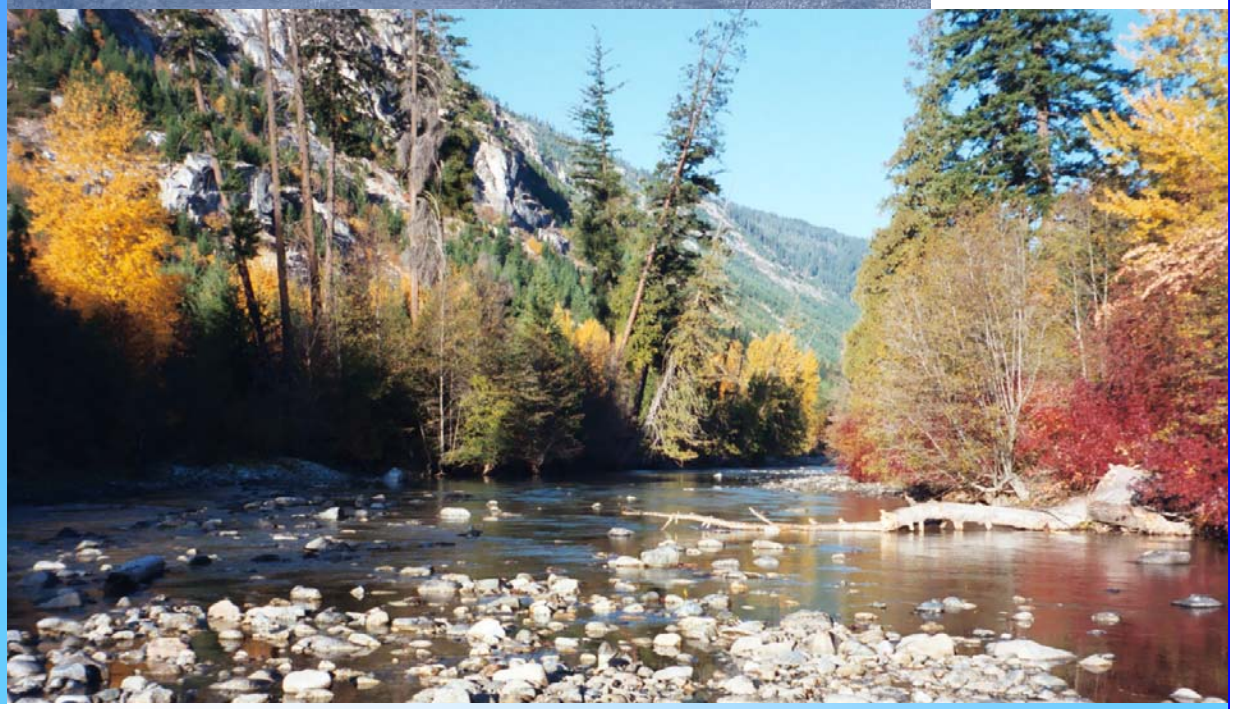
Entiat
Water Resource Inventory Area (WRIA) 46
Management Plan
October 2004

Entiat Valley, 1914

Entiat WRIA 46 Planning Unit Mission Statement:

"To voluntarily bring people together to improve communication, reduce conflicts, address problems, reach consensus, and implement actions to improve natural resource management on associated private and public lands in the Entiat WRIA 46."



Prepared for the Entiat WRIA Planning Unit by the Chelan County Conservation District

ENTIAT
WATER RESOURCE INVENTORY AREA (WRIA) 46
MANAGEMENT PLAN

Submitted pursuant to the
Washington Watershed Planning Act
Chapter 173-546

Prepared for
the Entiat WRIA Planning Unit
by the Chelan County Conservation District

Prepared under
Washington Department of Ecology
Grant No. G9900034

October 2004

Historic cover photograph courtesy of the Washington State Historical Society Curtis Collection, #30014.

LANDOWNER PREFACE

During the past several years the Entiat Coordinated Resource Management Planning (CRMP) group and Entiat WRIA Planning Unit have carefully assessed the Entiat and Mad River watersheds in Water Resource Inventory Area (WRIA) 46. It was due to the concern and hard work of local residents and the technical advisory committee many years ago that what began as a resource assessment evolved into a management plan rather than remaining a study.

An assessment or a study by itself only serves to collect dust. By creating this plan, we show how "optimum utilization" (see below) of existing water resources can enhance fish habitat, allow for growth, protect the integrity of the stream, and maintain or improve water quality.

"Optimum utilization of flow" is a term unique to the Entiat WRIA 46. It is a term that takes into consideration the need for enhanced habitat, governmental requirements for planning, and the rights of property owners. This delicate balance can easily be tipped even with the best intentions. Our goal was to make a plan that could be supported by humans regardless of their political persuasion and at the same time welcomed by the aquatic life present within the boundaries of the riparian zone. "Optimum utilization of flow" not only stops any further degradation of the riparian zone, it maximizes the stream itself for human and aquatic life. Since water holds the key to all forms of life, it is imperative to see that water in the Entiat valley is cycled and recycled in a way that provides habitat for aquatic life while maintaining existing human use, and allowing for growth.

We have identified ways to use water more efficiently, restore habitat for fish, address water temperature issues, and allow for future community and economic growth. Granted, there are some problems such as siltation (resulting from washouts after the big fires), which are not initially going to be fixed; it will be those issues that literally could take hundreds of years to alleviate. We therefore chose to use the best science possible and optimize water use.

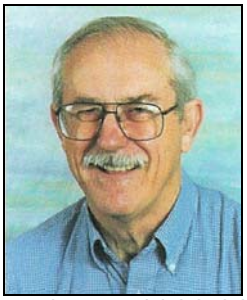
The unique solutions presented in this document to address resource problems could very likely set a precedent in the State of Washington as the most comprehensive river rehabilitation that has been attempted. Please take time and review what we have done! It took us ten years to get to this true point of beginning and many pitfalls faced by other watersheds might be avoided if some of these techniques are used.

Although the largest use of water (other than for fish habitat) in the Entiat WRIA is farming, it must be noted that due to the narrow valley floor farming has no significant place to expand. Water use associated with farming has also substantially declined through the use of technology. Continued wise use of water by this industry can only benefit fish habitat, and through education and communication aquatic habitat will be enhanced. To maximize the many positive effects optimum utilization will have on our society, we must sell our solutions to the end user or problems will only get half solved. We are not interested in being only half successful. As a group of local people with the support of technical people, we will sell this common sense approach of "optimum utilization of flow."

Russell Griffith, ca. 1998 *[2003 revision]*

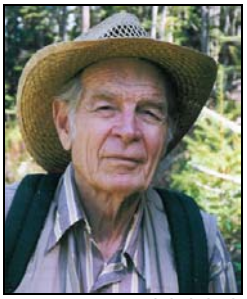
DEDICATION

This Plan is dedicated to the past, present and future landowners and land managers who have been and will be the stewards of the resources in the Entiat. These people are well represented by the current members of the Planning Unit recognized in the Acknowledgements section. In addition, we would like to specifically recognize the following two individuals who were significant contributors to this long-term, collaborative effort.



Phil McColley (1933-2002)

Representing the Chelan County Conservation District, Phil played a critical role in spurring the initial organization of the planning effort in 1993-1994. His guidance helped to bring together the small group that developed the Vision and Goals statement that initiated the first series of meetings, leading to the Coordinated Resource Management Planning phase of this effort. At the time, Phil had just retired from a long and productive career as a Forest Service soil scientist. He was a very strong advocate of the Conservation District and served on the Board for a number of years, including 3 years as Chairman. Phil had a vision of what could be done if people were brought together within the right environment. Phil was a dedicated physical scientist with an attitude ahead of his time, a tremendous mentor, a long time supporter of local theatre and a solid bass singer!



Marvin Hoover (1916-2003)

As a member of both the CRMP Group and Planning Unit, Marv played a critical role in nurturing the progress of this collaborative effort. He often provided a fresh perspective on issues that helped the group assess its position and identify its path. His contributions during meetings and field trips, his insightful written input, and support of individuals involved continue to help provide a strong foundation for the effort. Marv was retired from a distinguished career as a Forest Service research hydrologist and served with the group as the representative of the North Central Washington Audubon Society. Marv carried a strong vision of how things could be and should be. He was a gentle man, a gentleman, a thoughtful mentor, and a respected scientist with a passion for all living things.

ACKNOWLEDGEMENTS

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Many people and organizations have been involved with the Entiat planning effort since 1993, as illustrated by the long list of individuals and interests in the following section. We appreciate the fact that this Plan is the culmination of a multitude of individual and collective efforts, working toward a common end. We have made every effort in the following text to identify all those who should be acknowledged; however, we may have inadvertently omitted some group or individual. If you note any such omission, please let us know so that the error can be corrected in subsequent updates of this document.

NOTE: All official entities/representatives on the Entiat WRIA 46 Planning Unit (convened in 1999) are listed in bold. The Planning Unit was convened under the guidance of the Washington State Watershed Planning Act (Chapter 09.82 RCW).

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Over the past eleven years numerous individuals have spent countless hours working toward the watershed vision that is captured in the content of this document. Some of the details of how this planning effort started are captured in the Landowner Preface. Much of our success over time can be attributed to having the right people taking the right steps at opportune times, along with our tendency to move forward at a moderate, steady pace—adapting to new situations as they arise. The Entiat's well-focused group of stakeholders has taken lessons from the past and the best available information from the present to help guide its progress toward achieving the future defined by our Mission Statement and Goals.

First, thanks must be extended to the Entiat Chamber of Commerce for sponsoring a series of public information meetings in 1992-1993 that helped to focus the need for this locally-driven planning effort. The Chamber also stepped forward in late 1993 to co-sponsor the initial organizational meetings and has continued to be a strong supporter of the planning effort.

A dedicated group of Entiat landowners started/participated in the first watershed study organizational meetings early in 1994, and are still actively working as members of the Entiat Watershed Planning Unit: **Conard Petersen, Ray Sandidge, Jim Small, Jon Small, Russell Griffith, and Karin Whitehall (USFS).** Their longstanding, voluntary commitment to the Entiat planning process is truly remarkable, commendable, and an example to others. The balance between community and ecological considerations reflected throughout the Plan is due in large part to their wisdom, input, and continued support of and belief in the Entiat process.

We also acknowledge past Chelan County Conservation District Board Chair Phil McColley and Al Shannon (first planning group Chairman), Andrea Mann (NRCS), **Jim Fisher (BLM)**, and Rick Edwards (USFS) for their efforts in the initiation of the original planning effort (December 1993) and helping to develop the original mission statement, goals, stakeholders list and Coordinated Resource Management Planning (CRMP) process. WSU Cooperative Extension meeting facilitators Emmett Fiske, Tom Brannon, and Paul Tvergyak helped to keep the effort going during the early organizational meetings and throughout the process; facilitator Jeremy Pratt (Entrix, Inc.) helped us through our instream flow negotiations. Beginning in August 1994, Phil Jones' (CCCD) efforts as watershed

coordinator kept the CRMP phase on track, especially in regard to his significant work assisting Entiat landowners through the process.

Special thanks are extended to officers and members of the Entiat Grange for providing a meeting location and Cathy Montgomery for her assistance and scheduling. The volunteers of CCRF #8 Fire Station are also recognized for providing meeting space at the main fire station, and helping to share information with other members of the community about the Entiat process. The Entiat Community Historical Society and long-time valley residents Haven Stanaway, Phyllis Griffith, Albert Long, Kib Harris, along with Candace Corn (USFS) are recognized for their participation in the Entiat Valley History videotaping, help with the history section/table and supplying historic photos.

We are ever grateful for the continuing support of past and present members of the Chelan County Conservation District Board of Supervisors: (past) Phil McColley, Conard Petersen, Dale Fry, Scott McManus, Bob Carleton, David Stalheim; (present) Joel Teeley, Frank Andrews, Jack Davis, Doug Petersen, and Larry Cordes. CCCD staff must also be recognized for their assistance and ongoing efforts (Valerie Hampton, Scott Wolf, and Mike Rickel). We would especially like to recognize Conservation District Administrator Peggy Entzel for her major role in keeping the Entiat effort on budget and moving forward.

State elected officials including Representative Clyde Ballard, Senator Linda Evans Parlette, Representative Cary Condotta, former Senator George Sellar and former Representative Gary Chandler have provided continuing support. Representative Chandler played a key role in the creation and passage of the ESHB 2514 legislation. Thanks are also extended to members of the current and past Salmon Recovery Funding Board, especially Chair William Ruckelshaus, for his support of assessment and restoration projects in the Entiat Watershed; and Governor's Salmon Recovery Office (and former Chelan PUD) representative Bob Bugert, for his long-standing and continued support of the Entiat watershed planning effort.

We recognize the commitment of the Initiating Governments and their role in starting and participating in WRIA 46 watershed planning: City of Entiat mayors (past) Juanita Allen and John Huselton, and Wendell Black (present); Chelan County Commissioners (past) Tom Green, John Wall, Earl Marcellus and John Hunter; and (current) Ron Walter, Buell Hawkins, and Keith Goehner. Special recognition is extended to late Chelan County Commissioner Esther Stefaniw for her efforts and dedication to locally-driven watershed planning, as well as **EWPU Initiating government representatives Bob Whitehall (City of Entiat); Keith Vradenburg (Entiat Irrigation District); and Mike Kaputa (Chelan County Commissioners).** Bob and Keith are also acknowledged as dedicated landowner steering committee participants.

Other formal representatives to the original 1999 Entiat Planning Unit not previously mentioned include: Joe Williams and John Monahan (WDOE); Lee Carlson and Bob Rose (Yakama Nation); Marvin Hoover (NCW Audubon); Liz Tanke (Northwest Ecosystem Alliance); Kate Terrell (USFWS); Joe Kelly (BLM); Doug Allen (NRCS); Jeff Osborn (Chelan County PUD); Allen Hunter (Chelan-Douglas Health District); Steve Tift and Ron Simon (Longview Fibre Co.), and Entiat valley landowners Hal Hawley and Jon Stephan.

Particular thanks must be also be given to other local landowners Keystone Ranch/Dale Foreman, Mike Asher, Don Hawley, Jon Stephan, John Hinton, Mike Small, Bill Small, Karen Whitehall, Diane Gould, Al and Jack Asher, Cheri Marsh, Don Roundy, Randy Whitehall, Mike Sandidge and Ted Stevens for providing input to the process, helping to spread the word, and/or participating in project implementation throughout the years. Also, we are grateful to all additional valley residents who have come to community meetings, volunteered previously and/or continue to participate in EWPU data collection and habitat restoration initiatives.

Others who have provided input and assistance along the way include: Polly Zehm, Kevin Brown, Darlene Frye, Chris Hall, William Ehinger, John Milton, Derrick Sandison, Doug Rushton, Casey Clishe, Brad Caldwell, and Ron Dixon (WDOE); Russell Faux (Pacific Watershed Institute); Dana Peterson (BLM); Tom Ring and Bill Beckley (Yakama Nation); Joe Peone, Hilary Lyman, Scott Edson, and Chris Fisher (Colville Confederated Tribes); Steve Hayes (Chelan County PUD); Justin Erickson and Karl Lillquist (CWU); Lee Faulconer (WA Dept. of Ag.); Rick Parkin and Dan Robinson (USEPA); Ken Hyde (NCW RC&D); Gary Mitchell, Shiraz Vira, Larry Cooke, Kevin Guinn and Brian Sangster (NRCS); Frank Easter, W. Barry Southerland, Mark Schuller, Michael Burton, David Brower, Bianca Streif and Joan Mattson (NRCS Stream Team); Dave Carie, Malenna Cappellini, Jeff Thomas, Brian Cates, William Edwards, Tim McCracken, Sandy Noble, R.D. Nelle and Chuck Hamstreet (USFWS); Bob Knippel, Nancy Zornes, and Pat Murphy (USFS); Ken Bovee, Terry Waddle, Ray Smith, Galen Schuster, and Bill Taylor (USGS); Carmen Andonaegui and Ed Manary (Washington Conservation Commission); Gordon Congdon (CDLT); Greg Knott and Steve Kolk (USBR); Barb Swanson (NW Ecosystem Alliance); Richard Spencer Mills, Terry Nowka, Christina Katz, Jean Postlethwaite and David Jensen (Chelan County); Katherine March, Bob Steele, Tracy Lloyd, Dr. Robert Vadas, Jr., Greg Huckle, and John Musser (WDFW); Shari Schaftlein (WDOT); Jim Fox (IAC); Janet Andreas (Entiat Chamber of Commerce); John Dohrmann (Puget Sound Water Quality Action Team); Steve Wells (CTED); Erik Fairchild (WA Dept. of Health); Bill Jolly (WA Parks and Recreation Commission); Michael Cada (Farm Service Agency); Dale Bambrick and Kale Gullett (NOAA Fisheries); Woody Trihey and Tina Gary (Entrix, Inc.); Brent Billingsley, Sheri Felix, Craig Partridge and Lanny Quackenbush (WDNR); Jon Soest, Mark Oswood and Kim Lohse (North Central Washington Audubon Society); and past/present Washington Conservation Corps (WDOE) crews.

Special technical thanks are extended to Bob Barwin, Jim Pacheco, and Brad Caldwell (WDOE); and Hal Beecher, Dennis Beich, and Mark Cookson (WDFW) for water resources and instream flow technical input and ongoing policy support integral to implementation of the WRIA 46 Plan; to Gran Rhodus (Retired Forest Service Hydrologist) for continued assistance with water resource analyses; to Kurt Hosman (CCCD) for his support and role as water resources specialist; to Ross Hendrick for his work on the SNTEMP model and ongoing research contributions; and to Joe Lange (NRCS) for his engineering expertise and continued assistance with the design and implementation of Entiat projects.

Deep gratitude and appreciation are extended to John Monahan (WDOE and State Caucus representative on the Planning Unit) for his continued high level of involvement and inspiration, technical and policy input, and as a key mechanic of all aspects of the Entiat's 2514 process; to Phil Archibald (USFS), for his institutional memory, contributions to the

Entiat and Mad River watershed habitat portions of the plan, and ongoing monitoring of fish habitat (in addition to numerous other contributions); and to Rick Edwards (USFS), for contributions too numerous to list and for uncountable hours spent on this effort from 1993 to the present (and for being meeting note-taker extraordinaire and quality control expert).

Last but not least we thank Phil Jones and Sarah M. Walker as co-coordinators of the Entiat Planning Unit. Their roles supporting the Planning Unit span all aspects of the watershed planning effort including, but not limited to: coordinators, authors, facilitators, administrators, grant applicants/managers, field crew, technical support, data managers, counselors, problem solvers, and cheerleaders. There can be no doubt this Plan would not be the coherent, cohesive and comprehensive product it is were it not for their intelligent guidance, tenacity, stick-to-itiveness, patience, and confidence.

With sincere appreciation to all,

Joel Teeley, Chair
Chelan County Conservation District Board of Supervisors

EXECUTIVE SUMMARY

CHAPTER 1 - INTRODUCTION

History of Resource Planning in the Entiat Valley

In 1993 members of the Chelan County Conservation District (CCCD), the Natural Resources Conservation Service (NRCS) and the U.S. Forest Service Entiat Ranger District (USFS Entiat RD) met with the Entiat Chamber of Commerce and secured its support for a watershed planning effort for the Entiat and Mad River watersheds. In mid-1994 a decision was made to organize using the Coordinated Resource Management Plan (CRMP) model developed by the NRCS. "Stakeholders" included area landowners representing orchardists, logging and grazing interests; representatives of county, state, non-government, Yakama Nation and federal agencies; and environmental group affiliates.

The CRMP group made significant progress between 1994 and 1998. A Draft Entiat Coordinated Resource Management Plan (CCCD 1999) documented the progress made. Tackling unresolved issues, such as instream flow, was beyond the financial means of the group until the passage of key legislation in l998 that provided funding for locally led resource planning activities similar to what had already been initiated by Entiat CRMP participants.

Watershed Planning Act

Portions of the Watershed Planning Act (WPA) (Chapter 90.82 Revised Code of Washington) are described in this section, including a description of the Act's components and where they addressed in the WRIA 46 plan.

Initiation of Watershed Planning in WRIA 46

In 1998, the Chelan County Conservation District applied for funds on behalf of the CRMP group to develop a watershed plan under the Washington State Watershed Planning Act. The group reorganized to become the Entiat WRIA Planning Unit (EWPU). The Entiat Final Coordinated Resource Management Plan was released in June 2002, formally ending the CRMP process. The 2002 document also served as the EWPU's first draft of the WRIA 46 Management Plan.

Scope of the WRIA 46 Management Plan

The WRIA 46 Management Plan addresses the required water quantity component, as well as the three other components of instream flow, habitat and water quality. The EWPU decided to include all four components due largely to the fact that the original Entiat CRMP process and participants had already begun to address many resource issues, including fish habitat and water quality, as part of the effort initiated in 1993.

The WRIA 46 document covers the Entiat and Mad River watersheds as well as some of the minor Columbia River tributaries that lie to the north and south of the mouth of the Entiat River. Refer to Chapter 1 page 1-8 for a depiction of the Entiat WRIA.

A major goal of the EWPU was to produce a living watershed management plan – one that will grow, be added to, and improved over time. In keeping with that spirit, the group views this document as a "working" final version of the WRIA 46 Management Plan envisioned under the Watershed Planning Act. The EWPU fully anticipates revisiting and updating the plan in the years to come, and hopes that the WRIA 46 Plan will contribute valuable information and local input to other ongoing local and regional processes such as salmon recovery planning.

CHAPTER 2 - PLANNING CONTEXT AND REGULATORY CONSIDERATIONS

This chapter describes some of the major governing laws that have been considered during the development of this plan, and also discusses how watershed planning in the Entiat WRIA interfaces with other ongoing federal, state, regional and local planning processes.

Federal

The U.S. Forest Service manages approximately 83% of the Entiat WRIA. Other federal land mangers include the U.S. Bureau of Land Management (BLM) and the U.S. Fish and Wildlife Service (USFWS), which is responsible for the operation and management of the Entiat National Fish Hatchery (ENFH). Actions on USFS, BLM and USFWS lands within the Entiat WRIA result from the execution of various federal laws and regulations.

Some of the major federal laws governing agency practices that were considered during the development of this plan include: National Environmental Policy Act, Endangered Species Act, Clean Water Act, Federal Land Policy and Management Act, National Forest Management Act, and the Northwest Forest Plan.

Management strategies designed specifically for National Forest System lands within the Entiat WRIA area are contained in Chapter 2, Synthesis Summary Tables.

State

The development of the WRIA 46 Plan was governed by rules outlined in Chapter 90.82 RCW, described in Chapter 1. Many Washington state laws that regulate actions on private lands within the Entiat WRIA and that direct state and local agency decision-making about projects were also considered while developing this Plan.

Some of these pertinent state laws include, but are not limited to: Salmon Recovery Act of 1998 (Chapter 70.46 RCW), Shoreline Management Act of 1971 (Chapter 90.58 RCW), Water Resources Act o f 1971 (Chapter 90.54 RCW), Growth Management Act of 1990 (Chapter 36.70A RCW), Forestry Practices Act of 1974 (Chapter 76.09 RCW), and the State Environmental Policy Act of 1971 (Chapter 42.21C RCW).

Regional/Local

Regional/local considerations included: Subbasin Planning, Salmon Recovery Planning, Tribal Recovery Planning / Wy-Kan-Ush-Mi Wa-Kish-Wit, and County Comprehensive Land Use Planning.

CHAPTER 3 - WRIA CHARACTERIZATION

Chapter 3 describes the location and the human and natural environment of the Entiat WRIA. The Human Environment includes a Historic Overview and a description of Land Ownership, Land Uses, Demography, Economics and Cultural Resources.

Human Environment

The historical overview is based on information taken from a recorded oral history of lifelong valley residents and from the Watershed Assessment, Entiat Analysis Area (USFS WNF 1996), with additional corrections and updates from Conard Petersen and others in 1999.

Ownership within the WRIA is predominantly public. The US Forest Service (USFS) manages approximately 83% of lands within the WRIA. Other notable federal land owners include the Bureau of Land Management (BLM) and the US Fish and Wildlife Service (USFWS). Almost all state lands (5.7%) are managed by either the Washington Department of Fish and Wildlife (WDFW) or the Washington Department of Natural Resources (WDNR). Only about 8.8% of the land is in private ownership.

Current land uses within the watershed include agriculture, primarily pear and apple orchards; livestock production and grazing; timber harvest; residential housing; and recreation.

Wilderness, old growth reserves, wildlife and riparian reserves comprise 63% of federal reserve areas, which include some areas in the lower valley that do not fall within other land use categories. Reserve areas are primarily used by wildlife, but are not specifically designated for wildlife use. "Unusable" land is intermingled with designated timber and/or grazing lands, and is unsuitable for these uses due to topography or productivity, or is inaccessible for other reasons such as rock or cliff formations. Irrigated agriculture land area comprises 0.4% of the watershed, and with developed recreation areas (including trails) and residential areas, makes up approximately 1% of the total land area.

Land use practices have contributed to some of the current resource problems within the watershed. Grazing, logging and associated road construction, flood prevention practices and early agricultural practices that were initiated before the turn of the 20th century and continued through the 1970's have declined significantly in the past two decades. These types of land uses are not expected to increase in the next twenty or more years and are never likely to reach pre-1980 levels again.

The one exception to the downward trend in land use is subdivision development, which has recently surged due to the increase in urban residence and/or vacation home construction. High-density development of private lands on or near the river has the potential to threaten the existing water quality. The Chelan County Comprehensive Plan should help to reduce the threat of this trend.

The WRIA has experienced a fairly recent surge in urban population growth and rural part-time/vacation home construction. US Census data showed that the population within the city limits of Entiat remained relatively constant between 1981 and 1990; however,

between 1991 and 2000 it grew by 133%, from 449 to 957 people (US Census Bureau 1991a, 2001a). During the past decade, the rural year-round population within the subbasin portion of the Entiat CCD grew by approximately 11%, from 739 to 829 people (US Census Bureau 1991b, 2001b). Although recent year-round rural population growth occurred at a slower rate than urban population growth, 2000 Census data reported that the number of homes in the rural Entiat subbasin area of the WRIA grew by about 41%, from 278 to 470 units. Of these, 160 (34%) were reported as part-time/vacation homes (US Census Bureau 2001b). Economic strengths and weaknesses identified by the community are also covered in Chapter 3.

Native Americans were the first occupants of the Entiat WRIA. The Entiat band of the Moses-Columbia Indians, who lived along the Columbia River and its tributaries between Priest Rapids and Wells Dam, use the word Entiat to name the area around the mouth of the River. Their translated meaning of the word Entiat is "grassy water place" (M.D. Kinkade, pers. comm. 2002). The Entiat WRIA lies within territory ceded by the Yakama Nation in 1855. The traditional Yakama spelling is "Int-yat", which is described as meaning either a rich and abundant area, or happiness, depending on pronunciation (Johnson Meninick, pers. comm. October 31, 2003).

Cultural resources found within WRIA 46 represent a range of artifacts and sites, which may include:

- historic cabins, trails, mines, ditches, railroad grades, emigrant trails, original highway grades, mills, and homesteads; and
- historic Forest Service structures including guard stations, lookout towers, corrals, camps, administrative centers, and Depression-era campgrounds and buildings; and prehistoric campsites, villages, graves, quarries, pictographs, workshops, trails, rock shelters and religious sites.

Natural Environment

The combination of topography, climate, and hydrology found within the Entiat watershed results in a somewhat harsh environment for fish. The gradient of the Entiat River is steep due to the 8,500-foot change in elevation that occurs over only 25 miles between the headwaters near the Cascade Crest and the river's mouth at the Columbia River. The climate is highly variable year to year and even within a single year, with 90 and 100-degree temperatures that last for several weeks at a time in the summer, and sub-zero temperatures during many winters. Rapid snowmelt results in high volumes of run-off in late spring and early summer, and low stream flows in late summer, early fall, and throughout the winter. Refer to Chapter 3, Page 3-53 for a typical Entiat River hydrograph.

Soils within the Entiat valley are generally highly erodible due to deposits of volcanic ash and pumice or loess at the surface. Three general zones based on soils/geology/land type association exist in the WRIA (Refer to Chapter 3, page 3-41 for Analysis Zones Graphic):

- Transport zone– usually the source of most sediments,
- Transitional zone –most of the bedload and nearly all of the suspended sediments pass through this area,

- Depositional zone –significant portions of bedload and suspended sediments are normally deposited here. The depositional zone is often where many agricultural, residential and commercial properties are located.

Vegetation community types range from near-desert shrub steppe at lower elevations to sub-alpine at higher elevations. Forested and shrub- grassland communities varies depending on slope, aspect and elevation. Wildfire, fire suppression, logging, grazing and other land use activities have altered vegetation community structure within some areas of the watershed.

Natural events such as wildfire and floods occur frequently within the watershed. Over 60% of the Entiat watershed has been affected by wildfires that occurred between 1970 and 1994. One of the worst floods in recent history occurred in 1948, and significant flooding also occurred in 1972, twice in 1977 and in 1989 following wildfires.

CHAPTER 4 - WATER QUANTITY

This chapter describes estimates of surface and ground water present in the Entiat WRIA; a summary of water rights, claims, and applications; and estimates of actual water use. Information about the WRIA stream gaging network, results of the aquifer storage model and gain-loss analysis are also presented. Estimates of future water supply requirements are included.

Hydrograph Separation Analysis

The WDOE performed hydrograph separation on the Entiat River as part of an effort to evaluate groundwater contribution to total streamflow (baseflow) at active and inactive stream gaging stations throughout Washington State (Sinclair and Pitz 1999). The Planning Unit also used HYSEP to perform hydrograph separation analyses. Results comported well with the WDOE HYSEP analysis results based on the Entiat at Entiat and Stormy records.

Well Monitoring Study

In 2001, the EWPU initiated a domestic well monitoring effort in order to collect data on groundwater levels within the unconsolidated alluvial aquifer, and examine hydraulic continuity within the Entiat valley. All wells currently monitored within the Entiat WRIA are permit exempt domestic wells, and all but two of the monitored wells draw water from the shallow, unconfined and unconsolidated alluvial aquifer of the Entiat River. Well monitoring data indicate a high degree of connectivity of this aquifer to flow in the Entiat River, with seasonal variations in streamflow being reflected in static water levels within the wells.

Aquifer Storage Model

Aquifer areas ranged in size from 2 acres to as large as 3,210 acres with an average size of 52 acres. The total area of the mainstem Entiat River valley aquifer was estimated to be 10,732 acres. During 2002 the saturated thicknesses within the unconfined valley aquifer ranged from 10 feet to 151 feet, with an average aquifer depth of 52 feet. Exclusion of the 3,210 acre outlier polygon, which defines the uppermost headwater aquifer for which no

well data were available, reduced the average aquifer polygon size to 37 acres with a maximum polygon size of 467 acres.

Gain-Loss Study

The gain/loss analysis shows all mainstem measurement reaches, reach gain or loss in cubic feet per second (cfs), and the net rates of gain/loss per unit channel length. It is clear that the Entiat River experiences significant and widely varying ground-water/surface-water interchange within its identified reaches. Two lower mainstem Entiat reaches had a net gain in discharge per unit channel length greater than 10 ft^3/sec/mile; the overall net increase in discharge due to groundwater contribution on the mainstem Entiat River was 11.51 ft^3/sec. Overall, areas of measured gains and losses agreed well with predictions based on geologic interpretation (mentioned above). The Mad River also showed significant groundwater/surface water interchange within the study reaches.

Water Recharge Areas

Chapter 90.82.070 RCW requires watershed planning units to provide "an identification of the areas where aquifers are known to recharge surface bodies of water and areas known to provide for the recharge of aquifers from the surface". The most important and obvious cases of these relationships in WRIA 46 are the interactions between the Entiat River and the Entiat valley unconsolidated alluvial aquifer.

Water Rights, Claims and Applications

Summary of surface and ground water certificates, permits, and claims.

	# of Records	Sum of CFS	# of Records Reporting CFS	Sum of Ac-Ft	# of Records Reporting Ac-Ft	Calculated Ac-Ft[3]
Surface water certificates and permits	115	210,166.1[1]	111	392,131.3[1]	57	3,340.8
Surface water claims	173	5,392.0[2]	92	383,774.1[2]	140	18,227.0
Ground water certificates and permits	38	22.2	38	4,266.4	38	38
Ground water claims	172	15.4	122	4,806.1	119	172

1. Includes a reported 210,000 cfs and 390,000 ac-ft for power generation.
2. Includes numerous claims with questionable reported values totaling 3,400 cfs & 370,213 ac-ft.
3. Calculated acre-feet values for surface water rights and claims are based on irrigated acres reported multiplied by 4.0 acre-feet per acre plus reported values for non-irrigation uses.

Ardenvoir gage for the months of April - October show that sufficient water will likely be present 90% or more of the time from April through July for existing conditioned water right holders; however, certainty of water availability decreases during the months of August-October, as evidenced by the flow exceedence values.

The WDOE Water Rights Application Tracking System (WRATS) showed that 34 applications have been filed for water rights in WRIA 46 since 1991.

Actual Water Use

Obvious inconsistencies exist between the amount of water use reported in the paper record and what is observed at gaging stations in the subbasin. Thus, the EWPU employed a variety of methods and data sources to generate estimates of actual irrigation and in-house domestic water use.

Domestic In-house Net Water Use

The equations used to estimate total daily net water use were as follows:

470 housing units x 2.71 people per unit = 1274 people
1274 people x 35 gallons pcpd = 44,590 gallons net water use per day

Daily net water use was multiplied by the number of days in each month to approximate monthly net water use. Monthly in-house net water use estimates were converted to acre-feet using the standard 1 ac-ft = 325,850 gallons. Current domestic in-house net water use ranges from 3.8 to 4.2 ac-ft or approximately 0.07 cfs on an average monthly basis.

Irrigation Water Use

Refer to Chapter 4 page 4-35 for Table 4-16, WRIA 46 estimated average monthly/seasonal irrigation water use in acre-feet.

Reserve Water

It is important to note that water for homes, commercial enterprises, and other uses in the Entiat subbasin is not currently provided by a municipal water system, but via withdrawals occurring under permit exempt wells, water rights and claims. Thus, all future water withdrawals in the subbasin, whether associated with new water rights or permit exempt wells, would be conditioned by codified minimum instream flows. Codification of the Administrative Instream Flow regime proposed in Chapter 5, or for that matter the Planning Unit Flow regime (whose monthly flow exceedence values were usually higher than those of the Administrative Flow regime), would not provide a reliable year-round water supply sufficient to support new growth and associated water use in the valley. Recognizing this, the Planning Unit agreed to explore negotiation of a "Reserve" of water that would be senior to codified minimum instream flows.

A Reserve of 5 cfs was negotiated based on the Planning Unit's future water supply estimates and requirements discussed in Section 4.11, as well as evaluation of the potential impact of additional withdrawals. Biologists and resource specialists involved with creation of the Administrative [minimum] instream flow and Planning Unit flow recommendations described in Chapter 5 agreed that the Entiat system could support additional withdrawals up to 5 cfs without significantly impacting aquatic resources/existing beneficial uses.

Future Water Supply Requirements

A goal of the EWPU's water resources planning effort was to estimate what unconditioned reserve volume will likely be adequate to satisfy additional water needs in the Entiat subbasin through the year 2025. In doing so, the Planning Unit made a projection of the

population growth that may occur through the year 2025. A population larger than what was predicted by the county for the rural area of the Entiat CCD may or may not exist in 2025. Given that uncertainty, the EWPU used a higher projection to assure that adequate unconditioned water will be available for appropriation to beneficial uses in the Entiat valley if growth within this rural area of the Entiat CCD exceeds the county's projections, and ensure that adequate year-round water will be available to help the EWPU meet its long-term vision and goals for the subbasin, which include: providing for the coexistence of people, fish, and wildlife; sustaining lifestyles through planned community growth; and emphasizing local culture and economic stability in balance with natural resources. A future adequate tax base to insure support for the local school system is a high priority for local landowners.

In an effort to estimate what population was living solely in the Entiat and Mad watersheds in the year 2000, the Planning Unit used a GIS to select census blocks from the Entiat CCD that fell entirely or largely within the Entiat and Mad River watersheds, but outside of the UGA. Entiat CCD census blocks that included people living in the Entiat UGA or the minor Columbia River tributaries area were excluded from consideration. Data showed that approximately 839 people were living in the subbasin in the year 2000.

To project what future Entiat subbasin population may require water appropriated from within this area of the WRIA, the Planning Unit analyzed census block data from 1990 and 2000. The average annual rate of growth in the subbasin over this decade was 1.156%. This rate of population growth was applied to the year 2004 potential population of 1274 people (470 housing units x 2.71 people per household = 1274) to derive a future population estimate of 1641 people total, or up to 367 additional people living in the Entiat and Mad watersheds in 2025.

Future Domestic Water Estimates

It was estimated that 0.02 cfs of water may be necessary to satisfy future domestic in-house net water use needs for 135 new housing units through the year 2025.

It was estimated that about 1 cfs will likely be sufficient to accommodate future domestic in-house, irrigation and stock water needs in the Entiat and Mad River watersheds through 2025 if population growth in the subbasin continued at the rate experienced over the period 1991-2000.

Future Commercial Agriculture Irrigation Water Estimates

The EWPU estimated that if 150 acres of orchard were planted, about 220 acre-feet of water would be needed during a very dry year in July. This volume translated into a maximum instantaneous rate of approximately 3.6 cfs. The EPWU agreed that 3 cfs of the Reserve should be sufficient to satisfy new agricultural uses through the year 2025.

Future Commercial/Industrial Water Estimates

The EWPU estimated that approximately 1 cfs of water should be placed in reserve for appropriation to future commercial and light/clean industrial uses in the subbasin. This estimate was made based on discussions with the LSC and other members of the EWPU about the desire to assure that water is available to support future economic growth in the valley.

