).

MPR and UGA Return Flows

MPR and UGA return flows primarily are a combination of wastewater discharges, leakage, and irrigation return flows. Net consumptive use requirements are the difference between total diversion requirements and return flows. Aside from the stockwater component of Trendwest's mainstem water rights (which are authorized for continuous year-around use), all other water rights owned by Trendwest currently are authorized for seasonal use during the irrigation season (which varies by water right). The model was used to determine the extent to which UGA and MPR consumptive use outside the irrigation season was counterbalanced by (1) the consumptive use component of the year-around stockwater rights, (2) the non-delayed return flows (i.e., wastewater discharge) from the UGA and MPR sites, and (3) the time-delayed and attenuated return flows from irrigation and leakage on the MPR and UGA, which would enter the Cle Elum and Yakima Rivers year around. During the irrigation season, the model calculated the extent to which UGA and MPR consumptive use was counterbalanced by the three components described above, plus a fourth component consisting of transferring Trendwest's tributary water rights to instream flows. Monthly water requirements fluctuate on a seasonal basis with the highest consumptive use occurring between June and September (within the irrigation season).

Trendwest's proposed diversions would result in a reduction in Cle Elum River flow below the Cle Elum River diversion (when active) and in Yakima River streamflow at Cle Elum. However, as discussed previously the Cle Elum River diversion would operate on an intermittent basis, while the Yakima River diversion would always be active. The model therefore assumed all water diverted to supply the UGA and MPR was diverted from the City's Yakima River diversion works. Irrigation on the MPR and UGA properties would add return flows to the Cle Elum and Yakima Rivers. Other return flows would occur, most significantly from the wastewater treatment plant and from water supply systems leakage. The onsite return flows (MPR and UGA) infiltrating as groundwater would be delayed and "spread" through time (attenuated) before reaching the Cle Elum or Yakima Rivers. These delays and attenuating effects were estimated and are described in detail in Exhibit F. Wastewater treatment plant return flows were considered to be immediate for the purposes of analysis on a monthly average basis. Thus no time delays for wastewater return flows were put into the model. The difference between diversions and return flow (delayed and non-delayed) at any given time would be the net change in mainstem streamflow due to onsite water consumption by the MPR and residential UGA.

Stream-Specific Assumptions

Big Creek Water Availability Model

The water availability model for Big Creek calculates the amount of water available daily for the 1887 priority date Gentry water right, which was acquired to help offset consumptive use at the MPR and UGA site. The Gentry water right shares its priority date and diversion location with the Lund and Darling rights. These rights are the most senior on Big Creek. For the study period, there was sufficient water for all of the senior rights holders on Big Creek. The water availability model for Big Creek simulated the effects of transferring the Gentry water right by computing:

- The amount of water diverted daily from Big Creek by the senior users.
- The volume and timing of irrigation return flows before and after the water right transfer.
- The volume and timing of alluvial seepage return flow before and after the water right transfer.

Irrigation return flow routing and timing, and streambed seepage were important issues for determining the effects of water rights transfer on Big Creek. When Trendwest's share of the Gentry water right was operating, the water was conveyed via the Lund Ditch to the Gentry property. The Gentry property is located near the topographic divide between the Big Creek and Little Creek watersheds. Irrigation return flow from this property flowed vertically through the vadose zone to the water table, then laterally via groundwater to the Yakima River rather than back into Big Creek. The flow path to the Yakima River was approximately one mile, and delayed return flows in such a manner that some proportion of the return flow reached the Yakima River throughout the entire year. ECT estimated that about 80 percent of the total irrigation return flow reaches the Yakima River within 4 to 10 months after the start of irrigation season (PGG 2002).

ECT modified and expanded a groundwater model developed previously by Brown and Caldwell to estimate the timing of return flow (Figures 4.7 and 4.8). The predicted groundwater outflows shown in Figures 4.7 and 4.8 would be further delayed by two weeks due to estimated time lags in the unsaturated zone (Appendix G). ECT and the project team agreed on reasonable ranges in values for the background recharge, seepage from Big Creek ditches, and hydraulic properties of the local soils. Hydraulic properties of soils are described by their hydraulic conductivity (K), which is the rate at which soil can transmit a liquid under the influence of gravity. A high K value means the soils can transmit water quickly (for example, gravel), and a low K value means the soils transmit water slowly (for example, silts). ECT developed fast and slow return flow schedules from this range of inputs by groundwater modeling.[11] ECT and the project team agreed to use the average of the two schedules as the most probable schedule. The water availability model distributed the total annual irrigation return flow volume according to the schedule developed by ECT, using an average of the two schedules for the water balance model (see Section 4.1.2). The high and low return flow schedules were used to establish a reasonable range of expected outcomes from the simulation model (see Exhibit B).

Ecology streamflow monitoring during 2001 indicated that Big Creek loses surface water to its alluvial aquifer via streambed seepage. ECT quantified these losses by using field flow measurements to develop a relationship between flow and seepage (Figure 4.9). The water availability model routes the seepage volume for the "before" and "after" conditions to the Yakima River according to the schedule developed by ECT and shown in Figure 4.10.

11 Big Creek Basin Hydrologic Analysis (Pacific Groundwater Group 2002).

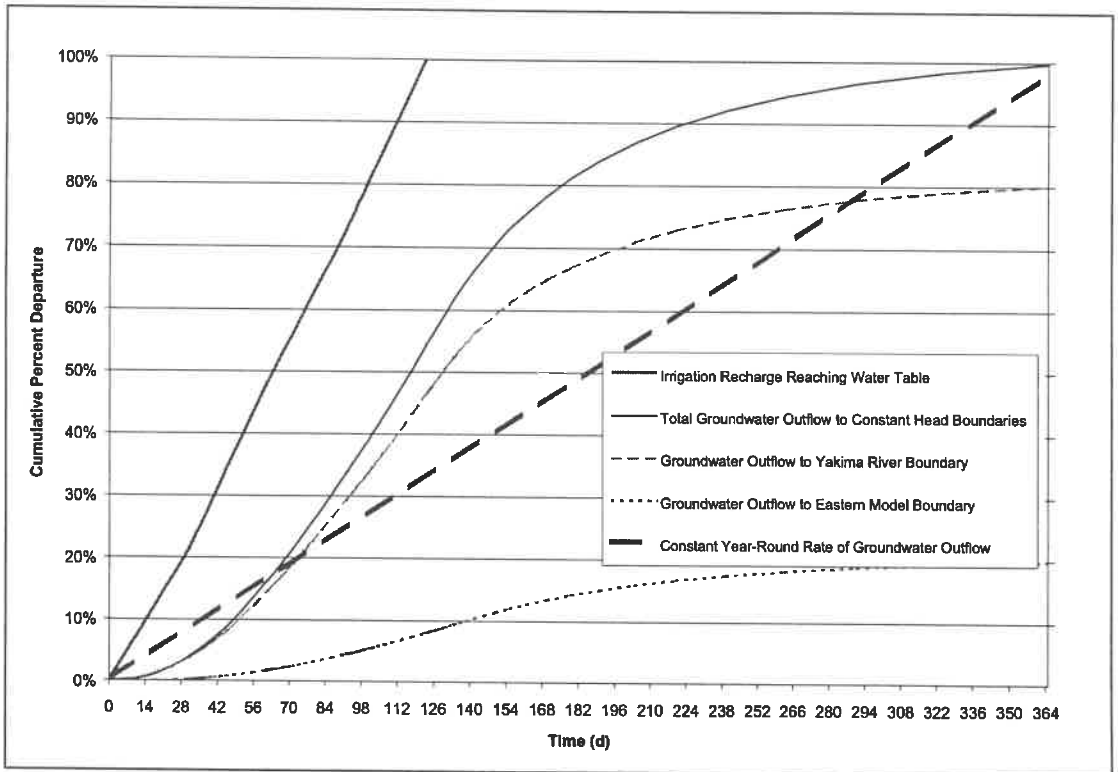

Figure 4.7. Irrigation Return Flow Schedule to Yakima River from Big Creek Diversion (Hydraulic Conductivity, K = 750 ft/day)

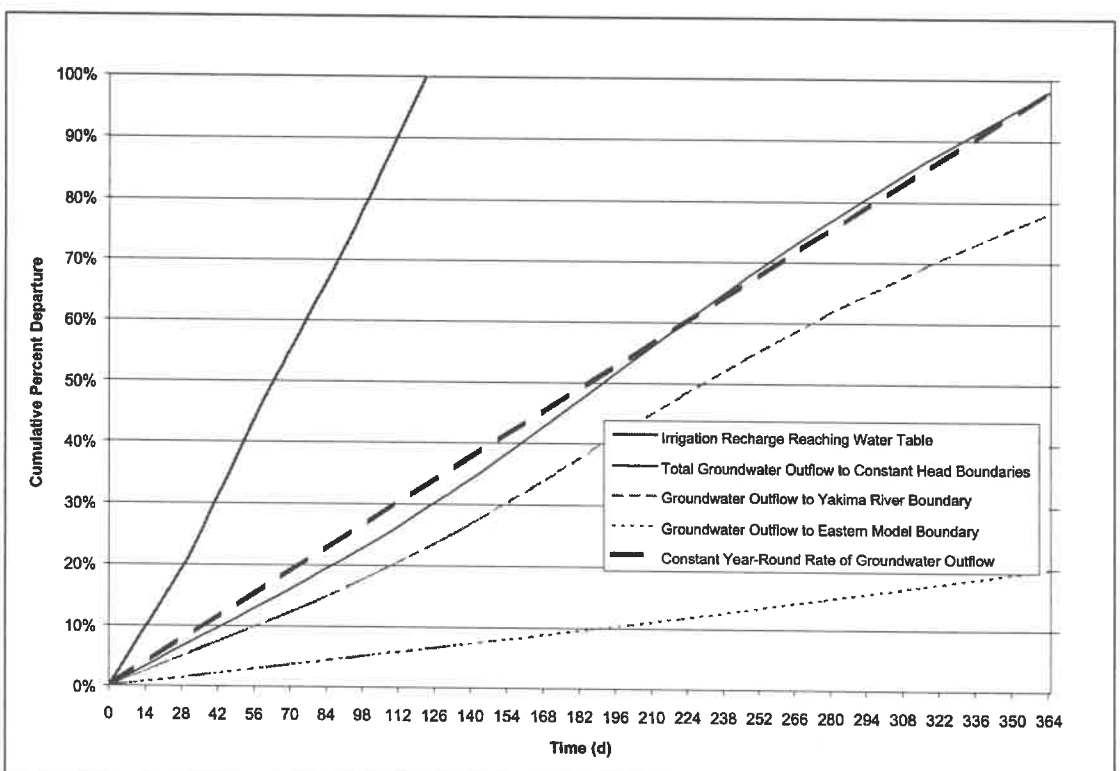

Figure 4.8. Irrigation Return Flow Schedule to Yakima River from Big Creek Diversion (Hydraulic Conductivity, K = 75 ft/day)

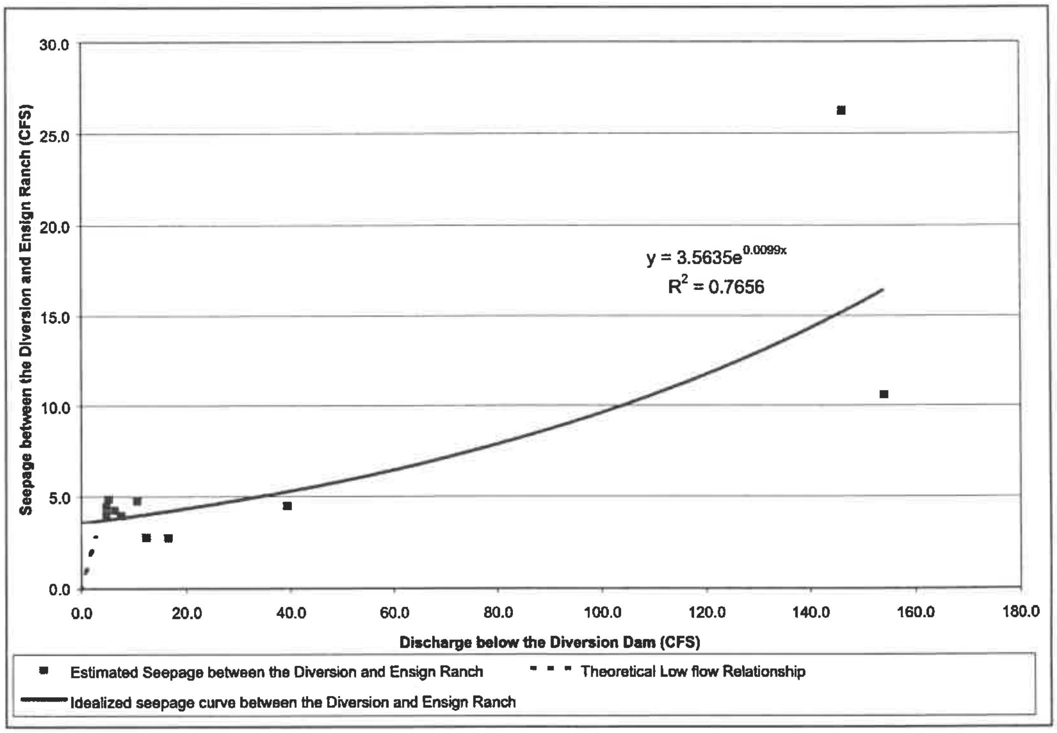

Figure 4.9. Empirical Relationship Between Streambed Seepage and Big Creek Flow at the Diversion Dam

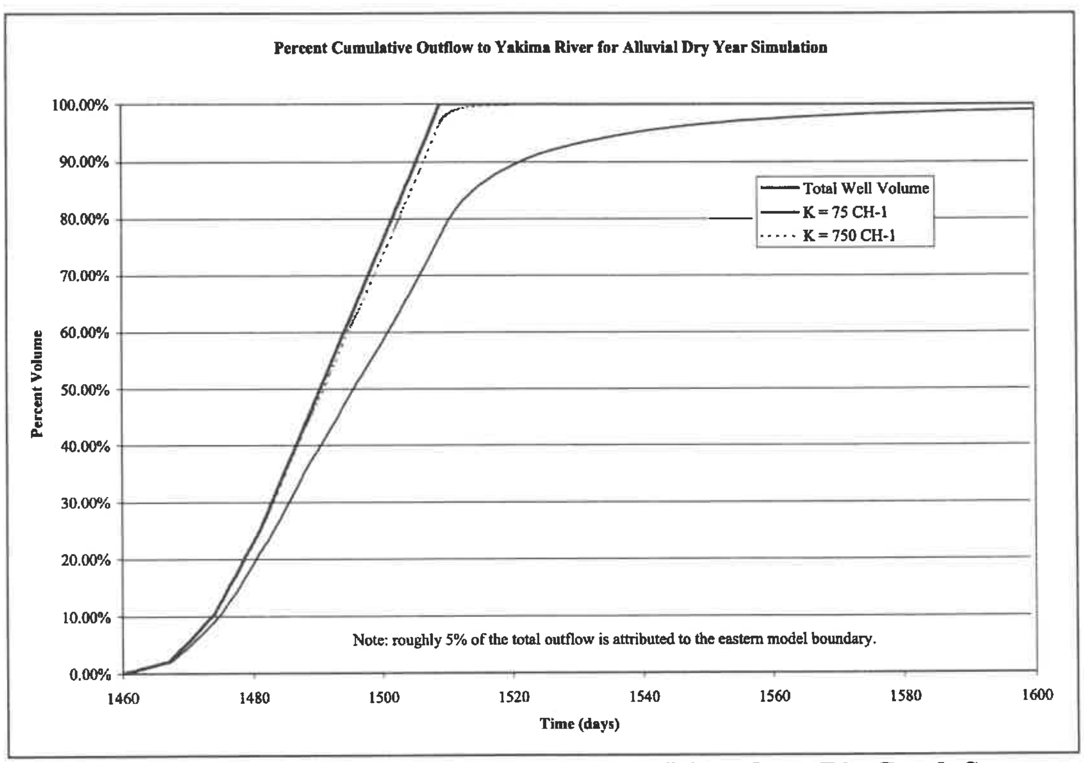

Figure 4.10. Alluvial Return Flow Schedule to Yakima River from Big Creek Seepage

There are four major irrigators on Swauk Creek: Hartman (acquired by Trendwest), Burke, Coe, and Tang. The Burke and Hartman properties, which are located just downstream of the confluence of First Creek and Swauk Creek, include rights that are senior to the Tang and Coe water rights, and the Hartman property also includes rights that are junior to the Tang and Coe water rights. Sufficient water must remain instream for the Tang and Coe properties before the junior Hartman right can be available to the Trust to help offset the consumptive use on the MPR and UGA site.

The Swauk Creek water availability model allocated water under Swauk Creek water rights, based on the priority date of each water right using the assumption that the water lost to streambed seepage between the former Hartman property and the downstream irrigators is insignificant. Although it was determined likely that a hydraulic connection exists between the creek and its floodplain, so that some subsurface irrigation return flows re-enter Swauk Creek near fields irrigated by diverters below the former Hartman property, the model was conservative in that it assumed upstream return flows were not available for use by other Swauk Creek irrigators. This had the effect of limiting water availability to supply Trendwest's junior Hartman water rights during some portions of the irrigation season to a greater extent than likely occurs. ECT field investigations and modeling supports the assumption of hydraulic connectivity, although some areas lacking continuity were noted during field investigations. ECT also estimated that seepage losses are insignificant at flows typical of the irrigation season. The cessation of the diversion at the Hartman property has resulted in an increase in surface water flow in Swauk Creek. Through a process of field investigation, geological inference, and groundwater modeling, ECT found that the Hartman property return flow enters the alluvial aquifer and discharges back to Swauk Creek both locally and throughout adjacent portions of Hidden Valley upstream of Swauk Canyon. ECT developed a return flow schedule for Swauk Creek that was incorporated into the Swauk Creek water availability model.[14]

Reecer Creek Return Flow Model

ECT field investigations found that there is water loss through seepage in the FCWUA ditches. Ditch seepage losses and irrigation return flows do not discharge to Reecer Creek. Based on hydrogeologic interpretation, ECT estimated that they return to the Yakima River uniformly throughout the year via a subsurface route.

ECT measured the changes in flow at different locations along the FCWUA ditch and provided a irrigation return flow schedule for use in the model.[15] The ditch losses are dependent on the amount of flow diverted and range from approximately 0.3 to 0.5 cfs. ECT estimated the on-field irrigation losses to be 50 percent of the water applied to the field, with return flow distributed evenly throughout the year.

The Reecer Creek return flow model computed the amount of water required for irrigation for the FCWUA properties, both before and after Trendwest acquired a portion of the FCWUA rights. Based on irrigation demand, the corresponding ditch seepage and total maximum

14 First and Swauk Creek Basin Hydrologic Analysis (Pacific Groundwater Group 2002).

15 Reecer Creek Basin Hydrologic Analysis (Pacific Groundwater Group 2002).

diversion were computed. The required diversion was compared with the water available in First Creek to determine how much water was (1) diverted, (2) lost to ditch seepage, and (3) applied to the FCWUA fields. The amount of the Trendwest's FCWUA diversion was fed back to the First Creek water availability model to estimate the change in flow in the First Creek/Swauk Creek system.

Mainstem Yakima River Water Rights

Trendwest acquired water rights from the Pautzke Bait Company to serve as the primary water supply for its MPR and UGA development proposals. The Pautzke water rights were delivered through Mill Ditch, which is a diversion canal for which water is diverted from the mainstem Yakima River upstream of Ellensburg. The Pautzke Bait Company property is located adjacent to the Yakima River, just downstream of the mouth of Reecer Creek. The Pautzke water rights are authorized for use both for irrigation and for stockwater. The season of use for the Pautzke irrigation rights is from April 1 to October 15. The stockwater right is available outside the irrigation season. The stockwater right helps offset consumptive use that occurs on the Trendwest property outside the irrigation season.

The Pautzke water rights are large, but have relatively low efficiency, so the consumptive use available ranges from 10 to 20 percent of the total diversion.

Ecology and the project team agreed to use a 10 percent consumptive fraction for stock water rights.

4.1.2 Water Balance Model Results

Since Trendwest purchased tributary and mainstem water rights, irrigation diversions to, return flows from, and crop evapotranspiration (consumption) within the formerly appurtenant properties ceased. Tributary and mainstem streamflows have already changed due to the water right purchases, which left water formerly diverted to irrigation as instream flow. Transfer of the tributary and mainstem water rights to the Trust (cessation of irrigation diversions) would direct Big Creek, First Creek, Swauk Creek, the Teanaway River and, to a lesser extent, the Yakima River, towards a more normative hydrologic condition. The normative flow concept stresses the importance of natural flow paths and hydrology to sustain the conditions to which naturally spawning salmon have adapted over centuries of evolution. (See Poff et al, 1997). For the purpose of assessing mitigation need for impacts to mainstem Yakima River flow, the model was also run under average and drought year conditions with only the consumptive portion of the tributary water rights transfers. Changes in flows due to changes in timing of irrigation return flows from the formerly appurtenant properties also result from transferring irrigation water rights to instream flows. Nevertheless, they were excluded from this series of model runs shown in this section. This distinction was made to account for the changes in mainstem flow that would result in impacts requiring mitigation (shown in this section), compared to termination of a human-caused irrigation delay, which also causes flow changes. Ceasing human-caused irrigation return flow delays is not identified as an impact under this SEPA evaluation (see Exhibit A).

The water balance model was run for a reduced density MPR consistent with the Ridge Settlement Agreement signed by Trendwest plus UGA Alternative 5 (combined lower density cumulative alternatives). In order to isolate the effects of consumptive use from time-lagged tributary irrigation return flows, the non-consumptive tributary irrigation return component was taken out of the equation. This is equivalent to assuming that subsurface irrigation return flows were left instream at the points of diversion. Diversions were limited by water availability; therefore, consumptive use could be less than the potential consumptive use (based on Blanney-Criddle estimates), especially for more junior water rights.

The long-term, average year impacts and drought year impacts due only to the consumptive use component of the proposed water right changes are shown in Tables 4-2 and 4.3, respectively.[16] The tables show the impact of the cumulative effects of the UGA Alternative 5 and MPR reduced density water use. The downstream cumulative effects of the proposed on-site water use and discontinued off-site irrigation is shown in the right-most column of each table. Mill Ditch is the lowest point in the Yakima River at which the water right transfers to instream flows under the Trust mitigate for consumptive uses on the MPR and UGA site. A negative value in this table column indicates a net reduction in mean monthly Yakima River streamflow. A positive value indicates an increase. Representative spreadsheets from the water balance model are appended in Exhibit D.

Table 4-2: Mean Monthly Changes in Yakima River Flow from the "Consumptive Use Model" (Excludes Tributary Irrigation Return Flow Timing Effects) under Long-Term Average Year Conditions (Study Years 1991-1993, 1995)[1]

	D/S[2] Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S City of Cle Elum (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)
Jan	0.0	0.7	0.0	0.0	0.0	0.1
Feb	0.0	0.7	0.0	0.0	0.0	0.1
Mar	0.0	0.6	0.0	0.0	0.0	0.1
Apr	0.0	0.6	-0.3	-0.3	0.9	2.3
May	0.4	1.0	-0.3	0.9	3.1	5.1
Jun	0.5	1.1	-3.2	-1.8	0.3	2.5
Jul	0.6	1.2	-5.2	-3.6	-2.3	0.2
Aug	0.6	1.2	-3.8	-2.5	-2.0	0.4
Sep	0.0	0.6	-3.1	-2.7	-2.3	-0.4
Oct	0.0	0.7	-0.3	-0.3	0.1	0.7
Nov	0.0	0.7	0.0	0.0	0.0	0.1
Dec	0.0	0.7	0.0	0.0	0.0	0.1

1 The upper and lower bound simulation results are shown in Tables B.2 and B.3 in Exhibit B. The flow changes shown are from the middle simulation run (Table B.1 in Exhibit B).

2 D/S = "Downstream of … ."

16 Exhibit A contains water balance model predictions of the changes in Yakima River streamflow, that include the effects of irrigation return flow lag time and cessation of agricultural irrigation, in addition to the impacts of transferring the consumptive portion of Trendwest acquired water rights shown in Tables 4.1 and 4.2.

Table 4-3: Mean Monthly Changes in Yakima River Flow from the "Consumptive Use Model" (Excludes Tributary Irrigation Return Flow Timing Effects) under the Drought Year Condition (Study Year 2001)

	D/S[1] Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S City of Cle Elum (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)
Jan	0.0	0.7	0.0	0.0	0.0	0.1
Feb	0.0	0.7	0.0	0.0	0.0	0.1
Mar	0.0	0.6	0.0	0.0	0.0	0.1
Apr	0.0	0.6	-0.3	-0.3	0.9	2.2
May	0.4	1.0	-0.3	1.0	3.2	5.0
Jun	0.5	1.1	-3.2	-1.9	0.0	2.1
Jul	0.6	1.2	-5.1	-3.6	-2.6	-0.2
Aug	0.6	1.2	-3.7	-2.5	-2.0	0.3
Sep	0.0	0.6	-3.1	-2.7	-2.4	-0.4
Oct	0.0	0.7	-0.3	-0.3	0.1	0.7
Nov	0.0	0.7	0.0	0.0	0.0	0.1
Dec	0.0	0.7	0.0	0.0	0.0	0.1

1 D/S = "Downstream of … ."

4.1.3 Conclusions

There would be no reductions in Yakima River flow outside of the irrigation season below Ellensburg (D/S Mill Ditch) due to transfer of Trendwest's water rights. The changes outside of the irrigation season would be about +0.1 cfs, which are relatively small. During lower flow periods of 2001, a drought year, the observed streamflows were often lower than the model-predicted flows in Big Creek, First Creek, and Swauk Creek, though above the lower 90% confidence bounds (see Figures 4.2, 4.4, and 4.6). Thus, accurate characterization of streamflow during the driest portion of the irrigation season is expected to occur between the middle and lower bound simulations that were run with the model (see the complete results in Tables B.1 and B.3 in Exhibit B). The middle and lower-bound simulations for the average flow condition give a relatively narrow range of results for the most probable flow changes. For example, below Mill Ditch the most probable range of change in the spring is a +5.0 to +5.1 cfs in May. The most probable ranges of change during the dry season below Mill Ditch are -0.5 to +0.2 cfs (July), +0.1 to +0.4 cfs (August), and -0.6 to -0.4 cfs (September). All other months showed flow increases for the lowest bound simulations.

During a severe drought such as occurred in water year 2001, a decrease in Yakima River streamflow would occur in July and September below Ellensburg. The September decrease shows as the same as the long-term average. This shows that under both very dry and more average conditions, little water is available at the end of the dry season to fulfill many of the acquired water rights, and thus there is little change between average and drought conditions at this time of the year. The difference between long-term and severe drought cumulative MPR and UGA change in July is a reduction of 0.4 cfs—from a 0.2 cfs increase to a -0.2 cfs decrease below Ellensburg. The maximum springtime mainstem flow increase during a drought year such as 2001 would be 5.0 cfs, which is also about the same as the long-term, average conditions (5.1 cfs) for May.

The model was also run to include the effect of terminating the former irrigation return flow time lags from the tributary water rights (named the "combined" model simulations). Those results are shown in Exhibit A.

4.2 IMPACTS ON THIRD-PARTY WATER USES

Changes in the consumptive use of water under Trendwest's mainstem and tributary water rights were examined for potential to affect three categories of third party water users. First, third parties diverting from the mainstem Yakima River between Cle Elum's intake and Reecer Creek were examined for impact arising from reductions in mainstem flow between those two points. Mainstem diverters were evaluated under the assumption that mitigation for TWSA flow reductions from the shift in consumptive use under Trendwest's proposed transfers could take place between Mill Ditch and Reecer Creek, below the potentially affected parties. Second, ECT investigated impacts to third party water users diverting from tributaries downstream of Trendwest's water rights transferred to the Trust. Third, ECT examined effects that third parties using groundwater from shallow wells might experience near lands fallowed by the irrigation transfer to the Trust. These third parties could experience lower groundwater elevations caused by cessation of irrigation return flow recharge from the fallowed lands.

The impacts are shown as a change in flow levels, but it is important to evaluate the significance of the changes in flow levels. Significance is related to the physical accuracy of measuring river flows, diversions and return flows. (USBR 1999, at page 115). Flow measurement accuracy depends upon flow level and measures devices employed. Typical gaging station error ranges from 5 to 20 percent to even higher during very high flows. Therefore, model results that rely on measured flows reflect the accuracy of flow measurements, and should be considered to be no more accurate than the accuracy of measured flows. To assess the significance of hydrologic impacts, USBR has used an overall measurement error of 10 percent to define a "non-measurable impact." USBR selected an impact of less than 10 percent of measured streamflows because impacts shown in a hydrologic model that are less than this amount are not measurable due to gaging error.

4.2.1 Mainstem Water Users

Trendwest representatives contacted all Mainstem water users and their diversion systems were evaluated to determine their susceptibility to interference from Trendwest's proposed water rights transfers. Given the small difference in mainstem TWSA flows between the Cle Elum diversion and Reecer Creek downstream, the main concern expressed was that diversion systems employed by these diverters were already marginal in most cases to collect their water rights from the river. The concern was not that mainstem flow rates would be insufficient to meet their needs. Any change in flow or head pressure past their headgates could adversely affect the diverter's ability to withdraw water.

To evaluate the effect of Trendwest's combined UGA and MPR projects on these third parties, the water balance model was run to include both the results of the Trendwest's mainstem water rights transfers to the UGA and MPR, and the results of leaving tributary irrigation return flows instream. Inclusion of the latter has the result of showing the result of terminating the slower irrigation return pathway on the tributaries by leaving that water instream at the former point of diversion, hastening its delivery to the mainstem. That change in timing of the former irrigation returns to the Yakima River, in conjunction with the transfer of the consumptive portion of the water rights to the City of Cle Elum's diversion upstream, provides average year and drought year simulations for the total change to mainstem flows these third parties might experience. Those combined consumptive transfer plus irrigation return flow timing change results[17] were used to analyze the hydraulic impact potential between Cle Elum and Ellensburg (Exhibit K).

The combined water balance model results for an average year show that monthly average mainstem flow reductions of up to 4.6 cfs could occur in July and in September downstream of the Cle Elum River intake and the Teanaway, respectively. The flow reductions during the mid- to early irrigation season are less than for the consumptive transfer evaluation only (a monthly high reduction of 5.2 cfs) because the former irrigation returns reach the Yakima River more quickly. Late in the season, and for the remainder of the year, the irrigation returns would no longer slowly reach the Yakima River via groundwater flow paths, and thus mainstem flows are reduced even outside of the irrigation season (Exhibit A, Table A.3).

Hydraulic impacts to diversions in the mainstem Yakima River reach between Cle Elum and Ellensburg were evaluated (from upstream to downstream) for Younger Ditch, Wallace Ranch (Bristol Flats), Westside Irrigation Diversion, Thorp Diversion, Packwood Diversion, Cascade Irrigation Diversion, and Mill Ditch (Northwest Hydraulic Consultants, Inc. 2002). Impacts on Yakima River water levels at each of these diversion sites were estimated using the Manningsolver computer program for the Packwood, Wallace Ranch (Bristol Flats), Thorp, and Younger Ditch sites. This program computes "normal depth" based on the channel cross-section, water surface slope, Mannings roughness value ('n'), and flow. The normal flow depth near each diversion intake was estimated for the date of the evaluation using surveyed cross-section and water surface slope data. The Mannings 'n' for each site was calibrated based on the surveyed water level and the observed flow (approximately 1300 cfs at the Younger ditch site, 600 cfs at the Wallace Ranch (Bristol Flats) site and 2000 cfs at the other sites. The stream channel geometry, slope, and Mannings 'n' were then used to estimate flow depths for the altered low flow conditions at each diversion. Results of a sensitivity analysis for higher roughness values that would likely occur with lower flows caused a slightly higher Mannings 'n' (increased by 0.01) to be used for the evaluation of impacts for all of the diversion sites except Wallace Ranch (Bristol Flats). The 600 cfs calibration flow at that site was in the middle to low range of the flows used in the analysis, so it was not determined necessary to adjust that roughness value.

The approach described above was not suitable for the Westside Irrigation Company (Westside), because it places ecology blocks in the river downstream of its diversion during low flows to create constriction and backwater into the diversion. A simple hydraulic backwater model (HEC-RAS) was used to estimate the impact at this site, based on three cross-sections field surveyed downstream of the diversion site where the ecology blocks are placed, at the diversion intake structure, and approximately 100 feet upstream of the diversion structure. The HEC-RAS model was also used to evaluate the effect additional ecology blocks could have to offset the estimated impact of the Trendwest water rights transfers.

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17 See Exhibit A, Combined Model Results, for a complete discussion of the combined model simulations. Combined model results are shown in Exhibit A, Table A.3.

Field reconnaissance at the Cascade Irrigation diversion (Cascade) indicated that this site is likely to experience significant difficulties regardless of the Trendwest transfers. Thus, review of this site was limited to discussion of current conditions and examination of alternatives to improve the long-term reliability of this diversion.

Hydraulics in Mill Ditch are complicated because water collected by the ditch originates from several sources in addition to the Yakima River. These sources include irrigation return flows. Flow from the Yakima River first enters a side channel with some of the side channel flow splitting off into a smaller channel leading under I-90 and ultimately to the diversion intake. The Mill Ditch site is the original point of diversion for the water rights that were acquired by Trendwest, thus Yakima River flows (and water levels) downstream of this point should not be affected by the proposed transfers. In fact, the tributary water rights and return flows incorporated in the Trendwest proposal would result in higher flows at this location than under baseline conditions (Brown & Caldwell 2002). Therefore, the discussion of potential impacts at the Mill Ditch diversion that follows is limited.

The Ellensburg Water Company / Olson Ditch diversion is also within the study reach. However, because of the dam across the Yakima River and the design of this diversion structure, the potential for impacts from a small flow reduction at this location are negligible.

The flow data used in comparing the baseline condition with the impacts of the proposed transfer are presented in Table 4-4.

Table 4-4: Baseline and Proposed Flow Conditions

Dates	Baseline	Proposed Condition			
	All sites based on Yakima River at Cle Elum Gauge (cfs)	D/S Water Supply Diversion (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)
May 1 - May 15	504	504	507	513	515
May 16 - May 31	580	580	583	588	590
June 1 - June 15	935	932	933	938	940
June 16 - June 30	1434	1431	1433	1438	1441
July 1 - July 15	1920	1916	1918	1922	1925
July 15 - July 31	2852	2847	2849	2850	2853
Aug 1 - Aug 15	2655	2652	2652	2652	2655
Aug 16 - Aug 31	1322	1317	1318	1318	1321
Sept 1 - Sept 15	380	376	377	377	379
Sept 16 - Sept 30	407	404	402	403	405
Oct 1 - Oct 15	363	362	361	361	362
Oct 16 - Oct 31	210	209	209	209	209

Source: Northwest Hydraulic Consultants, 2002.

The hydraulic computations for each diversion site used the estimated flows from the nearest upstream flow location. The diversion sites that were analyzed in detail, and the corresponding Yakima River flow used are given below.

- Younger Ditch Diversion Site – Yakima River at Cle Elum flow
- Wallace Ranch (Bristol Flats) Diversion Site – Yakima River at Teanaway flow
- Westside Irrigation Diversion Site – Yakima River at Swauk flow
- Thorp Diversion Site – Yakima River at Swauk flow
- Packwood Diversion Site – Yakima River at Swauk flow

The proposed low flow conditions (with the Trendwest water rights transfers) were determined as the estimated flows for current conditions less the estimated maximum diversion for the MPR and UGA. The maximum diversion data, estimated for each month to meet the demands of the MPR and UGA at buildout (100% developed), were provided by W&H Pacific. Conclusions drawn from the analysis were the following (see Northwest Hydraulic Consultants, 2002 for details):

Younger Ditch Diversion

Over the range of low flows used in the analysis, water levels at the inlet of the diversion channel would be reduced by approximately 0.00 to 0.01 feet as a result of the Trendwest water rights transfers. The greatest difference would occur in September when the diversion as a percentage of the flow is the highest.

Wallace Ranch (Bristol Flats) Diversion

Over the range of low flows analyzed, the water levels at the inlet of the diversion channel under the proposed conditions (Trendwest diversion relocation) are 0.01 feet greater early in the irrigation season to 0.01 feet less late in the season than under existing conditions. The largest difference (0.01 feet) is seen in the month of September when the diversion as a percentage of total flow is the highest.

Westside Diversion

The Trendwest diversion relocation would result in water level differences ranging from an increase of 0.02 feet to a reduction of 0.01 feet at the diversion site if ecology blocks are not in place (i.e. for the current river condition). With the ecology blocks in place the simulated differences in water levels at the diversion site range from +0.03 to –0.01 feet. The largest difference in water levels is predicted in the month of September when the diversion as a percentage of flow is the highest.

Thorp Diversion

Over the range of low flows used in this analysis, the water levels at the inlet of the diversion channel under the proposed conditions (Trendwest diversion relocation) would be +0.02 let early in the irrigation season to –0.01 feet than under existing conditions. The largest difference (0.01 feet) would be seen in the month of September when the diversion as a percentage of total flow is the highest. Based on this analysis the Trendwest diversion relocation may result in a small increase or decrease in water levels at the inlet to the Thorp diversion channel but the largest computed reductions were less than or equal to 0.01 feet.

Packwood Diversion

Over the range of low flows used in this analysis, the water levels at the inlet of the diversion channel under the proposed conditions (Trendwest diversion relocation) would increase 0.04 feet early in the irrigation season and decrease by 0.02 feet later in the season. The largest difference (0.02 feet) would be seen in the month of September when the diversion as a percentage of total flow is the highest. Based on this analysis the Trendwest diversion relocation may result in less than a 0.02 foot drop in water levels at the inlet of the Packwood diversion channel over the irrigation season.

Cascade Irrigation Company Diversion

Considering the ongoing geomorphic processes at this site, the history of human induced modifications to this reach of the river, and Cascade Irrigation's current program of in-channel structure placement, the impact of Trendwest's proposed diversion cannot be reasonably estimated at this time. However, any potential impacts would be minimal compared to changes that are occurring due to natural river processes.

Mill Ditch Diversion

The hydraulics and hydrology of the Mill Ditch diversion are complicated by a number of factors including the flow splits off the Yakima River, the hydrology of the groundwater lake, and the flow in Dry Creek.

Diversions Downstream of Mill Ditch

Because flows downstream of the Mill Ditch diversion would theoretically be the same in both the current and proposed conditions it seems unlikely that the Trendwest proposal would result in any significant impacts.

4.2.2 Tributary Surface Water Users

Impacts to Tributary Flows

Hydraulic effects on the tributaries affected by the Trendwest transfers were evaluated for Ecology by Montgomery Water Group, Inc. (MWG), an ECT member consultant (Exhibit J).

<u>Big Creek</u>

MWG determined the hydraulic effects of the Trendwest Big Creek tributary transfer using data collected in Big Creek and at the Darling and Lund diversion ditches during 2001. See Section 3.4. Changes in stage or depth are highest at the end of the season when average flows in Big Creek are significantly lower. In Big Creek below the Darling/Lund diversion dam, the change in stage resulting from the transfer of Trendwest's Big Creek water right to instream flow was graduated, rising from 0.00 ft in early May to 0.05 ft in the last half of August. These changes in stage persisted downstream to the West Nelson Siding Road. The change in stage in Big Creek at the Ensign Ranch was less, rising only by 0.04 ft in the last half of August.

Teanaway River

MWG determined the hydraulic effects of the Trendwest Teanaway River tributary transfers by using USBR data collected during 2001. The change in stage associated with increases in flow of 0.78 to 3.39 cfs ranges from approximately less than 0.01 to 0.16 ft from May to September 15. Immediately after the end of the season (September 16 through October 15), a decrease in flow and a corresponding decrease in stage of 0.01 to 0.02 ft are expected because of loss of return flows associated with irrigation on the Walker properties. These results are based upon the USBR Lambert Road rating curve and flow data. ECT's data suggest that the Lambert Road rating curve may incur some error at flows above 9 cfs. Any errors associated with those data would similarly affect the accuracy of these estimations.

Swauk Creek

MWG determined the hydraulic effects of the Trendwest Swauk Creek and First Creek tributary transfers on Swauk Creek using data collected in Swauk Creek during 2001. The increase in streamflow as a result of the Trendwest water rights transfers on Swauk and First Creeks are greater than the historical average flows in the creek from several biweekly periods during the season, especially in late summer. The estimated change in stage and depth at the Swauk Creek Martin gauge associated with changes in flow of 0.8 to 6.6 cfs ranges from 0.05 ft to 0.20 ft.

First Creek

Water used by the FCWUA is imported into the Reecer Creek subbasin from the Swauk Creek subbasin. Reecer Creek water users are not entitled under state law to rely on the continuation of return flows from water rights imported from another basin. Nevertheless, MWG determined the hydraulic effects of the Trendwest First Creek tributary transfers on First Creek using data collected during 2001. The estimated increase in stage and depth ranges from 0.17 to 0.39 ft at the upper First Creek station and 0.14 to 0.28 ft at the lower First Creek station. The highest flow measurement at the upper First Creek station was 2.8 cfs on July 3, 2001 and was taken when all the flow above the FCWUA diversion was diverted into First Creek. The highest flow measurement at the lower First Creek station was 2.0 cfs on June 11, 2001. Trendwest's water rights transfers to First Creek instream flows from mid-June to mid-October would increase creek flows, and therefore would result in a stage increase.

Reecer Creek

MWG determined the hydraulic effects of the Trendwest First Creek tributary transfers on Reecer Creek upstream of Dolarway Road using data collected in Reecer Creek during 2001. MWG estimated the reduction in stage on Reecer Creek associated with a reduction in flow of 25.4 to 28.2 cfs is approximately 0.6 ft at the Reecer Creek station. This estimate is based on the check structure configuration present from July 11, 2001 to September 26, 2001. Diverters on Reecer Creek change the check structures throughout the irrigation season and from year to year based on daily irrigation needs. Changes in the check structures since MWG's September 26th measurements may have changed the rating curve and thus the reported relationship between flow and stage at the Reecer Creek Upstream of Dolarway Road site.

4.2.3 Third Party Tributary Diversions

MWG evaluated the effects of changes in the affected irrigation ditches due to the proposed transfer of Trendwest water rights where the ditches would remain in use, reported in *Review of Effects of Water Rights Transfers on Tributary ad Ditch Hydraulics* (Montgomery Water Group, Inc. 2002). MWG's findings were based on field observations, flow measurements, cross-sectional geometry surveys, and continuous monitoring data in the associated tributaries. Seepage analyses were conducted on three of the ditches where Trendwest holds water rights: Lund/Gentry ditch; FCWUA ditch; and Mill Ditch. No flow measurements or monitoring occurred on the Burke-Hartman ditch during 2001 because the ditch was not in use.

Big Creek: Lund/Gentry Ditch

MWG monitored irrigation diversions in the Lund/Gentry ditch weekly over the 2001 irrigation season. A seepage survey was conducted on July 12, 2001. Measurements were taken at laterals used by the remaining irrigators on the ditch. From these activities, MWG estimated that depths in the upper and lower Lund ditches would be 0.2 to 0.3 ft lower after the Trendwest transfer than the typical depths observed prior to the transfer. Lund ditch users have a number of laterals that serve the irrigated properties on the lower end of the ditch as well as a number of storage ponds and irrigation pumps. Changes in flow and depth in the Lund/Gentry ditch during the 2001 season when Trendwest's water rights were not diverted did not appear to affect the remaining water users' ability to divert water from the main ditch and associated laterals.

Swauk Creek: Burke-Hartman Ditch

Drought transfers on the Burke-Hartman ditch during the 2001 irrigation season prevented flow measurements at key points along the ditch. Consequently, no data were available to evaluate changes in hydraulic conditions within the Burke-Hartman ditch. Given that Trendwest's water right is a majority of the water allowed to be diverted to the ditch, some impact is reasonably assumed, but could not be quantified during the study period.

First Creek: FCWUA Ditch

MWG monitored weekly irrigation diversions on the FCWUA ditch over the irrigation season. Weekly measurements were taken at the FCWUA flume just downstream of the irrigation diversion and at the Roan/Olsen weir split near the end of the ditch in the Reecer Creek basin. In addition, several seepage surveys were conducted on the ditch during the irrigation season to evaluate seasonal changes in the hydraulic conditions along the ditch. Depths in the FCWUA ditch at Green Canyon and upstream of the Roan/Olsen weir are estimated to change by 0.1 to 0.5 ft and 0.2 to 0.5 ft, respectively. Changes in depth did not appear to affect the ability of other water users to take water from the FCWUA ditch during the 2001 irrigation season when the Trendwest water rights were not diverted.

Yakima River/ Reecer Creek: Mill Ditch

MWG's analysis of how hydraulic conditions in Mill Ditch would change as a result of the proposed Trendwest water rights transfer were complicated by the relocation of a quarter mile section of Mill Ditch upstream of Hwy 97 in June 2001. This relocation changed both the channel hydraulics and the seepage characteristics in the ditch. These changes, as well as leasing of other water rights during the 2001 irrigation season, preclude the ability to separate the effects of the water rights transfer from the effects of the ditch relocation. In addition, there are a number of check structures on Mill Ditch and on Reecer Creek below the Mill Ditch confluence that facilitate water users' ability to alter water depths and improve delivery to their laterals. Field observations of Mill ditch during 2001 indicate that manipulation of the check structures allow adequate delivery to the remaining water users, even without the Pautzke water right.

4.2.4 Tributary Groundwater Users

Impacts to groundwater levels and wells resulting from the Trendwest transfers were evaluated by ECT (Exhibit I). PGG evaluated changes in groundwater from well logs on file with Ecology, ditch field seepage loss evaluations and geologic characterizations from its *Basin Hydrologic Analyses* for Big Creek, Teanaway River, First-Swauk Creeks, and Mill-Reecer Creek. The evaluation of impacts is limited to general observations about wells but does not estimate impacts to any particular well.

Big Creek

PGG estimated the maximum seasonal decline in groundwater resulting from retiring Trendwest water rights in the Big Creek subbasin would be 1. 5 to 2.0 ft. This maximum decline is centered in the northern half of Section 28, Township 20, Range 14 EWM. The area of groundwater change is roughly circular with a diameter of approximately 1.5 miles. No to very minor impacts to vicinity wells would result from this level of change. Groundwater level declines of this order are small relative to water columns reported in most wells. Nonetheless, declines on this order may cause minor yield reductions in some wells at some times of the year.

Teanaway River

PGG estimated the maximum seasonal decline in groundwater resulting from retiring Trendwest water rights in the Teanaway River subbasin would be 1.6 ft. This maximum decline is predicted to occur in Section 26, Township 20 North, Range 16 EWM. Because most wells are completed below (or deep within) the alluvial aquifer, only minor impacts to vicinity wells would likely result from this level of change. Declines of this order may cause minor yield reductions in some wells, particularly shallow wells completed in the alluvial aquifer, at some times of the year.

Swauk Creek

PGG estimated the maximum seasonal decline in groundwater resulting from retiring Trendwest water rights in the Swauk Creek subbasin would range from 3.0 ft to as much as 7.0 ft, depending on the value assumed for hydraulic conductivity in the Swauk basin. The area of change is confined to the Hidden Valley area and is approximately 1.25 miles in length. Groundwater level declines of this order are small relative to the reported completion depths of most nearby wells. Nonetheless, declines on this order may cause minor yield reductions in some wells, particularly shallow wells completed in the alluvial aquifer, at some times of the year.

Reecer Creek

PGG was unable to determine the maximum seasonal decline in groundwater resulting from retiring the Trendwest First Creek water rights in the Reecer Creek subbasin. Drilling information from area well logs was too vague and sufficient hydrogeologic information was not available. The change in field ditch seepage from the formerly irrigated properties associated with Trendwest water rights was estimated at 1 cfs during the irrigation season. This translates to an annual average recharge of 0.56 cfs. In addition, seasonal recharge from the FCWUA main ditch was estimated to be 0.1 cfs.

4.3 IMPACTS ON WINTER STREAMFLOWS

Average monthly mainstem Yakima River flows are either unchanged or slightly increased between Big Creek and Reecer Creek as a result of the consumptive use water rights transfers from November through March, in both average and the 2001 representative drought years (Tables 4-2 and 4-3). Below the Mill Ditch, Yakima River flows are increased every month during the winter under the long-term average year, and every month during the 2001 representative drought year for both the middle and lower bound simulations (see Table B.1 and B.3 in Exhibit B). Thus, there are no reductions in mainstem Yakima River winter streamflows that would result from the proposed transfer as determined by the consumptive use simulations.

Winter flows would be reduced as a result of transferring waters diverted to irrigation returns to instream flows, because the time-delay for water from those irrigation returns to reach the Yakima River would no longer occur. Some of those returns were delayed to return year-around, including during the winter. These reductions in winter flows are shown and discussed for the "combined model" simulations in Exhibit A (Tables A.1 and A.2 for the average and drought year characterizations, respectively). The most probable range of flow changes under the average year characterizations for the combined model simulations is shown in Tables B.4 and B.6 in Exhibit B (the middle and lower bound simulations for this series of model runs).

4.4 TWSA AND RESERVOIR STORAGE IMPACTS

TWSA represents the total water supply available for irrigation and other uses. The USBR includes three components in its TWSA calculations:

- Reservoir Storage on April 1

- Natural Streamflow between April 1 and September 30
- Irrigation return flow between April 1 and September 30.[18]

Two components of TWSA are natural streamflow and irrigation return flow between April 1 and September 30. These components of Trendwest's potential TWSA impacts are determined by estimating changes in flow from April 1 through September 30. To evaluate Trendwest's potential TWSA impact, Brown and Caldwell compared the combined effects of Trendwest's proposed water transfers, together with flow timing changes that would result from transferring Trendwest's tributary water rights to instream flows. The analysis was performed over the study period 1991 through 1995 and 2001, the years for which Trendwest had a simulated record incorporating the entire storage control period. Changes in Yakima River mainstem volumes and flows below Reecer Creek were totaled from monthly averages calculated from the model's simulated daily output. The "combined" water balance model describes mean monthly changes in Yakima River flow during both average year (characterized by 1991, 1992, 1993, and 1995) and drought year (characterized by 2001) conditions, including the influence of ending the time delays for the former irrigation return flows on the tributaries. For the average year, the "combined" model was also used to establish the most likely and reasonable range of flows to be expected (see Tables B.4 and B.6 in Exhibit B). In an average year, there would be a surplus of approximately 962 to 979 ac-ft during the period from April 1 through September 30, and in a drought year there would be a surplus of approximately 356 ac-ft.

The third component of TWSA is reservoir storage on April 1. Reservoir storage consists of carry over from the previous year together with accumulated runoff. The amount of water in storage also varies because of winter reservoir releases for flood control and to maintain fish egg incubation flows. Reservoir storage is utilized during periods of time when reservoir outflows are greater than reservoir inflows. This period is referred to as the storage control period. Changes in stream flows after October 1 caused by Trendwest's proposed transfers could affect the amount of water in storage at the beginning of the next irrigation season. That is because stream flow deficits from October 1 until the end of that year's storage control period[19] could reduce reservoir storage that is available for TWSA on April 1 of the following year if there is insufficient reservoir refill during the intervening period. Stream flow deficits following the end of storage control until April 1 could only affect reservoir storage if USBR determined it was necessary to release water from storage to compensate for streamflow reductions caused by the instream flow transfers. However, USBR would not operate to release flow as a result of any changes caused by Trendwest's water rights transfers from the beginning of flip-flop until the beginning of the next year's irrigation season. At that time of year, releases from the reservoirs are made to maintain flow targets to incubate salmon eggs. Flows in the Cle Elum River and in the Yakima River below Cle Elum are more than sufficient to meet those targets every year.[20]

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[18] See Yakima River Basin Conservation Advisory Group, Draft Basin Conservation Plan for the Yakima River Basin Water Conservation Program, Appendix III-B, page 1 (1997).

[19] For the purposes of this analysis, the storage control period is assumed to end when reservoir inflow again exceeds outflow, which occurs on or about October 20 or each year.

[20] Late season flows in the Yakima River below Cle Elum are a function of reservoir releases to maintain incubation flows in the Easton Reach (C. Lynch, Chief Hydrologist, Yakima Project, USBR, July 18, 2001)

When all three TWSA components are taken into consideration, the proposed water transfers would have a positive impact on TWSA. Under long-term average conditions, there would be an annual surplus of approximately 557 to 689 ac-ft. In a drought year (as represented by 2001), there would be an annual surplus of approximately 121 ac-ft.

Storage control begins later in a wet year than in a dry year. In a dry year, the transfers could result in a net increase in water supplies available during the storage control period. In a wet year, storage control begins later in the irrigation season, and the early-season surpluses that would result from Trendwest's water rights transfers would not add directly to reservoir storage. Nevertheless, early season increases in natural flows below USBR project reservoirs can delay storage control, and thus benefit TWSA indirectly.[21] In addition, the wetter the year, the more likely it is that flood control releases would occur before the beginning of the next irrigation season. If the following year is a dry year, storage control would begin earlier in the season, and the early irrigation season surpluses from Trendwest's water rights transfers would provide a benefit to the system.

On a year-to-year basis and seasonally within any given year, changes in reservoir storage and TWSA due to Trendwest's proposed transfers would vary because of climatic variation and associated changes in USBR's operations. Even though analysis of conditions over Trendwest's study years of 1991 through 1995 and 2001 indicate no adverse impact is reasonably expected to TWSA, all future circumstances cannot be identified at this time. For that reason, to ensure that TWSA would be protected in any given year in the future, there would be a need for water management, involving coordination with the USBR, City of Cle Elum, and other water users, and an ongoing commitment from both Ecology and the USBR. Water management would ensure that, on an operating basis, Trendwest's consumptive uses and hydraulic impacts to TWSA and other water users are neutral or positive (see Monitoring in Section 7.6, Mitigation Measures).

5. INDIRECT IMPACTS

Trendwest has agreed to obtain water to mitigate for some indirect uses in excess of what typically could be required under SEPA, through various agreements as follows:

- The Cooperative Agreement between Trendwest, the Washington Department of Fish and Wildlife (WDFW), and the Yakama Nation (described below) obliges Trendwest to provide funding to acquire additional water rights to augment instream flows, in part to compensate for indirect water usage on lands fallowed by transfer of Trendwest's mainstem water rights, and also in part to compensate for water used by direct housing growth in unincorporated areas (households of construction workers and employees directly related to the MPR and residential UGA);
- The RIDGE Settlement Agreement obliges Trendwest to provide water rights to augment instream flows, in part to compensate for indirect water usage on lands fallowed by transfer of Trendwest's tributary water rights, and also in part to compensate for water used by indirect housing growth in unincorporated areas; to provide water to Roslyn for induced

[21] Yakima Field Office, U.S. Bureau of Reclamation, *Draft Yakima Field Office Project Operations Outlook: 2001 Irrigation Season* 8 (May 2, 2001).

housing within Roslyn's municipal service area; and to provide water for expansion of the Cle Elum-Roslyn School District #404.

5.1 DEVELOPMENT ON FALLOWED LANDS

Trendwest purchased water rights appurtenant to approximately 888.3 acres of land in upper Kittitas County. Most of the property from which Trendwest purchased water rights has been or is being converted from agricultural use and subdivided to residential use. These properties are referred to as "fallowed lands." *Water Demand for Fallowed Lands* attached as Exhibit H, describes the anticipated future condition for these properties in detail.

Development of land from which Trendwest purchased water rights is functionally independent from Trendwest's development proposals; however, development of the properties from which Trendwest has transferred water rights might possibly result in new groundwater withdrawals within the basin in the form of small wells exempt from permitting (see Section 5.1.2). Use of these small groundwater withdrawals would result in an increase in the consumptive use of water in the basin.

Table 5-1 shows consumptive use from residential development of formerly irrigated properties in unincorporated areas. Increased consumptive use was calculated based on the average per household domestic water use less domestic return flows plus irrigation of one-half acre of lawn or garden, as allowed for groundwater withdrawals exempt from permitting under RCW 90.44.050. The average per household domestic water use assumes a domestic diversion of 240 gallons per household (100 gallons per person per day x 2.4 persons per household), less 80 percent return flows. Net consumptive use was calculated using the same factor calculated for the Trendwest water rights water model, applied to a half-acre of irrigation (see Appendix D, Water Supply Technical Report, Draft EIS).

Table 5-1: Consumptive Use (CU) from Future Use of Fallowed Lands

Subbasin	Lots[2]		Net CU in/yr	Domestic Div/ERU gpd	Domestic Return %	Domestic CU Total gpd	Domestic CU Total ac-ft/yr	Irrigation CU/unit ac-ft/yr	Irrigation CU Total ac-ft/yr	Total CU ac-ft/yr
	<20 ac	>20 ac								
Big Creek (Gentry)	4	0	18.7	240	80	192	0.2	0.8	3.1	3.4
Teanaway R (Walker)	15	1	23.2	240	80	816	0.9	1.0	16.4	17.34
Swauk Creek (Martin)	6	2	28.7	240	80	480	0.5	1.2	12.0	12.5
First Creek (Nelson)	4	4	28.6	240	80	576	0.6	1.2	14.3	15.0
First Creek (Roan)[2]	0	0	28.6	240	80	0	0.0	1.2	0.0	0.0
Total[3]	29	14								48.1

1 Consumptive use for parcels 20 acres or larger was doubled, in keeping with the Kittitas County land use code, which allows two residential units on parcels of that size.
2 The current owner of this property anticipates maintaining its use as range land for the foreseeable future.
3 Excludes consumptive use on the City of Ellensburg's fallowed lands, in Table 5-2.
Source: Brown & Caldwell 2001; Mentor Law Group 2001.

The City of Ellensburg now owns the 291 acres previously irrigated by the Pautzke water. This land is within the city limits and is not presently being used. Although the City has not formalized any plans for its use and has contemplated its sale, it has been proposed that approximately 96 acres be used for the development of a public baseball and recreation complex, 81 acres of which would be irrigated. Additionally, the City has prepared a *Comprehensive Flood Management Hazard Plan,* February 1999. The City proposes that approximately 60 acres in the northerly two-thirds of this property be retained by the city as flood way and that the dike presently east of Reecer Creek be relocated to the westerly edge of the built-up portion of West Ellensburg. It is anticipated that the balance of the land will obtain water from the City's municipal water system.

Table 5-2 shows consumptive use from the ball field complex proposed by the City of Ellensburg on the former Pautzke Bait Co., Inc. property.

Table 5-2: Water Demands from Pautzke Property Development

	Irrigated Area Acres	CU Total in/yr	CU total acft/yr
City of Ellensburg Ball Field Complex	81.0	32	216.0

Source: Brown & Caldwell, 2001; Mentor Law Group, 2001.

The impact on Trendwest's water balance from these consumptive uses is further discussed in Section 6. (Cumulative Impacts).

5.1.2 Employment-Induced Housing

Construction and operation of the Residential UGA and MPR would generate direct impacts from local and non-local (outside Kittitas County) employment demand. The increased economic activity associated with these proposals would produce a ripple effect through the Kittitas County economy in the form of indirect impacts and induced impacts. Among these impacts are water related impacts from employment related housing in-migration. Depending on their locations, the new households would increase consumptive use from groundwater withdrawals or from municipal systems.

The households locating in unincorporated areas of the county would most likely rely on small public water systems or individual wells. Any use of surface water to meet this demand would necessarily have to rely on existing water rights (as opposed to new water rights) because the Yakima River system has been, by every practical measure, fully appropriated during the latter half of the irrigation season since the early 1900s. Additionally, all remaining water that might be available for appropriation under new water rights has been withdrawn from appropriation, pursuant to RCW 90.40.030, by various actions of the United States.

Small ground water withdrawals for non-commercial irrigation and domestic purposes up to 5,000 gallons per day can be anticipated as a way of meeting the projected needs in unincorporated areas of the county. The effects on the Yakima River system would depend on the degree to which the ground water aquifer is connected to the river, and would vary in accordance with the distance from the well to the river, the aquifer characteristics, and the rate and volume of water pumped to meet the demand. For these reasons, no new surface water permits for year-round residential use and only ground water withdrawals that are exempt from permitting (see RCW 90.44.050) can be reasonably expected to meet this demand.

The Employment-Induced Water Demands Analysis, Appendix C to the Final EIS, distributes the estimated in-migrant households according to the Kittitas County Council of Government projections between incorporated and unincorporated County. Within unincorporated areas, the in-migrant households were further distributed by subbasins. Total water consumption is influenced by the distribution of households between incorporated and unincorporated areas and, to a lesser degree, by distributions in unincorporated areas by subbasin. Consumptive use varies throughout the County based on factors including different domestic water consumption rates among utility districts and climate variations that affect irrigation demands for crops and lawns. Based on the distribution of households, consumptive use was estimated based either on the development of exempt wells (when located within unincorporated areas) or on per unit water demands from the relevant Department of Health approved water system plans (incorporated areas). These consumptive uses were then placed in context of the average annual baseflows (unincorporated areas) or of the water system existing water rights (incorporated areas) to determine the magnitude of the impact.

In-Migrant Household Consumptive Use - Unincorporated Areas

Table 5-3 shows consumptive use for unincorporated in-migrant areas. New households in the unincorporated county are expected to receive water from groundwater withdrawals. Increased consumptive use was calculated based on the average per household domestic water use less domestic return flows plus irrigation of one-half acre of lawn or garden, as allowed for exempt water withdrawals under RCW 90.44.050. The average per household domestic water use assumes a domestic diversion of 240 gallons per household (100 gallons per person per day x 2.4 persons per household), less 80 percent return flows. Irrigation consumptive use was calculated using the Washington Irrigation Guide in Cle Elum for subbasins in the upper county (18.11 inches per acre per year) and in Ellensburg for subbasins in the lower county (31.46 inches per acre per year).

Consumptive use associated with in-migrant households in unincorporated areas are compared with the estimated mean annual subbasin base flows in Table 5-4. Mean annual subbasin baseflow was estimated at 13% of the mean annual precipitation in the subbasin times the total area of the subbasin. The 13% estimate is consistent with information contained in Ecology's Water Supply Bulletin 60 - Estimated Baseflow Characteristics of Selected Washington Rivers and Streams (Ecology 1999). The percentage of base flow that would be consumed by in-migrant households in unincorporated areas ranges from 0.02% to 2.07% for the MPR Reduced Density and UGA Alternative 5 development scenario. These low percentages indicate that consumptive use associated with in-migrant households in unincorporated Kittitas County would result in a minor impact on water availability in the upper Yakima River Basin.

Table 5-3: Consumptive Use, In-migrant Households Associated with Trendwest Employment—Unincorporated Areas

Households	Percent		Total Consumptive Use in Ac-Ft/yr
302.9	26%	Subbasins	
13.3	1.1	Subbasin No. 1 (Cle Elum)	10.7
43.3	3.7	Subbasin No. 2 (Easton)	35.0
36.0	3.1	Subbasin No. 3 (Teanaway)	29.1
12.1	1.0	Subbasin No. 4 (Swauk)	9.79
20.9	1.8	Subbasin No. 5 (Elk Heights)	16.9
10.0	0.9	Subbasin No. 6 (Taneum)	13.6
40.3	3.5	Subbasin No. 7 (Reecer)	55.0
21.5	1.8	Subbasin No. 8 (Thorp)	29.3
100.3	8.6	Subbasin No. 9 (Wilson-Naneum)	137
6.4	0.5	Subbasin No. 12 (Shushuskin)	8.68
		Total Subbasins	345
174.8	15%	Growth Nodes	
41.2	3.5	Subbasin No. 1 (Cle Elum) (Ronald) [1]	
90.9	7.8	Subbasin No. 2 (Easton) (Snoqualmie Pass & Easton)	73.5
42.5	3.6	Subbasin No. 8 (Thorp) (Thorp)	57.9
		Total Growth Nodes	131
		Total Unincorporated Areas	476

1 Consumptive use from the Ronald Urban Growth Node are calculated as incorporated consumptive use because Ronald receives water from Kittitas County Water District #2, which wholesales water from the City of Roslyn.

Source: Mentor Law Group, PLLC 2001; Brown & Caldwell 2001.

Table 5-4: Subbasin Groundwater Consumptive Use and Base Flow Comparison, MPR Reduced Density and UGA Alternative 5

Subbasin Number	Total Consumptive Use from In-Migrant Households ac-ft/yr[1]	Mean Annual Base Flow ac-ft/yr	Total Consumptive Use as a Percentage of Base Flow
Subbasin No. 1 (Cle Elum) [2]	18.2	115,076	0.02%
Subbasin No. 2 (Easton) [2]	183	143,986	0.13%
Subbasin No. 3 (Teanaway)	49.1	66,687	0.07%
Subbasin No. 4 (Swauk)	16.5	23,624	0.07%
Subbasin No. 5 (Elk Heights)	28.5	13,116	0.22%
Subbasin No. 6 (Taneum)	23.0	29,542	0.08%
Subbasin No. 7 (Reecer)	92.7	13,248	0.70%
Subbasin No. 8 (Thorp) [2]	147	7,099	2.07%
Subbasin No. 9 (Wilson-Naneum)	231	22,144	1.04%
Subbasin No. 12 (Shushuskin)	14.6	2,033	0.72%
Total	804	436,555	0.18% Avg. Annual[3]

Source: Brown & Caldwell 2001.

1 Consumptive use calculated for in-migrant households includes those associated with the Business Park.

2 Consumptive use calculations for Subbasin Nos. 2 and 8 reflect water use from both unincorporated and urban growth node households. UGN households for Subbasin 1 (Ronald) are reflected in incorporated water consumptive use because Ronald receives apart of its water from the City of Roslyn.

3 Average annual percentage was calculated by summing the total consumptive use for all of the subbasins and dividing this by the mean annual basin flow for all the subbasins.

The potential impact on tributary streamflow is discussed in more detail in the Employment-Induced Water Demand Analysis, MountainStar MPR and Cle Elum UGA, attached as Appendix C of the Final EIS. The analysis compares annual subbasin consumptive use to mean annual base flow. The analysis shows that groundwater consumptive use represents a small percentage of mean annual base flows in individual subbasins and an average annual percentage of approximately 0.18 percent (MPR and UGA Alternative 5, including the Business Park) for the basins combined (see Appendix C). This percentage is small and supports a reasonable conclusion of no significant adverse impact.

The potential impact on tributary streamflow is dependent on many factors such as the amount of base flow that discharges to an individual tributary stream, whether or not hydraulic continuity exists between the groundwater and the tributary, and the specific number, location, depth, and screened interval of future groundwater withdrawals within a basin. Where hydraulic continuity exists, the magnitude of this impact would depend on the percentage of groundwater base flow that would be pumped and consumed. Due to the complexity and uncertainty related to any analysis that would attempt to quantify all these variables, average annual values of consumptive groundwater use and tributary baseflow were used to provide a basis for assessing the potential magnitude of impact to tributary streamflows for all the basins. This analysis concludes there is no significant or measurable impact on tributary streams. It is unlikely that the conclusion of no adverse impact would be affected by speculating about the placement of future exempt wells and their hydraulic continuity to the streams draining each basin. However, some portion of the total groundwater base flow within each subbasin would discharge into tributaries where hydraulic continuity exists, and some portion of the wells associated with indirect/induced households within unincorporated Kittitas County could withdraw groundwater that is in hydraulic continuity with tributaries. Potential impacts on tributary streamflow would likely be lower during the high flow season and would be greater during the later summer months, when streamflows are more dependant on baseflow and instantaneous rates of baseflow are lower than the average annual baseflow. Summer low flows measured in the Teanaway River from 1999 to 2001 at the Forks gauge ranged from 8 to 16 cfs, which is about 9% to 17% of the annual average baseflow of 92 cfs. Summer baseflow can be substantially lower than average annual baseflow. Consequently, the relative impact of reduced groundwater availability can be greater during the summer flow-flow season.

On the Teanaway River, where the lower Teanaway is known to be in hydraulic continuity with groundwater, a worst-case secenario was assumed for the purposes of evaluating potential magnitude of impact during the summer low flow season. All of the in-migrant wells were assumed to be shallow and located next to the lower reach of the river, even though the available land supply would not support this intensity of development. In that case, the consumptive use as a percentage of base flow during the summer low-flow season would be approximately 0.57%. This more specific "worst case" seasonal analysis shows a higher consumptive use impact during the low flow season due to the assumed well placement and due to seasonally high consumptive water use for irrigation of lawns and gardens.

In-Migrant Households Consumptive Use --Incorporated Areas

Table 5-5 shows consumptive use estimates from Trendwest related households in incorporated areas. Consumptive use for in-migrant households in incorporated areas was determined based on estimates of "per household" water use from each jurisdiction's latest water system comprehensive plan. In many cases, data for these water systems are based on estimates from the early to mid-1990s.[22] Where data were available for per capita, per day consumption, a factor of 2.4 was applied to reach a per-household number.

Table 5-5: Consumptive Use, In-migrant Households Associated with Trendwest Employment—Incorporated Areas

Households	Percent		Total Consumptive Use (ac-ft/yr)
687	59%	Incorporated Areas[1]	
231.1	19.8	Cle Elum / UGA	26.3
18.3	1.6	South Cle Elum / UGA	3.0
415.8	36.6	Ellensburg / UGA	56.3
12.1	1.0	Roslyn / UGA	1.7
41.2		Ronald UGN[2]	2.4
		Total Incorporated Areas	89.7

1 The households allocated to the Kittitas UGA by the KCCOG were reallocated across the other UGAs because Kittitas was not a likely location for the in-migrant households.

2 Consumptive use from the Ronald Urban Growth Node are calculated as incorporated consumptive use because Ronald receives water from Kittitas County Water District #2, which wholesales water from the City of Roslyn.

Source: Mentor Law Group, PLLC 2001; Brown & Caldwell 2001.

For every jurisdiction except the City of Roslyn, the demands associated with potential in-migrant households is expected to be met by water available under that jurisdiction's water rights and within its projected future water demand. For every jurisdiction except the City of Roslyn, the demand associated with potential in-migrant households, if added to that jurisdiction's projected future water demands, would also fall within the amount of water available under its current water rights. The City of Roslyn was projecting a water supply deficit in meeting its projected future water demand, even without the Trendwest projects. As part of a settlement agreement entered with RIDGE, Trendwest has agreed to mitigate for increased water demands on Roslyn resulting from induced offsite development within Roslyn. (See discussion of RIDGE agreement in Section 2.4 above).

22 The City of Roslyn's average annual per day water use is estimated at 266 gallons per capita per day based on 1994-1995 data. Source: City of Roslyn Comprehensive Water System Plan (Gray & Osborne, Inc. June 1996), p.2-6. City of Cle Elum: Consumption per Service 508 gallons per day based on 1995 data. Source: City of Cle Elum Town of South Cle Elum Comprehensive Water Plan (Huibregtse, Louman Assoc., Inc., Oct. 1997), p. 32. Town of South Cle Elum: Consumption per Service 733 gallons per day based on 1981-1984 data. Source: City of Cle Elum Town of South Cle Elum Comprehensive Water Plan (Huibregtse, Louman Assoc., Inc. Oct. 1997), p. 32. Ellensburg: Average day demand 246 gallons per capita per day based on 1998 data. Source: Draft City of Ellensburg Water System Plan Update (HDR, Inc. 1999), p. 2-9.

6. CUMULATIVE IMPACTS

Cumulative impacts are estimated based on evaluation of the annual water demands and monthly diversion entitlements of other water users, and the effect of Trendwest's development proposals on USBR's ability to meet its water delivery requirements.

Consumptive use water balance results show that mitigation would be required to offset a reduction in mainstem Yakima River flow that would otherwise occur during September (a reduction of 0.4 cfs; Table 4-2). All other months show a net increase in mainstem flow below Reecer Creek, and thus no impact on mainstem flows. During 2001, representative of a severe single drought year, additional mitigation would be required to offset reductions of 0.8 cfs and 0.6 cfs in mainstem Yakima River flow below Reecer Creek during July and September, respectively (Table 4-3). All other months show no change or a net increase in mainstem flow below Reecer Creek during a drought comparable to 2001.

Mainstem Yakima River flows between the City of Cle Elum's diversion downstream to Reecer Creek are reduced at various points between April and September, under both average year and drought year conditions (Tables 4-2 and 4-3, respectively). In an average year, the greatest monthly reduction in mainstem flow would be 5.2 cfs between the City of Cle Elum diversion and the Teanaway River. Under 2001 drought year conditions, the greatest monthly reduction in mainstem flow due to the proposed transfers would be 5.4 cfs at the Teanaway River. Flow reductions tapering to 0.3 cfs would continue into October between Cle Elum's diversion and Swauk Creek (Table 4-3).

Return flows from upper basin water diversions are available for use further downstream, but water consumed anywhere in the Yakima system is lost to other downstream water users. For this reason, this report balances water consumption associated with currently authorized uses of Trendwest's water rights against water consumption on the Trendwest property, together with water consumption on fallowed lands and from induced development. The consumptive uses associated with Trendwest's water rights would exceed the annual consumptive quantity of water needed for development of the MPR and UGA projects (Table 2-6). Consumptive uses associated with induced offsite houseing and development on fallowed lands, however, are approximately equal to the consumptive uses associated with Trendwest's development proposals. The net water supply (i.e., annual quantity of water available for consumption under Trendwest's water supplies, less the amount consumed by the development proposals and induced and indirect development) would create a deficit of approximately 146 to 288 ac-ft. Table 6-1 shows a water balance for the proposals.

Table 6-1: Trendwest's Average Annual Consumptive Use and Supply Balance for Direct and Indirect Uses, in Ac-Ft

Net Consumptive Use		Available Water Supply[1]		
Direct Consumptive Use		Water Rights	Most Probable Lower Range[2]	Most Probable Upper Range[2]
		Tributary Water Rights		
Reduced Density MPR	981.7	Big Creek	124.7	126.5
UGA Alt. 5 (Residential)	129.2	Teanaway River	349.9	351.8
Direct Subtotal	1,110.9	Swauk Creek	366.8	486.6
Indirect Consumptive Use		Tributaries Subtotal	841.4	965.0
Fallowed Lands	264.1	Mainstem Water Rights		
Induced Housing	565.7	Yakima River	811.1	830.2
Indirect Subtotal	829.8	Mainstem Subtotal	811.1	830.2
Total Consumptive Use	1,940.7	Total Supply	1,652.5	1,795.2
Average Net Water Supply Likely Range			[-288.2]	[-145.5]

1 Model-predicted water supply for Trendwest's water rights incorporating water availability under the long-term average year conditions (Appendix B).

2 Long-term, average year, water supply availability would most likely occur within the range shown in these two columns, calculated from data in Tables B.1 and B.3 in Exhibit B.

Source: Brown & Caldwell 2002; W&H Pacific 2001; Mentor Law Group 2001.

7. MITIGATION MEASURES

Trendwest has identified three potential mitigation strategies to address adverse environmental impacts that result from decreases in Yakima River streamflow resulting from its water transfer proposals. Each strategy addresses impacts under conditions that are similar to those described as long-term average conditions.

7.1 GROUNDWATER INFILTRATION

A deficit occurs in September under average conditions, but substantial surpluses occur in April through June. Trendwest could divert water during the three months in which surpluses occur, and use stormwater infiltration facilities to infiltrate surplus diversions into groundwater. Subsurface returns of infiltrated water during the late spring and early summer would increase project streamflow contributions throughout the remainder of the year and, depending on the amount of water used for groundwater infiltration and the proximity of infiltration facilities to the Cle Elum River, could eliminate September streamflow deficits.[23]

7.2 ON-SITE STORAGE RELEASES

Trendwest is designing seven golf course water features on the MPR. Trendwest would circulate golf course irrigation water through these water features in order to provide storage and maintain water quality. However, it is feasible to use approximately 165 ac-ft of storage in the golf course

23 *On-Site Infiltration Option: Mitigation for Water Supply Deficit* (Associated Earth Sciences, Inc. 2001).

lakes to satisfy the approximate mean monthly September deficit of 24 ac-ft. Trendwest could use storage from these water features during the later part of the season, and replace that storage with surplus water available in April through July. Trendwest has sufficient water supply to refill these water features before each irrigation season.

7.3 WATER RIGHT ACQUISITION

Trendwest could acquire additional water rights and transfer them to instream flows to offset late irrigation season irrigation deficits. Additionally, under the environmental stewardship agreements described in Section 2.4 above, Trendwest has agreed to mitigate for increases in the consumptive use of water in the upper Yakima basin caused by Trendwest development activities, including increased water consumption from induced off-site housing.

7.4 DROUGHT MANAGEMENT

Under drought conditions, in addition to the above options, Trendwest could employ demand management by reducing irrigation on the MPR golf courses.

7.5 THIRD-PARTY WATER SYSTEM IMPROVEMENTS

7.5.1 Mainstem Water Users

Trendwest has been working with each of the mainstem diversions on the bypassed reach to identify needs for mitigation, if any. This includes working with various diverters over the last season to maintain diversion works. Trendwest has reached an agreement in principle with most of those diversions as to appropriate mitigation measures and fully anticipates agreements with all users in the near future.

7.5.2 Tributary Water Users

RCW 90.030.380 protects third-party water users from impairment of their water rights resulting from water right transfers. Trendwest's water rights formerly were used by water right owners who shared irrigation ditches with other water users. Trendwest has entered agreements with several Kittitas County irrigators who shared irrigation diversions with Trendwest's predecessors-in-interest to ensure their diversion rights are not affected.

Big Creek

Trendwest is working with the remaining water users on the Gentry/Lund ditch to address concerns of the remaining landowners on the Gentry/Lund ditch. Trendwest and the remaining diverters have identified issues to be addressed and are engaged in negotiations and anticipate a mitigation agreement to be in the near future. In addition to ongoing negotiations with the remaining water users, Trendwest in its agreement with RIDGE (see Section 2.4.2 above) has agreed to invest in upstream passage improvements and performance-based enhancements on Big Creek.

Swauk Creek

Trendwest is working with the remaining water user on the Burke-Hartman diversion to provide system improvements to prevent impairment of that party's water right caused by conveyance water reductions, as required under RCW 90.03.380.

First Creek

Following the purchase of the First Creek water rights, Trendwest worked with the remaining water users during the 2001 irrigation season to rebuild portions of the remaining canal, and to construct on-farm system improvements to reduce conveyance losses.

Mill Ditch

At this time, there does not appear to be an impact on Mill Ditch from the transfer of the Pautzke water right; however, Trendwest has agreed that if impacts are later discovered from the transfer of the Pautzke water right, Trendwest would negotiate the appropriate mitigation. If impacts are later identified due to the loss of the Pautzke right from the ditch, there remains the option of transferring Trendwest's Supplemental Reecer Creek water right to Mill Ditch as additional carriage water.

7.6 MONITORING

Trendwest would rely on compensatory transfers of tributary water rights to instream flows to ensure no net impacts on TWSA and no increase in consumptive use of water under its mainstem water rights. While the model runs performed were used to characterize the anticipated magnitude of impacts, actual water availability from year to year cannot be forecast by the model. As the 2001 monitoring program shows, water is not always physically available to satisfy Trendwest's tributary water rights, even though these rights generally are senior to the rights of most other tributary water users. Furthermore, Trendwest's tributary water rights may be subject to interception by intervening diverters, including those whose rights are junior in priority to those Trendwest has acquired.

An ongoing monitoring program would be established to ensure Trendwest and other water users that (1) the amount of water that would be used in connection with the MPR and UGA proposals is consistent with the water available under the several water rights that have been acquired by Trendwest and (2) the collective operations described in the water supply plan for the Trendwest resort are protective of other water users' rights on the Yakima River's tributaries and mainstem. This tributary monitoring program would include installation of equipment and data reporting consistent with existing state requirements to ascertain availability of water from Trendwest's proposed tributary water rights transfers. The program would also include installation of approved measuring devices and reporting of data by Cle Elum and Trendwest in connection with the Cle Elum water diversion and water use on the MPR and UGA properties. The data would be used, when necessary, to adjust the quantity of Trendwest's diversions to prevent any increase in the amount of water diverted under Trendwest's water rights over the amount actually available for diversion under its water rights, with allowance for other Trendwest obligations under the RIDGE Settlement Agreement and the Cooperative Agreement with WDFW and the Yakama Nation.

7.6.1 Monitoring Water Use by Trendwest

As described earlier in this report, Trendwest would receive water from a diversion on the mainstem Yakima River owned and operated by the City of Cle Elum. Under certain streamflow conditions, Trendwest also may receive water from Cle Elum's proposed Cle Elum River diversion works. Cle Elum's diversions would include in-line flow meters capable of recording both the instantaneous flow rate (in cubic feet per second or millions of gallons per day) and the total annual volume diverted (in acre-feet or millions of gallons per year). Cle Elum would report its diversions for Trendwest to the appropriate agencies. Currently, Cle Elum must report its water diversion data to USBR and Ecology weekly during the irrigation season (March 1 to October 30), and monthly during the off-irrigation season (November 1 to February 28). *See* Exhibit A. These requirements would remain in effect, and would provide the basis for adjustments in water deliveries to Trendwest to account for water availability under the proposed tributary transfers. In response to monitoring information gathered, Cle Elum could adjust the amount of water delivered to Trendwest as necessary to adjust for water availability data according to information collected from tributary gauges described below.

7.6.2 Monitoring Streamflows

Monitoring of the hydrologic conditions would be required for each tributary on which Trendwest has water rights. The mainstem river flow in the reach between Cle Elum and Ellensburg also would be monitored. The monitoring program would consist of several stations designed to acquire water surface stage (elevation) data to be correlated to flow (in cubic feet per second) and to cumulative diversions (measured in acre-feet).

The following sites are proposed for the installation of permanent gauges to monitor tributary streamflows. Actual gauge locations would depend on physical suitability and landowner permission.

- Big Creek: Downstream of the Lund-Darling Diversion Dam and upstream of the Big Creek-Kittitas Reclamation District (KRD) Canal siphon.
- Teanaway River: The existing USBR gauge on the lower Teanaway stream gauge; a new rating curve would be developed to correlate flows and stream levels.
- Swauk Creek: Below the Coe (Tang) Diversion, but above the fractured basalt formation upstream of the Swauk Creek mouth. Unless or until water meter data is available from upstream diversions, a temporary gauge would be installed below the Burke Diversion, in the vicinity of the temporary gauge installed by Trendwest during the 2001 irrigation season.
- First Creek: On lower First Creek at a location near the Boise Cascade bridge.

7.6.3 Monitoring & Reporting Diversions

When an acquired water right is one of two or more that are diverted at a common point, or share a ditch or canal, provision for monitoring the other water user diversions would be developed specifically to address the situation. Also, periodic monitoring of the other water users on the tributary streams that are downstream of stream gauges would be necessary to ensure that the tributary water rights are not diverted by junior appropriators. These data may be obtained by Ecology in the field in addition to any other measuring and reporting requirements that may exist.

Diverters on Big Creek, Teanaway River, and the Yakima mainstem are already required to report water use to USBR under interim Court Orders in Acquavella.[24] Under the monitoring and reporting orders, all parties who divert more than one cubic foot per second are required to keep diversion records and to provide those records to USBR on a weekly basis. USBR then is required to provide the records to Ecology. These reporting requirements are consistent with RCW 90.03.360, which requires all persons with surface water diversions over one cfs to install a measuring device. Ecology may require water users to report data describing the volume of water diverted.[25]

7.6.4 Frequency of Monitoring

Operational measurement of Cle Elum's diversions of water would be needed on a daily basis. Measurement of hydrologic conditions on the tributaries also would be recorded on at least a daily basis. Monitoring of other tributary water users would depend on compliance with applicable monitoring and reporting orders. Mainstem hydrologic conditions in the Cle Elum to Ellensburg reach of the Yakima River should be obtained at least weekly, consistent with information required to support USBR's TWSA calculations. The hydrologic monitoring by Trendwest and Cle Elum would be incorporated into USBR's monitoring network, either directly or through Ecology, and the two agencies would make the data available to one another and the public upon request.

7.6.5 Trendwest Monitoring and Reporting Institutional Requirements

The water rights transferred to the Yakima Trust Water Rights Program as a part of the Trendwest water supply plan will be managed by Ecology in accordance with Chapter 90.38 RCW. Coordination with the USBR, Cle Elum, and other water users would require an ongoing commitment from both Ecology and the USBR. As compared to historic institutional needs, the water supply plan requires additional coordination between the tributary water users, Cle Elum, Trendwest, Ecology and the USBR in order to ensure on an operating basis that consumptive uses and hydraulic impacts to TWSA and other water users are neutral or positive. Data from Trendwest's monitoring stations, the USBR's existing Teanaway River stations, and periodic field observations by Ecology staff would be used to gain that assurance. In general, Ecology would be responsible for management of tributary water rights transfers into the Yakima Trust Water Program until water available under the transferred rights reaches the mainstem of the

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24 Order Pendente Lite Re: Metering, Measuring and Reporting Requirements (Oct. 13, 1994); Order Pendente Lite Re: Metering, Measuring and Reporting Requirements, Teanaway River and Big Creek, Kittitas County (Aug. 27, 1998).

25 It should be noted that the Acquavella court has on other occasions requiring monitoring and reporting as a condition to entry of a subbasin Conditional Final Order. See e.g., Conditional Final Order for Subbasin No. 15 (Wenas Creek) (Nov. 12, 1998).

Yakima River. At that point, water transferred to the Yakima Trust Water Program would be managed by the USBR as part of TWSA. Tributary water rights that would not be transferred to the Yakima Trust Water Program would be managed by Trendwest as private instream flow rights to the confluence of each affected tributary stream with the mainstem Yakima River. Thereafter, water available under the transferred water rights would become part of TWSA and managed by the USBR. Cle Elum's and Trendwest's use of water under Trendwest's proposed water supply plan would be altered to reduce diversion or implement a pre-approved mitigation plan during periods when the diversion would conflict with USBR operations.

8. UNAVOIDABLE IMPACTS

8.1 SHALLOW GROUNDWATER WITHDRAWALS

Groundwater elevations under and near properties appurtenant to the Trendwest water rights are raised by irrigation returns during, and for a period following, the irrigation season. Transferring irrigation water rights to instream flows will reduce the groundwater table under and near properties appurtenant to the Trendwest water rights. Lowering of groundwater tables in areas formerly influenced by those returns is an unavoidable change. Shallow wells extending into the upper portion of the groundwater aquifer would be susceptible to interference from the lowered groundwater tables if they are located where groundwater was raised by the irrigation returns.

8.2 MAINSTEM FLOW LEVELS

Small reductions in mainstem flows would occur during the irrigation season at various points between the Cle Elum diversion and Reecer Creek downstream, as a result of the combined transfer of consumptive rights by Trendwest and from termination of time lags resulting from former irrigation returns on the tributaries, which would be left instream under transfer to the Trust. While mainstem flows would remain sufficient to supply all irrigation needs between Cle Elum diversion and Reecer Creek, diversion systems employed by these diverters are in many cases marginal in their ability to collect their water rights from the river. Thus, any change in flow or head pressure past their headgates could adversely affect their ability to withdraw water. The changes in river elevation are shown in Table 8-1.

Table 8-1: Water Surface Elevation Changes at Third Party Diversion Sites (in feet)

Diversion Sites (feet assumed datum)	July 1– July 15	July 16– July 31	Aug 1– Aug 15	Aug 16– Aug 31	Sep 1– Sep 15	Sep 16– Sep 31	Oct 1– Oct 15	Oct 16– Oct 31
Younger Ditch	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01
Wallace Ranch	0.00	-0.01	0.00	0.00	-0.01	-0.01	0.00	0.00
Westside Diversion[1]	0.00	-0.01	0.00	0.00	-0.01	-0.01	-0.01	0.00
Thorp Diversion	0.00	0.00	0.00	-0.01	-0.01	-0.01	0.00	-0.01
Packwood Diversion	+0.01	0.00	-0.01	-0.01	-0.02	-0.02	-0.02	-0.01
Cascade Irrigation	Natural and man-caused geomorphic processes, and Cascade Irrigations in-channel structure placement do not reasonably allow estimation of impact, however any impacts would be minimal relative to natural river process impacts.							
Mill Ditch Diversion	Flows downstream of the Mill Ditch diversion would likely be the same before and after Trendwest's water rights transfers.							

1 Westside Diversion with ecology blocks in place. Source: Northwest Hydraulics, Inc 2002.

8.3 IRRIGATION RETURN FLOWS

Irrigation on upper Yakima River tributaries has altered historic streamflow conditions in two ways. First, water is lost through evapotranspiration, thereby reducing streamflows throughout the irrigation season. Second, irrigation water that is not consumed (i.e., return flow) is delayed in its return to the tributary stream by the time of subflow travel from the point of irrigation to the tributary channel (including the river hyporheic zone). Water diverted but not consumed, which represents irrigation return flows, is delayed in its eventual arrival into the mainstem Yakima River by travel through subsurface pathways. The result is that streamflows are lower in summer months but higher later in the year. In a normative (i.e., pre irrigation) condition, water that contributes to mainstem flows arrives in the mainstem earlier in the irrigation season than water that is routed via subsurface irrigation return pathways. One consequence of Trendwest's proposed tributary transfers to the Trust Water Program is that the associated human-caused delays in streamflow contributions from irrigation return flows would be reduced or eliminated altogether (see Exhibit A).

Exhibits A, B, and C

EXHIBIT A:

A.1 Tributary Transfers

Ecology has requested a presentation of changes in streamflow conditions that would result from eliminating irrigation return flow delays. In response to Ecology's request, this subchapter shows the effect of transferring Trendwest's tributary water rights, with consideration of changes in streamflow resulting from changes in return flow timing in the affected tributaries. The analysis includes the effects of the transfers on both the consumptive and non-consumptive use components of Trendwest's tributary water rights, after transfer to Ecology's Trust Water Program. The non-consumptive use component changes streamflow because the time to reach the tributary or mainstem Yakima as irrigation return flow is changed when these flows are left instream. Tables A.1 and A.2 show changes in tributary return flow timing, and the resulting impacts of the tributary transfers on mainstem flows, for the long-term average and drought year conditions, respectively.

Table A.1: Effects of Tributary Instream Flow Transfers Long-Term Average Year Conditions

Mean Monthly Changes in Yakima River Flow

	D/S Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S City of Cle Elum (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)	D/S Reecer Creek (Ellensburg) (cfs)
Jan	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.8
Feb	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.8
Mar	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.8
Apr	-0.1	-0.1	-0.1	-0.1	2.6	2.6	2.0
May	0.9	0.9	0.9	4.1	8.9	8.9	8.3
Jun	1.2	1.2	1.2	2.6	6.7	6.7	6.1
Jul	1.2	1.2	1.2	3.0	5.3	5.3	4.7
Aug	0.9	0.9	0.9	1.9	2.5	2.5	1.9
Sep	-0.5	-0.5	-0.5	-1.5	-1.0	-1.0	-1.6
Oct	-0.4	-0.4	-0.4	-1.1	-0.6	-0.6	-1.2
Nov	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-1.0
Dec	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.9

Table A.2: Effects of Tributary Instream Flow Transfers Drought Year Conditions

Mean Monthly Changes in Yakima River Flow

	D/S Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S City of Cle Elum (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)	D/S Reecer Creek (Ellensburg) (cfs)
Jan	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.8
Feb	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.8
Mar	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.8
Apr	-0.1	-0.1	-0.1	-0.1	2.6	2.6	2.0
May	1.1	1.1	1.1	4.5	9.5	9.5	9.0
Jun	1.4	1.4	1.4	2.4	5.6	5.6	5.0
Jul	1.5	1.5	1.5	3.9	5.3	5.3	4.7
Aug	0.7	0.7	0.7	1.4	2.0	2.0	1.4
Sep	-0.5	-0.5	-0.5	-1.5	-1.2	-1.2	-1.8
Oct	-0.4	-0.4	-0.4	-1.0	0.0	0.0	-0.6
Nov	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-1.0
Dec	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.9

The main difference between the changes shown for the combined water balance (discussed below) and the consumptive use water balance (discussed in Section 4.1) is due to attenuated non-consumptive irrigation return flows, which are left instream under the transfers. These model runs show the effects of changing discontinued return flows to instream flows on the Yakima River. These effects include elimination of the out-of-basin diversion of purchased water rights from First Creek (Swauk basin) into Reecer Creek basin for irrigation. In the Big and Reecer Creek subbasins, groundwater is not in hydraulic continuity with the creek. Return flows are highly attenuated and are returned to the Yakima River throughout the year. Thus, terminating the time-delay inherent in the return flows lowers Yakima River flow during the non-irrigation season, but increases mainstem flow in the irrigation season. In the Swauk Creek and Teanaway River subbasins, groundwater is hydraulically connected to surface water and the return flows have much less attenuation, reaching the tributary or mainstem fairly quickly after irrigation. There are relatively large flow increases at the beginning of irrigation season, because previous irrigation season return flows have diminished and current season return flows are delayed.

A.2 "COMBINED" MODEL RESULTS

The water balance model was run to show the accumulated differences in flow changes resulting from the consumptive use transfers of the water rights in combination with the change in non-consumptive return flow timing. These simulations are referred to as "combined" model runs. As described above, the non-consumptive return flow timing change results from leaving formerly diverted water in the tributary channels. Changes in Yakima River flows were simulated for average and drought year representative conditions. The combined model output shows that the Yakima River streamflow would be reduced under the long-term, average conditions from August through March below Ellensburg. The reduction in flow is caused by the transfer of irrigation return flows (which were delayed in reaching the Yakima River) to instream tributary flows (which quickly reach the Yakima River and were not time-delayed in the model). During the winter, consumptive use on the MPR and UGA does not exceed the consumptive portion of the transferred stockwater rights. During the first half of the irrigation season, Yakima River flows would be increased by up to 9.6 cfs. As for the "consumptive use" model simulations described in Section 4.1, the combined model simulations were also run to estimate upper, middle, and lower bounds. Late in the irrigation season the most likely flows would be between the middle and lower bound simulations. The middle and lower bound simulations for the long-term average fit define a narrow range (see Tables B.4 and B.6 in Exhibit B). The greatest range of predicted flow change, expressed as a percentage of the range mid-point, is in August, when the most likely range in flow change is predicted to be -1.2 to -0.1 cfs below Reecer Creek.

Results of simulations with these combined effects display both mean monthly increases and decreases in Yakima River streamflow, and are shown in Tables A.3and A.4.

Table A.3: Mean Monthly Changes in Yakima River Flow from the "Combined Model" (Includes Tributary Irrigation Return Flow Timing Effects) under Long-term Average Year Conditions (Study Years 1991-1993, 1995)[1]

	D/S Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S City of Cle Elum (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)	D/S Reecer Creek (Ellensburg) (cfs)[2]
Jan	-0.2	0.4	-0.2	-0.2	-0.2	-0.1	-0.7
Feb	-0.2	0.5	-0.2	-0.2	-0.2	-0.1	-0.7
Mar	-0.2	0.5	-0.2	-0.2	-0.2	-0.1	-0.7
Apr	-0.1	0.5	-0.5	-0.5	2.3	3.7	3.1
May	0.9	1.5	0.2	3.4	8.2	10.2	9.6
Jun	1.2	1.8	-2.4	-1.1	3.0	5.2	4.6
Jul	1.2	1.8	-4.6	-2.8	-0.5	2.1	1.5
Aug	0.9	1.5	-3.5	-2.5	-1.9	0.5	-0.1
Sep	-0.5	0.1	-3.6	-4.6	-4.1	-2.2	-2.8
Oct	-0.4	0.3	-0.7	-1.4	-0.9	-0.3	-0.9
Nov	-0.3	0.4	-0.3	-0.3	-0.4	-0.3	-0.9
Dec	-0.3	0.4	-0.3	-0.3	-0.3	-0.2	-0.8

1 The middle and lower bound simulation results are shown in Tables B.4 and B.6 in Exhibit B.

2 Inclusion of tributary return flow effects in the "Combined Model" simulations causes a flow difference downstream (D/S) of Reecer Creek, whereas under the "Consumptive Use Model" simulations no further changes to Yakima River flow occur downstream of the Mill Ditch Diversion.

Table A.4: Mean Monthly Changes in Yakima River Flow from the "Combined Model" (Includes Tributary Irrigation Return Flow Timing Effects) under the Drought Year Condition (Study Year 2001)

	D/S Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S City of Cle Elum (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)	D/S Reecer Creek (Ellensburg) (cfs)
Jan	-0.2	0.4	-0.2	-0.2	-0.2	-0.1	-0.7
Feb	-0.2	0.5	-0.2	-0.2	-0.2	-0.1	-0.6
Mar	-0.2	0.5	-0.2	-0.2	-0.2	-0.1	-0.7
Apr	-0.1	0.5	-0.4	-0.4	2.2	2.9	2.3
May	1.1	1.7	0.3	3.7	8.8	9.6	9.0
Jun	1.4	2.0	-2.2	-1.3	1.9	3.6	3.0
Jul	1.5	2.1	-4.3	-1.9	-0.5	0.9	0.3
Aug	0.7	1.2	-3.7	-3.0	-2.4	-0.2	-0.8
Sep	-0.5	0.1	-3.6	-4.6	-4.3	-2.4	-3.0
Oct	-0.4	0.3	-0.7	-1.3	-0.3	0.2	-0.4
Nov	-0.3	0.4	-0.3	-0.3	-0.4	-0.3	-0.8
Dec	-0.2	0.4	-0.3	-0.3	-0.3	-0.2	-0.8

EXHIBIT B: UNCERTAINTY ANALYSIS

B.1 Model Uncertainty

An analysis of model uncertainty analysis was conducted. The input parameters that were tested include tributary streamflows, irrigation and stockwater efficiencies, and lag time distributions of irrigation and alluvial aquifer return flows. From these analyses, three sets of model inputs were prepared for the combined UGA Alternative 5 plus MPR Reduced Density scenario. These were the upper and lower bound reasonable values. The lower bound inputs used low streamflow, combined with low irrigation efficiency and slow return flow (high attenuation). The upper bound inputs used high streamflow, combined with higher irrigation efficiency and rapid return low (low attenuation). The third input set used values mid-way between the two bounds. ECT provided streamflow monitoring data and inputs to the lag-time algorithms in the water balance model, based on ranges agreed as reasonable with the project team. The input values to bracket the three model simulations are described in this section.

Tributary streamflows were estimated for the study period. The estimation technique relied on USBR's Teanaway River at Forks gauge as an index for the tributaries. A statistical regression analysis of the ECT monitoring and the Teanaway gauge data was conducted (see Section 4.4.1). The regression equations were used to estimate the middle simulation values, and the upper and lower 95 percent values of the tributary streamflows to use for the upper and lower bound simulation values, respectively. The regression graphs are shown in Figures B.1, B.2 and B.3 for Big, First and Swauk Creeks, respectively.

Irrigation efficiencies were estimated using three techniques. Typical on-farm irrigation efficiencies are published in the *Washington Irrigation Guide* (Washington State Cooperative Extension Service 1990). However, actual on-farm efficiencies and conveyance efficiencies can vary. Irrigation efficiency was also determined using the annual diversion quantity specified in the adjudicated water rights from Acquavella. Efficiency was computed by dividing the annual net consumptive use (from Blanney-Criddle method estimates appearing in the *Washington Irrigation Guide*) by the annual diversion quantity. Ecology's diversion metering on the 3M Ditch in the Teanaway River Basin was used to estimate efficiency. Consumptive uses of the irrigated areas served by the ditch were estimated using the Blanney-Criddle method. Once again, the consumptive use was divided by the diversions to compute efficiency, but actual diversion measurements were used. The lowest efficiency of approximately 32 percent resulted from using the water rights approach. The highest efficiency of approximately 45 percent was the typical efficiency used in the Draft EIS, which was based on an on-farm efficiency of 60 percent and a conveyance efficiency of 75 percent. The central value of 38 percent resulted from the 3M Ditch analysis, which corresponds to a 50 percent on-farm and a 75 percent conveyance efficiency. This distribution of efficiencies results in about a 17 percent variation about the central value. The efficiency of stockwater consumptive use is uncertain. After prior agreement from the Washington State Department of Ecology, an efficiency of 10 percent of the total annual diversion volume was assumed, with an uncertainty of plus or minus 5 percent.

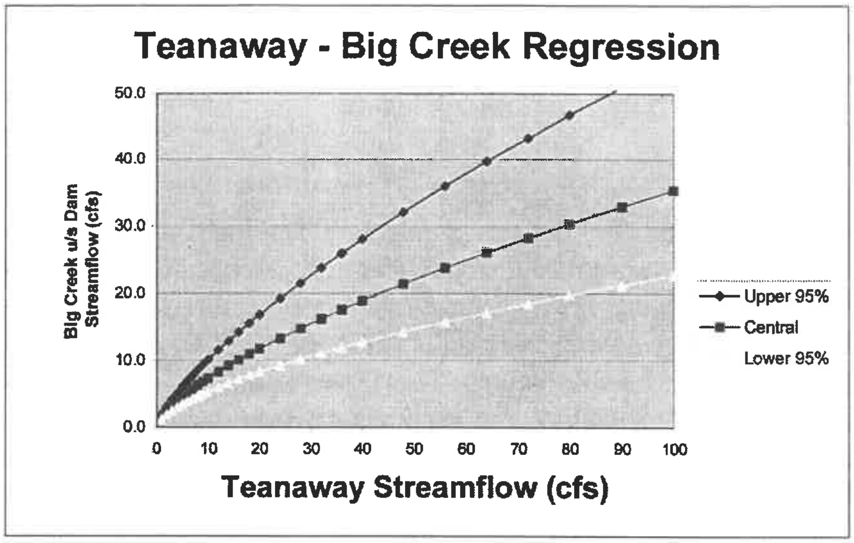

Figure B.1 Variability in Big Creek Streamflow Estimates

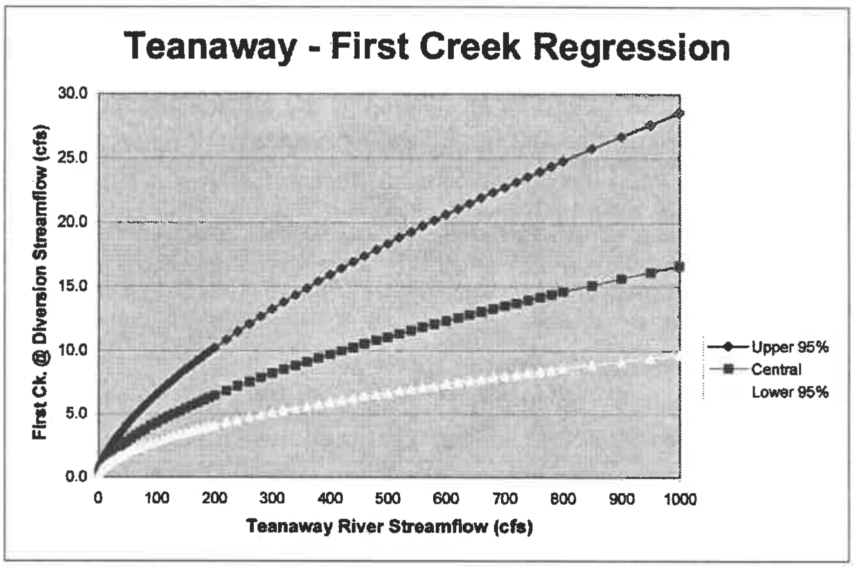

Figure B.2 Variability in First Creek Streamflow Estimates

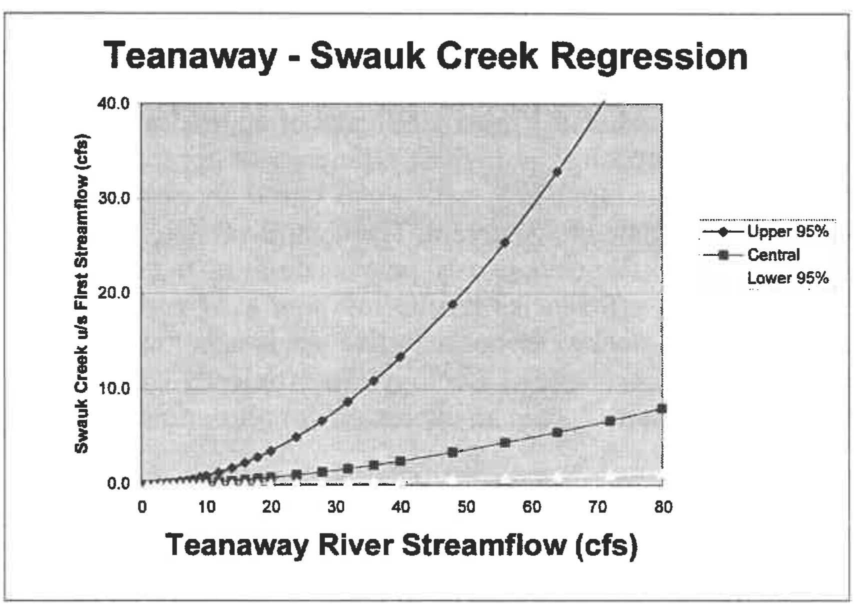

Figure B.3 Variability in Swauk Creek Streamflow Estimates

The lag time distributions of irrigation and alluvial aquifer return flows provided by ECT are shown in Figures B.4 and B.5. Only Big Creek had seepage through the creek bed, and thus required an alluvial aquifer return flow component. Where sufficient data were available, ECT developed groundwater models to derive irrigation return flow curves, which showed the lag time on a percentage basis. Lag time distributions were specified for each affected tributary sub-basin. For the Teanaway River sub-basin, a uniform lag time of 30 days, plus or minus 2 weeks was used. For the Reecer Creek sub-basin, the return flows were uniformly distributed over one year. For the Big and Swauk Creek sub-basins, the average of the two model generated curves was used as the central distribution. The curves represented high and low return flow attenuation for long-term average year conditions.

B.2 Uncertainty Analysis Results

The combined water balance and the consumptive use balance were affected differently by uncertainty in the input parameters that were tested. The consumptive use balance is affected primarily by tributary streamflows and irrigation efficiencies, but only during dry late summer and early fall seasons when water availability is low. The consumptive use balance is not affected by variability in timing of the lagged return flows because these flows are non-consumptive use components of the combined water balance. The consumptive use balance is not affected during the early irrigation season because sufficient water is available to supply all of the Trendwest water rights. Outside of the irrigation season, the total water balance is affected by lagged return flows from the previous irrigation season, but the consumptive use balance is not affected.

The results of the uncertainty analysis for the consumptive use balance under long-term average year conditions are shown in Tables B.1, B.2 and B.3. The changes in mainstem Yakima River streamflows are indicated by the "D/S Reecer Creek" column (far right) of each table. The middle values simulations show a net reduction in streamflow downstream of Reecer Creek during September (Table 4-1). The lower bound values simulations show a net flow reduction during September and July (Table 4-3). The upper bound values simulations show no net flow reductions below Reecer Creek. The greatest range in changes occurs during the months of June, July and August. The mean departure from the middle value is 0.8 cfs in July, 0.5 in August and 0.4 cfs in June. During the late irrigation season, the most likely actual result is expected between the middle and lower bound values, as described earlier. There is zero variability in April, and the mean range around the middle value is only 0.1 cfs outside of the irrigation season. The First/Swauk Creek basin availability is the primary driver of the consumptive variation shown in Tables 4-2 and 4-3.

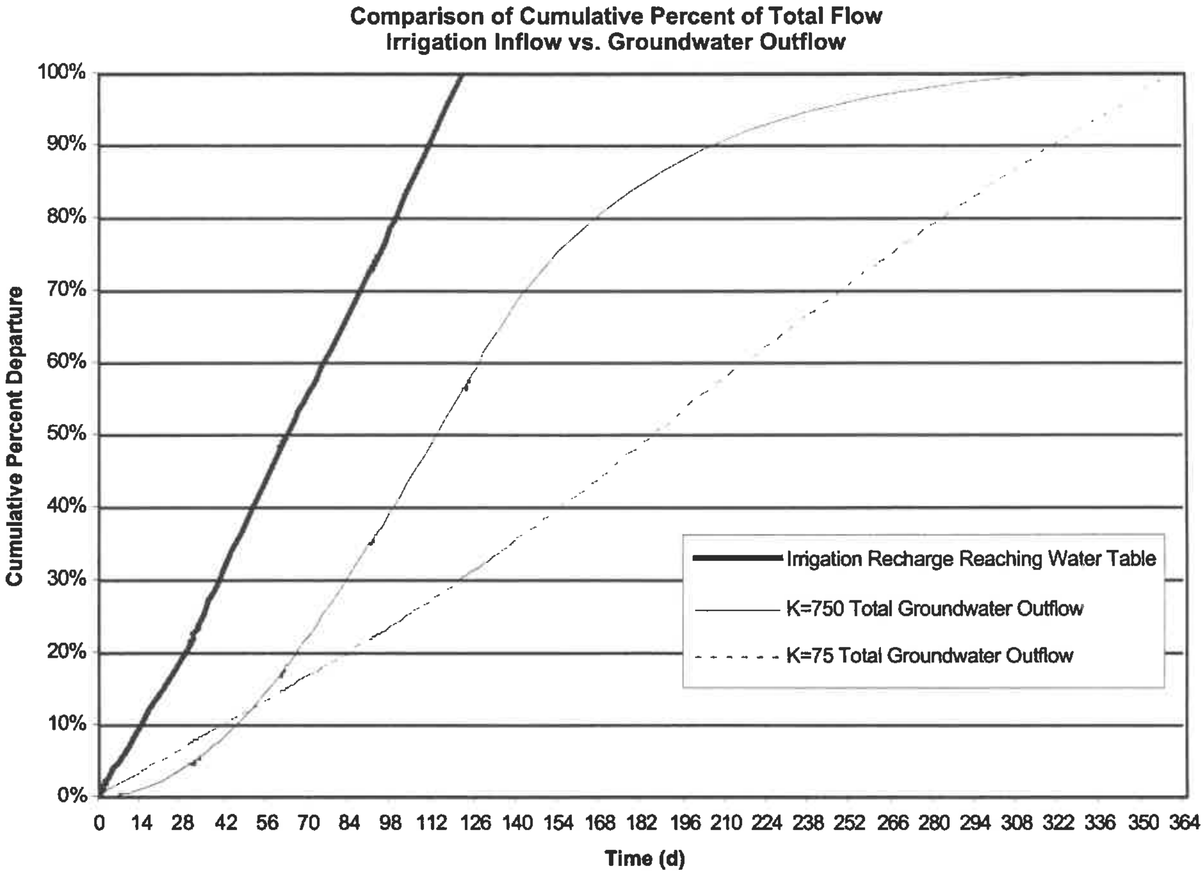

Figure B.4 ECT Big Creek Irrigation Return Flow Lag Time Distribution

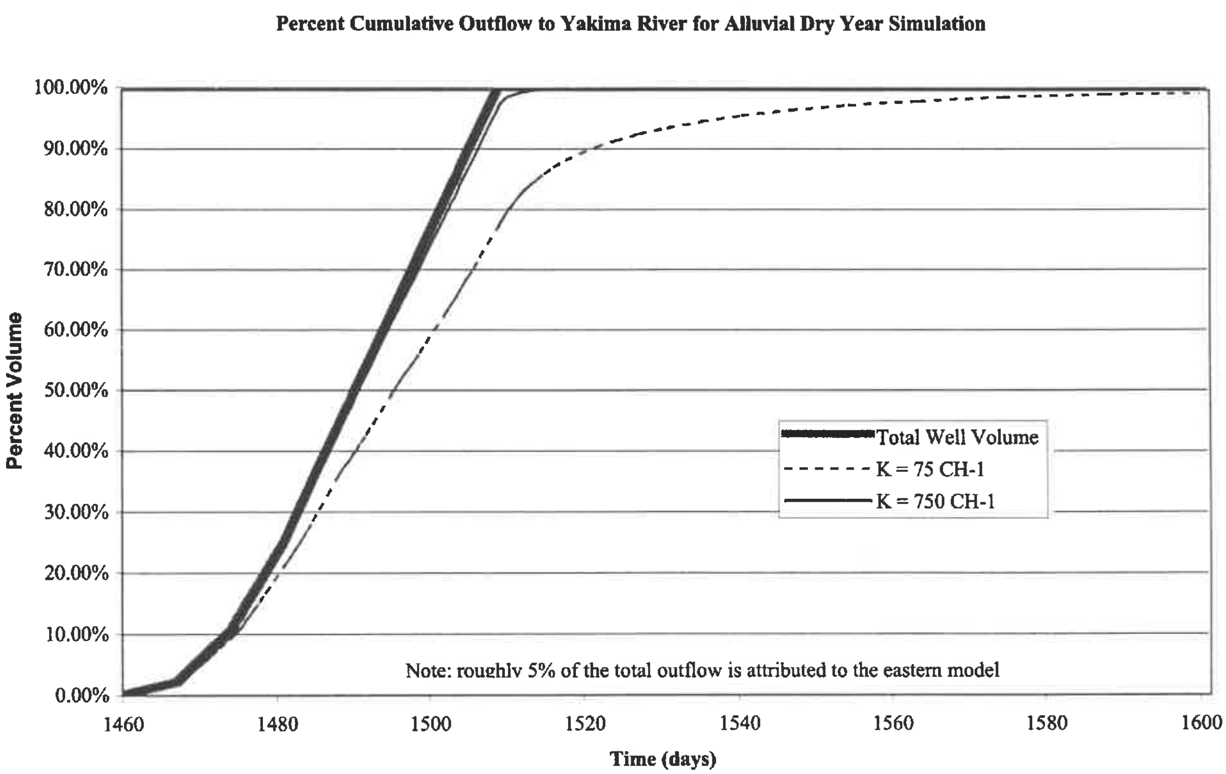

Figure B.5 ECT Big Creek Alluvial Aquifer Seepage Lag Time Distribution

Table B.1: Consumptive Use Model Results

Middle Values Simulation
Mean Monthly Changes in Yakima River Flow (Long-Term Average Flow Conditions)

	D/S Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S City of Cle Elum (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)	D/S Reecer Creek (Ellensburg) (cfs)
Jan	0.0	0.7	0.0	0.0	0.0	0.1	0.1
Feb	0.0	0.7	0.0	0.0	0.0	0.1	0.1
Mar	0.0	0.6	0.0	0.0	0.0	0.1	0.1
Apr	0.0	0.6	-0.3	-0.3	0.9	2.3	2.3
May	0.4	1.0	-0.3	0.9	3.1	5.1	5.1
Jun	0.5	1.1	-3.2	-1.8	0.3	2.5	2.5
Jul	0.6	1.2	-5.2	-3.6	-2.3	0.2	0.2
Aug	0.6	1.2	-3.8	-2.5	-2.0	0.4	0.4
Sep	0.0	0.6	-3.1	-2.7	-2.3	-0.4	-0.4
Oct	0.0	0.7	-0.3	-0.3	0.1	0.7	0.7
Nov	0.0	0.7	0.0	0.0	0.0	0.1	0.1
Dec	0.0	0.7	0.0	0.0	0.0	0.1	0.1

Table B.2: Consumptive Use Model Results

Upper Bound Values Simulation
Mean Monthly Changes in Yakima River Flow (Long-Term Average Flow Conditions)

	D/S Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S City of Cle Elum (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)	D/S Reecer Creek (Ellensburg) (cfs)
Jan	0.0	0.7	0.0	0.0	0.0	0.2	0.2
Feb	0.0	0.7	0.0	0.0	0.0	0.2	0.2
Mar	0.0	0.6	0.0	0.0	0.0	0.1	0.1
Apr	0.0	0.6	-0.3	-0.3	0.9	2.3	2.3
May	0.4	1.0	-0.3	0.9	3.1	5.1	5.1
Jun	0.5	1.1	-3.2	-1.8	0.5	2.7	2.7
Jul	0.6	1.2	-5.2	-3.6	-1.5	1.1	1.1
Aug	0.6	1.2	-3.8	-2.5	-1.3	1.1	1.1
Sep	0.0	0.6	-3.1	-2.7	-1.9	0.0	0.0
Oct	0.0	0.7	-0.3	-0.3	0.2	0.9	0.9
Nov	0.0	0.7	0.0	0.0	0.0	0.2	0.2
Dec	0.0	0.7	0.0	0.0	0.0	0.1	0.1

Table B.3: Consumptive Use Model Results

Lower Bound Values Simulation
Mean Monthly Changes in Yakima River Flow (Long-Term Average Flow Conditions)

	D/S Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S City of Cle Elum (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)	D/S Reecer Creek (Ellensburg) (cfs)
Jan	0.0	0.7	0.0	0.0	0.0	0.0	0.0
Feb	0.0	0.7	0.0	0.0	0.0	0.1	0.1
Mar	0.0	0.6	0.0	0.0	0.0	0.0	0.0
Apr	0.0	0.6	-0.3	-0.3	0.9	2.3	2.3
May	0.4	1.0	-0.3	0.9	3.0	5.0	5.0
Jun	0.5	1.1	-3.2	-1.8	-0.4	1.8	1.8
Jul	0.6	1.2	-5.2	-3.7	-3.1	-0.5	-0.5
Aug	0.6	1.2	-3.8	-2.5	-2.2	0.1	0.1
Sep	0.0	0.6	-3.1	-2.7	-2.5	-0.6	-0.6
Oct	0.0	0.7	-0.3	-0.3	0.0	0.6	0.6
Nov	0.0	0.7	0.0	0.0	0.0	0.1	0.1
Dec	0.0	0.7	0.0	0.0	0.0	0.0	0.0

The results of the analysis combining the consumptive use balance and changes in tributary return flow timing under long-term average year conditions are shown in Tables B.4, B.5 and B.6. The net change in mainstem Yakima River streamflows are indicated by the "D/S Reecer Creek" column (far right) of each table. The net change in Yakima River flow is positive for April through July for the range of estimates. At the end of the irrigation season, there is a drop in streamflow, because the reduction in irrigation diversions early in the summer results in a reduction in late season and wintertime return flow.

Table B.4: Combined Model Results

Middle Values Simulation
Mean Monthly Changes in Yakima River Flow (Long-Term Average Flow Conditions)

	D/S Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S City of Cle Elum (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)	D/S Reecer Creek (Ellensburg) (cfs)
Jan	-0.2	0.4	-0.2	-0.2	-0.2	-0.1	-0.7
Feb	-0.2	0.5	-0.2	-0.2	-0.2	-0.1	-0.7
Mar	-0.2	0.5	-0.2	-0.2	-0.2	-0.1	-0.7
Apr	-0.1	0.5	-0.5	-0.5	2.3	3.7	3.1
May	0.9	1.5	0.2	3.4	8.2	10.2	9.6
Jun	1.2	1.8	-2.4	-1.1	3.0	5.2	4.6
Jul	1.2	1.8	-4.6	-2.8	-0.5	2.1	1.5
Aug	0.9	1.5	-3.5	-2.5	-1.9	0.5	-0.1
Sep	-0.5	0.1	-3.6	-4.6	-4.1	-2.2	-2.8
Oct	-0.4	0.3	-0.7	-1.4	-0.9	-0.3	-0.9
Nov	-0.3	0.4	-0.3	-0.3	-0.4	-0.3	-0.9
Dec	-0.3	0.4	-0.3	-0.3	-0.3	-0.2	-0.8

Table B.5: Combined Model Results

Upper Bound Values Simulation
Mean Monthly Changes in Yakima River Flow (Long-Term Average Flow Conditions)

	D/S Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S City of Cle Elum (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)	D/S Reecer Creek (Ellensburg) (cfs)
Jan	-0.1	0.6	-0.1	-0.1	-0.1	0.0	-0.5
Feb	-0.1	0.7	0.0	0.0	0.0	0.1	-0.5
Mar	0.0	0.6	-0.1	-0.1	-0.1	0.1	-0.5
Apr	0.0	0.6	-0.3	-0.3	2.1	3.5	2.9
May	0.9	1.4	0.1	2.2	6.4	8.5	7.9
Jun	1.0	1.5	-2.7	-1.4	2.6	4.8	4.2
Jul	0.9	1.5	-4.9	-3.3	0.3	2.9	2.3
Aug	0.8	1.4	-3.6	-2.4	-0.6	1.7	1.1
Sep	-0.5	0.1	-3.6	-4.0	-2.9	-1.0	-1.6
Oct	-0.4	0.3	-0.7	-0.8	0.0	0.6	-0.1
Nov	-0.2	0.5	-0.2	-0.2	-0.3	-0.1	-0.7
Dec	-0.1	0.5	-0.2	-0.2	-0.2	0.0	-0.6

Table B.6: Combined Model Results

Lower Bound Values Simulation
Mean Monthly Changes in Yakima River Flow (Long-Term Average Flow Conditions)

	D/S Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S City of Cle Elum (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)	D/S Reecer Creek (Ellensburg) (cfs)
Jan	-0.4	0.2	-0.4	-0.4	-0.4	-0.4	-0.9
Feb	-0.4	0.3	-0.4	-0.4	-0.4	-0.3	-0.9
Mar	-0.4	0.3	-0.4	-0.4	-0.4	-0.3	-0.9
Apr	-0.3	0.3	-0.6	-0.6	2.5	3.9	3.3
May	1.2	1.7	0.4	4.4	9.5	11.6	11.0
Jun	2.3	2.8	-1.4	1.1	4.2	6.4	5.8
Jul	1.8	2.3	-4.0	-2.2	-1.2	1.3	0.8
Aug	0.0	0.6	-4.4	-3.2	-3.0	-0.7	-1.2
Sep	-0.3	0.3	-3.5	-5.1	-5.0	-3.1	-3.6
Oct	-0.4	0.2	-0.7	-2.8	-2.4	-1.8	-2.4
Nov	-0.4	0.3	-0.4	-0.4	-0.5	-0.4	-1.0
Dec	-0.4	0.2	-0.4	-0.4	-0.5	-0.4	-1.0

B.3 Demand Uncertainty

The water demands for diversion have been estimated on a conservative basis. The assumptions include: 1) 100 percent buildout, 2) 100 percent occupancy, and 3) that every residential lot would irrigate to the maximum allowed by water use policies. The realistic expectation is that in actual operations less water rather than more water would be diverted than has been forecast. Neither buildout nor occupancy likely would be 100 percent, but the water rights and mitigation measures necessary for such would be in place. It is not likely that every lot would be landscaped with the maximum allowable irrigated area allowed by the water policies, but the water rights and mitigations measures necessary for such would be in place.

B.4 Mitigation for Uncertainty

Uncertainty on the water supply side due to climatic variability and to reasonable ranges in hydrogeologic inputs to the model, and to a lesser extent on the demand side due to forecasting future conditions, are both accounted for by monitoring actual water availability and actual diversion under a monitoring plan (see Section 7-6).

EXHIBIT C: WATER RIGHTS INCORPORATED IN WATER BALANCE MODEL

Water Right Name	Priority	Source	Qi (cfs)	Qa (ac-ft)	Acres
Big Creek Water Rights					
Darling	June 30, 1887	Darling Ditch	1.50	360.0	75.0
Darling	June 30, 1887	Darling Ditch	0.03	7.2	1.5
Gentry (Retained)	June 30, 1887	Lund Ditch	1.37	378.0	78.5
Gentry (Trendwest)	June 30, 1887	Lund Ditch	1.53	390.1	81.5
Lund	June 30, 1887	Lund Ditch	0.16	38.4	8.0
Lund et al	June 30, 1887	Lund Ditch	1.60	384.0	80.0
Ranch Properties, Inc.	June 30, 1887	Lund Ditch	0.48	143.7	24.0
Darling	June 30, 1889	Darling Ditch	0.04	9.6	2.0
Griffith	June 30, 1889	Lund Ditch	0.34	81.6	17.0
Church of Jesus Christ LDS	June 30, 1906	Ensign Ranch	1.70	408.0	85.0
Swauk / First Creek Water Rights					
FCWUA (Retained)	Nov. 2, 1877	First Creek	2.19	274.1	54.8
FCWUA / Trendwest	Nov. 2, 1877	First Creek	2.79	348.9	69.7
Burke	June 30, 1878	Swauk via Burke	2.00	588.6	78.4
Hartman / Trendwest	June 30, 1878	Swauk via Burke-Hartman	0.89	150.0	20.0
Burke	June 30, 1878	Swauk via Burke-Hartman	1.77	297.0	39.6
FCWUA (Retained)	June 1, 1881	First Creek	3.92	639.3	127.8
FCWUA / Trendwest	June 1, 1881	First Creek	5.00	813.7	162.7
Coe	May 24, 1884	Swauk via Coe (N)	1.79	164.0	35.0
Coe	May 24, 1884	Swauk via Coe (S)	1.50	112.5	15.0
Tang	May 24, 1884	Swauk via Tang	0.17	80.0	8.0
Hartman / Trendwest	Sept. 20, 1889	Swauk via Burke-Hartman	3.34	562.5	75.0
Burke	Oct. 31, 1889	Swauk via Burke	2.00	150.0	20.0
Tang	Sept. 21, 1892	Swauk via Tang	0.17	80.0	8.0
Coe	Apr. 9, 1901	Swauk via Coe (S)	0.38	37.5	5.0
Teanaway River Water Rights from Mainstem to Forks					
Bonetto	June 30, 1882	Teanaway	0.09	13.8	4.6
Bonetto	June 30, 1882	Teanaway	0.10	27.5	5.1
McClure	June 30, 1882	Teanaway	0.17	45.9	8.5
Osmonovich	June 30, 1882	Teanaway	0.04	13.0	2.0
Masterson	June 30, 1883	Teanaway	4.80	1,527.5	235.0
Mundy	June 30, 1883	Teanaway	0.90	292.5	45.0
Walker/Trendwest	June 30, 1883	Teanaway	1.26	340.2	63.0
Walker /Trendwest	June 30, 1883	Teanaway	1.40	378.0	70.0
Walker /Trendwest	June 30, 1883	Teanaway	0.08	21.6	4.0
Bonetto	June 30, 1884	Teanaway	0.44	66.0	22.0
Bonetto	June 30, 1884	Teanaway	0.16	24.0	8.0
Downs	June 30, 1884	Teanaway	0.16	52.0	8.0
Miller	June 30, 1884	Teanaway	0.02	5.4	1.0
Estate of Bugni	June 30, 1885	Teanaway	1.50	410.4	76.0
Dickhaus	June 30, 1885	Teanaway	0.57	184.7	28.4
Downs	June 30, 1885	Teanaway	0.44	143.0	22.0
Drotning	June 30, 1885	Teanaway	0.16	52.0	8.0
Evenden	June 30, 1885	Teanaway	0.55	178.8	27.5
Fookes	June 30, 1885	Teanaway	0.49	159.1	24.5
Hancock	June 30, 1885	Teanaway	1.39	452.0	69.5
Hollingsworth	June 30, 1885	Teanaway	0.20	65.0	10.0
Johnson	June 30, 1885	Teanaway	0.23	74.2	11.4
Livengood	June 30, 1885	Teanaway	0.26	84.5	13.0
Lixvar	June 30, 1885	Teanaway	0.49	159.0	24.5

Water Right Name	Priority	Source	Qi (cfs)	Qa (ac-ft)	Acres
Lloyd	June 30, 1885	Teanaway	0.09	27.6	4.3
Montgomery	June 30, 1885	Teanaway	0.62 4	202.8 1	31.2
Nichols	June 30, 1885	Teanaway	1.50	489.1	75.2
Osmonovich	June 30, 1885	Teanaway	0.41	132.9	20.4
Pratt	June 30, 1885	Teanaway	0.17	54.3	8.4
Sparks	June 30, 1885	Teanaway	1.01	329.9	50.8
Teanaway Associates	June 30, 1885	Teanaway	0.51	165.4	25.5
Teanaway Valley Farms, Inc.	June 30, 1885	Teanaway	0.76	245.4	37.8
Boise Cascade	June 30, 1885	Teanaway	1.10	220.0	55.0
Conner	June 30, 1888	Teanaway	1.00	325.0	50.0
Teanaway Valley Family Farm & Crosetto	June 30, 1888	Teanaway	1.40	455.0	70.0
Badda	June 30, 1889	Teanaway	0.24	78.0	12.0
Carollo	June 30, 1889	Teanaway	0.01	4.6	0.7
Evenden	June 30, 1889	Teanaway	0.05	16.3	2.5
Monroe/Torgeson	June 30, 1889	Teanaway	0.20	54.0	10.0
Teanaway Ranch, Inc.	June 30, 1889	Teanaway	3.32	1,079.0	166.0
Teanaway Valley Family Farm & Crosetto	June 30, 1889	Teanaway	0.80	237.0	30.0
Teanaway Valley Farms, Inc.	June 30, 1889	Teanaway	0.06	17.9	2.8
Tidwell	June 30, 1889	Teanaway	0.30	97.5	15.0
US Bureau of Reclamation	June 30, 1889	Teanaway	0.20	54.0	10.0
US Bureau of Reclamation	June 30, 1889	Teanaway	0.20	54.0	10.0
Blackburn	June 30, 1890	Teanaway	0.88	286.0	44.0
Blackburn	June 30, 1890	Teanaway	0.30	97.5	15.0
Blackburn	June 30, 1890	Teanaway	0.32	86.4	16.0
Blackburn	June 30, 1890	Teanaway	0.04	10.8	2.0
Walker/Trendwest	June 30, 1890	Teanaway	0.68	183.6	34.0
Cernick	June 30, 1891	Teanaway	0.32	86.4	16.0
Miller	June 30, 1891	Teanaway	0.16	43.2	8.0
Osmonovich	June 30, 1891	Teanaway	0.04	10.8	2.0
Starkovich	June 30, 1891	Teanaway	0.66	178.2	33.0
Nichols	June 30, 1894	Teanaway	0.04	10.8	2.0
Walker/Trendwest	June 30, 1898	Teanaway	0.26	69.1	12.8
Walker/Trendwest	June 30, 1898	Teanaway	0.08	21.6	4.0
Conner	June 30, 1899	Teanaway	0.80	260.0	40.0
Fruhling	June 30, 1905	Teanaway	0.40	110.0	20.0
Pederson	June 30, 1905	Teanaway	0.20	2.0	0.0
Carollo	June 30, 1910	Teanaway	0.23	73.5	11.3
Yakima River at Mill & Klein Coble Ditchs					
Pautzke Bait / Trendwest	Oct. 30, 1884	Yakima via Klein Coble	4.59	1,609.0	67.0
Pautzke Bait / Trendwest	Oct. 30, 1884	Yakima via Klein Coble	3.90	967.2	78.0
Pautzke Bait / Trendwest	May 6, 1893	Yakima via Mill Ditch	12.90	1,825.0	146.0

Order Pendente Lite entered May 11, 1990, authorized a change in point of diversion for the Pautzke Bait Co. from the Klein Coble ditch to Mill Ditch for the pendency of the adjudication. The Order required Pautzke file a change application with DOE.

Exhibit D

	AP	AQ	BG	BH
10	Return Flow Schedule Lookup Tables			
11	Irrigation Return Flow		Alluvial Return Flow	
12	Intermediate Values		Intermediate Values	
13	Day	Incremental %Return	Day	Incremental %Return
14	0	0.00%	0	0.00%
15	1	0.11%	1	0.19%
16	2	0.14%	2	0.25%
17	3	0.15%	3	0.27%
18	4	0.10%	4	0.39%
19	5	0.12%	5	0.26%
20	6	0.14%	6	0.31%
21	7	0.18%	7	0.37%
22	8	0.11%	8	0.68%
23	9	0.11%	9	0.92%
24	10	0.14%	10	1.01%
25	11	0.14%	11	1.50%
26	12	0.18%	12	1.00%
27	13	0.18%	13	1.21%
28	14	0.23%	14	1.46%
29	15	0.23%	15	1.21%
30	16	0.20%	16	1.53%
31	17	0.20%	17	1.69%
32	18	0.20%	18	2.52%
33	19	0.20%	19	1.68%
34	20	0.20%	20	2.04%
35	21	0.20%	21	2.48%
36	22	0.20%	22	1.59%
37	23	0.25%	23	1.89%
38	24	0.25%	24	2.08%
39	25	0.25%	25	3.10%
40	26	0.25%	26	2.08%
41	27	0.26%	27	2.53%
42	28	0.26%	28	3.07%
43	29	0.26%	29	1.67%
44	30	0.26%	30	1.83%
45	31	0.26%	31	1.97%
46	32	0.21%	32	2.93%
47	33	0.26%	33	1.96%
48	34	0.27%	34	2.39%
49	35	0.18%	35	2.91%
50	36	0.23%	36	1.72%
51	37	0.27%	37	1.84%
52	38	0.33%	38	1.94%
53	39	0.41%	39	2.85%
54	40	0.25%	40	1.90%
55	41	0.25%	41	2.31%
56	42	0.31%	42	2.81%
57	43	0.31%	43	1.82%
58	44	0.26%	44	2.01%
59	45	0.26%	45	2.11%
60	46	0.26%	46	3.07%
61	47	0.32%	47	2.02%
62	48	0.32%	48	2.44%
63	49	0.32%	49	2.95%
64	50	0.40%	50	1.81%
65	51	0.40%	51	0.93%
66	52	0.40%	52	1.24%
67	53	0.38%	53	0.47%
68	54	0.38%	54	0.50%
69	55	0.38%	55	0.52%
70	56	0.38%	56	0.54%
71	57	0.38%	57	0.55%
72	58	0.38%	58	0.56%
73	59	0.38%	59	0.28%
74	60	0.38%	60	0.28%

	AP	AQ	BG	BH
	Return Flow Schedule Lookup Tables			
	Irrigation Return Flow		Alluvial Return Flow	
	Intermediate Values		Intermediate Values	
	Day	Incremental %Return	Day	Incremental %Return
105	91	0.46%	91	0.06%
106	92	0.46%	92	0.06%
107	93	0.37%	93	0.06%
108	94	0.46%	94	0.06%
109	95	0.48%	95	0.06%
110	96	0.32%	96	0.04%
111	97	0.39%	97	0.04%
112	98	0.46%	98	0.04%
113	99	0.56%	99	0.04%
114	100	0.33%	100	0.04%
115	101	0.33%	101	0.04%
116	102	0.41%	102	0.04%
117	103	0.41%	103	0.04%
118	104	0.49%	104	0.04%
119	105	0.49%	105	0.03%
120	106	0.60%	106	0.03%
121	107	0.60%	107	0.03%
122	108	0.49%	108	0.03%
123	109	0.49%	109	0.03%
124	110	0.49%	110	0.03%
125	111	0.45%	111	0.03%
126	112	0.45%	112	0.03%
127	113	0.45%	113	0.03%
128	114	0.45%	114	0.03%
129	115	0.54%	115	0.03%
130	116	0.54%	116	0.02%
131	117	0.54%	117	0.02%
132	118	0.54%	118	0.02%
133	119	0.53%	119	0.02%
134	120	0.53%	120	0.02%
135	121	0.53%	121	0.02%
136	122	0.53%	122	0.02%
137	123	0.53%	123	0.02%
138	124	0.44%	124	0.02%
139	125	0.55%	125	0.02%
140	126	0.26%	126	0.02%
141	127	0.69%	127	0.02%
142	128	0.45%	128	0.02%
143	129	0.54%	129	0.01%
144	130	0.32%	130	0.01%
145	131	0.32%	131	0.01%
146	132	0.75%	132	0.01%
147	133	0.44%	133	0.01%
148	134	0.44%	134	0.01%
149	135	0.52%	135	0.01%
150	136	0.52%	136	0.01%
151	137	0.40%	137	0.01%
152	138	0.40%	138	0.01%
153	139	0.40%	139	0.01%
154	140	0.47%	140	0.01%
155	141	0.47%	141	0.01%
156	142	0.47%	142	0.01%
157	143	0.41%	143	0.01%
158	144	0.41%	144	0.01%
159	145	0.41%	145	0.01%
160	146	0.41%	146	0.01%
161	147	0.46%	147	0.01%
162	148	0.46%	148	0.01%
163	149	0.46%	149	0.01%
164	150	0.46%	150	0.01%
165	151	0.35%	151	0.01%

	AP	AQ	BG	BH
	Return Flow Schedule Lookup Tables			
	Irrigation Return Flow		Alluvial Return Flow	
	Intermediate Values		Intermediate Values	
	Day	Incremental %Return	Day	Incremental %Return
195	181	0.27%	181	0.00%
196	182	0.27%	182	0.00%
197	183	0.27%	183	0.00%
198	184	0.27%	184	0.00%
199	185	0.27%	185	0.00%
200	186	0.27%	186	0.00%
201	187	0.27%	187	0.00%
202	188	0.27%	188	0.00%
203	189	0.27%	189	0.00%
204	190	0.27%	190	0.00%
205	191	0.27%	191	0.00%
206	192	0.28%	192	0.00%
207	193	0.28%	193	0.00%
208	194	0.28%	194	0.00%
209	195	0.28%	195	0.00%
210	196	0.28%	196	0.00%
211	197	0.28%	197	0.00%
212	198	0.28%	198	0.00%
213	199	0.28%	199	0.00%
214	200	0.28%	200	0.00%
215	201	0.28%	201	0.00%
216	202	0.28%	202	0.00%
217	203	0.28%	203	0.00%
218	204	0.28%	204	0.00%
219	205	0.25%	205	0.00%
220	206	0.25%	206	0.00%
221	207	0.25%	207	0.00%
222	208	0.25%	208	0.00%
223	209	0.25%	209	0.00%
224	210	0.25%	210	0.00%
225	211	0.25%	211	0.00%
226	212	0.25%	212	0.00%
227	213	0.25%	213	0.00%
228	214	0.25%	214	0.00%
229	215	0.25%	215	0.00%
230	216	0.25%	216	0.00%
231	217	0.25%	217	0.00%
232	218	0.25%	218	0.00%
233	219	0.25%	219	0.00%
234	220	0.25%	220	0.00%
235	221	0.22%	221	0.00%
236	222	0.22%	222	0.00%
237	223	0.22%	223	0.00%
238	224	0.22%	224	0.00%
239	225	0.22%	225	0.00%
240	226	0.22%	226	0.00%
241	227	0.22%	227	0.00%
242	228	0.22%	228	0.00%
243	229	0.22%	229	0.00%
244	230	0.22%	230	0.00%
245	231	0.22%	231	0.00%
246	232	0.22%	232	0.00%
247	233	0.22%	233	0.00%
248	234	0.22%	234	0.00%
249	235	0.22%	235	0.00%
250	236	0.22%	236	0.00%
251	237	0.22%	237	0.00%
252	238	0.22%	238	0.00%
253	239	0.22%	239	0.00%
254	240	0.22%	240	0.00%
255	241	0.20%	241	0.00%

	AP	AQ	BG	BH
	Return Flow Schedule Lookup Tables			
	Irrigation Return Flow		Alluvial Return Flow	
	Intermediate Values		Intermediate Values	
	Day	Incremental %Return	Day	Incremental %Return
284	270	0.18%	270	0.00%
285	271	0.18%	271	0.00%
286	272	0.18%	272	0.00%
287	273	0.18%	273	0.00%
288	274	0.18%	274	0.00%
289	275	0.18%	275	0.00%
290	276	0.18%	276	0.00%
291	277	0.18%	277	0.00%
292	278	0.18%	278	0.00%
293	279	0.18%	279	0.00%
294	280	0.18%	280	0.00%
295	281	0.18%	281	0.00%
296	282	0.18%	282	0.00%
297	283	0.18%	283	0.00%
298	284	0.18%	284	0.00%
299	285	0.18%	285	0.00%
300	286	0.18%	286	0.00%
301	287	0.18%	287	0.00%
302	288	0.18%	288	0.00%
303	289	0.18%	289	0.00%
304	290	0.18%	290	0.00%
305	291	0.18%	291	0.00%
306	292	0.15%	292	0.00%
307	293	0.15%	293	0.00%
308	294	0.15%	294	0.00%
309	295	0.15%	295	0.00%
310	296	0.15%	296	0.00%
311	297	0.15%	297	0.00%
312	298	0.15%	298	0.00%
313	299	0.15%	299	0.00%
314	300	0.15%	300	0.00%
315	301	0.15%	301	0.00%
316	302	0.15%	302	0.00%
317	303	0.15%	303	0.00%
318	304	0.15%	304	0.00%
319	305	0.15%	305	0.00%
320	306	0.15%	306	0.00%
321	307	0.15%	307	0.00%
322	308	0.15%	308	0.00%
323	309	0.15%	309	0.00%
324	310	0.15%	310	0.00%
325	311	0.15%	311	0.00%
326	312	0.15%	312	0.00%
327	313	0.15%	313	0.00%
328	314	0.15%	314	0.00%
329	315	0.15%	315	0.00%
330	316	0.15%	316	0.00%
331	317	0.15%	317	0.00%
332	318	0.15%	318	0.00%
333	319	0.15%	319	0.00%
334	320	0.15%	320	0.00%
335	321	0.15%	321	0.00%
336	322	0.15%	322	0.00%
337	323	0.15%	323	0.00%
338	324	0.15%	324	0.00%
339	325	0.15%	325	0.00%
340	326	0.14%	326	0.00%
341	327	0.12%	327	0.00%
342	328	0.12%	328	0.00%
343	329	0.12%	329	0.00%
344	330	0.12%	330	0.00%

	AP	AQ	BG	BH
10	Return Flow Schedule Lookup Tables			
11	Irrigation Return Flow		Alluvial Return Flow	
12	Intermediate Values		Intermediate Values	
13	Day	Incremental %Return	Day	Incremental %Return
75	61	0.38%	61	0.28%
76	62	0.31%	62	0.28%
77	63	0.39%	63	0.18%
78	64	0.42%	64	0.18%
79	65	0.27%	65	0.18%
80	66	0.34%	66	0.18%
81	67	0.40%	67	0.18%
82	68	0.48%	68	0.18%
83	69	0.29%	69	0.13%
84	70	0.29%	70	0.13%
85	71	0.35%	71	0.13%
86	72	0.35%	72	0.13%
87	73	0.43%	73	0.13%
88	74	0.43%	74	0.13%
89	75	0.52%	75	0.13%
90	76	0.52%	76	0.13%
91	77	0.43%	77	0.10%
92	78	0.43%	78	0.10%
93	79	0.43%	79	0.10%
94	80	0.39%	80	0.10%
95	81	0.39%	81	0.10%
96	82	0.39%	82	0.06%
97	83	0.39%	83	0.06%
98	84	0.47%	84	0.06%
99	85	0.47%	85	0.06%
100	86	0.47%	86	0.06%
101	87	0.47%	87	0.06%
102	88	0.46%	88	0.06%
103	89	0.46%	89	0.06%
104	90	0.46%	90	0.06%

	AP	AQ	BG	BH
	Return Flow Schedule Lookup Tables			
	Irrigation Return Flow		Alluvial Return Flow	
	Intermediate Values		Intermediate Values	
	Day	Incremental %Return	Day	Incremental %Return
166	152	0.35%	152	0.01%
167	153	0.35%	153	0.01%
168	154	0.35%	154	0.01%
169	155	0.35%	155	0.01%
170	156	0.35%	156	0.01%
171	157	0.39%	157	0.01%
172	158	0.39%	158	0.01%
173	159	0.39%	159	0.01%
174	160	0.39%	160	0.01%
175	161	0.39%	161	0.01%
176	162	0.39%	162	0.01%
177	163	0.33%	163	0.01%
178	164	0.33%	164	0.00%
179	165	0.33%	165	0.00%
180	166	0.33%	166	0.00%
181	167	0.33%	167	0.00%
182	168	0.33%	168	0.00%
183	169	0.33%	169	0.00%
184	170	0.33%	170	0.00%
185	171	0.33%	171	0.00%
186	172	0.33%	172	0.00%
187	173	0.33%	173	0.00%
188	174	0.33%	174	0.00%
189	175	0.33%	175	0.00%
190	176	0.33%	176	0.00%
191	177	0.33%	177	0.00%
192	178	0.33%	178	0.00%
193	179	0.33%	179	0.00%
194	180	0.27%	180	0.00%

	AP	AQ	BG	BH
	Return Flow Schedule Lookup Tables			
	Irrigation Return Flow		Alluvial Return Flow	
	Intermediate Values		Intermediate Values	
	Day	Incremental %Return	Day	Incremental %Return
256	242	0.20%	242	0.00%
257	243	0.20%	243	0.00%
258	244	0.20%	244	0.00%
259	245	0.20%	245	0.00%
260	246	0.20%	246	0.00%
261	247	0.20%	247	0.00%
262	248	0.20%	248	0.00%
263	249	0.20%	249	0.00%
264	250	0.20%	250	0.00%
265	251	0.20%	251	0.00%
266	252	0.20%	252	0.00%
267	253	0.20%	253	0.00%
268	254	0.20%	254	0.00%
269	255	0.20%	255	0.00%
270	256	0.20%	256	0.00%
271	257	0.20%	257	0.00%
272	258	0.20%	258	0.00%
273	259	0.20%	259	0.00%
274	260	0.20%	260	0.00%
275	261	0.20%	261	0.00%
276	262	0.20%	262	0.00%
277	263	0.20%	263	0.00%
278	264	0.18%	264	0.00%
279	265	0.18%	265	0.00%
280	266	0.18%	266	0.00%
281	267	0.18%	267	0.00%
282	268	0.18%	268	0.00%
283	269	0.18%	269	0.00%

	AP	AQ	BG	BH
	Return Flow Schedule Lookup Tables			
	Irrigation Return Flow		Alluvial Return Flow	
	Intermediate Values		Intermediate Values	
	Day	Incremental %Return	Day	Incremental %Return
345	331	0.12%	331	0.00%
346	332	0.12%	332	0.00%
347	333	0.12%	333	0.00%
348	334	0.12%	334	0.00%
349	335	0.12%	335	0.00%
350	336	0.12%	336	0.00%
351	337	0.12%	337	0.00%
352	338	0.12%	338	0.00%
353	339	0.12%	339	0.00%
354	340	0.12%	340	0.00%
355	341	0.12%	341	0.00%
356	342	0.12%	342	0.00%
357	343	0.12%	343	0.00%
358	344	0.12%	344	0.00%
359	345	0.12%	345	0.00%
360	346	0.12%	346	0.00%
361	347	0.12%	347	0.00%
362	348	0.12%	348	0.00%
363	349	0.12%	349	0.00%
364	350	0.12%	350	0.00%
365	351	0.12%	351	0.00%
366	352	0.12%	352	0.00%
367	353	0.12%	353	0.00%
368	354	0.12%	354	0.00%
369	355	0.12%	355	0.00%
370	356	0.12%	356	0.00%
371	357	0.12%	357	0.00%
372	358	0.12%	358	0.00%
373	359	0.12%	359	0.00%
374	360	0.12%	360	0.00%
375	361	0.01%	361	0.00%
376	362	0.00%	362	0.00%
377	363	0.00%	363	0.00%
378	364	0.00%	364	0.00%
379	365	0.00%	365	0.00%

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA

1 Assumptions:
2 All Lund and Darling Ditches share same priority dates
3 Seepage d/s of Ensign appears in Yakima immediately

River/Crk:	**Big Creek**
Owner:	Gentry
Priority Date:	6/30/1887
Begin Irr:	May
End Irr:	Sept
Net CU May-Sept:	18.73 in

	Acres	Qa (ac-ft)	Irr Eff	Area/Eff
Lund Ditch Non-TW Rights:	207.49	1025.7	0.385	538.93506
Darling Ditch Rights:	78.5	376.8	0.385	203.8961
Gentry Trendwest Rights:	81.51	390	0.385	211.71429
Ensign Ranch Rights:	85	408	0.385	220.77922

Annual Irrigation and Seepage Sums for use in Schedule Lookups

	Tot Irr	Pre Seep	Post Seep	
1991	168.69533	913.96054	925.52686	cfs*days
1992	178.05688	660.62601	695.13061	cfs*days
1993	163.85971	760.39383	772.26828	cfs*days
1994	177.06432	710.67801	761.58582	cfs*days
1995	148.97433	766.89054	775.72985	cfs*days
2001	90.176469	590.63219	594.56094	cfs*days

Row	Irr Yr	MonYY	Date	Withdrawl Period (1=Yes, 0=No)	Net CU (in/day)	Q Natural (cfs)	Senior Diversions: SumQ div Non-TW Rights (cfs)	Senior Diversions: SumQ div Trendwest-Gentry Right (cfs)	Pre Trendwest Action Q Calcs: Q Remaining (cfs)	Q lost to seepage (cfs)	Q @ Ensign Ranch (cfs)	Q Alluvial (cfs)	Q Irrigation Return TW (cfs)	Post Trendwest Action Q Calcs: Q Remaining (cfs)	Q lost to seepage (cfs)	Q @ Ensign Ranch (cfs)	Q Alluvial (cfs)	Q Irrigation Return TW (cfs)	Change in Yakima River Flow: DQ @ Yakima (Surface Inputs) (cfs)	DQ @ Yakima (Alluvial Inputs) (cfs)	DQ @ Yakima (Irrigation Return) (cfs)	DQ @ Yakima Total (cfs)	Change in Daily CU (cfs)
312	1991	Jul-91	26-Jul-1991	1	0.18	26.79	5.47	1.56	19.76	4.33	15.43	1.21	0.37	21.32	4.40	16.92	1.23	0.00	1.49	0.02	-0.37	1.14	0.60
313	1991	Jul-91	27-Jul-1991	1	0.18	25.12	5.47	1.56	18.09	4.26	13.83	1.17	0.45	19.65	4.33	15.32	1.18	0.00	1.49	0.01	-0.45	1.06	0.60
314	1991	Jul-91	28-Jul-1991	1	0.18	23.75	5.47	1.56	16.72	4.20	12.51	1.17	0.45	18.28	4.27	14.01	1.18	0.00	1.49	0.01	-0.45	1.06	0.60
315	1991	Jul-91	29-Jul-1991	1	0.18	22.86	5.47	1.56	15.84	4.17	11.67	1.17	0.54	17.39	4.23	13.16	1.18	0.00	1.49	0.01	-0.54	0.97	0.60
316	1991	Jul-91	30-Jul-1991	1	0.18	22.06	5.47	1.56	15.03	4.14	10.90	1.17	0.54	16.59	4.20	12.39	1.18	0.00	1.49	0.01	-0.54	0.97	0.60
317	1991	Jul-91	31-Jul-1991	1	0.18	21.09	5.47	1.56	14.06	4.10	9.97	0.89	0.44	15.62	4.16	11.46	0.90	0.00	1.50	0.01	-0.44	1.06	0.60
318	1991	Aug-91	1-Aug-1991	1	0.19	20.91	5.90	1.68	13.33	4.07	9.27	0.89	0.44	15.01	4.13	10.88	0.90	0.00	1.61	0.01	-0.44	1.18	0.65
319	1991	Aug-91	2-Aug-1991	1	0.19	19.99	5.90	1.68	12.41	4.03	8.38	0.89	0.44	14.09	4.10	9.99	0.90	0.00	1.61	0.01	-0.44	1.18	0.65
320	1991	Aug-91	3-Aug-1991	1	0.19	19.24	5.90	1.68	11.66	4.00	7.66	0.89	0.41	13.34	4.07	9.27	0.90	0.00	1.61	0.01	-0.41	1.22	0.65
321	1991	Aug-91	4-Aug-1991	1	0.19	18.85	5.90	1.68	11.28	3.98	7.29	0.89	0.41	12.96	4.05	8.91	0.90	0.00	1.61	0.01	-0.41	1.22	0.65
322	1991	Aug-91	5-Aug-1991	1	0.19	18.71	5.90	1.68	11.14	3.98	7.16	0.59	0.41	12.82	4.05	8.77	0.60	0.00	1.61	0.01	-0.41	1.22	0.65
323	1991	Aug-91	6-Aug-1991	1	0.19	26.58	5.90	1.68	19.01	4.30	14.71	0.59	0.41	20.69	4.37	16.31	0.60	0.00	1.61	0.01	-0.41	1.21	0.65
324	1991	Aug-91	7-Aug-1991	1	0.19	36.73	5.90	1.68	29.15	4.76	24.40	0.59	0.49	30.83	4.84	26.00	0.60	0.00	1.60	0.01	-0.49	1.12	0.65

A = YEAR	
B = MONTH/YEAR	
C = DATE	
D = PERIOD OF USE	
E = NET CONSUMPTIVE USE	Blanney-Criddle Net CU using mean monthly temperature and precipitation data (inches/day).
F = NATURAL STREAMFLOW	From Regression Equation and Teanaway River Data (cfs)
G = SUM OF NON-TRENDWEST SENIOR WATER DIVERSIONS	SUM($T$3:$T$4)/SUM($T$3:$T$5)*MIN($D338*$F338,$E338*(1/12)*SUM($T$3:$T$5)*43560/86400)
H = TRENDWEST DIVERSION	$T$5/SUM($T$3:$T$5)*MIN($D338*$F338,$E338*(1/12)*SUM($T$3:$T$5)*43560/86400)
J = PRE-TRANSFER STREAMFLOW D/S OF DIVERSION DAM	F338-SUM(G338:H338)
K = PRE-TRANSFER SEEPAGE TO ALLUVIAL AQUIFER D/S TO ENSIGN DIV.	MIN(J338,3.5635*EXP(0.0099*$J338),27)
L = PRE-TRANSFER STREAMFLOW AT ENSIGN DIVERSION	J338-K338
M = PRE-TRANSFER LAGGED SEEPAGE DISCHARGE AT MOUTH	VLOOKUP($C338-DATE($A338,5,15),$BG$14:$BH$379,2,FALSE)*IF($A338=1990,AVERAGE($X$3:$X$8),IF($A338=2000,AVERAGE($X$3:$X$8),VLOOKUP($A338,$V$3:$Y$8,3,FALSE)))
N = PRE-TRANSFER LAGGED IRRIGATION RETURN FLOW TO YAKIMA RIVER	VLOOKUP($C338-DATE($A338,5,15),$AP$14:$AQ$379,2,FALSE)*IF($A338=1990,AVERAGE($W$3:$W$8),IF($A338=2000,AVERAGE($W$3:$W$8),VLOOKUP($A338,$V$3:$W$8,2,FALSE)))*(1-$S$5)
P = POST-TRANSFER STREAMFLOW D/S OF DIVERSION DAM	F338-G338
Q = POST-TRANSFER SEEPAGE TO ALLUVIAL AQUIFER D/S TO ENSIGN DIV.	MIN($P338,3.5635*EXP(0.0099*$P338),27)
R = POST-TRANSFER STREAMFLOW AT ENSIGN DIVERSION	P338-Q338
S = POST-TRANSFER LAGGED SEEPAGE DISCHARGE AT MOUTH	VLOOKUP($C338-DATE($A338,5,15),$BG$14:$BH$379,2,FALSE)*IF($A338=1990,AVERAGE($Y$3:$Y$8),IF($A338=2000,AVERAGE($Y$3:$Y$8),VLOOKUP($A338,$V$3:$Y$8,4,FALSE)))
T = POST-TRANSFER LAGGED IRRIGATION RETURN FLOW TO YAKIMA RIVER	0.00 No irrigation -- no return flow
V = CHANGE IN STREAMFLOW AT MOUTH	R338-L338
W = CHANGE IN SEEPAGE DISCHARGE AT MOUTH	S338-M338
X = CHANGE IN IRRIGATION RETURN FLOW TO YAKIMA RIVER	T338-N338
Y = TOTAL CHANGE IN DISCHARGE TO YAKIMA RIVER	SUM(V338:X338)
Z = CONSUMPTIVE USE PORTION OF TOTAL CHANGE	H338*$S$5

	A	B	G	H	I	J	K
1	***WATER BALANCE MODEL FOR MOUNTAINSTAR RESORT***						
2							
3			On Site Demands and Returns				
4	Mon YY	Date	On Site Diversion Demand (cfs)	WW Return to Yakima (cfs)	Irrigation Return to Yakima (cfs)	Irrigation Return to Cle Elum (cfs)	Net On Site Water Requirement (cfs)
303	Jul-91	26-Jul-1991	8.32	1.95	0.17	0.42	5.78
304	Jul-91	27-Jul-1991	8.32	1.95	0.17	0.42	5.78
305	Jul-91	28-Jul-1991	8.32	1.95	0.17	0.42	5.78
306	Jul-91	29-Jul-1991	8.32	1.95	0.17	0.42	5.78
307	Jul-91	30-Jul-1991	8.32	1.95	0.17	0.42	5.78
308	Jul-91	31-Jul-1991	8.32	1.95	0.17	0.42	5.78
309	Aug-91	1-Aug-1991	6.87	1.92	0.17	0.42	4.37
310	Aug-91	2-Aug-1991	6.87	1.92	0.17	0.42	4.37
311	Aug-91	3-Aug-1991	6.87	1.92	0.17	0.42	4.37
312	Aug-91	4-Aug-1991	6.87	1.92	0.17	0.42	4.37
313	Aug-91	5-Aug-1991	6.87	1.92	0.17	0.42	4.37
314	Aug-91	6-Aug-1991	6.87	1.92	0.17	0.42	4.37
315	Aug-91	7-Aug-1991	6.87	1.92	0.17	0.42	4.37

	L	M	N	O	P	Q	R
3		Flow Increase Associated With Acquired Water Rights					
4		Big Creek (cfs)	Teanaway River (cfs)	First + Swauk Creek (cfs)	Reecer Creek (cfs)	Main Stem Rights (cfs)	Net Water Rights Available (cfs)
303		1.14	2.05	3.12	-0.67	2.56	8.19
304		1.06	2.05	2.70	-0.67	2.56	7.70
305		1.06	2.05	2.10	-0.67	2.56	7.10
306		0.97	2.05	1.86	-0.67	2.56	6.76
307		0.97	2.05	1.77	-0.67	2.56	6.67
308		1.06	1.47	1.71	-0.67	2.56	6.13
309		1.18	1.65	1.60	-0.67	2.36	6.12
310		1.18	1.65	1.53	-0.67	2.36	6.06
311		1.22	1.65	-0.35	-0.67	2.36	4.21
312		1.22	1.65	0.32	-0.67	2.36	4.88
313		1.22	1.65	0.30	-0.67	2.36	4.86
314		1.21	1.65	2.86	-0.67	2.36	7.41
315		1.12	1.65	3.78	-0.67	2.36	8.23

	S	T	U	V	W	X	Y
3		CU Balance				Water Balance	
4		Net CU Available from WR's (cfs)	% On Site CU Demand Met	Change in Daily CU (cfs)		% On Site Demand Met by Acquired Water Rights	Δ Flow in Yakima River D/S Ellensburg (cfs)
303		7.26	100%	1.48		100%	2.41
304		6.91	100%	1.12		100%	1.91
305		6.63	100%	0.84		100%	1.32
306		6.45	100%	0.67		100%	0.97
307		6.39	100%	0.61		100%	0.89
308		6.33	100%	0.54		100%	0.35
309		6.24	100%	1.88		100%	1.76
310		6.18	100%	1.82		100%	1.69
311		6.12	100%	1.76		97%	-0.15
312		6.09	100%	1.72		100%	0.52
313		6.08	100%	1.71		100%	0.50
314		7.09	100%	2.72		100%	3.05
315		7.81	100%	3.44		100%	3.87

	Z	AA	AB	AC	AD	AE	AF	AG
3		Change In Yakima River Under Alternative 5 Reduced Density						
4		D/S Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S Water Supply Diversion (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)	D/S Reecer Creek (Ellensburg) (cfs)
303		1.14	1.72	-4.65	-2.60	0.52	3.08	2.41
304		1.06	1.64	-4.72	-2.68	0.03	2.58	1.91
305		1.06	1.64	-4.72	-2.67	-0.57	1.99	1.32
306		0.97	1.55	-4.82	-2.77	-0.91	1.64	0.97
307		0.97	1.55	-4.82	-2.77	-1.00	1.56	0.89
308		1.06	1.65	-4.72	-3.25	-1.54	1.02	0.35
309		1.18	1.77	-3.18	-1.53	0.07	2.43	1.76
310		1.18	1.77	-3.18	-1.53	0.00	2.36	1.69
311		1.22	1.81	-3.15	-1.49	-1.84	0.52	-0.15
312		1.22	1.81	-3.15	-1.49	-1.17	1.19	0.52
313		1.22	1.81	-3.15	-1.50	-1.19	1.17	0.50
314		1.21	1.80	-3.16	-1.50	1.36	3.72	3.05
315		1.12	1.71	-3.25	-1.60	2.18	4.54	3.87

On Site Demands and Returns:	
G = Trendwest Diversion	From Trendwest: Mean Monthly Diversion for 30-year Buildout, 100 percent Occupancy
H = Wastewater Return to Yakima River	From Trendwest: Mean Monthly Wastewater Return for 30-year Buildout, 100 percent Occupancy
I = Trendwest Return to Yakima River	From Trendwest: Mean Monthly Yakima River Return for 30-year Buildout, 100 percent Occupancy
J = Trendwest Return to Cle Elum River	From Trendwest: Mean Monthly Cle Elum River Return for 30-year Buildout, 100 percent Occupancy
K = Trendwest Net Daily Consumptive Use	G303-SUM(H303:J303)
Flow Increase Associated with Trendwest Rights:	
M = Mainstem Flow Change Associated With Big Creek Water Rights	'[TWmodel12d2.xls]Big Ck'!Y312
N = Mainstem River Flow Change Associated With Teanaway Water Rights	[TWmodel12d2.xls]Teanaway River'!AQ312
O = Mainstem Flow Change Associated With Swauk/First Ck Water Rights	[TWmodel12d2.xls]Swauk Ck'!R312+'[TWmodel12d2.xls]First Ck'!R312
P = Mainstem Flow Change Associated With First/Reecer Creek Water Rights	[TWmodel12d2.xls]Reecer Ck'!V312
Q = Mainstem Flow Change Associated With Pautzke Water Rights	VLOOKUP(IF(MONTH(B303)=10,IF(DAY(B303)<=15,"10_1","10_2"),MONTH(B303)),[TWmodel12d2.xls]Main Stem'!$B$11:$G$23,6,FALSE)
R = Net Water Rights Available from Trendwest-Acquired Rights	SUM(M303:Q303)
Consumptive Use Balance:	
T = Net Available Consumptive Use from Trendwest Water Rights	[TWmodel12d2.xls]Big Ck'!Z312+'[TWmodel12d2.xls]Teanaway River'!AR312+'[TWmodel12d2.xls]First Ck'!S312+'[TWmodel12d2.xls]Swauk Ck'!S312+Q303
U = Percent of On-Site Net Consumptive Use Demand Met	IF(K303<0,1,MIN(1,T303/K303))
V = Change in Daily Net Consumptive Use in Basin	T303-K303
Water Balance:	
X = Percent On-Site Net Consumptive Use Demand Met w/lag	IF(R303<0,0,MIN(1,R303/K303))
Y = Change in Yakima River Flow d/s of Ellensburg	R303-K303
Change In Yakima River Under Alternative 5 Reduced Density	
AA = Change in Yakima River Flow d/s of Big Creek	M303
AB = Change in Yakima River Flow d/s of Cle Elum River	AA303+SUM(I303:J303)
AC = Change in Yakima River Flow d/s of Cle Elum Diversion	AB303-G303+H303
AD = Change in Yakima River Flow d/s of Teanaway River	AC303+N303
AE = Change in Yakima River Flow d/s of Swauk Creek	AD303+O303
AF = Change in Yakima River Flow d/s of Mill Ditch Diversion	AE303+Q303
AG = Change in Yakima River Flow d/s of Reecer Creek	AF303+P303

Exhibit E

PRELIMINARY WATER REQUIREMENTS AT BUILDOUT (100% OCCUPANCY ANALYSIS)

Reduced Density Plan - MPR - Year 30

11-Sep-01

Element	Oct. 1-15	Oct. 16-31	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun 1-12	Jun 13 -30	Jul	Aug	Sep	Total
Diversion Demands (Ac-Ft)															
Treated Non-Irrigation	55.0	58.7	109.3	112.9	112.8	101.9	112.9	109.9	114.5	44.2	66.3	113.4	113.9	110.2	1,335.8
Treated Irrigation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.8	17.7	58.2	43.0	31.3	162.0
Untreated Irrigation	8.6	9.2	0.0	0.0	0.0	0.0	0.0	12.9	32.9	60.2	90.3	236.3	176.4	122.5	749.4
Misc. Uses & Losses	6.9	7.4	12.5	12.5	12.5	12.5	12.5	13.8	15.8	11.0	16.5	36.1	30.1	24.7	224.7
Total Diversion	70.5	75.2	121.8	125.4	125.2	114.4	125.4	136.6	163.3	127.2	190.8	444.0	363.3	288.7	2,471.9
Return Flows (Ac-Ft)															
Wastewater Flows (w/o I/I)	45.2	48.2	89.9	91.1	92.8	83.8	92.9	90.4	94.2	36.6	54.9	94.5	92.3	91.3	1,098.2
Treated Irrigation*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	6.0	19.8	14.6	10.7	55.2
Untreated Irrigation*	1.5	1.6	0.0	0.0	0.0	0.0	0.0	2.0	4.1	9.5	14.2	37.7	27.9	20.2	118.8
Misc. Uses & System Losses**	6.7	7.1	12.1	12.1	12.1	12.1	12.1	13.4	15.3	10.7	16.0	35.0	29.2	24.0	218.0
Total Return	53.4	57.0	102.0	103.2	104.9	95.9	105.0	105.8	113.6	60.8	91.2	187.1	164.0	146.2	1,490.1
Net Water Requirement (Diversion Less Return Flows)	17.1	18.2	19.7	22.2	20.4	18.4	20.4	30.8	49.7	66.4	99.6	256.9	199.3	142.6	981.7
Peak Instantaneous Demands (cfs)															
Treated	3.0	3.0	2.9	3.0	3.0	2.7	3.0	2.9	3.0	3.7	3.7	4.4	4.0	3.8	
Untreated	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.2	0.6	2.8	2.8	4.2	3.2	2.3	
Total Normal Peak	3.3	3.3	2.9	3.0	3.0	2.7	3.0	3.1	3.6	6.5	6.5	8.6	7.2	6.0	
Untreated Emergency Storage Makeup	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	
Total Normal + Makeup Peak	4.1	4.1	2.9	3.0	3.0	2.7	3.0	4.0	4.4	7.4	7.4	9.5	8.0	6.9	

* From irrigation application inefficiency.

** From irrigation application inefficiency, and system maintenance requirements and system leakage.

Notes:

1. Miscellaneous uses and losses calculated as follows: Monthly demand = (Total annual treated demand * 10%)/12 months + 10% * Untreated irrigation demand for the month.
2. Peak Instantaneous flow for treated water = (1.5 * maximum month treated water demand) + (misc. uses and losses)
3. Peak instantaneous flow for untreated water = (average demand for month) + (misc. uses and losses)
4. Untreated storage makeup for maximum month golf course emergency storage (207.6 acre-feet) = (maximum month daily demand)* 25% (makeup of 7 days emergency storage in 28 days)
5. Does not include RV campground: Total Annual Diversion = 0.0
   Total Annual Return = 0.0
   Net Water Requirement = 0.0

PRELIMINARY WATER REQUIREMENTS AT BUILDOUT (100% OCCUPANCY ANALYSIS)

Alternative 5 UGA and Reduced Density MPR - Year 30

8-Nov-01

Element	Oct. 1- 15	Oct. 15 -31	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun 1 - 12	Jun 13 -30	Jul	Aug	Sep	Total
Diversion Demands (Ac-Ft)															
Treated Non-Irrigation	69.7	74.4	138.8	143.4	143.2	129.4	143.4	139.4	145.0	56.0	84.0	143.8	144.3	139.7	1,694.5
Treated Irrigation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.0	25.4	83.5	61.7	45.0	232.6
Untreated Irrigation	8.6	9.2	0.0	0.0	0.0	0.0	0.0	13.7	36.0	62.3	93.4	243.7	182.4	125.4	774.8
Misc. Uses & Losses	8.6	9.2	16.1	16.1	16.1	16.1	16.1	17.4	19.7	12.7	19.0	40.4	34.3	28.6	270.2
Total Diversion	86.9	92.7	154.8	159.5	159.3	145.5	159.4	170.6	200.7	147.9	221.8	511.5	422.7	338.7	2,971.9
Return Flows (Ac-Ft)															
Wastewater Flows (w/o I/I)	57.6	61.4	114.7	116.6	118.4	106.9	118.4	115.2	119.8	46.5	69.7	120.1	117.8	116.1	1,399.2
Treated Irrigation*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8	8.7	28.7	21.2	15.4	79.9
Untreated Irrigation*	1.5	1.6	0.0	0.0	0.0	0.0	0.0	2.0	4.1	9.6	14.4	38.1	28.2	20.4	119.8
Misc. Uses & System Losses**	8.4	8.9	15.6	15.6	15.6	15.6	15.6	16.9	19.1	12.3	18.4	39.2	33.3	27.7	262.1
Total Return	67.5	72.0	130.3	132.2	133.9	122.5	134.0	134.1	142.9	74.2	111.2	226.1	200.5	179.6	1,861.0
Net Water Requirement (Diversion Less Return Flows)	19.5	20.8	24.6	27.3	25.4	23.0	25.4	36.4	57.7	73.7	110.6	285.4	222.2	159.1	1,110.9
Peak Instantaneous Demands (cfs)															
Treated	3.8	3.8	3.6	3.8	3.8	3.4	3.8	3.7	3.8	4.9	4.9	5.8	5.3	4.9	
Untreated	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.2	0.6	2.9	2.8	4.4	3.3	2.3	
Total Normal Peak	4.1	4.1	3.6	3.8	3.8	3.4	3.8	3.9	4.4	7.7	7.7	10.2	8.5	7.2	
Untreated Emergency Storage Makeup	0.8	0.8	0.0	0.0	0.0	0.0	0.0	-0.8	0.8	0.8	0.8	0.8	0.8	0.8	
Total Normal + Makeup Peak	4.9	4.9	3.6	3.8	3.8	3.4	3.8	4.8	5.3	8.6	8.6	11.0	9.4	8.1	

* From irrigation application inefficiency.

** From irrigation application inefficiency, and system maintenance requirements and system leakage.

Notes

1. Miscellaneous uses and losses calculated as follows: Monthly demand = (Total annual treated demand * 10%)/12 months + 10% * Untreated irrigation demand for the month.
2. Peak Instantaneous flow for treated water = (1.5 * maximum month treated water demand) + (misc. uses and losses)
3. Peak instantaneous flow for untreated water = (average demand for month) + (misc. uses and losses)
4. Untreated storage makeup for maximum month golf course emergency storage (207.6 acre-feet) = (maximum month daily demand)* 25% (makeup of 7 days emergency storage in 28 days)
5. Does not include RV campground:
   Total Annual Diversion = 0.0
   Total Annual Return = 0.0
   Net Water Requirement = 0.0

PRELIMINARY WATER REQUIREMENTS AT BUILDOUT (100% OCCUPANCY ANALYSIS)

Alternative 5 - UGA - Year 30

8-Nov-01

Element	Oct. 1- 15	Oct. 15 -31	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun 1 - 12	Jun 13 -30	Jul	Aug	Sep	Total
Diversion Demands (Ac-Ft)															
Treated Non-Irrigation	14.7	15.7	29.5	30.5	30.5	27.5	30.5	29.5	30.5	11.8	17.7	30.5	30.5	29.5	358.7
Treated Irrigation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	7.7	25.4	18.7	13.7	70.6
Untreated Irrigation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	3.1	2.1	3.1	7.4	6.0	2.9	25.3
Misc. Uses & Losses	1.7	1.8	3.6	3.6	3.6	3.6	3.6	3.7	3.9	1.6	2.5	4.3	4.2	3.9	45.5
Total Diversion	16.5	17.6	33.1	34.0	34.0	31.1	34.0	33.9	37.4	20.6	31.0	67.5	59.3	50.0	500.1
Return Flows (Ac-Ft)															
Wastewater Flows (w/o I/I)	12.4	13.2	24.7	25.6	25.6	23.1	25.6	24.7	25.6	9.9	14.8	25.6	25.6	24.7	301.1
Treated Irrigation*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	2.7	8.9	6.6	4.8	24.7
Untreated Irrigation*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.4	0.3	0.2	1.0
Misc. Uses & System Losses**	1.7	1.8	3.5	3.5	3.5	3.5	3.5	3.5	3.8	1.6	2.4	4.2	4.0	3.8	44.1
Total Return	14.1	15.0	28.2	29.0	29.0	26.6	29.0	28.3	29.3	13.4	20.0	39.0	36.4	33.5	370.9
Net Water Requirement (Diversion Less Return Flows)	2.4	2.6	4.8	5.0	5.0	4.5	5.0	5.6	8.1	7.3	10.9	28.5	22.9	16.5	129.2
Peak Instantaneous Demands (cfs)															
Treated	0.8	0.8	0.8	0.8	0.8	0.7	0.8	0.8	0.8	1.1	1.1	1.4	1.3	1.1	
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	
Total Normal Peak	0.8	0.8	0.8	0.8	0.8	0.7	0.8	0.8	0.9	1.2	1.2	1.6	1.4	1.2	
Untreated Emergency Storage Makeup	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total Normal + Makeup Peak	0.8	0.8	0.8	0.8	0.8	0.7	0.8	0.8	0.9	1.2	1.2	1.6	1.4	1.2	

* From irrigation application inefficiency.

** From irrigation application inefficiency, and system maintenance requirements and system leakage.

Notes

1. Miscellaneous uses and losses calculated as follows: Monthly demand = (Total annual treated demand * 10%)/12 months + 10% * Untreated irrigation demand for the month.
2. Peak Instantaneous flow for treated water = (1.5 * maximum month treated water demand) + (misc. uses and losses)
3. Peak instantaneous flow for untreated water = (average demand for month) + (misc. uses and losses)
4. This analysis does not include the public demands (School expansion, community center, cemetery expansion, or business park)
5. This analysis does not include the 175 acre Reserve Area

Exhibit F

Associated Earth Sciences, Inc.

Technical Memorandum

Date December 12, 2001

To: Andy Kindig
A.C. Kindig & Co.

Tom Martin
Brown & Caldwell

From: Otto Paris

Project Name: MountainStar/UGA

Project No: KH00748C

Subject: On-Site Ground Water Return Flows from Irrigation
MountainStar MPR and Cle Elum UGA

This technical memorandum summarizes the results of Associated Earth Sciences, Inc.'s (AESI's) analysis of the timing of on-site irrigation return flows for the MountainStar Master Planned Resort (MPR) and the Cle Elum Urban Growth Area (UGA) for ground water discharge to the Yakima and Cle Elum Rivers. A brief description of the methodology used to calculate the timing and volume of the ground water return flows is also included in this document.

The objectives of AESI's analysis were to (1) estimate the time of travel for assumed irrigation return flows from proposed MPR/UGA development scenarios to be conveyed from the land surface to the Cle Elum and Yakima Rivers, and (2) to estimate the monthly volume of on-site return flow volumes reaching the rivers for the new hydraulic equilibrium conditions resulting from full buildout of the two projects. The resulting "lagged" return flows for the various development scenarios were incorporated into the existing water balance model for the upper Yakima River Basin. The water balance model will be used to evaluate potential impacts to stream flows due to the proposed transfers of surface water rights acquired by Trendwest Resorts (Trendwest). In addition, we completed estimates of the lagged irrigation return flow volumes for several time increments during buildout of the MPR and UGA development projects to ensure there were no time periods during construction when the total water demands (diversion minus return flows reaching the Cle Elum River and/or Yakima River) would exceed the total water rights available for consumptive use.

Two cumulative impact scenarios were used in the return flow analysis. The higher density scenario incorporated return flows estimated for the MPR as proposed in the Kittitas County development permit combined with Alternative 2 for the UGA. The lower density scenario incorporated return flows estimated for the reduced density MPR proposal combined with UGA Alternative 5. The following sections summarize (1) AESI's approach for calculating the timing of the estimated lagged return flow volumes, (2) the methods used to estimate the lagged return flow volumes including data inputs and underlying assumptions, and (3) the results of our analysis.

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Approach

W&H Pacific, Inc. (W&H Pacific) provided tables of estimated monthly irrigation return flows for each developed subbasin for the various MPR and UGA development alternatives (W&H Pacific, 2001a). The monthly irrigation return flows calculated by W&H Pacific are defined as "non-lagged return flows" in this memorandum. AESI assumed that all of the irrigation return flow water would migrate to the water table aquifer, and the resulting additional ground water volume would eventually discharge to the Yakima and Cle Elum Rivers. The overall increase in available ground water recharge would result in increased water table elevations. A portion of this additional ground water recharge would likely result in some additional long-term aquifer storage. Assuming full buildout conditions for the two scenarios, the water table aquifer would eventually reach a new equilibrium condition. Ground water elevations under the new equilibrium conditions would fluctuate seasonally in response to the seasonal variability of the on-site return flows.

Our analysis focused on estimating the net change in the water table elevations, hydraulic gradients, and ground water velocities for the anticipated new equilibrium condition within the water table aquifer. The new equilibrium condition would reflect both the additional long-term aquifer storage properties and seasonal "pulses" of ground water recharge migrating through the aquifer system as a result of seasonal irrigation at the land surface. After the water table aquifer system has reached a new equilibrium, the amount of additional ground water recharge from the estimated return flows for a given water year should equal the amount of additional ground water discharge. The overall objective of our approach was to estimate the monthly volume of ground water discharge to the Cle Elum and Yakima Rivers attributed to the increased ground water recharge from the estimated on-site irrigation return flows. The calculated irrigation return flow volumes discharging as ground water to the Cle Elum and Yakima Rivers are referred to as the "lagged return flow" volumes in this document.

The hydraulic effect of the additional recharge to the water table aquifer would not be confined to the subsurface areas delineated by the developed surface water hydrologic basins used to calculate the non-lagged return flow volumes. Therefore, the individual developed subbasins were combined into 16 ground water subbasins based on the best available information for (1) the ground water flow directions, (2) the locations of ground water discharge points, (3) the geometry of individual developed hydrologic subbasins, and (4) the orientation of developed subbasins relative to ground water discharge locations. Figure 1 shows the locations of the 16 ground water subbasins used to calculate the lagged irrigation return flow volumes.

Methods

Spreadsheet (Excel) models were developed to calculate monthly changes in ground water conditions resulting from the estimated return flows. Darcy equations for ground water flow were used to calculate ground water flow volumes (flux) and ground water velocities. The Green-Ampt Explicit Model for unsaturated flow was used to estimate the amount of time for return flow water to reach the underlying water table aquifer. Monthly ground water return flow volumes were simulated for about 20 water years to evaluate when each of the 16 ground water subbasins had reached a new equilibrium condition, which includes additional aquifer storage. The resulting new equilibrium return flow volumes were then compiled from the spreadsheet model to estimate the average lagged monthly return flows to the Yakima and Cle Elum Rivers at the discharge locations for the two MPR/UGA scenarios (cumulative high and low development densities).

Monthly return flows and surface acreages for full buildout of each of the MPR and UGA developed subbasins were provided by W & H Pacific (W&H Pacific, 2001a). Time periods used in our analysis are based on water years (October 1 through September 30). All known relevant subsurface data for the MPR and UGA sites were used to evaluate likely average ground water elevations and hydraulic gradients for existing conditions beneath each of the 16 subbasins. Average calculated hydraulic gradients were based on (1) average ground water elevations measured in the existing on-site wells, (2) probable subsurface stratigraphic controls on ground water flow in the water table aquifer, (3) the conceptual ground water model presented in the MPR Environmental Impact Statement (EIS), (4) gradients induced by pumping at the Cle Elum Hatchery wellfield, and (5) elevations of the Cle Elum River, the Yakima River, and Stream C.

AESI used the following average values for hydraulic characteristics of the sand and gravel water table aquifer beneath the MPR and UGA sites.

- Average total porosity of the aquifer is 0.25.
- Average effective porosity of the aquifer is 0.20.
- Average aquifer hydraulic conductivity of 300 feet per day (ft/day), which corresponds to an approximate median value for a reasonable average range of 50 to 500 ft/day.
- Using a 10:1 ratio of horizontal hydraulic conductivity to vertical hydraulic conductivity, a vertical hydraulic conductivity of 30 ft/day was used in the unsaturated flow analysis.

Additional parameters needed for the Green-Ampt Explicit Model were derived from published values for sand and gravel soils.

The spreadsheet model was designed to perform the following calculations at monthly time steps for each of the 16 subbasins.

1. Calculate the net rise in the ground water elevation resulting from the return flow recharge volumes.
2. Calculate a new hydraulic gradient based on the change in ground water elevation.
3. Calculate the volume of ground water discharging from the subbasin.
4. Calculate the residual volume of ground water derived from the return flows that remain in the subbasin at the end of the monthly time step.

5. Combine the residual ground water volume with the next month's return flow volume to calculate the subsequent month's ground water elevation, hydraulic gradient, and ground water discharge volume.

6. Continue this monthly iterative process until each subbasin reaches new hydraulic equilibrium conditions as observed by a repetitive annual cycle of monthly ground water discharge volumes.

7. Use the calculated ground water flow velocities and unsaturated flow travel times to calculate the overall lag time for the subbasin irrigation return flow volume to reach the discharge points for the Cle Elum and Yakima Rivers.

The spreadsheet model was then used to compile the monthly return flow volumes to the Yakima and Cle Elum Rivers after full buildout of the MPR and UGA sites. The discharge points were located along the edge of the Cle Elum and Yakima River floodplains based on the reasonable likelihood of direct hydraulic continuity between the rivers and the ground water table beneath the river floodplains.

Because the on-site irrigation returns would take many years to reach equilibrium, it was necessary to confirm that demands (diversion less return flows) would not exceed supply during any phase of the MPR and UGA construction. The spreadsheet model was used to estimate incremental lagged return flow volumes during buildout of the MPR and UGA sites. W&H Pacific provided total non-lagged on-site irrigation return flow volumes for Years 1, 2, 3, 4, 6, 10, 20, and 30 for the entire MPR and UGA sites during buildout for the low density scenario (W&H Pacific, 2001b, personal communication; W&H Pacific, 2001c, personal communication). On-site irrigation return flows for Years 1 through 9 were restricted to those subbasins comprising the MPR Phase 1 area and the UGA based on proposed development phases. The estimated incremental lagged irrigation return flow volumes were then added to the wastewater return flow volumes to calculate the net on-site consumptive water demands during buildout, and to compare the net on-site consumptive water demands to the total water rights acquired by Trendwest for consumptive use.

Results and Conclusions

Table 1 summarizes the lagged monthly return flows to the Cle Elum and Yakima Rivers for the two cumulative MPR/UGA development scenarios after the site has reached a new hydraulic equilibrium. The results of our analysis indicate that changes in ground water flow in the water table aquifer caused by return flows from the proposed MPR/UGA developments would reach equilibrium within a period of about 12 years after full buildout. Most of the net increase in simulated ground water elevations occurs within the first two water years for most of the subbasins. The resulting calculated rise in ground water elevations for new baseline equilibrium conditions in the individual subbasins ranged from less than 0.1 feet to 2.0 feet. Thirteen of the sixteen subbasins had simulated ground water elevation increases of less than 1.0 foot

The total time periods needed to reach the new equilibrium conditions in individual subbasins varied in response to (1) basin size relative to estimated return flows, (2) hydraulic gradients, and

(3) distance between the subbasins and the discharge locations. Effective hydraulic equilibrium conditions within individual subbasins were attained within periods ranging from 1 to 12 years, with all of the subbasins achieving 90 percent of the new equilibrium conditions within 8 years. Figures 2, 3 and 4 show the monthly lagged return flow volumes for three of the subbasins to illustrate the variability in seasonal pulses and time period needed for each of the individual subbasins to achieve new hydraulic equilibrium conditions. Simulated changes in return flow volumes for the other subbasins show similar patterns. Figure 5 shows the monthly cumulative return flows for all subbasins for a period of 12 years after full buildout for the cumulative reduced density MPR and UGA Alternative 5 projects.

Compiling all of the lagged return flows for the individual subbasins resulted in a relatively constant monthly total return flow from the MPR/UGA site to the rivers. Figures 6 and 7 are graphs comparing the lagged and non-lagged irrigation return flows to the rivers for the two cumulative MPR/UGA scenarios. Mass balance differences between the lagged and non-lagged return flow volumes for the two development scenarios were calculated to be less than 2 percent after the site reached a new hydraulic equilibrium.

A supplemental analysis using the low and high range of assumed hydraulic conductivity values (50 and 500 ft/day) indicated similar seasonal patterns in lagged return flow volumes. However, the amount of time needed for individual subbasins to reach the new effective hydraulic equilibrium varied according to the assumed hydraulic conductivity.

Using the results of our analysis of full buildout conditions, lagged return flow volumes were estimated for several time periods during buildout of the MPR (reduced density) and UGA (Alternative 5) sites. As stated previously, the on-site irrigation return flows for Years 1 through 9 were assumed to be confined to the hydrologic basins comprising the majority of the MPR Phase 1 area and the UGA areas. For the purpose of estimating the lagged return flow volumes at Year 20 and Year 30, 95 percent of the total annual non-lagged return flow volumes were assumed to be discharged to the Cle Elum and Yakima Rivers within a period of 10 years based on the results of the full buildout return flow analysis. Table 2 lists both the non-lagged and estimated lagged irrigation return flow volumes for Years 1, 2, 3, 4, 6, 10, 20, and 30 of site buildout for the low density scenario.

Our analysis of the hydraulic conditions at full buildout (Year 30) assumed instantaneous construction and initiation of return flows at the start of the model run. This model had the purpose of establishing total lagged return flows at full buildout of the MPR/UGA projects for incorporation in the water balance model. The secondary analysis of estimating return flow volumes during construction indicated that almost 90 percent of the total annual on-site irrigation return flow volumes will reach the Cle Elum and Yakima Rivers by Year 30 as the reduced density MPR and UGA Alternative 5 projects are built. Therefore, the project site should attain the new hydraulic equilibrium condition significantly sooner than 12 years after full buildout.

The lagged irrigation return flow volumes were then incorporated into an analysis of estimated on-site consumptive water demands during buildout to ensure there were no time periods when the total water demand (total diversion volume less returns) might exceed the total available consumptive use water rights acquired by Trendwest. This question was raised by the Pacific Groundwater Group in their memorandum dated October 31, 2001. The total estimated return flow volumes, including the wastewater return flow, were subtracted from the total water demand for the MPR and UGA to calculate a total on-site consumptive water demand during buildout. Table 3 lists the estimated total on-site consumptive water demand for Years 1, 2, 3, 4, 6, 10, 20, and 30 of site buildout for the low density scenario. At no time would the total on-site consumptive water demand exceed the total water right volume for these time periods (Table 3).

References

City of Cle Elum. 2001. Trendwest Properties: Cle Elum UGA Draft EIS, Appendix D: Water Supply, March 2001.

W&H Pacific, Inc. 2001a. Return flow analysis, MountainStar Master Planned Resort Cle Elum UGA. Unpublished consultant report prepared for Trendwest Properties, Inc., September 2001

W&H Pacific, Inc. 2001b. Personal communication. Fax transmittal: preliminary estimates of diversion demands and return flows by year, reduced density MPR and UGA Alternative 5, November 7, 2001.

W&H Pacific, Inc. 2001c. Personal communication. Fax transmittal: preliminary estimates of diversion demands and return flows by year, reduced density MPR and UGA Alternative 5, November 9, 2001.

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Table 1
Cumulative Monthly Lagged Irrigation Return Flows (Acre-Feet) Discharged to the Cle Elum and Yakima Rivers
MountainStar Master Planned Resort (MPR) and Cle Elum Urban Growth Area (UGA)

Cumulative High Density MPR / UGA Alternative 2 Scenario													
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**Total**
Cle Elum River	34.6	36.0	34.5	35.8	32.2	33.0	29.1	29.1	28.1	27.7	29.7	31.1	380.8
Yakima River	19.5	17.8	17.5	19.5	21.9	24.1	23.8	23.2	21.5	22.0	21.4	19.3	251.6
Total Monthly Return Flow	54.1	53.8	52.1	55.2	54.1	57.2	52.9	52.3	49.6	49.7	51.1	50.4	632.4

Cumulative Reduced Density MPR / UGA Alternative 5 Scenario													
	October	**November**	**December**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**Total**
Cle Elum River	31.1	32.2	33.3	32.0	30.2	29.7	27.1	25.4	25.0	26.0	26.0	28.4	346.4
Yakima River	9.9	9.2	9.2	9.2	9.5	10.2	9.9	9.8	9.5	10.2	10.3	9.6	116.5
Total Monthly Return Flow	41.0	41.4	42.5	41.2	39.7	39.8	36.9	35.3	34.6	36.2	36.2	38.0	462.9

Note: Water volumes are in acre-feet per month.

Table 2
Summary of Lagged Return Flow Volumes During Project Buildout
Cumulative Reduced Density MPR / UGA Alternative 5 Scenario

Year[1]	Non-Lagged Return Flow Volumes[2] (acre-feet/year)	Lagged Return Flows (acre-feet/year)
1	0.0	0.0
2	194.9	0.5
3	223.5	26.2
4	260.2	106.9
6	312.8	214.1
10	364.9	306.3
20	435.7	346.7
30	461.7	413.9

Notes:
[1]Years based on water years beginning in October.
[2]Reference: W&H Pacific, 2001b, personal communication.

Table 3
Comparison of Total Water Demand, Return Flows, and Net Consumptive Water Demand (acre-feet per year) During Project Buildout
Cumulative Reduced Density MPR / UGA Alternative 5 Scenario

Year[1]	(A) Total Water Demand[2]	(B) Wastewater Return Flow[2]	(C) Lagged Return Flow	(D) Total Return Flow (D=B+C)	(E) Net Onsite Consumptive Water Demand (E=A-D)	(F) Total Available Consumptive Water Rights[3]	(G) Surplus Consumptive Water Rights (G=F-E)
1	0.0	0.0	0.0	0.0	0.0	2050.9	2050.9
2	852.2	0.0	0.5	0.5	851.7	2050.9	1199.2
3	1071.4	143.1	26.2	169.3	902.1	2050.9	1148.8
4	1356.5	330.2	106.9	437.1	919.4	2050.9	1131.5
6	1768.8	601.2	214.1	815.3	953.5	2050.9	1097.4
10	2192.6	882.8	306.3	1189.1	1003.5	2050.9	1047.4
20	2762.4	1260.4	346.7	1607.1	1155.3	2050.9	895.6
30	2972.0	1399.3	413.9	1813.2	1158.8	2050.9	892.1

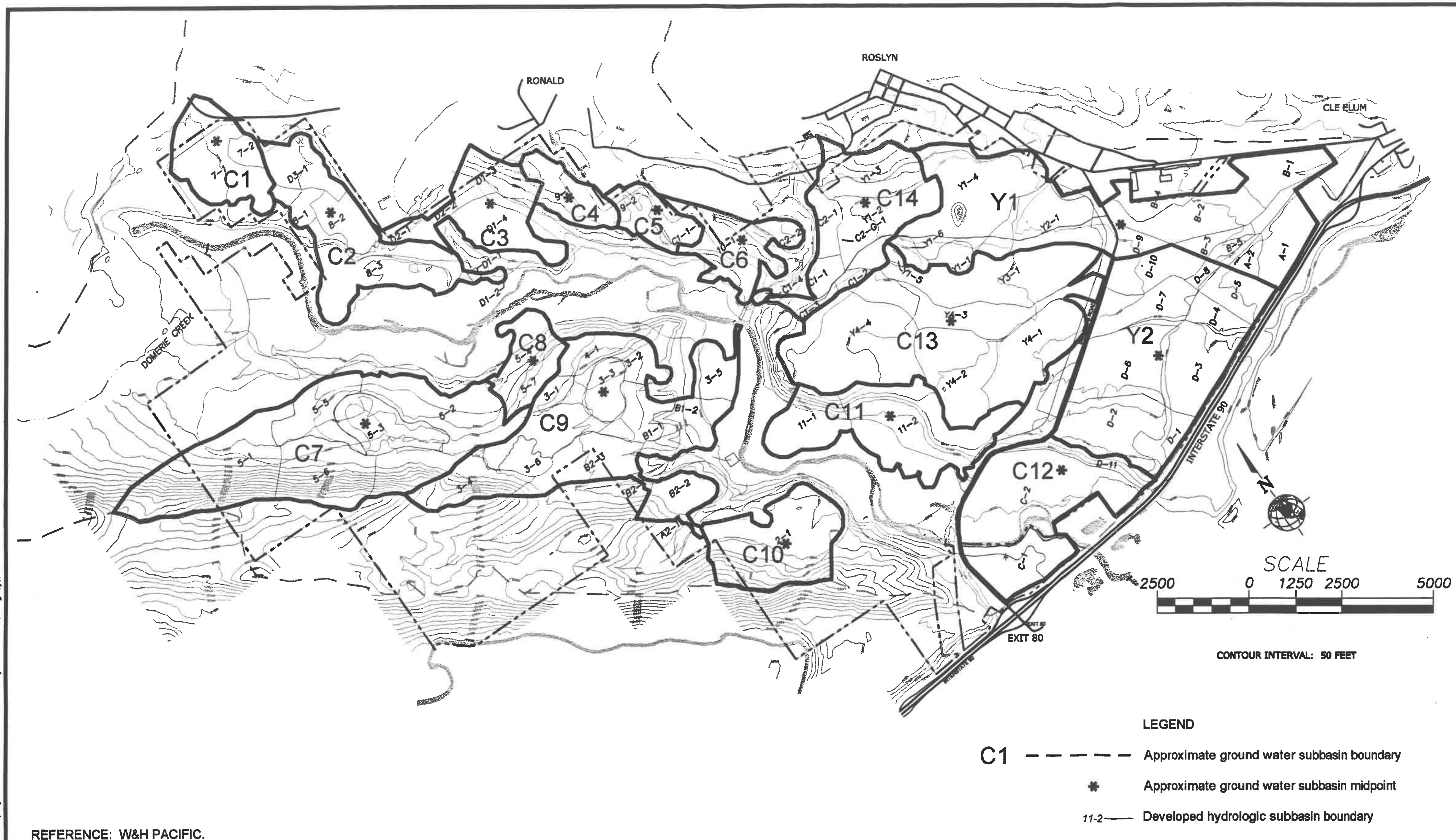
Notes:

All water volumes are in acre-feet per year.

[1]Years based on water years beginning in October.

[2]Reference: W&H Pacific, 2001b, personal communication.

[3]Reference: City of Cle Elum, 2001, Trendwest Properties: Cle Elum UGA Draft EIS.



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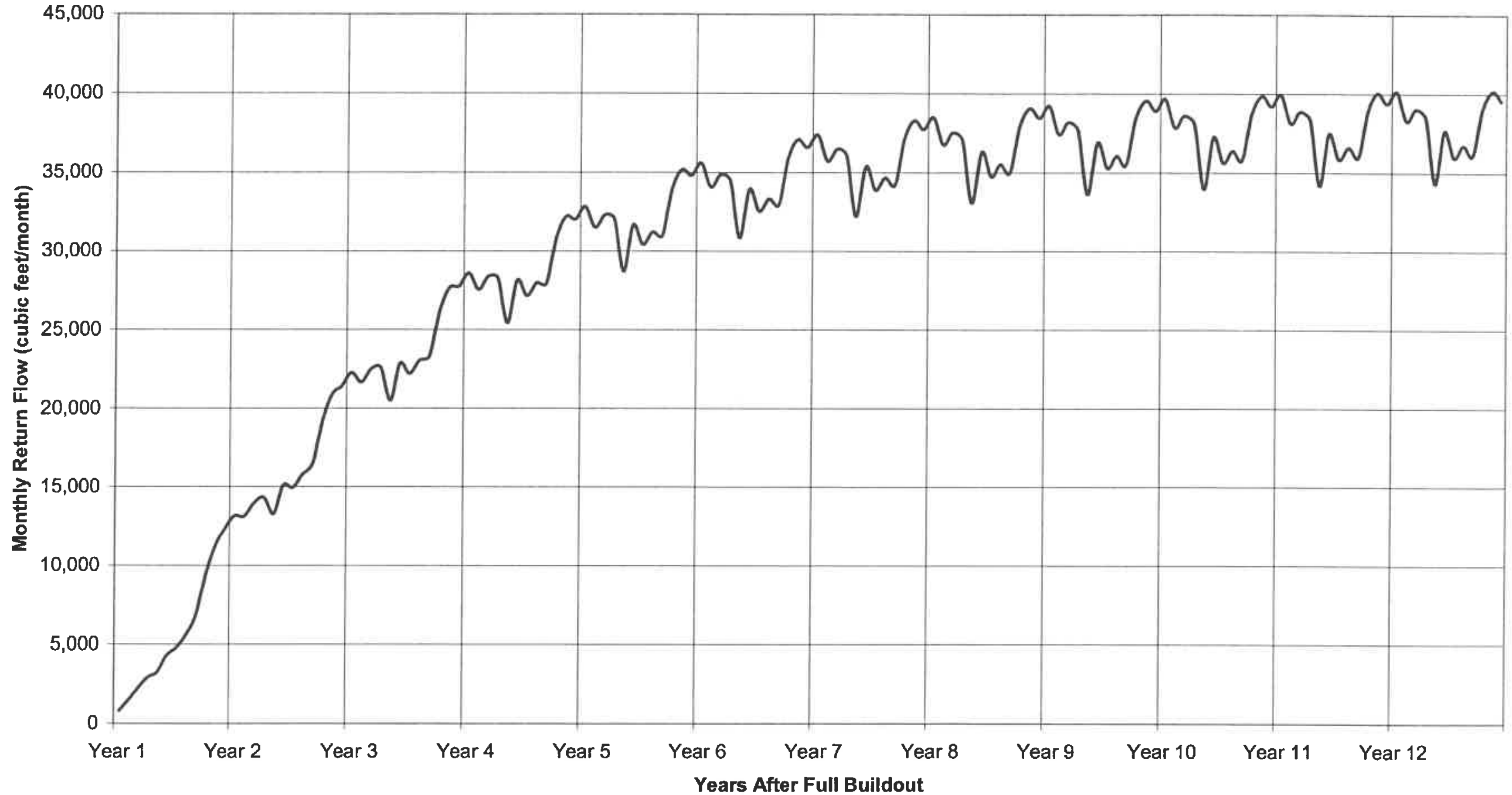
MountainStar MPR and Cle Elum UGA

Kittitas County, Washington

FIGURE 1
GROUND WATER SUBBASINS
ONSITE RETURN FLOW ANALYSIS



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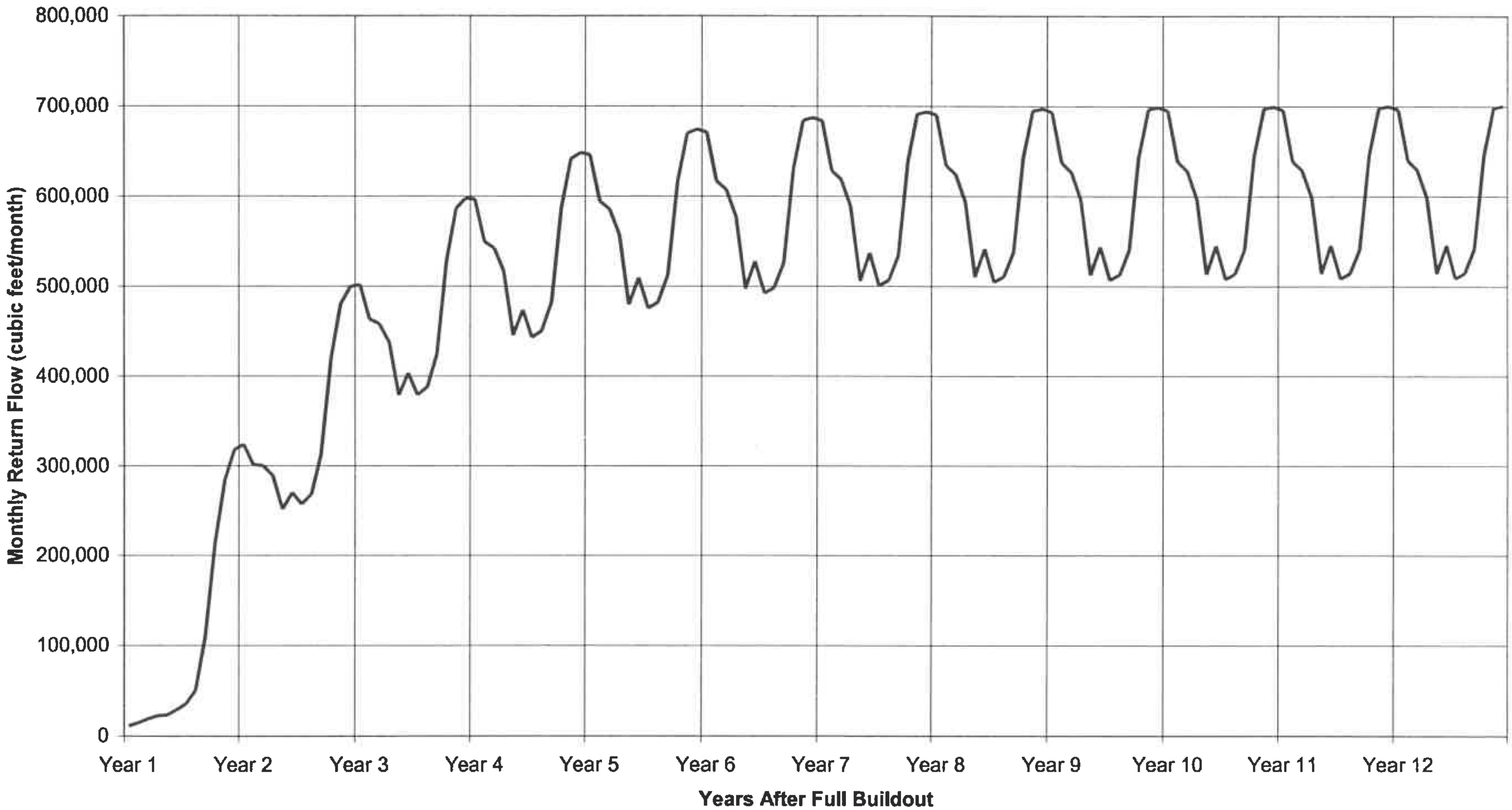
MountainStar MPR and Cle Elum UGA

Kittitas County, Washington

Figure 2
Simulated Monthly Irrigation Return Flows
Subbasin C1
Reduced Density Scenario



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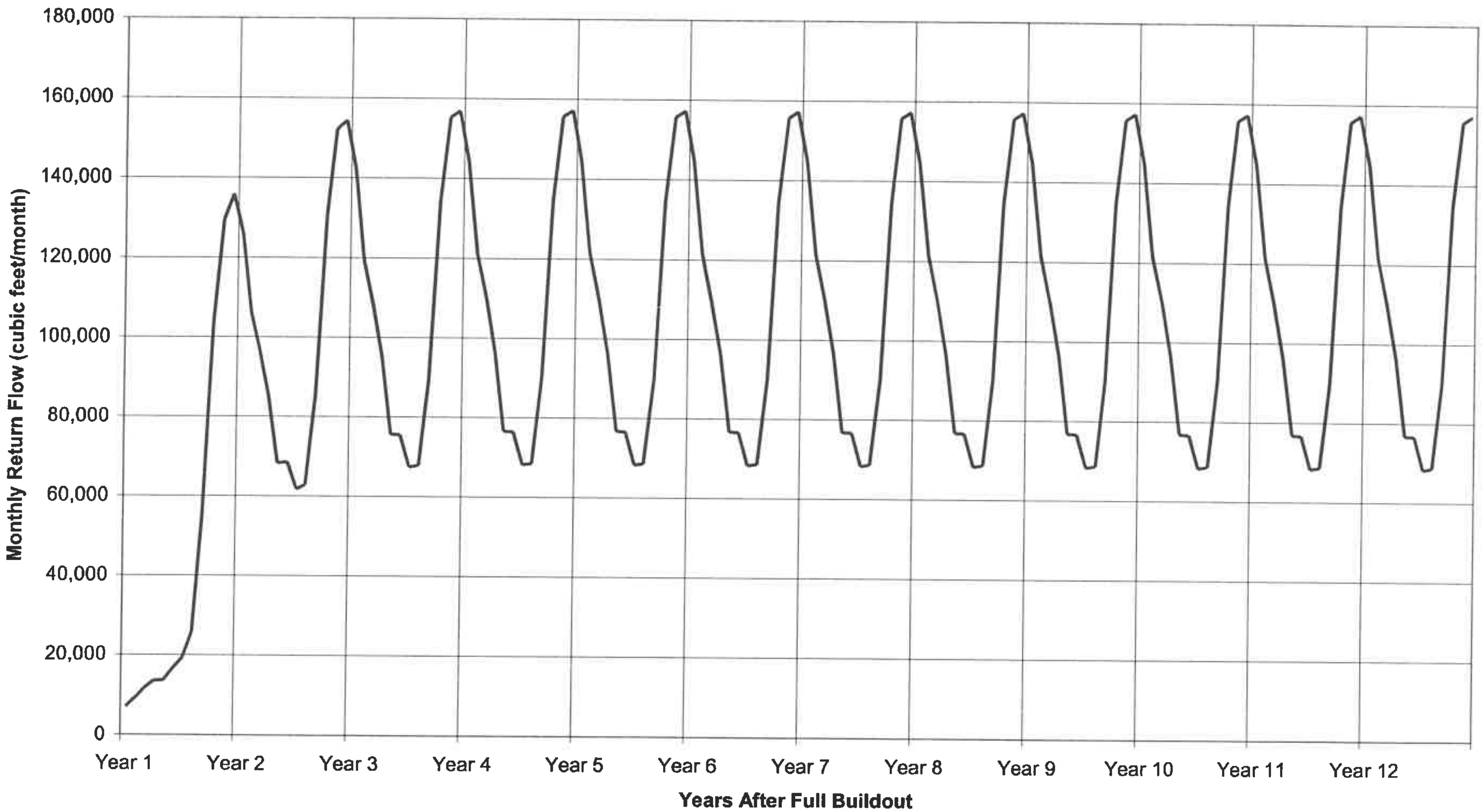
MountainStar MPR and Cle Elum UGA

Kittitas County, Washington

Figure 3
Simulated Monthly Irrigation Return Flows
Subbasin C13
Reduced Density Scenario



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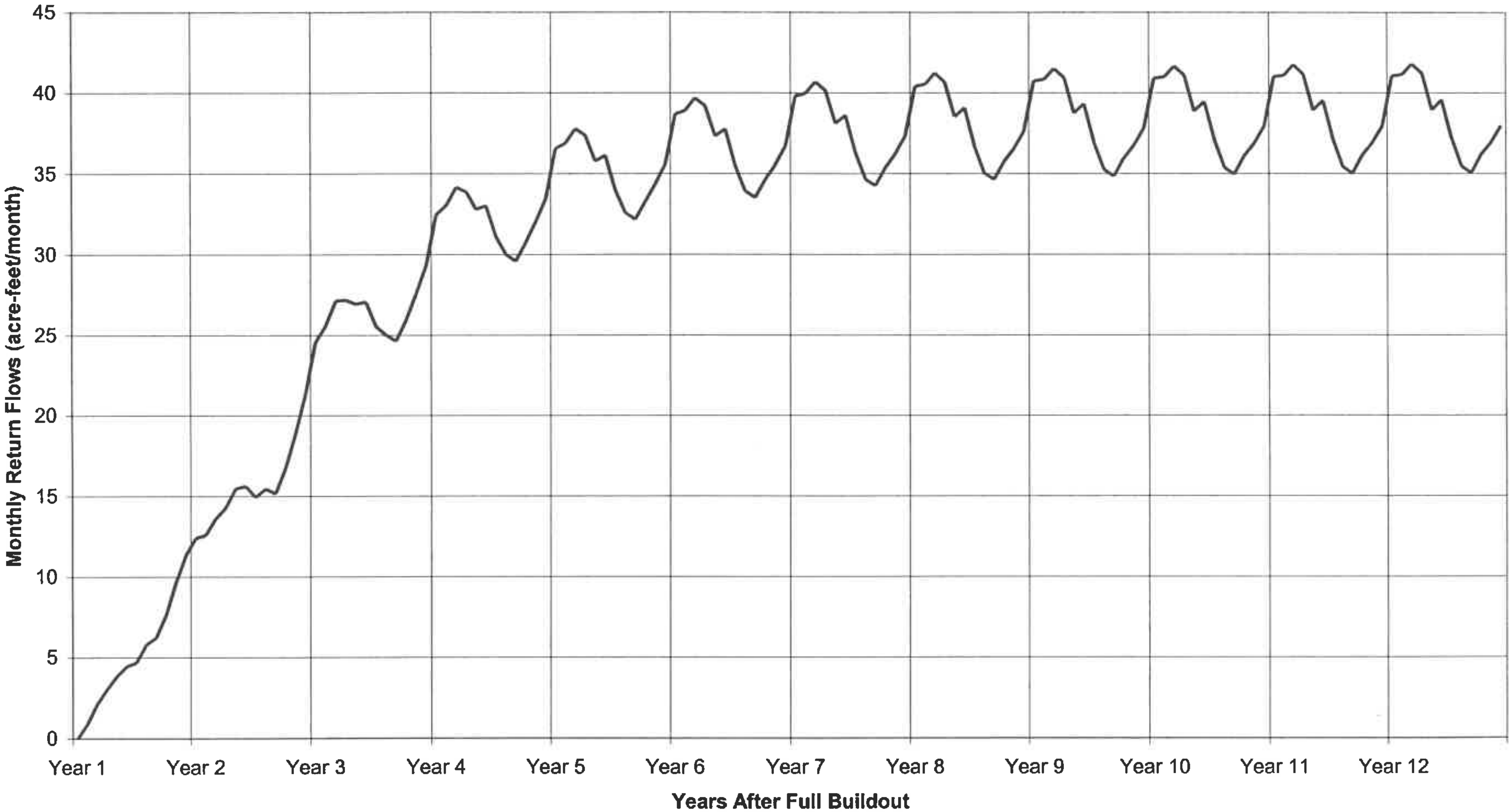
MountainStar MPR and Cle Elum UGA

Kittitas County, Washington

Figure 4
Simulated Monthly Irrigation Return Flows
Subbasin C14
Reduced Density Scenario



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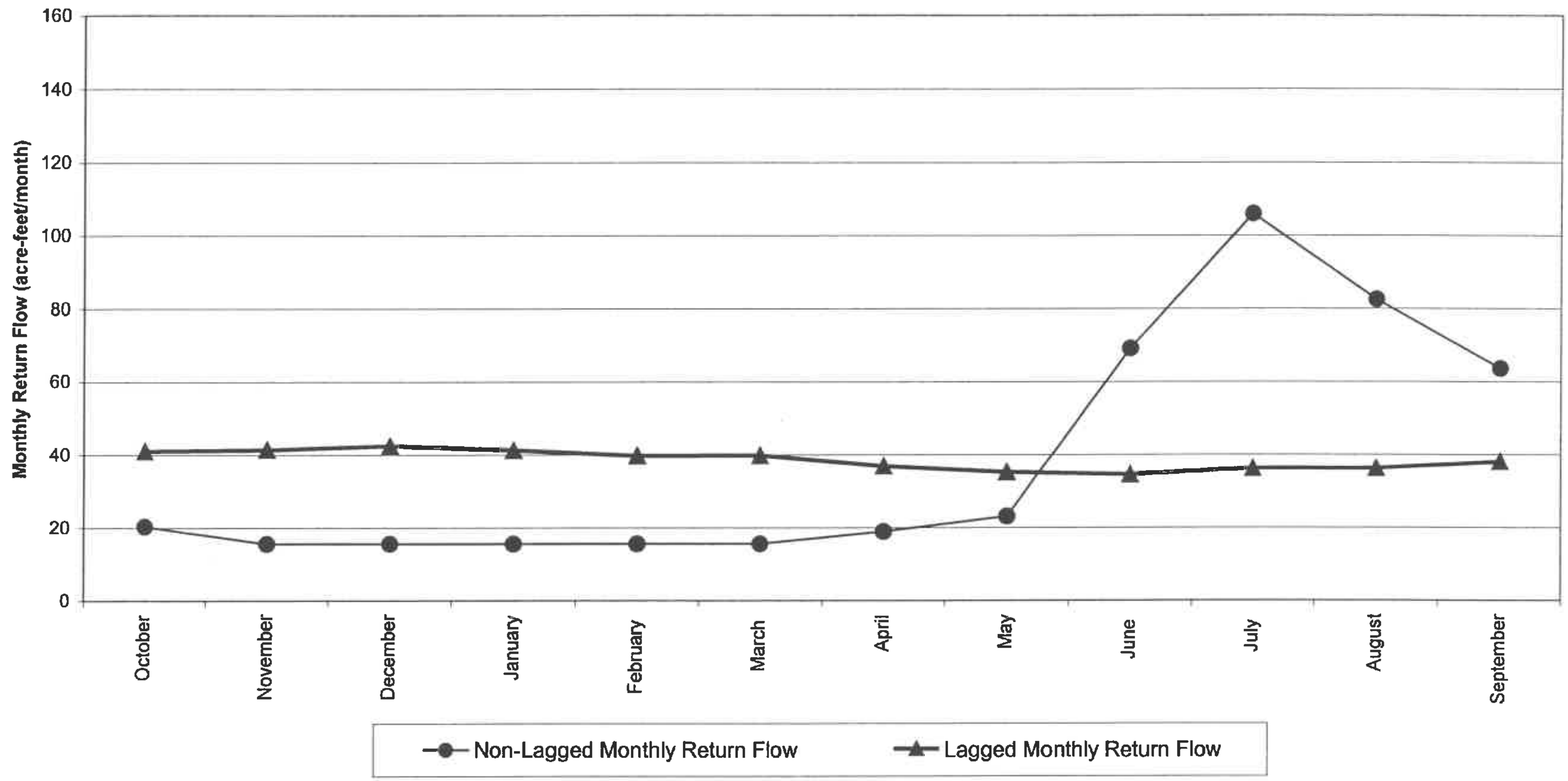
MountainStar MPR and Cle Elum UGA

Kittitas County, Washington

Figure 5
Simulated Total Irrigation Return Flow
to Cle Elum and Yakima Rivers
Reduced Density Scenario



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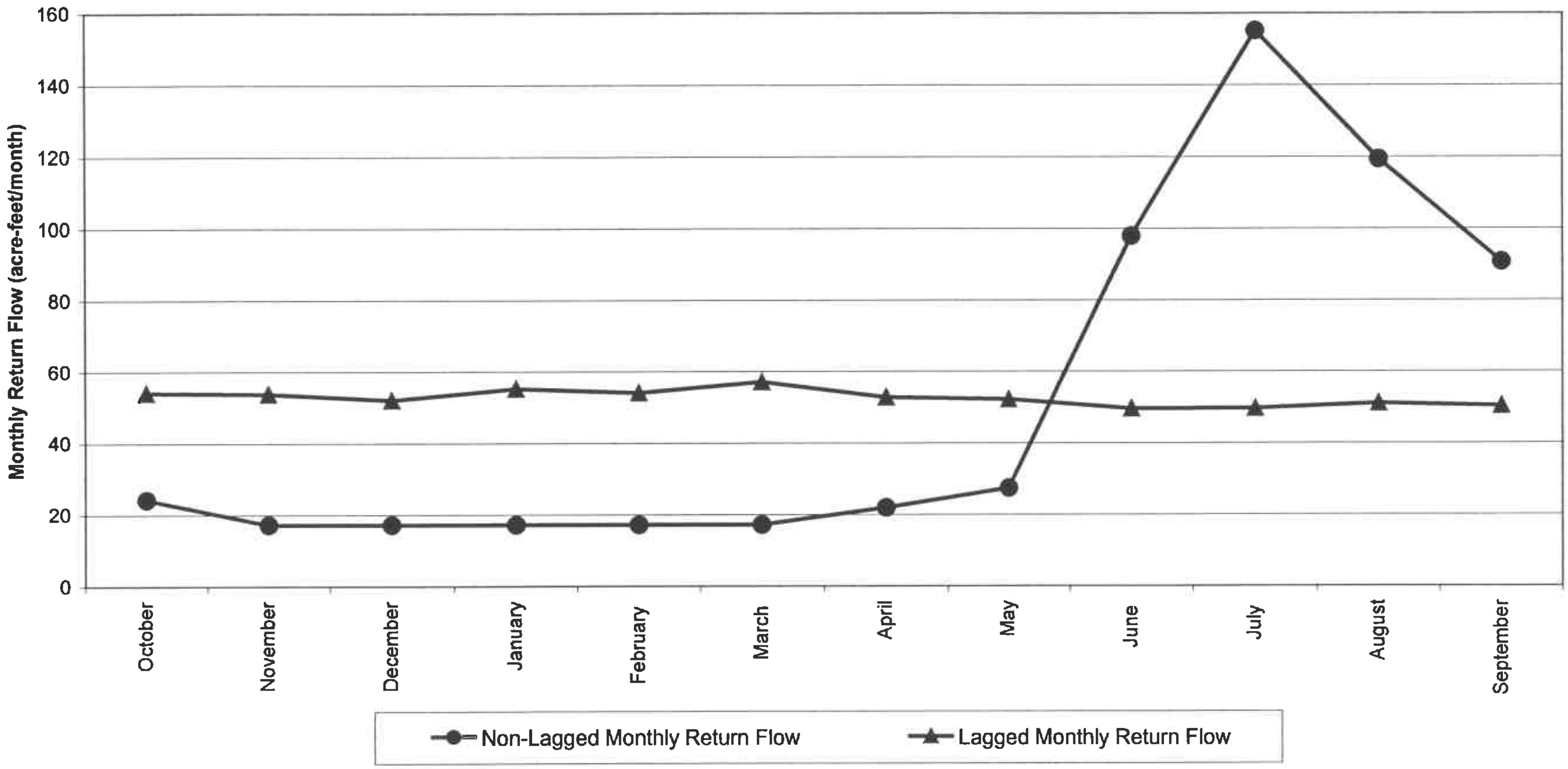
MountainStar MPR and Cle Elum UGA

Kittitas County, Washington

Figure 6
Simulated Monthly Irrigation Return Flows
at New Hydraulic Equilibrium
Reduced Density Scenario



Associated Earth Sciences, Inc.

MountainStar MPR and Cle Elum UGA

Kittitas County, Washington

Figure 7
Simulated Monthly Irrigation Return Flows
at New Hydraulic Equilibrium
High Density Scenario

Exhibit G

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Technical Memorandum

To: Randall Doneen, Department of Ecology
Joe Mentor, Mentor Law Group
Jamie Morin, Mentor Law Group
Andy Kindig, A. Kindig & Associates
Tom Martin, Brown and Caldwell

From: Peter Schwartzman, Associate Hydrogeologist, PGG
Chrysten Root, Geologist/Hydrologist, PGG

Re: **BIG CREEK BASIN HYDROLOGIC ANALYSIS**

Date: January 18, 2002

In this memorandum, Ecology's Consulting Team (ECT) estimates how Trendwest's proposed transfer of the former Gentry water right into the Yakima Basin Trust Water Program (the Trust) will affect streamflows. In the course of this evaluation, we present analysis of (1) the hydrogeology of the Big Creek Basin, (2) the hydrologic effects of leaving formerly diverted Gentry rights instream rather than routing them to crop consumptive use and subsurface irrigation return flows to the Yakima River, (3) streamflow partitioning between surface-water flow and alluvial (sub-surface) subflow, and (4) delivery of alluvial subflow to the Yakima River. Hydrogeologic conditions were analyzed based on evaluation of well logs and a field-visit to the study area. Subsurface irrigation return flows were evaluated using various models of flow through the unsaturated zone that underlies irrigated parcels and the regional water table aquifer. Partitioning of surficial and subsurface flow was based on Big Creek flow data collected by both Tom Martin and Montgomery Water Group (MWG). The timing required for alluvial subflow to reach the Yakima River was modeled for a dry-year condition, and discussed in light of model results for the average-year condition.

The water right transfer proposed by Trendwest on Big Creek is broken down into two components. Two thirds of Trendwest's total water right is proposed for transfer to mitigate Yakima River withdrawals for the Master Planned Resort (MPR), while the remaining one third is proposed for transfer to mitigate withdrawals for the City of Cle Elum Urban Growth Area (UGA). The modeling results presented in this memorandum are considered to be applicable to both the MPR and combined MPR/UGA transfers. The results are presented in a format that can be applied to both transfer scenarios (i.e. as relative percent of transferred water right vs. time). Slight variations in model response between the MPR and MPR/UGA transfer quantities appear to be too small to warrant independent analysis given other uncertainties inherent in quantifying the characteristics of the hydrologic system.

ECT's model predictions of the effect of terminating irrigation under the Gentry rights in favor of instream flows under the Trust will be used as one set of inputs to a separate model developed by Brown and Caldwell (B&C). That B&C model will simulate results of the combined Trendwest Master Plan Resort and Urban Growth Area water demand schedule and water right transfers on the Yakima River basin, from upstream of the Cle Elum River at the Big Creek confluence with the Yakima River and downstream to the Reecer Creek confluence with the Yakima River.

1 Summary of Findings

- Hydrogeologic characterization and assessment of seepage losses from Big Creek suggest that hydraulic continuity is likely absent (or very limited) between the creek and the underlying water table aquifer. Seepage gains from the groundwater flow system into Big Creek were not noted in our review of the available data.
- Trendwest's proposed water-right transfer from historic irrigation use to instream flow will result in a net addition of water to the Yakima basin downstream of Big Creek equivalent to the consumptive use of the irrigated crops. For the entire proposed transfer (MPR + UGA), B&C have estimated crop consumptive use to be 137 acre-feet per year (0.8 million gallons per year).
- Transfer of the entire water right will increase streamflows in Big Creek during the irrigation season by the amount previously diverted for irrigation use, because nonconsumptive irrigation returns from the Gentry fields went to the Yakima River, and not back into Big Creek. Estimates of historic diversions associated with the Gentry/Trendwest water right range from 1.1 cfs in May to 1.5 cfs in August. Lack of hydraulic continuity between the water-table aquifer and Big Creek dictates that the portion of historic diversions lost to seepage from the ditches and fields returned via groundwater to the Yakima River rather than Big Creek.
- One effect of leaving the Gentry rights as instream flows is that the man-caused routing of the irrigation return flow to the Yakima River via groundwater will be ended. Thus, former irrigation return flow will stay instream and reach the Yakima River more quickly than it did when the water was diverted to the Gentry fields. The water rights transfer will decrease streamflows in the Yakima River outside the irrigation season due to ending this man-caused routing of subsurface return flow from irrigation seepage losses. Modeling analysis was used to predict this change in timing of return flows using a reasonable range of aquifer permeability to predict a reasonable range of hydrologic effects. For the low-end value of aquifer permeability (75 feet/day), the model predicts a relatively constant rate of Yakima River groundwater inflow from historic irrigation seepage losses associated with Trendwest's water right. For simulation of the MPR transfer only, model predictions show an average rate of groundwater inflow of approximately 0.18 cfs, with a seasonal high of 0.22 cfs occurring about 7 months after the end of the irrigation season and a seasonal low of approximately 0.16 cfs occurring about 2 months after the beginning of the irrigation season. In contrast, simulations with the high-end aquifer permeability (750 ft/d) predict a more pronounced seasonal variation of subsurface return flow to the Yakima River. While the *average* rate of groundwater discharge is predicted to remain unaltered, a seasonal high of 0.50 cfs is predicted to occur about two weeks after the end of the irrigation season[1] and a seasonal low of approximately 0.02 cfs is predicted to occur in the first two weeks of the irrigation season.

[1] The two-week time lag is attributed to the time required for field and ditch irrigation seepage losses to reach the underlying water table.

- During the irrigation season, a portion of the water transferred to instream flow will seep through the streambed to become alluvial subflow. Seepage losses are estimated to be relatively insignificant prior to early July, when Big Creek is expected to flow all the way down to the Yakima River. However, historic observations suggest that Big Creek typically dries up near the mouth (and farther upstream) in the latter half of the irrigation season, and a significant portion of Trendwest's transferred water will likely reach the Yakima River as alluvial subsurface flow in those formerly dry reaches. For estimated "typical average" and "typical dry" years, Trendwest's added contribution to instream flow will likely extend the period of continuous streamflow down to the Yakima River, and will reduce the geographic length of the dry reach once dry conditions start to occur. Model simulations were performed to estimate how long it would take for the alluvial subflow to reach the Yakima River. Our model predicted that time lags between alluvial infiltration and outflows to the Yakima River will be relatively minor, with 90 percent of the infiltrated volume reaching the river within a week after the irrigation season ends. For the purpose of this analysis, time delays associated with alluvial subflow are considered to be insignificant.
- In summary, the net hydrologic effect of transferring Trendwest's water right will be to: 1) increase water availability to the overall hydrologic system; 2) increase instream flows in Big Creek during the irrigation season by the historic rates of diversion; and 3) shift the timing of former subsurface irrigation return flows reaching the Yakima River from the historic (year-round) condition to one where these flow volumes reach the river at a higher rate during the irrigation season (via Big Creek and alluvial subflow) but no longer reach the river during the remainder of the year. The net effect on Yakima River streamflows will be the combined effect of increased surface-water (and alluvial subflow) inflows during the irrigation season and the elimination of irrigation-caused subsurface return flows on a year-round basis.
- ECT recommends that the B&C water-balance model use an average of the return-flow schedules developed from the two groundwater model simulations for input as central, or most-reasonable estimate values. In addition, the water balance model should use the full range identified by the two groundwater model runs to assess uncertainty in the total predicted change in tributary and mainstem flows from the combined water right transfers for the MPR and UGA.

2 Hydrogeologic Conditions in the Big Creek Basin

Upstream of the Lund/Darling diversion dam, Big Creek flows through bedrock terrain composed of middle-to-late Eocene inter-bedded sandstone and volcanic rocks and occurrences of Easton schist (Frizzel et al, 1984). Just upstream of the diversion dam, Big Creek flows between knobs of Easton Schist and between deposits of alpine glacial drift. The creek encounters the Yakima River alluvium just upstream of the diversion dam at an elevation of about 2240 feet. It then flows over the alluvium at a gradual slope towards its confluence with the Yakima River (elevation 2060 feet).

The alluvial sediments were characterized based on well driller's logs on file with the Washington State Department of Ecology. Well logs were reviewed in Sections 20, 21, 28, and 29 of Township 20 North, Range 14 East. Well locations are reported by drillers to the nearest quarter-quarter section, and may exhibit some inaccuracies due to driller's estimates. Most of the wells in the area are reported to be domestic and are less than 100 feet deep. The logs in the immediate vicinity of Big Creek reported clean sand and gravel which we refer to as Big Creek Alluvium. Well logs farther away from Big Creek reported silt and clay from the surface to varying depths with underlying clean sand and gravel found at depth. These logs likely indicate well completions in the Yakima River Alluvium. The thickness of the alluvial sediments (Big Creek and Yakima River) is unknown based on the well logs. The soils that overlie the alluvial sediments are reported by the Kittitas Conservation District to be Kladnick Sandy Loam, Roslyn Sandy Loam, and Andic Xerumbrepts (characterized as a gravelly loam).

Groundwater elevations were reviewed and estimated to the accuracy of the topographic maps and reported well locations. Based on reported well locations, depth to groundwater in the alluvial aquifer commonly ranges from 5 to 30 feet below land surface in the Big Creek Basin (most of the reviewed wells are located east of the creek). Three deep wells (119, 140 and 196 feet deep) have very shallow and/or flowing water levels, thus suggesting regional upward flow from a deep confined aquifer to the shallow unconfined aquifer. In accordance with measured streamflow losses (discussed in Section 4), interpretation of the groundwater level data suggests that Big Creek is losing flow to the groundwater system over much of its course across the alluvial sediments. The water level (stage) in Big Creek is higher than nearby groundwater elevations estimated for adjacent locations in the alluvial aquifer. Direct hydraulic continuity between the creek and the underlying water table does not exist where the water table occurs below the streambed. This condition was locally confirmed in a domestic well near the creek, located near the northern boundary of the SW ¼ of the SW ¼ of Section 21, Township 20N, Range 14E. ECT estimated that groundwater beneath the creek was approximately 10.4 feet lower than the streambed by measuring depth to water in the well and surveying the vertical offset to the creek[2]. Seepage losses from Big Creek to adjacent groundwater are also suggested by mapping of estimated groundwater elevations, which shows groundwater contours bulging in a downstream direction along the creek (higher water level elevations in the immediate vicinity of the creek and lower levels ¼ to ½ mile away). Based on this understanding of the groundwater flow system, seepage losses from Big Creek and from irrigated areas adjacent to the creek would discharge to the Yakima River and not back to Big Creek.

3 Analysis of Subsurface Irrigation Return Flows

PGG estimated the timing of subsurface return flow to the Yakima River from seepage losses associated with irrigation. Irrigation seepage loss is conventionally defined as the portion of irrigation application that is not consumed by the crops, and instead percolates beyond the root zone to recharge directly-underlying groundwater. The procedure used to estimate the timing of return flow was to:

1. Estimate former ditch and field seepage loss to groundwater associated with the Gentry water right acquired by Trendwest based on site measurements, calculations and reasonable assumptions;
2. Estimate the timing for irrigation seepage losses from the land surface to reach the water table using a numerical model of downward unsaturated flow over a variety of soil properties; and
3. Estimate the timing of recharge at the water table to reach the Yakima River using a groundwater flow model of the Big Creek vicinity over a reasonable range of aquifer properties.

[2] Depth to water in the well, formerly owned by Jones and now owned by Starr, was measured at 25.4 feet below top of casing (BTC) on 6/14/01 and 27.6 feet BTC on 9/22/01. The streambed was estimated to be 17.2 feet BTC.

3.1 Estimation of Irrigation Seepage Loss to Groundwater

Irrigation seepage loss to groundwater was estimated by MWG for the entire Trendwest/Gentry water right based on measurements of ditch seepage and estimates of field irrigation efficiency. Ditch seepage was measured for a single flow condition in July 2001 and scaled to other flows using physical characteristics of the ditch. Field efficiency[3] was assumed to be 65 percent, except during the month of July when irrigation efficiency was assumed to rise to 73 percent to compensate for high crop demand and limitations in water available to the associated water right. During the irrigation season, periods occur when the ditches are flowing but water is not being applied to the fields. At these times, ditch water is either stored in ponds or allowed to infiltrate back into the ground. MWG estimated all three components of seepage loss to groundwater (ditch, field, and tailwater). For the purposes of our modeling, ECT assumed that both the field and tailwater losses infiltrated over the irrigated area associated with the Gentry water right, and that ditch seepage infiltrated over a section of ditch that supplied the Gentry property. The ditch seepage is a relatively large portion of the total groundwater recharge from the irrigation diversion. A more detailed discussion of MWG's seepage loss estimations is included as an attachment at the end of this memorandum, and the irrigation seepage losses applied to the model as groundwater recharge are summarized below:

Table 1 – MWG Estimates of Former Irrigation Seepage Losses for the Trendwest/Gentry Water Right

	Estimated Diversion (cfs)	Estimated Crop Consumptive Use (cfs)	Estimated Field + Tailwater Seepage Losses to Groundwater (cfs)	Estimated Ditch Seepage Loss to Groundwater (cfs)
May	1.1	0.4	0.4	0.25
June	1.4	0.5	0.6	0.25
July	1.5	0.7	0.6	0.25
August	1.5	0.6	0.6	0.25
Average	1.4	0.6	0.3	0.25

3.2 Timing of Subsurface Return Flow Transport Through the Unsaturated Zone

The timing required for field and tailwater irrigation seepage loss to reach the underlying water table was estimated using Hydrus-2D (Simunek et al, 1999), a finite element model of variably saturated flow in porous media. The modeled depth to the water table was 20 feet, consistent with PGG's hydrogeologic characterization in the vicinity of the Gentry property. A range of soil characteristics was used for the modeling in order to evaluate sensitivity to possible variations in soil texture. Hydrus-2D was run to simulate the following two soil types:

Table 2 – Properties of Soils Modeled with Hydrus-2D

Property:	Soil 1	Soil 2
Sand Content	100%	85%
Silt Content	0%	15%
Clay Content	0%	0%
Bulk Density (g/cm^3)	1.8	1.8
Saturated Hydraulic Conductivity (ft/d)	28.0	3.1

[3] Efficiency is defined as the ratio of seepage loss to consumptive use.

Soil 1 is characterized as sand, whereas soil 2 is characterized as sandy loam. Hydrus-2D estimates the hydraulic properties of the soils based on distributions between sand, silt and clay contents and bulk density. A "neural network analysis" uses these data to extract key hydraulic parameters from the U.S. Department of Agriculture UNSODA database, a large database compiled from rigorously tested soil characteristics and hydraulic properties. Soil moisture retention curves are estimated by Hydrus-2D using the method of van Genuchten (1980). **Figure 1** presents model predictions for the timing of the recharge pulse (defined in **Table 1**) to the water table. The time lags predicted for arrival of the recharge pulse to the water table are noted in the legend, but have been removed from the plot so that time zero is defined as the time when the recharge pulse is predicted to first reach the water table. The figure shows that the irrigation recharge pulse from the land surface occurs over a 17-week (four-month) irrigation season. The time lag for the recharge pulse to reach the water table for Soil 1 is approximately two weeks, and about 93 percent of the pulse has reached the water table over a 16-week period. In contrast, Soil 2 has a predicted time lag of 6.6 weeks, and requires considerably more time for the majority of the recharge pulse to reach the water table. Model predictions suggest that Soil 2 requires 27 weeks for 90 percent of the recharge to reach the water table.

Model predictions for Soil 1 showed very little dampening (spreading over time) of the recharge pulse and a two-week time lag. These results were used to define the input for the groundwater flow model developed to estimate the time lag and dampening of the recharge pulse to reach the Yakima River via saturated (groundwater) flow. Soil 1 was selected because:

1. sensitivity analysis of the Big Creek Groundwater Flow Model (discussed below) showed that aquifer materials had hydraulic conductivities reflecting very low silt content;
2. aquifer materials are known to have variable gravel contents, and gravelly regions within the unsaturated zone will conduct irrigation recharge to the water table at faster rates; and,
3. non-field (ditch) recharge will result from more aerially concentrated infiltration and therefore occur faster than the field recharge.

Because of the low degree of dampening predicted for Soil 1, MWG's original schedule of field seepage loss was applied to the groundwater flow model[4]. MWG irrigation recharge values were multiplied by 2/3 to represent the Master Planned Resort (MPR) component of the water right transfer. The groundwater flow model was run with the understanding that a two-week lag exists between the beginning of the irrigation season and the onset of seasonal irrigation recharge to the water table.

3.3 Timing of Subsurface Return Flow in the Water Table Aquifer

PGG obtained the Big Creek Groundwater Flow Model from Brown & Caldwell (B&C) in early September, 2001. Documentation of B&C revisions made to the model after issuing the UGA DEIS was attached. The B&C model specified an aquifer hydraulic conductivity (K_{sat}) of 750 ft/d, which is relatively high (e.g. representative of a clean gravel deposit). Recharge inflows specified for the B&C model were also considered to be high-end estimates[5]. PGG performed a sensitivity analysis on the model over a range of K_{sat} and recharge values, which also incorporated flexibility in

[4] Ditch seepage loss was applied at the near constant monthly rates shown on Table 1.
[5] Recharge was specified for agricultural lands, Big Creek, Little Creek, KRD Canal and natural background.

specifying the constant head values along the east and western boundaries of the model domain[6]. Our sensitivity analysis revealed that reasonable calibration to existing groundwater level targets could be achieved with hydraulic conductivity values as low as 50 ft/d with associated recharge reductions and boundary condition adjustments. Based on this information, PGG defined two model scenarios based on high-end K_{sat} (750 ft/d) and low-end K_{sat} (75 ft/d) estimates. Steady-state versions of both models were run, and inflows from upgradient constant head boundaries were converted to specified fluxes so that they would not be altered by adding estimated irrigation recharge (formerly associated with the Trendwest water right) to the model. **Figure 2** shows that the results of both model scenarios predict similar groundwater elevations and flow patterns. **Table 3** summarizes the parameters used in the two model scenarios. Additional description of the Big Creek Model can be found in the UGA DEIS.

Table 3 - Summary of Model Input Parameters

	K = 750		K = 75	
	Model Input	Model Flux	Model Input	Model Flux
Background Recharge	0.0023 ft/d	10.0 in/yr	0.0023 ft/d	10.0 in/yr
Recharge from Irrigated Areas	0.068 ft/d	297.2 in/yr	0.016 ft/d	70.1 in/yr
Recharge from Big Creek Seepage Loss	0.262 ft/d	11.0 cfs	0.130 ft/d	5.5 cfs
Recharge from KRD Canal Seepage Loss	1.05 ft/d	58.3 cfs	0.13 ft/d	7.2 cfs
Recharge from Little Creek Seepage Loss	0.022 ft/d	1.2 cfs	0.022 ft/d	1.2 cfs
Constant Head Value at NE Corner of Model	2039 ft msl		2039 ft msl	
Constant Head Value at SE Corner of Model	2107 ft msl		2096 ft msl	
Constant Head Value at W end of Southern Model Boundary	2185 ft msl		2164 ft msl	
Constant Head Value at NW Corner of Model	2100 ft msl		2100 ft msl	
Constant Head Value at S end of Western Model Boundary	2183 ft msl		2162 ft msl	

The timing required for the estimated irrigation recharge to reach the Yakima River was estimated by using the steady state predicted groundwater levels for the model's initial condition, and then running the model in transient mode for a period of at least 20 years with the Trendwest irrigation recharge seasonally added. After as many as 10 years, the model had achieved a "cyclic steady state" – at which point the aquifer responses to recharge were unchanged from year to year[7]. The estimated arrival schedule for the recharge pulse to reach the Yakima River was extracted from the model by removing the steady-state discharge from the hydrograph of discharge to the river predicted by the final-year transient simulation. This schedule is considered to reflect the delivery schedule for former irrigation seepage loss associated with Trendwest's Gentry water right to reach the Yakima River via its groundwater flowpath. In running the model, PGG noted that a portion of the model outflow discharges in a northeast direction across the eastern model boundary, rather than directly to the Yakima River boundary. This flow is assumed headed towards the Yakima River, further away to the northeast. Model discharge hydrographs to both the Yakima River and the eastern boundary were extracted from the model, and show similar seasonal timing.

Model predictions show a time lag for seasonal irrigation recharge originating at the Gentry property to cause seasonally increased groundwater flow to the Yakima River and a dampening

[6] Constant head values representing the Yakima River were not adjusted.
[7] The model reached cyclic steady state after 2 years for the K=750 ft/d simulation and after 10 years for the K=75 ft/d simulation.

(spreading over time) of the recharge pulse between its point of origin and the river. **Figure 3** and **Figure 4** present comparisons of recharge inflow and groundwater outflow hydrographs to the Yakima River for the K_{sat}=75 ft/d and K_{sat}=750 ft/d scenarios. The figures present charts of cumulative flow volume with respect to time, and show a bold dashed line that represents a uniform rate of delivery to the river throughout the year. Predicted time lags for irrigation recharge to the water table to cause increased groundwater discharge to the Yakima River range from several days for the K_{sat}=750 ft/d scenario to seven weeks for the K_{sat}=75 ft/d. Predicted dampening is greatest for the K_{sat}=75 ft/d scenario, with near uniform groundwater outflow throughout the year[8]. Dampening is less for K_{sat}=750 ft/d, because the higher hydraulic conductivity allows the recharge pulse to move through the aquifer more quickly. For the K_{sat}=750 ft/d simulation, approximately 54 percent of the annual irrigation recharge inflow is predicted to reach the Yakima River within 3 months of recharge reaching the water table, 83 percent within 6 months, and 95 percent within 9 months. Recall that an additional two-week delay is predicted between the onset of the irrigation season and recharge to the water table aquifer.

While both simulations suggest year-round delivery of sub-surface return flow to the Yakima River, the K_{sat}=75 ft/d scenario shows a more uniform rate of baseflow input throughout the year. The actual delivery schedule to the Yakima River is likely somewhere in between the schedules presented on **Figure 3** and **Figure 4**. In order to apply these model results to predict subsurface return flows for irrigators within the Big Creek Basin, we recommend using the average between the two model scenarios as the central best estimate. However, the full range of predictions should be used as a basis to evaluate uncertainty in the B&C water balance model for the total change in tributary and mainstem flows from all of the Trendwest water right transfers. The predicted schedules of sub-surface return flow to the Yakima River, expressed as cumulative percent of seasonal irrigation recharge from the Gentry property, can be reasonably used to simulate the effects of either the MPR water-rights transfer and the combined MPR+UGA water-rights transfer. ECT performed a separate simulation of the combined transfer using the full historic recharge rates (**Table 1**) and found insignificant difference between model predictions.

4 Streamflow Datasets Used for Flow Partitioning Analysis

Tom Martin collected spot measurements of streamflow between May 1999 and October 2000 at two locations, one upstream of the Lund-Darling diversion dam, and one 50 feet upstream of West Nelson Siding Road. Montgomery Water Group (MWG) collected both spot measurements and continuous flow data from May to October 2001 (this memorandum addresses the spot measurements). MWG measured flow at points upstream and downstream of the diversion dam, at Ensign Ranch, and within flumes at the heads of the various diversions. MWG also collected flow data from July to October 2001 at the Kallio's property, located about 800 feet downstream of West Nelson Siding Road. Data for both sets of spot measurements are displayed on **Figure 5** with the year of acquisition noted in the legend[9]. Based on a review of stream gage accuracy and measurement resolution, MWG concluded that Big Creek flow below the diversion dam can be best estimated by subtracting the measured diversions in the Lund and Darling flume from the gaging data collected at the station located upstream of the diversion dam. Since Tom Martin did not collect diversion measurements from the Lund and Darling flumes, ECT has estimated this flow by

[8] Note that even though K_{sat} is lower in this simulation, there is no apparent time lag from the beginning of the irrigation application because of carry-over groundwater outflow from the previous modeled year.
[9] At the original time of writing for this memorandum, 2001 flow data were available only though early September.

subtracting the average estimated rates of irrigation diversions on a seasonal basis. **Table 4** shows the corrections applied to Tom Martin's upstream flow data for average estimated irrigation diversions.

Table 4 – Water Rights for Lund and Darling Diversion Ditches

Lund Ditch Diversions:		Darling Ditch Diversions:	
Dates	Water Right (cfs)	Dates	Water Right (cfs)*
5/1 – 9/1	3.95	5/1 – 9/1	1.57
9/2 – 11/15	2.59	9/2 – 11/15	1.57
11/16 – 2/28	3.70	11/16 – 2/28	1.57
3/1 – 4/30	2.61	3/1 – 4/30	1.57

* Field checks show occurrences when diversions exceed water right.

We have observed some discrepancy between Tom Martin's and MWG's data sets regarding streambed seepage out of Big Creek. Since Big Creek is losing baseflow via seepage to the underlying water table, streambed seepage is also referred to here as seepage loss. Tom Martin's data indicate 3-6 cfs of seepage loss from Big Creek to the underlying alluvial aquifer during low flow conditions (<15 cfs flow downstream of the diversion) from below the Diversion Dam to West Nelson Siding Road ("Reach 1"). This results in only a minimal flow between West Nelson Siding Road and Ensign Ranch ("Reach 2") during the irrigation season (**Figure 5**). The MWG data indicate a smaller amount of streambed seepage loss over Reach 1 (1-3 cfs during low flow conditions), suggesting that the majority of the seepage occurs below West Nelson Siding Road.

The difference in seepage distributions between the two data sets could reflect natural conditions (e.g. variation between years) or measurement error. Under natural conditions, one would typically expect streambed seepage to vary as a function of stream discharge and/or variations in hydraulic continuity with groundwater. However, data from Tom Martin and MWG show different seepage losses at similar streamflows. Streamflow does not appear to be the dominant parameter to explain this inconsistency. In addition, should hydraulic continuity actually occur between Big Creek and shallow groundwater over a portion of Reach 1, the lower values of seepage loss estimated for year 2001 are counterintuitive to expected groundwater elevation changes. Under 2001 drought conditions, groundwater levels are expected to be lower than the prior years from which Tom Martin's flow data were collected. If hydraulic continuity did exist, lower groundwater levels would cause increased seepage losses. The relationship observed is opposite, with lower seepage losses expressed during the drier year. If hydraulic continuity does not exist (as suggested by hydrogeologic characterization performed to date), changes in groundwater levels would have no effect on changes in streambed seepage rates.

Thus, it appears that neither streamflow nor changes in hydraulic continuity can fully explain the discrepancy between the two data sets. The remaining factor is measurement error. In order to evaluate the degree of error in the MWG measurements, Julie Daigneau revisited the gaging sites to perform quality assurance checks. Her results were consistent with MWG's 2001 data set. Julie also noted that the streambed in the vicinity of Tom Martin's West Nelson Siding Road gaging location has a high component of cobbles and boulders. This type of streambed could accommodate a portion of the surface flow as shallow subflow. More importantly, a substrate of cobbles and boulders causes increased measurement error.

5 Analysis of Seepage Loss from Big Creek to Alluvial Groundwater Flow

The MWG data set is the most detailed data set available since flume measurements were taken concurrently with instream flow measurements and QA/QC was performed at the measurement stations. As a result, we have used this data set to assess the partition between surface flow and alluvial groundwater flow. We used MWG's data set to:

1. estimate seepage loss to groundwater as a function of streamflow;
2. apportion total seepage to stream reaches;
3. estimate flow conditions for average and dry years; and,
4. estimate change in seepage loss (as a function of time and stream location) due to transfer of Trendwest's Gentry water rights for both average and dry years.

5.1 Seepage as a Function of Streamflow

The spot measurements collected by MWG are shown in **Figure 6**, with the difference in flow between downstream of the diversion dam and Ensign Ranch (seepage loss to groundwater) plotted on the secondary axis. Since MWG only measured flow below the Ensign Ranch diversion, we have calculated flow above the diversion by adding the measured amount of the Ensign Diversion to the downstream measurement. The relationship between seepage loss and flow below the diversion dam is somewhat scattered. We have created an idealized curve to characterize seepage loss as a function of flow in Big Creek (**Figure 7**), which has the equation:

$$y=3.5635e^{0.0099x} \qquad \textit{Equation 1}$$

where x= flow downstream of the diversion dam (CFS)
y= net seepage loss from Big Creek to alluvial groundwater (CFS)

The correlation coefficient for the idealized seepage curve is slightly low (R= 0.77); however, this curve appears representative of the trends in the flow data set collected by MWG.

5.2 Differences in Total Seepage Loss Between Reaches

As shown on **Figure 8**, seepage loss from Big Creek is not evenly distributed across the channel length. Instead, approximately 25% of the observed seepage occurs over Reach 1 (average seepage rate = 0.0003 cfs/ft), and the remaining 75% over Reach 2 (average seepage rate = 0.0007 cfs/ft). While the difference between the two reaches is notable, the actual geographic distribution of seepage cannot be characterized based on comparison between the reaches alone because the reach boundaries are defined by gaging locations that may not correspond to actual transitions in seepage rates

5.3 Flow Conditions for Average and Dry Years

Although one would expect rates of summer streamflow to vary between average and dry water years, this pattern is not visible in the available data sets (**Figure 5**). Year 2001 is significantly drier than the preceding years 2000 and 1999, and yet does not show lower summer streamflows. The lack of distinguishable differences in our data set may be due to other controls on snowmelt and streamflow (e.g. temperature).

Hydrologic observations on Big Creek, however, do indicate a difference in the location of the wet/dry interface between average and dry water years. Stan Isley of the US Bureau of Reclamation has observed that during average water years (prior to Trendwest's purchase of the Gentry water right), the wet/dry interface typically receded back to the Ensign Ranch Bridge (60 feet downstream of the I-90 Bridge) by early August and remained in this vicinity through early September before migrating back towards the Yakima River. Isley noted that during the last several years (e.g. post Trendwest water rights purchase), conversations with Ensign Ranch personnel suggest that the wet/dry interface extended further downstream, perhaps halfway downstream from the Ensign Ranch Bridge towards the Yakima River. During extremely dry years (e.g. 1994), Isley notes that the wet/dry interface has migrated up to the Ensign Ranch Bridge by early August and continued as far upstream as halfway between the I-90 and West Nelson Siding Road bridges over a two-week period. Isley reported that the interface has remained in this vicinity through the end of September, and then migrated downstream to restore flow to the mouth by mid-October.

Larry Hallows of Ensign Ranch has observed conditions in Big Creek from 1998 to 2001 (Trendwest began leaving their allocated diversion instream starting 1999). He has noticed the wet/dry interface reaching approximately 600 feet downstream of the Ensign Ranch Bridge between the third week of July and the second week of August. Although this year is a low water year, he did not observe the channel drying faster than usual. In early September of 2001, MWG observed that the wet/dry interface had receded to approximately 800 feet downstream of the Ensign Ranch Bridge (200 feet below the Ensign Ranch gaging site) and continued to recede at approximately 50 feet per week. The data appear to indicate that the wet/dry interface has moved downstream since Trendwest began leaving their allocated diversion instream. The data period is too short and the descriptions too approximate to estimate exactly how much wet reach has been gained with the extra water left instream by Trendwest.

5.4 Changes in Seepage Loss due to the Transfer of Trendwest Water Rights

Hydrogeologic characterization by PGG and Brown and Caldwell suggests a low likelihood for hydraulic continuity between the water table aquifer and Big Creek along its entire reach. Based on the existing characterization, irrigation subsurface return flow discharges to the Yakima River rather than Big Creek. Under the proposed transfer, the entire former water use associated with Trendwest's water right (shown on **Table 4**) can be considered to be an increase in Big Creek flow. PGG estimated the increased seepage loss to alluvial subflow associated with leaving this amount of water in Big Creek over the irrigation season for both average-year and dry-year conditions. For the purpose of this analysis, two components of streambed seepage loss to alluvial subflow were identified and estimated:

1. seepage loss from reaches that exhibited summer flow prior to the Trendwest transfer, and
2. seepage loss from reaches that went dry prior to the Trendwest transfer, and are now expected to remain wet due to Trendwest's flow contribution.

The distinction between these two seepage components is based on delineation of reaches that typically remained wet over the irrigation season and those that went dry. Approximate locations of wet/dry interfaces throughout the irrigation season are discussed Section 5.3. The consistently wet reach (both pre- and post- Trendwest transfer) occurs upstream of Ensign Ranch. Seepage losses from this reach can be estimated based on the seepage relationships discussed in Section 5.1. During average years, the wet/dry transition likely extended as far upstream as the Ensign Ranch Bridge prior to the Trendwest transfer and is expected to occur farther downstream after the transfer. Equation 1, developed to estimate seepage loss between the diversion dam and the Ensign Ranch gage, can be used to estimate seepage loss in this reach before and after the Trendwest transfer. To do this, ECT defined a "typical hydrograph" based on the available spot measurements (see **Figure 5**) and extracted estimated biweekly streamflows over the irrigation season. This hydrograph was used to estimate seepage before and after the introduction of additional flow due to the Trendwest transfer, as shown below in **Table 5**.

Table 5 – Estimated Trendwest Increased Seepage Between the Diversion Dam and Ensign Ranch

Season	Estimated Flow Downstream of Diversion (Average Year)	Trendwest Flow Contribution	Total Seepage Pre-Trendwest	Total Seepage Post-Trendwest	Change in Seepage
Early May	125	1.10	12.28	12.42	0.13
Late May	95	1.10	9.13	9.23	0.10
Early June	60	1.40	6.45	6.54	0.09
Late June	20	1.40	4.34	4.40	0.06
Early July	13	1.50	4.05	4.11	0.06
Late July	10	1.50	3.93	3.99	0.06
Early August	8	1.50	3.86	3.91	0.06
Late August	6	1.50	3.78	3.84	0.06
Early September	6	0.00	3.78	3.78	0.00
Late September	6	0.00	3.78	3.78	0.00
Early October	10	0.00	3.93	3.93	0.00

***All flow units are in Cubic Feet per Second (CFS)**

During the average-year condition, the first component of seepage loss to alluvial subflow associated with additional streamflow from the Trendwest transfer is expected to be relatively small, ranging from 0.06 to 0.13 cfs. This is because the rate of change in seepage loss as a function of flow is estimated to be minimal during the lower flows typical of the irrigation season (**Figure 7**). As a result, the addition of 1.0 to 1.5 cfs does not have a significant effect on the amount of seepage loss from Big Creek. During the dry-year condition, the length of the consistently wet reach is shorter because the wet/dry transition extends further upstream. Thus, estimates for the first component of seepage loss will be smaller during dry-years than during wet years, and remain minimal.

The second component of seepage, which occurs downstream of the consistently wet reach, comprises a more significant portion of the additional flow resulting from the Trendwest transfer. This is because the portion of additional Trendwest streamflow that remains in Big Creek downstream of the consistently wet reach can seep into the streambed alluvium and flow as alluvial subflow during portions of the irrigation season. For instance, observations regarding the location of the wet/dry interface during the month of August suggest that addition of Trendwest's water right may have caused the wet/dry interface to shift from the Ensign Ranch Bridge to a point halfway downstream towards the Yakima River. While the additional streamflow assumably caused the wet/dry interface to shift downstream, it is still estimated to occur upstream of the Yakima River. Thus the major portion of Trendwest's water right (that remains in the stream after minor losses to the first component of seepage) is fully transferred via seepage loss to alluvial subflow on its pathway to the Yakima River.

Under average-year conditions, this dominant component of seepage loss to alluvial subflow is expected to occur relatively close to the Yakima River. The proximity of alluvial seepage to the river's active floodplain suggests that it will appear in the river relatively quickly, and can be treated as a relatively immediate contribution to the Yakima River system. Under the dry-year condition, the majority of alluvial seepage loss from Trendwest's water right occurs farther upstream on Big Creek. Based on described locations of the wet/dry interface during historic dry years, addition of Trendwest's water right is assumed to have shifted the wet/dry interface from a September location halfway between I-90 and the West Nelson Siding Road to its observed 2001 location downstream of the Ensign Ranch Bridge. Although available data are limited, our analysis assumes that all of Trendwest's water right would contribute to alluvial subflow between these two points during a "typical dry year". The increased distance from the Yakima River floodplain during a dry year will cause a longer time lag for this component of seepage to reach the river. ECT used the Big Creek model to estimate the timing for alluvial seepage to reach the Yakima River during a dry year. The time lag and dampening during an average year would be substantially less.

6 Model Simulation of Alluvial Subflow

The Big Creek model was modified by placing specified flux conditions in each model cell containing Big Creek and distributing the second component of seepage loss (described above) among those cells located where losses were expected to occur. The locations of the specified-flux cells are shown on **Figure 9**, with each cell assigned an index number over a consecutive series (1 through 24) starting at the confluence with the Yakima River. The model was run to estimate the timing for streamflow losses to alluvial subflow from Trendwest's transferred water right to reach the Yakima River under the assumed "typical dry-year" condition. Under this condition, the mouth of Big Creek is expected to begin drying out sometime in early July. The wet/dry interface then recedes up the creek until the onset of autumn rainstorms, at which time the wet/dry interface moves downstream, eventually regaining continuity with the Yakima River. The maximum distance to the wet/dry interface is estimated to be approximately 0.75 miles from the Yakima River.

In order to estimate seepage loss to alluvial groundwater from the Trendwest water right for input to the model, PGG assumed that all of the water input to the stream by Trendwest reaches the historic upstream point of the wet/dry interface with negligible loss to the first component of seepage (the analysis presented in Section 5 indicated that this component of Trendwest seepage loss is minimal in the upper reaches). Any additional instream flow, beyond the historical location of the wet/dry interface, was attributed to the Trendwest water rights transfers. Based on interpolation from observations, the location of the wet/dry interface was estimated on a weekly basis under both pre- and post- Trendwest transfer conditions. In our model, we assumed that Trendwest's water use (**Table 4**) seeped into alluvial subflow at a uniform rate between these two points[10]. During earlier portions of the season when the post-Trendwest transfer condition is likely to extend the wet/dry interface to the Yakima River, seepage rates (per model cell) were assumed equivalent to rates estimated when all of Trendwest's water seeps into alluvial subflow. Our weekly estimates of the geographic distribution of seepage loss to alluvial subflow associated with Trendwest's proposed transfer (used as input to the model) are presented below.

---

[10] The model actually simulated seepage from 5/6 of the estimated historic water use associated with Trendwest's water right in order to split the difference between the proposed MPR transfer (2/3) and the combined MPR/UGA transfer (3/3). Model results are considered applicable to both transfer scenarios.

Table 6 – Model Input: Estimate of Seepage Losses from Big Creek (Trendwest Portion Only)

		2nd wk Jul		3rd wk Jul		4th wk Jul		1st wk Aug		2nd wk Aug		3rd wk Aug		4th wk Aug	
Gage Locations	Model Cell Index #	Pre TW	Post TW	Pre TW	Post TW	Pre TW	Post TW	Pre TW	Post TW	Pre TW	Post TW	Pre TW	Post TW	Pre TW	Post TW
West Nelson	24														
	23														
	22														
Kallio	21														
	20														
	19														
	18														
	17														
Halfway Pnt	16											Dry	0.167	Dry	0.167
	15											Dry	0.167	Dry	0.167
	14											Dry	0.167	Dry	0.167
	13									Dry	0.167	Dry	0.167	Dry	0.167
	12									Dry	0.167	Dry	0.167	Dry	0.167
	11									Dry	0.167	Dry	0.167	Dry	0.167
Ensign RB	10							Dry	0.167	Dry	0.167	Dry	0.167	Dry	0.167
	9							Dry	0.167	Dry	0.167	Dry	0.167	Dry	0.167
Ensign	8							Dry	0.167	Dry	0.167	Dry	0.167	Dry	0.167
	7					Dry	0.167	Dry	0.167	Dry	0.167	Dry	Dry	Dry	Dry
	6					Dry	0.167	Dry	0.167	Dry	0.167	Dry	Dry	Dry	Dry
	5					Dry	0.167	Dry	0.167	Dry	0.167	Dry	Dry	Dry	Dry
	4			Dry	0.167	Dry	0.167	Dry	0.167	Dry	Dry	Dry	Dry	Dry	Dry
	3			Dry	0.167	Dry	0.167	Dry	0.167	Dry	Dry	Dry	Dry	Dry	Dry
	2			Dry	0.167	Dry	0.167	Dry	0.167	Dry	Dry	Dry	Dry	Dry	Dry
	1	Dry	0.167	Dry	0.167	Dry	0.167	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry

The model simulation was performed for a single, isolated dry-year event with additional alluvial infiltration from Trendwest's water beginning to occur near the Yakima River in the middle of July, and reaching its maximum length and extent (from the half-way point upstream to the Ensign gage downstream) by the third week in August. The alluvial infiltration was only modeled through the beginning of September, when Trendwest's water right ends. Thus the "recharge pulse" from alluvial seepage was modeled to occur over a 7-week (49-day) period. The model results predict relatively fast delivery to the Yakima River, with very little dampening (spreading-out over time) of the recharge pulse for both model scenarios.

Figure 10 presents model estimates of the cumulative percent of the seepage loss to alluvial subflow reaching the Yakima River over time. The model predictions suggest that the timing required for alluvial subflow to reach the Yakima River when K_{sat} = 750 ft/d is nearly coincident with the timing of the seepage loss itself. In the early portion of the recharge pulse, seepage loss is expected to reach the Yakima River quickly because the seepage location is immediately adjacent to the river. Later in the 7-week simulation period, the seepage moves farther upstream and a minor time lag is predicted to develop between the return flow and the seepage loss. By the end of the 7-week period for which seepage recharge is simulated, approximately 98.6 percent of the seepage lost to alluvial subflow is predicted to have reached the Yakima River, with most of the remainder reaching the river over the following 10 days. For the K_{sat} = 75 ft/d simulation, a more significant time lag is predicted for alluvial seepage to reach the Yakima River. By the end of the 7-week period for which seepage recharge is simulated, approximately 77 percent of the seepage to alluvial subflow is predicted to have reached the Yakima River. Approximately 90 percent of the seepage to alluvial subflow is predicted to reach the river about two weeks afterwards, and 95 percent is predicted to reach the river about one month afterwards. The remaining 5 percent is predicted to slowly reach the river over the following 4 months. In both cases, the predicted timing for the majority (e.g. 90 percent) of the alluvial seepage to reach the Yakima River is relatively fast, and only a small component continues to trickle into the river beyond a month's time delay.

Figure 1
Cumulative Flux vs. Time for Vadose Zone Time Lag Estimates

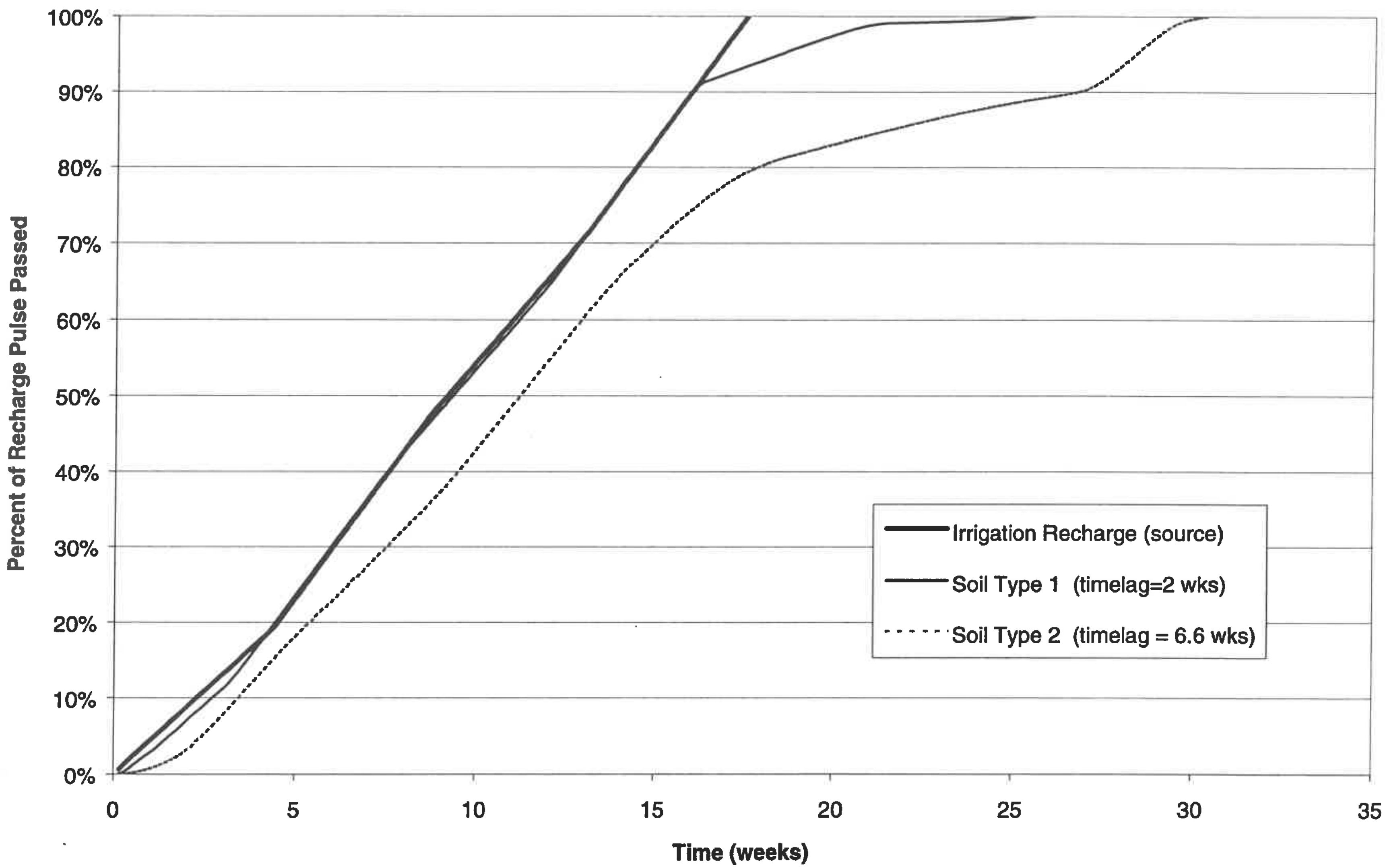
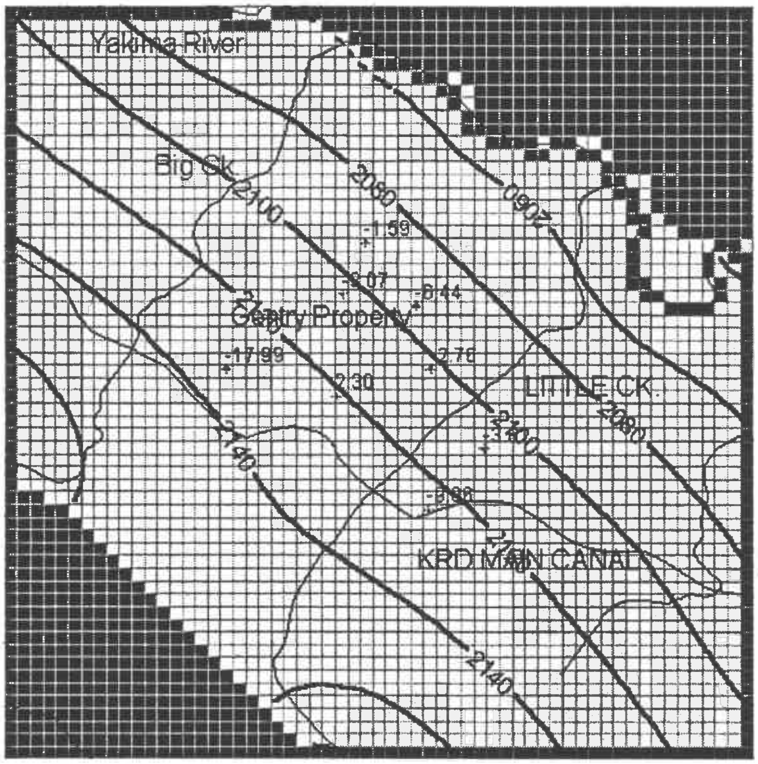


Figure 2
Comparison of Model Scenario Predictions

Hydraulic Conductivity = 750 ft/d



Hydraulic Conductivity = 75 ft/d

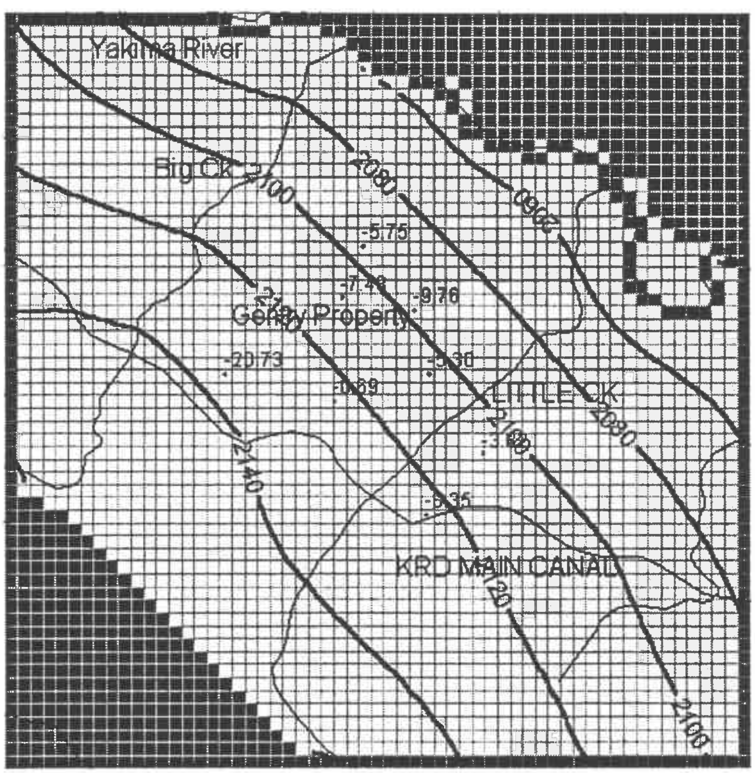


Figure 3
Comparison of Cumulative Percent of Total Flow
Irrigation Inflow vs. Groundwater Outflow (K=750 ft/d)

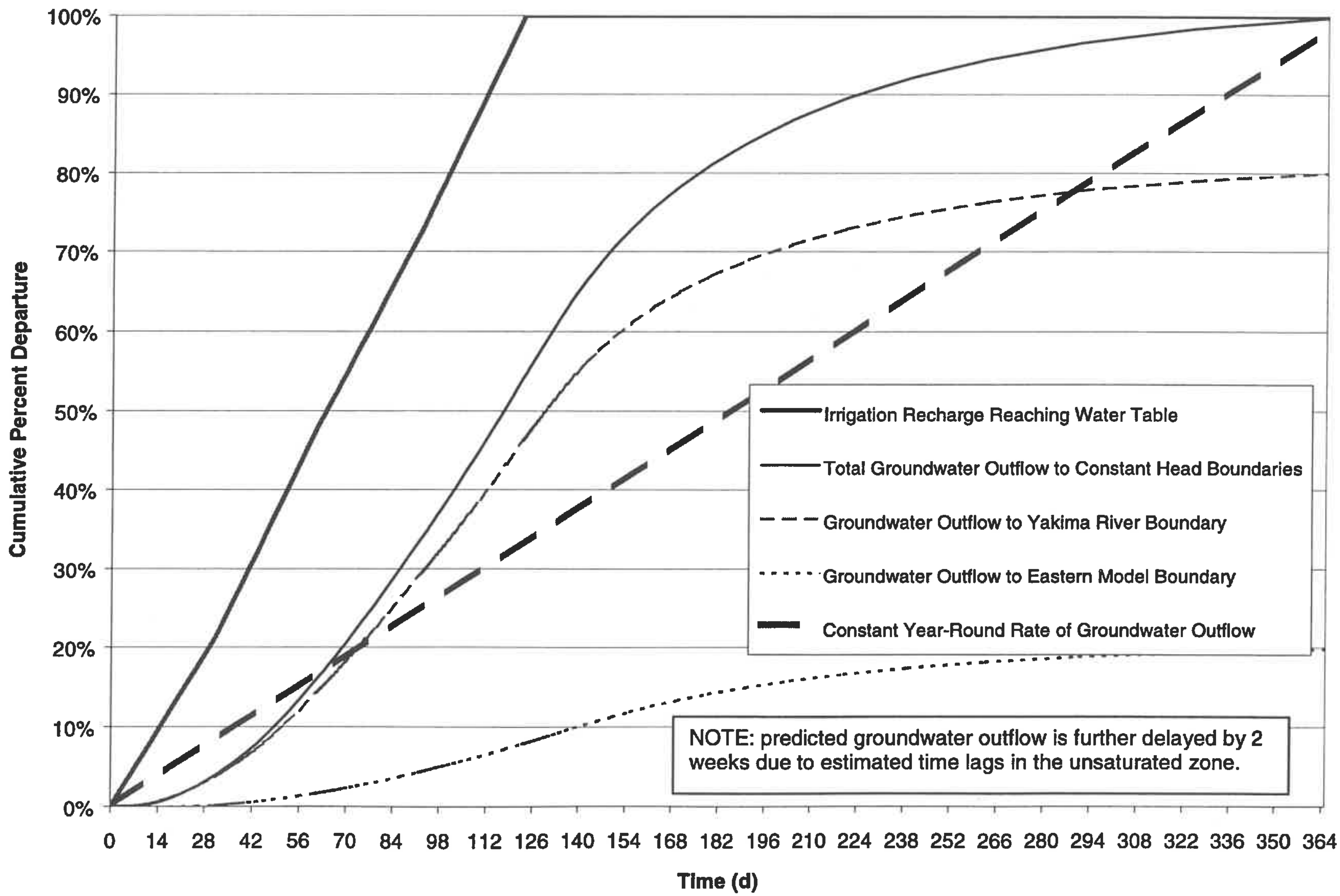


Figure 4
Comparison of Cumulative Percent of Total Flow
Irrigation Inflow vs. Groundwater Outflow (K=75 ft/d)

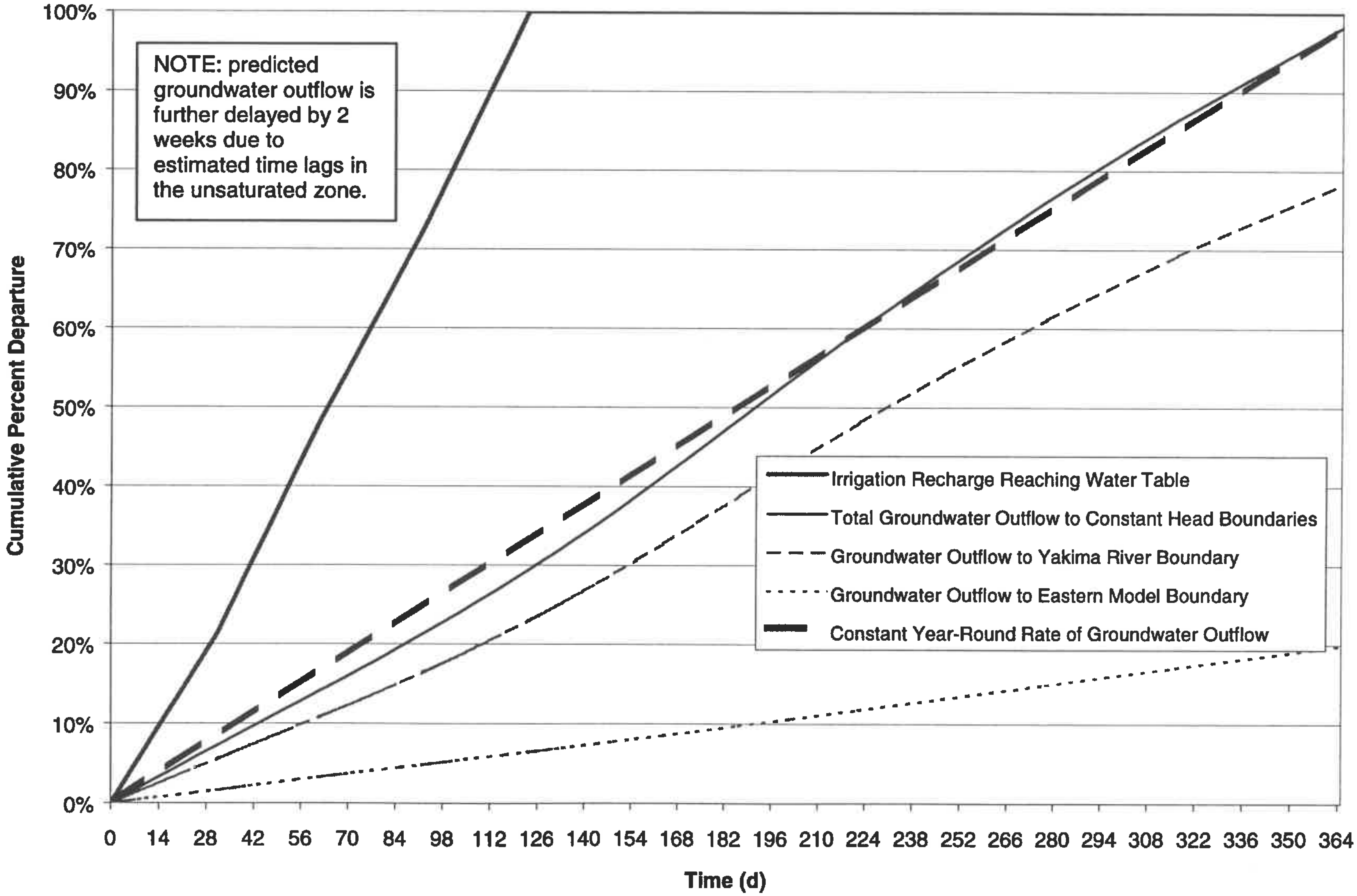


Figure 5
Compiled Flow Measurements on Big Creek
Tom Martin and Montgomery Water Group Data

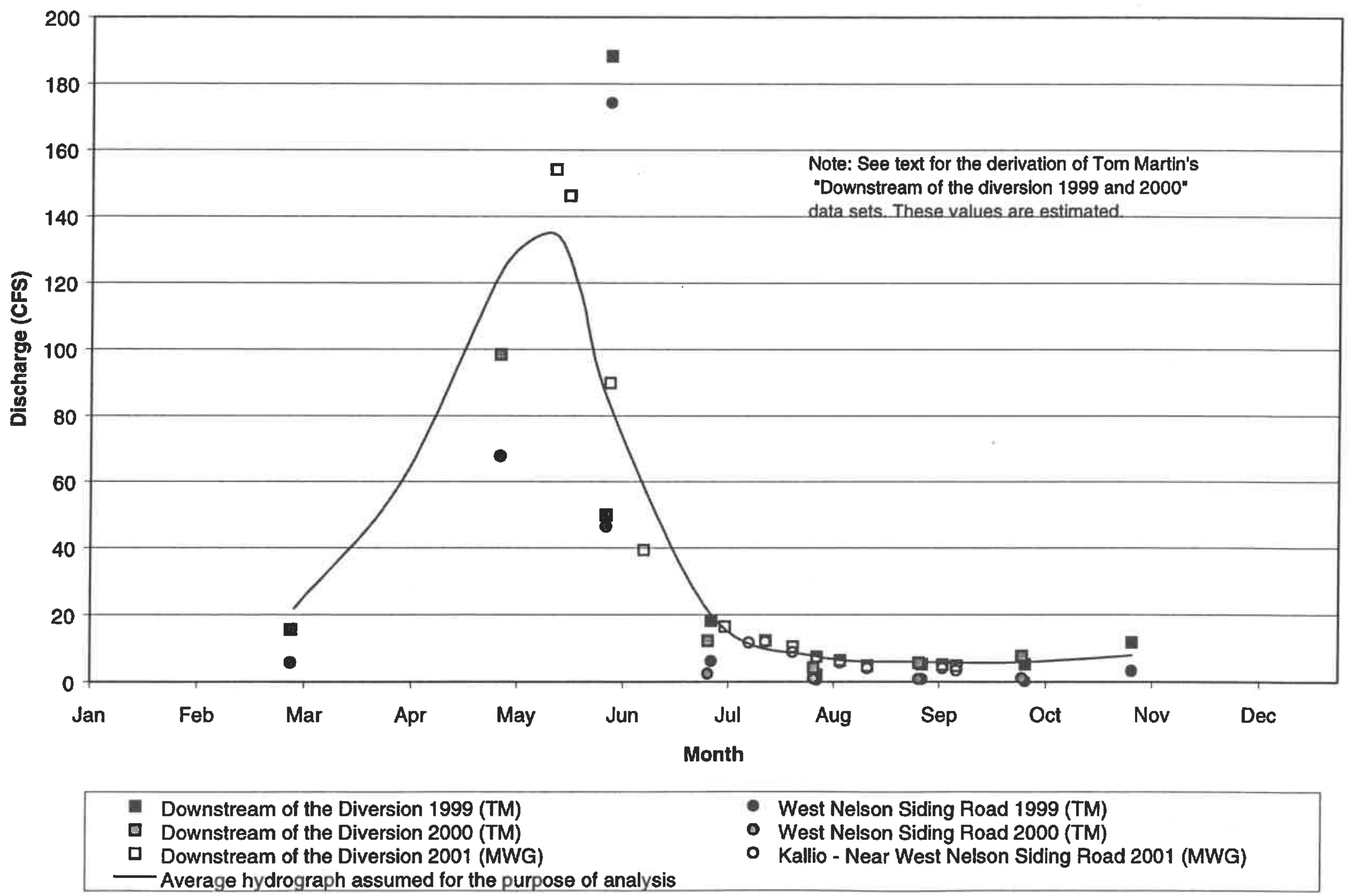


Figure 6
Big Creek Flow Measurements and Estimated Seepage
Montgomery Water Group Data

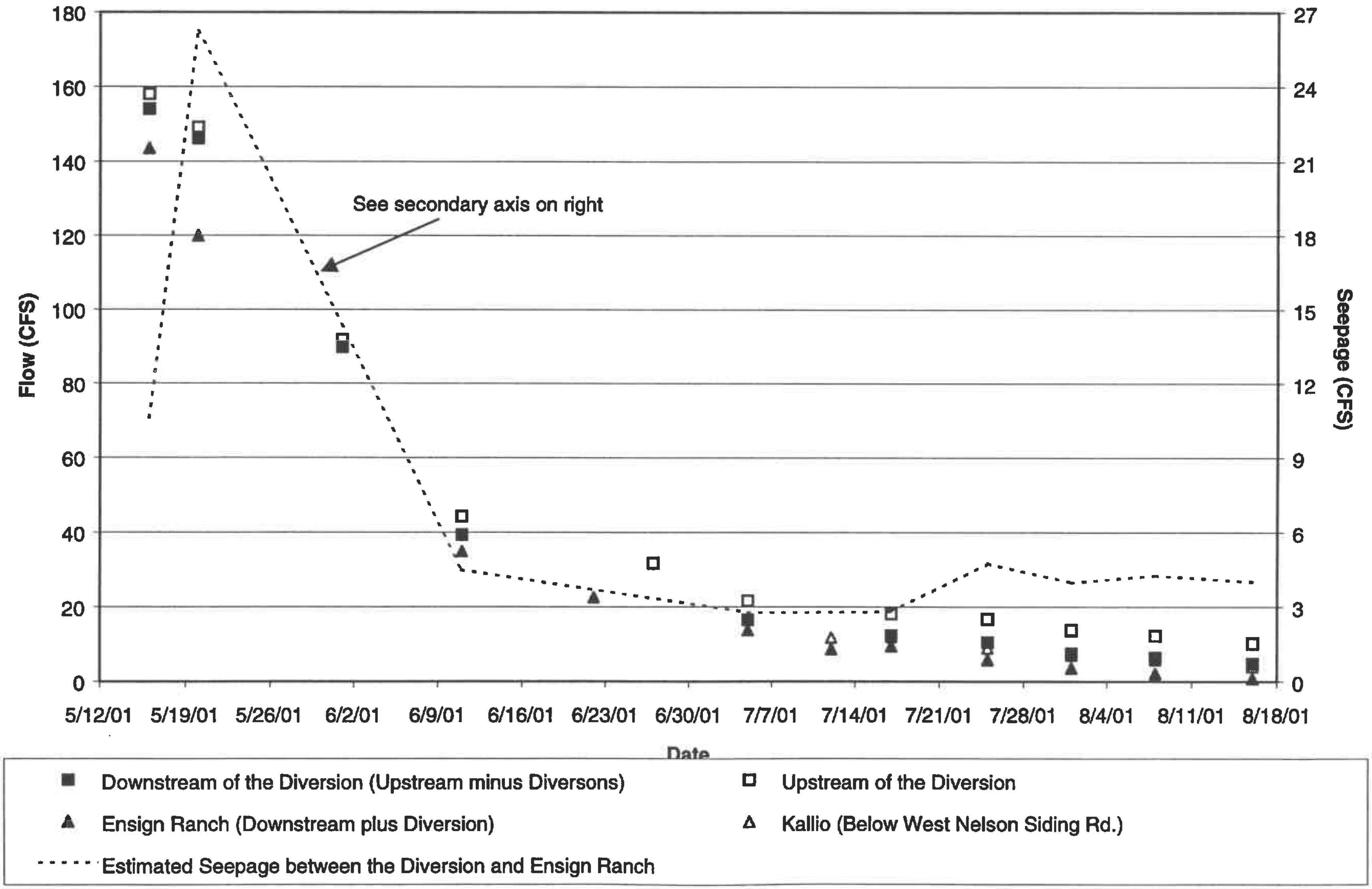


Figure 7
Idealized Seepage Curve for Big Creek (Reaches 1 and 2 Combined)
Montgomery Water Group Data

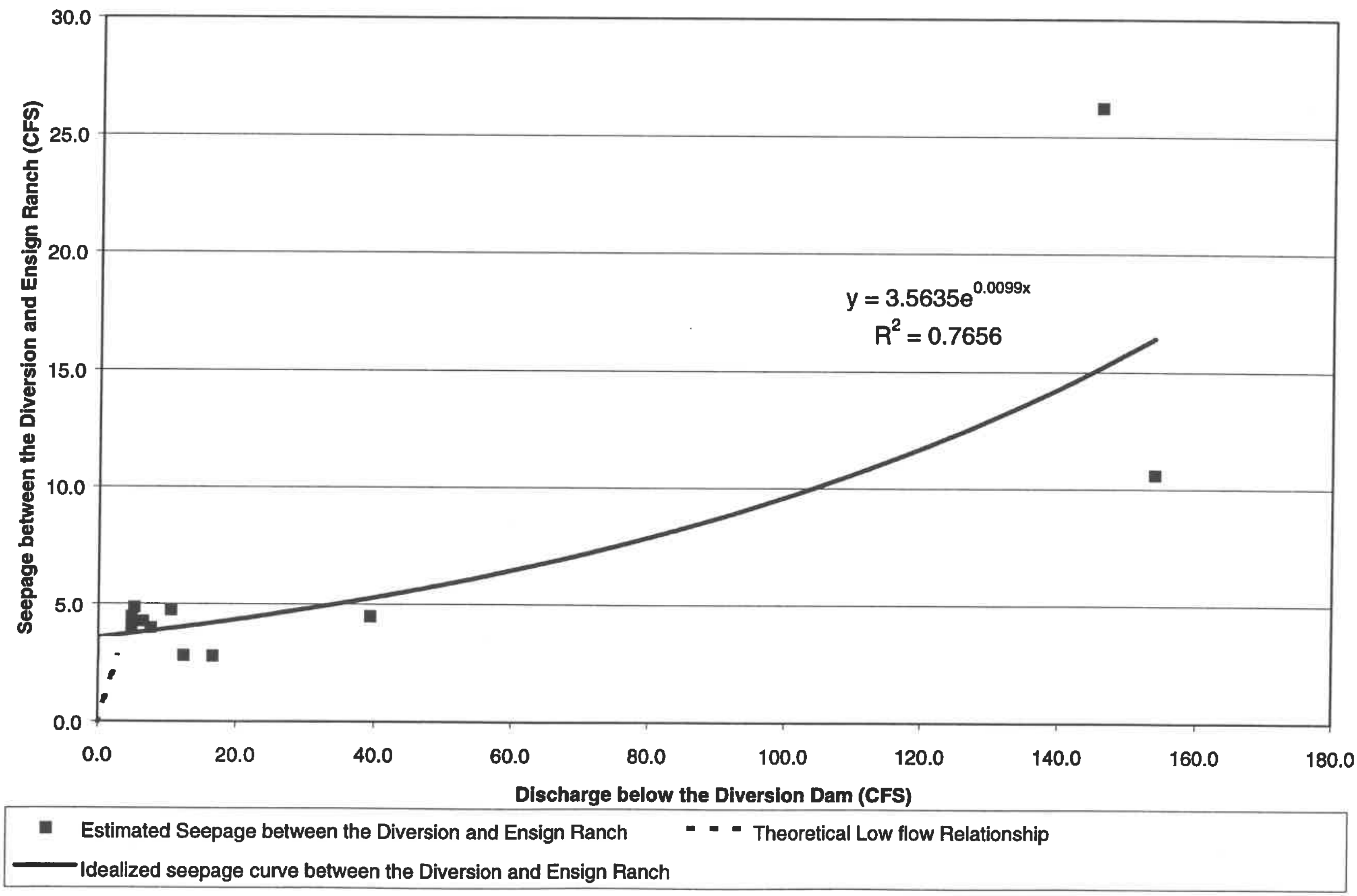


Figure 8
Comparison of Estimated Seepage Loss between Reach 1 (Diversion Dam to Kallio) and Reach 2 (Kallio to Ensign)

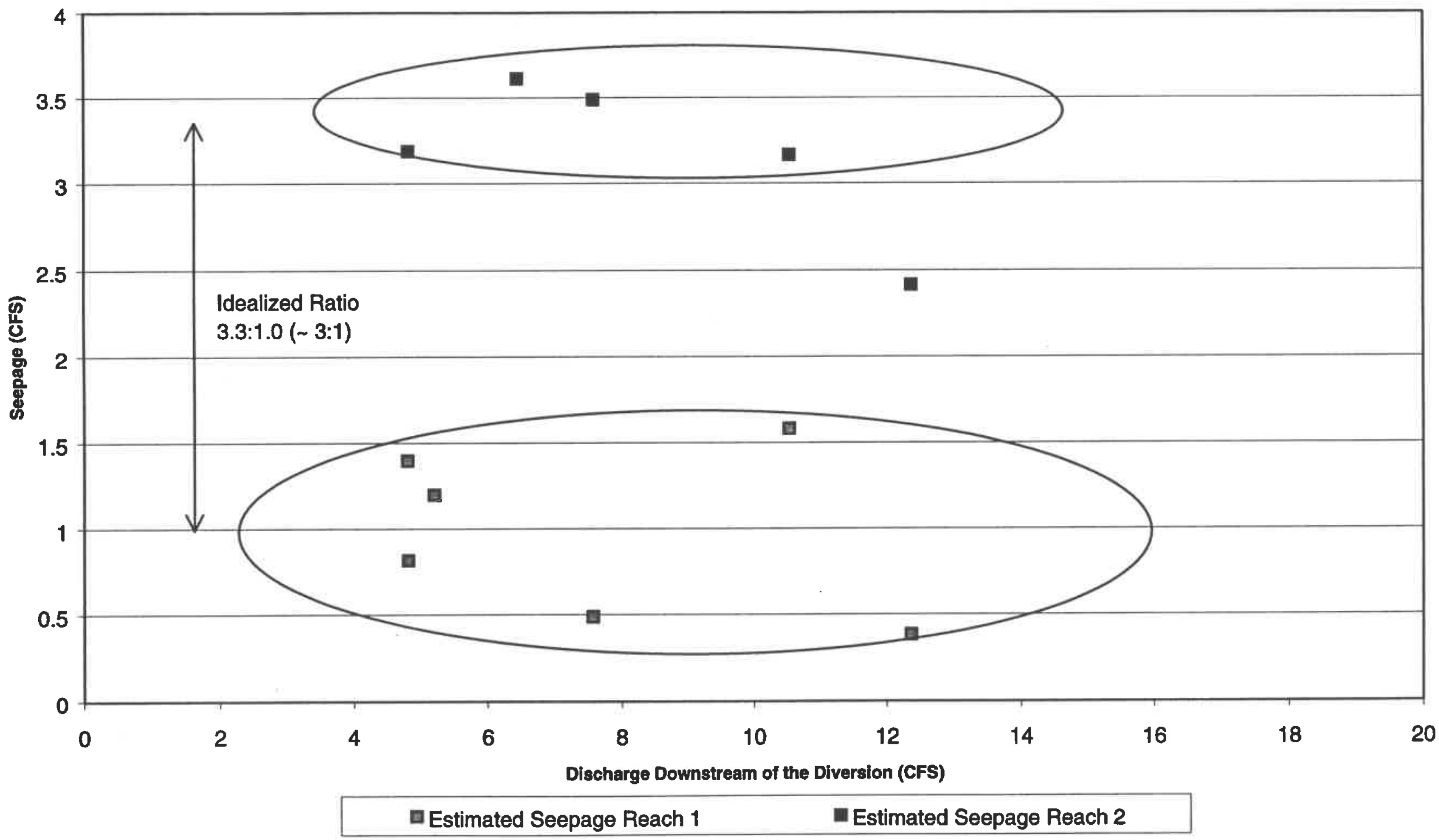
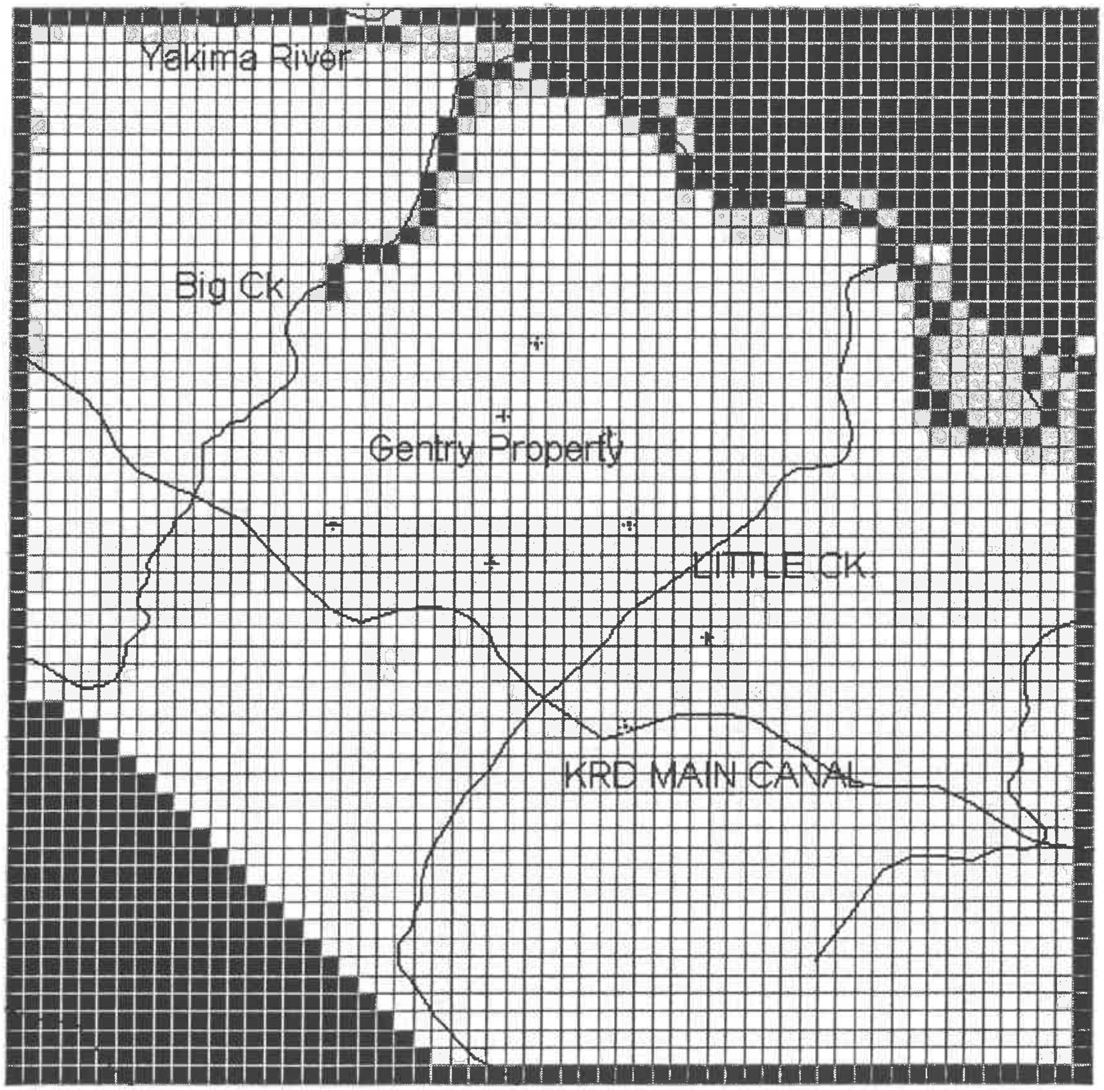


Figure 9
Model Domain for Simulation of Alluvial Subflow

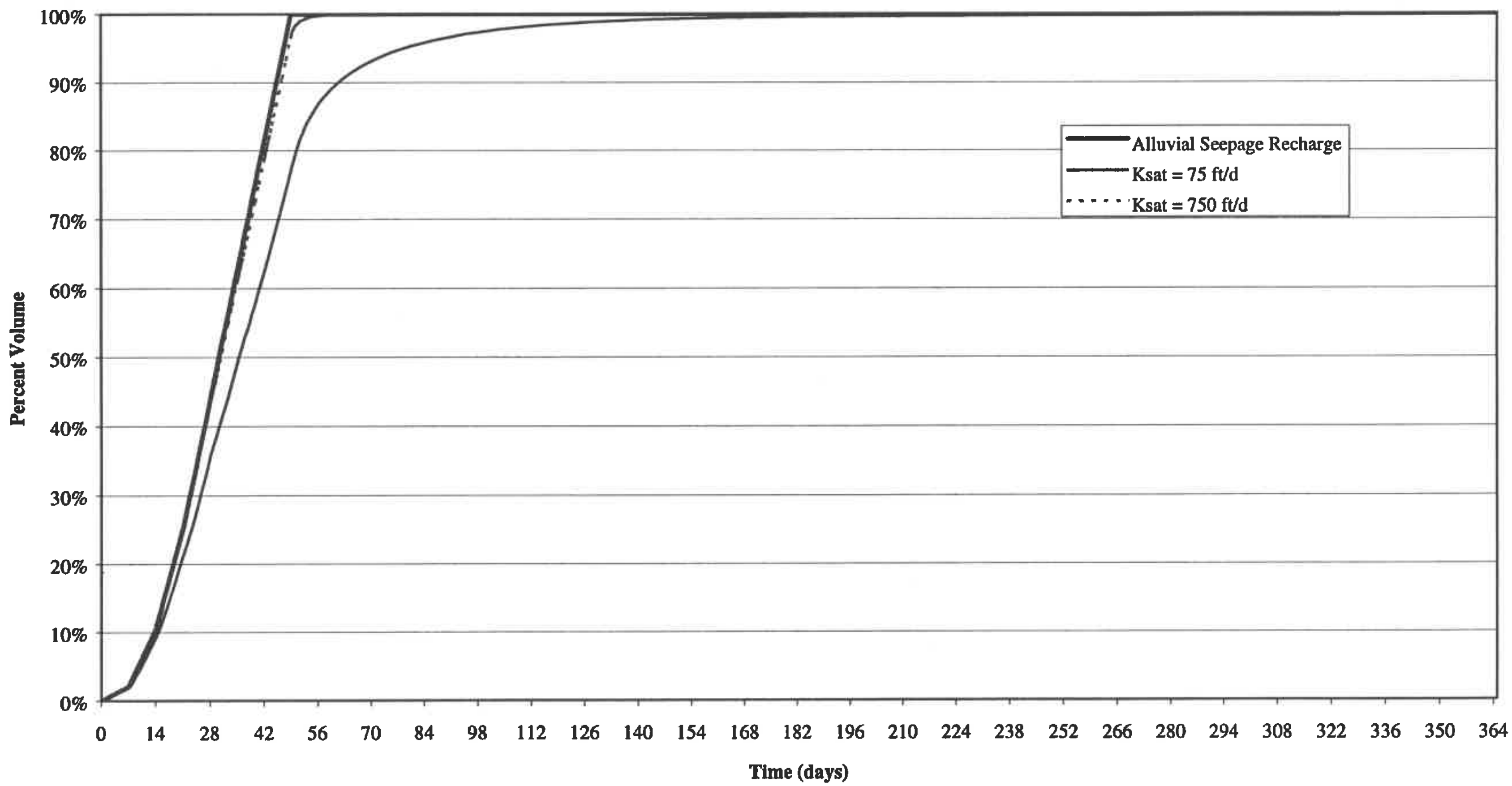


LEGEND

- Specified Flux Cell
- Constant Head Cell
- Inactive ("no-flow") Cell

Cell dimension 250x250 feet.

Figure 10
Comparison of Cumulative Percent of Total Flow
Yakima River Inflow vs. Alluvial Seepage Loss



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Technical Memorandum

To: Randall Doneen, Department of Ecology
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Andy Kindig, A. Kindig & Associates
Tom Martin, Brown and Caldwell

From: Peter Schwartzman, Associate Hydrogeologist, PGG
Chrysten Root, Geologist/Hydrologist, PGG

Re: **TEANAWAY RIVER BASIN HYDROLOGIC ANALYSIS**

Date: January 17, 2002

The purpose of this analysis is to estimate how Trendwest's proposed transfer of six water rights from the Teanaway River into the Yakima Basin Trust Water Program (the Trust) will affect streamflows. This memorandum describes how those transfers to the Trust are likely to affect streamflow in the Teanaway River down to the Yakima River. The results of this analysis will be used as one set of inputs to a separate model developed by Brown and Caldwell (B&C). That model will simulate the combined effects of the Trendwest Master Plan Resort (MPR) and Urban Growth Area (UGA) water demand schedule and the water right transfers on the Yakima River basin, from upstream of the Cle Elum River confluence downstream to the Reecer Creek confluence.

The six water rights Trendwest proposes to transfer were previously owned and used by the Walker family for irrigation of fields very near the Teanaway River. Water diverted under those rights was either consumed by evaporation and evapotranspiration, or returned to the Teanaway River system and the Yakima River as non-consumptive irrigation return flow. Changes in streamflow relative to pre-existing conditions would result from the cessation of irrigation withdrawals. Water would no longer be diverted, ending consumptive losses and non-consumptive irrigation returns from fields irrigated under those rights in the Teanaway River basin. Cessation of diversion would result in increased instream flows during the irrigation season. Irrigation returns are delayed in time between diversion and return as subsurface (groundwater) inflow to the Teanaway and/or Yakima Rivers. Terminating the diversion and resulting return flows from the six Walker irrigation rights would change the temporal pattern of streamflow and increase the volume of water available in the basin annually by the former annual volume of crop consumptive use.

For the purpose of this analysis, changes in the timing and volume of streamflow were estimated by evaluating subsurface return flow and alluvial subflow. Subsurface return flow is the non-consumptive portion of irrigation lost to seepage from ditches and fields that returns to the stream via groundwater. Changes in streamflow also affect the proportion of water moving downstream as alluvial subflow. Alluvial subflow occurs when a portion of the newly added streamflow seeps into alluvial sediments along the stream channel, and travels through a subsurface pathway on (all or part) of its way down to the Yakima River. Alluvial subflow is usually significantly slower than streamflow, which also affects when the diversions transferred to instream flows under the Trust would reach the Yakima River.

The water right transfer proposed by Trendwest on the Teanaway River is broken down into two components. Two thirds of Trendwest's total Teanaway water rights is proposed for transfer to mitigate Yakima River withdrawals for the MPR, while the remaining one third is proposed for transfer to mitigate withdrawals for the UGA. The modeling results presented in this memorandum are considered to be applicable to both the MPR and combined MPR/UGA transfers. The results are presented in a format that can be applied to both transfer scenarios (i.e. as relative percent of transferred water right vs. time).

The findings presented in this memorandum reflect our best estimate of Teanaway basin hydrology that could be reasonably achieved given available data. Where possible, Ecology's Consultant Team (ECT) made efforts to supplement available data with our own field investigations. Given uncertainties inherent in the available data, a degree of uncertainty cannot be avoided in the results of this analysis. However, the findings of this memorandum are considered the best available and most reasonable interpretations of the available data.

1 Overview of Findings

ECT's analysis of readily available data and information collected during our own field surveys show that a shallow alluvial aquifer exists in the Teanaway River floodplain that is comprised of both coarser grained sediments (gravels, cobbles and boulders) and finer grained sediments (clay and clay-bound materials). The Teanaway River is actively migrating over its floodplain, and the coarser sediments likely occur where prior river channels existed. Groundwater level measurements by ECT and other available information suggest that hydraulic continuity[1] likely exists between the alluvial aquifer and the Teanaway River. Streamflow data collected by the U.S. Bureau of Reclamation (USBR) are partly inconsistent with the interpretation of hydraulic continuity; however, this may be due to inaccuracies in the rating curve at the Lambert Gage. A conceptual model consistent with the USBR data would require a highly transmissive alluvial flow system not in continuity with the Teanaway River, which does not match many of the field observations in the basin. Our approach to estimating changes in streamflow associated with Trendwest's proposed transfer was based on the preponderance of evidence, which supports an assumption of hydraulic continuity between the Teanaway River and the shallow alluvial aquifer. For the purpose of comparison, the alternative conceptual model is also discussed in this memorandum.

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[1] In this memorandum, hydraulic continuity is defined as a saturated hydraulic connection between the aquifer and the stream by which a change in groundwater conditions adjacent to the stream alters nearby streamflow.

The net effect of transferring the six Walker water rights to the Trust on Teanaway River streamflow was assessed. At any given moment, flow changes would result from the combined influences of (1) leaving the former diversion instream (both the consumptive and non-consumptive return flow portions) and (2) the change in timing of delivery of the non-consumptive return flows back to the Teanaway River (instantaneous after transfer versus delayed under irrigation). Both of these changes would influence seepage losses to alluvial subflow, as seepage would increase when streamflow increased (and vice versa).

Irrigation return flow schedules to the Teanaway River were estimated under the hydraulic continuity assumption by evaluating a reasonable aquifer permeability value of 300 ft/d (and the implications of reasonably higher values). The model results predict that non-consumptive irrigation recharge will likely reach the Teanaway River within one month or less of the onset of irrigation. The "recharge pulse" caused by irrigation return flows will also exhibit minor "spreading out" (dampening) over time. After transfer of the Walker rights, Teanaway River instream flows would increase from 3.39 cfs in May to between 0.78 to 1.67 cfs over the remainder of the irrigation season. Instream flows would be reduced by 2.2 cfs for a single month after the irrigation season, as a result of ending the delayed irrigation return flow.