Water Banking/Water Leasing

The EWPU agreed to provide information to water right holders in the Entiat and Mad River watersheds about the Washington Trust Water Program and similar water banking/leasing programs designed to prevent the relinquishment of existing water rights due to non-use, especially when orchard/agricultural land conversion occurs, and encourage use of such programs.

Water Storage Opportunities

The EWPU determined that once Administrative Flow numbers have been met during a given month, the opportunity for water storage should be available. The WDOE made a preliminary determination of water availability for the May 1 – July 15 time period so that a certain portion of actual flows that exceed recommended minimum instream flow numbers could be stored,

CHAPTER 5 - INSTREAM FLOWS

Instream Flow Incremental Methodology (IFIM)

IFIM is made up of a combination of problem solving tools and integrated computer models, such as PHABSIM, as well as steps intended to involve all stakeholders. It consists of four interrelated phases:

- Phase I: Problem identification and diagnosis,
- Phase II: Study planning,
- Phase III: Study implementation, and
- Phase IV: Alternatives analysis/problem resolution.

In preparation for developing minimum instream flow recommendations, the Planning Unit and WDOE sponsored a three-day IFIM training in March 2000 to educate interested parties on the IFIM process and instream flow setting in Washington State. Subsequently, at their June 2000 meeting, the EWPU agreed to use a robust application of IFIM as their approach to addressing instream flow issues. The Planning Unit obtained Salmon Recovery Funding Board (SRFB) funding, and the consulting firm ENTRIX, Inc. (ENTRIX) was hired in September 2001 to work with the EWPU and the instream flow subcommittee on this issue. Information needed for setting instream flows was collected within the watershed in 2002/2003.

Instream Flows

Between February and October 2003, six professionally facilitated meetings were held to bring stakeholders together to craft instream flow recommendations for the Entiat and Mad Rivers. Significant effort was made to ensure that interested stakeholders not participating as regular Planning Unit members were either present at the table or informed of the EWPU's efforts.

Planning Unit Instream Flows

The Planning Unit and ENTRIX developed three biologically-based Planning Unit flow regimes for subbasin management and monitoring purposes. These flows are displayed in Chapter 5, beginning on page 5-13.

Administrative Instream Flows

The Planning Unit also developed Administrative Instream Flow recommendations for codification as minimum instream flows in Chapter 173-546 WAC. Three flow regimes were developed and tied to USGS gages:

- lower Entiat River, tied to the Keystone gage (USGS #12452800, Entiat near Entiat);
- upper Entiat River, tied to the Stormy gage (USGS #12452890, Entiat near Ardenvoir);
- Mad River, tied to USGS #12452990, Mad at Ardenvoir.

The following table displays the recommended administrative instream flows for the Entiat and Mad Rivers:

Monthly/Semi-monthly period	Recommended Flow (cfs) for **Lower Entiat** RM 0-16.2	Recommended Flow (cfs) for **Upper Entiat** RM 16.2-25.8 miles	Recommended Flow (cfs) for **Mad River** at RM 4
January	185	175	32
February	185	175	32
March 1-15	185	175	32
March 16-31	250	285	68
April 1-5	250	325	100
April 16-30	350	375	100
May 1-5	474	375	100
May 16-35	720	375	100
June 1-5	898	325	100
June 16-30	617	325	100
July 1-15	365	275	68
July 16-31	268	275	68
August 1-15	185	275	68
August 16-31	185	275	51
September	185	175	32
October	185	175	32
November	185	175	32
December	185	175	32

Percent exceedence levels associated with the above flows are displayed on tables in Chapter 5, e.g. an exceedence of 90% indicates that the given flow is expected to be met or exceeded 90 percent of the time. Refer to Chapter 5 for a discussion of Percent Exceedence levels; see page 5-17 for the beginning of the proposed Administrative Instream Flows tables and hydrographs.

CHAPTER 6 - WATER BUDGET

Introduction

A water budget is basically an accounting ledger that contains water credits and debits, i.e. an estimate of water present within the system (credit); what water is needed to accommodate future domestic, commercial and agricultural use (debit); what flows are required to be left in stream for the protection of *existing* beneficial uses, including water for

irrigation and fish (debit); and what actual water use is occurring (debit). The difference between the credit and debit numbers shows what water is available during different months of the year for future appropriation.

Water Budget Format

A primary reason for development of a water budget is to determine at what times of year water resources are scarce and/or require management. Consequently, the EWPU water budget shows flow and water use data by month, with semi-monthly values added as necessary due to administrative instream flow recommendations.

WRIA 46 is composed of two main drainages, the Entiat and Mad River watersheds, as well as an area containing minor Columbia River tributaries. A water budget spreadsheet was developed for each of the major drainage areas in the WRIA (Entiat River, Mad River, and minor Columbia River tributaries); the Entiat River was also split into upper and lower reaches. Dividing the WRIA into four different areas was done to facilitate estimation of the amount of water present and actual water use, as well as the development of instream flow and water management recommendations. Channel geomorphology, fish habitat and use, land and water use, settlement patterns, and the hydrologic connectivity of these areas, as well as where administrative instream flows would be monitored, were all used to help determine how to split the WRIA.

Data Inputs

A number of studies were sponsored by the EWPU to collect data for use in the development of its water budget. Data from a number of sources, including stream gage records, in-field flow measurements, and Geographic Information System (GIS) modeling of aquifer thickness and extent were used. These studies and data have been detailed previously in Chapter 4, Water Quantity.

Upper Entiat River Budget

Flows for the upper Entiat River are monitored at the Stormy gage (Entiat near Ardenvoir USGS gage, at RM 18). It was estimated that water use occurring upstream of this point is associated with the irrigation of approximately 20 acres of residential property (lawn), and totals only 80 acre-feet annually. Average peak monthly use in July accounts for approximately 20 acre-feet, which is negligible in comparison to the average July monthly volume of stream flow produced by the entire subbasin (46,955 acre-feet, based on composite Keystone gage record).

The tables in Chapter 6 on pages 6-4 and 6-5 show mean monthly and/or semi-monthly flow recorded at the Stormy gage in cfs and acre-feet, respectively, as well as the estimated water use occurring upstream of this point.

Lower Entiat River Budget

Flows in the lower Entiat River are monitored at the Keystone gage (USGS gage #1245990, Entiat near Entiat), located approximately 1.4 miles upstream of the Entiat's confluence with the Columbia River. In this portion of the Entiat River watershed irrigation water use accounts for almost all use occurring in the subbasin. Peak use occurs in July, with average monthly net irrigation water use totaling 1511 acre-feet (~25 cfs), or 3% of the average

monthly volume of water produced during this month (47,039 acre-feet or ~765 cfs). As the Keystone gage site is essentially the "pour point" for the entire Entiat subbasin, the water budget tables for the lower Entiat River in Chapter 6 on page 6-7 and 6-8 reflect all upstream water uses recorded within the subbasin. The "Naturalized" mean flow approximates what stream flow would be recorded at the Keystone gage were no upstream water use occurring. Additionally, *water use associated with residences found in the lower Mad River was included as part of the lower Entiat River use for the following reasons:*

- There is a high degree of connectivity between surface and ground water in the Entiat subbasin;
- There is very minimal private land ownership upstream of RM 2 in the Mad River;
- The primary domestic water source in the lower Mad River is wells; and
- The lower Mad River and area around its mouth are part of an alluvial fan, and therefore groundwater drawn from the lower Mad River is likely a part of the larger unconsolidated alluvial valley aquifer.

Mad River Budget

Refer to Chapter 6, page 6-9 for an overview of the Mad River budget.

Minor Columbia River Tributaries Budget

This water budget addresses the minor, often ephemeral streams above the Entiat River-Columbia River confluence as far north as Oklahoma Gulch and below the confluence as far south as Swakane Canyon (both drainages included). These drainages, though encompassed within the Entiat WRIA, flow directly into the Columbia River. Much of their area is either state (WDFW) or federally (USFS) owned; private property (excluding the City of Entiat) is largely concentrated in a narrow strip along the Columbia River and astride State Highway 97A.

Water is this area is not immediately connected to the Entiat subbasin system, nor is any surface flow from these drainages connected to or influenced by the Entiat system. For these reasons, and considering the limited potential for future residential or agricultural development of these drainages, the EWPU did not examined water quantity for the CRT with the same rigor as the upper and lower Entiat and Mad Rivers.

CHAPTER 7 - HABITAT

Aquatic Habitat

Physical, chemical and biological characteristics comprise the aquatic habitat of river systems. Physical habitat includes parameters such as channel dimension, stream flow and riparian vegetation; chemical variables include water pH and nitrate levels; and biological components serve as indicators of the ecological community that utilize the river, e.g. fish and macroinvertebrate species composition and diversity. Discussion in this chapter focuses mainly on the physical and biological habitat indicators of the Entiat subbasin, as many of its chemical characteristics are discussed in Chapter 8, Water Quality.

Physical Characteristics

Water Temperature

USFS Entiat RD temperature data collected annually since the early 1990's show state water quality temperature standard exceedences in the Entiat and Mad Rivers during the late summer/fall period for each year of monitoring. The Entiat Watershed Assessment (WNF 1996) reported that the (then) current data base showed much variation in the extent, duration, and location of summertime highs. Low winter water temperatures may be more of a limiting factor to the survival of salmonids than summer high water temperatures. Because water temperature is treated as a water quality element in this plan, additional historic data and information about Temperature modeling are contained in Chapter 8, Water Quality.

Erosion and Sedimentation

Erosion and sedimentation are natural processes, integrally woven into the hydrologic cycle. The erosion/sedimentation cycle in the Entiat is highly variable, and the natural or historic range of variability of sediment production in this system is unknown. Variability is largely a function of snowmelt runoff, storm events and related disturbances. In the Entiat subbasin, it is estimated that approximately 80% of the average annual sediment load within a given year is associated with snowmelt peak flows (USDA 1979).

Fine Sediment

The USFS initiated annual fine sediment monitoring in critical reaches of the Entiat and Mad Rivers in 1993 and 1994, respectively, to monitor fine sediment deposition in salmonid spawning habitat, and help identify baseline condition and the natural range of variability for the Entiat River subbasin. Analyses of all data collected since 1993 suggest that the Entiat and Mad River watersheds have been working to recover from the effects of fire-related events, as shown by the gradually improving trend in mean annual percent fines $\leq$ 1.0mm.

Channel Morphology

Stream channel morphology (general channel shape) and stream type classification consider numerous parameters, including channel width to depth ratio, slope/gradient, substrate composition and roughness, and sinuosity.

In the fall of 1995, the NRCS "Stream Team" (an interdisciplinary team composed of specialists in riparian ecology, stream geomorphology, fish ecology, aquatic habitat, and geology) conducted a comprehensive survey of the lower 20.1 miles of privately held lands in the Entiat River corridor in order to inventory and classify stream types "…for the purpose of generating alternatives for stream bank management, fish habitat improvement, and river restoration that was compatible with the river's geomorphic features and historic anadromous fish populations (CCCD 1998. The complete study report is contained in the reports file. Information on two of the Entiat River reaches is presented below.

The Potato Creek terminal moraine at Albert "Shorty" Long's property (RM 16.2) is a key location for discussion of channel structure in the drainage. Upstream of the moraine, channel morphology is glacially influenced, and channel shape is dictated primarily by natural fluvial processes, such as bankfull discharge, and valley geomorphology. This is illustrated by the C4 and C5 stream types present upstream of the moraine (low gradient,

meandering, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains). Within this reach, conflict between streamside development and floodplain function is an increasing concern.

Downstream of the Potato Creek moraine, between the town of Ardenvoir and the mouth of the Entiat, current stream channel shape has been influenced by past human activities, such as channel straightening/widening and diking (performed in an attempt to carry flood flows safely out of the subbasin) and streamside vegetation disturbance. Consequently, the F3 stream type is prevalent below the moraine, and the lack of aquatic habitat diversity, high width to depth ratio, and stream downcutting are concerns. The overall width to depth ratio of the lower 25 miles of the Entiat River is high (greater than 25), due to a combination of natural and human disturbances.

Biological Characteristics

Macroinvertebrates

Based on samples taken on April 22, 1992 Mad River site results showed good macroinvertebrate species richness and diversity; in comparison, the lower Entiat River site had low species richness with a high Percent Dominant Taxon value, which may have indicated environmental stress or an altered site (Smith 1992).

The WDOE Environmental Assessment Program collected biological samples in the lower Entiat River near the Keystone gage on August 15, 2002 as part of a state-wide effort to collect baseline macroinvertebrate community information, determine whether streams are biologically impaired, and provide a means to see whether biological results concur with ambient water quality monitoring data. Data indicate that the benthic macroinvertebrate community condition is generally healthy; however, specific characteristics of the community condition indicate slight degradation (C. Wiseman, WDOE, pers. comm. Dec. 2003).

Fish

Many species of anadromous and non-anadromous fish utilize the aquatic habitat of the Entiat and Mad River watersheds. Some fish found in the subbasin are currently listed under the Endangered Species Act. A summary of fish known and likely to occur in the subbasin, along with federally listed fish designations and candidate species which may be proposed for listing by the USFWS and/or NOAA Fisheries, is provided in Chapter 7.

The Washington Department of Fish and Wildlife maintains a state "Species of Concern" (SOC) list, which includes all *state* designated endangered, threatened, sensitive, and candidate species; state SOC list designations assigned to federally listed species are also provided. On 9/12/94, NOAA Fisheries initiated a status review of late-run Chinook, sockeye, and Coho salmon to determine if listing was warranted. Although it was determined at that time that listing was not warranted, these three species should also be considered Candidate ESA species.

Anadromous Fish

Several populations of economically and culturally important anadromous fish species reside within the Entiat subbasin. The Entiat and Mad Rivers currently support runs of steelhead and bull trout, and spring and late-run Chinook salmon. Coho salmon were once

present in the Entiat watershed (Mullan et al. 1992), but are now considered extinct (Nehlsen et al. 1991). Sockeye salmon were also introduced into the Entiat River at one point. Notably, both Coho and Sockeye have recently been found utilizing the Entiat River (USFWS MCRFRO 2002, 2003). Upper Columbia River (UCR) spring Chinook salmon and summer steelhead trout are listed as endangered and Columbia River bull trout are listed as threatened under the Federal Endangered Species Act (ESA).

Dams constructed near the mouth of the Entiat River beginning in 1889 blocked salmon from returning to the Entiat to spawn. Barriers erected on Entiat River persisted through the mid-1930s, and probably contributed to the Coho's extinction (Craig and Suomela 1941). A Bureau of Fisheries survey of the Entiat in 1934, 1935 and 1936 showed the river was virtually devoid of salmon and salmon runs in general were essentially nonexistent by the time Grand Coulee Dam was built in 1939 (Craig and Suomela 1941).

As part of the Grand Coulee Fish Maintenance Project (GCFMP), all returning adult salmon were trapped at Rock Island Dam from 1939 to 1943. A total of 3,015 adult late-run Chinook were collected from commingled upper river stocks and placed in upper Entiat River spawning areas; only an estimated 1,308 of these survived to spawn (Fish and Hanavan 1948). Shorty Long recalls that fish were planted in two locations above the terminal moraine, at Burns Creek and Decker's near Gray Canyon. A weir was constructed at the terminal moraine to keep the adult salmon from migrating downstream to the Columbia River before spawning.

Entiat National Fish Hatchery

The U.S. Bureau of Reclamation constructed the Entiat NFH approximately seven miles above the confluence of the Entiat and Columbia Rivers. It was authorized by Congress through the GCFMP on April 3, 1937 and reauthorized by the Mitchell Act (52 Stat. 345) on May 11, 1938. It was constructed by the US Bureau of Reclamation as mitigation for the Grand Coulee Dam, Columbia Basin Project. "The goal of these efforts was to rebuild salmon runs in the tributary streams to mitigate for lost production above Grand Coulee Dam" (USFWS MCRFRO 1998).

The U.S. Fish and Wildlife Service currently operate the hatchery as part of the Leavenworth NFH Mid-Columbia River Fisheries Research Office (MCRFRO) Complex. It is used for adult collection, egg incubation, and rearing of spring Chinook salmon. Rearing facilities include 42 starter tanks, 30 raceways, and two adult holding ponds. The Entiat River, Packwood Spring, and six wells provide water for the hatchery.

The average adult return for spring Chinook to the ENFH for the past 25 years has been just over 600 adults. This prohibits any significant harvest as all returning fish are needed to meet hatchery production level derived from the U.S. v. Oregon court decision, and other legal obligations.

<u>Late-Run Chinook Salmon</u>

It is suspected that late-run Chinook salmon were not a dominant life history type in the Entiat River system (Craig and Suomela 1941); however, a great effort was made to establish late-run Chinook in the Entiat after the GCFMP. Historically, two late-run

anadromous life history strategies may have been present in the subbasin. A summary of the past nine years of late-run Chinook salmon redd counts on the Entiat River is available in Chapter 7.

Spring Chinook Salmon

"Stream-type" Chinook salmon juveniles overwinter in the river and remain within the system for at least a year prior to migrating to the sea as yearlings. They return as adults to freshwater in the spring, but do not spawn until several months after their arrival. Stream-type Chinook are also referred to as spring Chinook. See Chapter 7 for a summary of spring Chinook redd expanded survey on the Entiat River.

Steelhead

Upper Columbia River summer steelhead spawn in the lower and mid-Entiat River (RM 0.5 to RM 28) and some of its tributaries, and in the lower Mad River, from March 15 to May 31. Mid-to-late-April has been observed to be the most likely steelhead spawning window in the Entiat and Mad Rivers (USFS 2003).

Survey data were used to designate a steelhead spawning index reach on the lower Mad River (RM 1.3-7.2), and future surveys of the Mad River will focus on this area. A summary of USFS spawning survey results in the Mad River may be found in Chapter 7.

USFS Entiat RD fish biologists have surveyed lower Roaring Creek (RM 1-2 during the spring of each year since 1999 in an attempt to confirm anecdotal accounts of historic steelhead spawning there. In 2003, two definite rainbow/steelhead redds with one 20-inch adult steelhead present were observed at approximately RM 1.5 (USFS 2003). A summary of steelhead redds by USFWS MCRFRO staff in the Entiat River during the spring of 2003 is found in the habitat chapter.

Sockeye Salmon

Sockeye salmon are not indigenous to the Entiat River (Craig and Suomela 1941). They were stocked only twice, in 1943 and 1944, from Lake Quinault and Lake Whatcom stocks (Mullan 1986). A small run of sockeye became established in the Entiat River, and were observed spawning in the Entiat River from 1945 to 1955 (Mullan 1986). The Entiat NFH collected sockeye from 1944 to 1963, propagated them between 1941 and 1969, and planted them elsewhere (Mullan 1986). Between 75 and 150 sockeye salmon were noted in the Entiat River during incidental counts over the period 1969 - 1981 (Mullan 1986).

Coho Salmon

Although Coho were once present in the Entiat subbasin, only 475 Coho were counted at Rock Island Dam from 1933-1943 (Andonaegui 1999). In October 2001, during their late-run Chinook spawning ground surveys on the Entiat River, the USFWS identified 12 Coho redds, three adults, and three carcasses between Dinkleman Canyon and Fire Station restoration sites. In 2002, one Coho carcass was noted between Keystone Bridge and the confluence with the Columbia River.

Non-Anadromous Fish

Rainbow (a resident form of steelhead), bull, westslope cutthroat, brook and interior redband trout use Entiat River and tributary habitat most or all their lives. Other important resident species found within the subbasin include mountain whitefish and Pacific lamprey. Bull trout are listed as threatened under the ESA, and in 2001 petition was made to list westslope cutthroat, Pacific lamprey, and other lamprey.

Bull Trout

Currently, bull trout found in the mainstem Entiat and Mad River are considered to be two distinct local populations. Bull trout have been found in small numbers in the mainstem Entiat River up to Entiat Falls, a natural barrier. The 1998 Bull Trout/Dolly Varden volume of the SaSI (Salmon Stock Inventory) report lists Entiat River bull trout stock as native with wild reproduction; however, stock status is listed as unknown. A summary of the results of all bull trout spawning surveys performed in the index reach of the Mad River is provided in Chapter 7.

Riparian Condition

The NRCS Stream Team performed an extensive survey of the lower 20 RMs of the Entiat River in 1995 (CCCD 1998). During the riparian inventory, they determined the dominant overstory species, percent of canopy cover, and dominate age class of the existing vegetation along the river. The study reported that degradation to riparian vegetation in the upper Entiat watershed was tied to historical overgrazing, road construction, certain timber harvesting activities, and recreation (CCCD 1998). Riparian vegetation and function in the lower portion of the Entiat watershed (below the FS boundary) has been affected by wildfire, agricultural encroachment on the floodplain, past flood control and channel straightening efforts, historic grazing, and rural residential development in the floodplain (CCCD 1998, Andonaegui 1999). Wildfire was noted as one of the primary disturbance factors affecting riparian vegetation.

A summary of vegetation inventory findings is provided in Chapter 7. Also refer to Chapter 9, Recommendations, for recommended riparian revegetation sites. The following text summarizes current riparian condition within the three analysis zones as described by the USFS Watershed Assessment (USFS WNF 1996).

From the headwaters to Entiat Falls, near RM 34 (transport zone): As described previously, riparian condition within this reach is good to excellent. Because most of this land is publicly owned the threat of future development and other environmental change is minimal.

From Entiat Falls to McCrea Creek, near RM 25 (transitional zone): Riparian condition within this reach is fair to excellent. As most of this zone is also publicly owned, the threat of development and other environmental change is again minimal.

From McCrea Creek to Mad River Confluence, near RM 10 (depositional zone): This reach includes the "stillwater" area, which is considered a prime fish habitat area. Some areas within this reach have been permanently protected via acquisition by the Chelan-Douglas Land Trust. Large segments of this reach burned in the 1994 Tyee fire; recreation and

residential development has also affected riparian condition and function. As a result there are some areas within this reach that are either completely void of vegetation or have poor riparian function (small width.

From Mad River Confluence, near RM 10, to the river mouth (depositional zone): This is considered the priority area for riparian plantings within the Entiat watershed. Most of the stream-side land within this reach is privately owned, and data from the CWU study show that many of these areas are used for agriculture, including irrigated orchards and pastures.

The Planning Unit used riparian information documented in previous reports (USFS 1996; Lillquist and Erickson 2002; CCCD 1998), GIS analysis, and field checks to identify priority areas for riparian restoration and/or enhancement.

Fish Habitat Condition

The NRCS Stream Team inventoried the type and quality of fish habitat during their survey of the lower 20.1 miles of the Entiat River in 1995. Pools, riffles, glides/runs, and cascades were noted, as well as the presence of large pools, overhanging vegetation, large woody debris, large boulders, substrate, and undercut banks. Habitat frequency was also determined. The USFS Entiat RD also collects habitat data in reaches upstream of RM 20 via recurring stream surveys. The following synopsis of fish habitat conditions in the Entiat is based on the three analysis zones (transport, transitional, and depositional) described in the Watershed Assessment Entiat Analysis Area (USFS 1996) and also contains information from the NRCS "Stream Team" inventory (CCCD 1998) and the WRIA 46 Limiting Factors Analysis (Andonaegui 1989).

Refer to the figures beginning on page 7-43 in Chapter 7 for graphic overviews of longitudinal profile, analysis zones, channel type, gradient, fish use, and landmarks for the Entiat and Mad Rivers.

Transport Zone

In the transport zone [headwaters downstream to Entiat Falls (RM 33.8)], fish habitat condition in the mainstem is stable and assumed to be similar to the historic condition, with unembedded cobble/gravel streams and the number of large pools similar to or higher than numbers observed in the 1930's

Transitional Zone

In the transitional zone [RM 33.8 to McCrea confluence] the current condition of fish habitat in the mainstem Entiat has been modified from the condition found in 1930's surveys. Data indicate a 30-60% loss of pool habitat, yet the amount of pool habitat and large woody debris within this reach is the highest of the three Entiat reaches (CCCD 1998).

Depositional Zone

The depositional zone [McCrea Creek confluence downstream to the mouth] contains the principal spawning and rearing habitat for anadromous fish in the Entiat River. Spring and summer Chinook and sockeye salmon, steelhead and bull trout, and other resident species all use the zone. The distribution of salmonids within this area is limited to the few fish-accessible tributaries above (Stormy Creek) and below (Roaring Creek, Mad River, Potato

Creek) the Potato Creek moraine (RM16.2). Overall, the condition of fish habitat in the depositional zone is fair to poor.

Fish habitat in the zone upstream from the Potato Creek Moraine is in good condition. In general, this reach has a good pool-riffle ratio, with pool habitat (geomorphic) at every 5 to 7 bankfull channel widths. Off-channel habitat exists in stable locations. In general, above the Potato Creek moraine, spawning and rearing conditions for salmon and steelhead are considered to be good to excellent, with adequate cover, favorable velocities and high flow refuge habitat (USDA Forest Service 1996).

Spawning and rearing conditions for salmonids in the lower mainstem Entiat River below the moraine are generally deemed poor (USFS 1996). The first 15.4 miles of the Entiat River show the result of human disturbances (CCCD 1998); county roads, flood control dikes and channel straightening associated with past flood control projects have dramatically simplified habitat in this section of the river, particularly below the Mad River confluence (RM 10.5).

All of the aforementioned practices in combination constitute the greatest impact to salmonid habitat in the mainstem Entiat downstream of the Mad River confluence. Alterations to channel shape have reduced the amount of habitat available at current flow levels: the increase in water required to provide historic habitat in the altered channel is simply unavailable or impractical to attempt to achieve. A more pragmatic approach is to focus on restoring an appropriate channel morphology that supports adequate habitat given the existing hydrology. This does not preclude water conservation measures, it merely emphasizes that water alone is not the solution to restoring lost habitat.

Entiat Ecosystem Diagnosis and Treatment (EDT) Analysis

The Yakama Nation and other EWPU Habitat Subcommittee members worked with Mobrand Biometrics, Inc. to model Chinook salmon response to various restoration scenarios using the Ecosystem Diagnosis and Treatment (EDT) methodology. EDT is an analytical method relating habitat features and biological performance to support conservation and recovery planning. It brings together information from empirical observation, stakeholders and local experts, and other models and analyses tools. The Diagnosis is based on an assessment of the relative contributions of environmental factors to the biologic performance of naturally produced Chinook salmon.

A team of technical specialists using all of the information relating to habitat contained in this and other chapters and the EDT model developed alternative treatments for the habitat of the Entiat watershed. This work included field verifying reach habitat attribute values to help ensure that model inputs accurately reflected current conditions. Because the EDT analysis is highly technical and would be extremely difficult to summarize here, those interested in specifics should refer to the full analysis in the report files.

Alternative Management and Restoration Scenarios (Treatments)

In an EDT analysis, restoration scenarios are comprised of different combinations of distinct types of restoration actions. In the Entiat analysis, five types of restoration actions were combined into five restoration scenarios targeting 11 of the 16 reaches of the Entiat River.

Alternative Management Scenarios for EDT Modeling

Actions	Rock Cross Vanes or other structures (Reaches 2-9)	Riparian Plantings (Reaches 2-9)	Log / LWD Placement	Side Channel Connection (Reach 3)	Irrigation Ditch as Habitat	Habitat Protection and Restoration (Reaches 10,11,12)
Alternatives	(structures)	(lineal feet)	(sites)	Yes / No	Yes / No	(sites)
1	20	10,000	5	No	No	No
2	40	20,000	10	No	No	No
3	80	40,000	20	No	No	No
4	80	40,000	20+	Yes / No	Yes / No	Yes / No
5	80	50,000	40	Yes / No	Yes / No	Yes / No

Alternative Themes

Alt 1	This alternative describes a relatively low level of effort towards application of the "Bridge to Bridge" concept (focuses Fire Station Bridge to J/S Bridge), using additional rock cross vanes or other instream structures, associated riparian plantings and some channel stability using root-wads and LWD structures.
Alt 2	This alternative is directly associated with **Alternative 2 from the Entiat Coordinated Resource Management Plan (CRMP)**. Most of the work would occur in the lower Entiat main-stem. This alternative describes a "minimal" requirement for migration, spawning, resting and rearing habitats in CRMP Reaches 1-6 and minimum root-wad revetments in CRMP Reaches 7-8.
Alt 3	This alternative is directly associated with **Alternative 4 from the Entiat CRMP**. All of the work would be spread throughout Reaches 2-9 (as identified in the CRMP) of the Entiat main-stem. This alternative provides for "approximately 40% of the historic pool frequency, resulting in an average of 3 pools per mile in Reaches 1-6 and 8 pools per mile in Reaches 7-8".
Alt 4	This alternative provides for the maximum recommended action included in the CRMP Alternative 4. Additional enhancement components are anticipated in the Bridge to Bridge concept (Reach 3), and upstream into the Stillwater area Reaches 10, 11, 12.
Alt 5	This alternative enhances Alternative 4 by providing substantially more large wood structures, and consequently more pool habitat and habitat diversity to reaches 10 and 11. Approximately 4 lineal miles of riparian plantings are also considered. This alternative assumes some degree of conservation easements and/or habitat protection would be implemented by willing landowners.

Wildlife Habitat

Wildlife and plant species and habitats with Federal designations in the Entiat subbasin include:

LISTED

Threatened

Bald eagle (*Haliaeetus leucocephalus*)
Canada lynx (*Lynx canadensis*)
Gray wolf (*Canis lupus*)

Grizzly bear (*Ursus arctos = U.a. horribilis*)
Marbled murrelet (*Brachyramphus marmoratus marmoratus*)
Northern spotted owl (*Strix occidentalis caurina*)
Ute ladies'-tresses (*Spiranthes diluvialis*), plant

Designated
Critical habitat for the northern spotted owl (*Strix occidentalis caurina*)

CANDIDATE

Fisher (*Martes pennanti*), West Coast distinct population segment
Yellow-billed cuckoo (*Coccyzus americanus*)

The Washington State Department of Fish and Wildlife publishes a "Priority Habitats and Species List" which helps to identify vertebrate and invertebrate species and habitats that are considered to be priorities for conservation and management. Priority species require protective measures for their perpetuation due to their population status, sensitivity to habitat alteration, and/or recreational, commercial, or tribal importance. These species include State Endangered, Threatened, Sensitive, and Candidate species; animal aggregations considered vulnerable; and those species of recreational, commercial, or tribal importance that are vulnerable. Many priority species use the wildlife habitats within the Entiat WRIA for at least part of the year. Habitats included in the priority listing which occur in the Entiat WRIA include: aspen stands, caves, cliffs, old-growth/mature forests, prairies and steppe, instream, riparian, shrub-steppe (both large and small blocks), snag habitat, talus, urban natural open space, freshwater wetlands and deepwater habitats.

The WDFW also publishes a Species of Concern list of only native Washington fish and wildlife species that are listed as Endangered, Threatened, or Sensitive, or as Candidates for these designations. Endangered, Threatened, and Sensitive species are legally established in Washington Administrative Codes. The USFWS provides a list of Species of Concern as advance notice to federal agencies of species that may be proposed for listing in the future. See Appendix K for Priority Habitats and Species, Species of Concern, and rare/sensitive plants that may be found within the Entiat WRIA.

CHAPTER 8 - WATER QUALITY

The Entiat River is classified as a Class A (excellent) stream from its confluence with the Columbia River to the boundary of the Wenatchee National Forest at approximately RM 26, and as a Class AA (extraordinary) stream from the National Forest boundary to its headwaters. It supports beneficial uses including domestic, industrial and agricultural water supply and primary contact recreation.

With the exception of the post-1994 Tyee Fire sampling, and ongoing USFS temperature data collection, very little of the available tributary data are more recent than the mid-1980s. Temperature exceedences are the most common type of water quality issue in the

tributaries, with infrequent excursions for dissolved oxygen, fecal coliform and pH also occurring. No increasing trends were seen.

There is no indication of any significant degradation within the WRIA with respect to fecal coliform, dissolved oxygen, pH, or turbidity. Temperature exceedences in the summer months have been identified throughout the record, beginning in 1960. Occasional temperature exceedences may have occurred naturally prior to settlement of the Entiat valley; however, it is impossible to determine the magnitude or frequency of this type of historic exceedence given the existing data record. It is likely that the number and frequency of exceedences has increased due to a combination of historic manipulation of channel geometry and removal of riparian plants, coupled with natural flood and wildfire events, which have also affected streamside vegetation.

The Planning Unit used the Stream Network Temperature Model to examine temperature exceedence patterns in the Entiat subbasin and identify actions, such as enhancing riparian vegetation, which can be implemented to help mitigate high summer water temperatures. The WDOE is recommending to the USEPA that the Entiat *not* be placed on the 2002/2004 303(d) list for temperature, but rather receive a "4b" categorization -- impaired but has a pollution control plan -- as a result of the Planning Unit's past and current efforts to address the problem.

Ongoing monitoring of water quality by the WDOE ensures that any trends indicating degradation of the Entiat River will be quickly identified. Maintaining current efforts and practices, and the future implementation of specific projects aimed at improving water quality will ensure that the Entiat River and its tributaries continue to regularly meet or exceed state standards in the foreseeable future.

CHAPTER 9 - RECOMMENDATIONS

Refer to Chapter 9 for all recommendations developed during the CRMP/2514 process.

CHAPTER 10 - MONITORING AND EVALUATION

Chapter 10 provides a summary of ongoing monitoring activities, types of data collected, and partners involved with monitoring in the Entiat subbasin.

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1.0 INTRODUCTION

1.1 HISTORY OF RESOURCE PLANNING IN THE ENTIAT VALLEY

In 1993 members of the Chelan County Conservation District (CCCD), Natural Resource Conservation Service (NRCS), and the US Forest Service (USFS) - Entiat Ranger District (Entiat RD) met with the Entiat Chamber of Commerce and secured its support for a watershed planning effort for the Entiat and Mad River watersheds. The Chamber initiated a search for local citizens interested in initiating and participating in the watershed study.

A small planning group composed of local landowners and representatives of the CCCD, NRCS and USFS Entiat RD began meeting in December 1993 to outline a planning process, identify stakeholders and craft the following preliminary mission statement and goals:

> To voluntarily bring people together to improve communication, reduce conflicts, address problems, reach consensus and implement actions to improve natural resource management on associated private and public lands in the Entiat watershed.

The preliminary goals of the planning group included the following:

1. Assure a continuous flow of clean water in the Entiat River system.
2. Provide for the coexistence of people, vegetation, fish and wildlife.
3. No human-caused mortality of Threatened and Endangered species.
4. Develop and implement an action plan to address priority issues, emphasizing local customs, culture and economic stability.

Monthly meetings began in February 1994, culminating in mid-1994 with a decision to organize using the NRCS Coordinated Resource Management Plan (CRMP) model. The CRMP framework involved formation of a Landowner Steering Committee (LSC), for input of local knowledge and representation of local priorities and interests; formation of a Technical Advisory Committee (TAC), for scientific and policy support of the citizen-based effort; and designation of a watershed planning coordinator.

The LSC included residents born and raised in the Entiat valley, as well as recent settlers. Orchardists, logging and grazing interests, and the interests of semi-retired and retired citizens were all represented. Some committee members resided in the valley and earned their living outside of the watershed, while others were directly dependent on its resources for their income. The TAC was composed of county, state, non-government, Yakama Nation and federal employees (some of whom were also valley residents) involved with the management of resources associated with issues identified by the planning group.

The CRMP group made significant progress between 1994 and 1998. It compiled existing natural resource and community information, and collected new data. The NRCS “Stream Team” gathered key information during a stream survey of the lower 20 miles of the Entiat River that led to recommendations for channel and riparian restoration (CCCD 1998).

Prior to 1998 the Entiat CRMP group accomplished all of its work on a shoestring budget, largely supported by donated time and effort. The Draft Entiat Coordinated Resource Management Plan (CCCD 1999) documented the progress made. Tackling unresolved issues, such as instream flow, was beyond the financial means of the group until the passage of key legislation in l998 that provided funding for locally led resource planning activities similar to what had already been initiated by Entiat CRMP participants.

1.2 WATERSHED PLANNING

In 1998 the Washington State Legislature passed Engrossed Substitute House Bills (ESHB) 2514 and 2496, the Watershed Planning Act and Salmon Recovery Management Act, respectively, in response to diminishing water availability and quality, and the decline of salmonid stocks. The Watershed Planning Act (Chapter 90.82, Revised Code of Washington (RCW)) enabled the state to offer grants up to $500,000 for planning within each of its 62 Water Resource Inventory Areas (WRIAs).

1.2.1 The Watershed Planning Act

The purpose of the Watershed Planning Act (WPA) is to increase local involvement in decision-making and planning for water resources through a process that provides "...local citizens with the maximum possible input concerning their goals and objectives for water resource management and development" (Chapter 90.82.005 RCW). Although watershed planning is not state-mandated, if initiated the scope of planning must include the water quantity component to "...address water quantity in the management area by undertaking an assessment of water supply and use in the management area and developing strategies for future use" (Chapter 90.82.070 RCW). The scope of planning may also include an instream flow component (Chapter 90.82.080 RCW), water quality component (Chapter 90.82.090 RCW), and/or habitat component (90.82.100 RCW).

Under the water quantity component, the assessment shall include:

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

> rule under this chapter for stream in the management area including the data necessary to evaluate necessary flows for fish (Chapter 90.82.070 RCW).

The water quantity assessment shall also include:

> ...strategies for increasing water supplies in the management area, which may include, but are not limited to, increasing water supplies through water conservation, water reuse, the use of reclaimed water, voluntary water transfers, aquifer recharge and recovery, additional water allocations, or additional water storage and water storage enhancements (Chapter 90.82.070 RCW).

If the initiating governments opt to include an instream flow component, part (1) (a) (ii) of the instream flow component rules (Chapter 90.82.080 RCW) stipulates that:

> If minimum stream flows have not been adopted by rule for a stream within the management area, setting the minimum instream flows shall be a collaborative effort between the department [(Washington State Department of Ecology)] and members of the planning unit. The department must attempt to achieve consensus and approval among the members of the planning unit regarding the minimum flows to be adopted by the department. Approval is achieved if all government members and tribes that have been invited and accepted on the planning unit present for a recorded vote unanimously vote to support the proposed minimum instream flows, and all nongovernmental members of the planning unit present for the recorded vote, by a majority, vote to support the proposed minimum instream flows.

If the initiating governments opt to include the water quality component of the watershed plan, it shall include the following elements:

(1) An examination based on existing studies conducted by federal, state, and local agencies of the degree to which legally established water quality standards are being met in the management area;
(2) An examination based on existing studies conducted by federal, state, and local agencies of the causes of water quality violations in the management area, including an examination of information regarding pollutants, point and nonpoint sources of pollution, and pollution-carrying capacities of water bodies in the management area. The analysis shall take into account seasonal stream flow or level variations, natural events, and pollution from natural sources that occurs independent of human activities;
(3) An examination of the legally established characteristic uses of each of the nonmarine bodies of water in the management area;
(4) An examination of any total maximum daily load established for nonmarine bodies of water in the management area, unless a total maximum daily load process had begun in the management area as of the date the watershed planning process is initiated under RCW 90.82.060;
(5) An examination of existing data related to the impact of fresh water on marine water quality;

(6) A recommended approach for implementing the total maximum daily load established for achieving compliance with water quality standards for the nonmarine bodies of water in the management area, unless a total maximum daily load process has begun in the management area as of the date the watershed planning process is initiated under RCW 90.82.060; and
(7) Recommend means of monitoring by appropriate government agencies whether actions taken to implement the approach to bring about improvements in water quality are sufficient to achieve compliance with water quality standards (Chapter 90.82.060 RCW).

Finally, if the initiating governments choose to include a habitat component, then:

…the watershed plan shall be coordinated or developed to protect or enhance fish habitat in the management area. Such planning must rely on existing laws, rules, or ordinances created for the purpose of protecting, restoring, or enhancing fish habitat, including the shoreline management act, Chapter 90.58 RCW, the Growth Management Act, Chapter 36.70A RCW, and the Forest Practices Act, Chapter 76.09 RCW. Planning established under this section shall be integrated with strategies developed under other processes to respond to potential and actual listings of salmon and other fish species as being threatened or endangered under the federal endangered species act, 16 U.S.C. Sec. 153e1 et seq. (Chapter 90.82.100 RCW).

1.2.2 Initiation of Watershed Planning in WRIA 46

Watershed planning under the Act may be initiated for a WRIA only with the concurrence of: all counties within the WRIA; the largest city or town within the WRIA; and the water supply utility obtaining the largest quantity of water from the WRIA (Chapter 90.82.060 RCW). Recognizing that the voluntary emphasis and locally-led focus of the Watershed Planning Act paralleled the existing Entiat CRMP group's structure and collaborative nature, the CCCD and USFS worked with Chelan County, the City of Entiat, and the Entiat Irrigation District to initiate the watershed planning process for the Entiat WRIA (WRIA 46)) in 1998; see Chapter 173-500 WAC. The invitation to become initiating governments was also extended to the Yakama Nation and the Confederated Tribes and Bands of the Colville Nation. Although neither tribe accepted this offer, the Yakama Nation did agree to actively participate in the effort as part of the Planning Unit.

The initiating governments designated the CCCD as the lead agency responsible for developing the WRIA 46 planning process and scope of work; convening representation from a wide range of water resource interests; coordinating watershed plan development; and applying for and managing watershed planning grant funds. In 1998 the CRMP group successfully secured watershed planning act funds from the Washington Department of Ecology to develop a management plan for the Entiat WRIA (WRIA 46), and continue the group's efforts under the framework outlined in the act. With support of the initiating governments and the CCCD, stakeholders and participants that were already part of the Entiat CRMP group reorganized to become the Entiat WRIA (or Watershed) Planning Unit (EWPU). Additional interest groups such as the Yakama Nation and Chelan County P.U.D. also joined and broadened the makeup of the EWPU.

1.2.3 Vision and Goals of the Entiat WRIA Planning Unit (EWPU)

Expanded stakeholder participation and consideration of watershed planning process objectives prompted members of the EWPU to refine the mission statement first developed by the Entiat CRMP group in 1993.

On April 19, 2000, a revised vision and set of goals were adopted by the EWPU:

> To ***voluntarily*** bring people together in a collaborative setting to improve communication, reduce conflicts, address problems, reach consensus and implement actions to improve coordinated natural resource management on private and public lands in the Entiat Water Resource Inventory Area (WRIA 46). Our strategy is to complete a science based watershed management plan using watershed specific information ultimately leading towards compliance with the Federal Endangered Species and Clean Water Acts. Our end products will reflect a balance between existing natural resources and human uses and will capitalize on opportunities to improve these values.

Our specific goals to move us toward this vision under the Watershed Planning Act are as follows:

(1) Optimize quantity and quality of water to achieve a balance between natural resources and current and projected human use.
(2) Provide for coexistence of people, fish and wildlife while sustaining lifestyles through planned community growth, and maintaining and/or improving habitats.
(3) No avoidable human-caused mortality of State and Federal Threatened, Endangered and Candidate species.
(4) Develop and implement an adaptive action plan to address priority issues, emphasizing local customs, culture and economic stability in balance with natural resources. All actions will comply with existing laws and regulations. However, changes to existing laws and regulations will be recommended as needed to attain our common vision and avoid one-size-fits-all solutions.

Recognizing the significance of the roles of limiting factors outside of the watershed and natural events within the watershed, the long-term goal is to have the Entiat River's existing and future habitats contribute to the recovery of listed species and to eventually provide harvestable and sustainable populations of fishes and other aquatic resources.

Since 1993, landowner members of the CRMP Group/EWPU have always insisted that good science be applied to the collection and interpretation of information for all resource elements of concern. They hope that through the continued use of good science, the mission and goals of the group will be met, and with landowner cooperation during implementation, regulating agencies may not find it necessary to apply "One-Size-Fits-All" regulations to achieve their management objectives for the Entiat WRIA.

1.3 SCOPE AND DEVELOPMENT OF THE ENTIAT WRIA 46 MANAGEMENT PLAN

The Entiat and Mad River watersheds together make up what is commonly referred to as the Entiat subbasin. The "Entiat Valley Watershed Study - Draft Coordinated Resource Management Plan" (CCCD 1999) focused largely on this area. Information contained in the document "Watershed Assessment, Entiat Analysis Area, version 2.0" (USFS WNF 1996) covered federal lands within the Entiat subbasin; however, it also included data pertinent to adjacent Columbia River tributaries that fall within the official boundary of the Wenatchee National Forest (WNF) Entiat Ranger District. The additional area covered by the USFS watershed assessment is located along the Columbia River, roughly between Swakane Canyon and the mouth of Navarre Coulee (see Figure 1-1 on page1-8).

The Entiat Final Coordinated Resource Management Plan was released in June 2002, formally ending the CRMP process. The 2002 document also served at the EWPU's first draft of the WRIA 46 Management Plan. The first draft WRIA 46 Management Plan covered the Entiat and Mad River watersheds, as well as the minor Columbia River tributaries that lie to the north and south of the mouth of the Entiat River (see Figure 1-1). It incorporated and updated version 2.0 of the 1996 Watershed Assessment. Revisions to the USFS assessment contained in the 2002 first draft and this final draft document include: edits to Management Strategy Tables 2-3 through 2-8 (found in Chapter 2); an update of the proposed watershed restoration project list (Appendix A); and the addition of a summary of watershed restoration projects completed on National Forest System (and private) lands since 1992 (Appendix B).

A "Final Review Draft" WRIA 46 Management Plan was released to the public on January 23, 2004 for a 70-day review and comment period. A summary of the substantive comments received and responses may be found in Appendix C. This iteration of the Entiat Plan synthesized all data and findings, including new information developed to address the required 2514 water quantity component, as well as the three other components of instream flow, habitat and water quality. The EWPU addressed all four Watershed Planning Act components due largely to the fact that the original Entiat CRMP process and participants had already begun to tackle many resource issues, including fish habitat and water quality, as part of the effort initiated in 1993. The Final Review Draft provided an updated, comprehensive set of policy and project recommendations for resource management in the Entiat valley.

This Entiat WRIA 46 Management Plan was prepared pursuant to Chapter 90.82 RCW. Table 1-1 through Table 1-4 on pages 1-9 through 1-11 summarize the Watershed Planning Act requirements for each of the four components and indicate where associated information is located within the Plan. The WRIA 46 Management Plan also serves as Version 2.5 of the Watershed Assessment for federal lands. It incorporates federal assessment information into a document that emphasizes resource issues on private lands in order to provide a better overall perspective of resource management in the Entiat WRIA.

On May 17, 2004 the Entiat Planning Unit approved this document for submittal to the Chelan County Commissioners for their consideration. A summary of all 2514/EWPU decision points made by consensus prior to this milestone may be found in Appendix D. A

summary of the CRMP group/EWPU outreach and involvement efforts that have occurred throughout the Entiat planning process is found in Appendix E.

A major goal of the EWPU has always been to produce a "living" watershed management plan that will grow, advance, and improve over time rather than sit on the shelf collecting dust. In keeping with that spirit, the Planning Unit views this document as a "working" Entiat WRIA 46 Management Plan. The EWPU fully anticipates that the WRIA 46 Plan will be revisited and updated in the years to come, and continue contributing valuable local input to other processes such as salmon recovery planning.

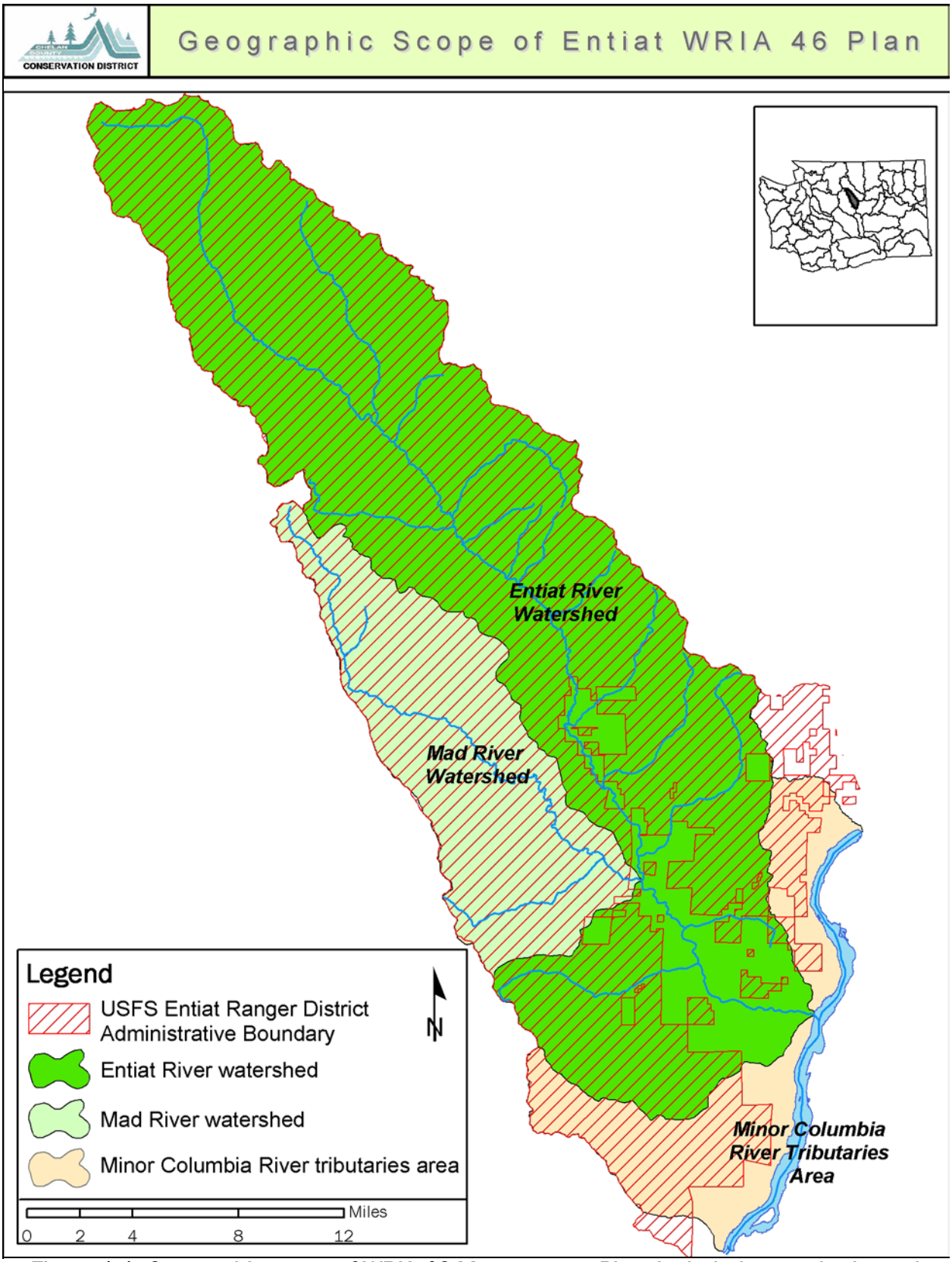


Figure 1-1. Geographic scope of WRIA 46 Management Plan, included watersheds, and comparison to USFS WNF Entiat Ranger District administrative boundary.

Table 1-1. Water quantity component compliance items and crosswalk to plan content.

RCW Section	Stated Items the Assessment Shall Include	Where Addressed in WRIA 46 Plan
90.82.070 (1a)	An estimate of the surface and ground water present in the management area.	Chapter 4: Sections 4.1, 4.3, 4.4, 4.6, 4.7, 4.8, and 4.9
90.82.070 (1b)	An estimate of the surface and ground water available in the management area, taking into account seasonal and other variations.	Chapter 4: Sections 4.3, 4.5, 4.6, 4.7; Chapter 6: Sections 6.4, 6.5, and 6.6
90.82.070 (1c)	An estimate of the water in the management area represented by claims in the water rights claims registry, water use permits, certificated rights, existing minimum instream flow rules, federally reserved rights, and any other rights to water.	Chapter 4, Section 4.8
90.82.070 (1d)	An estimate of the surface and ground water actually being used in the management area.	Chapter 4, Section 4.9
90.82.070 (1e)	An estimate of the water needed in the future for use in the management area.	Chapter 4, Section 4.11
90.82.070 (1f)	An identification of the location of areas where aquifers are known to recharge surface bodies of water and areas known to provide for the recharge of aquifers from the surface.	Chapter 4, Sections 4.6 and 4.7
90.82.070 (1g)	An estimate of the surface and ground water available for further appropriation, taking into account the minimum instream flows adopted by rule or to be adopted by rule under this chapter for streams in the management area including the data necessary to evaluate necessary flows for fish.	Chapter 6
90.82.070 (2)	Strategies for increasing water supplies in the management area, which may include, but are not limited to, increasing water supplies through water conservation, water reuse, the use of reclaimed water, voluntary water transfers, aquifer recharge and recovery, additional water allocations, or additional water storage and water storage enhancements.	Chapter 9, Section 9.1
90.82.070 (3)	The assessment may include the identification of potential site locations for water storage projects. The potential site locations may be for either large or small projects and cover the full range of possible alternatives. The possible alternatives include off-channel storage, underground storage, the enlargement or enhancement of existing storage, and on-channel storage.	Chapter 4, Section 4.13; Chapter 9

Table 1-2. Instream flow component compliance items and crosswalk to plan content.

RCW Section	Stated Items the Assessment Shall Include	Where Addressed in WRIA 46 Plan
90.82.080	If minimum stream flows have not been adopted by rule for a stream within the management area, setting the minimum instream flows shall be a collaborative effort between the department [(Washington State Department of Ecology)] and members of the planning unit. The department must attempt to achieve consensus and approval among the members of the planning unit regarding the minimum flows to be adopted by the department. Approval is achieved if all government members and tribes that have been invited and accepted on the planning unit present for a recorded vote unanimously vote to support the proposed minimum instream flows, and all nongovernmental members of the planning unit present for the recorded vote, by a majority, vote to support the proposed minimum instream flows.	Chapter 5 & Chapter 9

Table 1-3. Habitat component compliance items and crosswalk to plan content.

RCW Section	Stated Items the Assessment Shall Include	Where Addressed in WRIA 46 Plan
90.82.100	If including the habitat component, the watershed plan shall be coordinated or developed to protect or enhance fish habitat in the management area. Such planning must rely on existing laws, rules, or ordinances created for the purpose of protecting, restoring, or enhancing fish habitat, including the shoreline management act, chapter 90.58 RCW, the growth management act, chapter 36.70A RCW, and the forest practices act, chapter 76.09 RCW. Planning established under this section shall be integrated with strategies developed under other processes to respond to potential and actual listings of salmon and other fish species as being threatened or endangered under the federal endangered species act, 16 U.S.C. Sec. 153e1 et seq.	Chapters 7 and 9

Table 1-4. Water quality component compliance items and crosswalk to plan content.

RCW Section	Stated Items the Assessment Shall Include	Where Addressed in WRIA 46 Plan
90.82.090 (1)	An examination based on existing studies conducted by federal, state, and local agencies of the degree to which legally established water quality standards are being met in the management area.	Chapter 8: Sections 8.2, 8.3 and 8.4
90.82.090 (2)	An examination based on existing studies conducted by federal, state, and local agencies of the causes of water quality violations in the management area, including an examination of information regarding pollutants, point and nonpoint sources of pollution, and pollution-carrying capacities of water bodies in the management area. The analysis shall take into account seasonal stream flow or level variations, natural events, and pollution from natural sources that occurs independent of human activities.	Chapter 8: Sections 8.2, 8.3 and 8.4
90.82.090 (3)	An examination of the legally established characteristic uses of each of the nonmarine bodies of water in the management area.	Chapter 8: Section 8.1.2
90.82.090 (4)	An examination of any total maximum daily load established for nonmarine bodies of water in the management area, unless a total maximum daily load process had begun in the management area as of the date the watershed planning process is initiated under RCW 90.82.060.	Chapter 8: Section 8.1.5, 8.5
90.82.090 (5)	An examination of existing data related to the impact of fresh water on marine water quality.	N/A
90.82.090 (6)	A recommended approach for implementing the total maximum daily load established for achieving compliance with water quality standards for the nonmarine bodies of water in the management area, unless a total maximum daily load process has begun in the management area as of the date the watershed planning process is initiated under RCW 90.82.060.	N/A
90.82.090 (7)	Recommend means of monitoring by appropriate government agencies whether actions taken to implement the approach to bring about improvements in water quality are sufficient to achieve compliance with water quality standards.	Chapter 8, Chapter 9, Chapter 10.

2.0 PLANNING CONTEXT AND REGULATORY CONSIDERATIONS

The Plan Parameters section of the Watershed Planning Act (Chapter 90.82.120 RCW) states that:

> "Watershed planning developed and approved under this chapter shall not contain provisions that: are in conflict with existing state statues, federal laws, or tribal treaty rights; ...change existing local ordinances or existing state rules or permits; ...and shall not create any obligations or restrictions on forest practices additional to or inconsistent with the forest practices act and its implementing rules..."

This chapter describes some of the major governing laws that have been considered during the development of this plan, and also discusses how watershed planning in the Entiat WRIA interfaces with other ongoing federal, state, regional and local planning processes.

2.1 FEDERAL

The U.S. Forest Service manages approximately 83% of the land in the Entiat WRIA. Other federal mangers include the U.S. Bureau of Land Management (BLM) and the U.S. Fish and Wildlife Service (USFWS), which is responsible for the operation and management of the Entiat National Fish Hatchery (ENFH). Actions on USFS, BLM and USFWS lands within the Entiat WRIA result from the execution of various federal laws and regulations. Some of the major federal laws governing agency practices that were considered during the development of this plan are described in this section. Management strategies designed specifically for National Forest System (NFS) lands within the Entiat WRIA are contained in the Synthesis Summary Tables section, beginning on page 2-6.

Although most of this section details conditions and management strategies on NFS and BLM lands, partnership opportunities exist for the application of Federal funds to other ownerships. NFS and BLM funds can be utilized off Federal lands if a proposed project supports the agencies' watershed restoration goals (e.g., correcting a fish passage barrier downstream on private lands that restores aquatic connectivity to stream reaches upstream on NFS lands). USFWS funding is available for culvert/diversion replacement, fish screening, and other activities that involve private lands. Other federal and private sources of restoration funding also exist. The potential to obtain such funding is greatly enhanced if an initiative is part of an approved action plan that has been generated through a watershed-wide assessment and prioritization process. The management recommendations outlined in Chapter 9 are designed to guide the development of natural resource management actions on private lands, while noting and emphasizing coordinated restoration efforts across all ownerships.

2.1.1 National Environmental Policy Act

The National Environmental Policy Act (NEPA) of 1969 mandates that all federal agencies "utilize a systematic, interdisciplinary approach that will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision

making, which may have an impact on man's environment." NEPA integrates with a wide variety of existing environmental legislation, including the: Clean Air Act (CAA), Clean Water Act (CWA), Coastal Zone Management Act (CZMA), National Historic Preservation Act (NHPA), Marine Protection, Research and Sanctuaries Act (MPRSA), Pollution Prevention Act (PPA), and the Endangered Species Act (ESA). The NEPA process requires that a detailed statement on the environmental impact of major federal actions that significantly affect the environment be included in every recommendation or report on proposals for legislation.

The USFS publishes a quarterly report, Schedule of Proposed Actions, which details the status of ongoing environmental analyses and announces proposed projects or actions in order to initiate early involvement by interested and affected parties. The BLM conducts environmental analyses and produces decision documents for all ground disturbing activities on Bureau lands. They also publish an annual report on the status of BLM projects. The USFWS publishes a strategic plan for hatchery operations, as well as annual performance plans, to document their goals and project achievements. Appendix A lists some proposed watershed restoration projects, which may be evaluated through the Federal NEPA process. Anyone wanting to be involved in the analysis of any of these projects should contact the agencies to be placed on their mailing list(s).

2.1.2 Endangered Species Act

The Endangered Species Act (ESA) of 1973, as amended, applies to the management of fish, wildlife and plant species that are in danger of or threatened with extinction. The purposes of the Act are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, and to provide a program for the conservation of such endangered and threatened species (T&E species). All federal departments and agencies must seek to conserve T&E species and utilize their authorities to further the purposes of the ESA. Federal agencies are also required to cooperate with State and local agencies to resolve water resource issues in concert with conservation of endangered species.

In addition to mandating specific federal management actions, the ESA also applies to the actions of any person subject to the jurisdiction of the United States. The ESA prohibits the "take" of any species listed as threatened or endangered. "Take" under the ESA, is defined as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct. Significant consideration is given to the ESA when any type of activity within the Entiat WRIA is proposed or undertaken, as T&E species exist within the management area on lands under both public and private management. Proposed habitat recommendations in this plan have been designed to help protect and restore threatened bull trout and endangered steelhead and spring Chinook habitat on private lands within the Entiat and Mad River watersheds.

2.1.3 Clean Water Act

The Federal Water Pollution Control Act of 1972, as amended in 1977, is commonly known as the Clean Water Act (see Appendix F). The Act established a basic structure to regulate discharge of pollutants into U.S. waters, and gave the U.S. Environmental Protection Agency

(EPA) the authority to implement pollution control programs. The Act made it illegal for any person to discharge any pollutant from a point source into navigable waters without a permit, and recognized the need to address nonpoint source pollution issues. The EPA set federal water quality standards, and delegated authority to the Washington Department of Ecology to monitor whether State surface waters are meeting federal water quality standards (see Appendix G). The state is also required to maintain a list of impaired streams (see Chapter 8, Water Quality). The water quality recommendations in this plan have been designed to help address these concerns within the Entiat WRIA.

2.1.4 Federal Land Policy and Management Act

The Federal Land Policy and Management Act (FLPMA) requires the Bureau of Land Management to develop land use plans. In order to meet this requirement the BLM developed the Spokane Resource Management Plan, which includes lands within the Entiat WRIA (approximately 4,424 acres). BLM administered lands in WRIA 46 are designated as Scattered Tracts, and allow most resource activities including recreation, timber harvest, and grazing. These lands have high value as wildlife winter range. BLM lands north of the Entiat River are included within the Entiat Wildlife Recreation Management Area, a wildlife emphasis area that incorporates multiple ownerships and is coordinated through the Washington State Department of Fish and Wildlife (WDFW). Refer to Chapter 3 for more information on public land ownership in the Entiat WRIA.

2.1.5 National Forest Management Act and Northwest Forest Plan

The National Forest Management Act (NFMA) significantly affects the management and decisions of Forest Service land managers. The NFMA directs the Forest Service to develop a Resource Management Plan for each National Forest. The Wenatchee National Forest (WNF) prepared and distributed a programmatic Draft Environmental Impact Statement that analyzed several alternatives for coordinated resource management, and in 1990 released a Final Environmental Impact Statement and a Record of Decision for the preferred Land and Resource Management Plan. The 1990 "Wenatchee Forest Plan" contains management direction for the forest in the form of forest-wide standards and guidelines and management prescriptions for specific management areas (USFS WNF 1990). The various management areas emphasize certain key values and indicate what practices will and/or will not occur within each management area.

The Northwest Forest Plan amended the Wenatchee Forest Plan in April 1994. This amendment modified the Wenatchee Forest Plan management designations and created Late Successional and Riparian Reserves (see Figure 2-1 on the next page). The Northwest Forest Plan also provides numerous standards and guidelines directing management practices on federal lands. Table 2-1 on page 2-5 summarizes the resulting NFS land allocations by acreage within the Entiat WRIA and describes permitted management actions. The BLM's management plan was not affected by the amendment because its administrative lands in the Entiat WRIA are outside of the range of the northern spotted owl.

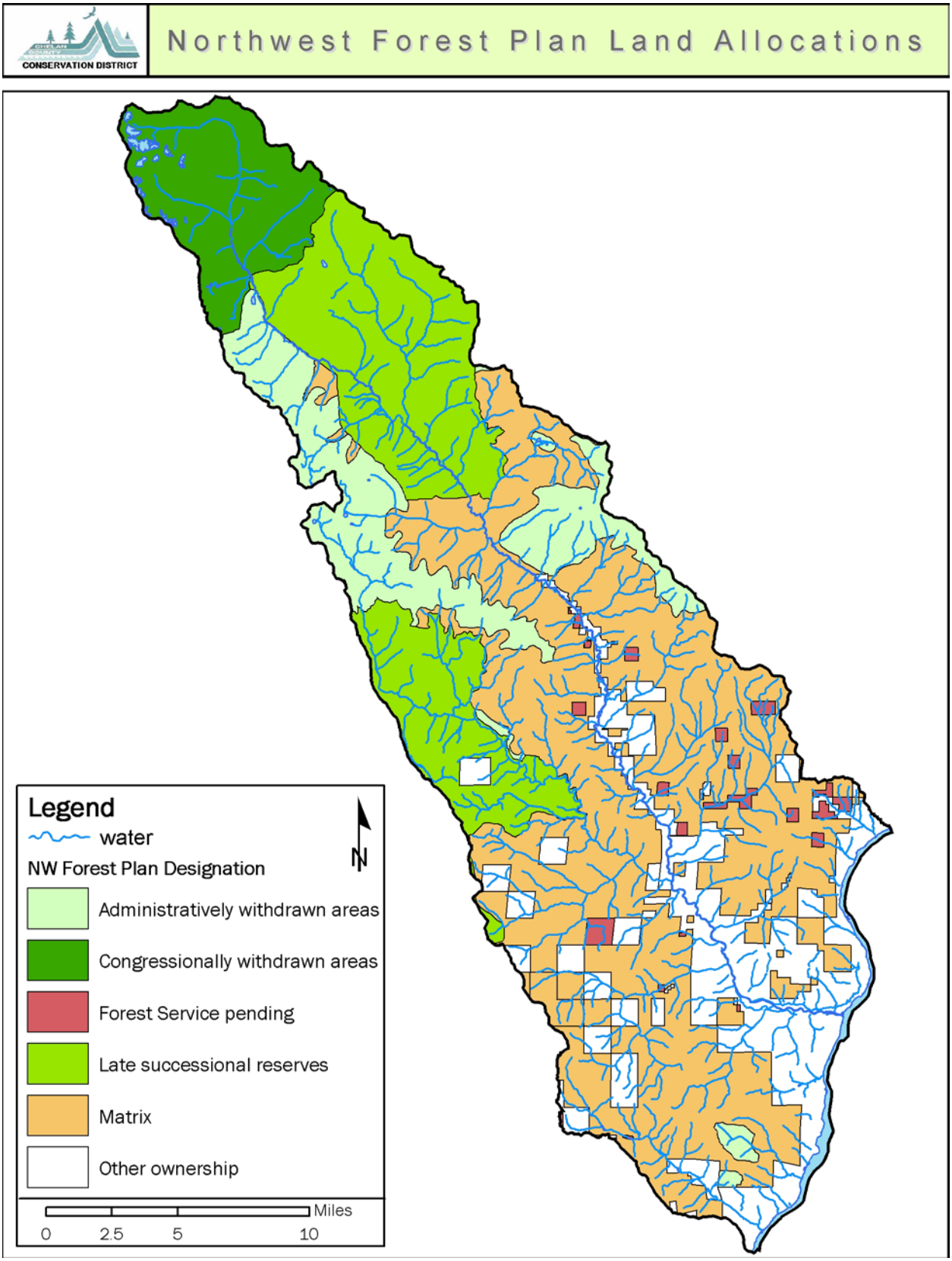


Figure 2-1. USFS Northwest Forest Plan land allocations within WRIA 46.

Table 2-1. USFS land allocations, acreages*, and management emphasis.

LAND ALLOCATION	ACRES+	MANAGEMENT EMPHASIS
Congressionally Withdrawn Areas	25,554.37	Part of the Glacier Peak Wilderness Area. Managed for primitive recreation and research in a primitive setting. No timber harvest.
Late-Successional Reserves	60,139.33	Managed to protect and enhance habitat for late-successional and old-growth related species. No scheduled timber harvest, but allows some tree thinning to enhance desired late successional/old-growth habitat.
Administratively Withdrawn	34,834.61	Wenatchee Forest Plan: Unroaded Dispersed Recreation. No timber harvest.
Riparian Reserves*		Emphasizes protection along all streams, wetlands, ponds and lakes. No scheduled timber harvest but some silvicultural treatments are permitted when they benefit riparian resources.
Matrix*	130,822.96	Lands outside of reserves and managed under prescriptions described in The Wenatchee Forest Plan land allocations. Approximately 65% or 62,958 acres are available for regularly scheduled timber harvest.
Forest Service Pending	3531.31	Lands acquired through exchange or purchase that do not have a Forest Plan allocation assigned to them yet.

***** *Due to varying size of Riparian Reserves, acreage has not officially been calculated for the Entiat RD. The Northwest forest Plan Record of Decision (ROD) reported that Riparian Reserves make up approximately 11% of the federal lands within the range of the northern spotted owl. The following riparian reserve widths are from p.9 of the ROD: Fish-bearing streams - 300 feet slope distance on each side; permanently flowing nonfish-bearing streams - 150 feet slope distance on each side; lakes and natural ponds 300 feet slope distance; seasonally flowing/intermittent streams 100 feet slope distance on each side; and wetlands < 1 acre and unstable/potentially unstable areas - to outer edges of riparian vegetation or extent of unusable areas. The ROD acknowledges these riparian reserve widths are larger than may be necessary in some cases. Site-specific watershed assessments and project analysis can change these default widths.*

+ *Acres reflect USFS allocations within the Entiat WRIA, calculated using WNF Northwest Forest Plan GIS data.*

In addition to creating reserves and prescribing standards and guidelines, the Northwest Forest Plan identified "key watersheds" in Washington, Oregon and Northern California as part of the Aquatic Conservation Strategy. Key watersheds provide habitat critical for the maintenance and recovery of anadromous salmonids and resident fish species. Both the Entiat and the Mad Rivers have been designated as "Tier 1 Key Watersheds", and contribute directly to the conservation of at-risk fish species.

The Northwest Forest Plan requires that watershed assessments be completed before federal land managers proceed with most activities within key watersheds. The first federal watershed assessment for the Entiat subbasin (Version 1.0) was completed in April 1995 as a part of the Tyee Fire Recovery effort. NFS and BLM lands were both addressed in the Assessment. The Watershed Assessment, Entiat Analysis Area, Version 2.0 (USFS WNF 1996) was released to update Version 1.0, expand the analysis area to include adjacent

Columbia River tributaries (e.g., Swakane Canyon), and address rangeland and recreation issues not included in Version 1.0.

A key product of the watershed assessment process was the description of existing resource conditions, identification of desired ecological conditions, and the development of management strategies that would move elements in the watershed toward the desired future condition (refer to Synthesis Summary Tables section, below). As mentioned in Chapter 1, this Plan incorporates and updates Version 2.0 of the 1996 Watershed Assessment and serves as Version 2.5 of the Watershed Assessment for NFS and BLM lands in the Entiat WRIA.

Synthesis Summary Tables

Table 2-2 illustrates the relationship between the dominant issues that framed the scope of both previous iterations of the federal Watershed Assessment, Entiat Analysis Area. Six management strategy tables on the following pages summarize the significant findings of the assessment. Table 2-3 covers items common to all vegetative groups, and Tables 2-4 through 2-8 correspond to each of the five vegetative groups. Tables 2-4 through 2-8 describe existing and desired ecological conditions, and management strategies to move the existing condition towards the desired condition. Desired conditions are focused on ecological conditions and are not intended to make decisions about the occurrence or intensity of management activities (e.g., developed recreation, grazing, timber harvest). Specific decisions regarding management activities are made at the NEPA planning level.

Table 2-2. Assessment issues and related management strategies, Entiat Analysis Area.

Issue	Management Strategies (MS)
Vegetative Structure and Condition	3,8,9,13,15,17,18,28-30,33,34,36,46-50,52-55,58,60,62-64
Wildlife and Fish Populations	1,2,5,6,7,10,12,15,16,18, 23,25,26-37,45,47,49-56, 58,59,62,63
Historic Events/Human Impacts	2-18,21,23,26-31,34,36-42, 46,47,57-59,61,64
Sedimentation	1-7,10-12,17,18,30,34,36,57
Scenic Quality	7,9,11,13-19,21,23,24,30,34,36,38-43,47,49,53,60, 62,63
Watershed Improvement Efforts	1-7,10-12,18,19,27,29,34,36,37,46,47,57,61
Commercial Livestock Grazing	3,6,8,10,25,30,33,44,45,64
Recreation	7,10,11,14,16-24,26,31,42,43,51

More detailed information regarding these results can be found in Chapters 1 through 3 and the supporting appendices of the federal Watershed Assessment; recommended priorities for implementation of proposed management strategies are discussed in Chapter 5 of the Assessment (USFS WNF 1996). Please note that the vegetative groups (e.g., Open Forest) used to organize these tables are delineated based on the potential to develop to the defined group, not the current condition.

Table 2-3. Conditions and management strategies common to all vegetative groups.

Existing Condition	Desired Condition	Management Strategies
Riparian and Wetland Function: In areas where riparian or wetland function is impaired, conditions may include: reduced sediment buffering, decreased organic matter input (fines to large woody debris), increased temperatures (303(d) listing), unstable banks, reduced water storage, reduced riparian vegetation, channel confinement and increased flow velocities. Diminished riparian and hydrologic function translates into decreased habitat structure and diversity.	Improved riparian/wetland hydrologic function to buffer sediment delivery (ground cover), enhance nutrient cycling, provide wildlife security and thermal cover, improve channel stability and flow regulation. Sustained diverse riparian vegetation condition and structure.	**1)** Designate Riparian Reserves using guidelines from WNF Forest Plan, as amended by the NW Forest Plan, until site-specific analysis can refine width needs. **2)** Implement actions that promote maintenance or improvement of riparian area function and channel stability (e.g., road upgrade, relocation or obliteration, beaver re-introduction, revegetation, obstruction removal, large woody debris/boulder placement, water chance reconstruction, etc.). Also follow MSs 34 and 36.
Soil Quality and Hydrologic Function: Soil productivity losses have occurred due to decreases in ground cover, compaction, concentration of runoff and accelerated erosion. The extent and magnitude of this reduction varies widely over the analysis area, depending on the location and cumulative disturbances involved (grazing, high intensity fire, timber harvest, roads, and recreation). **Catchment basins** (zero order drainages) provide important hydrologic functions (collection, storage and release) that may be locally impaired by soil compaction and other disturbances.	Soil-hydrologic processes are properly functioning: infiltration/percolation rates, storage and release of water, aeration characteristics and nutrient cycling are restored. Physical/chemical conditions of the soil profile support overstory and vigorous understory plant communities and associated organic matter content (duff and soil wood) that are within the ecological capability of the site.	**3)** Implement management activities that achieve Forest Plan standards for soil productivity, ground cover and grazing utilization. Also follow MSs 5, 7, and 29. **4)** Implement restoration treatments, which will establish conditions where soils within activity areas will make significant progress toward properly functioning conditions. Investigate and implement ecologically sound techniques for reducing detrimental soil disturbance. Also follow MSs 3, 5, 47, 55, and 61. High priority in deposition zone (LTA E), moderate in transition (LTA C), low in transport zone (LTA A, B).
Tyee Fire-Flood Risk: There is an increased risk of flooding with associated threats to life and property due to the effects of the 1994 Tyee fire.	Vegetative ground cover is restored. Infiltration rates on hydrophobic soils are restored. Concentration of surface runoff is reduced, especially on roadways.	**5)** Implement projects to reduce surface runoff and surface/mass erosion from disturbed sites, especially from roads and moderate-high intensity burned areas (e.g., site revegetation, log terracing, road obliteration, road surfacing, surface water control, activity avoidance, etc.). Also follow MSs 2, 3, 7, 29, 34, and 36.