ECT estimated incremental increases in alluvial subflow associated with transfer of Trendwest's water right by evaluating seepage losses at both high-end and low-end values of streamflow. Seepage loss to alluvial subflow was estimated to be insignificant at all flow levels.

2 Study Approach and Data Sources

In order to estimate streamflow credit, ECT performed supporting analysis of:

- hydrogeologic conditions in the Teanaway River floodplain;
- Teanaway River streamflows
- hydraulic continuity between the groundwater flow system and the river;
- former consumptive use, ditch losses and field losses associated with the six Walker/Trendwest water rights;
- the likely magnitude and timing of historic non-consumptive irrigation return flows (both surface and subsurface) from the former Walker water rights to their receiving surface-water body; and,
- the likely magnitude of "alluvial subflow" from seepage losses associated with leaving Trendwest's water right as instream flow, and the timing required for such subflow to reach the Yakima River.

ECT first compiled and reviewed readily available hydrogeologic and streamflow data and technical reports, and spoke with researchers and water managers in the study area. Driller's logs of water wells were obtained from the Department of Ecology (Ecology), and continuous streamflow data were downloaded from the U.S. Bureau of Reclamation (USBR) web site. Aerial photographs and summaries of the Walker water rights were obtained from Mentor Law Group, and diversion measurements were obtained from USBR. Topographic and geologic maps were obtained from the U.S. Geological Survey (USGS). Technical reports were acquired from the USGS and Ecology, but were of limited value for the purposes stated above. Data from the most recent Kittitas County Soil Survey (in press) were obtained from the Natural Resources Conservation Service (NRCS). ECT interviewed Stan Isley (the USBR irrigation enforcement officer for the Teanaway Basin) and Eric Snyder, a post-doctoral researcher with the University of Montana, who is investigating subsurface flow in the Teanaway River alluvium.

The groundwater and surface water flow systems could not be confidently described from readily available, existing information. There were inconsistencies that could not be resolved without additional data collection. ECT performed three site visits to gather additional data to reduce or resolve apparent inconsistencies. ECT's understanding of the groundwater flow system and hydraulic continuity was augmented by Pacific Groundwater Group (PGG) field reconnaissance of the Teanaway River floodplain near the Walker property (formerly appurtenant to Trendwest's water rights). Our understanding of river losses and gains was augmented by a Montgomery Water Group (MWG) seepage study on the Teanaway River below Red Bridge Road, completed after the 2001 irrigation season ended. These field visits filled data gaps and helped to resolve apparent inconsistencies in the available data. Detailed descriptions of these analyses and associated findings are presented in the sections below:

3 Characterization of Hydrogeologic Conditions

3.1 Review of Existing Data and Interviews with Researchers/Water Managers

Based on its broad, flat floodplain and the minimal degree of channel incision observed, the Teanaway River appears to be actively migrating across its floodplain. Soil survey data from the Teanaway River floodplain (NRCS, in press) indicate the presence of gravelly sub-soils (Patnish-Meirmick-Myzel soil complex). Patnish and Meirmick sub-soils are characterized as "extremely gravelly sand and extremely cobbly sand", whereas Myzel sub-soils range from "clay loam" to "very gravelly very sandy clay loam". The NRCS soil map groups all three soils into one unit, thus making distinction between the three impossible from the maps. The variable texture of the sub-soils is not surprising given alluvial deposition within the floodplain.

Driller's logs of wells located near the Walker property were reviewed from Sections 25, 26, 27 and 34 of Township 20 N, Range 16 E. Most of the well locations were specified to the nearest quarter-quarter section, and in some cases ECT was unable to determine whether wells were located on the floodplain or surrounding uplands based on information provided by the drillers. Near the bend in the river at Red Bridge, well logs show variable thicknesses of alluvium (from zero to over 72 feet) overlying the bedrock that can be seen in outcrop near the bridge. Driller's descriptions of the alluvial materials are highly variable, ranging from clay to "river rock" to mixtures of clay, cobbles and boulders[2]. Red Bridge Road defines the northern extent of the floodplain along the Walker property. Well logs from homes along Red Bridge road show 10 to 20 feet of alluvium overlying bedrock described as "sandstone" or "shale". Farther south into the floodplain, well logs suggest a thickening of the alluvium overlying bedrock or "hard clay". Driller's descriptions of the alluvial materials range from clay; to clay mixed with sand, cobbles or boulders; to clean sands, gravels, cobbles and boulders (i.e., without mention of clay). Well

[2] To further complicate the geologic interpretation, wells drilled in the northern upland (Cle Elum Ridge) have also encountered a mixture of granular and fine-grained soils of the Swauk Prairie Drift mapped by Tabor, et al (1982).

logs along the Teanaway River near State Route 970 in Section 26 suggest that the alluvial thickness could reach several hundred feet[3].

Some well logs describe the alluvium as dominated by fine-grained (clayey) materials, while others show the presence of coarser grained materials such as cobbles and boulders. In general, coarser materials appear to occur closer to the land surface. About two thirds of the logs on record in alluvial-valley portions of Sections 25 and 26 reported cobbles or boulders, mostly within 30 feet of the land surface. In Section 34, about 60 percent of the logs in the alluvial valley reported cobbles and boulders at a wider range of depths from the land surface. Near Lambert and Seaton Roads, some logs report the alluvium overlying a substantial thickness of clay. The fact that the upper portions of the alluvium generally contain higher amounts of boulders, cobbles, and clean gravels suggests that these coarse sediments were derived from channel migration by the Teanaway River.

Most of the well logs located on the floodplain are completed into bedrock below the alluvial sediments. Well depths of 100 to 400 feet are common. As expected, yields from bedrock wells vary significantly, as do static water level elevations. A continuum exists between wells with static water levels close to the land surface (or providing artesian flow) to wells with water levels 200 feet below land surface. Several wells on record are less than 75 feet deep and are completed in the alluvium. Water levels in these wells range from several feet below land surface to 50 feet below land surface.

The relative absence of wells completed in the shallow alluvial aquifer cannot be used to make inferences regarding the permeability of the associated coarse-grained deposits. Current regulations on well drilling require that surface seals be completed to a depth of 18 feet, which may rule out screening many of the more shallow productive zones. More importantly, saturation of the coarse-grained materials may be relatively thin and insufficient to maintain pump submergence, either seasonally or year-round. Seasonal variations in saturation may occur if the shallow zones are dependent on river stage and/or river seepage. Finally, wells completed in recent years are generally drilled into deeper aquifers in order to reduce the risk of contaminants from the land surface reaching the well water.

Current research on the Teanaway River floodplain indicates the occurrence of shallow, coarse-grained sediments deposited as former channels of the river ("paleochannel deposits"). Eric Snyder is a University of Montana post-doctoral researcher investigating groundwater flow in the alluvial sediments near the mouth of the Teanaway River. He has installed a series of shallow (<30-foot) wells in the floodplain alluvium just upstream of Highway 10, and is monitoring water levels, temperature, electrical conductance, dissolved oxygen and biological parameters. He notes that these paleochannels have higher permeability than the surrounding finer-grained alluvium, and therefore can represent preferential pathways for groundwater flow. **Figure 1** presents spot measurements of groundwater and river elevations available for two wells in Eric Snyder's study area. ECT's interpretation of the data appears to show that groundwater conditions vary throughout the year without a discernable, direct correlation to streamflow. Groundwater levels are sometimes higher than river levels and sometimes the opposite.

[3] Driller's locations showed some of these wells on the uplands; however sediment descriptions suggest that they are located in the floodplain.

Observed differences between river and groundwater elevations are commonly less than 1.5 feet in wells installed between 100 and 250 feet from the river.

3.2 Interviews with Local Residents

PGG interviewed residents for local knowledge regarding groundwater sources and how irrigation water infiltrates into the groundwater flow system. The compiled information is anecdotal and subject to some inconsistencies. We spoke with Don Walker (the farmer who irrigated the Walker property over many years), his son Earl, and a resident renting a house on their property. The following reported observations are presented in order to provide an overview of hydrogeologic impressions. We note the source of the information, and sometimes qualify information that we believe to be suspect. For the analyses presented in this memorandum, we weight actual measurements and research findings higher than anecdotal observations. However, we do relate our findings to anecdotal observations where appropriate.

- Don Walker describes the existence of "rock bars" in his fields that cover approximately 10 percent of his irrigated acreage. These rock bars are comprised of coarse-grained materials and absorb about as much irrigation water as he had available to apply. The irrigation water would infiltrate rapidly into the ground in these locations.
- Earl Walker notes that some of the water absorbed by the rock bars would emerge from the ground out of other rock bars. He also notes that some of the return flow from irrigation returns to the Teanaway River via ditches. Don Walker states that he hasn't observed water coming back out of the rock bars, and that irrigation ditches transmit only a small portion of the return flow (e.g. 0.2 cfs) back to the river.
- Don Walker describes two shallow hand-dug wells on his property. The first is at his residence along Red Bridge Road. Don believes that water levels in this well went down after the Masterson ditch was retired, about five years ago. After this point, the well went temporarily dry at Thanksgiving when high use (and potentially low groundwater levels) limited well production.
- The second hand-dug well is located closer to SR-970 near a U-fish pond on the Walker property. Don knows less about the water levels in this well, however his renter noted that she observed a muddy bottom in the well in early summer of 2001. PGG inspected the well and noted a mat of organic material floating over a portion of the water surface. It is unknown whether the renter's observation reflected the well going dry or the presence of this organic mat.
- Don Walker has observed the groundwater table to be approximately 8 feet below ground surface (bgs) on the floodplain based on excavations in several areas.
- Don Walker believes that the depth to water in the hand dug wells responds more to river elevation (coming up in the winter and spring) than it responded to past irrigation of his fields.
- Earl and Don Walker report that prior to selling their water rights to Trendwest and the retiring of the Masterson ditch, the Teanaway River used to go dry immediately downstream of the Masterson diversion. When water was being diverted under those rights, it would begin seeping back into the river about 0.5 to 1 mile downstream

3.3 PGG Field Investigations

PGG visited the Teanaway basin on September 22 and 27, 2001 to directly observe and measure hydrologic features on the floodplain near the Walker Property. Our activities included:

- measuring groundwater levels in the two hand-dug wells;
- inspecting two springs that emit from the Walker's property, one of which flows to a U-Fish pond via ditches;
- augering soil borings to depths of up to 5.5 feet in the field near the springs to evaluate local soil saturation;
- measuring elevation differences between hydrologic features using a hand level; and
- inspecting the USBR gaging station above Lambert Road to assess channel complications that could contribute to rating curve inaccuracy.

Figure 2 is an aerial photograph of the Walker property that shows the location of the residences, U-fish pond, ditches, springs, wells, and the Teanaway River. A pattern of greener vegetation occurs east of the springs. This area had been planted in dry-land alfalfa. Auger borings revealed a loamy soil overlying a gravelly subsoil. The higher yielding (southern) spring emits into a perforated collector sunk approximately 2.5 feet into the ground. The downgradient ditch is similar in depth, and transmits water to the U-Fish pond (approximately 0.2 cfs measured at the pond's inflow culvert). The lower yielding spring emits to a ditch sunk approximately 1 foot into the ground, with seepage appearing about 6 inches below ground surface. The first boring was augured approximately 20 feet east of the main spring, and reached gravel at about 5 feet below ground surface (bgs). This gravel may be conducting shallow groundwater, but there was no saturation at a five-foot depth. The second boring was augured approximately 5 feet north of the southern ditch. It reached gravel at 4 feet bgs and some moisture was observed. The third boring was augured on the eastern boundary of the Walker property and reached unsaturated gravel at 3.5 feet bgs. The soil boring data were too shallow to explain the springs. Differences in permeability and elevation likely cause groundwater to emit from the land surface.

The green area observed near the springs may reflect soils with a greater water-holding capacity. The pattern of greener vegetation suggests the presence of paleochannels; however, the channelized areas appear to be greener whereas gravels should be better drained. The number and depth of PGG auger borings was insufficient to discern a possible relationship between the green and brown (wet/dry) areas and the occurrence of paleochannels. The wetter area below the springs is approximately four feet higher in elevation than the U-Fish pond. The U-Fish pond appears to be perched over the shallow water table, and may be contained by silty or clayey soils. Mentor Law Group surveyed a 5.5-foot elevation difference between the pond and the Teanaway River. PGG used a hand level to measure the pond elevation at about 6.7 feet above the water table measured in a nearby hand-dug well. The water level in the hand dug well along Red Bridge Road is estimated to be within ± 2 feet of the water level in the well near the pond. The water table elevation of the pond well appears to be about 1.2 (± 0.5) feet below the river at its nearest point. Given the local river gradient of approximately 7 feet elevation drop per 1,000 feet distance, the elevation similarity between the river and the shallow water table suggests hydraulic continuity between the two water bodies. Paleochannel deposits observed in the bank of the Teanaway River also support the likelihood of hydraulic continuity. The paleochannel deposits were exposed by recent flooding, and showed gravelly channel deposits within a finer grained groundmass (**Figure 3**).

Potential sources of recharge to the shallow alluvial aquifer include groundwater flow from the surrounding uplands, seepage losses from irrigation (where present), upward flow from deeper aquifers, and seepage from the Teanaway River in upstream locations. Upstream of the river bend east of the Walker property, the Teanaway River flows through an alluvial valley about as wide as the valley downstream. Although the upstream alluvial valley is constrained by bedrock on either side, the lateral extent of the alluvium appears sufficient to contain similar paleochannels and groundwater conditions. About 1.5 miles downstream of the Walker property, the Teanaway River valley joins the floodplain of the Yakima River. The Yakima River is about 1.3 miles downstream of the downstream border of the Walker property.

4 Teanaway River Streamflow

ECT compiled and evaluated streamflow data from the Teanaway River to characterize seasonal variations in flow, gaining and losing behavior of specific river reaches, and hydraulic continuity with groundwater. This information was required to predict how additional water introduced from the application of the Trendwest water rights to instream flow use would partition between surface and subsurface (alluvial) flow, and how changes in streamflow could be estimated based on the time required for (the former) irrigation return flow from the Walker property to reach the river.

Streamflow data are available on the Teanaway River at two gages, one located "below the forks" (record: 1909-15, 1948-50, 1966-present) and the other located downstream "above Lambert Road" (record: late 1998 to present). The relatively long period of record at the Forks gage allowed ECT to prepare a chart of average daily flow over the period of record (**Figure 4**). Streamflow tends to increase from late fall through winter, and still higher flows are derived from snowmelt between April and June during the spring freshet. Freshet flows recede into early- to mid-July, at which point streamflow falls into an extended low-flow period through early October. Fall rains allow flows to recover during October and November as the winter season is approached.

ECT compared flows at the Forks and Lambert gages to evaluate how the Teanaway River gains and/or loses flow over the course of the year. Our analysis identified likely problems with the flow data at the Lambert gage, discussed later in this section. The flows reported at the Lambert gage are typically higher than flows reported at the Forks gage during the winter and early freshet. This relationship likely exists due to the fact that winter and early spring precipitation goes into snow storage in the upper watershed elevations, but may fall as rain to provide surface runoff and shallow recharge in the lower elevations. During the late freshet, however, the Lambert gage shows significantly less flow than the Forks gage. **Figures 5 thru 7** show flow comparisons at the two gages from the late freshet through the end of the irrigation season. Acknowledging the possible limitations of the Lambert flow data, several observations can be derived for the time period towards the end of the freshet:

1) Flow losses of 50 cfs to over 100 cfs are reported between the two gages during the tail end of the freshet (mid-July through mid-August);

2) The Lambert gage falls dramatically until it reaches a minimum baseflow of 8 to 10 cfs, and then shows only a minor flow reduction over the remainder of the irrigation season; and

3) Periods of record occur when flows reported at the two gages have either parallel or differing trends. Differing flow trends do not occur in any consistent pattern.

These observations raise a number of questions regarding the hydrology of the Teanaway River flow system and the accuracy of the flow measurements collected by the U.S. Bureau of Reclamation (USBR). The alluvial aquifer would need to have a transmissivity of 1,300,000 gallons per day per foot (equivalent to a 50-foot thick aquifer with a permeability of 3,500 ft/d) to conduct a subsurface flow of 50 cfs[4]. This value is on the far upper end of what would be reasonably expected for an alluvial aquifer associated with a stream the size of the Teanaway River. Moreover, if this were truly the case, it seems unlikely that late summer baseflows of 8-10 cfs would be maintained in the river. A conceptual hydrogeologic model consistent with direct interpretation of the USBR flow data at the Lambert gage can only be supported by assuming a complex set of field conditions that cannot be substantiated by the existing data[5].

ECT has reviewed the rating curve of the Lambert gage and noted that a significant discontinuity exists in the curve at approximately 9 cfs **(Figure 8)**. The curve was developed in 1998, and has been used over three years of record by applying a "shift" to the stream stage measurement. Given the gravelly nature of the streambed, and the variability of flows in the Teanaway, shifting the rating curve may not sufficiently adjust for changes in the streambed configuration. Furthermore, a large number of spot measurements at a variety of flows would be required to accurately develop the "shift". Flow measurements by MWG on September 19, 2001 showed a discrepancy between the measured flow of (11.2 cfs) and the flow reported by USBR (8.5 cfs). Field observations of the gaging site made by PGG on September 27, 2001, indicate that the shape of the channel is inconsistent with the existing rating curve. Although, the USBR has stated that the rating curve for the lower gage is highly dependant on the presence and location of a gravel bar located near the gage, PGG observed no evidence of a "lip" or other channel feature that would require a discontinuity in the rating curve. A photograph of the gaging site is presented as **Figure 9**.

The behavior of the hydrograph reported for the lower gage also suggests inaccuracies in the associated rating curve. Over the three years of available data, the lower gage typically tracks closely with the flows observed at the Forks gage. However, there are periods when the two gages diverge. During the end of the spring freshet the upper gage exhibits a relatively gradual recession towards a baseflow condition (as would be expected), whereas the lower gage shows an abrupt drop to from flood flow to baseflow. The reported drop appears to be far too abrupt and inconsistent with typical river hydrographs, and the magnitude of reported flow losses is

[4] At the river gradient of 0.01, an aquifer 2,500 feet wide and 50 feet thick would require a permeability of 3,500 ft/d (1.2 cm/sec) to pass 50 cfs of water. If 50 cfs of water went into storage over a 30-day period, the same aquifer would show a 10-foot rise assuming that all the leakage occurs over a 4-mile reach and porosity equals 0.25.

[5] In order to explain the presence of 8-10 cfs baseflow in the stream, one could postulate inflow from a shallow perched system or perhaps subsurface flow off the southern valley upland. Late summer baseflow could also be explained by the theory that streamflow losses to groundwater from upstream locations gradually make their way through the alluvial system and contribute to downgradient baseflow, with the associated time lag perhaps explaining observed late-summer seepage gains.

inconsistent with losses observed at other flow levels and during other times of the year. The slow recessional pattern observed on the Forks gage is much more typical. The apparent large amount of seepage loss observed between the two gages during the spring freshet may be an artifact of the inaccuracies in the gaging sites and associated rating curves. Although some loss between the gages during the spring freshet likely occurs, the magnitude of that loss may be significantly lower than the USBR hydrographs suggest. In order to understand the gains and losses that occur in the Teanaway river basin, additional quality assurance on both ratings curves would be necessary.

Under an assumption that the USBR's flow data are more accurate during the summer low flow period, ECT reviewed these data to evaluate whether the Teanaway River loses or gains flow between the two gages. The USBR data show flow losses ranging from 5 to 20 cfs between the two gages during the late irrigation season (August and September). During the late year 2000 season and immediately following the 2001 irrigation season, an apparent flow gain was observed between the two gages. Flow losses can be compared to typical irrigation diversions between the two gages ranging from 5 to as much as 20 cfs. If the summer flow data can be trusted, both losing and gaining conditions can be interpreted at various times between the two gages. Over most of the irrigation season, distinction between loss and gain is obscured by the fact that irrigation diversions are on the same order of magnitude as measured flow losses.

The locations of the two USBR gages, and potential inaccuracies in the existing data, required field assessments be performed to evaluate gains or losses over the river reach adjacent to the Walker property. MWG performed a seepage survey from Red Bridge to State Route 10 on September 19, 2001, four days after the irrigation season ended (**Table 1**). Flow between the four measurement points did not vary more than the likely measurement error of ten percent[6]. While a small loss of 0.9 cfs is noted over the surveyed reach, measurement error could account for this flow variability. ECT concluded that no significant gain or loss was observed over this reach.

Table 1 – Teanaway River Seepage Study Measurements

Location on Teanaway River	Distance from Red Bridge Site (ft)	Discharge (cfs) on 9/19/2001
Upstream Of Red Bridge	0	12.1
Upstream Of USBR Gage	5500	11.6
Upstream Of Lambert Bridge	9300	13.1
Upstream Of SR 10 Bridge Near Mouth	10400	11.2

5 Hydraulic Continuity Assessment

For the purposes of this analysis, hydraulic continuity is defined as a direct, saturated connection between an aquifer and the adjacent reach of a stream. When hydraulic continuity occurs, a change in groundwater level will affect seepage to or from the stream. Under conditions of hydraulic continuity, a stream can be either losing or gaining. Whereas observation of a gaining

[6] Measurement error may be higher at the Lambert Road site, where the stream bed was significantly more cobbly and bouldery.

stream ensures hydraulic continuity, observation of a losing stream does not determine hydraulic continuity (losses can occur through an unsaturated zone beneath the streambed). The efficiency of hydraulic coupling between an aquifer and a stream is reduced when a lower permeability streambed impedes seepage gains or losses. The degree of hydraulic continuity determines the magnitude, location, and timing of stream gains or losses in response to changes in the groundwater flow system.

Our evaluation of hydraulic continuity on the Teanaway River was drawn from the information presented above, and is summarized below. Hydraulic continuity on the river reach adjacent to the Walker property means that former non-consumptive irrigation return flows from fields and ditches would have returned locally to the Teanaway River. Without hydraulic continuity, former irrigation losses would have returned to the Yakima River. Identifying receiving water bodies is an important detail for evaluating changes in streamflow associated with Trendwest's proposed water rights transfer. Evaluation of hydraulic continuity has remained a primary focus throughout ECT's investigation. The information collected by ECT supports the likely existence of hydraulic continuity adjacent to the Walker property. In contrast, the USBR flow data, identified as suspect at the Lambert gage, support a conceptual model where hydraulic continuity is more questionable. The following bullets summarize observations related to hydraulic continuity, and in some cases include necessary qualification:

- Hydraulic continuity is supported by the similarity between groundwater levels and river stage during 2001 field studies by ECT, both near the Walker property and further downstream near Highway 10;
- Hydraulic continuity is supported by the existence of a steady late-season baseflow at the Lambert gage, regardless of possible error in the rating curve;
- Hydraulic continuity is supported by the historic observation that flow would return to the Teanaway river within 0.5 to 1 mile downstream of the former Masterson ditch where diversion dewatered the river;
- The USBR streamflow data, if accurate, support a conclusion of hydraulic continuity towards the end of the irrigation season, by virtue of gaining conditions between the two gages reported during some seasons;
- Hydraulic continuity is neither indicated nor disproved by the USBR data (if accurate) during the early irrigation season (late freshet) because a losing condition is observed.

The most likely conceptual model suggests a shallow alluvial aquifer in continuity with the Teanaway River, with coarse-grained paleochannels supporting moderately high permeability.

6 Water Use Associated with the Trendwest Water Right

ECT compared estimates of consumptive crop use for the lower Teanaway Basin reported in the UGA DEIS to the allocated water right, to estimate how much of the total diversion was used by crops and how much returned to the river as non-consumptive return flow. The following table presents a summary of the water use estimates for total use associated with all six Walker water rights.

Table 2 - Estimated Irrigation Water Use Associated with the Trendwest Water Right

Month	Net Consumptive Use (cfs)	Field & Ditch Loss (cfs)	Total Diversion[6] (cfs)	1-Month Lag Streamflow Change (cfs)
May	1.18	2.21	3.39	3.39
Jun	1.43	2.33	3.76	1.55
Jul	1.67	2.09	3.76	1.43
Aug	1.46	2.30	3.76	1.67
Sep 1-15	0.98	2.10	3.08	0.78
Sep 15-30	n/a*	n/a*	n/a*	-2.30
Oct 1-15	n/a*	n/a*	n/a*	-2.10

* Irrigation season includes only the first 15 days of September.

Values for net consumptive use were used to estimate field loss based on an assumed irrigation efficiency of 65 percent. During the hot months of July and August, the difference between the maximum instantaneous diversion rate (Qi) and crop consumptive use requires an assumption of increased irrigation efficiency by the farmer. Ditch irrigation loss was assumed constant throughout the irrigation season, and raised to the maximum value allowable without exceeding either allocated Qi or the maximum total diversion volume (Qa)[7]. Ditch loss estimates could not be confirmed through field studies, as the Walker property is no longer used for irrigated agriculture. Based on Acquavella adjudication (Yakima River Basin Surface Water Rights Adjudication) maps, several miles of irrigation ditches formerly crossed the Walker property. Acquavella documentation also presents measurements of ditch gain/loss performed by Ecology on selected Teanaway Basin ditches, which can be used to estimate gain/loss per 1,000 feet of ditch. The gain/loss values vary widely, with a number of ditch reaches gaining water presumably from return flow. The losses estimated for Trendwest's water right in **Table 2** fall within the range of losses estimated from the Acquavella data.

The monthly values of total diversion, consumptive use, and field/ditch loss presented above were used to estimate changes in streamflow associated with transferring the irrigation water right to Teanaway River instream flows under the Trust. The following section evaluates the timing of irrigation return flow to the river and estimates the streamflow change resulting from the Walker water rights transfer to the Trust.

7 Irrigation Subsurface Return Flows

Trendwest's water rights allow up to 3.76 cfs to be diverted from the Teanaway River from two former points of diversion immediately below Red Bridge. The actual diversion is limited by the

[7] Trendwest holds six separate water rights with different dates of priority that total 3.76 cfs. The water rights include three 1883 priority water rights (totaling 2.74 cfs) and one 1890 priority water right, which are expected to be typically available for the full irrigation. Stan Isley notes that the last two water rights are 1898 priority rights (totaling 0.34 cfs) that are junior in priority and are usually only available only for the May 1 through July 15 period each year (i.e., they enjoy only "half season availability"). This information became available after performing the analyses described in this memorandum; however, these junior water rights comprise only about 10% of the total late-season diversion. In addition, the B&C Water Balance Model will account for actual water availability and water right seniority.

Qi limit rather than the Qa limit. The portion of the diversion lost to ditch and field seepage returns to the Teanaway River via both subsurface and surface return flow. Conversations with Don Walker (pers. comm., 2001) suggest that the majority of this return flow infiltrates to the subsurface. In order for nonconsumptive irrigation losses to reach the Teanaway River, they must first pass through the unsaturated zone down to the water table and then flow laterally to the river. Groundwater level measurements and conversations with Don Walker suggest that the unsaturated zone is about 6 to 8 feet thick beneath the Walker property. While some of the irrigation loss may infiltrate directly into paleochannels for fast transmittal to the water table, most likely moves more slowly through arable soils. PGG performed a series of calculations using Hydrus-2D (a variably-unsaturated numerical flow model) under varying soil textures at the average rate of former irrigation loss on the Walker property. PGG's evaluation suggests that estimated ditch loss comprises about two thirds of the total irrigation loss. A series of ditches cross the Walker property, which would infiltrate water considerably faster than the fields. High infiltration rates lead to fast rates of transmittal through the unsaturated zone. PGG's calculations show that estimated time lags required for irrigation losses to reach the water table are likely to range from very short periods below ditches and via paleochannels to about three weeks below fields.

The southern boundary of the Walker property is nowhere more than 1,000 feet from the Teanaway River, and the northern boundary is nowhere more than 3,000 feet. Once the irrigation seepage loss reaches the water table, the travel time required to reach the Teanaway River depends on the geometry of the alluvial flow system and former place of use, aquifer properties (permeability (K) and storage coefficient (S)), and degree of hydraulic continuity with the Teanaway River. The fastest return flows will occur where permeability is high, storage coefficient is low, and full hydraulic continuity exists between the alluvial aquifer and the Teanaway River. Paleochannel deposits are considered to be high permeability, and have the capacity to return irrigation losses quickly to the river if the network of paleochannels is continuously connected between the areas of irrigation recharge and the river. If paleochannels are not well interconnected, the bulk permeability of the alluvial flow system will be limited by the permeability of the finer-grained matrix in which the channels occur. Bulk permeability can also affect the degree to which the 4.5-month irrigation recharge pulse gets spread out over time (dampened) before reaching the river. Data available to ECT did not allow assessment of the connectivity of the paleochannels or the permeability of the finer grained matrix. In order to estimate a likely range of the time lag and dampening required for irrigation losses to reach the Teanaway River, PGG developed groundwater flow models with the USGS MODFLOW code and constrained modeled aquifer permeabilities to reasonable values.

Figure 10 presents the flow model used for PGG's model simulations. The model simulates a 60-foot thick alluvial valley aquifer confined by relatively impermeable bedrock on either side. The aquifer receives a small amount of year-round recharge (0.4 cfs) along its bedrock contacts and approximately 5 in/yr of year-round areal recharge. Full hydraulic continuity with the Teanaway River is defined by a "drain" boundary, which allows streamflow gain from groundwater but does not allow outflow back to the alluvial aquifer. The rates of recharge were selected over a reasonable range to ensure that the drain gained flow from groundwater over the modeled reach. The absolute accuracy of these recharge estimates is of low importance relative to the fact that they define a flow system that discharges to the Teanaway River. Constant head boundaries were defined at the upstream and downstream ends of the alluvial valley based on the river elevation mapped on USGS topographic maps of the project vicinity. The model was run in transient mode, with 4 years of simulation without any input from former Walker irrigation followed by 6 years with seasonal irrigation losses. Viewed as irrigation recharge rates, estimated irrigation seepage losses range from 0.26 to 0.3 inches per day. Specified flux boundaries were used to define transient recharge from the Walker property at an average irrigation-season rate consistent with seepage loss from the full Walker water right[8] (documented on **Table 2**).

An S value of 0.25 and a range of aquifer permeability between 30 to 300 ft/d were originally defined to constrain estimates of the timing of former return flows to the Teanaway River. However, springflow rates estimated during PGG's second field visit suggested that a K value of 30 ft/d was too low to match the observed conditions. The spring that emanates from the Walker property east of the U-Fish pond has an estimated discharge of about 0.2 cfs. Screening level calculations of groundwater flow in the alluvial aquifer, similar to those presented in Section 4, suggest that a K value of 30 ft/d corresponds to a total groundwater flow of 0.43 cfs through the alluvial aquifer. It is highly unlikely that the Walker's spring, which "skims" water off the top of the alluvial water table over a limited width of the valley, is able to capture almost half the groundwater flow in the valley. A much smaller proportion of the total groundwater flow is likely warranted. Thus, we adjusted our range of model simulation to K values of 300 ft/d and above (corresponding to alluvial aquifer capacities of 4.3 cfs and above). Time series predictions of inflow to the Teanaway River from the model results were used to estimate the timing of irrigation return flow reaching the Teanaway River.

Figure 11 presents predicted hydrographs of the groundwater inflow to the Teanaway River resulting from the former Walker irrigation recharge based on an aquifer permeability of 300 ft/d. Within the first two weeks of irrigation, only a small portion (less than 50 percent) of the rate of non-consumptive irrigation return is predicted to reach the river. After the season has ended, approximately 80 percent of the irrigation return volume has reached the river **(Figure 12)**. About 10 percent of the total irrigation return volume is predicted to reach the river over the next three weeks, with the remaining 10 percent reaching the river over the remainder of the year. With a K value of 300 ft/d, a time lag of about one month is a reasonable upper-end limit for the irrigation return to the Teanaway River. This time lag represents a combined lag from unsaturated flow through the soil profile and saturated flow to the river. If higher K values were modeled, associated time lags would likely be shortened to no more than one or two weeks. The "tail end" of the modeled return flow schedule represents only a small portion of the total irrigation seepage loss.

Given the estimated upper-end time lag of one month associated with the K=300 ft/d model simulation, the change in streamflow from the instream transfer of Trendwest's water rights averaged over a given month during the irrigation season can be estimated as the total diversion returned to the stream minus the irrigation return flow that would have returned to the stream under historic irrigation practices during the same period. If the return flow were instantaneous (i.e. for K values much greater than 300 ft/d), the change in streamflow would be an increase

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[8] The values used in the model were actually 10% higher than the full Walker water right; however, this should have little bearing on model results.

equivalent to the estimated consumptive use. This portion of the diversion was historically used by the crops, and would now be available to contribute to increased streamflows. **Table 2** presents estimates of consumptive use and changes in streamflow based on a one-month delay for irrigation returns. During the month of May, increased flows in the Teanaway below the points of diversion would equal the estimated consumptive use (3.39 cfs) because prior irrigation is unavailable to provide return flow to the stream. Starting in June, streamflow increases would be a result of the added instream flows from ceasing diversions, minus non-consumptive return flow from irrigation during the prior month (0.78 to 1.67 cfs). Streamflow reductions of 2.1 to 2.3 cfs would occur for one month after the irrigation season is over relative to historic conditions, because historic irrigation return flow would no longer occur for that portion of the streamflow.

The simplified method discussed above presents estimates of streamflow change for the full water-rights transfer (MPR+UGA); however, the same approach can be used to estimate return flows for the MPR transfer alone. In both cases, change in streamflow is approximated by subtracting the prior month's return flow from the current month's diversion returned to Trust. As noted earlier, the proposed MPR transfer represents about 2/3 the total transfer for the MPR and UGA combined. ECT recommends that B&C use a one-month time delay for non-consumptive irrigation returns in its modeling. A plus or minus 2-week error range should be used as inputs to the upper and lower model bound simulations to represent uncertainty associated with the model results.

The analytical model discussed above is based on the conceptual model that incorporates hydraulic continuity between the alluvial aquifer and the Teanaway River. This conceptual model is best supported by the available data, and is considered to be the most reasonable representation of the hydrologic system. However, interpretation of the USBR streamflow data could support an alternative model with limited (or zero) hydraulic continuity between the alluvial aquifer and the Teanaway River. For the purpose of completeness, ECT notes that this alternative conceptual model would indicate that prior irrigation return flows would discharge to the Yakima River (rather than the Teanaway River) over a more spread-out, year-round schedule. Under this model, the proposed transfer would result in larger increases in irrigation-season streamflow in the Teanaway and Yakima Rivers, but reductions in Yakima River streamflow outside the irrigation season.

8 Alluvial Subflow and Associated Time Lag

Theoretically, a portion of the streamflow credit delivered to the Teanaway River could flow in the alluvium along the river rather than in the river itself. This subsurface flow component, termed "alluvial subflow", occurs at a slower velocity than flow in the stream. If a significant portion of the former irrigation diversions returned to instream flow were to flow in the alluvium along the stream, some time lag might occur between the former points of diversion and the Yakima River. The timing of water delivery to the Yakima River is significant because the water balance accounting for the Trendwest MPR and UGA will require estimates of monthly water availability for the water rights transferred to the Trust.

ECT estimated the contribution to alluvial subflow associated with Trendwest's water right transfer over two portions of the irrigation season: the period dominated by the spring freshet

(May through early July) and the period dominated by summer low flows (early July to the middle of September). During the freshet, streamflows are relatively high and addition of 1 to 4 cfs is expected to have negligible impact on seepage loss. Despite questions about the rating curve for the Lambert Road gage, it is still worthwhile to note that at 200 cfs, a 4 cfs change in flow causes a 0.01 foot change in stream stage. While this example is specific to the Lambert gage, significant incremental stage increases at such high flows are not expected for 1 to 4 cfs additional streamflow. We estimate that the change in seepage loss is negligible when flows at the Forks gage are above 200 cfs (typically until early July).

In contrast, during low flow conditions significant stage increases are expected due to the addition of Trendwest's water rights to instream flows. Summer low flows are generally observed at the Lambert gage after early July. Based on MWG's seepage survey, little natural gain/loss is expected to occur over the reach between Red Bridge and SR-10 under the summer low flow regime. MWG performed hydraulic calculations based on cross-sections measured during their seepage survey to estimate how average values of wetted perimeter and hydraulic radius would vary with streamflow variations of ±4 cfs, as a departure from the 11 cfs measured in the field. As a conservative measure, the field-measured loss of 0.89 cfs along this reach of the river was used as a basis for the seepage loss estimates. Seepage loss was assumed to increase proportionally with relative increases in both wetted perimeter (representing the surface area of the streambed) and hydraulic radius (representing the height of the stream stage above the streambed). While these calculations are hypothetical and approximate, they suggest that changing the flow by ±4 cfs would result in a change in seepage loss of ±0.2 cfs. The calculations are presented on **Table 3** at the end of this memorandum. Thus, during the summer low flow season, seepage loss to alluvial subflow associated with Trendwest's water right transfer to instream flows under the Trust is likely to be insignificant.

Table 3
Hydraulic Analysis of Streambed Seepage

Teanaway River Seepage Calculations
Rev. 9/20/01

Location on Teanaway River	Distance from Red Bridge Site (ft)	discharge (cfs) on 9/19/2001	estimated Manning's n	wetted perimeter (ft)	area (sq. ft)	hydraulic radius (ft)	calc. friction slope
UPSTREAM OF RED BRIDGE	0	12.1	0.05	34.4	16.5	0.480	0.00161
UPSTREAM OF USBR GAGE	5500	11.6	0.05	31.0	24.2	0.781	0.00036
UPSTREAM OF LAMBERT BRIDGE	9300	13.1	0.05	34.2	18.3	0.535	0.00133
UPSTREAM OF SR 10 BRIDGE NEAR MOUTH	10400	11.2	0.05	36.2	20.9	0.577	0.00067
	Average W.P.	34.0					
	Surface Area (sq.ft)	353080				0.593	

Assuming same friction slope and Manning's n at 9/19/2001 flow plus 4 cfs, an extrapolated bank (because we do not have a surveyed bank cross section), and that top width approximates wetted perimeter in wide shallow streams, the following estimates give wetted perimeter and area at the cross sections with the additional TW water. ManningSolver was used to calculate top width and area at the Q+4 cfs flows.

Location on Teanaway River	9/19/01 Q + 4 cfs	wetted perimeter (ft)	delta w.p.	flow area (sq. ft)	delta A		hydraulic radius
UPSTREAM OF RED BRIDGE	16.1	37.8	3.4	20.5	4.0		0.542
UPSTREAM OF USBR GAGE	15.6	32.4	1.4	29.6	5.4		0.914
UPSTREAM OF LAMBERT BRIDGE	17.1	34.4	0.2	21.9	3.6		0.637
UPSTREAM OF SR 10 BRIDGE NEAR MOUTH	15.2	38.1	1.9	25.8	4.9		0.677
	Average W.P.	35.7					
	Surface Area (sq.ft)	371020					
	Delta S.A (sq. ft)	17940				Ave.	0.692

Similar calculation as above except with Q minus 4 cfs...

Location on Teanaway River	9/19/01 Q - 4 cfs	wetted perimeter (ft)	delta w.p.	flow area (sq. ft)	delta A		hydraulic radius
UPSTREAM OF RED BRIDGE	8.1	30.8	-3.6	12.5	-4.0		0.406
UPSTREAM OF USBR GAGE	7.6	29.4	-1.6	18.5	-5.7		0.629
UPSTREAM OF LAMBERT BRIDGE	9.1	30.7	-3.5	14.3	-4.0		0.466
UPSTREAM OF SR 10 BRIDGE NEAR MOUTH	7.2	34	-2.2	15.7	-5.2		0.462
	Average W.P.	31.2					
	Surface Area (sq.ft)	324740					
	Delta S.A (sq. ft)	-28340				Ave.	0.491

Calculations	Surface Area	Hydraulic Radius	Multiplying Factors	Seepage cfs	Change in Seepage, cfs
12.1 cfs	353080	0.5930		0.89	0
16.1 cfs	371020	0.6924		1.09	0.20
8.1 cfs	324740	0.4907		0.68	-0.21
% change +4 cfs	1.05	1.1676	1.23		
% change - 4 cfs	0.92	0.8275	0.76		

Note: Seepage loss was assumed to increase proportionally with relative increases in both wetted perimeter (representing the surface area of the streambed) and hydraulic radius (representing the height of the stream stage above the streambed).

Figure 1
Comparison of Water Elevations Near the Teanaway River at Highway 10

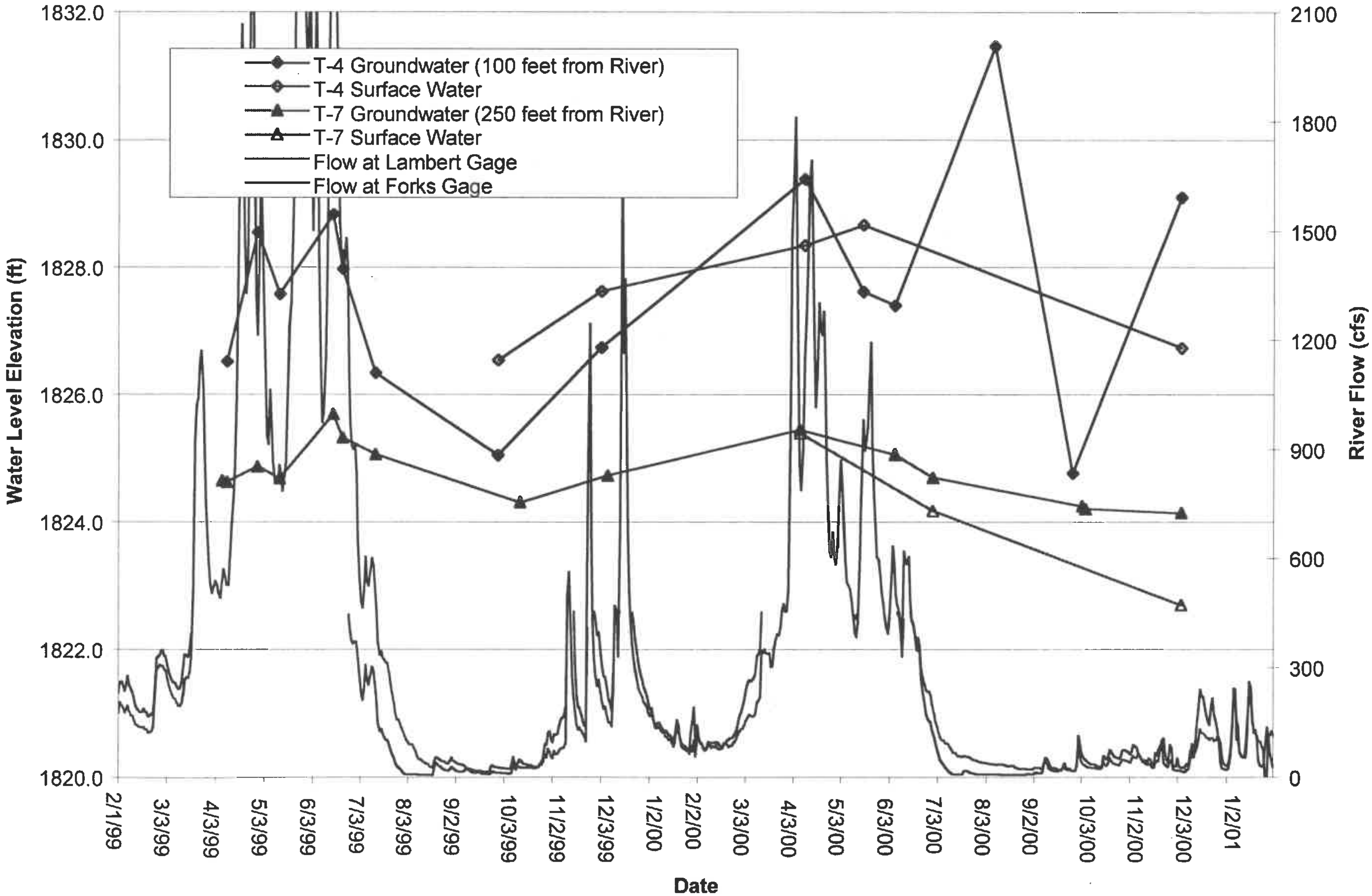


Figure 2
Aerial Photograph of Walker Property Dated 8/11/01

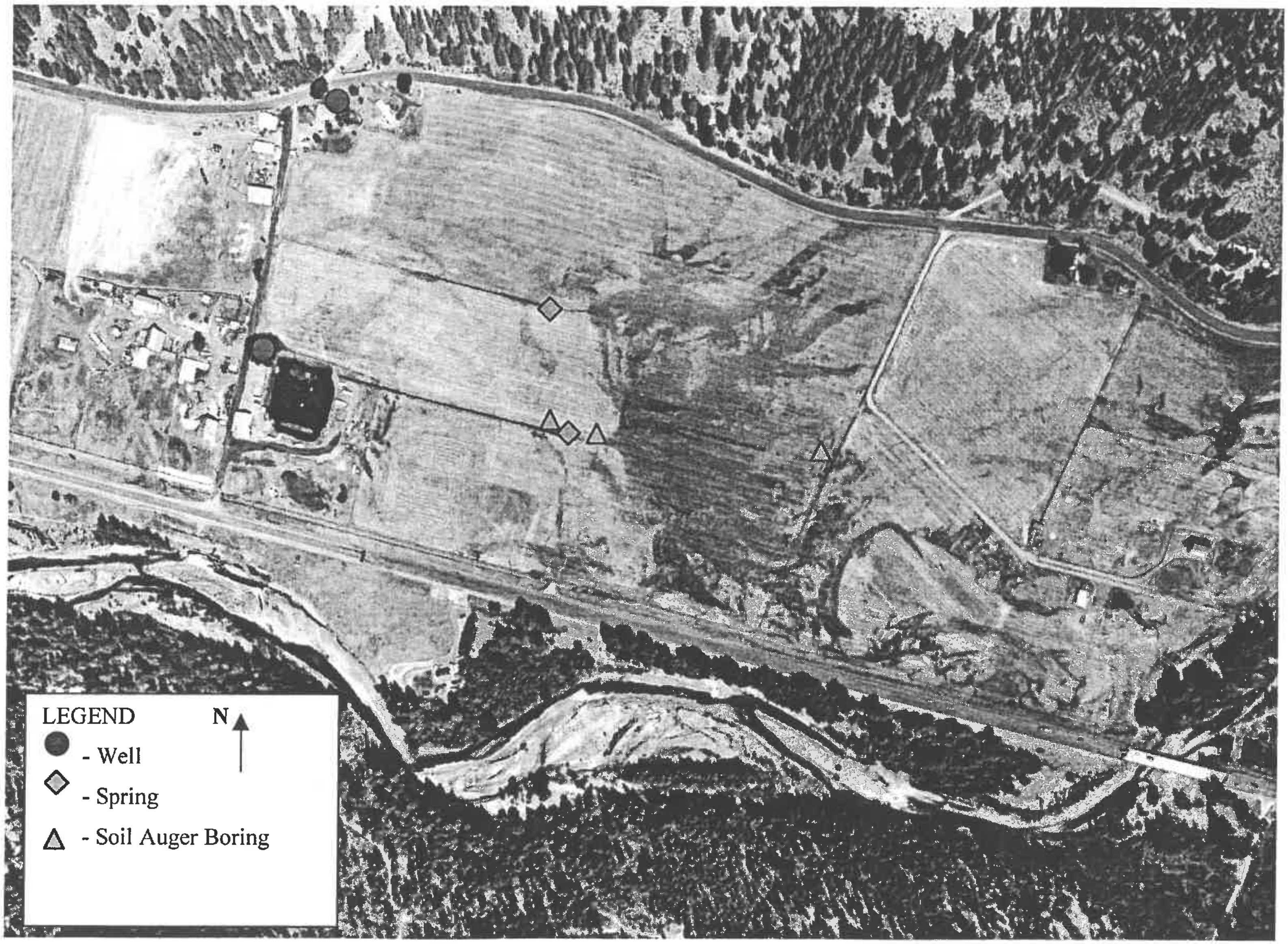


Figure 3
Paleochannel Gravels Exposed in the Teanaway River Bank

Figure 4
Average Daily Flows at the Teanaway Forks Gage

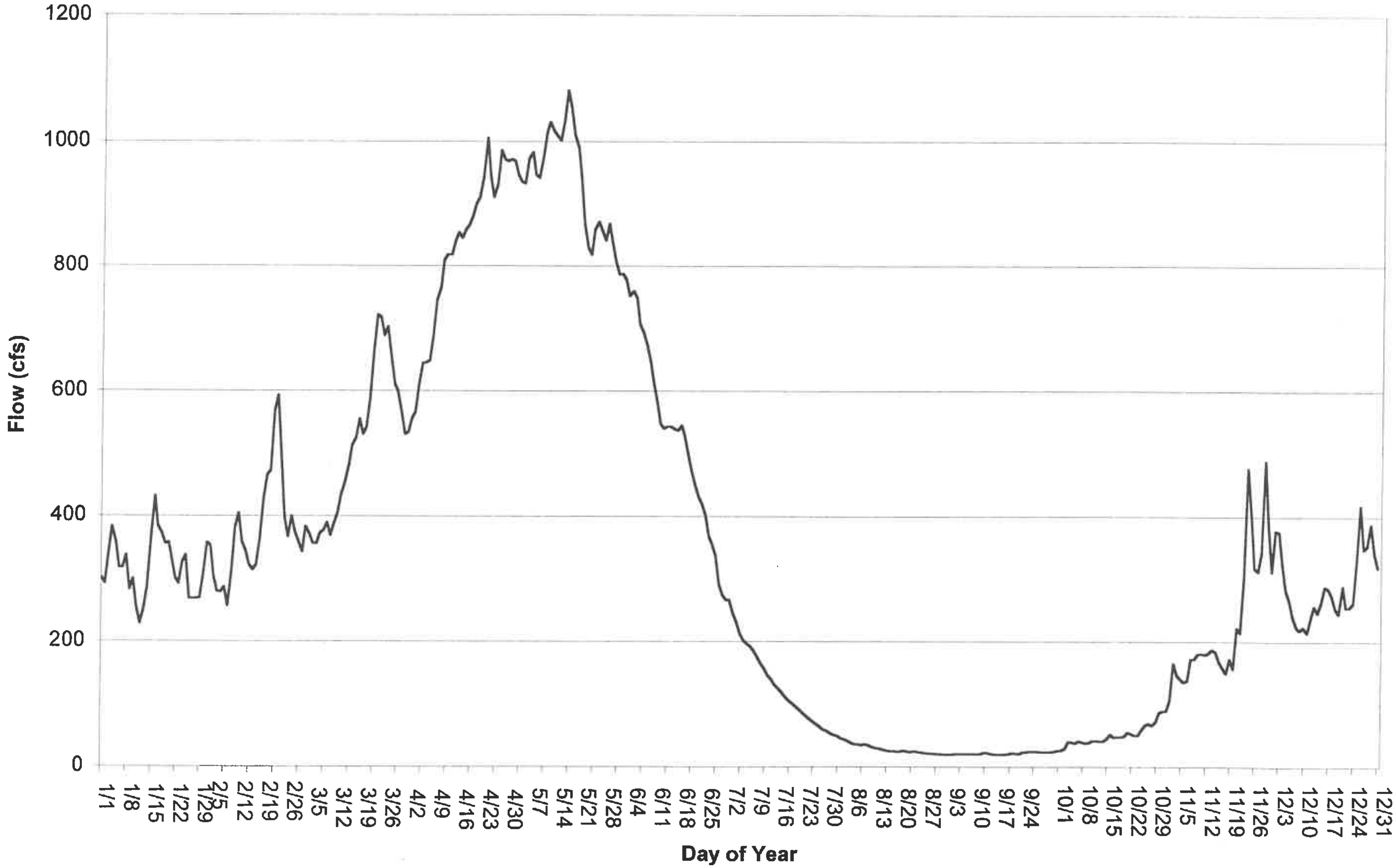


Figure 5
1999 Teanaway River Daily Average Discharge

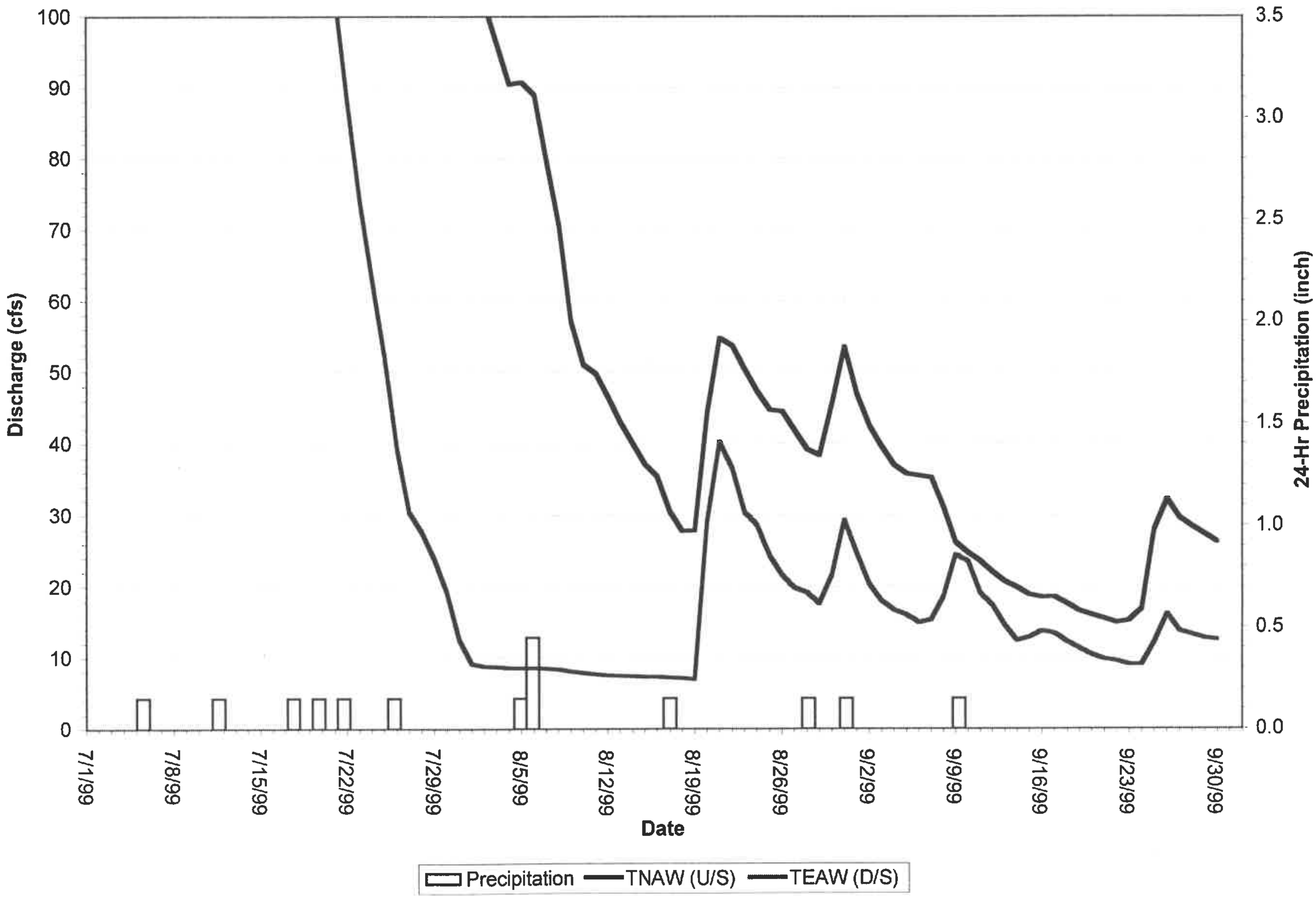


Figure 6
2000 Teanaway River Daily Average Discharge

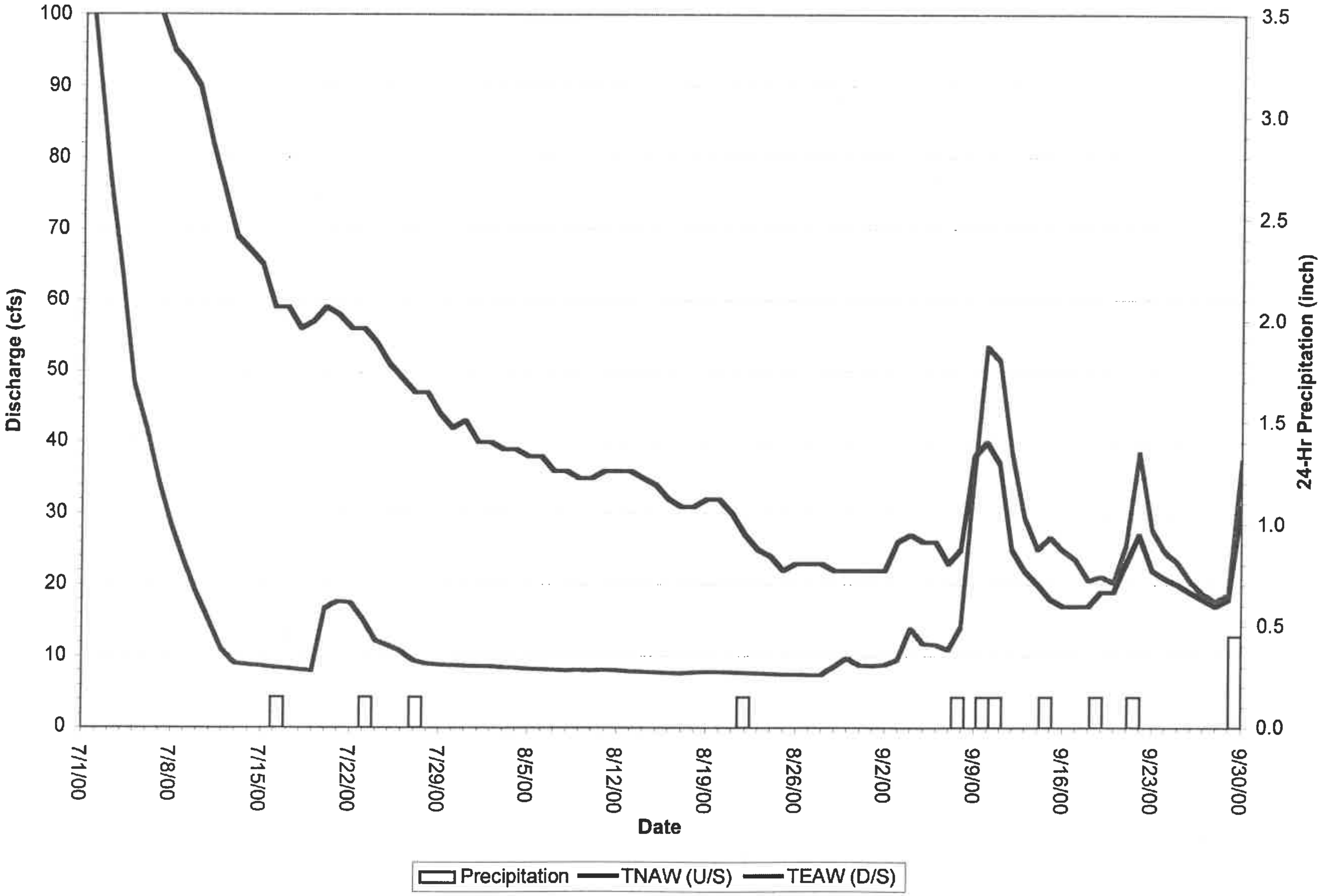


Figure 7
2001 Teanaway River Daily Average Discharge

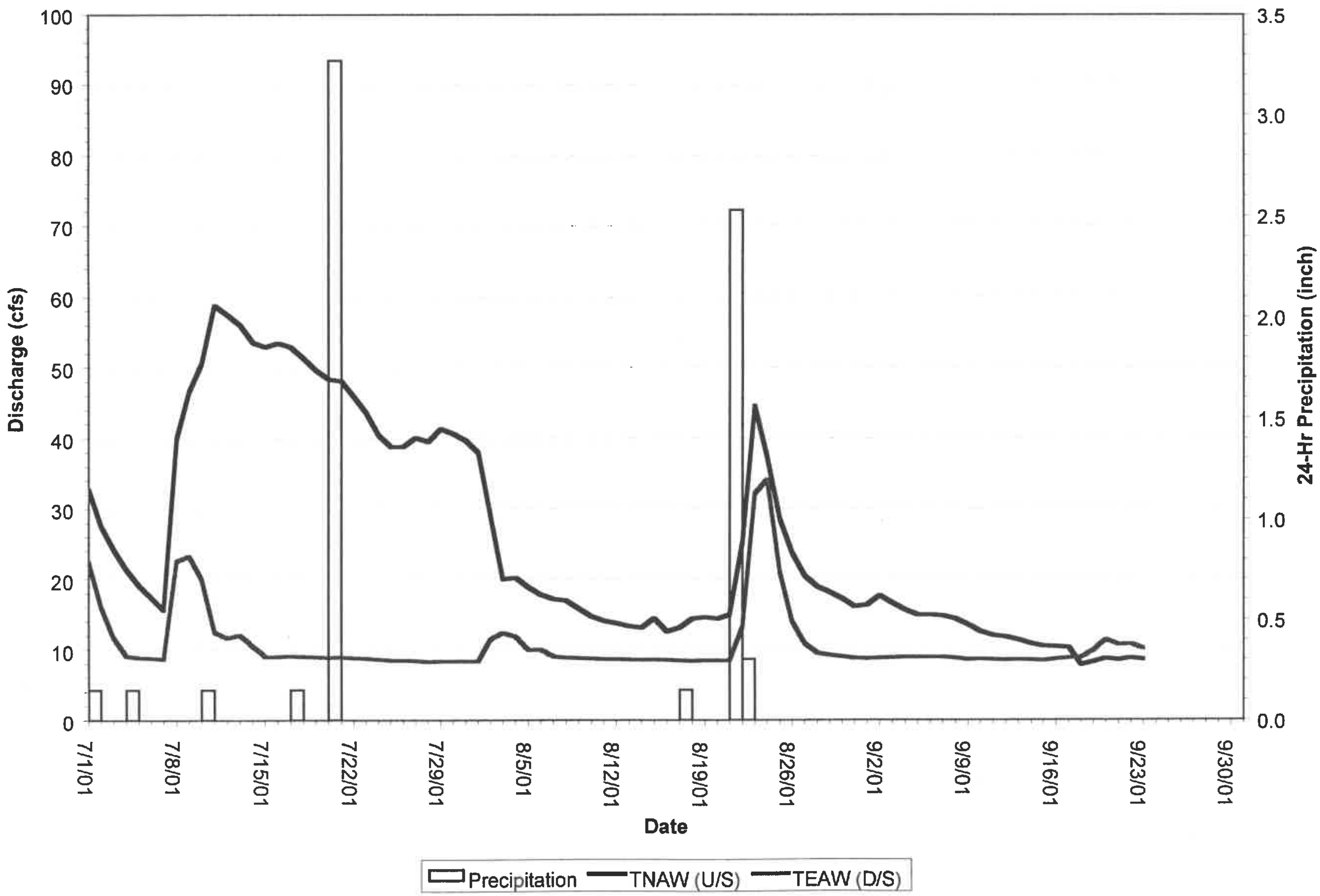


Figure 8
Rating Curve for the Teanaway River Streamflow Gage Above Lambert Road

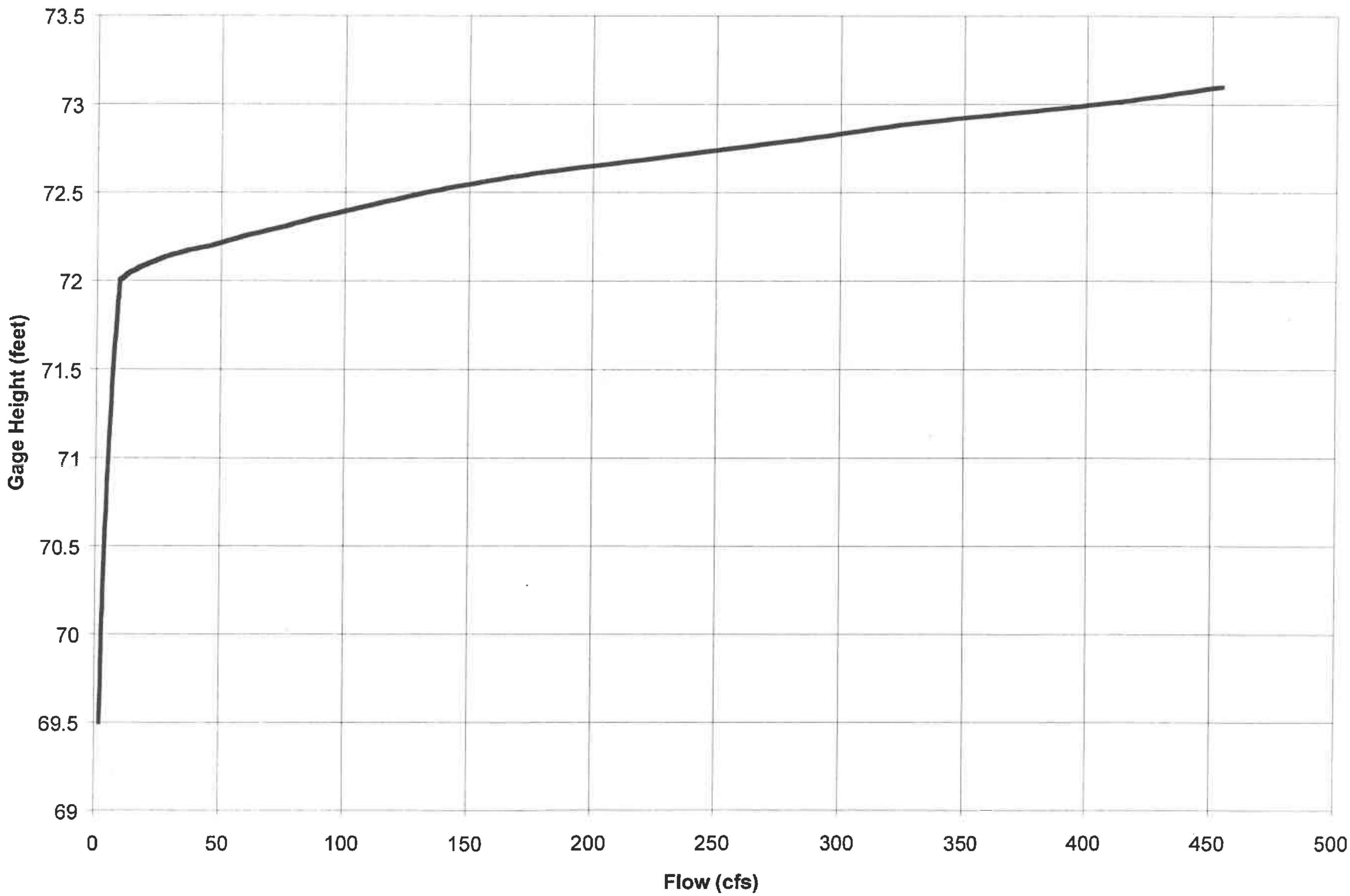


Figure 9
Stream Channel at the Teanaway River Streamflow Gage Above Lambert Road

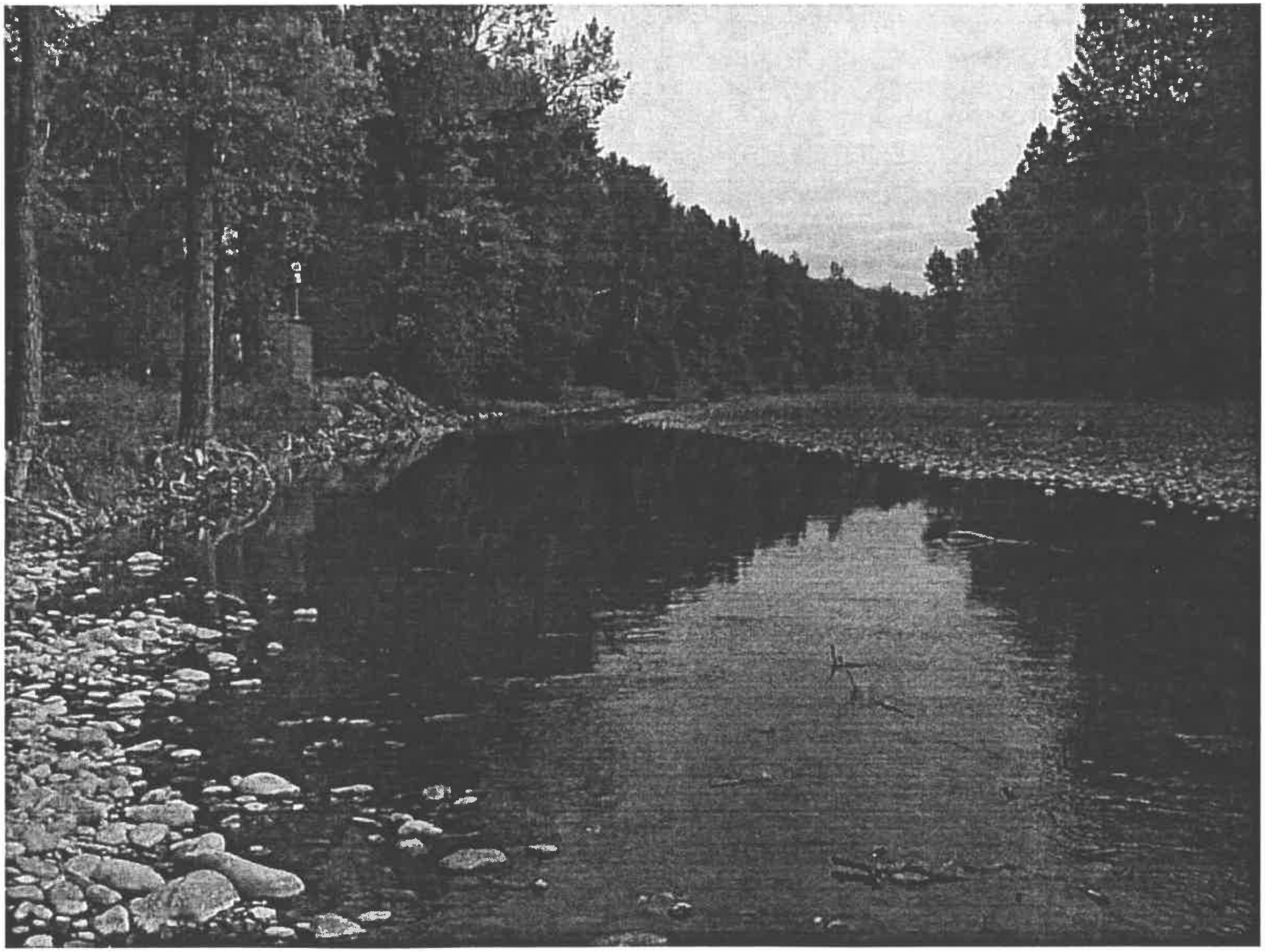


Figure 10
MODFLOW Model for Used for Teanaway River Simulations

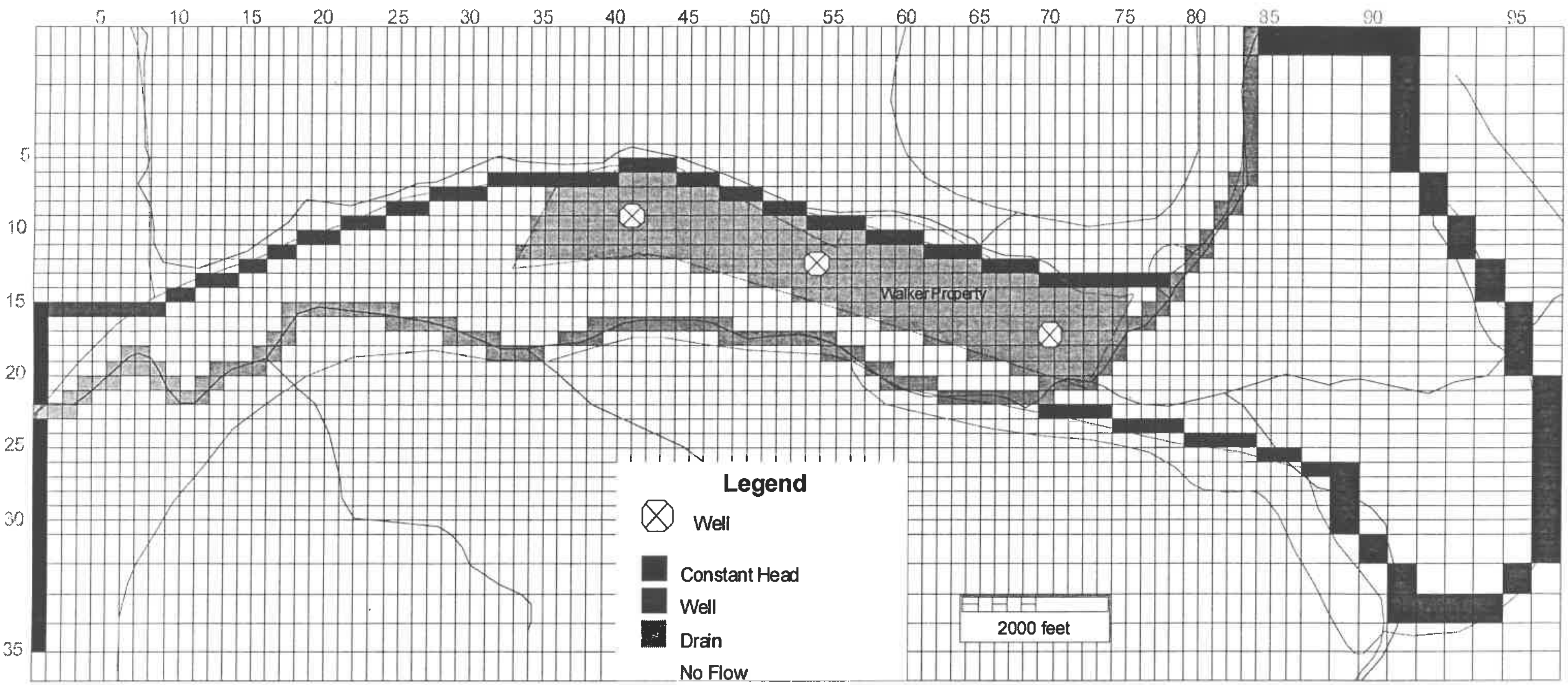


Figure 11
Predicted Rates of Irrigation Recharge vs. Stream Inflow for the Hydraulic Continuity Model Scenarios

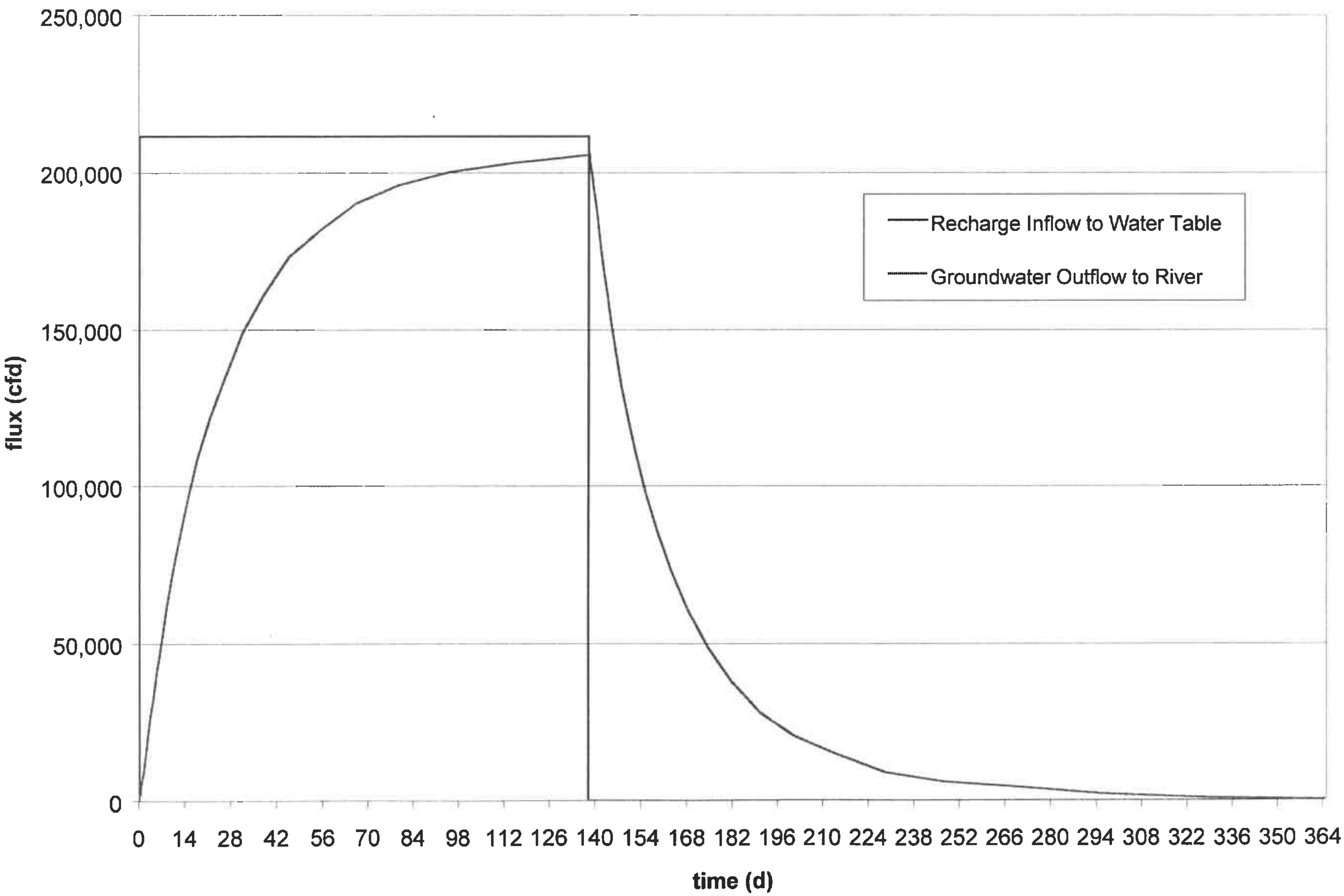
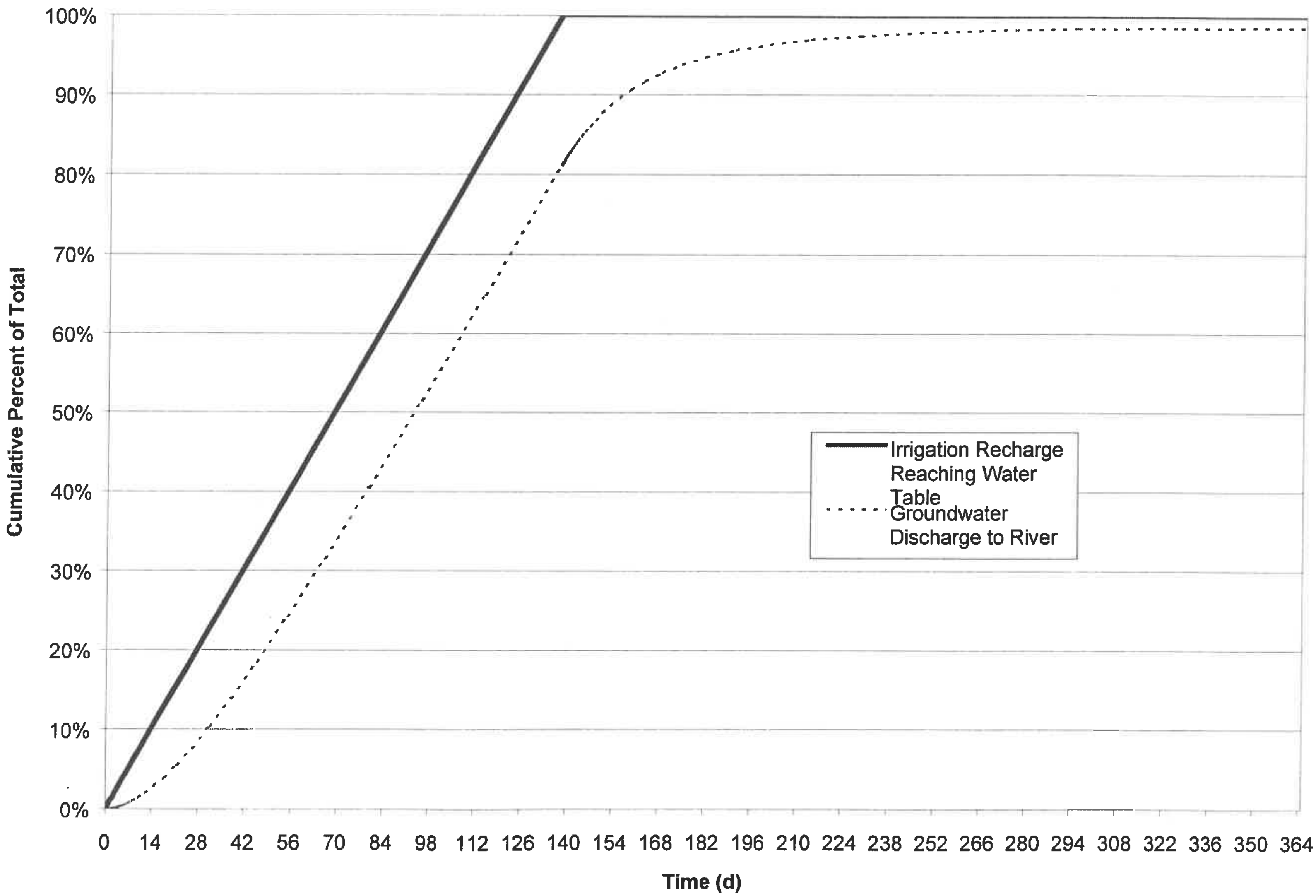


Figure 12
Predicted Cumulative Percent of Irrigation Recharge vs. Stream Inflow for the Hydraulic Continuity Model Scenarios



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Technical Memorandum

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From: Peter Schwartzman, Associate Hydrogeologist, PGG
Chrysten Root, Geologist/Hydrologist, PGG

Re: **FIRST AND SWAUK CREEK BASIN HYDROLOGIC ANALYSIS**

Date: January 24, 2002

The purpose of this analysis is to estimate how Trendwest's proposed transfer of the former Hartman and First Creek Water User's Association (FCWUA) irrigation water rights into the Yakima Basin Trust Water Program (the Trust) will affect streamflows. This memorandum describes how that transfer to the Trust is likely to affect streamflow in the First Creek and Swauk Creek tributary system down to the Yakima River. The results of this analysis will be used as one set of inputs to a separate model developed by Brown and Caldwell (B&C). That model will simulate results of the combined Trendwest Master Plan Resort and Urban Growth Area water demand schedule and water right transfers on the Yakima River basin, from upstream of the Cle Elum River confluence downstream to the Reecer Creek confluence.

The former Hartman water rights proposed for transfer to the Trust were used for irrigation in the fields adjacent to Swauk Creek in the Hidden Valley area. Water diverted under the Hartman rights was either consumed by evaporation and evapotranspiration, or returned to the tributary system and the Yakima River as non-consumptive irrigation return. Changes in streamflow relative to pre-existing conditions would result from the cessation of irrigation withdrawals. Water would no longer be diverted, ending consumptive losses and non-consumptive irrigation returns from fields. Irrigation returns are delayed in time between diversion and return as groundwater discharge to streamflow. Terminating the Hartman diversion would increase overall flow availability in Swauk Creek by the former quantity of consumptive use, and would change the temporal pattern of streamflow. Swauk Creek streamflows would increase during portions of the year when former diversions exceeded former return flows, but would decrease when former return flows exceeded diversions.

First Creek, a tributary to Swauk Creek, has water diverted to irrigation in the Reecer Creek Basin through the First Creek Water Users Association (FCWUA) ditch. Trendwest proposes to transfer its FCWUA irrigation rights to Trust, thus leaving approximately 56 percent of the historic FCWUA diversion in First Creek and increasing flow in both First and Swauk Creeks. Irrigation return flows from fields supplied by the FCWUA ditch historically remained in the Reecer Basin, and did not return to First Creek. The proposed FCWUA transfer would result in increased First and Swauk Creek flows amounting to Trendwest's entire FCWUA water right, including the former consumptive and non-consumptive (return flow) portions. The effects of Trendwest's proposed transfer of First Creek FCWUA water rights on flows in the Reecer Creek basin is analyzed separately in the Reecer Creek Basin Hydrologic Analysis (PGG, January 2002).

For the purpose of this analysis, Ecology's Consulting Team (ECT) estimated changes in streamflow by evaluating two elements of the flow system: subsurface return flow and alluvial subflow. Subsurface return flow is the non-consumptive portion of irrigation lost to seepage from ditches and fields that returns to the stream via a groundwater pathway. Alluvial subflow occurs when a portion of the newly added streamflow seeps into alluvial sediments along the stream channel, and travels through a subsurface pathway on (all or part) of its way down to the Yakima River. Alluvial subflow is usually significantly slower than streamflow, which also affects when the diversions transferred to the Trust would reach the Yakima River.

This memorandum evaluates and describes the following as part of the First and Swauk Creek hydrologic analysis:

- Hydrogeologic conditions in the First Creek and Swauk Creek subbasins;
- Streamflow hydrographs from First Creek and Swauk Creek,
- Streamflow gains from and losses to groundwater, and the hydraulic continuity between surface water and groundwater in the two subbasins;
- Consumptive use and non-consumptive recharge (ditch losses and field losses) associated with historic irrigation practices; and,
- Water-right availability relative to observed or estimated streamflows.

A vicinity map of Swauk Creek is presented in **Figure 1**. The map shows surficial geology and the locations of roads, streams, stream gages, identified wells and test pits.

1 Summary of Findings

1. Hydrogeologic data for Hidden Valley and downstream portions of Swauk Creek are limited in their ability to characterize the groundwater flow system and its interaction with Swauk Creek. Only four wells could be located on the Hidden Valley floodplain, and the relationship between groundwater and surface water is poorly defined along lower reaches of Swauk Creek. This analysis provides our best estimation of the groundwater and surface-water flow systems, but the uncertainty associated with this characterization should be considered relatively high. For this and all other memoranda on the tributary basins, the best prediction for hydrologic changes is identified along with a reasonable range about that best estimate to establish a reasonable range of uncertainty.
2. Geologic logs from two of the four Hidden Valley wells, along with conversations with a locally experienced well driller, suggest the presence of a shallow alluvial aquifer below the

valley floodplain. For the purpose of analysis, the presence of this aquifer was assumed, as was its capability to transmit recharge from natural rainfall and irrigation seepage losses.

3. Streamflow data were collected on Swauk and First Creeks between 1998 and late October 2001 by Tom Martin (Brown & Caldwell) and Montgomery Water Group (MWG). The data indicate that Swauk Creek gains groundwater from just upstream of First Creek to approximately 0.8 miles downstream. Further downstream, Swauk Creek loses water over an intermediate reach and then is likely to gain water as it approaches a bedrock constriction in the Hidden Valley. The geographic extent of the intermediate (losing) reach is not well known, and may vary over the course of the year.

4. Flow data also reveal that First Creek loses flow to groundwater close to its mouth. The majority of First Creek seepage loss to alluvial subflow is believed to return to Swauk Creek in the gaining reach immediately downstream of the confluence, although portions may recharge the creek at locations further downstream[1].

5. Historic streamflow diversions associated with Trendwest's Hartman water rights were estimated to range from 0.3 to 2.6 cfs over the irrigation season. Seepage losses associated with irrigation inefficiencies were estimated to range from 0.2 to 1.8 cfs over the irrigation season, and were assumed wholly infiltrated into the alluvial aquifer. These non-consumptive seepage losses are heretofore referred to as "irrigation recharge".

6. A groundwater flow model was constructed to estimate the historic return flow schedule of the irrigation recharge from fields irrigated by the former Hartman water rights, and to predict the future return flow schedule for alluvial subflow generated by increased First Creek flows associated with the proposed FCWUA transfer. The model was used to constrain uncertainties about the hydraulic properties of the alluvial aquifer, and sensitivity analysis was used to address uncertainties about hydraulic properties of the Swauk Creek streambed and locations where hydraulic continuity between the stream and the alluvial aquifer are likely to occur.

7. Model simulations of Hartman irrigation recharge showed that most of the reasonable combinations assumed for key variables resulted in a well-grouped set of subsurface return flow schedules. Subsurface return flow estimates are highest towards the end of the irrigation season, lowest at the start of a new irrigation season, and suggest a year-round component of groundwater discharge to Swauk Creek. While the year-round component is estimated to be approximately 0.2 cfs, the seasonal component is estimated to reach a maximum of 0.9 cfs.

8. On Lower First Creek, seepage loss associated with the proposed FCWUA transfer was estimated to range from about 0.4 to 0.8 cfs out of a proposed transfer to instream flow ranging from about 1.1 to 5.2 cfs. Model simulations predict that this addition to alluvial subflow will return to Swauk Creek under a relatively rapid return schedule due to occurrence of hydraulic continuity in a 0.8-mile reach downstream of the First/Swauk Creek confluence.

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[1] Seepage loss is defined as infiltration of water from above the land surface to below the land surface. For instance, water flowing within a stream channel or applied to fields as irrigation can seep into the subsurface and recharge the groundwater flow system. Seepage loss remains in the hydrologic system, but is transferred from surface water to groundwater.

9. Analysis of in-stream seepage losses to alluvial subflow, associated with the proposed Trendwest transfer, was based on limited data and related inference on seepage loss as a function of streamflow. The analysis suggests that seepage loss from Swauk Creek is likely to vary from several tenths of a cfs to just over 1 cfs between low- and high-flow conditions. Based on this analysis, seepage losses to alluvial subflow associated with Trendwest's proposed water-right transfer are expected to range from 0.01 to 0.08 cfs. These seepage losses are considered to be insignificant relative to estimates of the amount of water Trendwest proposes to transfer to instream flow.

10. Net changes in streamflow resulting from Trendwest's transfer to the Trust can be calculated for any period of time from estimations of subsurface return flows and the estimated water available for transfer back into the stream during that period. For the proposed Hartman transfer, estimates for the first 15 weeks of the irrigation season show an increase in streamflow ranging from 1 to 2 cfs. Due to an abrupt reduction in streamflow availability and thus the historic Hartman diversion in late July, net streamflows are reduced during the middle 9 weeks of the irrigation season because predicted non-consumptive return flows from earlier in the irrigation season exceeded diversions during this period. Water availability increases at the end of the irrigation season, and thus the proposed transfer to the Trust would increase streamflows during this period because diversions historically exceeded return flows. The net increase in flow estimated over the final 4 weeks of the irrigation season is predicted to range from 0.05 to 0.9 cfs. After the irrigation season, streamflows would be reduced by between –0.63 cfs immediately following the end of irrigation to –0.2 cfs prior to the beginning of the next season, because of the effect of eliminating non-consumptive irrigation return flow pathways in favor of transfer to instream flow during the irrigation season.

11. The proposed FCWUA transfer will increase flows in First and Swauk Creeks during the irrigation season. When combined with predicted effects of the Hartman transfer, increased flows from the FCWUA transfer are estimated to offset the mid- irrigation season flow reductions discussed above. While the cumulative affect of the two transfers results in increased flows in both creeks throughout the irrigation season, flow reductions from discontinued subsurface return flows are not significantly offset outside of the irrigation season.

2 Hydrogeology of First Creek

Geologic maps show First Creek predominantly flows through a narrow, bedrock-confined valley. However, in the final mile upstream of its mouth, the valley widens and the creek flows over alluvial sediments, portions of which were deposited by both First Creek and Swauk Creek. The 1:100,000 surficial geology map shows that First Creek flows across the Rosslyn Formation (lower member) conglomerate and pebbly sandstone for two miles below the First Creek Water Use Association (FCWUA) diversion ditch (Tabor, et. al.). Downstream of the conglomerate, the creek flows across a patch of landslide debris and then over Teanaway basalt. The creek continues flowing over basalt until it reaches its own alluvium (and eventually the Swauk Creek alluvium) approximately one mile above its mouth. The Swauk Creek alluvial valley is significantly wider than First Creek's, and is also likely to be deeper.

In the upper reaches of First Creek, existing alluvium is likely to be shallow and well confined by the bedrock. Its capacity to transmit subsurface flow is defined by its thickness, lateral extent, permeability and hydraulic gradient. Field reconnaissance of lower First Creek revealed that existing alluvium is fairly coarse grained, but can also include fractions of lower permeability silty materials. Measurement of seepage loss in First Creek during a September 1999 test indicates that the alluvium has capacity to store and transmit water. The "First Creek Test" started at a nearly dry streamflow condition and increased flow at the point of diversion from 0.3 to 2 cfs. Portions of the newly released flow were lost to alluvial storage and later drained back into streamflow. However, the narrow bedrock valley limits the amount of water that can be lost from the stream to alluvial subflow. A higher potential for alluvial subflow exists near the confluence of First Creek and Swauk Creek where the alluvial fill is more extensive and the valley less confined by bedrock. Historic placer mining operations along Swauk Creek near its confluence with First Creek suggest that the alluvium is largely composed of gravel in this vicinity[2]. PGG observed a hand dug well along First Creek just east of Highway 97 that was reportedly constructed entirely in alluvial gravels.

3 Hydrogeology of Swauk Creek

In order to assess and understand the hydrogeology of Swauk Creek, ECT obtained all well logs on record with Department of Ecology and evaluated those located in Sections 27, 28, and 33 (Township 20 N, Range 17 E). ECT also interviewed a local driller with many years of experience in the area (pers. comm., John Riebe, 2001) and an Ecology Eastern Regional Office hydrogeologist (pers. com., Gene Potts, 2001). Finally, ECT performed field reconnaissance in the area and obtained parcel maps from Mentor Law Group to help locate wells. Our analysis focused largely on the alluvial valley, where irrigation and groundwater/surface-water interactions occur. Very few logs are on record for the area, and some of those available could not be accurately located as in the valley or on the surrounding uplands. Our ability to characterize the geology of the alluvial valley is largely limited to the existing large-scale (1:100,000) geologic map (Tabor, et. al.), discussions with John Riebe, and four well logs that could be reasonably located on the valley floor.

Available geologic mapping (Tabor, et. al.) shows that upper Swauk Creek flows through a narrow alluvial valley underlain by sandstone, conglomerate, and conglomeratic sandstones from the Wenatchee Mountains until approximately 1.5 miles above its confluence with First Creek. From this point down to First Creek, the stream's alluvium is underlain mostly by the Teanaway Basalts. Below the First Creek confluence, Swauk Creek is no longer confined by bedrock. At this point, Swauk Creek opens out into the wide alluvial floodplain of Hidden Valley. Within Hidden Valley, ECT observed exposures of coarse-grained sediments in the near surface layer overlain by several feet of finer-grained soil. At the lower end of the valley, Swauk Creek is again confined to a narrow bedrock canyon where the creek flows through basalt bedrock (Yakima subgroup of the Columbia River Flood Basalts). This canyon (herein referred to as "Swauk Canyon") is about 4 miles long and opens out just above the confluence of the Yakima River. Based on the topographic map, the width of the floodplain within Swauk Canyon varies from approximately 50 to 750 feet.

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[2] Historic placer mining was reported by a resident of the area (pers. com, Irvin Benesh, 2001).

Available well logs and field observations in Hidden Valley suggest that the upper portion (near the First Creek confluence) contains a significant portion of gravel, sand, and other high permeability soils. One well log, located near where Highway 97 crosses Swauk Creek, was completed at 20-feet below land surface after drilling through clay, clayey gravels and cobbles, and clean gravels and cobbles. A second well, hand dug near the confluence of First Creek, was reported by the owner to be completed in alluvial gravels. These well data, combined with a history of placer mining along Swauk Creek in this vicinity, suggest that the alluvium is coarse-grained in texture. The coarse-grained materials could represent a local alluvial fan immediately downstream from where Swauk Creek emerges from its bedrock constriction, or could suggest the texture of alluvium in other portions of Hidden Valley.

Farther downstream, near Lauderdale Junction, four well logs could be associated by parcel ownership to locations on the east side of Swauk Creek. Only one of these wells is located on the valley floor, and reports 25 feet of "cemented cobbles" underlain by 90 feet of blue-gray clay with occasional gravels and sandstone bedrock. The cobbles likely represent streamside alluvium whereas the clay likely represents the glacial materials in which the valley has eroded. Alluvial materials in Hidden Valley are typically underlain by glacial deposits, which are further underlain by consolidated sedimentary or basaltic bedrock (pers. comm., Riebe, 2001). The glacial materials typically show an abundance of clay, but can also include gravelly, water-bearing zones (ibid.). Farther downstream, near the area where Hidden Valley opens to its maximum width, an additional well was drilled to 161 feet and abandoned for lack of water. While the exact location of the well is unknown, the log shows clay and gravel, clay, and sand and gravel down to a depth of 40 feet predominantly underlain by clay to the bottom of the boring. The driller did not believe that the 40-feet of alluvial deposits could yield sufficient water for the owner. According to Holly Duncan of the Kittitas County Department of Environmental Health, the owner chose to drill three wells on the adjacent hillside to obtain the required water supply (pers. com., Duncan, 2001). No additional well logs were encountered on the valley floor; however, John Riebe reports that hand dug wells on the valley floor were historically used by residents (pers. comm., Riebe, 2001).

Well logs were unavailable in the lower portion of Hidden Valley and in the alluvial valley of Swauk Canyon. Hidden Valley becomes narrower downstream of the abandoned well, and any alluvial aquifer present in the Swauk Canyon is likely very limited in both width and depth. Relative to the constrained floodplains of upper Swauk Creek, First Creek and Swauk Canyon, the highest potential for alluvial groundwater storage is likely to occur within Hidden Valley. While development of a well-documented conceptual hydrogeologic model of Hidden Valley is limited by the scarcity of well logs, available data do suggest the presence of a shallow alluvial aquifer along the creek. Aquifer permeability likely varies from relatively high in areas where subsurface gravels and cobbles occur absent of silt or clay, to relatively low where silt and clay are abundant.

The alluvial aquifer is likely to exhibit hydraulic continuity (a saturated hydraulic connection) with Swauk Creek in portions of Hidden Valley. Data suitable for evaluating this hydraulic connection were very sparse. A soil test pit located about 10 feet from Swauk Creek, approximately 2000 feet downstream of Highway 97 (**Figure 1**), was visited by Andy Kindig on July 18, 2001 and by ECT on September 27, 2001. The pit showed an alluvial groundwater level about 2 to 2.5 feet below Swauk Creek in both cases, thus indicating lack of hydraulic continuity in its vicinity between mid and late summer. Both the bottom of the test pit and the streambed were observed to be quite cobbly, but the hydraulic disconnect between the two suggests that water is retained in the stream due to lower permeability streambed materials. Groundwater levels relative to the creek at other locations in Hidden Valley are unknown; however, it stands to reason that hydraulic continuity will occur near the bottom of the valley where shallow bedrock forces groundwater flow from the alluvial aquifer into the stream. Groundwater flow modeling (discussed in Sections 7 and 8) suggests that groundwater levels likely drop in the vicinity of the test pit because the wider valley requires less aquifer thickness to conduct subsurface flow. Modeling further predicts that the aquifer thickness will increase (causing water levels closer to the land surface) farther downstream where the valley narrows. The following two sections discuss gains and losses and hydraulic continuity along First and Swauk creeks.

4 First Creek Streamflow and Hydraulic Continuity Analysis

Flow data from First Creek were collected by Tom Martin as monthly spot measurements between 1998 and 2000, and continuously during the 8-day "First Creek Test" in 1999. First Creek flow data were also collected by Montgomery Water Group (MWG) as both spot and continuous measurements during the summer of 2001. Tom Martin collected spot data at three locations on First Creek: downstream of the FCWUA diversion dam, upstream of highway 97, and at the confluence of First and Swauk Creeks. MWG collected streamflow data at two gaging sites: one downstream of the FCWUA diversion ditch, and the second at a point approximately 0.5 miles upstream of the confluence with Swauk Creek (shown on **Figure 1**). Data collected from the FCWUA diversion ditch by both Tom Martin and MWG (concurrent with measurements taken below the diversion) were used to estimate flows above the diversion **(Figure 2)**. While limited over time, the data show flows in First Creek ranging from a maximum of almost 50 cfs during the Spring freshet, to a minimum of approximately 1 cfs in August and September. Tom Martin provided an estimated "representative" historic hydrograph for streamflow above the diversion **(Figure 2)**. His flow estimates are based on regression analysis with Teanaway River streamflow, and represent an average (e.g. non-drought) year. Monthly values derived from these flow estimates were used for various aspects of the analyses presented herein[3].

ECT evaluated gains and losses on First Creek during low-flow months based on MWG's 2001 data and observations from the 1999 First Creek Test[4]. Spot measurements taken at the two MWG gaging sites do not show any consistent pattern of flow gain or loss from the creek over this reach **(Figure 3)**. The difference between measurements at the two gages ranged between 0.0 cfs and 0.2 cfs, suggesting that any observed difference in flow could be associated with measurement error. The continuous data collected from these gages show a more constant pattern of seepage loss between the two gages **(Figure 3)**, however this difference is again within the measurement error of the gages and the associated rating curves, and is not a definitive observation of actual flow losses. Because seepage loss at low flows is within associated

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[3] The flow estimates were generated with a prior version of Brown & Caldwell's regression-based streamflow prediction model (Tom Martin, pers. comm., 10/6/01) and are sufficient for use in the analyses presented in herein.

[4] The test involved the removal of an upstream diversion to release a 2 cfs pulse of water into the creek system. Alterations to the diversion were periodically made by outside parties resulting in a test that consisted of a series of pulses and lags.

measurement error and is also relatively small, the data collected during the 2001 sampling period do not suggest that loss to alluvial subflow has appreciable effect on the water budget for this reach. Given the bedrock confinement and limited extent of alluvial deposits along the reach, it is reasonable to expect that a prolonged input of additional water (such as Trendwest's proposed water rights transfer) will not exhibit much loss to alluvial subflow between the diversion dam and MWG's downstream gage.

ECT also evaluated gains and losses on First Creek during high-flow months based on spot measurements by Tom Martin. These data show large gains in flow between the FCWUA diversion and the mouth of First Creek during the winter months, and smaller gains during April and May **(Table 1)**. The data suggest that during the early irrigation season, net seepage losses are negligible over the entire stream length (although localized areas of streambed seepage may exist).

Table 1: Tom Martin's First Creek Spot Measurements (High Flow Conditions)

	March-99	April-99	May-99	June-99	March-00
First Creek Downstream of FCWUA Diversion	0.17 cfs	0.55 cfs	20.1 cfs	3.7 cfs	6.2 cfs
First Creek at Mouth	12.1 cfs	10.7 cfs	27.5 cfs	11.4 cfs	9.36

In the middle-to-late irrigation season, seepage loss from First Creek to the surrounding alluvium appears to occur below MWG's lower gage. During the late irrigation season, when flows were not high enough to be accurately measured at the mouth, MWG observed that when flow at the lower gage was approximately 0.5 cfs, flow at the mouth was approximately 0.2 cfs. Data from the First Creek Test can also be used to evaluate seepage losses on this lower reach. Streamflows were measured continuously at several locations along the creek. The "diversion" gage was located near MWG's upstream gaging site, the "bridge" gage was located near MWG's downstream gaging site, the "waters end" gage was located half way between the bridge site and the "mouth" gage, which was located at the confluence of First and Swauk Creeks. Flow measurements taken during the First Creek Test suggest that about 0.6 cfs is lost to alluvial subflow when flow at the "bridge" gage is on the order of 1.5 cfs. A hydrograph of seepage losses measured below the "bridge" gage during the First Creek Test is presented on **Figure 4**. The hydrograph shows an asymptotic decline of seepage loss to about 0.6 cfs, which occurs as the alluvium near the stream is resaturated by the added streamflow. Once this period of "rewetting" is completed, seepage loss appears to stabilize into a steady state of about 0.6 cfs.

In order to analyze gains and losses in Swauk Creek streamflow later in this memorandum, ECT required estimates of stream inflow from First Creek at its mouth. To estimate the amount of seepage loss near the mouth of First Creek, ECT employed estimates from the First Creek Test, MWG observations, and analysis of channel cross-sections surveyed by Tom Martin. As discussed above, two seepage estimates were available during low-flow conditions: loss of 0.3 cfs at a flow of 0.5 cfs, and loss of 0.6 cfs at a flow of 1.5 cfs. In order to estimate seepage loss during high flows, ECT compared the amount of wetted channel perimeter and the amount of hydraulic head over the streambed, estimated during low flow and high flow conditions. To make this comparison we looked at photographs of the channel between MWG's lower gage and the mouth (taken at flows of approximately 2 cfs), as well as at a channel cross-section surveyed by Tom Martin at the mouth when the flow was 27.5 cfs. In the portion of the channel near

MWG's lower gage the channel is wide and flat, so increases in flow will result in large increases in wetted channel perimeter but only negligible increases in hydraulic head. At this location, we estimate that when flows are increased from 2 to 25 cfs the wetted perimeter will increase by a factor of 4. Since increases in hydraulic head are negligible, this would likely correlate to a 4-fold increase in seepage loss. Further down the channel, near Highway 97, the channel is still wide, but the banks are steeper and the channel somewhat more confined. In this reach we estimate that an increase in flow to 25 cfs would result in a 2-fold increase in wetted perimeter, and the hydraulic head would increase by a factor of 1.5. This suggests that net seepage would likely increase by a factor of 3. Near the mouth of First Creek the channel is narrow with steeper banks. Increases in flow in this reach will result in large increases in hydraulic head, but only negligible increases in wetted perimeter. At 2 cfs, we estimate the average water depth in the channel to be 0.2 ft. The cross-section that Tom Martin surveyed at a similar location when the flow was 27.5 cfs shows an average water depth 0.6 ft. This suggests a 3-fold increase in seepage at this location. Based on these estimates we will assume that an increase in flow from 1.5 cfs to 25 cfs at MWG lower gage will result in a 3-fold increase in net seepage, or a seepage loss of 1.8 cfs. The estimated relationship between streamflow and seepage loss between MWG's lower gage and the mouth is presented as a best-fit logarithmic curve on **Figure 5**.

5 Swauk Creek Streamflow and Hydraulic Continuity Analysis

Flow data from Swauk Creek were collected by Tom Martin as monthly spot measurements between 1998 and 2000, and by Montgomery Water Group (MWG) as both spot and continuous measurements in the summer of 2001. Tom Martin collected data at two locations on Swauk Creek: upstream of the confluence with First Creek, and at the mouth. MWG collected streamflow data at the same two locations as well as at the Martin Property. The upstream and Martin gaging station locations are shown on **Figure 1**. Although limited in time, the data collected above the confluence with First Creek reveal that flows in Swauk Creek exhibit significant variation. Flows during the spring freshet in 1999 were estimated as high as 225 cfs, whereas flows during the 2000 freshet were considerably lower. From these data, ECT derived a "representative hydrograph" for Swauk Creek above the confluence with First Creek **(Figure 6)**. The hydrograph assigns less weight to the 1999 freshet data due to an associated unseasonably wet winter, and should only be construed as a best available representation given the (limited) existing data. The hydrograph suggests that typical flows during the spring freshet reach a maximum of about 100 cfs but generally drop to 1-2 cfs in the late summer. As a result, flows in the late summer are heavily influenced by the amount of water discharged from First Creek into Swauk. **Figure 7** shows that below First Creek, late summer flows in Swauk Creek (calculated by adding estimated flows at the First Creek mouth to concurrent Swauk Creek measurements upstream) ranged from about 1.7 to 3.6 cfs.

To evaluate whether significant flow losses from Swauk Creek occur in the Hidden Valley region, ECT analyzed gains and losses in flow between MWG's gaging sites. The flow measurements taken above the confluence with First Creek were combined with the estimated flow contributions from First Creek (MWG data minus the seepage loss estimates described in Section 3), to derive an estimate of the flow in Swauk Creek below its confluence with First

Creek[5]. However, between the confluence with First Creek and the Martin gage, an additional tributary flows into Swauk Creek that has not been gaged. Limited visual observation by MWG during the summer of 2001 suggested that tributary flow did not commonly exceed 0.25-0.50 cfs, except possibly during rainstorm events. The tributary was observed to go dry in early July, 2001. In addition, the Burke diversion ditch is located between the two gages (return flow from the Burke diversion enters Swauk Creek below the Martin gage). The maximum instantaneous water right (Qi) from this diversion is 4.25 cfs, although only 2.25 cfs is available after June 15 in a typical water year[6]. Actual use of this water right could not be determined due to property access limitations. Areal photographs of area taken on August 11, 2001 suggest that approximately 50 of the allowable 100 acres were being actively irrigated from the Burke diversion.

The year-2001 flow curves derived from the Upstream and Martin Property gages show this reach to be gaining from May through mid July **(Figure 8)**. After mid July, a drop in flow occurs at the Martin gage, making the reach appear to be losing water from mid-July through September. Since the magnitude of the inputs and outputs of water to Swauk Creek in this reach are not known, exact calculations of streamflow gains and/or losses cannot be performed. However, interpretations of the curves should consider the additional inputs and outputs to the stream. Even if the ungaged tributary adds 0.5 cfs throughout May, June, and early July, gains between the upstream and Martin gages are still observed for this period. In addition, the Burke diversion ditch was probably active during portions of this period, which would also increase the observed gain. For the period from mid July through September, the flow curves suggest the channel is losing water between the gages. This loss is likely attributed to irrigation diversion from the Burke ditch rather than seepage. In the time-series plot, the shift from a gaining to a losing reach occurs on July 14 when a 1.8 cfs drop in flow is observed at the lower gage. The 15-minute continuous flow data show that this drop in flow occurred over a 3-hour period. Since 1.8 cfs is less than the water right owned by Mary Burke, this drop likely resulted from a change in the amount of diversion at the Burke ditch.

These data suggest that no net seepage loss occurred on this reach of Swauk Creek during the summer 2001 monitoring season, and that seepage gains occurred in early summer and may have continued through the mid- to late- irrigation season. If gaining conditions occur, the likely source is alluvial subflow along portions of Swauk and First creeks immediately upstream. Several interpretations can be formulated to explain the gaining behavior as follows:

1. Spatial variations in the thickness of streambed alluvium can cause variations in measured streamflow;
2. A local drop in stream elevation could allow the stream to cut deeper into saturated alluvial deposits and gain additional groundwater; or,
3. If alluvial fan sediments exist immediately downstream of where Swauk Creek emerges from bedrock confinement (near First Creek), the gaining behavior could be explained by a change in texture between the fan and downstream alluvium. A transition between more

[5] The remaining discussion in this section pertains to the combined flow estimate.
[6] The total Burke water right is for 4.25 cfs, but 2.00 cfs of that has a priority date junior to other water rights on Swauk Creek.

transmissive fan deposits and less transmissive valley alluvium would force water back into the stream.

Gaining conditions also suggest hydraulic continuity between the alluvial aquifer and Swauk Creek upstream of the Martin gage. However, these gaining conditions are most likely to occur in the upstream portion of the reach. The soil test pit, located about 800 feet downstream of the Martin gage, showed groundwater below the streambed elevation, thus implying no hydraulic continuity and conditions characteristic of a losing stream reach. The location of the transition between gaining and losing conditions is unknown.

From late July to September 2001, flow curves presented on **Figure 9** suggest that the lower reach of Swauk Creek (Martin Property to Mouth) is losing most of its flow. During this time period, the average flow loss between the two gages was 0.4 cfs, and the stream was dry at the mouth from early August through September (except during short-term rainstorm events). However, since the water rights for this reach are greater than the amount of water lost, discerning which portion of the loss is attributed to seepage and which to irrigation diversions is impossible.

ECT attempted to assess seepage gains/losses in the lower portion of Hidden Valley between the Martin gage and the head of Swauk Canyon. In September 2001, MWG performed a seepage survey over a 1.2-mile reach between the Martin gage and the downstream end of the Martin property. Due to the size of the channel substrate and the relatively low flow conditions in September, MWG was unable to accurately gage flows during the study. Observations of flows during the study indicated that about 0.1 cfs of water was present and flowing at either end of the study reach. This suggests that seepage losses under very low flow conditions are minimal, however, these observations cannot be extended to higher flow conditions, since seepage losses may be reduced during low flow periods due to the deposition of silt in the channel bed.

Further analysis suggests that seepage losses during low flow periods can be constrained by comparing measured streamflow with downstream irrigation diversions. Bruce Coe owns a large portion of the water rights for Swauk Creek in the valley. Although he leased most of his rights this summer, he maintained a right of 0.375 cfs. In conversions with Mr. Coe (personal comm., 2001) he indicated that he actively used his water right to irrigate his property on a daily basis from dawn to dusk throughout the 2001 irrigation season. Based on the allocated Qa of 37.5 acre-feet, this irrigation schedule results in an average rate of instantaneous diversion of 0.19 cfs over the entire 6.5-month irrigation season (or 0.28 cfs if most of the diversion is assumed to occur over 4.5 months of the irrigation season between June 1 to October 15). Mr. Coe's statement that he is able to use his entire water right throughout the irrigation season becomes significant for estimating seepage losses in Swauk Creek during the period in which Swauk Creek flows decline to close to the amount of his water right. In order to constrain the maximum amount of seepage loss likely in Hidden Valley during low flow conditions, it can be assumed that only enough water for the Coe irrigation diversion remains instream at his property (located near the downstream end of the valley). In mid August, when flows at the Martin property drop to 0.30 cfs, the maximum possible seepage loss would be 0.11 cfs or 36%, since 0.19 cfs are likely being removed at the Coe diversion. Based on this set of assumptions and data, seepage losses are expected to be less than 36% of August flows since August irrigation rates are likely higher than the season average. For the purpose of analysis, a maximum low-flow seepage loss of 25 percent was assumed.

Few data are available on channel conditions in the lower portion of Hidden Valley during high flows. Relative seepage loss could be increased due to scouring of the channel bed but could also be reduced because stage and wetted channel perimeter do not increase linearly with increases in flow. In order to estimate seepage losses during high flow conditions (up to 130 cfs), MWG evaluated photographs of the channel at flows up to approximately 15-20 cfs, and channel cross-sections surveyed at a variety of flows up to 14.1 cfs. MWG used the cross-sections from low and moderate flows to interpolate average cross-sections for higher flow conditions. These cross-sections were used to estimate the flow parameters that control seepage loss such as the wetted perimeter and hydraulic head (average depth). The estimated cross-section data are presented in **Table 2** (below). Similar to estimates of seepage loss on First Creek, seepage was assumed to increase linearly with both increases in wetted perimeter and increases in hydraulic head. For example, a 2-fold increase in hydraulic head and a 3-fold increase in wetted perimeter would result in a 6-fold increase in seepage. Using the estimates of seepage loss under a variety of flow conditions, a polynomial describing seepage loss was derived (**Figure 10**). This curve was used to estimate the likely additional alluvial subflow associated with Trendwest's proposed water right transfer (Section 9).

Table 2

Estimates of hydraulic parameters for Swauk Creek at the Martin Gage

Cross-sections were solved for using *ManningSolver*

Q (cfs)	TW=WP (ft)	Average Depth (ft)	Increase factor	Estimated Seepage (cfs)
0.3	9.3	0.55	1.0	0.1
14.1	22.0	0.86	3.7	0.3
30.0	24.5	1.16	5.6	0.4
130.0	*35.8*	*2.23*	*15.6*	1.2

Assumptions:

1. Friction slope is the same at high flows as low flows.
2. Right and left banks were extropolated based on field observations of cross sectional geometry at low flows:
   Assumed the right bank is steep and vertical.
   Assumed left bank slope is same as slope of the last few measurements on left bank during low flows.
3. The Manning's n value derived for low flows applies to high flows.
4. The top width approximates the wetted perimeter at the Swauk Creek Martin cross section.
6. Increases in seepage at high flows are proportional to the increase in depth and wetted perimeter.

Downstream of Hidden Valley, other water rights (Qi = 0.334 cfs) are held by Tang that were not leased during the 2001 irrigation season. The actual amount and frequency of use on this diversion is unknown, although aerial photographs from August, 2001 indicate that a portion of the fields located near the Tang diversion was irrigated. Although little seepage loss is expected within Swauk Canyon due to bedrock confinement, the short stream reach below the canyon crosses alluvial deposits of the Yakima River, and may exhibit a higher degree of seepage loss. Any loss that occurs in the Yakima River alluvium is expected to flow rapidly to the Yakima River since Swauk Creek is less than 2,000 feet from the river in this area.

6 Water Use and Water Right Availability

The amount of water that Trendwest can potentially transfer to instream flow is not only dependent on the amount of the purchased water rights, but also on the availability of water in First and Swauk Creeks during the irrigation season. Based on flow data collected by both Tom Martin from the years 1998-2000, B&C estimated a representative hydrograph of First Creek flow (shown on **Figure 2**) and ECT estimated a representative hydrograph for Swauk Creek (**Figure 6**). These representative streamflows were used to estimate historic water use and to develop input for analyzing the timing and relative magnitude or subsurface return flows and alluvial subflow associated with the water right transfers. The historic water use estimates are considered approximate, but sufficient for the analyses contained in this memorandum.

ECT compared the estimates of available instream flow to the amount and priority of existing water rights. On First Creek, the water rights from the FCWUA ditch total 13.9 cfs, and on Swauk Creek, the water rights for the reach below the confluence with First Creek total 14.25 cfs. Based on the existing streamflow data, this amount of water is not available in either of the creeks from early June through the end of the irrigation season, so the availability of water rights is determined by the priority dates of the rights (summarized below on **Table 3**) and actual irrigation requirements (discussed below).

Table 3: Swauk / First Creek Water Rights

Name	Priority	Source	CFS	AF	Acres
FCWUA (Retained)	Nov. 2, 1877	First Creek	2.19	274.12	54.8
FCWUA / Trendwest	**Nov. 2, 1877**	**First Creek**	**2.79**	**348.88**	**69.7**
Burke	June 30, 1878	Swauk via Burke	2.25	589.00	78.4
Hartman / Trendwest	**June 30, 1878**	**Swauk via Burke-Hartman**	**0.89**	**150.00**	**20.0**
Burke	June 30, 1878	Swauk via Burke-Hartman	1.77	297.00	39.6
FCWUA (Retained)	June 1, 1881	First Creek	3.92	639.32	127.8
FCWUA / Trendwest	**June 1, 1881**	**First Creek**	**5.00**	**813.68**	**162.7**
Coe, Bruce	May 24, 1884	Swauk via Coe (N)	1.79	164.00	
Coe, Bruce	May 24, 1884	Swauk via Coe (S)	1.50	112.50	
Tang (Michael Coe, SV Ranch)	May 24, 1884	Swauk via Tang	0.167	80.00	
Hartman / Trendwest	**Sept. 20, 1889**	**Swauk via Burke-Hartman**	**3.34**	**563.00**	**75.0**
Burke	Oct. 31, 1889	Swauk via Burke	2.00	150.00	20.0
Tang (Michael Coe, SV Ranch)	Sept. 21, 1892	Swauk via Tang	0.167	80.00	
Coe, Bruce	Apr. 9, 1901	Swauk via Coe (S)	0.375	37.50	
			28.149	**4,299.00**	

Data from Mentor Law Group. Trendwest Water Rights are shown in bold face type.

The most senior water rights in the basin (1877) are located on First Creek. Of the 4.98 cfs with this priority, Trendwest owns 56%. An additional 8.92 cfs of water rights are held on First Creek that are dated 1881. Trendwest also owns 56% of these junior First Creek rights. Based on the estimated representative monthly flows, instream flows are typically insufficient to meet the entire FCWUA allocated instantaneous diversion throughout the irrigation season (**Figure 2**). MWG estimated historic FCWUA water use based on monthly values of the representative monthly streamflows provided by B&C, estimates of crop water requirements, and estimates of field and ditch irrigation seepage losses. **Table 4** presents MWG's water-use estimates for the average (i.e. non-drought) year. All of the data in **Table 4** were derived from the Montgomery Water Group technical memorandum entitled "FCWUA Ditch Seepage Loss Analysis" (10/12/01), and a copy of this memorandum is attached. Historic diversions for April and May were estimated to be less than available flows based on consideration of crop requirements and

FCWUA's allocated annual water right volume (Qa). In the month of June, historic water use by the junior (1881) water right holders is limited by estimated flow availability. After June, water is estimated to be unavailable to the junior water right holders and flow limited to the senior (1877) water right holders. During the driest portions of the year (August and September) when total First Creek streamflow is on the order of about 2 cfs, only about 1.1 cfs is generally available for Trendwest to leave instream given 56% of the total water right.

Table 4 – Estimated Historic FCWUA Water Use

	Estimated Flow in First Creek[1]	Total Historic FCWUA Diversion	Roan (Sr) and Olson Diversions (Retained)	Nelson and Roan (Jr) Diversions (Trendwest)
Apr	11.7	9.00	3.96	5.04
May	12.5	9.30	4.09	5.21
Jun	7.8	7.80	3.43	4.37
Jul	3.4	3.40	1.50	1.90
Aug	2.1	2.10	0.92	1.18
Sept	1.9	1.90	0.84	1.06
Oct 1-15	2	2.00	0.88	1.12

On Swauk Creek there are three water rights dated 1878 that total 4.91 cfs. Although these rights take priority over the 1881 rights on First Creek, once Swauk Creek flows drop to a level that requires additional flow from First Creek, First Creek flows are not sufficient to provide the additional water. **Figure 2** shows that flows on First Creek are less than FCWUA's 1877 water rights (4.98 cfs) from late June through the end of the irrigation season. As a result, any instream flow in First Creek is likely used to satisfy the 1877 water rights that have priority over all Swauk Creek water rights. Of the 4.91 cfs of water rights dated 1878, Trendwest owns 0.89 cfs (18%). **Figure 11** is a detailed plot of low flow conditions in Swauk Creek (downstream of the confluence with First Creek) from 1998-2000. The 2001 data are not included on the figure because Trendwest's water rights were left instream in 2001, and therefore 2001 flow conditions are not representative of the historical conditions. **Figure 11** suggests that from early July through the end of the irrigation season, less than 4.91cfs typically flows through Swauk Creek, therefore Trendwest may only dedicate 18% of the available water to instream flow. Earlier in the irrigation season, additional water is available for other water rights **(Figure 6)**. Three water rights totaling 3.457 cfs are dated 1884, and Trendwest owns a right for 3.34 cfs dated 1889 that should be available from the beginning of the irrigation season through early June. All other water rights on Swauk Creek have junior priority to the Trendwest water rights.

On Swauk Creek, ECT estimated historic diversions associated with Trendwest's water rights by comparing estimated typical streamflows to typical irrigation requirements along the stream. Irrigation requirements were estimated based on Tom Martin's estimates of typical crop consumptive use (based on the Blaney-Criddle equation and local climatic conditions), and then applying an irrigation efficiency of 33 percent[7]. ECT developed a spreadsheet that took estimated streamflows in Swauk Creek below the First Creek confluence, and removed the estimated water requirements of irrigators in the order of water-right priority. Irrigation

[7] The Report of Referee from the Aquavella water-right adjudication assigns a water duty of 7.5 feet for irrigation on the Burke and Hartman properties, based on a technical report on local irrigation conditions. Blaney-Criddle calculations estimate a crop consumptive use requirement of 2.5 feet, thus implying an efficiency of 33 percent.

diversions were assumed to be taken continuously, in order to maximize the use of available water. **Table 5** presents the results of the analysis:

Table 5 – Estimated Historic Water Use for Hartman Water Rights

Period of Irrigation Season	Historic Water Available Below First Creek	Estimated Irrigation Require-ment	Sr. Burke & Sr. Hartman Historic Irrigation Use	Sr. Coe & Sr. Tang Historic Irrigation Use	Jr. Hartman Historic Irrigation Use	Total Hartman Irrigation Use (Jr. + Sr.)	Total Hartman Non-Consumptive Use (Jr. + Sr.)	Total Hartman Irrigation Use with 2-month Return Flow
April 1-15	130 cfs	0.026 ft/d	1.8 cfs	0.8 cfs	1.0 cfs	1.2 cfs	0.8 cfs	1.2 cfs
April 16-30	110 cfs	0.026 ft/d	1.8 cfs	0.8 cfs	1.0 cfs	1.2 cfs	0.8 cfs	1.2 cfs
May 1-15	45 cfs	0.039 ft/d	2.7 cfs	1.1 cfs	1.5 cfs	1.9 cfs	1.3 cfs	1.9 cfs
May 16-31	25 cfs	0.037 ft/d	2.6 cfs	1.1 cfs	1.4 cfs	1.8 cfs	1.2 cfs	1.8 cfs
June 1-15	20 cfs	0.045 ft/d	3.2 cfs	1.3 cfs	1.7 cfs	2.2 cfs	1.5 cfs	2.2 cfs
June 16-30	14 cfs	0.045 ft/d	3.2 cfs	1.3 cfs	1.7 cfs	2.2 cfs	1.5 cfs	2.2 cfs
July 1-15	10 cfs	0.055 ft/d	3.8 cfs	1.6 cfs	2.1 cfs	2.6 cfs	1.8 cfs	2.6 cfs
July 16-31	4 cfs	0.051 ft/d	3.6 cfs	0.4 cfs	0.0 cfs	0.5 cfs	0.3 cfs	1.2 cfs
Aug. 1-15	3 cfs	0.048 ft/d	3.0 cfs	0.0 cfs	0.0 cfs	0.4 cfs	0.3 cfs	0.5 cfs
Aug. 15-31	3 cfs	0.045 ft/d	3.0 cfs	0.0 cfs	0.0 cfs	0.4 cfs	0.3 cfs	0.5 cfs
Sept. 1-15	3 cfs	0.032 ft/d	2.2 cfs	0.8 cfs	0.0 cfs	0.3 cfs	0.2 cfs	0.3 cfs
Sept. 16-30	4 cfs	0.032 ft/d	2.2 cfs	0.9 cfs	0.8 cfs	1.1 cfs	0.8 cfs	1.5 cfs
Oct. 1-15	5 cfs	0.014 ft/d	1.0 cfs	0.4 cfs	0.5 cfs	0.7 cfs	0.5 cfs	0.7 cfs

The analysis suggests that the historic water use associated with Trendwest's Hartman water rights ranged from 0.3 cfs in early September to 2.6 cfs in early July. The water availability analysis was performed prior to ECT analysis of irrigation return flow, and initial calculations did not include possible return flows to the stream. ECT evaluated the sensitivity to return flow with the same spreadsheet, assuming that the non-consumptive portion of the irrigation requirement returns to the stream after a 2-month time lag. Estimates of historic Hartman diversions, along with the 33-percent irrigation efficiency, were used to estimate the non-consumptive portion of Hartman's water use. This water was assumed to return to Swauk Creek via subsurface return flow downstream of the Burke-Hartman diversion. **Table 5** shows that estimates of subsurface return flow range from 0.2 cfs in early September to 1.8 cfs in early July. Supplemental consideration of return flow caused minor increases in availability for the Hartman water rights. For the purpose of evaluating the timing and relative magnitude of subsurface return flows and alluvial subflow, consideration of return flow was regarded unnecessary.

7 Construction of Groundwater Flow Model

ECT developed a groundwater flow model of the Hidden Valley area (including the First Creek confluence) to assess:

1. The timing and relative magnitude of former subsurface return flows from irrigation recharge associated with the Hartman water right back to Swauk Creek, and
2. The timing and relative magnitude of future subsurface return flows from First Creek seepage loss to alluvial subflow back to Swauk Creek.

Both assessments were necessary to evaluate the change in streamflow associated with the proposed water rights transfers. The model was constructed using the USGS finite difference code "MODFLOW" and the graphical user's interface "Groundwater Vistas". The assumptions used to design the model are consistent with the elements of the conceptual hydrogeologic model presented in Sections 2 through 5. The most significant model design assumptions were that the following:

- An alluvial aquifer exists that is capable of conducting both natural and irrigation recharge down-valley and back to the stream;
- The majority of groundwater flowing through Hidden Valley discharges back to Swauk Creek upstream of the Swauk Canyon (i.e. upstream of the bedrock constriction);
- Narrowing of Hidden Valley below the (former) Hartman property may also cause groundwater to discharge to Swauk Creek;

Uncertainties identified in the conceptual model were evaluated with the groundwater flow model by performing constraining analyses and uncertainty analyses. These analyses evaluated reasonable ranges of aquifer permeability (or transmissivity), streambed conductance, and the location(s) of hydraulic continuity between the alluvial aquifer and Swauk Creek.

Figure 12 presents an overview of the model design in both map and cross-section view. The active areal extent of the model domain is defined topographically by the "valley floor" and geologically by mapping of the valley alluvium. Thus, the model footprint widens and narrows with the areal extent of the valley. In the vertical dimension, the model included two layers, with top and bottom elevations constructed as sloping planes defined by the average gradient of Swauk Creek over the entire model domain. The top layer is 32 feet thick and the bottom layer is 25 feet thick. The top layer extends above the creek level and is modeled as unconfined; therefore, only a portion of the top layer was saturated and total model saturation varied as a function of location. Constant head cells were positioned at the upstream end of the model at the elevations of First and Swauk Creeks. The fluxes out of these cells were extracted from the model under steady-state simulation, and their values were used to convert the constant head cells into specified flux cells (shown in red on **Figure 12**). For the purpose of simplicity, Swauk Creek was represented as a "drain" with bottom elevation defined based on stream elevations shown on the topographic map. Drain cells allow water to flow *into* a simulated surface-water feature (e.g. gaining conditions on a stream), but do allow losing conditions from the stream. Areal recharge was not simulated, as the purpose of the analysis was to use superposition to evaluate the timing and magnitude of subsurface irrigation return flows. Aquifer specific yield was assumed to be 0.25.

7.1 Constraining Analyses

Aquifer permeability (K) was estimated by using the model as a constraining tool to evaluate various possibilities. The two constraining criteria employed were the following:

1. Model predictions of groundwater level mounding from irrigation recharge should not exceed the estimated thickness of the unsaturated zone below the Hartman field, which was measured with a hand level to be about 7 or 8 feet near the upstream end of the property; and
2. Model predictions of total flux through the valley alluvium should be sufficient to accommodate 3 in/yr of areal recharge (approximately 0.44 cfs of valley through-flow) with

extra capacity for other sources of recharge, such as recharge from groundwater subflow along the edges of the valley and upstream seepage losses from First and Swauk Creeks.

The constraining analyses simulated historic Burke and Hartman irrigation of the west side of Swauk Creek, with the assumed initial condition being observations made in 2001 (when Burke was irrigating on the east side of the creek). Hydraulic continuity, discussed later in this section, was assumed to occur though out the reach extending from the southern end of the Hartman property downstream. Groundwater levels were initially assumed to occur about 2.5 feet below the streambed near the soil test pit (**Figure 1**); however, simulated irrigation recharge mounded groundwater levels sufficiently to cause hydraulic continuity with the stream. The constraining models were run in transient mode to simulate a one-year period with an 198-day irrigation season. Initially, a K range of 30 to 3000 feet per day (ft/d) was considered. However, 30 ft/d was eliminated because calculated steady-state flux through the valley during the pre-irrigation condition was only 0.3 cfs and predicted groundwater mounding exceeded 8 feet (thus "swamping" the field). A K value of 100 ft/d was chosen as a lower end for the simulated K value because it allowed about 1 cfs to pass through the valley as steady groundwater flow, and showed up to 7 feet of estimated mounding. **Figure 13** shows a map of mounding and a hydrograph at various observation points developed in our predictive simulations using a K value of 100 ft/d (predictive simulations are discussed later in this section). Locations of the observation points are shown on the mounding map. A K value of 500 ft/d caused mounding from irrigation recharge up to 3 feet (over a wider area than the K=100 ft/d simulation), and allowed about 5.2 cfs of subsurface flow through the modeled valley. This K value translated to a transmissivity value of nearly 200,000 gallons per day per foot (gpd/ft). Both the transmissivity and the steady flow capacity associated with 500 ft/d were considered to be upper limits for the Swauk Valley system. **Figure 14** presents a mounding map and hydrographs associated with the K=500 ft/d simulations.

ECT's constraining analysis also addressed the effect of streambed conductance on predicted mounding. ECT evaluated streambed permeability (K') values of 1, 10 and 30 ft/d over various values of aquifer permeability. The constraining analysis showed that predicted mounding from irrigation recharge was not very sensitive to K'. Additional sensitivity analysis to K' was performed when running the predictive models for subsurface return flow, and showed that modeled return-flow schedules to the stream were only mildly sensitive to K'. Calculations presented on **Table 6** indicated that a K' value of 1 ft/d supports low flow seepage losses on the order of about 0.15 cfs/mile and high-flow seepage losses on the order of 1.2 cfs/mile. These values are consistent with the estimates of Swauk Creek seepage loss discussed in Section 5. A K' value of 1 ft/d was used in all models except on one sensitivity run.

Table 6 – Estimates of Streambed Seepage Under Low and High Flow Conditions

	Low Flow	Low Flow	Low Flow	High Flow	High Flow	High Flow
Length of Losing Channel (miles)	1	1	1	1	1	1
Wetted Perimeter (ft)	2	2	2	10	10	10
Head Over Channel Bottom (ft)	0.2	0.2	0.2	1	1	1
Thickness of Streambed Skin (ft)	1	1	1	1	1	1
Gradient Across Streambed Skin (ft/ft)	1.2	1.2	1.2	2	2	2
Streambed Permeability (ft/d)	1	10	30	1	10	30
Seepage Rate (cfs)	0.15	1.5	4.4	1.2	12	37

8 Analysis of Former Subsurface Return Flow from Hartman Irrigation Applications

The model was run to predict the timing of subsurface irrigation return flows using K values of 100 ft/d to 500 ft/d and a K' value of 1 ft/d. The model was first run in steady-state mode without any irrigation recharge from the former Hartman diversion. The model was then run in transient mode over a relatively long time period (at least 15 years) to simulate repeated year-after-year application of the Hartman diversion. In this manner, the model achieved a "cyclic steady state" (repeating condition from one year to the next). Hydrographs of groundwater inflow to Swauk Creek resulting from the irrigation recharge were extracted from the model by subtracting transient values of drain outflow from the steady state (pre-irrigation) value.

Model inflows from irrigation recharge were represented by a series of specified flux cells that occupy the footprint of former Hartman irrigation. The discharge rates from these cells were defined over a series of two-week stress periods to provide model inflows equivalent to the estimated irrigation recharge (non-consumptive use values on **Table 5**). Two sets of cells were defined: 42 cells were modeled as irrigated throughout the entire season, and 165 cells were forced to discontinue irrigation between late July and early September. The two groups of cells are shown with blue and green colors (respectively) on **Figure 12.**

Because field information was limited regarding the location(s) of hydraulic continuity between the alluvial aquifer and Swauk Creek, predictive simulations were used to consider the following range of hydraulic continuity scenarios[8]:

1. "Local Hydraulic Continuity" is represented by pre-irrigation continuity as far upstream as the southern Hartman property line. Farther upstream, pre-irrigation conditions specify a streambed elevation as high as 2.5 feet above the water table at the northern end of the Hartman property. During irrigation simulations, local mounding causes hydraulic continuity along the Hartman property, but hydraulic continuity is not permitted beyond 2000 feet upstream of the Hartman property.
2. "Enhanced Local Hydraulic Continuity" is represented by pre-irrigation continuity as far upstream as the southern Hartman property line. Along the Hartman property, pre-irrigation conditions specify a streambed elevation within several tenths of a foot above the water table. During irrigation simulations, local mounding causes enhanced hydraulic continuity along the Hartman property, but hydraulic continuity is not permitted beyond 2000 feet upstream of the Hartman property.
3. "Maximum Hydraulic Continuity" is represented by pre-irrigation continuity along the *entire* length of Swauk Creek, except along the Hartman property where streambed elevations are within several tenths of a foot above the water table. During irrigation simulations, local mounding causes hydraulic continuity along all of Swauk Creek.
4. "No Local Hydraulic Continuity" is represented by pre-irrigation and post-irrigation continuity as far upstream as the southern Hartman property line. No hydraulic continuity is allowed farther upstream.

[8] For the purpose of this analysis, the term "hydraulic continuity" is defined on page 6.

In addition, a single model sensitivity run was performed to evaluate the significance of increasing the streambed conductance to 10 ft/d using the K=100 ft/d, "local hydraulic continuity" model scenario.

Figure 15 presents model predictions of seepage inflow associated with former Hartman irrigation into Swauk Creek under the various simulated hydraulic continuity scenarios. For the first three scenarios listed above, the model showed very little sensitivity to K values and degree of hydraulic continuity. These model predictions suggest that subsurface return flow ranges from about 0.2 to 0.9 cfs, with a year-round component of constant return flow of 0.2 cfs. Assuming local hydraulic continuity, the model exhibited higher sensitivity to streambed conductance. Increasing K' from 1 ft/d to 10 ft/d caused a more rapid response to seasonal irrigation recharge and a faster "flush-through" of the irrigation pulse, but did not significantly affect the predicted year-round component of discharge to Swauk Creek. The model was also sensitive to limiting the capacity for hydraulic continuity to reaches downstream of the Hartman property ("no local continuity"). The K=100 ft/d simulation predicts an almost steady, year-round discharge of 0.5 cfs to Swauk Creek; however, this simulation should be discarded because predicted mounding would surely cause the very same hydraulic continuity disallowed by the model. However, mounding associated with the K=500 ft/d simulation causes hydraulic continuity over a limited portion of the irrigation season, and the K=500 ft/d simulation of no local continuity could be considered a reasonable endpoint for the limited continuity suggested under K=500 ft/d mounding.

Based on the sensitivity analyses performed, limited estimation of streambed conductance, and the general likelihood for local hydraulic continuity suggested by modeling results, ECT recommends using the simulations that allow local continuity at a K' value of 1 ft/d to predict changes in streamflow resulting from the Hartman water right transfer to the Trust. An average of the two "local hydraulic continuity" runs (K=100 ft/d and K=500 ft/d) is presented on **Figure 16**. This is the input recommended as the most reasonable "central value" estimate to the Brown and Caldwell model. In addition, based on agreement between Ecology, Brown & Caldwell and PGG, the results of the "K=100 ft/d, local continuity" and "K=500 ft/d, no local continuity" model runs were considered the most reasonable estimates of upper- and lower- bounds for the Brown & Caldwell model.

It is worthwhile to note that hydraulic continuity (a saturated hydraulic connection) was not observed at the test pit in late June and mid September of 2001. This may partly be due to drought conditions this year, but is more likely due to the fact that both the Burke and (former) Hartman irrigation applications were not occurring this year on the west side of the creek. Mounding from these two irrigation applications could have put shallow groundwater in full continuity with the stream. However, the observation that it wasn't in full continuity when only Burke (east of the Creek) was irrigating is indicative of uncertainty over where local continuity would occur in the future with transfer of the former Hartman irrigation rights to the Trust. The implications of this are that future return flow schedules for remaining nearby water users (i.e. both Burke diversions) could shift to one showing less seasonality than the historic curve predicted for the Hartman diversion. The longer the distance the groundwater needs to travel to reach the stream, the greater the time lag and smaller the seasonal variation.

9 Timing of Subsurface Return Flows from First Creek Seepage to Swauk

Transfer of Trendwest's FCWUA water rights will allow more water to remain in First Creek at the FCWUA diversion. Because a portion of this water will be lost to alluvial subflow near the First Creek mouth, the model was used to estimate the timing for this subsurface flow to discharge downstream into Swauk Creek. For the purpose of this analysis, the average estimated additional First Creek flow is assumed equivalent to the average estimated diversion associated with Trendwest's water rights shown on **Table 4**. Once transferred, the additional water will flow down First Creek, into Swauk Creek, and ultimately to the Yakima River. Analysis of seepage loss to alluvial subflow on First Creek (Section 4) indicates that little net seepage is expected between the FCWUA diversion and MWG's lower gage. However some seepage to alluvial subflow is expected over the one-mile stretch between MWG's lower gage and the mouth.

ECT assessed the relationship between First Creek flow and seepage loss below MWG's lower gage to estimate the portion of Trendwest's transferred water right to become alluvial subflow when the diverted water is left instream. Our analysis is documented in **Table 7**, at the end of this report. During the high-flow months of April and May, Trendwest's addition to First Creek flow (about 5.0 to 5.2 cfs) is estimated to result in about 0.4 to 0.5 cfs of seepage to alluvial subflow, with about 4.6 to 4.8 cfs additional surface flow to Swauk Creek. In the lower-flow months of July and August, Trendwest's addition to First Creek flow (about 1.2 to 1.9 cfs) is estimated to result in about 0.6 to 0.8 cfs of seepage to alluvial subflow, with about 0.6 to 1.3 cfs additional surface flow to Swauk Creek. Alluvial subflow is a higher proportion of Trendwest's streamflow contribution during the lower-flow months because predicted streamflows are almost entirely comprised of Trendwest's transfer to instream flow (thus almost *all* the seepage to alluvial subflow is generated by the Trendwest contribution). During April and May, natural flows in First Creek (generated predominantly as inflow from smaller tributaries between the diversion dam and the mouth) represent a significant portion of the total streamflow and are thus associated with a significant portion of the seepage loss.

Seepage loss from lower First Creek will become alluvial subflow in the First Creek alluvium. It will then flow into the Swauk Creek alluvium and return to Swauk Creek where hydraulic continuity and gaining conditions occur. ECT concluded that gaining conditions occurred over some, if not all, of the 2001 irrigation season between the First Creek confluence and the Martin gage (approximately one-half mile downstream). ECT used the groundwater flow model of the alluvial aquifer along Swauk Creek (including the mouth of First Creek) to predict the timing required for return flow from First Creek seepage losses to re-enter Swauk Creek via alluvial subflow. The modeling assumed that all of the First Creek seepage loss associated with Trendwest's transfer re-enters Swauk Creek within Hidden Valley[9]. Seepage loss was simulated with a series of specified flux cells along the portion of First Creek included within the model domain[10]. Seepage loss was specified over bimonthly portions of the irrigation season based on calculations shown on **Table 7**. The primary set of model runs specified hydraulic continuity

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[9] Although a small portion of the seepage loss may travel as alluvial subflow along the full length of Swauk Creek and ultimately discharge to the Yakima River alluvium.

[10] Five specified flux cells were used along First Creek where hydraulic continuity was modeled up to the First Creek confluence, whereas a single specified flux cell was used where hydraulic continuity was modeled far from the First Creek confluence.

between Swauk Creek and the alluvial aquifer in a manner most consistent with the characterization presented in Section 5. The model simulated a gaining reach between the First Creek confluence and Lauderdale Junction, a losing reach between Lauderdale Junction and the downstream end of the former Hartman property, and gaining conditions farther downstream. The model was run using aquifer permeability values of 100 and 500 ft/d.

The results of the model predictions are shown on **Figure 17**, with First Creek seepage loss to alluvial subflow shown in dark blue and estimated inflow back to Swauk Creek shown in green and red. The model predicts that Swauk Creek surface flow begins to climb immediately after Trendwest's additional seepage loss becomes alluvial subflow. The increase in surface flow continues to rise in parallel to the increase in First Creek seepage loss over a 4-month period and then begins to decline in parallel to reductions in seepage loss. Over the first 4 months of the irrigation season, predicted subsurface return flow to Swauk Creek is less than seepage loss from First Creek. Over the next 2.5 months, predicted return flows are similar to seepage estimated losses. A significant portion of the alluvial subflow from seepage loss continues to contribute to Swauk Creek surface flows for about 4 to 6 weeks after the irrigation season. The model predicts that a small portion of the seasonal seepage loss to alluvial flow (about 0.03 cfs) recharges Swauk Creek on a year-round basis.

ECT evaluated the model's sensitivity to the location of hydraulic continuity by performing two additional sets of simulations (both run at aquifer permeability values of 100 and 500 ft/d). The first sensitivity run allowed hydraulic continuity to occur from the downstream end of the model domain (at Swauk Canyon) to the soil test pit in the middle of the Hartman property (shown as a purple triangle on **Figure 12**). The second sensitivity allowed hydraulic continuity to occur from the downstream end of the model domain to the downstream boundary of the Hartman Property (shown as a orange square on **Figure 12**). **Figure 17** shows that increasing the distance from the location of First Creek seepage to the reach showing hydraulic continuity dramatically reduces seasonal variation of the predicted return-flow "pulse". Dampening of the pulse (i.e. "smearing" over time) occurs because the alluvial aquifer stores and slowly releases the water added from First Creek seepage. The second sensitivity simulation predicted a nearly constant year-round return flow to Swauk Creek at an aquifer permeability value of 100 ft/d.

Among the return flow curves shown on **Figure 17**, the curves derived from the assumption of hydraulic continuity both above and below the Hartman property are considered to be most consistent with the available hydrogeologic model, and therefore most representative of the timing of actual return flow from First Creek seepage. For this reason, these curves are shown in bold lines on the figure. ECT recommends that an average return-flow schedule derived from these two curves be used for assessment of the change in timing of Yakima River inflow associated with the proposed transfer.

The transferred FCWUA water that flows within Swauk Creek down to the Yakima River is expected to have minor seepage loss to alluvial subflow within the Hidden Valley, as discussed in the following section.

10 Analysis of Swauk Creek Alluvial Subflow

Assessment of potential seepage losses to alluvial subflow along Swauk Creek was performed to estimate whether a significant portion of Trendwest's water rights transfer to instream flow might infiltrate into near-stream alluvium and take a subsurface pathway for a portion of its migration to the Yakima River. Were this to occur, increased Swauk Creek surface flows associated with Trendwest's water rights transfers would be reduced by the seepage to alluvial subflow. In addition, because alluvial subflow typically travels much slower than surface flow, subflow originating from Trendwest's water rights transfers would reach the Yakima River later than water conveyed via surface flow

The highest potential for significant seepage loss to alluvial subflow is likely to occur in strongly losing reaches of Swauk Creek. Data regarding seepage loss on Swauk Creek are limited, and as a result, no definitive conclusions regarding seepage gains and losses could be drawn. However, available data and the inductive reasoning necessary to make coarse estimates of seepage loss are presented in Section 5. Gaging data suggest that a portion of the reach between First Creek and the Martin gage is gaining, however losing conditions are likely directly downstream of the gage. Locations of the transition between gaining to losing conditions upstream of the Martin gage, and losing to gaining conditions downstream of the Martin gage, are unknown. Based on existing analysis and available data, the most likely location for seepage losses occurs between the Martin gage and some location upstream of the Coe diversion. Our analysis of the available data also suggests that best estimates of net seepage losses between the Martin gage and the Coe diversion may range from several tenths of a cfs at low flows to slightly over 1 cfs at high flows (typically outside the irrigation season). This relationship between streamflow and seepage loss, illustrated on **Figure 10**, was used to estimate seepage to alluvial subflow associated with the proposed Hartman and FCWUA water rights transfers.

Changes in alluvial subflow associated with the proposed water rights transfers were estimated by comparing predicted streambed seepage losses over the irrigation season with and without Trendwest's proposed instream transfers to the Trust. The irrigation season was divided into a series of half-month periods, and average flows with and without the transfers to instream flows were estimated. In addition, changes in streamflow associated with the Hartman transfer were distinguished from those associated with the FCWUA transfer to facilitate distinction of the contribution to alluvial subflow associated with each transfer. Seepage loss was assumed to occur between the Martin gage and the Coe property at the rates predicted in Section 5 and presented on **Figure 10**. The following bullets summarize the procedure used to estimate Trendwest's contributions to alluvial subflow, and the results are presented at the end of this report in **Table 7**. The table is divided up into three calculation sub-sections (7a, 7b, 7c), and the reader is recommended to refer to these sections when reviewing the calculation procedure.

1. Estimates of historic irrigation-season streamflow at the Martin gage were taken from the streamflow availability analysis discussed in Section 6. Initial values were the available streamflows after all irrigation requirements, down to the priority of Hartman (1889), were taken. These values were adjusted by adding in the Coe/Tang water rights (1884), since the Coe/Tang diversions occur significantly downstream and, rather than reducing physical streamflows in the reach of concern, only reduce streamflow *availability*. *(Section 7a)*

2. Historic water use from the Hartman diversion, as limited by the water availability analysis in Section 6, was added to historic streamflows at the Martin gage to estimate future streamflows due to transferring the diversion back to the stream. *(Section 7a)*

3. Swauk Creek inflow from First Creek was estimated to calculate the total addition to Swauk Creek streamflow from both the Hartman transfer and the FCWUA transfer in the following manner:

   - Historic flows at the mouth of First Creek were estimated based on data collected by Tom Martin from 1998 to 2000 and presented on **Figure 18.** Using the First Creek seepage loss curve (**Figure 5**), flows at the mouth were used to back-calculate flows at MWG's lower gage. *(Section 7b)*

   - Historically available Trendwest FCWUA water rights, estimated by MWG, were added to historic flows at the lower MWG gage to estimate future flows at the gage. The seepage loss curve was then used to estimate losses to alluvial subflow below the lower MWG gage and future flows at the mouth of First Creek. *(Section 7b)*

   - Trendwest's portion of the future seepage loss on lower First Creek were calculated by multiplying Trendwest's portion of the future flow at the MWG gage by the total seepage loss, and then subtracted from Trendwest's contribution to future increased First Creek flow, thus yielding Trendwest's *surface-water* contribution to First Creek inflow to Swauk Creek. As a reasonable simplification, Trendwest's groundwater contribution to Swuak Creek via return of alluvial subflow was estimated by lagging Trendwest seepage losses by one month. *(Section 7b)*

   - Future Swauk Creek flows below the Martin gage were estimated by adding the increased flow from First Creek to the predicted flows in Swauk Creek. Trendwest's total contribution to future Swauk Creek streamflow at the Martin gage was considered the sum of *surface-water* components of their contributions from the Hartman and FCWUA transfers plus the return flow from alluvial subflow originating from the lower portion of First Creek *(Section 7c)*

4. Total Trendwest seepage loss on Swauk Creek was estimated by multiplying the portion of the total future flow at the Martin gage associated with Trendwest's transfer by the seepage loss estimated for that total flow, as calculated by the curve shown on **Figure 10**. *(Section 7c)*

5. Trendwest seepage loss associated with the Hartman diversion alone was estimated by multiplying the total estimated Trendwest seepage loss on Swauk Creek by the portion of the increased flow (below Hartman) from the Hartman transfer relative to the increased flow from the combined Hartman and FCWUA transfer. The seepage loss associated with the FCWUA was estimated as the remainder of the Hartman seepage loss minus the total seepage loss. *(Section 7c)*

Although the above analysis simplifies some of the hydrologic functions in the First-Swauk Creek complex resulting from the proposed water rights transfers, it allows reasonable estimation of the magnitude of seepage loss to Swauk Creek alluvial subflow associated with the two transfers. **Table 6** presents results of the above analysis where historic water availability for the Hartman water right was estimated without consideration of return flow; however parallel calculations with consideration of return flow showed no appreciable difference in results (±0.01

cfs). Estimated total Trendwest seepage loss from Swauk Creek ranges from 0.05 to 0.11 cfs, with from 0.01 to 0.06 cfs attributed to the Hartman transfer and 0.03 to 0.08 cfs attributed to the FCWUA transfer. Relative to the total magnitude of each transfer (expressed as increased flow below Hartman), average seepage loss to alluvial subflow represents about 3 percent of the Hartman transfer and 2 percent of the FCWUA transfer. Due to the small magnitude of the seepage loss estimates, the alluvial subflow component of the proposed water right transfers was considered to be relatively insignificant and not worthy of detailed groundwater flow modeling.

11 Changes in Streamflow Associated with the Transfers

Based on the finding that seepage losses to Swauk Creek alluvial subflow from Trendwest's proposed water right transfers are relatively insignificant, estimation of the net change in streamflow is based on changes in consumptive use and the timing of non-consumptive subsurface return flow. For the proposed Hartman transfer, the change from historic to future conditions involves restoring the full historic diversion (both consumptive and non-consumptive components) into instream flow, but losing the historic time-lagged sub-surface return flows from non-consumptive irrigation losses. ECT calculated the net change in flow over time by subtracting the predicted (time-delayed) subsurface return flow from the estimated water available for transfer back into the stream[11]. **Figure 19** presents the estimated change in streamflow associated with the proposed Hartman transfer predicted over a one-year period. During the first 15 weeks of the irrigation season, streamflow would increase by 1 to 2 cfs. Due to an abrupt reduction in streamflow availability and associated historic Hartman diversion in late July, streamflow would be reduced during the middle 9 weeks of the irrigation season because return flows from earlier in the season historically exceeded estimated diversions. Under the proposed transfer, the water that used to supply these lagged return flows would be left instream earlier in the season discontinuing the historic diversion. Increased availability at the end of the irrigation season once again results in a net increase in streamflow, when historic diversions exceeded historic return flows. The net increase in stream flow estimated over the final 4 weeks of the irrigation season ranges from 0.05 to 0.9 cfs. After the irrigation season, streamflows would be reduced by approximately –0.63 cfs to –0.2 cfs, because time-lagged irrigation returns would have been transferred to instream flows during the irrigation season. The jagged appearance of the calculated streamflow-credit curve is due to the fact that irrigation water availability was estimated on a two-week basis.

For the proposed FCWUA transfer, the change from historic to future conditions involves allowing the full historic diversion to remain instream. For the purpose of this analysis, the historic diversion was estimated to range from 1.06 to 5.21 cfs (**Table 6**). Streamflows in all but the lower mile of First Creek are expected to benefit by these amounts during the irrigation season. Between lower First Creek and upper Hidden Valley (Swauk Creek), predicted increases in flow from the FCWUA transfer will be slightly reduced by seepage loss to alluvial subflow. Losses to alluvial subflow are estimated to range from 0.41 to 0.77 cfs, so that remaining flow increases range from 0.52 to 4.7 cfs (**Table 6**). On Swauk Creek, flow increases associated with the FCWUA transfer are expected to be restored back to values ranging from 1.06 to 5.21 cfs with increasing distance from the First Creek confluence. The location(s) where subsurface return flow from First Creek seepage loss returns to Swauk Creek are unknown;

[11] The water available for transfer (i.e. the historically available diversion) equals the historic irrigation seepage loss shown of Figures 15 and 16 divided by 1 minus the irrigation efficiency (1-0.33 = 0.66).

however, gaining conditions above the Martin gage and results of model simulations suggest that most of the flow returns to Swauk Creek above the gage.

The combined effect of the proposed Hartman and FCWUA transfers is estimated to result in increased First and Swauk Creek flow throughout the irrigation season, decreased Swauk Creek flow outside the irrigation season, and no change in First Creek flow outside the irrigation season[12]. **Figure 20** presents estimated changes in Swauk Creek flow for lower Hidden Valley, where former subsurface return flows from former Hartman irrigation likely returned to the stream. The figure was prepared by subtracting the estimated loss in historic Hartman irrigation subsurface return flows from the sum of the estimated historic Hartman diversion and total inflow to Swauk Creek (below Hartman) from the Trendwest FCWUA transfer[13]. The values shown on **Figure 20** should be considered approximate, since they employ various simplifying assumptions discussed in previous sections and because discrete bi-weekly values of irrigation subsurface return flow were estimated from the continuous model results on **Figure 16**. Nevertheless, the figure shows the general net increase in streamflow predicted from the combined transfers to trust throughout the irrigation season ranging from 0.8 to 6.7 cfs, and a general decrease in streamflow predicted outside the irrigation season ranging from –0.06 to –0.48 cfs.

[12] In actuality, First Creek flows will likely increase from historic levels outside the irrigation season because improvements to the diversion structure and new management will likely discontinue the past practice of diverting the entire streamflow throughout the year.

[13] As shown on **Table 6**, this value incorporates a one-month time lag for subsurface return flow from First Creek seepage loss near the Swauk Creek confluence.

Table 7
Analysis of Seepage Losses to Alluvial Subflow
(All Values in CFS)

7a: Hartman Transfer - Change in Streamflow Below Burke-Hartman (B-H) Diversion

	Historic Water Available Below Burke & Hartman	Historic Coe/Tang Diversion	Historic Actual Flow Below B-H Diversion	Historic Total Hartman Diversion	Future Flow Below B-H Diversion w/ Transferred Hartman
Apr 1-15	126.5	0.8	127.2	1.2	128.5
Apr 16-30	106.5	0.8	107.2	1.2	108.5
May 1-15	39.7	1.1	40.8	1.9	42.7
May 16-31	20.0	1.1	21.1	1.8	22.8
Jun 1-15	13.8	1.3	15.1	2.2	17.3
Jun 16-30	7.8	1.3	9.1	2.2	11.3
Jul 1-15	2.5	1.6	4.1	2.6	6.7
Jul 16-31	0.0	0.4	0.4	0.5	1.0
Aug 1-15	0.0	0.0	0.0	0.4	0.4
Aug 16-31	0.0	0.0	0.0	0.4	0.4
Sep 1-15	0.0	0.8	0.8	0.3	1.1
Sep 16-31	0.0	0.9	0.9	1.1	2.1
Oct 1-15	3.1	0.4	3.5	0.7	4.2

7b: Change in Flow and Seepage Loss from FCWUA Transfer

	Estimated Historic First Creek Inflow to Swauk Creek	Historic First Creek Flow at MWG Gage (Back Calculated)	Available TW First Creek Water Rights	Future First Creek Flow at MWG Gage	Total Seepage Loss Associated with Future Flow	Future First Creek Inflow to Swauk Creek	TW Percent of Future Flow at MWG Gage	TW Seepage Loss on Lower First Creek	TW Surface Inflow to Swauk Creek	TW GW Inflow to Swauk Creek
Apr 1-15	14.50	16.11	5.04	21.15	1.71	19.43	24%	0.41	4.63	0.00
Apr 16-30	14.50	16.11	5.04	21.15	1.71	19.43	24%	0.41	4.63	0.00
May 1-15	13.00	14.56	5.21	19.77	1.69	18.08	26%	0.44	4.76	0.41
May 16-31	10.00	11.48	5.21	16.69	1.62	15.07	31%	0.51	4.70	0.41
Jun 1-15	5.00	6.24	4.37	10.61	1.44	9.17	41%	0.59	3.77	0.44
Jun 16-30	2.00	2.95	4.37	7.32	1.30	6.02	60%	0.77	3.59	0.51
Jul 1-15	0.50	1.04	1.90	2.94	0.94	2.00	65%	0.61	1.30	0.59
Jul 16-31	0.00	0.00	1.90	1.90	0.77	1.13	100%	0.77	1.13	0.77
Aug 1-15	0.00	0.00	1.18	1.18	0.58	0.60	100%	0.58	0.60	0.61
Aug 16-31	0.00	0.00	1.18	1.18	0.58	0.60	100%	0.58	0.60	0.77
Sep 1-15	0.00	0.00	1.06	1.06	0.54	0.52	100%	0.54	0.52	0.58
Sep 16-31	0.00	0.00	1.06	1.06	0.54	0.52	100%	0.54	0.52	0.58
Oct 1-15	0.00	0.00	1.12	1.12	0.56	0.56	100%	0.56	0.56	0.54

7c: Seepage Loss from Swauk Creek on Martin-Coe Reach

	TW Total Inflow to Swauk Creek (Below B-H Diverson) from FCWUA Transfer	Future Flow Below B-H Diversion with First Creek Increase	Trendwest Total Addition to Future Surface Flow Below B-H Diversion	Trendwest Addition to Future Surface Flow (%)	Martin-Coe Seepage Loss Associated with Future Flow	Total Trendwest Portion of Future Martin-Coe Seepage Loss	Trendwest Hartman Portion of Future Martin-Coe Seepage Loss	Trendwest FCWUA Portion of Future Martin-Coe Seepage Loss
Apr 1-15	4.6	133.4	5.87	4%	1.22	0.05	0.01	0.04
Apr 16-30	4.6	113.4	5.87	5%	1.11	0.06	0.01	0.05
May 1-15	5.2	48.2	7.05	15%	0.62	0.09	0.02	0.07
May 16-31	5.1	28.3	6.87	24%	0.41	0.10	0.03	0.07
Jun 1-15	4.2	21.9	6.39	29%	0.34	0.10	0.03	0.07
Jun 16-30	4.1	15.8	6.27	40%	0.27	0.11	0.04	0.07
Jul 1-15	1.9	8.8	4.51	51%	0.19	0.10	0.06	0.04
Jul 16-31	1.9	2.9	2.43	85%	0.12	0.10	0.02	0.08
Aug 1-15	1.2	1.6	1.64	100%	0.10	0.10	0.03	0.08
Aug 16-31	1.4	1.8	1.80	100%	0.11	0.11	0.03	0.08
Sep 1-15	1.1	2.2	1.43	65%	0.11	0.07	0.02	0.06
Sep 16-31	1.1	3.2	2.25	70%	0.12	0.09	0.04	0.04
Oct 1-15	1.1	5.3	1.78	34%	0.15	0.05	0.02	0.03

Figure 1
Location Map of Hidden Valley and Swauk Creek

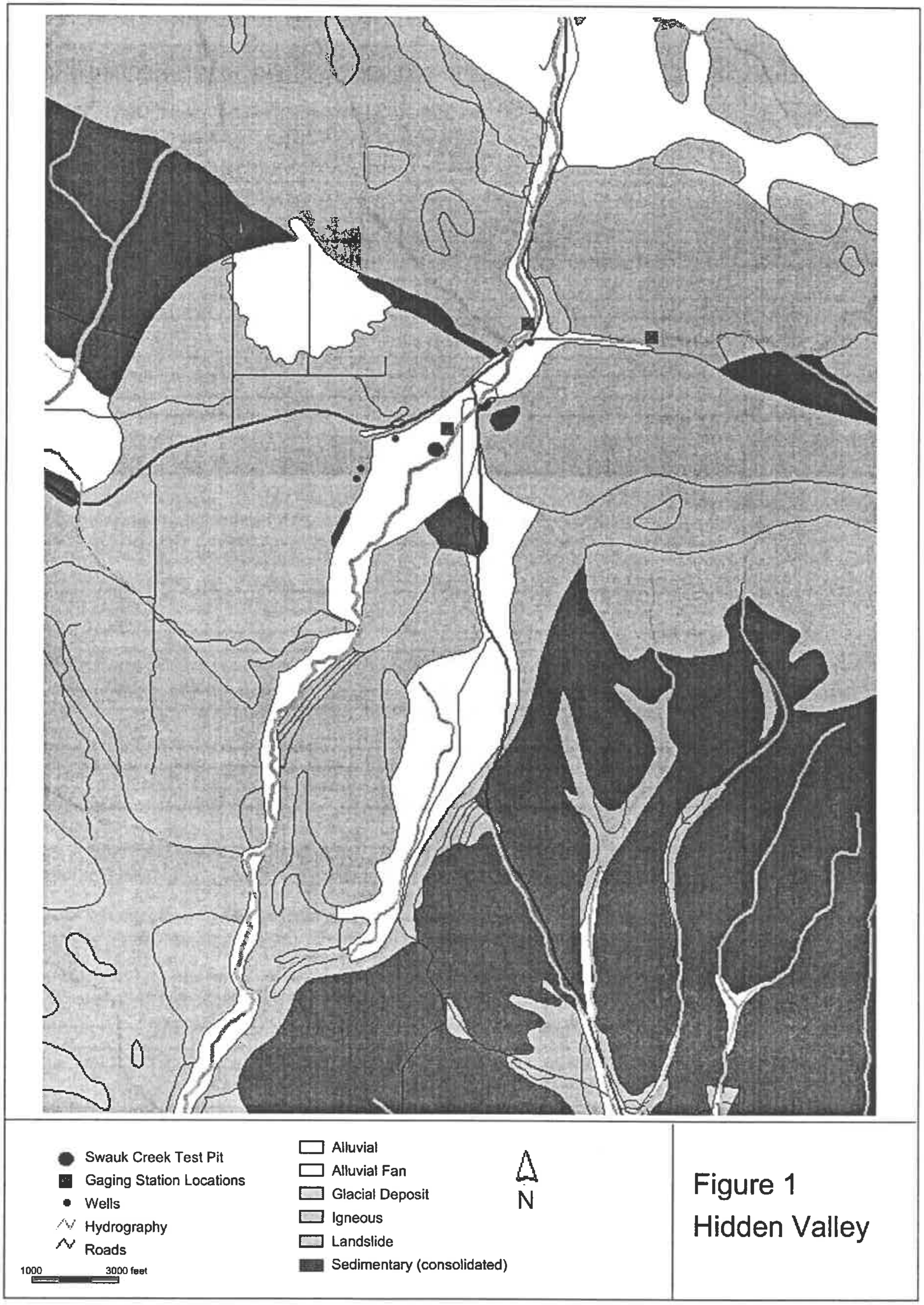


Figure 2
First Creek Flow Data for 1998-2001
Estimated Above the FCWUA Diversion

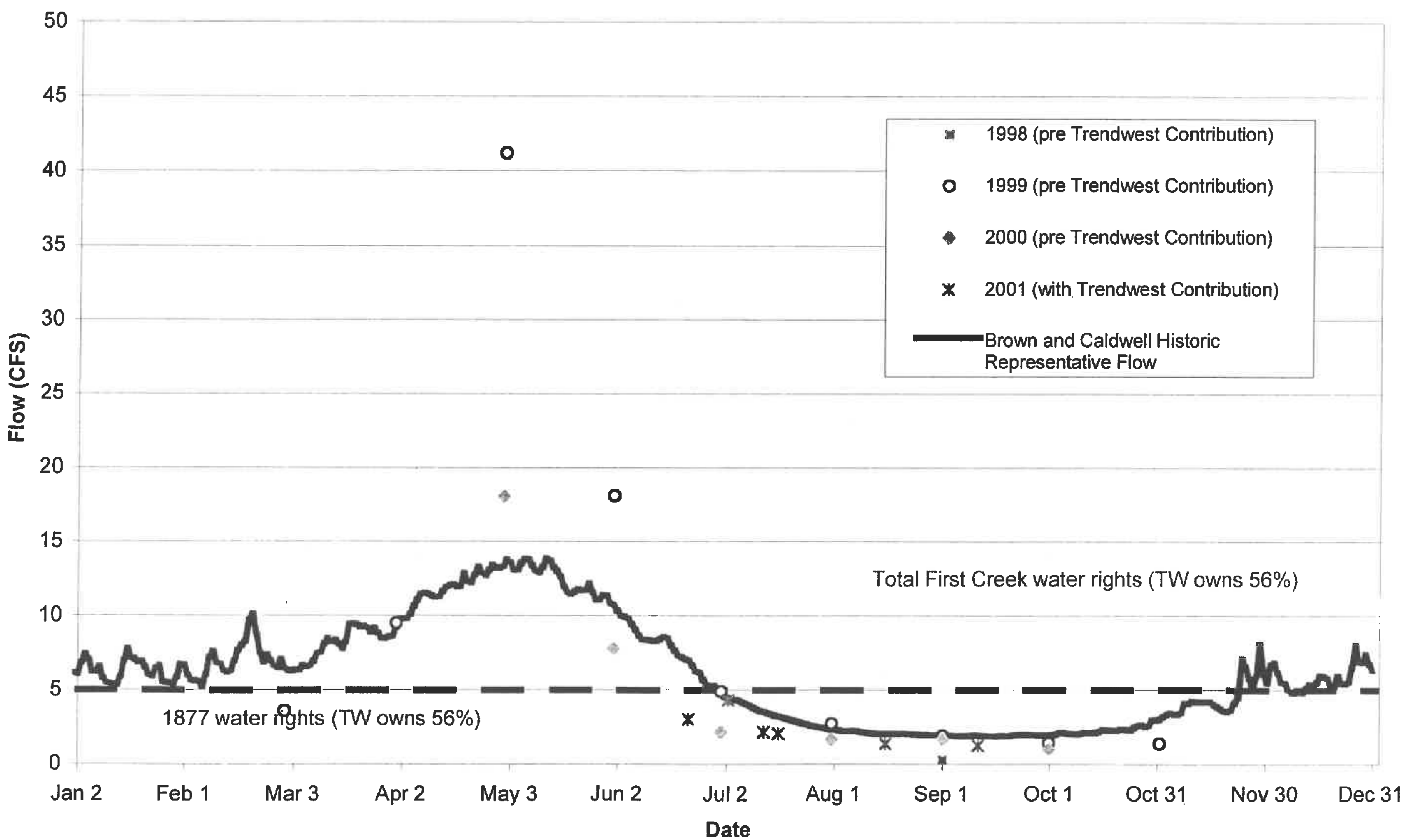


Figure 3
First Creek Flow Data for 2001

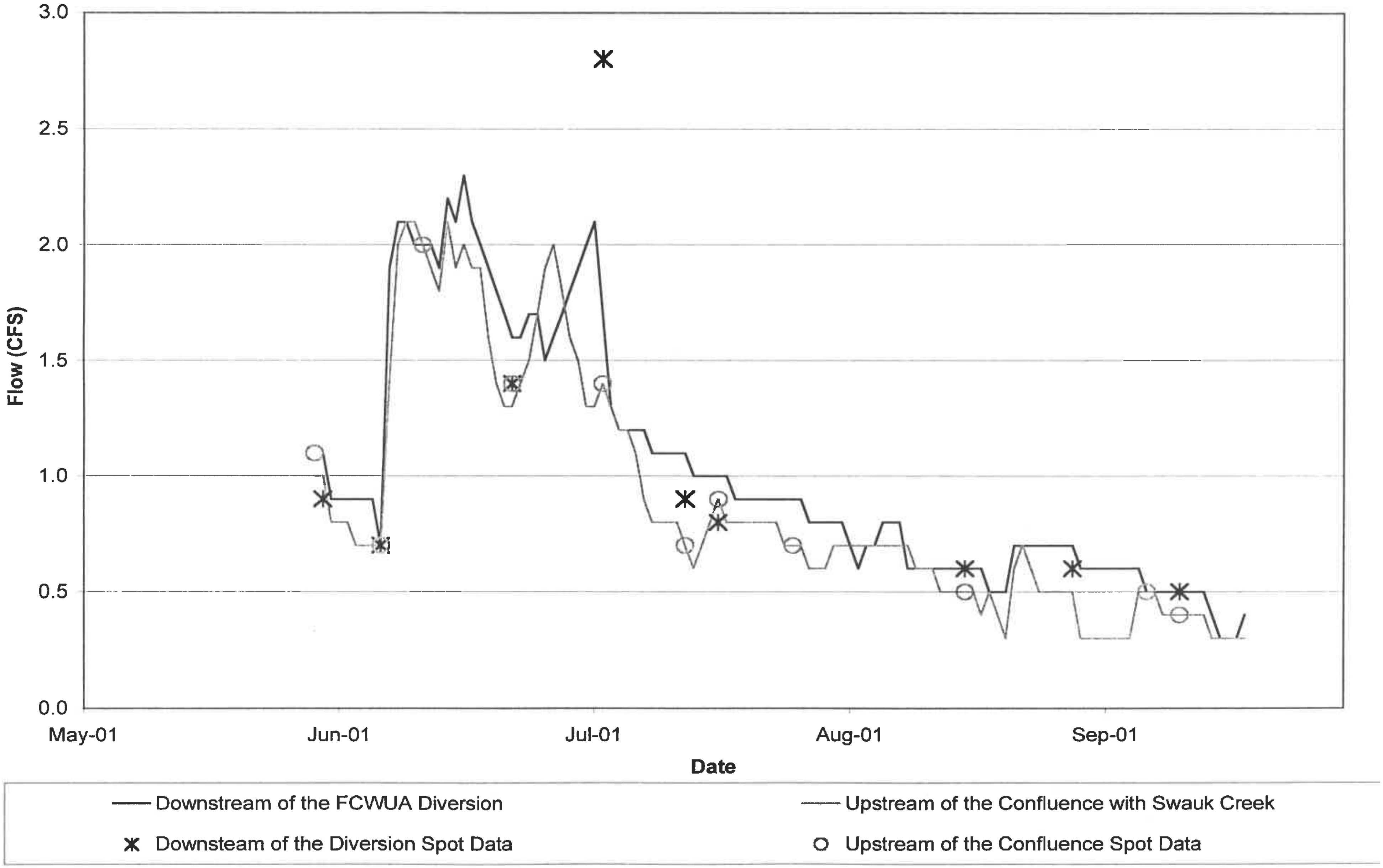


Figure 4
Seepage Losses Between Lower Gages from 1999 First Creek Test

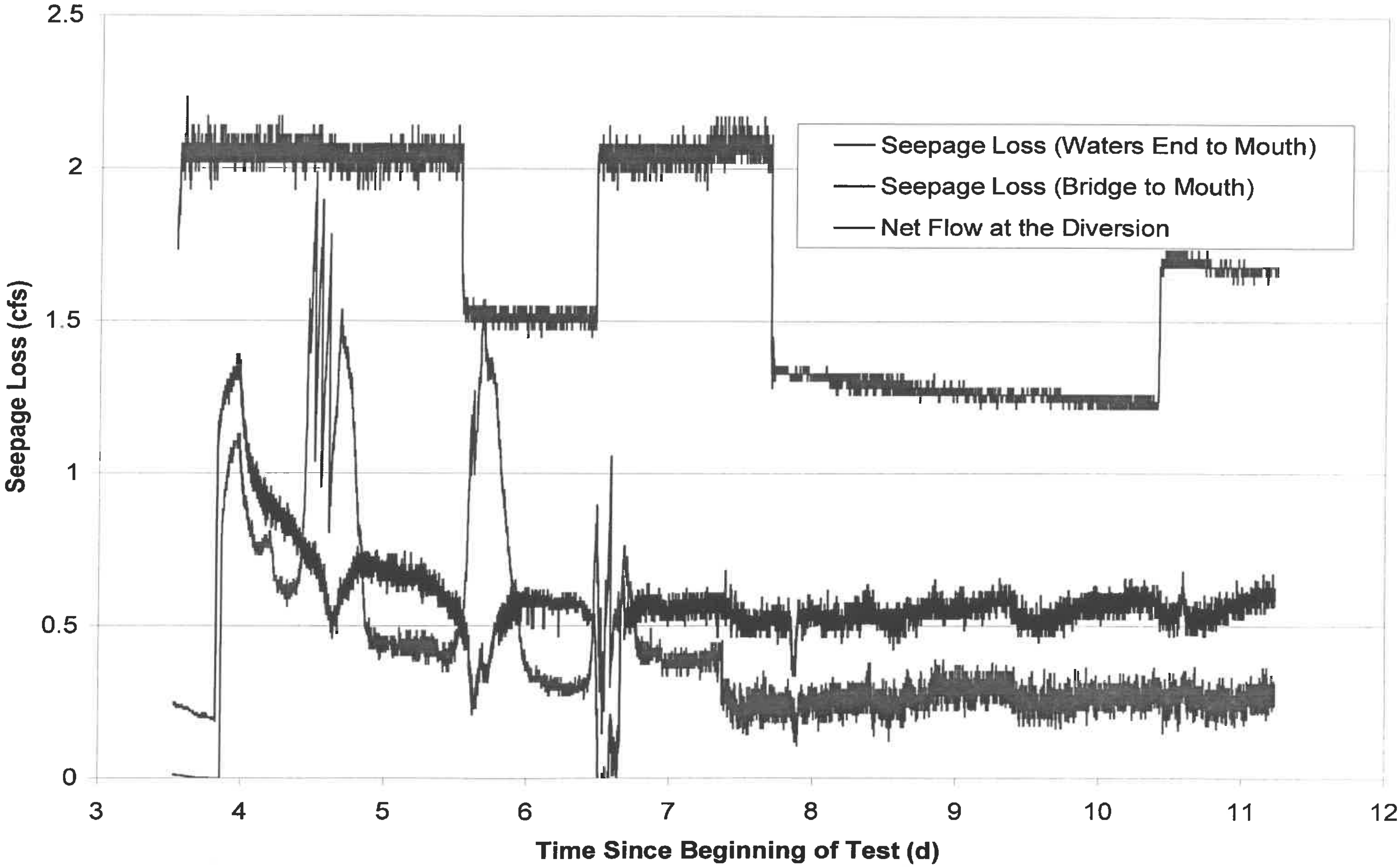


Figure 5
Estimated Seepage Loss on First Creek
Between MWG's Downstream Gage and the Mouth

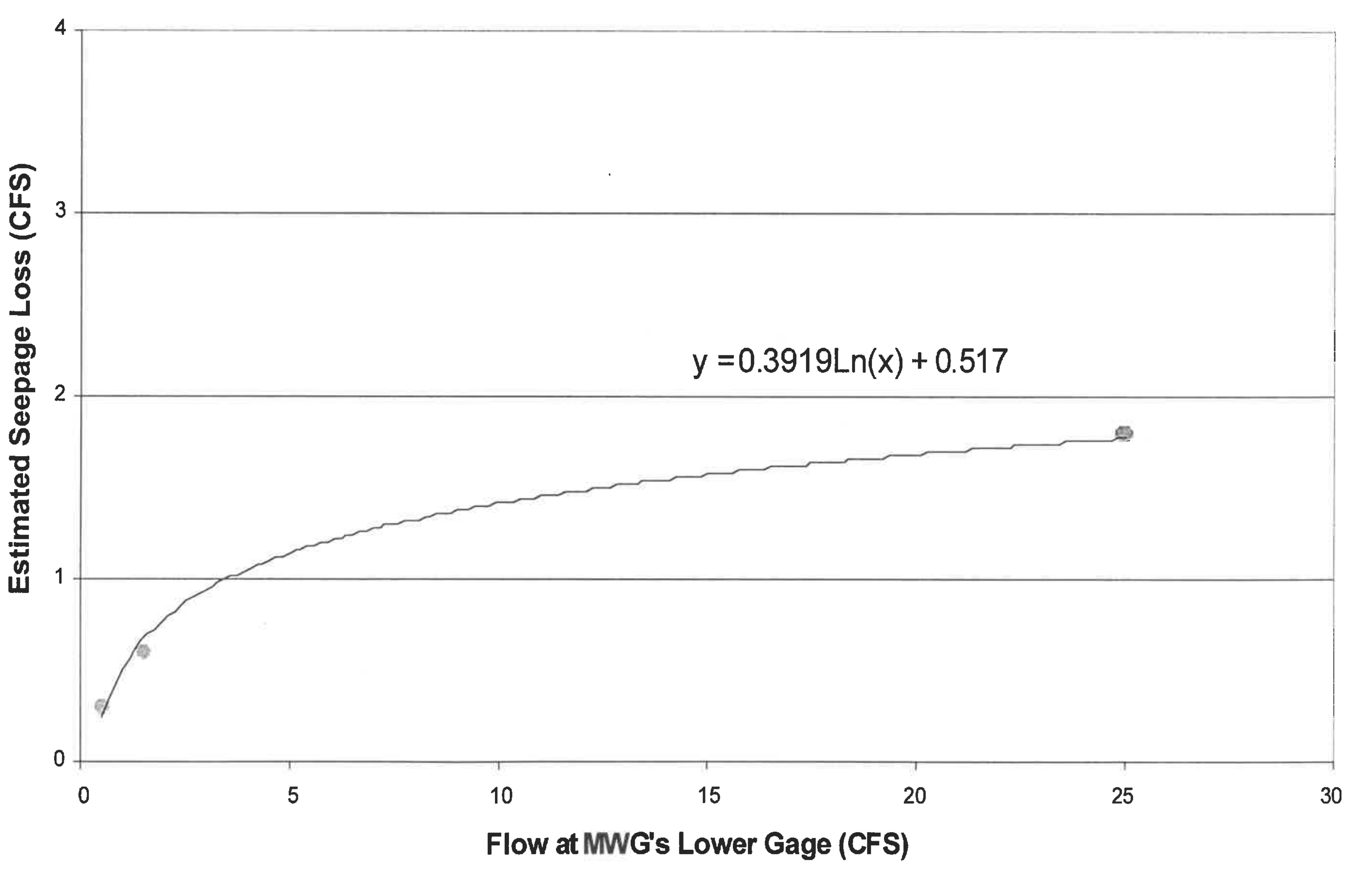


Figure 6
Swauk Creek Flows (1998-2001)
Upsteam of the Confluence with First Creek

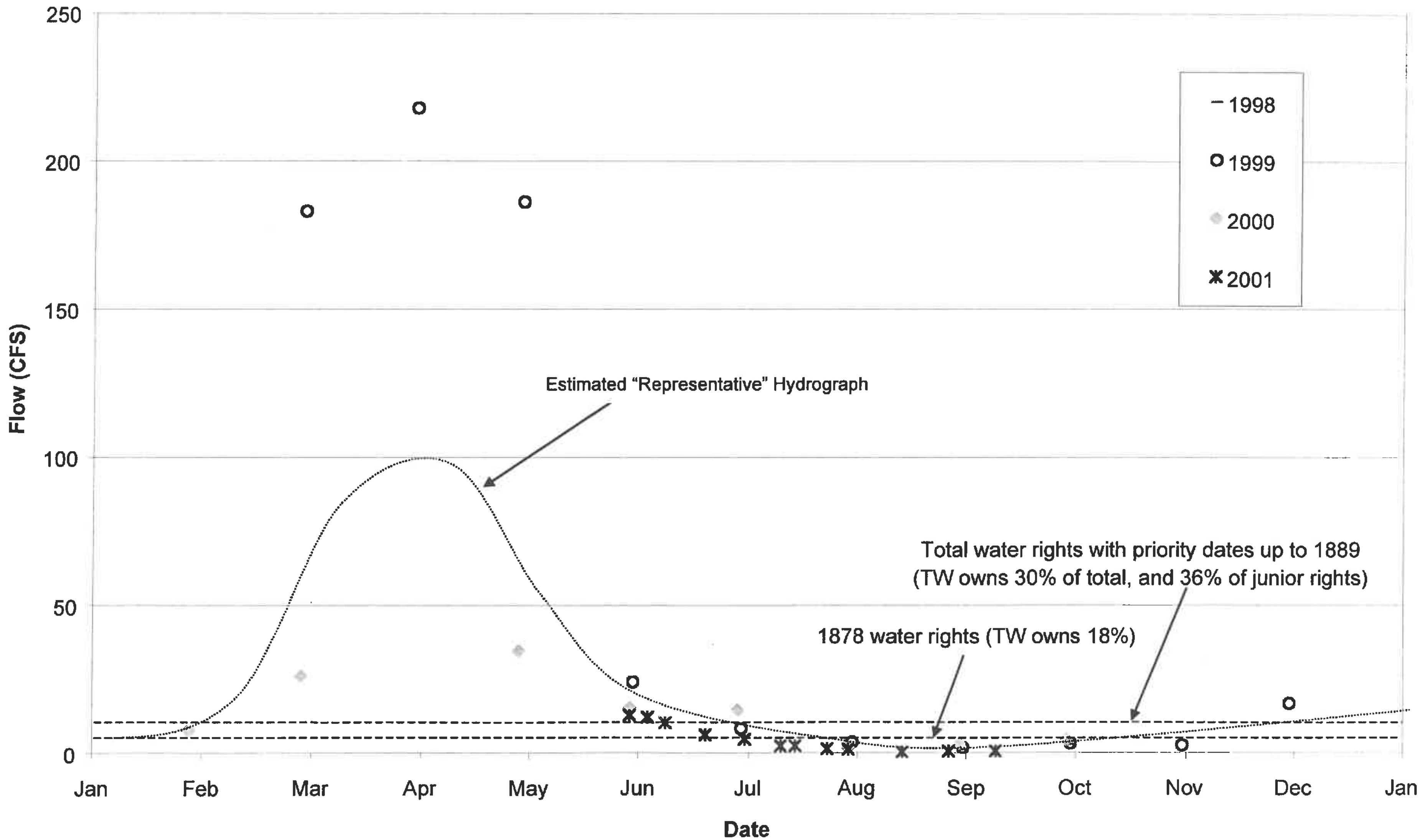


Figure 7
Spot Measurements of Swauk Creek Flows (1998-2001 Data)

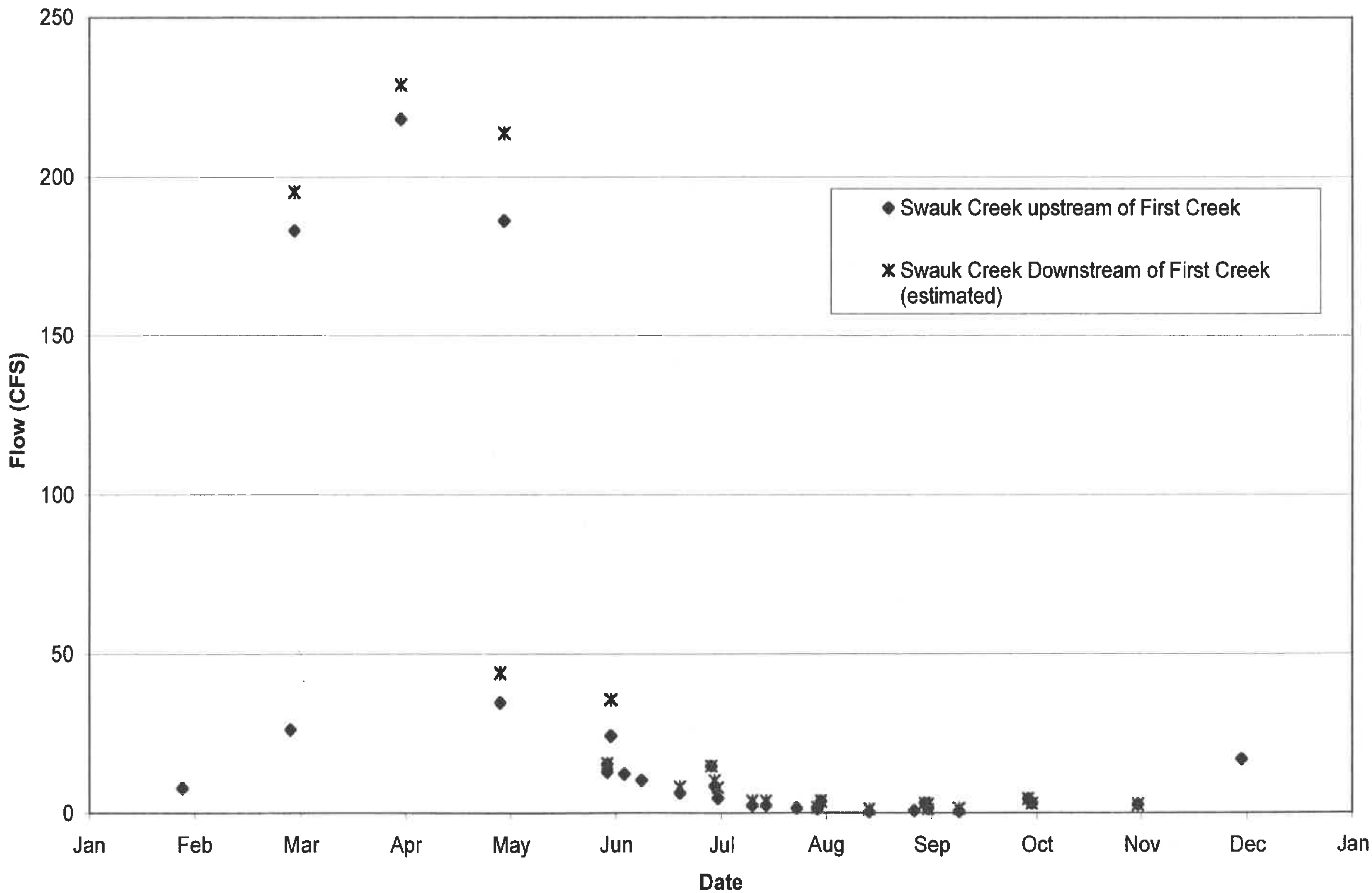


Figure 10
Estimated Seepage Loss in Hidden Valley below the Martin Property Gage

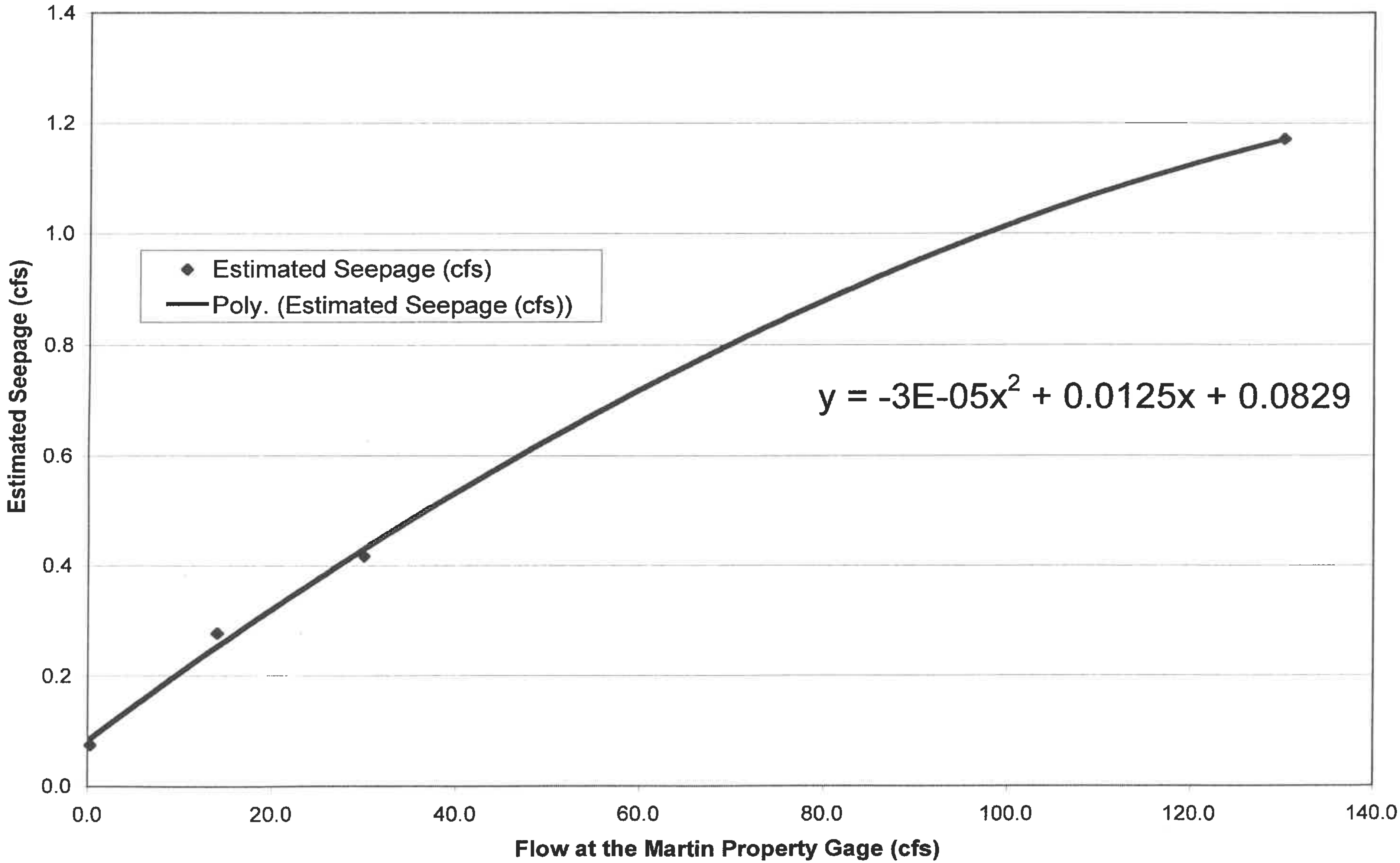


Figure 11
Detail of Low Flow Conditions in Swauk Creek
(Downstream of the Confluence with First Creek)

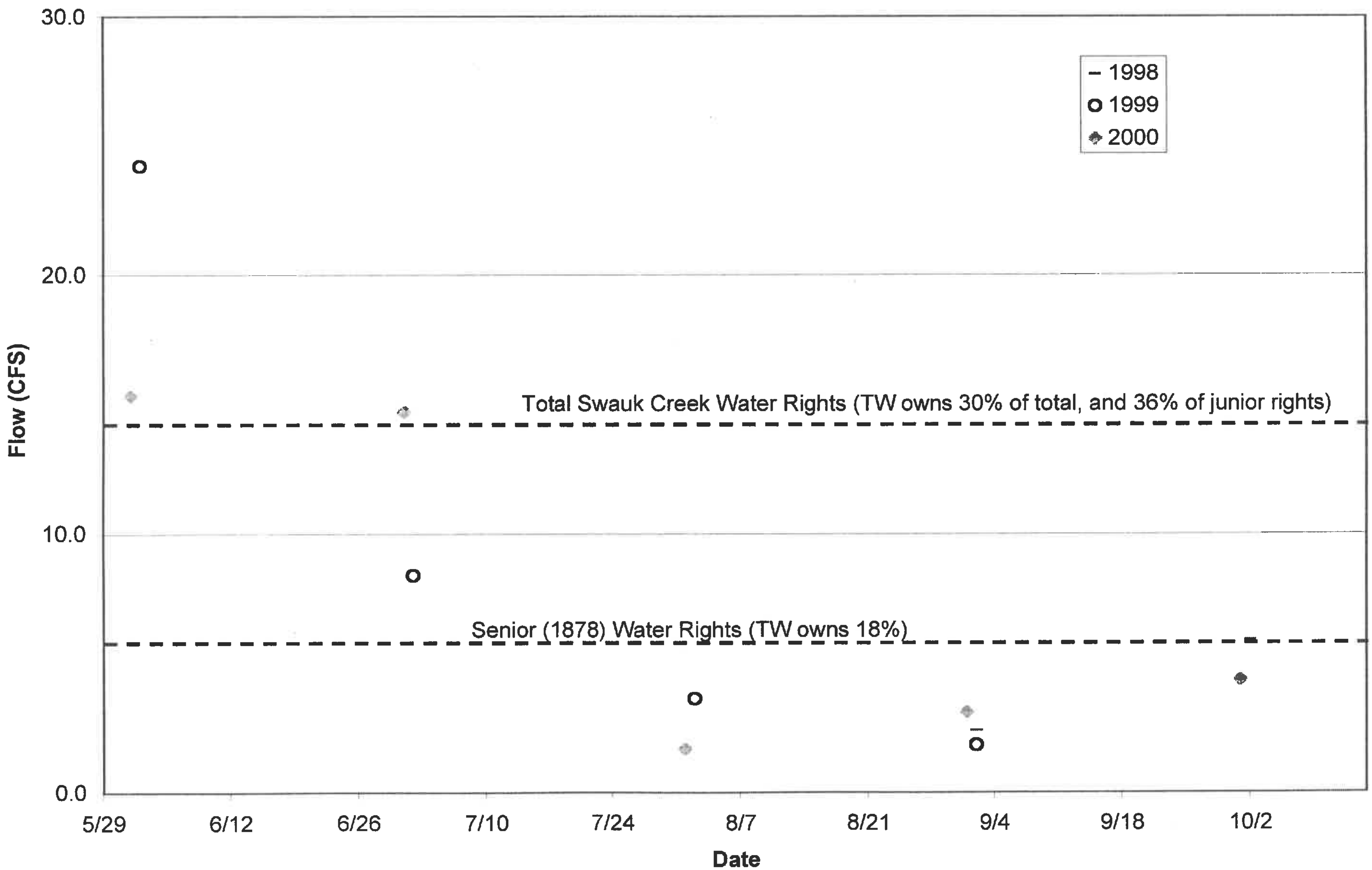
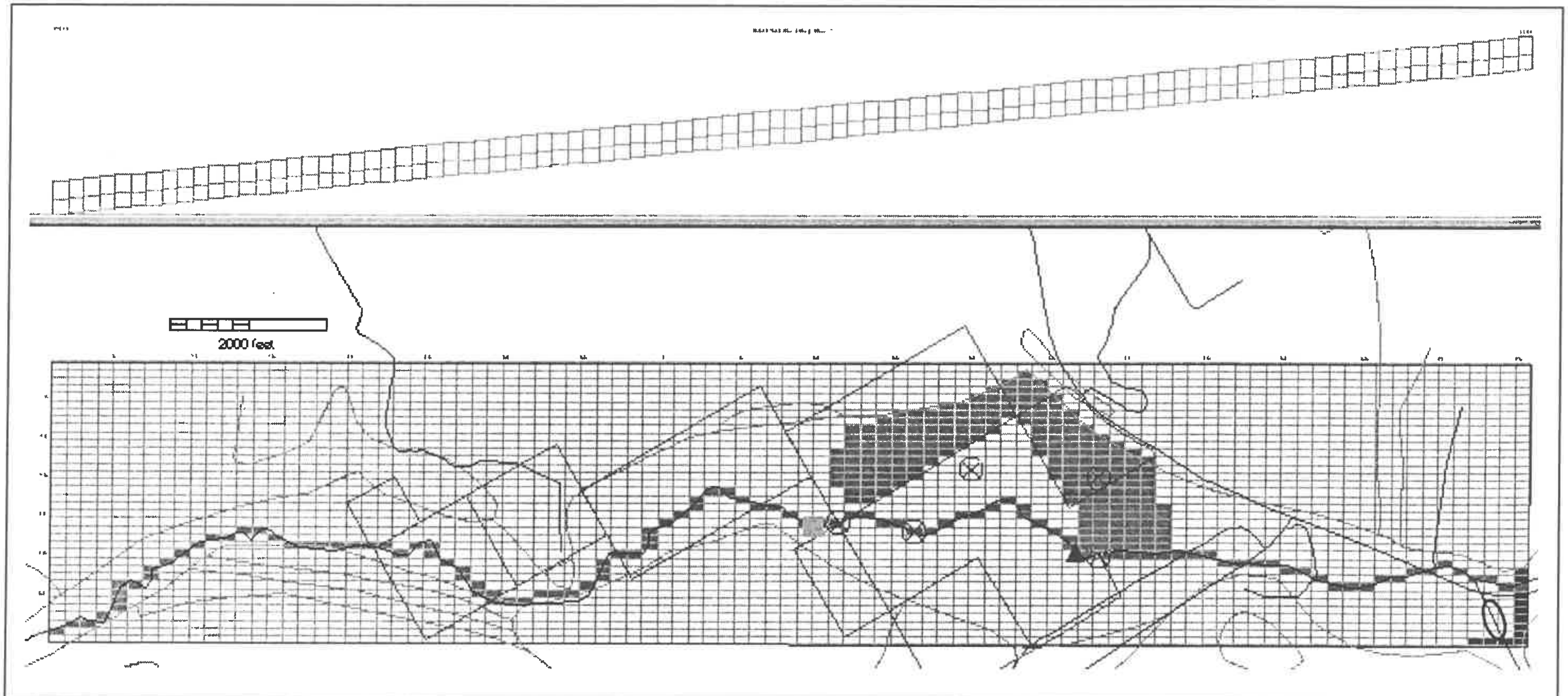


Figure 12
MODFLOW Model Design in Cross-Section and Map Views

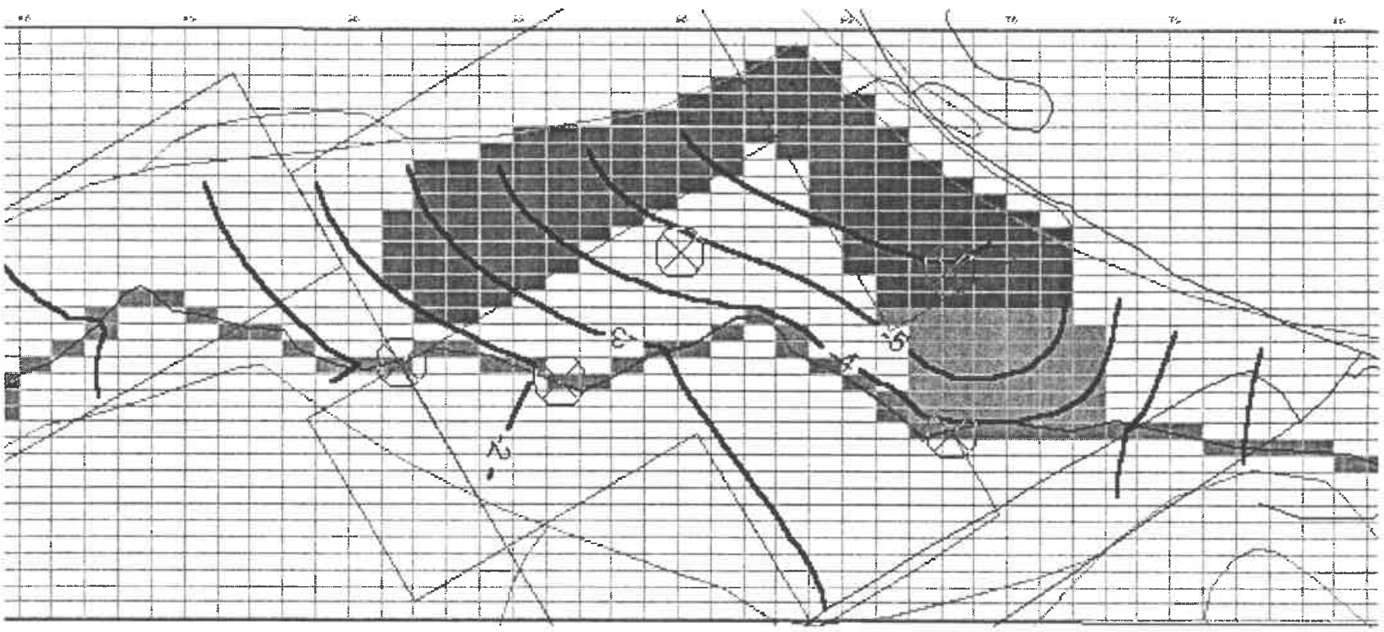


LEGEND

- Model Inflow Location for First Creek Seepage Loss
- Location of Soil Test Pit
- Downstream Location of Former Hartman Property
- Monitoring Points for Hydrograph Extraction
- Specified Flux Cells Receiving Recharge Throughout Irrigation Season
- Specified Flux Cells Receiving Recharge Over a Limited Portion of the Irrigation Season
- Specified Flux Cells Simulating Inflow Along Model Boundary

Figure 13
Groundwater Mounding and Water Level Hydrographs
Predicted with Local Hydraulic Continuity and K=100

Mid-Summer Mounding (feet drawdown) and Irrigated Acreage (green & blue cells)



Hydrographs at Observation Points (feet drawdown)

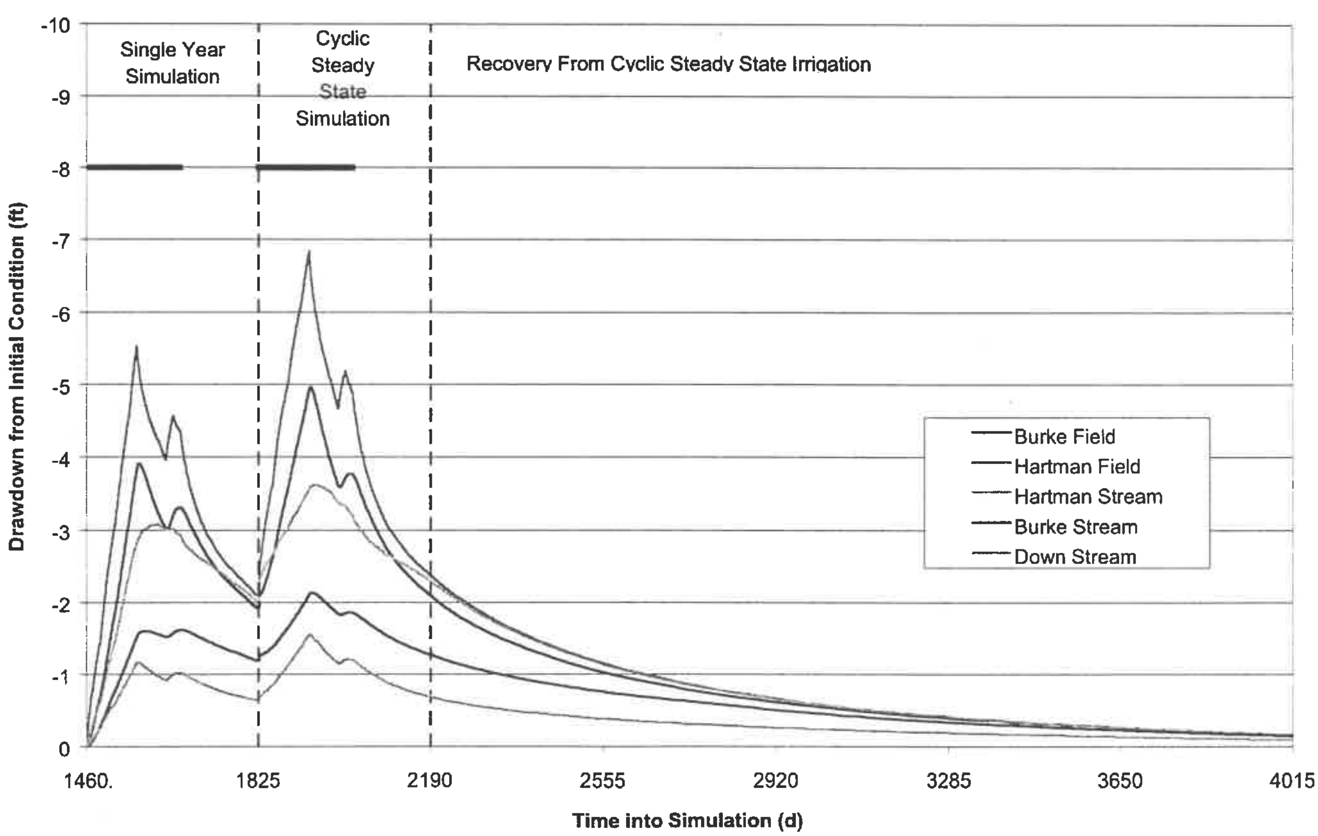
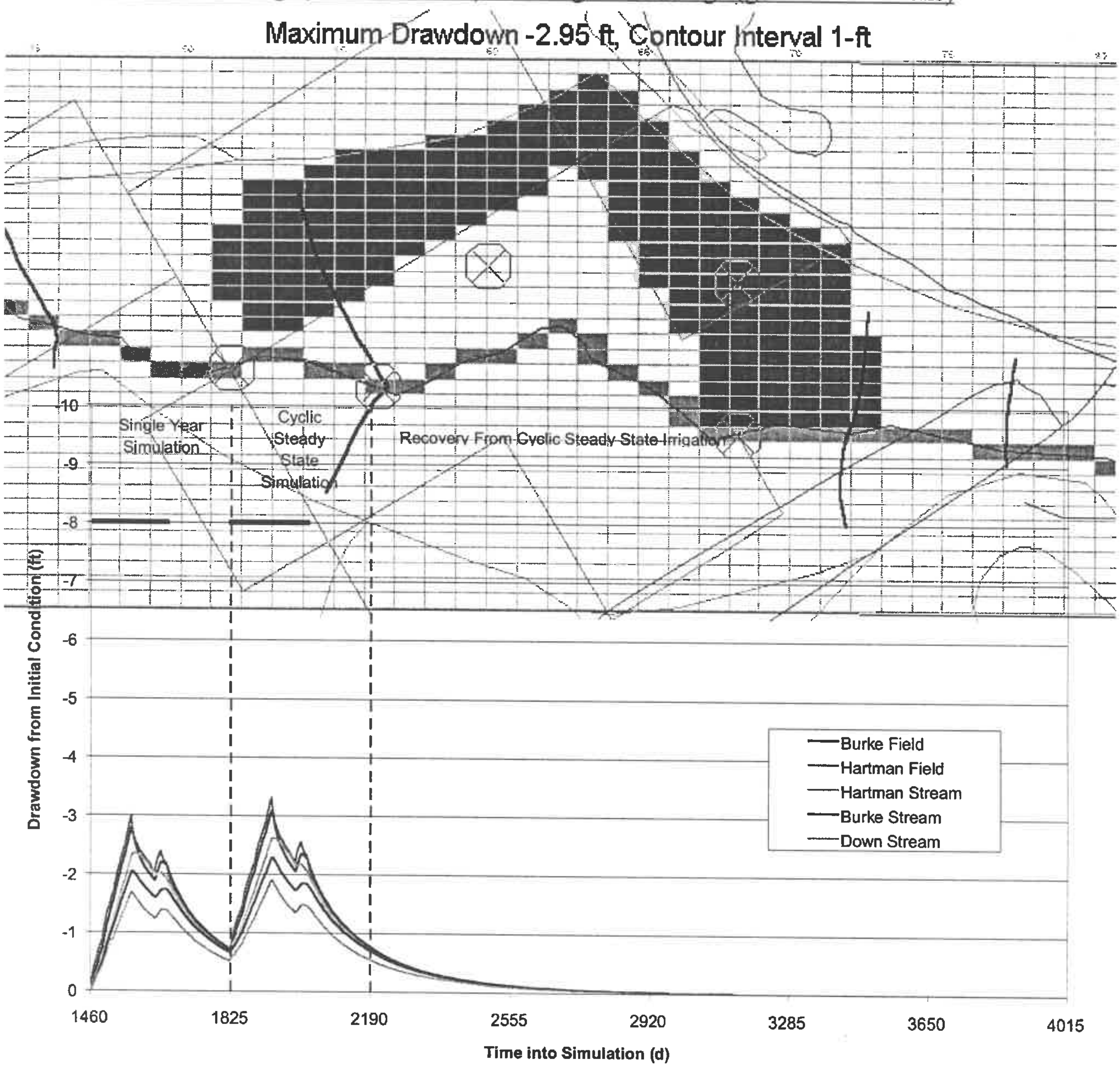


Figure 14
Groundwater Mounding and Water Level Hydrographs
Predicted with Local Hydraulic Continuity and K=500

Mid-Summer Mounding (feet drawdown) and Irrigated Acreage (green & blue cells)



Hydrographs at Observation Points (feet drawdown)

Figure 15
MODFLOW Predictions of Subsurface Return Flow to Swauk Creek

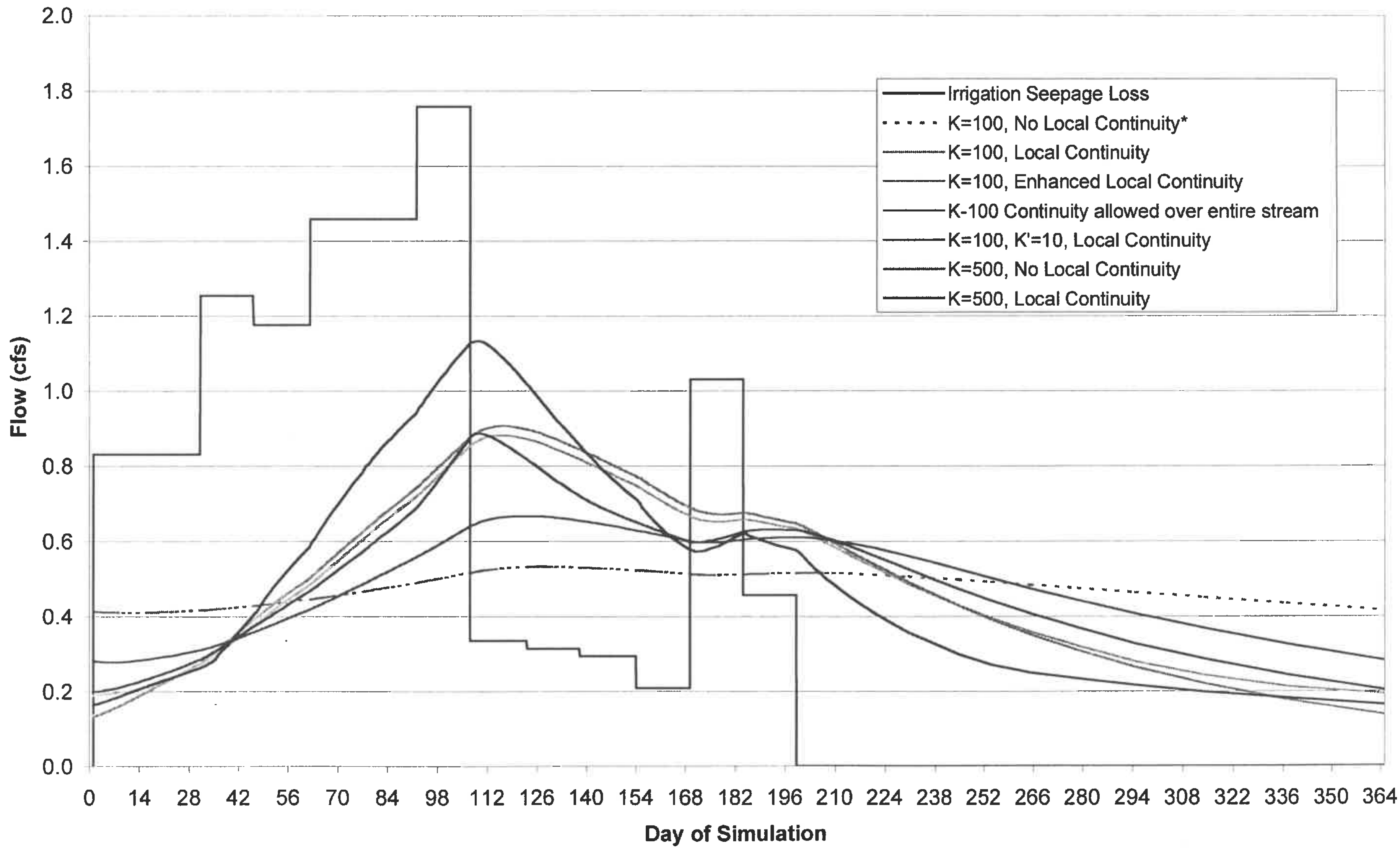


Figure 16
Recommended Schedule for Subsurface Return Flow to Swauk Creek

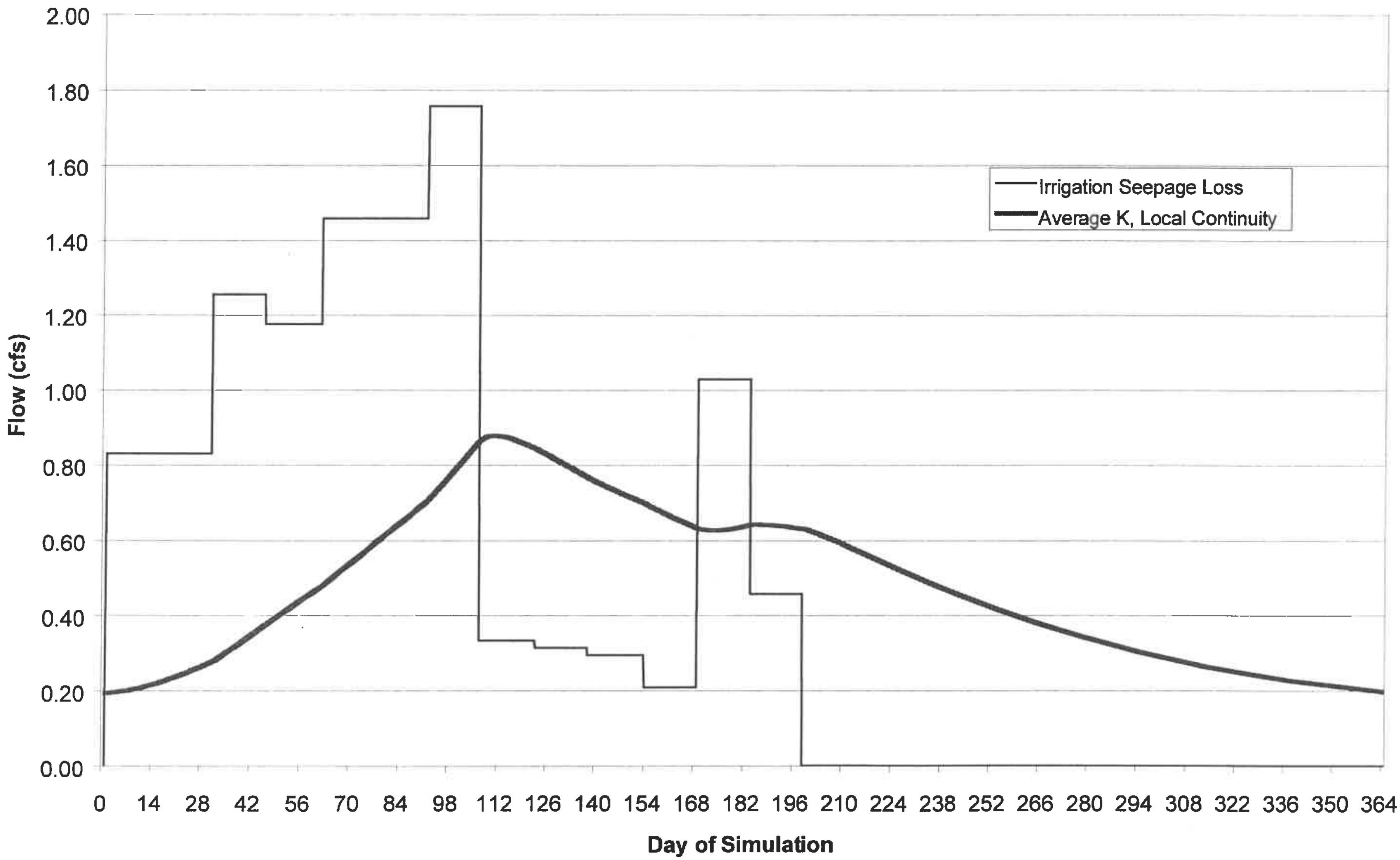


Figure 17
Predicted Return Flows to Swauk Creek from First Creek Seepage to Alluvial Subflow

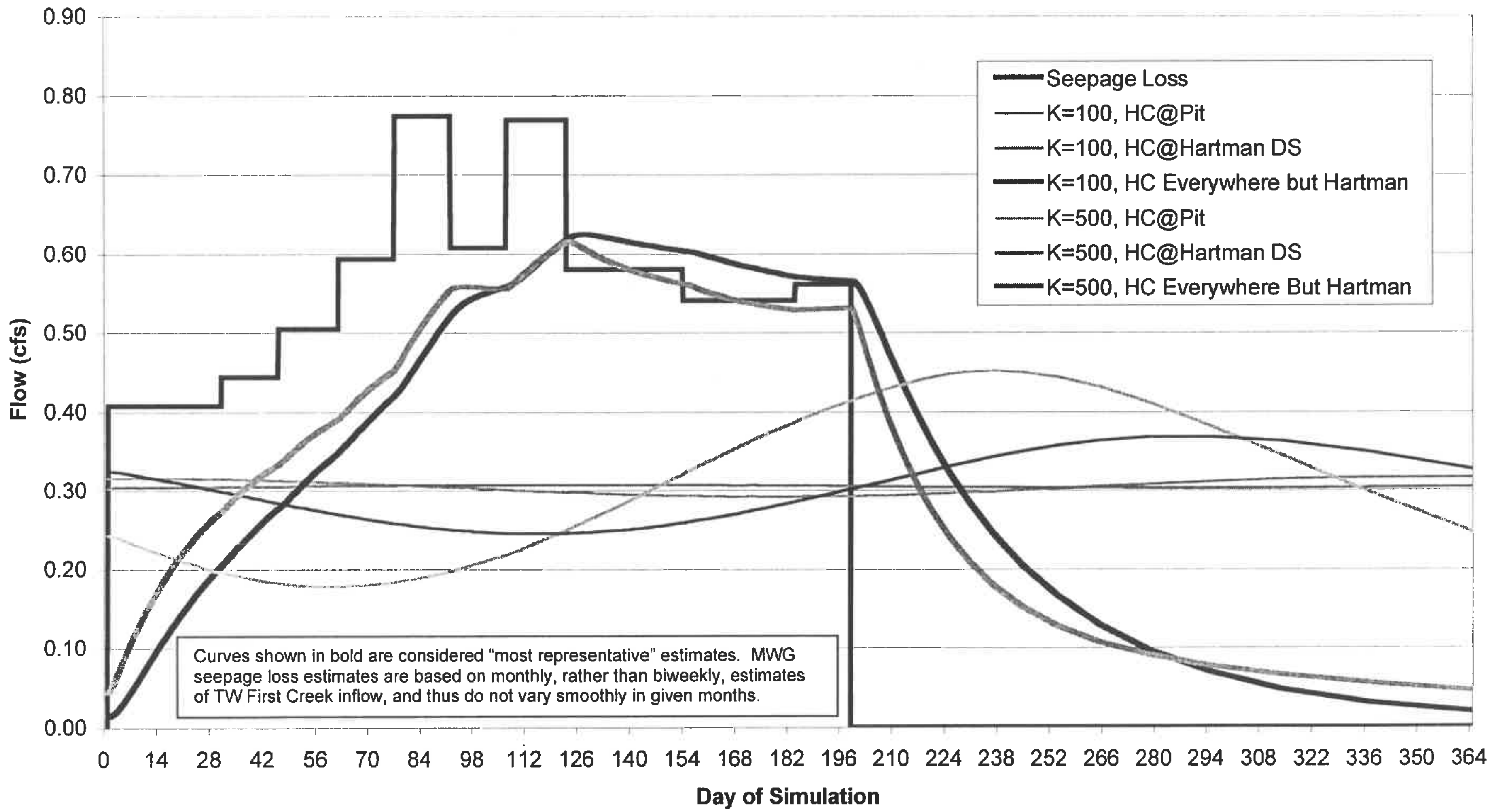


Figure 18
Streamflow Recorded at the Mouth of First Creek

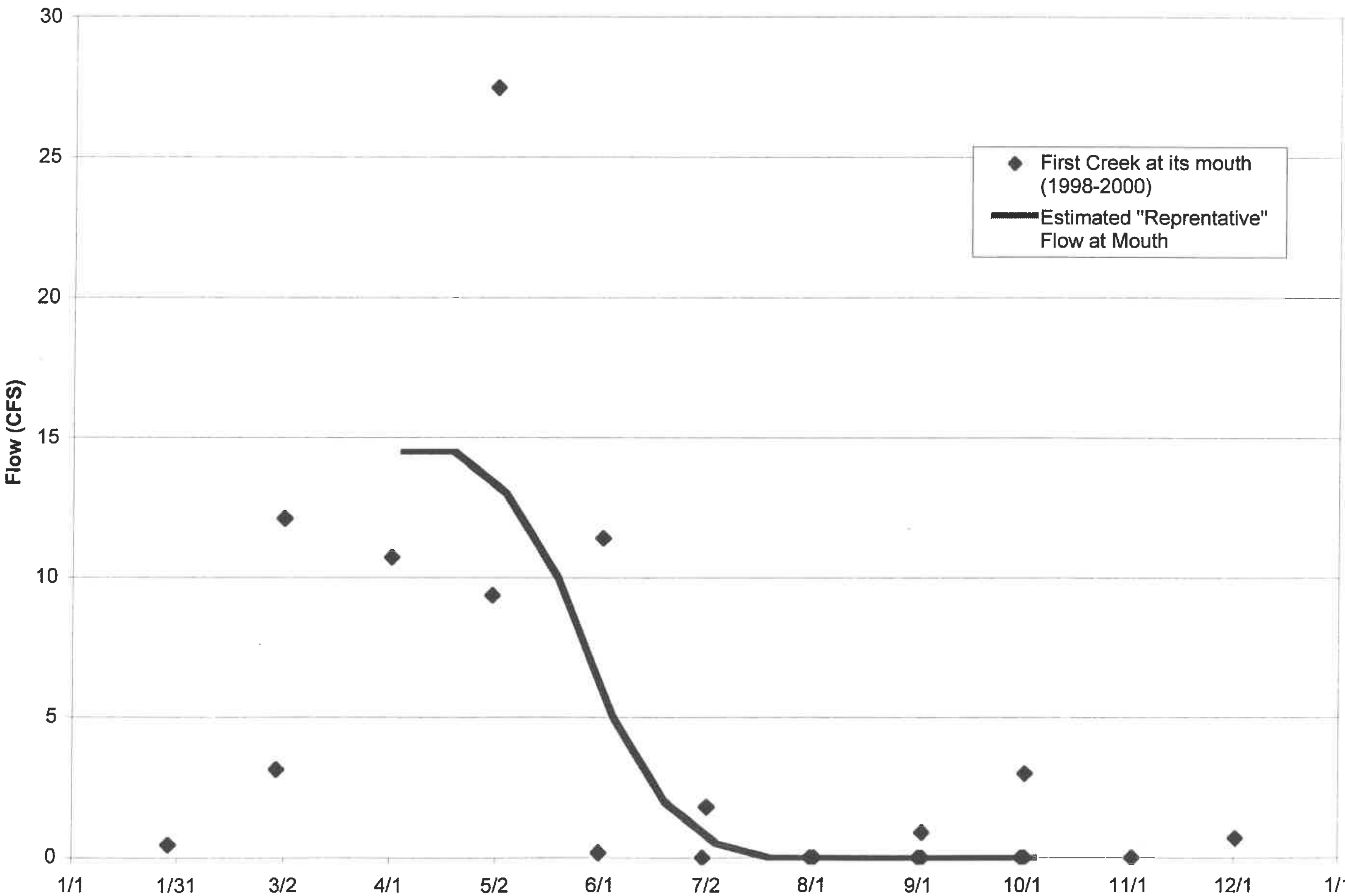


Figure 19
Estimated Total Irrigation Diversion and Change in Streamflow Associated with Trendwest's Proposed Hartman Water Right Transfer

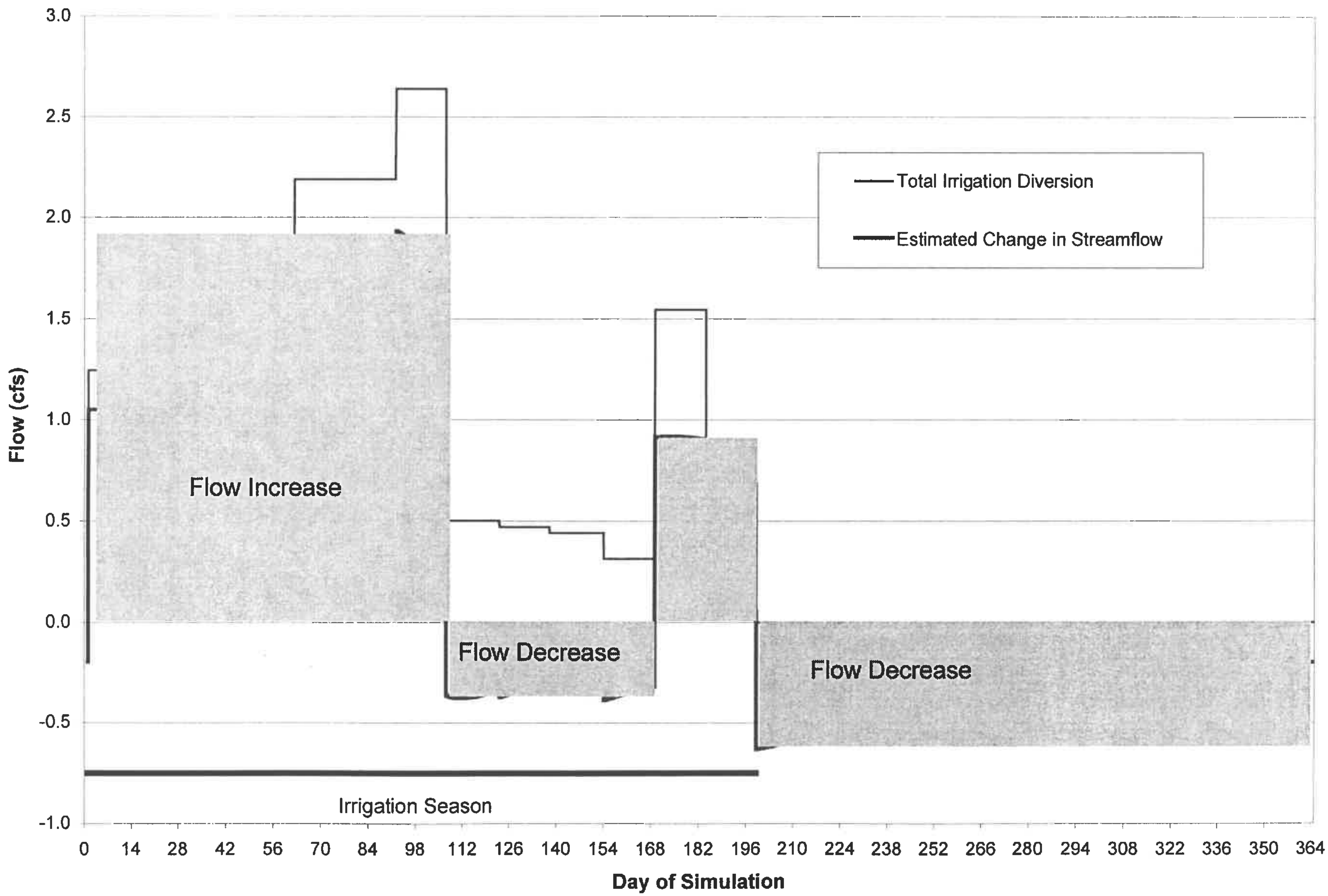


Figure 20
Estimated Net Change in Swauk Creek Flow from Combined Trendwest Hartman and FCWUA Water Right Transfer

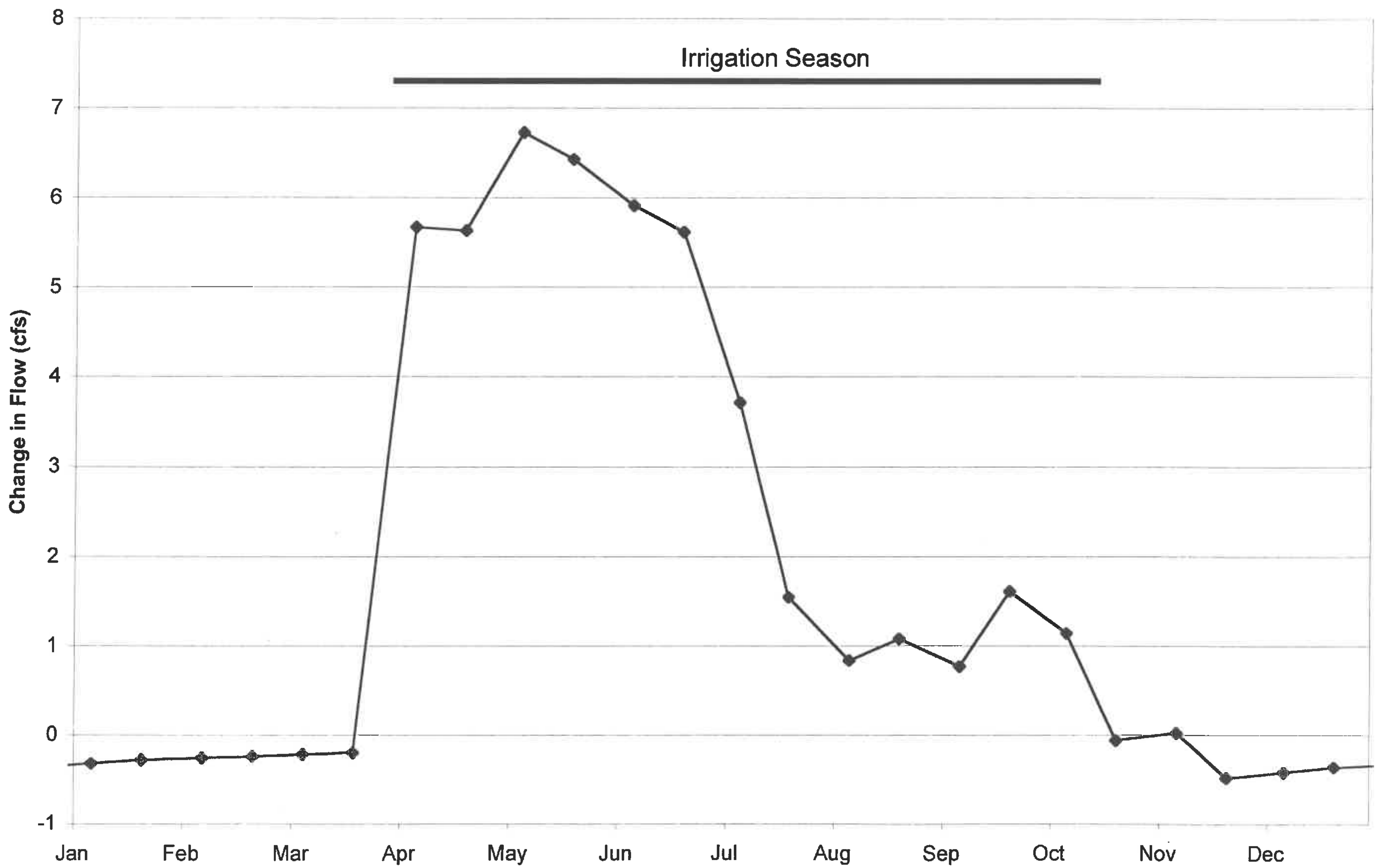


Table 1 - Big Creek Area Well Information
(T20N R14E)

Section	Quarter-Quarter Section	Estimated Land Surface Elevation (ft)	Depth to Water (ft)	Hole Depth (ft)	Water Column (ft)	Tested Well Yield (gpm)	Test Drawdown (ft)	Specific Capacity (gpm/ft)	Low Water Column	DD Exceeds Water Column
Sec 20	NW NW	2090	1	196	195	15	80	0.2		
Sec 20	NW NW	2090	10	40	30	25	20	1.3		
Sec 20	NW NW	2090	8	32	24					
Sec 20	NW NW	2090	Dry	42						
Sec 20	NW NW	2090	10	42	32	75				
Sec 20	NE NW	2085	40	80	40	10				
Sec 20	SW NW	2095	20	58	38	30				
Sec 20	SW NE		Flowing	119	119					
Sec 20	SE NE	2085	18	40	22	50	28	1.8		Yes
Sec 20	SE SE	2130	26	67	41	100	39	2.6		
Sec 20	SE SE	2130	23	67	44	60	65	0.9		Yes
Sec 20	SE SE	2130	18	52	34	15	15	1.0		
Sec 20	SW SW		Flowing	140	140					
Sec 20	SW SW	Dry Hole								
Sec 20	SW SW	2120	10	35	25	12	20	0.6		
Sec 20	SW SW	2120	20	78	58	40				
Sec 20	SW SW	2120	20	59	39	40				
Sec 20	SE SW	2120	23	35	12	10	0.1	100		
Sec 20	SE SW	2120	15	38	23	10	0.1	100		
Sec 21	NE NE	?	19	63	44	30	41	0.73		
Sec 21	NW NE	Dry Hole								
Sec 21	NW? NW	?								
Sec 21	NE NW	2075	16	40	24					
Sec 21	SE SE	2085	23	54	31	40				
Sec 21	SE SE	2085	26	50	24	100				
Sec 21	SW SE	2085	10	80	70	20	70	0.29		
Sec 21	SW SW	2120	20	60	40	20				
Sec 21	NW SW	2110	18	27	9	80	4	20	Yes	
Sec 21	NE SW	2090	12	40	28	45	26	1.7		
Sec 21	NE SW	2090	14	80	66	30	66	0.5		
Sec 21	SE SW	2110	19	40	21	35	18	1.9		
Sec 21	SE SW	2110	13	71	58	20	57	0.4		
Sec 28	NW NW	2130	10	45	35	30	30	1.0		
Sec 28	NE NW	2120	20	60	40	25				
Sec 28	NE NW	2120	80	100	20	30	15	2.0		
Sec 28	SW NW	2140	15	50	35	100	33	3.0		
Sec 28	NE SW	2170	70	100	30	10	25	0.4		
Sec 28	NW SE	2150	15	80	65	20	60	0.3		
Sec 28	NE SE	2140	19	75	56	100				
Sec 28	NE SE	2140	16	40	24	50	22	2.3		
Sec 28	SE SE	2155	15	30	15	10	15	0.7	Yes	
Sec 28	SE SE	2150	49	120	71	15	66	0.2		
Sec 28	SE SE	2150	14	92	78	100	78	1.3		
Sec 28	SE SE	2150	28	90	62	18				
Sec 28	NW NE	2115	14	92	78	300	76	3.9		
Sec 28	SE NE	2125	20	55	35	30	35	0.9		
Sec 28	SE NE	2125	21	50	29	65				
Sec 28	SW NE	2140	220	320	100	25	90	0.3		
Sec 28	NE NE	2115	19	70	51	30				
Sec 28	NE NE	2115	20	64	44	80	40	2.0		
Sec 28	NE NE	2115	19	63	44	60	36	1.7		
Sec 28	NE NE	2115	18	120	102	75				
Sec 28	NE NE	2115	20	80	60	100	50	2.0		
Sec 29	NE NE	2150	20	42	22	20				
Sec 29	NE NE	2150	46	60	14	22	19	1.2	Yes	Yes
Sec 29	NE NE	2150	44	59	15	8	24	0.3	Yes	Yes
Sec 29	NE NE	2150	22	52	30	15	28	0.5		
Sec 29	NE NE	2150	46	69	23	25	19	1.3		
Sec 29	NE NE	2150	38	63	25	22	17	1.3		
Sec 29	NW NE	2150	18	60	42	25	6	4.2		
Sec 29	SW NE	2150				60				

Table 2 - Teanaway River Area Well Information
(T20N R16E)

Section	Quarter-Quarter Section	Estimated Land Surface Elevation (ft)	Depth to Water (ft)	Hole Depth (ft)	Water Column (ft)	Tested Well Yield (gpm)	Stem Setting for Airlift Test (ft)	Test Drawdown* (ft)	Specific Capacity (gpm/ft)	Estimated gal/day/ft
Sec 25	S1/2 NW	1940	3	160	157	8				
Sec 25	S1/2 NW	1940	-2	260	260	5				
Sec 25	S1/2 NW	1940	50	160	110	10	150	100	0.1	200
Sec 25	SW NW	1940	-2	265	265	30	260	262	0.1	229
Sec 25	NE NW	2010	?	245		20				
Sec 25	SE NW	1900	20	400	380	100		2.5	40	80000
Sec 25	NW NE	1950	205	400	195	4	359	154	0.03	52
Sec 25	NE NE	1960	-2	320	320	4				
Sec 25	SW NE	1950	28	205	177	3				
Sec 25	SE NE	1955	47	72	25	8				
Sec 25	NE	1955	6	185	179	15	185	179	0.1	168
Sec 25	NE SW	1950	4	127	123	33	190	186	0.2	355
Sec 25	NE SW	1950	6	160	154	17				
Sec 25	SW SW	2040	80	116	36	4	115	35	0.1	229
Sec 25	SW	2200	80	280	200	25	275	195	0.1	256
Sec 25	SE SE	2200	35	115	80	5				
Sec 25	SE SE	2200	127	245	118	12				
Sec 25	SE SE	2200	66	103	37	30				
Sec 25	SE SE	2200	272	525	253	10	435	163	0.1	123
Sec 25	NE SE	2000	93	109	16	15	108	15	1.0	2000
Sec 25	SE	?	120	310	190	5				
Sec 26	NW NW	2150	117	425	308	4				
Sec 26	NE NW	2150	2	185	183	20	180	178	0.1	225
Sec 26	SW NW	2100		165		10				
Sec 26	SW NW	2100		160						
Sec 26	N1/2 NE	2150	110	365	255	50				
Sec 26	NW NE	2150	-2	285	285	30				
Sec 26	N NE		100	86	?	30	175	75	0.4	800
Sec 26	NW SW	2000	130	300	170	3	360	230	0.01	26
Sec 26	NW SW	1950	38	200	162	10	180	142	0.1	141
Sec 26	NE SW	1925	-1	340	340	35	320	321	0.1	218
Sec 26	SW SW	1890	220	360	140	7	340	120	0.1	117
Sec 26	SW SW	1890	30	190	160	15	180	150	0.1	200
Sec 26	SW SW	1890	49	69	20					
Sec 26	SW SW	1890	77	123	46					
Sec 26	SE SW	1900	10	303	293	10				
Sec 26	SE SW	1900	6	240	234	30	240	234	0.1	256
Sec 26	SW		10	197	187	25	195	185	0.1	270
Sec 26	SW SE	1910	60	215	155	10	255	195	0.1	103
Sec 26	SE SE	1915	7	50	43	40	18	11	3.6	7273
Sec 26	SE SE	2000	84	182	98	22	72	-12		Values transcribed c
Sec 26	SE SE	2000	6	56	50	50				
Sec 26	SE SE	2000	205	380	175	7	380	175	0.04	80
Sec 26	SE SE	2000	-1	265	265	38				
Sec 26	SE SE	2000	35	140	105					
Sec 26	SE SE	2000	90	157	67	10	155	65	0.2	308

* Estimated for airlift tests by subtracting depth-to-water from stem setting.

Table 3 - Swauk Creek Area Well Information (T20N R17E)

Section	Quarter-Quarter Section	Depth to Water (ft)	Hole Depth (ft)	Water Column (ft)	Tested Well Yield (gpm)	Completion Type
Sec 22	S1/2 SW	71	190	119		Open Hole
Sec 22	S1/2 SW	106	386	280	1	Perforated
Sec 22	SW SW	190	500	310	1.5	Perforated
Sec 22	SW SW		264	264	0.5	Open Hole
Sec 22	SW SW	90	210	120	2.5	Perforated
Sec 22	SW SW		300	300	3	Open Hole
Sec 22	SE SE	30	80	50	20	Open Hole
Sec 27	N1/2 NW	100	145	45	10	Open Hole
Sec 27	N1/2 NW	93	380	287	3.5	Open Hole
Sec 27	NE NW	15	232	217	4	Open Hole
Sec 27	SW NE	147	265	118		Screened
Sec 27	SW SW	8	145	137	5	Perforated
Sec 27	SW SW	10	205	195		Screened
Sec 27	SW SE	80	145	65		Perforated
Sec 27	SE SE	200	705	505	15	Perforated
Sec 28	SW	110	190	80	15	Open Hole
Sec 28	SW	80	167	87	20	Open Hole

Table 4 - Reecer Creek Area Well Information
(T19N R18E)

Section	Quarter-Quarter Section	Estimated Land Surface Elevation (ft)	Depth to Water (ft)	Hole Depth (ft)	Geology of Completion Interval	Water Column (ft)	Tested Well Yield (gpm)	Stem Setting for Airlift Test (ft)	Test Drawdown* (ft)	Specific Capacity (gpm/ft)	Completion Note
Sec 6	N? NW	2920	30	100	Bas	70	5	70	40	0.13	
Sec 6	NW NW	3000	23	80	Bas	57	15				
Sec 6	NW NW	3000	471	800	Bas	329	11				
Sec 6	SE NW	2900	100	180	Bas	80	20	175	75	0.27	
Sec 6	SE NW	3000	150	245	Bas	95	7				
Sec 7	E1/2 NE	2700	410	832	Bas	422	35	775	365	0.1	
Sec 8	NW NW	2735	510	626	EF	116	25	600	90	0.3	
Sec 8	SW NW	2665	480	600	Bas	120	10	595	115	0.1	
Sec 8	NE NE	2880	312	435	Sed	123	5				
Sec 8	SE SW	2570	500	660	EF	160	15				
Sec 8	SW SE	2560	465	640	Bas/EF	175	15	630	165	0.1	
Sec 8	SW SE	2560	470	560	Bas	90	4	550	80	0.1	
Sec 8	SW SE	2560	485	560	Bas	75	3	560	75	0.04	
Sec 17	NW NW	2530	340	440	Sed	100	12				
Sec 17	SE NW	2460		520	EF	520	7				
Sec 17	SE NW	2460	380	540	Bas	160	15				
Sec 17	NW NE	2510	400	550	Sed	150	10				
Sec 17	NW NE	2510	408	640	Sed	232	35				
Sec 17	NE NE	2500	375	480	EF	105	15	475	100	0.2	
Sec 17	SW NE	2460	390	600	Bas	210	15	430	40	0.4	
Sec 20	NE NE	2340	186	380	Bas/EF	194	30				
Sec 21	NE NE	2360	180	700	Bas	520	400	pump test	120	3.3	Perf 300-325, completed in broken basalt
Sec 22	NW NW	2360	230	370	Sed	140					
	SE NW	2340	180	300	Bas/EF	120	25				
	SE NE	2320	205	300	Sed	95	25	29			Log says stem set at 29 feet but it doesn'
	NE SE	2300	163	285	Sed	122	45				
	E E		96.6	154	Sed	57.4	15				Elevation ranges from 2200 to 2440
	E E		253	380	Sed	127	40				Elevation ranges from 2200 to 2440
Sec 27	SE NE	2100	195	282	Sed	87	10			0.0	Log says zero feet drawdown
	SE SE	2050	138	200	Sed	62	16	180	42	0.4	
Sec 28	NW	2160	250	390	Sed	140	20	330	80	0.25	
Sec 28	NW NW	2192	?	940	Bas/EF		?				
Sec 28	SE NE	2110	230	343	Sed	113	60	pump test	123	0.49	No perfs, no screens, in sand and gravel
Sec 30	NE SE	2100	15	160	Sed	145	20	140	125	0.16	
Sec 31	NE	2020	90	160	Sed	70	20	158	68	0.29	
Sec 31	NE	2020	100	160	Bas	60	15	155	55	0.27	
Sec 31	NE NE	2030	85	160	Sed	75	16	155	70	0.23	
Sec 31	NE NE	2030	82	170	Sed	88	30				
Sec 31	NE NE	2030	120	207	EF	87	20	180	60	0.33	
Sec 31	SW	1950	50	100	Bas	50	20	98	48	0.42	
Sec 31	SW SW	1920	27	131	Sed	104	18	pump test	4	4.50	Screened 5' length, in sand and gravel.
Sec 31	SW SW	1920	30	160	Sed	130	20	95	65	0.31	
Sec 31	NE SE	1970	33	180	Sed	147	27	160	127	0.21	
Sec 31	SE SE	1930	80	240	Sed	160	20	235	155	0.13	
Sec 31	SE SE	1930	64	167	Sed	103	22				
Sec 32	SW NW	1980	18	103	Sed	85	25				
Sec 32	SE NW	2000	40	100	Bas	60	15				
Sec 32	SE NW	2000	55	142	Sed	87	20				
Sec 32	E1/2 SW	1960	60	125	Sed	65	15	pump test	20	0.75	No Screen, No Perfs, in sand.
Sec 32	SW SW	1900	13	40	Sed	27	20	30	17	1.18	

* Estimated for airlift tests by subtracting depth-to-water from stem setting.

GEOLOGIC DESIGNATIONS:
Sed - Unconsolidated sedimentary aquifer above basalt
Bas - Basalt (obvious Columbia River Basalt or no other rock type likely near completion zone)
EF - Ellensburg Formation - well is completed in sedimentary material encounterd below basalt
Bas/EF - open to both basalt and EF

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Technical Memorandum

To: Randall Doneen, Department of Ecology
Joe Mentor, Mentor Law Group
Jamie Morin, Mentor Law Group
Andy Kindig, A. Kindig & Associates
Tom Martin, Brown and Caldwell

From: Peter Schwartzman, Associate Hydrogeologist, PGG
Chrysten Root, Geologist/Hydrologist, PGG

Re: **REECER BASIN HYDROLOGIC ANALYSIS**

Date: January 25, 2002

The purpose of this memorandum is to discuss how the proposed transfer of Trendwest's First Creek water rights from irrigation in the Reecer Creek basin to instream flow in the Swauk Creek basin would affect the timing and volume of return flows through the Reecer Creek basin to the Yakima River. All water rights from First Creek were historically diverted at the First Creek Waters Users Association (FCWUA) diversion into the FCWUA ditch. The ditch runs through Green Canyon, and is distributed to lateral ditches approximately two to three miles below its exit from the canyon. The lateral ditches historically supplied four water rights owned by Roan, Nelson and Olson. As shown on **Table 1**, Trendwest has purchased the senior Nelson and the junior Roan water rights. Because FCWUA water was historically taken from the Swauk Creek Basin via First Creek and used in the Reecer Creek Basin, the proposed transfer would result in a reduction of water imported into the Reecer Creek Basin and an equivalent increase in water availability to the Swauk Creek Basin (via First Creek). The proposed transfer would leave 56% of the historically diverted water in First Creek rather than diverting it to the Reecer Creek basin. This water would then be transmitted to the Yakima River via Swauk Creek and associated groundwater flow. **Figure 1** is a study-area map that presents the locations of streams, ditches, and referenced properties[1].

Trendwest's proposed transfer would also result in a net increase in water availability to the Yakima River in an amount equivalent to the consumptive use associated with former irrigation practices. However, estimating the change in timing by which this newly available water reaches the Yakima River requires consideration of a number of factors. Water rights transfer from irrigation use to instream flow means that the entire former diversion would become immediately

[1] The property locations shown on Figure 1 are generalized, and were provided by Mentor Law Group. There are minor discrepancies between the locations shown and the legal descriptions of the historic places of use.

available to supplement streamflow in the Swauk Creek basin. However, much of the non-consumptive portion of the former diversion historically seeped into the groundwater system and therefore took a slower flowpath to the Yakima River, both during and after the irrigation season. Changing the water right from irrigation to instream flow would make the entire (former) diversion available to streamflow in First Creek during the irrigation season, but would also result in discontinuation of the irrigation return flow that historically reached the Yakima River via a slower groundwater pathway.

In this memorandum, Ecology's Consultant Team (ECT) presents analysis of the change in volume and timing of irrigation return flows through the Reecer Creek basin to the Yakima River due to the proposed water rights transfer. Our analysis also addresses changes in flow available to First Creek due to the proposed transfer. Hydrologic responses to increases in First Creek flow are discussed in the First and Swauk Basin Hydrologic Analysis (PGG, 1/24/02). During our Reecer Basin investigation, ECT examined the following:

- hydrogeologic conditions in the Reecer Creek basin;
- potential hydraulic continuity between streams and aquifers in the Reecer Creek basin;
- typical historic streamflow in First Creek and its affect on water availability to FCWUA irrigators;
- historic and predicted future seepage gains/loss from the FCWUA ditch, and the associated groundwater return-flow pathway;
- historic irrigation seepage loss[2] associated with Trendwest's water rights, and the associated groundwater return-flow pathway;
- changes in the amount of water travelling through the Reecer Creek basin between the historic and proposed future conditions.

For the purpose of this analysis, water reaching the Yakima River via surface-water pathways is considered to reach the river instantaneously. Delivery schedules for water reaching the Yakima River via groundwater pathways in the Reecer Creek basin were estimated using hydrogeologic characterization. Under both conditions (historic and future), the apportionment between surface-water and groundwater return-flow pathways was estimated based on historic water availability and estimates of seepage losses associated with how the water right is routed through the hydrologic system. Characterization of hydrogeology, streamflow and seepage losses in the Swauk Creek Basin are contained in the Swauk Creek Memorandum (PGG, 1/24/02) and are incorporated by reference into this memorandum.

1 Summary of Findings

- There is no evidence of hydraulic continuity[3] in the area of the Roan and Nelson properties (the historic place of use of the Trendwest water rights). As a result, field and ditch seepage

[2] Seepage loss is defined as infiltration of water from above the land surface to below the land surface. For instance, water flowing within a stream channel or applied to fields as irrigation can seep into the subsurface and recharge the groundwater flow system. Seepage loss remains in the hydrologic system, but is transferred from surface water to groundwater.

return flows reach the Yakima River via subsurface pathways. Tailwater from irrigation is assumed to return to Reecer Creek and the Yakima River via surface flow.

- Subsurface return flows to the Yakima River from the Reecer Creek basin were estimated to occur at a near constant rate year-round. Historic water use associated with Trendwest's FCWUA water rights is estimated to have resulted in about 56 percent of the historic total subsurface return flows from the First Creek Water User's Association irrigators (equal to Trendwest's water right percentage of the total FCWUA diversion).
- The proposed transfer of Trendwest water rights to instream flows at the point of diversion in First Creek would result in a net increase in flow to the Yakima equal to the consumptive use formerly associated with those water rights (about 377 acre-feet per year).
- The proposed transfer would increase flows in First Creek and Swauk Creek during the irrigation season. At the former point of diversion, irrigation-season flows in First Creek flows would increase by an estimated 1.1 to 5.2 cfs.
- The proposed transfer would cause a reduction in subsurface return flows to the Yakima River via the Reecer Basin. Historic subsurface return flows associated with the water rights proposed for transfer are estimated at approximately 0.66 cfs, and likely discharged to the Yakima River in a fairly constant, year-round manner.
- The most significant effect of the proposed transfer on Reecer Creek streamflow would be a loss of historic tailwater returns, estimated to have ranged from about 2.9 to 0.71 cfs during April, May, and June. Rather than reaching the Yakima River via the Reecer Creek pathway, these flows would reach the river via First and Swauk Creeks.
- The transfer is estimated to result in higher flows on the Yakima River throughout the irrigation season. Specifically, flow increases would occur on the 9-mile reach between the Yakima River confluences with Swauk and Reecer creeks, and further downstream. However, flow reductions on the order of about 0.66 cfs are predicted to occur below Reecer Creek over most of the non-irrigation season.

2 Hydrogeology of the Reecer Creek Basin

In order to assess and understand the hydrogeology of the Reecer Creek basin, ECT evaluated geologic maps and well logs from the region and completed one day of field reconnaissance. Our hydrogeologic evaluation focused on the portion of the irrigation system downstream of Green Canyon, since this is the portion of the basin where most of the seepage losses from ditches and fields occurs (Section 3). Our study area included Sections 6, 7, 8, 17, 20, 21, 28, 31, and 32 of Township 19 N, Range 18 E. The land parcels that were historically irrigated with Trendwest water rights are located in Sections 21 and 28. **Figure 1** presents a map of surficial geology and the locations of irrigated parcels associated with the FCWUA diversion.

2.1 Geology

Based on previously published geologic mapping (Tabor et al, 1982) and field reconnaissance, Reecer Creek flows through two unconsolidated units called the Kittitas Drift and sidestream

[3] For the purpose of this memorandum, hydraulic continuity is defined as a saturated hydraulic connection.

alluvium. The drift is characterized by basalt gravel in silty matrixes. In well driller's logs, the drift is often logged as "cemented gravel". The sidestream alluvium mapped near Reecer Creek on the hillslope extending down to the Yakima River is comprised of silty gravels. The lithology of the gravel in the sidestream alluvium is dependent on nearby rock exposures, which in the case of Reecer Creek is also basalt. The FCWUA ditch flows over the drift unit from the mouth of Green Canyon until approximately 3000 feet upstream of the Roan/Olsen weirs. The remainder of FCWUA ditch is primarily located on the sidestream alluvium. Most of the Roan and Nelson properties are located on the sidestream alluvium, as only the western 1000 feet of the Roan property and western 800 feet of the Nelson property are underlain by the Kittitas Drift. Downstream of the Roan and Nelson properties, Reecer Creek flows over sidestream alluvial deposits, although exposures of the Kittitas Drift and the Thorp gravel (a Pliocene consolidated sedimentary unit) are observed near the creek. Near its confluence with the Yakima River, Reecer Creek flows over Yakima River alluvium.

The geology of the Reecer Creek hillslope is mapped based on geomorphic criteria rather than lithology or soil texture. Kittitas Drift units are mapped based on small topographic expressions that protrude 2 to 3 feet above the sidestream alluvium, while deposits of granular material from individual small streams are mapped as sidestream alluvium. Since the two mapped units have similar soil textures, subsurface infiltration and groundwater flow likely behave in a similar manner in both units.

2.2 Hydrogeology

Driller's logs of wells located near the Roan and Nelson properties were reviewed from Sections 6, 7, 8, 17, 20, 21, 28, 31, and 32 of Township 19 N, Range 18 E. Most of the well locations were specified to the nearest quarter-quarter section, however some were located in the field with the assistance of Mr. Roan. In the study area, hydrogeologic parameters can be roughly divided into two sub-areas – north and south (uphill and downhill) of the east-west power line located approximately one mile north of the North Branch Canal (KRD). The historic place of use for the water rights purchased by Trendwest is within 2000 feet of the power line. Portions of the properties are located to both the north and the south of the power line in sections 21 and 28.

The well logs suggest that the thickness of the drift and alluvial deposits increases from north to south. In the north near the mouth of Green Canyon, three well logs in Section 6 indicate thicknesses of 58, 78, and 110 feet for the drift and/or alluvial deposits. Two logs in Section 6, indicate thicknesses of 8 and 35 feet, but appear to be drilled in landslide material that overlies basalt bedrock based on their quarter-quarter section locations. Sections 20 and 21, where the power lines are located, each have one well in the NE _ of the NE _. These well logs indicate drift or alluvium thicknesses of 55 and 150 feet. In the south, the well logs from Section 31 indicated that basalt bedrock was not encountered within depths ranging from 100 to 240 feet. This suggests that beneath the Roan and Nelson properties, the alluvium is roughly 100 feet thick.

Well depths and associated depths to groundwater also vary from North to South. North of the power line all wells are greater than 400 feet deep and are completed in bedrock, except for three wells in Section 6. The three wells are located far from the FCWUA places of use, and may suggest locally perched conditions near the mouth of Green Canyon (by a small side stream, downhill from a small surface water impoundment). Water levels in the northern area are generally 300 to 500 feet below ground surface with the exception of the shallow wells in Section 6 noted above. Well yields from wells north of the powerline that tap bedrock are relatively low. Most of the yields from wells in Section 8 are less than 5 gallons per minute (gpm) based on air discharge tests by the drillers. In wells drilled in Sections 20, 21, 28, which are located near the power lines (and the Roan and Nelson properties), intermediate water levels of 180 to 250 feet deep are found. In this area, the wells are also completed in the bedrock rather than in the alluvium, and well yields based on discharge tests by the drillers range from 20 to 50 gpm. One additional well in this area was drilled into the basalt bedrock as a source of irrigation water, and produces 400 gpm. South of the power line, wells are generally completed within the drift or alluvial sediments. All wells are less than 400 feet deep, and most are less than 200 feet deep, except in Section 28 where two wells exist that are 390 and 343 feet deep. In the south, static water levels are generally 30 to 100 feet below ground surface and well yields are generally 15 to 20 gpm based on air discharge tests by the drillers. One anomolously deep well (940 feet) was drilled in the NW _ of the NW _ of Section 28 as a source for irrigation water (pers. comm., JP Roan, 2001) and likely does not tap the first water encountered.

On a regional scale, groundwater appears to flow north to south along a water table that generally follows the topography (although at a less steep angle). The difference between the land surface slope and the (gentler) groundwater gradient explains why depth to groundwater is less in the south. In addition, well logs suggest that a significant thickness of unsaturated material exists throughout most of the study area. The water table occurs within bedrock (usually basalt) in the northern portion of the study area and within unconsolidated material (Kittitas Drift and sidestream alluvium) in the southern portion. The depth to water beneath the Roan and Nelson properties ranges from 180 to 250 feet deep. Although data are limited, there is no indication of shallow or perched aquifer in the vicinity of the Roan and Olson properties.

3 Surface Water Flows and Hydraulic Continuity in the Reecer Creek Basin

Surface water in the Reecer Creek basin flows not only through Reecer Creek, but also through an extensive network of irrigation ditches. ECT evaluated flow data collected on both the Reecer Creek and the FCWUA ditch to assess whether the ditches and streams in this area gain or lose flow, and if they are in hydraulic continuity with the groundwater system.

Little data are available on flow conditions and potential seepage losses in the upper reaches of Reecer Creek beyond one streamflow survey completed by Tom Martin in early April of 1999. The available data from Tom Martin's survey indicate that flows declined from 6.0 cfs at the First Creek Canal crossing to 1.2 cfs downstream at the North Branch of the KRD Canal. Between the KRD Canal and the Cascade Irrigation Canal, flow in Reecer Creek increased to 2.8 cfs. The Roan and Nelson properties are located in the reach between the First Creek Canal Crossing and the KRD Canal, where Reecer Creek appears to be losing. This suggests that hydraulic continuity is not present along this reach. However, several irrigation diversions are shown in this reach on the Aquavella adjudication maps. Since the magnitude of April 1999 diversions from Reecer Creek in this area is unknown, definitive conclusions on the amount of gains or losses from the creek cannot be made.

In the lower portion of Reecer Creek, from Mill Ditch down to the Yakima River, Montgomery Water Group (MWG) evaluated gaining/losing conditions observed during a single set of spot flow measurements. In October 2001, flows in Reecer Creek were gaged at 13.1 cfs upstream of Dolarway Road and 12.8 cfs downstream of Dolarway Road near I-90. With measurement error, these data do not show any gains or losses over this one mile reach, however conditions in the creek may vary during higher flows. MWG observed that water levels in ponds adjacent to the creek were similar to those in the creek, suggesting that hydraulic continuity may occur in this reach.

MWG completed a seepage survey on the FCWUA ditch during the 2001 irrigation season from the FCWUA diversion down to the ditch laterals leading to irrigation places of use (see attached memorandum). The results of the survey suggest that seepage gains generally occur where the ditch passes through Green Canyon, and that seepage losses to groundwater generally occur in the portion of the FCWUA ditch between the Green Canyon Diversion and the Roan /Olsen Weir **(Table 2)**. In the reach between the weir and the Roan property, no change in flow was observed. Since seepage losses were observed in the middle portion of the FCWUA ditch, hydraulic continuity is not likely present in that area. However, for the lower portion of the ditch where no gains or losses were observed, the data do not provide any information about the presence or lack of hydraulic continuity.

Although the seepage surveys only provide limited evidence for a lack of hydraulic continuity in the study area, this conclusion is supported by the deep groundwater levels observed in the area of the Roan and Nelson properties. Since the groundwater elevations in this region are significantly lower than the surface water elevations, our best professional judgement is that hydraulic continuity is not present in the study area.

4 Magnitude and Timing of Historic Subsurface Return Flows in the Reecer Creek Basin

Historic subsurface return flows originated as groundwater recharge from FCWUA ditch losses during conveyance from First Creek to the Reecer basin, and from field and ditch losses on the irrigated properties. Quantities of field and ditch loss vary with irrigation rates throughout the growing season, which are in turn limited by First Creek streamflow available for FCWUA diversion. **Figure 2** shows Tom Martin's estimates of long-term average streamflow available at the First Creek diversion. All analyses related to water availability in this memorandum are based on these streamflow estimates[4]. Actual streamflow is likely to depart both seasonally and annually from this average due to variability in climate and precipitation. Monthly averages of total FCWUA diversions, as well as estimates of ditch and field seepage loss are summarized in **Table 3** on a monthly basis for the irrigation season. **Table 3a** presents estimates of the historic distribution of seepage loss between water rights now owned by Trendwest (Nelson and junior-priority Roan) and those retained by Olson and Roan (senior priority). **Table 3b** presents estimates of the proposed future condition, with total diversions divided to the portion left in the basin (labeled "post water rights transfer") and the resulting change to the irrigation system. The data in **Table 3a** were derived from personal communication with Montgomery Water Group,

[4] The flow estimates were generated with a prior version of Brown & Caldwell's regression-based streamflow prediction model (Tom Martin, pers. comm., 10/6/01) and are sufficient for estimating the timing of discontinued return flows in the Reecer Creek basin.

and the data in **Table 3b** were derived from the Montgomery Water Group technical memorandum entitled "FCWUA Ditch Seepage Loss Analysis" (1/24/02), and a copy of this memorandum is attached.

Based on the flow availability estimated on **Figure 2**, irrigation diversions become limited by available streamflow starting in June. The diversion estimates in **Tables 3a and 3b** assume that the irrigators do not exceed the maximum net volume (Qa) limits of their water rights. However, anecdotal information suggests that the irrigators generally diverted all of the water in First Creek into the FCWUA ditch unless First Creek flows exceeded ditch capacity[5].

Based on **Table 3a**, estimates of historic average monthly seepage losses associated with the water rights purchased by Trendwest range from 2.07 cfs in June to 0.64 cfs in September, while the tailwater component is greatest in April and May (2.7 and 1.9 cfs), but is negligible during most of the irrigation season when crop requirements exceed available streamflow.

Estimating the timing of subsurface return flows depends on the velocity of the seepage loss as it travels in the subsurface. This rate depends on several factors:

- The depth to groundwater,
- The length of the flowpath from areas of seepage loss to the receiving surface-water body,
- The hydraulic conductivity and storage of the unsaturated portion of the flowpath, and
- The hydraulic conductivity, storage and gradient of the saturated portion of the flowpath.

For the study area, the receiving body for subsurface return flow is considered to be the Yakima River. However it is possible that creeks and ditches located near the base of the Reecer Creek basin hillside are also receiving bodies. Given that the distance from the irrigated parcels to such ditches is almost as long as from the irrigated parcels to the Yakima River, we believe there is no merit in distinguishing between these two flow paths.

The expected pathway of seepage loss to groundwater from fields and ditches in the irrigated parcels to the Yakima River is long. Seepage is expected to flow vertically downward until it encounters the water table, generally at depths of over 100 feet. The apparent low permeability of the geologic units that comprise the unsaturated zone delay the irrigation recharge pulse and spread it out over time. Once the seepage loss encounters groundwater, it must then travel along a groundwater flowpath for several miles to reach the surface water receiving body, generally the Yakima River. Seepage loss from the fields and ditches will be greater during high surface water flow periods and smaller during low flow periods. This mechanism has the potential to create a "pulse" of water as it travels along the flowpath. However, in the case of the Reecer Creek basin, the length and permeability of the flowpath is such that any pulse would likely be attenuated before reaching the Yakima River. The net effect is that water lost from ditches and irrigated parcels likely discharges to the Yakima River at a near-constant rate.

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[5] If the anecdotal information is accurate, the estimates of historic diversion rates shown in Table 3a would increase in the early irrigation season (April – May) when the available streamflow exceeds the historic diversion estimates based on water rights (Qa). However, given the estimates of irrigation requirements, any additional water diverted into the Reecer basin in April and May would have become tailwater and returned rapidly to the Yakima River, thereby not effecting the magnitude of subsurface return flows.

Terminating the Trendwest portion of the FCWUA water rights into First Creek will reduce the amount of water traveling from the Reecer Creek basin to the Yakima River via subsurface flow paths. Under historic conditions, we estimate that total subsurface return flow to the Yakima River amounted to approximately 1.18 cfs, of which Trendwest's water rights accounted for approximately 0.66 cfs (**Table 4**). However, under the historic conditions, not all of the diverted water was routed through subsurface pathways. The tailwater portion of the diversion returned to the Yakima River via Reecer Creek and a series of ditches. **Table 5** summarizes both the historic groundwater and surface-water discharges to the Yakima River, and shows that average estimated monthly tailwater flows to Reecer Creek associated with the Trendwest water rights ranged from 2.7 to 0.5 cfs between April and June. As data are generally unavailable to estimate seepage losses from Reecer Creek below the FCWUA places-of-use, this analysis assumed that all of this tailwater reached the Yakima River rapidly through surface water pathways[6].

The changes in Reecer Basin subsurface return flow and tailwater flow to the Yakima River associated with Trendwest's proposed FCWUA transfer are unlikely to *exactly* equal the historic estimates of these return flows. When Trendwest ceases diversion of 56 percent of the FCWUA water right, the remaining water users will likely devote a larger portion of their retained water rights to offsetting seepage losses in the FCWUA ditch. This is because ditch seepage will not be reduced by 56 percent of historic losses, but instead by only about 15 to 30 percent (based on values in **Table 3b**). Because future seepage losses are estimated to become a higher portion of the total ditch flow, the remaining irrigators will have less water to apply to their fields. Consumptive use by remaining FCWUA user's crops will therefore be reduced, and a higher portion of the retained water right will go to subsurface return flows. ECT's calculations show that the estimated future reduction in subsurface return flow will be about 9 percent less than the historic return flows attributed to Trendwest's water rights. The proposed transfer would also result in a reduction of tailwater flow to the Yakima River larger than the tailwater flow historically attributable to Trendwest's FCWUA water rights. **Table 3b** shows that while Trendwest's estimated historic tailwater flows ranged from 0.53 to 2.69 cfs, the predicted change in tailwater flows ranges from 0.71 to 2.9 cfs. However, since tailwater is considered to be transmitted quickly to the Yakima River, changes in tailwater flows have little effect on downstream flows in the Yakima River.

It should be noted that the above distinction, on which changes to the future condition are differentiated from historic values associated with Trendwest's water rights, assumes that the hydraulics of the FCWUA irrigation ditch will remain the same. If the ditch were modified, these estimates would vary from the discussion presented above. For example, if the ditch were lined over reaches with high seepage loss, seepage could be reduced and more water would again become available to supply historic rates of field application and consumptive use by crops..

5 Effect of Proposed Transfer on the Timing of Associated Flow to the Yakima River

The proposed water-rights transfer will cause a net increase in water availability to the Yakima River equivalent to the historic consumptive use associated with Trendwest's water right.

[6] Ecology, ECT and Trendwest agreed upon this assumption on a 10/15/01 conference call.

Consumptive use over the irrigation season is estimated to be approximately 377 acre-feet. Under the proposed transfer, this volume of water will reach the Yakima River through the Swauk Creek basin. In addition, the proposed transfer would alter the timing and flowpath by which the non-consumptive portion of the Trendwest water right reaches the Yakima River. Under the historic condition, a significant amount of the non-consumptive irrigation water returned to the Yakima via sub-surface pathways in the Reecer basin at relatively constant, year-round rates (**Table 5**). If this water is left in the First and Swauk Creek basins, almost all of the water will reach the Yakima River via surface water pathways[7] (PGG, 1/24/02). Thus, more of the non-consumptively used portion of the water will reach the Yakima River as a seasonal pulse, rather than as a constant rate subsurface input to the river.

In the Swauk Creek Basin, the most significant noticeable change associated with the transfer is additional surface flows in First and Swauk Creek. The magnitude and timing of these additional flows is discussed in the First and Swauk Basin Memorandum (PGG, 1/24/02). In the Reecer Basin, the most significant noticeable change associated with the proposed transfer is the loss of tailwater inflows during portions of the irrigation season. As previously noted, historic average monthly tailwater inflows are estimated to range from 2.7 to 0.53 cfs between April and June, and likely future changes in tailwater flows will likely show reductions between 0.71 and 2.9 cfs (**Table 3**). Actual values will vary on a year-to-year basis depending on climatic conditions. The overall transfer will cause an increase in streamflow in First Creek, Swauk Creek and the Yakima River during the irrigation season. For most of the non-irrigation season, Yakima River flows will be reduced by discontinuation of historic year-round subsurface return flows via the Reecer Basin (approximately 0.66 cfs)[8].

Changing the water routing from the Reecer Creek Basin to the Swauk Creek Basin causes a geographic shift in the associated tributary contribution to the Yakima River. In the future condition, the entire former diversion under Trendwest's water right will flow though approximately 9 more miles of the Yakima River than was the case when water was diverted to the Reecer Creek basin (where a portion was lost to crop consumption).

6 References

Pacific Groundwater Group (PGG), 2002. First and Swauk Creek Basin Hydrologic Analysis. Technical Memorandum dated January 24, 2002.

Martin, Tom. 2001. Personal communication to Peter Schwartzman (PGG) regarding preliminary estimates of long-term stream hydrographs. Email dated October 16, 2001.

[7] A portion of this water experiences a short timelag in its path to the Yakima River due to the time required for seepage losses near the First Creek mouth to discharge back to Swauk Creek at locations immediately downstream.
[8] The timelag discussed immediately above (footnote 7) will partially offset subsurface return flow reductions during the first several weeks following the irrigation season (PGG, 1/24/02).

Table 1
Swauk / First Creek Water Rights

Name	Priority	Source	CFS	AF	Acres
FCWUA (Retained)	Nov. 2, 1877	First Creek	2.19	274.12	54.8
FCWUA / Trendwest	**Nov. 2, 1877**	**First Creek**	**2.79**	**348.88**	**69.7**
Burke	June 30, 1878	Swauk via Burke	2.25	589.00	78.4
Hartman / Trendwest	**June 30, 1878**	**Swauk via Burke-Hartman**	**0.89**	**150.00**	**20.0**
Burke	June 30, 1878	Swauk via Burke-Hartman	1.77	297.00	39.6
FCWUA (Retained)	June 1, 1881	First Creek	3.92	639.32	127.8
FCWUA / Trendwest	**June 1, 1881**	**First Creek**	**5.00**	**813.68**	**162.7**
Coe, Bruce	May 24, 1884	Swauk via Coe (N)	1.79	164.00	
Coe, Bruce	May 24, 1884	Swauk via Coe (S)	1.50	112.50	
Tang (Michael Coe, SV Ranch)	May 24, 1884	Swauk via Tang	0.167	80.00	
Hartman / Trendwest	**Sept. 20, 1889**	**Swauk via Burke-Hartman**	**3.34**	**563.00**	**75.0**
Burke	Oct. 31, 1889	Swauk via Burke	2.00	150.00	20.0
Tang (Michael Coe, SV Ranch)	Sept. 21, 1892	Swauk via Tang	0.167	80.00	
Coe, Bruce	Apr. 9, 1901	Swauk via Coe (S)	0.375	37.50	
			28.149	**4,299.00**	

*Trendwest Water Rights are shown in bold face type

Table 2
Summary of FCWUA Ditch Seepage Loss Measurements

Location No.	Location	Measured Discharge (cfs)				
		5/31/2001	7/13/2001	8/8/2001	8/29/2001	9/11/2001
1 to 2	FCWUA Flume to Green Canyon	0.8	-0.2	ND*	0.3	0.1
2 to 4	Green Canyon to Weirs Minus Green Canyon Diversion	0.5	-0.1	ND	-0.5	-0.4
5b to 6	Roan Weir to Top of Roan Property	ND	0.0	0.0	0.1	0.0
	Net Loss (negative) or Gain in Main Ditch (positive)	1.3	-0.3	-0.4	-0.2	-0.3

* ND = No Data

Table 3
Summary of Seepage Losses Associated with FCWUA Water Rights

3a – Historic Condition

		Average FCWUA Diversion			FCWUA Ditch Seepage Loss			Onsite Field/Ditch Seepage Loss			Losses to Surface Water		
	Estimated Flow in First Creek[1]	Total	Roan (Sr) and Olson	Nelson and Roan (Jr)	Total	Roan (Sr) and Olson	Nelson and Roan (Jr)	Total	Roan (Sr) and Olson	Nelson and Roan (Jr)	Total	Roan (Sr) and Olson	Nelson and Roan (Jr)
Apr	11.7	9.00	3.96	5.04	0.50	0.22	0.28	1.85	0.81	1.03	4.81	2.11	2.69
May	12.5	9.30	4.09	5.21	0.60	0.26	0.34	2.64	1.16	1.48	3.41	1.50	1.91
Jun	7.8	7.80	3.43	4.37	0.53	0.23	0.30	3.16	1.39	1.77	0.95	0.42	0.53
Jul	3.4	3.40	1.50	1.90	0.42	0.18	0.24	1.49	0.66	0.83	0.00	0.00	0.00
Aug	2.1	2.10	0.92	1.18	0.39	0.17	0.22	0.86	0.38	0.48	0.00	0.00	0.00
Sept	1.9	1.90	0.84	1.06	0.39	0.17	0.22	0.76	0.33	0.42	0.00	0.00	0.00
Oct 1-15	2	2.00	0.88	1.12	0.39	0.17	0.22	0.81	0.36	0.45	0.00	0.00	0.00

3b – Post Trendwest Transfer Condition

		Average FCWUA Diversion			FCWUA Ditch Seepage Loss			Onsite Field/Ditch Seepage Loss			Losses to Surface Water		
	Estimated Flow in First Creek[1]	Prior to Transfer	Post Transfer	Change	Prior to Transfer	Post Transfer	Change	Prior to Transfer	Post Transfer	Change	Prior to Transfer	Post Transfer	Change
Apr	11.70	9.00	3.96	5.04	0.50	0.43	0.07	1.85	0.81	1.03	4.81	1.90	2.90
May	12.50	9.30	4.09	5.21	0.60	0.43	0.17	2.64	1.16	1.48	3.41	1.33	2.08
Jun	7.80	7.80	3.43	4.37	0.53	0.41	0.12	3.16	1.39	1.77	0.95	0.24	0.71
Jul	3.40	3.40	1.50	1.90	0.42	0.36	0.06	1.49	0.57	0.92	0.00	0.00	0.00
Aug	2.10	2.10	0.92	1.18	0.39	0.32	0.07	0.86	0.30	0.55	0.00	0.00	0.00
Sept	1.90	1.90	0.84	1.06	0.39	0.32	0.07	0.76	0.26	0.50	0.00	0.00	0.00
Oct 1-15	2.00	2.00	0.88	1.12	0.39	0.32	0.07	0.81	0.28	0.53	0.00	0.00	0.00

NOTES: 1) Long term average monthly streamflow in First Creek above diversion provided by Tom Martin, Brown and Caldwell.
2) The diversion in April and May has been adjusted downward to meet the total annual water right.

Table 4
Estimated Subsurface Return Flows to the Yakima River from the Reecer Creek Basin

	Diversion (af)	Ditch Seepage Loss (af)	Field Seepage Loss (af)	Field + Ditch Loss (af)	Field + Ditch Loss (cfs) (annual)
FCWUA Total	2,082	183	674	856	1.18
Roan (Sr) and Olson	916	80	296	377	0.52
Nelson and Roan (Jr)	1,166	102	377	480	0.66

Table 5
Historic Discharges of Trendwest's FCWUA Water Rights to the Yakima River

	Reecer Creek Basin		
	Historic Groundwater Discharge (cfs)	Historic Surface Water Discharge (cfs)	Historic Net Discharge to the Yakima (cfs)
Jan	0.66	0.00	0.66
Feb	0.66	0.00	0.66
Mar	0.66	0.00	0.66
Apr	0.66	2.69	3.35
May	0.66	1.91	2.57
Jun	0.66	0.53	1.19
Jul	0.66	0.00	0.66
Aug	0.66	0.00	0.66
Sep	0.66	0.00	0.66
Oct 1-15	0.66	0.00	0.66
Oct 16-31	0.66	0.00	0.66
Nov	0.66	0.00	0.66
Dec	0.66	0.00	0.66

Figure 1
Location Map

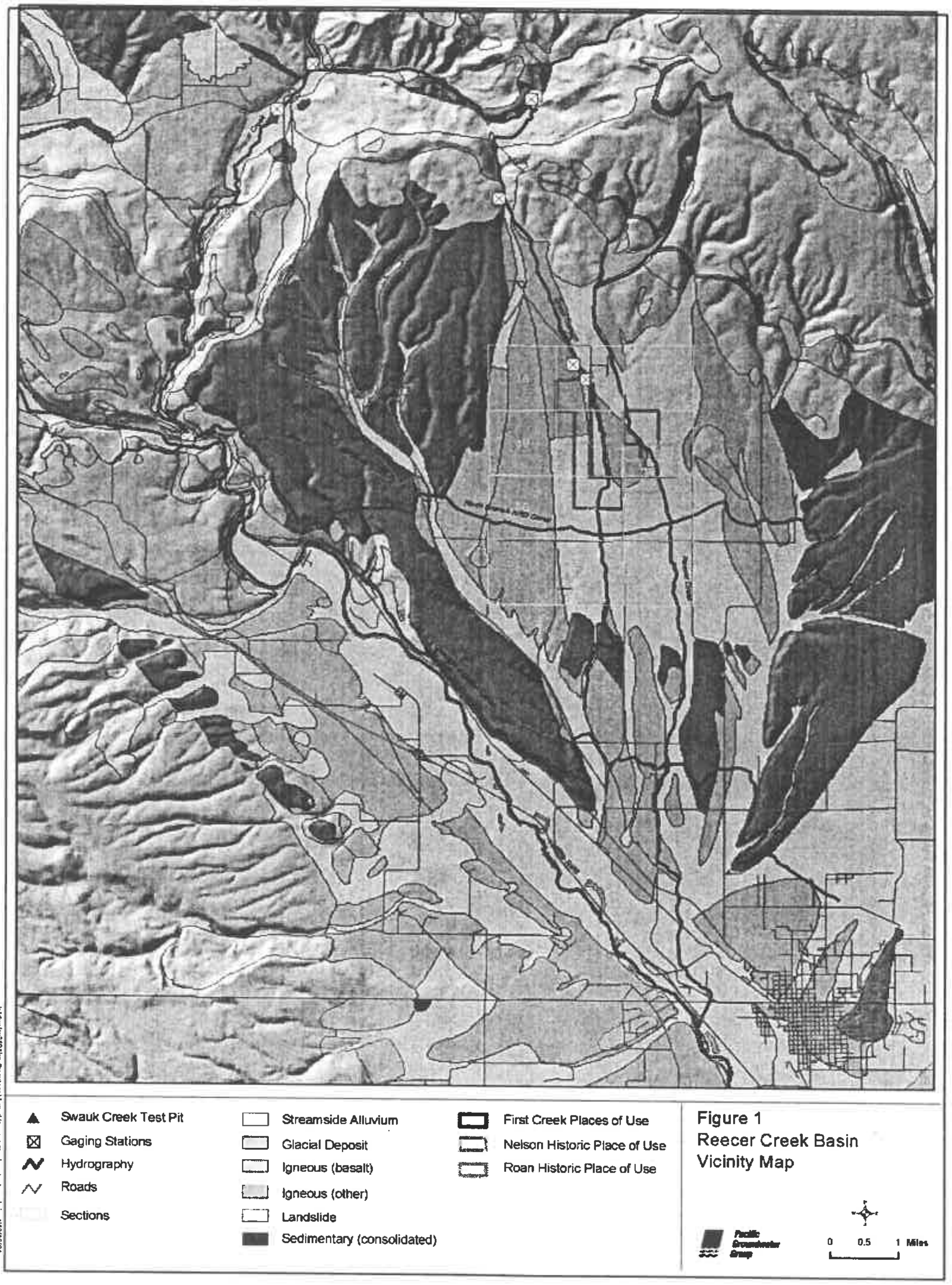


Figure 2
Long Term Average Daily Streamflow at First Creek FCWUA Diversion
Estimated by Tom Martin (Brown & Caldwell)

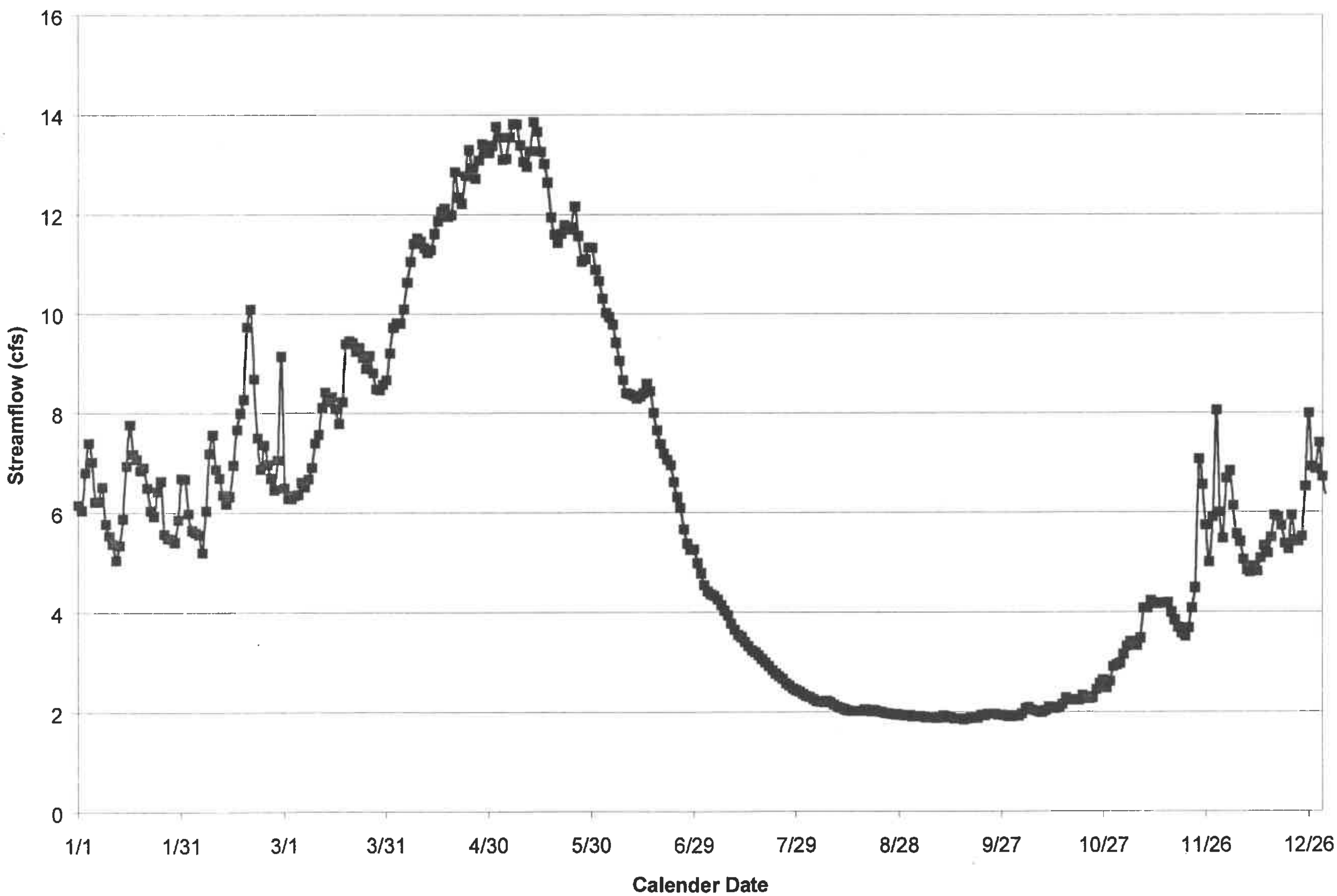


Exhibit H

WATER DEMANDS FROM FALLOWED LANDS
Trendwest Properties: Cle Elum UGA Final EIS
Draft Report

INTRODUCTION

This analysis describes the likely future condition of the properties from which Trendwest Resorts, Inc., purchased water rights and the estimated water demands from those properties.

ANTICIPATED FUTURE DEVELOPMENT OF FALLOWED LANDS

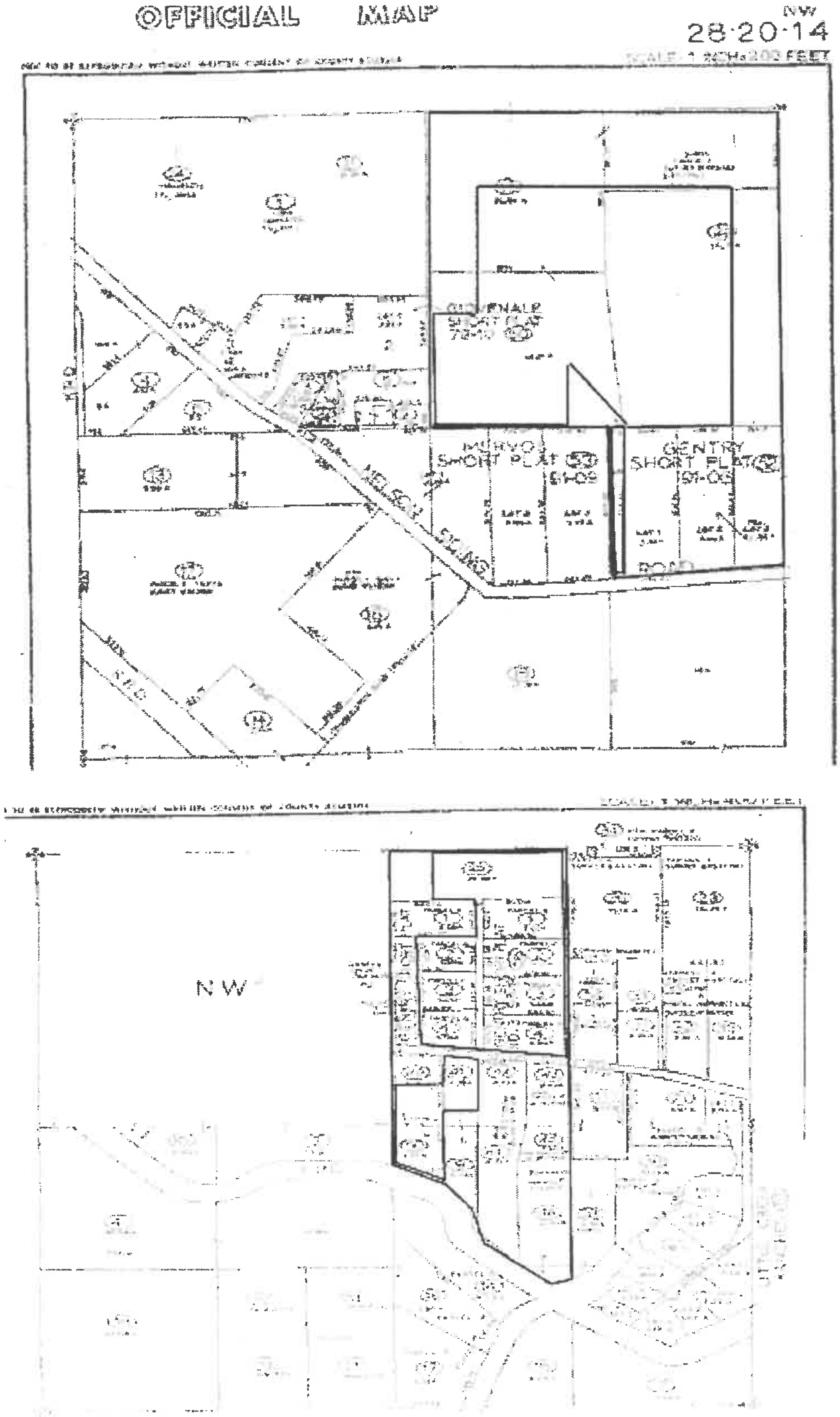
Big Creek

Trendwest purchased water rights appurtenant to approximately 81.5 acres of land in the Big Creek watershed under Court Claim No. 00755 (known as the Gentry water right). The Acquavella Court has conditionally confirmed the Gentry water right for 3.0 cfs, not to exceed 768 acre-feet each year, with the addition of up to an additional 3.0 cfs, not to exceed 166 additional acre-feet when the rights to Big Creek are otherwise fully satisfied. Trendwest owns 50.9% of the water Gentry water right. Trendwest is entitled to 1.53 cfs, not to exceed 390.1 acre-feet each year plus and an additional 1.53 cfs, not to exceed 84.49 acre-feet when the rights to Big Creek are otherwise fully satisfied.

The Gentry property is located in Section 28 of Township 20 North, Range 14 East in Kittitas County. The Gentry property lies north of the Kittitas Reclamation District Canal and is formerly part of the Lund and Richards homesteads. Before 1998, water was diverted from Big Creek into Lund Ditch primarily for irrigation and for stockwater. The 81.5 acres is part of a larger 160 acre property in private ownership that is currently surveyed and platted into 25 parcels ranging from 2.86 to 26.34 acres in size. The subdivision of the Gentry property dates back to the early 1990's with Gentry Short Plat No. 1, recorded in December 1991; Gentry Short Plats No's. 2 and 3 recorded in June 1994; and additional surveys recorded in July 1993 and September 1994.

Trendwest purchased rights from 14 of the 25 Gentry parcels, however only four of the five acre parcels were fallowed completely as a result of Trendwest's water right purchases. The remaining ten parcels retained a portion of the existing water rights for use within each parcel. Figure 1 is a Kittitas County Assessors Map showing the historic place of use under the Gentry water right claim (area within the red boundary line) and the Trendwest portion of that water right (area within the blue boundary line).

Figure 1: Big Creek Property



Teanaway River

Trendwest purchased water rights appurtenant to approximately 188 acres of land formerly irrigated from two points of diversion on the Teanaway River under Court Claim No. 02255 (known as the Walker water rights). As recommended for confirmation in the Supplemental Report of Referee for Subbasin No. 3, these water rights entitle Trendwest to divert approximately 3.76 cfs, not to exceed 1,016 acre-feet each year.

The property is located in Sections 25 and 26 of Township 20 North, Range 16 East in Kittitas County. The property lies west of the Teanaway River, north of State Route 970 and south of East Masterson Road. Before 1996, water was diverted from the Teanaway River into Masterson Ditch and Seaton Ditch primarily for irrigation of timothy hay and for stockwater.

In September 1986, a survey was filed with the Kittitas County Auditor subdividing the property into 16 individual lots, 15 of which are between 10 and 12 acres in size, and one 48 acre lot. Trendwest purchased water rights from the entire property. Figure 2 shows the survey maps as filed with the County Auditors office.

Figure 2: Teanaway River Property

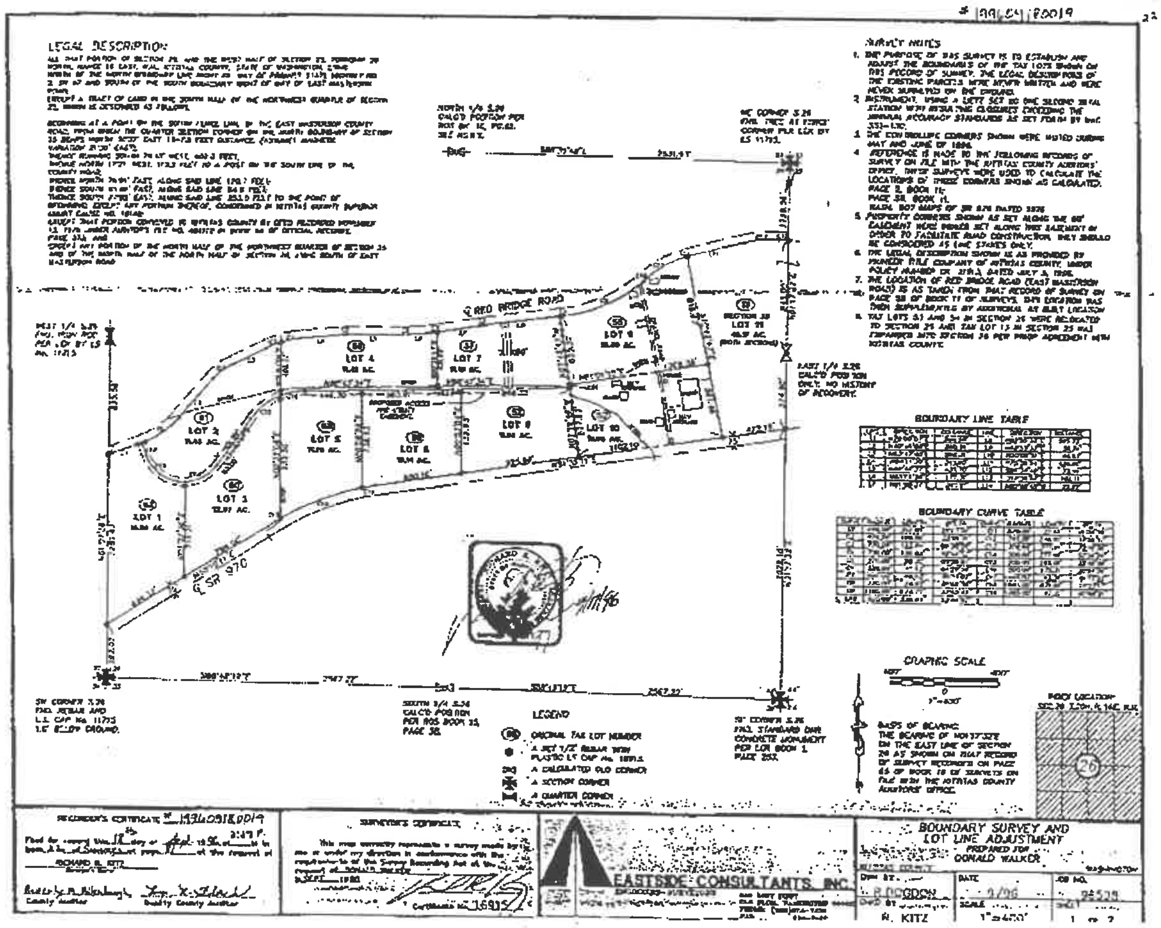
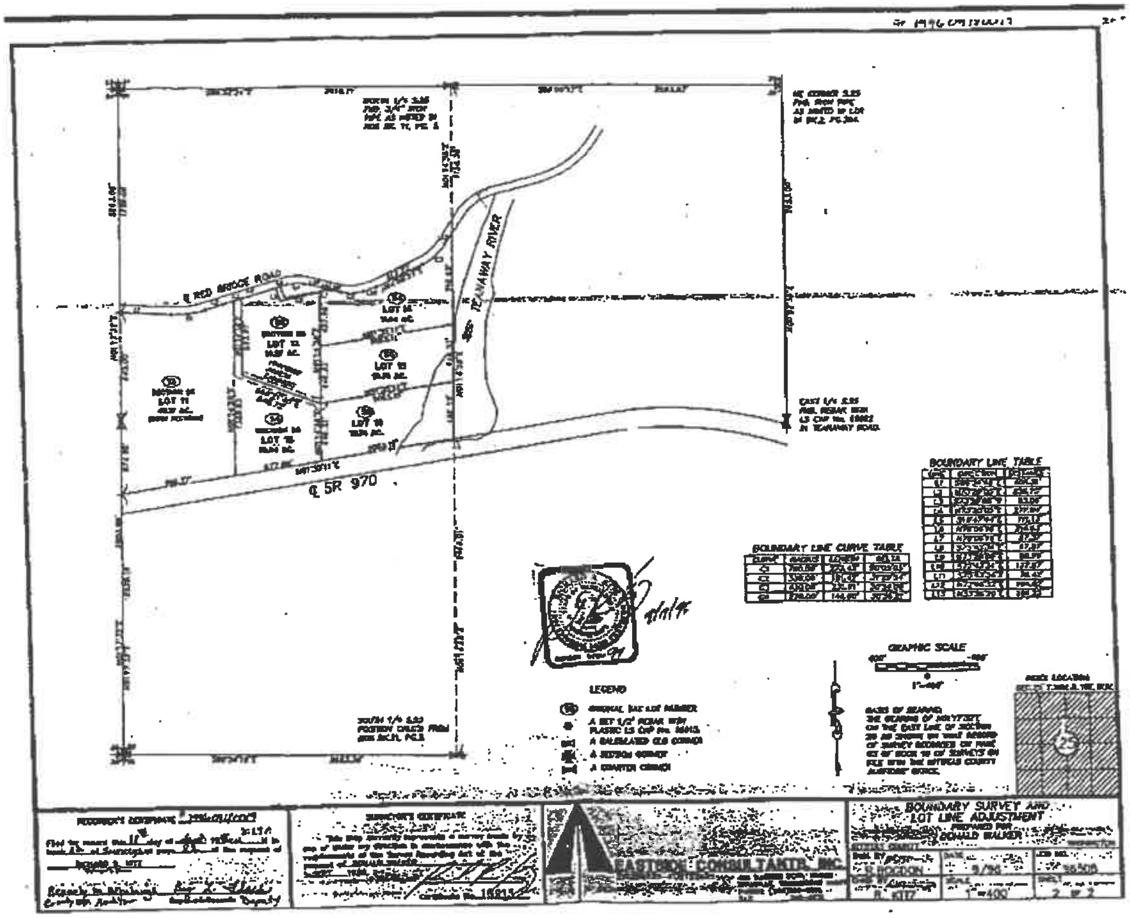


Figure 2: Continued



Swauk Creek

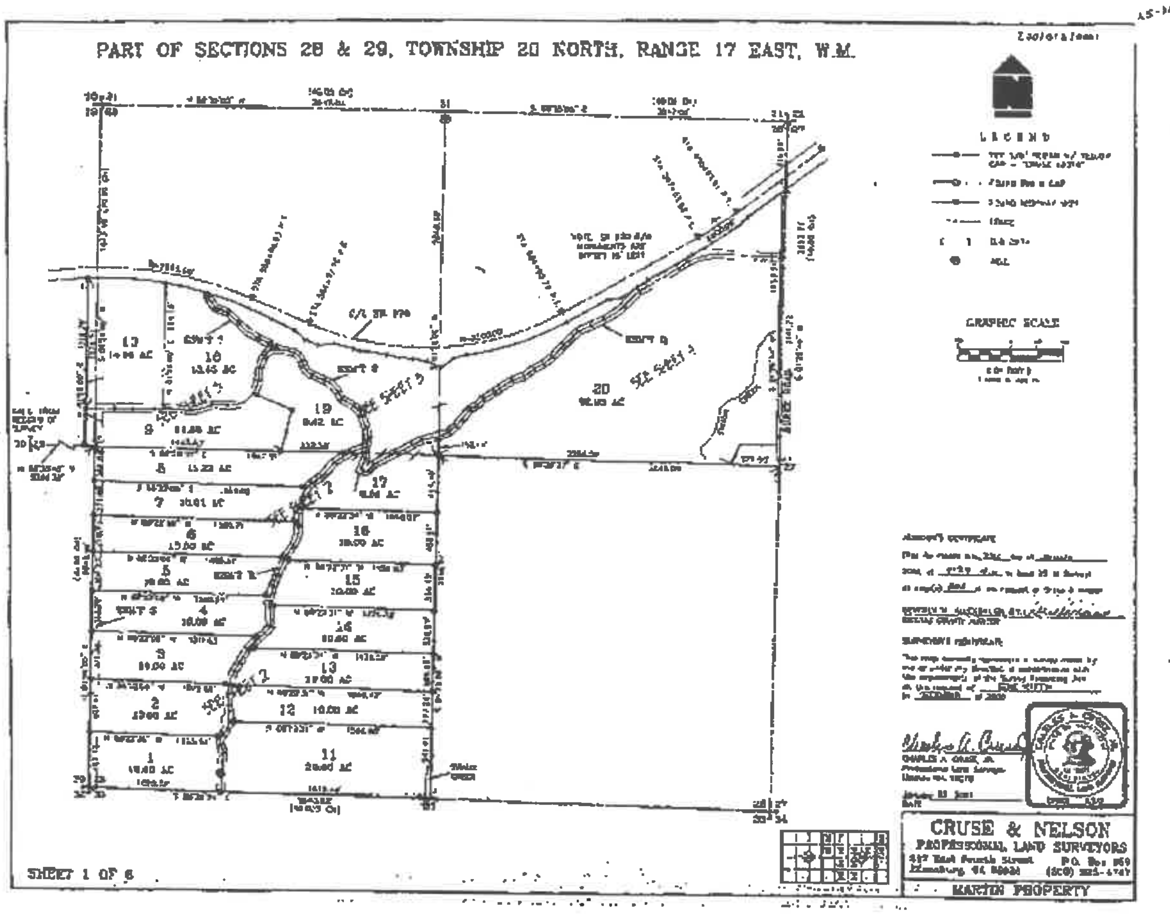
Trendwest purchased Swauk Creek water rights appurtenant to 95 acres of land formerly irrigated from Swauk Creek under Court Claim No. 01685 (known as the Hartman water rights). The Supplemental Report of Referee for Subbasin No. 4 recommends confirmation of 4.05 cfs plus 0.18 cfs for conveyance loss, not to exceed 712.5 acre-feet each year.

The 95 acre property is located in Section 28 of Township 20 North, Range 17 East in Kittitas County, south of Highway 970. This property has historically been irrigated from the Burke-Hartman Ditch from Swauk Creek.

The 95 acres is part of a larger 260 acre property in private ownership. In January 2001, a survey plat was filed with the Kittitas County Auditor's office. The short plat divides the property into 20 parcels, eight of which are located all or in part on the formerly irrigated portion of the property. Specifically, the formerly irrigated portion of the property is divided into eight parcels, six of which are approximately 10 acres and two of which are 20 or more acres.

Figure 3 shows the subdivision as filed with the County Auditor's office.

Figure 3: Swauk Creek Properties



First Creek

Trendwest purchased First Creek water rights from two separate landowners. These water right arise under Court Claim No. 00648, filed by the First Creek Water Users Association (FCWUA Claim). A dam owned by the FCWUA diverts almost the entire flow of First Creek into the Wold-Munson Ditch. The Wold-Munson Ditch delivers water to meet the irrigation needs of several farmers in the upper Reecer Creek Basin north of Ellensburg.

Trendwest owns water rights appurtenant to two properties under the FCWUA Claim. The water right for an approximately 150 acre property entitles Trendwest to divert approximately 5.0 cfs, not to exceed 754.2 acre-feet each year. The water right for an approximately 83 acre property entitles Trendwest to divert approximately 2.8 cfs, not to exceed 419 acre-feet each year. Together, Trendwest's water rights under the FCWUA Claim total 7.8 cfs, not to exceed 1,173.2 acre-feet each year.

The 150 acre property is part of a 667 acre tax parcel which has not been subdivided, and which is not intended for subdivision in the foreseeable future (Mentor Law Group 2001). The 83 acre property has been divided into eight separate parcels, comprised of two 20 acre parcels, four three acre parcels, and parts of two 30 to 40 acre parcels.