**Note Management Strategies 6b, p.2-8 and 12b, p.2-10 have been added since version 2.0.*

Existing Condition	Desired Condition	Management Strategies
Critical, Unique & key Species and Habitats: Critical, unique & key habitats for PETS, MIS, S&M and unique endemic species of plants and animals occur in the analysis area. Many of these components are limited and susceptible to natural and management disturbances. The location of many of these species and habitats is unknown. Adequate condition and trend data are lacking to determine status of some of these species.	Critical, unique & key species and habitats locations are identified, sustainable and in sufficient quality and quantity to insure species viability.	**6a)** Identify critical/unique/key species and habitats and their limiting components. Implement management recommendations developed for Survey and Manage (S&M) species where those species occur. Develop species management guides for species and habitats as needed to insure population viability to meet Forest Plan objectives. Avoid creating situations that will contribute to potential hazardous interactions between humans and wildlife. Develop Conservation Strategies and Agreements for sensitive plants as needed. Consider use of protective Forest Plan designations for some of these sites (e.g., Special Interest Areas). Also follow MSs 1, 2, 7, 15, 16, 29, 34 and 36.
Grizzly Bear/Gray Wolf: Grizzly bear and gray wolf are endangered and threatened species, respectively. Habitat occurs in the watershed, but these species are not recovering. Human access and activities limit security needed for these animals to fully utilize their various seasonal habitat components.	Seasonal habitat components are good quality and sufficient quantity for denning, foraging, etc., and remote enough from high human activities to allow the animals the security to use these habitats without adverse interactions.	**6b)** Reduce road densities throughout the watershed. Assess seasonal habitat distribution and needs for these species when developing roads, trails, recreation areas, and other activities. Map habitat components, assess quantity and distribution, establish standards for sufficient habitat within each Bear Management Unit, and monitor for compliance.
Road and Trail System: Road and trail density is high in several subwatersheds. A high percentage of lower slope or riparian roads exists in many of these areas. The maintenance needs of the existing road system exceed annual funding levels. Poor surface water control on roadways alters hillslope hydrology and increases erosion and sedimentation. Riparian roads alter floodplain function. Dense road and trail systems increase human activities, reducing wildlife security, and limiting wildlife use in Fall, Winter and Spring.	The road and trail system is scaled properly to meet access needs and maintenance limitations, while reducing negative impacts to wildlife and other resources (e.g., runoff concentration and accelerated sedimentation from roads and trails is significantly reduced, especially at stream crossings). Hydrologic function is restored. Open road densities are limited in habitats where access is a management concern (e.g., mule deer winter range or near raptor nest sites).	**7)** Continue implementation of restoration projects treating priority road-related problems. Complete and implement an Access and Travel Management (ATM) Plan that will establish season of use, road densities, closure strategies, maintenance requirements, etc. for the system. Develop ATM in concert with all ecosystem uses including recreation. (MS 16). Use trail or road closures as needed to direct recreation use away from key habitat areas and/or areas allocated to specific uses. Identify access routes used for recreation, level of use and potential conflicts with wildlife/plant habitats. Also follow MSs 2 and 5.

Existing Condition	Desired Condition	Management Strategies
Noxious Weeds: Noxious weeds are present. Soil conditions and ground disturbing activities promote further spread. Decline in vegetative conditions is especially prevalent in areas with soil productivity losses (e.g., compaction, and soil disturbance/loss through accelerated erosion of sandy soils in shrub/steppe). Problems are most significant in the open vegetative conditions of the shrub/ steppe, open forest and open subalpine; whereas, roads, trails and short-term openings are a concern in the closed forest and closed subalpine.	Noxious weeds are absent or populations are at very low levels. Healthy stands of native vegetation retard invasion and establishment of noxious weeds and soil productivity losses are minimized.	**8)** Develop an integrated weed management strategy for the area. Reduce the risk of infestation and spread of noxious weeds. Establish desirable, aggressive grasses and shrubs capable of restricting expansion of weeds, using natives where possible (e.g., Mud Creek meadows). Consider direct control activities on populations. Identify highly erodible, invasion-prone areas as unsuitable for livestock grazing in Allotment Management Plans, including the Columbia River Breaks. Also follow MSs 3, 7, 29, 30 and 44.
Vegetation Management: Management practices have altered disturbance processes such as fire, insects and disease, allowing these processes to affect ecosystem conditions at a larger scale than occurred historically.	Fire, insect and disease processes are present and function at the tree, stand and small-scale landscape levels.	**9)** Conduct vegetative management projects designed to retain these processes at appropriate scales. Also follow MSs 28-30, 46-49, 52-55 and 62-64.
Planning Coordination: Coordination between the public, private landowners, land management and regulatory agencies, the Yakama Nation and the Colville Confederated Tribes and local schools on resource management issues has been limited.	Coordination on management issues and actions provides a role for all stakeholders in the watershed.	**10)** Foster coordination with the public, other agencies, landowners, tribes and the Entiat community for aquatic, riparian, fire protection/suppression and recreation issues to accomplish mutual watershed goals. **11)** Expand existing public involvement and information program, focused on a shared understanding of the ecological roles of people, fire, erosion, etc. Continue active support of Columbia Breaks Fire Interpretive Center.
Inventory/Monitoring Coordination: Various agencies and private citizens are collecting inventory and monitoring information on resources and management activities within the analysis area; however, coordination of these efforts is still somewhat limited.	Inventory and monitoring activities conducted in the drainage are well coordinated, eliminating duplication of effort, increasing quality control and improving information sharing.	**12a)** Implement a coordinated monitoring plan targeted at priority issues and post-fire recovery, including an early warning system for storm events.

Existing Condition	Desired Condition	Management Strategies
Project Implementation on Non-Federal Lands: Existing opportunities to enhance the effectiveness of watershed restoration and community development efforts through partnerships with adjacent landowners, governments and other agencies are not being fully realized. As a result, complete watershed restoration packages cannot be assembled, coordinated treatments cannot be implemented and resulting cost efficiencies are not being achieved in some areas.	Federal participation in watershed restoration and community development projects on non-Federal lands is increased, resulting in more rapid and efficient achievement of ecosystem goals for the entire watershed. Federal policies supporting such coordinated actions are maintained (e.g., Rural Community Development Program, Wyden Amendment authorization, USFWS Partners Program).	**12b)** Develop and maintain working partnerships with adjacent landowners, local governments and other resource agencies that incorporate Federal participation in priority projects on non-Federal lands that achieve goals of mutual benefit to all parties (e.g., correcting a fish passage barrier downstream on private lands that restores aquatic connectivity to stream reaches upstream on NFS lands through a watershed restoration agreement).
Landscape Appearance: Some of the landscape is in an altered condition as shown on the scenic condition map.	Landscape appears to be natural.	**13)** Within the Tyee Fire perimeter, maintain representative mix of all 3 burn intensities for short-term scenic purposes. Also follow MS 34. **14)** Revise the Entiat Valley Visual Corridor Plan (1978) in concert with the recreation use plan (MS 16).
Snags and Logs: Within burned areas, large amounts of standing dead trees exist now in all size classes; there will likely be a shortage of snags in the future when these trees fall and before replacement trees can grow.	Snags and logs are present at levels meeting the ecological capacity of the site.	**15)** Manage snags and logs based on site-specific analysis using current policies and guidelines (quantitative standards in WNF Forest Plan and NW Forest Plan in unburned areas; WNF Fire Recovery snag guidelines in Tyee Fire burned area).
Recreation Planning: Conflicts exist between user groups and values. During recent years the District has experienced an increase in recreation use (sightseeing, hiking, snowmobiles, motorcycles, horseback riders, mountain bikers to name a few).	No conflicts between competing user groups.	**16)** Develop a Comprehensive Recreation Use Strategy Plan linked to Access Travel and Management Plan. Discourage recreation developments near critical, unique & key wildlife habitats. Use trail or road closures as needed and other management actions to direct recreation use away from key habitat areas and/or areas allocated to specific uses. Identify access routes used for dispersed recreation, level of use and potential conflicts with wildlife/plant habitats. Foster coordination with the public, other agencies, landowners, and the Entiat Community to accomplish recreation goals and address recreation issues. Follow MSs 7, 10, 11, 14 and 40.

Existing Condition	Desired Condition	Management Strategies
Developed Recreation Uses, Site Impacts: Heavy use of developed campgrounds and popular trailheads has resulted in: unacceptable levels of soil disturbance (compaction, erosion); vegetation loss/removal (trampling, firewood cutting); excess noxious weed establishment; lack of down woody debris (particularly in riparian areas); and bank stability problems at localized concentrated-use points. User-built trails are a problem.	Natural Appearing landscape character and scenic condition. Maintained and/or improved vegetative cover. Noxious weeds are minimized. Minimize adverse impacts on soil productivity, riparian and channel conditions at developed campgrounds and popular trailheads. Minimize transfer of adverse impacts to other areas (riparian areas). Acceptable travel routes are provided through riparian areas and acceptable recreation facilities are provided.	**17)** Vegetation management plan developed that will allow for long-term, sustainable use of the resource (Including noxious weed management). Harden high use areas with material compatible with ROS (Recreation Opportunity Spectrum). Provide structures such as hitch rails to control stock at primary horse entry points. Evaluate sites and develop a management strategy that considers site upgrades, closures/hardening of sites and trails and construction of sanitation facilities in appropriate locations. Limit vehicle access to dispersed sites. Turnpike, bridge, harden, or relocate trails to protect wet areas. Restoration of some areas as needed. Promote and educate public about use of weed-seed-free feed. **18)** Implement a socially acceptable, developed site rehabilitation/maintenance program, to include: a) Public info about need to protect riparian vegetation and banks, b) Provide firewood and actively enforce cutting ban, c) Plant native grass/forb/tree species for ground cover and rooting, d) Provide suitable cover in high-traffic areas (chips), e) rehabilitate damaged banks and f) relocate campsites away from banks wherever feasible. Utilize the Respect the River Program as an implementation tool. Also follow MS 20. **19)** Provide recreation stock facilities at appropriate developed recreation sites. Follow MSs 3, 8, 16, 20, 29 36, and38.
Developed Recreation Sites, Safety Concern: Dead, dying and defective trees pose a safety hazard.	Sites meet established standards for health and safety code.	**20)** Manage vegetation to be compatible with human use and safety. Also follow MSs 2, 3, 34, 36 and38.

Existing Condition	Desired Condition	Management Strategies
Dispersed Recreation Use, Site Impacts: Localized detrimental soil disturbance, particularly compaction, loss of ground cover, erosion and surface water concentration, has occurred at heavily used dispersed sites; especially at alpine sites (meadows) and trail channel crossings. Heavy use of dispersed sites has resulted in unacceptable loss/removal of woody debris and vegetation (trampling, firewood cutting). Dispersed sites have inadequate sanitation facilities.	Natural appearing landscape character and scenic condition. Hydrologic processes are properly functioning; infiltration rate, storage capacity and release of water are restored. Minimize adverse impacts to riparian and channel conditions at dispersed sites. Minimize transfer of adverse impacts to other areas (riparian areas). Acceptable travel routes are provided through riparian areas and acceptable recreation facilities are provided. Sanitation strategies are adequate.	**21)** Implement a socially acceptable dispersed site rehabilitation/maintenance program. Utilize the Respect the River Program as an implementation tool. Also follow MSs 2, 6, 7, 16-18, 34 and 38. **22)** Provide recreation stock facilities within the Wilderness and at appropriate dispersed recreation sites.
Change of Viewshed - Smoke and Dust Impacts on Air quality: Summertime dust from roads and trails, smoke from all types of burning, and "metro" area smog detracts from the viewing and recreation experience.	Natural appearing landscape character and scenic condition. Recognition that some level of smoke from natural and prescribed fire will be present at times in the process of achieving this landscape character. Human-caused levels of dust are reduced in major campgrounds and roadways Smog reduced due to the effectiveness of regional control efforts.	**23)** Design prescribed fire to promote maintenance of natural landscape character within smoke management constraints. Utilize burning techniques that minimize smoke production and maximize dispersal (follow Washington State Smoke Management Plan). On existing facilities (e.g., roads, campgrounds), promote frequent maintenance and use dust abatement techniques where appropriate. Incorporate dust abatement measures into the design of new facilities where appropriate. Reduce number of roads or convert to trails. Also follow MS 7.
Expectation of Quality Recreation Facilities: There are a wide variety of recreation facilities at various levels of condition. In some cases the needed facilities are absent or existing sites require upgrading to meet projected use and accessibility standards.	Attractive, well-maintained and designed recreation facilities appropriate to the ROS class of the area are present.	**24)** Develop a long-term strategy for the improvement and expansion of recreation facilities to accommodate the growing need where other resources can be protected. Component actions would include: a) implementation of the Recreation Facility Accessibility Survey findings, b) update of recreation facilities condition surveys through the INFRAstructure program, c) update of facility improvement priorities (Forest Plan Appendix A), and d) review and validation of current inventory of areas for potential expansion of recreation opportunities. Also follow MSs 11, 16, 18 and 40.

Existing Condition	Desired Condition	Management Strategies
Domestic-Bighorn Sheep Contacts: Swakane bighorn sheep population is not growing as expected. There is a potential for disease in bighorn sheep from exposure to domestic sheep from adjacent allotments.	Desired population levels and areas to be managed for bighorn sheep are clearly defined.	**25)** Develop a comprehensive bighorn sheep management plan in cooperation with WDFW and USFWS. This plan will integrate existing State and Forest plans and will extend beyond the Entiat Analysis Area. Annual operating plans will require that domestic sheep grazing will be kept within allotments.
Native Aquatic Biota: Reduced native sport fish populations and altered distribution by stocking as a result of proximity of trail/road system to streams.	Genetic viability and variability of existing native aquatic biota are not reduced.	**26)** Minimize/avoid streamside trails and camps. Also follow MS 7.
Pre-Attack Facilities: Pre-Attack facilities such as fuel breaks and water chances exist throughout the watershed. Some are in poor condition (due to lack of past maintenance or effects of recent fires) and are causing resource damage.	Pre-Attack facilities are functional and are an important part of limiting effects of catastrophic fires.	**27)** Maintain a mix of Pre-Attack facilities consistent with other resource needs and the Federal/private interface. For example, water chances constructed to maintain channel stability and fish passage.

Table 2-4. Conditions and management strategies for the Shrub/Steppe vegetative group.

Existing Condition	Desired Condition	Management Strategies
Vegetation		
Altered Vegetative Structure and Condition - Fire: Most of area burned in Tyee and Dinkelman fires resulted in loss of much of shrub component and scattered large pines. Condition of the shrub component in these recently burned areas approximates pre-settlement conditions; whereas, unburned areas have a higher percentage of shrubs (lower percentage of grass-forb) than existed prior to pre-settlement.	There is a mix of shrub age classes, grasses and forbs associated with scattered large pines. Native ground cover capable of resisting noxious weed expansion. Plant communities produce structurally diverse, vigorous groundcover that approaches a natural grassland condition.	**28)** Replicate natural fire regimes, on a landscape scale, with low intensity underburns that promote fire resilient understory and fire tolerant overstory (minimize development of ladder fuel structures). **29)** Encourage the development of native shrubs and forbs to provide a mix of vegetative composition and structure.
Altered Vegetative Structure and Condition - Grazing: Altered vegetative community structure due to historic over-grazing with fire exclusion: decline of native perennials--increase of annuals and noxious weeds; decline of native mid-level shrubs, especially in riparian areas. Concentration of livestock in valley bottoms has resulted in loss of vegetation and trampling of streambanks in some areas.	A structurally diverse, vigorous native shrub and grassland community (natives) exists. Vegetative structure and condition in riparian areas supports fully functional riparian-channel system. Naturally appearing vegetative mosaic exists at the landscape scale.	**30)** Manage grazing levels to maintain understory plant vigor and structure in allotments. Also follow MSs 4, 8, 28, 29, 34, 40, 44 and 64.
Wildlife		
Mule Deer Cover and Forage: There are abnormally low levels of mule deer cover and forage due to the extent of recent burns.	Deer populations and the level of mule deer cover and forage are in balance.	Follow MS 29 and work with the WDFW to balance mule deer populations with available cover and forage.
Human Activities in Mule Deer Winter Range: Human activities reduce habitat effectiveness of deer winter range. Concern exists that increasing levels of winter recreation in lower Entiat mule deer winter range may be causing harassment and displacement of wolves and deer from key habitat.	Human activities in winter are confined to corridors and have minimal impact on deer and wolves.	**31)** Direct winter recreation use to corridors through deer winter range during access management planning and implementation. Also follow MSs 7 and 16.
Grouse Populations: Sage grouse and sharp-tailed grouse are extirpated.	Areas to be managed and potential populations of these grouse are defined and managed under a Species Management Guide.	**32)** Inventory habitat and potential for these species. Develop species management plans for sharp-tailed grouse and sage grouse.

Existing Condition	Desired Condition	Management Strategies
Cover for Ground-Nesting Birds: Reduced vegetation height, density, and composition resulting from grazing, fire and exclusion of disturbance reduces nesting cover for ground-nesting birds. Limited quality cover exposes these birds to the elements and greater predation, resulting in lowered reproductive success.	Proper forage utilization maintains sufficient cover for prolific populations of ground-nesting birds.	**33)** Promote development of more diverse structure and distribution of native shrubs and forbs over the entire landscape. Also follow MSs 6, 28 and30.
Riparian Vegetative Structure and Condition: Vegetative structure in riparian areas is poor, with low populations of low to mid-level shrubs. Riparian areas not providing wildlife habitat near their capability i.e., they are lacking the structure provided by deciduous components. Vegetative functions in buffering sediment delivery, providing shade, organic input (fines and large wood) and bank stability are degraded.	Vegetation structure in riparian areas approximates historic conditions and supports natural functions (diverse mix of low and mid-level shrubs, as well as deciduous trees).	**34)** Promote all layers of vegetative structure in riparian areas (grass, forbs, low to mid-level shrubs, trees and unique habitats). Also Follow MS 2.
Unique Habitat-Columbia River Breaks: The varied terrain and rocky sites in close proximity to the Columbia River add to the potential for unique habitats for plants and animals to be found within these areas. There is little current knowledge of these areas on which to draw for analysis of effects of potential management activities.	The areas are surveyed for better understanding of distribution of species and habitats. Information is available for proper management and analysis of potential management activities on these lands, the adjacent watersheds and within the province.	**35)** Complete provincial-level wildlife species guild analysis. Also follow MS 6.
Soil/Water/Fish (also applicable to Open Forest)		
Large Woody Debris: In this zone, large woody debris (both present and potential) is lacking in many streams, especially fish-bearing waters (Ref App page F-62 in Watershed Assessment Entiat Analysis Version 2.0 WNF).	Vegetative structure and condition in riparian areas is restored, providing for adequate recruitment of large woody debris.	**36)** Maintain, plant or encourage large diameter native tree species in riparian reserves. Also follow MS 34.
Erosion/Sedimentation: In this zone, erosion, sediment delivery and sediment storage in channels and on floodplains are all high.	Accelerated sedimentation is reduced from existing condition and not adversely affecting beneficial uses.	Follow MSs 2, 5, 7, 29 and 36.

Existing Condition	Desired Condition	Management Strategies
Riparian Road Density: Road densities are high in riparian areas. These roads intercept sub-surface flows, concentrate runoff, increase sedimentation, confine channel migration and reduce security and other wildlife habitat values.	Riparian habitat values and floodplain function are restored.	Follow MSs 2, 5, 7, 34 and 36.
Stream Channels: Many stream channel segments in this zone are artificially constrained and simplified by roads, development, channelization, event response structures (flood and fire rehabilitation) and other uses.	Stream channels are healthy and functioning within historic limits.	**37)** Evaluate the need to remove or modify existing BAER (define) structures (check dams) following their effective lifespan. In developing rehab plans for future events, consider habitat connectivity and long-term, material transport processes at sites proposed for treatment. Major emphasis on coordinated resource management (MS 10).
Fish Habitat: Rearing and holding habitat, off-channel and in-channel winter rearing habitat, spawning habitat and resident adult habitat in this zone are in fair to poor condition in all stream segments.	Spawning, rearing and holding habitats are at or near their natural capabilities. Habitat connectivity is present, man-made barriers to fish passage are not present.	Follow MS 2. Major emphasis on coordinated resource management (MS 10).
Scenery/ Recreation		
Landscape Appearance: Landscapes are a mix of altered and natural-appearing.	A natural-appearing character theme and condition is present for scenic travel routes, viewsheds and recreation settings.	**38)** Manage foreground and middle ground for scenic purposes. **39)** Rehabilitate altered landscapes as shown on scenic condition map. **40)** Use scenic management system for landscape aesthetics to maintain and enhance scenic resource. **41)** Recent Decision Notices manage foreground of Potato Creek Road #5380, Baldy Mtn. Road #8410, Steliko Ridge Trail and Tyee Road # 5700 at a higher Visual Quality Objective (VQO) than Forest Plan indicates. Future actions will consider the appropriateness of continuing these VQOs given the extent of wildfire disturbance. Also follow MSs 13, 14 and 34.

Existing Condition	Desired Condition	Management Strategies
Change of Viewshed - Road Density: Road density and/or locations present an altered appearing landscape. As a result of the Tyee fire, some roads are more visible because vegetative screening burned.	Landscape that appears more natural, roads blend in and are more subordinate to the characteristic landscape patterns. Some roads may be converted to trails. A Natural Appearing landscape character theme and scenic condition is present for scenic travel routes, viewsheds and recreation settings.	**42)** Evaluate foreground and middleground views from major and secondary travel routes. Reduce middleground views of high-density roads in the following areas as viewed from major and secondary travel routes: Preston/Brennegan Creek, Mills Canyon/Roaring Ridge, Lower Mad River, and Chumstick. Reduce views of roading by establishing vegetative screens. Roads may be converted to trails where appropriate for all ranges of ROS classes. Also follow MSs 7, 38-41.
Change of Viewshed – U.S. Highway 97, 97A (U.S. Hwy 2) and Hwy 971 –Segment of Cascade Loop Tour: Most of the viewshed is Natural Appearing, but some areas are altered through management activities in middleground areas.	A Natural Appearing landscape character theme and scenic condition is present for scenic travel routes, viewsheds and recreational settings.	**43)** Manage middlegrounds for scenic purposes. Maintain/establish native vegetation in altered areas. Also follow MSs 11, 29, 38 and 40.
Range Uses		
Range Allotment Conditions: Prior to the Tyee Fire, most upland areas in existing allotments were in fair to good condition. Valley bottoms were in poor to very poor condition. Livestock concentration in valley bottoms is a concern. Desirable perennials are being replaced by annuals and noxious weeds in shrub/steppe and open forest areas. Many range improvements were damaged or destroyed by Tyee Fire.	Adequate ground cover is maintained to promote infiltration and reduce surface runoff. Vegetative structure and condition in riparian areas supports fully functional riparian-channel system. A diverse and vigorous assortment of well-established perennial grasses is maintained in the uplands. Noxious weed populations are confined. Range improvements are well maintained and do not promote resource damage (e.g., valley bottom concentrations).	**44)** Develop Allotment Management Plans that will: (a) Prioritize range improvement rehabilitation, (b) Identify and resolve grazing concerns (e.g., south slopes, weed prone areas, etc.), (c) Identify transitory range opportunities, (d) evaluate opportunities to realign pasture boundaries in more logical manner or adjust timing and (e) Identify key use areas and develop management strategy for protection, rehab, etc. Inventory range improvement conditions and develop multi-year plan to rehabilitate priority developments. Follow FP Standards for RNAÆs and sensitive species management. Use water developments to avoid negative impacts on vegetation (e.g., riparian areas, seeps and springs, sensitive areas). Also follow MSs 1, 2, 6, 8, 29, 30, 34 and 64.
Wildlife-Domestic Forage Competition: Mule deer, bighorn sheep and domestic livestock compete for existing forage. The degree of competition between them is unknown.	Permitted grazing and wildlife forage needs are in balance with proper use of forage production.	**45)** Analyze forage availability, refer to Forest Plan Standards and allocate forage use between mule deer, bighorn sheep, and domestic livestock appropriately. Season of use and varied grazing systems may be used to regulate forage use. Also follow MS 29.

Table 2-5. Conditions and management strategies for the Open Forest vegetative group.

Existing Condition	Desired Condition	Management Strategies
Vegetation		
Altered Vegetative Structure and Condition - Recent Fires: Early and mid successional stages are predominant due to fires since 1970. Shrub component in understory greatly reduced due to recent fires; much of existing overstory is dead with the exception of occasional green clumps.	A mix of successional stages exists, providing a mosaic of vegetation. Grassland shrub understory with pine overstory 10 to 50% crown closure. Understory consists of 5 to 15% shrubs.	**46)** Manage to achieve vegetative conditions and fuel profiles/distributions that support low to moderate fire intensities and more natural frequency regime. **47)** Maintain sufficient snag, down wood and soil wood levels to meet soil productivity, wildlife and scenic needs. **48)** Utilize varied strategies that reduce the development of high stocking levels including prescribed fire, mechanical fuel treatment and harvest. Also follow MS 28.
Altered Vegetative Structure and Condition - Unburned Areas: Unburned portions of this zone have low levels of standing dead and down, high levels of standing small diameter green trees. Stocking is higher than under historic conditions and ladder fuels are high (shrub and suppressed trees). With these fuel loadings, the potential for moderate-high intensity fires is high.	Stand structures are such that the potential for high and moderate intensity fires is low. Fuel profiles are present that support low to moderate intensity fires as opposed to high intensity, stand replacing fires. Fire frequency closer to natural regime.	**49)** Maintain a wide spacing of park-like ponderosa pine. Thin smaller diameter trees to reduce densities. Maintain denser stands (protected by surrounding low fuel areas) on selected sites to meet other resource management objectives. Also follow MSs 28 and 46.
Altered Vegetative Structure and Condition - Grazing:		See text for MS 30.
Wildlife		
Mule Deer Forage and Cover: There is a shortage of both forage and cover areas for deer.	Clumps of coniferous trees providing cover and open foraging areas are present and well distributed.	**50)** Manage stands of thermal cover on strategically selected sustainable sites. Also follow MSs 28 and 29.
Human Activities in Mule Deer Winter Range:		See text for MS 31.
Unique Habitat-Columbia River Breaks:		See text for MS 35.
Riparian Vegetative Structure and Condition:		See text for MS 34.
Soil/Water/Fish		
See Existing Condition for Shrub/Steppe.	See Desired Condition for Shrub/Steppe.	See Management Strategies for Shrub/ Steppe.
Scenery/Recreation		
Landscape Appearance: Some of the landscape is in an altered condition as shown on the scenic condition map.	Landscape is natural appearing.	Follow MSs 13, 14, 34, 38-41.
Change of Viewshed-Road Density:		See text for MS 42.
Change of Viewshed - U.S. Highway 97, 97A (U.S. Highway 2) and Segment of Cascade Loop Tour:		See text for MS 43.

Existing Condition	Desired Condition	Management Strategies
Large Woody Debris (LWD) and Recreation Facilities Protection: Debris jams in this zone (e.g., Mad River) have impacted recreational facilities (primarily bridges and trails).	Recreational facilities are located or constructed in such a way that they do not interfere with natural channel-forming processes.	**51)** Relocate facilities where appropriate. In other situations (e.g., emergency responses), implement actions that result in retention of LWD material in existing sizes, while protecting recreation facility (e.g., winching and realignment, temporary abandonment, etc.). Also follow MSs 2 and 16.
Range Uses		
Range Allotment Conditions:		See text for MS 44.
Wildlife-Domestic Forage Competition:		See text for MS 45.
Cover for Ground-nesting Birds:		See text for MS 33.

Table 2-6. Conditions and manaement strategies for the Closed Forest vegetative group.

Existing Condition	Desired Condition	Management Strategies
Vegetation		
Successional Stages: Disapportionate amounts of early successional stage exist due to large fires since 1970. Unburned portions of zone are predominantly mid-successional and higher in density than under historic conditions. Unburned, higher elevation portion of zone is providing excellent spotted owl habitat (i.e., late successional stage with multi-layered grand fir understory).	Areas of open grown, park-like ponderosa pine are present with interspersed mosaic of early-mid-late successional stages, as needed to meet resource requirements. For example, a mosaic of successional stages throughout the higher elevation portion of the zone (at roughly 1/3 of each structural stage) should exist for spotted owl habitat.	52) In reforestation, favor ponderosa pine widely spaced in lower elevations of zone and dry sites; favor Douglas-fir over grand fir in higher elevation, mixed conifer, and moist sites. 53) Protect remaining green stands (late successional) and manage entire zone to achieve a mosaic of successional stages, arranged in a natural functioning and appearing mosaic (Further analysis is needed to evaluate ability to create 1/3 mosaic, especially in the short-term, within existing constraints (e.g., LSRs)). 54) Manage stocking levels in green stands to favor larger diameter, wider tree spacing where owl habitat is not a primary consideration (ponderosa pine in drier areas, Douglas-fir in more moist sites). Also follow MSs 15, 46, and 47.
Fuel Loading: This zone contains a high density of smaller-diameter, standing dead trees. Unburned sites are also characterized by relatively high fuel loadings.	Fuel profiles are characteristic of low-moderate fire intensity instead of supporting high intensity, stand replacing fires. Fire frequency closer to natural regime. Defensible space is maintained around structures.	Follow MSs 46 and 47.
Large Diameter Trees: There is a shortage of large diameter trees (> 20 inches dbh) due to past fires or timber harvest in the unburned portions of zone. Those present have low levels of cavities suitable for wildlife.	Large trees are present, many having defect characteristics that support cavity development.	55) Maintain existing and favor growing large diameter trees. Also follow MSs 54 and 58.
Wildlife		
Carnivore Habitat Limitations: Habitat is limited for native species such as fisher, wolverine, marten and lynx.	Native animal species are present Habitat supports viable population levels. Road densities < 1 mile per sq mi.	56) Maintain high density down wood concentrations for native species. Also follow MSs 7and 53 within existing constraints (e.g., LSRs).
Human Activities in Mule Deer Winter Range:		See Text for MS 31.
Soil/Water/Fish		
Existing Debris Slides: Debris slides and channels have formed as a result of fire-flood events.	Old debris channels are undisturbed; surface runoff is not concentrated as a result of human activity. Channels and riparian corridors are in a condition to accommodate natural hillslope functions.	57) Avoid road locations or other management disturbances in and tributary to old debris channels and in areas of high mass wasting hazard.

Existing Condition	Desired Condition	Management Strategies
Large Woody Debris (LWD): Approximately 50% of surveyed stream reaches in this zone do not meet Forest Plan standards for large woody debris.	LWD is present at Forest Plan standards in all stream reaches. Debris jams and step pool profiles approximate historic conditions. LWD recruitment is at the appropriate, sustainable level for the vegetative type and site conditions.	**58)** Avoid removal of trees larger than 20 inches dbh from riparian reserves. (especially on class I to III waters). **59)** Where appropriate, change Forest Plan standards to be in line with natural capability. Also follow MSs 2 and 36.
Primary Pools: Less than 25% of surveyed stream reaches have large pools that meet Forest Plan standards.	Deep pools exist that meet Forest Plan standards with adequate cover and well vegetated banks.	Follow MSs 2, 34, 36, 58 and 59.
Aquatic Habitat Diversity: Riffle habitat dominates most reaches, but diversity is provided by small pools formed by large woody debris.	Habitat complexity provides for all life stages of all native aquatic species.	Follow MSs 2, 34 and 59.
Scenery/Recreation		
Landscape Appearance: The zone consists of a mix of natural appearing and altered landscapes.	Landscapes are natural appearing and consist of a diverse composition of plants and age classes including large (> 20 inch dbh) trees.	**60)** Re-establish and/or maintain western larch where adapted and appropriate. Also follow MSs 13, 14, 38-41, 53 and 55.
Change of Viewshed - Road Density:		See text for MS 42.
Recreation Facilities Protection:		See text for MS 51.
Range Uses		
Range Allotment Conditions:		See text for MS 44.
Wildlife-Domestic Forage Competition:		See text for MS 45.
Cover for Ground-Nesting Birds:		See text for MS 33.

Table 2-7. Conditions and management strategies for Closed Subalpine vegetative group.

Existing Condition	Desired Condition	Management Strategies
Vegetation		
Successional Stage: Vegetation is predominantly mid and late successional stage with mid successional often comprised of mature lodgepole pine overstory. In such cases stands are typically dense with > 1000 stems per acre. High numbers of snags and down woody debris < 20 inches dbh.	Zone is made up of a mosaic of vegetative conditions with most stands in mid-late stage.	Follow MS 53 to favor lynx habitat where appropriate.
Wildlife		
Carnivore Habitat Limitations:		See text for MS 56.
Soil/Water/Fish (Also applies to Open Subalpine)		
Groundwater Interception: Management activities, primarily roads, have intercepted near-surface groundwater, especially in the Cougar and Lake Creek areas (LTAs C and B).	Subsurface flow interception and runoff concentration from existing facilities is reduced. Additional disruptions of near-surface groundwater movement are minimized.	**61)** Existing and planned road and trail locations and drainage structures need to be improved/ planned to account for high levels of near surface groundwater storage and flow in these soils. Also follow MSs 5 and 7.
Stream Channel Confinement: Some stream channel segments are constrained by roads and riparian function (sediment buffering) is impaired.	Floodplains are fully functional and streamflows are well regulated over the entire year. Maximize storage of subsurface flows as near surface ground water.	Follow MSs 2-4, 7, 34 and 61.
Primary Pools: Less than 25% of surveyed stream reaches meet Forest Plan standards for primary pools.	Pools exist within the ecological capability of the site. In this case pool occurrence is partially limited by high gradient reaches. Existing Forest Plan standards are not achievable.	Follow MS 59.
Fish Habitat Condition: Rearing and holding habitat, off-channel winter rearing habitat, in-channel winter rearing habitat and spawning habitat are in fair to good condition.	Substrate fines are acceptable for bull trout spawning and other aquatic organisms (<20% fines of <1.0mm diameter).	Follow MSs 2, 5, 34 and 36.
Scenery/Recreation		
Landscape Appearance: Natural Appearing landscape.	Natural Appearing landscape.	Follow MSs 38, 40 and 41.

Table 2-8. Conditions and management strategies for the Open Subalpine vegetative group.

Existing Condition	Desired Condition	Management Strategies
Vegetation		
Meadow Succession: Some conifer encroachment of meadows exists, forested areas are mostly late successional. Encroachment is escalating in some "significant" meadows that provide special recreation experiences. They are special places for people.	There is a naturally appearing mosaic of meadows and conifer patches.	62) Inventory, analyze and evaluate site-specific conditions and develop integrated meadow plan. Identify conditions that maintained meadows naturally and how to best restore desired openings. Implement restoration of "significant" meadows with low intensity underburns or mechanical/manual treatments to retard or reverse conifer encroachment. Emphasize appropriate fire suppression response while considering maintaining a natural appearing vegetative mosaic. Also follow MS 11.
Whitebark Pine: Whitebark pine is infested with blister rust.	Healthy whitebark pine is an important component of forested landscape, providing food and cover for a variety of birds and mammals.	63) Evaluate appropriate options for preserving WB pine stands through disease resistant stock (genetic resistance to blister rust). Also follow MS 62.
Sheep Grazing Effects: Past sheep grazing has caused vegetative changes including more bare areas and reduced forb component.	Meadows and open areas consist of 4-inch to 12-inch mix of shrubs forbs and grasses. Meadows occupy their historic niche.	64) Complete limit of acceptable change analysis and include assessment of past sheep grazing. Implement restoration work as appropriate.
Wildlife		
Grazing effects: Zone consists of a mixture of meadows, forested clumps and non-vegetated rocky areas. There are localized impacts from past grazing and human use.	Natural characteristics of open subalpine landscape.	Maintain existing condition. Restore sites of localized impacts where feasible. Also follow MSs 29 and 62.
Soil/Water/Fish		
See Existing Conditions for Closed Subalpine.	See Existing Conditions for Closed Subalpine.	See Management Strategies for Closed Subalpine.
Scenery/Recreation		
Landscape Appearance: Natural Appearing landscape.	Natural Appearing landscape.	Follow MS 62 to maintain natural appearing conditions.

2.2 STATE

The development of the Entiat WRIA 46 Management Plan was governed by rules outlined in Chapter 90.82 RCW, described in Chapter 1. Many Washington state laws that regulate actions on private lands within the Entiat WRIA, and that direct state and local agency decision-making about projects, were also considered while developing this document. Some of these pertinent state laws include, but are not limited to:

Salmon Recovery Act of 1998 (Chapter 70.46 RCW)
Shoreline Management Act of 1971 (Chapter 90.58 RCW)
Water Resources Act o f 1971 (Chapter 90.54 RCW)
Growth Management Act of 1990 (Chapter 36.70A RCW)
Forestry Practices Act of 1974 (Chapter 76.09 RCW)
State Environmental Policy Act of 1971 (Chapter 42.21C RCW)

Details about the Salmon Recovery Act (SRA) are provided below because of the close link between the SRA and the Watershed Planning Act. For more information about these and other state laws, you may visit the following link: http://www.leg.wa.gov/rcw/index.cfm

2.2.1 Salmon Recovery Act

The Salmon Recovery Act authorizes a lead entity to coordinate the development of locally-directed Habitat Restoration Project Lists and salmon recovery plans. Chelan County is the lead entity for salmon recovery activities occurring in the county. If restoration activities are already being developed under the Salmon Recovery Act, a planning unit that opts to include the habitat component in its watershed plan is required to rely upon those activities as "the primary non-regulatory habitat component" of their plan. Past Habitat Restoration Project Lists developed by Chelan County have relied on EWPU input and recommendations to identify habitat restoration actions in the Entiat WRIA, as the group has been working to address salmon habitat issues for nearly a decade.

The habitat recommendations section of this plan is a result of the EWPU's ongoing effort to take a proactive role in contributing to salmon recovery efforts. Actions detailed in Chapter 9 were designed to improve salmon habitat, as well as identify management practices to improve overall watershed health. The habitat restoration actions put forth in this plan were developed using the "Critical Pathways Methodology" identified in the Salmon Recovery Act, and are the result of a locally-directed, collaborative effort among federal, tribal, state, local, and other stakeholder interests.

For more information on Salmon Recovery, refer to:
http://www.leg.wa.gov/RCW/index.cfm?fuseaction=chapterdigest&chapter=77.85

2.3 REGIONAL/LOCAL

2.3.1 Subbasin Planning

National Oceanographic and Atmospheric Administration (NOAA) Fisheries (formerly the National Marine Fisheries Service - NMFS) released a biological opinion (BiOp) on the operation of the Federal Columbia River Power System (FCRPS). This system is operated by the U.S. Bureau of Reclamation (BOR), the Bonneville Power Administration (BPA), and the U.S. Army Corps of Engineers (ACOE). FCRPS operation impacts to six fish species listed in 1999 as threatened or endangered by NOAA Fisheries. The FCRPS BiOp set out a Reasonable and Prudent Alternative (RPA) for the operation and configuration of hydropower facilities on the Columbia River to mitigate impacts to the survival of listed juvenile and adult salmonids in the Columbia River basin. As part of the 2000 FCRPS BiOp, NOAA Fisheries also advised the aforementioned federal agencies that, in addition to hydropower facility modifications, offsite mitigation for habitat, hatcheries and harvest would be required to avoid jeopardy. It also established performance standards and schedules to monitor the success of mitigation measures.

In order to help meet offsite ESA obligations under the 2000 FCRPS BiOp, the Northwest Power and Conservation Council's Fish and Wildlife Program collaborated with other federal caucus members to develop the Subbasin Planning process. When complete, subbasin plans will identify and prioritize actions needed to recover listed salmonids in tributary habitats within the Columbia River basin, and guide the expenditure of BPA revenues on these offsite mitigation projects. The Ecosystem Diagnosis and Treatment (EDT) methodology is being utilized in the development of subbasin plans in order to compare the ecological effects of proposed actions, and determine what benefit is likely from each restoration alternative (see Chapter 7, Habitat, for a discussion on the use of EDT in the Entiat WRIA).

Information contained in the full Entiat EDT Watershed Analysis (Mobrand Biometrics, Inc. 2003) and the habitat recommendations section of Chapter 9 will contribute significantly to the development of the Entiat Subbasin Plan and its recommendations for habitat restoration projects.

2.3.2 Regional Salmon Recovery Planning

It is anticipated that information contained in this document pertinent to habitat restoration and salmon recovery in the Entiat subbasin will contribute to the regional recovery strategy being developed for the Upper Columbia River ESU. Additionally, the recommendations contained in Chapter 9 should provide a roadmap for implementation of complimentary projects by other groups involved with identification and funding of recovery actions.

2.3.3 Tribal Recovery Planning/Spirit of the Salmon (Wy-Kan-Ush-Mi Wa-Kish-Wit)

The Spirit of the Salmon is an anadromous fish restoration plan for the Columbia River developed by the Columbia River Inter-Tribal Fish Commission (CRITFC), which represents the Yakima Nation and other tribes. One of the plan's long-term objectives is to restore

salmon populations to a level that will support Tribal ceremonial, subsistence, and commercial harvests. The Planning Unit feels that many of the recommended actions contained in Chapter 9 complement Tribal goals, and should help to achieve restoration objectives. For more information on Tribal Recovery, refer to the following link: http://www.critfc.org/text/water_action.html

2.3.4 Chelan County Comprehensive Land Use Planning

Planning units are required to consider city and county planning activities during the development of their watershed plan. The EWPU has given particular attention to local planning being done under the Growth Management Act (GMA). GMA is quite significant in that it mandates cities and counties to plan for land use and development and to designate and protect critical areas including wetlands, aquifer recharge areas, frequently flooded areas, and fish and wildlife habitat conservation areas. GMA also guides the development of comprehensive plans using other goals such as enhancing water quality and water availability, promoting new businesses, and involving citizen participation in the planning process. Actions recommended in this plan were designed in consideration of the goals used to guide planning under GMA, and to provide local input to Chelan County during the update of its Comprehensive Plan, scheduled for completion by December 1, 2006. The EWPU has also agreed to provide input during County revisions of its critical areas ordinances. To access Chelan County Comprehensive Plan documents, refer to: http://www.co.chelan.wa.us/bl/bl4.htm

3.0 WRIA CHARACTERIZATION

3.1 LOCATION[1]

Water Resource Inventory Area (WRIA) 46 is located along the eastern slopes of the Cascade Mountains in north-central Washington State, Chelan County. It comprises the Entiat and Mad River watersheds, collectively known as the Entiat subbasin, as well as some minor Columbia River tributary drainages. The WRIA is approximately 305,641 acres, and is bounded on the northeast by the Chelan Mountains and the Lake Chelan drainage; to the southwest are the Entiat Mountains and the Wenatchee River subbasin. Figure 3-1 on page 3-2 shows the location of the Entiat WRIA within Chelan County, the Upper Columbia Region Evolutionarily Significant Unit (ESU) for salmon recovery, and the state of Washington.

The Entiat River is the largest within the WRIA. It originates in glaciated basins 4.5 miles east of the Cascade crest and flows 43 miles in a southeasterly direction to its confluence with the Columbia River (RM 482.7on the Columbia) near the city of Entiat, approximately 20 miles north of the city of Wenatchee. The Entiat River has two major tributaries: the North Fork Entiat, which joins the mainstem at river mile 34; and the Mad River, which flows into the lower Entiat River near the town of Ardenvoir (RM 10.5). The Entiat's headwaters are fed by a rim of snow-covered peaks that include Tinpan, Buckskin, and the Pinnacle Mountains; Mt. Maud, Seven Fingered Jack, and Mt. Fernow; Ice Creek Ridge, Spectacle Buttes, Fourth of July Mountain, Garland Peak, and Rampart Mountain. The highest elevation in the watershed is the 9,249-foot summit of Mt. Fernow. The lowest elevation occurs at the Entiat River's mouth, at approximately 713 feet. This range of elevations results in a wide variety of ecosystems from alpine, with 90 inches of precipitation per year, to shrub-steppe, which receives less then 10" of precipitation/year. Refer to Figure 3-19 on page 3-36 for a depiction of the ranges of annual precipitation experienced in WRIA 46.

3.2 HUMAN ENVIRONMENT

3.2.1 Historical Overview[2]

Native Americans used the Entiat valley for hunting and gathering prior to its use by trappers and settlers of European origin. Bitterroot was gathered on the lower valley hillsides, and is still relatively common in some locations today. Native Americans also harvested game from the forests and grasslands, and fish and other water dependent species from the Entiat River and its tributaries. The Yakama Nation, under the 1855 Treaty with the Yakima, maintains hunting and gathering rights in the WRIA (see Appendix H and Section 3.2.5 for more information about the ethnology of the WRIA, and Appendix I for the full 1855 Treaty).

[1] Information in this section, and the topography and geology section, has been excerpted from the Entiat Co-operative River Basin Study (USDA et. al. 1976).

[2] This overview is based on information taken from a recorded oral history of lifelong valley residents (Entiat Valley History videotapes #1 and #2, CCCD 1996) and from the Watershed Assessment, Entiat Analysis Area (USFS WNF 1996), with additional corrections and updates from Conard Petersen and others in 1999. The Wenatchee National Forest Overview (Hollenbeck and Carter 1986), listed as a reference on p. 3-16, was prepared as part of the Wenatchee National Forest Plan effort.

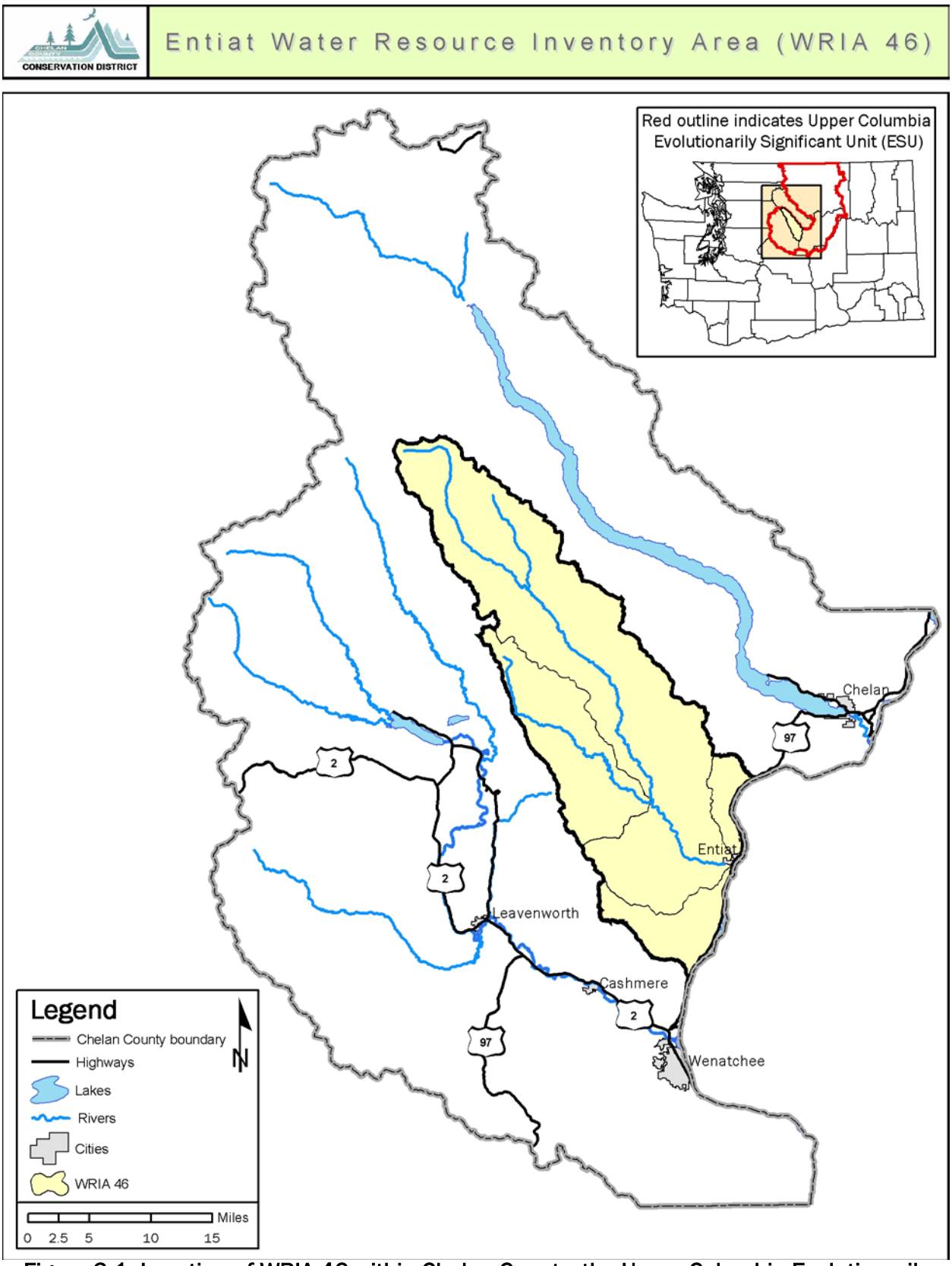


Figure 3-1. Location of WRIA 46 within Chelan County, the Upper Columbia Evolutionarily Significant Unit, and Washington State.

Trapping in the 1880s was the first non-Native American activity to occur in the Entiat watershed. It is thought that pine martens were the primary furbearers that early trappers targeted, and marten sets cut into trees can still be seen today. Speck (1970), in his book Northwest Explorations, documented some of this early resource use, and long time residents relate stories about early trappers and trapper cabins throughout the mid and upper valley. Relics of trappers' old cabins are still evident in some locations, and one of the cabins near the mouth of the North Fork Entiat River has the Northwest Fur Company logo on some of its logs. Trapping continued through the 1980s and into the 1990's as a source of revenue for some current residents' ancestors.

Sheep grazing also began about 1880, and was one of the most extensive earlier uses of the valley. Before the coming of the railroad, sheep were herded from their winter grounds to the mountains, grazing as they went. Various sources indicate that 13,000 to 16,000 sheep grazed the valley in the late 1800s and early 1900s. The Plummer report indicated that in 1902 there were upwards of 60,000 sheep along the head of Mad River (USDI Geologic Survey 1902). Sheep also came into the valley via the Chumstick drainage. After 1911 many sheep were brought into a stockyard in the old town of Entiat by railroad, and grazed along the Columbia Breaks before being herded into the valley for the late spring, summer and early fall months.

Many of the sheep bands moved into and out of the subbasin throughout the year, using both the Wenatchee and Chelan River subbasins concurrently with the Mad and Entiat River valleys during the grazing season. In 1908 A.H. Sylvester, an early supervisor of the Washington Forest Reserve, stated that the district between Baldy Mountain and Snowbrushy Creek had been overgrazed for at least 10 years and needed careful handling to be restored to its original condition. At the same time, the Federal Grazing Act required that herders run their bands of sheep on a permit basis. In the 1940s sheep grazing on federal lands in the Entiat was cut back from two to three bands (1,000 sheep/band) to one band annually, the number allowed to graze for 1-2 months annually or semi-annually today.

Cattle and horses also used the valley, although not as heavily or extensively as sheep. In the early 1900s wild horses were rounded up and brought to the railroad stockyard at Entiat. Hogs and dairy cows were grazed in a few locations. The number of cattle now grazing on federal lands is less than 200 head, with approximately another 100 head using private lands for part of the year.

Prospecting and mining for gold and other minerals occurred in the valley between 1885 and 1910. Most of this activity was concentrated around Crum Canyon. In the late 1940s, pumice was taken out of open pit mines between Stormy Creek and Cottonwood, and commercial pumice was mined in Stormy Creek up until 1956.

Logging within the valley has had a rich and varied history. In 1892 the first log mill was established near the mouth of the Entiat River. Early timber activities focused primarily on roading and harvest along valley bottoms of private lands, particularly holdings of the Northern Pacific Railroad Company. The presence of valuable species led to roading and harvest activities over much of the lower Entiat River area. Mud Creek (RM 11.7) was one of

the first tributaries to be developed for harvesting, and logging eventually spread into mid-elevation areas, especially for fire salvage purposes.

At the turn of the twentieth century, logging began to increase in response to home construction and the apple box industry. Other mills were built near the mouth of the river and in some of the lower river tributaries, including: Mills Canyon, Crum Canyon, and Muddy Creek (Mud Creek). Small portable mills were also located within the valley. Prior to significant road construction, logs were transported to mill sites using horses as well as the river.

Figure 3-2. Entiat valley-bottom log holding area associated with the Kellogg Mill (background) near the mouth of Mills Canyon, 1914.

*photograph courtesy of the Washington State Historical Society, Curtis Collection, #30017.

Because downriver log drives relied on higher streamflows and a passable channel way, the Entiat River was impounded at varying levels and lengths of time between the late 1880s and the first half of the 1900s. A large holding dam associated with the Harris-Cannon sawmill was constructed near the mouth of the river in 1898 (see Figure 3-3 on page 3-5). A log-holding dam built in association with a sawmill constructed in Mills Canyon created a barrier that prevented log transport to the mill downstream near the river mouth. The controversy that ensued resulted in litigation and preemption rights of navigation

designation for a portion of the mainstem Entiat River. In 1904 Gray built an electric power plant at the site of the dam; the plant experienced winter closure due to low water levels from 1905-1906. In 1909 C.A. Harris constructed a dam and power plant about 1.5 miles up the river, near the present day Keystone Bridge. In some years only a little water remained in the channel below the Harris dam. In 1932 the Harris mill moved from Mud Creek to the mouth of the Mad River at Ardenvoir (RM 10.5) and some remnants of the 13.5 foot high log storage dam constructed to serve the mill are still evident just upstream of Cooper's store (see Figure 3-5 on page 3-6).

Figure 3-3. Log holding dam constructed at the mouth of the Entiat River, 1898. The Entiat community later removed it to restore fish passage into the Entiat River.

Most of the road network that exists within the Entiat WRIA today was constructed by 1980 for access to timber sales. Jammer logging, a yarding system involving the construction of closely spaced contour roads within harvest units, was common and required the most extensive roading. Harvest techniques progressed over time from horse, to tractor, to current cable and helicopter methods that enable access to more difficult, steep ground. Timber harvest reached its peak in the valley just after the 1970 Entiat Fires; between 1972 and 1977 almost 50 million board feet of fire salvage timber was sold from National Forest lands. Logs were milled locally and also shipped out of valley to other mills.

Logging and milling were an important part of the local economy until 1979 when the last operating sawmill in the valley (Ardenvoir Mill) closed. The Big Toys mill, located in the town of Entiat, opened in the early 1980's and is the only local timber-manufacturing mill still active today. Logging still occurs to some extent today, with notable "booms" due to timber salvage from the 1988 Dinkelman (58 million board feet) and the 1994 Tyee wildfires.

The Entiat valley has been shaped in large part by a long history of natural disturbance events such as wildfire, flooding, earthquakes, landslides, glaciation, and volcanic eruptions. Wildfire and flooding are very common events in the subbasin, as evidenced by the past 50 years: wildfires in 1970, 1976, 1988, and in 1994 have affected over 60% of the subbasin. The flood of record occurred in 1948 (approximately 10,800 cfs). Other significant floods occurred in 1972, twice in 1977, and in 1989 following wildfire events. See section 3.3.8 for more wildfire information.

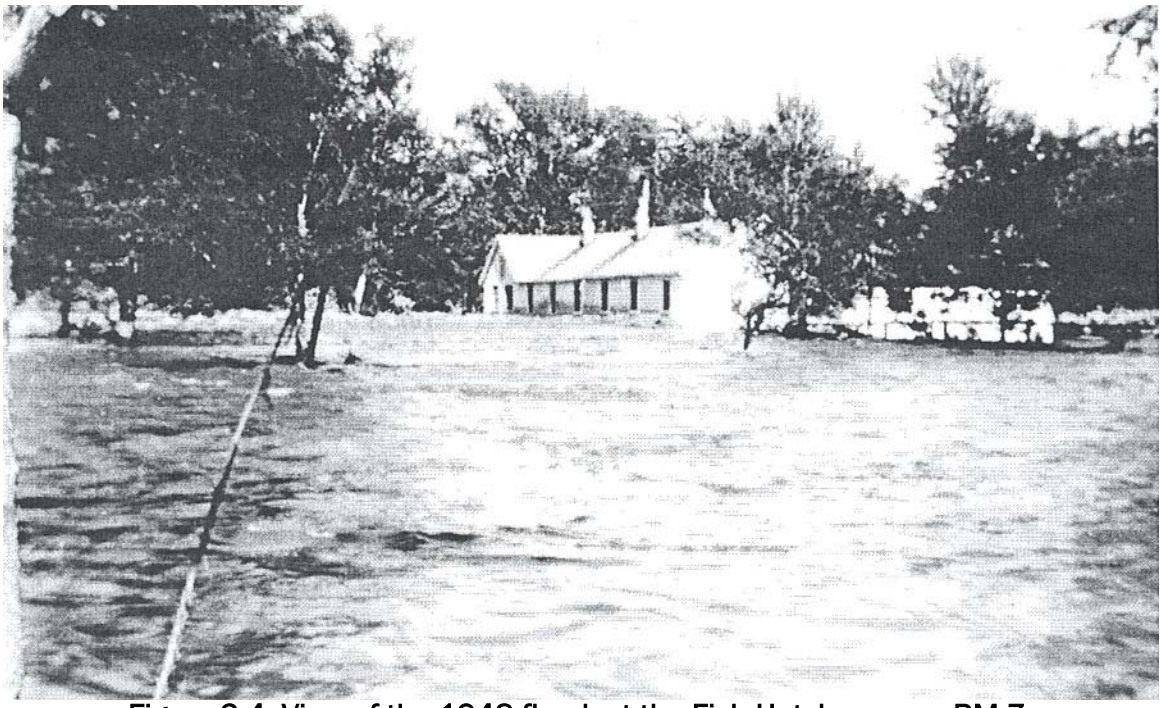


Figure 3-4. View of the 1948 flood, at the Fish Hatchery near RM 7.

Figure 3-5. Remnant of the Ardenvoir Mill dam, washed out by the 1948 flood.

U.S. Bureau of Fisheries surveys in 1934, 1935 and 1936 noted that three dams still remained on the Entiat River (Bryant and Parkhurst 1950). Of the three the last to remain was the Ardenvoir Mill dam, which was washed out in the 1948 flood and never rebuilt (see Figures 3-4 and 3-5).

Fruit production has always been and still is very important to the local economy. The first orchard irrigation ditch, built in 1887, was the Hanan-Detwiler ditch. In 1888 a small peach orchard was planted near the mouth of the river. The site had as its irrigation source a ditch used prior to that time for placer mining. Orchard growing conditions in the lower valley were favorable. By 1889-90 almost every homesteader had fruit trees for subsistence. The Entiat Improvement Co. Ranch constructed a ditch in 1894 that ran from four miles upriver downstream to the mouth and Ribbon Cliff. The Knapp-Wham ditch was filed for in 1903 and was furnishing water to three and one-half miles of land on the south side of the Entiat River between Roaring Creek and Keystone Canyon by 1905. The first tree fruit nursery in the State had been established in 1865, and by 1900 the resulting nurseries on the west side of the Cascades were used as a source for tree stock in the area. In 1906 fruit trees were made available locally, and by 1912-1913 about 40,000 fruit trees had been planted in the lower Entiat valley. The Knapp-Wham and Hanan-Detwiler partnership ditches, along with several smaller ditches for orchard and/or hay and pasture irrigation, still exist today.

Figure 3-6. Keystone orchard, 1914.

*photograph courtesy of the Washington State Historical Society, Curtis Collection, #30014.

Valley residents and others have enjoyed hunting and fishing in the Entiat valley for many years. Hunting mule deer and fishing for local trout were important recreational and subsistence activities for local residents. They feel that deer numbers may be higher now than in the past, and remember a significant winterkill in 1943. Senior lifelong residents recall that when they were younger it was relatively easy to catch a 20 fish limit, and that there were at least two bull trout in the limit. They feel that this fishery has declined significantly since in the 1940's. Current residents do not recall significant salmon runs but have heard stories from earlier residents of significant steelhead spawning activity in the Mad River. Early Bureau of Fisheries surveys of the Entiat River from the 1930s showed that it was virtually devoid of salmon (Bryant and Parkhurst 1950).

Table 3-1 beginning on page 3-10 provides a historical overview of events that have occurred in the Entiat valley since the late 1800s.

Figure 3-7. Old town of Entiat, circa 1900.

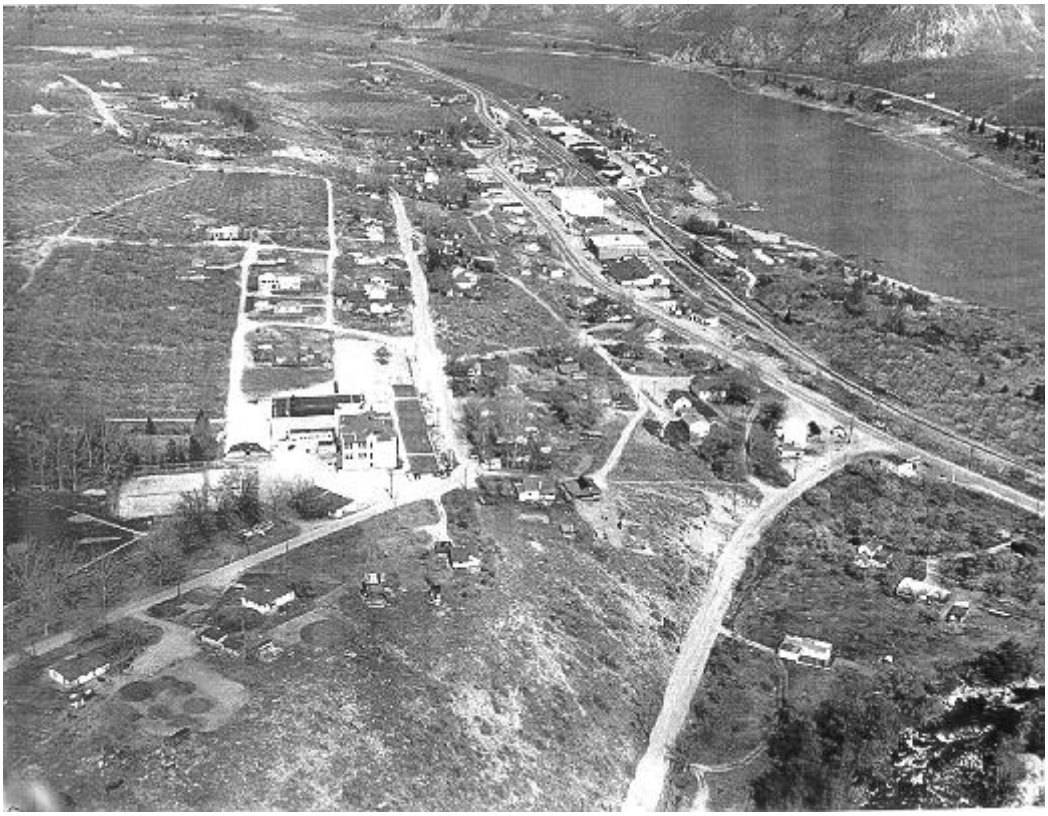


Figure 3-8. City of Entiat circa 1950, pre-Rocky Reach dam construction.

Figure 3-9. City of Entiat in 1999, post-Rocky Reach dam construction.

* Photographs of the City of Entiat (ca. 1900, 1950, 1999) courtesy of Phyllis Griffith.

Table 3-1. Entiat valley history.

DATE	EVENT	REFERENCE INDEX NO.
Dec. 14, 1872	-Ribbon Cliff Earthquake.	1
1888	-Fire - Mad River Gorge to Blue Creek Meadows.	2
1890	-Overuse of forage by sheep grazing. USDA photos of upper Entiat region show 13,000 sheep grazing. There are reports of eight bands of 2,000 sheep grazing in the Mad River and Entiat range areas.	4 & 16
1892	-C.A. Harris sawmill (Grays Mill) located below the present day Numeral Mountain at the mouth of the Entiat River. Logs were harvested upriver, along the riverbanks and driven down the Entiat River during high water.	5 & 16
	-C.A. Harris plants orchard two miles above mouth of Entiat River.	21
1894	-Major flood.	7
	-Grazing reports - 1,000 cattle and 400 horses graze year round, between the town of Entiat and Stormy Creek. In the head of Entiat Valley 13,000 sheep graze, and in the foothills there were 150 hogs.	
	-Irrigation ditch constructed for the 600-acre Entiat Improvement Co. Ranch. The intake was located above the present-day Naumes Orchard, four miles up the Entiat River, extending to the mouth of the River and toward Ribbon Cliff. Cattle ranged as far as Potato Creek. Corrals for summer grazing were located at Mud Creek.	4 & 8
	-The dam and bridge at C.A. Harris Mill washed out by flooding.	
Oct. 27, 1894	-A.L. Rogers of Waterville files water rights on behalf of Entiat Improvement Company.	22
1898	-A dam/sawmill constructed one mile from the mouth of the Entiat River.	7
	-Reports show significant salmon and steelhead runs prior to 1898.	2
1902	-Upwards of 60,000 sheep graze in the head of Mad River.	16
1904	-Gray constructs electric power plant at the mouth of the Entiat River.	8
	-Construction of Knapp sawmill at Mills Canyon. Logs were harvested up valley. Mills Canyon originally named Gray's Canyon and then Knapp Canyon.	3 & 8
	-The last (sizable) Chinook salmon run on the Entiat River.	2
	-Entiat Ranger District experiences heavy fire season.	25
1905 & 1906	-Gray's power plant experiences winter closures due to low water levels.	3
1906	-Shift from cattle to apples hits the Valley. Orchard tracts begin to appear.	3
1908	-Sheep grazing allotments in Mad Lake area; included approximately 18,000 sheep.	4
	-Forest Service Supervisor, A.H. Sylvester, states at least ten-year period of overgrazing has occurred in Baldly Mountain and Snowbrushy Creek areas.	4
1909	-C.A. Harris's 2,000 horsepower electric plant constructed at present day Keystone Bridge 1 ½ miles up the Entiat River. Puget Sound Power eventually buys plant and shuts it down in the 1950's. Power provided from Wenatchee.	3 & 8
July 31, 1910	-Signal/Tyee Peak Fire - 2,560 acres.	2
1912	-Forest Service records show two permittees for sheep grazing; about 7,300 sheep for a four-month season. H. Harder grazed Entiat Summit to the Mad Lake. George Hendricks grazed North Fork and upper Entiat. Both permittees operated until 1940 and 1950.	4
	-Kellogg Lumber Mill located three miles up the Entiat River operates until 1918. The River is dammed and logs are floated from up-valley logging areas.	5

DATE	EVENT	REFERENCE INDEX NO.
1913	-First recorded timber sale located in the South Fork of Mud Creek.	9
Jun 13, 1913	-The Entiat Times reported that "250,000 trout from the Spokane fish hatchery were deposited in the Entiat River last month."	17
1914	-Coleman Mill located at Crum Canyon.	14
Aug. 31, 1914	-Burns Creek Fire - 600 acres.	2
1915	-Gordon Mill located up Johnson Creek - operated until 1940's.	8
Jan. 1, 1915	-Severe winter 1915/1916.	1
	-Extreme conditions cause starvation of wildlife.	8 (photo)
Jan. 29, 1915	-Entiat River planted with 310,000 trout from a Seattle hatchery.	17
1916	-Mott Mill located at Mud Creek and later purchased by C.A. Harris.	8
	-Cannon logging camp located at mouth of Tyee Creek. Operated through 1918, and utilized horse skidding and chutes.	8
1917	-Period of drought through 1932.	18
	-Harris circular sawmill located at Mills Canyon; operated through 1919. Logs harvested from Mills Canyon and processed at 15 MBF per day.	5
1919	-Harris Mill moved from Mills Canyon location due to depletion of logs. New location three miles up Mud Creek. Mill operated as a box factory until 1932, when it moved to Mad River location.	5 &11
April 8, 1921	-Entire town of Entiat burns.	1
1922	-Harris Mill at Mud Creek becomes a single-band mill with a 40 MBF per day capacity. Logging performed in the winter on snow. Logs decked to run in the summer.	5
Aug. 15, 1924	-Summer rainstorm causes extensive flooding in Goman, Byrd and Ribbon Cliff Canyons. Electrical storm preceding heavy rains, responsible for largest number of forest fires ever reported (to date) on the Entiat District.	17
1925	**-Large Fires** * Mad River Fire (between Windy and Young Creeks) - 1,500+ acres * Spectacle Butte Fire - 600 acres * Borealis Ridge Fire - 500 acres	12 & 24
	-Fires in the 300-acre range, included: * Three Creeks * Lake Creek * Brennegan Creek * Gray Canyon * Mud Creek	12&24
	-Horse logging continued, but transportation to the Mill was by Mac trucks with hard rubber tires. Logging began to change with Road construction, new equipment and transportation methods.	5
1926	-Potato Creek Allotment. Area included Potato and Stormy Creeks. One permit issued for 65 cattle and 6 horses.	4
1928	-Harris Mill purchased first shovel loader.	5
	-Forest Service land acquisition in T24, 26 and 27N, R20E, which expands range in Mud Creek and Moe and Crum Canyons.	4
Aug. 28, 1928	-Coal Oil Fire - 600+ acres, caused from coal oiling irrigation canal.	17
1929	-Extreme fire season.	1
Aug. 1, 1929	-Upper Entiat River planted with 160,000 rainbow trout.	17
1930	-Construction of fire lookouts begins.	2
	-Entiat River survey shows the river is virtually devoid of salmon.	
1932	-Harris Mill at Mud Creek moved to mouth of Mad River (Ardenvoir) due to low water caused by the drought period. The Mill is steam-powered with a capacity of 60 MBF per day.	5
1935	-By this year, three dams on the Entiat R. and 19 irrigation diversions still exist.	5

DATE	EVENT	REFERENCE INDEX NO.
1939	-Harris Company entered into voluntary cooperative sustained-yield agreement, which reduced ponderosa pine harvest while increasing minor species.	5
	-New inventions bring about discontinuation of horse skidding.	5
1940	-Truckloads of salmon planted into the Entiat River for four consecutive years at several locations in Still Water Meadows vicinity.	8
1941	-Larch Lake Fire - 400 acres.	16
	-Introduction of contract loggers.	5
	-National Fish Hatchery fish culture began.	
1946	-Flood Control Act.	
1948	-Harris Mill at Ardenvoir began conversion from box shooks to commercial lumber.	5
June 8, 1948	-Worst flood in Entiat valley history (10,800 cfs); major regional flooding. Extensive damage from Ardenvoir to mouth of river, which was caused by a spring rainstorm. Several bridges were lost or damaged.	1
	-Army Corps of Engineers begins flood rehabilitation, including channelization of the lower river.	30, 34
	-Logging of cottonwood begins in the Stillwater area and continued until 1950. Logs were hauled to the railhead in Entiat.	
1950	-Winter '49-'50 coldest/heaviest snowfall on record for 61 years. Coldest recorded day in history (2/1/50 at 24 degrees F below zero). Eastern Washington paralyzed during 1/13/50 blizzard	10, 32
1953	-Harris mill installed horizontal resaw, which increased production capacity to 70 MBF per day.	5
1955	-Harris Mill increased to year-round production, processing more timber per employee than any other mill in the area.	5
1956	-In 1956-57, Mud Creek area is relogged. Trees too small by 1917 standards were cut under U.S. Forest Service marking rules.	5
July 13, 1956	-Unusually heavy snowfall in higher elevations in Cascades in early part of year; high flood threat relieved by gradual spring melt	31
	-Flash flood covers Highway 97 with up to four feet of mud, water and debris.	1
Sept. 1957	-USGS establishes continuous recording stream gage on the Entiat near Ardenvoir (Gage #12452800; near Stormy Creek).	26
1958	-No. 1 hottest recorded year.	10
	-Potato Creek erosion control project covered 110-acre area. It resulted from the impacts of logging and grazing.	2 & 11
Aug. 26, 1958	-Entiat Fire 12,000 acres. Lightning caused.	1 & 12
October 1958	-USGS removes old stream gage on the Entiat River near Entiat (RM 0.5) (Gage #12453000; located 0.25 miles above mouth of the River).	26
1960	-Potato Creek Allotment permit - 219 cattle AUM. Intensive three-year development study initiated.	4
June 29, 1961	-Tenas George Fire - 3,750 acres. Equipment caused.	12 & 23
Nov. 11, 1961	-Rocky Reach Dam commences commercial operation.	1
1962	-Forest Mountain Fire - 520 acres. Lightning caused.	12 & 23
1964	-Potato Creek Allotment improvements include six stock ponds and 25 springs. Study shows that the Allotment could support 159 AUM for a 4.5-month season.	4
	-First steelhead planting in the Entiat River.	2
Aug. 26, 1966	-Hornet Creek Fire #143 - 1,520 acres. Lightning caused.	12 & 23
Aug. 5, 1968	-Harris Mill Fire #065 - 1,210 acres. Started at mill site and moved to private, National Forest, BLM and county lands.	12 & 23

DATE	EVENT	REFERENCE INDEX NO.
1970	-Department of Game permitted cattle to graze in Mud Creek (Stepping C Ranch). Lands sold to City of Seattle in 1974. Through a tripartite exchange, lands became National Forest in 1995.	4
July 7, 1970	-Mills Canyon fire - 933 acres, human caused.	12 & 23
Aug. 23, 1970	-Lightning storms cause major fires covering over 122,000 acres on Entiat and Chelan Districts. * Gold Ridge Fire - 16,100 acres. * Entiat/Slide Ridge Fire - 49,200 acres	1
	-Fires involve 25 percent of the Entiat watershed.	2
1971	-One of three highest recorded April snowpacks in Entiat (73" at Pope Ridge; 180" at Fox Camp; also see '72 and '74)	33
	-Agreement between Department of Game, Entiat Valley Stockman's Association and Forest Service curtails grazing in Johnson Creek, Oklahoma Gulch and Entiat Breaks.	4
April 1971	-Corps of Engineers removes ten miles of river debris.	2
Nov. 18, 1971	-First helicopter fire salvage sale contract on Wenatchee National Forest and first in Washington State history.	1
1972	-Preston Creek slide area debris removal.	2
	-Entiat River channel altered below Fox Creek to protect road.	11
	-Pack River purchases Harris' Ardenvoir Mill.	5
	-Ardenvoir Mill begins to rely on logs from outside the Entiat basin to continue production levels.	
	-One of three highest recorded April snowpacks in Entiat (55" at Pope Ridge; 182" at Fox Camp; also see '71 & '74)	33
Jan. 16, 1972	-River ice jams blasted in Entiat River. Entiat River freezes from the bottom upward (termed "anchor ice").	2
March 1972	-Record high temps with 150 percent normal snowpack, which increased flow rates; McCrea Creek slope failure and debris-dam break flood.	2
June 1972	-Record 1971-1972 snowpack combined with heavy rainfall results in severe flooding and streambank erosion (325 acres of agricultural land is damaged by floodwaters).	2
June 10, 1972	-Preston Creek slides and floods; four people killed; mud and debris avalanches also occur in Brennegan, McCrea & Fox Creeks.	1 & 2
1973	-Drought forces cattle off federal rangelands early.	1
Aug. 23, 1973	-Northwest experiences worst drought in history.	1
1974	-One of three highest recorded April snowpacks in Entiat (74" at Pope Ridge; 182" at Fox Camp; also see '71 & '72)	33
Jan. 15, 1974	-Entiat River rises 1.5 feet as a result of three inches of rain in three days.	1
Spring 1974	-Above-average spring runoff causes severe bank erosion over entire basin.	
Dec. 12, 1975	-Ardenvoir Mill Fire, 150 mill workers affected.	1
1976	-Ardenvoir Mill rebuilt.	11
July 24, 1976	-Crum Canyon Fire #050 - 9,000 acres.	12
Oct. 24, 1976	-Entiat River planted with 570,000 salmon eggs.	1
	-Construction of spawning channel below Fox Creek.	1
June 13, 1977	-First Crum Canyon flood with runoff estimated at 5,050 cfs in Crum Canyon; 1,260 cfs in Ringstead Canyon.	1
July 25, 1977	-Second Crum Canyon flood with nearly same runoff	1
1979	-Ardenvoir Mill closes.	11
1983	-No. 1 wettest recorded year (from 1952).	10
	-Establishment of the 11,600 acre Mosquito Ridge Sheep Allotment.	6