Yakima Mainstem/Reecer Creek

Trendwest purchased water rights to Reecer Creek and the mainstem of the Yakima River, appurtenant to three parcels of approximately 291 acres of land formerly owned by Pautzke Bait Company, Inc., arising under Court Claim No. 01724 (Pautzke water rights). These water rights entitle Trendwest to divert up to 27.4 cfs, not to exceed about 6,053 acre-feet of water each year.

The Pautzke properties are located within the Ellensburg city limits, in Sections 3 and 10 of Township 17 North, Range 18 East. The first property, formerly known at Hundley Ranch, is 117 acres historically irrigated for timothy hay with grain rotation and pasture through the Klein, Castle, and Coble Ditch and later through Mill Ditch to Reecer Creek. Of this property, Trendwest purchased water appurtenant to 67 acres. The second and third properties, formerly known as Riverside Farm, comprise 146 acres and 78 acres, respectively, that were historically irrigated for hay and pasture grass through Mill Ditch and the Klein, Castle, and Coble Ditch.

The Pautzke property has since been acquired by the City of Ellensburg. A number of development proposals have been discussed for this property. The City anticipates hiring a contract planning consultant to develop a comprehensive master plan for the property sometime in 2002. The City expects to use the property for an 81 acre ball field complex and to leave approximately 60 acres undeveloped for flood control. This would leaving approximately 130 acres available for future development. At this time, however, the only reasonably foreseeable development of this property is for flood control and an 81 acre ball field complex.

WATER DEMAND ASSOCIATED WITH FUTURE USES OF FALLOWED LANDS

Water demand for unincorporated Kittitas County was calculated based on the average household domestic water use less domestic return flows plus irrigation of one-half acre of lawn. This analysis assumes a domestic diversion of 240 gallons per household (100 gallons per person per day x 2.4 persons per household), less 80% return flows. Irrigation demands were calculated using the Blanney-Criddle Method for the specific properties consistent with the methodology used to determine the net consumptive use available under the Trendwest water rights. A more detailed discussion of these calculations can be found in Draft EIS, Appendix D: Water Supply Technical Report, at Exhibit B.1.3.

Water demand for parcels 20 acres or larger was doubled, in keeping with the Kittitas County land use code, which allows two residential units on parcels of that size. Table 1 shows water demands for fallowed lands. Table 2 shows water demands from the ball field complex proposed by the City of Ellensburg on the former Pautzke property.

Table 1: Water Demands from Future Use of Fallowed Lands

Sub-Basin	No. of Lots		Net CU in/yr	Domestic Div/ERU gpd	Domestic Return %	Domestic CU/ERU gpd	Domestic CU Total gpd	Domestic CU Total ac ft/yr	Irrigation CU/unit ac ft/yr	Irrigation CU Total ac ft/yr	Total CU ac ft/yr
	< 20 ac	>= 20 ac									
Big Creek (Gentry)	4	0	18.73	240	80	48	192	0.215	0.780	3.122	3.337
Teanaway R (Walker)	15	1	23.19	240	80	48	816	0.914	0.966	16.426	17.340
Swauk Creek (Martin)	6	2	28.69	240	80	48	480	0.538	1.195	11.954	12.492
First Creek (Nelson)	4	4	28.61	240	80	48	576	0.645	1.192	14.305	14.950
First Creek (Roan)	0	0	28.61	240	80	48	0	0.000	1.192	0.000	0.000
Total	29	14									48.119

Source: Brown & Caldwell, 2001; Mentor Law Group, 2001.

Table 2: Water Demands from Development of Pautzke Property

	Irrigated Area Acres	CU Total in/yr	CU total acft/yr
City of Ellensburg Ball Field Complex	81.0	32	216.0
Total			216.0

Source: Brown & Caldwell, 2001; Mentor Law Group, 2001.

Exhibit I

Pacific Groundwater Group

2377 Eastlake Avenue East
Suite 200
Seattle, WA 98102
206-329-0141 v
206-329-6968 f
www.pgwg.com

Technical Memorandum

To: Randall Doneen, Department of Ecology
Joe Mentor, Mentor Law Group
Andy Kindig, A. Kindig & Associates
Tom Martin, Brown and Caldwell

From: Peter Schwartzman, Associate Hydrogeologist, PGG
Russell Prior, Principal Geologist, PGG

Re: Assessment of Impacts to Groundwater Levels and Wells from Discontinued Irrigation Seepage Recharge

Date: January 24, 2001

1 Purpose and Approach

This memorandum presents estimates of how discontinued diversion of water rights held by Trendwest and associated reductions in ditch/field seepage losses would affect underlying groundwater levels. In addition, wells in the vicinity of areas with altered groundwater levels are listed and a general description of potential impacts to these wells is provided.

ECT has reviewed well logs on file with Ecology to characterize subsurface conditions and identify wells located near to formerly-appurtenant properties associated with Trendwest's water rights. This analysis assumes that review of driller's logs on file with Ecology is sufficient to identify nearby wells to be included in the analyses. For the Big Creek, Swauk Creek and Teanaway River basins, Ecology's Consultant Team (ECT) has used modeling results to define a reasonable range of change in groundwater levels in the vicinity of the formerly-appurtenant properties. Data are insufficient to predict groundwater level changes in the Reecer Creek Basin. For all four basins, ECT has provided a general discussion of well completion information and relatively susceptibility to impacts from changes in groundwater levels.

The following text summarizes the results of the analyses employed and provides a general overview as to whether known wells in the affected areas could be adversely affected. Maps are included that show estimated groundwater level changes in areas surrounding formerly-appurtenant properties, and tables summarize known wells by location (public land survey) to be related to the maps. The evaluation of potential impacts to wells is limited to providing general observations about typical well completions and discussing how projected changes in groundwater levels would generally affect wells completed in this manner. However, the evaluation does not estimate potential impacts to any particular well.

It should be noted that our analyses of potential changes in groundwater levels associated with discontinued irrigation recharge from ditch/field losses predicted impacts to the *uppermost* aquifer underlying the formerly-appurtenant properties. Because of limited saturated thickness and local variations in aquifer permeability, many wells are not constructed in uppermost aquifers. For those wells completed in deeper aquifers (such as bedrock aquifers that underlie alluvium), the magnitude of predicted groundwater level changes is expected to be smaller. The vertical permeability between shallow and deep zones will control the degree to which deep zones are affected by water-level changes in shallow zones. Where vertical permeability is relatively low, impacts to the deep zones are likely to be insignificant.

The text presented herein references ECT technical memoranda that provide estimates of changes in irrigation subsurface return flows associated with the proposed water right transfers and detailed descriptions of the models used to estimate changes in groundwater levels. The reader is also recommended to refer to these memoranda for hydrogeologic descriptions of the aforementioned basins.

2 Big Creek

2.1 Estimated Changes in Groundwater Levels

The Big Creek model (PGG, 1/18/02) was used to estimate changes in groundwater levels associated with discontinuation of groundwater recharge from irrigation seepage losses associated with the proposed Trendwest water right transfer. Mounding associated with former seepage recharge from the portion of the Gentry property for which Trendwest purchased water rights was estimated by running the model with estimates of pre-transfer irrigation recharge and then adding a change in recharge equivalent to the former irrigation seepage. Changes in recharge were modeled for the full water rights transfer (MPR+UGA), and impacts independently associated with either development will be less than those presented herein. The model was run in steady-state mode for pre-transfer conditions, and was then run in transient mode for a series of years to simulate seasonal water-level variations associated with former recharge from irrigation seepage loss. The difference between the steady-state and transient runs represents the mounding effect of the water rights, and equivalently, the predicted groundwater level decline associated with discontinuing associated irrigation practices. The model was run at both endpoints of the hydraulic conductivity (K) range agreed upon by ECT, Ecology, and Trendwest's consultants (75 ft/d and 750 ft/d).

Figure 1 presents predicted groundwater hydrographs extracted from model results for selected locations beneath the formerly irrigated field and beneath a section of irrigation ditch leading to the field. The figure shows 4 years of modeled groundwater levels with no variation in recharge input (equivalent to the steady-state simulation) followed by 20 years where seasonal recharge from irrigation seepage loss is superimposed on top of existing steady recharge. The figure shows that a groundwater mound builds up over the irrigation season and then dissipates over the remainder of the year. On an annual basis, the modeled irrigation recharge also causes a year-round increase in groundwater level. Groundwater mounding estimated at the two monitoring points for the K=75 ft/d model simulation reaches a maximum increase from pre-change conditions on the order 1.5 to 2 feet, whereas the maximum water-level increase predicted for the K=750 ft/d simulation is on the order of 0.3 feet. **Figure 2** shows a "snapshot" of the seasonal maximum change in groundwater levels for the mound predicted under the K=75 ft/d simulation. Predicted water-level changes are consistent with the hydrograph and are all less than 2 feet. A similar figure was not prepared for the K=750 ft/d; however, all associated water-level changes are predicted to be less than 0.5 feet. Discontinued irrigation over portions of the Gentry property is predicted to cause an equivalent maximum seasonal decline in groundwater levels.

2.2 Summary of Wells in the Vicinity of Area of Predicted Groundwater Level Change

The area of predicted groundwater level change encompasses portions of sections 20, 21, 28, and 29 in township 20N, range 14E. A total of 61 wells are estimated to exist in these four sections based on well logs on file with Ecology. All of the wells are completed in an unconsolidated aquifer comprised of Yakima River alluvium, and are reported to encounter unconsolidated soils ranging from clay to gravel. **Table 1** summarizes the pertinent data for these wells. The wells in these four sections average about 70 feet deep with yields that average 45 gpm. The depth to the water level is, on average, about 26 feet below ground surface. Only one well among the 61 evaluated is completed with perforations. The others are fully cased and completed as open holes, which means the only entrance area is the bottom of the open casing. This is a common completion design for domestic wells that tap aquifers with significant quantities of gravel. Most of the wells are used for domestic purposes, and likely penetrate only a limited thickness of the alluvial aquifer from which they draw water. A section-by-section summary of well depth, well yield, and depth to water is presented in the following bullets:

- In Section 20, well depth averages 68 feet deep, well yields average 35 gpm, and the depth to water averagtes 17 feet. Of note, are three relatively deep wells that are 119, 140, and 196 feet deep. The averages indicated above include these three wells. These wells have water levels that are either shallow (1 foot below ground) or are flowing (static water level is above ground surface). Most of the wells have depths to water that are closer to the average value of 17 feet. Reported water columns within the well casings (the distance between the well bottom and the water level) are greater than 30 feet.

- In Section 21, the well depth averages 55 feet deep, well yields average 42 gpm, and the depth to water averages 17 feet. Most of the wells are located in the southern half of the section. Reported water columns within the well casings are typically greater than 20 feet; however, one well is reported to have a water column of only 9 feet.

- In Section 28, the well depth averages 86 feet deep, well yields average 61 gpm, and the depth to water averages 34 feet. Well yield values range from 10 to 300 gpm. One well in the NE quarter is 320 feet deep; it appears to be an outlier as the next deepest well is 120 feet deep. Reported water columns within the well casings are typically greater than 20 feet; however, one well is reported to have a water column of only 15 feet.

- In section 29, the well depth averages 58 feet deep, well yields average 25 gpm, and the depth to water averages 33 feet. Based on Ecology well logs, only the east half of the section has wells. Reported water columns within the well casings are typically greater than 20 feet; however, two wells are reported to have water columns of 14 and 15 feet.

2.3 Potential Impacts to Nearby Wells

The area with predicted groundwater level changes is centered in the northern half of Section 28 where maximum seasonal declines are predicted to be about 1.75 feet for the K=75 ft/d model simulation. The area of groundwater level change is roughly circular with a diameter of about 1_ miles. A section-by-section summary of potential well impacts relative to maximum predicted groundwater declines is presented in the following bullets. Relevant well information is presented in **Table 1**.

- In Section 20 the groundwater level decline is predicted to be largest in the SW quarter where 0.5 feet is predicted. The predicted decline in the NW is 0.25 feet. The west half of Section 20 has no predicted effects. Predicted groundwater level declines are small relative to reported water columns present in wells.

- The groundwater level decline is predicted to be largest in the southern half of Section 21 with 0.5 to 1.25 feet of change in the SW quarter and 0.25 to 1.25 feet of change in the SE quarter. Small declines are predicted in the northern half with values of 0.25 to 0.5 feet in the NW quarter and 0.25 feet in the NE quarter. Predicted groundwater level declines are small relative to reported water columns present in wells. The single well with a water column of 9 feet appears to have a sufficiently high specific capacity to provide domestic yields under the predicted maximum water level decline.

- Section 28, groundwater level declines are predicted to be highest among the four sections in the Big Creek area. In both the NW and NE quarters of Section 28, the effects are predicted to be 0.75 to 1.75 feet. In the SW quarter, the effects are predicted to range from 0.75 to 1.25 feet and in the SE quarter, the effects are predicted to be 0.5 to 1.25 feet. Predicted groundwater level declines are small relative to reported water columns present in wells. The single well with a water column of 15 feet is yield-limited due to its lesser penetration of the water-table aquifer. The predicted groundwater level decline at this location is about 0.75 feet, and could cause minor reductions in the yield of this well.

- Predicted declines in groundwater levels in Section 29 occur only the eastern half. Both the NE and the SE quarters have predicted to have changes that range from 0.5 to 0.75 feet. Predicted groundwater level declines are small relative to reported water columns present in wells. The two wells with water columns of 14 and 15 feet are yield-limited due to lesser penetration of the water-table aquifer. The predicted groundwater level decline at this location is about 0.65 feet, and could cause minor reductions in the yields of these wells.

3 Teanaway River

3.1 Estimated Changes in Groundwater Levels

The Teanaway River model (PGG, 1/17/02) was used to estimate changes in groundwater levels in the shallow alluvial aquifer associated with discontinuation of groundwater recharge from irrigation seepage losses on the Walker property associated with the proposed Trendwest water right transfer. Although depth to groundwater can be relatively shallow in the Teanaway River Valley, the alluvial deposits can be as much as several hundred feet thick with sedimentary textures ranging from clay to gravel (ibid). Mounding in shallow water-bearing zones associated with seepage recharge formerly associated with Trendwest water rights was estimated by running the model both with and without estimated (Walker property) irrigation recharge. The change in recharge was modeled for the full water rights transfer (MPR+UGA), and impacts independently associated with either development will be less than those presented herein. The model was run in transient mode, first simulating 4 years without the Walker irrigation recharge and then simulating 6 years with recharge from irrigation seepage loss. The difference in water levels between the two conditions represents the mounding effect of the water rights, and equivalently, the predicted groundwater level decline associated with discontinuing associated irrigation practices.

Figure 3 presents predicted groundwater hydrographs extracted from model results for locations beneath the formerly irrigated Walker property (near the center, upstream and downstream sides of the property). The figure shows 4 years of modeled groundwater levels without Walker irrigation recharge input followed by 6 years where seasonal recharge from irrigation seepage loss is superimposed on top of background recharge. The figure shows that a groundwater mound historically built up over the irrigation season and then dissipated over the remainder of the year. On an annual basis, the modeled irrigation recharge also caused a year-round increase in groundwater level. Estimated historic groundwater mounding reached a maximum seasonal increase from non-irrigated conditions on the order 0.8 to 1.6 feet. **Figure 4** shows a "snapshot" of the seasonal maximum change in groundwater levels for the mound. Predicted water-level changes are consistent with the hydrograph and reach a maximum of just over 1.6 feet. Discontinued irrigation at the Walker property is predicted to cause an equivalent maximum seasonal decline in groundwater levels.

3.2 Summary of Wells in the Vicinity of Area of Predicted Groundwater Level Change

The area of predicted groundwater level declines encompasses portions of the following four sections: 25, 26, 27, and 34. Only Sections 25 and 26 have well logs on file with Ecology in the area with predicted groundwater level change. Section 34 has well logs but none are located in the NE quarter, the only quarter of Section 34 with predicted groundwater level change. Section 27 has no well logs on file. A total of 46 wells are estimated to exist in these two sections based on well logs on file with Ecology. Most of the wells tap consolidated materials of either sandstone or basalt. Most of the wells appear to be located on or near the bottom of the hillsides and do not tap Teanaway River alluvium. **Table 2** summarizes the pertinent data for the well log in Sections 25 and 26. The wells in these two sections average about 223 feet deep with yields that average about 20 gpm. The depth to the water level is, on average, 61 feet below ground surface. Water columns reported for most wells exceed 100 feet; however, several shallow wells exist with water columns as low as 16 to 25 feet. About half the wells are completed with hand slotted perforations and half are completed as open holes. In wells completed in bedrock, the entrance area is that portion of the hole that is uncased.

In addition to the wells on file with Ecology, PGG identified two shallow, hand-dug wells on the Walker property that are completed in the alluvial aquifer. The dug depths of these wells are unknown, but it is unlikely that the wells were excavated far below the seasonal low water table. One well, located at the Walker residence, is no longer used for domestic purposes. The use status of the second well, located near the fish pond, is unknown.

3.3 Potential Impacts to Nearby Wells

The area with predicted groundwater level declines is centered in the valley portion of Section 26 where maximum predicted groundwater level changes are about 1.6 feet. The area of groundwater level change is confined to the valley area and is about 2 miles long. It extends into the NE quarter of Section 25 and into the NE quarter of Section 34. Predictions of groundwater level decline apply to the alluvial aquifer. Lesser declines are expected in deeper water-bearing zones in the consolidated rocks. A section-by-section summary is presented below, and relevant well information is presented in **Table 2**.

In Section 25, the magnitude of groundwater level decline is predicted to range from none to about 1.4 feet. The six wells in the NW quarter are predicted to have groundwater level declines of 0.6 to 1.4 feet. The five wells in the NE quarter are predicted to have a groundwater level decline of zero to 0.4 feet. The four wells in the SW quarter are predicted to have a groundwater level change of decline to 1.2 feet. No effect is predicted in the SE quarter of Section 25 where six wells are known to exist based on Ecology files. Wells in this section with water columns of 16 and 25 feet may exhibit minor reductions in potential yield under the predicted maximum water level decline.

In Section 26, the magnitude of groundwater level change is predicted to range from none to about 1.6 feet. No effect is predicted in the NW quarter of Section 26 where four wells are known to exist based on Ecology files. The three wells in the NE quarter are predicted to have groundwater level changes of around 1.6 feet. The ten wells in the SW quarter are predicted to have a groundwater level change of 0.2 to 1.6 feet. The eight wells in the SE quarter are predicted to have groundwater level changes ranging from 0.2 to 1.6 feet. Predicted groundwater level declines are small relative to reported water columns present in most wells. However, water production capacity in the two hand-dug wells is already noted as seasonally intermittent (Don Walker, personal communication, 2001) and will likely be further reduced due to the predicted groundwater level declines.

In Section 27, only the SE quarter lies in the valley area, which has predicted groundwater level changes. However, no well logs are on file with Ecology for Section 27 even though a few houses are indicated on the USGS map. The predicted groundwater level change ranges from 0.2 to 1.2 feet in the SE quarter.

In Section 34, only the NE quarter is predicted to have groundwater level changes. The predicted changes range from zero to 0.4 feet. Other portions of Section 34 lie in the valley but the effect dissipates to zero in the NE quarter.

4 Swauk Creek

4.1 Estimated Changes in Groundwater Levels

The Swauk Creek model (PGG, 1/24/02) was used to estimate changes in groundwater levels in the shallow alluvial aquifer associated with discontinuation of groundwater recharge from irrigation seepage losses associated with the proposed Trendwest water right transfer. The alluvial aquifer along Swauk Creek is likely between tens-of-feet to about 100 feet thick in most places within Hidden Valley, and known wells completed in associated water-bearing zones are typically no more than 25 feet deep. Mounding in shallow water-bearing zones associated with seepage recharge formerly associated with Trendwest water rights was estimated by running the model both with and without estimated irrigation recharge from the formerly-appurtenant Hartman property. The model was first run in steady-state mode to simulate conditions without the formerly-appurtenant irrigation recharge, then in transient mode over 20 years to simulate long-term trends in seasonal groundwater levels with the irrigation recharge. The difference between the steady-state and transient runs represents the mounding effect of the water rights, and equivalently, the predicted groundwater level decline associated with discontinuing associated irrigation practices. The model was run at both endpoints of the hydraulic conductivity (K) range (50 ft/d and 500 ft/d) with a streambed permeability (K') of 1 ft/d. The change in recharge was modeled for the full water rights transfer (MPR+UGA) for both K values, and for the MPR water rights transfer for the K=100 ft/d simulation (where predicted water-level changes were larger). Unless otherwise specified, the discussion below presents model results for the full water rights transfer.

Figures 5a and 5b present predicted groundwater hydrographs extracted from model results for locations in the alluvial aquifer beneath the formerly irrigated Hartman property and adjoining Burke property (near the center of irrigated fields, near Swauk Creek, and immediately downstream of both properties). Both figures show the change in groundwater level over the course of a year relative to the base condition (without formerly-appurtenant irrigation). The figures show that groundwater mounding historically built up over the irrigation season and then dissipated over the remainder of the year. The greatest mounding is predicted to have occurred about 110 days after the onset of the irrigation season, which begins on April 1. On an annual basis, the modeled irrigation recharge also caused a year-round increase in groundwater level. Groundwater mounding estimated for the K=100 ft/d model simulation reached a maximum increase from pre-change conditions on the order 7 feet, whereas the maximum water-level increase predicted for the K=500 ft/d simulation was on the order of 3 feet. Water level changes for (deeper) aquifers that underlie alluvial aquifer are likely to be significantly less than those changes predicted for the alluvial aquifer.

Figures 6a and 6b show "snapshots" of the seasonal maximum change in alluvial aquifer water levels for the mound predicted for the K=100 ft/d and K=500 ft/d simulations, respectively. The water-level change maps are consistent with the hydrographs in the scale of the predicted mounding[1]. Because the formerly-appurtenant property covers a relatively large portion of Hidden Valley, the predicted mounding also occurs over a large portion of the alluvial aquifer. Discontinued irrigation at the former Hartman property is predicted to cause an equivalent range in maximum seasonal declines in alluvial aquifer groundwater levels.

PGG performed supplemental analysis of the maximum historic mounding associated with the MPR water right transfer alone for the K=100 ft/d model scenario (total irrigation recharge was reduced by 33 percent). The predicted mounding was reduced by less than 33 percent, with maximum water-level changes of about 5.4 feet relative to 7 feet for the MPR and UGA

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[1] The contouring package does not show a 3-foot contour for the K=500 simulation due to the small area with water-level change above 3 feet and the coarser resolution of the contouring grid.

combined. In reality, the distribution of reduced recharge associated with the MPR-only transfer would likely differ from a uniform recharge reduction of 33 percent. Instead, portions of the formerly appurtenant area would likely be retired whereas others would remain in irrigation. ECT did not attempt to predict what the future distribution of irrigation recharge might be should the water rights transfer be approved for the MPR only.

Although Trendwest's proposed FCWUA transfer to First Creek is expected to result in 0.4 to 0.8 cfs of seepage inflow to the alluvial aquifer near the First/Swauk Creek confluence, this additional inflow is unlikely to significantly offset the predicted groundwater level changes associated with the proposed Hartman transfer in Hidden Valley. Seepage losses from First Creek enter the Swauk Creek alluvial aquifer upstream of a constriction between Swauk Creek and the eastern valley wall (**Figure 7**). Field investigations reveal that Swauk Creek is gaining in the reach that includes this constriction (PGG, 1/24/02), and model simulations suggest that most of the seepage loss from lower First Creek returns to Swauk Creek above this constriction (ibid.). While model simulations predict that the increased First Creek seepage associated with the FCWUA transfer may increase groundwater levels near the Swauk/First confluence by nearly 10 feet, groundwater discharge to Swauk Creek above the constriction results in predicted groundwater level changes in the Hartman vicinity of less than 0.1 feet.

4.2 Summary of Wells in the Vicinity of Area of Predicted Groundwater Level Change

The area of predicted groundwater level decline occurs in the valley areas in the Swauk Creek vicinity. Most of the predicted groundwater level decline occurs substantially in Section 28 with small portions of Sections 27 and 33 also affected. A portion of Section 22 also occurs in the valley area, however, maximum predicted groundwater level declines in this section are less than 0.5 feet. Sections 27 and 28 have 8 and 2 (respectively) well logs on file with Ecology. Apparently no logs are filed for Section 33.

Most of the wells tap consolidated materials composed of either sandstone or basalt. The two wells located in Section 28 (SW quarter) apparently tap gravel zones at depth (e.g. greater than 150 feet). Most of the wells appear to be located on the hillsides and do not tap Swauk Creek River alluvium; however, undocumented wells are known to exist in the Lauderdale Junction area of Section 22. It should be noted that wells completed in shallow alluvium (especially hand-dug wells) may not penetrate the full thickness of the alluvial deposit, and therefore may not provide full access to groundwater available in the alluvial aquifer. **Table 3** summarizes the pertinent data for well logs submitted to Ecology in Sections 22, 27, and 28. For sections 27 and 28 (where predicted groundwater declines exceed 0.5 feet), reported wells range in depth from 145 to 705 feet deep. They average about 258 feet deep including the 705 foot deep well. Well yields average about 10 gpm for wells in Section 27 and 28. The depth to the water level is, on average, 84 feet below ground surface. This relatively deep value is indicative of the location of most of the wells on the hillside. Water columns in these wells range from 45 to 505 feet. Five of the wells are completed as open holes and five are completed with either perforations or well screens. In wells completed in bedrock, the entrance area is that portion of the hole that is uncased.

During ECT's evaluation of the Swauk Basin (PGG, 1/24/02), several additional well logs were encountered that were not on file with Ecology. Two of these wells were completed in the shallow alluvial aquifer. One well log, located near where Highway 97 crosses Swauk Creek, was completed at 20-feet below land surface after drilling through clay, clayey gravels and cobbles, and clean gravels and cobbles. A second well, hand dug near the confluence of First Creek, was reported by the owner to be completed in alluvial gravels (no well log available). Further downstream, near Lauderdale Junction and beyond, several wells were reported to penetrate alluvial sediments but were completed in deeper aquifers.

4.3 Potential Impacts to Nearby Wells

The area with predicted groundwater level declines is centered in the valley portion of Section 28 where maximum predicted groundwater level changes depends on the permeability used in the simulation. For the K=100 ft/day simulation, maximum predicted seasonal water-level declines reach as much as 7 feet. For the K=500 ft/day simulation, maximum predicted seasonal water-level declines approach 3 feet. The area of groundwater level change is confined to the valley area and is about 1_ miles long. A section-by-section summary is presented in the following bullets. Relevant well information is presented in **Table 3.**

In Section 27, the alluvial valley of Swauk Creek occurs only in the NW quarter of the section. Because the model simulates changes only in the alluvial valley, water-level declines are predicted only for this portion of Section 27. In this quarter section, three wells are known to exist based on Ecology well log files. The predicted groundwater level changes range from 0.5 to 1.5 feet based on the high permeability (K=500 ft/day) simulation. Using the low permeability (K=100 ft/day) simulation, the predicted groundwater change ranges from 1 to 3 feet. Predicted groundwater level declines are small relative to reported water columns present in wells. All other quarter sections (NE, SW, and SE quarters) of Section 27 are likely to have insignificant effects due to their distance from the alluvial valley. A total of five wells exist in these three quarter sections.

In Section 28, the magnitude of groundwater level change is predicted to range from 1.5 to almost 3 feet under the high K simulation and from 2 to 7 feet under the low K simulation. The maximum predicted groundwater level changes occur in the center of the section. Only the SW quarter of Section 28 has well logs in Ecology files. Here, the predicted groundwater level change ranges from 1.5 to 2.5 feet under the high K simulation and from 2 to 6 feet under the low K simulation. Predicted groundwater level declines are small relative to reported water columns present in wells. The other three quarter sections have no well logs on file.

5 Reecer Creek Basin (FCWUA Transfer)

5.1 Estimated Changes in Groundwater Levels

Transfer of Trendwests First Creek Water User's Association (FCWUA) water rights from use in the Reecer Creek Basin to instream flow in First Creek will result in a reduction in groundwater recharge from field/ditch seepage losses on the formerly-appurtenant Trendwest properties and ditch seepage losses from the main FCWUA ditch. The uppermost aquifer is comprised of Kittitas glacial drift and streamside alluvium. These unconsolidated deposits are estimated to be 100 feet thick beneath the formerly appurtenant properties, and are further underlain by water-bearing basalt bedrock, which is further underlain by sedimentary Ellensberg Formation. Wells located in the immediate vicinity of the formerly appurtenant properties draw water from the basalt aquifer, whereas wells located further to the south gain water from the unconsolidated drift and alluvium. Irrigation seepage losses to groundwater are expected to discharge to the Yakima River at a relatively constant rate due to the thickness of the unsaturated zone between the land surface and the regional water table and the distance between the formerly-appurtenant properties and the river (PGG, 1/25/01).

The change in field/ditch seepage from the formerly-appurtenant properties associated with the proposed Trendwest transfer (MPR+UGA) is estimated to average 1.0 cfs during the irrigation season (ibid). The associated change in recharge to the underlying regional aquifer is estimated to average approximately 0.56 cfs annually and to occur in a relative uniform manner throughout the year (ibid). The change in seepage from the main FCWUA ditch associated with the proposed transfer is estimated to be about 0.1 cfs during the irrigation season (ibid). Due to shallower depths to water along portions of the main FCWUA ditch, seepage losses from the ditch may recharge the underlying water table with a more pronounced seasonal variation.

Available hydrogeologic data were insufficient to support prediction of groundwater level declines in the uppermost regional aquifer due to discontinued irrigation on formerly appurtenant properties for which Trendwest holds water rights. Both modeling and analytical calculations require estimates of aquifer properties, particularly aquifer transmivity (T) when year-round (steady-state) predictions are desired. Data available to estimate T values for the uppermost regional aquifer were limited to specific capacity (SC) measured in wells, because driller's descriptions of aquifer materials (e.g. "clay and gravel") were too general to be used for aquifer property estimation. Twenty-five driller's logs were available for wells completed in this area, showing specific capacity values ranging from 0.04 to 4.5 gpm/ft (**Table 4**). However, 24 of the specific capacity values were considered unreliable because they were either obtained from airlift tests, from wells completed with an open-ended casing (no perforations or screen), or from wells completed in the deeper (basalt) regional aquifer. The remaining SC value of 4.5 gpm/ft was assessed using methods of Driscoll (1986) and Razack & Huntley (1991) to obtain approximated T values ranging from 9,000 to 23,000 gpd/ft (1,200 to 3,100 ft^2/d). While calculations could be performed to estimate steady-state groundwater level declines associated with this range of T values, it is not recommended to estimate T from a single SC capacity from a single well. Variability in SC is typically high among wells completed in the same aquifer, and it would likely be misleading to use a single value to characterize a regionally extensive aquifer.
Because information was lacking to estimate groundwater level declines associated with Trendwest's proposed water right transfers (due to discontinued irrigation seepage losses), the following section provides a description of the wells located in the vicinity of the formerly appurtenant properties associated with Trendwest's water rights.

5.2 Summary of Wells in the Vicinity of Area of Discontinued Irrigation

A vicinity map in the area of the formerly appurtenant properties is provided on **Figure 7**. The area in which groundwater declines are likely to occur is unknown. The largest water-level declines are expected to occur beneath and immediately surrounding the formerly appurtenant properties. Smaller declines are expected to occur in the vicinity of the main FCWUA irrigation ditch. For this reason, ECT has evaluated well logs submitted to Ecology for Sections 6, 7, 8, 17, 20, 21, 22, 27, 28, 29, 30, 31 and 32 of Township 19N, Range 18E (Sections 16, 18, and 19 have no well logs on file). The formerly appurtenant properties occur in the NW quarter of Section 28 and the southern half of Section 21. Based on well logs on file with Ecology, four wells are located in these two sections. Section 21 has one well (owned by Mr. Roan) in the NE quarter. Section 28 has two wells in the NW quarter and one well in the NE quarter.

The wells can be divided into two groupings that are demarcated north and south of Sections 27, 28, and 29. In general, the well grouping north of these sections contains wells that average 491 feet deep and the grouping south of these sections contains wells that average 147 feet deep. The northern group of wells generally taps Columbia River Basalt while the southern group of wells generally taps unconsolidated materials (clay, sand, and gravel). Sections 27 and 28 are the only transitional sections that have well logs on file. In Section 27 two logs are on file. One well is 280 feet deep and taps clay and basalt boulders and sandstone. The other well is 200 feet deep and taps cemented gravel and sand. Three wells occur in Section 28. Two of these wells are in the 350 to 400 foot depth range and tap unconsolidated materials. The third well is 955 feet deep and taps basalt. It should be noted that wells completed in the unconsolidated deposits may not penetrate the full thickness of the deposits, and therefore may not provide full access to groundwater available in the unconsolidated aquifer.

The water levels in the northern group of wells average 326 feet deep. The water levels in the southern group of wells average 57 feet deep. The northern group is slightly more productive on average compared to the southern group of wells. In the north the average yield is 34 gpm while in the south the average yield is 20 gpm. The northern group has water columns that range from 57 to 520 feet, and the southern group has water columns that range from 27 to 160 feet. The majority of the wells in the northern group are completed with perforations while the majority of the wells in the southern group are completed as fully cased open holes.

Effects on the function of any particular well depends on the degree of water-level decline, the amount of water column in the well available for drawdown during pumping, and the specific capacity of the well. For a given groundwater level decline, greater impacts to well yield will occur where the thickness of the water column and/or the well's specific capacity is more limited. **Table 4** includes a summary of water column and specific capacity data derived from the driller's logs submitted to Ecology. While water columns in the well casings appear to be relatively thick, specific capacity values are on the low side (typically several tenths of a gallon per minute per foot of drawdown). Further evaluation of potential impacts on well yields would require additional hydrogeologic characterization, particularly quantification of transmissivity for the uppermost, regionally extensive, unconsolidated aquifer.

6 References

Pacific Groundwater Group (PGG), 2002. Teanaway River Basin Hydrologic Analysis. Technical Memorandum dated January 17, 2002.

Pacific Groundwater Group (PGG), 2002. Big Creek Basin Hydrologic Analysis. Technical Memorandum dated January 18, 2002.

Pacific Groundwater Group (PGG), 2002. First and Swauk Creek Basin Hydrologic Analysis. Technical Memorandum dated January 24, 2002.

Pacific Groundwater Group (PGG), 2002. Analysis of Hydrologic Changes in the Reecer Creek Basin Associatedwith Trendwest Proposed First Creek Water Rights Transfer. Technical Memorandum dated January 25, 2002.

Figure 1 - Predicted Hydrographs for Model Observation Points in the Gentry Property Vicinity (Big Creek)

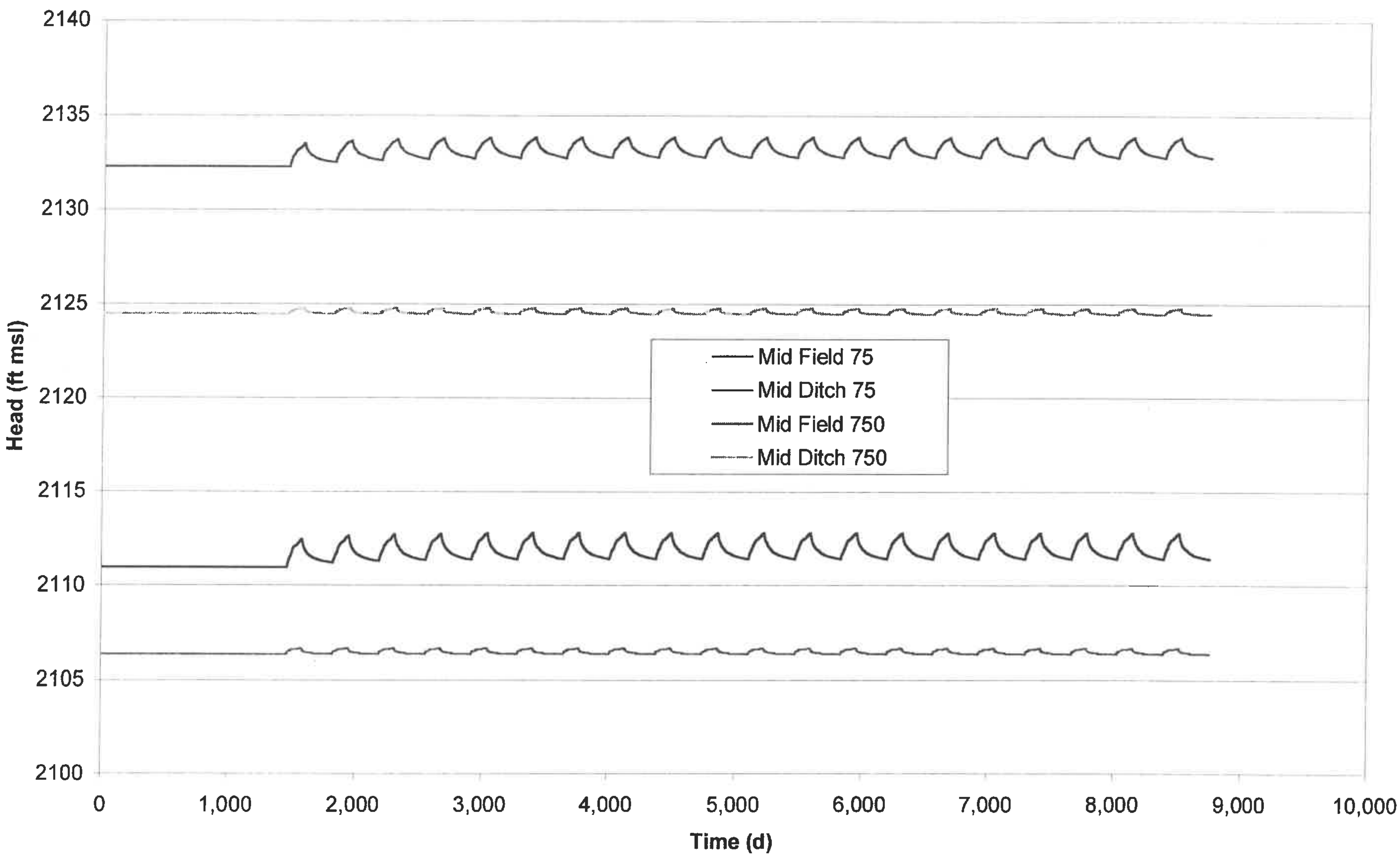

Figure 2 - Maximum Predicted Drawdown in Gentry Property Vicinity (Big Creek)
(Model K = 75 ft/d; Contour Interval = 0.25 feet)

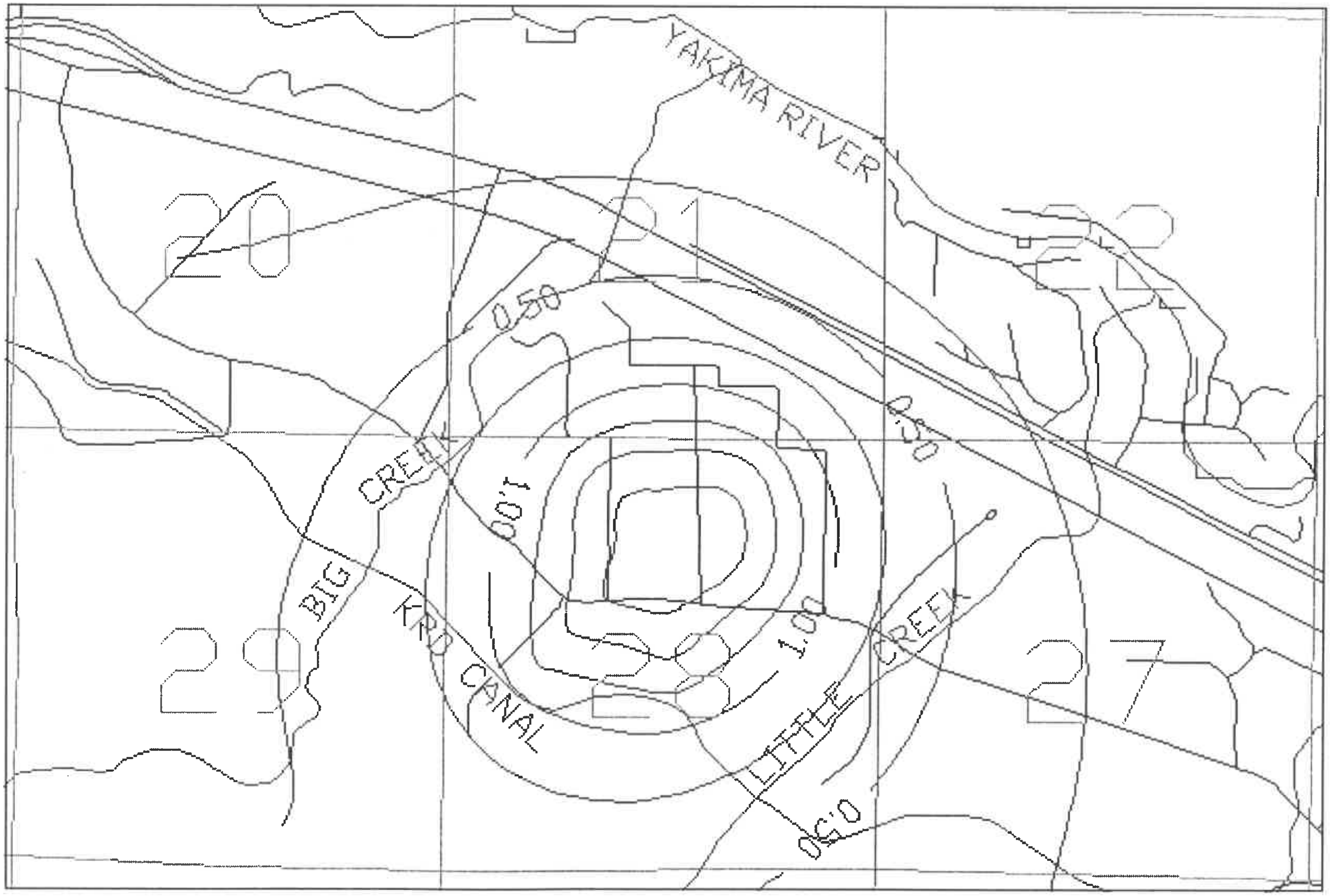

Figure 3 - Predicted Hydrographs for Model Observation Points in the Walker Property Vicinity (Teanaway River)

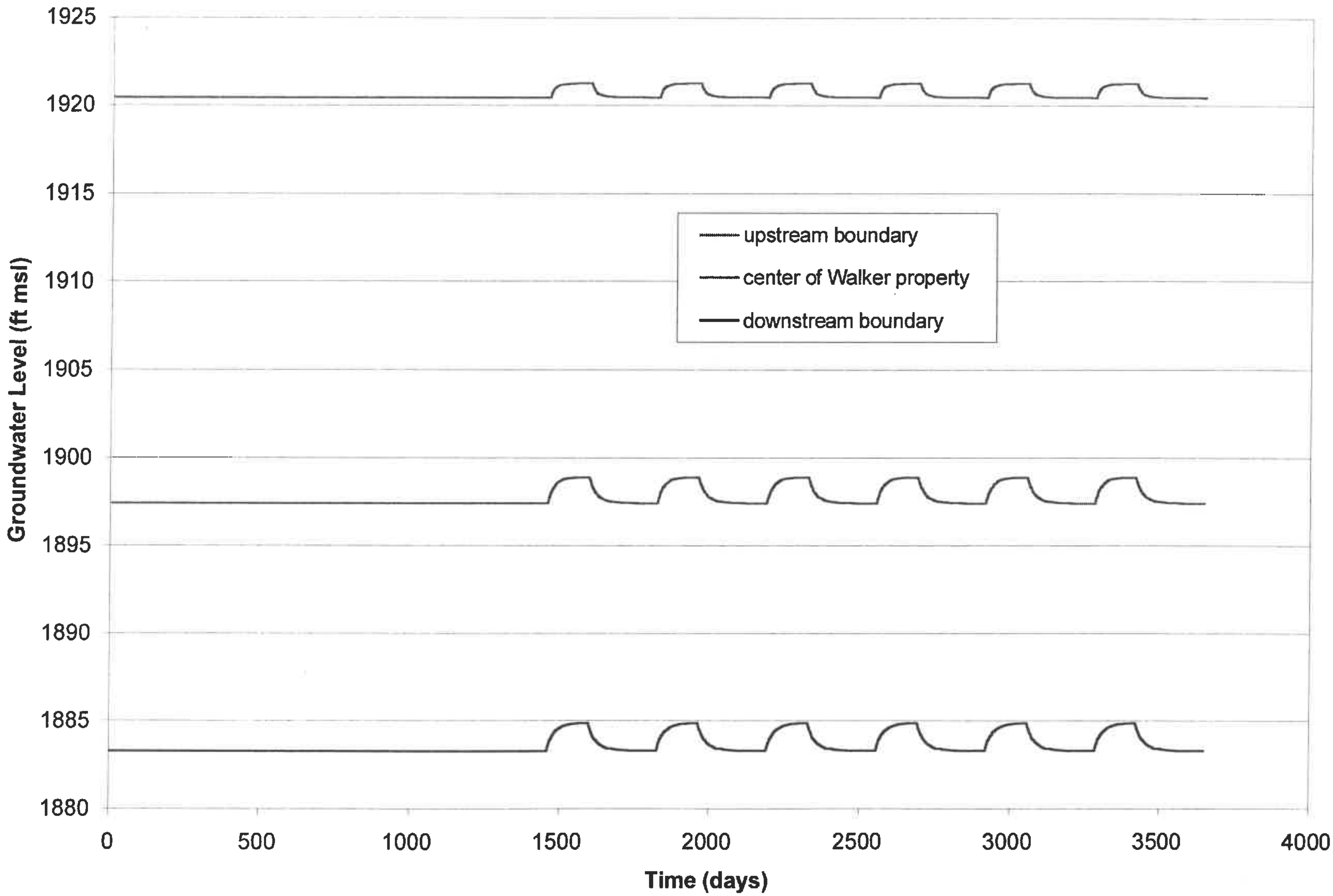

Figure 4 - Maximum Predicted Drawdown in Walker Property Vicinity (Teanaway River)
(Contour Interval = 0.2 feet)

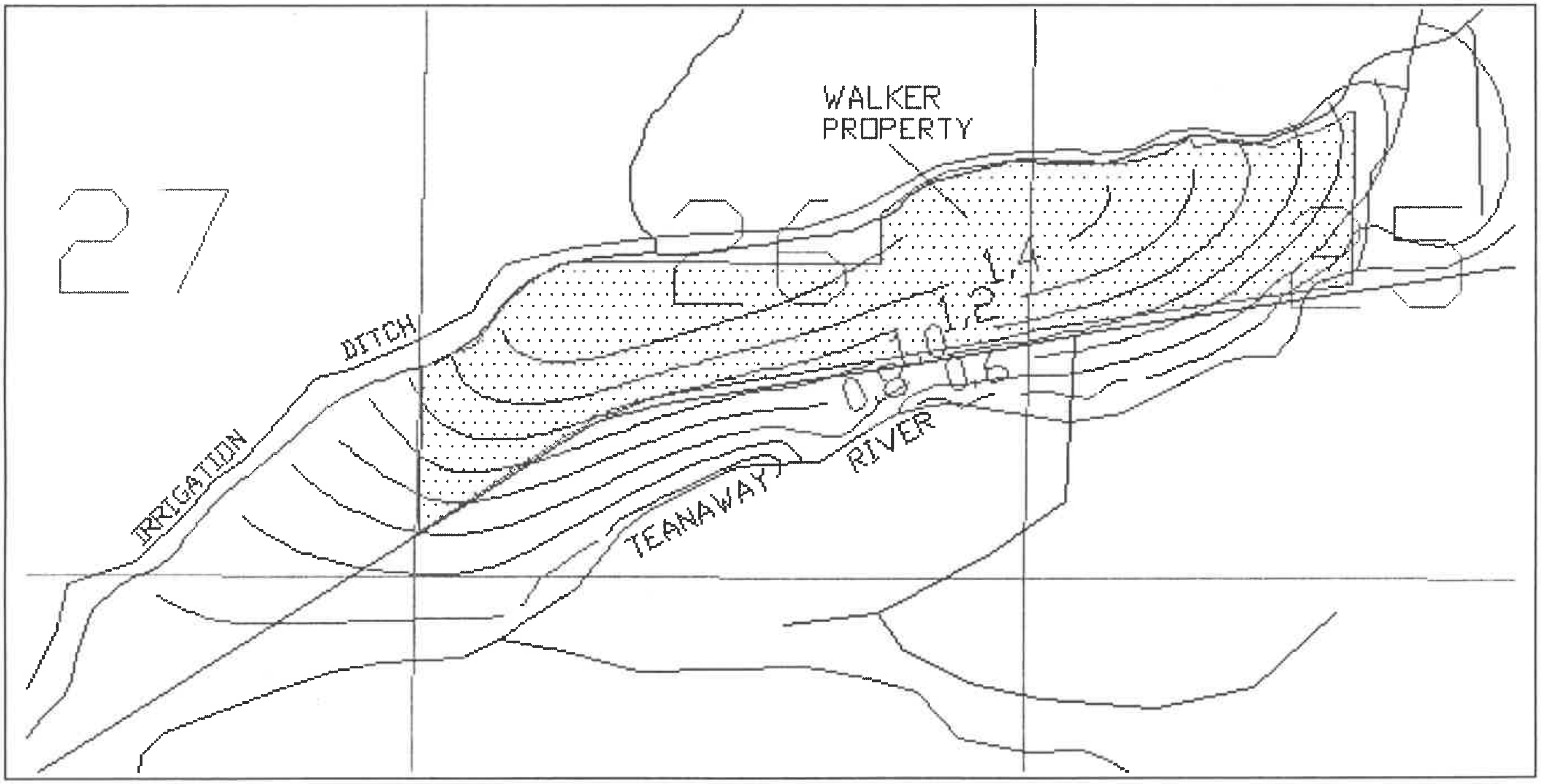

Figure 5a - Predicted Seasonal Water Level Changes from Non-Irrigated Condition Swauk Creek Model Simulation - K=100 ft/d

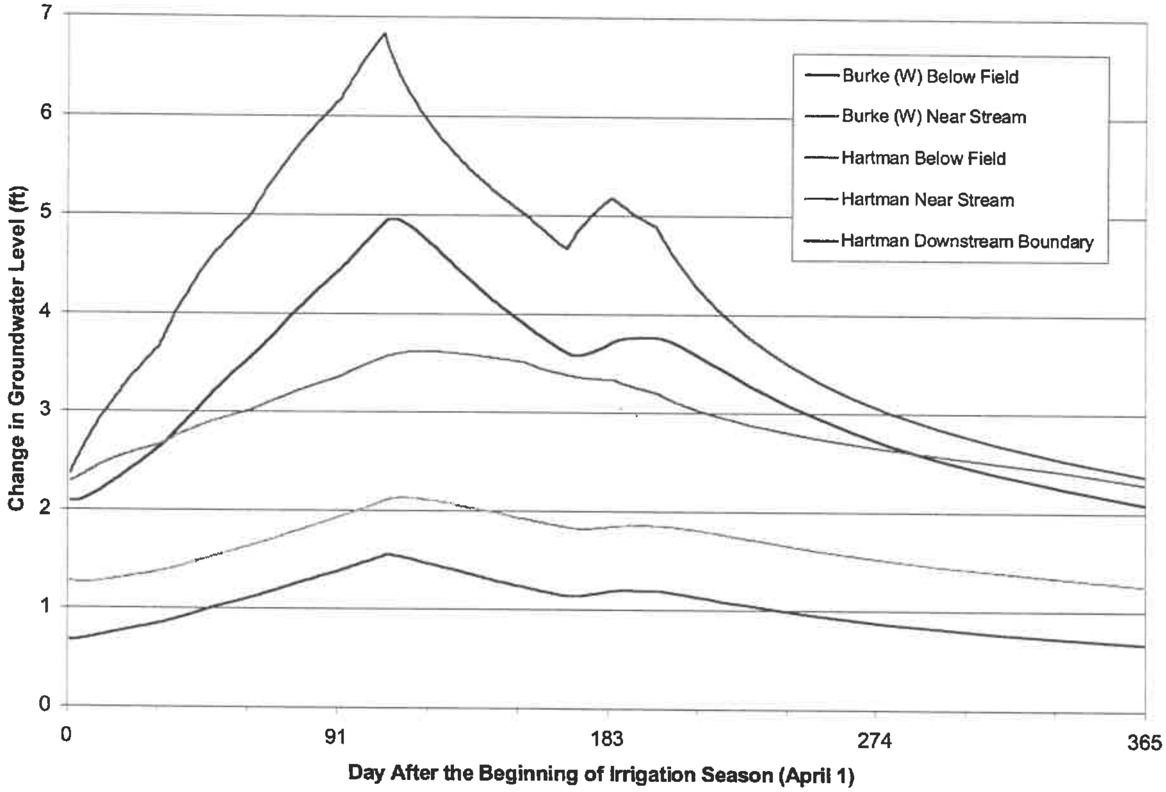

Figure 5b - Predicted Seasonal Water Level Changes from Non-Irrigated Condition Swauk Creek Model Simulation - K=500 ft/d

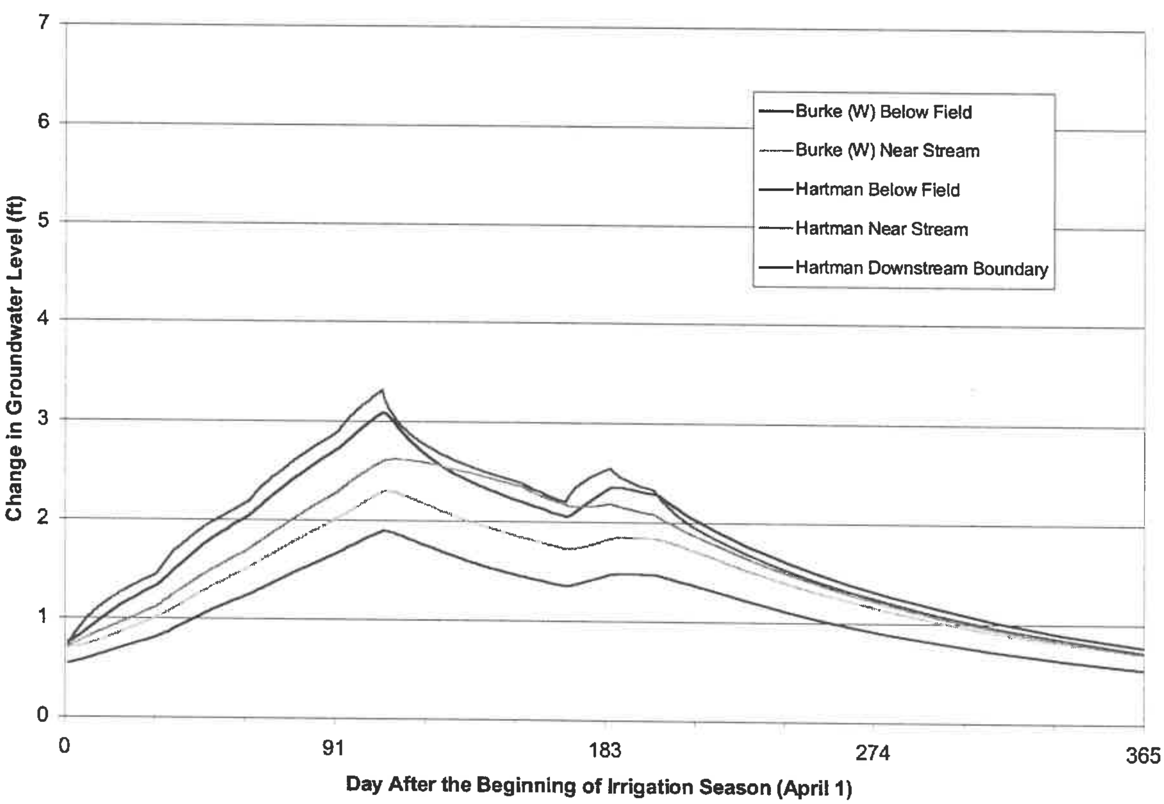

Figure 6a - Maximum Predicted Drawdown in Hartman Property Vicinity (Swauk Creek)
(Model K = 100 ft/d; Contour Interval = 1 foot)

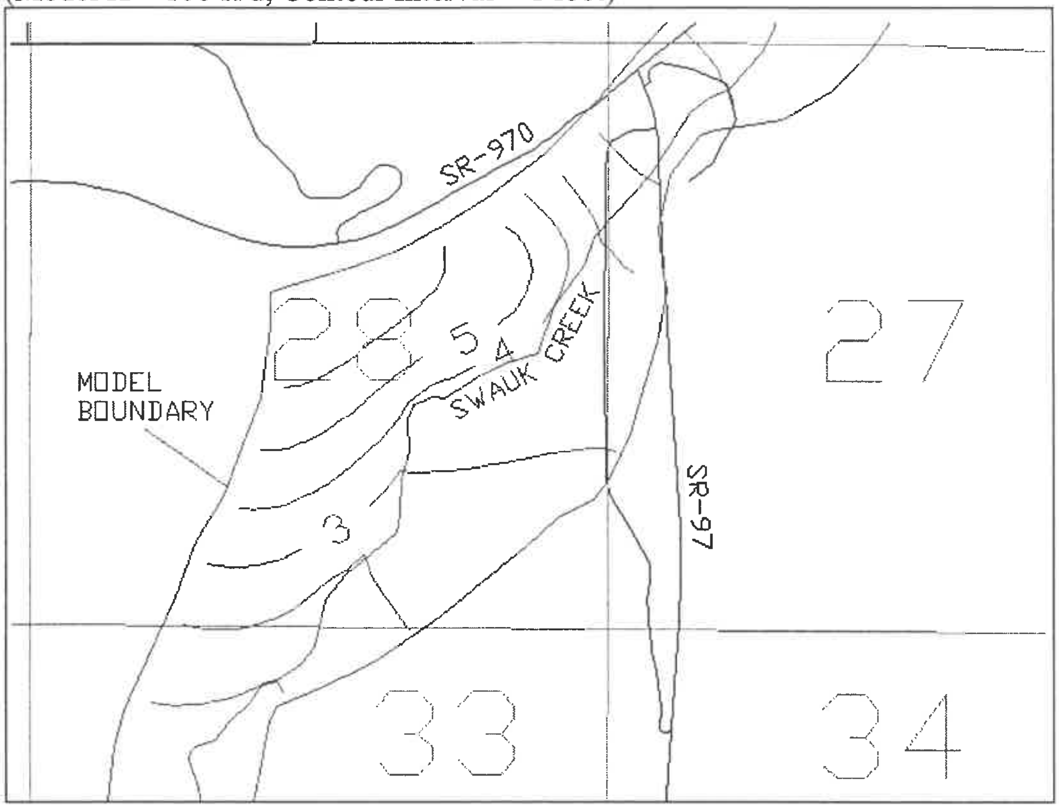

Figure 6b - Maximum Predicted Drawdown in Hartman Property Vicinity (Swauk Creek)
(Model K = 500 ft/d; Contour Interval = 0.5 feet)

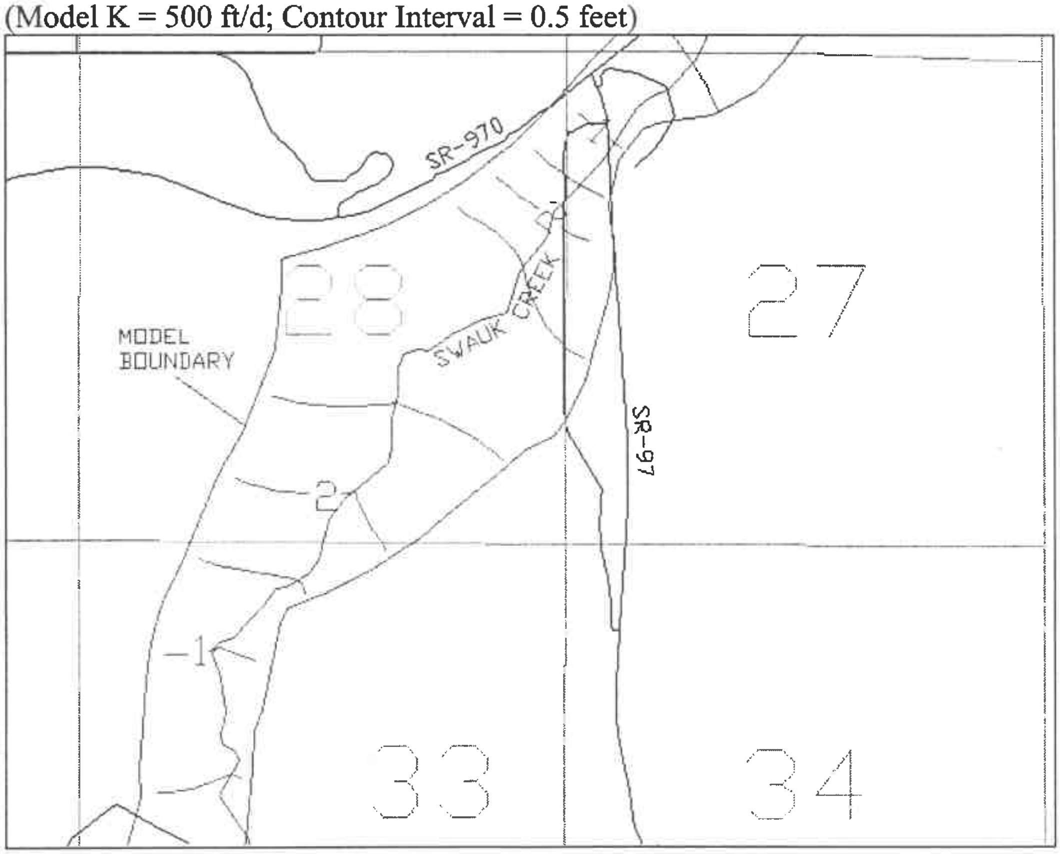

Figure 7 – Locations of First Creek Water User's Association Points of Use

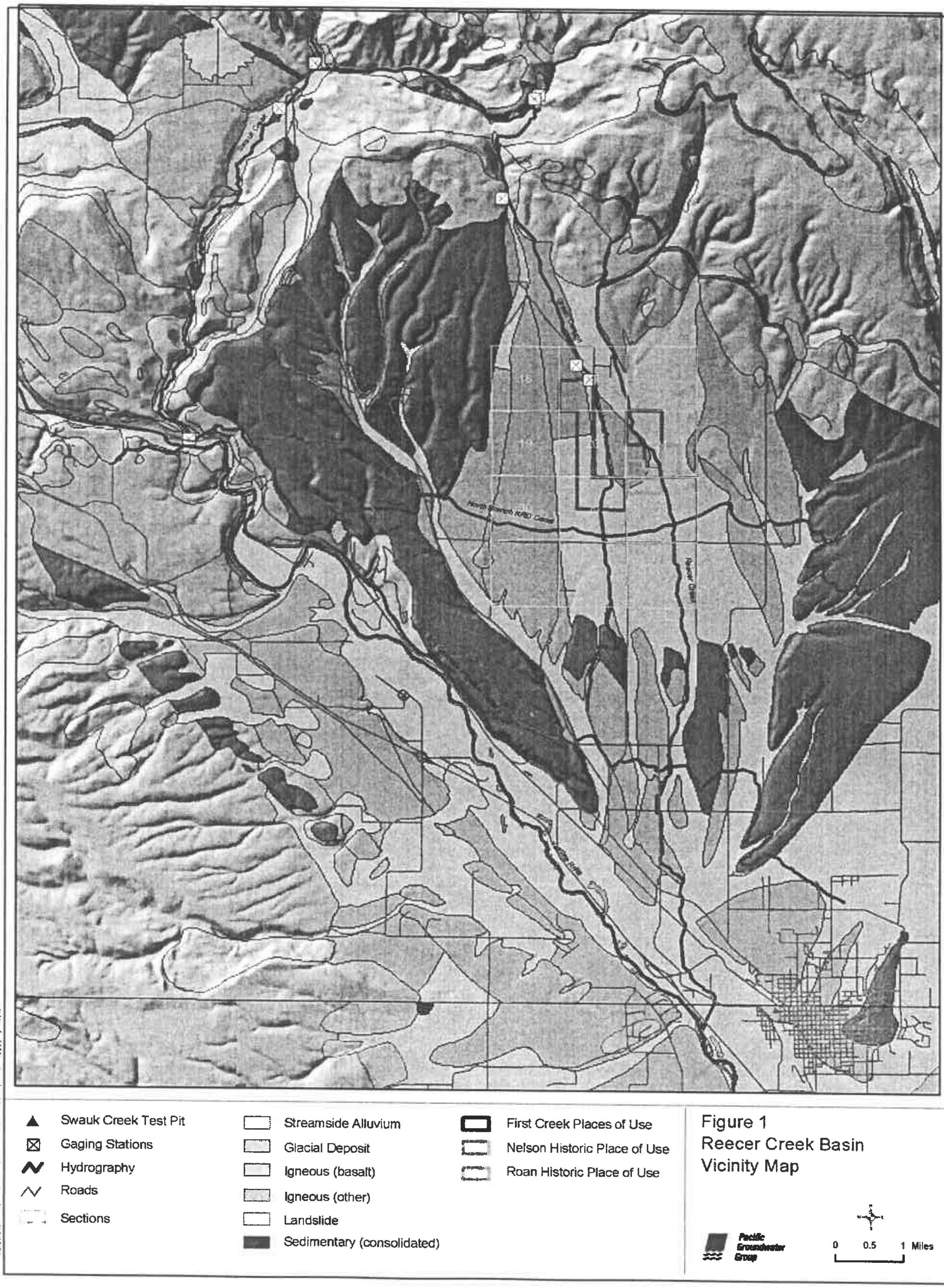

Table 1 - Big Creek Area Well Information
(T20N R14E)

Section	Quarter-Quarter Section	Estimated Land Surface Elevation (ft)	Depth to Water (ft)	Hole Depth (ft)	Water Column (ft)	Tested Well Yield (gpm)	Test Drawdown (ft)	Specific Capacity (gpm/ft)
Sec 20	NW NW	2090	1	196	195	15	80	0.2
Sec 20	NW NW	2090	10	40	30	25	20	1.3
Sec 20	NW NW	2090	8	32	24			
Sec 20	NW NW	2090	Dry	42				
Sec 20	NW NW	2090	10	42	32	75		
Sec 20	NE NW	2085	40	80	40	10		
Sec 20	SW NW	2095	20	58	38	30		
Sec 20	SW NE		Flowing	119	119			
Sec 20	SE NE	2085	18	40	22	50	28	1.8
Sec 20	SE SE	2130	26	67	41	100	39	2.6
Sec 20	SE SE	2130	23	67	44	60	65	0.9
Sec 20	SE SE	2130	18	52	34	15	15	1.0
Sec 20	SW SW		Flowing	140	140			
Sec 20	SW SW	Dry Hole						
Sec 20	SW SW	2120	10	35	25	12	20	0.6
Sec 20	SW SW	2120	20	78	58	40		
Sec 20	SW SW	2120	20	59	39	40		
Sec 20	SE SW	2120	23	35	12	10	0.1	100
Sec 20	SE SW	2120	15	38	23	10	0.1	100
Sec 21	NE NE	?	19	63	44	30	41	0.73
Sec 21	NW NE	Dry Hole						
Sec 21	NW? NW	?						
Sec 21	NE NW	2075	16	40	24			
Sec 21	SE SE	2085	23	54	31	40		
Sec 21	SE SE	2085	26	50	24	100		
Sec 21	SW SE	2085	10	80	70	20	70	0.29
Sec 21	SW SW	2120	20	60	40	20		
Sec 21	NW SW	2110	18	27	9	80	4	20
Sec 21	NE SW	2090	12	40	28	45	26	1.7
Sec 21	NE SW	2090	14	80	66	30	66	0.5
Sec 21	SE SW	2110	19	40	21	35	18	1.9
Sec 21	SE SW	2110	13	71	58	20	57	0.4
Sec 28	NW NW	2130	10	45	35	30	30	1.0
Sec 28	NE NW	2120	20	60	40	25		
Sec 28	NE NW	2120	80	100	20	30	15	2.0
Sec 28	SW NW	2140	15	50	35	100	33	3.0
Sec 28	NE SW	2170	70	100	30	10	25	0.4
Sec 28	NW SE	2150	15	80	65	20	60	0.3
Sec 28	NE SE	2140	19	75	56	100		
Sec 28	NE SE	2140	16	40	24	50	22	2.3
Sec 28	SE SE	2155	15	30	15	10	15	0.7
Sec 28	SE SE	2150	49	120	71	15	66	0.2
Sec 28	SE SE	2150	14	92	78	100	78	1.3
Sec 28	SE SE	2150	28	90	62	18		
Sec 28	NW NE	2115	14	92	78	300	76	3.9
Sec 28	SE NE	2125	20	55	35	30	35	0.9
Sec 28	SE NE	2125	21	50	29	65		
Sec 28	SW NE	2140	220	320	100	25	90	0.3
Sec 28	NE NE	2115	19	70	51	30		
Sec 28	NE NE	2115	20	64	44	80	40	2.0
Sec 28	NE NE	2115	19	63	44	60	36	1.7
Sec 28	NE NE	2115	18	120	102	75		
Sec 28	NE NE	2115	20	80	60	100	50	2.0
Sec 29	NE NE	2150	20	42	22	20		
Sec 29	NE NE	2150	46	60	14	22	19	1.2
Sec 29	NE NE	2150	44	59	15	8	24	0.3
Sec 29	NE NE	2150	22	52	30	15	28	0.5
Sec 29	NE NE	2150	46	69	23	25	19	1.3
Sec 29	NE NE	2150	38	63	25	22	17	1.3
Sec 29	NW NE	2150	18	60	42	25	6	4.2
Sec 29	SW NE	2150				60		

Table 2 - Teanaway River Area Well Information
(T20N R16E)

Section	Quarter-Quarter Section	Estimated Land Surface Elevation (ft)	Depth to Water (ft)	Hole Depth (ft)	Water Column (ft)	Tested Well Yield (gpm)	Stem Setting for Airlift Test (ft)	Test Drawdown* (ft)	Specific Capacity (gpm/ft)
Sec 25	S1/2 NW	1940	3	160	157	8			
Sec 25	S1/2 NW	1940	-2	260	260	5			
Sec 25	S1/2 NW	1940	50	160	110	10	150	100	0.1
Sec 25	SW NW	1940	-2	265	265	30	260	262	0.1
Sec 25	NE NW	2010	?	245		20			
Sec 25	SE NW	1900	20	400	380	100		2.5	40
Sec 25	NW NE	1950	205	400	195	4	359	154	0.03
Sec 25	NE NE	1960	-2	320	320	4			
Sec 25	SW NE	1950	28	205	177	3			
Sec 25	SE NE	1955	47	72	25	8			
Sec 25	NE	1955	6	185	179	15	185	179	0.1
Sec 25	NE SW	1950	4	127	123	33	190	186	0.2
Sec 25	NE SW	1950	6	160	154	17			
Sec 25	SW SW	2040	80	116	36	4	115	35	0.1
Sec 25	SW	2200	80	280	200	25	275	195	0.1
Sec 25	SE SE	2200	35	115	80	5			
Sec 25	SE SE	2200	127	245	118	12			
Sec 25	SE SE	2200	66	103	37	30			
Sec 25	SE SE	2200	272	525	253	10	435	163	0.1
Sec 25	NE SE	2000	93	109	16	15	108	15	1.0
Sec 25	SE	?	120	310	190	5			
Sec 26	NW NW	2150	117	425	308	4			
Sec 26	NE NW	2150	2	185	183	20	180	178	0.1
Sec 26	SW NW	2100		165		10			
Sec 26	SW NW	2100		160					
Sec 26	N1/2 NE	2150	110	365	255	50			
Sec 26	NW NE	2150	-2	285	285	30			
Sec 26	N NE		100	86	?	30	175	75	0.4
Sec 26	NW SW	2000	130	300	170	3	360	230	0.01
Sec 26	NW SW	1950	38	200	162	10	180	142	0.1
Sec 26	NE SW	1925	-1	340	340	35	320	321	0.1
Sec 26	SW SW	1890	220	360	140	7	340	120	0.1
Sec 26	SW SW	1890	30	190	160	15	180	150	0.1
Sec 26	SW SW	1890	49	69	20				
Sec 26	SW SW	1890	77	123	46				
Sec 26	SE SW	1900	10	303	293	10			
Sec 26	SE SW	1900	6	240	234	30	240	234	0.1
Sec 26	SW		10	197	187	25	195	185	0.1
Sec 26	SW SE	1910	60	215	155	10	255	195	0.1
Sec 26	SE SE	1915	7	50	43	40	18	11	3.6
Sec 26	SE SE	2000	84	182	98	22	72	-12	
Sec 26	SE SE	2000	6	56	50	50			
Sec 26	SE SE	2000	205	380	175	7	380	175	0.04
Sec 26	SE SE	2000	-1	265	265	38			
Sec 26	SE SE	2000	35	140	105				
Sec 26	SE SE	2000	90	157	67	10	155	65	0.2

* Estimated for airlift tests by subtracting depth-to-water from stem setting.

Table 3 - Swauk Creek Area Well Information
(T20N R17E)

Section	Quarter-Quarter Section	Depth to Water (ft)	Hole Depth (ft)	Water Column (ft)	Tested Well Yield (gpm)	Completion Type
Sec 22	S1/2 SW	71	190	119		Open Hole
Sec 22	S1/2 SW	106	386	280	1	Perforated
Sec 22	SW SW	190	500	310	1.5	Perforated
Sec 22	SW SW		264	264	0.5	Open Hole
Sec 22	SW SW	90	210	120	2.5	Perforated
Sec 22	SW SW		300	300	3	Open Hole
Sec 22	SE SE	30	80	50	20	Open Hole
Sec 27	N1/2 NW	100	145	45	10	Open Hole
Sec 27	N1/2 NW	93	380	287	3.5	Open Hole
Sec 27	NE NW	15	232	217	4	Open Hole
Sec 27	SW NE	147	265	118		Screened
Sec 27	SW SW	8	145	137	.5	Perforated
Sec 27	SW SW	10	205	195		Screened
Sec 27	SW SE	80	145	65		Perforated
Sec 27	SE SE	200	705	505	15	Perforated
Sec 28	SW	110	190	80	15	Open Hole
Sec 28	SW	80	167	87	20	Open Hole

Table 4 - Reecer Creek Area Well Information
(T19N R18E)

Section	Quarter-Quarter Section	Estimated Land Surface Elevation (ft)	Depth to Water (ft)	Hole Depth (ft)	Geology of Completion Interval	Water Column (ft)	Tested Well Yield (gpm)	Stem Setting for Airlift Test (ft)	Test Drawdown* (ft)	Specific Capacity (gpm/ft)
Sec 6	N? NW	2920	30	100	Bas	70	5	70	40	0.13
Sec 6	NW NW	3000	23	80	Bas	57	15			
Sec 6	NW NW	3000	471	800	Bas	329	11			
Sec 6	SE NW	2900	100	180	Bas	80	20	175	75	0.27
Sec 6	SE NW	3000	150	245	Bas	95	7			
Sec 7	E1/2 NE	2700	410	832	Bas	422	35	775	365	0.1
Sec 8	NW NW	2735	510	626	EF	116	25	600	90	0.3
Sec 8	SW NW	2665	480	600	Bas	120	10	595	115	0.1
Sec 8	NE NE	2880	312	435	Sed	123	5			
Sec 8	SE SW	2570	500	660	EF	160	15			
Sec 8	SW SE	2560	465	640	Bas/EF	175	15	630	165	0.1
Sec 8	SW SE	2560	470	560	Bas	90	4	550	80	0.1
Sec 8	SW SE	2560	485	560	Bas	75	3	560	75	0.04
Sec 17	NW NW	2530	340	440	Sed	100	12			
Sec 17	SE NW	2460		520	EF	520	7			
Sec 17	SE NW	2460	380	540	Bas	160	15			
Sec 17	NW NE	2510	400	550	Sed	150	10			
Sec 17	NW NE	2510	408	640	Sed	232	35			
Sec 17	NE NE	2500	375	480	EF	105	15	475	100	0.2
Sec 17	SW NE	2460	390	600	Bas	210	15	430	40	0.4
Sec 20	NE NE	2340	186	380	Bas/EF	194	30			
Sec 21	NE NE	2360	180	700	Bas	520	400	pump test	120	3.3
Sec 22	NW NW	2360	230	370	Sed	140				
	SE NW	2340	180	300	Bas/EF	120	25			
	SE NE	2320	205	300	Sed	95	25	29		
	NE SE	2300	163	285	Sed	122	45			
	E E		96.6	154	Sed	57.4	15			
	E E		253	380	Sed	127	40			
Sec 27	SE NE	2100	195	282	Sed	87	10			0.0
	SE SE	2050	138	200	Sed	62	16	180	42	0.4
Sec 28	NW	2160	250	390	Sed	140	20	330	80	0.25
Sec 28	NW NW	2192	?	940	Bas/EF		?			
Sec 28	SE NE	2110	230	343	Sed	113	60	pump test	123	0.49
Sec 30	NE SE	2100	15	160	Sed	145	20	140	125	0.16
Sec 31	NE	2020	90	160	Sed	70	20	158	68	0.29
Sec 31	NE	2020	100	160	Bas	60	15	155	55	0.27
Sec 31	NE NE	2030	85	160	Sed	75	16	155	70	0.23
Sec 31	NE NE	2030	82	170	Sed	88	30			
Sec 31	NE NE	2030	120	207	EF	87	20	180	60	0.33
Sec 31	SW	1950	50	100	Bas	50	20	98	48	0.42
Sec 31	SW SW	1920	27	131	Sed	104	18	pump test	4	4.50
Sec 31	SW SW	1920	30	160	Sed	130	20	95	65	0.31
Sec 31	NE SE	1970	33	180	Sed	147	27	160	127	0.21
Sec 31	SE SE	1930	80	240	Sed	160	20	235	155	0.13
Sec 31	SE SE	1930	64	167	Sed	103	22			
Sec 32	SW NW	1980	18	103	Sed	85	25			
Sec 32	SE NW	2000	40	100	Bas	60	15			
Sec 32	SE NW	2000	55	142	Sed	87	20			
Sec 32	E1/2 SW	1960	60	125	Sed	65	15	pump test	20	0.75
Sec 32	SW SW	1900	13	40	Sed	27	20	30	17	1.18

* Estimated for airlift tests by subtracting depth-to-water from stem setting.

GEOLOGIC DESIGNATIONS:
Sed - Unconsolidated sedimentary aquifer above basalt
Bas - Basalt (obvious Columbia River Basalt or no other rock type likely near completion zone)
EF - Ellensburg Formation - well is completed in sedimentary material encounterd below basalt
Bas/EF - open to both basalt and EF

Exhibit J

MONTGOMERY
WATER GROUP, INC.

MEMORANDUM

To:	Peter Schwartzman, Pacific Groundwater Group (PGG)	***Date:***	January 18, 2002
From:	Julie L. Daigneau, Water Resources Engineer		
	Robert A. Montgomery, P.E., Principal Engineer		
RE:	Review of Effects of Water Rights Transfers on Tributary and Ditch Hydraulics		

1.0 INTRODUCTION

This draft memorandum presents our review of the hydraulic effects of changes in streamflows on the tributaries and irrigation ditches for which Trendwest proposes to transfer water rights. Hydraulic conditions in the tributaries were analyzed by estimating changes in stage and depths associated with changes in flow at the tributary gauging stations. Rating curves developed on stations monitored during the 2001 irrigation season were used to assess the changes in stage expected from the increased streamflow in the creeks. Changes in ditch hydraulics at key locations on the irrigation ditches relative to pre-existing conditions were evaluated using data from seepage surveys performed during summer 2001 and hydraulic analyses. Pacific Groundwater Group provided average monthly flow data for the creeks and estimates of changes in streamflow attributable to Trendwest based on their analysis of the surface and subsurface hydrology in the basins. These estimates of changes in streamflow do not include the portion of consumptive use that is associated with consumptive use for future residential development on formerly appurtenant properties (those properties are assumed to have exempt wells to provide their water supply).

This discussion is divided into two main sections: 1) the estimated effects of the transfers on the stage and depth at applicable gauging locations on the tributary streams and 2) the estimated effects of the transfer on depths in the irrigation ditches that deliver water to other water users on the ditch. The tributaries affected by the water rights transfers include Big Creek, Swauk Creek, First Creek, Reecer Creek, and the Teanaway River. Water rights will be transferred from the Lund/Gentry, First Creek Water Users Association (FCWUA), Mill, Burke-Hartman, and Walker ditches. However, the Burke-Hartman ditch was not analyzed because we were unable to collect data to estimate the change in ditch hydraulics due to this year's drought transfers. Additionally, the Walker diversion has been retired.

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2.0 HYDRAULIC EFFECTS ON TRIBUTARIES AFFECTED BY THE TRENDWEST WATER RIGHTS TRANSFERS

2.1 Big Creek

Montgomery Water Group (MWG) installed and monitored four continuous water level recording stations on Big Creek from late May to late October 2001. The four monitoring stations were located above and below the Darling/Lund diversion dam, approximately 800 feet downstream of West Nelson Siding Road and at Ensign Ranch (approximately 800 feet downstream of the I-90 bridge over Big Creek.) The Darling and Lund diversion ditches were also monitored weekly to compare measured diversions to differences in the measured streamflows upstream and downstream of the diversion dam. Weekly to bi-weekly flow measurements were collected with a Swoffer current meter throughout the monitoring period. Rating curves were developed at each of the stations from the spot measurements and are included in Appendix A.

The rating curves were used to determine expected changes in stage at the monitoring stations resulting from the transfer of a portion of the Gentry water rights on the Lund/Gentry Ditch to Trendwest. Trendwest proposes to designate the purchased water right (390 acre-feet annual volume, 81.51 irrigated acres, and 1.53 cubic feet per second (cfs) instantaneous flow) for in-stream flows and mitigation for increased consumptive use associated with proposed water right changes for the MPR and UGA, under the Department of Ecology's Yakima River Trust Water Program. The stations that will be affected by the increase in streamflow are below the Lund/Gentry diversion and consist of the following stations: Big Creek Below the Diversion Dam, Big Creek Downstream of West Nelson Siding Road and Big Creek at Ensign Ranch.

Table 1 shows estimated changes in hydraulic conditions at each of the monitoring stations as a result of the water rights transfer from the Lund/Gentry Ditch. Average semi-monthly flows in Big Creek during the irrigation season were used to determine expected changes in stage and depth as well as the estimated maximum depth at a cross section near the gauging station. Field reconnaissance indicates that irrigation return flows follow a subsurface pathway via groundwater, and that most or all of the return flows likely discharge to the Yakima River rather than Big Creek due to the general lack of hydraulic continuity between the water-table aquifer and the creek (PGG memorandum dated January 18, 2002 entitled "Big Creek Basin Hydrologic Analysis"). PGG estimated that the transfer of the entire water right would increase streamflow by the amount previously diverted for irrigation. PGG also estimated the increased seepage associated with this additional water. For purposes of this analysis, the increased streamflow associated with the proposed Trendwest transfer was based on the estimated average monthly diversion associated with the Trendwest water right and the associated increased seepage estimated by PGG. The methodology to determine the estimated monthly diversion is described in MWG's memorandum dated January 4, 2002 entitled "Seepage Loss Analysis for the Lund/Gentry Ditch." Estimates of flows at the West Nelson Siding Road site and Ensign Ranch site incorporate the seepage estimates from PGG, and the Darling and Lund/Gentry diversions.

The maximum depth in Big Creek at the three stations is estimated using the streamflow measurements. The maximum depth was estimated from one point in a single cross section near the gauging station and would not necessarily be representative of the maximum depths at other locations in the stream. The change in depth after the water right transfer is assumed to be equal to the estimated change in stage.

Changes in stage or depth are highest at the end of the season when average flows in Big Creek are significantly lower. The change in stage varies from 0.01 to 0.04 feet at the three stations throughout the irrigation season. We could not estimate the expected change of stage at West Nelson Siding Road for the average May flows because our rating curve does not extend to these flowrates. The highest measurement at the West Nelson Siding Road site was 24.3 cfs on October 24, 2001. USGS does not recommend extrapolating rating curves to more than twice the highest flow measurement. However, it is our professional opinion that changes in stage at these higher flowrates are likely to be small (i.e. less than 0.01 feet), as they are at the other two stations on Big Creek.

2.2 Swauk Creek

Three continuous water level recorders were installed and monitored on Swauk Creek over the irrigation season. The stations were located: 1) upstream of the confluence of Swauk Creek with First Creek; 2) downstream of the Burke and Burke-Hartman diversions; and 3) upstream of the mouth of Swauk Creek near the Yakima River. Rating curves were developed from bi-weekly to weekly flow measurements taken from early June to late October and are included in Appendix A.

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Table 1
Estimated Changes in Hydraulic Conditions at Big Creek Monitoring Stations Below Lund/Gentry Diversion Resulting From the Trendwest Water Rights Transfer

Irrigation Season for the Big Creek Water Users	Estimated Change in Flow After Water Rights Transfer (cfs)	Big Creek Below Darling/Lund Diversion Dam				Big Creek Below West Nelson Siding Road				Big Creek At Ensign Ranch			
		Average Historic Flow at Site Below Div.	Est. Future Flow after Water Rights Transfer	Est. Change in Stage (ft)	Est. Max. Depth at Station After Water Rights Transfer[1] (ft)	Average Historic Flow at W. Nelson Site	Est. Future Flow after Water Rights Transfer[2] (ft)	Est. Change in Stage (ft)	Est. Max. Depth at Station After Water Rights Transfer (ft)	Average Historic Flow at Ensign Ranch Site	Est. Future Flow After Water Rights Transfer	Est. Change in Stage (ft)	Est. Max. Depth at Station After Water Rights Transfer (ft)
May 1-15	1.1	125	126.1	0.00	2.19	121.9	123.0	ND[3]	ND	112.7	113.7	0.00	1.64
May 16-31	1.1	95	96.1	0.01	2.05	92.7	93.8	ND	ND	85.9	86.9	0.01	1.52
June 1-15	1.5	60	61.5	0.01	1.85	58.4	59.9	0.01	2.19	53.6	54.6	0.01	1.33
June 16-30	1.5	20	21.5	0.02	1.47	18.9	20.4	0.02	1.78	15.7	16.7	0.01	0.98
July 1-15	1.5	13	14.5	0.03	1.36	12.0	13.5	0.03	1.66	9.0	10.0	0.02	0.87
July 16-31	1.5	10	11.5	0.03	1.30	9.0	10.5	0.04	1.60	6.1	7.1	0.03	0.81
August 1-15	1.5	8	9.5	0.04	1.26	7.0	8.5	0.04	1.55	4.1	5.2	0.03	0.76
Aug 16-Sept 1	1.5	6	7.5	0.05	1.20	5.1	6.5	0.05	1.50	2.2	3.3	0.04	0.70

1 The estimated maximum depth in a cross section at the monitoring station is based on the depths obtained from one point in a single cross section measurement near the water level sensor location and does not necessarily represent the expected depths at other locations in the reach. Flow measurements were taken at the best gauging location near the sites and therefore were not always at the same cross section. Change in stage is assumed to equal change in maximum depth.

2 The estimated average historic flows and future flows after water rights transfers at the W. Nelson Siding Road and the Ensign Ranch sites include PGG's estimates of the change in seepage in these reaches as documented in PGG's memorandum dated January 18, 2002 titled "Big Creek Basin Hydrologic Analysis." Seepage losses after the transfer of the water right are expected to be slightly greater due to the increase streamflow associated with the transferred water right.

3 ND =No data were available at these high flows at the site. The rating curve does not extend to high flow region to allow estimate of change in stage.

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The rating curve at the monitoring station below the Burke-Hartman diversion was used to determine the expected change in stage and depth at this location as a result of an increase in streamflow from the transferred Hartman water right and the increased inflow to Swauk Creek from First Creek as part of the Trendwest's transferred water rights on First Creek. Trendwest proposes to designate the purchased water rights (713 acre-feet annual volume, 95 irrigated acres, and 4.23 cubic feet per second (cfs) instantaneous flow on Swauk Creek and 56 percent of the available flow in First Creek during the irrigation season) for in-stream flows and mitigation for increased consumptive use associated with the proposed water right changes for the MPR and UGA, under the Department of Ecology's Yakima River Trust Water Program. Trendwest's water rights transfers on First and Swauk Creeks do not affect the station on Swauk Creek upstream of First Creek. Estimates of change in stage and depth are not included for the station at the mouth of Swauk Creek near the Yakima River because there are no historical monthly flow data available and the rating curve does not extend to flows higher than 6 cfs. This station was installed late in the monitoring season (July 25, 2001) when there was little flow left in the creek at the mouth. Additionally, the rating curve consists of only five measurements at flows between 0.2 and 3.2 cfs.

PGG provided MWG with estimates of average historical monthly flows on the Swauk Creek below the Burke and Burke-Hartman diversions and estimates of the changes in streamflow due to the transfer of the Trendwest water rights on First and Swauk Creeks. Their estimates of changes in streamflow attributable to Trendwest's water rights transfers is based on a detailed analysis of streamflow, subsurface return flow, and alluvial sub-flow in the Swauk and First Creek basins and is detailed in a memorandum dated January 24, 2002 entitled "First and Swauk Creek Basin Hydrologic Analysis" and in subsequent communication (Peter Schwartzman, pers. communication, January 8, 2002). Table 2 gives estimates of the change in stage and depth at the station below the Burke-Hartman diversions (also referred to as the Martin Property gage) based on PGG's estimates of changes in streamflow at this station.

The values of historic flow below the Burke-Hartman diversions reflect best estimates of typical conditions prior to the transfer of Trendwest's Hartman and FCWUA water rights. The Martin gage is located downstream of both the Burke and Burke-Hartman diversions, and the historic flow values represent Swauk Creek flows above the First Creek confluence plus historic inflow from First Creek (when present) minus both diversions. Actual historic flows may be slightly higher due to return flows from water use on the Burke and Hartman properties; however, the locations that subsurface return flows re-enter Swauk Creek and the amount of return flow discharging above the Martin gage are not well known. The estimated change in flow at the Martin gage after the water rights incorporates best estimates of: 1) diversions associated with Trendwest's Hartman and FCWUA water rights; 2) return flow to Swauk Creek associated with Trendwest's Hartman water rights; and

3) seepage losses near the mouth of First Creek and associated return flows to Swauk Creek associated with Trendwest's FCWUA water right. The values shown in Table 2 assume that the entire change in flow associated with the transfer of Trendwest's Hartman water right (diversion minus return flow as estimated in PGG's "First and Swauk Creek Basin Hydrologic Analysis") occurs upstream of the Martin gage. In the likely scenario that only a portion of this return flow discharges to Swauk Creek upstream of the Martin gage, estimated changes in flow at the gage would be higher. However, data were insufficient to determine the portion of former Hartman return flow discharging to Swauk Creek upstream of the gage.

Table 2
Estimated Changes in Hydraulic Conditions at the Swauk Creek Monitoring Station on the Martin Property Below Burke-Hartman Diversions

Irrigation Season for the Swauk and First Creek Water Users[1]	Average Historical Flow in Swauk Creek below Burke-Hartman Diversions	Estimated Change in Flow After Water Rights Transfer (cfs)	Estimated Change in Stage at Martin Property Station (ft)	Estimated Maximum Depth at Station After Water Rights Transfer[3] (ft)
April 1-15	127.2	5.6	ND[2]	ND
April 16-30	107.2	5.6	ND	ND
May 1-15	40.8	6.6	ND	ND
May 16-31	21.1	6.6	0.11	1.58
June1-15	15.1	5.8	0.11	1.47
June 16-30	9.1	5.7	0.14	1.35
July 1-15	4.1	3.6	0.13	1.17
July 16-31	1.5	1.6	0.09	0.99
August 1-15	0.0	0.9	0.19	0.84
August 16-31	0.0	1.0	0.20	0.85
September 1-15	0.9	0.8	0.06	0.91
September 16-31	0.9	1.6	0.11	0.96
October 1-15	3.5	1.1	0.05	1.06

1 Swauk and First Creek water users irrigation season is April 1 through October 15. Increased inflow from Trendwest's First Creek water right transfer contributes to flow change on Swauk Creek at the Martin Property Gage.
2 ND = No data
3 The estimated maximum depth in a cross section at the monitoring station is based on the depths obtained from one point in a single cross section measurement near the water level sensor location and does not necessarily represent the expected depths at other locations in the reach. Flow measurements were taken at the best gauging location near the sites and therefore were not always at the same cross section. Change in stage is assumed to equal change in maximum depth.

The estimated change in stage and depth at the Swauk Creek Martin gage associated with changes in flow of 0.8 to 6.6 cfs ranges from 0.05 feet to 0.20 feet. Note that the increase in streamflow as a result of the Trendwest water rights transfers on Swauk and First Creeks are greater than the

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historical average flows in the creek from several biweekly periods during the season, especially in late summer. It is in these months where the greatest change of stage is represented. We could not estimate the expected change in stage at the Swauk Creek Martin property gage (below Burke-Hartman diversions) for the average April and early May streamflows because our rating curve does not extend to these higher flowrates. The highest measurement at the Martin site was 14.1 cfs on June 1, 2001, which is significantly lower than the average spring flows in Swauk Creek.

2.3 First Creek

Data were collected at two monitoring stations on First Creek. The upper First Creek station was located just downstream of the First Creek Water Users Association (FCWUA) diversion. The lower station was installed approximately 0.5 mile upstream of the confluence of First Creek and Swauk Creek. Rating curves for the station downstream of the FCWUA diversion and the station upstream of the mouth were developed from weekly to bi-weekly flow measurements throughout the 2001 monitoring season and are attached in Appendix A.

Table 3 shows our estimates of the expected changes in stage and depth calculated from the rating curves developed for the upper and lower First Creek stations. PGG provided estimates of the average semi-monthly flows in First Creek below the FCWUA diversion over the irrigation season, and MWG estimated changes in flow associated with the proposed water rights transfer. These estimated flow changes are based on the Trendwest's transfer of 56 percent of the available water in First Creek from FCWUA back to First Creek during the irrigation season. Trendwest proposes to designate the purchased First Creek water right for in-stream flows and mitigation for increased consumptive use associated with the proposed water right changes for the MPR and UGA under the Department of Ecology's Yakima River Trust Water Program. Continuous flow data from the summer monitoring program indicates that there is little loss between the upper and lower gages of First Creek. Therefore, we assumed that the same flow is present at the upper and lower gages. Frequent field reconnaissance of flow conditions at the mouth of First Creek at the low flows indicated that there were seepage losses in the alluvial section of the creek located just upstream of the confluence with Swauk Creek. These losses were not measured but were estimated to be on the order of 0.3 cfs to 0.6 cfs at flow rates ranging from 0.5 cfs to 1.5 cfs at the lower gage. Seepage losses in the First Creek and Swauk Creek basins are described in detail in PGG's memorandum dated January 24, 2002 titled "First and Swauk Creek Basin Hydrologic Analysis."

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Table 3
Estimated Changes in Hydraulic Conditions at the First Creek Monitoring Stations

Irrigation Season for the First Creek Water Users	Average Historical Flow in First Creek (cfs) [1]	Estimated Change in Flow from Water Rights Transfers (cfs)	First Creek Below FCWUA Diversion		First Creek Upstream of the Confluence with Swauk Creek	
			Estimated Change in Stage (ft)	Est. Maximum Depth at Station After Water Rights Transfer (ft) [2]	Estimated Change in Stage (ft)	Est. Maximum Depth at Station After Water Rights Transfer (ft)
April 1-15	16.1	5.0	ND[3]	ND	ND	ND
April 16-30	16.1	5.0	ND	ND	ND	ND
May 1-15	14.6	5.2	ND	ND	ND	ND
May 16-31	11.5	5.2	ND	ND	ND	ND
June 1-15	6.2	4.4	ND	ND	ND	ND
June 16-30	3.0	4.4	0.22	0.97	0.20	0.82
July 1-15	1.0	1.9	0.17	0.77	0.14	0.60
July 16-31	0.0	1.9	0.39	0.70	0.28	0.52
August 1-15	0.0	1.2	0.32	0.64	0.22	0.45
August 16-31	0.0	1.2	0.32	0.64	0.22	0.45
September 1-15	0.0	1.1	0.30	0.63	0.21	0.43
September 16-31	0.0	1.1	0.30	0.63	0.21	0.43
October 1-15	0.0	1.1	0.31	0.64	0.22	0.44

1 The average historical flow in First Creek was estimated below the FCWUA diversion.
2 The estimated maximum depth in a cross section at the monitoring station is based on the depths obtained from one point in a single cross section measurement near the water level sensor location and does not necessarily represent the expected depths at other locations in the reach. Flow measurements were taken at the best gauging location near the sites and therefore were not always at the same cross section. Change in stage is assumed to equal change in maximum depth.
3 ND =No data

The estimated increase in stage and depth ranges from 0.17 to 0.39 feet at the upper First Creek station and 0.14 to 0.28 feet at the lower First Creek station. Similar to the other stations at higher (spring freshet) flows, we could not estimate change in stage at the First Creek stations for flows higher than 6 cfs. The highest flow measurement at the upper First Creek station was 2.8 cfs on July 3, 2001 and was taken when all the flow above the FCWUA diversion was diverted into First Creek. The highest flow measurement at the lower First Creek station was 2.0 cfs on June 11, 2001. Trendwest water rights transfers to First Creek from mid-June to mid-October represent more flow than what was historically in the creek and therefore represent modest increase in stage.

2.4 Reecer Creek

Montgomery Water Group installed and monitored continuous water level recording stations on Reecer Creek downstream of the confluence of Mill Ditch and immediately downstream of the Mill

Ditch intake structures at the Mill Ditch rectangular weir. A portion of the flow in Mill Ditch (including the former Pautzke water rights purchased by Trendwest) is conveyed by Reecer Creek in the reach from Hwy 97 to just upstream of the Klein-Coble Castle diversion located near the mouth of Reecer Creek at the Yakima River. Weekly flow measurements were also taken on Mill Ditch upstream of the confluence with Reecer Creek. Rating curves were developed from the spot measurements collected throughout the irrigation season and are included for reference in Appendix A.

Trendwest's purchase of the Pautzke water rights consisted of a total instantaneous water right of 21.39 cfs and an annual water right volume of 4401.2 ac-ft for 291 formerly irrigated acres. Trendwest did not divert the former Pautzke water right in 2001. Additionally, the Lamb water right of 4 cfs, 1054 ac-ft, and 85 irrigated acres was also not diverted into Mill Ditch during the 2001 irrigation season because it was leased this year to the Department of Ecology. The total of the leased water rights for the 2001 monitoring season on Mill Ditch was 25.4 cfs instantaneous, 5455.2 ac-ft annual volume, and 376 irrigated acres. There were little historical monthly flow data available to evaluate differences in stage at the Reecer Creek gauging site upstream of Dolarway Road. Tom Martin, Brown and Caldwell, collected the only data on Reecer Creek that we are aware of prior to this year's leasing of the former Pautzke water rights and the Lamb water right. His data consists of spot measurements taken monthly from September 1998 to October 2000.

It is our experience from the 2001 monitoring program at the gauging site that flows in Reecer Creek are highly variable. For that reason, we were unable to use Tom Martin's 1999 and 2000 data on Reecer Creek for estimates of historical flows since these measurements are not necessarily indicative of the average monthly historical flows in Reecer Creek prior to the water rights transfer. Additionally, there were no data available to indicate what the average monthly historical diversions were on Mill Ditch. Therefore our estimates of change in stage at the Reecer Creek station are based on the assumption that the average monthly historical flows at this station can be represented by the average monthly flow from the 2001 monitoring program plus the sum of the leased Trendwest (formerly Pautzke) water rights, the Lamb water right, and the former monthly FCWUA surface water return flows. The reduced FCWUA surface water return flows are credited to Reecer Creek because excess flow on the irrigated properties of the FCWUA ditch return to Reecer Creek rather than the First Creek basin. These assumptions may not account for all of the changes in flow due to the water right transfers and leases by Trendwest and others.

There were no data available during the summer 2001 monitoring season in the months of April through June since the monitoring station on Reecer Creek was not installed until July 11, 2001. As a result, we assumed that the average flows for April through June are the same as the average monthly flows calculated for July. This is probably a conservative assumption since spring runoff and wetter soil conditions in the early months of the irrigation season likely result in higher Reecer Creek flows and changes in stage are smaller at the higher flows. Estimates of change in stage and maximum depth at the gauging station are given in Table 4. It should be noted that Mill Ditch/Reecer Creek water users are able to manipulate check structures in the reach downstream of Dolarway Road to facilitate water delivery to ditch laterals (i.e. the top of the Pautzke property and Klein-Coble ditch. Data taken in October 2001 have also indicated that the rating curve developed during the 2001 monitoring program shifted several times at the Reecer Creek Upstream of Dolarway station. The cause of that shift is unknown but may be related to a downstream diverter adjusting check structures or otherwise backing up the water in the creek. Therefore, the changes in stage and maximum depths given in Table 4 may change as configuration of the check structures changes throughout the irrigation season.

Table 4
Estimated Changes in Hydraulic Conditions at the Reecer Creek Upstream of Dolarway Road Monitoring Station

Irrigation Season for Reecer Creek/Mill Ditch Users	Average Monthly Flows Recorded during the 2001 Monitoring Season After the Water Rights Transfer[1] (cfs)	Estimated Additional Flow Before Water Rights Transfer [3] (cfs)	Estimated Change in Stage at Reecer Creek Station After Transfer (ft)	Estimated Maximum Depth at the Station After Water Rights Transfer (ft)[4]
April	18.9[2]	28.2	-0.6	0.98
May	18.9[2]	27.4	-0.6	0.98
June	18.9[2]	26.1	-0.6	0.98
July	18.9	25.4	-0.6	0.98
August	23.3	25.4	-0.6	1.10
September 1-15	19.8	25.4	-0.6	1.01
October 1-15	16.6	25.4	-0.6	0.92

1 Historical average monthly flow data was not available. Therefore, this analysis is based on average monthly flow data from the 2001 monitoring season at the Reecer Creek Upstream of Dolarway Road site.

2 Data were not available for the months of April through June because the monitoring station was not installed until July 11, 2001. Therefore, we assumed that average monthly flows in April through June were the same as the average monthly flow in July.

3 There were no data to indicate historical diversions on Mill Ditch. The estimated change in flow was assumed to be the sum of the FCWUA diversion surface water return flows and the total of the 2001-leased Trendwest (formerly Pautzke) and Lamb instantaneous water rights (25.4 cfs).

4 The estimated maximum depth in a cross section at the monitoring station is based on the depths obtained from one point in a single cross section measurement near the water level sensor location and does not necessarily represent the expected depths at other locations in the reach. Flow measurements were taken at the best gauging location near the sites and therefore were not always at the same cross section. Change in stage is assumed to equal change in maximum depth.

The reduction in stage associated with a reduction in flow of 25.4 to 28.2 cfs is approximate 0.6 feet at the Reecer Creek station upstream of Dolarway Road. This estimate is based on the check structure configuration present from July 11, 2001 to September 26, 2001. Changes in the check structures since the September 26th measurement have changed the rating curve and thus this

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relationship between flow and stage a t the Reecer Creek Upstream of Dolarway Road site.

2.5 Teanaway River

The United States Bureau of Reclamation (USBR) monitors flows in the reach of the Teanaway River near the former Walker Diversion (USBR-TEAW upstream of Lambert Road). Continuous flow data and a rating curve were obtained from USBR and are included in Appendix A. Evaluation by PGG and MWG suggests that the Lambert gage rating curve and associated flow data may include some degree of error, as described in PGG's technical memorandum "Teanaway River Basin Hydrologic Analysis" dated January 17, 2002. Trendwest proposes to transfer the former Walker water right of 3.76 cfs (instantaneous) and 1014.2 acre-feet (annual volume) on 187.8 irrigated acres for in-stream flows and mitigation for increased consumptive use associated with the proposed water right changes for the MPR and UGA, under the Department of Ecology's Yakima River Trust Water Program. PGG provided estimates of the changes in streamflow and associated timing (Peter Schwartzman, pers. communication, 11/6/2001) for use in the analysis of expected changes in hydraulic conditions at the USBR Teanaway River gage near Lambert Road as a result of the water rights transfer. The flow changes shown in Table 5 are included in the average monthly flows measured at the Teanaway USBR gage for the 2001 irrigation season. These flow increases were subtracted from the average monthly flows to obtain an estimate of change in stage associated with the transfer of the water right. There were no data to provide estimates of maximum depth at this gauging location.

Table 5
Estimated Changes in Hydraulic Conditions at the USBR Station on the Teanaway River Upstream of Lambert Road

Irrigation Season for the Teanaway Water Users	Average Monthly Flows at the USBR Teanaway Gage (TEAW) for the 2001 Monitoring Season (cfs)[1]	Estimated Change in Flow After Water Rights Transfer (cfs)[2]	Estimated Change in Stage at USBR Teanaway Station (TEAW) from USBR Rating Curve (ft)
May	393.2	3.39	<0.01
June	87.6	1.55	<0.01
July	11.1	1.43	0.02
August	11.4	1.67	0.02
September 1-15	8.7	0.78	0.16
September 16-30	11.5	-2.3	-0.02
October 1-15	26.5	-2.1	-0.01

1 Provisional data for the TEAW gage obtained from the USBR web site (http://mac1.pn.usbr.gov/yakima/index.html).
2 Estimates provided by PGG's analysis (Peter Schwartzman, pers. communication, 11/6/01).
3 Estimated from USBR rating curve attached in Appendix A.

The change in stage associated with increases in flow of 0.78 to 3.39 cfs ranges from approximately less than 0.01 to 0.16 feet from May to September 15. Immediately after the end of the season (September 16 through October 15), a decrease in flow and a corresponding decrease in stage of 0.01 to 0.02 ft are expected because of loss of typical return flows associated with irrigation practices on the Walker properties. These results are based upon the USBR Lambert Road rating curve and flow data and any errors associated with that data will similarly affect the accuracy of these estimations.

3.0 HYDRAULIC CHANGES ON IRRIGATION DITCHES WHERE TRENDWEST PROPOSES THE TRANSFER OF WATER RIGHTS

Evaluation of the effects of changes in flow in the affected irrigation ditches due to the proposed transfer of Trendwest water rights were based on field observations, flow measurements, cross-sectional geometry surveys, and continuous monitoring data in the associated tributaries. Seepage analyses were conducted on three of the ditches where Trendwest holds water rights: 1) Lund/Gentry ditch; 2) FCWUA ditch; and 3) Mill Ditch. Flow measurements were taken at key points on the Lund/Gentry, FCWUA, and Mill ditches during the irrigation season. MWG performed the seepage surveys on Lund/Gentry and FCWUA ditches. Dick Bain conducted the Mill Ditch seepage survey (detailed in memorandums dated July 26, 2001 and September 4, 2001 to Mr. Mark Anderson of Anderson Hay & Grain). No flow measurements or monitoring occurred on the Burke-Hartman ditch this season because drought transfers have rendered the ditch dry. As a result, data could not be collected to analyze how the proposed water rights transfer would affect hydraulic conditions in this ditch.

3.1 Lund/Gentry Ditch

Irrigation diversions on the Lund/Gentry ditch were monitored weekly over the summer 2001 irrigation season. A seepage survey was conducted on July 12, 2001. Measurements were taken at laterals used by the remaining irrigators on the ditch. Changes in hydraulic conditions due to the water rights transfer at these key turnouts were evaluated and the analysis is described in MWG's memorandum titled "Seepage Loss Analysis of the Lund/Gentry Ditch" dated November 5, 2001 Table 6 provides a summary of expected changes in depth at key locations on the Lund Ditch.

Table 6
Summary of Estimated Changes in Depth and Maximum Depth at Typical Cross Sections on the Lund/Gentry Ditch

Month of Irrigation Season	Average Diversion Prior to Water Rights Transfer (cfs)	Estimated Change in Diversion Due to Water Rights Transfer (cfs)	Upper Lund Ditch Typical Cross Section		Lower Lund Ditch Typical Cross Section	
			Estimated Change in Depth from Water Rights Transfer (ft)	Estimated Maximum Depth After Water Rights Transfer (ft)	Estimated Change in Depth from Water Rights Transfer (ft)	Estimated Maximum Depth After Water Rights Transfer (ft)
May	4.3	1.1	0.2	0.85	0.2	0.50
June	5.4	1.5	0.3	1.00	0.3	0.70
July	5.6	1.5	0.3	1.05	0.3	0.75
August	5.6	1.5	0.3	1.05	0.3	0.75
Average	5.2	1.4	0.3	0.95	0.3	0.70

Depths in the upper and lower Lund ditches are estimated to be 0.2 to 0.3 feet lower than the typical depths observed prior to the water rights transfer. Lund ditch users have a number of laterals that serve the irrigated properties on the lower end of the ditch as well as a number of storage ponds and irrigation pumps.

3.2 FCWUA Ditch

Montgomery Water Group monitored weekly irrigation diversions on the FCWUA ditch over the irrigation season. Weekly measurements were taken at the FCWUA flume just downstream of the irrigation diversion and at the Roan/Olsen weir split near the end of the ditch in the Reecer Creek basin. In addition, several seepage surveys were conducted on the ditch during the irrigation season to evaluate seasonal changes in the hydraulic conditions along the ditch. Analyses of expected changes in hydraulic conditions in the FCWUA ditch are described in MWG's memorandum titled "FCWUA Ditch Seepage Loss Analysis" dated October 17, 2001. Table 7 provides a summary of expected changes in flow depth at typical cross sections (average cross section in the respective reach of the ditch) of the FCWUA ditch as a result of the proposed transfer of Trendwest water rights.

The transfer of the former Roan and Nelson water rights represent 56% of the water right on the FCWUA ditch. Depths in the FCWUA ditch at Green Canyon and upstream of the Roan/Olsen weir are estimated to change by 0.1 to 0.5 feet and 0.2 to 0.5 feet, respectively.

Table 7
Summary of Estimated Changes in Depth and Maximum Depth at Typical Cross-Sections on the FCWUA Ditch

Irrigation Season Months for the Lund/ Gentry Ditch Water Users	Average Monthly FCWUA Diversion		Change in Average Depth at Typical Cross Section After Water Rights Transfer (ft)		Estimated Maximum Depth in a Typical Cross Section After Water Rights Transfer (ft)	
	Prior to Water Rights Transfer (cfs)	Change in Amount Diverted (cfs)	Reach between Diversion and Green Canyon	Reach between Green Canyon and Roan/Olsen Weirs	Reach between Diversion and Green Canyon	Reach between Green Canyon and Roan/Olsen Weirs
April	9.0	5.0	0.4	0.5	0.7	0.8
May	9.3	5.2	0.5	0.5	0.7	0.8
June	7.8	4.4	0.3	0.5	0.6	0.8
July	3.4	1.9	0.2	0.3	0.5	0.5
August	2.1	1.2	0.1	0.2	0.4	0.4
September	1.9	1.1	0.1	0.2	0.4	0.3
October	2.0	0.9	0.1	0.2	0.4	0.4

3.3 Mill Ditch

Analyses of how hydraulic conditions in Mill Ditch would change as a result of the proposed Trendwest water rights transfer were complicated by the relocation of a quarter mile section of Mill Ditch upstream of Hwy 97 in June 2001. Channel hydraulics and seepage characteristics in the ditch have changed both due to the water rights transfers and as a result of the relocation of the ditch along I-90. These geometric and hydraulic changes, as well as leasing of other water rights during the 2001 irrigation season, preclude the ability to separate the effects of the water rights transfer from the effects of the ditch relocation. In addition, there are a number of check structures on Mill Ditch and on Reecer Creek below the Mill Ditch confluence that facilitate water user's ability to alter water depths and improve delivery to their laterals. For these reasons, we were unable to compare depths at the key turnouts relative to the pre-existing conditions.

A review of previous reports and our own field observations and measurements throughout the monitoring season indicate that although the transfer of the Pautzke Water Rights to Trendwest represents a significant change in Mill Ditch diversion flows and likely a change in seepage losses in the reach, delivery of water to the remaining users is allowed by the existence and placement of a number of check structures in both Mill Ditch and Reecer Creek. Dick Bain determined from seepage survey measurements collected in August 2001 that adjustment of the check structures in the reach between the intake and Hwy 97 allowed adequate delivery of water to the Becker Ditch and lateral serving the house behind Blue Grouse Restaurant (the two turnouts in the reach). These measurements were taken without diversion of the full remaining water right on Mill Ditch. His

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findings are detailed in memorandums dated July 26, 2001 and September 4, 2001 to Mr. Mark Anderson of Anderson Hay & Grain. Our field observations of the ditch lateral at the top of the Pautzke property south of Dolarway Road and the Klein-Coble intake, similarly indicate that manipulation of the check structures allows adequate delivery to the remaining water users.

3.4 Burke-Hartman Ditch

Drought transfers on the Burke-Hartman ditch during the 2001 irrigation season prevented flow measurements at key points along the ditch. No data were available to evaluate changes in hydraulic conditions within the Burke-Hartman ditch.

4.0 SUMMARY OF HYDRAULIC CHANGES IN TRIBUTARY STREAMS AND DITCHES WHERE TRENDWEST PROPOSES WATER RIGHTS TRANSFERS

A review of the expected changes in hydraulic conditions in the tributary streams indicated that changes in stage and depth are expected to be greatest during the months of the irrigation season when flows in the tributary streams are the lowest. The greatest increases in flow, stage, and depths will occur at the Swauk Creek gage below the Burke Hartman diversions and at the First Creek gages because the water rights transfers from FCWUA to First Creek represent a significant increase in flow over the pre-existing historical conditions. Swauk Creek below the Burke-Hartman diversions will benefit both from the increase in inflow from First Creek and the transferred Hartman water right. Reecer Creek upstream of Dolarway Road is estimated to absorb the greatest decrease in stage or depth from historical conditions. However, Mill Ditch and Reecer Creek water users have the use of a number of check structures in the reach between Mill Ditch to the Yakima River that allow them to alter water depths in the reaches to facilitate delivery of water to their ditch laterals.

The largest decreases in flow and depth for a ditch with no check structures will occur in FCWUA ditch. Changes in depth in the upper and lower ditch reaches of FCWUA are estimated to be as large as 0.5 feet as a result of the water rights transfer. These changes did not appear to affect the ability of other water users to take water from the FCWUA ditch during the 2001 irrigation season when the Trendwest water rights were not diverted. Changes in depths due to a decrease in the diversion on the Lund/Gentry Ditch will result in changes in depth as great as 0.3 feet. Similarly, the changes in flow and depth in the Lund/Gentry ditch did not appear to affect the remaining water users ability to divert water from the main ditch and associated laterals. Although the transfer of the former Pautzke water right on Mill Ditch to Trendwest represents the largest flow transfer (19.5 cfs), the existence of a number of check structures on the ditch both upstream of the Hwy 97 and in the reach downstream of Dolarway Road allow Mill Ditch water users to manipulate water levels to their desired stage and reduce changes in depth at laterals as diversions change.

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APPENDIX A

RATING CURVES FOR 2001 MONITORING STATIONS ON TRENDWEST TRIBUTARY STREAMS AND THE USBR GAGE ON THE TEANWAY RIVER (TEAW)

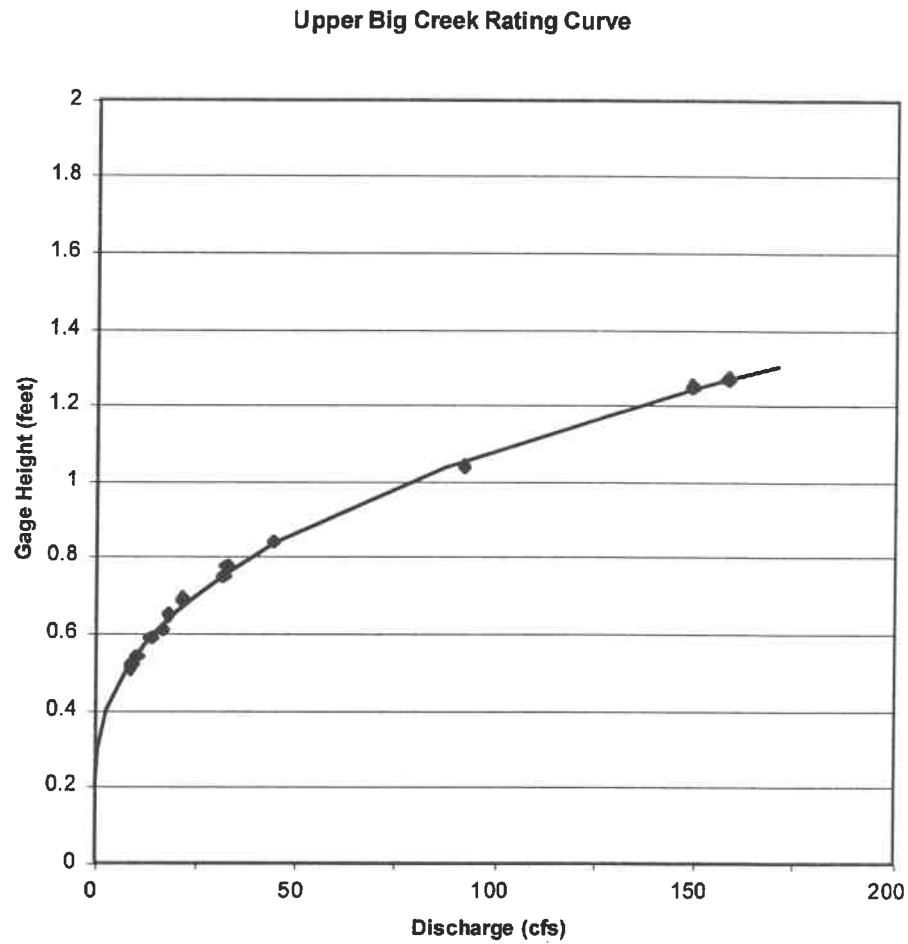
Big Creek Upstream of the Darling/Lund Diversion Dam

PROVISIONAL DATA Rev. 1/7/02

Q=C(ght-A)^r

c=	133.6	
a=	0.2	
r=	2.43	1.00

Date	ght (ft)	Measured Discharge (cfs)	Estimated Discharge (cfs)	Percent Error
	0.2		0	
	0.3		0.5	
	0.4		2.7	
9/12/2001	0.51	8.5	7.7	9.4
9/7/2001	0.52	8.9	8.4	5.6
8/16/2001	0.54	10.2	9.7	4.9
8/1/2001	0.59	13.7	13.5	1.5
7/25/2001	0.61	16.7	15.3	8.4
7/17/2001	0.65	18.1	19.2	-6.1
7/5/2001	0.69	21.6	23.6	-9.3
6/27/2001	0.75	31.7	31.2	1.6
10/24/2001	0.78	32.5	35.5	-9.2
6/11/2001	0.84	44.3	45.1	-1.8
5/29/2001	1.04	91.9	87.4	4.9
5/20/2001	1.25	149.2	150.5	-0.9
5/16/2001	1.27	158.1	157.5	0.4
	1.305		170.4	



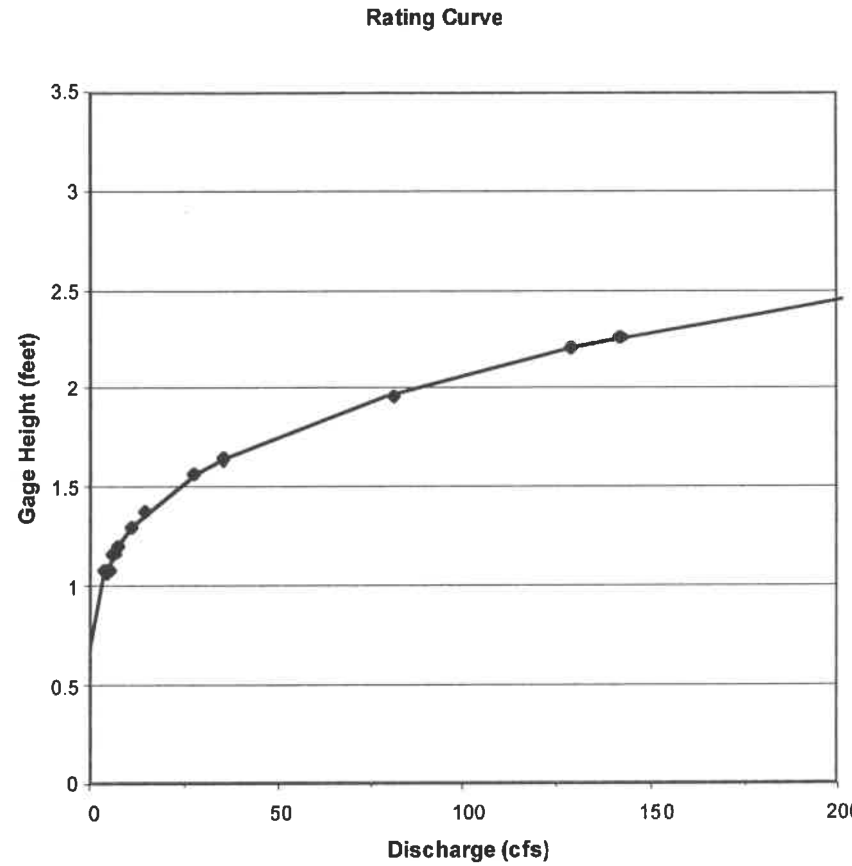
Big Creek Downstream of the Darling/Lund Diversion Dam

PROVISIONAL DATA REV. 1/7/02

Q=C(ght-A)^r

c=	23.4	
a=	0.5	
r=	3.21	1.00

Date	ght (ft)	Measured Discharge (cfs)	Estimated Discharge (cfs)	Percent Error
	0.7		0.0	
	1		2.5	
9/12/2001	1.07	4.5	3.8	15.6
9/7/2001	1.08	4.7	4.1	12.8
8/16/2001	1.08	3.8	4.1	-7.9
8/1/2001	1.16	6	6.2	-3.3
7/25/2001	1.20	7.1	7.4	-4.2
7/17/2001	1.29	10.7	11.0	-2.8
7/5/2001	1.38	14.2	15.5	-9.2
10/24/2001	1.56	27.2	28.2	-3.7
6/11/2001	1.64	35.1	35.6	-1.4
5/29/2001	1.96	81.2	78.8	3.0
5/20/2001	2.2	128.8	128.4	0.3
5/16/2001	2.26	142	143.5	-1.1
	2.5		216.3	



Big Creek Below West Nelson Siding Road

PROVISIONAL DATA Rev. 1/7/02

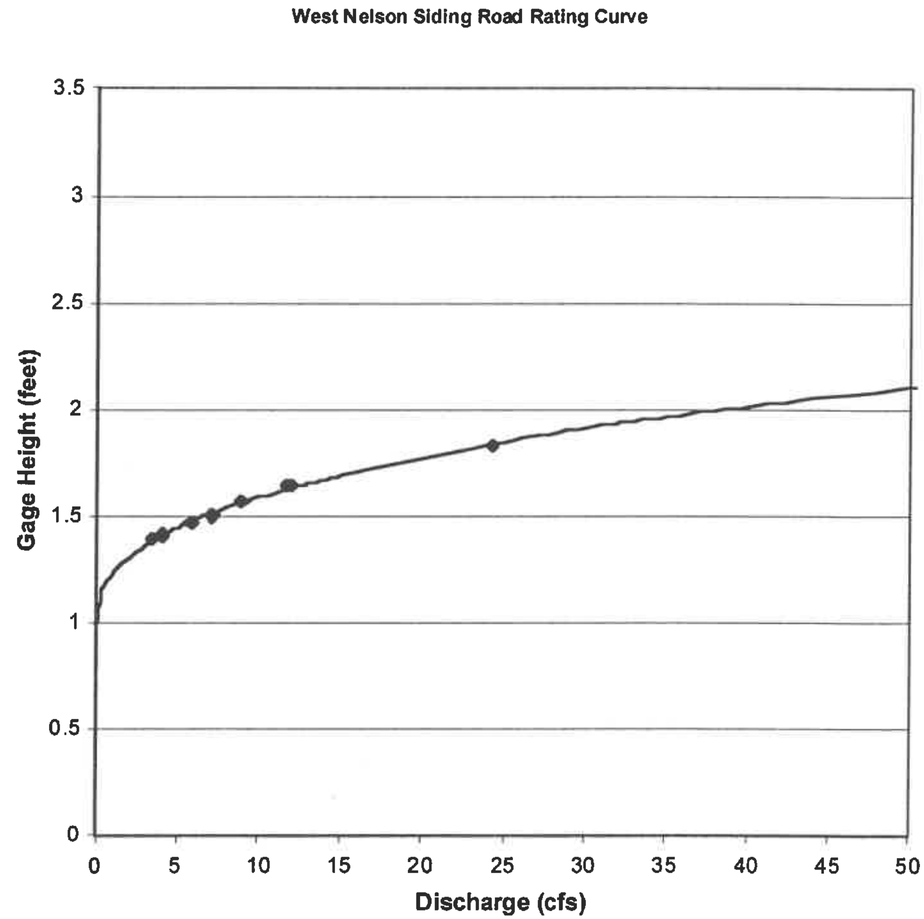
Q=C(ght-A)^r

c= 38.3

a= 1

r= 2.54 1.00

Date	ght (ft)	Measured Discharge (cfs)	Estimated Discharge (cfs)	Percent Error
	1		0	
	1.2		0.6	
9/12/2001	1.39	3.4	3.5	-2.9
9/7/2001	1.41	4.0	4.0	0.0
8/16/2001	1.41	4.0	4.0	0.0
8/8/2001	1.47	5.8	5.6	3.4
8/1/2001	1.50	7.1	6.6	7.0
7/25/2001	1.57	8.9	9.2	-3.4
7/17/2001	1.64	12.0	12.3	-2.5
7/11/2001	1.64	11.7	12.3	-5.1
10/24/2001	1.83	24.3	23.8	2.1
	1.96		34.5	
	2.2		60.9	
	2.26		68.9	
	2.5		107.4	



Big Creek at Ensign Ranch Campground

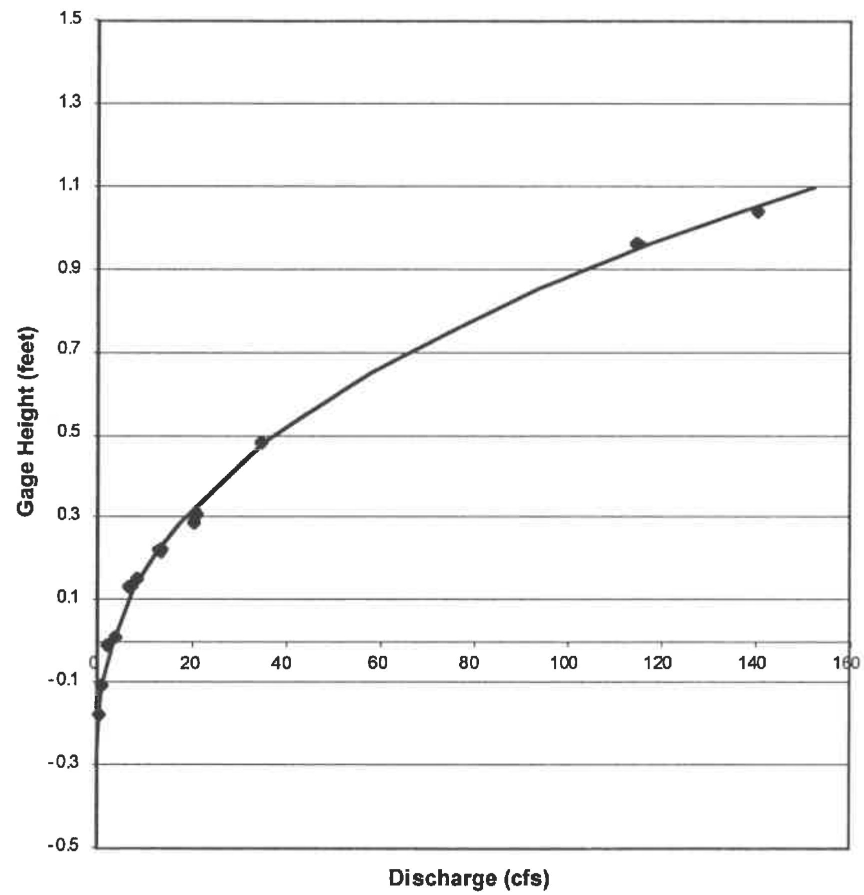
PROVISIONAL DATA Rev. 1/7/02

Q=C(ght-A)^r

c=	66.0	
a=	-0.3	
r=	2.49	1.00

Date	ght (ft)	Measured Discharge (cfs)	Estimated Discharge (cfs)	Percent Error
	-0.3		0	
8/16/2001	-0.18	0.3	0.3	0.0
8/8/2001	-0.11	0.9	1.1	-22.2
8/1/2001	-0.01	2.3	3.0	-30.4
7/25/2001	0.01	4.0	3.6	10.0
7/11/2001	0.13	6.9	8.1	-17.4
7/17/2001	0.15	8.3	9.0	-8.4
7/5/2001	0.22	13.3	12.9	3.0
10/24/2001	0.29	20.5	17.7	13.7
6/22/2001	0.31	21.0	19.2	8.6
6/11/2001	0.48	34.7	35.5	-2.3
	0.55		44.0	
	0.65		58.1	
	0.75		74.5	
	0.85		93.5	
5/20/2001	0.96	115.0	117.4	-2.1
5/16/2001	1.04	140.5	136.9	2.6
	1.1		152.7	

Ensign Ranch Rating Curve



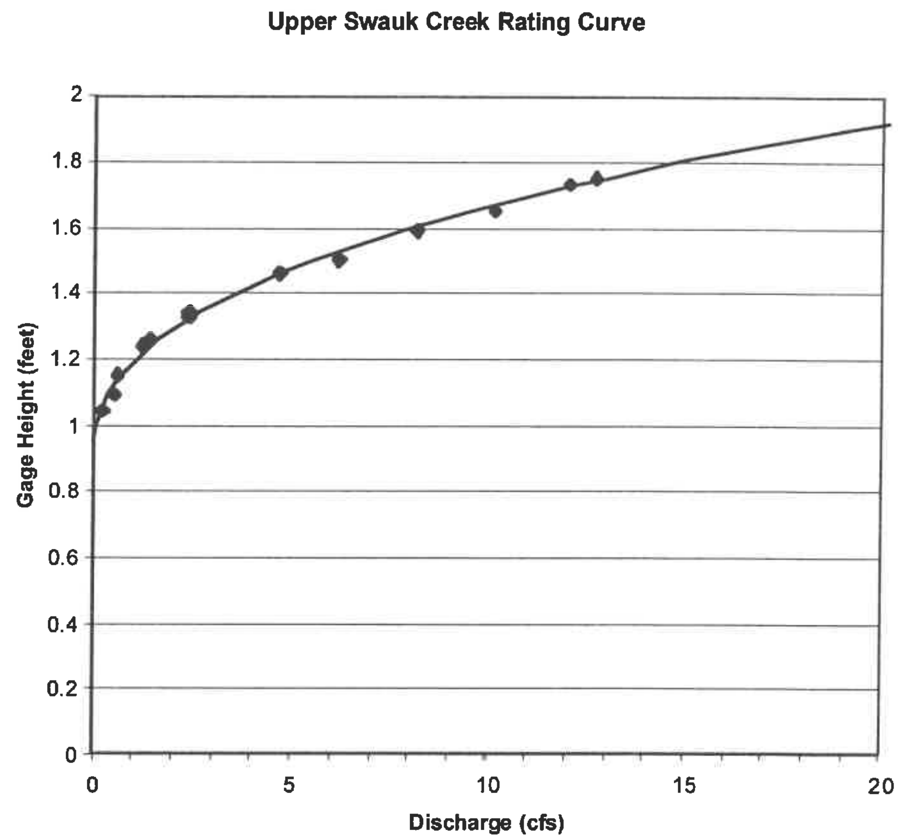
Swauk Creek Upstream of the Confluence with First Creek

PROVISIONAL DATA Rev. 1/7/02

$Q=C(ght-A)^r$

c=	19.2	
a=	0.9	
r=	2.41	1.00

Date	ght (ft)	Measured Discharge (cfs)	Estimated Discharge (cfs)	Percent Error
	0.95		0	
	1		0.1	
8/16/2001	1.04	0.2	0.2	0.0
9/11/2001	1.09	0.5	0.4	20.0
8/29/2001	1.15	0.6	0.7	-16.7
8/1/2001	1.24	1.2	1.4	-16.7
7/26/2001	1.26	1.4	1.6	-14.3
7/17/2001	1.33	2.4	2.5	-4.2
7/13/2001	1.34	2.4	2.7	-12.5
7/3/2001	1.46	4.7	4.8	-2.1
6/22/2001	1.5	6.2	5.6	9.7
10/24/2001	1.59	8.2	7.9	3.7
6/11/2001	1.65	10.2	9.6	5.9
6/6/2001	1.73	12.1	12.3	-1.7
6/1/2001	1.75	12.8	13.0	-1.6
	1.8		14.9	
	1.9		19.2	
	2		24.1	



Swauk Creek at the Martin Property

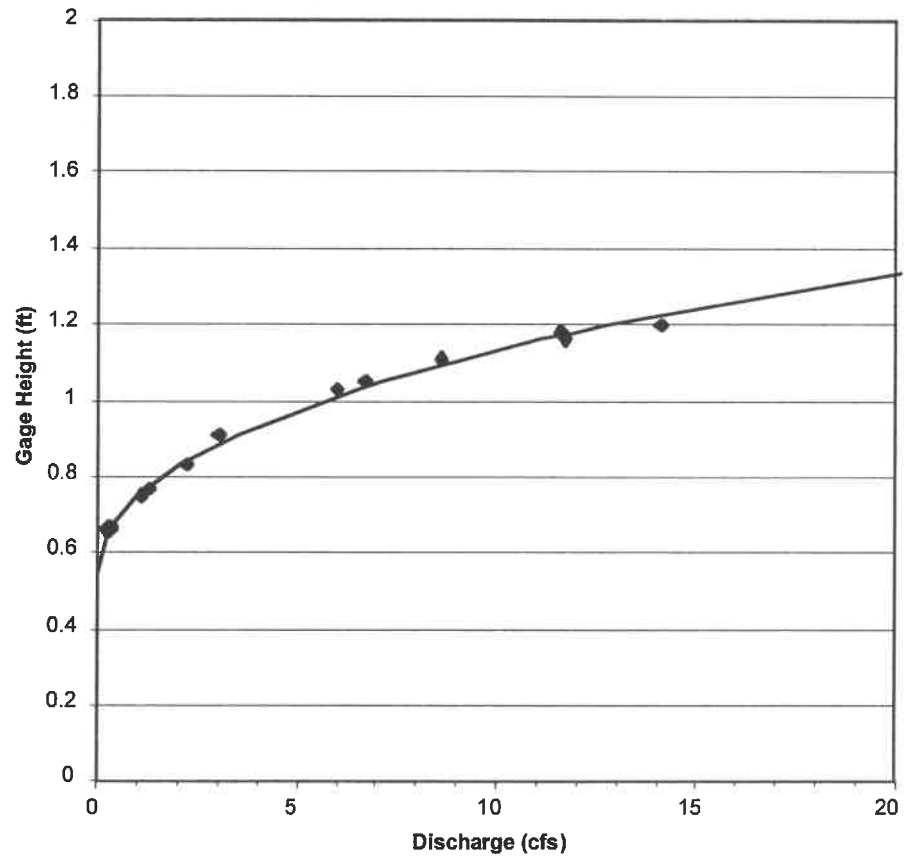
PROVISIONAL DATA Rev. 1/7/02

Q=C(ght-A)^r

c=	32.7	
a=	0.55	
r=	2.19	1.00

Date	ght (ft)	Measured Discharge (cfs)	Estimated Discharge (cfs)	Percent Error
	0.55		0	
9/11/2001	0.66	0.2	0.3	-50.0
9/7/2001	0.67	0.3	0.3	0.0
8/16/2001	0.66	0.3	0.3	0.0
8/1/2001	0.75	1.1	1.0	9.1
7/26/2001	0.77	1.3	1.2	7.7
7/17/2001	0.83	2.2	2.0	9.1
7/13/2001	0.91	3	3.5	-16.7
7/3/2001	1.03	6	6.5	-8.3
6/22/2001	1.05	6.7	7.2	-7.5
10/23/2001	1.11	8.6	9.2	-7.0
6/11/2001	1.16	11.7	11.1	5.1
6/6/2001	1.18	11.6	11.9	-2.6
6/1/2001	1.2	14.1	12.7	9.9
	1.5		29.2	
	1.6		36.4	
	1.7		44.4	

Swauk Creek at Martin Property Rating Curve



Mouth of Swauk Creek

PROVISIONAL DATA Rev. 1/7/02

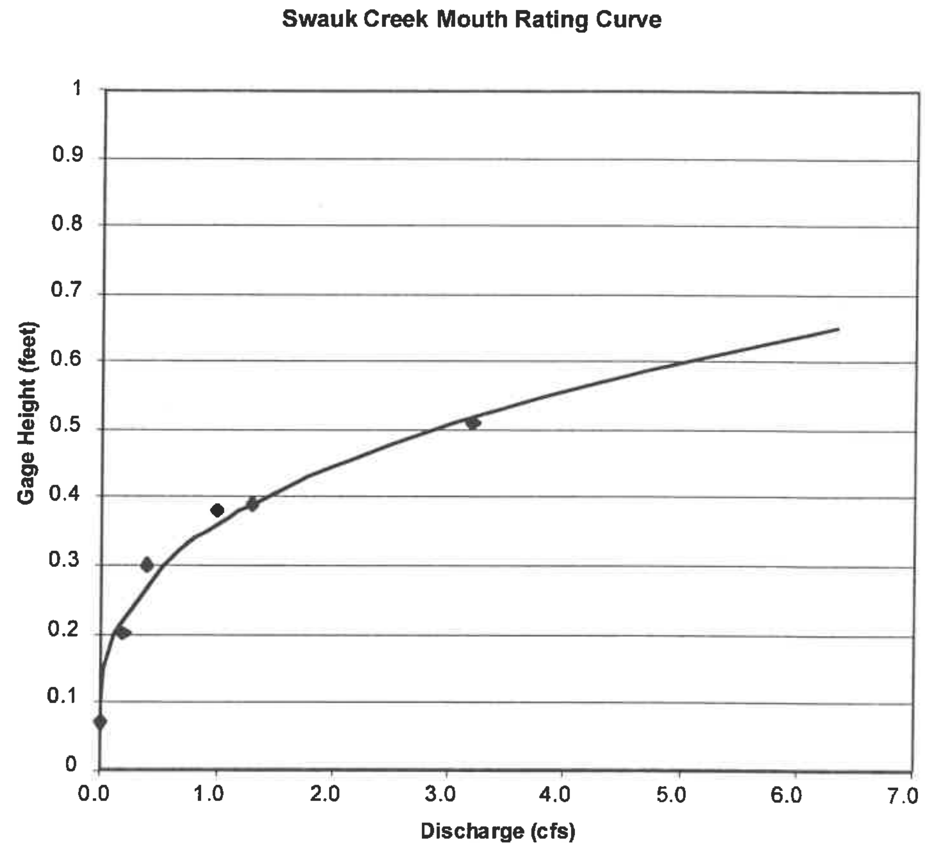
Q=C(ght-A)^r

c= 27.1

a= 0.07

r= 2.7 1.00

Date	ght (ft)	Measured Discharge (cfs)	Estimated Discharge (cfs)	Percent Error
	0.07	0	0.0	
	0.1		0.0	
	0.15		0.0	
8/8/2001	0.2	0.2	0.1	50.0
8/1/2001	0.3	0.4	0.5	-25.0
	0.32		0.7	
	0.34		0.8	
	0.35		0.9	
	0.37		1.1	
7/25/2001	0.38	1	1.2	-20.0
10/12/2001	0.39	1.3	1.3	0.0
	0.43		1.8	
	0.48		2.5	
10/23/2001	0.51	3.2	3.0	6.3
	0.55		3.8	
	0.59		4.7	
	0.65		6.3	



First Creek Downstream of FCWUA Diversion

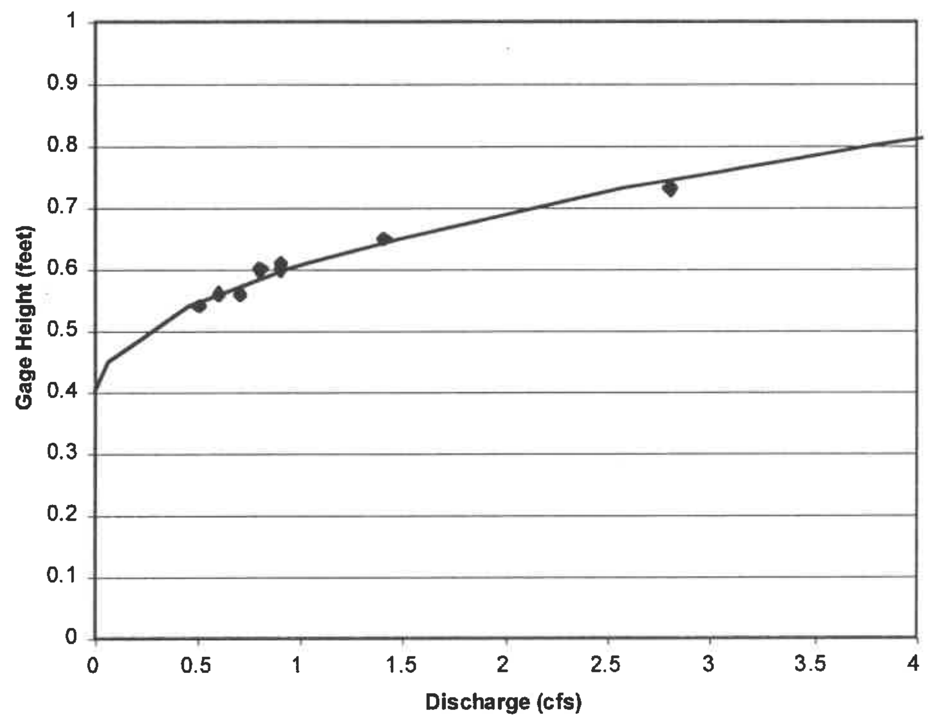
PROVISIONAL DATA Rev.1/7/02

Q=C(ght-A)^r

c=	24.2	
a=	0.4	
r=	2.02	1.00

Date	ght	Measured Discharge (cfs)	Estimated Discharge (cfs)	Percent Error
	0.4		0.0	
	0.45		0.1	
9/11/2001	0.54	0.5	0.5	0.0
8/29/2001	0.56	0.6	0.6	0.0
8/16/2001	0.56	0.6	0.6	0.0
6/6/2001	0.56	0.7	0.6	14.3
7/17/2001	0.60	0.8	0.9	-12.5
5/30/2001	0.60	0.9	0.9	0.0
7/13/2001	0.61	0.9	1.0	-11.1
6/22/2001	0.65	1.4	1.5	-7.1
7/3/2001	0.73	2.8	2.6	7.1
	0.75		2.9	
	0.8		3.8	
	0.85		4.8	
	0.9		6.0	

Upper First Creek Rating Curve



First Creek Upstream of the Confluence with Swauk Creek

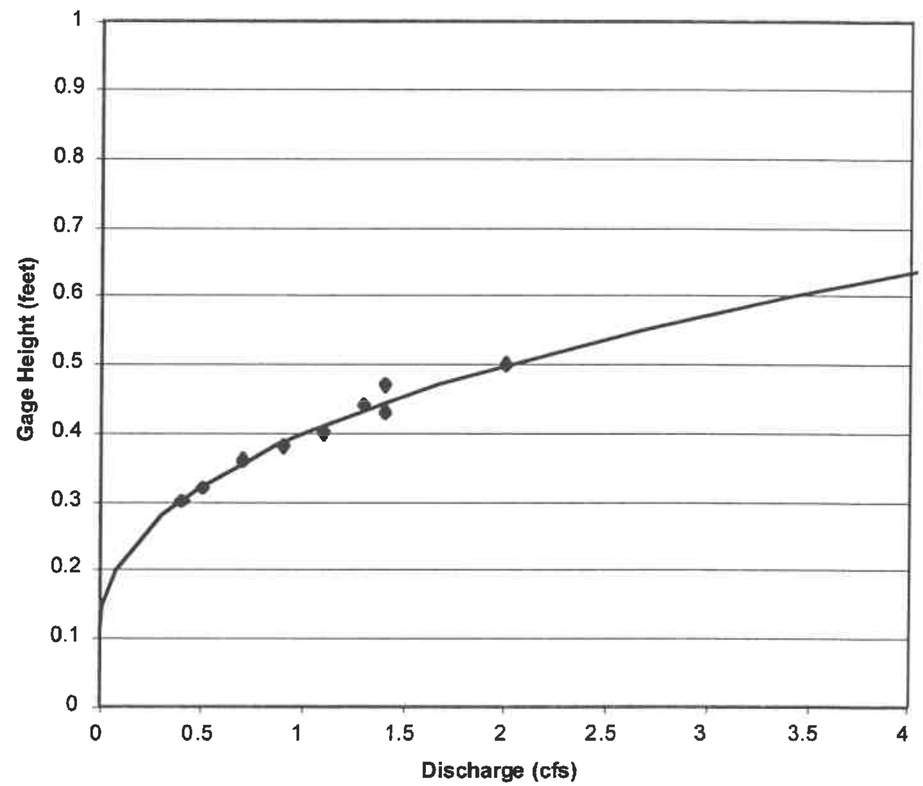
PROVISIONAL DATA Rev. 1/702

Q=C(ght-A)^r

c=	17.6	
a=	0.1	
r=	2.36	1.00

Date	ght (ft)	Measured Discharge (cfs)	Estimated Discharge (cfs)	Percent Error
	0.1		0.0	
	0.15		0.0	
	0.2		0.1	
	0.28		0.3	
9/11/2001	0.3	0.4	0.4	0.0
9/7/2001	0.32	0.5	0.5	0.0
8/16/2001	0.32	0.5	0.5	0.0
6/6/2001	0.36	0.7	0.7	0.0
7/26/2001	0.36	0.7	0.7	0.0
7/13/2001	0.36	0.7	0.7	0.0
7/17/2001	0.38	0.9	0.9	0.0
5/29/2001	0.40	1.1	1.0	9.1
6/22/2001	0.43	1.4	1.3	7.1
10/24/2001	0.44	1.3	1.4	-7.7
7/3/2001	0.47	1.4	1.7	-21.4
6/11/2001	0.5	2	2.0	0.0
	0.55		2.7	
	0.6		3.4	
	0.65		4.3	

Lower First Creek Rating Curve



Reecer Creek Upstream of Dolarway Road

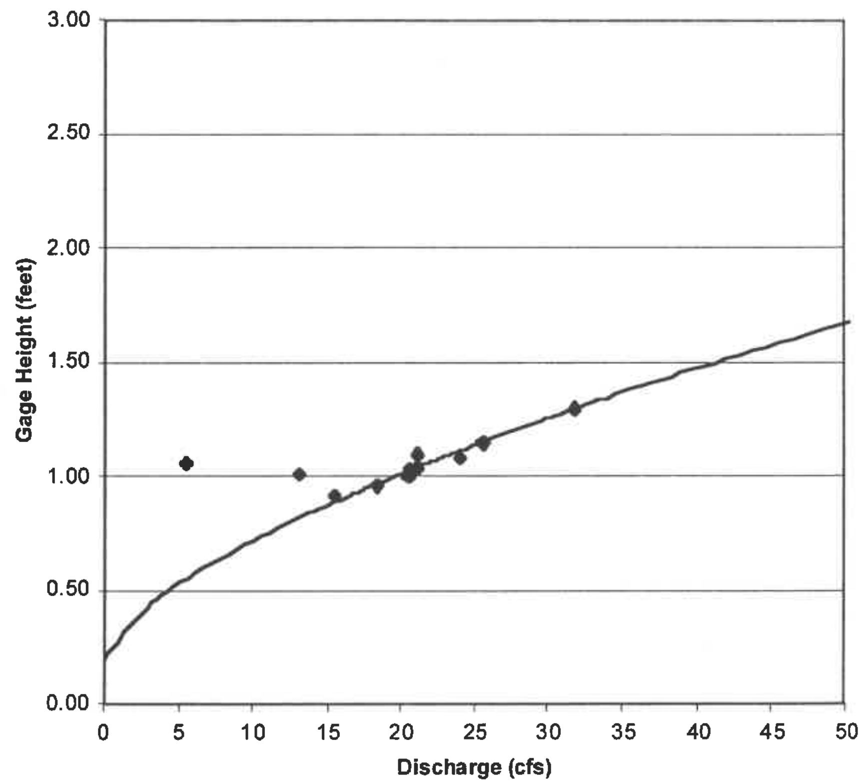
PROVISIONAL DATA Rev. 1/7/02

Q=C(ght-A)^r

c=	27.5	
a=	0.2	
r=	1.54	1.00

Date	ght (ft)	Measured Discharge (cfs)	Estimated Discharge (cfs)	Percent Error	Notes
	0.20		0.0		
	0.50		4.3		
	0.80		12.5		
7/17/2001	0.92	15.5	16.6	-7.1	
7/11/2001	0.96	18.4	18.0	2.2	
7/25/2001	1.00	20.5	19.5	4.9	
9/12/2001	1.03	20.6	20.6	0.0	
8/16/2001	1.04	21.1	21.0	0.5	
8/1/2001	1.08	24.0	22.6	5.8	
9/26/2001	1.10	21.1	23.4	-10.9	
8/8/2001	1.15	25.6	25.4	0.8	
	1.20		27.5		
	1.25		29.6		
8/23/2001	1.30	31.8	31.8	0.0	
	1.50		41.2		
	1.80		56.8		
10/12/2001	1.01	13.1	19.9	-51.9	*Rating Shift*
10/23/2001	1.06	5.5	21.8	-296.4	*Rating Shift*

Reecer Creek Rating Curve



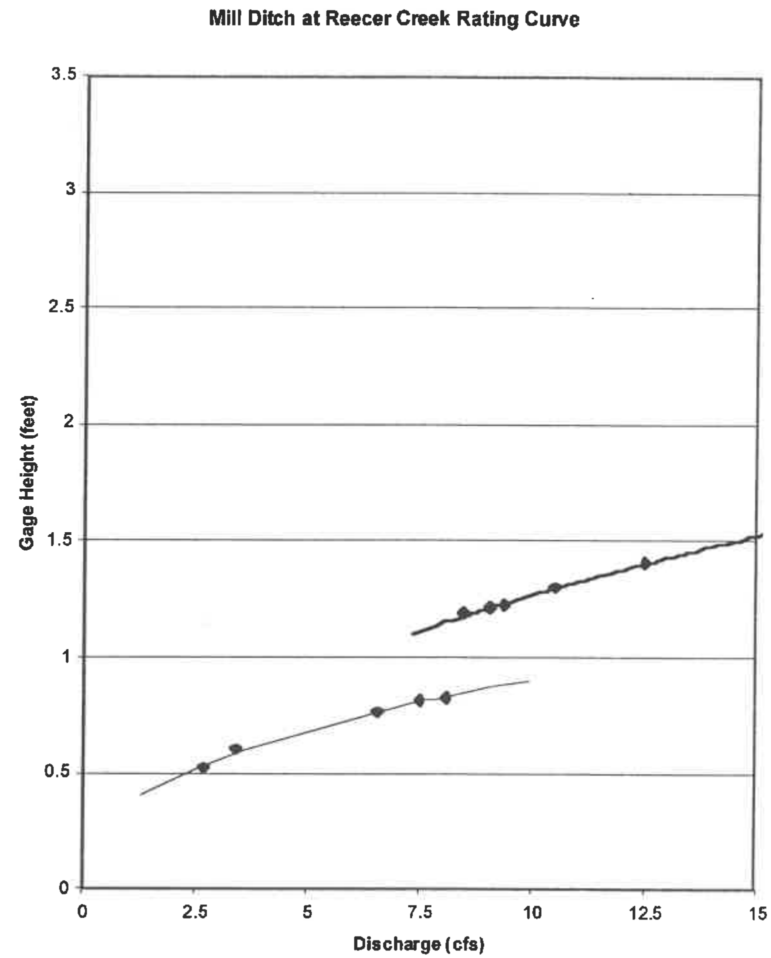
Mill Ditch Upstream of Reecer Creek at Hwy 97

PROVISIONAL DATA Rev. 1/7/02

Rating Equation 1			*Rating Equation 2*		
Q=C(ght-A)^r			Q=C(ght-A)^r		
c=	5.9		c=	12.9	
a=	0		a=	0	
r=	2.19	1.00	r=	2.48	1.00

Date	ght (ft)	Measured Discharge (cfs)	Estimated Discharge (cfs)	Percent Error	Notes
	0.4		1.3		
10/12/2001	0.52	2.7	2.6	3.7	*Rating Shift- Eqn 2*
10/4/2001	0.6	3.4	3.6	-5.9	*Rating Shift- Eqn 2*
9/12/2001	0.76	6.6	6.5	1.5	*Rating Shift- Eqn 2*
9/26/2001	0.81	7.5	7.7	-2.7	*Rating Shift- Eqn 2*
8/27/2001	0.82	8.1	7.9	2.5	*Rating Shift- Eqn 2*
	0.87		9.1		
	0.9		9.9		
	1.1		7.3		
	1.15		8.1		
8/16/2001	1.19	8.5	8.7	-2.4	*Eqn 1*
8/8/2001	1.21	9.1	9.0	1.1	*Eqn 1*
7/25/2001	1.22	9.4	9.2	2.1	*Eqn 1*
8/1/2001	1.3	10.5	10.6	-1.0	*Eqn 1*
	1.35		11.5		
8/23/2001	1.41	12.5	12.6	-0.8	*Eqn 1*
	1.5		14.5		
	1.75		20.3		

Rating Curve shifted because of change in check structures along the ditch. Rating equation 1 applies through August 23, 2001. Rating Equation 2 applies post August 23rd to end of monitoring program.