DATE	EVENT	REFERENCE INDEX NO.
1984	-Permit for 2,000 to 2,500 sheep on Mosquito Ridge Sheep Allotment from May 15 through August 31.	4
1987	-No. 1 record year of consecutive days without precipitation - a total of 103 days (July 20 through October 30, 1987).	10
Sept. 4, 1988	-Dinkelman Fire - 53,000 acres. Human-caused fire.	1 & 12
1989	-Salvage logging operations allowed for only five percent ground disturbance, logging by helicopter, cable, or tractor on snow.	1 & 15
Jan. 17, 1989	-Hurricane-force winds cause massive blowdown in Lake Creek basin, and Young, Billy and Cougar Creeks.	1
July 1989	-Roaring Creek flood.	1
Aug. 19, 1989	-Dinkelman flood; Thousands of small chinook salmon and 10,000-50,000 non-game fish perish as a result.	1
July 24, 1990	-Dick Mesa Fire #110 - 1,151 acres. Lightning caused.	12
Jan. 10, 1991	-Ice dam in Entiat blasted. Largest build-up in 50 years.	1
May 1993	-City of Seattle & USFS close riparian pastures in Mud & Potato Creeks.	6
12/24/1993	-Lowest mean daily flow for the 43-day period of record at the Entiat near Ardenvoir gage -- 22 cfs (25 cfs 12/17/64; 27 cfs 2/16/93; 32 cfs 12/12/01)	26
1994	-City of Seattle closes Mud Creek lands to range due to overuse.	6
June 1994	-USFWS found bull trout populations in the Columbia River Population Segment (including Entiat System) to be warranted for listing as a threatened species.	27
	-Tyee Fire Complex #047 - 140,196 acres. Lightning caused. Total Entiat District acres 85,968; accounts for 61% of fire area.	12
	-Fire involved 33% of Entiat watershed.	12
Oct. 1994	-No. 1 wettest recorded month.	10
Nov. 1994	-Tyee Fire salvage begins on private lands (most fire salvage activity on private lands completed by November 1996).	17
	-State Department of Fish and Wildlife implements winter deer feeding (continued winters of 95-96 & 96-97; discontinued winter 97-98).	28
Aug. 1995	-Tyee Fire salvage begins on National Forest System Lands	27
Sept. 1995	-Tyee Fire Burned Area Emergency Rehabilitation work substantially completed; approximately $15,000,000 spent on revegetation and road/channel/slope stabilization work by several federal agencies.	20
Nov. 1995	-City of Seattle-USFS land trade; City holdings in Entiat area traded for USFS lands in Cedar River watershed.	
March 1996	-New stream gage installed on the Entiat River near Entiat (Gage #12452990; located at Keystone Bridge, at RM 1.5).	26
May 1996	-Reforestation work on Tyee Fire area continues with completion of 6,500 acres of tree planting in the spring of 1997 (5,000 acres in 1996; 1,800 acres in 1995).	27
June 17, 1996	-Oklahoma Gulch debris torrent/flood initiated by severe thunderstorm.	27
Aug.-Oct. 1996	-Three streambank restoration/fish habitat enhancement demonstration projects completed on the Entiat upstream of the Potato Creek moraine through cooperative effort of landowners, conservation groups and State/Federal agencies.	17
Apr. 1, 1997	-Snowpack well above average in the Entiat at 223% of normal; March precipitation was 225% of normal.	29
Aug. 26, 1997	-Potato Creek/Stormy Creek debris torrent/flood initiated by severe thunderstorm.	27

DATE	EVENT	REFERENCE INDEX NO.
Oct. 1997	-Approximately 12,145 acres of salvage logging have been completed on National Forest lands to date since 8/95; 14,560 acres were included in 10 salvage sales sold; completion anticipated in 1998 field season.	27
Oct. 17, 1997	-Upper Columbia Steelhead were listed as a proposed Endangered Species by NMFS.	27
Nov. 1997	-Forest Service completes another group of watershed restoration projects targeted as road rehabilitation, a continuation of emphasis on road system rehabilitation started in 1992.	27
Dec. 1997	-Local deer population very low due to a combination of adverse conditions.	28
Aug. 1998	-Entiat CRM group receives first installment of grant funding for development of a watershed plan under the Washington State Watershed Planning Act	
1999	-First year for Entiat River longitudinal temperature monitoring network	35
March 2000	-Entiat WRIA Planning Unit sponsors 3-day regional workshop on Instream Flow analysis using the Instream Flow Incremental Methodology (IFIM)	38
Apr.-May 2000	-Salmon Recovery Funding Board Chairman and State Ag-Fish-Water Committee tour the Entiat	38
Apr. 19, 2000	-Entiat WRIA Planning Unit formally adopts a robust application of IFIM as the approach to address Instream Flow issues for watershed planning	38
Sept. 20, 2000	-Entiat WRIA Planning Unit formally adopts EDT as the habitat analysis technique for watershed planning and received assistance from the Yakama Nation and Colville Tribes.	39
Dec. 2000	-An earthquake registering 3.3 on the Richter Scale hits the Entiat area. Source is likely the active fault that lies between the Entiat and Lake Chelan	
2001	-Low flow year – regional drought conditions. Lowest total water yield for the 43 year period of record at the Entiat near Ardenvoir gage (116,200 acre-feet). Seven day low flow for 2001 WY at this gage was 44 cfs (32 cfs in 1994 & 36 cfs in 1974 and 1993 – need to move 7-day lows for 1994, 1974, and 1993 to those years).	26
June 2001	-Entiat WRIA Planning Unit holds first "Resource Roundup" Open House to advertise EWPU and related activities	38
Aug. 2001	-BLM installs demo LWD habitat structures at RMs 10.3 and 15	36
Sept. 2001	-CCCD/NRCS installs 3 demo habitat rock cross vanes between RMs 3-4 -ENTRIX, Inc. selected to develop Instream Flow Work Plan for IFIM -Tommy Creek Fire burns 640 acres in the Entiat valley.	37
Nov 2001	-EWPU submits formal statement to WDOE that it will develop instream flows EWPU becomes a partner in the Institute for Rural Innovation and Stewardship (IRIS)	38
Jan. 2002	-Entiat Watershed Project Co-coordinator hired -Well monitoring initiated with volunteer landowner participants	38
April 2002	-"Working" Final Instream Flow Work Plan Completed -New USGS continuous recording gage (#12452890) installed at mouth of Mad River. -EWPU members present at Trans Boundary Watershed Conference in Spokane, WA	38
May 2002	-Real-time data from Keystone USGS gage made available online	38
June 2002	-CWU/EWPU Entiat land use and riparian vegetation community inventory begins	38
July 2002	-Final CRMP/First Draft WRIA 46 Management Plan released for comment -EDT Alternatives approved for first treatment model run -IFIM field work begins -CCCD Water Resources specialist hired	38

DATE	EVENT	REFERENCE INDEX NO.
Aug 2002	-Water Quality assessment and Stream Network Temperature Modeling (SNTEMP) begins	38
Sept-Oct 2002	- WDOE-SHU / CCCD staff install 8 continuous recording gages, 6 staff gages, and 3 bank operated cableways in the Entiat subbasin	
	-Land Use/Riparian inventory completed and presented to Planning Unit	
	-EWPU receives National Rural Community Assistance funds and "Spirit Award"	38
Nov 2002	-LSC members participate on panel at Governor's Water Resources/Implementation conference in Olympia, WA.	38
Dec 2002	-Comment period on First Draft WRIA plan ends	38
Feb 2003	-First of 6 facilitated Instream Flow meetings held	
	-EWPU hosts evening community water balance meeting	38
Jun 2003	-Water Quality analysis completed	38
Aug 2003	-Facilitated Instream Flow meetings end; 2 sets of instream flows and reserve developed	38
Sep 2003	-Field work done to check riparian vegetation planting recommendations, and identify additional potential planting sites.	38
Oct 2003	-Content approved for release of Internal review/EWPU draft WRIA 46 Plan	
	-SRFB Chair, William Ruckelshaus, UCSRB members and elected officials tour the Entiat valley	38
Jan 2004	-Final Review Draft WRIA 46 Plan content/recommendations approved. Plan released to public for comment	38
Mar 2004	-Landowner Steering Committee hosts community meeting on March 18 re: WRIA 46 Plan	38
April 2004	-70-day public comment period on Final Review Draft ends April 2, 2004	
	-EWPU approves final edits/additions to WRIA 46 Plan in preparation for Final Draft Plan presentation to County on May 21, 2004.	38
May 2004	-EWPU unanimously recommends that the priority date of proposed minimum instream flows be the date of rule adoption, and votes to submit the Plan to Chelan County for approval.	
	-Final Draft WRIA 46 Management Plan presented to County on May 21, 2004.	38

For specific detail related to all EWPU Decision Points made from 1999-2004 and a summary of public involvement and outreach activities, see Appendices D and E, respectively.

Reference index for Entiat valley history table:

1. *Wenatchee World Newspaper*
2. *Entiat Cooperative River Basin Survey*
3. *Entiat School publication*
4. *Grazing publications/Albert "Shorty" Long's notes*
5. *Soil Conservation publication (1958). January - February "Western Conservation Journal"*
6. *Entiat Ranger District - 2200 Grazing files*
7. *"Production and Habitat of Salmonids in mid-Columbia River Tributary Streams", USFWS*
8. *Albert Long, Entiat Valley historian*
9. *Entiat Ranger District timber atlas*
10. *NOAA Climate of Wenatchee, Washington, 1994 publication*
11. *Reflections, Images of our Past, WVC publication*
12. *Entiat District fire reports*
13. *Dinkelman Restoration Accomplishment Report*
14. *Power and sawmill literature*
15. *Entiat Ranger District fire occurrence map*
16. *Plummer Report*
17. *The Entiat Times (newspaper)*
18. *USDA Handbook - Climate Agricultural Atlas, 1941 Precipitation Almanac*
19. *A Historical Overview of the WNF, WA*
20. *WNF Supervisor's Office historical files*
21. *Thesis of Lois Morrell Harmon*
22. *A History of the Famous Wenatchee, Entiat, Chelan and Columbia Valleys, by Lindsay Hull*
23. *Land and Resource Management Plan Wenatchee National Forest (1990a)*
24. *Historical microfiche files*
25. *Wenatchee Republic Newspaper*
26. *USGS streamflow records*
27. *Entiat Ranger District files*
28. *Washington Department of Fish and Wildlife*
29. *Natural Resources Conservation Service (formally SCS) snow measurement data.*
30. *Personal contact with Conard Peterson 2001.*
31. *NOAA Annual Climatological Summary for 1956*
32. *Washington State Top Ten 20th Century Events (NOAA)*
33. *NRCS and USFS snow survey data*
34. *Historic Flood Restoration Records, US Army Corps of Engineers, Seattle*
35. *USDA Forest Service monitoring records*
36. *USDI-BLM, Joe Kelly, Project Coordinator*
37. *USDA-NRCS, Joe Lange, Project Coordinator*
38. *Entiat Watershed Planning Unit records*
39. *The Entiat Explorer (newspaper)*

3.2.2 Land Ownership

Ownership patterns in WRIA 46 result from public domain, railroad land grants, homestead and timber entries, and subsequent land sales and exchanges. The majority of privately owned land is located within one mile of the mainstem Entiat River in a band that extends 26 miles upriver to the National Forest boundary. The settlement pattern along the valley bottom is a result of accessibility and the agricultural suitability of the land. There are some privately held sections intermingled with National Forest lands outside of the valley bottom area in the eastern portion of the watershed. This checkerboard ownership pattern is a result of historic railroad land grants.

Ownership is predominantly public. Slightly less than nine percent of the land in the Entiat WRIA is in private ownership. The US Forest Service (USFS) manages approximately 83% of lands. Other notable federal land owners include the Bureau of Land Management (BLM) and the US Fish and Wildlife Service (USFWS). Almost all state lands are managed by either the Washington Department of Fish and Wildlife (WDFW) or the Washington Department of Natural Resources (WDNR). Table 3-2 and Figure 3-10 on page 3-19 provide an overview and depiction of primary land ownership in WRIA 46.

Table 3-2. WRIA 46 Land Ownership Acreages.

Owner	Approximate Acreage+	Percentage of WRIA
Federal	**258,477**	**84.6%**
BLM	4424	
USFWS	798	
USFS	253,255	
State	**17,467**	**5.7%**
WDFW	7525	
WDNR	9930	
Other	12	
County/City/Local	**361**	**0.1%**
Chelan County	2	
City of Entiat	68	
City of Seattle	261	
Districts (Fire, Cemetery, Irrigation, School)	30	
Private	**26,720**	**8.8%**
NCW Museum	36	
Chelan-Douglas Land Trust	415	
Longview Fibre Company	9878	
Chelan County PUD	543	
Boat Club	32	
Other	15,816	
Columbia River*	**2436**	**0.8%**
TOTAL	**305,641**	**100%**

+ Acreages generated via GIS analysis of USFS ownership, Chelan County parcel, and WDOE WRIA shapefiles.
***** The WRIA 46 boundary extends into and encompasses a portion of the Columbia River.

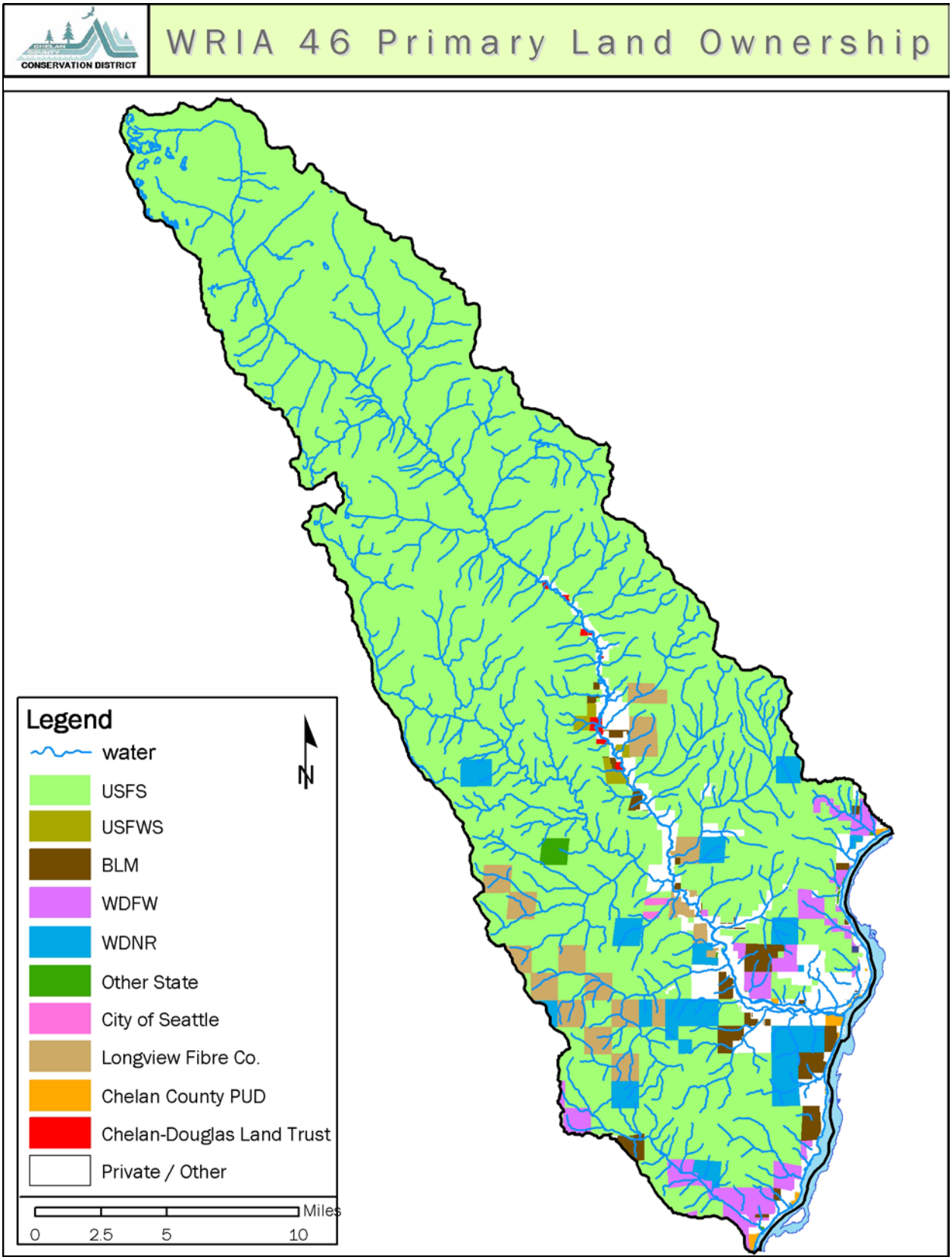


Figure 3-10. WRIA 46 primary land ownership in 2003.

3.2.3 Land Use

Current land uses within the Entiat WRIA include agriculture, primarily pear and apple orchards; livestock production and grazing; timber harvest; residential housing; and recreation. These uses have been discussed previously in a historical context; this section elaborates on the current situation.

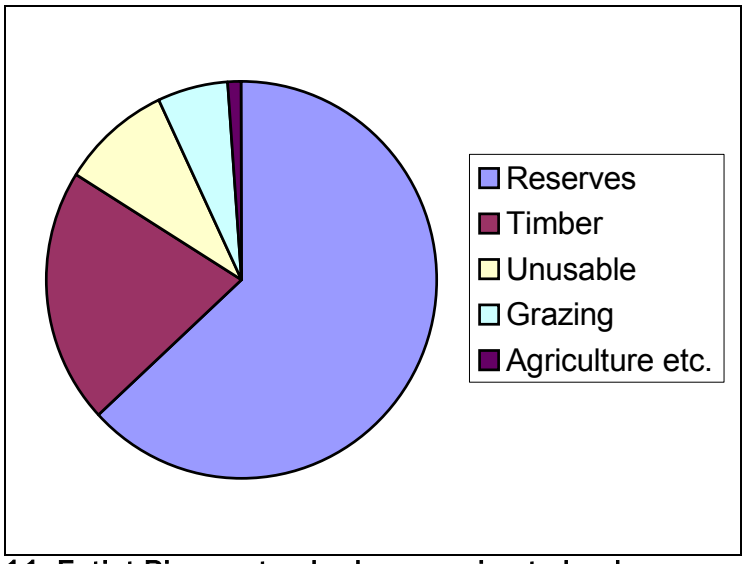


Figure 3-11. Entiat River watershed - approximate land use percentages.

Figure 3-11 shows the approximate apportionment of various land use areas within the Entiat subbasin. Wilderness, old growth reserves, wildlife and riparian reserves comprise about 63% of the USFS reserves land designation, which includes some areas in the lower valley that currently do not fall within the other land use categories. Federally designated reserve areas are primarily used by wildlife, but are not specifically designated for wildlife use. The unusable category is land intermingled with designated timber and/or grazing lands that is unsuitable for these uses due to topography or productivity, or is inaccessible for other reasons such as rock or cliff formations. Data show that irrigated agricultural lands comprise approximately 0.5% of the WRIA. It is estimated that agricultural lands, developed recreation areas (including trails), and residential areas, make up approximately 1% of the total land area.

Agriculture (Crops)

Pears and apples are the primary economic crop within the Entiat WRIA, although some cherry and grape production is also present. Orchards within the Entiat subbasin are primarily concentrated in a narrow band near or adjacent to the mainstem Entiat River, between its mouth and the Mud Creek confluence (RM 11.7). Few orchards exist upstream of this point, as distribution is largely dictated by climate/length of growing season. The orchards on the north side of the river/Entiat River Road, stretching for approximately 1.5 miles upstream from river mouth, are irrigated from the Entiat Irrigation District. This system originates at the Columbia River. The remaining orchards in the valley depend on either wells or the Entiat River and a few of its tributaries for irrigation water. With the exception of

the Naumes holdings, the orchards are owned and, in most cases, operated by local residents dependent on their profits as the primary source of family income.

The 1979 Entiat River Co-Operative River Basin Study reported 1,300 acres of irrigated orchard existed within the Entiat valley (USDA 1979). In 1996 the CCCD estimated[3] that approximately 910 irrigated orchard acres of pears and apples existed in the Entiat watershed at that time, indicating that fruit production continued to be the single most important industry in the watershed. A more recent GIS assessment of irrigated orchard performed by Central Washington University (CWU) in 2002 and updated by the Planning Unit, identified approximately 1427 acres of orchard within WRIA 46 (Lillquist and Erickson 2002). It was estimated that 890 of these acres are irrigated by water drawn from within the Entiat subbasin, while the remaining 537 are irrigated by water drawn from areas in hydraulic continuity with the Columbia River, or pumped directly from it. The 2002 land use assessment also showed that at that time, approximately 111 acres of orchard that are located/draw water from within subbasin had been pulled (taken out of production) since 1992 (Lillquist and Erickson 2002).

The CCCD data from 1996 showed that, of the 33.8 miles (mouth to Entiat Falls) of the mainstem Entiat River that are capable of supporting anadromous fish, approximately 6.7 miles of the lower 11.4 miles between the mouth of the Entiat and Mud Creek had orchards adjacent to the river. Three and three quarters of the 6.7 miles lay along only one side of the river. Further, only 1.05 miles had orchard along both banks of the same reach. It was estimated that 25,300 linear feet of commercial orchard existed adjacent to the river in 1996, amounting to 7.1% of the total linear feet of habitat capable of supporting anadromous fish.

The Knapp-Wham and Hanan-Detwiler irrigation systems, along with smaller irrigation ditches and individual irrigators, utilize Entiat River flows. The Hanan-Detwiler system is largely an open ditch, while the Knapp-Wham was recently converted to a pipeline system. Both systems experience sediment build-up during high flows and flood events in the mainstem; however, this condition has improved over the years since the 1972 floods. Benefits realized from converting the Knapp-Wham system to pipeline include decreases in water loss and water temperature, fewer pathogens and less seed pick-up, eliminated need for ditch bank repairs, and protection of the system from side canyon washouts. Options for consolidation of the two major ditches, along with other water conveyance efficiency improvements in the subbasin, are currently being pursued by the Planning Unit

Fish screening measures have been greatly improved on both systems over the last several years (C. Petersen, per. comm. 1999). The photographs on the next page show the upgraded fish screen that was installed on the Hanan-Detwiler irrigation ditch intake in 1998 by the WDFW Yakima Screen Shop. Staff from the screen shop has worked with Entiat valley irrigators over the past several years to improve their systems. WDFW completed an inventory of irrigation structures in the Entiat valley in 1997, which determined there were six irrigation ditches and 45 irrigation pumps being used to irrigate approximately 1,100 acres (approximately 900 orchard and 200 hay and/or pasture). Of the six ditches, four

[3] Aerial photos combined with ground truthing were used to estimate acreage.

were reported as adequately screened and two were not; 37 of the 45 pumps were adequately screened, with eight reported as inadequately screened. In total, 41 out of the 51 irrigation structures identified by WDFW in 1997 were reported as adequately screened.

Figure 3-12. General view Hanan-Detwiler fish screen, completed April 1998.

Figure 3-13. Close-up view Hanan-Detwiler fish screen.

In October 2003 the WDFW Yakima Screen Shop received funding from the Bonneville Power Administration (BPA) to perform an inventory and prioritization of fish passage and screening problems in the Entiat and Wenatchee subbasins; passage improvements to a side-channel associated with the Hanan-Detwiler irrigation ditch; and a comprehensive re-assessment, re-inventory and mitigation of pump screen sites in the Entiat that were identified by the 1997 inventory. The EWPU is also pursuing additional irrigation system and screening improvement assistance from the U.S. Bureau of Reclamation (USBR) to continue their work to address the screening and passage issues that have been identified within the subbasin.

Timber

As stated earlier, logging and milling were very important to the local economy from about 1900 through the mid-1980s. The harvest levels and types of logging activities seen in the Entiat watershed in the past are not likely to be duplicated again in the foreseeable future. Logging activities increased again briefly in the mid-to-late 1990s as a result of timber salvage operations on lands burned in the 1994 Tyee Fire. Factors contributing to the overall decrease in logging activities include the effect wildfire has had on over 60% of the subbasin since 1970. Management strategies developed as part of the Wenatchee National Forest Land and Resource Management Plan, as amended by the Northwest Forest Plan (discussed in Chapter 2), also reduced allowable harvest acres.

Timber on Federal Lands

Table 3-3 on page 3-24 shows the volume of timber sold from National Forest System lands on the Entiat RD over the past several decades, and the declining trend in harvest. Timber related activities on NFS lands in the Entiat WRIA during the next few decades will focus on reforestation of burned areas, underburning, and thinning overstocked unburned stands in order to bring the landscape back to a more natural condition, and to enhance other values such as old growth and riparian ecosystems. Forest Service officials estimate that they will treat between 1,500 to 2,000 acres annually for forest health purposes over the next decade. These practices may result in an average of approximately 500,000 board feet of timber a year being made available for sale over the next five years. For more information on National Forest System lands available for timber harvest, refer to Chapter 2. Most of the scattered BLM lands within the subbasin were burned over in the last few decades. The BLM sold approximately 1 million board feet of timber after the Tyee fire, but has no immediate plans for timber sales in the near future.

Timber on State and Private Lands

Most of the State school lands administered by the Washington State Department of Natural Resources (WDNR) were affected by fire over the past few decades, and salvage timber has been harvested from WDNR lands. Currently, silvicultural practices on WDNR lands are primarily focused on the reforestation of burned areas. There are some scattered tracts of WDFW land within the watershed, but very few are forested lands that could be commercially harvested. Minor amounts of timber harvest may occur in order to reduce fuel loading after wildfires.

Some timber harvest could potentially occur on a few parcels of private land adjacent to the river and above Dill Creek that were not burned by wildfires in the past few decades;

however, most of these lands are being subdivided for homesites. Almost all land in the Entiat valley below Dill Creek has been involved in wildfires. Most of the private land in this area that is not long term agricultural land has either been logged in the past or salvage logged. Sections of Longview Fibre Company timberlands have also been logged in the past and/or salvaged logged after the wildfires. These private lands are interspersed throughout the WRIA, primarily in the southeast portion. Although Longview Fibre may currently conduct some logging on a few unburned areas in Stormy Creek and the Dinkelman fire areas, there is not expected to be very much timber harvest from these corporate lands within the next few decades.

Table 3-3. Volume of timber sold (in millions of board feet), Entiat Ranger District.

Time Period	Volume	Annual Average
1962 - 1970	196.5	24.56
1971	36.1*	-
1972 -1977	49.5	8.25
1977 - 1983 +	-	-
1984 - 1989	64.5	10.75
1990	58.4*	-
1991	1.0	-
1992	3.4	-
1993	6.0	-
1994	3.0	-
1995	18.1*	-
1996	39.4*	-
1997	14.2*	-
1998	0.25	-
1999	0.20	-
2000	0.52	-
2001	1.03	-
2002	1.02	
2003	.619	

***** *Volumes reflect salvage from major fires in 1970, 1988 & 1994.*
+ *Sell volumes for 1977 through 1983 were not readily available.*
Sell volumes for 1962 through 1977 taken from the Entiat Co-operative River Basin Study (USDA et al. 1979); volumes for 1984 through 1997compiled by B. Modic (WNF); volumes for 1998-2001 provided by T. Graham (WNF); 2002 volumes provided by W. Armes, E. Stutzman (WNF).

Grazing on Federal Lands

Current livestock grazing on federal lands is confined to a few locations in the lower valley in tributaries to, but away from, the mainstem Entiat River. There is a sheep allotment in the Tillicum Creek - Gold Ridge area where a band of sheep (1,000 ewes with lambs) grazes each year. This allotment includes land in the Wenatchee River watershed, outside of the Entiat WRIA.

The Potato Creek allotment includes the largest area grazed by livestock within the Entiat watershed. Two permittees are able to graze cattle on several wildland pastures within this allotment. One permittee was allowed to graze 56 cows with calves on pastures in the Mud

Creek drainage. As a result of the 1994 Tyee fire the permitee was notified that cattle would not be allowed to utilize the burned area until certain vegetation and range readiness recovery criteria were met, and was thus granted a temporary 5-year permit on Dinkelman Ridge in 1996 (T. Graham, pers. comm. November 17, 2003). In 2001 the range readiness conditions were met; however, the grazing permit was turned back to the National Forest Service by the permittee and is currently vacant (T. Graham, pers. comm. November 17, 2003). A second permittee is allowed 48 head of cattle with calves in the Crum Canyon and the Bear Gulch/Roaring Ridge areas where he alternates years of use. The operations were/are managed under a modified rest-rotation system of grazing where season of use and/or rest is rotated among several pastures annually.

Grazing on Private Lands

In 1996 the CRMP group used aerial photography interpretation and ground truthing to determine that there were approximately 180 to 200 acres of irrigated private land used for hay production and/or pasture in the subbasin at that time. It was estimated from interviews with various individuals and a count of animals performed the second week of April 1996 (see Appendix J) that there were between 215 and 250 head of various classes of livestock that may have occupied private lands within the subbasin for at least part of the year.

The 1996 survey estimated that between 145 and 185 of these animals utilized the Entiat River valley bottom; a few other locations were noted as having very limited mainstem river "watering" access. The survey identified three locations where livestock had direct access to the river, which may have had the potential to affect water quality. The study determined there were 12-15 donkeys on about two acres near Saunders Canyon that had unlimited access to the river; between 40 and 60 cows on about five acres near Ringstead Canyon had river access, and a complex of fenced corrals associated with these cows was immediately adjacent to the main river. The 30-40 head of cattle brought onto the Tyee Ranch during the summer each year also had access to the river. Overall, the 1996 mapping showed that many of the pastures from Potato Creek to the river mouth were fenced along the riverfront; with fewer than 2000 feet of river in this 15.5 mile reach open to direct access by livestock.

Of the remaining livestock, 27 head of horses were "on and off" the watershed in the Dick Mesa area north of the river mouth and the town of Entiat. In 1997 there were 60+ head of horses in this area. Entiat tributary drainages with livestock included: Mills Canyon, 12 horses; Roaring Creek, 5 horses; Crum Canyon, 8 horses; and the Mud Creek area above the mouth, 5 horses.

Concern for water quality exists where livestock have direct access to the river (for more information on water quality, see Chapter 8). The planning group estimated that less than 2000 feet of riverbank was available to livestock from the Potato Creek confluence downstream to the mouth of the Entiat River. Many pastures in this 15.5 mile reach were, and still are, fenced along the river front. Only at two or three of the livestock locations identified in the 1996 study did there appear to be some stream bank stability and water quality implications as a result of private land use by livestock. Water sampling data collected at various locations in the subbasin have shown few fecal coliform excursions

above State standards; data indicated infrequent elevations in Mud and Potato Creeks. Thus, it appears that neither the limited direct access livestock had to the river in the past, nor current land use practices have notably affected water quality in the subbasin.

Recreation

The Entiat River its tributaries, especially the Mad River, provide users with a wide range of recreation experiences, from developed campgrounds to undeveloped primitive campsites. An extensive road network that ranges from two-lane asphalt roads to single lane dirt trails provides access to recreation within the subbasin. Although a few of the scattered parcels of private lands have trails and roads passing through them, there is little developed recreation associated with private lands in the WRIA. As mentioned in the demography and economics section, the 2000 census reported just over one-third of the residences in the Entiat subbasin were part-time/vacation homes.

Forest Service Recreation Management

Developed Recreation

Most of the developed recreation in the Entiat subbasin is confined to areas along the Entiat River, except for the Pine Flats Campground, which is located along the Mad River. The Entiat RD provides recreational opportunities through 107 family-oriented campgrounds, with all but 11 being fee sites (full-service sites); two observation points; two summer home tracts; and two group reservation sites. Currently, the condition of the Entiat RD's recreation facilities ranges from good to poor.

Over the past decade, recreation on the Entiat RD has increased steadily, with most weekends running over 100 percent capacity and weekday use during July and August at 50 to 60%. The Silver Falls complex is the most popular recreation site, receiving approximately 27,000 campers annually. The National Recreation barrier-free trail at this site receives an additional 6,000 visitors annually.

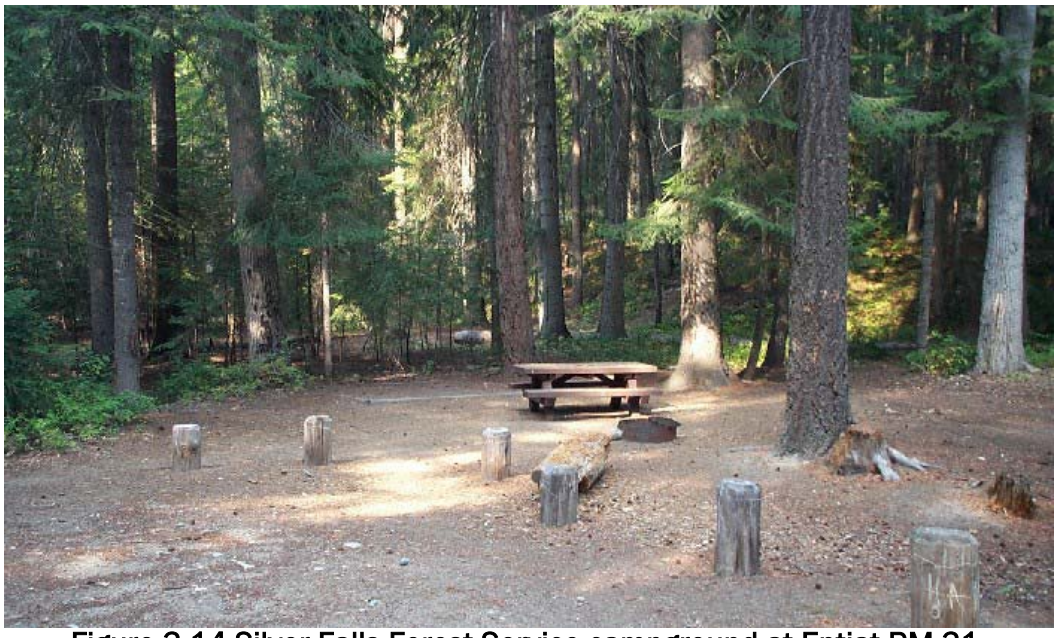


Figure 3-14 Silver Falls Forest Service campground at Entiat RM 31.

The recreation use level for all National Forest developed campsites in the Entiat valley in 2001 was 80,000 visitor days (T. Graham, pers. comm. 2002). This use estimate was based on campground receipts only and did not include dispersed recreation activities like trail use, fishing, sight seeing, etc.

Recreation Trails

The Entiat RD provides the trail traveler with a wide range of recreation experiences. The District presently manages 292 miles of forest single-track trails. This system is divided into three different management areas: Wilderness Trail System (65 miles), Non-Motorized Trail System (35 miles), and Multiple-Use Trail System (184 miles). There are also 6.5 miles of hiker only trails.

Wilderness trails are closed to all mechanized modes of travel. The main access route into this trail system is from the Entiat River trailhead at Cottonwood via trail #1400. Prior to the Washington Wilderness Act a portion of this trail, from the trailhead to the old wilderness boundary, was unrestricted to motorized vehicle travel.

The Non-motorized Trail System lies primarily near the North Fork of the Entiat River. Prior to the implementation of the 1990 Land and Resource Management Plan, the system was managed as unrestricted, with vehicle travel allowed.

The Multiple-Use Trail System managed by the Entiat RD represents the hub of one of the largest and most unique systems of interconnecting trail networks in the Northwest, consisting of over 235 miles of trails, 184 of which are on the Entiat. This system is primarily used by the motorized recreationists, but is also enjoyed by hundreds of mountain bikers, equestrians, hikers and the occasional llama/goat packer. More than 50% of the use that occurs on the District's Multiple-Use Trail System originates in western Washington. The Upper Mad River area is the most popular destination within this system. The gentle topography of this area and trails with limited exposure to danger make this an attractive family recreation area.

Dispersed Recreation

Currently, the Entiat Ranger District has an estimated 250 dispersed camps scattered throughout the WRIA, 200 of which have been mapped. Extensive impact surveys have been completed for camps in the wilderness. These dispersed areas provide opportunities that are very different from those found in more developed locations. Most camps throughout the District are concentrated around water sources.

Winter Recreation Activities

Winter recreation in the WRIA consists mainly of snowmobiling, with some cross-country skiing. Snowmobiling is one of the Entiat RD's fastest growing recreational activities. Popular groomed routes include Eagle Creek along Entiat Ridge to Sugarloaf Lookout, and from 25 Mile Creek over Shady Pass and down to the Sno-Park located 1/2 mile above the forest boundary sign along the Entiat River Road. Since 1997 additional grooming has occurred on routes near Sugarloaf, Tillicum, Moe Ridge, Gold Ridge and Roaring Ridge. Use varies from area to area, with the highest-use areas occurring along the Entiat Ridge (groomed) and Tyee ridge (ungroomed).

Other Recreation Activities

Other popular activities in WRIA 46 include hunting, fishing, and sightseeing from forest roads and trails. Roads, which were primarily constructed for logging, now serve a variety of purposes including administrative access, public access, logging, and fire control activities.

Wild, Scenic and Recreational Rivers

The USFS, in the Land and Resource Management Plan for the Wenatchee National Forest (USFS WNF 1990a), identified portions of the Entiat River as candidates for potential designation by Congress as part of the National Wild, Scenic and Recreational Rivers system. The Entiat has been determined to exhibit outstandingly remarkable scenic resource values, which makes it eligible for designation. Designation is intended to preserve and protect scenery, recreation, geologic, fish, wildlife, and historical, cultural and ecological resource values within the river corridor. Recreation activities including water sports, viewing scenery, and camping would be enhanced through this designation. River sections proposed for designation include:

- from the headwaters to the Glacier Peak Wilderness boundary (12.5 miles) – wild classification;
- from the Glacier Peak Wilderness boundary to the Cottonwood trailhead (4.0 miles) – scenic classification; and
- from the Cottonwood trailhead to above the confluence with Burns Creek (15.0 miles) – recreational classification.

3.2.4 Demography and Economics

Residential Housing and Population Trends

Past housing development was primarily associated with historic settlement and tied to the growth of the logging/sawmill and orchard industries. Although there were many homesteads and timber claims in the lower tributaries and the mid-Entiat River area, most of these became uneconomical. Landowners often worked elsewhere in or outside of the valley. Some landowners later used the residences associated with their homesteads, although often they were sold to adjacent owners and/or abandoned.

The Chelan-Douglas Health District started tracking septic system installations in the mid 1950s, and all systems approved for installation since 1983 meet system standards. According to the Health District, systems that were installed prior to 1983 are generally in good condition and most early residences were located away from the river and floodplain, thus helping to protect water quality. Only a few of the older systems may not meet today's standards; however, many of these have been and continue to be upgraded to meet septic system standards. Furthermore, valley residents have had a good record of compliance with upgrade requirements.

The Chelan-Douglas Health District reported in 1998 that there were over 300 septic systems in the Entiat valley, over one-half of which were installed between 1993 and 1998. Accordingly, the WRIA has experienced a fairly recent surge in urban population growth and rural part-time/vacation home construction. US Census data showed that the population within the city limits of Entiat remained relatively constant between 1981 and 1990;

however, between 1991 and 2000 it grew by 133%, from 449 to 957 people (US Census Bureau 1991a, 2001a). During the past decade, the rural year-round population within the subbasin portion of the Entiat CCD grew by approximately 11%, from 739 to 829 people (US Census Bureau 1991b, 2001b). Although recent year-round rural population growth occurred at a slower rate than urban population growth, 2000 Census data reported that the number of homes in the rural Entiat subbasin area of the WRIA grew by about 41%, from 278 to 470 units. Of these, 160 (34%) were reported as part-time/vacation homes (US Census Bureau 2001b). For more information about growth trends and future population estimates, refer to Chapter 4, Section 4.1.11.

Figure 3-15 shows the number of well logs submitted to WDOE annually. The surge in the number after 1975 was partially due to the resolution of landline location disputes and litigation in the late 1970s. During the dispute/litigation period, land title companies were not offering title insurance to prospective land purchasers.

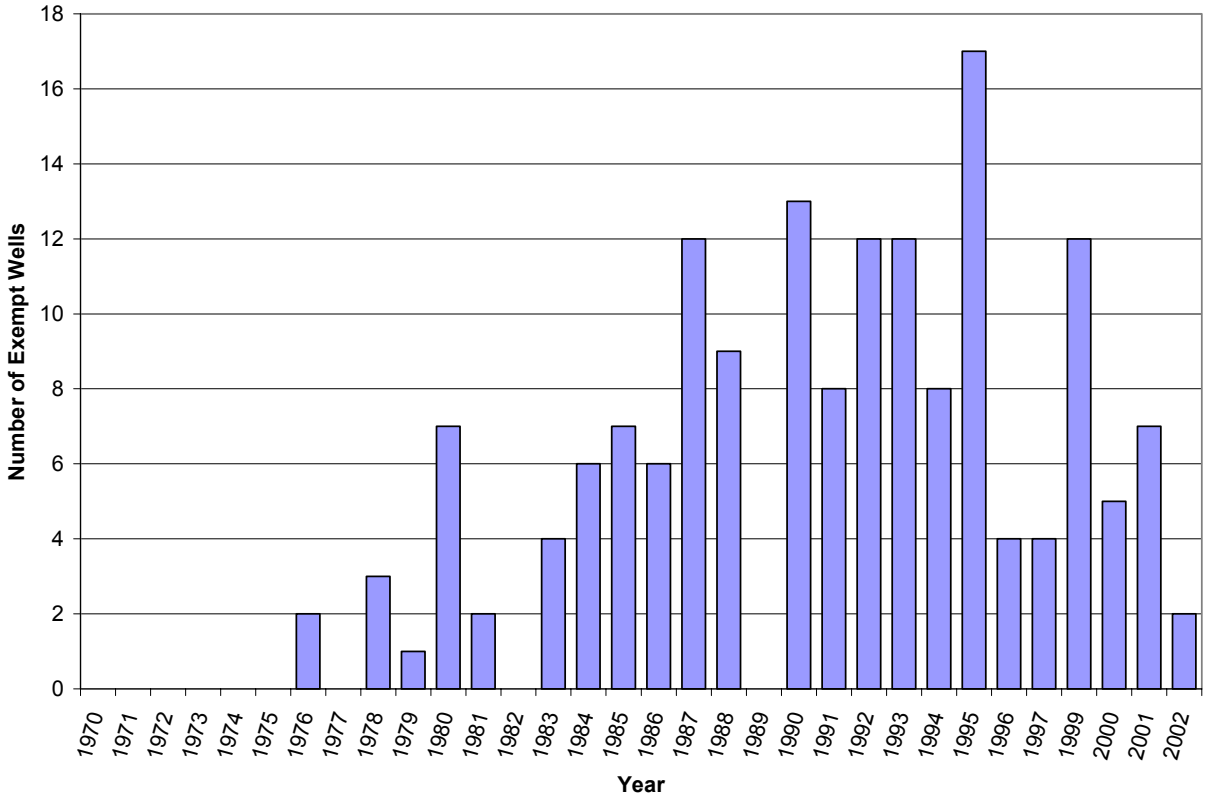


Figure 3-15. Number of exempt well logs submitted annually to WDOE since 1970.

Continued high-density development of private lands near the river on floodplains has the potential to threaten existing water quality (see Chapter 8, Water Quality). Water quality sampling has not indicated non-point source pollution problems related to septic systems or runoff from home sites and other developed areas in the valley, nor has it indicated regular fecal coliform bacteria, nitrate or phosphate level exceedences of State standards. Increasing concern exists regarding accelerated development in flood prone areas. Several parcels have been subdivided for additional home sites, and many new residences have

been/are being built in close proximity to the river on the floodplain and tributary alluvial fans, which have a high risk for inundation by flood flows.

Some citizens view an increase in population as an opportunity for new services. However, they recognize that more people and residences mean more septic systems, which raises important concerns about the long-term health of the river and other fragile environmental systems. Development pressure has increased the level of construction occurring on lands and areas on which earlier residents avoided building. In some locations, development and the removal of riparian vegetation has degraded the condition of streamside areas, promoting bank instability and reducing the ability of these areas to mitigate high flows. Residents have questioned how much additional growth the rural valley area of the WRIA can absorb before it detracts from the quality of life and/or threatens the environment, yet they are generally supportive of promoting additional balanced growth in the city center and its surrounding commercial/industrial area. Development, new land uses, and growth potential in the Entiat WRIA are now regulated to some degree by the Chelan County and City of Entiat Comprehensive Land Use Plans.

Economic Trends

The construction of Rocky Reach Dam in 1960 has been reported as having the greatest cumulative net negative impact on the fiscal situation of the City of Entiat and the Entiat School District (ECONorthwest 2003). The dam flooded a large area of the city's downtown business area and adjacent residential and agricultural land. It has been estimated that the dam's direct and indirect impacts caused the city and the school district to lose millions of dollars in past and projected revenues (revenues that they otherwise would have expected if the dam had not been built) from: property tax, sales tax, real estate excise tax, hotel/motel tax, and from state general-fund education revenue (ECONorthwest 2003).

Additional factors have contributed to poor economic conditions in the WRIA. Washington State Department of Revenue data (see Figure 3-16 on the following page) show that City of Entiat retail sales plummeted over 75% from about 6.5 million dollars a year to less than 1.5 million dollars a year between 1981 and 1982, and that retail sales were essentially stagnant between 1982 and 1992. Local residents indicate stagnancy was caused by setbacks in different sectors of the economy occurring at the same time. The mill at Ardenvoir, which employed up to 100 people, closed in the early 1980s; a manufacturer of specialized sleeper cabs for tractor-trailers also closed its doors. In addition, fruit packinghouses in the Entiat area closed. The Entiat Valley Community Action Plan (Gillis Group 1994), a document developed from the results of a survey of the Entiat community and a canvass of the entire Entiat valley, noted that hard economic times have affected the income level of some residents. Data from the 2000 census showed 9.1% of all families and 14% of individual residents of the City of Entiat fell below the federal poverty level (US Census Bureau 2001a). The poverty level in Entiat subbasin was lower than the level within the city limits.

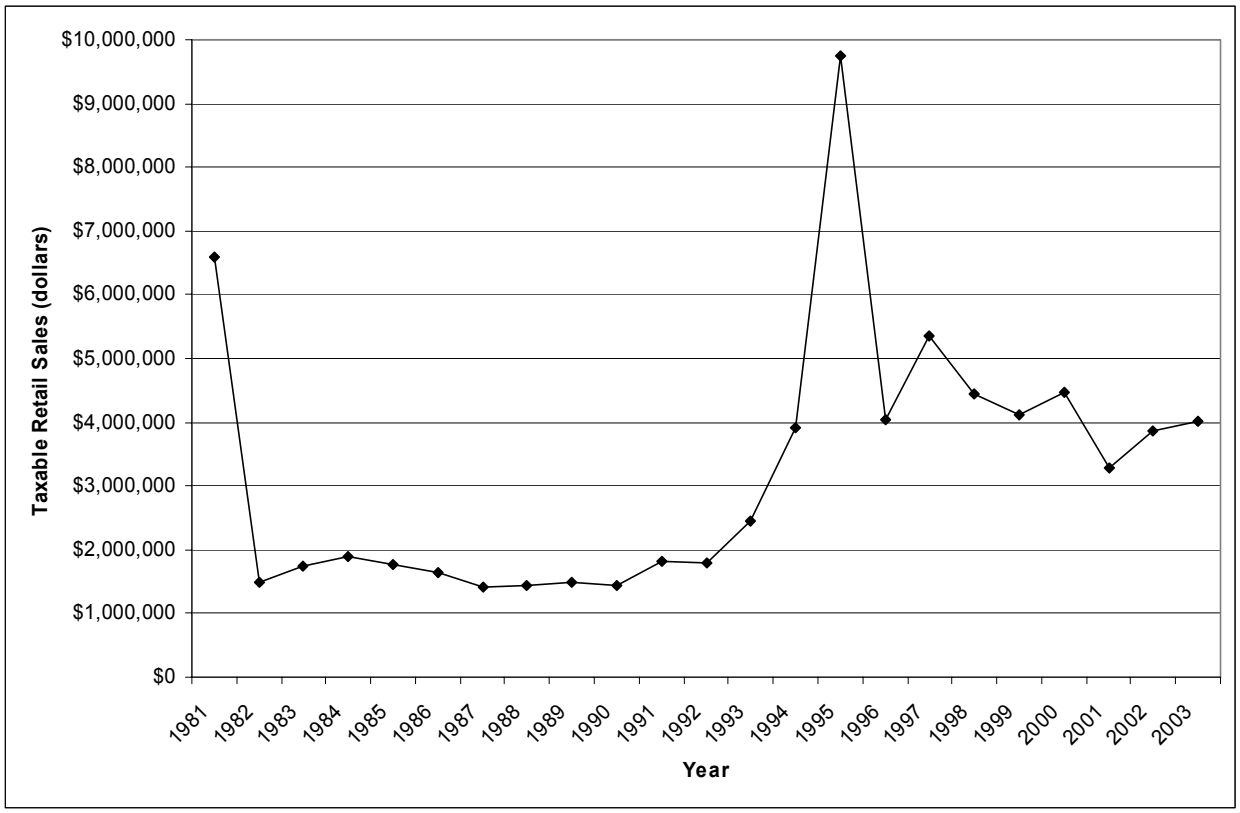


Figure 3-16. City of Entiat taxable retail sales, 1981-2003.

The 1994 Community Action Plan substantiated the continuing importance of the agricultural/orchard community as the most stable, enduring industry in the Entiat WRIA, and contained information about several economic assets and weaknesses of and/or constraints on future economic development efforts in the City and rural area. The Community Action Plan included three key goals to achieve the Entiat's definition of economic success:

- Focus primarily on manufacturing to create year-round jobs that pay a living wage.
- Develop Entiat's town center as a focal point for activity and shopping through strategic actions.
- Preserve the beauty of the Entiat valley through good local planning and cooperative efforts with the County.

The 1994 Action Plan was updated by the Report on the Update of the Community Action Plan and A Vision and Goals for Entiat, Washington (Stewart 1999). Both the 1994 Action Plan and the 1999 update were funded jointly by the USFS Entiat RD and the City of Entiat. The 1999 update report noted that job creation, population growth and economic expansion in the Entiat and the region overall had increased due to new manufacturing and service industry positions throughout the region, and the Entiat area had benefited in particular from the addition of Aeromet America Industries (see Table 3-4 on page 3-32).

Table 3-4. Economic issues identified by 1994 Community Action Plan and 1999 Update Report.

Economic Assets identified in 1994 Report	Additional Assets added by 1999 Report
High quality of life	Completion of the City of Entiat Comprehensive Land Use Plan, which is contributing to sound development and quality residential areas.
Abundant and diverse recreational opportunities	Organization and development of the Columbia Breaks Fire Interpretive Center Foundation.
Located in a growing, prosperous region	
Available local labor force with access to additional workers through the Link bus system	
Pro-active local officials, volunteers and regional organizations	
Close access to medical facilities and other services in Wenatchee and Chelan	
Relatively low cost of living and affordable power rates	
Local people support job creation	
Available industrial land with access to services and transportation	
Economic Weaknesses/Constraints identified in 1994 Report	**Additional Weaknesses added by 1999 Report. Asterisk items based on LSC review**
Limited local population base and income to support new businesses	Very low tax base, both in sales and property tax, for the City of Entiat.
Lack of a well-defined town center, as a result of the dam, and few local stores/services	*Elements of Growth Management Act
Stiff retail competition from Chelan and Wenatchee	*Regulatory & environmental constraints
Distance from major urban markets	Lack of physical space (see Section 3.2.2,)
Lack of local communication vehicles	
Water rates that are currently higher than in other small communities	
Current housing shortage	
Declining availability of local timber	
Located in an environmentally sensitive area	
Limited planning mechanisms to ensure compatibility and appropriateness of local uses of land	

The 1999 update document reported that several of the aforementioned weaknesses are changing or have already been modified, and that significant population growth and home construction have occurred within the City of Entiat and the Entiat rural area, and these trends are expected to continue. Technological innovations such as the Internet and the potential installation of fiber optic lines by the PUD, coupled with the elimination of long distance charges between the cities of Chelan and Douglas Counties, are making the concern about lack of communication almost obsolete. Finally, land use planning and comprehensive plan development and adoption by the City of Entiat and the County have provided a framework to help plan for and guide growth within the Entiat WRIA.

Refer to Entiat Valley Community Action Plan (Gillis Group 1994) and the Report on the Update of the Community Action Plan and A Vision and Goals for Entiat, Washington (Stewart 1999) for further information on vision and goals; also see the 1996 Columbia Breaks Fire Interpretive Center Foundation Business & Development Plan for more material related to this topic. Refer to the Comprehensive Plan for the City of Entiat, Chelan County, Washington (1997) and the Comprehensive Plan for Chelan County, Washington (2000) for City and County land use policy and planning information, respectively.

3.2.5 Cultural Resources

Native Americans were the first occupants of the Entiat WRIA. The Entiat band of the Moses-Columbia Indians, who lived along the Columbia River and its tributaries between Priest Rapids and Wells Dam, use the word Entiat to name the area around the mouth of the River. Their translated meaning of the word Entiat is "grassy water place" (M.D. Kinkade, pers. comm. 2002). The Entiat WRIA lies within territory ceded by the Yakama Nation in 1855. The traditional Yakama spelling is "Int-yat", which is described as meaning either a rich and abundant area, or happiness, depending on pronunciation (Johnson Meninick, pers. comm. October 31, 2003). Plants found in dry lithosol areas, wetlands, and other areas within the WRIA are significant to the Yakama Nation for medicinal and other purposes. Salmon continue to be an important natural, spiritual and cultural resource. In addition to ancestral and present use, legendary stories about the Entiat are told by Yakama elders to preserve the history of and respect for areas of cultural significance in perpetuity.

Cultural resources found within WRIA 46 represent a range of artifacts and sites, which may include:

- historic cabins, trails, mines, ditches, railroad grades, emigrant trails, original highway grades, mills, and homesteads;
- historic Forest Service structures including guard stations, lookout towers, corrals, camps, administrative centers, and Depression-era campgrounds and buildings; and
- prehistoric campsites, villages, graves, quarries, pictographs, workshops, trails, rock shelters and religious sites.

As of July 1997, six cultural resource sites have been inventoried on private lands within the subbasin and classified as historic sites on a list maintained by the State Historic Preservation Office. The identification and listing of these sites is in compliance with national and state Historic Preservation laws. Federal law requires federal agencies to do a preliminary cultural survey of any area where ground-disturbing activities take place; the law also applies to activities on private lands where a federal agency is expending federal funds as a cooperator. As of April 2002, approximately 37 sites had been inventoried on National Forest lands within the subbasin. Of the 37 sites, 32 are classified as historic and 5 are classified as prehistoric. Four of the 32 historic properties are listed on the National Register of Historic Places (P. Gadd, pers. comm. 2002). The Badger Mountain lookout (Figure 3-17 on the next page), which was moved to the Columbia Breaks Fire Interpretive Center in the minor Columbia River tributaries portion of the WRIA, and Tyee lookout are both listed on the National Register. The Steliko Ranger Station (Figure 3-18) is not currently listed but is eligible for listing.

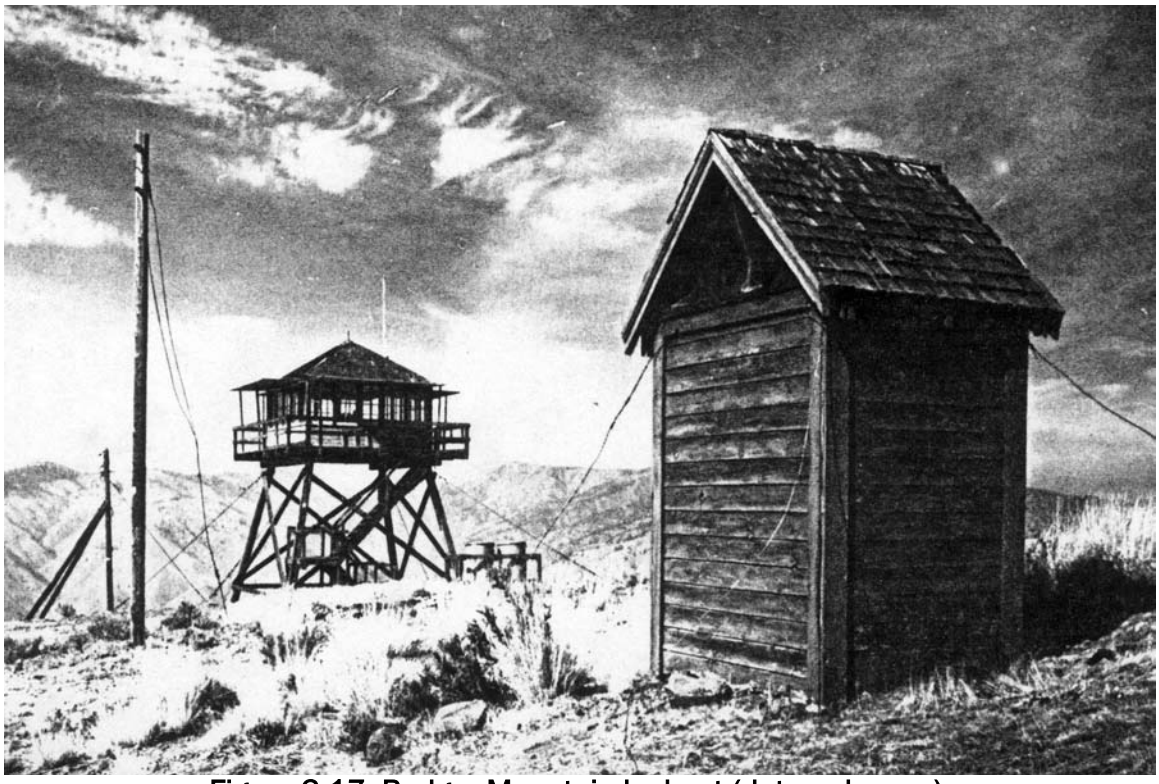


Figure 3-17. Badger Mountain lookout (date unknown).

Figure 3-18. Steliko Ranger Station, circa 1926.

*Photographs courtesy of the National Archives and USFS Wenatchee National Forest Supervisor's Office, Wenatchee, WA.

Visual Resources

Scenic vistas and natural beauty are critical to the quality of life and recreational economy of the Entiat WRIA. The landscape is typical of the Northeast Cascade Mountains. The parallel mountain forms have approximately uniform crest elevations. Rock forms are common, especially on the ridge tops and steep upper slopes where jagged rocky peaks occur and glacier-carved outcrops abound. The physical features of the geology and climate influence the landscape pattern. The most predominant physical geographical features are the naturally established elements of landform. The structure of mountain peaks and the glaciated U-shaped main valley with hanging valley tributaries, often featuring waterfalls, are outstanding.

The change in elevation within the WRIA, from 9,249 feet at the Entiat's headwaters to 713 feet the river mouth, offers a wide range of vegetation from alpine to near desert types. The vegetation is characterized by a wide variety of communities and species, and patterns vary throughout the basin; the landscape is dominated by true fir and hemlock in higher elevations, and pines as elevation drops. Shrubs and grasslands dominate south slopes and lower elevations. Development of human settlement has created a rural feeling in the landscape character of the lower valley where irrigated orchards offer a welcome contrast to the arid grass-shrub hillsides in mid and late summer.

3.3 NATURAL ENVIRONMENT

3.3.1 Climate

Climate in the Entiat WRIA is strongly influenced by orographic effects associated with its location extending from the Columbia River to near the crest of the Cascade Mountains. Climate is discussed below in averages for winter and summer; however, fluctuations outside of average are very common, and extremes may best describe the local climate. Examples of such extremes include temperatures in the 90s and 100s, which may last for several weeks at a time during the summer, and single digit and sub-zero temperatures (occasionally double digit) for short periods during many winters.

Mean annual precipitation can range up to 90 inches in the headwater areas near the Cascade crest to less than 10 inches along the Columbia River. Approximately 50% of the mean annual precipitation falls from October through January, and 75% falls from October through March. Most winter precipitation falls as snow; however, rain is not unusual at some mid- and lower elevations. Cumulative snow depths range from less than 24 inches in lower elevations to nearly 400 inches. Precipitation in July and August, the two driest months, is 5-10% of the annual mean. High intensity, short duration thunderstorms frequently develop over the mountains in the summer, resulting in heavy downpours of short duration in the subbasin. Occasionally these heavy rains produce flash floods. Long-term records (1949-1992) from climatological stations in the surrounding area do not show any definitive increasing or decreasing trend in annual precipitation (Kirk et al. 1995). Refer to Figure 3-19 on the following page for a depiction of annual precipitation ranges estimated for the Entiat WRIA. The isohyet GIS data were derived from PRISM model outputs based on 1961-1990 mean monthly precipitation data (Daly et al. 1994, Daly et al. 1997).

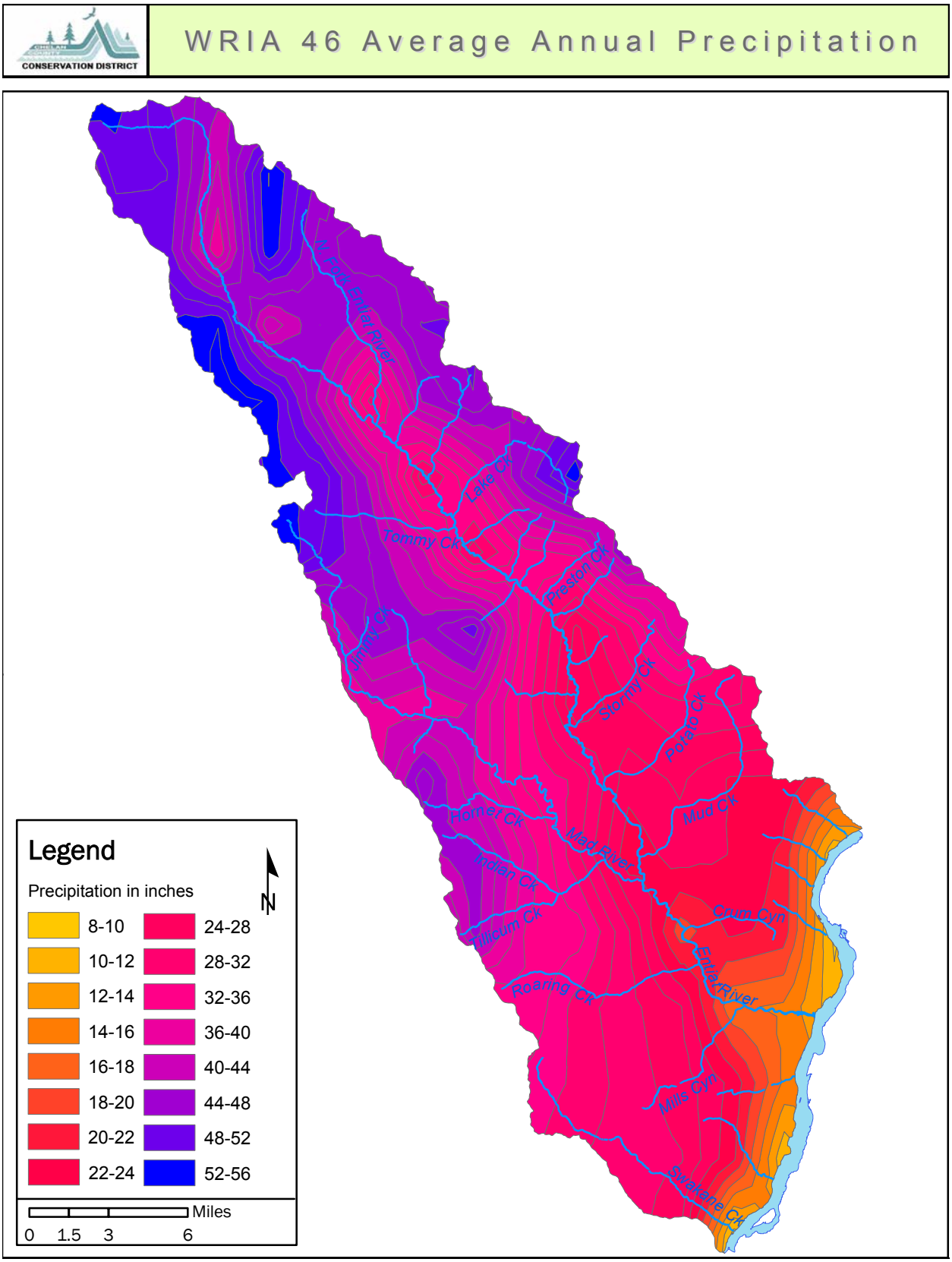


Figure 3-19. WRIA 46 average annual precipitation in inches.

Average daily summer temperatures in the mid-elevations range between 60 and 70 degrees, decreasing to the 50s at higher elevations. High temperatures in the 90s frequently occur in the lower valley during July and August. In winter, storm systems moving east from the Pacific, as well as outbreaks of cold air from the north produce frequent weather changes. During an average winter, temperatures range from the teens to the 40s depending on elevation. The frost-free season is generally mid-May through early October; however, frost in the lower valley has occurred as late as the first week in June. The first frost of the fall is likely to occur about October 1. The average growing season in the agricultural area of the subbasin averages 150 days; the upper valley experiences a shorter growing season due to increased elevation and later departure/earlier onset of frost.

Air Quality

The Entiat valley is classically positioned on the east slope of the Cascade Mountains, where climate and air patterns predispose the valley to periods of air stagnation, especially during the fall and winter. During periods of air stagnation, air contaminants generated at the surface within the valley tend to accumulate, rather than disperse. Pollutants generated within the Entiat "airshed" more readily disperse during times of air movement.

The Entiat airshed is impacted by many forms of outdoor burning, including forest prescribed burning and wildfire, agricultural burning, and residential burning, and is also seasonally affected by residential woodstove use. High levels of air pollution can put visual as well as air quality resources at risk. As population continues to grow and the area becomes more developed it could become increasingly difficult to protect visual resources and air quality.

The WDOE administers an air quality registration and permitting program for commercial and industrial sources of air contaminants. There are no registered sources within the Entiat watershed adjacent the Entiat River, although there are a few regulated sources within the City of Entiat. Although WDOE monitors airsheds across the state, no monitoring data exist for the Entiat airshed. The nearest monitoring site is in the Wenatchee area, where the WDOE has been collecting information since 1998. WDOE has no immediate plans to expand their air monitoring to include the Entiat airshed.

3.3.2 Topography

The Entiat WRIA is characterized by three distinct types of topography. Rolling hills found in the minor Columbia River tributaries area of the WRIA are indicative of an earlier geologic era when streams were downcutting slowly. Steeper topography created by uplifting and the formation of the Cascade Mountains is more commonly found throughout the subbasin. During uplifting, streams became more erosive resulting in narrow incised canyons in the mid to lower valley portions of the subbasin. Soil and bedrock were eroded in these canyons and alluvial fans formed in areas where the streams met the Entiat River floodplain.

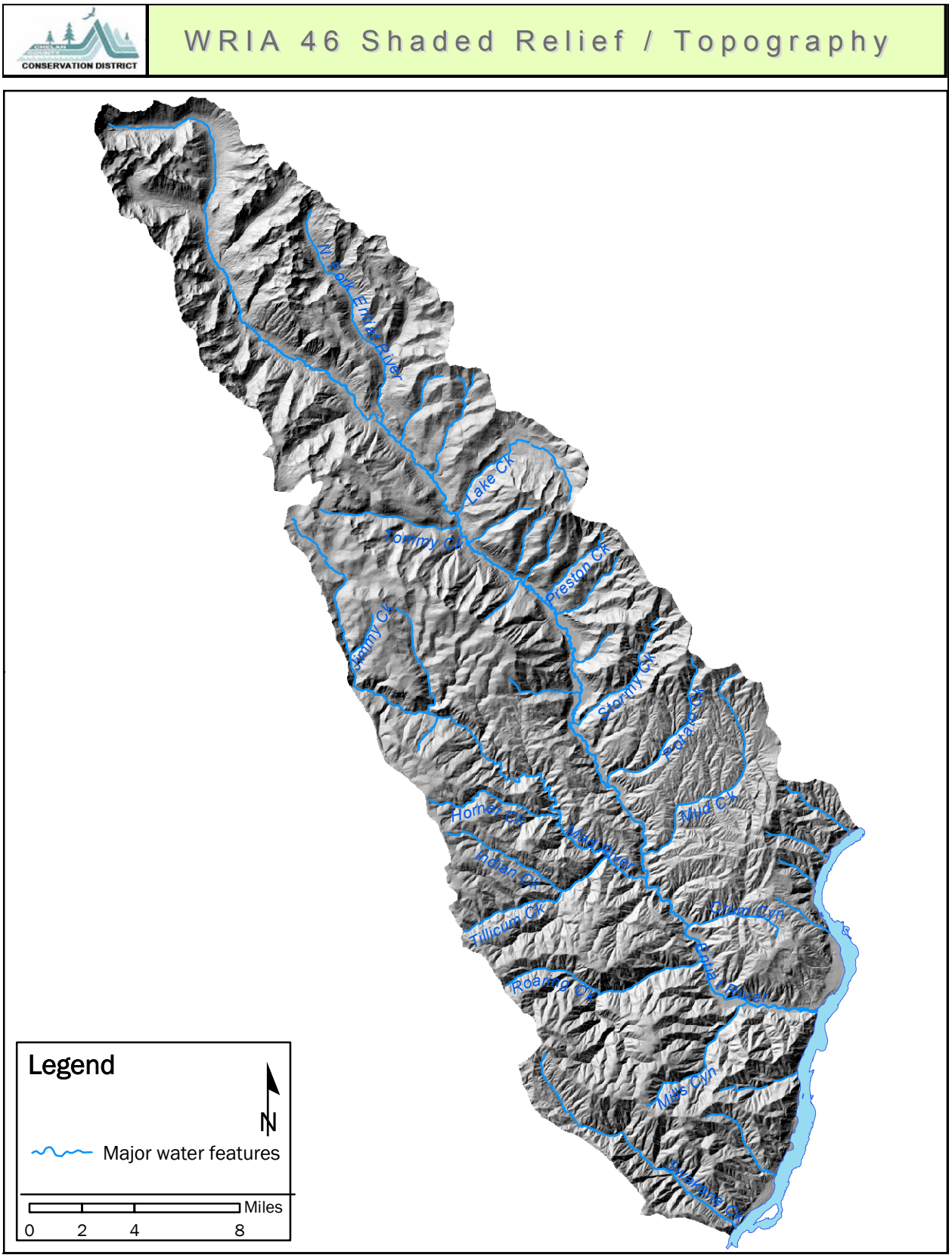


Figure 3-20. WRIA 46 shaded relief / topography.

Most of the topography in the WRIA is the result of alpine glaciation, which significantly affected the upper half of the Entiat subbasin. During the neo-glaciation period a valley glacier that was nearly 25 miles long extended from its source at the headwall of the Entiat watershed to just below Potato Creek, which is marked by a terminal moraine indicating the furthest downstream influence of the glacier on channel geomorphology and bed material. Above the terminal moraine the Entiat valley has a characteristic U-shaped appearance and is covered with glacial till. Glaciation resulted in hanging valleys and a moderately broad floodplain in the mid-Entiat River that contains water-stratified silt, sand, gravel and cobbles.

Figure 3-21. Entiat U-shaped valley created by glaciation, looking northwest near RM 24.

3.3.3 Geology

Geology in WRIA 46 is characterized as being composed primarily of metamorphic schist and gneiss, intrusive granodiorite, and quartz diorite. The Chelan and Entiat Mountain ranges consist of rugged angular forms indicative of hard rocks, predominantly quartz diorite and granodiorite, with lesser amounts of schist and gneiss. More resistant dikes of rhyolite porphyry traverse some areas. Mt. Maude and Seven Fingered Jack are massive quartz diorite formations, while Spectacle Butte is part of an exposed quartz diorite/gneiss pluton.

Major geologic formations include Swakane Gneiss, Chiwaukum Schist, and Mt. Stuart Granodiorite. Swakane Gneiss is the oldest and is composed of medium grained gneiss, coarse amphibolite schist, and many small stringers of pegmatite and mylonite. Chiwaukum Schist contains foliated rocks ranging from phyllite to fine gneiss. Mt. Stuart granodiorite consists of medium to coarse-grained gray granodiorite containing abundant biotite and some hornblende. This formation is often highly weathered where exposed.

The Entiat WRIA includes at least two outcrops of Columbia River basalt. The northernmost outcrop is located in the Dick Mesa area about one mile northwest of the City of Entiat. The Dick Mesa basalt cap is covered with a layer of loess very similar to Palouse Loess deposits

found to the southwest. The southern outcrop, called the Tenas Basalt, is located west of Rattlesnake point near the head of the south fork of Tenas George Canyon. The readily observable part of the Tenas Basalt is on the east end of the Entiat Ridge. It reappears in several places along the Entiat Ridge and into the head end of Roaring Creek, especially at Prairie Springs and the junction of Dinkelman ridge and the Entiat Ridge. The Tenas Basalt soil cap is associated with the natural weathering of the exposed basalt. The presence of local basalt dikes might suggest local extrusions, but the presence of loess on Dick Mesa may indicate a relationship to the Miocene lava flows from the southwest. Both basalt deposits are mini-aquifers with several springs seeping out at or near their contact with bedrock.

Glacier Peak, a currently inactive volcano that lies 14 miles west of the headwaters area of the WRIA, has covered most of the area with volcanic ash and pumice thrown from within it at different intervals over the past 12,000 years. Prevailing winds carried pyroclastic debris east; hence, the amount and type of deposition is related to topographic aspect and distance from Glacier Peak. The pumice and ash deposits are deepest on north and east facing slopes, and in some places they are deep enough to obscure the underlying bedrock.

3.3.4 Land Type Associations[4]

Land Type Associations (LTAs) are defined by geomorphic process expressed by landforms (topographic characteristics), geology and potential natural vegetation groups. LTAs express patterns of similar geomorphic processes and conditions, which in turn help explain unique landscape level ecological and hydrological processes such as erosion and sedimentation, soil productivity, riparian/stream channel function, and natural disturbance regimes.