UNITED STATES BUREAU OF RECLAMATION

TEAW TEANAWAY RIVER ab. LAMBERT BRIDGE 1998 WY

Rating # 2 from 07/20/98 Scale Offset = 0.00

SUBJECT TO REVISION

DISCHARGE IN CUBIC FEET PER SECOND

GH	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	1ST.DIF	2ND.DIF
69.5	2.00*	2.01	2.02	2.04	2.05	2.06	2.07	2.09	2.10	2.11	0.13	
69.6	2.13	2.14	2.16	2.17	2.18	2.19	2.21	2.22	2.23	2.25	0.13	0.008
69.7	2.26	2.27	2.29	2.30	2.32	2.33	2.34	2.36	2.37	2.39	0.14	0.008
69.8	2.40	2.42	2.43	2.45	2.46	2.48	2.49	2.51	2.52	2.54	0.15	0.009
69.9	2.55	2.57	2.58	2.60	2.62	2.63	2.65	2.66	2.68	2.70	0.16	0.009
70.0	2.71	2.73	2.75	2.76	2.78	2.80	2.81	2.83	2.85	2.87	0.17	0.010
70.1	2.88	2.90	2.92	2.94	2.95	2.97	2.99	3.01	3.03	3.05	0.18	0.010
70.2	3.06	3.08	3.10	3.12	3.14	3.16	3.18	3.20	3.22	3.24	0.19	0.011
70.3	3.25	3.27	3.29	3.31	3.33	3.35	3.38	3.40	3.42	3.44	0.20	0.012
70.4	3.46	3.48	3.50	3.52	3.54	3.56	3.59	3.61	3.63	3.65	0.22	0.012
70.5	3.67	3.70	3.72	3.74	3.76	3.79	3.81	3.83	3.86	3.88	0.23	0.013
70.6	3.90	3.93	3.95	3.97	4.00	4.02	4.05	4.07	4.09	4.12	0.24	0.014
70.7	4.14	4.17	4.19	4.22	4.25	4.27	4.30	4.32	4.35	4.37	0.25	0.015
70.8	4.40	4.43	4.45	4.48	4.51	4.54	4.56	4.59	4.62	4.65	0.27	0.016
70.9	4.67	4.70	4.73	4.76	4.79	4.82	4.85	4.87	4.90	4.93	0.28	0.016
71.0	4.96	4.99	5.02	5.05	5.08	5.11	5.14	5.18	5.21	5.24	0.31	0.017
71.1	5.27	5.30	5.33	5.36	5.40	5.43	5.46	5.49	5.53	5.56	0.33	0.018
71.2	5.59	5.63	5.66	5.70	5.73	5.76	5.80	5.83	5.87	5.90	0.34	0.020
71.3	5.94	5.97	6.01	6.05	6.08	6.12	6.15	6.19	6.23	6.27	0.37	0.021
71.4	6.30	6.34	6.38	6.42	6.46	6.49	6.53	6.57	6.61	6.65	0.39	0.022
71.5	6.69	6.73	6.77	6.81	6.85	6.89	6.93	6.97	7.02	7.06	0.41	0.023
71.6	7.10	7.14	7.18	7.23	7.27	7.31	7.36	7.40	7.45	7.49	0.44	0.025
71.7	7.53	7.58	7.62	7.67	7.72	7.76	7.81	7.85	7.90	7.95	0.46	0.026
71.8	8.00	8.04	8.09	8.14	8.19	8.24	8.29	8.33	8.38	8.43	0.49	0.027
71.9	8.48	8.53	8.58	8.64	8.69	8.74	8.79	8.84	8.89	8.95	0.52	0.029
72.0	9.00*	9.80	10.70	11.60	12.60	13.70	15.00	16.30	17.70	19.30	13.00	11.000
72.1	21.0*	22.70	24.60	26.60	28.70	31.30	33.60	36.40	39.30	42.50	26.00	13.000
72.2	46.0*	48.40	51.0*	[illegible]	[illegible]	[illegible]	61.00	[illegible]	65.70	[illegible]	27.50	[illegible]
72.3	70.0*	[illegible]	76.10	83.70	[illegible]	[illegible]	89.20	92.30	[illegible]	[illegible]	29.00	[illegible]
72.4	102.0*	104.30	[illegible]	109.0*	112.10	115.40	118.70	122.10	125.70	129.30	31.00	[illegible]
72.5	133.0*	136.80	140.30	143.80	147.60	151.70	155.70	[illegible]	164.10	168.60	40.00	[illegible]
72.6	173.0*	177.60	182.80	187.60	193.30	[illegible]	204.30	209.60	215.60	221.60	[illegible]	[illegible]
72.7	228.0*	233.30	238.80	245.40	251.70	258.0*	262.80	267.70	272.70	277.80	[illegible]	[illegible]
72.8	283.0*	287.70	292.80	297.40	302.40	307.60	312.60	317.60	323.10	328.50	[illegible]	
72.9	334.0*	340.40	347.00	353.60	360.40	367.30	374.40	381.60	388.80	394.40	70.00	[illegible]
73.0	404.0*	408.70	413.50	418.40	423.30	428.30	433.30	438.40	443.50	448.70	50.00	
73.1	454.0*											

* skeletal rating point
This rating is provisional and subject to change

Exhibit K

Review of Yakima River Diversion Intakes - Cle Elum to Ellensburg Reach

Analysis of Potential Hydraulic Impacts
of Proposed Relocation of Trendwest Point of Diversion

Final Report

Prepared for:
Trendwest Resorts, Inc.

Prepared by:
northwest hydraulic consultants, inc.

February 1, 2002

TABLE OF CONTENTS

INTRODUCTION

Trendwest Resorts, Inc. proposes to develop the MountainStar Master Planned Resort (MPR) and a master planned community within Cle Elum's Urban Growth Area (UGA), on approximately 7,300 acres west of the City of Cle Elum, Washington. To provide water for the proposed development, Trendwest has acquired water rights sufficient to meet project-related demands. Trendwest's proposal calls for diverting water from the Yakima River at a location upstream of the historic point of diversion of the acquired water rights. The Yakima River reach between Cle Elum (the proposed new diversion location) and Ellensburg (the historic diversion location) will hereinafter be referred to as the "study reach". Flows in the study reach would be altered by the diversion relocation and other aspects of Trendwest's proposal as described in the Water Supply Technical Report (Brown and Caldwell, 2002).

Trendwest retained northwest hydraulic consultants, inc. (**nhc**) to investigate, at a reconnaissance level, potential impacts of the proposal on other diversions in the study reach. From the standpoint of irrigation diversions, the most significant anticipated impact of lower flows would be lower water levels at diversion intakes. Hydraulic impacts at the following diversion locations on the Yakima River (listed in order from upstream to downstream) have been investigated:

- Younger Ditch
- Wallace Ranch (Bristol Flats)
- Westside Irrigation Diversion
- Thorp Diversion
- Packwood Diversion
- Cascade Irrigation Diversion
- Mill Ditch

Figure 1 is a map of the Yakima River showing the approximate location of each of these diversions. For each diversion site a description of the diversion facilities and a discussion of the present hydraulic/geomorphic setting and the results from the hydraulic analysis is provided below. The descriptions include photographs, location maps, and a written summary of possible hydraulic, geomorphic, and sedimentation issues at the diversion. River cross sections and other survey data collected by W&H Pacific, Inc. are provided as an appendix to this report.

APPROACH

Where feasible, potential impacts on Yakima River water levels at the diversion sites, resulting from the relocation of the Trendwest point of diversion, were estimated. For the Packwood, Wallace Ranch (Bristol Flats), Thorp, and Younger Ditch sites, differences were estimated using the ManningSolver© computer program. ManningSolver computes "normal depth" based on a user supplied channel cross section, energy slope, Mannings roughness value (Mannings 'n'), and input flow data. Note that throughout this report the water surface slope was used as an estimate of the energy slope. The terms energy slope and water surface slope are thus used interchangeably in this report.

Using surveyed cross section and water surface slope data the normal flow depth near each diversion intake was estimated for the date of the survey. The Mannings "n" for each site was calibrated based on the observed flows (approximately 1300 cfs at the Younger ditch site, 600 cfs at the Wallace Ranch (Bristol Flats) site, and 2000 cfs at the other sites) and the surveyed water levels. The stream channel geometry, energy slope, and Mannings "n" were then used to estimate flow depths for the anticipated low flow conditions. A sensitivity analysis was also performed to examine the impact that higher roughness values (which might be expected with lower flows) would have on the results. Based on this analysis, a slightly higher Mannings "n" (increased by 0.01) was used for the evaluation of impacts for all of the diversion sites except the Wallace Ranch (Bristol Flats) site. The calibration flow at the Wallace Ranch (Bristol Flats) site of about 600 cfs was in the middle to low range of the flows used in the analysis so it was not felt necessary to adjust the roughness value.

It is our understanding that the Westside Irrigation Company (Westside) places ecology blocks in the river channel downstream of their diversion site annually during low flow periods to create a constriction and backwater into their diversion (Vern Burkhardt, Westside Irrigation District, Pers. Comm.). Therefore the normal depth approach discussed above would not be appropriate for this site. For the Westside diversion site a simple hydraulic backwater model (HEC-RAS) was developed and used to estimate the impact of the Trendwest withdrawal relocation. The model was created based on three cross sections field surveyed by W&H Pacific located: 1) downstream of the diversion site at the point at which the irrigation district places ecology blocks, 2) at the diversion intake structure, and 3) approximately 100 feet upstream of the diversion structure.

Using the HEC-RAS model the anticipated water levels at the diversion site for current and proposed low flow conditions were estimated. Simulations were performed for the existing stream channel without ecology blocks and with the assumption of ecology blocks placed as described by Mr. Burkhardt. The HEC-RAS model was also used to evaluate possible mitigation measures (i.e. additional ecology blocks) that could be used to offset the estimated impact of the Trendwest withdrawal relocation.

Complexities at the Cascade Irrigation Diversion (Cascade) site make estimation of potential water level impacts at this location infeasible without substantial effort beyond the scope of this study. Analysis of this site would require hydraulic and sedimentation studies to assess the current condition and likely future conditions. Furthermore, field reconnaissance indicates that Cascade is likely to experience significant difficulties getting adequate flow to their intake regardless of the Trendwest diversion. Thus, review of the Cascade site was limited to a discussion of current conditions and a proposed approach for examining alternatives for improving the long-term reliability of this diversion. In a separate but related study, **nhc** investigated geomorphic issues at the Cascade diversion site and alternatives for improving the reliability of the Cascade intake (**nhc**, 2001).

The hydraulics of the Mill Ditch diversion are also complicated. Water diverted at the Mill Ditch site originates from several sources in addition to the Yakima River including irrigation return flows. Diversions from the Yakima River first enter a side channel with some of the side channel flow splitting off into a smaller channel leading under I-90, which joins with seepage return flows and ultimately pass down a constructed channel to the diversion intake. The Mill Ditch intake structure was observed during the field reconnaissance but the Yakima River channels were not. The Mill Ditch site is the original point of diversion for the water rights that were acquired by Trendwest, thus Yakima River flows (and water levels) downstream of this point would theoretically not be affected by the proposed transfer. In fact, the tributary water rights and return flows incorporated in the Trendwest proposal would result in higher flows at this location than under baseline conditions (Brown and Caldwell, 2002). Therefore, our discussion of potential impacts at the Mill Ditch diversion is limited.

Finally, it should be noted that the Ellensburg Water Company/Olson Ditch diversion is also within the study reach. However, considering the design of the Ellensburg Water Company diversion structure, in particular the dam across the Yakima River, the potential hydraulic impacts of a small flow reduction at this site were considered to be negligible, and were not investigated in detail.

FLOW DATA

To examine the potential hydraulic impact of the Trendwest proposal, estimates of water levels were required for existing (baseline) and proposed conditions. This, in turn, required the development of baseline and proposed condition flow data. Baseline flows at each of the diversion sites were assumed to be equal to the observed flows on the Yakima River at Cle Elum gage currently operated by the USBR (USGS gage 12479500). The period of analysis was chosen as water years 1991-1993, 1995, and 2001 to maintain consistency with the Water Supply Technical Report (Brown and Caldwell, 2002). Observed mean daily flow data for this period were obtained from USBR records. Observed data for water years 1991-1995 were provided to **nhc** by Tom Martin of Brown and Caldwell. Provisional observed flow data for water year 2001 were provided to **nhc** by the USBR Yakima Basin Field Office.

To examine the potential impact of the proposal on low flow conditions throughout the irrigation season (May 1 to October 31) the season was split into 12 increments of approximately 15 days each. For each 15 day period, the minimum mean daily flow from the five year period of analysis was determined. These data are summarized in Table 1. The use of flow data from across the entire range of irrigation conditions (i.e. prior to storage control, during storage control, and post flip-flop) facilitates evaluation of potential impacts of the proposal for all likely hydrologic scenarios.

Observed data from the Cle Elum gage were then adjusted to provide an estimate of proposed condition flows at each of the diversion sites. Flow adjustments were based on modeled diversions, return flows, and tributary inflows computed by Brown and Caldwell and provided to **nhc** for use in this study. The development of these data is described in detail in Section IV.A. of the Water Supply Technical Report (Brown and Caldwell, 2002). Adjusted flow time series were computed by **nhc** for the Yakima River at the Water Supply Diversion site, the Yakima River at the Teanaway River confluence and the Yakima River at the Swauk Creek confluence. The computed minimum daily flows over the 5 year analysis period for each 15-day time increment are shown in Table 1. Figure 1 shows the locations on the Yakima River at which flows were computed.

It should be noted that the data used in this study (water years 1991-1993, 1995 and 2001) encompassed a particularly dry cycle and included water year 2001, which is generally considered to be one of the lowest flow irrigation seasons in recent memory. Use of the minimum flow data from these dry years maintains consistency with the project's Water Supply Technical Report and provides a reasonable estimate of extremely low flow conditions.

Table 1. Baseline and Proposed Condition Flows

Dates	Baseline	Proposed Condition			
	All sites based on Yakima River at Cle Elum Gage (cfs)	D/S Water Supply Diversion (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)
May 1 - May 15	504	504	507	513	515
May 16 - May 31	580	580	583	588	590
June 1 - June 15	935	932	933	938	940
June 16 - June 30	1434	1431	1433	1438	1441
July 1 - July 15	1920	1916	1918	1922	1925
July 15 - July 31	2852	2847	2849	2850	2853
Aug 1 - Aug 15	2655	2652	2652	2652	2655
Aug 16 - Aug 31	1322	1317	1318	1318	1321
Sept 1 - Sept 15	380	376	377	377	379
Sept 16 - Sept 30	407	404	402	403	405
Oct 1 - Oct 15	363	362	361	361	362
Oct 16 - Oct 31	210	209	209	209	209

The hydraulic computations for each diversion site used the computed proposed condition flows from the nearest upstream location. The diversion sites that were analyzed in detail and the corresponding proposed condition flow are as follows:

- Younger Ditch Diversion Site – Yakima River at Water Supply Diversion Site flow
- Wallace Ranch (Bristol Flats) Diversion Site – Yakima River at Teanaway River flow
- Westside Irrigation Diversion Site – Yakima River at Swauk Creek flow
- Thorp Diversion Site – Yakima River at Swauk Creek flow
- Packwood Diversion Site – Yakima River at Swauk Creek flow

LIMITATIONS

A comparison of the estimated Yakima River flow depths for the current and proposed conditions provides an indication of the potential relative impact of the Trendwest diversion relocation at each of the diversion sites in the study reach. Because the surveyed cross sections collected for this study were typically referenced to an arbitrary vertical datum, and data were generally not collected for hydraulic structures, it is not possible to report actual water levels at the intakes or fish screens. Furthermore, the limited model calibration performed for this study, and the simplified normal depth approach being used, does not lend itself to the computation of accurate absolute water levels. However, for the purposes of this study the approach taken herein was considered to be appropriate.

It should be noted that **nhc** has not conducted a comprehensive study of impacts of the proposed relocation of the Trendwest point of diversion. Sufficient information is not available at this time to comprehensively evaluate potential impacts of reduced Yakima River water levels on the irrigator's operations. A comprehensive analysis of this sort would require significantly greater effort and additional information including:

- Information about current operations at each of the diversions including maintenance issues,
- detailed survey data for all hydraulic structures and diversion channels,
- detailed information about the timing, location, and design of temporary in-channel dams,
- knowledge of the rate of water to be diverted at each location coincident with all Yakima River flow levels, and
- an understanding of current irrigation diversion shortfalls

The following pages document the findings of this reconnaissance level investigation.

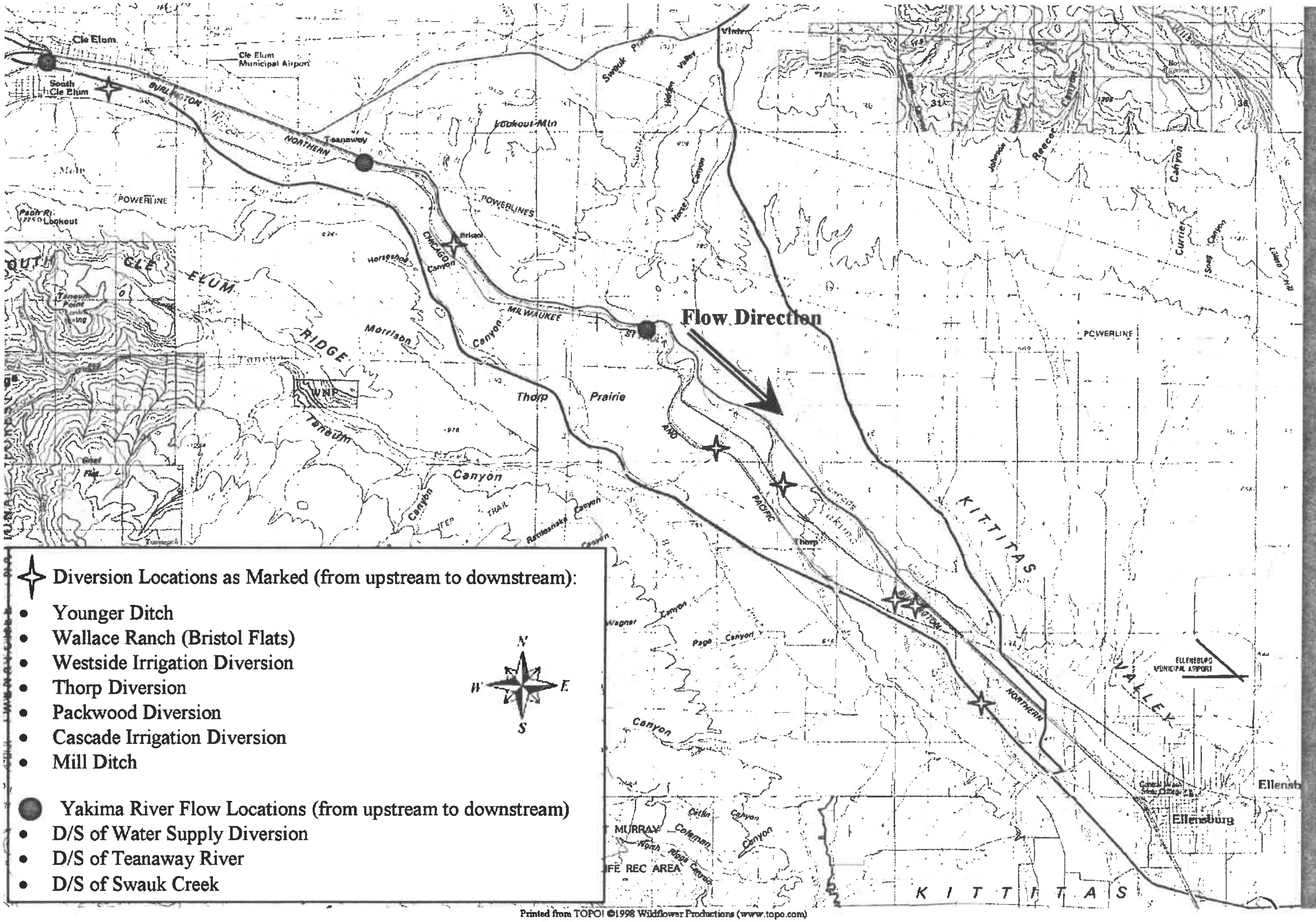
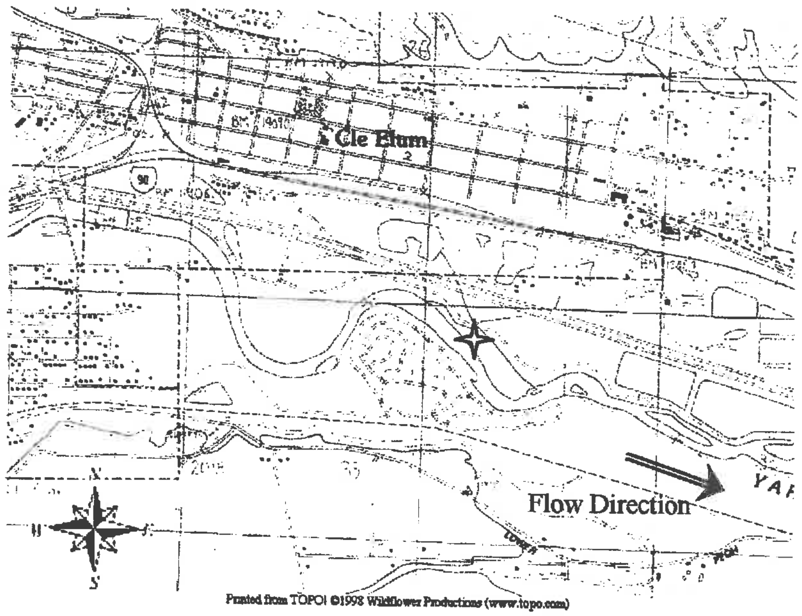


Figure 1. Location Map of study diversion sites and locations for which Yakima River flows were derived

YOUNGER DITCH DIVERSION

Location: The Younger Ditch Diversion is located on the left (north) bank of the Yakima River approximately 6600 feet downstream of the East 4th Street bridge in South Cle Elum (see Figure at right).



Facilities: The diversion consists of a side channel diversion from the Yakima River which directs flow into a 15 foot wide channel leading approximately 200 feet to an intake structure. The intake includes a rolling drum fish screen, several gated diversion openings, and a return flow bypass to the Yakima River. Downstream of the intake structure diverted flows pass over a measurement weir and enter the Younger Ditch irrigation canal.

Hydraulic/Geomorphic Setting: The Younger Ditch diversion channel sits on the left bank of the Yakima River on the outside of a large meander bend. Because of the meander bend the river is deepest and flows are swiftest along the left bank near the diversion channel. The higher flow along this bank would also tend to carry more entrained sediments. Flow in the Yakima River at Cle Elum at the time of the site reconnaissance was approximately 1300 cfs. Flow along the left bank near the diversion site was approximately 5 feet deep. Flow appeared to be relatively uniform across the river upstream of the diversion. Yakima River flows would tend to form an eddy at the diversion channel as the river expands at the channel opening. Because of this eddy it is likely that fine-grained sediments are deposited at this location and accumulate in the diversion channel. This was evidenced both by the current condition of the channel inlet and by the dredge spoils piled upstream and downstream of the inlet.

Hydraulic Analysis: The water level impacts of the Trendwest relocation for this site were computed with ManningSolver. The water levels were calculated for existing and proposed low flow conditions using the surveyed cross section provided by W&H Pacific, a Manning 'n' estimate of 0.045 and a water surface slope of 0.00234 ft/ft. The water surface slope was calculated from the W&H Pacific survey data. Over the range of low flows used in this analysis, water levels at the inlet of the diversion channel under the proposed conditions (Trendwest diversion relocation) are 0.00 to 0.01 feet less than under baseline conditions. The largest difference (0.01 feet) is seen in the month of September when the Trendwest diversion as a percentage of Yakima River flow is the highest. Based on our analysis the Trendwest proposal may result in up to a 0.01 foot drop in water levels at the inlet of the Younger Ditch diversion channel, but differences of 0.01 feet or more are only anticipated in the months of August through October.

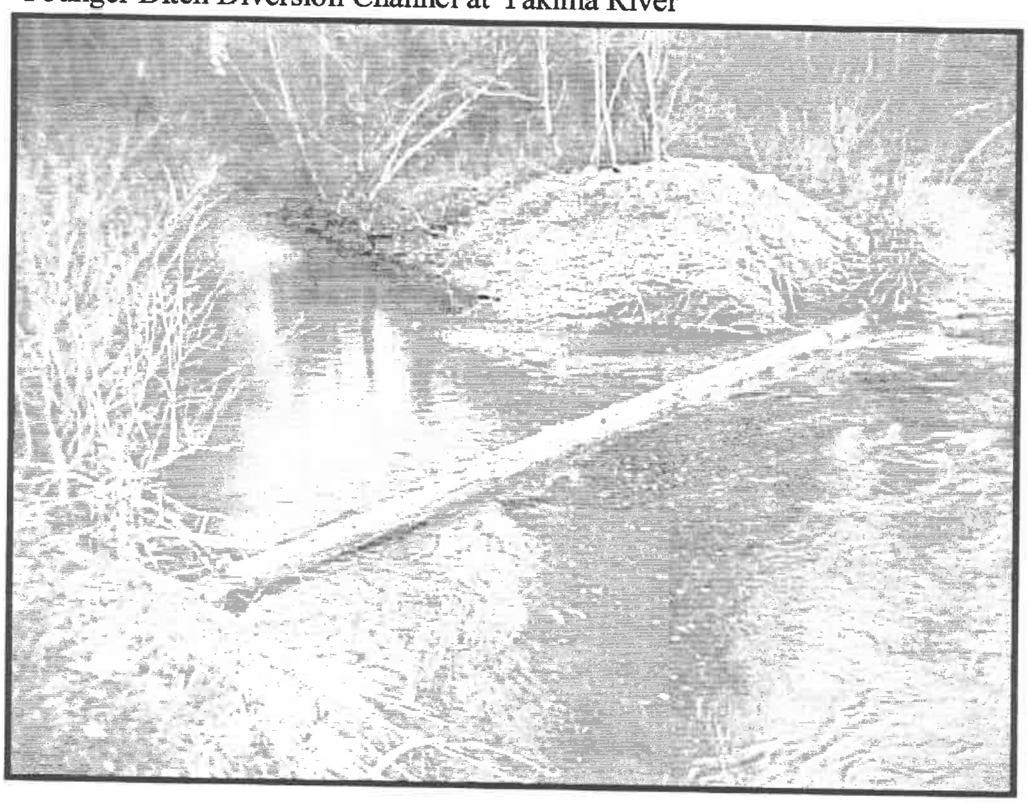
Table 2. Younger Ditch Diversion Site Analysis Results

Time Period	Minimum Flow (cfs)		Water Surface Elevation (feet assumed datum)		
	Baseline Conditions	Proposed Conditions	Current Conditions	Proposed Conditions	Difference
May 1 – May 15	504	504	96.27	96.27	0.00
May 16 – May 31	580	580	96.44	96.44	0.00
June 1 – June 15	935	932	96.95	96.95	0.00
June 16 – June 30	1434	1431	97.46	97.46	0.00
July 1 – July 15	1920	1916	97.89	97.89	0.00
July 16 – July 31	2852	2847	98.59	98.59	0.00
Aug 1 – Aug 15	2655	2652	98.45	98.45	0.00
Aug 16 – Aug 31	1322	1317	97.36	97.35	-0.01
Sep 1 – Sep 15	380	376	96.04	96.03	-0.01
Sep 16 – Sep 30	407	404	96.09	96.08	-0.01
Oct 1 – Oct 15	363	362	96.00	96.00	-0.01
Oct 16 – Oct 31	210	209	95.50	95.50	-0.01

Younger Ditch Diversion

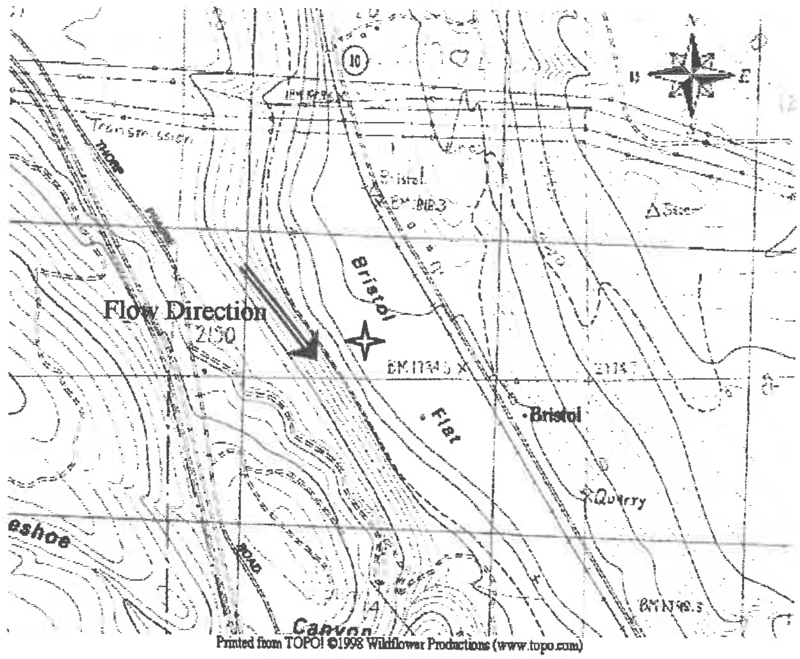
Diversion Intake Structure

Younger Ditch Diversion Channel at Yakima River



WALLACE RANCH (BRISTOL FLATS) DIVERSION

Location: The Wallace Ranch (Bristol Flats) Diversion is located on the left (northeast) bank of the Yakima River approximately 7.5 miles downstream from the City of Cle Elum (see Figure at right).



Facilities: The diversion consists of a backwater channel off the Yakima River which allows flow into a pump intake. The diversion channel is approximately 20 feet wide and 80 feet long.

Hydraulic/Geomorphic Setting: The Wallace Ranch (Bristol Flats) diversion channel sits on the left bank of the Yakima River on a relatively straight reach of the river. The diversion is located approximately 100 feet downstream of a small constriction and riffle in the river. The river width at the inlet to the diversion channel is approximately 210 feet. The flow depth in the main channel near the diversion site was approximately 1.8 feet at the time of the survey (corresponding to a flow of about 624 cfs). It appears that there is considerable sedimentation in the backwater channel leading from the Yakima River to the pump intake. At the time of the survey, the water depth at the inlet to the backwater channel was approximately 8 inches. If Yakima River water levels drop below the level of the sediment deposits, diversions at this site would be precluded.

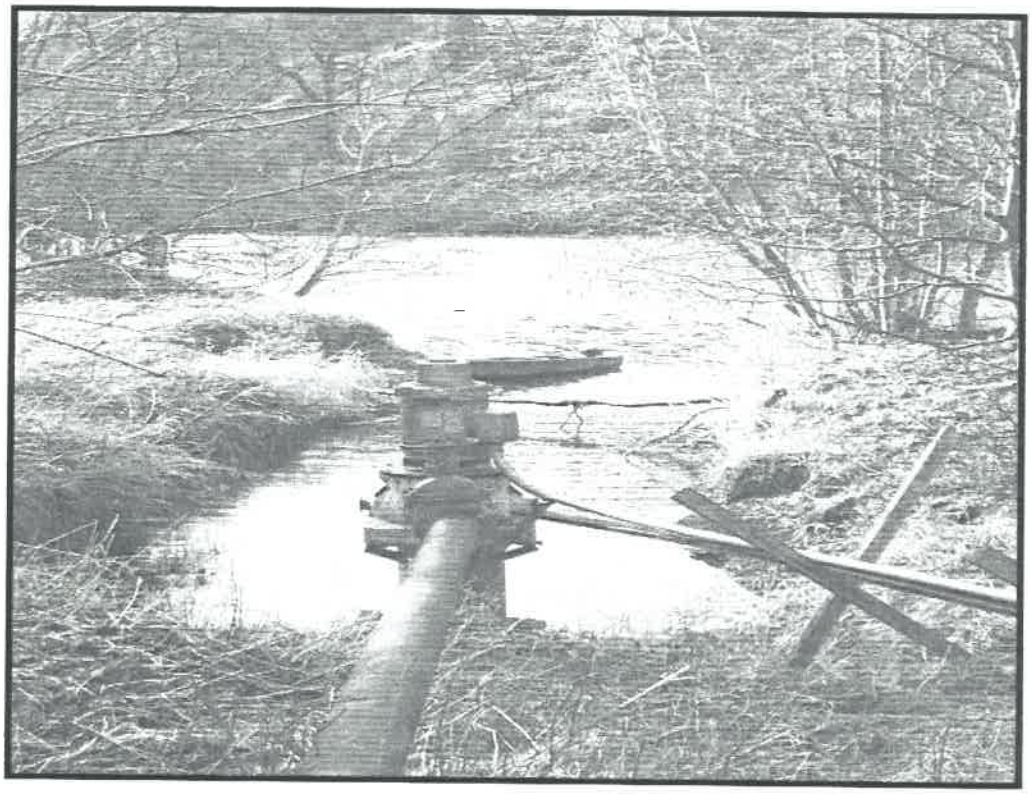
Hydraulic Analysis: The potential water level impacts of the proposed Trendwest point of diversion relocation for this site were computed using ManningSolver. The water levels were calculated for existing and proposed low flow conditions using the surveyed cross sections provided by W&H Pacific, a Mannings 'n' estimate of 0.043 and a water surface slope of 0.00152 ft/ft. The water surface slope was calculated from the W&H Pacific survey data. Comparing the proposed and baseline condition, computed water level differences at the inlet to the Wallace Ranch diversion channel range from +0.01 feet early in the irrigation season to -0.01 feet later in the season. The largest reduction in water surface is seen in the month of September when the Trendwest diversion, as a percentage of Yakima River flow, is the highest. Based on our analysis the proposed diversion relocation may result in small increases or decreases in water levels at the inlet to the Wallace Ranch diversion channel but computed differences were in the range of ±0.01 feet.

Table 3. Wallace Ranch (Bristol Flats) Diversion Site Analysis Results

Time Period	Minimum Flow (cfs)		Water Surface Elevation (feet assumed datum)		
	Baseline Conditions	Proposed Conditions	Current Conditions	Proposed Conditions	Difference
May 1 – May 15	504	507	93.85	93.86	0.01
May 16 – May 31	580	583	93.98	93.99	0.01
June 1 – June 15	935	933	94.51	94.50	-0.01
June 16 – June 30	1434	1433	95.11	95.11	0.00
July 1 – July 15	1920	1918	95.61	95.61	0.00
July 16 – July 31	2852	2849	96.46	98.45	-0.01
Aug 1 – Aug 15	2655	2652	96.29	96.29	0.00
Aug 16 – Aug 31	1322	1318	94.98	94.98	0.00
Sep 1 – Sep 15	380	377	93.63	93.62	-0.01
Sep 16 – Sep 30	407	402	93.68	93.67	-0.01
Oct 1 – Oct 15	363	361	93.59	93.59	0.00
Oct 16 – Oct 31	210	209	93.26	93.26	0.00

Wallace Ranch (Bristol Flats) Diversion

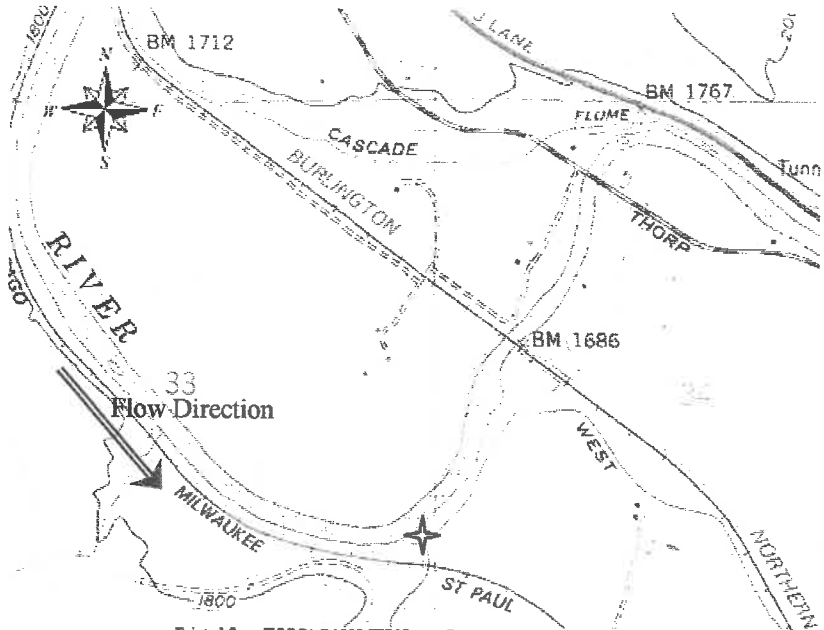
View looking from the Wallace Ranch pump towards the Yakima River along the backwater channel



View looking southwest across the Yakima River just downstream of the diversion channel

WESTSIDE DIVERSION

Location: The Westside Irrigation Company diversion is located on the right (south) bank of the Yakima River approximately 2000 feet upstream of the Burlington Northern Railroad Bridge and approximately 5700 feet upstream of the Thorp Highway bridge north of Thorp, Washington.



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Facilities: The Westside diversion consists of a gated intake structure on the right bank of the Yakima River which directs flow into a 20 foot wide trapezoidal channel leading approximately 1500 feet to a second hydraulic structure. The second facility includes a rolling drum fish screen with a return flow bypass to the Yakima River and several gated openings leading to irrigation canals.

Hydraulic/Geomorphic Setting: The Westside diversion intake structure is located on the right bank of the Yakima River on the outside of a large meander bend. The Yakima River is approximately 160 feet wide near the location of the diversion. As a result of the meander bend, channel is deeper along the right bank than at other points across this section. Thus, the siting of this diversion structure is appropriate from a hydraulic standpoint. Although the diversion structure is located appropriately, it is our understanding that flow depths in this wide reach of the river are typically too low for the Westside Irrigation Company to make their full diversion during the low flow season. It is our understanding that Westside annually places ecology blocks part way across the Yakima River downstream from the diversion site to backwater into the intake structure (Vern Burkhardt, Westside, Pers. Comm..). The placement (location, design, size) of these ecology blocks was described to us by Mr. Burkhardt as two rows high across about 2/3 of the river channel (i.e. approximately 110 feet out from the right (south) channel bank).

Hydraulic Analysis: The water level impacts of the Trendwest relocation for the Westside diversion site with and without ecology blocks were computed with the HEC-RAS hydraulic model. The model was created based on three cross sections field surveyed by W&H Pacific located: 1) downstream of the diversion site at the point at which the irrigation district places ecology blocks, 2) at the diversion intake structure, and 3) approximately 100 feet upstream of the diversion structure. Using the HEC-RAS model the anticipated water levels at the diversion site for the existing and proposed low flow conditions were estimated. Simulations were performed for the existing stream channel without ecology blocks and with the assumption of ecology blocks placed as described by Vern Burkhardt.

Based on the simulations, the Trendwest diversion relocation would result in water level differences ranging from an increase of 0.02 feet to a reduction of 0.01 feet at the diversion site if ecology blocks are not in place (i.e. for the natural river condition). With the ecology blocks in place the simulated differences in water levels at the diversion site range from +0.03 to -0.01 feet. The largest reduction in water level is predicted in the month of September when the diversion as a percentage of flow is the highest.

Potential mitigation measures to offset the impacts of the proposed diversion relocation were evaluated using HEC-RAS. These simulations indicate the ecology blocks would need to be extended approximately 1.0 feet further into the river to offset the effects of the Trendwest proposal in any of the periods being studied.

Table 4. Westside Diversion Site Analysis Results (With No Ecology Blocks in Place)

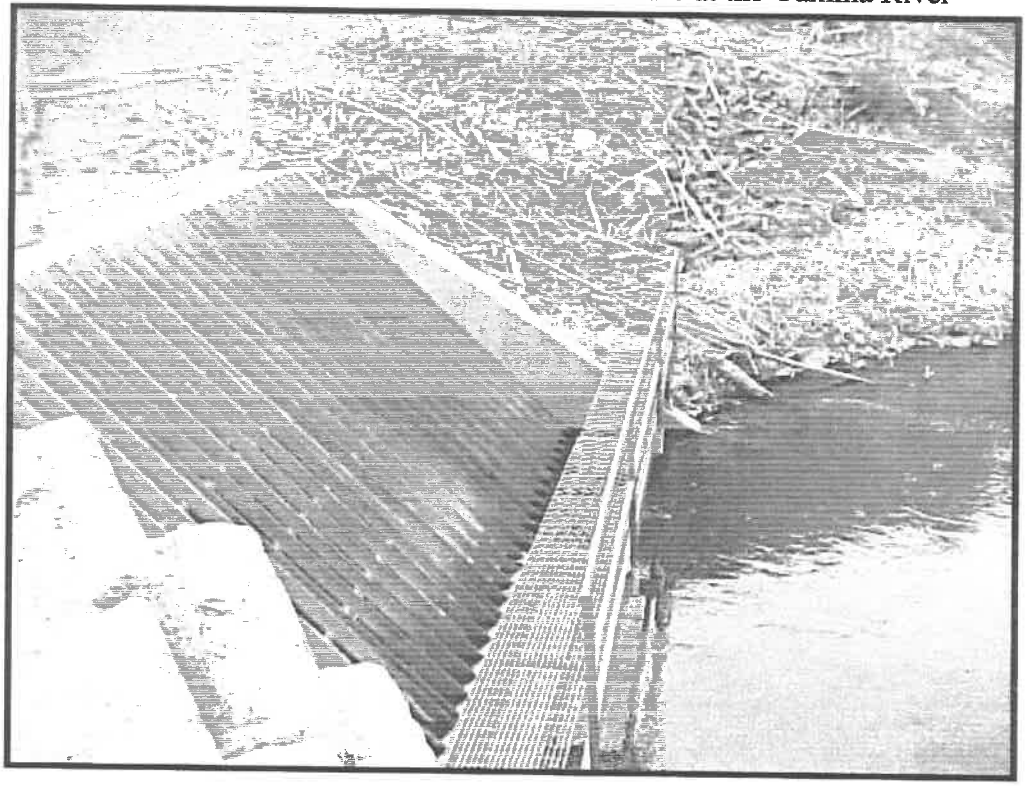
Time Period	Minimum Flow (cfs)		Water Surface Elevation (feet assumed datum)		
	Baseline Conditions	Proposed Conditions	Current Conditions	Proposed Conditions	Difference
May 1 – May 15	504	513	88.80	88.82	0.02
May 16 – May 31	580	588	88.95	88.97	0.02
June 1 – June 15	935	938	89.53	89.54	0.01
June 16 – June 30	1434	1438	90.18	90.18	0.00
July 1 – July 15	1920	1922	90.70	90.70	0.00
July 16 – July 31	2852	2850	91.54	91.54	0.00
Aug 1 – Aug 15	2655	2652	91.38	91.37	-0.01
Aug 16 – Aug 31	1322	1318	90.04	90.04	0.00
Sep 1 – Sep 15	380	377	88.54	88.53	-0.01
Sep 16 – Sep 30	407	403	88.60	88.59	-0.01
Oct 1 – Oct 15	363	361	88.48	88.48	0.00
Oct 16 – Oct 31	210	209	87.99	87.99	0.00

Table 5. Westside Diversion Site Analysis Results (With Ecology Blocks in Place)

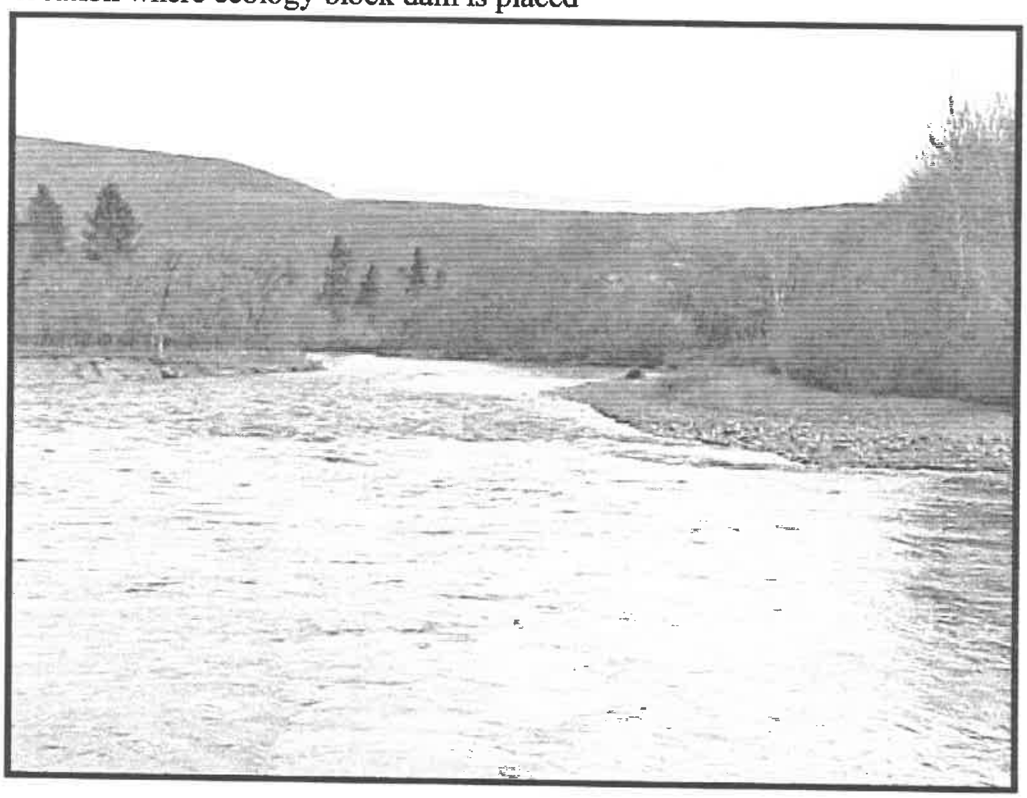
Time Period	Minimum Flow (cfs)		Water Surface Elevation (feet assumed datum)		
	Baseline Conditions	Proposed Conditions	Current Conditions	Proposed Conditions	Difference
May 1 – May 15	504	513	89.66	89.69	0.03
May 16 – May 31	580	588	89.90	89.92	0.02
June 1 – June 15	935	938	90.83	90.83	0.00
June 16 – June 30	1434	1438	91.73	91.73	0.00
July 1 – July 15	1920	1922	92.20	92.20	0.00
July 16 – July 31	2852	2850	93.02	93.01	-0.01
Aug 1 – Aug 15	2655	2652	92.85	92.85	0.00
Aug 16 – Aug 31	1322	1318	91.60	91.60	0..00
Sep 1 – Sep 15	380	377	89.26	89.25	-0.01
Sep 16 – Sep 30	407	403	89.35	89.34	-0.01
Oct 1 – Oct 15	363	361	89.20	89.19	-0.01
Oct 16 – Oct 31	210	209	88.57	88.57	0.00

Westside Irrigation Company Diversion

View looking across the front of the intake structure at the Yakima River

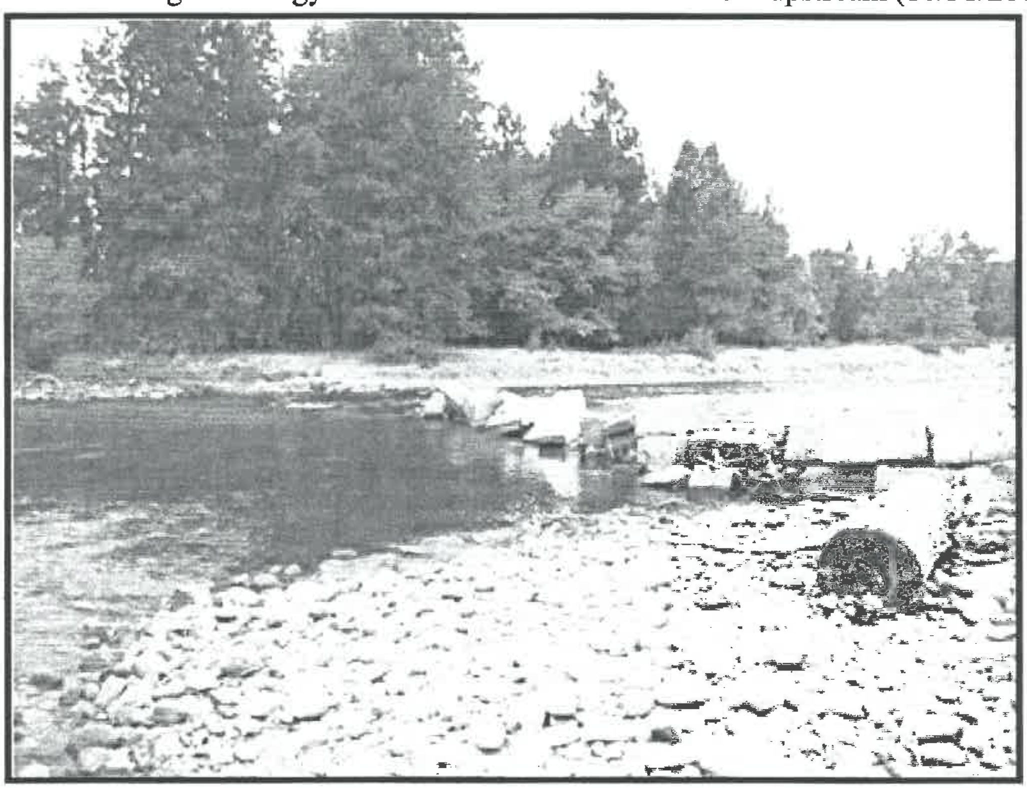


View looking across Yakima River downstream of diversion site at approximate location where ecology block dam is placed



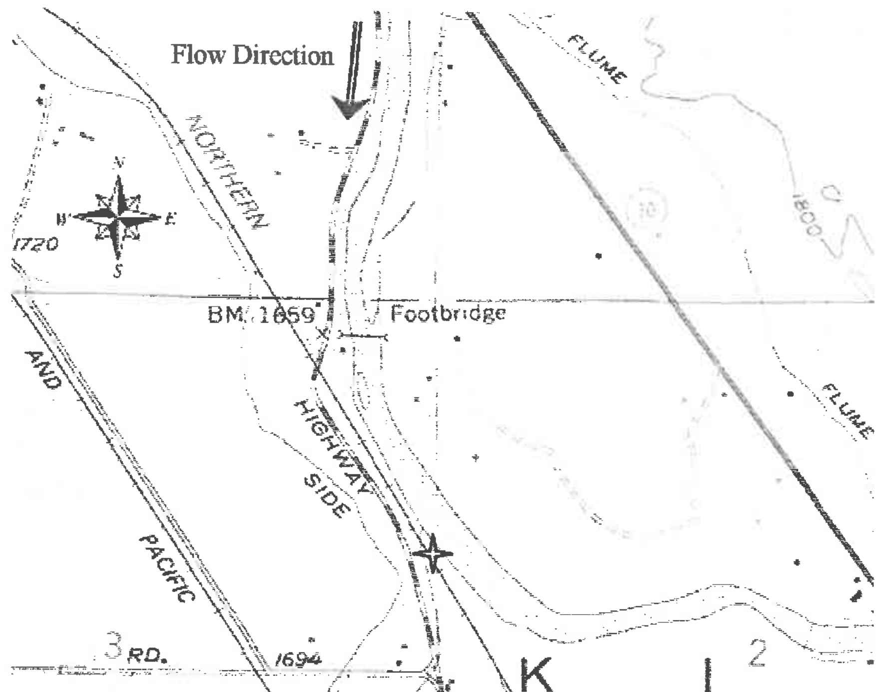
View looking north at ecology block dam in Yakima River (10/31/2001)

View looking at ecology block dam in Yakima River from upstream (10/31/2001)



THORP DIVERSION

Location: The Thorp Diversion is located on the right (south) bank of the Yakima River approximately 2.8 miles downstream of the Thorp Highway Bridge north of the town of Thorp, Washington.



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Facilities: The Thorp diversion consists of an ungated side channel diversion from the Yakima River which directs flow into a 3-5 foot wide diversion channel. The diversion structure consists of 4 side by side box culverts that pass under the Burlington Northern railroad track. At the time of the site reconnaissance most of the intake structure was blocked with fine-grained sediments. The section of the diversion channel near the Yakima River was also very overgrown, with tall grasses and some trees encroaching on the channel. The irrigation ditches and any hydraulic structures associated with the diversion were not observed during the March field reconnaissance.

Hydraulic/Geomorphic Setting: The Thorp diversion channel sits on the right bank of the Yakima River in a relatively straight reach of the river which is constrained from lateral movement by the Burlington Northern Railroad fill. At the time of the site visit flows in this section of the river were shallow and swift moving. As noted above much of the diversion structure is currently blocked with fine-grained sediments. At the time of the site reconnaissance, with estimated Yakima River flows of about 2,000 cfs, the water in the one open box was about 8 inches deep and formed a channel about 3 feet wide.

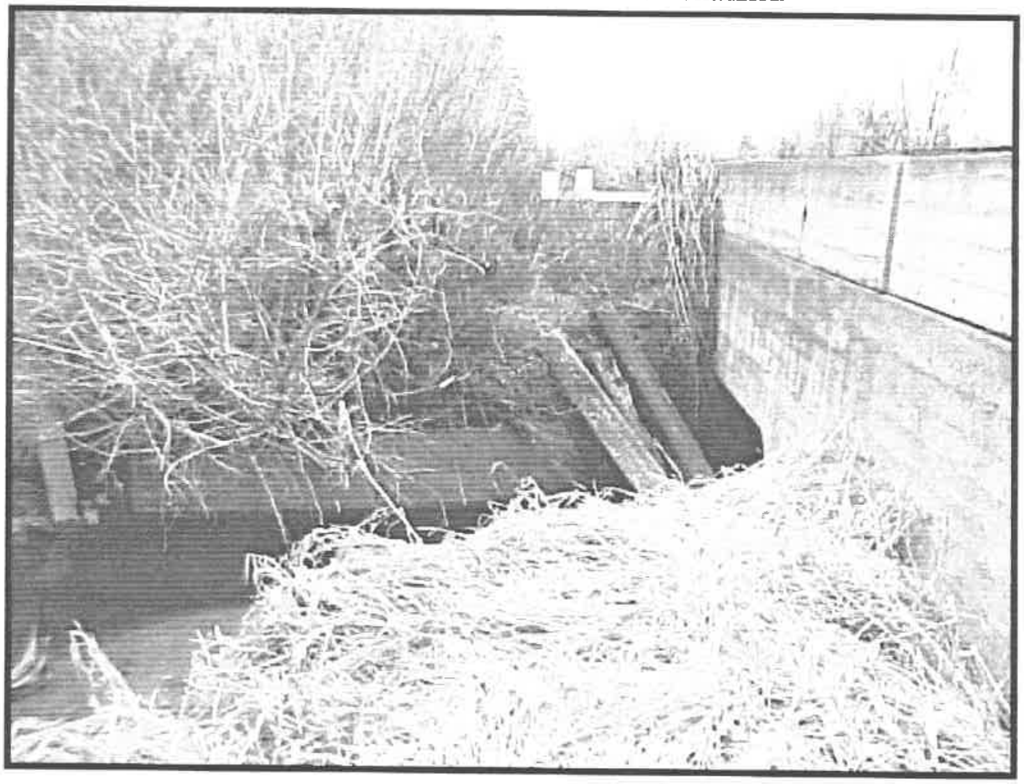
Hydraulic Analysis: The water level impacts of the Trendwest relocation for this site were computed with ManningSolver. The water levels were calculated for existing and proposed low flow conditions using the surveyed cross section provided by W&H Pacific, a Manning 'n' estimate of 0.045 and a water surface slope of 0.00182 ft/ft. The water surface slope was calculated from the W&H Pacific survey data. Comparing the proposed and baseline condition, computed water level differences at the inlet to the Thorp diversion channel range from +0.02 feet early in the irrigation season to -0.01 feet later in the season. The largest reduction in water surface is seen in the month of September when the Trendwest diversion as a percentage of Yakima River flow is the highest. Based on this analysis the proposed diversion relocation may result in a small increase or decrease in water levels at the inlet to the Thorp diversion channel but the largest computed reductions were less than or equal to 0.01 feet.

Table 6. Thorp Diversion Site Analysis Results

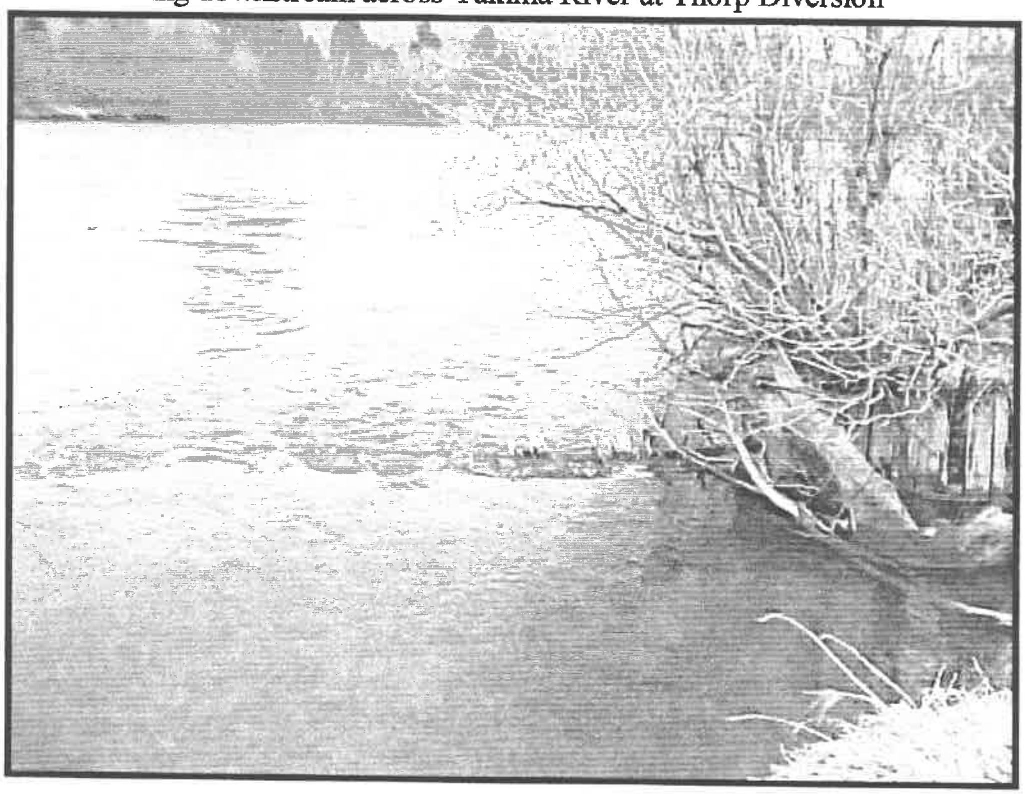
Time Period	Minimum Flow (cfs)		Water Surface Elevation (feet assumed datum)		
	Baseline Conditions	Proposed Conditions	Current Conditions	Proposed Conditions	Difference
May 1 – May 15	504	513	89.46	89.48	0.02
May 16 – May 31	580	588	89.60	89.61	0.01
June 1 – June 15	935	938	90.17	90.17	0.00
June 16 – June 30	1434	1438	90.83	90.83	0.00
July 1 – July 15	1920	1922	91.35	91.35	0.00
July 16 – July 31	2852	2850	92.20	92.20	0.00
Aug 1 – Aug 15	2655	2652	92.03	92.03	0.00
Aug 16 – Aug 31	1322	1318	90.69	90.68	-0.01
Sep 1 – Sep 15	380	377	89.20	89.19	-0.01
Sep 16 – Sep 30	407	403	89.26	89.25	-0.01
Oct 1 – Oct 15	363	361	89.15	89.15	0.00
Oct 16 – Oct 31	210	209	88.70	88.69	-0.01

Thorp Diversion

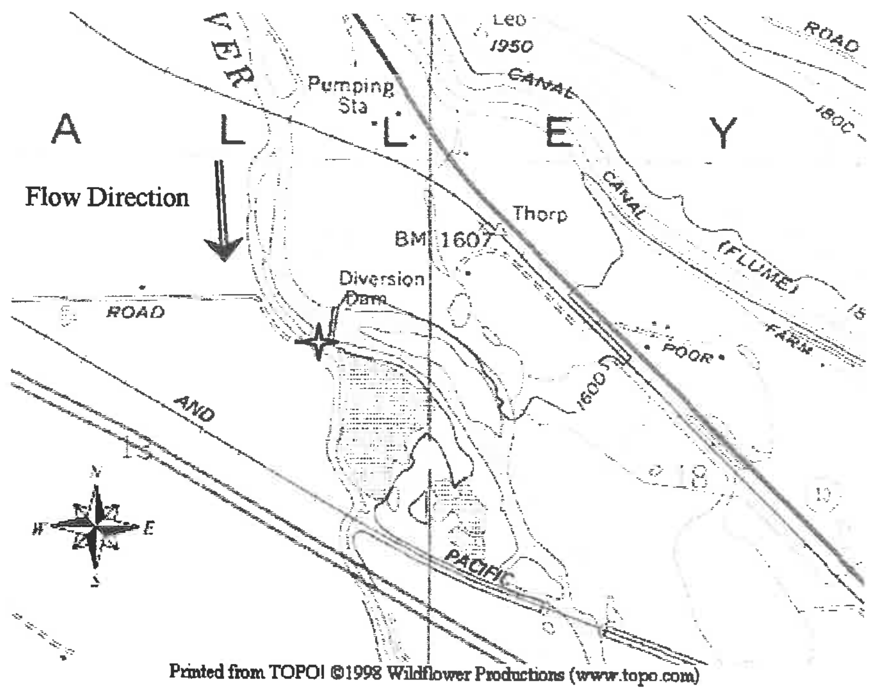
View looking downstream at Thorp Diversion structure showing sediment accumulations and debris in the diversion channel.



View looking downstream across Yakima River at Thorp Diversion



PACKWOOD DIVERSION



Location: The Packwood Diversion is located on the right (west) bank of the Yakima River approximately 2000 feet downstream of the Burlington Northern Railroad Bridge near Thorp, Washington.

Facilities: The diversion consists of an ungated side channel diversion from the Yakima River that directs flow into the Ellensburg canal. The intake was only viewed from across the Yakima River, thus it is not known what hydraulic controls are present. The USGS topographic maps for this location indicate that the irrigation canal leading from this diversion structure is quite large. We are not aware of any operational difficulties due to low flows at the Packwood diversion.

Hydraulic/Geomorphic Setting: The Packwood Diversion structure protrudes out from the right bank of the Yakima River on the outside of a large meander bend. As a result of this meander, flow depths are likely to be deeper along the right channel bank than at other points across this section. Thus, the siting of this diversion structure is appropriate from a hydraulic standpoint. Analysis of aerial photos of this reach of the river indicate that there is extensive erosion and deposition occurring near the diversion and significant human induced modifications have been undertaken over the last 40 years (see discussion of Cascade Irrigation diversion which follows). For example, it is clear that the river has been eroding the right bank upstream of the diversion over time. It is also apparent that bank protection measures (armoring and barbs) have been installed to constrain additional channel migration. Without the bank protection measures it is likely that the meander would continue to move downstream and could crate problems for the Packwood diversion. During the field visit, the Packwood diversion structure looked to be full of wood debris. This debris was not accounted for in any of our computations

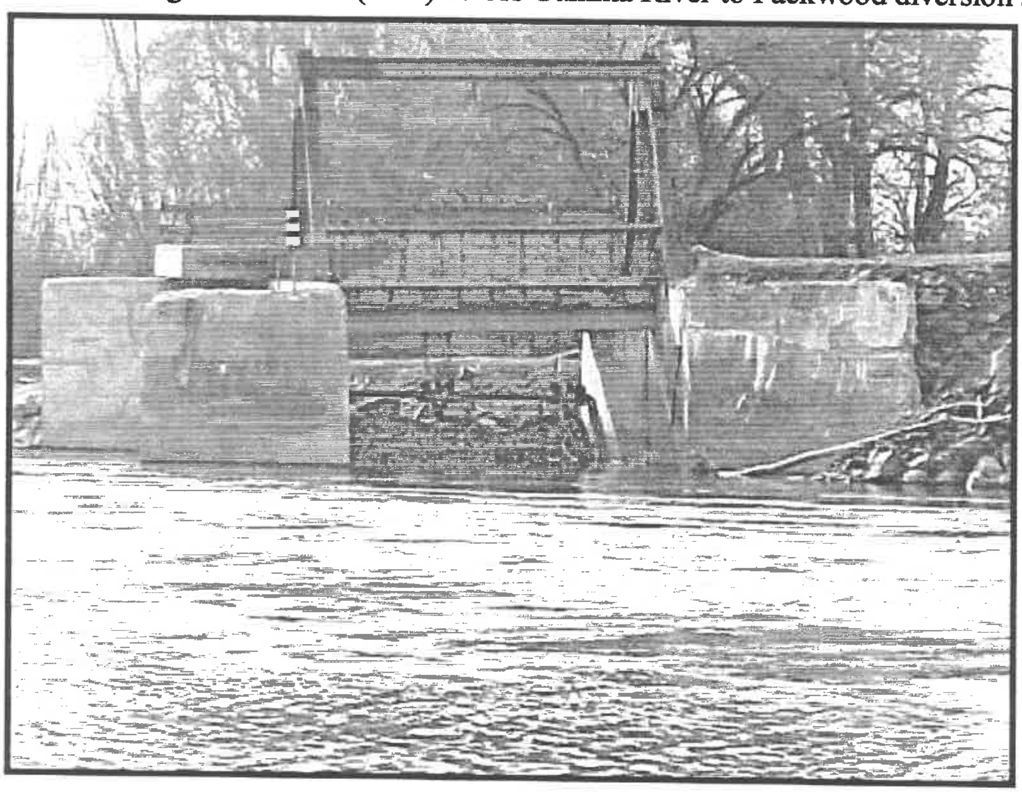
Hydraulic Analysis: The water level impacts of the Trendwest relocation for this site were computed with ManningSolver. The water levels were calculated for existing and proposed low flow conditions using the surveyed cross section provided by W&H Pacific, a Manning 'n' estimate of 0.045 and a water surface slope of 0.00078 ft/ft. The water surface slope was calculated from the W&H Pacific survey data. Comparing the proposed and baseline conditions, computed water level differences at the inlet to the Packwood diversion channel range from +0.04 feet early in the irrigation season to -0.02 feet later in the season. The largest reduction in water surface is seen in the month of September when the Trendwest diversion as a percentage of Yakima River flow is the highest. Based on our analysis the water surface elevation reductions anticipated under the proposed diversion relocation would be 0.02 feet or less.

Table 7. Packwood Diversion Site Analysis Results

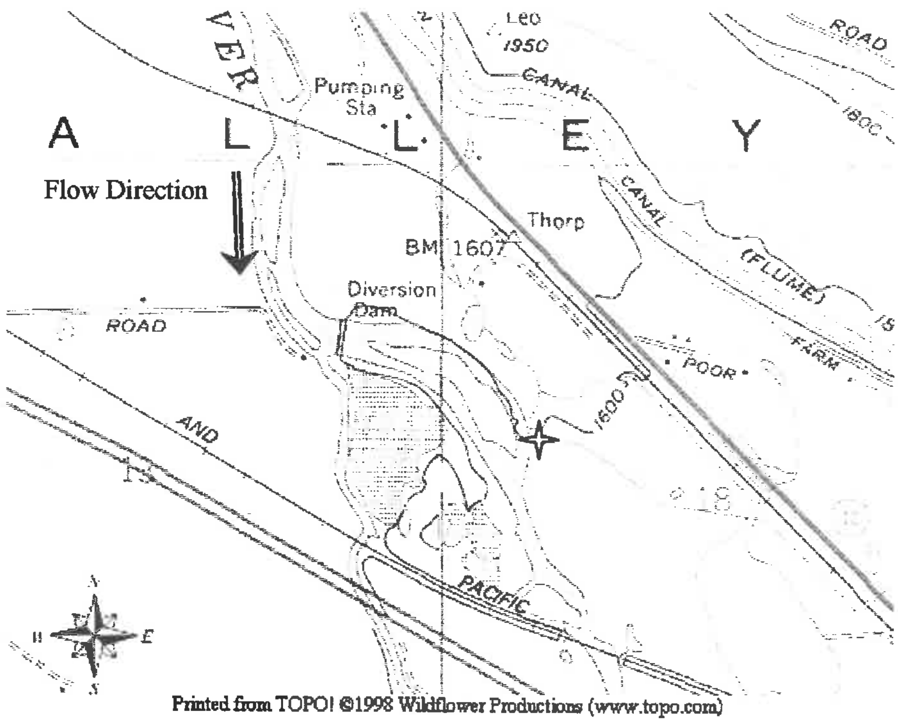
Time Period	Minimum Flow (cfs)		Water Surface Elevation (feet assumed datum)		
	Baseline Conditions	Proposed Conditions	Current Conditions	Proposed Conditions	Difference
May 1 – May 15	504	513	95.21	95.25	0.04
May 16 – May 31	580	588	95.54	95.57	0.03
June 1 – June 15	935	938	96.84	96.85	0.01
June 16 – June 30	1434	1438	98.57	98.58	0.01
July 1 – July 15	1920	1922	99.56	99.57	0.01
July 16 – July 31	2852	2850	101.15	101.15	0.00
Aug 1 – Aug 15	2655	2652	100.84	100.83	-0.01
Aug 16 – Aug 31	1322	1318	98.33	98.32	-0.01
Sep 1 – Sep 15	380	377	94.62	94.60	-0.02
Sep 16 – Sep 30	407	403	94.75	94.73	-0.02
Oct 1 – Oct 15	363	361	94.53	94.52	-0.02
Oct 16 – Oct 31	210	209	93.64	93.63	-0.01

Packwood Diversion

View looking downstream (west) across Yakima River to Packwood diversion structure



Cascade Irrigation Company Diversion



Location: The Cascade Irrigation Co. diversion is located on the left (north) bank of the Yakima River approximately 4000 feet downstream of the Burlington Northern Railroad Bridge near Thorp, Washington.

Facilities: The Cascade diversion consists of an intake structure on the left bank of a side channel of the Yakima River. The intake structure comprises 4 independently operable gates that direct flow into a large irrigation canal. Approximately 100 feet along the irrigation canal is another hydraulic structure and a measurement flume. A pump station is also located at this point.

Hydraulic/Geomorphic Setting: The Cascade Irrigation diversion intake sits on the left bank of a side channel of the Yakima River downstream of a complex flow split. Upstream of the diversion flow is divided among the following four potential routes: 1) the Packwood diversion, 2) the Gladmar channel, 3) the main stem Yakima River, and 4) the Cascade side channel. At the time of the site reconnaissance the total flow in the Yakima River upstream of the flow split was estimated to be about 2,000 cfs. It appeared that discharges to the Gladmar channel were larger than the combined discharges down the Yakima River main stem and Cascade side channel. It didn't appear that there were any discharges down the Packwood diversion.

The hydraulic complexities upstream of the Cascade irrigation diversion are a result of ongoing natural geomorphic processes and human induced river modifications. Extensive sediment movement and deposition by the river results in continually changing hydraulic conditions. Review of aerial photographs spanning the period 1972 through 1998 show that the Cascade side channel has been transformed from the primary flow path to a small side channel that likely requires extensive sediment removal to keep flowing. Analysis of the aerial photos indicates that human modifications to this stretch of the river over the last 40 years include levee building, bank armoring, construction of barbs, dredging of channels, and opening the Gladmar channel. Each of these modifications has had an effect on sediment deposition, and by extension, flows in the Cascade side channel.

Some of these modifications, for instance the armoring of the left bank upstream of the Packwood diversion and the opening of the Gladmar channel, have likely had a significant effect on depositional processes that affect the ongoing operation of the Cascade Irrigation diversion. As observed at the site reconnaissance, it appears that the head of the Cascade irrigation side channel is being infilled with sediment as a result of deposition associated with the upstream point bar. Furthermore, initial review of aerial photos indicates that the Yakima River may be shifting towards the south at the location of the Gladmar channel opening. If the revetment blocking the Gladmar channel opening is not maintained, it is possible that the Gladmar channel might become the main flow path for the Yakima River. If this were to occur, it is possible that the side channel leading to the Cascade Irrigation diversion could be cutoff from the flow entirely.

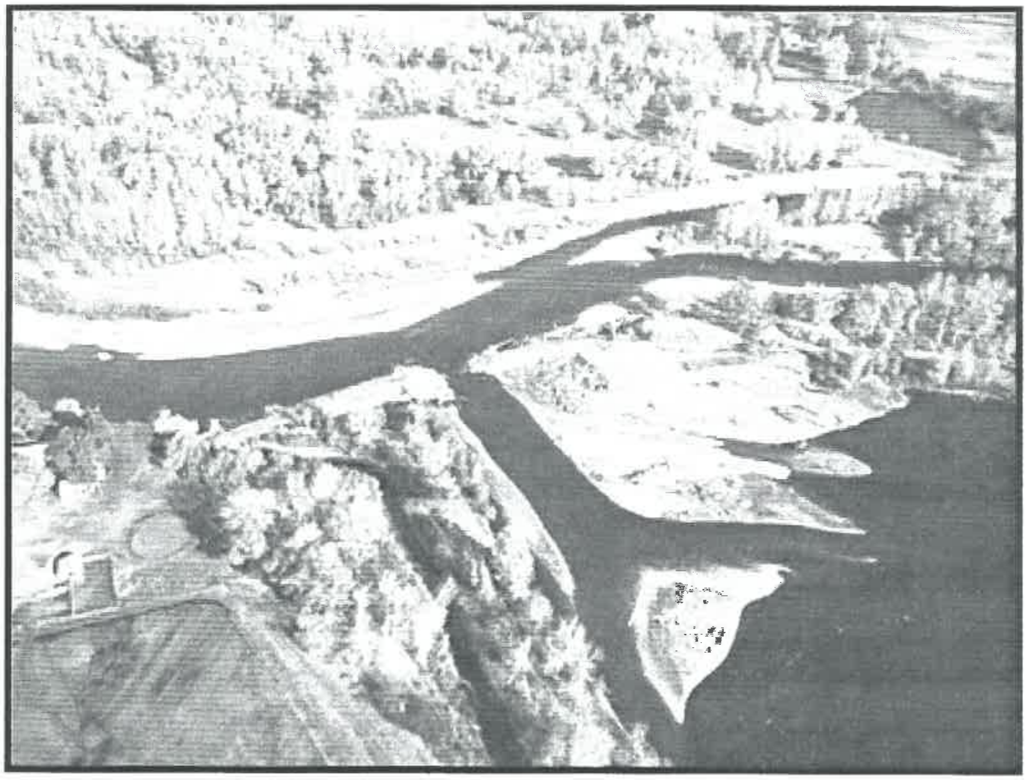
In addition to the human related river modifications described above we understand that the Cascade Irrigation Company annually installs temporary structures in the Yakima River (Tony Jantzer, Cascade Irrigation, Pers. Comm.). According to Mr. Jantzer, ecology block dams are installed in the main stem at the head of the island that divides the river, and in the Cascade side channel downstream of the diversion intake. We do not know the exact nature of these structures but we understand they are necessary if full irrigation diversions are to be made during periods of low flow.

Considering the ongoing geomorphic processes at this site, the history of human induced modifications to this reach of the river, and Cascade Irrigation's current program of in-channel structure placement, the impact of Trendwest's proposed diversion cannot be reasonably estimated at this time. However, we believe that any potential impacts will be minimal compared to changes that are occurring due to natural river processes. Clearly there are long-term geomorphic issues associated with this diversion that should be investigated and remediated. It was previously recommended that Cascade undertake a geomorphic review of the Yakima river near the Gladmar channel to examine current sedimentation processes, potential future sedimentation at the head of the Cascade side channel, the impacts of past river modifications on sedimentation in this reach, and alternatives for improving flow down the Cascade side channel. **nhc,** under contract to Trendwest, recently completed such an analysis for Cascade (2001).

Hydraulic Analysis: Considering the complexity of the flow split upstream of the Cascade Irrigation diversion and the ongoing geomorphic changes, low flow discharges at the diversion site could not be reasonably estimated for this preliminary analysis. Therefore no hydraulic analysis was undertaken for the Cascade diversion site. In lieu of hydraulic analysis, Trendwest is assisting Cascade with a geomorphic review and the development of mitigation alternatives for this site.

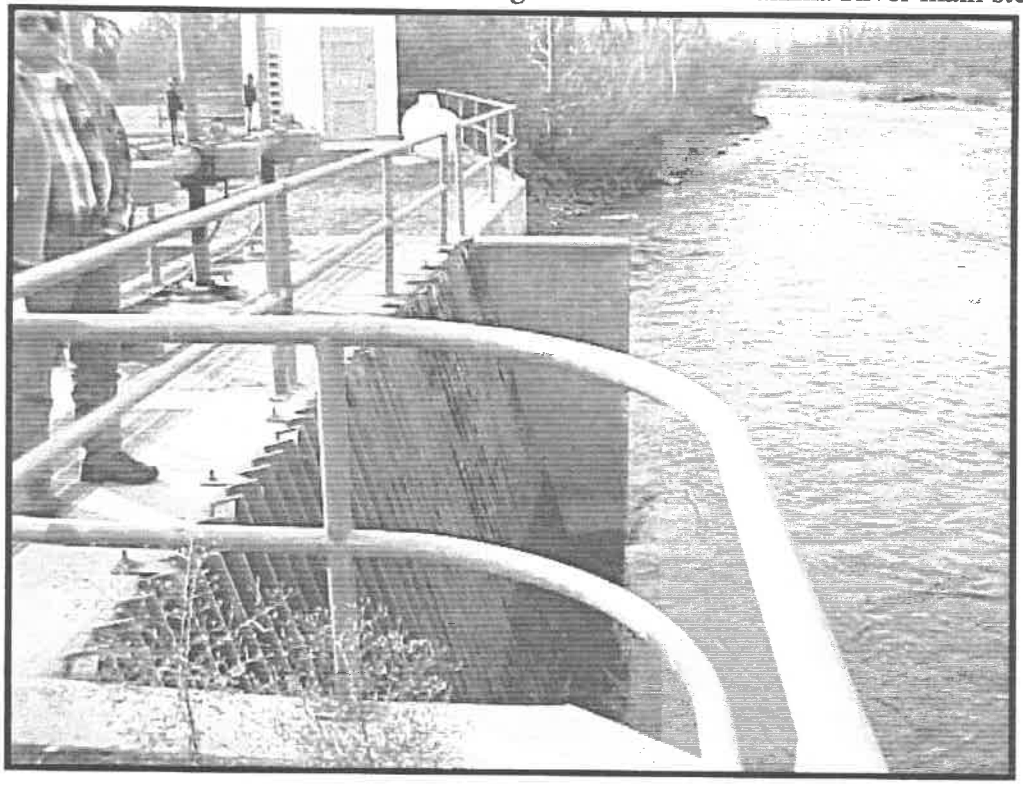
Cascade Irrigation Diversion

Aerial View of Packwood-Gladmar-Cascade Flow split looking north

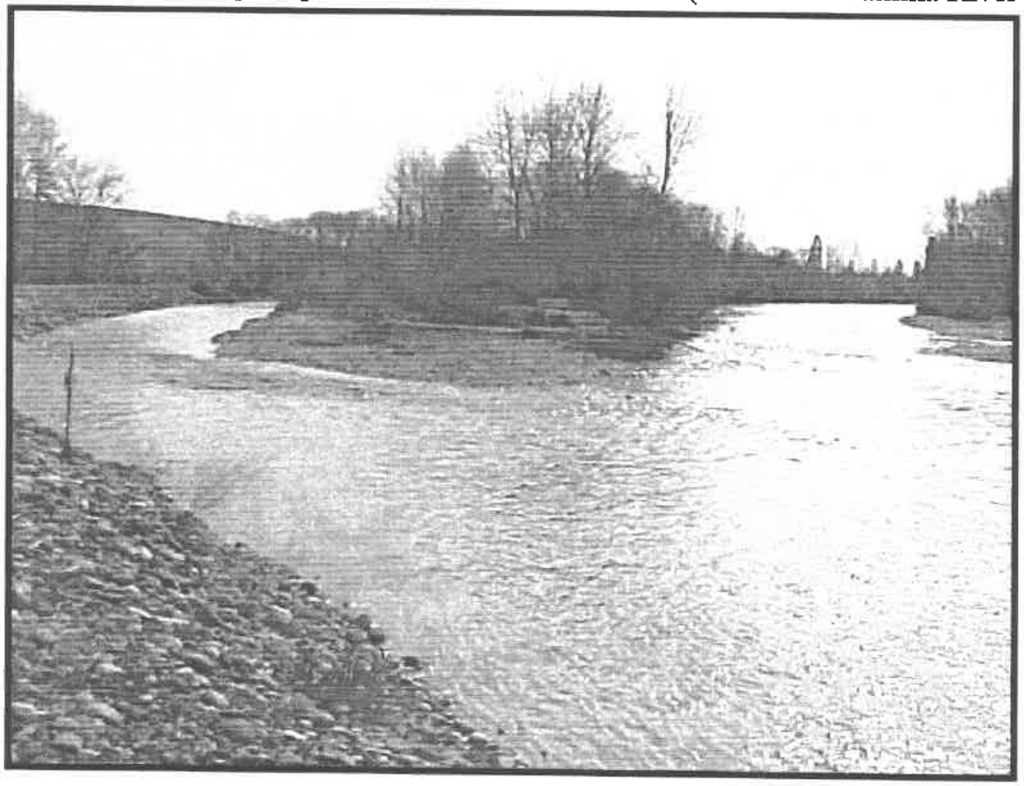


Aerial View of Packwood-Gladmar-Cascade Flow split looking south

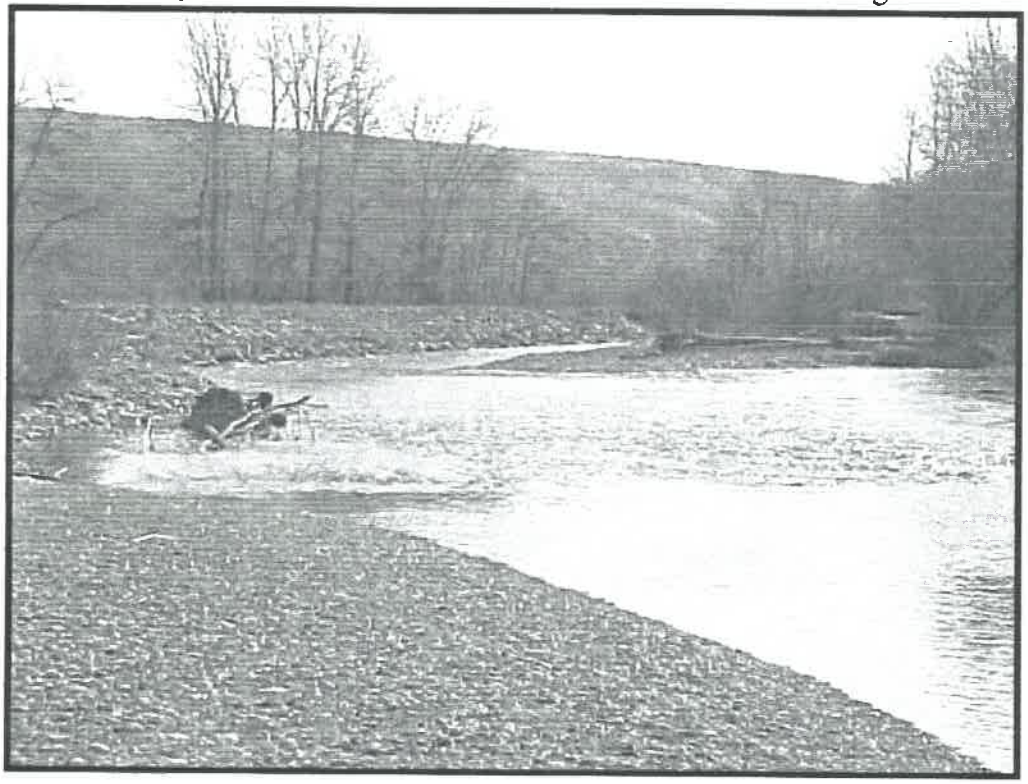
Upstream of diversion structure looking downstream to Yakima River main stem



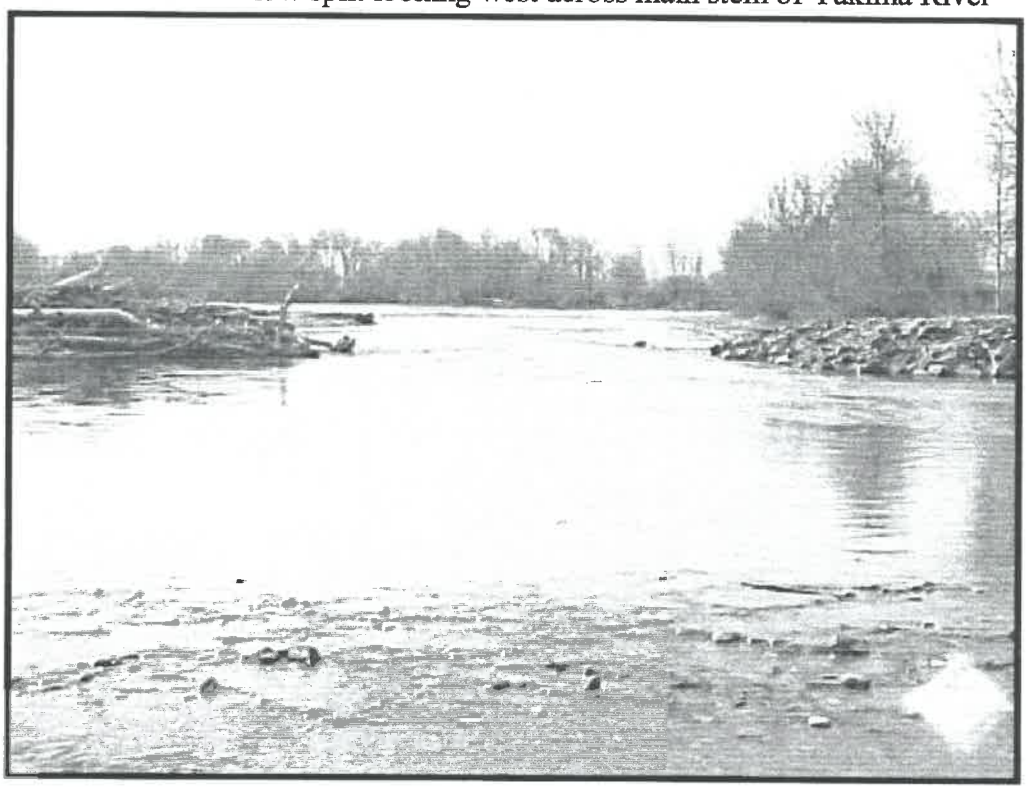
Island and flow split upstream of Cascade diversion (main stem Yakima River to right of island)



View looking south down side channel which leads to Cascade Irrigation diversion structure

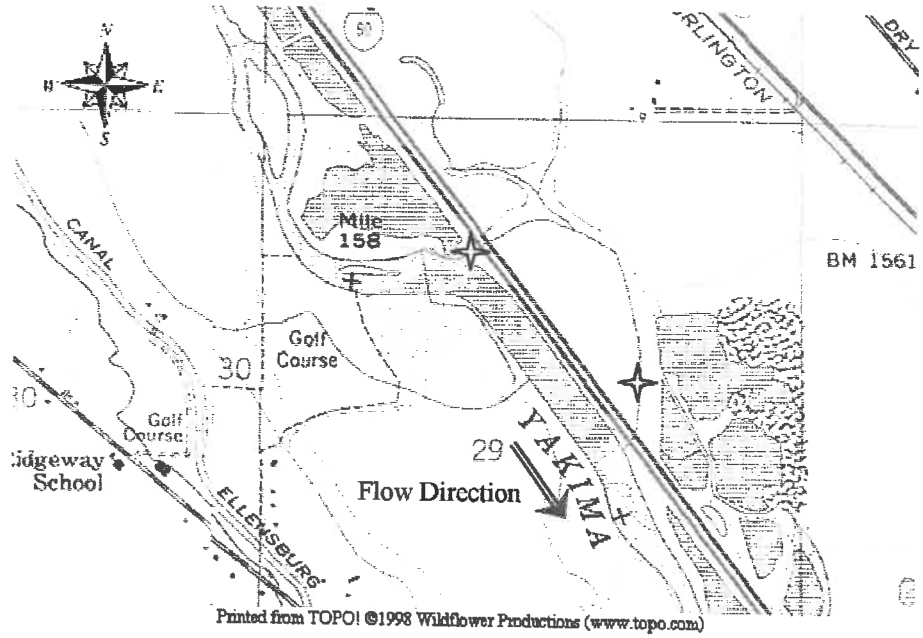


Gladmar channel flow split looking west across main stem of Yakima River



MILL DITCH DIVERSION

Location: The Mill Ditch Diversion is located on the left (north) bank of the Yakima River near Ellensburg, Washington.



Facilities: The diversion consists of a lateral diversion off a side channel of the Yakima River. Flow diverted from the Yakima River side channel is directed into a 15 foot wide ditch leading approximately 100 feet to a twin culvert crossing under I-90. Approximately 500 feet downstream of the I-90 crossing the diversion ditch joins with flow from a small groundwater fed lake and discharges from Dry Creek. From there, flow passes approximately 1750 feet before reaching the Mill Ditch diversion intake structure. A rock weir across the channel maintains water levels at the diversion structure with return flows bypassing to the Yakima River via another channel under I-90. The intake includes several gated diversion openings. Downstream of the intake structure diverted flows pass over a measurement weir and then enter the Mill Ditch irrigation system.

Hydraulic/Geomorphic Setting: The Mill Ditch diversion channel sits on the left bank of a side channel of the Yakima River. Discharges to the diversion channel are controlled by the level of water in the side channel and the level of a gravel bar on the left bank of the side channel. Discharges (and by extension water levels) in the side channel are controlled by a flow split in the Yakima River. This flow split was not visited during the field reconnaissance. It is our understanding that the Washington Department of Transportation periodically removes gravel from the side channel entrance to increase flows being directed towards the diversion channel (Lathrop, Pers. Comm.). We do not know if this includes maintenance dredging only at the main stem of the Yakima River, maintenance dredging only in the side channel, or both.

Hydraulic Analysis: No hydraulic analysis was undertaken for this site. The hydraulics and hydrology of the Mill Ditch diversion are complicated by a number of factors including the dynamics of flow splits off the Yakima River, the hydrology of the groundwater lake, and the quantity of surface and subsurface flows in Dry Creek. Because Yakima River flows (and stages) downstream of the Mill Ditch site would theoretically not be affected by simply moving the point of diversion further upstream, and because the hydrologic modeling indicated that flows at this site would actually be increased in most months under the Trendwest proposal (due to additional tributary flows) the proposal should not result in any significant hydraulic impacts. Furthermore if WSDOT continues to manage sediment and maintain the Yakima River flow split, it appears that potential changes, resulting from either modified flows or future sedimentation at this site, could be dealt with through the current maintenance dredging program.

Mill Ditch Diversion

Mill Ditch Diversion intake structure (looking downstream)

Mill Ditch Diversion Channel Split from Side Channel of Yakima River (looking west)

REFERENCES

Northwest Hydraulic Consultants, Inc., December 2001, "Yakima River - Cascade Irrigation District Intake - Reconnaissance Of Sedimentation Problems", Letter Report prepared for Trendwest Resorts, Inc.

Brown and Caldwell, Inc., January 2002, Water Supply Technical Report - MountainStar Master Planned Resort and Cle Elum Urban Growth Area, Report prepared for Trendwest Resorts, Inc.

Appendix A

Flow Data

Summary of Upper Yakima River Water Balance Model Output
WY 1991 to 1993 and 1995 represent the average year condition
WY 2001 represents the drought condition
The individual columns show the change in flow at specific river locations due to the MPR and UGA resort development.

Minimum Flow (All Study Periods)

Dates	Yakima River at Cle Elum Gage (cfs)	D/S Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S Water Supply Diversion (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)	D/S Reecer Creek (Ellensburg) (cfs)
May 1 - May 15	504	505	505	504	507	513	515	514
May 16 - May 31	580	581	581	580	583	588	590	590
June 1 - June 15	935	936	937	932	933	938	940	940
June 16 - June 30	1434	1435	1436	1431	1433	1438	1441	1440
July 1 - July 15	1920	1921	1922	1916	1918	1922	1925	1924
July 15 - July 31	2852	2853	2854	2847	2849	2850	2853	2852
Aug 1 - Aug 15	2655	2656	2657	2652	2652	2652	2655	2654
Aug 16 - Aug 31	1322	1321	1322	1317	1318	1318	1321	1320
Sept 1 - Sept 15	380	379	380	376	377	377	379	379
Sept 16 - Sept 30	407	407	407	404	402	403	405	404
Oct 1 - Oct 15	363	363	363	362	361	361	362	362
Oct 16 - Oct 31	210	210	210	209	209	209	209	208

Minimum Flow (Oct 1990 - Sept 1993, Oct 1994 - Sept 1995)

Dates	Yakima River at Cle Elum Gage (cfs)	D/S Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S Water Supply Diversion (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)	D/S Reecer Creek (Ellensburg) (cfs)
May 1 - May 15	504	505	505	504	507	513	515	514
May 16 - May 31	580	581	581	580	583	588	590	590
June 1 - June 15	935	936	937	932	933	938	940	940
June 16 - June 30	1434	1435	1436	1431	1433	1438	1441	1440
July 1 - July 15	1920	1921	1922	1916	1918	1922	1925	1924
July 15 - July 31	2852	2853	2854	2847	2849	2850	2853	2852
Aug 1 - Aug 15	2900	2901	2902	2897	2898	2899	2902	2901
Aug 16 - Aug 31	1322	1321	1322	1317	1318	1318	1321	1320
Sept 1 - Sept 15	380	379	380	376	377	377	379	379
Sept 16 - Sept 30	425	425	425	421	420	420	422	422
Oct 1 - Oct 15	363	363	363	362	361	361	362	362
Oct 16 - Oct 31	210	210	210	209	209	209	209	208

Minimum Flow (Oct 2000 - Sept 2001)

Dates	Yakima River at Cle Elum Gage (cfs)	D/S Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S Water Supply Diversion (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)	D/S Reecer Creek (Ellensburg) (cfs)
May 1 - May 15	901	901	902	900	902	904	906	906
May 16 - May 31	710	710	711	709	711	713	715	715
June 1 - June 15	1414	1414	1415	1411	1412	1415	1417	1416
June 16 - June 30	1725	1725	1726	1722	1723	1726	1728	1727
July 1 - July 15	1980	1981	1982	1975	1977	1978	1981	1980
July 15 - July 31	2941	2942	2942	2936	2938	2940	2942	2941
Aug 1 - Aug 15	2655	2656	2657	2652	2652	2652	2655	2654
Aug 16 - Aug 31	2077	2078	2079	2074	2074	2075	2078	2077
Sept 1 - Sept 15	437	437	437	434	434	434	436	435
Sept 16 - Sept 30	407	407	407	404	402	403	405	404
Oct 1 - Oct 15	548	548	548	547	546	547	548	548
Oct 16 - Oct 31	516	516	516	515	515	516	517	516

Date	Yakima River at Cle Elum Gage (cfs)	Change In Yakima River Under Alternative 5 Reduced Density						
		D/S Big Creek (cfs)	D/S Cle Elum River (cfs)	D/S Water Supply Diversion (cfs)	D/S Teanaway River (cfs)	D/S Swauk Creek (cfs)	D/S Mill Ditch Diversion (cfs)	D/S Reecer Creek (Ellensburg) (cfs)
10/1/90	363.0	362.62	363.30	362.31	360.89	361.11	362.28	361.69
10/2/90	363.0	362.56	363.24	362.25	360.82	361.33	362.49	361.91
10/3/90	442.0	441.56	442.24	441.25	439.82	440.55	441.72	441.13
10/4/90	468.0	467.56	468.24	467.25	465.82	467.02	468.19	467.60
10/5/90	434.0	433.62	434.30	433.31	431.88	433.08	434.25	433.66
10/6/90	394.0	393.62	394.30	393.31	391.88	393.55	394.72	394.13
10/7/90	370.0	369.62	370.30	369.31	367.88	369.50	370.67	370.08
10/8/90	363.0	362.62	363.30	362.31	360.88	362.29	363.46	362.87
10/9/90	363.0	362.56	363.24	362.26	360.83	361.87	363.04	362.45
10/10/90	378.0	377.56	378.24	377.26	375.83	377.07	378.24	377.65
10/11/90	386.0	385.56	386.24	385.26	383.83	384.86	386.03	385.44
10/12/90	442.0	441.56	442.24	441.26	439.83	441.70	442.87	442.28
10/13/90	418.0	417.67	418.35	417.37	415.94	417.84	419.01	418.43
10/14/90	434.0	433.67	434.35	433.37	431.94	433.85	435.01	434.43
10/15/90	580.0	579.67	580.35	579.37	577.94	579.85	581.01	580.43
10/16/90	590.0	589.67	590.31	589.32	589.32	590.56	590.68	590.09
10/17/90	477.0	476.67	477.31	476.32	476.32	477.56	477.68	477.09
10/18/90	504.0	503.67	504.31	503.32	503.32	502.95	503.06	502.47
10/19/90	477.0	476.63	477.27	476.28	476.28	476.37	476.49	475.90
10/20/90	434.0	433.63	434.27	433.28	433.28	433.84	433.95	433.37
10/21/90	610.0	609.63	610.27	609.28	609.28	610.30	610.41	609.83
10/22/90	706.0	705.63	706.27	705.28	705.28	706.30	706.42	705.83
10/23/90	739.0	738.63	739.27	738.28	738.28	739.30	739.42	738.83
10/24/90	762.0	761.63	762.27	761.28	761.28	762.31	762.42	761.83
10/25/90	798.0	797.69	798.32	797.34	797.34	798.59	798.70	798.12
10/26/90	846.0	845.69	846.32	845.34	845.34	846.59	846.70	846.12
10/27/90	810.0	809.69	810.32	809.34	809.34	810.59	810.71	810.12
10/28/90	651.0	650.69	651.32	650.34	650.34	651.59	651.71	651.12
10/29/90	600.0	599.69	600.32	599.34	599.34	600.59	600.71	600.12
10/30/90	580.0	579.69	580.32	579.34	579.34	580.59	580.71	580.12
10/31/90	590.0	589.69	590.32	589.34	589.34	590.60	590.71	590.13
11/1/90	590.0	589.69	590.37	589.70	589.70	589.49	589.60	589.01
11/2/90	570.0	569.69	570.37	569.70	569.70	569.56	569.68	569.09
11/3/90	540.0	539.69	540.37	539.70	539.70	539.56	539.68	539.09
11/4/90	861.0	860.69	861.37	860.70	860.70	860.56	860.68	860.09
11/5/90	1194.0	1193.69	1194.37	1193.70	1193.70	1193.60	1193.71	1193.13
11/6/90	998.0	997.69	998.37	997.70	997.70	997.60	997.71	997.13
11/7/90	812.0	811.69	812.37	811.70	811.70	811.60	811.71	811.13
11/8/90	839.0	838.69	839.37	838.70	838.70	838.60	838.71	838.13
11/9/90	2141.0	2140.69	2141.37	2140.70	2140.70	2140.62	2140.74	2140.15
11/10/90	6013.0	6012.69	6013.37	6012.70	6012.70	6012.62	6012.74	6012.15
11/11/90	2559.0	2558.74	2559.43	2558.75	2558.75	2558.67	2558.79	2558.20
11/12/90	1572.0	1571.74	1572.43	1571.75	1571.75	1571.67	1571.79	1571.20
11/13/90	1367.0	1366.74	1367.43	1366.75	1366.75	1366.67	1366.79	1366.20
11/14/90	1206.0	1205.74	1206.43	1205.75	1205.75	1205.68	1205.79	1205.20
11/15/90	1098.0	1097.74	1098.43	1097.75	1097.75	1097.68	1097.79	1097.20
11/16/90	1022.0	1021.74	1022.43	1021.75	1021.75	1021.68	1021.79	1021.20
11/17/90	899.0	898.74	899.43	898.75	898.75	898.68	898.79	898.20
11/18/90	880.0	879.74	880.43	879.75	879.75	879.68	879.79	879.20
11/19/90	839.0	838.74	839.43	838.75	838.75	838.70	838.82	838.23
11/20/90	798.0	797.74	798.43	797.75	797.75	797.70	797.82	797.23
11/21/90	552.0	551.74	552.43	551.75	551.75	551.70	551.82	551.23
11/22/90	1251.0	1250.74	1251.43	1250.75	1250.75	1250.70	1250.82	1250.23
11/23/90	2013.0	2012.73	2013.42	2012.75	2012.75	2012.70	2012.81	2012.22
11/24/90	7426.0	7425.73	7426.42	7425.75	7425.75	7425.70	7425.81	7425.22
11/25/90	10600.0	10599.73	10600.42	10599.75	10599.75	10599.70	10599.81	10599.22
11/26/90	3606.0	3605.73	3606.42	3605.75	3605.75	3605.70	3605.81	3605.23

11/27/90	2732.0	2731.73	2732.42	2731.75	2731.75	2731.70	2731.81	2731.23
11/28/90	2168.0	2167.73	2168.42	2167.75	2167.75	2167.70	2167.81	2167.23
11/29/90	2732.0	2731.73	2732.42	2731.75	2731.75	2731.70	2731.81	2731.23
11/30/90	5047.0	5046.73	5047.42	5046.75	5046.75	5046.70	5046.81	5046.23
12/1/90	5847.0	5846.73	5847.41	5846.71	5846.71	5846.66	5846.78	5846.19
12/2/90	6080.0	6079.73	6080.41	6079.71	6079.71	6079.66	6079.78	6079.19
12/3/90	5754.0	5753.73	5754.41	5753.71	5753.71	5753.68	5753.79	5753.21
12/4/90	5717.0	5716.73	5717.41	5716.71	5716.71	5716.68	5716.79	5716.21
12/5/90	5828.0	5827.73	5828.41	5827.71	5827.71	5827.68	5827.79	5827.21
12/6/90	5717.0	5716.77	5717.44	5716.74	5716.74	5716.71	5716.82	5716.24
12/7/90	5643.0	5642.77	5643.44	5642.74	5642.74	5642.71	5642.82	5642.24
12/8/90	5606.0	5605.77	5606.44	5605.74	5605.74	5605.71	5605.82	5605.24
12/9/90	5606.0	5605.77	5606.44	5605.74	5605.74	5605.71	5605.82	5605.24
12/10/90	5717.0	5716.77	5717.44	5716.74	5716.74	5716.71	5716.82	5716.24
12/11/90	5754.0	5753.77	5754.44	5753.74	5753.74	5753.71	5753.82	5753.24
12/12/90	5643.0	5642.77	5643.44	5642.74	5642.74	5642.71	5642.82	5642.24
12/13/90	5569.0	5568.77	5569.44	5568.74	5568.74	5568.71	5568.83	5568.24
12/14/90	5680.0	5679.77	5680.44	5679.74	5679.74	5679.71	5679.83	5679.24
12/15/90	5606.0	5605.77	5606.44	5605.74	5605.74	5605.71	5605.83	5605.24
12/16/90	5532.0	5531.77	5532.44	5531.74	5531.74	5531.71	5531.83	5531.24
12/17/90	5791.0	5790.77	5791.44	5790.74	5790.74	5790.71	5790.83	5790.24
12/18/90	5421.0	5420.77	5421.44	5420.74	5420.74	5420.71	5420.83	5420.24
12/19/90	3875.0	3874.77	3875.44	3874.74	3874.74	3874.71	3874.83	3874.24
12/20/90	2239.0	2238.77	2239.44	2238.74	2238.74	2238.71	2238.83	2238.24
12/21/90	2115.0	2114.77	2115.44	2114.74	2114.74	2114.71	2114.83	2114.24
12/22/90	2140.0	2139.80	2140.47	2139.77	2139.77	2139.75	2139.86	2139.27
12/23/90	2165.0	2164.80	2165.47	2164.77	2164.77	2164.75	2164.86	2164.27
12/24/90	2232.0	2231.80	2232.47	2231.77	2231.77	2231.75	2231.87	2231.28
12/25/90	2280.0	2279.80	2280.47	2279.77	2279.77	2279.75	2279.87	2279.28
12/26/90	2349.0	2348.80	2349.47	2348.77	2348.77	2348.75	2348.87	2348.28
12/27/90	2287.0	2286.80	2287.47	2286.77	2286.77	2286.75	2286.87	2286.28
12/28/90	1285.0	1284.80	1285.47	1284.77	1284.77	1284.75	1284.87	1284.28
12/29/90	1167.0	1166.80	1167.47	1166.77	1166.77	1166.75	1166.87	1166.28
12/30/90	1215.0	1214.80	1215.47	1214.77	1214.77	1214.75	1214.87	1214.28
12/31/90	1230.0	1229.80	1230.47	1229.77	1229.77	1229.75	1229.87	1229.28
1/1/91	1260.0	1259.80	1260.45	1259.78	1259.78	1259.76	1259.88	1259.29
1/2/91	1230.0	1229.80	1230.45	1229.78	1229.78	1229.76	1229.88	1229.29
1/3/91	1185.0	1184.80	1185.45	1184.78	1184.78	1184.76	1184.88	1184.29
1/4/91	1155.0	1154.80	1155.45	1154.78	1154.78	1154.76	1154.88	1154.29
1/5/91	1140.0	1139.80	1140.45	1139.78	1139.78	1139.76	1139.88	1139.29
1/6/91	1112.0	1111.80	1112.45	1111.78	1111.78	1111.77	1111.88	1111.29
1/7/91	1112.0	1111.80	1112.45	1111.78	1111.78	1111.77	1111.88	1111.29
1/8/91	1126.0	1125.80	1126.45	1125.78	1125.78	1125.77	1125.88	1125.29
1/9/91	1098.0	1097.80	1098.45	1097.78	1097.78	1097.77	1097.88	1097.29
1/10/91	1098.0	1097.80	1098.45	1097.78	1097.78	1097.77	1097.88	1097.29
1/11/91	1084.0	1083.81	1084.46	1083.79	1083.79	1083.78	1083.90	1083.31
1/12/91	1140.0	1139.81	1140.46	1139.79	1139.79	1139.78	1139.90	1139.31
1/13/91	1381.0	1380.81	1381.46	1380.79	1380.79	1380.78	1380.90	1380.31
1/14/91	1698.0	1697.81	1698.46	1697.79	1697.79	1697.78	1697.90	1697.31
1/15/91	2430.0	2429.81	2430.46	2429.79	2429.79	2429.78	2429.90	2429.31
1/16/91	2164.0	2163.81	2164.46	2163.79	2163.79	2163.78	2163.90	2163.31
1/17/91	1872.0	1871.81	1872.46	1871.79	1871.79	1871.78	1871.90	1871.31
1/18/91	1828.0	1827.81	1828.46	1827.79	1827.79	1827.78	1827.90	1827.31
1/19/91	1750.0	1749.81	1750.46	1749.79	1749.79	1749.78	1749.90	1749.31
1/20/91	1692.0	1691.81	1692.46	1691.79	1691.79	1691.78	1691.90	1691.31
1/21/91	1549.0	1548.81	1549.46	1548.79	1548.79	1548.78	1548.90	1548.31
1/22/91	1478.0	1477.81	1478.46	1477.79	1477.79	1477.78	1477.90	1477.31
1/23/91	1665.0	1664.81	1665.46	1664.79	1664.79	1664.78	1664.90	1664.31
1/24/91	1662.0	1661.81	1662.46	1661.79	1661.79	1661.78	1661.90	1661.31
1/25/91	1605.0	1604.81	1605.46	1604.79	1604.79	1604.78	1604.90	1604.31
1/26/91	1551.0	1550.81	1551.46	1550.79	1550.79	1550.78	1550.90	1550.31
1/27/91	1514.0	1513.81	1514.46	1513.79	1513.79	1513.78	1513.90	1513.31
1/28/91	1495.0	1494.81	1495.46	1494.79	1494.79	1494.78	1494.90	1494.31

1/29/91	1458.0	1457.81	1458.46	1457.79	1457.79	1457.78	1457.90	1457.31
1/30/91	1422.0	1421.81	1422.46	1421.79	1421.79	1421.78	1421.90	1421.31
1/31/91	1420.0	1419.81	1420.46	1419.79	1419.79	1419.78	1419.90	1419.31
2/1/91	1401.0	1400.81	1401.52	1400.82	1400.82	1400.81	1400.93	1400.34
2/2/91	1398.0	1397.81	1398.52	1397.82	1397.82	1397.81	1397.93	1397.34
2/3/91	1494.0	1493.83	1494.54	1493.85	1493.85	1493.84	1493.95	1493.37
2/4/91	1508.0	1507.83	1508.54	1507.85	1507.85	1507.84	1507.95	1507.37
2/5/91	1696.0	1695.83	1696.54	1695.85	1695.85	1695.84	1695.95	1695.37
2/6/91	1765.0	1764.83	1765.54	1764.85	1764.85	1764.84	1764.95	1764.37
2/7/91	1708.0	1707.83	1708.54	1707.85	1707.85	1707.84	1707.95	1707.37
2/8/91	1669.0	1668.83	1669.54	1668.85	1668.85	1668.84	1668.95	1668.37
2/9/91	1630.0	1629.83	1630.54	1629.85	1629.85	1629.84	1629.95	1629.37
2/10/91	1609.0	1608.83	1609.54	1608.85	1608.85	1608.84	1608.95	1608.37
2/11/91	1505.0	1504.83	1505.54	1504.85	1504.85	1504.84	1504.96	1504.37
2/12/91	1639.0	1638.83	1639.54	1638.85	1638.85	1638.84	1638.96	1638.37
2/13/91	1780.0	1779.83	1780.54	1779.85	1779.85	1779.84	1779.96	1779.37
2/14/91	2182.0	2181.83	2182.54	2181.85	2181.85	2181.84	2181.96	2181.37
2/15/91	2442.0	2441.83	2442.54	2441.85	2441.85	2441.84	2441.96	2441.37
2/16/91	2530.0	2529.83	2530.54	2529.85	2529.85	2529.84	2529.96	2529.37
2/17/91	2457.0	2456.83	2457.54	2456.85	2456.85	2456.84	2456.96	2456.37
2/18/91	2254.0	2253.83	2254.54	2253.85	2253.85	2253.84	2253.96	2253.37
2/19/91	4326.0	4325.83	4326.54	4325.85	4325.85	4325.84	4325.96	4325.37
2/20/91	5828.0	5827.83	5828.54	5827.85	5827.85	5827.84	5827.96	5827.37
2/21/91	4321.0	4320.83	4321.54	4320.85	4320.85	4320.84	4320.96	4320.37
2/22/91	2140.0	2139.83	2140.54	2139.85	2139.85	2139.84	2139.96	2139.37
2/23/91	1960.0	1959.83	1960.54	1959.85	1959.85	1959.84	1959.96	1959.37
2/24/91	1622.0	1621.83	1622.54	1621.85	1621.85	1621.84	1621.96	1621.37
2/25/91	1437.0	1436.83	1437.54	1436.85	1436.85	1436.84	1436.96	1436.37
2/26/91	1343.0	1342.83	1343.54	1342.85	1342.85	1342.84	1342.96	1342.37
2/27/91	1266.0	1265.83	1266.54	1265.85	1265.85	1265.84	1265.96	1265.37
2/28/91	1222.0	1221.83	1222.54	1221.85	1221.85	1221.84	1221.96	1221.37
3/1/91	1193.0	1192.83	1193.47	1192.81	1192.81	1192.80	1192.92	1192.33
3/2/91	1135.0	1134.83	1135.47	1134.81	1134.81	1134.80	1134.92	1134.33
3/3/91	1123.0	1122.85	1123.50	1122.83	1122.83	1122.82	1122.94	1122.35
3/4/91	1138.0	1137.85	1138.50	1137.83	1137.83	1137.82	1137.94	1137.35
3/5/91	1111.0	1110.85	1111.50	1110.83	1110.83	1110.82	1110.94	1110.35
3/6/91	1245.0	1244.85	1245.50	1244.83	1244.83	1244.82	1244.94	1244.35
3/7/91	1217.0	1216.85	1217.50	1216.83	1216.83	1216.82	1216.94	1216.35
3/8/91	1203.0	1202.85	1203.50	1202.83	1202.83	1202.82	1202.94	1202.35
3/9/91	1190.0	1189.85	1190.50	1189.83	1189.83	1189.82	1189.94	1189.35
3/10/91	1161.0	1160.85	1161.50	1160.83	1160.83	1160.82	1160.94	1160.35
3/11/91	1140.0	1139.85	1140.50	1139.83	1139.83	1139.82	1139.94	1139.35
3/12/91	1134.0	1133.85	1134.50	1133.83	1133.83	1133.82	1133.94	1133.35
3/13/91	1108.0	1107.85	1108.50	1107.83	1107.83	1107.82	1107.94	1107.35
3/14/91	1095.0	1094.85	1095.50	1094.83	1094.83	1094.82	1094.94	1094.35
3/15/91	1082.0	1081.85	1082.50	1081.83	1081.83	1081.82	1081.94	1081.35
3/16/91	1070.0	1069.85	1070.50	1069.83	1069.83	1069.82	1069.94	1069.35
3/17/91	1057.0	1056.85	1057.50	1056.83	1056.83	1056.82	1056.94	1056.35
3/18/91	1044.0	1043.85	1044.50	1043.83	1043.83	1043.82	1043.94	1043.35
3/19/91	1060.0	1059.85	1060.50	1059.83	1059.83	1059.82	1059.94	1059.35
3/20/91	1047.0	1046.85	1047.50	1046.83	1046.83	1046.82	1046.94	1046.35
3/21/91	1062.0	1061.85	1062.50	1061.83	1061.83	1061.82	1061.94	1061.35
3/22/91	1049.0	1048.85	1049.50	1048.83	1048.83	1048.82	1048.94	1048.35
3/23/91	1037.0	1036.85	1037.50	1036.83	1036.83	1036.82	1036.94	1036.35
3/24/91	1066.0	1065.85	1066.50	1065.83	1065.83	1065.82	1065.94	1065.35
3/25/91	997.0	996.85	997.50	996.83	996.83	996.82	996.94	996.35
3/26/91	999.0	998.85	999.50	998.83	998.83	998.82	998.94	998.35
3/27/91	1014.0	1013.85	1014.50	1013.83	1013.83	1013.82	1013.94	1013.35
3/28/91	1080.0	1079.85	1080.50	1079.83	1079.83	1079.82	1079.94	1079.35
3/29/91	1132.0	1131.85	1132.50	1131.83	1131.83	1131.82	1131.94	1131.35
3/30/91	1292.0	1291.85	1292.50	1291.83	1291.83	1291.82	1291.94	1291.35
3/31/91	1335.0	1334.85	1335.50	1334.83	1334.83	1334.82	1334.94	1334.35
4/1/91	1442.0	1441.85	1442.47	1441.54	1441.54	1445.01	1446.40	1445.73

4/2/91	1556.0	1555.85	1556.47	1555.54	1555.54	1558.83	1560.22	1559.54
4/3/91	1534.0	1533.85	1534.47	1533.54	1533.54	1536.46	1537.85	1537.18
4/4/91	1722.0	1721.85	1722.47	1721.54	1721.54	1724.64	1726.03	1725.36
4/5/91	2576.0	2575.85	2576.47	2575.54	2575.54	2578.64	2580.03	2579.36
4/6/91	2829.0	2828.87	2829.49	2828.55	2828.55	2831.84	2833.23	2832.56
4/7/91	2381.0	2380.88	2381.50	2380.57	2380.57	2383.85	2385.24	2384.57
4/8/91	1646.0	1645.88	1646.50	1645.57	1645.57	1648.85	1650.24	1649.57
4/9/91	1804.0	1803.88	1804.50	1803.57	1803.57	1806.85	1808.24	1807.56
4/10/91	1726.0	1725.88	1726.50	1725.57	1725.57	1728.94	1730.33	1729.66
4/11/91	2075.0	2074.88	2075.50	2074.57	2074.57	2077.94	2079.33	2078.66
4/12/91	2957.0	2956.88	2957.50	2956.57	2956.57	2959.94	2961.33	2960.66
4/13/91	3522.0	3521.88	3522.50	3521.57	3521.57	3524.94	3526.33	3525.66
4/14/91	3550.0	3549.88	3550.50	3549.57	3549.57	3552.94	3554.33	3553.65
4/15/91	3254.0	3253.88	3254.50	3253.57	3253.57	3256.94	3258.33	3257.65
4/16/91	3202.0	3201.88	3202.50	3201.57	3201.57	3204.93	3206.32	3205.65
4/17/91	3202.0	3201.88	3202.50	3201.57	3201.57	3204.93	3206.32	3205.65
4/18/91	3075.0	3074.88	3075.50	3074.57	3074.57	3077.40	3078.80	3078.12
4/19/91	2732.0	2731.88	2732.50	2731.57	2731.57	2734.61	2736.00	2735.33
4/20/91	3125.0	3124.88	3125.50	3124.57	3124.57	3127.60	3128.99	3128.32
4/21/91	3100.0	3099.88	3100.50	3099.57	3099.57	3102.82	3104.21	3103.54
4/22/91	3438.0	3437.88	3438.50	3437.57	3437.57	3440.81	3442.20	3441.53
4/23/91	3410.0	3409.88	3410.50	3409.57	3409.57	3412.81	3414.20	3413.53
4/24/91	3254.0	3253.88	3254.50	3253.57	3253.57	3256.81	3258.20	3257.53
4/25/91	3025.0	3024.88	3025.50	3024.57	3024.57	3027.92	3029.31	3028.64
4/26/91	2732.0	2731.88	2732.50	2731.57	2731.57	2734.92	2736.31	2735.64
4/27/91	2614.0	2613.88	2614.50	2613.57	2613.57	2616.92	2618.31	2617.63
4/28/91	2684.0	2683.88	2684.50	2683.57	2683.57	2686.92	2688.31	2687.63
4/29/91	2828.0	2827.88	2828.50	2827.57	2827.57	2830.91	2832.30	2831.63
4/30/91	2876.0	2875.88	2876.50	2875.57	2875.57	2878.91	2880.30	2879.63
5/1/91	2780.0	2780.86	2781.43	2780.12	2783.22	2787.92	2789.99	2789.31
5/2/91	2756.0	2756.85	2757.42	2756.11	2759.21	2763.91	2765.98	2765.31
5/3/91	2660.0	2660.84	2661.42	2660.10	2663.21	2667.25	2669.31	2668.64
5/4/91	2637.0	2637.83	2638.41	2637.09	2640.20	2644.49	2646.56	2645.89
5/5/91	2684.0	2684.82	2685.40	2684.08	2687.19	2691.47	2693.53	2692.86
5/6/91	2732.0	2732.82	2733.40	2732.08	2735.19	2739.74	2741.80	2741.13
5/7/91	2684.0	2684.83	2685.40	2684.09	2687.19	2691.74	2693.80	2693.13
5/8/91	2950.0	2950.81	2951.39	2950.07	2953.18	2957.72	2959.78	2959.11
5/9/91	3050.0	3050.83	3051.41	3050.09	3053.20	3057.73	3059.79	3059.12
5/10/91	3150.0	3150.85	3151.42	3150.11	3153.21	3157.89	3159.95	3159.28
5/11/91	3306.0	3306.95	3307.53	3306.21	3309.32	3313.99	3316.06	3315.39
5/12/91	3280.0	3280.94	3281.52	3280.20	3283.31	3287.98	3290.04	3289.37
5/13/91	2930.0	2930.94	2931.51	2930.20	2933.30	2937.97	2940.04	2939.37
5/14/91	2766.0	2766.94	2767.52	2766.20	2769.31	2773.97	2776.03	2775.36
5/15/91	2842.0	2842.95	2843.52	2842.21	2845.31	2849.97	2852.04	2851.37
5/16/91	2017.0	2017.86	2018.43	2017.12	2020.23	2024.88	2026.94	2026.27
5/17/91	2147.0	2147.83	2148.41	2147.09	2150.20	2154.85	2156.92	2156.25
5/18/91	1692.0	1692.80	1693.38	1692.07	1695.17	1698.94	1701.00	1700.33
5/19/91	1552.0	1552.84	1553.42	1552.10	1555.21	1559.32	1561.38	1560.71
5/20/91	1370.0	1370.79	1371.37	1370.05	1373.16	1377.25	1379.32	1378.65
5/21/91	1386.0	1386.77	1387.34	1386.03	1389.13	1393.59	1395.65	1394.98
5/22/91	1501.0	1501.77	1502.34	1501.03	1504.13	1508.58	1510.65	1509.97
5/23/91	1467.0	1467.90	1468.48	1467.16	1470.27	1474.71	1476.78	1476.10
5/24/91	1434.0	1434.95	1435.53	1434.21	1437.32	1441.95	1444.01	1443.34
5/25/91	1501.0	1501.95	1502.52	1501.21	1504.31	1508.94	1511.01	1510.34
5/26/91	1322.0	1323.01	1323.59	1322.27	1325.38	1329.80	1331.87	1331.19
5/27/91	1386.0	1386.92	1387.49	1386.18	1389.28	1393.90	1395.97	1395.30
5/28/91	1338.0	1338.94	1339.52	1338.20	1341.31	1345.93	1347.99	1347.32
5/29/91	1418.0	1418.91	1419.49	1418.17	1421.28	1425.96	1428.03	1427.36
5/30/91	1402.0	1402.88	1403.46	1402.14	1405.25	1409.93	1412.00	1411.33
5/31/91	1552.0	1552.95	1553.53	1552.21	1553.41	1558.09	1560.16	1559.49
6/1/91	1840.0	1840.94	1841.57	1837.31	1838.28	1842.51	1844.72	1844.04
6/2/91	1900.0	1901.02	1901.66	1897.40	1898.37	1902.59	1904.80	1904.13
6/3/91	1960.0	1960.94	1961.57	1957.31	1958.28	1961.37	1963.58	1962.91

6/4/91	1920.0	1921.00	1921.63	1917.37	1918.34	1921.87	1924.08	1923.41
6/5/91	1710.0	1711.05	1711.69	1707.43	1708.40	1711.91	1714.13	1713.45
6/6/91	1728.0	1728.94	1729.58	1725.32	1726.29	1730.26	1732.48	1731.80
6/7/91	1710.0	1710.92	1711.55	1707.29	1708.26	1712.23	1714.44	1713.77
6/8/91	2000.0	2000.94	2001.57	1997.32	1998.29	2002.25	2004.46	2003.79
6/9/91	3100.0	3101.06	3101.69	3097.43	3098.40	3102.35	3104.56	3103.89
6/10/91	2732.0	2732.94	2733.57	2729.31	2730.28	2734.48	2736.69	2736.02
6/11/91	3466.0	3466.97	3467.60	3463.34	3464.31	3468.51	3470.72	3470.04
6/12/91	3466.0	3467.05	3467.68	3463.42	3464.39	3468.58	3470.79	3470.12
6/13/91	2105.0	2105.90	2106.45	2102.19	2103.16	2107.35	2109.56	2108.89
6/14/91	1620.0	1620.92	1621.47	1617.22	1618.19	1622.37	1624.58	1623.91
6/15/91	1518.0	1518.94	1519.50	1515.24	1516.21	1520.39	1522.60	1521.93
6/16/91	1674.0	1675.11	1675.67	1671.41	1672.38	1676.55	1678.76	1678.09
6/17/91	1764.0	1764.95	1765.51	1761.25	1762.22	1766.39	1768.60	1767.93
6/18/91	1764.0	1764.99	1765.54	1761.28	1762.25	1765.02	1767.23	1766.56
6/19/91	2084.0	2085.14	2085.69	2081.43	2082.40	2085.72	2087.93	2087.26
6/20/91	2125.0	2125.94	2126.49	2122.23	2123.20	2126.50	2128.72	2128.04
6/21/91	2296.0	2296.90	2297.45	2293.19	2294.17	2298.03	2300.24	2299.57
6/22/91	2611.0	2611.86	2612.41	2608.16	2609.13	2612.99	2615.20	2614.53
6/23/91	2472.0	2472.89	2473.44	2469.18	2470.16	2474.01	2476.22	2475.55
6/24/91	2121.0	2121.95	2122.50	2118.24	2119.21	2123.06	2125.27	2124.60
6/25/91	1834.0	1835.00	1835.55	1831.29	1832.26	1836.40	1838.61	1837.94
6/26/91	1953.0	1953.99	1954.54	1950.28	1951.25	1955.39	1957.60	1956.93
6/27/91	2118.0	2118.88	2119.43	2115.17	2116.14	2120.28	2122.49	2121.82
6/28/91	2311.0	2311.96	2312.51	2308.25	2309.22	2313.35	2315.56	2314.89
6/29/91	2465.0	2465.97	2466.52	2462.26	2463.23	2467.36	2469.57	2468.90
6/30/91	2487.0	2488.08	2488.63	2484.37	2485.34	2489.47	2491.68	2491.01
7/1/91	2395.0	2396.35	2396.93	2390.56	2392.61	2398.08	2400.64	2399.97
7/2/91	2262.0	2263.39	2263.97	2257.61	2259.66	2265.13	2267.69	2267.02
7/3/91	2645.0	2646.45	2647.03	2640.66	2642.71	2646.51	2649.07	2648.40
7/4/91	3235.0	3236.24	3236.82	3230.45	3232.50	3236.96	3239.52	3238.85
7/5/91	2369.0	2370.14	2370.73	2364.36	2366.41	2370.84	2373.40	2372.73
7/6/91	2046.0	2047.19	2047.77	2041.40	2043.45	2048.56	2051.12	2050.45
7/7/91	2548.0	2549.13	2549.71	2543.35	2545.39	2550.28	2552.84	2552.17
7/8/91	2455.0	2456.13	2456.72	2450.35	2452.40	2457.15	2459.71	2459.04
7/9/91	2615.0	2616.14	2616.72	2610.35	2612.40	2617.05	2619.61	2618.94
7/10/91	2852.0	2853.14	2853.72	2847.36	2849.41	2854.33	2856.89	2856.22
7/11/91	3075.0	3076.15	3076.73	3070.36	3072.41	3077.12	3079.68	3079.01
7/12/91	3332.0	3333.15	3333.73	3327.36	3329.41	3333.98	3336.54	3335.87
7/13/91	3410.0	3411.12	3411.70	3405.33	3407.38	3411.91	3414.47	3413.80
7/14/91	3438.0	3439.12	3439.70	3433.33	3435.38	3439.75	3442.31	3441.64
7/15/91	3466.0	3467.12	3467.70	3461.34	3463.38	3467.66	3470.22	3469.55
7/16/91	3332.0	3333.19	3333.77	3327.41	3329.45	3333.62	3336.18	3335.51
7/17/91	3228.0	3229.10	3229.68	3223.32	3225.36	3229.40	3231.96	3231.29
7/18/91	3228.0	3229.08	3229.66	3223.29	3225.34	3227.22	3229.78	3229.11
7/19/91	3358.0	3359.22	3359.80	3353.44	3355.49	3358.09	3360.65	3359.98
7/20/91	3522.0	3523.16	3523.74	3517.38	3519.42	3521.92	3524.48	3523.81
7/21/91	3662.0	3663.10	3663.68	3657.31	3659.36	3662.54	3665.10	3664.42
7/22/91	3840.0	3841.01	3841.59	3835.23	3837.27	3840.34	3842.90	3842.23
7/23/91	4054.0	4055.20	4055.79	4049.42	4051.47	4054.51	4057.07	4056.40
7/24/91	4342.0	4343.20	4343.79	4337.42	4339.47	4342.93	4345.49	4344.82
7/25/91	4502.0	4503.14	4503.72	4497.35	4499.40	4502.94	4505.50	4504.82
7/26/91	4470.0	4471.14	4471.72	4465.35	4467.40	4470.39	4472.95	4472.28
7/27/91	4406.0	4407.06	4407.64	4401.28	4403.32	4405.97	4408.53	4407.85
7/28/91	4374.0	4375.06	4375.64	4369.28	4371.33	4373.37	4375.93	4375.26
7/29/91	4342.0	4342.97	4343.55	4337.18	4339.23	4341.05	4343.61	4342.94
7/30/91	4342.0	4342.97	4343.55	4337.18	4339.23	4340.97	4343.53	4342.85
7/31/91	4342.0	4343.06	4343.65	4337.28	4338.75	4340.43	4342.99	4342.32
8/1/91	4374.0	4375.18	4375.77	4370.82	4372.47	4374.03	4376.39	4375.72
8/2/91	4406.0	4407.18	4407.77	4402.82	4404.47	4405.96	4408.32	4407.65
8/3/91	4374.0	4375.22	4375.81	4370.85	4372.51	4371.92	4374.28	4373.61
8/4/91	4342.0	4343.22	4343.81	4338.85	4340.51	4340.69	4343.05	4342.37
8/5/91	4470.0	4471.22	4471.81	4466.85	4468.50	4468.68	4471.04	4470.36

8/6/91	4438.0	4439.21	4439.80	4434.84	4436.50	4439.30	4441.66	4440.99
8/7/91	3930.0	3931.12	3931.71	3926.75	3928.40	3932.13	3934.49	3933.82
8/8/91	3840.0	3841.13	3841.72	3836.76	3838.41	3840.58	3842.94	3842.27
8/9/91	3750.0	3751.13	3751.72	3746.76	3748.42	3749.60	3751.96	3751.29
8/10/91	3720.0	3721.13	3721.72	3716.76	3718.42	3719.88	3722.24	3721.56
8/11/91	3690.0	3691.14	3691.73	3686.77	3688.43	3689.76	3692.12	3691.44
8/12/91	3720.0	3721.14	3721.73	3716.77	3718.43	3719.70	3722.06	3721.39
8/13/91	3780.0	3781.14	3781.73	3776.77	3778.43	3779.62	3781.98	3781.31
8/14/91	3810.0	3811.14	3811.73	3806.78	3808.43	3809.54	3811.90	3811.23
8/15/91	3900.0	3901.14	3901.73	3896.78	3898.43	3899.44	3901.80	3901.13
8/16/91	4022.0	4023.24	4023.83	4018.87	4020.32	4021.30	4023.66	4022.98
8/17/91	3960.0	3961.15	3961.74	3956.78	3958.43	3959.45	3961.81	3961.14
8/18/91	3840.0	3841.12	3841.71	3836.76	3837.96	3837.09	3839.45	3838.78
8/19/91	3810.0	3811.29	3811.88	3806.93	3808.13	3807.92	3810.28	3809.60
8/20/91	3810.0	3811.22	3811.81	3806.85	3808.06	3807.79	3810.15	3809.48
8/21/91	3900.0	3901.15	3901.74	3896.78	3897.98	3898.39	3900.75	3900.08
8/22/91	3900.0	3901.05	3901.64	3896.68	3897.88	3898.26	3900.62	3899.95
8/23/91	3870.0	3871.28	3871.87	3866.91	3868.11	3868.47	3870.83	3870.16
8/24/91	3930.0	3931.28	3931.87	3926.91	3928.11	3928.82	3931.18	3930.51
8/25/91	3840.0	3841.20	3841.79	3836.84	3838.04	3838.73	3841.09	3840.41
8/26/91	3780.0	3781.20	3781.79	3776.84	3778.04	3778.36	3780.72	3780.05
8/27/91	2758.0	2759.11	2759.70	2754.74	2755.95	2756.73	2759.09	2758.42
8/28/91	2904.0	2905.11	2905.70	2900.74	2902.39	2903.53	2905.89	2905.22
8/29/91	2810.0	2810.99	2811.58	2806.63	2808.28	2809.72	2812.08	2811.41
8/30/91	2668.0	2668.99	2669.59	2664.63	2666.28	2667.59	2669.95	2669.28
8/31/91	2647.0	2648.11	2648.70	2643.75	2645.29	2646.50	2648.86	2648.19
9/1/91	2603.0	2602.50	2603.13	2599.39	2599.81	2600.80	2602.71	2602.04
9/2/91	2054.0	2053.50	2054.13	2050.39	2050.81	2051.76	2053.67	2053.00
9/3/91	1444.0	1443.54	1444.17	1440.43	1440.85	1440.12	1442.03	1441.36
9/4/91	2798.0	2797.54	2798.17	2794.43	2794.85	2794.76	2796.67	2796.00
9/5/91	2360.0	2359.54	2360.17	2356.43	2356.85	2356.72	2358.63	2357.96
9/6/91	2145.0	2144.54	2145.17	2141.43	2141.85	2142.34	2144.25	2143.58
9/7/91	2021.0	2020.44	2021.07	2017.33	2017.75	2018.24	2020.14	2019.47
9/8/91	1927.0	1926.44	1927.07	1923.33	1923.75	1924.25	1926.16	1925.49
9/9/91	1349.0	1348.44	1349.07	1345.33	1345.75	1346.34	1348.25	1347.58
9/10/91	786.0	785.44	786.07	782.33	782.75	783.59	785.49	784.82
9/11/91	922.0	921.45	922.08	918.34	918.76	919.57	921.48	920.80
9/12/91	774.0	773.45	774.08	770.34	770.76	771.53	773.44	772.77
9/13/91	695.0	694.45	695.08	691.34	691.48	691.98	693.89	693.22
9/14/91	580.0	579.45	580.08	576.34	576.50	577.25	579.16	578.48
9/15/91	610.0	609.45	610.08	606.34	606.61	607.35	609.26	608.59
9/16/91	610.0	609.55	610.18	606.44	603.98	604.67	606.58	605.91
9/17/91	673.0	672.44	673.07	669.33	667.14	667.82	669.73	669.06
9/18/91	684.0	683.73	684.36	680.62	678.44	677.60	679.51	678.84
9/19/91	662.0	661.29	661.92	658.18	655.99	655.73	657.64	656.97
9/20/91	684.0	683.54	684.17	680.43	678.24	677.98	679.88	679.21
9/21/91	728.0	727.45	728.08	724.34	722.15	722.48	724.39	723.72
9/22/91	728.0	727.67	728.30	724.56	722.38	722.72	724.63	723.95
9/23/91	728.0	727.67	728.30	724.56	722.38	722.71	724.62	723.95
9/24/91	717.0	716.22	716.85	713.11	710.93	711.27	713.18	712.50
9/25/91	684.0	683.54	684.18	680.44	678.25	678.89	680.80	680.13
9/26/91	673.0	672.54	673.18	669.44	667.25	667.88	669.79	669.12
9/27/91	673.0	672.46	673.09	669.35	666.89	667.52	669.43	668.76
9/28/91	662.0	661.46	662.09	658.35	655.89	656.53	658.43	657.76
9/29/91	651.0	650.58	651.21	647.47	645.01	645.65	647.56	646.89
9/30/91	620.0	619.58	620.21	616.47	614.01	614.64	616.55	615.88
10/1/91	774.0	773.58	774.26	773.28	771.50	772.11	773.28	772.60
10/2/91	728.0	727.51	728.19	727.21	725.43	726.03	727.20	726.53
10/3/91	695.0	694.51	695.19	694.21	692.43	691.51	692.68	692.01
10/4/91	706.0	705.51	706.19	705.21	703.43	703.13	704.30	703.62
10/5/91	695.0	694.58	695.26	694.27	692.50	692.21	693.37	692.70
10/6/91	684.0	683.58	684.26	683.27	681.50	681.81	682.98	682.31
10/7/91	630.0	629.58	630.26	629.27	627.50	627.82	628.98	628.31

10/8/91	620.0	619.58	620.26	619.27	617.50	617.82	618.99	618.32
10/9/91	610.0	609.52	610.20	609.22	607.44	607.76	608.93	608.26
10/10/91	610.0	609.52	610.20	609.22	607.44	608.05	609.22	608.55
10/11/91	590.0	589.52	590.20	589.22	587.44	588.04	589.21	588.54
10/12/91	662.0	661.52	662.20	661.22	659.44	660.03	661.19	660.52
10/13/91	600.0	599.64	600.32	599.33	597.73	598.31	599.48	598.81
10/14/91	531.0	530.64	531.32	530.33	528.72	529.31	530.47	529.80
10/15/91	600.0	599.64	600.32	599.33	597.73	598.32	599.49	598.82
10/16/91	728.0	727.64	728.28	727.29	727.29	727.82	727.94	727.27
10/17/91	706.0	705.64	706.28	705.29	705.29	705.87	705.99	705.32
10/18/91	706.0	705.64	706.28	705.29	705.29	703.79	703.91	703.24
10/19/91	706.0	705.59	706.23	705.25	705.25	704.35	704.46	703.79
10/20/91	684.0	683.59	684.23	683.25	683.25	682.95	683.06	682.39
10/21/91	590.0	589.59	590.23	589.25	589.25	589.54	589.66	588.99
10/22/91	522.0	521.59	522.23	521.25	521.25	521.60	521.71	521.04
10/23/91	418.0	417.59	418.23	417.25	417.25	417.64	417.75	417.08
10/24/91	370.0	369.59	370.23	369.25	369.25	369.71	369.83	369.16
10/25/91	370.0	369.66	370.29	369.31	369.31	370.20	370.32	369.64
10/26/91	363.0	362.66	363.29	362.31	362.31	363.21	363.33	362.66
10/27/91	370.0	369.66	370.29	369.31	369.31	370.13	370.24	369.57
10/28/91	370.0	369.66	370.29	369.31	369.31	370.10	370.21	369.54
10/29/91	378.0	377.66	378.29	377.31	377.31	378.09	378.21	377.53
10/30/91	378.0	377.66	378.29	377.31	377.31	378.03	378.15	377.48
10/31/91	370.0	369.66	370.29	369.31	369.31	370.10	370.22	369.55
11/1/91	386.0	385.66	386.34	385.67	385.67	385.40	385.51	384.84
11/2/91	418.0	417.66	418.35	417.67	417.67	417.49	417.61	416.94
11/3/91	434.0	433.66	434.35	433.67	433.67	433.49	433.61	432.94
11/4/91	426.0	425.66	426.35	425.67	425.67	425.49	425.61	424.94
11/5/91	426.0	425.66	426.35	425.67	425.67	425.54	425.66	424.98
11/6/91	434.0	433.66	434.35	433.67	433.67	433.54	433.66	432.98
11/7/91	410.0	409.66	410.35	409.67	409.67	409.54	409.66	408.98
11/8/91	386.0	385.66	386.35	385.67	385.67	385.54	385.66	384.98
11/9/91	386.0	385.66	386.35	385.67	385.67	385.57	385.69	385.01
11/10/91	394.0	393.66	394.35	393.67	393.67	393.57	393.69	393.01
11/11/91	418.0	417.72	418.40	417.73	417.73	417.63	417.74	417.07
11/12/91	450.0	449.72	450.40	449.73	449.73	449.63	449.74	449.07
11/13/91	450.0	449.72	450.40	449.73	449.73	449.63	449.74	449.07
11/14/91	434.0	433.72	434.40	433.73	433.73	433.63	433.75	433.07
11/15/91	426.0	425.72	426.40	425.73	425.73	425.63	425.75	425.07
11/16/91	426.0	425.72	426.40	425.73	425.73	425.63	425.75	425.07
11/17/91	426.0	425.72	426.40	425.73	425.73	425.63	425.75	425.07
11/18/91	426.0	425.72	426.40	425.73	425.73	425.63	425.75	425.07
11/19/91	442.0	441.72	442.40	441.73	441.73	441.66	441.78	441.11
11/20/91	600.0	599.72	600.40	599.73	599.73	599.66	599.78	599.11
11/21/91	550.0	549.72	550.40	549.73	549.73	549.66	549.78	549.11
11/22/91	504.0	503.72	504.40	503.73	503.73	503.66	503.78	503.11
11/23/91	486.0	485.71	486.40	485.72	485.72	485.66	485.77	485.10
11/24/91	477.0	476.71	477.40	476.72	476.72	476.66	476.77	476.10
11/25/91	662.0	661.71	662.40	661.72	661.72	661.66	661.77	661.10
11/26/91	640.0	639.71	640.40	639.72	639.72	639.66	639.78	639.10
11/27/91	590.0	589.71	590.40	589.72	589.72	589.66	589.78	589.10
11/28/91	580.0	579.71	580.40	579.72	579.72	579.66	579.78	579.10
11/29/91	600.0	599.71	600.40	599.72	599.72	599.66	599.78	599.10
11/30/91	550.0	549.71	550.40	549.72	549.72	549.66	549.78	549.10
12/1/91	550.0	549.71	550.38	549.69	549.69	549.62	549.74	549.07
12/2/91	600.0	599.71	600.38	599.69	599.69	599.62	599.74	599.07
12/3/91	590.0	589.71	590.38	589.69	589.69	589.65	589.76	589.09
12/4/91	600.0	599.71	600.38	599.69	599.69	599.65	599.76	599.09
12/5/91	774.0	773.71	774.38	773.69	773.69	773.65	773.76	773.09
12/6/91	1014.0	1013.74	1014.42	1013.72	1013.72	1013.68	1013.79	1013.12
12/7/91	1484.0	1483.74	1484.42	1483.72	1483.72	1483.68	1483.79	1483.12
12/8/91	1402.0	1401.74	1402.42	1401.72	1401.72	1401.68	1401.79	1401.12
12/9/91	1434.0	1433.74	1434.42	1433.72	1433.72	1433.68	1433.79	1433.12

12/10/91	1434.0	1433.74	1434.42	1433.72	1433.72	1433.68	1433.79	1433.12
12/11/91	1290.0	1289.74	1290.42	1289.72	1289.72	1289.68	1289.79	1289.12
12/12/91	1501.0	1500.74	1501.42	1500.72	1500.72	1500.68	1500.79	1500.12
12/13/91	1484.0	1483.74	1484.42	1483.72	1483.72	1483.69	1483.80	1483.13
12/14/91	1140.0	1139.74	1140.42	1139.72	1139.72	1139.69	1139.80	1139.13
12/15/91	1005.0	1004.74	1005.41	1004.72	1004.72	1004.69	1004.80	1004.13
12/16/91	918.0	917.74	918.41	917.72	917.72	917.69	917.80	917.13
12/17/91	858.0	857.74	858.41	857.72	857.72	857.69	857.80	857.13
12/18/91	814.0	813.74	814.41	813.72	813.72	813.69	813.80	813.13
12/19/91	782.0	781.74	782.41	781.72	781.72	781.69	781.80	781.13
12/20/91	750.0	749.74	750.41	749.72	749.72	749.69	749.80	749.13
12/21/91	717.0	716.74	717.41	716.72	716.72	716.69	716.80	716.13
12/22/91	684.0	683.78	684.45	683.75	683.75	683.72	683.83	683.16
12/23/91	651.0	650.78	651.45	650.75	650.75	650.72	650.83	650.16
12/24/91	640.0	639.78	640.45	639.75	639.75	639.73	639.84	639.17
12/25/91	620.0	619.78	620.45	619.75	619.75	619.73	619.84	619.17
12/26/91	600.0	599.78	600.45	599.75	599.75	599.73	599.84	599.17
12/27/91	580.0	579.78	580.45	579.75	579.75	579.73	579.84	579.17
12/28/91	570.0	569.78	570.45	569.75	569.75	569.73	569.84	569.17
12/29/91	560.0	559.78	560.45	559.75	559.75	559.73	559.84	559.17
12/30/91	550.0	549.78	550.45	549.75	549.75	549.73	549.84	549.17
12/31/91	531.0	530.78	531.45	530.75	530.75	530.73	530.84	530.17
1/1/92	522.0	521.78	522.43	521.76	521.76	521.74	521.85	521.18
1/2/92	522.0	521.78	522.43	521.76	521.76	521.74	521.85	521.18
1/3/92	513.0	512.78	513.43	512.76	512.76	512.74	512.85	512.18
1/4/92	504.0	503.78	504.43	503.76	503.76	503.74	503.85	503.18
1/5/92	495.0	494.78	495.43	494.76	494.76	494.74	494.85	494.18
1/6/92	486.0	485.78	486.43	485.76	485.76	485.74	485.86	485.19
1/7/92	468.0	467.78	468.43	467.76	467.76	467.74	467.86	467.19
1/8/92	450.0	449.78	450.43	449.76	449.76	449.74	449.86	449.19
1/9/92	442.0	441.78	442.43	441.76	441.76	441.74	441.86	441.19
1/10/92	442.0	441.78	442.43	441.76	441.76	441.74	441.86	441.19
1/11/92	450.0	449.79	450.44	449.78	449.78	449.76	449.87	449.20
1/12/92	418.0	417.79	418.44	417.78	417.78	417.76	417.87	417.20
1/13/92	442.0	441.79	442.44	441.78	441.78	441.76	441.87	441.20
1/14/92	442.0	441.79	442.44	441.78	441.78	441.76	441.87	441.20
1/15/92	434.0	433.79	434.44	433.78	433.78	433.76	433.87	433.20
1/16/92	513.0	512.79	513.44	512.78	512.78	512.76	512.87	512.20
1/17/92	580.0	579.79	580.44	579.78	579.78	579.76	579.87	579.20
1/18/92	531.0	530.79	531.44	530.78	530.78	530.76	530.87	530.20
1/19/92	513.0	512.79	513.44	512.78	512.78	512.76	512.87	512.20
1/20/92	495.0	494.79	495.44	494.78	494.78	494.76	494.87	494.20
1/21/92	495.0	494.79	495.44	494.78	494.78	494.76	494.87	494.20
1/22/92	477.0	476.79	477.44	476.78	476.78	476.76	476.88	476.21
1/23/92	580.0	579.79	580.44	579.78	579.78	579.76	579.88	579.21
1/24/92	1053.0	1052.79	1053.44	1052.78	1052.78	1052.76	1052.88	1052.21
1/25/92	1149.0	1148.79	1149.44	1148.78	1148.78	1148.76	1148.88	1148.21
1/26/92	1132.0	1131.79	1132.44	1131.78	1131.78	1131.76	1131.88	1131.21
1/27/92	1073.0	1072.79	1073.44	1072.78	1072.78	1072.76	1072.88	1072.21
1/28/92	1230.0	1229.79	1230.44	1229.78	1229.78	1229.76	1229.88	1229.21
1/29/92	1583.0	1582.79	1583.44	1582.78	1582.78	1582.76	1582.88	1582.21
1/30/92	1686.0	1685.79	1686.44	1685.78	1685.78	1685.76	1685.88	1685.21
1/31/92	1700.0	1699.79	1700.44	1699.78	1699.78	1699.76	1699.88	1699.21
2/1/92	1607.0	1606.79	1607.50	1606.81	1606.81	1606.79	1606.91	1606.24
2/2/92	1451.0	1450.79	1451.50	1450.81	1450.81	1450.79	1450.91	1450.24
2/3/92	1288.0	1287.82	1288.53	1287.83	1287.83	1287.82	1287.94	1287.26
2/4/92	1079.0	1078.82	1079.53	1078.83	1078.83	1078.82	1078.94	1078.26
2/5/92	954.0	953.82	954.53	953.83	953.83	953.82	953.94	953.26
2/6/92	861.0	860.82	861.53	860.83	860.83	860.82	860.94	860.26
2/7/92	799.0	798.82	799.53	798.83	798.83	798.82	798.94	798.26
2/8/92	738.0	737.82	738.53	737.83	737.83	737.82	737.94	737.26
2/9/92	703.0	702.82	703.53	702.83	702.83	702.82	702.94	702.26
2/10/92	657.0	656.82	657.53	656.83	656.83	656.82	656.94	656.26

2/11/92	709.0	708.82	709.53	708.83	708.83	708.82	708.94	708.27
2/12/92	718.0	717.82	718.53	717.83	717.83	717.82	717.94	717.27
2/13/92	716.0	715.82	716.53	715.83	715.83	715.82	715.94	715.27
2/14/92	703.0	702.82	703.53	702.83	702.83	702.82	702.94	702.27
2/15/92	723.0	722.82	723.53	722.83	722.83	722.82	722.94	722.27
2/16/92	710.0	709.82	710.53	709.83	709.83	709.82	709.94	709.27
2/17/92	686.0	685.82	686.53	685.83	685.83	685.82	685.94	685.27
2/18/92	684.0	683.82	684.53	683.83	683.83	683.82	683.94	683.27
2/19/92	681.0	680.82	681.53	680.83	680.83	680.82	680.94	680.27
2/20/92	657.0	656.82	657.53	656.83	656.83	656.82	656.94	656.27
2/21/92	677.0	676.82	677.53	676.83	676.83	676.82	676.94	676.27
2/22/92	800.0	799.82	800.53	799.83	799.83	799.82	799.94	799.27
2/23/92	858.0	857.82	858.53	857.83	857.83	857.82	857.94	857.27
2/24/92	856.0	855.82	856.53	855.83	855.83	855.82	855.94	855.27
2/25/92	769.0	768.82	769.53	768.83	768.83	768.82	768.94	768.27
2/26/92	767.0	766.82	767.53	766.83	766.83	766.82	766.94	766.27
2/27/92	813.0	812.82	813.53	812.83	812.83	812.82	812.94	812.27
2/28/92	834.0	833.82	834.53	833.83	833.83	833.82	833.94	833.27
2/29/92	820.0	819.82	820.53	819.83	819.83	819.82	819.94	819.27
3/1/92	794.0	793.82	794.46	793.79	793.79	793.78	793.90	793.23
3/2/92	767.0	766.84	767.48	766.82	766.82	766.81	766.92	766.25
3/3/92	753.0	752.84	753.48	752.82	752.82	752.81	752.92	752.25
3/4/92	763.0	762.84	763.48	762.82	762.82	762.81	762.92	762.25
3/5/92	760.0	759.84	760.48	759.82	759.82	759.81	759.92	759.25
3/6/92	758.0	757.84	758.48	757.82	757.82	757.81	757.92	757.25
3/7/92	744.0	743.84	744.48	743.82	743.82	743.81	743.92	743.25
3/8/92	742.0	741.84	742.48	741.82	741.82	741.81	741.92	741.25
3/9/92	729.0	728.84	729.48	728.82	728.82	728.81	728.92	728.25
3/10/92	785.0	784.84	785.48	784.82	784.82	784.81	784.92	784.25
3/11/92	794.0	793.84	794.48	793.82	793.82	793.81	793.92	793.25
3/12/92	804.0	803.84	804.48	803.82	803.82	803.81	803.92	803.25
3/13/92	826.0	825.84	826.48	825.82	825.82	825.81	825.92	825.25
3/14/92	897.0	896.84	897.48	896.82	896.82	896.81	896.92	896.25
3/15/92	999.0	998.84	999.48	998.82	998.82	998.81	998.92	998.25
3/16/92	1038.0	1037.84	1038.48	1037.82	1037.82	1037.81	1037.92	1037.25
3/17/92	903.0	902.84	903.48	902.82	902.82	902.81	902.92	902.25
3/18/92	826.0	825.84	826.48	825.82	825.82	825.81	825.92	825.25
3/19/92	764.0	763.84	764.48	763.82	763.82	763.81	763.92	763.25
3/20/92	797.0	796.84	797.48	796.82	796.82	796.81	796.92	796.25
3/21/92	795.0	794.84	795.48	794.82	794.82	794.81	794.92	794.25
3/22/92	757.0	756.84	757.48	756.82	756.82	756.81	756.92	756.25
3/23/92	732.0	731.84	732.48	731.82	731.82	731.81	731.92	731.25
3/24/92	708.0	707.84	708.48	707.82	707.82	707.81	707.92	707.25
3/25/92	706.0	705.84	706.48	705.82	705.82	705.81	705.92	705.25
3/26/92	704.0	703.84	704.48	703.82	703.82	703.81	703.92	703.25
3/27/92	724.0	723.84	724.48	723.82	723.82	723.81	723.92	723.25
3/28/92	721.0	720.84	721.48	720.82	720.82	720.81	720.92	720.25
3/29/92	686.0	685.84	686.48	685.82	685.82	685.81	685.92	685.25
3/30/92	600.0	599.84	600.48	599.82	599.82	599.81	599.92	599.25
3/31/92	425.0	424.84	425.48	424.82	424.82	424.81	424.92	424.25
4/1/92	367.0	366.84	367.46	366.53	366.53	369.39	370.78	370.21
4/2/92	373.0	372.84	373.46	372.53	372.53	375.25	376.64	376.07
4/3/92	396.0	395.84	396.46	395.53	395.53	397.97	399.36	398.79
4/4/92	560.0	559.84	560.46	559.53	559.53	562.11	563.50	562.93
4/5/92	715.0	714.86	715.47	714.54	714.54	717.12	718.51	717.95
4/6/92	702.0	701.87	702.49	701.56	701.56	704.28	705.67	705.10
4/7/92	1062.0	1061.87	1062.49	1061.56	1061.56	1064.28	1065.67	1065.10
4/8/92	1116.0	1115.87	1116.49	1115.56	1115.56	1118.27	1119.67	1119.10
4/9/92	1419.0	1418.87	1419.49	1418.56	1418.56	1421.27	1422.66	1422.10
4/10/92	1567.0	1566.87	1567.49	1566.56	1566.56	1569.35	1570.74	1570.17
4/11/92	1547.0	1546.87	1547.49	1546.56	1546.56	1549.35	1550.74	1550.17
4/12/92	1509.0	1508.87	1509.49	1508.56	1508.56	1511.34	1512.73	1512.17
4/13/92	1455.0	1454.87	1455.49	1454.56	1454.56	1457.34	1458.73	1458.17

4/14/92	1436.0	1435.87	1436.49	1435.56	1435.56	1438.34	1439.73	1439.17
4/15/92	1798.0	1797.87	1798.49	1797.56	1797.56	1800.34	1801.73	1801.17
4/16/92	1854.0	1853.87	1854.49	1853.56	1853.56	1856.34	1857.73	1857.16
4/17/92	2074.0	2073.87	2074.49	2073.56	2073.56	2076.34	2077.73	2077.16
4/18/92	1987.0	1986.87	1987.49	1986.56	1986.56	1988.94	1990.33	1989.76
4/19/92	1503.0	1502.87	1503.49	1502.56	1502.56	1505.09	1506.48	1505.92
4/20/92	1289.0	1288.87	1289.49	1288.56	1288.56	1291.09	1292.48	1291.91
4/21/92	996.0	995.87	996.49	995.56	995.56	998.25	999.64	999.08
4/22/92	1050.0	1049.87	1050.49	1049.56	1049.56	1052.25	1053.64	1053.07
4/23/92	1644.0	1643.87	1644.49	1643.56	1643.56	1646.25	1647.64	1647.07
4/24/92	1883.0	1882.87	1883.49	1882.56	1882.56	1885.24	1886.63	1886.07
4/25/92	1781.0	1780.87	1781.49	1780.56	1780.56	1783.33	1784.72	1784.15
4/26/92	1796.0	1795.87	1796.49	1795.56	1795.56	1798.33	1799.72	1799.15
4/27/92	1738.0	1737.87	1738.49	1737.56	1737.56	1740.33	1741.72	1741.15
4/28/92	1717.0	1716.87	1717.49	1716.56	1716.56	1719.33	1720.72	1720.15
4/29/92	1572.0	1571.87	1572.49	1571.56	1571.56	1574.32	1575.71	1575.15
4/30/92	1386.0	1385.87	1386.49	1385.56	1385.56	1388.32	1389.71	1389.15
5/1/92	1138.0	1138.99	1139.57	1138.26	1141.82	1147.25	1149.32	1148.75
5/2/92	1108.0	1109.01	1109.58	1108.27	1111.84	1117.27	1119.33	1118.77
5/3/92	1063.0	1064.01	1064.58	1063.27	1066.83	1071.76	1073.83	1073.26
5/4/92	1005.0	1006.00	1006.57	1005.26	1008.82	1013.95	1016.01	1015.45
5/5/92	1003.0	1003.98	1004.56	1003.24	1006.81	1011.92	1013.99	1013.42
5/6/92	1029.0	1029.97	1030.54	1029.23	1032.79	1038.11	1040.18	1039.61
5/7/92	1069.0	1069.97	1070.54	1069.23	1072.80	1078.11	1080.17	1079.61
5/8/92	1136.0	1136.99	1137.56	1136.25	1139.81	1145.12	1147.19	1146.62
5/9/92	1120.0	1121.01	1121.59	1120.27	1123.84	1129.14	1131.20	1130.64
5/10/92	1251.0	1252.14	1252.71	1251.40	1254.96	1260.38	1262.44	1261.88
5/11/92	1733.0	1734.16	1734.73	1733.42	1736.99	1742.40	1744.46	1743.90
5/12/92	2191.0	2192.16	2192.74	2191.42	2194.99	2200.40	2202.46	2201.90
5/13/92	2475.0	2476.17	2476.74	2475.43	2478.99	2484.40	2486.47	2485.90
5/14/92	2895.0	2896.17	2896.74	2895.43	2898.99	2904.40	2906.46	2905.90
5/15/92	3041.0	3042.16	3042.74	3041.42	3044.99	3050.39	3052.46	3051.89
5/16/92	3012.0	3013.11	3013.69	3012.37	3015.94	3021.34	3023.40	3022.83
5/17/92	3033.0	3034.10	3034.67	3033.36	3036.92	3042.32	3044.39	3043.82
5/18/92	3104.0	3105.09	3105.66	3104.35	3107.92	3112.63	3114.70	3114.13
5/19/92	3050.0	3051.19	3051.76	3050.45	3054.01	3058.99	3061.06	3060.49
5/20/92	2993.0	2994.11	2994.69	2993.37	2996.94	3001.91	3003.97	3003.41
5/21/92	2961.0	2962.11	2962.69	2961.37	2964.94	2970.19	2972.25	2971.69
5/22/92	2955.0	2956.10	2956.68	2955.36	2958.93	2964.17	2966.24	2965.67
5/23/92	2948.0	2949.29	2949.86	2948.55	2952.11	2957.35	2959.41	2958.85
5/24/92	2891.0	2892.36	2892.94	2891.62	2895.19	2900.57	2902.63	2902.07
5/25/92	2741.0	2742.36	2742.93	2741.62	2745.18	2750.56	2752.63	2752.06
5/26/92	2639.0	2640.52	2641.10	2639.78	2643.35	2648.57	2650.64	2650.07
5/27/92	2541.0	2542.31	2542.89	2541.57	2545.14	2550.51	2552.58	2552.01
5/28/92	2769.0	2770.39	2770.96	2769.65	2773.22	2778.59	2780.65	2780.09
5/29/92	2859.0	2860.42	2861.00	2859.68	2863.25	2868.67	2870.73	2870.17
5/30/92	2804.0	2805.34	2805.91	2804.60	2808.16	2813.58	2815.65	2815.08
5/31/92	2701.0	2702.48	2703.06	2701.74	2703.12	2708.35	2710.41	2709.85
6/1/92	2719.0	2720.71	2721.34	2717.08	2718.66	2723.90	2726.11	2725.54
6/2/92	3030.0	3031.99	3032.63	3028.37	3029.95	3035.06	3037.27	3036.71
6/3/92	3356.0	3357.71	3358.34	3354.08	3355.67	3359.67	3361.88	3361.31
6/4/92	3245.0	3246.84	3247.47	3243.21	3244.79	3248.96	3251.18	3250.61
6/5/92	3237.0	3238.99	3239.62	3235.36	3236.94	3241.02	3243.23	3242.67
6/6/92	3553.0	3554.68	3555.32	3551.06	3552.64	3556.98	3559.19	3558.62
6/7/92	3685.0	3686.73	3687.36	3683.10	3684.68	3688.96	3691.17	3690.61
6/8/92	3509.0	3510.79	3511.42	3507.16	3508.75	3512.96	3515.17	3514.61
6/9/92	3287.0	3289.15	3289.78	3285.52	3287.10	3291.18	3293.39	3292.83
6/10/92	3332.0	3333.79	3334.43	3330.17	3331.75	3335.90	3338.11	3337.54
6/11/92	3358.0	3359.94	3360.57	3356.31	3357.89	3361.93	3364.15	3363.58
6/12/92	3332.0	3334.12	3334.75	3330.49	3332.08	3336.57	3338.78	3338.22
6/13/92	3125.0	3126.64	3127.19	3122.93	3124.51	3128.99	3131.20	3130.64
6/14/92	3075.0	3076.70	3077.25	3072.99	3074.57	3078.76	3080.97	3080.40
6/15/92	3150.0	3151.75	3152.30	3148.04	3149.62	3153.54	3155.75	3155.18

6/16/92	2950.0	2952.14	2952.69	2948.43	2950.01	2953.88	2956.09	2955.53
6/17/92	2828.0	2829.75	2830.30	2826.04	2827.62	2831.50	2833.71	2833.15
6/18/92	2828.0	2829.88	2830.43	2826.17	2827.76	2830.46	2832.67	2832.10
6/19/92	2975.0	2977.16	2977.71	2973.45	2975.04	2978.08	2980.29	2979.72
6/20/92	3100.0	3101.70	3102.26	3098.00	3099.58	3102.52	3104.73	3104.16
6/21/92	3202.0	3203.70	3204.25	3199.99	3201.57	3204.52	3206.73	3206.16
6/22/92	3384.0	3385.67	3386.23	3381.97	3383.55	3385.91	3388.12	3387.56
6/23/92	3438.0	3439.90	3440.46	3436.20	3437.78	3439.67	3441.88	3441.32
6/24/92	3522.0	3523.75	3524.30	3520.04	3521.62	3523.19	3525.40	3524.83
6/25/92	3662.0	3663.89	3664.44	3660.18	3661.76	3663.50	3665.71	3665.14
6/26/92	3690.0	3692.00	3692.55	3688.29	3689.87	3691.55	3693.76	3693.20
6/27/92	3720.0	3721.66	3722.21	3717.95	3719.53	3721.17	3723.38	3722.82
6/28/92	3662.0	3663.78	3664.33	3660.07	3661.65	3663.28	3665.49	3664.92
6/29/92	3522.0	3523.81	3524.36	3520.10	3521.68	3525.24	3527.46	3526.89
6/30/92	3306.0	3308.14	3308.69	3304.43	3306.01	3308.10	3310.31	3309.75
7/1/92	3254.0	3255.83	3256.42	3250.05	3251.58	3253.28	3255.84	3255.28
7/2/92	3550.0	3551.98	3552.56	3546.19	3547.72	3549.38	3551.94	3551.37
7/3/92	3438.0	3440.15	3440.74	3434.37	3435.90	3436.25	3438.81	3438.24
7/4/92	3254.0	3255.67	3256.25	3249.89	3251.41	3252.76	3255.32	3254.75
7/5/92	3202.0	3203.36	3203.95	3197.58	3199.11	3202.01	3204.57	3204.01
7/6/92	3176.0	3177.47	3178.05	3171.69	3173.21	3175.02	3177.58	3177.01
7/7/92	3125.0	3126.24	3126.82	3120.46	3121.98	3123.47	3126.03	3125.46
7/8/92	3125.0	3126.25	3126.83	3120.47	3121.99	3123.37	3125.93	3125.36
7/9/92	3332.0	3333.26	3333.84	3327.47	3329.00	3330.28	3332.84	3332.27
7/10/92	3466.0	3467.26	3467.85	3461.48	3463.01	3464.56	3467.11	3466.55
7/11/92	3578.0	3579.27	3579.85	3573.48	3575.01	3576.52	3579.08	3578.51
7/12/92	3410.0	3411.27	3411.85	3405.49	3407.01	3408.40	3410.96	3410.39
7/13/92	3228.0	3229.17	3229.76	3223.39	3224.49	3225.79	3228.34	3227.78
7/14/92	3176.0	3177.17	3177.76	3171.39	3172.49	3173.69	3176.25	3175.68
7/15/92	3332.0	3333.17	3333.76	3327.39	3328.49	3329.64	3332.19	3331.63
7/16/92	3438.0	3439.25	3439.83	3433.46	3434.56	3435.61	3438.17	3437.61
7/17/92	3466.0	3467.13	3467.71	3461.35	3462.45	3463.44	3465.99	3465.43
7/18/92	3494.0	3495.10	3495.68	3489.32	3490.42	3489.79	3492.35	3491.78
7/19/92	3438.0	3439.26	3439.84	3433.47	3434.57	3434.53	3437.09	3436.52
7/20/92	3522.0	3523.19	3523.77	3517.40	3518.50	3518.55	3521.10	3520.54
7/21/92	3494.0	3495.12	3495.70	3489.34	3490.43	3491.14	3493.70	3493.14
7/22/92	3438.0	3439.03	3439.61	3433.24	3434.34	3435.22	3437.78	3437.21
7/23/92	3202.0	3203.22	3203.80	3197.43	3198.71	3199.91	3202.47	3201.91
7/24/92	2852.0	2853.22	2853.80	2847.43	2848.96	2850.47	2853.03	2852.46
7/25/92	2876.0	2877.15	2877.73	2871.37	2872.68	2874.02	2876.58	2876.01
7/26/92	3000.0	3001.15	3001.73	2995.37	2996.65	2997.59	3000.15	2999.59
7/27/92	3000.0	3001.07	3001.65	2995.28	2996.38	2997.52	3000.08	2999.51
7/28/92	3125.0	3126.07	3126.65	3120.28	3121.38	3122.44	3125.00	3124.43
7/29/92	3176.0	3176.96	3177.55	3171.18	3172.28	3173.39	3175.95	3175.38
7/30/92	3254.0	3254.97	3255.55	3249.18	3250.28	3251.35	3253.91	3253.34
7/31/92	3332.0	3333.06	3333.64	3327.28	3328.34	3329.34	3331.90	3331.34
8/1/92	3662.0	3663.13	3663.73	3658.77	3659.87	3660.71	3663.07	3662.51
8/2/92	3900.0	3901.13	3901.73	3896.77	3897.87	3898.66	3901.02	3900.45
8/3/92	3840.0	3841.17	3841.77	3836.81	3837.91	3837.15	3839.51	3838.95
8/4/92	3606.0	3607.17	3607.77	3602.81	3603.91	3603.76	3606.12	3605.56
8/5/92	3384.0	3385.16	3385.75	3380.80	3381.90	3381.76	3384.12	3383.56
8/6/92	3438.0	3439.16	3439.75	3434.80	3435.90	3436.41	3438.77	3438.21
8/7/92	3466.0	3467.07	3467.66	3462.70	3463.81	3464.44	3466.80	3466.23
8/8/92	3438.0	3439.07	3439.66	3434.70	3435.81	3436.44	3438.80	3438.24
8/9/92	3306.0	3307.07	3307.66	3302.70	3303.81	3304.37	3306.73	3306.17
8/10/92	3202.0	3203.07	3203.66	3198.71	3199.81	3200.63	3202.99	3202.42
8/11/92	3075.0	3076.08	3076.67	3071.72	3072.19	3072.94	3075.30	3074.73
8/12/92	3100.0	3101.08	3101.67	3096.71	3097.45	3098.16	3100.52	3099.96
8/13/92	3100.0	3100.79	3101.38	3096.42	3097.16	3097.83	3100.19	3099.63
8/14/92	3100.0	3100.46	3101.05	3096.10	3096.84	3097.48	3099.84	3099.28
8/15/92	3100.0	3100.33	3100.92	3095.97	3096.71	3097.34	3099.70	3099.13
8/16/92	3100.0	3100.26	3100.85	3095.89	3096.63	3097.25	3099.61	3099.05
8/17/92	3100.0	3100.01	3100.61	3095.65	3096.39	3097.00	3099.36	3098.79

8/18/92	3075.0	3074.49	3075.08	3070.12	3070.87	3070.02	3072.38	3071.82
8/19/92	3050.0	3049.67	3050.26	3045.30	3046.04	3045.68	3048.04	3047.48
8/20/92	3025.0	3024.59	3025.18	3020.22	3020.96	3020.59	3022.95	3022.38
8/21/92	3025.0	3024.51	3025.10	3020.14	3020.88	3021.09	3023.45	3022.88
8/22/92	3000.0	2999.41	3000.00	2995.04	2995.67	2995.90	2998.26	2997.69
8/23/92	2900.0	2899.65	2900.24	2895.28	2895.76	2896.01	2898.37	2897.80
8/24/92	2756.0	2755.65	2756.24	2751.28	2751.89	2752.44	2754.80	2754.24
8/25/92	2660.0	2659.57	2660.16	2655.20	2655.83	2656.35	2658.71	2658.15
8/26/92	2499.0	2498.57	2499.16	2494.20	2494.94	2495.17	2497.53	2496.96
8/27/92	1980.0	1979.47	1980.06	1975.11	1975.85	1976.32	1978.68	1978.12
8/28/92	1535.0	1534.47	1535.06	1530.10	1530.84	1531.31	1533.67	1533.10
8/29/92	1322.0	1321.35	1321.94	1316.98	1317.73	1318.26	1320.62	1320.05
8/30/92	1402.0	1401.35	1401.94	1396.98	1397.72	1398.26	1400.62	1400.05
8/31/92	1407.0	1406.47	1407.07	1402.11	1402.82	1403.38	1405.74	1405.17
9/1/92	1331.0	1330.47	1331.11	1327.36	1327.03	1327.45	1329.36	1328.80
9/2/92	1320.0	1319.47	1320.11	1316.36	1316.03	1316.46	1318.36	1317.80
9/3/92	1373.0	1372.52	1373.15	1369.41	1369.08	1368.21	1370.12	1369.56
9/4/92	1252.0	1251.52	1252.15	1248.41	1248.08	1247.73	1249.64	1249.07
9/5/92	984.0	983.52	984.15	980.41	980.08	979.79	981.70	981.13
9/6/92	896.0	895.52	896.15	892.41	892.08	892.32	894.23	893.66
9/7/92	826.0	825.41	826.04	822.30	821.97	822.21	824.12	823.56
9/8/92	793.0	792.41	793.04	789.30	789.64	790.14	792.05	791.49
9/9/92	639.0	638.41	639.04	635.30	635.64	636.25	638.16	637.60
9/10/92	380.0	379.41	380.04	376.30	376.80	377.50	379.41	378.84
9/11/92	430.0	429.42	430.05	426.31	426.45	427.08	428.99	428.42
9/12/92	432.0	431.42	432.05	428.31	428.37	428.93	430.84	430.28
9/13/92	435.0	434.42	435.05	431.31	431.37	431.92	433.83	433.26
9/14/92	421.0	420.42	421.05	417.31	417.37	417.98	419.88	419.32
9/15/92	423.0	422.42	423.05	419.31	419.37	419.99	421.90	421.34
9/16/92	425.0	424.53	425.16	421.42	419.67	420.28	422.18	421.62
9/17/92	428.0	427.41	428.04	424.30	422.55	423.12	425.03	424.46
9/18/92	430.0	429.72	430.35	426.61	424.86	424.29	426.20	425.64
9/19/92	448.0	447.25	447.88	444.14	442.39	442.24	444.14	443.58
9/20/92	469.0	468.52	469.15	465.41	463.66	463.48	465.39	464.83
9/21/92	462.0	461.42	462.05	458.31	456.56	456.93	458.84	458.27
9/22/92	439.0	438.66	439.29	435.55	433.80	434.16	436.07	435.51
9/23/92	442.0	441.66	442.29	438.55	436.80	437.14	439.05	438.49
9/24/92	488.0	487.18	487.81	484.07	482.32	483.18	485.09	484.52
9/25/92	527.0	526.52	527.15	523.41	521.66	524.68	526.59	526.02
9/26/92	485.0	484.52	485.15	481.41	479.66	481.30	483.20	482.64
9/27/92	487.0	486.43	487.07	483.32	481.58	482.91	484.82	484.25
9/28/92	490.0	489.43	490.07	486.32	484.58	485.72	487.63	487.06
9/29/92	492.0	491.56	492.19	488.45	486.70	487.74	489.65	489.09
9/30/92	513.0	512.56	513.19	509.45	507.70	508.70	510.61	510.04
10/1/92	504.0	503.56	504.24	503.26	502.15	503.05	504.22	503.65
10/2/92	462.0	461.49	462.17	461.18	460.08	460.95	462.12	461.55
10/3/92	464.0	463.49	464.17	463.18	462.08	461.78	462.95	462.39
10/4/92	467.0	466.49	467.17	466.18	465.08	465.23	466.40	465.83
10/5/92	451.0	450.56	451.24	450.25	449.15	449.29	450.45	449.89
10/6/92	481.0	480.56	481.24	480.25	479.15	479.74	480.91	480.35
10/7/92	483.0	482.56	483.24	482.25	481.14	481.74	482.90	482.34
10/8/92	477.0	476.56	477.24	476.25	474.73	475.32	476.48	475.92
10/9/92	471.0	470.50	471.18	470.19	468.67	469.22	470.39	469.83
10/10/92	491.0	490.50	491.18	490.19	488.81	489.55	490.72	490.15
10/11/92	494.0	493.50	494.18	493.19	492.03	492.75	493.92	493.35
10/12/92	496.0	495.50	496.18	495.19	494.08	494.80	495.97	495.41
10/13/92	490.0	489.62	490.30	489.32	488.21	488.95	490.12	489.55
10/14/92	483.0	482.62	483.30	482.32	481.21	481.93	483.10	482.53
10/15/92	477.0	476.62	477.30	476.32	475.21	475.95	477.12	476.56
10/16/92	246.0	245.62	246.26	245.27	245.27	245.93	246.05	245.48
10/17/92	230.0	229.62	230.26	229.27	229.27	230.00	230.12	229.55
10/18/92	230.0	229.62	230.26	229.27	229.27	228.42	228.54	227.97
10/19/92	220.0	219.57	220.21	219.23	219.23	218.91	219.02	218.45

10/20/92	215.0	214.57	215.21	214.23	214.23	214.42	214.53	213.97
10/21/92	210.0	209.57	210.21	209.23	209.23	209.84	209.96	209.39
10/22/92	220.0	219.57	220.21	219.23	219.23	219.86	219.98	219.41
10/23/92	276.0	275.57	276.21	275.23	275.23	275.84	275.96	275.39
10/24/92	282.0	281.57	282.21	281.23	281.23	281.82	281.93	281.37
10/25/92	288.0	287.64	288.28	287.29	287.29	288.05	288.17	287.60
10/26/92	300.0	299.64	300.28	299.29	299.29	300.03	300.15	299.58
10/27/92	294.0	293.64	294.28	293.29	293.29	294.04	294.15	293.59
10/28/92	294.0	293.64	294.28	293.29	293.29	294.03	294.15	293.58
10/29/92	282.0	281.64	282.28	281.29	281.29	282.13	282.25	281.68
10/30/92	240.0	239.64	240.28	239.29	239.29	240.24	240.35	239.78
10/31/92	225.0	224.64	225.28	224.29	224.29	225.31	225.43	224.86
11/1/92	246.0	245.64	246.32	245.65	245.65	245.44	245.56	244.99
11/2/92	307.0	306.64	307.33	306.65	306.65	306.52	306.63	306.07
11/3/92	335.0	334.64	335.33	334.65	334.65	334.52	334.63	334.07
11/4/92	356.0	355.64	356.33	355.65	355.65	355.52	355.63	355.07
11/5/92	342.0	341.64	342.33	341.65	341.65	341.55	341.67	341.10
11/6/92	335.0	334.64	335.33	334.65	334.65	334.55	334.67	334.10
11/7/92	342.0	341.64	342.33	341.65	341.65	341.55	341.67	341.10
11/8/92	426.0	425.64	426.33	425.65	425.65	425.55	425.67	425.10
11/9/92	459.0	458.64	459.33	458.65	458.65	458.58	458.69	458.13
11/10/92	459.0	458.64	459.33	458.65	458.65	458.58	458.69	458.13
11/11/92	459.0	458.70	459.39	458.71	458.71	458.64	458.75	458.18
11/12/92	513.0	512.70	513.39	512.71	512.71	512.64	512.75	512.18
11/13/92	477.0	476.70	477.39	476.71	476.71	476.64	476.75	476.18
11/14/92	349.0	348.70	349.39	348.71	348.71	348.64	348.75	348.19
11/15/92	402.0	401.70	402.39	401.71	401.71	401.64	401.75	401.19
11/16/92	402.0	401.70	402.39	401.71	401.71	401.64	401.75	401.19
11/17/92	394.0	393.70	394.39	393.71	393.71	393.64	393.75	393.19
11/18/92	410.0	409.70	410.39	409.71	409.71	409.64	409.75	409.19
11/19/92	442.0	441.70	442.39	441.71	441.71	441.66	441.78	441.21
11/20/92	459.0	458.70	459.39	458.71	458.71	458.66	458.78	458.21
11/21/92	477.0	476.70	477.39	476.71	476.71	476.66	476.78	476.21
11/22/92	504.0	503.70	504.39	503.71	503.71	503.66	503.78	503.21
11/23/92	495.0	494.69	495.38	494.71	494.71	494.66	494.77	494.21
11/24/92	342.0	341.69	342.38	341.71	341.71	341.66	341.77	341.21
11/25/92	356.0	355.69	356.38	355.71	355.71	355.66	355.77	355.21
11/26/92	418.0	417.69	418.38	417.71	417.71	417.66	417.77	417.21
11/27/92	394.0	393.69	394.38	393.71	393.71	393.66	393.77	393.21
11/28/92	394.0	393.69	394.38	393.71	393.71	393.66	393.77	393.21
11/29/92	386.0	385.69	386.38	385.71	385.71	385.66	385.77	385.21
11/30/92	426.0	425.69	426.38	425.71	425.71	425.66	425.77	425.21
12/1/92	426.0	425.69	426.37	425.67	425.67	425.62	425.74	425.17
12/2/92	394.0	393.69	394.37	393.67	393.67	393.62	393.74	393.17
12/3/92	370.0	369.69	370.37	369.67	369.67	369.64	369.75	369.19
12/4/92	386.0	385.69	386.37	385.67	385.67	385.64	385.75	385.19
12/5/92	442.0	441.69	442.37	441.67	441.67	441.64	441.75	441.19
12/6/92	378.0	377.73	378.40	377.70	377.70	377.67	377.79	377.22
12/7/92	378.0	377.73	378.40	377.70	377.70	377.67	377.79	377.22
12/8/92	363.0	362.73	363.40	362.70	362.70	362.67	362.79	362.22
12/9/92	356.0	355.73	356.40	355.70	355.70	355.67	355.79	355.22
12/10/92	363.0	362.73	363.40	362.70	362.70	362.67	362.79	362.22
12/11/92	342.0	341.73	342.40	341.70	341.70	341.67	341.79	341.22
12/12/92	335.0	334.73	335.40	334.70	334.70	334.67	334.79	334.22
12/13/92	328.0	327.73	328.40	327.70	327.70	327.68	327.79	327.23
12/14/92	356.0	355.73	356.40	355.70	355.70	355.68	355.79	355.23
12/15/92	477.0	476.73	477.40	476.70	476.70	476.68	476.79	476.23
12/16/92	442.0	441.73	442.40	441.70	441.70	441.68	441.79	441.23
12/17/92	434.0	433.73	434.40	433.70	433.70	433.68	433.79	433.23
12/18/92	410.0	409.73	410.40	409.70	409.70	409.68	409.79	409.23
12/19/92	394.0	393.73	394.40	393.70	393.70	393.68	393.79	393.23
12/20/92	410.0	409.73	410.40	409.70	409.70	409.68	409.79	409.23
12/21/92	426.0	425.73	426.40	425.70	425.70	425.68	425.79	425.23

12/22/92	450.0	449.76	450.44	449.74	449.74	449.71	449.83	449.26
12/23/92	590.0	589.76	590.44	589.74	589.74	589.71	589.83	589.26
12/24/92	620.0	619.76	620.44	619.74	619.74	619.72	619.84	619.27
12/25/92	600.0	599.76	600.44	599.74	599.74	599.72	599.84	599.27
12/26/92	570.0	569.76	570.44	569.74	569.74	569.72	569.84	569.27
12/27/92	560.0	559.76	560.44	559.74	559.74	559.72	559.84	559.27
12/28/92	540.0	539.76	540.44	539.74	539.74	539.72	539.84	539.27
12/29/92	513.0	512.76	513.44	512.74	512.74	512.72	512.84	512.27
12/30/92	495.0	494.76	495.44	494.74	494.74	494.72	494.84	494.27
12/31/92	477.0	476.76	477.44	476.74	476.74	476.72	476.84	476.27
1/1/93	459.0	458.76	459.42	458.75	458.75	458.73	458.85	458.28
1/2/93	459.0	458.76	459.42	458.75	458.75	458.73	458.85	458.28
1/3/93	434.0	433.76	434.42	433.75	433.75	433.73	433.85	433.28
1/4/93	434.0	433.76	434.42	433.75	433.75	433.73	433.85	433.28
1/5/93	434.0	433.76	434.42	433.75	433.75	433.73	433.85	433.28
1/6/93	402.0	401.76	402.42	401.75	401.75	401.74	401.85	401.29
1/7/93	394.0	393.76	394.42	393.75	393.75	393.74	393.85	393.29
1/8/93	459.0	458.76	459.42	458.75	458.75	458.74	458.85	458.29
1/9/93	477.0	476.76	477.42	476.75	476.75	476.74	476.85	476.29
1/10/93	450.0	449.76	450.42	449.75	449.75	449.74	449.85	449.29
1/11/93	426.0	425.78	426.43	425.76	425.76	425.75	425.87	425.30
1/12/93	426.0	425.78	426.43	425.76	425.76	425.75	425.87	425.30
1/13/93	418.0	417.78	418.43	417.76	417.76	417.75	417.87	417.30
1/14/93	370.0	369.78	370.43	369.76	369.76	369.75	369.87	369.30
1/15/93	356.0	355.78	356.43	355.76	355.76	355.75	355.87	355.30
1/16/93	349.0	348.78	349.43	348.76	348.76	348.75	348.87	348.30
1/17/93	342.0	341.78	342.43	341.76	341.76	341.75	341.87	341.30
1/18/93	342.0	341.78	342.43	341.76	341.76	341.75	341.87	341.30
1/19/93	342.0	341.78	342.43	341.76	341.76	341.75	341.87	341.30
1/20/93	342.0	341.78	342.43	341.76	341.76	341.75	341.87	341.30
1/21/93	342.0	341.78	342.43	341.76	341.76	341.75	341.87	341.30
1/22/93	335.0	334.78	335.43	334.76	334.76	334.76	334.87	334.30
1/23/93	328.0	327.78	328.43	327.76	327.76	327.76	327.87	327.30
1/24/93	335.0	334.78	335.43	334.76	334.76	334.76	334.87	334.30
1/25/93	640.0	639.78	640.43	639.76	639.76	639.76	639.87	639.30
1/26/93	1111.0	1110.78	1111.43	1110.76	1110.76	1110.76	1110.87	1110.30
1/27/93	1138.0	1137.78	1138.43	1137.76	1137.76	1137.76	1137.87	1137.30
1/28/93	984.0	983.78	984.43	983.76	983.76	983.76	983.87	983.30
1/29/93	842.0	841.78	842.43	841.76	841.76	841.76	841.87	841.30
1/30/93	757.0	756.78	757.43	756.76	756.76	756.76	756.87	756.30
1/31/93	701.0	700.78	701.43	700.76	700.76	700.76	700.87	700.30
2/1/93	656.0	655.78	656.49	655.79	655.79	655.79	655.90	655.33
2/2/93	624.0	623.78	624.49	623.79	623.79	623.79	623.90	623.33
2/3/93	593.0	592.81	593.52	592.82	592.82	592.81	592.93	592.36
2/4/93	562.0	561.81	562.52	561.82	561.82	561.81	561.93	561.36
2/5/93	542.0	541.81	542.52	541.82	541.82	541.81	541.93	541.36
2/6/93	523.0	522.81	523.52	522.82	522.82	522.81	522.93	522.36
2/7/93	513.0	512.81	513.52	512.82	512.82	512.81	512.93	512.36
2/8/93	503.0	502.81	503.52	502.82	502.82	502.81	502.93	502.36
2/9/93	503.0	502.81	503.52	502.82	502.82	502.81	502.93	502.36
2/10/93	502.0	501.81	502.52	501.82	501.82	501.81	501.93	501.36
2/11/93	501.0	500.81	501.52	500.82	500.82	500.82	500.93	500.37
2/12/93	501.0	500.81	501.52	500.82	500.82	500.82	500.93	500.37
2/13/93	491.0	490.81	491.52	490.82	490.82	490.82	490.93	490.37
2/14/93	490.0	489.81	490.52	489.82	489.82	489.82	489.93	489.37
2/15/93	480.0	479.81	480.52	479.82	479.82	479.82	479.93	479.37
2/16/93	462.0	461.81	462.52	461.82	461.82	461.82	461.93	461.37
2/17/93	436.0	435.81	436.52	435.82	435.82	435.82	435.93	435.37
2/18/93	443.0	442.81	443.52	442.82	442.82	442.82	442.93	442.37
2/19/93	443.0	442.81	443.52	442.82	442.82	442.82	442.93	442.37
2/20/93	434.0	433.81	434.52	433.82	433.82	433.82	433.93	433.37
2/21/93	425.0	424.81	425.52	424.82	424.82	424.82	424.93	424.37
2/22/93	409.0	408.81	409.52	408.82	408.82	408.82	408.93	408.37

2/23/93	384.0	383.81	384.52	383.82	383.82	383.82	383.93	383.37
2/24/93	354.0	353.81	354.52	353.82	353.82	353.82	353.93	353.37
2/25/93	325.0	324.81	325.52	324.82	324.82	324.82	324.93	324.36
2/26/93	318.0	317.81	318.52	317.82	317.82	317.82	317.93	317.36
2/27/93	310.0	309.81	310.52	309.82	309.82	309.82	309.93	309.36
2/28/93	303.0	302.81	303.52	302.82	302.82	302.82	302.93	302.36
3/1/93	296.0	295.81	296.45	295.78	295.78	295.78	295.89	295.32
3/2/93	295.0	294.81	295.45	294.78	294.78	294.78	294.89	294.32
3/3/93	295.0	294.83	295.47	294.81	294.81	294.80	294.92	294.35
3/4/93	301.0	300.83	301.47	300.81	300.81	300.80	300.92	300.35
3/5/93	342.0	341.83	342.47	341.81	341.81	341.80	341.92	341.35
3/6/93	419.0	418.83	419.47	418.81	418.81	418.80	418.92	418.35
3/7/93	452.0	451.83	452.47	451.81	451.81	451.80	451.92	451.35
3/8/93	488.0	487.83	488.47	487.81	487.81	487.80	487.92	487.35
3/9/93	554.0	553.83	554.47	553.81	553.81	553.80	553.92	553.35
3/10/93	575.0	574.83	575.47	574.81	574.81	574.80	574.92	574.35
3/11/93	565.0	564.83	565.47	564.81	564.81	564.80	564.92	564.35
3/12/93	536.0	535.83	536.47	535.81	535.81	535.80	535.92	535.35
3/13/93	511.0	510.83	511.47	510.81	510.81	510.80	510.92	510.35
3/14/93	511.0	510.83	511.47	510.81	510.81	510.80	510.92	510.35
3/15/93	809.0	808.83	809.47	808.81	808.81	808.80	808.92	808.35
3/16/93	961.0	960.83	961.47	960.81	960.81	960.80	960.92	960.35
3/17/93	846.0	845.83	846.47	845.81	845.81	845.80	845.92	845.35
3/18/93	786.0	785.83	786.47	785.81	785.81	785.80	785.92	785.35
3/19/93	774.0	773.83	774.47	773.81	773.81	773.80	773.92	773.35
3/20/93	774.0	773.83	774.47	773.81	773.81	773.80	773.92	773.35
3/21/93	798.0	797.83	798.47	797.81	797.81	797.80	797.92	797.35
3/22/93	846.0	845.83	846.47	845.81	845.81	845.80	845.92	845.35
3/23/93	1155.0	1154.83	1155.47	1154.81	1154.81	1154.80	1154.92	1154.35
3/24/93	1322.0	1321.83	1322.47	1321.81	1321.81	1321.80	1321.92	1321.35
3/25/93	1200.0	1199.83	1200.47	1199.81	1199.81	1199.80	1199.92	1199.35
3/26/93	1084.0	1083.83	1084.47	1083.81	1083.81	1083.80	1083.92	1083.35
3/27/93	1000.0	999.83	1000.47	999.81	999.81	999.80	999.92	999.35
3/28/93	935.0	934.83	935.47	934.81	934.81	934.80	934.92	934.35
3/29/93	786.0	785.83	786.47	785.81	785.81	785.80	785.92	785.35
3/30/93	495.0	494.83	495.47	494.81	494.81	494.80	494.92	494.35
3/31/93	468.0	467.83	468.47	467.81	467.81	467.80	467.92	467.35
4/1/93	450.0	449.83	450.45	449.52	449.52	452.17	453.57	452.99
4/2/93	620.0	619.83	620.45	619.52	619.52	622.04	623.43	622.85
4/3/93	1000.0	999.83	1000.45	999.52	999.52	1001.76	1003.15	1002.57
4/4/93	1056.0	1055.83	1056.45	1055.52	1055.52	1057.90	1059.29	1058.71
4/5/93	1042.0	1041.83	1042.45	1041.52	1041.52	1043.89	1045.28	1044.71
4/6/93	974.0	973.85	974.47	973.54	973.54	976.05	977.44	976.87
4/7/93	935.0	934.86	935.48	934.55	934.55	937.06	938.45	937.88
4/8/93	909.0	908.86	909.48	908.55	908.55	911.06	912.45	911.88
4/9/93	1070.0	1069.86	1070.48	1069.55	1069.55	1072.06	1073.45	1072.88
4/10/93	1126.0	1125.86	1126.48	1125.55	1125.55	1128.13	1129.52	1128.95
4/11/93	1070.0	1069.86	1070.48	1069.55	1069.55	1072.13	1073.52	1072.95
4/12/93	987.0	986.86	987.48	986.55	986.55	989.13	990.52	989.95
4/13/93	909.0	908.86	909.48	908.55	908.55	911.13	912.52	911.95
4/14/93	870.0	869.86	870.48	869.55	869.55	872.13	873.52	872.95
4/15/93	846.0	845.86	846.48	845.55	845.55	848.13	849.52	848.95
4/16/93	858.0	857.86	858.48	857.55	857.55	860.13	861.52	860.94
4/17/93	870.0	869.86	870.48	869.55	869.55	872.13	873.52	872.94
4/18/93	922.0	921.86	922.48	921.55	921.55	923.73	925.12	924.54
4/19/93	935.0	934.86	935.48	934.55	934.55	936.88	938.27	937.70
4/20/93	774.0	773.86	774.48	773.55	773.55	775.88	777.27	776.70
4/21/93	610.0	609.86	610.48	609.55	609.55	612.04	613.43	612.86
4/22/93	550.0	549.86	550.48	549.55	549.55	552.04	553.43	552.85
4/23/93	580.0	579.86	580.48	579.55	579.55	582.04	583.43	582.85
4/24/93	580.0	579.86	580.48	579.55	579.55	582.03	583.42	582.85
4/25/93	620.0	619.86	620.48	619.55	619.55	622.12	623.51	622.93
4/26/93	673.0	672.86	673.48	672.55	672.55	675.12	676.51	675.93

4/27/93	695.0	694.86	695.48	694.55	694.55	697.11	698.51	697.93
4/28/93	630.0	629.86	630.48	629.55	629.55	632.11	633.51	632.93
4/29/93	590.0	589.86	590.48	589.55	589.55	592.11	593.50	592.93
4/30/93	834.0	833.86	834.48	833.55	833.55	836.11	837.50	836.93
5/1/93	1014.0	1014.85	1015.42	1014.11	1017.43	1022.52	1024.58	1024.01
5/2/93	922.0	922.85	923.42	922.11	925.43	930.52	932.58	932.01
5/3/93	834.0	834.85	835.43	834.11	837.44	842.03	844.09	843.52
5/4/93	739.0	739.86	740.44	739.12	742.44	747.23	749.29	748.72
5/5/93	662.0	662.86	663.43	662.12	665.44	670.21	672.28	671.71
5/6/93	662.0	662.82	663.40	662.08	665.41	670.38	672.45	671.87
5/7/93	706.0	706.83	707.40	706.09	709.41	714.38	716.45	715.88
5/8/93	620.0	620.85	621.43	620.11	623.44	628.40	630.47	629.90
5/9/93	550.0	550.87	551.44	550.13	553.45	558.41	560.48	559.90
5/10/93	504.0	504.86	505.43	504.12	507.44	512.51	514.57	514.00
5/11/93	858.0	858.88	859.46	858.14	861.47	866.53	868.60	868.03
5/12/93	1098.0	1099.11	1099.68	1098.37	1101.69	1106.76	1108.82	1108.25
5/13/93	1140.0	1141.11	1141.68	1140.37	1143.69	1148.76	1150.82	1150.25
5/14/93	896.0	896.84	897.41	896.10	899.42	904.48	906.54	905.97
5/15/93	774.0	774.90	775.48	774.16	777.49	782.54	784.61	784.04
5/16/93	706.0	706.84	707.41	706.10	709.42	714.48	716.54	715.97
5/17/93	706.0	706.83	707.41	706.09	709.42	714.47	716.54	715.96
5/18/93	728.0	728.83	729.40	728.09	731.41	735.79	737.86	737.28
5/19/93	728.0	728.90	729.47	728.16	731.48	736.12	738.19	737.61
5/20/93	695.0	695.87	696.44	695.13	698.45	703.08	705.14	704.57
5/21/93	610.0	610.88	611.45	610.14	613.46	618.36	620.43	619.86
5/22/93	580.0	580.87	581.44	580.13	583.45	588.35	590.41	589.84
5/23/93	640.0	640.98	641.56	640.24	643.57	648.46	650.52	649.95
5/24/93	1000.0	1001.01	1001.59	1000.27	1003.60	1008.63	1010.70	1010.13
5/25/93	1230.0	1230.99	1231.57	1230.25	1233.58	1238.61	1240.68	1240.11
5/26/93	1467.0	1468.05	1468.63	1467.31	1470.64	1475.52	1477.58	1477.01
5/27/93	1674.0	1674.96	1675.53	1674.22	1677.54	1682.57	1684.63	1684.06
5/28/93	1535.0	1535.98	1536.56	1535.24	1538.57	1543.60	1545.66	1545.09
5/29/93	1275.0	1275.96	1276.54	1275.22	1278.55	1283.62	1285.69	1285.12
5/30/93	1140.0	1140.94	1141.52	1140.20	1143.52	1148.60	1150.67	1150.09
5/31/93	1170.0	1171.00	1171.58	1170.26	1171.54	1176.62	1178.69	1178.11
6/1/93	1084.0	1084.98	1085.62	1081.36	1082.32	1086.80	1089.01	1088.44
6/2/93	935.0	936.08	936.72	932.46	933.42	937.90	940.11	939.54
6/3/93	948.0	948.99	949.62	945.36	946.32	949.95	952.16	951.58
6/4/93	1056.0	1057.03	1057.67	1053.41	1054.37	1058.32	1060.53	1059.96
6/5/93	1126.0	1127.08	1127.71	1123.45	1124.42	1128.36	1130.57	1130.00
6/6/93	948.0	948.98	949.61	945.35	946.31	950.60	952.82	952.24
6/7/93	1056.0	1056.96	1057.59	1053.33	1054.29	1058.58	1060.79	1060.22
6/8/93	1354.0	1354.99	1355.62	1351.36	1352.32	1356.60	1358.81	1358.24
6/9/93	1603.0	1604.11	1604.74	1600.48	1601.44	1605.72	1607.93	1607.36
6/10/93	1710.0	1710.99	1711.62	1707.36	1708.32	1712.78	1714.99	1714.42
6/11/93	1840.0	1841.03	1841.67	1837.41	1838.37	1842.83	1845.04	1844.46
6/12/93	2147.0	2148.10	2148.73	2144.47	2145.43	2149.89	2152.10	2151.52
6/13/93	2476.0	2476.93	2477.49	2473.23	2474.19	2478.64	2480.85	2480.28
6/14/93	2684.0	2684.95	2685.51	2681.25	2682.21	2686.65	2688.87	2688.29
6/15/93	2900.0	2900.97	2901.52	2897.26	2898.22	2902.67	2904.88	2904.31
6/16/93	2741.0	2742.14	2742.69	2738.43	2739.39	2743.84	2746.05	2745.47
6/17/93	2846.0	2846.98	2847.53	2843.27	2844.23	2848.58	2850.79	2850.22
6/18/93	2807.0	2808.01	2808.57	2804.31	2805.27	2808.45	2810.66	2810.08
6/19/93	2840.0	2841.17	2841.72	2837.46	2838.42	2841.92	2844.13	2843.56
6/20/93	2801.0	2801.98	2802.54	2798.28	2799.24	2802.57	2804.78	2804.21
6/21/93	2858.0	2858.95	2859.51	2855.25	2856.21	2859.89	2862.10	2861.53
6/22/93	2991.0	2991.91	2992.46	2988.20	2989.16	2992.83	2995.04	2994.47
6/23/93	2975.0	2975.94	2976.49	2972.23	2973.19	2977.02	2979.23	2978.65
6/24/93	2780.0	2780.99	2781.54	2777.28	2778.24	2781.80	2784.02	2783.44
6/25/93	2828.0	2829.04	2829.59	2825.33	2826.29	2829.95	2832.16	2831.58
6/26/93	2900.0	2901.03	2901.59	2897.33	2898.29	2901.87	2904.08	2903.51
6/27/93	2950.0	2950.92	2951.47	2947.21	2948.17	2951.70	2953.91	2953.34
6/28/93	2950.0	2950.99	2951.55	2947.29	2948.25	2951.57	2953.78	2953.21

6/29/93	2900.0	2901.01	2901.56	2897.30	2898.26	2901.48	2903.69	2903.12
6/30/93	2876.0	2877.12	2877.67	2873.41	2874.37	2877.58	2879.79	2879.22
7/1/93	3000.0	3001.37	3001.95	2995.58	2997.56	3001.15	3003.71	3003.13
7/2/93	3100.0	3101.42	3102.00	3095.63	3097.61	3101.10	3103.65	3103.08
7/3/93	3125.0	3126.48	3127.06	3120.69	3122.67	3124.65	3127.21	3126.64
7/4/93	3125.0	3126.26	3126.84	3120.48	3122.45	3124.55	3127.11	3126.54
7/5/93	3100.0	3101.16	3101.74	3095.38	3097.35	3099.00	3101.56	3100.98
7/6/93	3202.0	3203.20	3203.78	3197.41	3199.39	3201.21	3203.77	3203.20
7/7/93	3332.0	3333.13	3333.71	3327.35	3329.32	3330.96	3333.52	3332.94
7/8/93	3306.0	3307.14	3307.72	3301.35	3303.33	3304.81	3307.37	3306.79
7/9/93	3280.0	3281.14	3281.72	3275.35	3277.33	3278.77	3281.33	3280.76
7/10/93	3410.0	3411.14	3411.72	3405.36	3407.33	3409.01	3411.57	3410.99
7/11/93	3438.0	3439.14	3439.72	3433.36	3435.33	3436.97	3439.53	3438.96
7/12/93	3410.0	3411.14	3411.72	3405.36	3407.33	3408.96	3411.52	3410.94
7/13/93	3410.0	3411.11	3411.69	3405.32	3407.30	3409.03	3411.59	3411.02
7/14/93	3410.0	3411.11	3411.69	3405.32	3407.30	3409.03	3411.59	3411.01
7/15/93	3358.0	3359.11	3359.69	3353.32	3355.30	3356.91	3359.47	3358.90
7/16/93	3306.0	3307.18	3307.76	3301.39	3303.37	3304.95	3307.51	3306.93
7/17/93	3254.0	3255.09	3255.67	3249.30	3251.27	3253.06	3255.62	3255.04
7/18/93	3176.0	3177.06	3177.64	3171.28	3173.25	3173.38	3175.94	3175.37
7/19/93	3075.0	3076.20	3076.78	3070.42	3072.32	3073.03	3075.59	3075.01
7/20/93	3000.0	3001.14	3001.72	2995.36	2997.33	2998.10	3000.65	3000.08
7/21/93	2900.0	2901.08	2901.66	2895.29	2896.79	2898.13	2900.69	2900.12
7/22/93	2852.0	2852.99	2853.57	2847.21	2848.88	2850.19	2852.75	2852.18
7/23/93	2925.0	2926.18	2926.76	2920.40	2921.89	2923.08	2925.64	2925.06
7/24/93	3000.0	3001.18	3001.76	2995.40	2996.89	2998.26	3000.82	3000.25
7/25/93	3050.0	3051.12	3051.70	3045.33	3047.31	3048.74	3051.29	3050.72
7/26/93	2950.0	2951.12	2951.70	2945.33	2947.23	2948.24	2950.80	2950.22
7/27/93	2876.0	2877.04	2877.62	2871.26	2873.13	2874.37	2876.93	2876.36
7/28/93	2925.0	2926.04	2926.62	2920.26	2922.23	2923.48	2926.04	2925.47
7/29/93	3000.0	3000.95	3001.53	2995.16	2997.14	2998.62	3001.18	3000.60
7/30/93	2925.0	2925.95	2926.53	2920.16	2922.14	2923.62	2926.18	2925.60
7/31/93	2852.0	2853.04	2853.62	2847.26	2848.73	2849.99	2852.55	2851.98
8/1/93	2900.0	2901.14	2901.73	2896.77	2898.31	2899.36	2901.72	2901.15
8/2/93	2950.0	2951.14	2951.73	2946.77	2948.14	2949.14	2951.50	2950.93
8/3/93	3075.0	3076.17	3076.76	3071.81	3072.92	3072.27	3074.63	3074.06
8/4/93	3358.0	3359.17	3359.76	3354.81	3355.92	3355.77	3358.13	3357.55
8/5/93	3494.0	3495.17	3495.76	3490.80	3491.91	3491.74	3494.10	3493.53
8/6/93	3438.0	3439.17	3439.76	3434.80	3435.91	3436.33	3438.69	3438.12
8/7/93	3384.0	3385.09	3385.68	3380.72	3381.83	3382.25	3384.61	3384.04
8/8/93	3358.0	3359.09	3359.68	3354.72	3355.83	3356.27	3358.63	3358.06
8/9/93	3332.0	3333.09	3333.68	3328.72	3329.83	3330.25	3332.61	3332.04
8/10/93	3332.0	3333.09	3333.68	3328.72	3329.83	3330.54	3332.90	3332.33
8/11/93	3306.0	3307.10	3307.69	3302.73	3303.84	3304.57	3306.93	3306.35
8/12/93	3332.0	3333.09	3333.69	3328.73	3329.84	3330.56	3332.92	3332.35
8/13/93	3306.0	3307.09	3307.69	3302.73	3303.84	3304.67	3307.03	3306.46
8/14/93	3306.0	3307.09	3307.69	3302.73	3303.43	3304.40	3306.76	3306.19
8/15/93	3280.0	3281.09	3281.68	3276.73	3277.32	3278.33	3280.69	3280.12
8/16/93	3176.0	3177.19	3177.78	3172.82	3173.93	3174.93	3177.29	3176.72
8/17/93	3125.0	3126.10	3126.69	3121.73	3122.33	3123.30	3125.66	3125.08
8/18/93	3025.0	3026.07	3026.67	3021.71	3022.24	3021.79	3024.15	3023.58
8/19/93	3000.0	3001.24	3001.83	2996.87	2997.36	2997.35	2999.71	2999.14
8/20/93	3050.0	3051.17	3051.76	3046.80	3047.59	3047.54	3049.90	3049.33
8/21/93	2950.0	2951.10	2951.69	2946.73	2947.40	2947.96	2950.33	2949.75
8/22/93	2828.0	2829.00	2829.59	2824.63	2825.42	2825.96	2828.32	2827.75
8/23/93	2828.0	2829.22	2829.81	2824.86	2825.64	2826.18	2828.54	2827.97
8/24/93	2804.0	2805.22	2805.81	2800.86	2801.35	2802.17	2804.54	2803.96
8/25/93	2756.0	2757.15	2757.74	2752.78	2753.32	2754.11	2756.47	2755.90
8/26/93	2828.0	2828.75	2829.34	2824.39	2824.94	2825.36	2827.72	2827.15
8/27/93	2852.0	2852.50	2853.09	2848.14	2848.68	2849.35	2851.71	2851.13
8/28/93	2828.0	2828.60	2829.19	2824.24	2825.35	2826.02	2828.38	2827.81
8/29/93	2804.0	2804.65	2805.24	2800.29	2801.40	2802.18	2804.54	2803.96
8/30/93	2804.0	2804.62	2805.21	2800.26	2801.37	2802.15	2804.51	2803.93

8/31/93	2804.0	2804.74	2805.34	2800.38	2800.82	2801.60	2803.96	2803.39
9/1/93	2732.0	2731.51	2732.14	2728.40	2728.02	2728.62	2730.53	2729.96
9/2/93	2780.0	2779.51	2780.14	2776.40	2776.18	2776.77	2778.67	2778.10
9/3/93	2780.0	2779.55	2780.18	2776.44	2776.22	2775.54	2777.45	2776.88
9/4/93	2732.0	2731.55	2732.18	2728.44	2728.22	2728.03	2729.94	2729.37
9/5/93	2684.0	2683.55	2684.18	2680.44	2680.22	2680.05	2681.96	2681.39
9/6/93	2476.0	2475.55	2476.18	2472.44	2472.22	2472.57	2474.47	2473.90
9/7/93	2147.0	2146.45	2147.09	2143.34	2143.12	2143.47	2145.38	2144.80
9/8/93	1920.0	1919.45	1920.09	1916.34	1916.12	1916.46	1918.37	1917.80
9/9/93	1638.0	1637.45	1638.09	1634.34	1634.12	1634.46	1636.37	1635.79
9/10/93	804.0	803.45	804.09	800.34	800.12	800.70	802.60	802.03
9/11/93	640.0	639.46	640.10	636.36	636.13	636.73	638.64	638.06
9/12/93	585.0	584.46	585.10	581.36	581.60	582.34	584.24	583.67
9/13/93	522.0	521.46	522.10	518.36	518.83	519.56	521.47	520.89
9/14/93	486.0	485.46	486.10	482.36	482.77	483.48	485.39	484.81
9/15/93	495.0	494.46	495.10	491.36	491.60	492.35	494.26	493.68
9/16/93	504.0	503.56	504.19	500.45	498.64	499.34	501.25	500.68
9/17/93	513.0	512.45	513.08	509.34	507.60	508.28	510.18	509.61
9/18/93	504.0	503.74	504.37	500.63	498.88	498.41	500.32	499.75
9/19/93	513.0	512.31	512.94	509.20	507.45	507.42	509.33	508.76
9/20/93	504.0	503.55	504.18	500.44	498.69	498.68	500.59	500.02
9/21/93	486.0	485.46	486.09	482.35	480.61	481.06	482.97	482.39
9/22/93	450.0	449.68	450.31	446.57	444.83	445.28	447.18	446.61
9/23/93	434.0	433.68	434.31	430.57	428.83	429.26	431.17	430.59
9/24/93	468.0	467.24	467.88	464.13	462.39	462.81	464.71	464.14
9/25/93	468.0	467.56	468.19	464.45	462.70	463.35	465.26	464.69
9/26/93	468.0	467.56	468.19	464.45	462.67	463.29	465.20	464.63
9/27/93	468.0	467.48	468.11	464.37	462.24	462.84	464.75	464.17
9/28/93	468.0	467.48	468.11	464.37	462.24	462.75	464.66	464.09
9/29/93	477.0	476.59	477.23	473.48	471.36	471.82	473.73	473.15
9/30/93	477.0	476.59	477.23	473.48	471.74	472.18	474.09	473.51
10/1/93	468.0	467.59	468.27	467.29	466.12	466.55	467.72	467.15
10/2/93	468.0	467.53	468.21	467.22	466.05	466.49	467.66	467.08
10/3/93	477.0	476.53	477.21	476.22	475.05	474.34	475.50	474.93
10/4/93	477.0	476.53	477.21	476.22	475.05	474.80	475.97	475.39
10/5/93	468.0	467.59	468.27	467.29	466.12	465.85	467.02	466.44
10/6/93	459.0	458.59	459.27	458.29	457.12	457.30	458.47	457.90
10/7/93	468.0	467.59	468.27	467.29	466.12	466.35	467.52	466.95
10/8/93	468.0	467.59	468.27	467.29	466.12	466.42	467.58	467.01
10/9/93	459.0	458.54	459.22	458.23	457.06	457.32	458.49	457.92
10/10/93	459.0	458.54	459.22	458.23	457.06	457.54	458.71	458.14
10/11/93	468.0	467.54	468.22	467.23	466.06	466.56	467.73	467.16
10/12/93	477.0	476.54	477.22	476.23	474.77	475.30	476.47	475.89
10/13/93	468.0	467.65	468.33	467.35	465.89	466.53	467.70	467.12
10/14/93	459.0	458.65	459.33	458.35	456.98	457.61	458.78	458.20
10/15/93	450.0	449.65	450.33	449.35	447.88	448.53	449.70	449.12
10/16/93	442.0	441.65	442.29	441.30	441.30	441.91	442.02	441.45
10/17/93	442.0	441.65	442.29	441.30	441.30	441.89	442.00	441.43
10/18/93	270.0	269.65	270.29	269.30	269.30	268.29	268.40	267.83
10/19/93	263.0	262.61	263.24	262.26	262.26	261.69	261.80	261.23
10/20/93	269.0	268.61	269.24	268.26	268.26	268.13	268.25	267.67
10/21/93	268.0	267.61	268.24	267.26	267.26	267.58	267.69	267.12
10/22/93	261.0	260.61	261.24	260.26	260.26	260.57	260.69	260.11
10/23/93	261.0	260.61	261.24	260.26	260.26	260.62	260.74	260.17
10/24/93	260.0	259.61	260.24	259.26	259.26	259.70	259.81	259.24
10/25/93	253.0	252.67	253.30	252.32	252.32	252.94	253.06	252.49
10/26/93	253.0	252.67	253.30	252.32	252.32	252.91	253.03	252.45
10/27/93	252.0	251.67	252.30	251.32	251.32	251.90	252.01	251.44
10/28/93	258.0	257.67	258.30	257.32	257.32	257.89	258.00	257.43
10/29/93	257.0	256.67	257.30	256.32	256.32	256.87	256.99	256.42
10/30/93	256.0	255.67	256.30	255.32	255.32	255.85	255.97	255.39
10/31/93	256.0	255.67	256.30	255.32	255.32	255.86	255.97	255.40
11/1/93	255.0	254.67	255.35	254.68	254.68	254.47	254.59	254.01

11/2/93	248.0	247.67	248.36	247.68	247.68	247.55	247.66	247.09
11/3/93	296.0	295.67	296.36	295.68	295.68	295.55	295.66	295.09
11/4/93	301.0	300.67	301.36	300.68	300.68	300.55	300.66	300.09
11/5/93	294.0	293.67	294.36	293.68	293.68	293.58	293.70	293.12
11/6/93	276.0	275.67	276.36	275.68	275.68	275.58	275.70	275.12
11/7/93	269.0	268.67	269.36	268.68	268.68	268.58	268.70	268.12
11/8/93	256.0	255.67	256.36	255.68	255.68	255.58	255.70	255.12
11/9/93	250.0	249.67	250.36	249.68	249.68	249.60	249.72	249.15
11/10/93	255.0	254.67	255.36	254.68	254.68	254.60	254.72	254.15
11/11/93	254.0	253.72	254.41	253.73	253.73	253.66	253.77	253.20
11/12/93	254.0	253.72	254.41	253.73	253.73	253.66	253.77	253.20
11/13/93	253.0	252.72	253.41	252.73	252.73	252.66	252.77	252.20
11/14/93	252.0	251.72	252.41	251.73	251.73	251.66	251.78	251.20
11/15/93	252.0	251.72	252.41	251.73	251.73	251.66	251.78	251.20
11/16/93	251.0	250.72	251.41	250.73	250.73	250.66	250.78	250.20
11/17/93	251.0	250.72	251.41	250.73	250.73	250.66	250.78	250.20
11/18/93	262.0	261.72	262.41	261.73	261.73	261.66	261.78	261.20
11/19/93	261.0	260.72	261.41	260.73	260.73	260.69	260.80	260.23
11/20/93	255.0	254.72	255.41	254.73	254.73	254.69	254.80	254.23
11/21/93	266.0	265.72	266.41	265.73	265.73	265.69	265.80	265.23
11/22/93	302.0	301.72	302.41	301.73	301.73	301.69	301.80	301.23
11/23/93	289.0	288.72	289.40	288.73	288.73	288.68	288.80	288.22
11/24/93	270.0	269.72	270.40	269.73	269.73	269.68	269.80	269.22
11/25/93	269.0	268.72	269.40	268.73	268.73	268.68	268.80	268.22
11/26/93	269.0	268.72	269.40	268.73	268.73	268.68	268.80	268.23
11/27/93	244.0	243.72	244.40	243.73	243.73	243.68	243.80	243.23
11/28/93	243.0	242.72	243.40	242.73	242.73	242.68	242.80	242.23
11/29/93	243.0	242.72	243.40	242.73	242.73	242.68	242.80	242.23
11/30/93	248.0	247.72	248.40	247.73	247.73	247.68	247.80	247.23
12/1/93	283.0	282.72	283.39	282.69	282.69	282.65	282.76	282.19
12/2/93	371.0	370.72	371.39	370.69	370.69	370.65	370.76	370.19
12/3/93	386.0	385.72	386.39	385.69	385.69	385.66	385.78	385.21
12/4/93	393.0	392.72	393.39	392.69	392.69	392.66	392.78	392.21
12/5/93	392.0	391.72	392.39	391.69	391.69	391.66	391.78	391.21
12/6/93	347.0	346.75	347.42	346.73	346.73	346.70	346.81	346.24
12/7/93	325.0	324.75	325.42	324.73	324.73	324.70	324.81	324.24
12/8/93	310.0	309.75	310.42	309.73	309.73	309.70	309.81	309.24
12/9/93	310.0	309.75	310.42	309.73	309.73	309.70	309.81	309.24
12/10/93	330.0	329.75	330.42	329.73	329.73	329.70	329.81	329.24
12/11/93	395.0	394.75	395.42	394.73	394.73	394.70	394.81	394.24
12/12/93	402.0	401.75	402.42	401.73	401.73	401.70	401.81	401.24
12/13/93	386.0	385.75	386.42	385.73	385.73	385.70	385.82	385.24
12/14/93	362.0	361.75	362.42	361.73	361.73	361.70	361.82	361.24
12/15/93	340.0	339.75	340.42	339.73	339.73	339.70	339.82	339.24
12/16/93	332.0	331.75	332.42	331.73	331.73	331.70	331.82	331.24
12/17/93	318.0	317.75	318.42	317.73	317.73	317.70	317.82	317.24
12/18/93	310.0	309.75	310.42	309.73	309.73	309.70	309.82	309.24
12/19/93	302.0	301.75	302.42	301.73	301.73	301.70	301.82	301.24
12/20/93	277.0	276.75	277.42	276.73	276.73	276.70	276.82	276.24
12/21/93	246.0	245.75	246.42	245.73	245.73	245.70	245.82	245.24
12/22/93	235.0	234.78	235.45	234.76	234.76	234.73	234.85	234.28
12/23/93	229.0	228.78	229.45	228.76	228.76	228.73	228.85	228.28
12/24/93	224.0	223.78	224.45	223.76	223.76	223.74	223.85	223.28
12/25/93	218.0	217.78	218.45	217.76	217.76	217.74	217.85	217.28
12/26/93	218.0	217.78	218.45	217.76	217.76	217.74	217.85	217.28
12/27/93	212.0	211.78	212.45	211.76	211.76	211.74	211.85	211.28
12/28/93	212.0	211.78	212.45	211.76	211.76	211.74	211.85	211.28
12/29/93	211.0	210.78	211.45	210.76	210.76	210.74	210.85	210.28
12/30/93	211.0	210.78	211.45	210.76	210.76	210.74	210.85	210.28
12/31/93	220.0	219.78	220.45	219.76	219.76	219.74	219.85	219.28
1/1/94	251.0	250.78	251.43	250.77	250.77	250.75	250.86	250.29
1/2/94	257.0	256.78	257.43	256.77	256.77	256.75	256.86	256.29
1/3/94	293.0	292.78	293.43	292.77	292.77	292.75	292.86	292.29

1/4/94	340.0	339.78	340.43	339.77	339.77	339.75	339.86	339.29
1/5/94	455.0	454.78	455.43	454.77	454.77	454.75	454.86	454.29
1/6/94	455.0	454.78	455.43	454.77	454.77	454.75	454.87	454.30
1/7/94	389.0	388.78	389.43	388.77	388.77	388.75	388.87	388.30
1/8/94	351.0	350.78	351.43	350.77	350.77	350.75	350.87	350.30
1/9/94	323.0	322.78	323.43	322.77	322.77	322.75	322.87	322.30
1/10/94	364.0	363.78	364.43	363.77	363.77	363.75	363.87	363.30
1/11/94	395.0	394.80	395.45	394.78	394.78	394.77	394.88	394.31
1/12/94	450.0	449.80	450.45	449.78	449.78	449.77	449.88	449.31
1/13/94	610.0	609.80	610.45	609.78	609.78	609.77	609.88	609.31
1/14/94	739.0	738.80	739.45	738.78	738.78	738.77	738.88	738.31
1/15/94	717.0	716.80	717.45	716.78	716.78	716.77	716.88	716.31
1/16/94	706.0	705.80	706.45	705.78	705.78	705.77	705.88	705.31
1/17/94	673.0	672.80	673.45	672.78	672.78	672.77	672.88	672.31
1/18/94	630.0	629.80	630.45	629.78	629.78	629.77	629.88	629.31
1/19/94	570.0	569.80	570.45	569.78	569.78	569.77	569.88	569.31
1/20/94	522.0	521.80	522.45	521.78	521.78	521.77	521.88	521.31
1/21/94	495.0	494.80	495.45	494.78	494.78	494.77	494.88	494.31
1/22/94	468.0	467.80	468.45	467.78	467.78	467.77	467.89	467.31
1/23/94	450.0	449.80	450.45	449.78	449.78	449.77	449.89	449.31
1/24/94	450.0	449.80	450.45	449.78	449.78	449.77	449.89	449.31
1/25/94	468.0	467.80	468.45	467.78	467.78	467.77	467.89	467.31
1/26/94	486.0	485.80	486.45	485.78	485.78	485.77	485.89	485.31
1/27/94	459.0	458.80	459.45	458.78	458.78	458.77	458.89	458.31
1/28/94	426.0	425.80	426.45	425.78	425.78	425.77	425.89	425.31
1/29/94	396.0	395.80	396.45	395.78	395.78	395.77	395.89	395.31
1/30/94	390.0	389.80	390.45	389.78	389.78	389.77	389.89	389.31
1/31/94	385.0	384.80	385.45	384.78	384.78	384.77	384.89	384.31
2/1/94	379.0	378.80	379.51	378.81	378.81	378.80	378.92	378.34
2/2/94	373.0	372.80	373.51	372.81	372.81	372.80	372.92	372.34
2/3/94	367.0	366.82	367.53	366.84	366.84	366.83	366.94	366.37
2/4/94	362.0	361.82	362.53	361.84	361.84	361.83	361.94	361.37
2/5/94	364.0	363.82	364.53	363.84	363.84	363.83	363.94	363.37
2/6/94	366.0	365.82	366.53	365.84	365.84	365.83	365.94	365.37
2/7/94	368.0	367.82	368.53	367.84	367.84	367.83	367.94	367.37
2/8/94	349.0	348.82	349.53	348.84	348.84	348.83	348.94	348.37
2/9/94	363.0	362.82	363.53	362.84	362.84	362.83	362.94	362.37
2/10/94	363.0	362.82	363.53	362.84	362.84	362.83	362.94	362.37
2/11/94	356.0	355.82	356.53	355.84	355.84	355.83	355.95	355.37
2/12/94	342.0	341.82	342.53	341.84	341.84	341.83	341.95	341.37
2/13/94	342.0	341.82	342.53	341.84	341.84	341.83	341.95	341.37
2/14/94	342.0	341.82	342.53	341.84	341.84	341.83	341.95	341.37
2/15/94	328.0	327.82	328.53	327.84	327.84	327.83	327.95	327.37
2/16/94	314.0	313.82	314.53	313.84	313.84	313.83	313.95	313.37
2/17/94	328.0	327.82	328.53	327.84	327.84	327.83	327.95	327.37
2/18/94	342.0	341.82	342.53	341.84	341.84	341.83	341.95	341.37
2/19/94	328.0	327.82	328.53	327.84	327.84	327.83	327.95	327.37
2/20/94	314.0	313.82	314.53	313.84	313.84	313.83	313.95	313.37
2/21/94	307.0	306.82	307.53	306.84	306.84	306.83	306.95	306.37
2/22/94	307.0	306.82	307.53	306.84	306.84	306.83	306.95	306.37
2/23/94	374.0	373.82	374.53	373.84	373.84	373.83	373.95	373.37
2/24/94	363.0	362.82	363.53	362.84	362.84	362.83	362.95	362.37
2/25/94	332.0	331.82	332.53	331.84	331.84	331.83	331.95	331.37
2/26/94	314.0	313.82	314.53	313.84	313.84	313.83	313.95	313.37
2/27/94	304.0	303.82	304.53	303.84	303.84	303.83	303.95	303.37
2/28/94	328.0	327.82	328.53	327.84	327.84	327.83	327.95	327.37
3/1/94	406.0	405.82	406.46	405.80	405.80	405.79	405.91	405.33
3/2/94	335.0	334.82	335.46	334.80	334.80	334.79	334.91	334.33
3/3/94	353.0	352.85	353.49	352.82	352.82	352.81	352.93	352.36
3/4/94	394.0	393.85	394.49	393.82	393.82	393.81	393.93	393.36
3/5/94	406.0	405.85	406.49	405.82	405.82	405.81	405.93	405.36
3/6/94	402.0	401.85	402.49	401.82	401.82	401.82	401.93	401.36
3/7/94	390.0	389.85	390.49	389.82	389.82	389.82	389.93	389.36

3/8/94	513.0	512.85	513.49	512.82	512.82	512.82	512.93	512.36
3/9/94	545.0	544.85	545.49	544.82	544.82	544.82	544.93	544.36
3/10/94	495.0	494.85	495.49	494.82	494.82	494.82	494.93	494.36
3/11/94	527.0	526.85	527.49	526.82	526.82	526.82	526.93	526.36
3/12/94	522.0	521.85	522.49	521.82	521.82	521.82	521.93	521.36
3/13/94	545.0	544.85	545.49	544.82	544.82	544.82	544.93	544.36
3/14/94	640.0	639.85	640.49	639.82	639.82	639.82	639.93	639.36
3/15/94	744.0	743.85	744.49	743.82	743.82	743.82	743.93	743.36
3/16/94	858.0	857.85	858.49	857.82	857.82	857.82	857.93	857.36
3/17/94	870.0	869.85	870.49	869.82	869.82	869.82	869.93	869.36
3/18/94	870.0	869.85	870.49	869.82	869.82	869.82	869.93	869.36
3/19/94	834.0	833.85	834.49	833.82	833.82	833.82	833.93	833.36
3/20/94	750.0	749.85	750.49	749.82	749.82	749.82	749.93	749.36
3/21/94	728.0	727.85	728.49	727.82	727.82	727.82	727.93	727.36
3/22/94	651.0	650.85	651.49	650.82	650.82	650.82	650.93	650.36
3/23/94	610.0	609.85	610.49	609.82	609.82	609.82	609.93	609.36
3/24/94	560.0	559.85	560.49	559.82	559.82	559.82	559.93	559.36
3/25/94	531.0	530.85	531.49	530.82	530.82	530.82	530.93	530.36
3/26/94	504.0	503.85	504.49	503.82	503.82	503.82	503.93	503.36
3/27/94	531.0	530.85	531.49	530.82	530.82	530.82	530.93	530.36
3/28/94	610.0	609.85	610.49	609.82	609.82	609.82	609.93	609.36
3/29/94	762.0	761.85	762.49	761.82	761.82	761.82	761.93	761.36
3/30/94	870.0	869.85	870.49	869.82	869.82	869.82	869.93	869.36
3/31/94	961.0	960.85	961.49	960.82	960.82	960.82	960.93	960.36
4/1/94	1042.0	1041.85	1042.46	1041.53	1041.53	1044.62	1046.02	1045.48
4/2/94	1170.0	1169.85	1170.46	1169.53	1169.53	1172.48	1173.87	1173.34
4/3/94	1185.0	1184.85	1185.46	1184.53	1184.53	1187.20	1188.59	1188.05
4/4/94	1140.0	1139.85	1140.46	1139.53	1139.53	1142.34	1143.73	1143.19
4/5/94	1014.0	1013.85	1014.46	1013.53	1013.53	1016.34	1017.73	1017.19
4/6/94	974.0	973.86	974.48	973.55	973.55	976.50	977.89	977.35
4/7/94	935.0	934.87	935.49	934.56	934.56	937.51	938.90	938.36
4/8/94	883.0	882.87	883.49	882.56	882.56	885.51	886.90	886.36
4/9/94	858.0	857.87	858.49	857.56	857.56	860.51	861.90	861.36
4/10/94	846.0	845.87	846.49	845.56	845.56	848.58	849.97	849.43
4/11/94	846.0	845.87	846.49	845.56	845.56	848.58	849.97	849.43
4/12/94	896.0	895.87	896.49	895.56	895.56	898.58	899.97	899.43
4/13/94	922.0	921.87	922.49	921.56	921.56	924.58	925.97	925.43
4/14/94	870.0	869.87	870.49	869.56	869.56	872.58	873.97	873.43
4/15/94	786.0	785.87	786.49	785.56	785.56	788.58	789.97	789.43
4/16/94	786.0	785.87	786.49	785.56	785.56	788.57	789.96	789.43
4/17/94	896.0	895.87	896.49	895.56	895.56	898.57	899.96	899.43
4/18/94	1185.0	1184.87	1185.49	1184.56	1184.56	1187.17	1188.56	1188.02
4/19/94	1434.0	1433.87	1434.49	1433.56	1433.56	1436.32	1437.71	1437.18
4/20/94	1306.0	1305.87	1306.49	1305.56	1305.56	1308.32	1309.71	1309.17
4/21/94	1215.0	1214.87	1215.49	1214.56	1214.56	1217.48	1218.87	1218.34
4/22/94	1084.0	1083.87	1084.49	1083.56	1083.56	1086.48	1087.87	1087.34
4/23/94	896.0	895.87	896.49	895.56	895.56	898.48	899.87	899.33
4/24/94	728.0	727.87	728.49	727.56	727.56	730.48	731.87	731.33
4/25/94	630.0	629.87	630.49	629.56	629.56	632.56	633.95	633.42
4/26/94	522.0	521.87	522.49	521.56	521.56	524.56	525.95	525.42
4/27/94	459.0	458.87	459.49	458.56	458.56	461.56	462.95	462.41
4/28/94	410.0	409.87	410.49	409.56	409.56	412.56	413.95	413.41
4/29/94	434.0	433.87	434.49	433.56	433.56	436.56	437.95	437.41
4/30/94	450.0	449.87	450.49	449.56	449.56	452.56	453.95	453.41
5/1/94	434.0	434.90	435.48	434.16	437.37	442.25	444.31	443.78
5/2/94	418.0	418.91	419.49	418.17	421.38	426.25	428.32	427.78
5/3/94	450.0	450.91	451.49	450.17	453.38	457.75	459.82	459.28
5/4/94	728.0	728.91	729.48	728.17	731.38	735.94	738.01	737.47
5/5/94	1051.0	1051.90	1052.48	1051.16	1054.37	1058.92	1060.99	1060.45
5/6/94	1715.0	1715.89	1716.47	1715.15	1718.36	1723.12	1725.19	1724.65
5/7/94	1672.0	1672.86	1673.44	1672.12	1675.33	1680.09	1682.15	1681.62
5/8/94	1476.0	1476.83	1477.41	1476.09	1479.30	1484.05	1486.12	1485.58
5/9/94	989.0	989.84	990.41	989.10	992.31	997.05	999.12	998.58

5/10/94	608.0	608.86	609.44	608.12	611.33	616.19	618.25	617.71
5/11/94	525.0	525.98	526.56	525.24	528.45	533.31	535.38	534.84
5/12/94	477.0	478.00	478.58	477.26	480.47	485.33	487.39	486.85
5/13/94	423.0	424.02	424.60	423.28	426.49	431.34	433.41	432.87
5/14/94	452.0	453.04	453.61	452.30	455.51	460.35	462.42	461.88
5/15/94	683.0	684.05	684.62	683.31	686.51	691.36	693.43	692.89
5/16/94	657.0	658.03	658.61	657.29	660.50	665.34	667.41	666.87
5/17/94	675.0	676.03	676.61	675.29	678.50	683.34	685.41	684.87
5/18/94	880.0	881.03	881.61	880.29	883.50	887.65	889.72	889.18
5/19/94	966.0	967.15	967.72	966.41	969.62	974.04	976.10	975.56
5/20/94	786.0	787.05	787.62	786.31	789.52	793.92	795.99	795.45
5/21/94	547.0	548.06	548.63	547.32	550.52	555.21	557.28	556.74
5/22/94	506.0	507.06	507.63	506.32	509.52	514.21	516.27	515.74
5/23/94	485.0	486.29	486.86	485.55	488.75	493.43	495.50	494.96
5/24/94	615.0	616.40	616.98	615.67	618.87	623.70	625.76	625.23
5/25/94	937.0	938.42	938.99	937.68	940.88	945.71	947.77	947.24
5/26/94	919.0	920.67	921.24	919.93	923.13	927.80	929.86	929.33
5/27/94	803.0	804.37	804.95	803.63	806.84	811.66	813.72	813.19
5/28/94	896.0	897.49	898.06	896.75	899.95	904.77	906.84	906.30
5/29/94	1107.0	1108.56	1109.14	1107.82	1111.03	1115.89	1117.96	1117.42
5/30/94	1174.0	1175.44	1176.01	1174.70	1177.91	1182.77	1184.84	1184.30
5/31/94	1244.0	1245.64	1246.21	1244.90	1246.13	1251.00	1253.06	1252.53
6/1/94	1363.0	1364.86	1365.49	1361.23	1362.67	1367.70	1369.91	1369.38
6/2/94	1421.0	1423.28	1423.91	1419.65	1421.09	1426.11	1428.32	1427.79
6/3/94	1447.0	1448.85	1449.49	1445.23	1446.66	1450.85	1453.06	1452.53
6/4/94	1474.0	1476.04	1476.67	1472.41	1473.85	1478.37	1480.58	1480.05
6/5/94	1921.0	1923.26	1923.89	1919.63	1921.07	1925.58	1927.79	1927.26
6/6/94	1686.0	1687.81	1688.44	1684.18	1685.62	1690.45	1692.66	1692.12
6/7/94	1455.0	1456.90	1457.54	1453.28	1454.71	1459.34	1461.55	1461.02
6/8/94	1433.0	1435.00	1435.63	1431.37	1432.81	1437.27	1439.48	1438.94
6/9/94	1527.0	1529.52	1530.15	1525.89	1527.33	1531.70	1533.91	1533.38
6/10/94	1623.0	1625.00	1625.63	1621.37	1622.81	1627.39	1629.60	1629.07
6/11/94	1653.0	1655.22	1655.85	1651.59	1653.03	1657.68	1659.90	1659.36
6/12/94	1628.0	1630.49	1631.13	1626.87	1628.30	1632.95	1635.16	1634.63
6/13/94	1570.0	1571.78	1572.33	1568.07	1569.51	1574.23	1576.44	1575.91
6/14/94	1496.0	1497.86	1498.41	1494.16	1495.59	1500.14	1502.35	1501.82
6/15/94	1455.0	1456.94	1457.49	1453.23	1454.67	1459.00	1461.21	1460.68
6/16/94	1673.0	1675.49	1676.04	1671.78	1673.21	1677.40	1679.61	1679.07
6/17/94	1951.0	1952.94	1953.49	1949.23	1950.67	1954.77	1956.98	1956.44
6/18/94	2172.0	2174.14	2174.69	2170.43	2171.86	2175.28	2177.49	2176.95
6/19/94	1976.0	1978.50	1979.05	1974.80	1976.23	1979.84	1982.05	1981.51
6/20/94	1718.0	1719.85	1720.40	1716.14	1717.58	1721.06	1723.27	1722.73
6/21/94	1747.0	1748.87	1749.42	1745.16	1746.59	1750.46	1752.67	1752.14
6/22/94	2099.0	2100.86	2101.41	2097.15	2098.59	2102.41	2104.62	2104.08
6/23/94	2217.0	2219.24	2219.79	2215.53	2216.96	2220.80	2223.02	2222.48
6/24/94	2041.0	2042.92	2043.48	2039.22	2040.65	2044.33	2046.54	2046.00
6/25/94	2180.0	2182.13	2182.69	2178.43	2179.86	2183.64	2185.85	2185.31
6/26/94	2259.0	2261.32	2261.87	2257.61	2259.05	2262.76	2264.97	2264.43
6/27/94	2250.0	2251.82	2252.37	2248.11	2249.55	2253.15	2255.37	2254.83
6/28/94	2286.0	2287.97	2288.52	2284.26	2285.70	2289.21	2291.42	2290.89
6/29/94	2366.0	2368.03	2368.58	2364.32	2365.76	2369.19	2371.40	2370.87
6/30/94	2492.0	2494.51	2495.07	2490.81	2492.24	2495.62	2497.84	2497.30
7/1/94	2622.0	2624.37	2624.95	2618.58	2620.79	2623.58	2626.14	2625.60
7/2/94	2613.0	2615.58	2616.16	2609.79	2612.00	2615.16	2617.72	2617.18
7/3/94	2536.0	2538.84	2539.42	2533.05	2535.26	2536.38	2538.94	2538.40
7/4/94	2550.0	2552.17	2552.75	2546.39	2548.59	2549.72	2552.27	2551.74
7/5/94	2587.0	2588.72	2589.30	2582.93	2585.14	2588.56	2591.11	2590.58
7/6/94	2396.0	2397.88	2398.46	2392.09	2394.30	2397.36	2399.92	2399.39
7/7/94	2524.0	2525.52	2526.10	2519.73	2521.94	2523.81	2526.37	2525.83
7/8/94	2585.0	2586.53	2587.11	2580.75	2582.96	2584.52	2587.08	2586.55
7/9/94	2668.0	2669.55	2670.13	2663.76	2665.97	2667.45	2670.01	2669.47
7/10/94	2755.0	2756.56	2757.14	2750.77	2752.98	2754.65	2757.21	2756.67
7/11/94	2818.0	2819.56	2820.14	2813.78	2815.98	2817.56	2820.12	2819.59

7/12/94	2931.0	2932.56	2933.15	2926.78	2928.45	2929.89	2932.45	2931.91
7/13/94	3121.0	3122.42	3123.00	3116.64	3118.31	3119.65	3122.21	3121.67
7/14/94	3241.0	3242.42	3243.00	3236.64	3238.31	3239.61	3242.17	3241.63
7/15/94	3257.0	3258.42	3259.00	3252.64	3254.31	3255.59	3258.15	3257.62
7/16/94	3273.0	3274.50	3275.08	3268.71	3270.38	3271.59	3274.14	3273.61
7/17/94	3185.0	3186.36	3186.94	3180.58	3182.25	3183.37	3185.93	3185.40
7/18/94	3176.0	3177.34	3177.92	3171.55	3173.22	3172.72	3175.27	3174.74
7/19/94	3218.0	3219.49	3220.07	3213.71	3215.38	3215.48	3218.04	3217.50
7/20/94	3208.0	3209.42	3210.00	3203.64	3205.31	3205.35	3207.91	3207.37
7/21/94	3277.0	3278.35	3278.94	3272.57	3274.24	3274.86	3277.42	3276.88
7/22/94	3397.0	3398.26	3398.84	3392.48	3394.15	3394.71	3397.27	3396.74
7/23/94	3361.0	3362.45	3363.03	3356.66	3358.33	3358.86	3361.41	3360.88
7/24/94	3403.0	3404.45	3405.03	3398.66	3400.33	3401.14	3403.69	3403.16
7/25/94	3316.0	3317.38	3317.96	3311.59	3313.27	3314.10	3316.66	3316.13
7/26/94	3176.0	3177.38	3177.96	3171.60	3173.27	3173.72	3176.28	3175.74
7/27/94	3202.0	3203.29	3203.87	3197.51	3199.18	3199.91	3202.47	3201.93
7/28/94	3332.0	3332.95	3333.53	3327.16	3328.83	3329.53	3332.08	3331.55
7/29/94	3438.0	3438.72	3439.30	3432.94	3434.61	3435.39	3437.95	3437.42
7/30/94	3438.0	3438.63	3439.21	3432.84	3434.52	3435.29	3437.85	3437.32
7/31/94	3410.0	3410.39	3410.97	3404.61	3405.79	3406.54	3409.10	3408.56
8/1/94	3358.0	3358.24	3358.83	3353.87	3354.81	3355.41	3357.77	3357.24
8/2/94	3358.0	3358.01	3358.61	3353.65	3354.58	3355.17	3357.53	3356.99
8/3/94	3358.0	3358.50	3359.10	3354.14	3355.07	3354.16	3356.52	3355.99
8/4/94	3466.0	3466.91	3467.51	3462.55	3463.48	3463.23	3465.59	3465.06
8/5/94	3466.0	3466.49	3467.09	3462.13	3463.06	3462.78	3465.14	3464.61
8/6/94	3384.0	3384.42	3385.01	3380.05	3380.99	3381.31	3383.67	3383.14
8/7/94	3116.0	3116.65	3117.25	3112.29	3113.22	3113.58	3115.94	3115.41
8/8/94	3006.0	3007.13	3007.72	3002.77	3003.70	3004.14	3006.50	3005.96
8/9/94	2922.0	2923.03	2923.63	2918.67	2919.60	2920.01	2922.37	2921.83
8/10/94	2900.0	2900.34	2900.93	2895.97	2896.29	2896.93	2899.29	2898.75
8/11/94	2879.0	2878.90	2879.49	2874.54	2875.13	2875.73	2878.09	2877.55
8/12/94	2846.0	2845.52	2846.12	2841.16	2841.76	2842.32	2844.68	2844.14
8/13/94	2813.0	2812.52	2813.12	2808.16	2808.76	2809.29	2811.65	2811.11
8/14/94	2900.0	2899.52	2900.12	2895.16	2895.76	2896.26	2898.62	2898.09
8/15/94	2867.0	2866.52	2867.12	2862.16	2862.76	2863.23	2865.59	2865.05
8/16/94	2690.0	2689.63	2690.22	2685.26	2685.86	2686.35	2688.71	2688.17
8/17/94	2681.0	2680.53	2681.12	2676.17	2676.76	2677.26	2679.62	2679.08
8/18/94	2696.0	2695.50	2696.10	2691.14	2691.74	2690.84	2693.20	2692.66
8/19/94	2640.0	2639.67	2640.27	2635.31	2635.91	2635.56	2637.92	2637.39
8/20/94	2608.0	2607.60	2608.19	2603.23	2603.83	2603.48	2605.84	2605.30
8/21/94	2554.0	2553.52	2554.11	2549.15	2549.75	2549.95	2552.31	2551.77
8/22/94	2476.0	2475.42	2476.01	2471.05	2471.65	2471.85	2474.21	2473.68
8/23/94	2467.0	2466.66	2467.25	2462.29	2462.89	2463.12	2465.48	2464.94
8/24/94	2459.0	2458.66	2459.25	2454.29	2454.89	2455.38	2457.74	2457.20
8/25/94	2450.0	2449.58	2450.17	2445.21	2445.81	2446.28	2448.64	2448.11
8/26/94	2375.0	2374.62	2375.21	2370.25	2370.85	2371.18	2373.54	2373.00
8/27/94	2257.0	2256.48	2257.07	2252.12	2252.71	2253.26	2255.62	2255.09
8/28/94	2142.0	2141.48	2142.07	2137.11	2137.71	2138.20	2140.56	2140.02
8/29/94	2008.0	2007.36	2007.95	2002.99	2003.59	2004.15	2006.51	2005.98
8/30/94	1764.0	1763.36	1763.95	1758.99	1759.55	1760.10	1762.47	1761.93
8/31/94	1597.0	1596.48	1597.07	1592.12	1592.83	1593.38	1595.74	1595.20
9/1/94	1522.0	1521.48	1522.11	1518.37	1518.22	1518.64	1520.55	1520.01
9/2/94	1432.0	1431.48	1432.11	1428.37	1428.22	1428.63	1430.54	1430.00
9/3/94	1378.0	1377.52	1378.16	1374.42	1374.26	1373.45	1375.36	1374.82
9/4/94	1324.0	1323.52	1324.16	1320.42	1320.26	1320.15	1322.06	1321.52
9/5/94	1181.0	1180.52	1181.16	1177.42	1177.26	1177.09	1179.00	1178.46
9/6/94	1019.0	1018.52	1019.16	1015.42	1015.26	1015.52	1017.43	1016.89
9/7/94	961.0	960.42	961.05	957.31	957.16	957.37	959.28	958.74
9/8/94	702.0	701.42	702.05	698.31	698.15	698.35	700.26	699.72
9/9/94	573.0	572.42	573.05	569.31	569.53	569.73	571.64	571.10
9/10/94	550.0	549.42	550.05	546.31	546.56	547.09	549.00	548.46
9/11/94	495.0	494.43	495.06	491.32	491.57	492.14	494.05	493.52
9/12/94	459.0	458.43	459.06	455.32	455.57	456.21	458.11	457.58

9/13/94	468.0	467.43	468.06	464.32	464.57	465.12	467.03	466.50
9/14/94	495.0	494.43	495.06	491.32	491.57	492.13	494.04	493.51
9/15/94	522.0	521.43	522.06	518.32	518.57	519.23	521.13	520.60
9/16/94	504.0	503.53	504.17	500.43	498.63	499.19	501.10	500.56
9/17/94	486.0	485.41	486.05	482.30	480.51	481.00	482.91	482.38
9/18/94	477.0	476.72	477.36	473.62	471.82	471.11	473.02	472.49
9/19/94	468.0	467.26	467.89	464.15	462.36	462.09	464.00	463.46
9/20/94	468.0	467.52	468.15	464.41	462.62	462.33	464.24	463.70
9/21/94	459.0	458.42	459.05	455.31	453.52	453.68	455.59	455.05
9/22/94	468.0	467.66	468.29	464.55	462.76	462.90	464.81	464.27
9/23/94	459.0	458.66	459.29	455.55	453.76	453.90	455.81	455.27
9/24/94	459.0	458.19	458.82	455.08	453.29	453.41	455.32	454.79
9/25/94	459.0	458.53	459.16	455.42	453.62	453.97	455.88	455.35
9/26/94	450.0	449.53	450.16	446.42	444.62	444.97	446.88	446.34
9/27/94	442.0	441.44	442.07	438.33	436.54	436.86	438.77	438.23
9/28/94	442.0	441.44	442.07	438.33	436.54	436.89	438.80	438.26
9/29/94	459.0	458.57	459.20	455.46	453.66	454.06	455.97	455.43
9/30/94	450.0	449.57	450.20	446.46	444.66	445.07	446.98	446.45
10/1/94	450.0	449.57	450.25	449.26	448.00	448.29	449.45	448.92
10/2/94	450.0	449.49	450.17	449.19	447.93	448.21	449.38	448.85
10/3/94	450.0	449.49	450.17	449.19	447.93	447.04	448.21	447.68
10/4/94	442.0	441.49	442.17	441.19	439.93	439.51	440.68	440.14
10/5/94	442.0	441.56	442.24	441.26	440.00	439.58	440.75	440.21
10/6/94	442.0	441.56	442.24	441.26	440.00	440.06	441.23	440.69
10/7/94	450.0	449.56	450.24	449.26	448.00	448.10	449.27	448.73
10/8/94	434.0	433.56	434.24	433.26	432.00	432.07	433.23	432.70
10/9/94	442.0	441.50	442.18	441.20	439.94	440.01	441.18	440.64
10/10/94	434.0	433.50	434.18	433.20	431.94	432.23	433.40	432.87
10/11/94	426.0	425.50	426.18	425.20	423.94	424.28	425.45	424.92
10/12/94	434.0	433.50	434.18	433.20	431.94	432.35	433.52	432.98
10/13/94	434.0	433.62	434.31	433.32	432.06	432.54	433.71	433.18
10/14/94	468.0	467.62	468.31	467.32	466.06	466.54	467.71	467.18
10/15/94	434.0	433.62	434.31	433.32	432.06	432.54	433.71	433.18
10/16/94	426.0	425.62	426.26	425.28	425.28	425.51	425.63	425.09
10/17/94	378.0	377.62	378.26	377.28	377.28	377.51	377.63	377.09
10/18/94	211.0	210.62	211.26	210.28	210.28	208.90	209.02	208.48
10/19/94	212.0	211.58	212.22	211.23	211.23	210.32	210.44	209.90
10/20/94	229.0	228.58	229.22	228.23	228.23	227.79	227.90	227.37
10/21/94	264.0	263.58	264.22	263.23	263.23	263.24	263.36	262.82
10/22/94	244.0	243.58	244.22	243.23	243.23	243.25	243.36	242.83
10/23/94	242.0	241.58	242.22	241.23	241.23	241.25	241.37	240.83
10/24/94	241.0	240.58	241.22	240.23	240.23	240.25	240.37	239.83
10/25/94	239.0	238.64	239.28	238.29	238.29	238.54	238.66	238.12
10/26/94	267.0	266.64	267.28	266.29	266.29	266.54	266.66	266.12
10/27/94	380.0	379.64	380.28	379.29	379.29	379.54	379.66	379.12
10/28/94	458.0	457.64	458.28	457.29	457.29	457.54	457.66	457.12
10/29/94	566.0	565.64	566.28	565.29	565.29	565.55	565.66	565.13
10/30/94	507.0	506.64	507.28	506.29	506.29	506.55	506.66	506.13
10/31/94	884.0	883.64	884.28	883.29	883.29	883.55	883.67	883.13
11/1/94	1531.0	1530.64	1531.33	1530.65	1530.65	1530.44	1530.56	1530.02
11/2/94	1063.0	1062.64	1063.33	1062.65	1062.65	1062.52	1062.63	1062.10
11/3/94	848.0	847.64	848.33	847.65	847.65	847.52	847.63	847.10
11/4/94	619.0	618.64	619.33	618.65	618.65	618.52	618.63	618.10
11/5/94	546.0	545.64	546.33	545.65	545.65	545.56	545.67	545.13
11/6/94	453.0	452.64	453.33	452.65	452.65	452.56	452.67	452.13
11/7/94	402.0	401.64	402.33	401.65	401.65	401.56	401.67	401.13
11/8/94	328.0	327.64	328.33	327.65	327.65	327.56	327.67	327.13
11/9/94	342.0	341.64	342.33	341.65	341.65	341.58	341.69	341.16
11/10/94	356.0	355.64	356.33	355.65	355.65	355.58	355.69	355.16
11/11/94	356.0	355.70	356.39	355.71	355.71	355.64	355.75	355.22
11/12/94	356.0	355.70	356.39	355.71	355.71	355.64	355.75	355.22
11/13/94	342.0	341.70	342.39	341.71	341.71	341.64	341.75	341.22
11/14/94	342.0	341.70	342.39	341.71	341.71	341.64	341.76	341.22

11/15/94	335.0	334.70	335.39	334.71	334.71	334.64	334.76	334.22
11/16/94	342.0	341.70	342.39	341.71	341.71	341.64	341.76	341.22
11/17/94	335.0	334.70	335.39	334.71	334.71	334.64	334.76	334.22
11/18/94	307.0	306.70	307.39	306.71	306.71	306.64	306.75	306.22
11/19/94	314.0	313.70	314.39	313.71	313.71	313.66	313.78	313.24
11/20/94	513.0	512.70	513.39	512.71	512.71	512.66	512.78	512.24
11/21/94	477.0	476.70	477.39	476.71	476.71	476.66	476.78	476.24
11/22/94	418.0	417.70	418.39	417.71	417.71	417.66	417.78	417.24
11/23/94	410.0	409.70	410.38	409.71	409.71	409.66	409.77	409.24
11/24/94	386.0	385.70	386.38	385.71	385.71	385.66	385.77	385.24
11/25/94	363.0	362.70	363.38	362.71	362.71	362.66	362.77	362.24
11/26/94	356.0	355.70	356.38	355.71	355.71	355.66	355.78	355.24
11/27/94	356.0	355.70	356.38	355.71	355.71	355.66	355.78	355.24
11/28/94	356.0	355.70	356.38	355.71	355.71	355.66	355.78	355.24
11/29/94	378.0	377.70	378.38	377.71	377.71	377.66	377.78	377.24
11/30/94	1042.0	1041.70	1042.38	1041.71	1041.71	1041.66	1041.78	1041.24
12/1/94	2298.0	2297.70	2298.37	2297.67	2297.67	2297.62	2297.74	2297.20
12/2/94	1569.0	1568.70	1569.37	1568.67	1568.67	1568.62	1568.74	1568.20
12/3/94	1185.0	1184.70	1185.37	1184.67	1184.67	1184.64	1184.76	1184.22
12/4/94	974.0	973.70	974.37	973.67	973.67	973.64	973.76	973.22
12/5/94	717.0	716.70	717.37	716.67	716.67	716.64	716.76	716.22
12/6/94	630.0	629.73	630.40	629.71	629.71	629.68	629.79	629.26
12/7/94	570.0	569.73	570.40	569.71	569.71	569.68	569.79	569.26
12/8/94	531.0	530.73	531.40	530.71	530.71	530.68	530.79	530.26
12/9/94	503.0	502.73	503.40	502.71	502.71	502.68	502.79	502.26
12/10/94	441.0	440.73	441.40	440.71	440.71	440.68	440.79	440.26
12/11/94	417.0	416.73	417.40	416.71	416.71	416.68	416.79	416.26
12/12/94	393.0	392.73	393.40	392.71	392.71	392.68	392.79	392.26
12/13/94	369.0	368.73	369.40	368.71	368.71	368.68	368.80	368.26
12/14/94	355.0	354.73	355.40	354.71	354.71	354.68	354.80	354.26
12/15/94	341.0	340.73	341.40	340.71	340.71	340.68	340.80	340.26
12/16/94	334.0	333.73	334.40	333.71	333.71	333.68	333.80	333.26
12/17/94	368.0	367.73	368.40	367.71	367.71	367.68	367.80	367.26
12/18/94	416.0	415.73	416.40	415.71	415.71	415.68	415.80	415.26
12/19/94	448.0	447.73	448.40	447.71	447.71	447.68	447.80	447.26
12/20/94	502.0	501.73	502.40	501.71	501.71	501.68	501.80	501.26
12/21/94	627.0	626.73	627.40	626.71	626.71	626.68	626.80	626.26
12/22/94	617.0	616.77	617.44	616.74	616.74	616.72	616.83	616.30
12/23/94	567.0	566.77	567.44	566.74	566.74	566.72	566.83	566.30
12/24/94	528.0	527.77	528.44	527.74	527.74	527.72	527.84	527.30
12/25/94	492.0	491.77	492.44	491.74	491.74	491.72	491.84	491.30
12/26/94	519.0	518.77	519.44	518.74	518.74	518.72	518.84	518.30
12/27/94	806.0	805.77	806.44	805.74	805.74	805.72	805.84	805.30
12/28/94	943.0	942.77	943.44	942.74	942.74	942.72	942.84	942.30
12/29/94	853.0	852.77	853.44	852.74	852.74	852.72	852.84	852.30
12/30/94	757.0	756.77	757.44	756.74	756.74	756.72	756.84	756.30
12/31/94	679.0	678.77	679.44	678.74	678.74	678.72	678.84	678.30
1/1/95	626.0	625.77	626.42	625.75	625.75	625.73	625.85	625.31
1/2/95	615.0	614.77	615.42	614.75	614.75	614.73	614.85	614.31
1/3/95	668.0	667.77	668.42	667.75	667.75	667.73	667.85	667.31
1/4/95	646.0	645.77	646.42	645.75	645.75	645.73	645.85	645.31
1/5/95	635.0	634.77	635.42	634.75	634.75	634.73	634.85	634.31
1/6/95	605.0	604.77	605.42	604.75	604.75	604.74	604.85	604.32
1/7/95	414.0	413.77	414.42	413.75	413.75	413.74	413.85	413.32
1/8/95	389.0	388.77	389.42	388.75	388.75	388.74	388.85	388.32
1/9/95	373.0	372.77	373.42	372.75	372.75	372.74	372.85	372.32
1/10/95	381.0	380.77	381.42	380.75	380.75	380.74	380.85	380.32
1/11/95	373.0	372.78	373.43	372.77	372.77	372.75	372.87	372.33
1/12/95	359.0	358.78	359.43	358.77	358.77	358.75	358.87	358.33
1/13/95	358.0	357.78	358.43	357.77	357.77	357.75	357.87	357.33
1/14/95	358.0	357.78	358.43	357.77	357.77	357.75	357.87	357.33
1/15/95	358.0	357.78	358.43	357.77	357.77	357.75	357.87	357.33
1/16/95	344.0	343.78	344.43	343.77	343.77	343.75	343.87	343.33

1/17/95	330.0	329.78	330.43	329.77	329.77	329.75	329.87	329.33
1/18/95	337.0	336.78	337.43	336.77	336.77	336.75	336.87	336.33
1/19/95	316.0	315.78	316.43	315.77	315.77	315.75	315.87	315.33
1/20/95	302.0	301.78	302.43	301.77	301.77	301.75	301.87	301.33
1/21/95	289.0	288.78	289.43	288.77	288.77	288.75	288.87	288.33
1/22/95	277.0	276.78	277.43	276.77	276.77	276.76	276.87	276.34
1/23/95	271.0	270.78	271.43	270.77	270.77	270.76	270.87	270.34
1/24/95	271.0	270.78	271.43	270.77	270.77	270.76	270.87	270.34
1/25/95	265.0	264.78	265.43	264.77	264.77	264.76	264.87	264.34
1/26/95	259.0	258.78	259.43	258.77	258.77	258.76	258.87	258.34
1/27/95	253.0	252.78	253.43	252.77	252.77	252.76	252.87	252.34
1/28/95	253.0	252.78	253.43	252.77	252.77	252.76	252.87	252.34
1/29/95	264.0	263.78	264.43	263.77	263.77	263.76	263.87	263.34
1/30/95	307.0	306.78	307.43	306.77	306.77	306.76	306.87	306.34
1/31/95	620.0	619.78	620.43	619.77	619.77	619.76	619.87	619.34
2/1/95	1403.0	1402.78	1403.49	1402.80	1402.80	1402.79	1402.90	1402.37
2/2/95	1484.0	1483.78	1484.49	1483.80	1483.80	1483.79	1483.90	1483.37
2/3/95	1260.0	1259.81	1260.52	1259.82	1259.82	1259.81	1259.93	1259.39
2/4/95	1070.0	1069.81	1070.52	1069.82	1069.82	1069.81	1069.93	1069.39
2/5/95	974.0	973.81	974.52	973.82	973.82	973.81	973.93	973.39
2/6/95	909.0	908.81	909.52	908.82	908.82	908.81	908.93	908.39
2/7/95	883.0	882.81	883.52	882.82	882.82	882.81	882.93	882.39
2/8/95	883.0	882.81	883.52	882.82	882.82	882.81	882.93	882.39
2/9/95	870.0	869.81	870.52	869.82	869.82	869.81	869.93	869.39
2/10/95	870.0	869.81	870.52	869.82	869.82	869.81	869.93	869.39
2/11/95	870.0	869.81	870.52	869.82	869.82	869.82	869.93	869.40
2/12/95	834.0	833.81	834.52	833.82	833.82	833.82	833.93	833.40
2/13/95	774.0	773.81	774.52	773.82	773.82	773.82	773.93	773.40
2/14/95	706.0	705.81	706.52	705.82	705.82	705.82	705.93	705.40
2/15/95	684.0	683.81	684.52	683.82	683.82	683.82	683.93	683.40
2/16/95	640.0	639.81	640.52	639.82	639.82	639.82	639.93	639.40
2/17/95	640.0	639.81	640.52	639.82	639.82	639.82	639.93	639.40
2/18/95	636.0	635.81	636.52	635.82	635.82	635.82	635.93	635.40
2/19/95	1714.0	1713.81	1714.52	1713.82	1713.82	1713.82	1713.93	1713.40
2/20/95	3628.0	3627.81	3628.52	3627.82	3627.82	3627.82	3627.93	3627.40
2/21/95	2960.0	2959.81	2960.52	2959.82	2959.82	2959.82	2959.93	2959.40
2/22/95	2342.0	2341.81	2342.52	2341.82	2341.82	2341.82	2341.93	2341.40
2/23/95	1734.0	1733.81	1734.52	1733.82	1733.82	1733.82	1733.93	1733.40
2/24/95	1413.0	1412.81	1413.52	1412.82	1412.82	1412.82	1412.93	1412.40
2/25/95	1322.0	1321.81	1322.52	1321.82	1321.82	1321.82	1321.93	1321.40
2/26/95	1311.0	1310.81	1311.52	1310.82	1310.82	1310.82	1310.93	1310.40
2/27/95	1225.0	1224.81	1225.52	1224.82	1224.82	1224.82	1224.93	1224.40
2/28/95	1112.0	1111.81	1112.52	1111.82	1111.82	1111.82	1111.93	1111.40
3/1/95	1033.0	1032.81	1033.45	1032.78	1032.78	1032.78	1032.89	1032.36
3/2/95	957.0	956.81	957.45	956.78	956.78	956.78	956.89	956.36
3/3/95	896.0	895.83	896.47	895.81	895.81	895.80	895.92	895.38
3/4/95	850.0	849.83	850.47	849.81	849.81	849.80	849.92	849.38
3/5/95	806.0	805.83	806.47	805.81	805.81	805.80	805.92	805.38
3/6/95	762.0	761.83	762.47	761.81	761.81	761.80	761.92	761.38
3/7/95	717.0	716.83	717.47	716.81	716.81	716.80	716.92	716.38
3/8/95	684.0	683.83	684.47	683.81	683.81	683.80	683.92	683.38
3/9/95	696.0	695.83	696.47	695.81	695.81	695.80	695.92	695.38
3/10/95	775.0	774.83	775.47	774.81	774.81	774.80	774.92	774.38
3/11/95	847.0	846.83	847.47	846.81	846.81	846.80	846.92	846.38
3/12/95	885.0	884.83	885.47	884.81	884.81	884.80	884.92	884.38
3/13/95	898.0	897.83	898.47	897.81	897.81	897.80	897.92	897.38
3/14/95	937.0	936.83	937.47	936.81	936.81	936.80	936.92	936.38
3/15/95	1059.0	1058.83	1059.47	1058.81	1058.81	1058.80	1058.92	1058.38
3/16/95	1087.0	1086.83	1087.47	1086.81	1086.81	1086.80	1086.92	1086.38
3/17/95	1059.0	1058.83	1059.47	1058.81	1058.81	1058.80	1058.92	1058.38
3/18/95	1059.0	1058.83	1059.47	1058.81	1058.81	1058.80	1058.92	1058.38
3/19/95	1159.0	1158.83	1159.47	1158.81	1158.81	1158.80	1158.92	1158.38
3/20/95	1234.0	1233.83	1234.47	1233.81	1233.81	1233.80	1233.92	1233.38

3/21/95	1234.0	1233.83	1234.47	1233.81	1233.81	1233.80	1233.92	1233.38
3/22/95	1130.0	1129.83	1130.47	1129.81	1129.81	1129.80	1129.92	1129.38
3/23/95	1047.0	1046.83	1047.47	1046.81	1046.81	1046.80	1046.92	1046.38
3/24/95	966.0	965.83	966.47	965.81	965.81	965.80	965.92	965.38
3/25/95	875.0	874.83	875.47	874.81	874.81	874.80	874.92	874.38
3/26/95	815.0	814.83	815.47	814.81	814.81	814.80	814.92	814.38
3/27/95	779.0	778.83	779.47	778.81	778.81	778.80	778.92	778.38
3/28/95	767.0	766.83	767.47	766.81	766.81	766.80	766.92	766.38
3/29/95	756.0	755.83	756.47	755.81	755.81	755.80	755.92	755.38
3/30/95	768.0	767.83	768.47	767.81	767.81	767.80	767.92	767.38
3/31/95	804.0	803.83	804.47	803.81	803.81	803.80	803.92	803.38
4/1/95	840.0	839.83	840.45	839.52	839.52	842.18	843.57	842.98
4/2/95	864.0	863.83	864.45	863.52	863.52	866.01	867.40	866.81
4/3/95	864.0	863.83	864.45	863.52	863.52	865.67	867.06	866.47
4/4/95	943.0	942.83	943.45	942.52	942.52	944.84	946.23	945.64
4/5/95	994.0	993.83	994.45	993.52	993.52	995.84	997.23	996.64
4/6/95	878.0	877.85	878.47	877.54	877.54	880.03	881.42	880.83
4/7/95	647.0	646.86	647.48	646.55	646.55	649.04	650.43	649.84
4/8/95	617.0	616.86	617.48	616.55	616.55	619.04	620.43	619.84
4/9/95	691.0	690.86	691.48	690.55	690.55	693.04	694.43	693.84
4/10/95	892.0	891.86	892.48	891.55	891.55	894.12	895.51	894.92
4/11/95	970.0	969.86	970.48	969.55	969.55	972.12	973.51	972.92
4/12/95	945.0	944.86	945.48	944.55	944.55	947.12	948.51	947.92
4/13/95	1011.0	1010.86	1011.48	1010.55	1010.55	1013.12	1014.51	1013.92
4/14/95	1182.0	1181.86	1182.48	1181.55	1181.55	1184.12	1185.51	1184.92
4/15/95	1335.0	1334.86	1335.48	1334.55	1334.55	1337.12	1338.51	1337.92
4/16/95	1351.0	1350.86	1351.48	1350.55	1350.55	1353.12	1354.51	1353.92
4/17/95	1335.0	1334.86	1335.48	1334.55	1334.55	1337.12	1338.51	1337.92
4/18/95	1320.0	1319.86	1320.48	1319.55	1319.55	1321.63	1323.02	1322.43
4/19/95	1288.0	1287.86	1288.48	1287.55	1287.55	1289.82	1291.21	1290.62
4/20/95	1083.0	1082.86	1083.48	1082.55	1082.55	1084.81	1086.20	1085.61
4/21/95	1041.0	1040.86	1041.48	1040.55	1040.55	1043.01	1044.40	1043.81
4/22/95	1055.0	1054.86	1055.48	1054.55	1054.55	1057.01	1058.40	1057.81
4/23/95	1083.0	1082.86	1083.48	1082.55	1082.55	1085.00	1086.39	1085.80
4/24/95	1140.0	1139.86	1140.48	1139.55	1139.55	1142.00	1143.39	1142.80
4/25/95	1275.0	1274.86	1275.48	1274.55	1274.55	1277.10	1278.49	1277.90
4/26/95	1656.0	1655.86	1656.48	1655.55	1655.55	1658.10	1659.49	1658.90
4/27/95	1710.0	1709.86	1710.48	1709.55	1709.55	1712.10	1713.49	1712.90
4/28/95	1764.0	1763.86	1764.48	1763.55	1763.55	1766.10	1767.49	1766.90
4/29/95	1746.0	1745.86	1746.48	1745.55	1745.55	1748.10	1749.49	1748.90
4/30/95	1692.0	1691.86	1692.48	1691.55	1691.55	1694.10	1695.49	1694.90
5/1/95	1674.0	1674.64	1675.21	1673.90	1676.95	1681.65	1683.72	1683.13
5/2/95	1710.0	1710.63	1711.21	1709.89	1712.95	1717.65	1719.71	1719.12
5/3/95	1820.0	1820.62	1821.20	1819.88	1822.94	1827.03	1829.09	1828.50
5/4/95	1746.0	1746.62	1747.20	1745.88	1748.94	1753.26	1755.33	1754.74
5/5/95	1728.0	1728.63	1729.20	1727.89	1730.94	1735.26	1737.32	1736.73
5/6/95	1692.0	1692.61	1693.18	1691.87	1694.92	1699.48	1701.55	1700.96
5/7/95	1710.0	1710.57	1711.15	1709.83	1712.89	1717.44	1719.51	1718.92
5/8/95	1800.0	1800.56	1801.13	1799.82	1802.87	1807.42	1809.49	1808.90
5/9/95	1402.0	1402.75	1403.33	1402.01	1405.06	1409.61	1411.67	1411.08
5/10/95	1112.0	1112.75	1113.33	1112.01	1115.06	1119.74	1121.81	1121.22
5/11/95	1014.0	1014.87	1015.45	1014.13	1017.19	1021.87	1023.93	1023.34
5/12/95	822.0	822.73	823.31	821.99	825.05	829.72	831.78	831.19
5/13/95	651.0	651.76	652.33	651.02	654.07	658.74	660.81	660.22
5/14/95	610.0	610.75	611.32	610.01	613.06	617.73	619.79	619.20
5/15/95	673.0	673.69	674.27	672.95	676.00	680.67	682.74	682.15
5/16/95	834.0	834.80	835.38	834.06	837.12	841.78	843.84	843.25
5/17/95	870.0	870.78	871.36	870.04	873.09	877.75	879.82	879.23
5/18/95	739.0	739.59	740.16	738.85	741.90	745.74	747.80	747.21
5/19/95	651.0	651.69	652.27	650.95	654.01	658.16	660.22	659.63
5/20/95	651.0	651.67	652.25	650.93	653.98	658.12	660.19	659.60
5/21/95	728.0	728.66	729.23	727.92	730.97	735.45	737.51	736.92
5/22/95	750.0	750.63	751.21	749.90	752.95	757.42	759.48	758.89

5/23/95	834.0	834.73	835.30	833.99	837.04	841.50	843.57	842.98
5/24/95	1746.0	1746.75	1747.32	1746.01	1749.06	1753.70	1755.77	1755.18
5/25/95	3286.0	3286.73	3287.30	3285.99	3289.04	3293.68	3295.74	3295.15
5/26/95	3795.0	3795.77	3796.34	3795.03	3798.08	3802.52	3804.59	3804.00
5/27/95	3833.0	3833.69	3834.27	3832.95	3836.00	3840.63	3842.70	3842.11
5/28/95	3662.0	3662.70	3663.28	3661.96	3665.02	3669.64	3671.71	3671.12
5/29/95	3557.0	3557.66	3558.24	3556.92	3559.97	3564.66	3566.73	3566.14
5/30/95	3825.0	3825.63	3826.21	3824.89	3827.95	3832.63	3834.70	3834.11
5/31/95	4494.0	4494.70	4495.28	4493.96	4495.14	4499.83	4501.89	4501.30
6/1/95	4374.0	4375.06	4375.69	4371.43	4373.25	4378.74	4380.95	4380.36
6/2/95	4046.0	4047.14	4047.77	4043.51	4045.33	4050.83	4053.04	4052.45
6/3/95	3536.0	3537.08	3537.71	3533.45	3535.27	3539.71	3541.92	3541.33
6/4/95	3339.0	3340.12	3340.75	3336.49	3338.31	3343.16	3345.37	3344.78
6/5/95	2232.0	2233.17	2233.80	2229.54	2231.36	2236.20	2238.41	2237.82
6/6/95	1446.0	1447.11	1447.74	1443.48	1445.30	1450.56	1452.77	1452.18
6/7/95	1378.0	1379.09	1379.72	1375.46	1377.29	1382.54	1384.75	1384.16
6/8/95	1144.0	1145.11	1145.74	1141.48	1143.31	1148.55	1150.77	1150.18
6/9/95	1170.0	1171.20	1171.84	1167.58	1169.40	1174.64	1176.85	1176.26
6/10/95	1185.0	1186.11	1186.74	1182.49	1184.31	1189.77	1191.98	1191.39
6/11/95	1215.0	1216.13	1216.76	1212.50	1214.32	1219.79	1222.00	1221.41
6/12/95	1306.0	1307.19	1307.82	1303.56	1305.38	1310.84	1313.05	1312.46
6/13/95	1185.0	1186.07	1186.62	1182.36	1184.18	1189.64	1191.85	1191.26
6/14/95	1306.0	1307.09	1307.64	1303.38	1305.20	1310.65	1312.86	1312.27
6/15/95	1501.0	1502.10	1502.66	1498.40	1500.22	1505.67	1507.88	1507.29
6/16/95	1467.0	1468.24	1468.79	1464.53	1466.35	1471.80	1474.01	1473.42
6/17/95	1450.0	1451.11	1451.66	1447.40	1449.22	1454.66	1456.87	1456.28
6/18/95	1535.0	1536.13	1536.68	1532.42	1534.25	1538.39	1540.60	1540.01
6/19/95	1603.0	1604.26	1604.82	1600.56	1602.38	1607.03	1609.24	1608.65
6/20/95	1603.0	1604.12	1604.67	1600.41	1602.24	1606.72	1608.93	1608.34
6/21/95	1552.0	1553.09	1553.64	1549.38	1551.21	1556.19	1558.40	1557.81
6/22/95	1484.0	1485.05	1485.60	1481.34	1483.16	1488.32	1490.53	1489.94
6/23/95	1434.0	1435.06	1435.61	1431.35	1433.17	1438.32	1440.53	1439.94
6/24/95	1484.0	1485.12	1485.67	1481.41	1483.23	1488.37	1490.58	1489.99
6/25/95	1603.0	1604.15	1604.71	1600.45	1602.27	1607.66	1609.87	1609.28
6/26/95	1764.0	1765.15	1765.70	1761.44	1763.26	1768.43	1770.64	1770.05
6/27/95	1960.0	1961.06	1961.61	1957.35	1959.17	1964.11	1966.32	1965.73
6/28/95	1980.0	1981.13	1981.68	1977.42	1979.24	1983.96	1986.17	1985.58
6/29/95	1960.0	1961.14	1961.69	1957.43	1959.25	1963.85	1966.07	1965.47
6/30/95	1900.0	1901.22	1901.77	1897.52	1899.34	1903.90	1906.11	1905.52
7/1/95	1920.0	1921.45	1922.04	1915.67	1917.63	1922.34	1924.89	1924.30
7/2/95	1960.0	1961.49	1962.07	1955.71	1957.67	1962.35	1964.91	1964.32
7/3/95	1940.0	1941.54	1942.12	1935.75	1937.72	1940.75	1943.31	1942.72
7/4/95	2000.0	2001.36	2001.95	1995.58	1997.54	2001.18	2003.74	2003.15
7/5/95	2320.0	2321.29	2321.87	2315.50	2317.46	2321.01	2323.57	2322.98
7/6/95	2756.0	2757.32	2757.90	2751.53	2753.49	2757.58	2760.14	2759.55
7/7/95	3112.0	3113.27	3113.85	3107.49	3109.45	3113.49	3116.04	3115.45
7/8/95	3174.0	3175.27	3175.86	3169.49	3171.45	3175.48	3178.04	3177.45
7/9/95	3160.0	3161.27	3161.85	3155.48	3157.45	3161.96	3164.52	3163.93
7/10/95	2873.0	2874.27	2874.85	2868.49	2870.45	2875.09	2877.65	2877.06
7/11/95	2622.0	2623.28	2623.86	2617.49	2619.46	2623.73	2626.29	2625.70
7/12/95	2609.0	2610.28	2610.86	2604.50	2606.46	2610.56	2613.12	2612.53
7/13/95	2666.0	2667.26	2667.84	2661.47	2663.44	2667.43	2669.98	2669.39
7/14/95	2846.0	2847.26	2847.84	2841.47	2843.44	2847.34	2849.90	2849.31
7/15/95	3030.0	3031.26	3031.84	3025.48	3027.44	3031.26	3033.82	3033.23
7/16/95	3245.0	3246.32	3246.90	3240.54	3242.50	3246.23	3248.79	3248.20
7/17/95	3470.0	3471.24	3471.82	3465.46	3467.42	3470.52	3473.08	3472.49
7/18/95	3768.0	3769.22	3769.80	3763.44	3765.40	3766.07	3768.63	3768.04
7/19/95	3902.0	3903.35	3903.93	3897.57	3899.53	3900.51	3903.06	3902.47
7/20/95	4039.0	4040.30	4040.88	4034.51	4036.46	4037.06	4039.61	4039.02
7/21/95	4182.0	4183.24	4183.82	4177.45	4178.91	4180.22	4182.78	4182.19
7/22/95	4182.0	4183.16	4183.74	4177.38	4178.84	4180.11	4182.67	4182.08
7/23/95	4182.0	4183.33	4183.91	4177.55	4179.51	4180.78	4183.33	4182.74
7/24/95	4182.0	4183.33	4183.92	4177.55	4179.51	4181.13	4183.69	4183.10

7/25/95	4246.0	4247.28	4247.86	4241.49	4243.45	4245.01	4247.57	4246.97
7/26/95	4278.0	4279.28	4279.86	4273.49	4275.45	4276.67	4279.23	4278.64
7/27/95	4214.0	4215.21	4215.79	4209.42	4211.38	4212.98	4215.54	4214.95
7/28/95	4214.0	4215.21	4215.79	4209.42	4211.38	4212.80	4215.36	4214.77
7/29/95	4182.0	4183.12	4183.70	4177.34	4179.30	4180.71	4183.26	4182.67
7/30/95	4278.0	4279.12	4279.70	4273.34	4275.30	4276.67	4279.23	4278.64
7/31/95	4214.0	4215.21	4215.79	4209.43	4211.06	4212.33	4214.88	4214.29
8/1/95	4246.0	4247.01	4247.60	4242.65	4243.60	4244.66	4247.02	4246.43
8/2/95	4342.0	4343.01	4343.61	4338.65	4339.60	4340.61	4342.97	4342.38
8/3/95	4278.0	4279.05	4279.64	4274.68	4275.63	4274.76	4277.12	4276.53
8/4/95	4214.0	4215.05	4215.64	4210.68	4211.63	4211.44	4213.80	4213.21
8/5/95	4406.0	4407.04	4407.64	4402.68	4403.63	4403.38	4405.74	4405.15
8/6/95	4162.0	4163.04	4163.63	4158.68	4159.63	4160.15	4162.51	4161.92
8/7/95	3952.0	3952.97	3953.56	3948.60	3949.55	3950.32	3952.68	3952.09
8/8/95	3932.0	3932.97	3933.56	3928.60	3929.55	3930.42	3932.78	3932.19
8/9/95	3823.0	3823.97	3824.56	3819.60	3820.55	3821.26	3823.62	3823.03
8/10/95	3744.0	3744.97	3745.56	3740.60	3741.55	3742.54	3744.90	3744.31
8/11/95	3725.0	3725.98	3726.57	3721.61	3722.56	3723.53	3725.89	3725.30
8/12/95	3565.0	3565.98	3566.57	3561.61	3562.56	3563.44	3565.80	3565.21
8/13/95	3519.0	3519.98	3520.57	3515.61	3516.56	3517.42	3519.78	3519.19
8/14/95	3501.0	3501.98	3502.57	3497.61	3498.30	3499.13	3501.49	3500.90
8/15/95	3374.0	3374.98	3375.57	3370.61	3371.55	3372.41	3374.77	3374.18
8/16/95	3305.0	3306.06	3306.65	3301.70	3302.31	3303.10	3305.46	3304.87
8/17/95	3288.0	3288.98	3289.57	3284.61	3285.57	3286.84	3289.20	3288.61
8/18/95	3168.0	3168.96	3169.55	3164.59	3165.54	3165.11	3167.47	3166.88
8/19/95	3126.0	3127.11	3127.70	3122.74	3123.70	3123.71	3126.07	3125.48
8/20/95	3160.0	3161.04	3161.64	3156.68	3157.53	3157.44	3159.80	3159.21
8/21/95	3222.0	3222.98	3223.57	3218.61	3218.91	3219.39	3221.75	3221.16
8/22/95	3309.0	3309.89	3310.48	3305.53	3305.52	3305.94	3308.30	3307.71
8/23/95	3318.0	3319.09	3319.69	3314.73	3314.76	3315.16	3317.52	3316.93
8/24/95	3302.0	3303.09	3303.69	3298.73	3298.79	3299.48	3301.84	3301.25
8/25/95	3311.0	3312.03	3312.62	3307.66	3308.27	3308.96	3311.32	3310.73
8/26/95	3217.0	3218.03	3218.62	3213.66	3214.27	3214.62	3216.98	3216.39
8/27/95	3278.0	3278.95	3279.54	3274.58	3275.19	3275.86	3278.22	3277.63
8/28/95	3287.0	3287.95	3288.54	3283.58	3283.84	3284.50	3286.86	3286.27
8/29/95	3219.0	3219.85	3220.44	3215.48	3216.03	3216.95	3219.31	3218.72
8/30/95	3176.0	3176.85	3177.44	3172.48	3173.26	3174.27	3176.63	3176.04
8/31/95	3157.0	3157.95	3158.54	3153.58	3154.56	3155.49	3157.85	3157.26
9/1/95	3039.0	3038.55	3039.19	3035.45	3035.17	3035.87	3037.78	3037.19
9/2/95	2896.0	2895.55	2896.19	2892.45	2892.17	2892.83	2894.74	2894.15
9/3/95	2855.0	2854.59	2855.22	2851.48	2851.21	2850.30	2852.21	2851.62
9/4/95	2814.0	2813.59	2814.22	2810.48	2810.21	2809.94	2811.85	2811.26
9/5/95	2725.0	2724.59	2725.22	2721.48	2721.21	2720.97	2722.88	2722.29
9/6/95	2408.0	2407.59	2408.22	2404.48	2404.21	2404.59	2406.50	2405.91
9/7/95	1967.0	1966.50	1967.14	1963.39	1963.12	1963.96	1965.87	1965.28
9/8/95	1023.0	1022.50	1023.13	1019.39	1019.12	1019.88	1021.79	1021.20
9/9/95	477.0	476.50	477.13	473.39	473.12	473.73	475.64	475.05
9/10/95	570.0	569.50	570.13	566.39	566.12	566.92	568.83	568.24
9/11/95	540.0	539.51	540.14	536.40	536.13	536.86	538.77	538.18
9/12/95	522.0	521.51	522.14	518.40	518.13	518.81	520.72	520.13
9/13/95	522.0	521.51	522.14	518.40	518.29	518.95	520.85	520.26
9/14/95	513.0	512.51	513.14	509.40	509.14	509.77	511.68	511.09
9/15/95	504.0	503.51	504.14	500.40	500.34	500.95	502.85	502.26
9/16/95	495.0	494.60	495.23	491.49	489.30	489.88	491.79	491.20
9/17/95	495.0	494.50	495.13	491.39	489.20	489.77	491.68	491.09
9/18/95	513.0	512.76	513.39	509.65	507.46	506.65	508.56	507.97
9/19/95	504.0	503.37	504.00	500.26	498.32	498.06	499.97	499.38
9/20/95	495.0	494.59	495.22	491.48	489.89	489.63	491.53	490.94
9/21/95	495.0	494.51	495.14	491.40	489.81	490.08	491.99	491.40
9/22/95	495.0	494.71	495.34	491.60	489.98	490.24	492.15	491.56
9/23/95	486.0	485.71	486.34	482.60	480.96	481.23	483.14	482.55
9/24/95	495.0	494.31	494.94	491.20	489.23	489.48	491.39	490.80
9/25/95	495.0	494.60	495.23	491.49	489.51	490.03	491.94	491.35

9/26/95	504.0	503.60	504.23	500.49	498.51	499.06	500.97	500.38
9/27/95	504.0	503.52	504.16	500.42	498.65	499.26	501.16	500.57
9/28/95	504.0	503.52	504.16	500.42	498.47	499.18	501.09	500.50
9/29/95	495.0	494.63	495.26	491.52	489.44	490.13	492.04	491.45
9/30/95	504.0	503.63	504.26	500.52	498.57	499.30	501.21	500.62
10/1/00	890.0	889.62	890.30	889.31	888.14	889.87	891.04	890.45
10/2/00	826.0	825.56	826.24	825.25	824.07	825.80	826.97	826.39
10/3/00	728.0	727.56	728.24	727.25	726.07	726.63	727.80	727.21
10/4/00	652.0	651.56	652.24	651.25	650.07	651.08	652.25	651.66
10/5/00	631.0	630.62	631.30	630.31	629.13	630.06	631.23	630.65
10/6/00	606.0	605.62	606.30	605.31	604.13	605.25	606.42	605.83
10/7/00	606.0	605.62	606.30	605.31	604.13	605.05	606.22	605.63
10/8/00	597.0	596.62	597.30	596.31	595.13	595.95	597.12	596.53
10/9/00	589.0	588.56	589.24	588.26	587.08	587.83	589.00	588.42
10/10/00	589.0	588.56	589.24	588.26	587.08	588.08	589.25	588.66
10/11/00	589.0	588.56	589.24	588.26	587.08	588.07	589.24	588.65
10/12/00	572.0	571.56	572.24	571.26	570.08	571.03	572.20	571.61
10/13/00	572.0	571.67	572.35	571.37	570.19	571.12	572.29	571.70
10/14/00	556.0	555.67	556.35	555.37	554.19	555.11	556.28	555.69
10/15/00	548.0	547.67	548.35	547.37	546.19	547.11	548.28	547.69
10/16/00	548.0	547.67	548.31	547.32	547.32	548.18	548.29	547.70
10/17/00	564.0	563.67	564.31	563.32	563.32	564.45	564.56	563.98
10/18/00	606.0	605.67	606.31	605.32	605.32	604.76	604.87	604.28
10/19/00	674.0	673.63	674.27	673.28	673.28	673.14	673.26	672.67
10/20/00	841.0	840.63	841.27	840.28	840.28	840.71	840.83	840.24
10/21/00	731.0	730.63	731.27	730.28	730.28	731.18	731.30	730.71
10/22/00	670.0	669.63	670.27	669.28	669.28	670.19	670.30	669.71
10/23/00	579.0	578.63	579.27	578.28	578.28	579.19	579.31	578.72
10/24/00	566.0	565.63	566.27	565.28	565.28	566.19	566.31	565.72
10/25/00	568.0	567.69	568.32	567.34	567.34	568.44	568.56	567.97
10/26/00	554.0	553.69	554.32	553.34	553.34	554.41	554.52	553.93
10/27/00	541.0	540.69	541.32	540.34	540.34	541.39	541.50	540.91
10/28/00	551.0	550.69	551.32	550.34	550.34	551.48	551.59	551.01
10/29/00	546.0	545.69	546.32	545.34	545.34	546.48	546.60	546.01
10/30/00	516.0	515.69	516.32	515.34	515.34	516.48	516.60	516.01
10/31/00	516.0	515.69	516.32	515.34	515.34	516.48	516.60	516.01
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5/1/01	1185.0	1185.03	1185.61	1184.29	1185.74	1188.13	1190.19	1189.61
5/2/01	978.0	978.03	978.61	977.29	978.74	981.13	983.20	982.61
5/3/01	940.0	940.03	940.61	939.29	940.74	942.85	944.92	944.33
5/4/01	1150.0	1150.03	1150.61	1149.29	1150.74	1152.96	1155.02	1154.44
5/5/01	1230.0	1230.03	1230.61	1229.29	1230.74	1232.95	1235.02	1234.43
5/6/01	1216.0	1216.03	1216.61	1215.29	1216.74	1219.07	1221.13	1220.55
5/7/01	1152.0	1152.03	1152.61	1151.29	1152.74	1155.07	1157.13	1156.55
5/8/01	1028.0	1028.03	1028.61	1027.29	1028.74	1031.06	1033.13	1032.54
5/9/01	965.0	965.03	965.61	964.29	965.74	968.06	970.12	969.54
5/10/01	901.0	901.03	901.61	900.29	901.74	904.12	906.19	905.60
5/11/01	917.0	917.14	917.71	916.40	917.85	920.23	922.29	921.70
5/12/01	903.0	903.14	903.72	902.40	903.85	906.23	908.30	907.71
5/13/01	999.0	999.14	999.71	998.40	999.85	1002.22	1004.29	1003.70
5/14/01	1025.0	1025.14	1025.72	1024.40	1025.85	1028.23	1030.29	1029.70
5/15/01	952.0	952.15	952.72	951.41	952.86	955.23	957.29	956.71
5/16/01	928.0	928.09	928.67	927.35	928.80	931.17	933.24	932.65
5/17/01	844.0	844.08	844.66	843.34	844.79	847.16	849.23	848.64
5/18/01	822.0	822.08	822.65	821.34	822.79	824.78	826.84	826.25
5/19/01	970.0	970.11	970.69	969.37	970.82	972.96	975.02	974.44
5/20/01	1080.0	1080.09	1080.67	1079.35	1080.80	1082.93	1085.00	1084.41
5/21/01	1040.0	1040.09	1040.66	1039.35	1040.80	1043.08	1045.15	1044.56
5/22/01	970.0	970.07	970.64	969.33	970.78	973.06	975.12	974.54
5/23/01	1080.0	1080.11	1080.69	1079.37	1080.82	1083.10	1085.16	1084.58
5/24/01	1050.0	1050.12	1050.69	1049.38	1050.83	1053.19	1055.25	1054.66
5/25/01	841.0	841.11	841.68	840.37	841.82	844.18	846.24	845.66
5/26/01	755.0	755.13	755.71	754.39	755.84	758.11	760.18	759.59
5/27/01	710.0	710.09	710.67	709.35	710.80	713.16	715.22	714.63
5/28/01	710.0	710.10	710.68	709.36	710.81	713.17	715.23	714.64
5/29/01	780.0	780.08	780.66	779.34	780.79	783.18	785.24	784.66
5/30/01	883.0	883.08	883.65	882.34	883.79	886.17	888.23	887.65
5/31/01	1240.0	1240.11	1240.68	1239.37	1239.92	1242.31	1244.37	1243.78
6/1/01	1414.0	1414.42	1415.05	1410.79	1411.82	1414.78	1416.99	1416.41
6/2/01	1509.0	1509.45	1510.08	1505.82	1506.85	1509.82	1512.03	1511.44
6/3/01	1543.0	1543.42	1544.06	1539.80	1540.83	1543.30	1545.51	1544.93
6/4/01	1587.0	1587.44	1588.07	1583.81	1584.84	1587.51	1589.72	1589.13

6/5/01	1731.0	1731.46	1732.09	1727.83	1728.86	1731.52	1733.73	1733.14
6/6/01	1826.0	1826.42	1827.05	1822.80	1823.83	1826.68	1828.89	1828.31
6/7/01	1880.0	1880.40	1881.04	1876.78	1877.81	1880.66	1882.87	1882.29
6/8/01	1830.0	1830.41	1831.04	1826.78	1827.82	1830.67	1832.88	1832.29
6/9/01	1780.0	1780.45	1781.08	1776.83	1777.86	1780.70	1782.91	1782.33
6/10/01	1710.0	1710.41	1711.05	1706.79	1707.82	1710.77	1712.98	1712.39
6/11/01	1680.0	1680.42	1681.06	1676.80	1677.83	1680.78	1682.99	1682.40
6/12/01	1670.0	1670.45	1671.08	1666.82	1667.85	1670.80	1673.01	1672.42
6/13/01	1570.0	1570.39	1570.94	1566.68	1567.72	1570.66	1572.87	1572.29
6/14/01	1617.0	1617.40	1617.95	1613.69	1614.72	1617.67	1619.88	1619.29
6/15/01	1725.0	1725.40	1725.96	1721.70	1722.73	1725.67	1727.88	1727.30
6/16/01	1782.0	1782.47	1783.03	1778.77	1779.80	1782.72	1784.93	1784.34
6/17/01	1869.0	1869.41	1869.96	1865.70	1866.73	1869.55	1871.76	1871.17
6/18/01	1956.0	1956.42	1956.97	1952.71	1953.74	1955.84	1958.05	1957.46
6/19/01	2034.0	2034.49	2035.04	2030.78	2031.81	2034.05	2036.26	2035.67
6/20/01	2128.0	2128.42	2128.97	2124.71	2125.74	2127.93	2130.14	2129.55
6/21/01	2206.0	2206.40	2206.95	2202.69	2203.72	2206.12	2208.34	2207.75
6/22/01	2251.0	2251.37	2251.92	2247.66	2248.69	2251.05	2253.27	2252.68
6/23/01	2323.0	2323.36	2323.92	2319.66	2320.69	2322.94	2325.15	2324.57
6/24/01	2384.0	2384.41	2384.97	2380.71	2381.74	2383.75	2385.96	2385.37
6/25/01	2332.0	2332.43	2332.98	2328.72	2329.75	2332.12	2334.33	2333.75
6/26/01	2280.0	2280.42	2280.97	2276.71	2277.74	2279.40	2281.61	2281.03
6/27/01	2232.0	2232.38	2232.93	2228.67	2229.70	2232.37	2234.58	2233.99
6/28/01	2149.0	2149.41	2149.96	2145.70	2146.73	2149.64	2151.85	2151.26
6/29/01	2061.0	2061.42	2061.97	2057.71	2058.74	2061.17	2063.39	2062.80
6/30/01	2000.0	2000.45	2001.01	1996.75	1997.78	1999.68	2001.89	2001.30
7/1/01	1980.0	1980.95	1981.53	1975.17	1976.95	1978.42	1980.98	1980.39
7/2/01	2121.0	2121.97	2122.55	2116.18	2117.97	2119.25	2121.81	2121.22
7/3/01	2358.0	2358.99	2359.57	2353.21	2354.99	2355.43	2357.99	2357.40
7/4/01	2662.0	2662.90	2663.48	2657.12	2658.90	2659.52	2662.08	2661.49
7/5/01	2911.0	2911.87	2912.45	2906.08	2907.47	2908.00	2910.56	2909.97
7/6/01	2911.0	2911.88	2912.46	2906.09	2907.48	2908.24	2910.80	2910.21
7/7/01	2928.0	2928.86	2929.44	2923.08	2924.46	2925.15	2927.71	2927.12
7/8/01	2996.0	2996.86	2997.44	2991.08	2992.86	2994.33	2996.88	2996.30
7/9/01	3048.0	3048.86	3049.44	3043.08	3044.86	3046.83	3049.39	3048.81
7/10/01	3102.0	3102.86	3103.44	3097.08	3098.86	3101.46	3104.02	3103.43
7/11/01	3210.0	3210.86	3211.44	3205.08	3206.86	3209.99	3212.55	3211.96
7/12/01	3267.0	3267.86	3268.44	3262.08	3263.86	3266.97	3269.52	3268.94
7/13/01	3216.0	3216.85	3217.43	3211.06	3212.85	3215.93	3218.49	3217.90
7/14/01	3149.0	3149.85	3150.43	3144.07	3145.85	3148.80	3151.36	3150.77
7/15/01	3190.0	3190.85	3191.43	3185.07	3186.85	3189.72	3192.28	3191.69
7/16/01	3178.0	3178.89	3179.47	3173.10	3174.89	3177.83	3180.38	3179.80
7/17/01	3111.0	3111.84	3112.42	3106.06	3107.84	3110.71	3113.27	3112.68
7/18/01	3080.0	3080.83	3081.41	3075.04	3076.82	3078.61	3081.17	3080.59
7/19/01	3032.0	3032.90	3033.49	3027.12	3028.90	3030.84	3033.40	3032.81
7/20/01	3037.0	3037.87	3038.45	3032.09	3033.87	3035.65	3038.21	3037.62
7/21/01	2991.0	2991.84	2992.42	2986.05	2987.83	2989.95	2992.51	2991.92
7/22/01	2945.0	2945.79	2946.37	2940.00	2941.79	2943.65	2946.21	2945.62
7/23/01	2941.0	2941.89	2942.48	2936.11	2937.89	2939.50	2942.06	2941.47
7/24/01	2971.0	2971.89	2972.48	2966.11	2967.89	2969.50	2972.06	2971.47
7/25/01	3071.0	3071.86	3072.44	3066.08	3067.86	3069.43	3071.99	3071.40
7/26/01	3156.0	3156.86	3157.44	3151.08	3152.86	3154.25	3156.81	3156.23
7/27/01	3174.0	3174.82	3175.40	3169.03	3170.82	3172.42	3174.97	3174.39
7/28/01	3210.0	3210.82	3211.40	3205.03	3206.82	3208.40	3210.96	3210.38
7/29/01	3210.0	3210.77	3211.35	3204.98	3206.76	3208.45	3211.01	3210.42
7/30/01	3156.0	3156.77	3157.35	3150.98	3152.76	3154.44	3156.99	3156.41
7/31/01	3009.0	3009.82	3010.40	3004.03	3005.18	3006.82	3009.38	3008.79
8/1/01	2868.0	2868.96	2869.55	2864.59	2865.84	2867.39	2869.76	2869.17
8/2/01	2752.0	2752.96	2753.55	2748.59	2749.84	2751.10	2753.46	2752.88
8/3/01	2655.0	2655.98	2656.57	2651.61	2652.37	2652.46	2654.82	2654.23
8/4/01	2716.0	2716.98	2717.57	2712.61	2713.67	2714.11	2716.47	2715.88
8/5/01	2780.0	2780.98	2781.57	2776.61	2777.27	2777.67	2780.03	2779.45
8/6/01	2796.0	2796.98	2797.57	2792.61	2793.27	2793.97	2796.33	2795.75

8/7/01	2812.0	2812.93	2813.52	2808.57	2809.47	2810.15	2812.51	2811.92
8/8/01	2844.0	2844.93	2845.52	2840.57	2841.47	2842.14	2844.50	2843.91
8/9/01	2877.0	2877.93	2878.52	2873.57	2874.47	2875.11	2877.47	2876.88
8/10/01	2911.0	2911.93	2912.52	2907.57	2908.47	2909.23	2911.59	2911.00
8/11/01	2911.0	2911.94	2912.53	2907.57	2908.48	2909.21	2911.57	2910.98
8/12/01	2894.0	2894.94	2895.53	2890.57	2891.48	2892.20	2894.56	2893.97
8/13/01	2894.0	2894.94	2895.53	2890.57	2891.48	2892.18	2894.54	2893.95
8/14/01	2911.0	2911.94	2912.53	2907.57	2908.48	2909.18	2911.54	2910.95
8/15/01	2911.0	2911.94	2912.53	2907.57	2908.48	2909.23	2911.59	2911.00
8/16/01	2928.0	2928.99	2929.58	2924.63	2925.53	2926.21	2928.57	2927.98
8/17/01	2945.0	2945.94	2946.53	2941.58	2942.48	2943.18	2945.54	2944.96
8/18/01	2945.0	2945.93	2946.52	2941.56	2942.46	2942.44	2944.80	2944.21
8/19/01	2911.0	2912.02	2912.61	2907.65	2908.56	2908.85	2911.21	2910.63
8/20/01	2860.0	2860.98	2861.57	2856.61	2857.52	2857.81	2860.17	2859.58
8/21/01	2788.0	2788.94	2789.53	2784.57	2785.48	2786.10	2788.46	2787.87
8/22/01	2748.0	2748.88	2749.48	2744.52	2745.77	2746.77	2749.13	2748.54
8/23/01	2602.0	2603.00	2603.60	2598.64	2599.89	2601.44	2603.80	2603.22
8/24/01	2455.0	2456.01	2456.60	2451.64	2452.89	2454.45	2456.81	2456.22
8/25/01	2391.0	2391.97	2392.56	2387.60	2388.85	2390.12	2392.48	2391.89
8/26/01	2371.0	2371.97	2372.56	2367.60	2368.85	2369.80	2372.16	2371.57
8/27/01	2299.0	2299.92	2300.51	2295.55	2296.80	2297.79	2300.15	2299.56
8/28/01	2220.0	2220.92	2221.51	2216.55	2217.47	2218.40	2220.76	2220.18
8/29/01	2178.0	2178.86	2179.45	2174.49	2175.40	2176.35	2178.71	2178.12
8/30/01	2127.0	2127.86	2128.45	2123.49	2124.40	2125.32	2127.68	2127.09
8/31/01	2077.0	2077.92	2078.51	2073.56	2074.40	2075.29	2077.65	2077.06
9/1/01	2010.0	2009.73	2010.36	2006.62	2007.02	2007.81	2009.72	2009.13
9/2/01	1950.0	1949.73	1950.36	1946.62	1947.33	1948.17	1950.07	1949.49
9/3/01	1880.0	1879.75	1880.38	1876.64	1877.31	1877.41	1879.31	1878.73
9/4/01	1710.0	1709.75	1710.38	1706.64	1707.35	1707.69	1709.60	1709.01
9/5/01	1490.0	1489.75	1490.38	1486.64	1487.23	1487.55	1489.46	1488.87
9/6/01	1240.0	1239.75	1240.38	1236.64	1236.94	1237.54	1239.45	1238.86
9/7/01	1037.0	1036.70	1037.33	1033.59	1033.84	1034.44	1036.34	1035.76
9/8/01	826.0	825.70	826.33	822.59	822.72	823.30	825.21	824.62
9/9/01	633.0	632.70	633.33	629.59	629.58	630.14	632.04	631.46
9/10/01	500.0	499.70	500.33	496.59	496.58	497.23	499.14	498.56
9/11/01	451.0	450.70	451.34	447.60	447.59	448.22	450.13	449.54
9/12/01	451.0	450.70	451.34	447.60	447.59	448.21	450.12	449.53
9/13/01	437.0	436.70	437.34	433.60	433.59	434.19	436.10	435.51
9/14/01	437.0	436.70	437.34	433.60	433.59	434.17	436.08	435.49
9/15/01	437.0	436.70	437.34	433.60	433.59	434.16	436.07	435.48
9/16/01	437.0	436.76	437.39	433.65	431.97	432.52	434.42	433.84
9/17/01	451.0	450.70	451.33	447.59	445.91	446.45	448.36	447.77
9/18/01	451.0	450.86	451.49	447.75	446.07	445.86	447.77	447.18
9/19/01	451.0	450.62	451.25	447.51	445.83	445.90	447.81	447.22
9/20/01	451.0	450.75	451.38	447.64	445.97	446.05	447.96	447.37
9/21/01	458.0	457.70	458.34	454.59	452.71	453.04	454.95	454.36
9/22/01	472.0	471.82	472.46	468.72	466.83	467.17	469.08	468.49
9/23/01	465.0	464.82	465.46	461.72	459.83	460.16	462.07	461.49
9/24/01	465.0	464.58	465.22	461.47	459.59	459.91	461.82	461.24
9/25/01	493.0	492.76	493.39	489.65	487.76	488.20	490.11	489.52
9/26/01	417.0	416.76	417.39	413.65	411.76	412.27	414.18	413.59
9/27/01	414.0	413.71	414.34	410.60	408.92	409.62	411.52	410.94
9/28/01	411.0	410.71	411.34	407.60	405.93	406.62	408.53	407.94
9/29/01	407.0	406.78	407.41	403.67	401.99	402.61	404.52	403.94
9/30/01	410.0	409.78	410.41	406.67	404.99	405.56	407.47	406.88

Appendix B

Survey Data

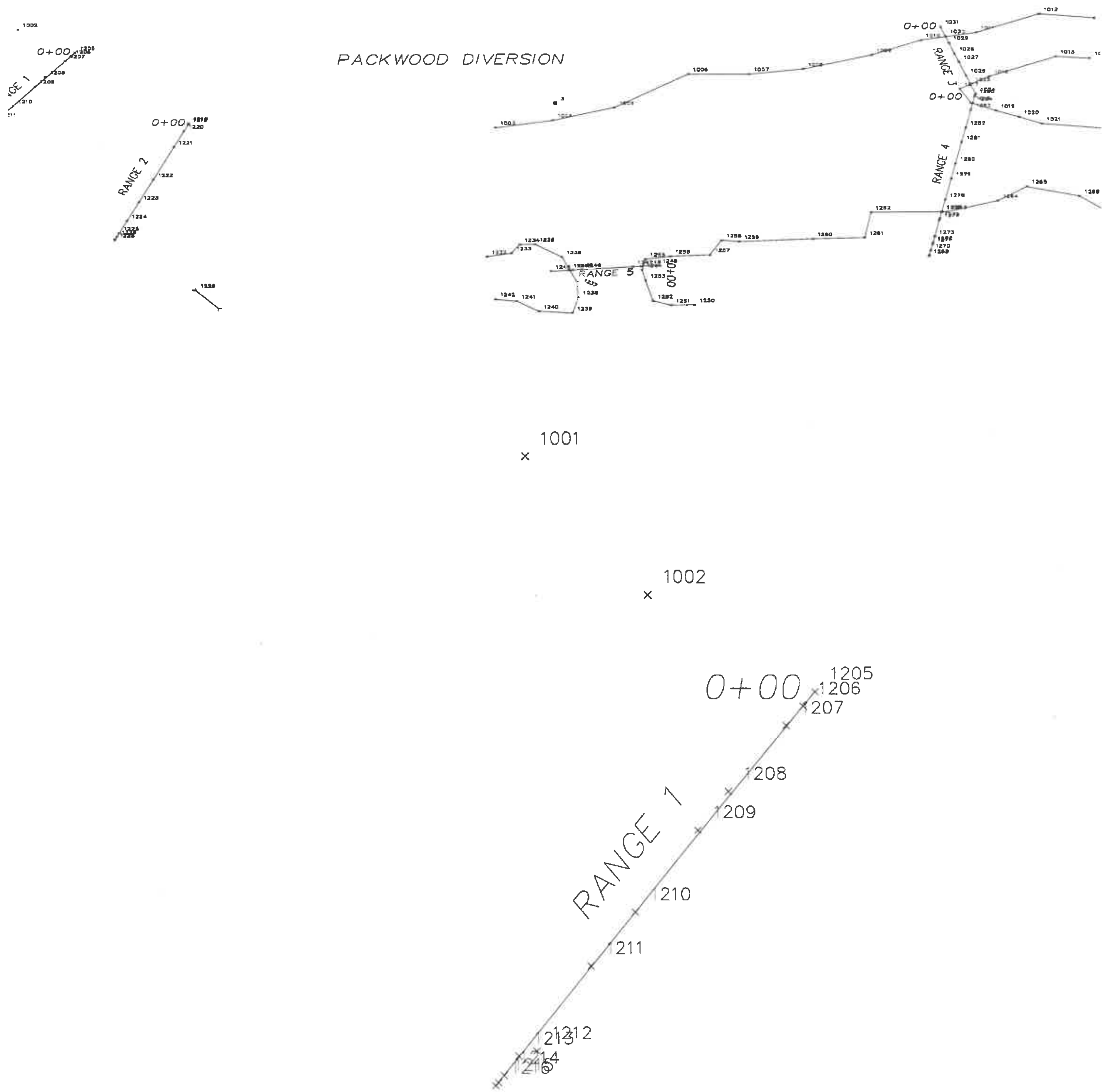
APPENDIX B

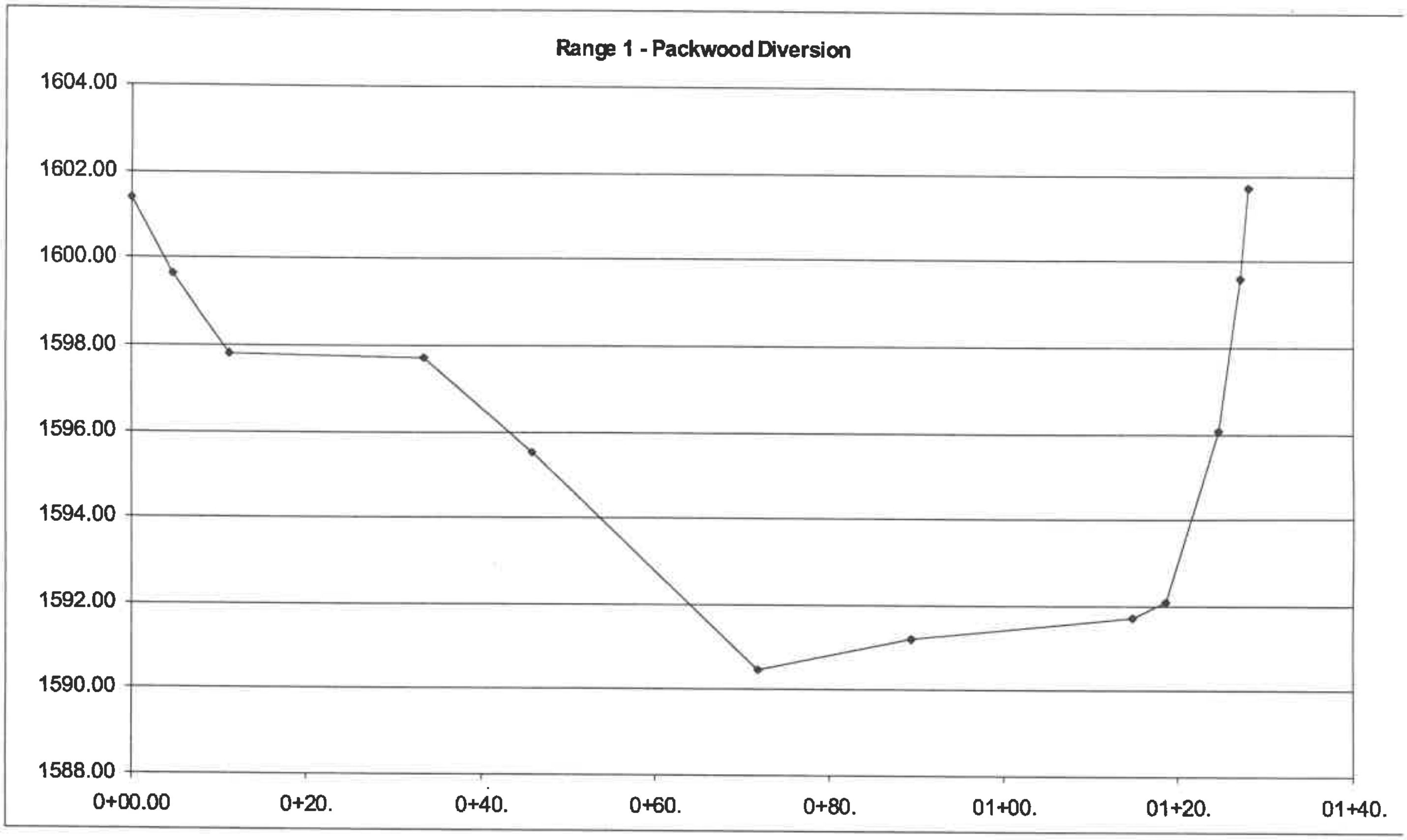
YAKIMA RIVER CROSS SECTIONS
WATER DIVERSION HYDRAULIC STUDY
APRIL 3RD, 2000

PROJECT NARRATIVE:

W&H Pacific surveyed 18 cross sections (ranges) near five diversion structures on theYakima River between March 29th and March 31st. The diversions included the Packwood Diversion, the Cascade Diversion, the West Side Diversion, the Thorp Diversion, and the Younger Ditch Diversion. A Wild TC1010 Total Station Instrument and a Husky FS/2 Data Collector with TDS software was used to collect the data. The horizontal datum was assumed and all cross sections within each Diversion are relative to each other. Vertically, Ranges 1-5 of the Packwood Diversion and Ranges 6-8 of the Cascade Diversion were based on a found 3" brass disk in the concrete headwall of the Cascade Diversion structure stamped "1603.53". For the West Side Diversion, Ranges 9-12, an elevation of 100.00' was assumed on W&H Pacific (WHP) control point #6. An assumed elevation of 100.00' was held on WHP control point #4 for Thorp Diversion Ranges 13&14 and an assumed elevation of 100.00' was held on WHP control point #8 for Younger Ditch Diversion Ranges 15-18. The data was downloaded into Autocad Version 14 and the Ranges were put into an Excel spreadsheet. The following pages show each Range as it is listed in the Excel Spreadsheet along with a sketch of the Diversion imported from Autocad.

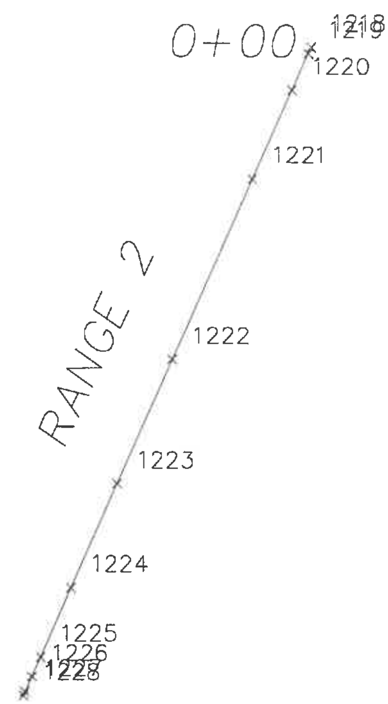
PACKWOOD DIVERSION OVERALL SKETCH

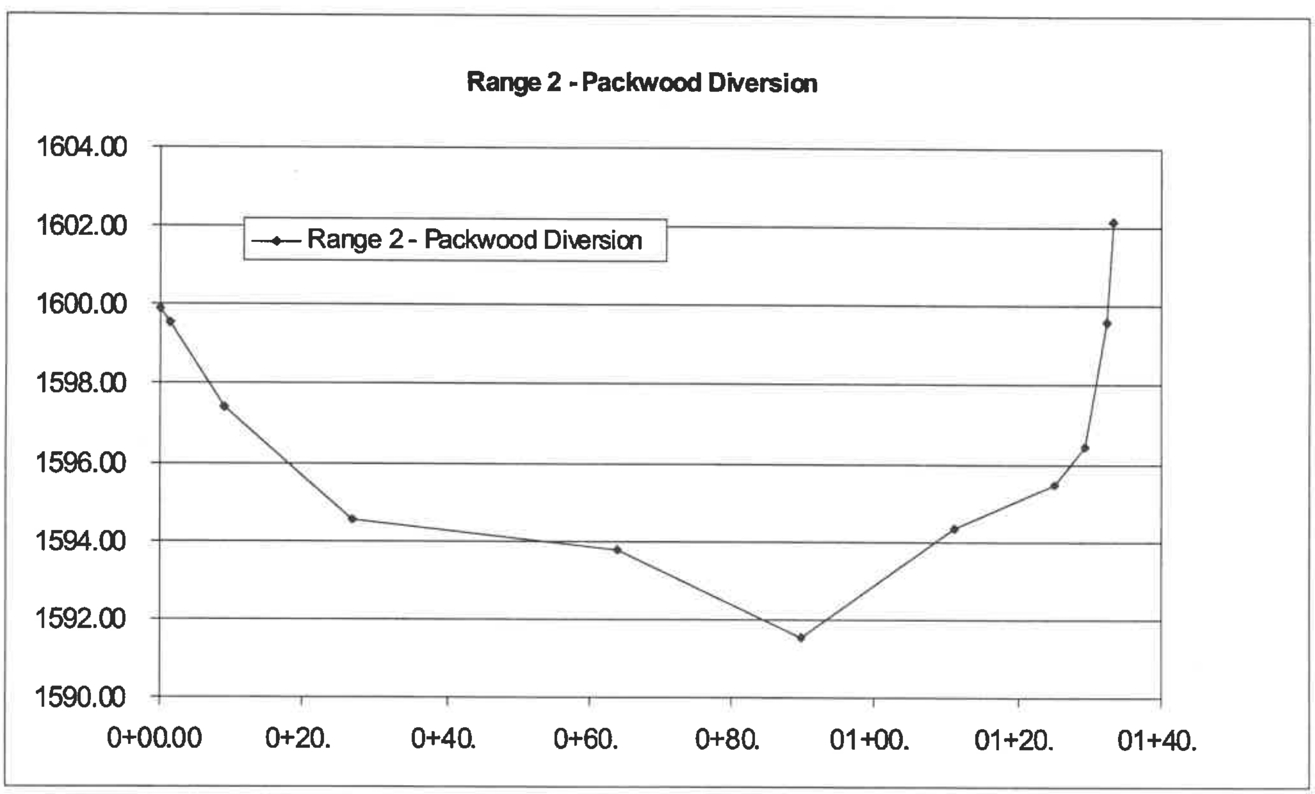




RANGE 1

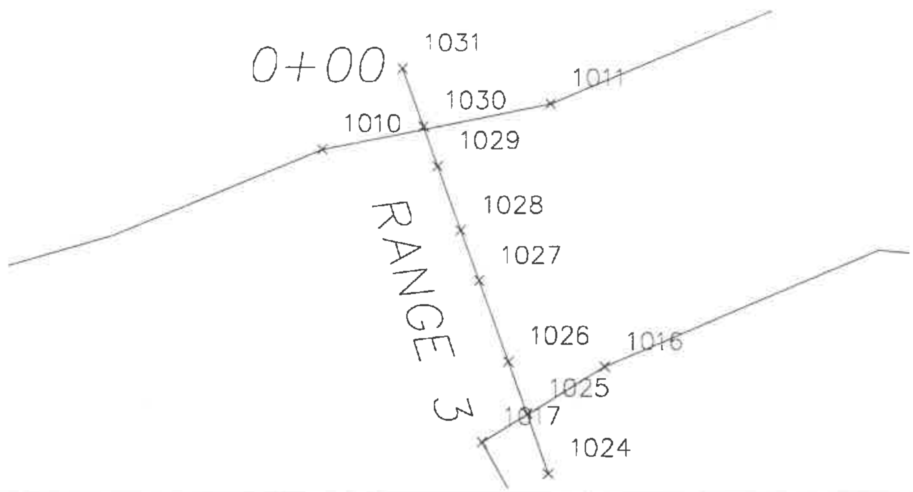
STATION	ELEVATION	POINT DESCRIPTION	POINT #
0+00.00	1601.38	GROUND TOP	1205
0+04.77	1599.64	WATER SURFACE EDGE@5:35PM 3/30	1206
0+11.30	1597.79	GROUND TOE	1207
0+33.42	1597.73	GROUND BREAK	1208
0+45.87	1595.50	GROUND	1209
0+71.80	1590.47	GROUND	1210
0+89.51	1591.20	GROUND	1211
1+14.76	1591.72	GROUND	1212
1+18.63	1592.10	GROUND BREAK	1213
1+24.78	1596.09	GROUND TOE	1214
1+27.11	1599.60	WATER SURFACE EDGE@6:11PM 3/30	1215
1+28.14	1601.72	GROUND TOP	1216

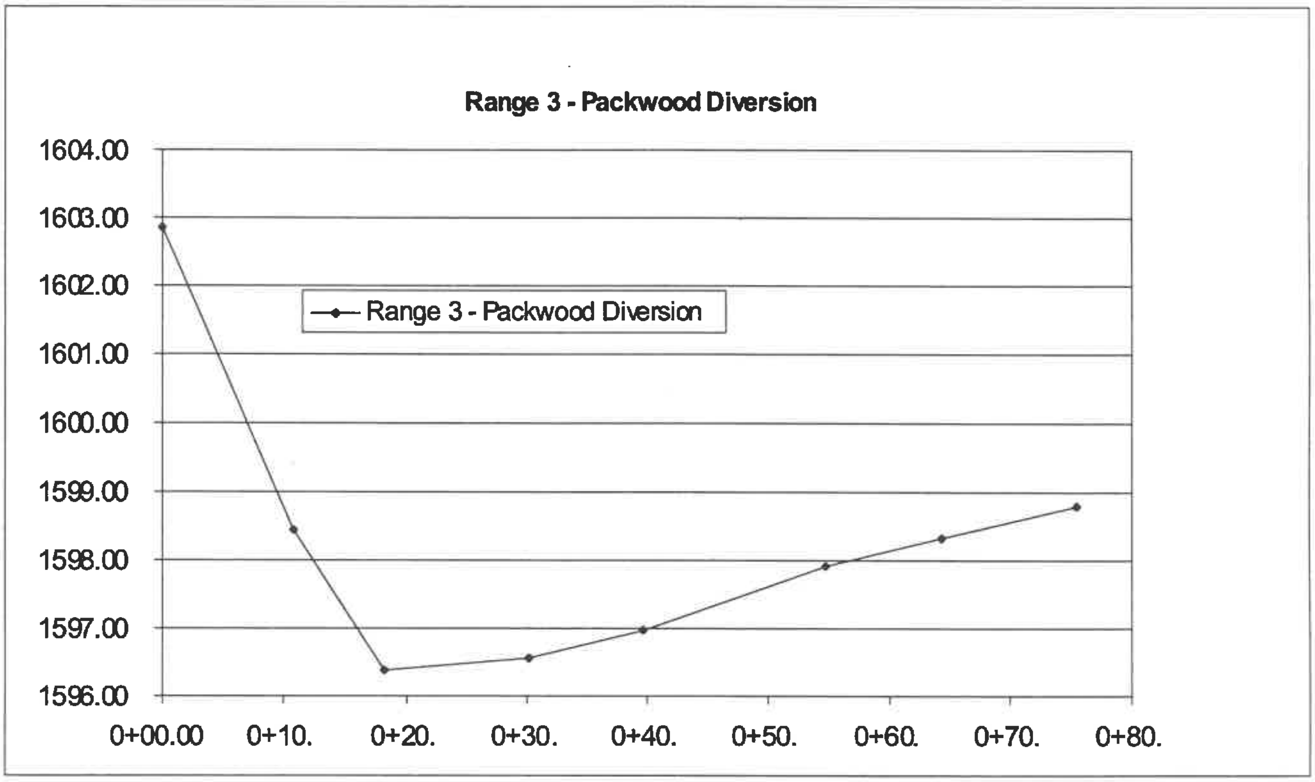

0+00
1218
1219
1220
1221
RANGE 2
1222
1223
1224
1225
1226
1228


Range 2 - Packwood Diversion
Range 2 - Packwood Diversion
1604.00
1602.00
1600.00
1598.00
1596.00
1594.00
1592.00
1590.00
0+00.00
0+20.
0+40.
0+60.
0+80.
01+00.
01+20.
01+40.

RANGE 2

STATION	ELEVATION	POINT DESCRIPTION	POINT #
0+00.00	1599.91	GROUND TOP	1218
0+01.31	1599.54	WATER SURFACE EDGE@6:22PM 3/30	1219
0+08.92	1597.40	GROUND TOE	1220
0+27.07	1594.57	GROUND	1221
0+64.03	1593.76	GROUND	1222
0+89.77	1591.54	GROUND	1223
1+11.13	1594.33	GROUND	1224
1+25.26	1595.49	GROUND	1225
1+29.27	1596.46	GROUND TOE	1226
1+32.42	1599.61	WATER SURFACE EDGE@6:26PM 3/30	1227
1+33.19	1602.18	GROUND TOP	1228

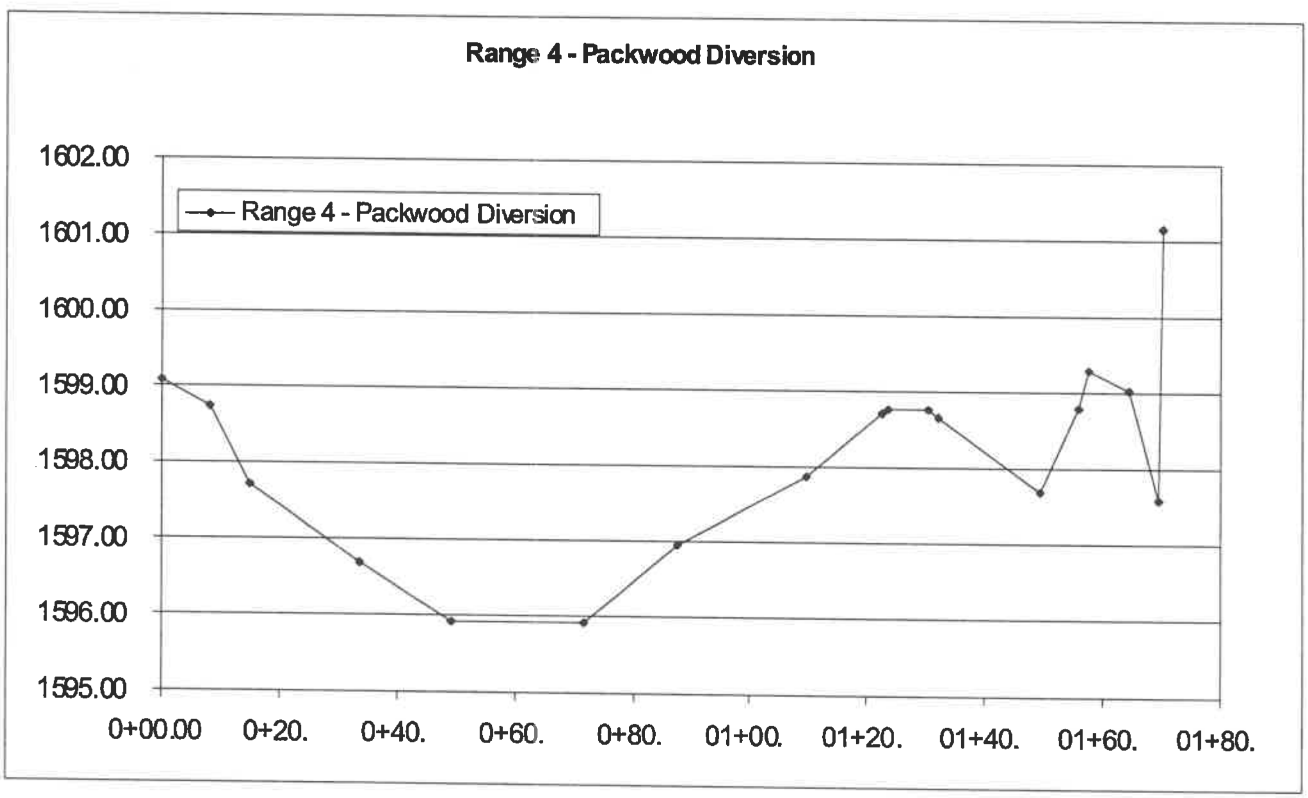




RANGE 3

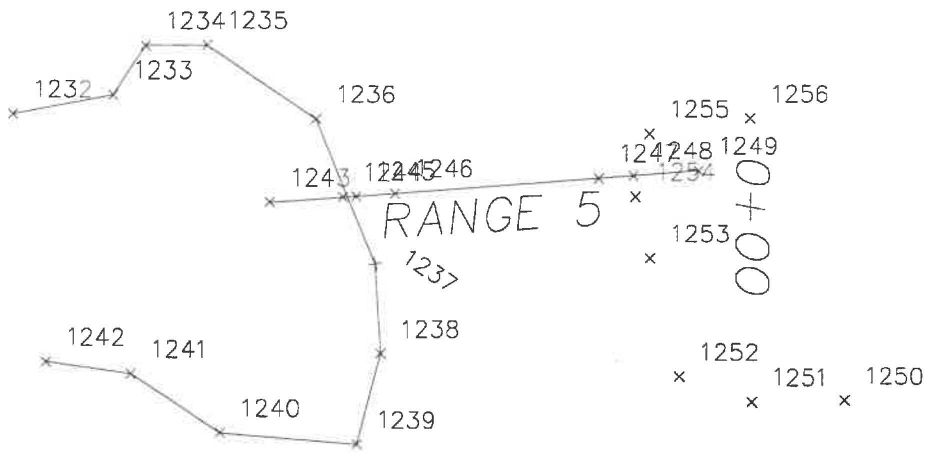
STATION	ELEVATION	POINT DESCRIPTION	POINT #
0+00.00	1602.86	GROUND TOP	1031
0+10.79	1598.43	WATER SURFACE EDGE@11:50AM 3/31	1030
0+18.20	1596.38	GROUND BREAK	1029
0+30.22	1596.56	GROUND	1028
0+39.62	1596.97	GROUND	1027
0+54.73	1597.90	GROUND BREAK	1026
0+64.44	1598.33	WATER SURFACE EDGE@11:50AM 3/31	1025
0+75.54	1598.80	GROUND	1024

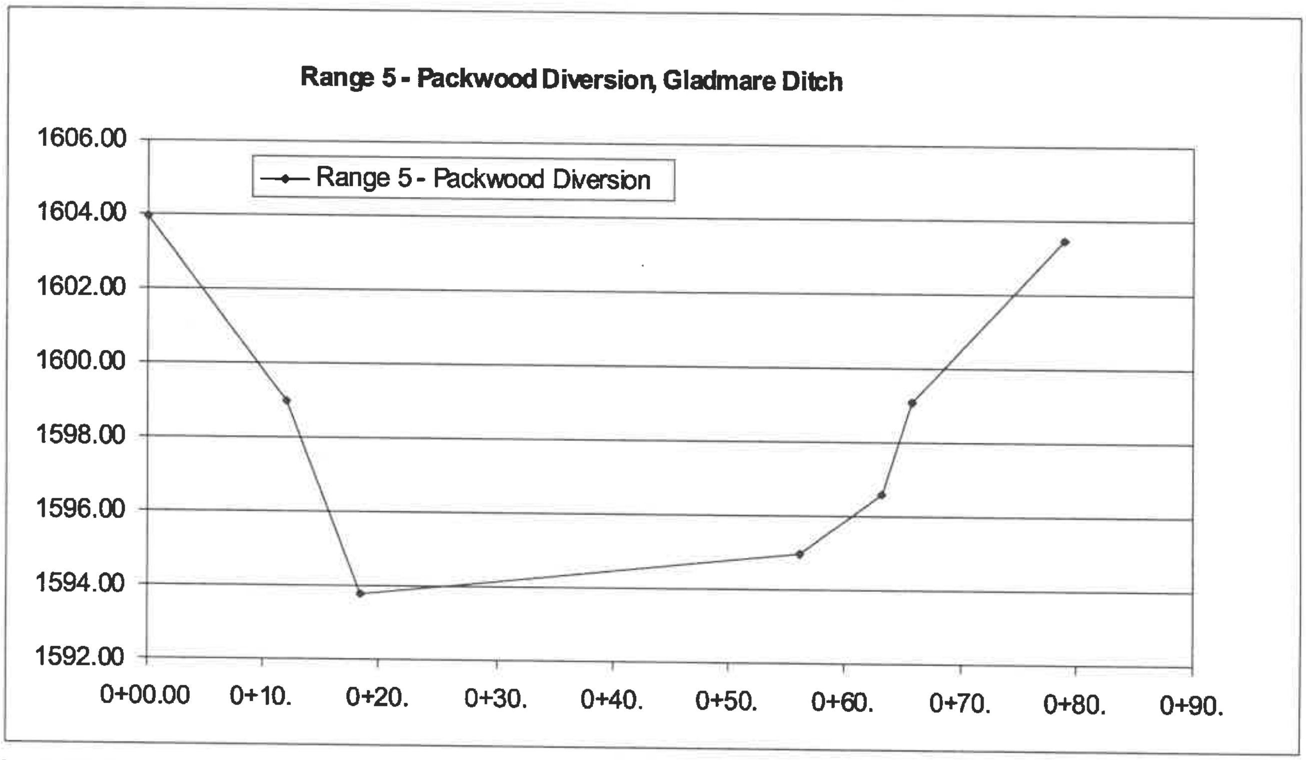

0+00
1285
1283
1019
1282
1281
RANGE 4
1280
1279
1278
1264
1273
1270


Range 4 - Packwood Diversion
Range 4 - Packwood Diversion
1602.00
1601.00
1600.00
1599.00
1598.00
1597.00
1596.00
1595.00
0+00.00
0+20.
0+40.
0+60.
0+80.
01+00.
01+20.
01+40.
01+60.
01+80.

RANGE 4

STATION	ELEVATION	POINT DESCRIPTION	POINT #
0+00.00	1599.09	GROUND TOP	1285
0+08.14	1598.75	WATER SURFACE EDGE@10:11AM 3/31	1284
0+14.89	1597.72	GROUND	1283
0+33.71	1596.68	GROUND	1282
0+49.23	1595.91	GROUND	1281
0+71.83	1595.92	GROUND	1280
0+87.75	1596.94	GROUND	1279
1+09.83	1597.87	GROUND BREAK	1278
1+22.71	1598.70	WATER SURFACE EDGE@9:53AM 3/31	1277
1+23.47	1598.76	GROUND TOP@ GRAVEL BAR	1276
1+30.50	1598.76	GROUND TOP@ GRAVEL BAR	1275
1+32.22	1598.66	WATER SURFACE EDGE@SIDE CHANNEL 9:47AM 3/31	1274
1+49.34	1597.69	GROUND BREAK	1273
1+55.96	1598.79	WATER SURFACE EDGE@SIDE CHANNEL 9:47AM 3/31	1272
1+57.56	1599.29	GROUND BREAK	1271
1+64.25	1599.02	GROUND BREAK	1270
1+69.53	1597.59	GROUND TOE	1269
1+70.16	1601.16	GROUND TOP	1268





RANGE 5

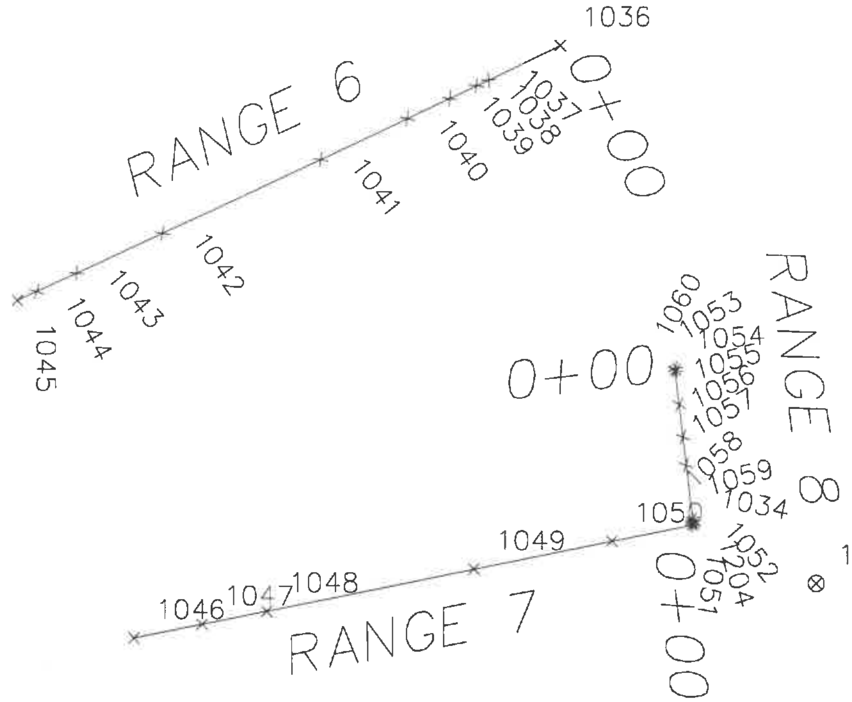
STATION	ELEVATION	POINT DESCRIPTION	POINT #
0+00.00	1603.93	GROUND TOP	1249
0+12.07	1599.00	WATER SURFACE EDGE@CTR LOG JAM 9:24AM 3/31	1248
0+18.41	1593.76	GROUND TOE@ CENTER LOG JAM	1247
0+56.24	1594.95	GROUND	1246
0+63.28	1596.57	GROUND BREAK	1245
0+65.81	1599.06	WATER SURFACE EDGE@8:51AM 3/31	1244
0+79.08	1603.47	GROUND TOP	1243

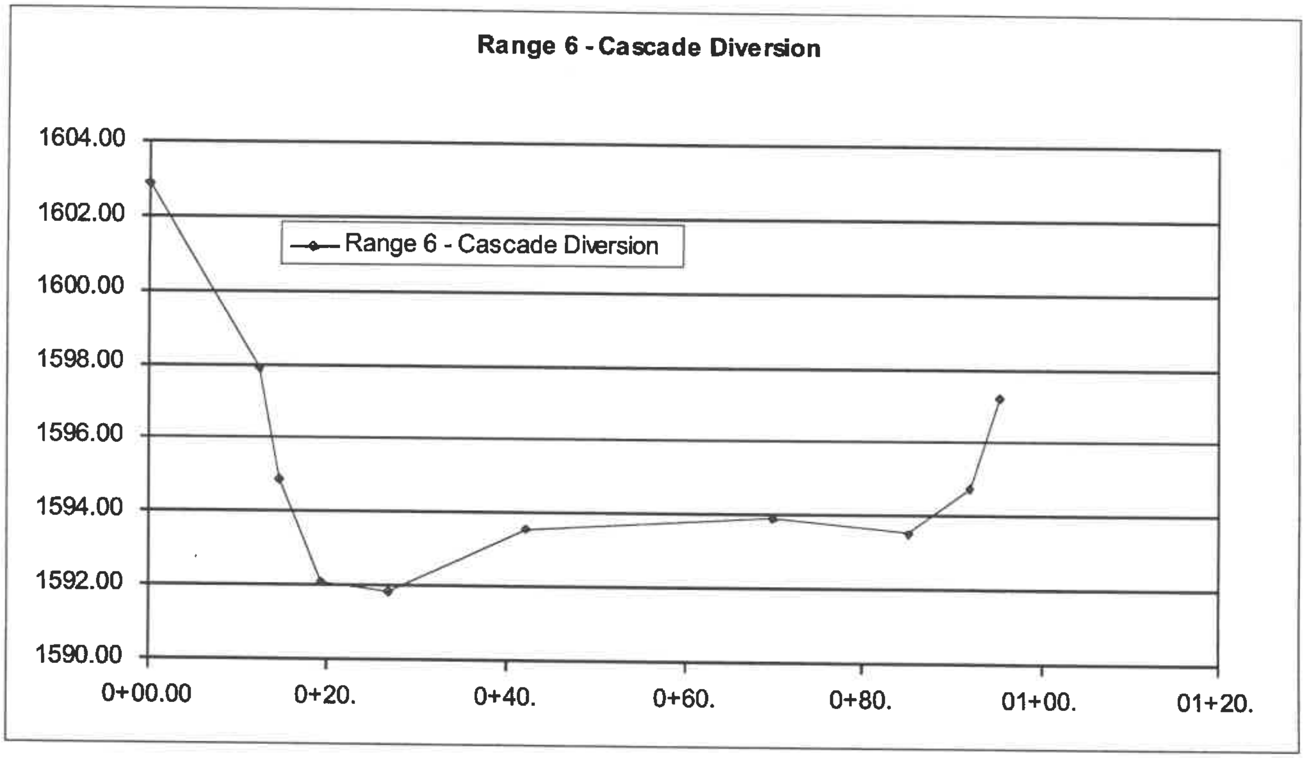
ADDITIONAL TOPO PACKWOOD DIVERSION

POINT NUMBER	ELEVATION	POINT DESCRIPTION
1001	1599.62	Water Surface Edge
1002	1599.61	Water Surface Edge
1003	1599.10	Water Surface Edge
1004	1599.14	Water Surface Edge
1005	1599.14	Water Surface Edge
1006	1599.05	Water Surface Edge
1007	1599.03	Water Surface Edge
1008	1598.99	Water Surface Edge
1009	1598.90	Water Surface Edge
1010	1598.62	Water Surface Edge
1011	1598.03	Water Surface Edge
1012	1597.94	Water Surface Edge
1013	1597.58	Water Surface Edge
1014	1597.44	Water Surface Edge
1015	1597.44	Water Surface Edge
1016	1598.14	Water Surface Edge
1017	1598.61	Water Surface Edge
1018	1598.78	Water Surface Edge
1019	1598.54	Water Surface Edge
1020	1597.62	Water Surface Edge
1021	1597.55	Water Surface Edge
1022	1597.59	Water Surface Edge
1023	1597.46	Water Surface Edge
1229	1596.36	Culvert In
1232	1599.44	Water Surface Edge
1233	1599.41	Water Surface Edge
1234	1599.28	Water Surface Edge
1235	1599.14	Water Surface Edge
1236	1599.07	Water Surface Edge
1237	1598.92	Water Surface Edge
1238	1598.85	Water Surface Edge
1239	1598.78	Water Surface Edge
1240	1598.63	Water Surface Edge
1241	1598.45	Water Surface Edge
1242	1598.50	Water Surface Edge
1250	1598.70	Water Surface Edge
1251	1598.77	Water Surface Edge
1252	1598.84	Water Surface Edge
1253	1598.97	Water Surface Edge
1254	1598.98	Water Surface Edge
1255	1599.60	Water Surface Edge
1256	1599.48	Water Surface Edge
1257	1599.46	Water Surface Edge
1258	1599.27	Water Surface Edge
1259	1599.19	Water Surface Edge
1260	1599.17	Water Surface Edge
1261	1599.03	Water Surface Edge

1262	1598.90	Water Surface Edge
1263	1598.60	Water Surface Edge
1264	1598.28	Water Surface Edge
1265	1597.43	Water Surface Edge
1266	1597.34	Water Surface Edge
1267	1597.44	Water Surface Edge

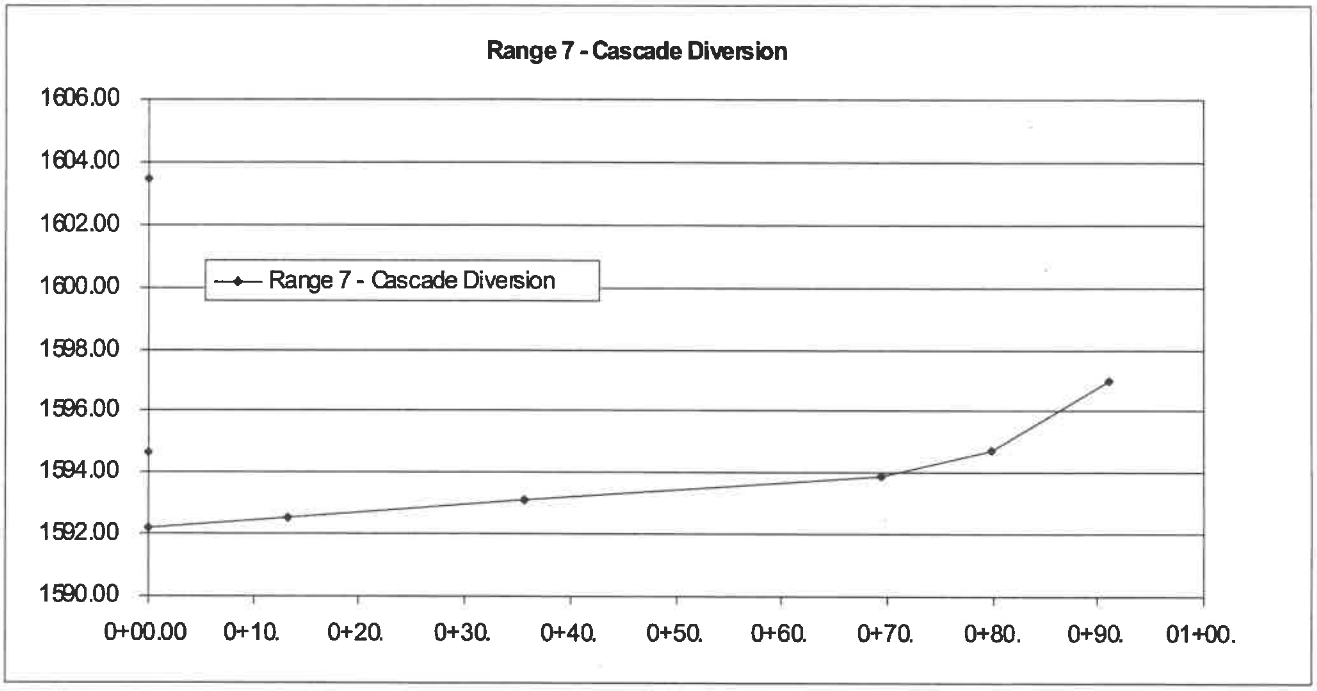
CASCADE DIVERSION





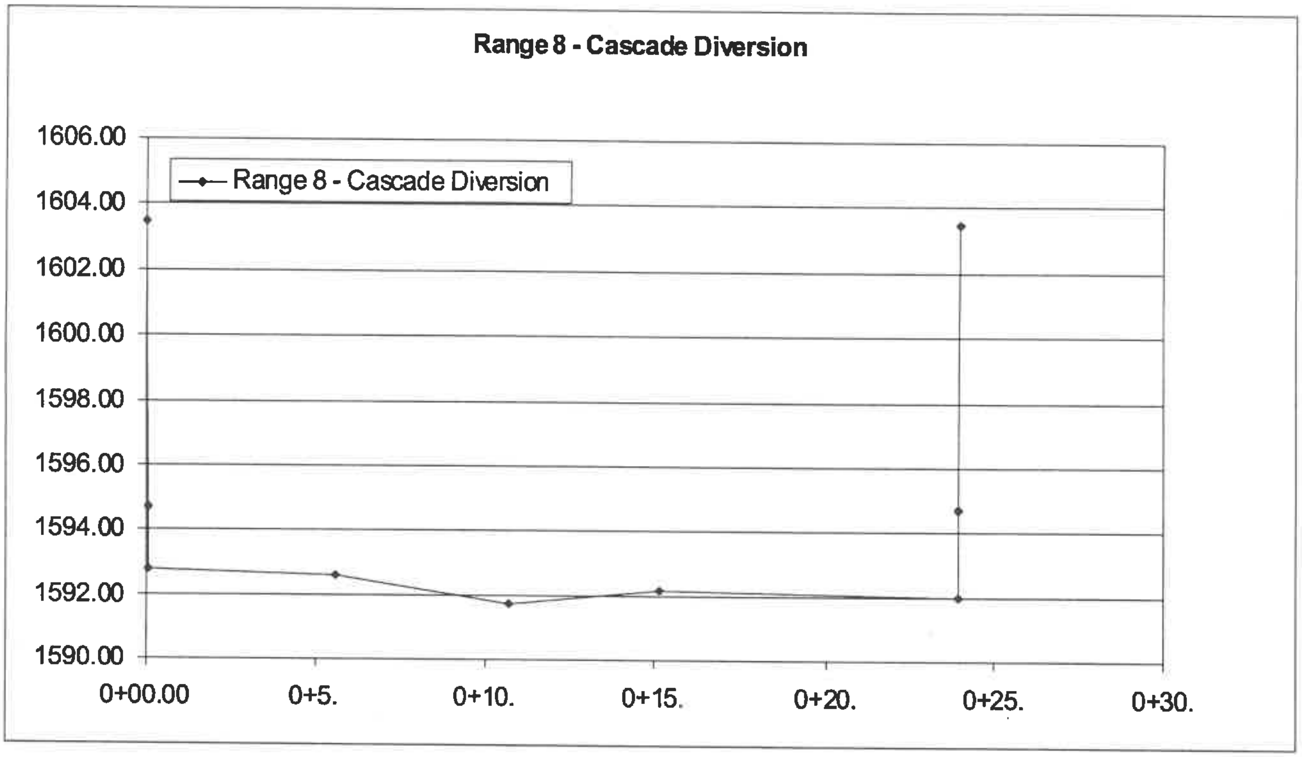
RANGE 6

STATION	ELEVATION	POINT DESCRIPTION	POINT #
0+00.00	1602.86	GROUND TOP	1036
0+12.58	1597.88	GROUND BREAK	1037
0+14.76	1594.88	WATER SURFACE EDGE@1:10PM 3/29	1038
0+19.46	1592.13	GROUND TOE	1039
0+27.00	1591.82	GROUND BREAK	1040
0+42.28	1593.56	GROUND BREAK	1041
0+70.00	1593.88	GROUND	1042
0+85.05	1593.50	GROUND BREAK	1043
0+92.12	1594.75	WATER SURFACE EDGE@1:10PM 3/29	1044
0+95.47	1597.20	GROUND TOP	1045



RANGE 7

STATION	ELEVATION	POINT DESCRIPTION	POINT #
0+00.00	1603.47	RETAINING WALL TOP	1052
0+00.02	1594.67	WATER SURFACE EDGE@4:43PM 3/30	1204
0+00.04	1592.18	RETAINING WALL TOE	1051
0+13.23	1592.54	GROUND	1050
0+35.71	1593.14	GROUND	1049
0+69.48	1593.89	GROUND BREAK	1048
0+79.97	1594.70	WATER SURFACE EDGE@1:20PM 3/29	1047
0+90.99	1596.99	GROUND TOP	1046



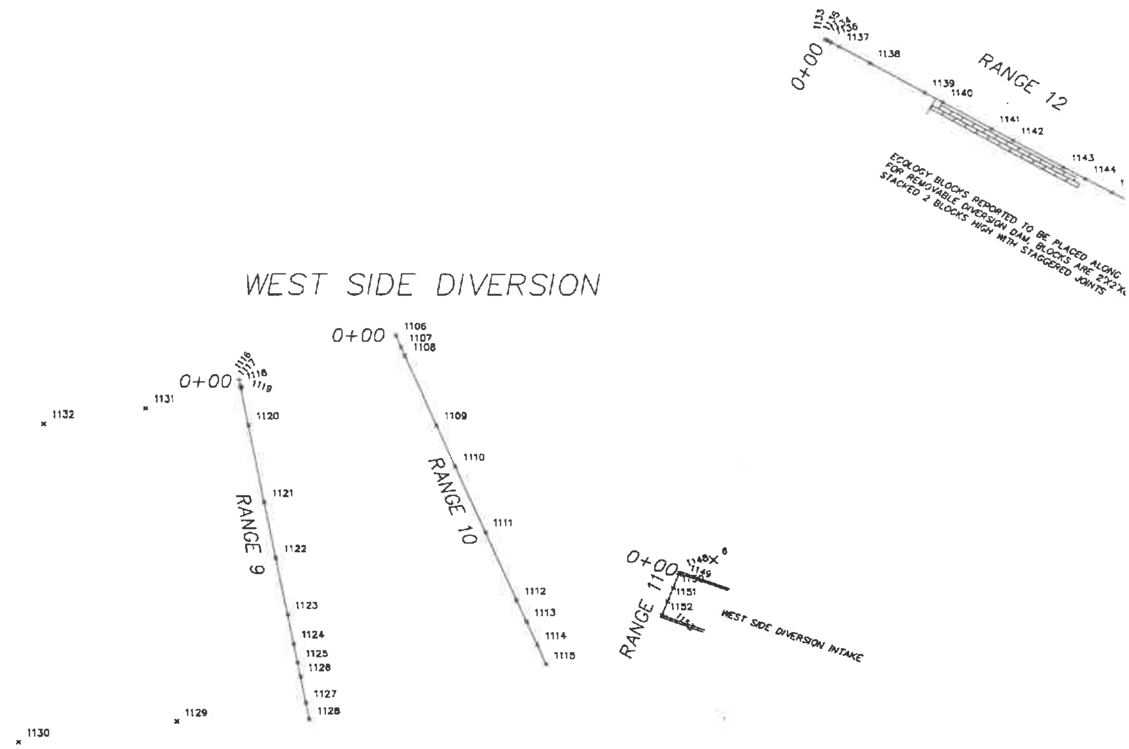
RANGE 8

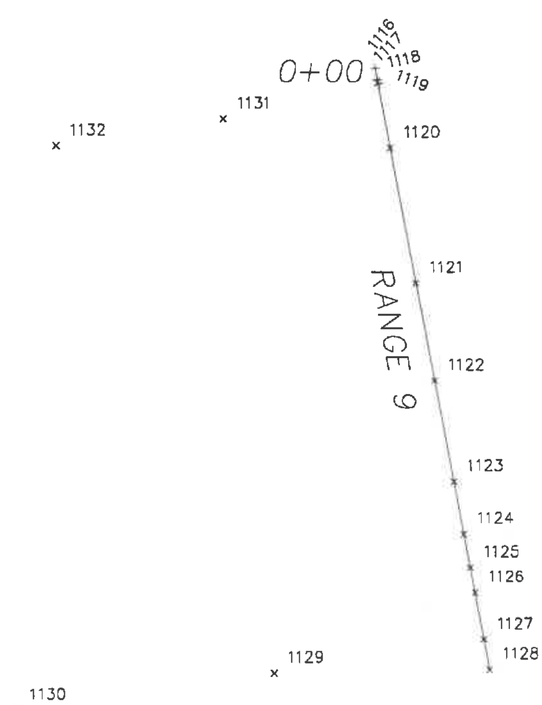
STATION	ELEVATION	POINT DESCRIPTION	POINT #
0+00.00	1603.48	RETAINING WALL TOP	1060
0+00.04	1594.69	WATER SURFACE EDGE@1:35PM 3/29	1053
0+00.07	1592.81	RETAINING WALL TOE	1054
0+05.55	1592.57	GROUND BREAK	1055
0+10.68	1591.75	GROUND BREAK	1056
0+15.13	1592.14	GROUND BREAK	1057
0+23.97	1592.00	RETAINING WALL TOE	1058
0+23.98	1594.70	WATER SURFACE EDGE@1:35PM 3/29	1059
0+24.00	1603.47	RETAINING WALL TOP	1034

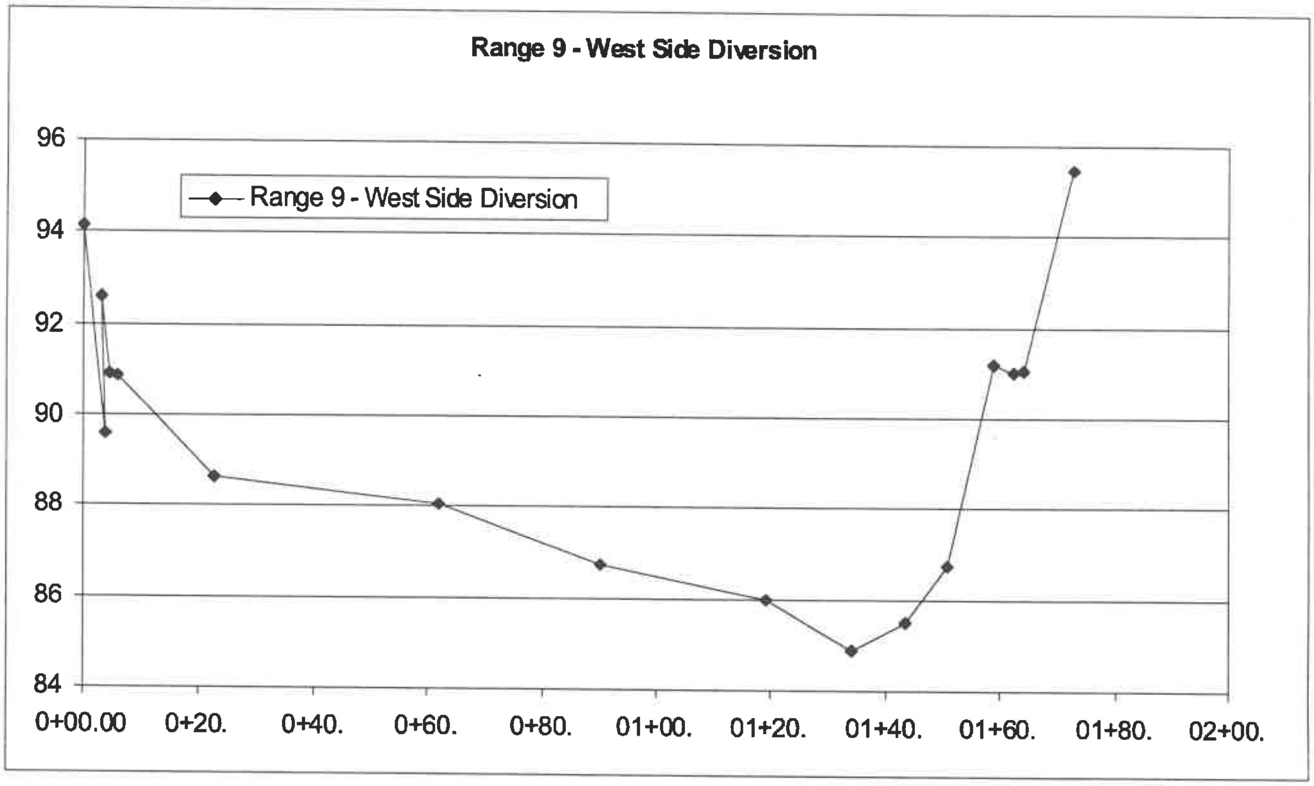
ADDITIONAL TOPO CASCADE DIVERSION

POINT NUMBER	ELEVATION	POINT DESCRIPTION
1035	1594.57	Water Surface Edge

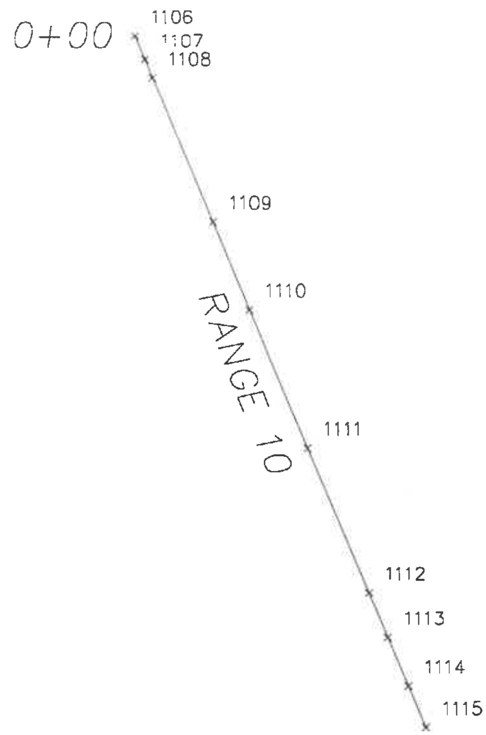
WEST SIDE DIVERSION

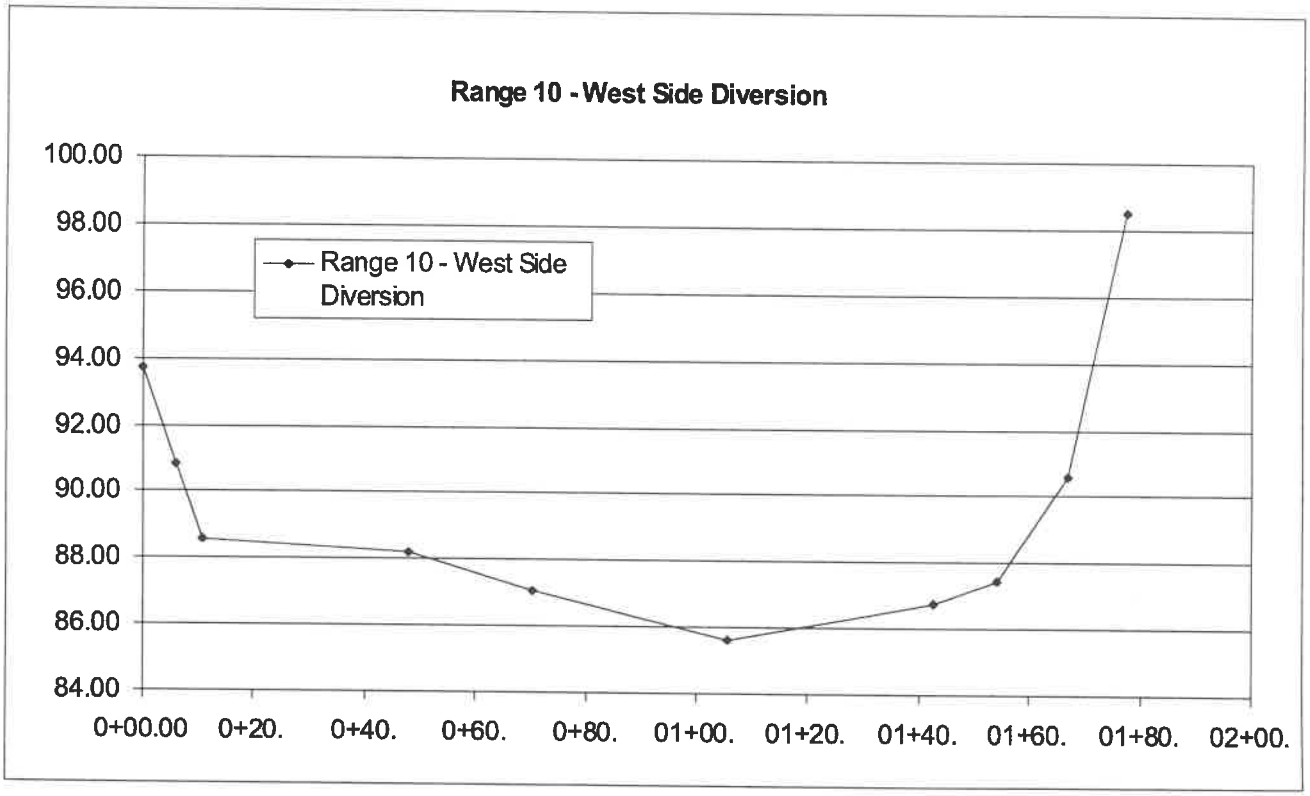






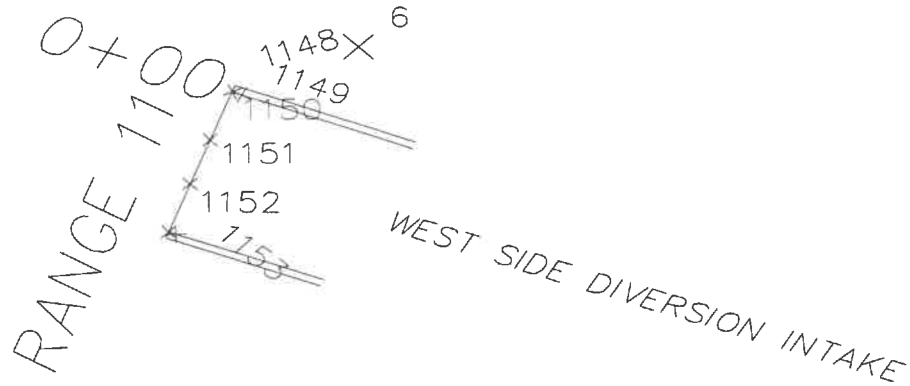
RANGE 9 STATION	ELEVATION	POINT DESCRIPTION	POINT #	OFFSET UPSTREAM
0+00.00	94.13	GROUND TOP	1116	
0+03.83	89.61	GROUND TOE	1118	
0+03.25	92.59	GROUND BREAK	1117	
0+04.46	90.92	WATER SURFACE EDGE@10:15AM 3/30	1119	
0+04.69	90.94	WATER SURFACE EDGE@10:15AM 3/30	1132	92.71
0+05.95	90.90	WATER SURFACE EDGE@10:15AM 3/30	1131	44.81
0+22.82	88.65	GROUND BREAK	1120	
0+61.92	88.05	GROUND	1121	
0+90.13	86.74	GROUND	1122	
1+19.13	85.97	GROUND BREAK	1123	
1+34.08	84.88	GROUND	1124	
1+43.60	85.49	GROUND	1125	
1+50.77	86.73	GROUND BREAK	1126	
1+59.00	91.18	WATER SURFACE EDGE@10:15AM 3/30	1130	133.86
1+62.45	91.02	WATER SURFACE EDGE@10:15AM 3/30	1129	60.22
1+64.14	91.08	WATER SURFACE EDGE@10:15AM 3/30	1127	
1+72.69	95.45	GROUND TOP	1128	

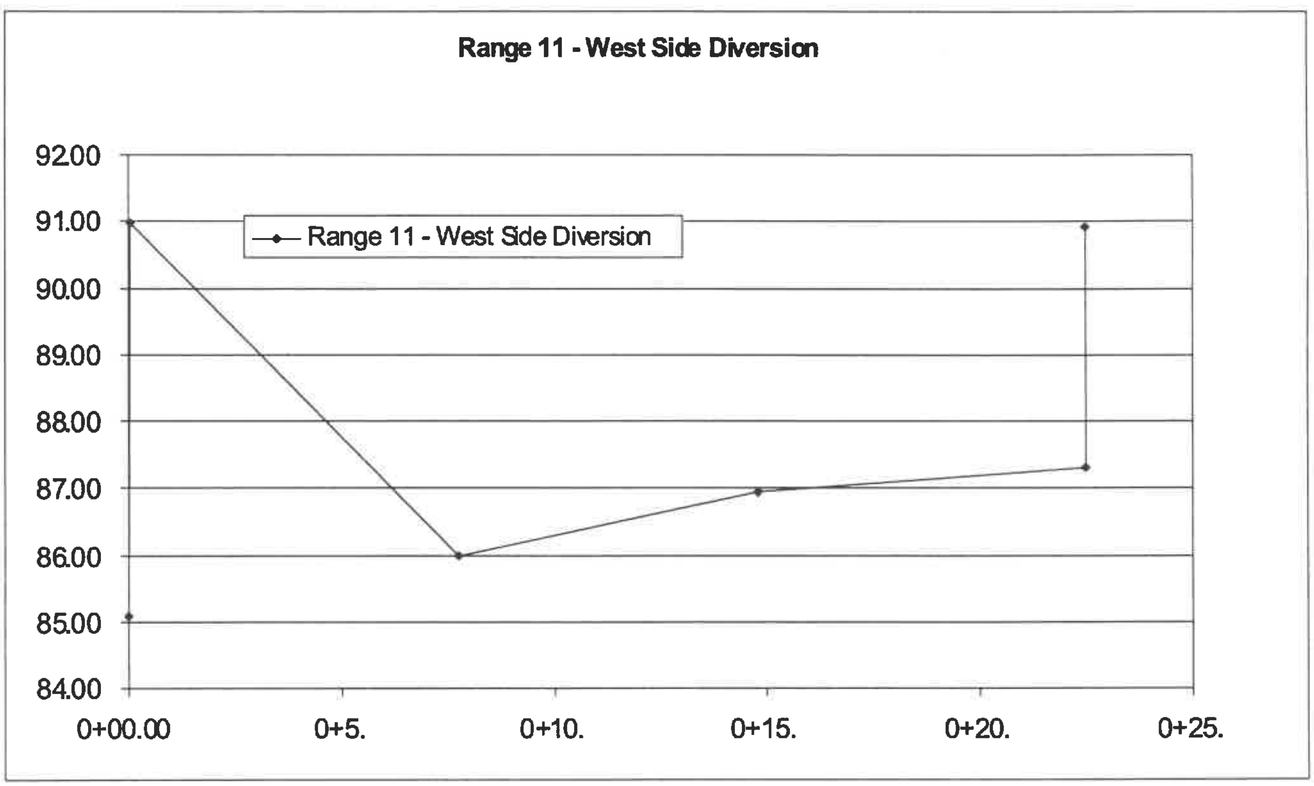

0+00
1106
1107
1108
1109
1110
RANGE 10
1111
1112
1113
1114
1115



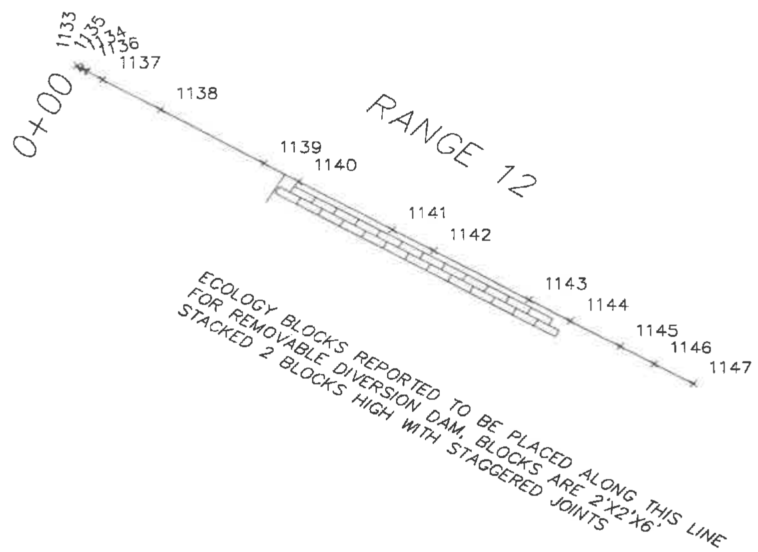
RANGE10

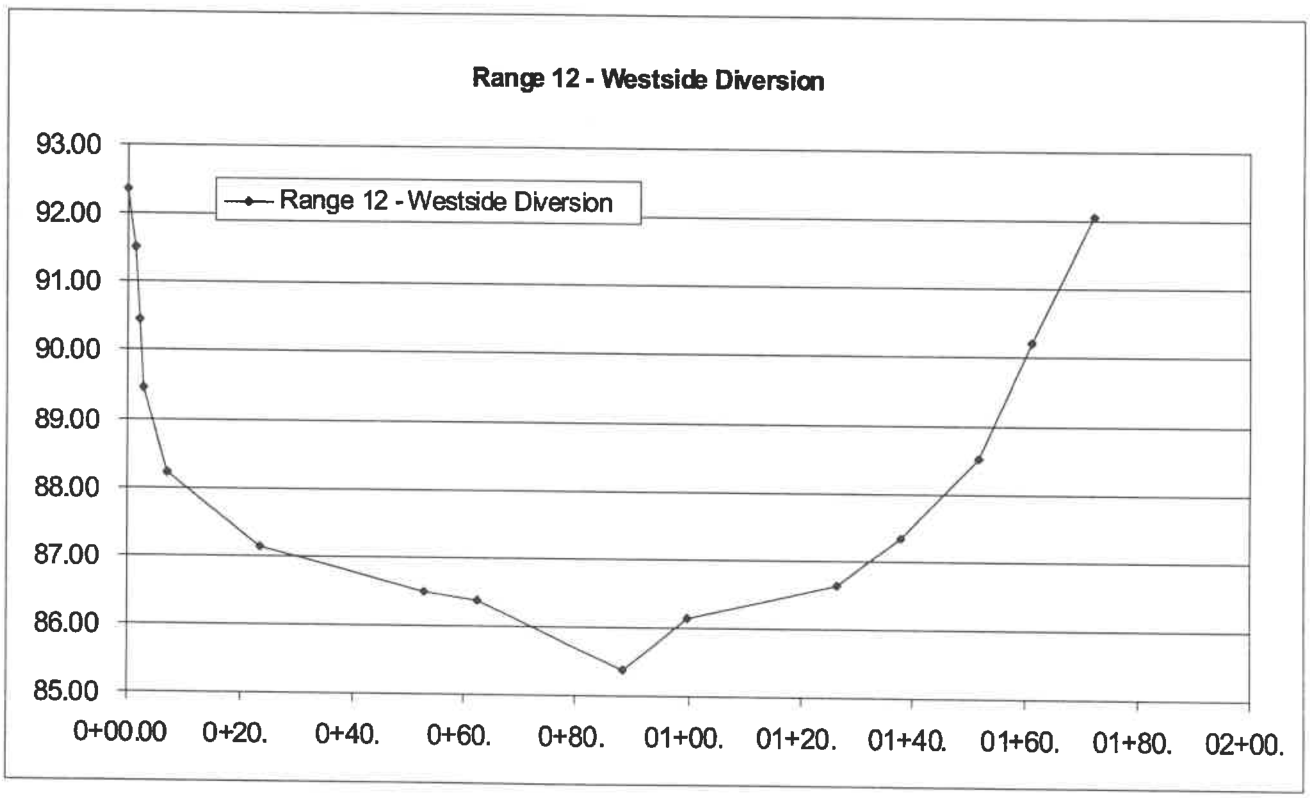
STATION	ELEVATION	POINT DESCRIPTION	POINT #
0+00.00	93.74	GROUND TOP	1106
0+06.16	90.84	WATER SURFACE EDGE@9:40AM 3/30	1107
0+10.86	88.57	GROUND TOE	1108
0+48.00	88.19	GROUND	1109
0+70.33	87.07	GROUND	1110
1+05.62	85.63	GROUND	1111
1+42.77	86.74	GROUND	1112
1+54.35	87.47	GROUND BREAK	1113
1+66.89	90.60	WATER SURFACE EDGE@9:40AM 3/30	1114
1+77.48	98.52	GROUND TOP	1115





RANGE11 STATION	ELEVATION	POINT DESCRIPTION	POINT #	OFFSET DOWNSTREAM
0+00.00	85.09	RETAINING WALL TOE	1149	
0+00.03	90.97	WATER SURFACE EDGE/ WING WALL@ 11:55AM 3/30	1148	-1.35
0+07.73	86.00	GROUND BREAK	1150	
0+14.79	86.96	GROUND BREAK	1151	
0+22.50	87.30	RETAINING WALL TOE	1152	
0+22.50	90.93	WATER SURFACE EDGE/ WING WALL@ 11:55AM 3/30	1153	-1.03


0+00
1133
1135
1134
1136
1137
1138
RANGE 12
1139
1140
1141
1142
1143
1144
1145
1146
1147
ECOLOGY BLOCKS REPORTED TO BE PLACED ALONG THIS LINE
FOR REMOVABLE DIVERSION DAM, BLOCKS ARE 2'X2'X6'
STACKED 2 BLOCKS HIGH WITH STAGGERED JOINTS


Range 12 - Westside Diversion
Range 12 - Westside Diversion
93.00
92.00
91.00
90.00
89.00
88.00
87.00
86.00
85.00
0+00.00
0+20.
0+40.
0+60.
0+80.
01+00.
01+20.
01+40.
01+60.
01+80.
02+00.

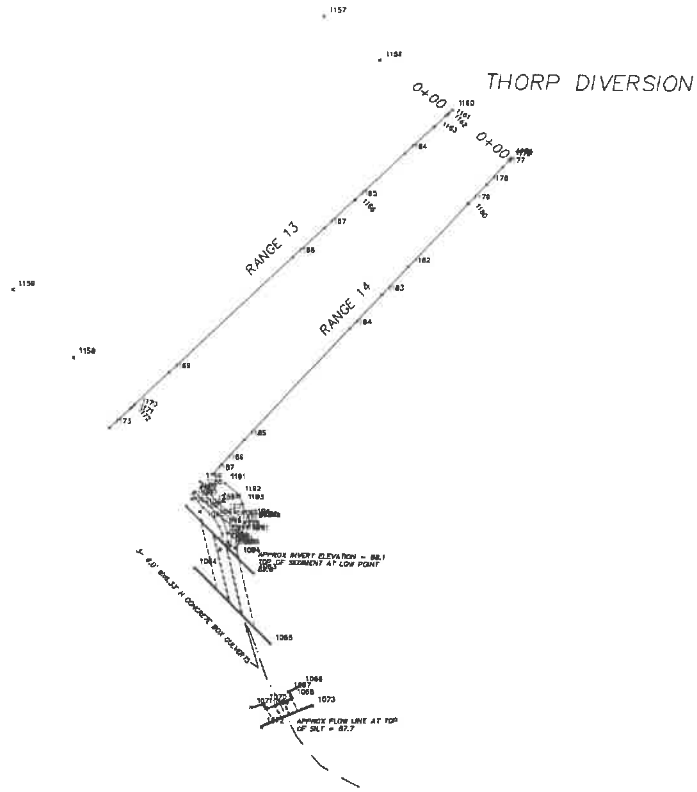
RANGE12

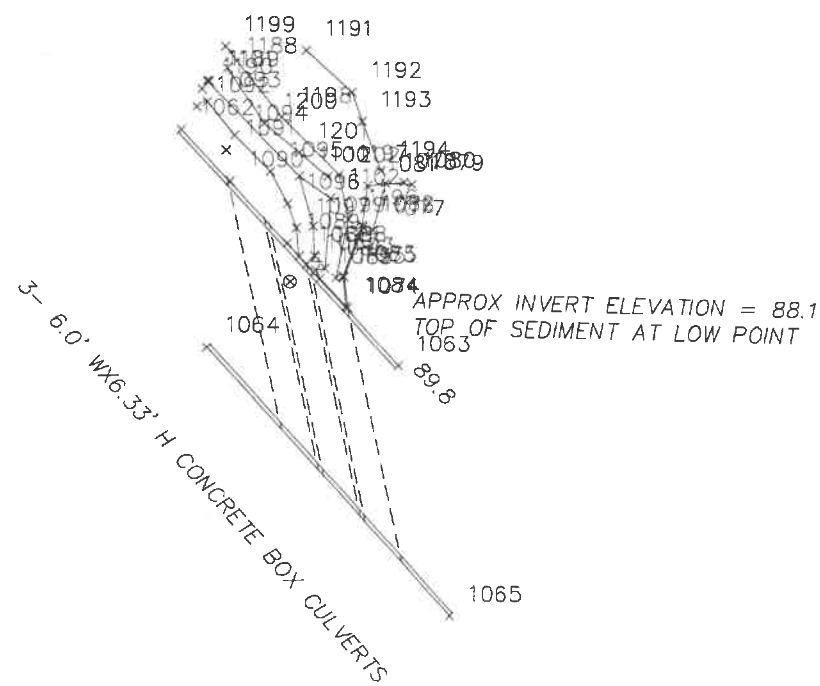
STATION	ELEVATION	POINT DESCRIPTION	POINT #
0+00.00	92.35	GROUND TOP	1133
0+01.27	91.50	GROUND BREAK	1134
0+02.01	90.46	WATER SURFACE EDGE@11:25AM 3/30	1135
0+03.03	89.46	GROUND TOE	1136
0+07.24	88.22	GROUND BREAK	1137
0+23.57	87.14	GROUND BREAK	1138
0+52.59	86.48	GROUND	1139
0+62.22	86.39	GROUND	1140
0+88.24	85.39	GROUND	1141
0+99.78	86.14	GROUND	1142
1+26.42	86.63	GROUND BREAK	1143
1+37.99	87.34	GROUND BREAK	1144
1+51.80	88.53	GROUND BREAK	1145
1+61.22	90.21	WATER SURFACE EDGE@11:25AM 3/30	1146
1+72.09	92.07	GROUND TOP	1147

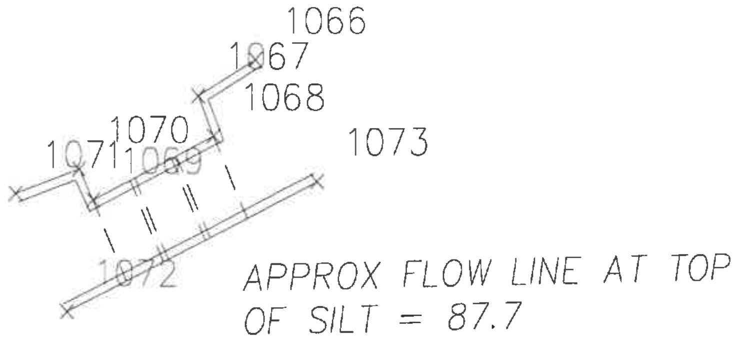
ADDITIONAL TOPO WEST SIDE DIVERSION

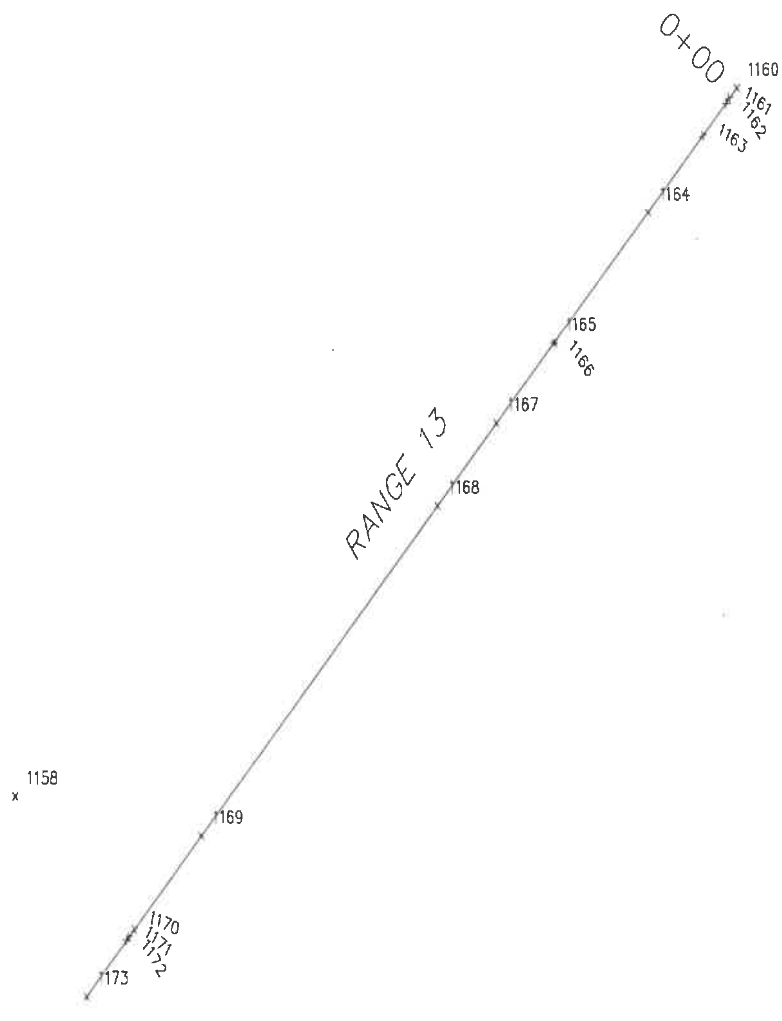
POINT NUMBER	ELEVATION	POINT DESCRIPTION
6	100.00	Set Cross
1129	91.02	Water Surface Edge
1130	91.18	Water Surface Edge
1131	90.91	Water Surface Edge
1132	90.94	Water Surface Edge

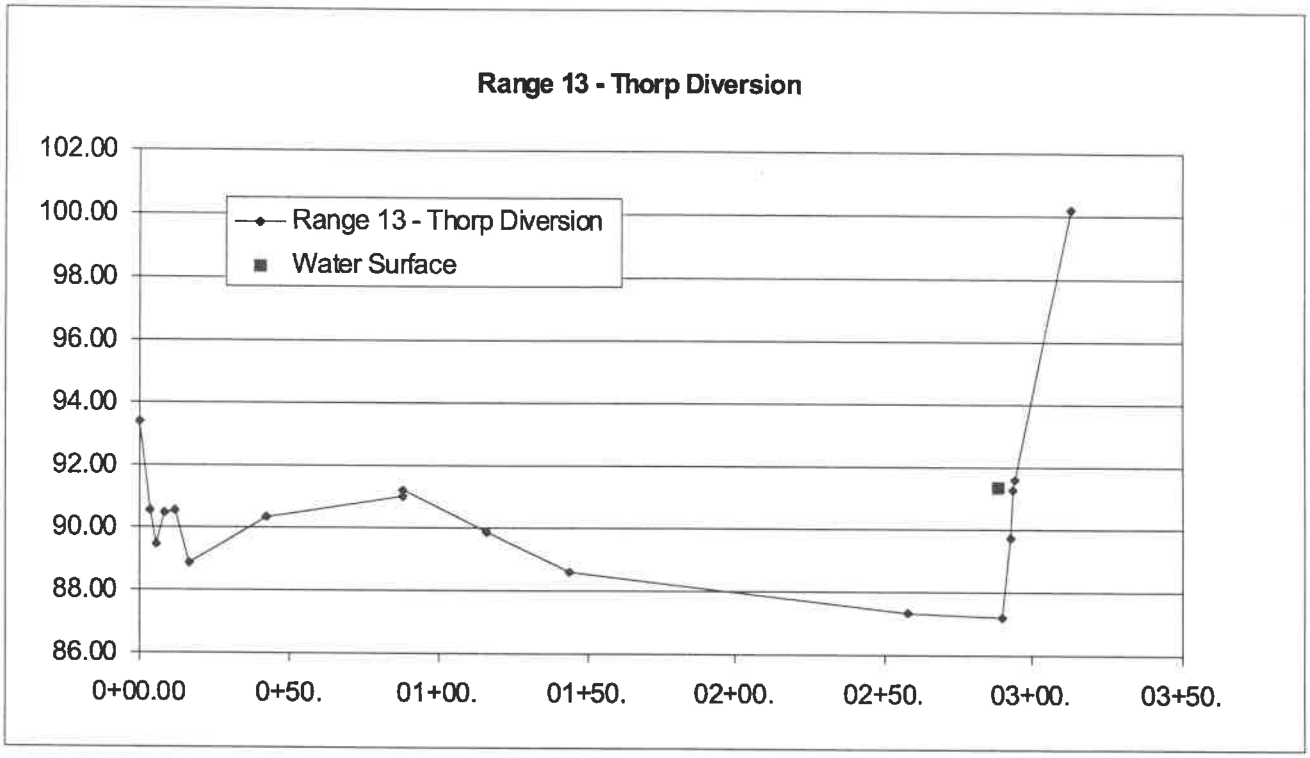
THORP DIVERSION





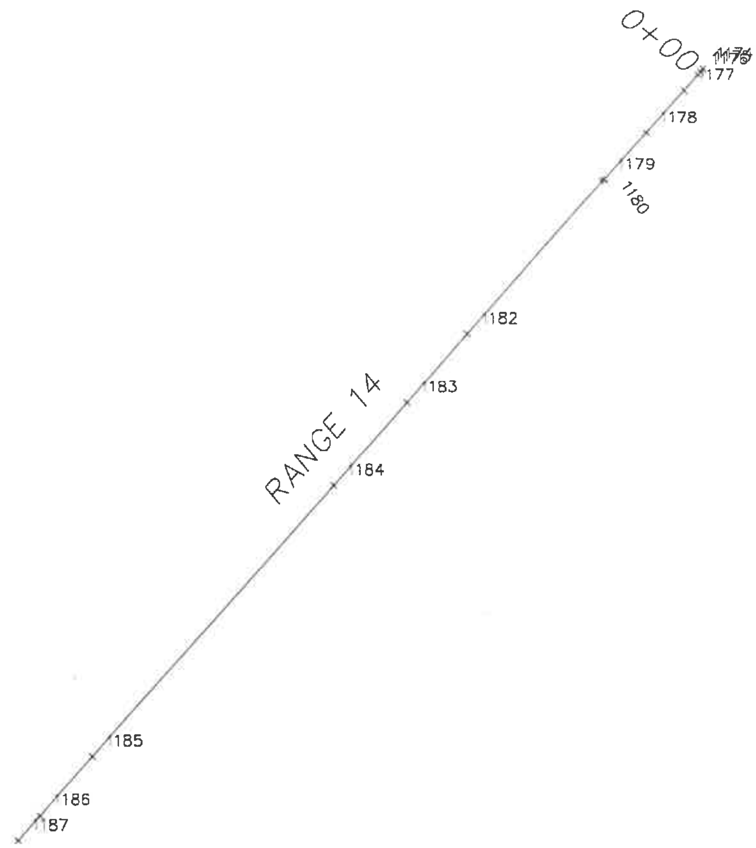

1066
1067
1068
1070
1071
1069
1073
1072
APPROX FLOW LINE AT TOP
OF SILT = 87.7

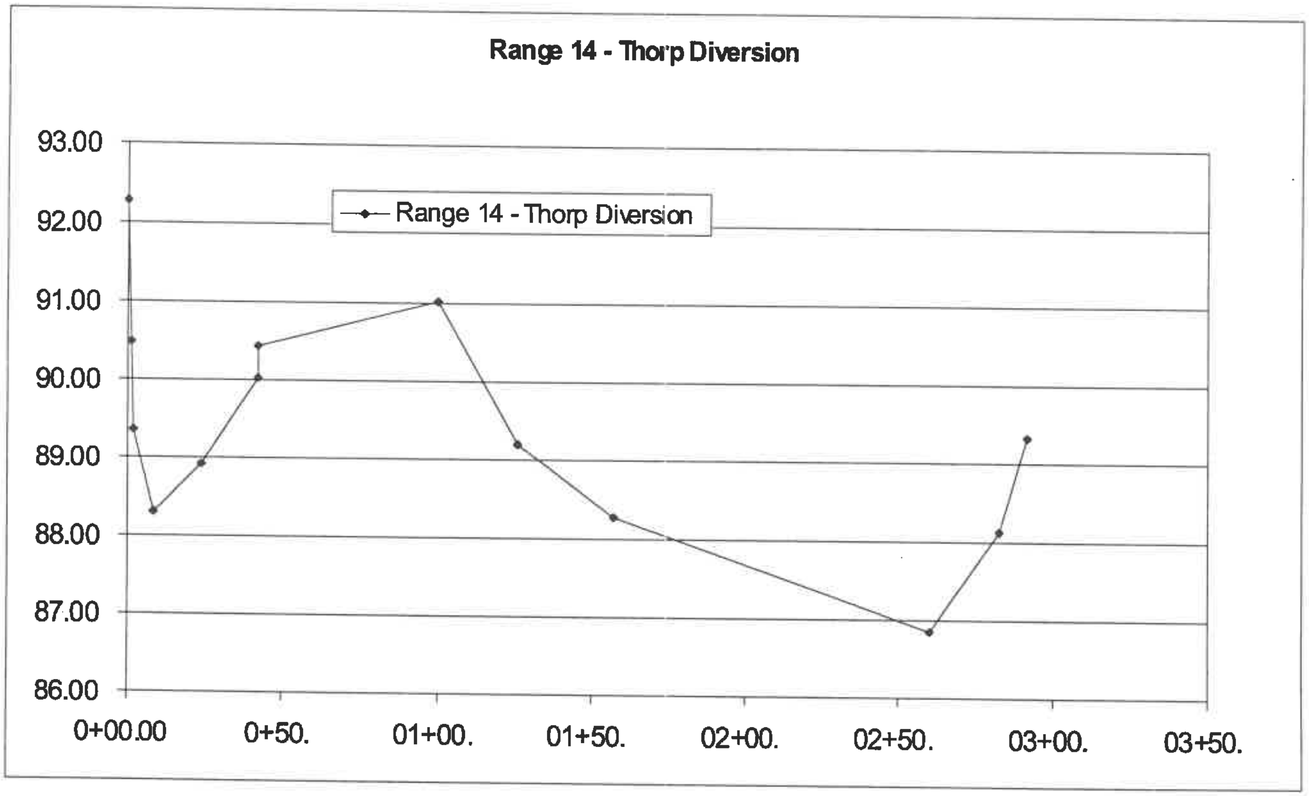

0+00
1160
1161
1162
1163
1164
1165
1166
1167
RANGE 13
1168
1158
1169
1170
1171
1172
1173



RANGE13

STATION	ELEVATION	POINT DESCRIPTION	POINT #	OFFSET UPSTREAM
0+00.00	93.41	GROUND TOP	1160	
0+03.58	90.53	WATER SURFACE EDGE@1:59PM 3/30	1161	
0+05.29	89.50	GROUND TOE	1162	
0+08.39	90.46	WATER SURFACE EDGE@11:55AM 3/30	1156	56.75
0+12.06	90.52	WATER SURFACE EDGE@11:55AM 3/30	1157	103.70
0+16.42	88.85	GROUND BREAK@ EDGE GRAVEL BAR	1163	
0+42.88	90.31	GROUND BREAK	1164	
0+87.95	91.00	GROUND BREAK	1165	
0+88.10	91.17	WATER SURFACE EDGE@ 1:59PM 3/30	1166	
1+15.65	89.89	GROUND	1167	
1+43.95	88.63	GROUND BREAK	1168	
2+57.91	87.32	GROUND	1169	
2+88.35	91.34	WATER SURFACE EDGE@11:55AM 3/30	1159	111.37
2+89.94	87.23	GROUND TOE	1170	
2+92.42	89.73	GROUND TOP@ TOP RIP RAP	1171	
2+93.67	91.30	WATER SURFACE EDGE@2:11PM 3/30	1172	
2+94.40	91.62	WATER SURFACE EDGE@11:55AM 3/30	1158	51.02
3+12.79	100.22	GROUND TOP	1173	


0+00
177
178
179
1180
182
183
RANGE 14
184
185
186
187



RANGE14

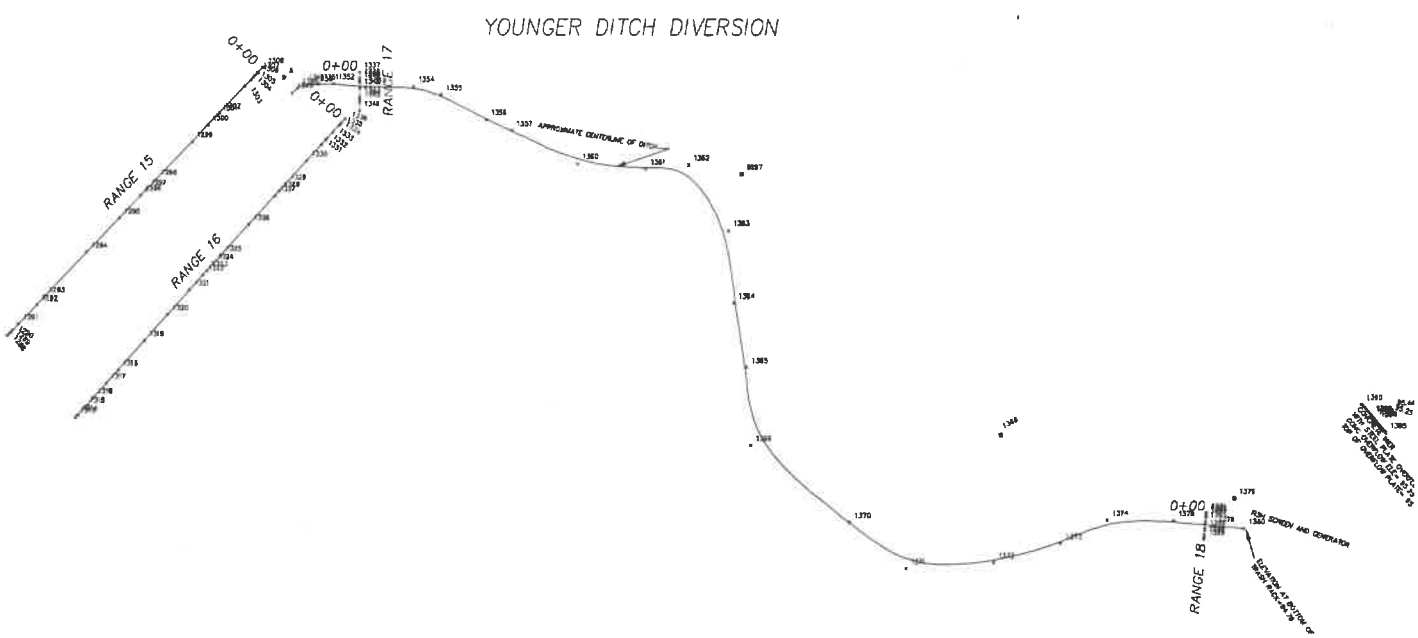
STATION	ELEVATION	POINT DESCRIPTION	POINT #
0+00.00	92.27	GROUND TOP	1174
0+01.10	90.49	WATER SURFACE EDGE@2:15PM 3/30	1175
0+02.11	89.36	GROUND TOE	1176
0+08.10	88.32	GROUND BREAK	1177
0+24.13	88.92	GROUND BREAK	1178
0+41.97	90.03	GROUND BREAK@ EDGE GRAVEL BAR	1179
0+42.12	90.43	WATER SURFACE EDGE@GRAVEL BAR 2:23PM 3/30	1180
1+00.11	91.02	WATER SURFACE EDGE@GRAVEL BAR 2:25PM 3/30	1182
1+25.96	89.20	GROUND	1183
1+57.31	88.29	GROUND	1184
2+60.33	86.85	GROUND	1185
2+82.64	88.13	GROUND BREAK	1186
2+92.09	89.33	GROUND BREAK	1187

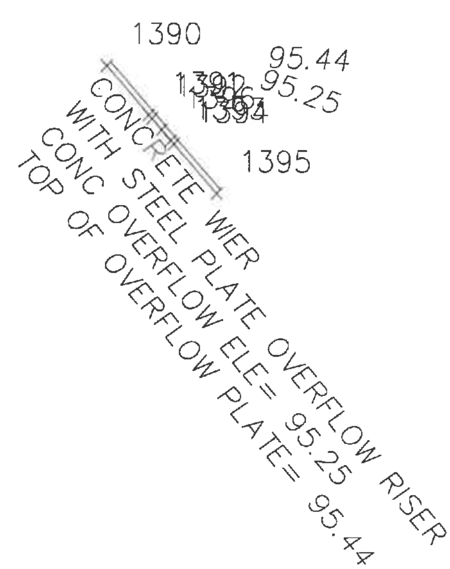
ADDITIONAL TOPO THORP DIVERSION

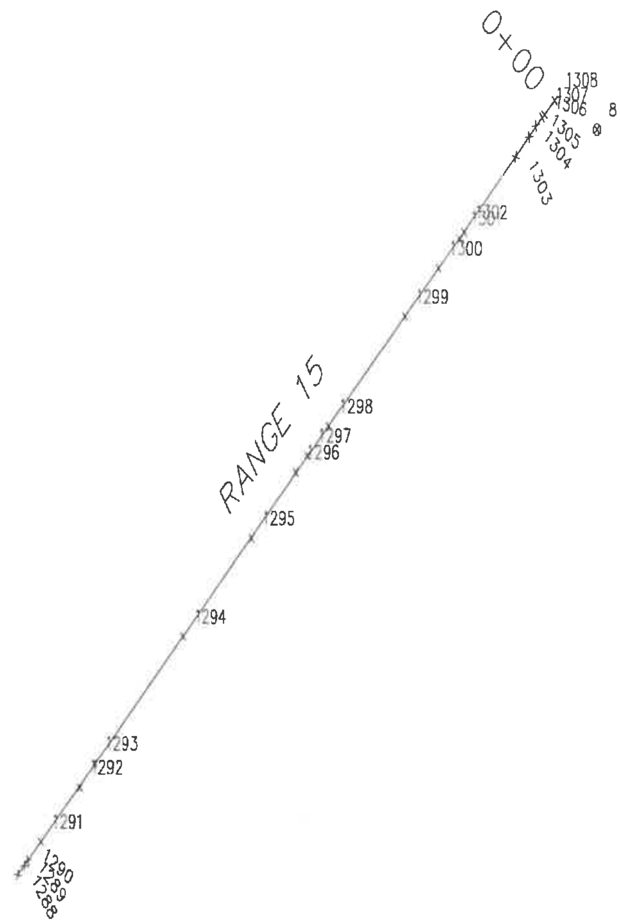
POINT NUMBER	ELEVATION	POINT DESCRIPTION
4	100.00	Set Rebar Control
1156	90.46	Water Surface Edge
1157	90.52	Water Surface Edge
1158	91.62	Water Surface Edge
1159	91.34	Water Surface Edge
1062	100.57	Retaining Wall Top
1063	100.18	Retaining Wall Top
1064	100.46	Retaining Wall Top
1065	100.30	Retaining Wall Top
1066	99.40	Retaining Wall Top
1067	99.78	Retaining Wall Top
1068	99.84	Retaining Wall Top
1069	99.78	Retaining Wall Top
1070	99.70	Retaining Wall Top
1071	100.00	Retaining Wall Top
1072	99.90	Retaining Wall Top
1073	99.67	Retaining Wall Top
1074	98.26	Retaining Wall Top
1075	93.80	Retaining Wall Top
1076	93.06	Retaining Wall Top
1077	93.57	Ground Top
1078	93.27	Ground Top
1079	92.51	Ground Top
1080	90.81	Ground Toe
1081	91.19	Ground Toe
1082	91.25	Ground Toe
1083	89.74	Ground Toe
1084	89.58	Ground Toe
1085	90.35	Ground Break
1086	91.12	Water Surface Edge
1087	91.53	Ground Break
1088	93.29	Ground Top
1089	94.84	Ground Break
1090	94.62	Ground Shot
1091	94.95	Ground Shot
1092	95.99	Ground Shot
1093	93.57	Ground Top
1094	94.45	Ground Top
1095	95.31	Ground Top
1096	95.37	Ground Top
1097	94.70	Ground Top
1098	92.20	Ground Toe
1099	92.16	Ground Toe
1100	91.71	Ground Toe
1101	91.06	Ground Toe
1102	91.24	Ground Break
1103	91.46	Ground Break

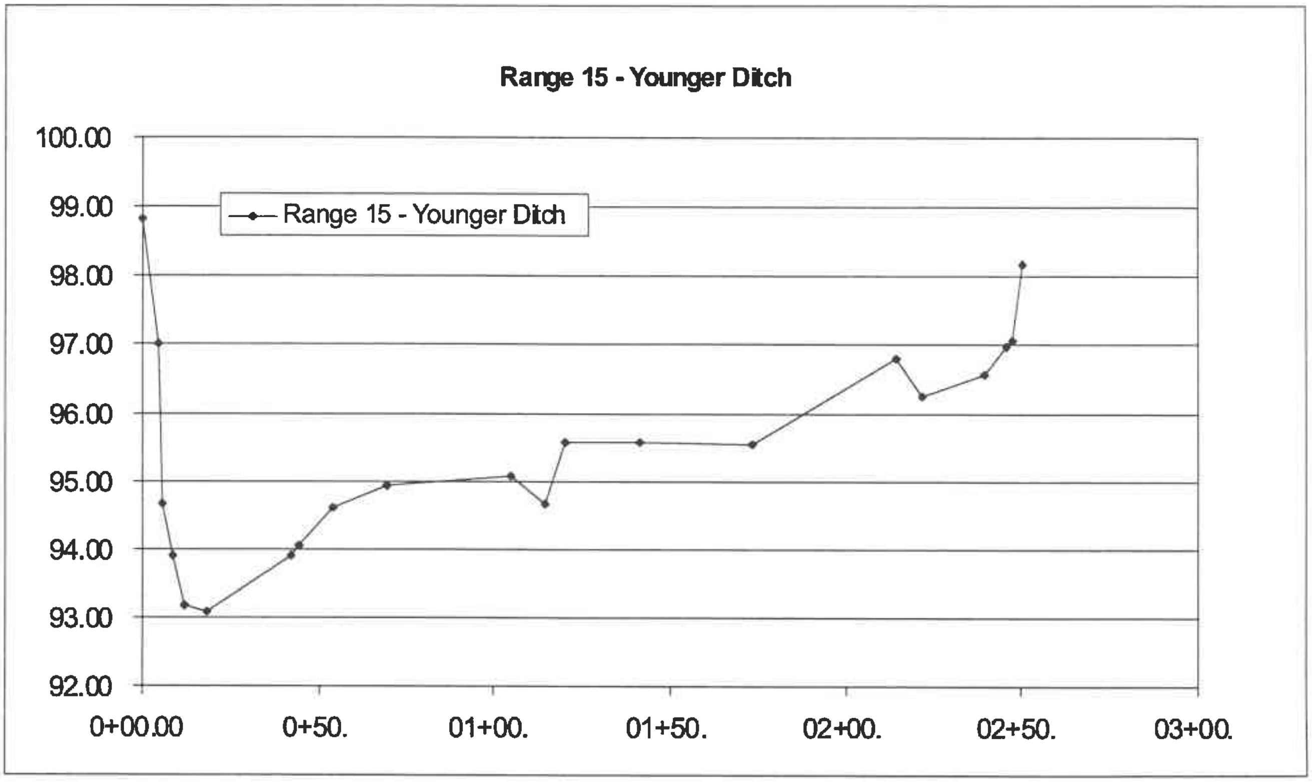
1188	88.78	Ground Break
1189	91.18	Water Surface Edge
1190	93.54	Ground Top
1191	90.32	Ground Break
1192	91.13	Ground Break
1193	90.85	Ground Break
1194	92.03	Ground Break
1195	89.83	Ground Break
1196	90.32	Ground Break
1197	89.93	Ground Break
1198	88.98	Ground Break
1199	88.87	Ground Break
1200	89.15	Ground Break
1201	89.13	Ground Break
1202	90.04	Ground Break

YOUNGER DITCH DIVERSION



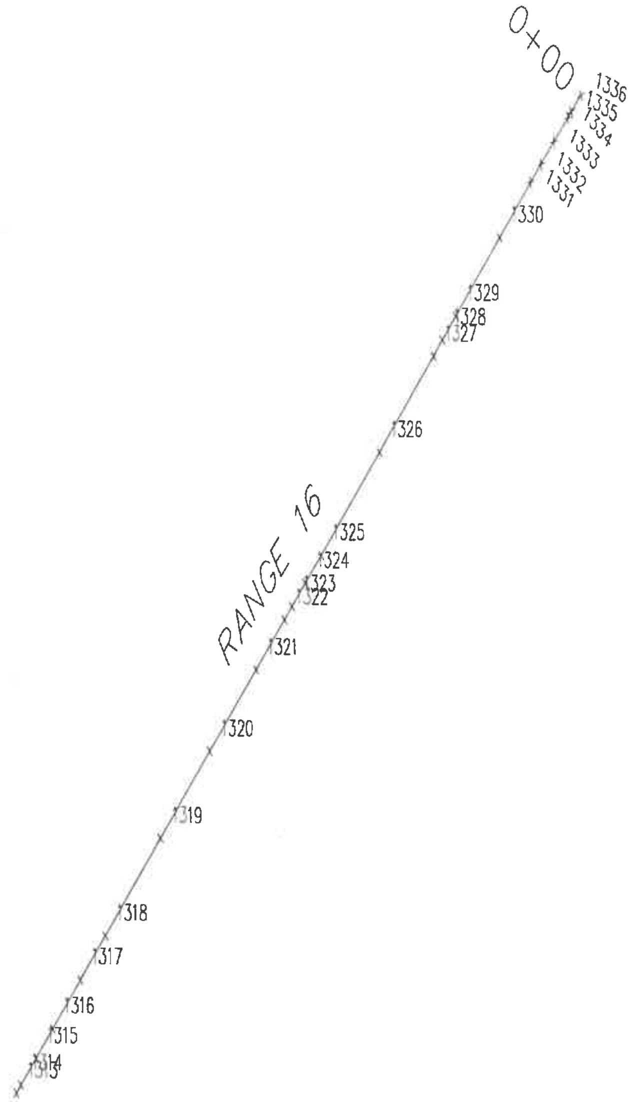


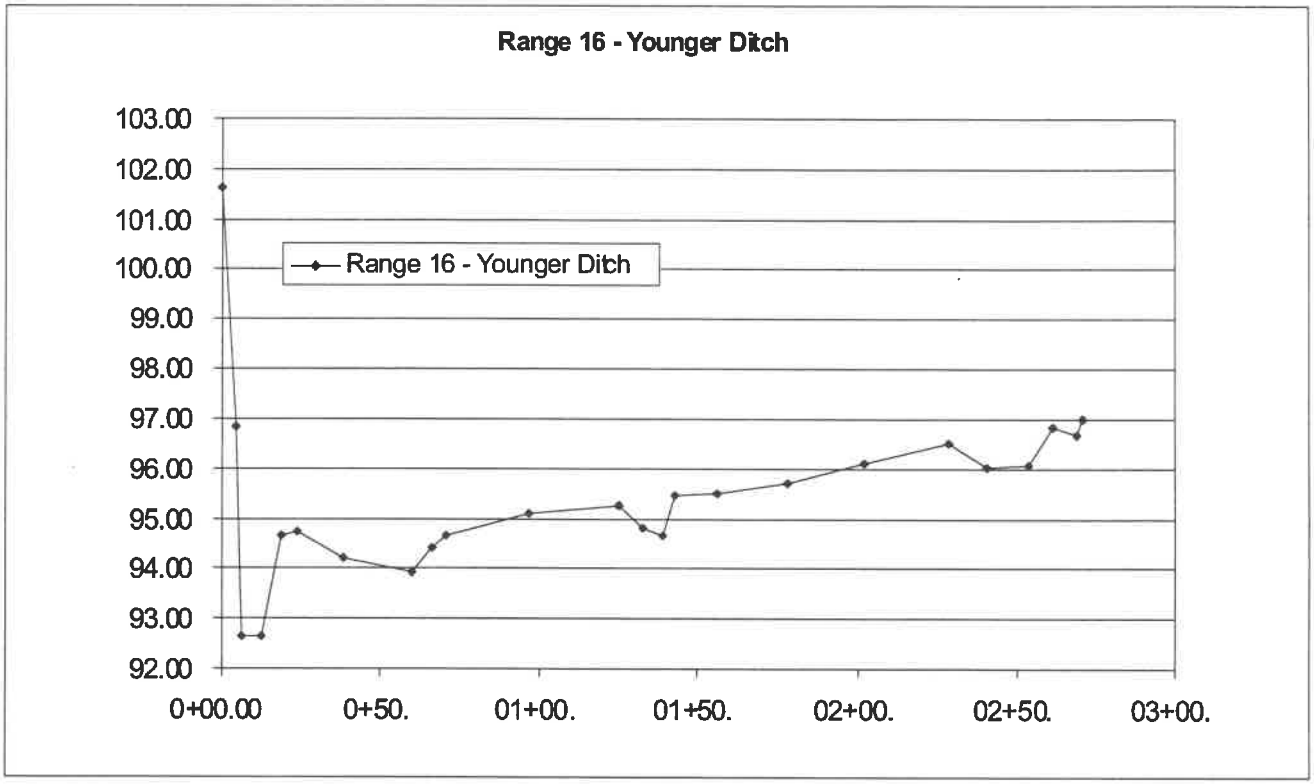

0+00
1308
1307
1306
8
1305
1304
1303
1302
1301
1300
1299
RANGE 15
1298
1297
1296
1295
1294
1293
1292
1291
1290
1289
1288



RANGE15

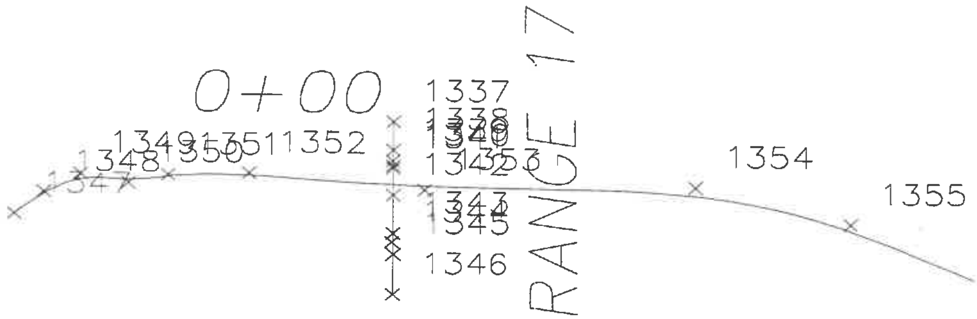
STATION	ELEVATION	POINT DESCRIPTION	POINT #
0+00.00	98.82	GROUND TOP	1308
0+04.60	97.02	WATER SURFACE EDGE@ 3:15PM 3/31	1307
0+05.69	94.66	GROUND BREAK	1306
0+08.44	93.90	GROUND TOE	1305
0+11.78	93.17	GROUND BREAK	1304
0+18.18	93.08	GROUND BREAK	1303
0+42.27	93.90	GROUND BREAK	1302
0+44.39	94.06	GROUND BREAK	1301
0+53.97	94.61	GROUND BREAK	1300
0+69.71	94.94	GROUND	1299
1+05.18	95.09	GROUND BREAK	1298
1+14.91	94.66	GROUND BREAK	1297
1+20.29	95.57	GROUND BREAK	1296
1+41.34	95.57	GROUND BREAK	1295
1+73.24	95.56	GROUND	1294
2+14.67	96.81	GROUND TOP@ GRAVEL BAR	1293
2+21.97	96.26	GROUND BREAK	1292
2+39.73	96.57	GROUND BREAK	1291
2+45.97	96.97	WATER SURFACE EDGE@1:49PM 3/31	1290
2+47.65	97.07	GROUND TOE	1289
2+50.61	98.17	GROUND TOP	1288

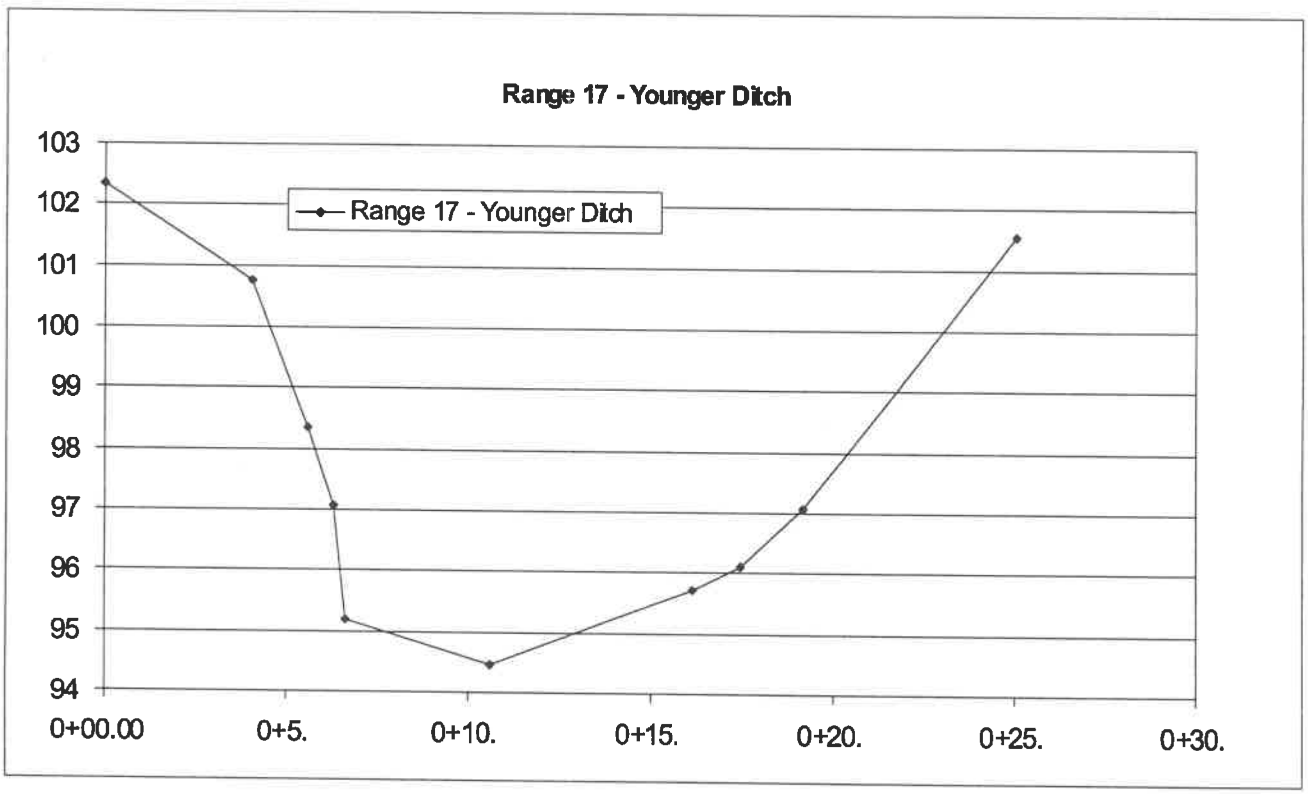

0+00
1336
1335
1334
1333
1332
1331
1330
1329
1328
1327
1326
RANGE 16
1325
1324
1323
1322
1321
1320
1319
1318
1317
1316
1315
1314
1313



RANGE16

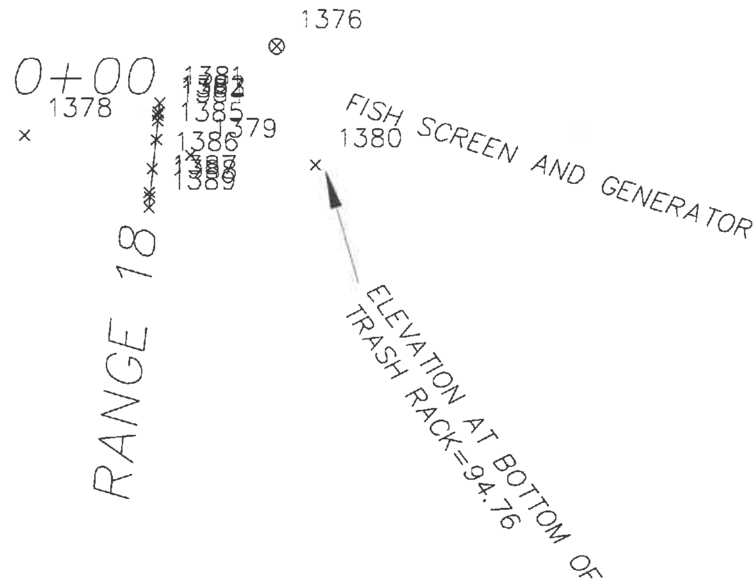
STATION	ELEVATION	POINT DESCRIPTION	POINT #
0+00.00	101.65	GROUND TOP	1336
0+04.53	96.85	WATER SURFACE EDGE@ 2:23PM 3/31	1335
0+06.21	92.66	GROUND TOE	1334
0+12.79	92.63	GROUND BREAK	1333
0+18.83	94.65	GROUND BREAK	1332
0+23.80	94.73	GROUND	1331
0+38.76	94.20	GROUND	1330
0+59.84	93.93	GROUND BREAK	1329
0+66.32	94.43	GROUND BREAK	1328
0+70.68	94.66	GROUND	1327
0+96.86	95.10	GROUND	1326
1+24.85	95.28	GROUND BREAK	1325
1+32.47	94.82	GROUND BREAK	1324
1+38.88	94.64	GROUND BREAK	1323
1+42.52	95.45	GROUND BREAK	1322
1+56.12	95.51	GROUND	1321
1+78.24	95.71	GROUND	1320
2+01.87	96.09	GROUND	1319
2+28.36	96.53	GROUND BREAK	1318
2+40.35	96.03	GROUND BREAK	1317
2+53.68	96.05	GROUND BREAK	1316
2+61.74	96.83	WATER SURFACE EDGE@2:35PM 3/31	1315
2+69.08	96.66	GROUND TOE	1314
2+71.24	97.00	GROUND TOP	1313

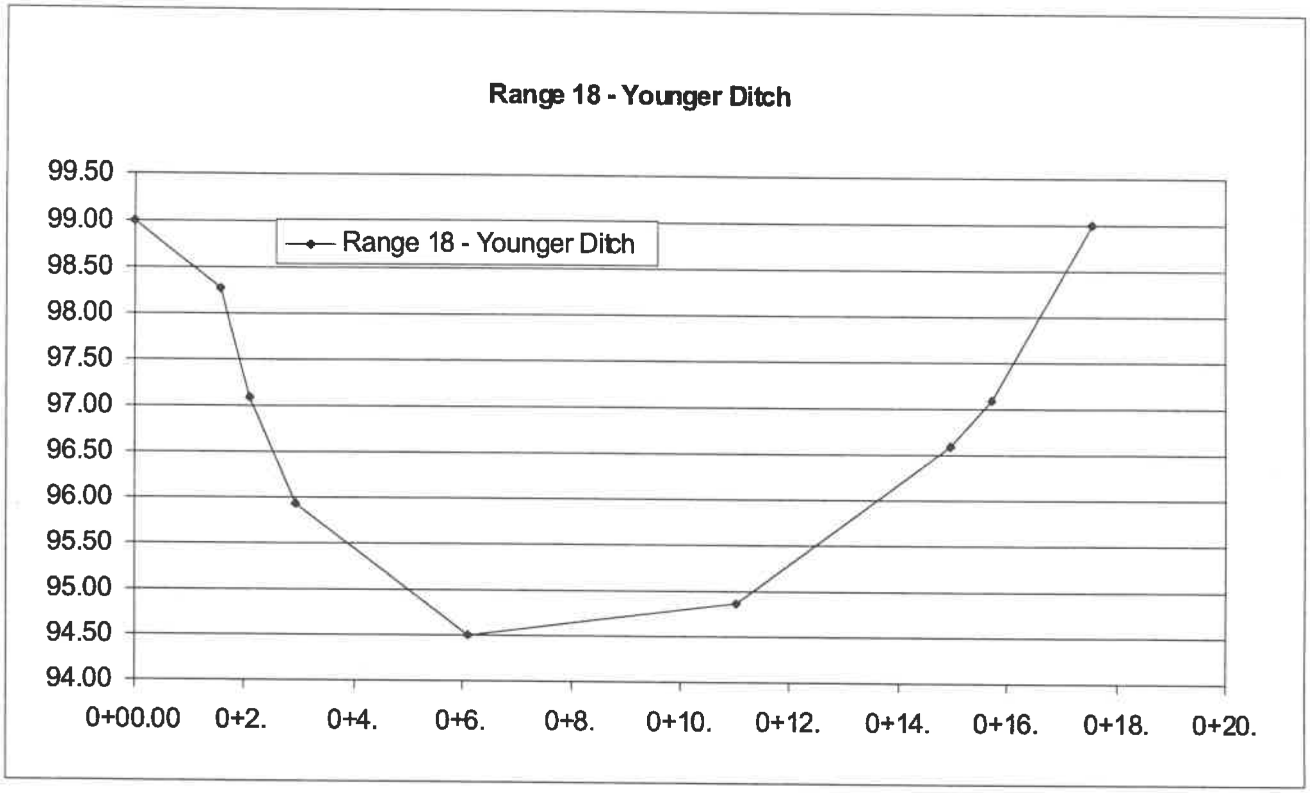




RANGE17

STATION	ELEVATION	POINT DESCRIPTION	POINT #
0+00.00	102.35	GROUND TOP	1337
0+04.06	100.77	GROUND BREAK	1338
0+05.62	98.36	GROUND BREAK	1339
0+06.29	97.06	WATER SURFACE EDGE@3:21PM 3/31	1340
0+06.65	95.19	GROUND BREAK	1341
0+10.56	94.45	DITCH CENTERLINE	1342
0+16.17	95.72	GROUND BREAK	1343
0+17.48	96.11	GROUND TOE	1344
0+19.21	97.05	WATER SURFACE EDGE@3:26PM 3/31	1345
0+25.07	101.54	GROUND TOP	1346


1376
0+00
1378
1385
1379
1380
1386
1389
FISH SCREEN AND GENERATOR
RANGE 18
ELEVATION AT BOTTOM OF
TRASH RACK=94.76



RANGE18

STATION	ELEVATION	POINT DESCRIPTION	POINT #
0+00.00	99.00	DITCH TOP	1381
0+01.57	98.27	GROUND BREAK	1382
0+02.93	95.94	GROUND TOE	1384
0+02.11	97.10	WATER SURFACE EDGE@4:59PM 3/31	1383
0+06.12	94.51	GROUND BREAK	1385
0+11.03	94.87	GROUND BREAK	1386
0+14.97	96.58	GROUND TOE	1387
0+15.74	97.10	WATER SURFACE EDGE@5:04PM 3/31	1388
0+17.57	99.01	GROUND TOP	1389

ADDITIONAL TOPO YOUNGER DIVERSION

POINT NUMBER	ELEVATION	POINT DESCRIPTION
8	100.00	Set Rebar Control
9	99.74	Set Rebar Control
1287	99.73	Check Shot
1347	94.12	Ditch Center Line
1348	95.43	Ditch Center Line
1349	95.18	Ditch Center Line
1350	95.86	Ditch Center Line
1351	96.10	Ditch Center Line
1352	94.30	Ditch Center Line
1353	94.37	Ditch Center Line
1354	93.82	Ditch Center Line
1355	94.32	Ditch Center Line
1356	94.27	Ditch Center Line
1357	95.72	Ditch Center Line
1360	95.35	Ditch Center Line
1361	94.97	Ditch Center Line
1362	95.05	Ditch Center Line
1363	95.08	Ditch Center Line
1364	94.75	Ditch Center Line
1365	94.99	Ditch Center Line
1366	94.87	Ditch Center Line
1368	99.87	Set Spike
1370	94.74	Ditch Center Line
1371	95.47	Ditch Center Line
1372	95.03	Ditch Center Line
1373	95.23	Ditch Center Line
1374	94.57	Ditch Center Line
1376	99.23	Set Spike
1378	94.65	Ditch Center Line
1379	93.95	Ditch Center Line
1380	94.76	SEE NOTES
1390	97.80	Retaining Wall Top
1391	97.79	Retaining Wall Top
1392	95.26	Retaining Wall Toe
1393	95.27	Retaining Wall Toe
1394	97.79	Retaining Wall Top
1395	97.78	Retaining Wall Top
1396	95.44	Retaining Wall Top
1287	99.73	Check Shot

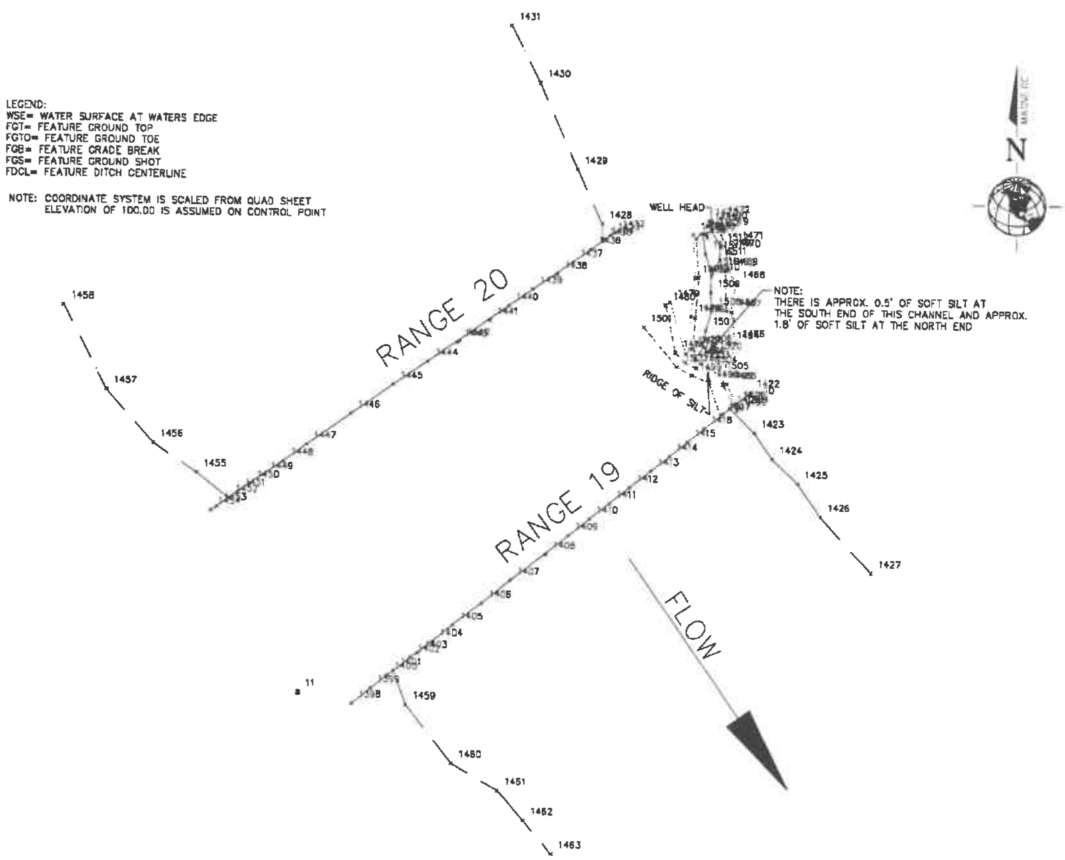
SUPPLEMENTAL APPENDIX B

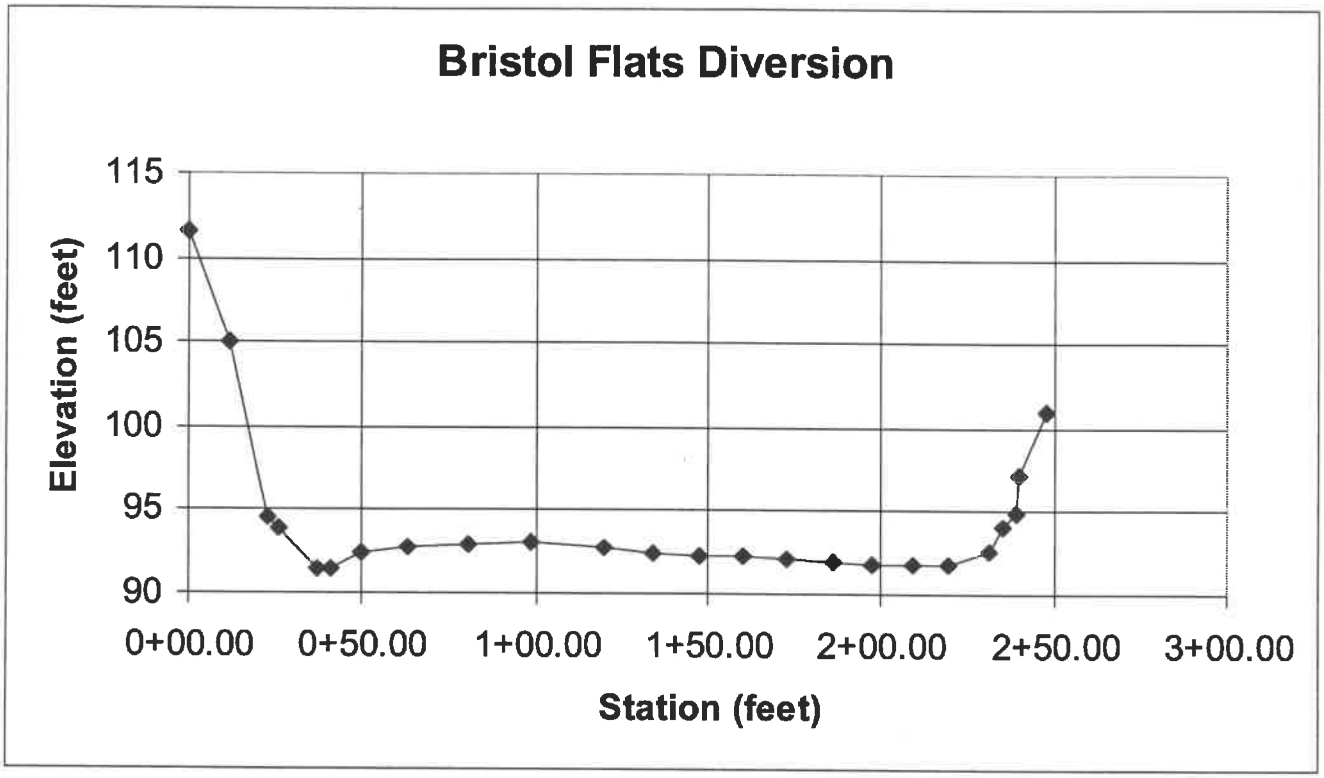
ADDITIONAL YAKIMA RIVER CROSS SECTIONS WATER DIVERSION HYDRAULIC STUDY July 23rd, 2001

PROJECT NARRATIVE:

W&H Pacific surveyed 2 additional cross sections (ranges) near the Bristol Flats (Wallace Ranch) diversion on the Yakima River on March 15th 2001. A Wild TC1010 Total Station Instrument and a Husky FS/2 Data Collector with TDS software was used to collect the data. The horizontal and vertical datums were assumed, however both cross sections were based on the same reference datums. An assumed elevation of 100.00' was held on WHP control point #10 for Bristol Flats Diversion Ranges 19&20. The data was downloaded into Autocad Version 14 and the Ranges were put into an Excel spreadsheet. A sketch of the diversion site imported from AutoCAD and cross section 19, as used in the hydraulic analysis, is provided below.

BRISTOL FLATS DIVERSION OVERALL SKETCH





RANGE 19

STATION	ELEVATION	POINT DESCRIPTION	POINT #
0+00.00	111.58	FGT	1398
0+11.77	105.03	FGB	1399
0+22.60	94.54	FGTO	1400
0+26.00	93.98	WSE	1401
0+36.72	91.42	FGB	1402
0+40.99	91.52	FGB	1403
0+50.11	92.51	FGB	1404
0+62.86	92.79	FGB	1405
0+80.65	92.98	FGS	1406
0+98.39	93.12	FGS	1407
1+20.04	92.78	FGB	1408
1+34.55	92.52	FGS	1409
1+47.70	92.32	FGS	1410
1+60.00	92.31	FGS	1411
1+72.80	92.06	FGS	1412
1+85.97	91.88	FGS	1413
1+97.68	91.82	FGS	1414
2+08.99	91.76	FGS	1415
2+19.47	91.82	FGB	1416
2+30.93	92.65	FGB	1417
2+35.53	94.09	WSE	1418
2+39.00	94.93	FGTO	1419
2+39.65	97.23	FGT	1420
2+48.22	100.97	FGS	1422

Appendix C

Yakima River Water Rights Data

THIRDPARTY DIVERSIONS FROM BYPASSED REACH
April 7, 2000

	NAME	LOCATION (to nearest ¼ section)	SUBBASIN	CLAIM	PRIORITY DATE	REFEREE RECOMMENDED (QA) / (QI)	IRRIGATED ACREAGE	STOCK WATER	ENTITLEMENT SUMMARY (ES) / 1945 CONSENT DECREE & LIMITING AGREEMENTS (CD)
	CLE ELUM RIVER TO TEANAWAY RIVER								
(0) CITY OF CLE ELUM		(Legal Description)							
(I) YOUNGER DITCH		SE ¼ NW ¼ NE ¼ Sec. 35 T20N R15E	No. 5 (Elk Heights)						(ES) 3,010 AF (NP)
	Baker/Morgan			01688	06/05/1886	49 AF / 0.86 CFS	7.5	1.0 AF	
	Bator			02230	06/05/1886	116 AF / 1.91 CFS	9.5	0.5 AF	
	Bronkema			01268 02225	06/05/1886	36 AF / 0.18 CFS	6		
	Carveth			01678	06/05/1886	60 AF / 0.455 CFS	10	0.50 AF	
	Fudacz			02224	06/05/1886	66 AF / 0.67 CFS	11	1.0 AF	
	Garrett			01279	06/05/1886	45 AF / 0.32 CFS	11	1.0 AF	
	Haas			01279	06/05/1886	12 AF / 0.09 CFS	2	0.25 AF	
	Hankins			01279	06/05/1886	21 AF / 0.166 CFS	3.5	0.5 AF	
	Henshaw			00365	06/05/1886	450 AF / 1.82 CFS	75	3.0 AF	
	Merritt			01279	06/05/1886	24 AF / 0.19 CFS	4	0.10 AF	
	Telerico			05671	06/05/1886	21 AF / 0.24 CFS	4	0.5 AF	
	Telerico			01279	06/05/1886	12 AF / 0.235 CFS	3.5		
	Winslow			01279	06/05/1886	12 AF / .085 CFS	2	0.25 AF	
	Frederick, Richey, Newton & Fredericksen.			02222 01676	06/30/1900	1,585 AF / 5.8 CFS	270	4 AF	
	TEANAWAY RIVER TO SWAUK CREEK								
(2) WALLACE RANCH									
	Wallace Ranch	SW ¼ SW ¼ Sec. 2 T19N, R16E.	No. 4 (Swauk)	02267	05/24/1884	673.06 AF / 3.35 CFS (w/ 1884 right)	92.2		
	Wallace Ranch	NW ¼ NE ¼ Sec. 14 T19N, R16E.	No. 4 (Swauk)	02267	09/25/1894	279.6 AF / 3.35 CFS	38.2		
	SWAUK CREEK TO TANEUM CREEK								
(3) CASCADE IRRIGATION DISTRICT*		NW ¼ NW ¼ Sec. 28 T19N. R17E. (Original Site)	Major Claimant						
(4) CLARK		SW ¼ NE ¼ Sec. 28 T19 N. R17 E.	No. 4 (Swauk)						

794 Dudley Rd
Thorp

THIRDPARTY DIVERSIONS FROM BYPASSED REACH
April 7, 2000

	Clark			01087	07/27/1889	250 AF / 1.0 CFS	50		
(5) WESTSIDE IRRIGATION CO.		SE ¼ SE ¼ Sec. 33 T19 N. R17 E.	No. 6 (Taneum)						
	Knoke		No. 6 (Taneum)	01628	05/0/1883	1,967.885 AF / 13.826 CFS	113.75	0.5 AF	(ES) 1,600 AF (NP)
	Hagemeyer		No. 6 (Taneum)	01628	05/0/1883	90.83 AF / 0.537 CFS	5.25		
	West Side Irr. Co.		Major Claimant		06/06/1889	17,530 AF / 80 CFS	5,373		(ES) 31,128 AF (NP) / 8,200 AF (P) (CD) 80 CFS (Apr.-Sept.) & 34 CFS (Oct.) / Storage Contract: 25 CFS & 8,200 AF 4/20-8/20
	West Side Irr. Co.		Major Claimant		05/10/1905	8,200 AF / 25 CFS	5,373		
	TANEUM CREEK TO REECER CREEK								
(6) CASCADE IRRIGATION DISTRICT*		SE ¼ SE ¼ Sec. 34, T19N, R17E (Clark Flats)							
(7) THORP		NE ¼ SE ¼ NE ¼ Sec. 3 T18N, R17E	No. 8 (Thorp)						
	Hutchison			00877	12/03/1879	240 AF / 2 CFS	14	10AF	
	Fields			02372	12/03/1879	9.25 AF / 0.06 CFS	2.5	1 AF	
	Fields			02372	12/03/1879	9.25 AF / 0.06 CFS	2.5	1 AF	
	Lindsey			01189	12/03/1879	11 AF / 0.06 CFS	3		
	Wilson			00718	12/03/1879	18.25 AF / 0.08 CFS	3.5	1 AF	
	Chamberlain			02316	01/01/1881	36 AF / 0.15 CFS	6	1 AF	
	Chamberlain			02316	06/09/1881	270 AF / 1.125 CFS	45		
	Chamberlain			02316	01/29/1887	78 AF / 0.325 CFS	13		
	Loucks			02046	12/28/1888	300 AF / 1.80 CFS	15	0.50 AF	
	Loucks			02046	03/01/1890	540 AF / 3.2 CFS	27	1.5 AF	
	Thorp Town Ditch			00725	06/30/1893	80.6 AF / 0.33 CFS	15.5	2 AF	
	Chamberlain			02316	03/03/1900	96 AF / 0.40 CFS	16		
(8) ELLENSBURG WATER COMPANY									
	Ellensburg Water	NE ¼ NW ¼ SE ¼ Sec. 12 T 18 N. R17 E.	Major Claimant		04/25 1885	43,840 AF / 125 CFS	9,749.33		(ES) 47,758 AF (NP) (CD) 125 CFS (Apr.-Aug), 100 CFS (Sept.), 63 CFS (Oct.)
(8) OLSON DITCH		NE ¼ NW ¼ SE¼ Sec. 12 T18 N. R17 E.	No. 7 (Reecer)						(ES) 12,973 AF (NP) (CD) 24 CFS (Apr.-Aug), 16 CFS (Sept.), 8 CFS (Oct.)

THIRDPARTY DIVERSIONS FROM BYPASSED REACH
April 7, 2000

	Olson Ditch			00169	02/21/1876	2,444.20 AF 168 (Nov) / 17.36 CFS	121.5	72.3 AF (12/1-3/31)	
	Olson Ditch			00169	02/21/1876	2,200.5 AF 240 (Nov) / 10.6 CFS	174	72.3 AF	
	Olson Ditch			00169	07/30/1885	633.5 AF / 2.3 FS	70		
	Olson Ditch			00169	07/01/1889	86.34 AF / 0.485 CFS	8	10.4 AF (Nov) 3.25 AF 12/1-3/31	
	Olson Ditch			00169	04/07/1891	8,179 AF / 41.537 CFS (w/ time limitations)	183.4	392 AF (Nov); 118 AF 12/1-3/31	
	Bain			01207	12/21/1882	867.58 AF / 5.5 AF	39.7	5 AF 10/16-3/31)	
	Fitterer			05175	12/21/1882	342.7 AF / 2.37 CFS	23	5 AF	
	Klocke			01696	12/21/1882	7.5 AF / 0.07 CFS	1.5	1 AF	
	Fitterer			05175	05/24/1884	4 AF / 0.06 CFS	2	1 AF	
	Holmes			00487	05/24/1884	675 AF / 3.31 CFS	26.8	2 AF	
	McManamy, Soebert			00521	07/30/1885	585.4 AF / 4.29 CFS	38.2		
	Merten			00750	07/30/1885	124.7 AF / 0.30 CFS	10.5		
	Clapper			01565	04/07/1891	100 AF / 1 CFS			
	Bain, Donovan			01207	04/25/1891	445.26 AF / 4 CFS	20.4	5 AF	
(9) PACKWOOD CANAL		NW ¼ SE ¼ NE ¼ Sec. 13, T18N, R17E.							
	Packwood Canal		No. 8 (Thorp) See: Memo Op. 1/28/20000	00785 A04801	06/30/1903	7,971.2 AF / 23.5 CFS (4/1-7/10); 21 CFS (7/11-10/1); 7 CFS (10/2-10/31)	424		
	Lapen		No. 8 (Thorp)	01446	06/30/1885	11 AF / 0.0313 CFS	1.25		
(10) CASCADE IRRIGATION DISTRICT									
	Cascade Irrigation	SW ¼ NW ¼ Sec. 18 T18N., R18E. (CID Pumping Station)	Major Claimant		02/28/1903	35,612 AF / 120 CFS	12,446.3		(ES) 49,525 AF (NP) (CD) 150 CFS (3/15-7/20), 30 CFS (stock 10/15-3/15) / Contract: 16,800 AF @ 150 CFS (7/20-10/15)

THIRDPARTY DIVERSIONS FROM BYPASSED REACH
April 7, 2000

(11) MILL DITCH		SE ¼ SW ¼ NE ¼ Sec. 29 T18 N. R18 E.	No. 7 (Reecer)						(ES) 7,530 AF (NP) (Mills & Son)
	Anderson			00296	05/20/1885	744 AF / 1.56 CFS	60		
	Anderson			00637	05/20/1885	111.6 AF / 0.225 CFS	9		
	Anderson			00626	05/20/1885	500 AF / 1.0 CFS	40		
	Anderson			00636	05/20/1885	155 AF / 0.324 CFS	12.5		
	Barton			00910 01719	05/20/1885	316.2 AF / 0.662 CFS	25.5		
	Lamb			00908	05/20/1885	620 AF / 4.0 CFS	50		
	Mill Ditch Co.			00626	05/20/1885	105.4 AF / 0.2125 CFS	8.5		
	Mill Ditch Co.			00626	05/20/1885	/ 1.14 CFS		375 AF	
	Pautzke Bait Co.			01724	05/06/1893	1,825 AF / 12.9 CFS	146	375 AF	
	Calaway Pacific			01720	05/06/1893	96 AF / 1.3 CFS	16		
	Guy			01983	05/06/1893	3 AF / 0.067 CFS	1.5		
	Jewett			00140 02098 02105	05/06/1893	20 AF / 0.50 CFS	2		
	Lentz			00637	05/06/1893	483.6 AF / 1.0 CFS	40		
(12) PAUTZKE BAIT CO II.		NW ¼ SW ¼ NW ¼ Sec. 3 T17 N. R 18 E.	No. 7 (Reecer)						
	Pautzke Bait Co.			01724	10/30/1884	2,808 AF / 12 CFS	117 (50 acres Par 5)	12 AF	
	Pautzke Bait Co.			01724	10/30/1884	967.2 AF / 3.9 CFS	78		
	Wyatt			01558	10/30/1884	2.76 AF / 0.02 CFS	0.50		
	Bull Ditch	Sec. 10 T17N R18E	No. 9 (Wilson-Nameum)						

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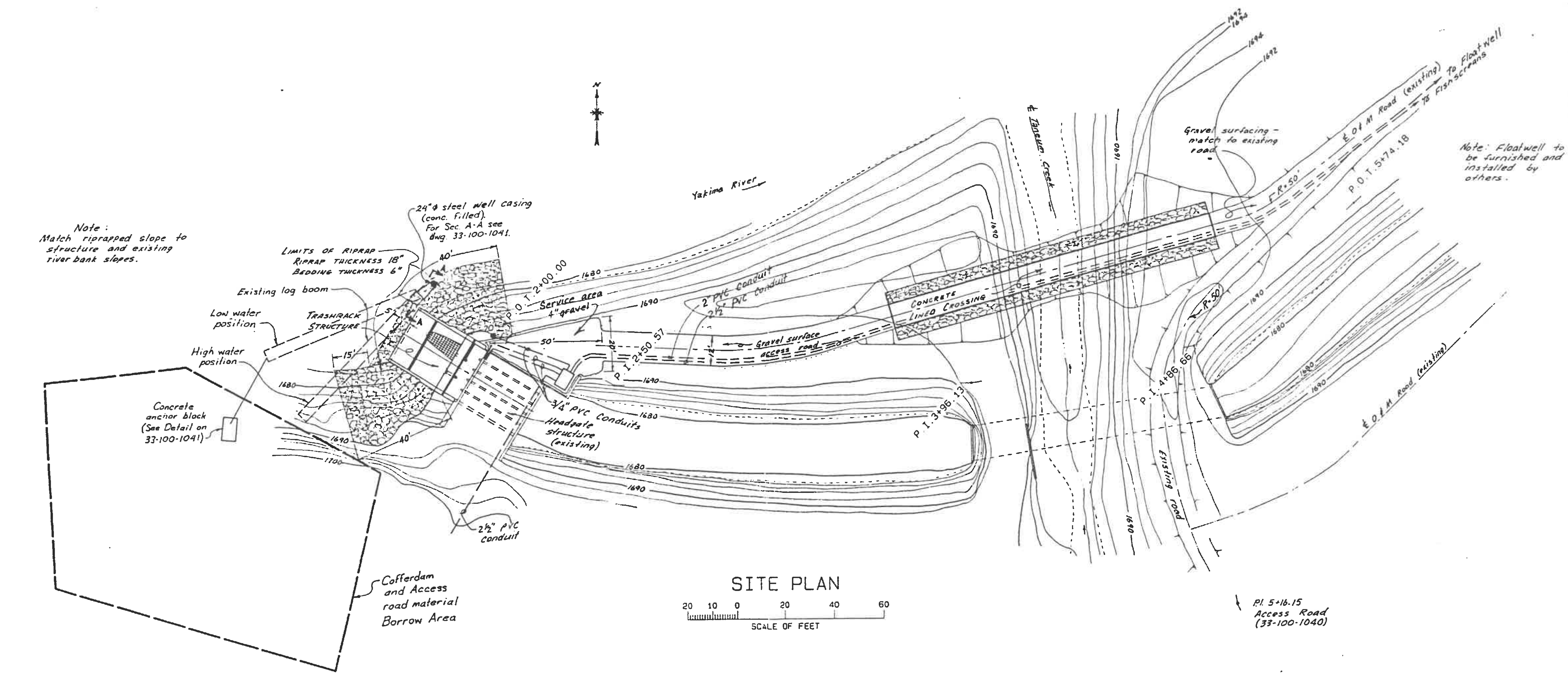
Appendix D

Westside Irrigation District Facility Plans

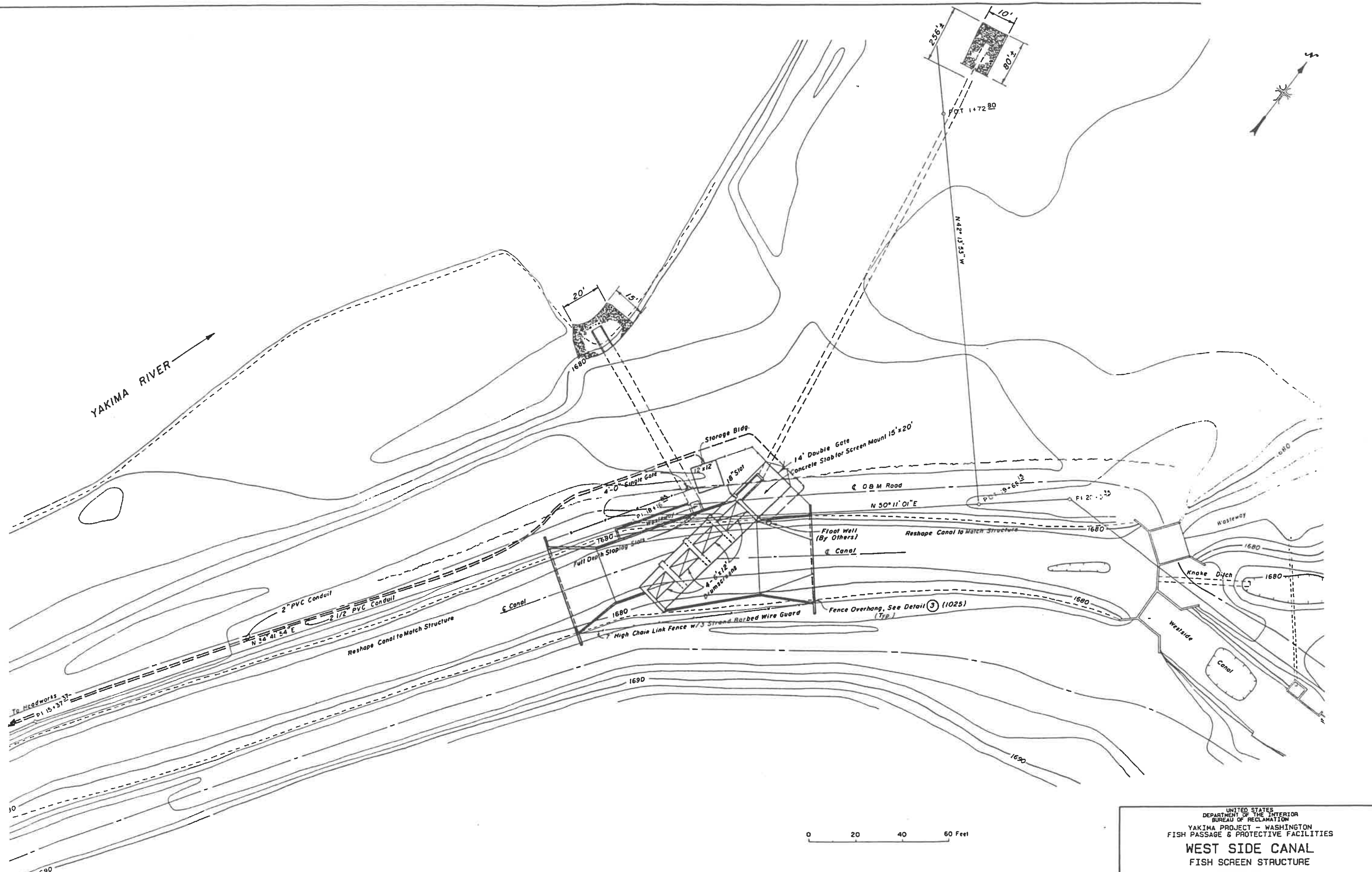


UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA PROJECT - WASHINGTON
FISH PASSAGE AND PROTECTIVE FACILITIES

WEST SIDE CANAL
FISH SCREEN STRUCTURE
HEADWORKS STRUCTURE - SITE PLAN

DESIGNED ______ SUBMITTED [signature]
DRAWN Guy F. Grooms ______ RECOMMENDED [signature]
CHECKED UB ______ APPROVED [signature]
REGIONAL ENGINEER

BOISE, IDAHO | APRIL 1987 | 33-100-1013



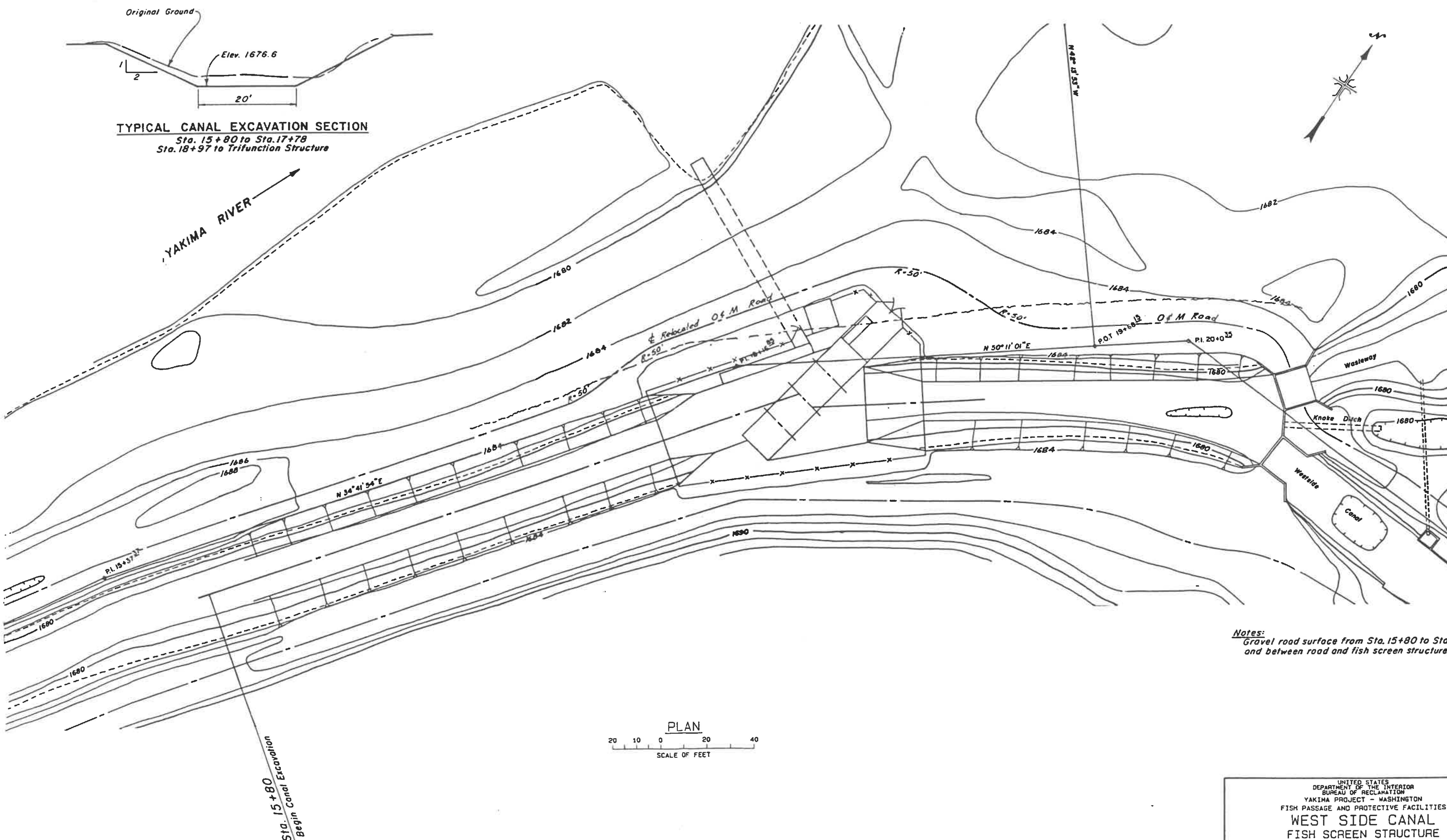
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA PROJECT - WASHINGTON
FISH PASSAGE & PROTECTIVE FACILITIES

WEST SIDE CANAL

FISH SCREEN STRUCTURE

SITE PLAN

DESIGNED John Brozovich	SUBMITTED John J. Brozovich
DRAWN Guy F. Grooms	RECOMMENDED
CHECKED	APPROVED — REGIONAL ENGINEER
BOISE, IDAHO — JULY 1987	33-100-1021



UNITED STATES
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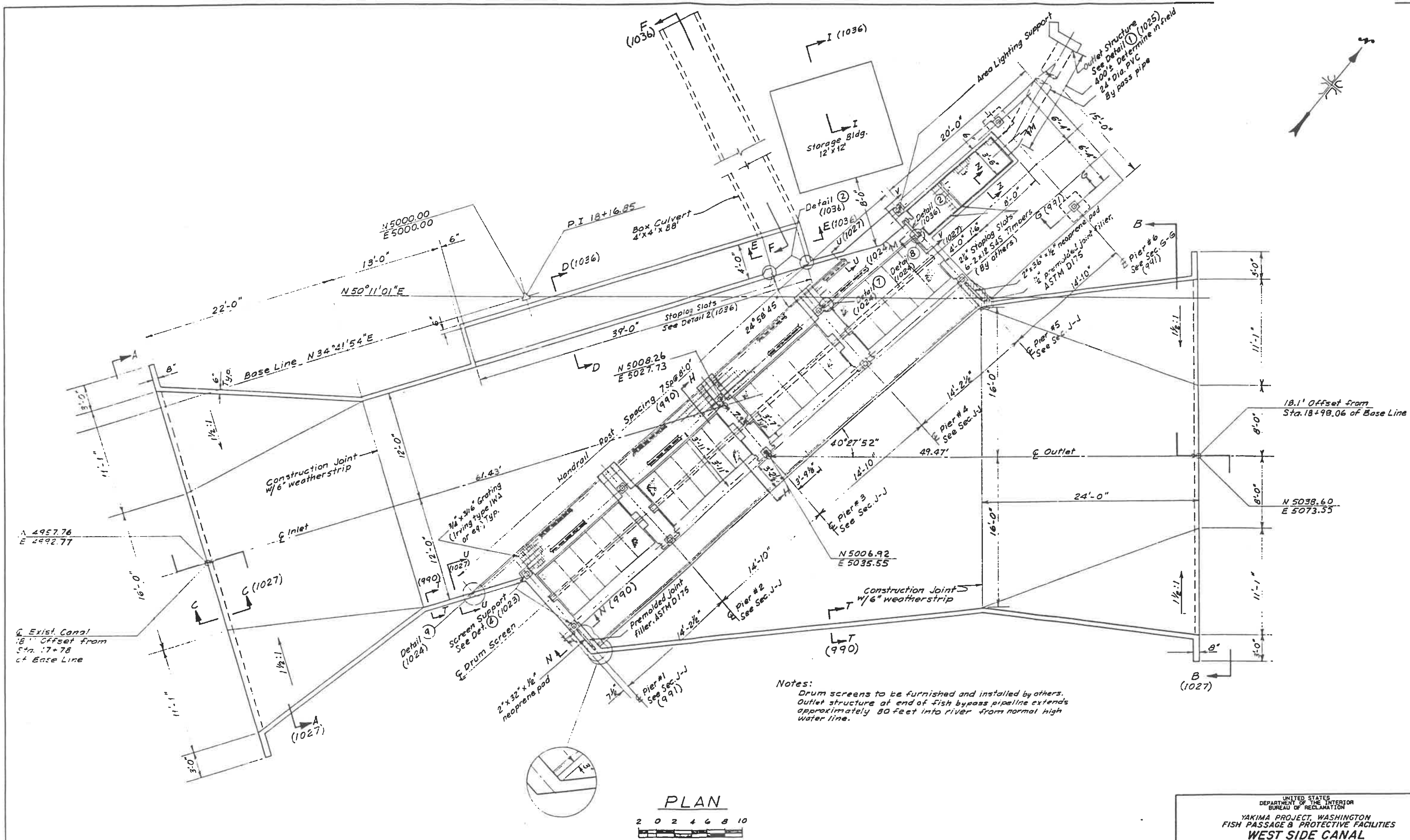
BUREAU OF RECLAMATION
YAKIMA PROJECT - WASHINGTON
FISH PASSAGE AND PROTECTIVE FACILITIES

WEST SIDE CANAL
FISH SCREEN STRUCTURE
GRADING PLAN

DESIGNED ________ SUBMITTED [signature]
DRAWN Guy F. Grooms RECOMMENDED [signature]
CHECKED UB APPROVED [signature] REGIONAL ENGINEER

BOISE, IDAHO APRIL 1987 33-100-10



Notes:
Drum screens to be furnished and installed by others.
Outlet structure at end of fish bypass pipeline extends approximately 80 feet into river from normal high water line.

PLAN

2 0 2 4 6 8 10

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

YAKIMA PROJECT, WASHINGTON
FISH PASSAGE & PROTECTIVE FACILITIES

WEST SIDE CANAL
FISH SCREEN STRUCTURE
GENERAL PLAN

DESIGNED John Brazovich	SUBMITTED [signature]
DRAWN Roy Marchesini	RECOMMENDED [signature]
CHECKED JJB	APPROVED [signature] REGIONAL ENGINEER
BOISE, IDAHO	MAR 1987 33-100-1022