The USFS completed an ecological land unit inventory of the Wenatchee, Okanogan and Colville National Forests in 1999, in which 134 unique LTAs were identified and mapped. LTA information and data pertaining to percent fine sediment in substrate gravels were used to stratify the WRIA into three broad, landscape-level analysis zones: Transport, Transitional and Depositional. Figure 3-22 on page 3-42 depicts the extent of these zones within the WRIA, as well as USFS Entiat RD fine sediment sampling sites. Although distinct transport/transitional/depositional reaches lie within these three zones, more detailed geomorphic assessment work is needed to clearly classify/delineate reach-level processes.

Transport Zone

The upper part of the WRIA, which includes the mainstem Entiat from its headwaters to Entiat Falls, contains strongly glaciated land types. This zone has high subsurface water storage capacity favorable for vegetative growth and regulated baseflows. Coarse and fine sediment and large woody debris are recruited by a naturally high occurrence of debris flows. Fine sediment (diameter <1 mm) is transported through this zone with minimal deposition. The management effects in this zone have been relatively minor, with the exception of dispersed recreation, localized grazing, and trail impacts.

[4] Information on land types and soils was condensed from the Watershed Assessment Entiat Analysis Area, Version 2.0, Wenatchee National Forest (USDA Forest Service 1996), which includes information from all of the sources discussed.

Transitional Zone

The mainstem from Entiat Falls to the confluence with McCrea Creek lies within this zone, which exhibits characteristics of both transport and depositional zones, as influenced by glaciation. It is not unusual for a transitional zone to have characteristics of both transport and depositional zones. What may be somewhat atypical of the Entiat's transitional zone is that it contains an expansive depositional zone known as the "stillwater" area where glacial alluvium has accumulated and resulted in low gradient, meandering river channels composed of fine bed elements such as silts, sand, and small gravels. Above and below this reach are higher gradient Rosgen B and F-type channels, characteristic of transport reaches. This expansive depositional area places constraint on the channel length one might otherwise expect to be "transitional" throughout the mid-elevations of the WRIA.

Depositional Zone

The depositional zone characterizes the lower part of the Entiat WRIA, an area of non-glaciated mountain slopes dissected by stream down-cutting. Sediment deposition is a dominant process within this zone, and periodic floods generated from high intensity, convective storms are a significant transport mechanism. Fine sediments from steep hill slopes, swales and high gradient channel reaches are transported by surface erosion and debris flows and deposited along floodplains and alluvial fans during these events. A cycle of fill and scour occurs naturally along low gradient reaches within this zone. Recent wildfires have affected a large portion of this area (e.g., Crum, Dinkelman, and Tyee fires). Historic and current management influences in this zone are primarily wildfire and fire suppression; logging and associated road construction; grazing and agricultural development; riparian channel alterations from roading; housing development and fire/flood rehabilitation. Erosion and compaction of surface soils have reduced soil moisture holding capacity and productivity in many areas.

Table 3-5 provides a simplified summary of hazard interpretations for the LTAs found in the Entiat WRIA above and below the Potato Creek moraine.

Table 3-5. Land Type Associations, hazard interpretations, and associated risk levels.

LTA Hazard	Risk Level Above Moraine	Risk Level Below Moraine
Surface erosion	high	high
Debris slide	high	moderate
Sediment delivery	high	high
Soil compaction	low/moderate	high
Soil moisture stress	low	high
Surface runoff	high	moderate
Subsurface water storage	high	moderate
Regulation of stream flow	high	low/moderate

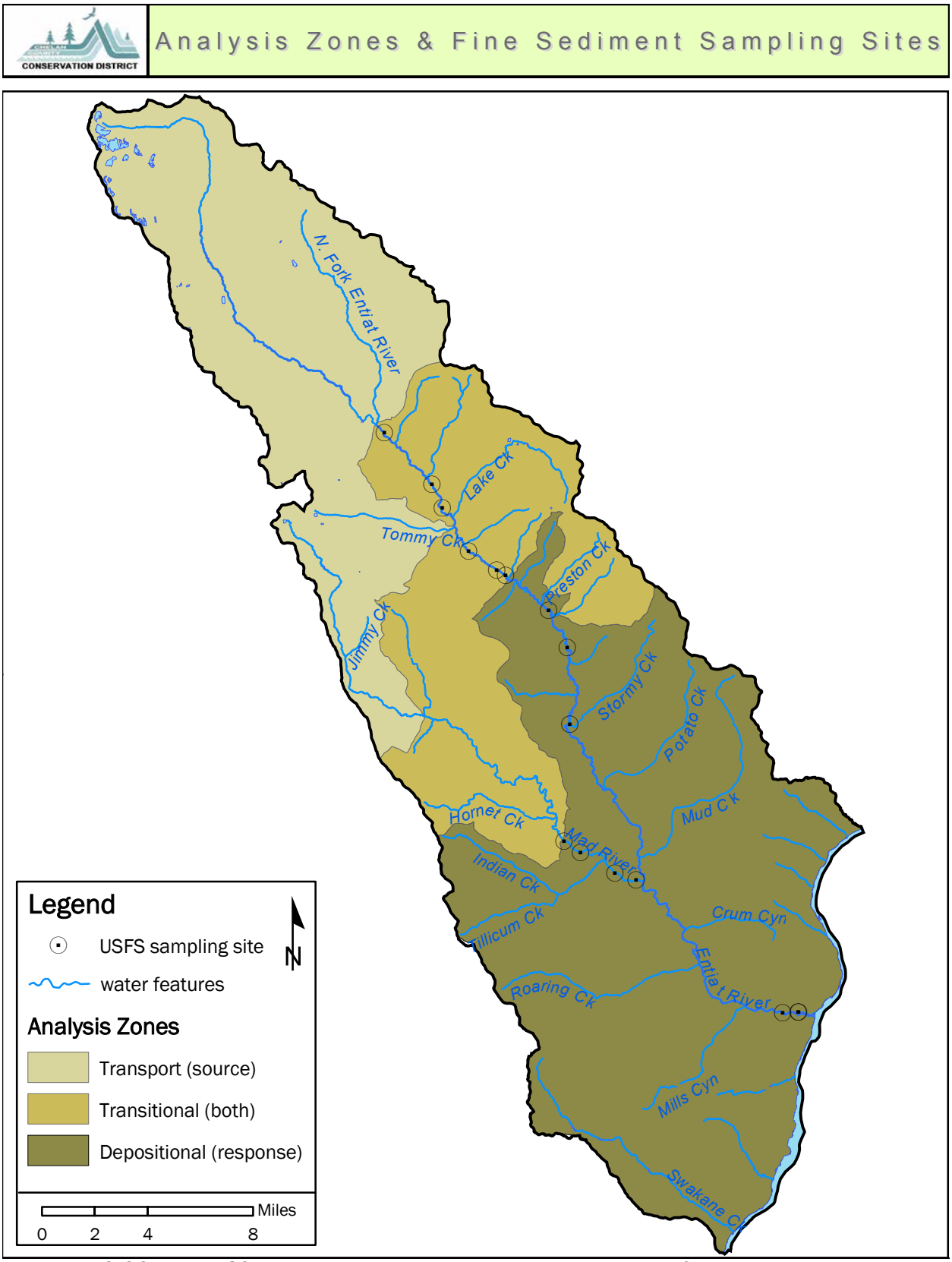


Figure 3-22. WRIA 46 land type association analysis zones and fine sediment sampling sites.

3.3.5 Soils and Prime Farmlands

Soils

Soils within the WRIA have been described in several reports. The earliest soil survey, "Soil Survey of Chelan Area, Washington, Parts of Chelan and Kittitas Counties" (SCS 1969), included private lands near the mouth of the Entiat River to approximately RM 10. In 1976 the USFS published a soils management report for the Entiat area, "Soils on Forest Service Lands" (USFS WNF 1976). The Soil Resource Inventory for the Wenatchee Forest incorporated information from the earlier Entiat area survey and report. The Soil Conservation Service, in cooperation with the US Forest Service, conducted a soil survey that mapped soil types on National Forest System and private lands, titled Soil Survey of Cashmere Mountain Area, Washington, in parts of Chelan and Okanogan Counties (SCS 1990).

Soils in the Entiat are generally highly erodible due to widespread deposits of volcanic ash and pumice or loess at the surface. Sediment delivery rates are typically high, primarily as a result of steep slope and high stream densities. Flooding and debris flows are significant transport processes for both sediment and organic material. Management disturbances such as grazing, tractor yarding and roading generally accelerate natural erosion and sediment delivery hazards on sensitive soils. Once fine-textured soils at the surface are disturbed, certain climatic conditions and coarse-textured sub-soils can create an environment that limits the amount of soil moisture available for vegetative growth.

Prime Farmlands

When the National Environmental Policy Act (NEPA) became law, it was recognized that the nation's farmlands, forestlands, rangelands and wetlands were being converted to other uses. There was a concern that continued conversion of these lands would impair the ability of the United States to produce sufficient food, fiber and wood to meet domestic needs. As a result of the NEPA and direction by the Secretary of Agriculture, the NRCS defined classifications for important farmlands and published rules in the Natural Register to be used to bring agency programs into compliance with the Act and the direction of the Secretary.

Important farmland classes include Prime Farmland, Unique Farmland, and Additional Farmland of Statewide Importance. All three classes have criteria that include landform, physical and chemical characteristics of soil and moisture. Prime farmlands have the most stringent criteria, with unique farmland being somewhat less notable but important for high value crops. The third class is for land that is of statewide importance to a specific state.

The Soil Conservation Service, as part of a 1969 survey that covered lands from the mouth of the river to one-half mile above Crum Canyon, designated approximately 1336 acres in the Entiat WRIA as "prime farmlands if irrigated" (SCS 1969). The Cashmere Mountain Soil Survey (SCS 1990) identified an additional 633 acres of prime farmlands in the WRIA, for a total of 1969 acres. Lands designated as prime farmlands include orchard land, but not all orchards fall within this designation. Lands other than orchard land, including pasture or land not managed for crops or livestock, are also included in the prime farmland

designation. The 1969 SCS survey also identified approximately 1111 acres as "farmlands of unique importance" and about 232 acres as "farmlands of statewide importance".

3.3.6 Vegetation

Vegetative Groups

Vegetation in the Entiat WRIA has been described over the years using a variety of methods. For example, one characterization emphasized vegetation important to grazing animals and identification of suitable range areas for range management analyses, while another characterization emphasized timber management interests by identifying stands with high commercial value.

The USFS identified vegetative groups on federal lands in the WRIA that had similar disturbance regimes. An approach comparable to that taken by Agee (1994) was used to delineate vegetation groups based on structure, general characteristics of the vegetation, tree species presence and tree canopy density. Designations also reflected a similarity in fire frequency and, to some extent, fire intensities and soil characteristics. The vegetative groups identified in the Watershed Assessment Entiat Analysis Area (USFS WNF 1996) are summarized below. Refer to the Synthesis Summary Tables section in Chapter 2 for additional vegetative information and USFS management strategies for these groups.

Shrub/Steppe

This dry plant community is dominated by shrubs, grasses, or both (see Figure 3-23 on the following page). Tree canopy cover is less than 10 percent and tree species are ponderosa pine or sometimes Douglas-fir. Common and dominant shrubs are bitterbrush and sagebrush. Common grasses are bluebunch wheatgrass, junegrass, Sandberg's bluegrass, and bottlebrush squirreltail. In the Entiat, this group is found below the forest margin or on drier sites within forested areas at elevations of less than 4,500 feet.

Open Forest

This group is found mostly at lower elevations on relatively dry sites, commonly with grass or shrub understories similar to the Shrub/Steppe Group. Typical tree canopy cover is 10-50% with grass/shrub cover of 10-90%. Ponderosa pine and Douglas-fir are the dominant tree species, with grand fir on some sites. These stands are essentially a transition between the shrub/steppe below and the closed forest above at elevations of less than 4,500 feet.

Closed Forest

Closed forest communities exhibit tree canopy covers of over 50%, with various understory species (see Figure 3-24). This group is typically found at elevations between 1,500 and 4,000 feet; it may occur on north slopes at lower elevations and southerly aspects in the subalpine zone. Climax tree species are either Douglas-fir or grand fir; however, ponderosa pine and to a lesser extent lodgepole pine may temporally dominate some areas as a result of fire occurrence and frequency. This group combines fairly dry stands with relatively low site productivity and moist closed forest with fairly high site productivity.

Figure 3-23. Shrub/steppe vegetation in the lower Entiat valley.

Figure 3-24. Typical closed forest near the Shady Pass Road junction (RM 30).

Closed Subalpine
This group is typified by more than 50% tree canopy cover and various understory species. Communities are found between 4,500-6,000 feet, although this group can be found at lower elevations in cold air drainage areas and on north slopes. The predominant climax tree species in this group in the Entiat is subalpine fir, and lodgepole pine is the typical seral tree stand dominant.

Open Subalpine/Alpine
Open forest/park land interspersed with subalpine and alpine meadows typifies this group. Stands are generally open (canopy <50 percent) except in small clumps. Understory composition is commonly low shrubs, forbs, and graminoids. Conditions are often cold and snowy at the typical elevation range of this group (4,500-7,500 feet, with most over 6,000 feet). Common trees are subalpine fir, Englemann spruce, whitebark pine, and subalpine larch. Mountain hemlock may be present, but has limited distribution in the Entiat.

A summary of USFS Entiat Ranger District vegetative group acreages is provided below.

Table 3-6. Summary of vegetative groups found within the USFS Entiat Ranger District.

Vegetation Type	Acres	Percent
Shrub-Steppe	36,777	13.7
Open Forest	48,925	18.3
Closed Forest	109,936	41.0
Sub-alpine Forest	20,966	7.8
Open Subalpine	49,941	18.7
Non-vegetation (rock and/or water)	1,190	0.5
Total	267,735	100

Noxious Weeds
Several species of noxious weeds are found on both public and private lands within the Entiat WRIA. The most common noxious weeds include Dalmatian Toadflax, Canada thistle and Knapweeds, which are abundant in several locations throughout the WRIA. Knapweeds are especially prevalent along roads and other disturbed areas such as construction sites, gravel pits, utility and transportation corridors, as well as previously cultivated and/or semi-abandoned croplands and pastures. Some livestock pastures are heavily infested. Noxious weeds identified in the Entiat WRIA by the Chelan County Weed Control Board and others include:

Spotted Knapweed
Russian Knapweed
Diffuse Knapweed
Yellowstar Thistle
Canada Thistle
Perennial Sow Thistle
Musk Thistle
Scotch Thistle
Scotch Broom
Jointed Goatgrass
Eurasion Watermilfoil
Rush Skeletonweed
Common Crupina
Puncture vine
Purple Loosestrife
Dalmation Toadflax
Spotted Catsear
Perennial Pepperweed
St. Johnswort
Longspine Sandbur
Tansy Ragwort
Oxeye Daisy
Wild Four o'clock

Proposed, Threatened, Endangered and Sensitive Plants

State and federal agencies maintain lists of proposed, threatened, endangered and sensitive plant species that occur or may occur within WRIA 46. It is estimated that less than 50% of the WRIA has been surveyed, thus it is likely the lists are incomplete. The data included in Table 3-7 and in Appendix K are maintained by state and federal agencies. Status classifications for some of the same plants may differ, depending on agency criteria.

Table 3-7. Endangered, threatened and sensitive plant species and occurrence in WRIA 46.

Scientific Name	Common Name	Occurrence	State Status	Federal Status
Astragalus arrectus	Palouse milk-vetch	documented	sensitive	R-6
Astragalus sinuatus	Whited's milk-vetch	may occur	endangered	SOC
Carex buxbaumii	Buxbaum's sedge	documented	sensitive	R-6
Carex proposita	Smoky mountain sedge	documented	sensitive	R-6
Chaenactis thompsonii	Thompson's chaenactis	documented	sensitive	R-6
Cypripedium fasciculatum	Clustered lady's slipper	documented	sensitive	R-6, SOC
Delphinium viridesens	Wenatchee larkspur	may occur	threatened	R-6, SOC
Hackelia hispida var. disjuncta	Sagebrush stickseed	documented	sensitive	R-6
Hackelia venusta	Showy stickseed	may occur	endangered	R-6, endangered
Iliamna longisepala	Longsepal globemallow	documented	sensitive	R-6
Nicotiana attenuata	Coyote tobacco	documented	sensitive	R-6
Orobanche pinorum	Pine broomrape	documented	sensitive	R-6
Petrophytum cinerascens	Chelan rockmat	may occur	threatened	R-6, SOC
Sidalcea oregana var. calva	Oregon checker-mallow	may occur	endangered	R-6, endangered
Silene seelyi	Seely's silene	may occur	threatened	R-6, SOC
Trifolium thompsonii	Thompson's clover	documented	threatened	R-6, SOC

R-6 – Designates plant species listed as sensitive by the USFS Region 6 Regional Forester.
SOC - Designates plant species listed as Species of Concern by the USFWS.
Documented occurrence data: P. Camp, BLM 8/26/97; T. Lillybridge, USFS 10/09/97; M.G. Miller, USFWS 1/03/00.

3.3.7 Wetlands

Generally, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface (Cowardin et al. 1979). Wetlands vary widely due to regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance. Wetlands typically include swamps, marshes, bogs and similar areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year.

The USFWS National Wetlands Inventory (NWI) is the best existing information on wetlands in WRIA 46. Table 3-8 provides a summary of the primary wetland systems and subsystems found within the WRIA. NWI data do not include all forested or seasonal wetlands, due to the mapping method used (high altitude aerial photography analysis). Wetlands are also dynamic, with plant communities and boundaries changing over time due to natural and human disturbances; thus, the accuracy of NWI data is limited. For more information about NWI data and wetlands codes/habitats, refer to the following links:
http://www.fws.gov/stand/standards/dl_wetl.html
http://wetlands.fws.gov/Pubs_Reports/Class_Manual/class_titlepg.htm (Cowardin report)

An accurate assessment of historic and current wetlands distribution within the WRIA is difficult due a lack field data. The NRCS has collected some on the ground data during wetlands surveys, and the WDOE's Shorelands Environmental Assistance program staff also collects wetlands data within the WRIA. Information from the NRCS and WDOE will eventually be used to update the digital NWI wetland maps and data layers. A comprehensive, detailed inventory of wetland resources in the Entiat WRIA would provide information about the location of various wetland habitats and help identify potential restoration/enhancement areas.

Table 3-8. Primary wetland systems and subsystems found within WRIA 46.

NWI Code	Definition	Approximate Acreage+
L1OW	Lacustrine, limnetic, open water	2412
L2UB	Lacustrine, littoral, unconsolidated bottom	23
L2US	Lacustrine, littoral, unconsolidated shore	6
PEM	Palustrine, emergent	514
PFO	Palustrine, forested	334
POW	Palustrine, open water	71
PSS	Palustrine, shrub-scrub	546
PUSC	Palustrine, unconsolidated shore	4
R3OWH	Riverine, upper perennial, open water	414
R3USA	Riverine, upper perennial, unconsolidated shore	93
U	Upland	301,223
	Total	**305,640**

+ Acreages generated using digital USFWS NWI GIS data.

3.3.8 Wildfire

As stated previously, large wildfires have always occurred in WRIA 46 due to its relatively dry hot climate, low summer precipitation, and the occurrence of summer and fall lightning storms. Over 60 % of the Entiat WRIA has been affected by large, stand-replacing wildfires that occurred in the 24 years from 1970-1994. Figure 3-25 on page 3-50 shows some of the effects of the 1994 Tyee Fire, which burned thousands of acres in the WRIA.

Natural fire events have had an important influence on natural resources in the WRIA, including vegetation types and patterns. Stand replacing fires in particular have affected wildlife and wildlife habitat. Some of the recent wildfires were followed by high intensity

storms, resulting in mud and debris flows that affected channel and riparian condition, aquatic habitat and water quality. Mud and debris flows also occurred historically, as evidenced by alluvial deposits at the mouths of most streams and canyons in the Entiat and Mad River watersheds.

Table 3-9 was developed from a timeline included in the Watershed Assessment, Entiat Analysis Area (USFS WNF 1996). Data for fires that occurred prior to 1888 are not readily available.

Table 3-9. Stand replacing fire occurrence and estimated acreages.

Year	Fire Name	Estimated Size (acres)
1888	Mad River	?
July 31, 1910	Signal Peak	2,560
August 31, 1914	Burns Creek	600
1925	Mad River Spectacle Butte Borealis Ridge	1500+ 600 500
1928	Coal Oil Fire	600
1941	Larch Lakes	400
1958	Entiat Fire	6,500
June 29, 1961	Tenas George	3,750
1962	Forest Mt.	520
August 26, 1966	Hornet Creek	1,520
August 5, 1968	Harris Mill	1,210
July 7, 1970	Mills Canyon	933
August 24, 1970	Entiat/Slide Ridge Gold Ridge	49,200 16,100
August 24, 1976	Crum Canyon	9,000
September 4, 1988	Dinkelman	53,000
July 4, 1990	Dick Mesa	1,151
July 24, 1994	Tyee	135,170
September 2001	Tommy Creek	640

Figure 3-25. Area where 1994 Tyee fire crossed the main Entiat road near Roundy Creek (background).

3.3.9 Hydrology

Hydrologic processes in the Entiat WRIA result from interactions among weather, climate, geology, soils, topography, vegetation, and an array of disturbance processes. Although disturbances from human activity include: grazing, roads, domestic/agricultural development, timber harvest, fire suppression, beaver control, recreation and government flood/fire rehabilitation work, natural disturbance processes dominate in the WRIA. These include: historic episodes of uplifting, glaciation, volcanism, earthquakes, high intensity storms, flooding, windstorm and wildfire. Wildfire has been the most notable natural disturbance process in recent years. Disturbance processes are described in more detail elsewhere in this document and in the Watershed Assessment, Entiat Analysis Area (USFS WNF 1996).

As described earlier, climate and topography create a wide range in annual precipitation. The capture, storage and release of precipitation control many of the WRIA's physical and biological processes. A large portion of the annual precipitation falls as snow and accumulates to form the winter snowpack. Warm spring temperatures and rain release water accumulated in snowpack as runoff. Thus, snowmelt is the dominant source of streamflow and groundwater in the Entiat WRIA. Occasional, large frontal and convective storms in the spring, summer and fall may increase flow or cause flooding.

Meltwater and precipitation in the WRIA can take several routes in the hydrologic cycle, including:

- evaporation from the soil and other surfaces
- use and transpiration by vegetation
- infiltration into the soil and shallow, sub-surface storage and transfer
- infiltration, deep percolation, storage and transfer in the Entiat aquifer
- streamflow discharge fed by groundwater and surface runoff, and
- groundwater discharge through the Entiat River aquifer to the Columbia River aquifer.

The routing of rain and meltwater is dependent on the physical characteristics of the soil. Surface infiltration rates, percolation rates and soil moisture storage are critical parameters that help determine runoff characteristics and plant water availability. These parameters vary by soil type and are subject to alteration by disturbance, as illustrated by these local examples:

- A reduction in infiltration rates may occur following a high intensity fire if a hydrophobic or water-repellent layer forms near the soil surface, which increases the potential for concentrated surface runoff, erosion and fine sediment delivery to streams. Infiltration rates return to normal over time as the hydrophobic layer is broken down.
- Loss of vegetation following wildfire reduces the amount of water previously used by plants, leading to increases in soil moisture that eventually translate into greater stream flows. This phenomenon was notable in affected portions of the Entiat after the major fire events of 1970, 1988 and 1994.
- Past human disturbances have had a detrimental effect on the soil's water conveyance and retention characteristics in many areas (USFS WNF 1996). In some areas, ground-disturbing activities (e.g., site conversions, grazing, roading, tractor yarding) have caused soil compaction, which decreases infiltration rates. Slope excavation for roads or other developments may intercept shallow sub-surface flows, increasing surface runoff and altering soil moisture distribution patterns. Over-grazing by domestic animals in the WRIA at the turn of the century may have contributed to surface soil changes that reduced soil moisture storage and increased soil moisture stress.

Annual water yield from the Entiat WRIA varies considerably from year to year. Steep topography, relatively short drainage length, pinnate drainage structure, and other factors promote a rapid mainstem flow response time to runoff and a wide range between peak flows and low flows in the lower Entiat River. Mean volume produced from 1951-1958 by the Entiat subbasin (419 sq. mile drainage area), as recorded at the mouth by the Entiat at Entiat gage, was 367,379 acre-feet. Mean annual volume recorded at the same site for the period 1970-1976 was 528,275 acre-feet, indicating a 44% increase in yield during the period following the 1970 fires (USDA 1979). Mean annual runoff recorded upstream at the Entiat near Ardenvoir gage (203 sq. mile drainage area) for the period 1957-1999 was 283,527 acre-feet, with an annual high of 451,140 acre-feet in 1972 and a low of 178,970 acre-feet in 1973.

Table 3-10 summarizes mean annual runoff in cfs recorded at the Entiat at Entiat and Entiat near Ardenvoir USGS gages, and details the extremes in runoff experienced after large fire

events and/or as a result of natural fluctuation in precipitation and runoff. A comparison between the gages shows approximately 75% of the mean annual runoff for the entire Entiat subbasin originates from an area just less than 50% of its total drainage area. Sustained runoff from the upper watersheds is critical to the maintenance of flows in the lower reaches of the Entiat River. The Mad River contributes approximately 32% of total surfacewater runoff to the Entiat River during the low flow period. Although no modeling has been conducted, changes in water yield resulting from past timber harvest activities are considered to be relatively minor when compared to natural variation caused by climate changes or large wildfire events.

Table 3-10. Select streamflow parameters for the Entiat River recorded at two USGS gages.

Parameter	Flow (cfs) at USGS gage Entiat at Entiat (RM 0.5)*	Flow (cfs) at USGS gage Entiat near Ardenvoir (RM 18)**
Mean annual flow range	275-800	175-621
Peak annual flow range	1,100-10,800	900-6,800
7-day mean low flow range	45-120	36-90

* Drainage area 419 sq. mi.; Period of record 1911-1925 & 1951-1958.
** Drainage area 203 sq. mi.; Period of Record 1961-1991.

Figure 3-26 shows the annual runoff volume in acre-feet recorded by the Entiat near Entiat (Keystone) and Entiat near Ardenvoir mainstem gages.

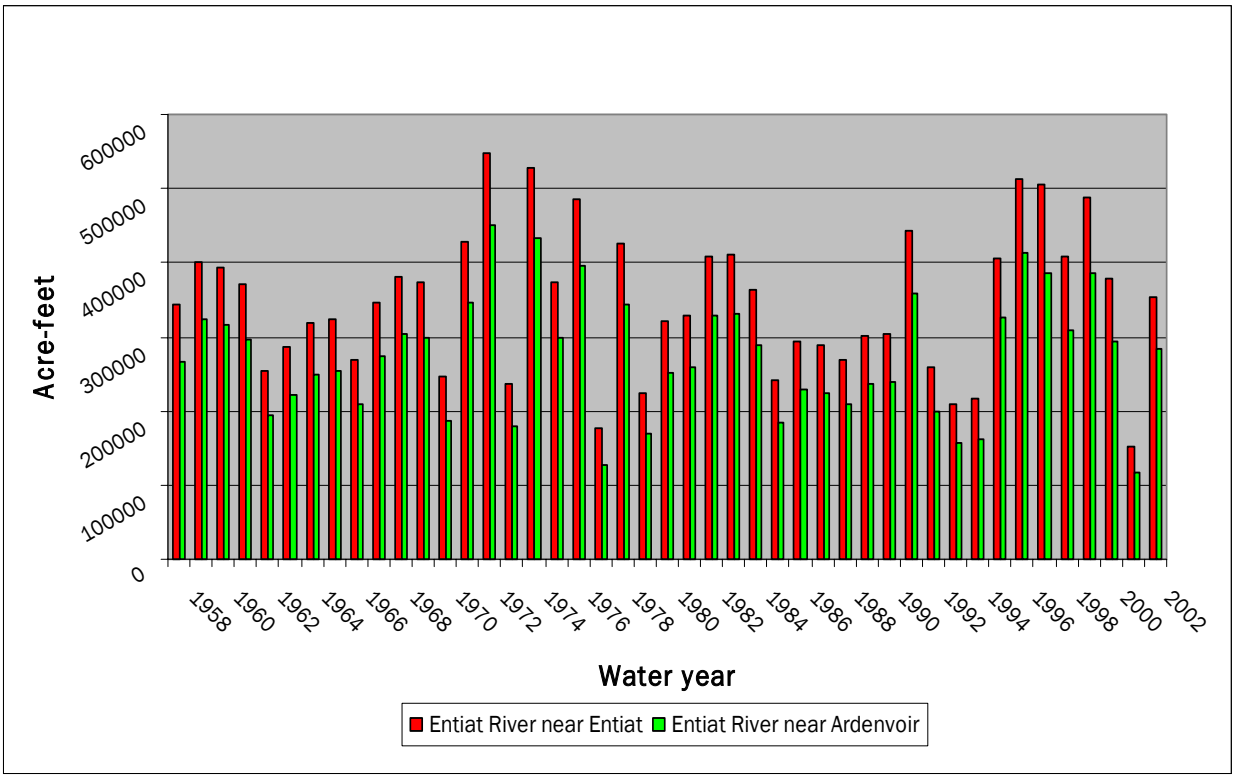


Figure 3-26. Annual runoff (ac-ft) recorded at the Entiat near Entiat and Entiat near Ardenvoir USGS gages, 1957-2002.

Mean monthly runoff data for the Entiat subbasin are indicative of a snowmelt dominated system, and the alluvial and glacially derived sediments in the valley bottoms are the primary storage for groundwater in the Entiat subbasin. A pattern of high elevation snowmelt, aquifer recharge, and the gradual release of groundwater defines streamflows in the Entiat subbasin. Snowmelt influences on peak flows in lower elevation tributaries (e.g., Mud Creek) can begin as early as February; however, the vast majority of the annual runoff typically occurs during the period between early May and mid-July when mid to upper elevation snowmelt reaches its peak. Groundwater movement into the Entiat River and its tributaries from late summer through the winter helps sustain streamflows for the remainder of the year. This exchange of water between sub-surface and surface flows is a function of the height of the water table in relation to the channel.

High flows in the Entiat subbasin commonly result from either rapid spring snowmelt, large storms (1948 and 1972), including warm rain-on-snow events, or high intensity convective storms. Post-fire flooding triggered by one of these mechanisms is a frequent disturbance process. Since 1970, flooding has followed most major fires in the subbasin. The 1972 flood was a drainage-wide event resulting from a large frontal storm combined with the late melt of a record snow pack. The Preston Creek debris torrent that occurred during this event originated from lands burned in 1970. The Crum/Ringsted/Byrd Canyon floods of 1977, the Dinkelman/Mills/Roaring flood of 1989, and the Potato Creek and Oklahoma Gulch floods of 1997 were all post-fire responses triggered by short duration, high intensity convective storms.

Past experience has shown that there are several periods of flood risk following wildfire, all related to the ability of the soil profile to handle water. The first high-risk period is the summer/fall immediately after the fire when lack of vegetation/ground cover and potential for hydrophobic conditions make the affected area highly susceptible to rapid runoff and erosion from thunderstorms or heavy frontal systems. Another high-risk period occurs in the first spring/summer following the fire when ground cover and vegetation are just beginning to recover. During this period, soil moisture storage is being recharged at a relatively rapid rate since water use by plants has been significantly reduced. A later high-risk period is the second spring/summer period following the fire. At this point, although vegetation and ground cover are on the way toward recovery, soil moisture storage is now at an unusually high level due to a post-fire reduction in vegetative growth and transpiration. Increased surface runoff may occur due to the reduced infiltration capacity of saturated or nearly saturated soils. In addition, the potential exists for mass erosion (e.g., debris slides) to occur in sensitive areas.

Average daily streamflow data for the 1997 water year (a relatively “wet” water year) and 2001 (a relatively “dry” water year) are compared in Figure 3-27 on page 3-54. The data from 1997 show both the effects of an above average precipitation year and the yield increase from recently burned areas.

While much attention has been focused on fire-related flood events in the Entiat WRIA, the potential for flooding always exists, given the right conditions. A key element to consider is the land’s capability to distribute water. Any weather event that produces meltwater or precipitation that exceeds the land’s storage ability may result in a "flood" event.

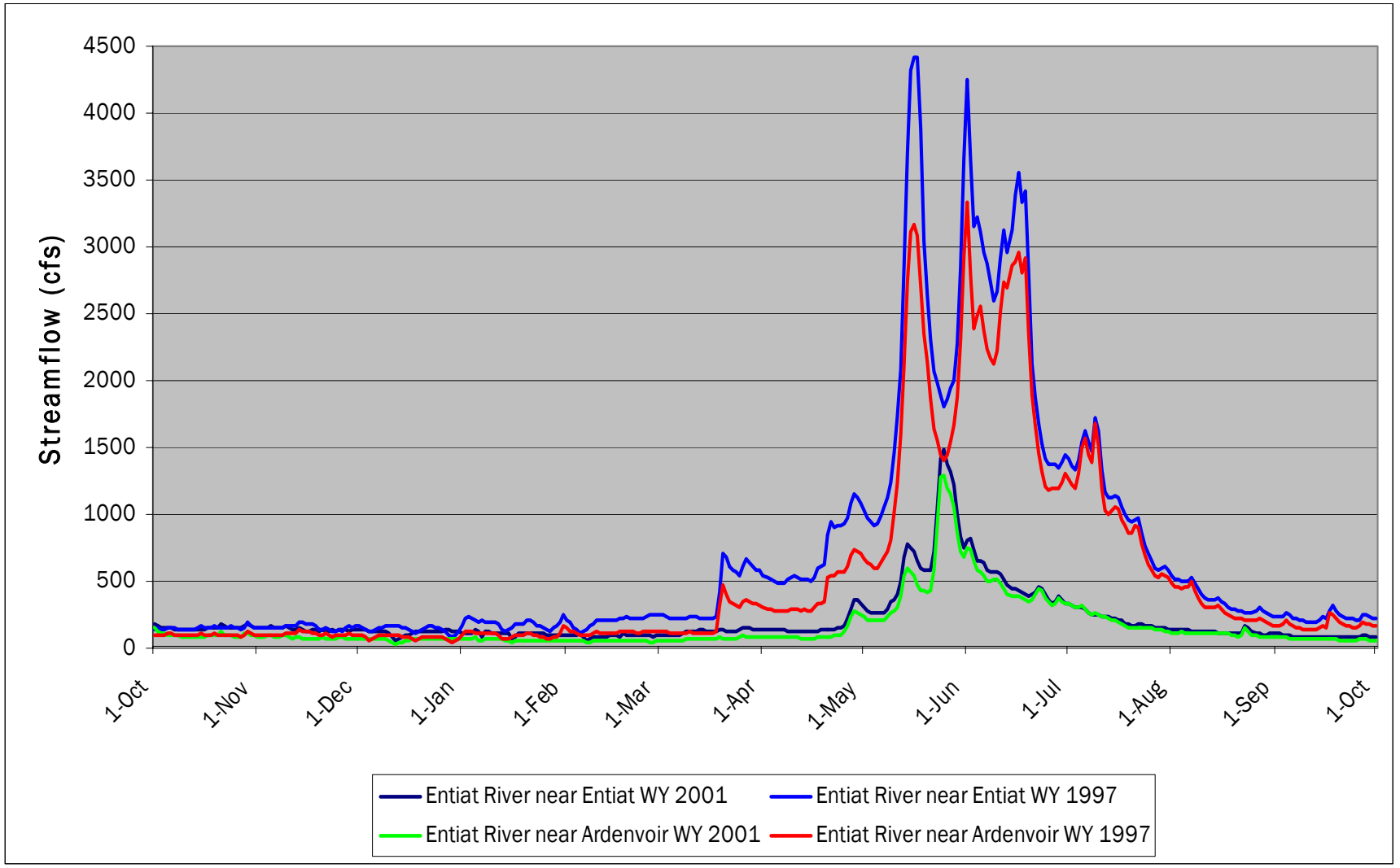


Figure 3-27. Comparison of daily mean streamflows as recorded at USGS gages Entiat near Entiat and Entiat near Ardenvoir, WY 1997 and 2001.

For example, frozen ground can reduce infiltration rates and result in concentrated overland flow and flooding. The most significant flood in recent history (June 1948 regional flood - approximately 10,800 cfs) occurred not after a significant fire, but as a result of heavy rains and the rapid melt of a record snow pack. Flood events in 1956, 1972 and 1974 were also the result of heavy spring rains that accelerated snowmelt and runoff.

Flood events help to shape and rejuvenate landscapes and transport materials to downstream reaches (e.g., gravels for spawning areas, soil for floodplain areas, and woody debris for habitat diversity). Development on alluvial fans and floodplains ignores the risks associated with flood-prone areas (see Figure 5 in the Entiat River Inventory and Analysis). Most of the past, post-flood rehabilitation work conducted in the Entiat focused on channel clearing and bank armoring, which in turn degraded aquatic habitat and instream values.

Refer to Chapter 4, Water Quantity, for much more information on the history of gaging in the Entiat subbasin, streamflows, groundwater/surface water interactions, and the Entiat valley alluvial aquifer. See Chapter 7, Habitat, for more information on aquatic habitat, riparian condition and historical changes to channel geometry.

4.0 WATER QUANTITY

4.1 STREAM GAGING NETWORK

4.1.1 Mainstem Entiat and Mad Rivers

The Entiat subbasin has a relatively plentiful stream flow gaging record compared to other drainages of similar size and land use history in the region. The USGS, USFS, WDOE and CCCD have played major roles in the acquisition and long-term management of these hydrologic data. Figure 4-1 on page 4-6 shows major gaging sites past and present within the WRIA. Table 4-1 on page 4-2 summarizes basic information about these locations.

Mainstem Entiat gaging began in 1911 with the installation of a continuous recording gage at the mouth of the River (Entiat River at Entiat; USGS Gage #12453000 at RM 0.5). This gage was operated from 1911-1925 and then reactivated in 1951 in association with the construction of the Rocky Reach Dam. The Entiat at Entiat gage was operated through Water Year (WY) 1958 and then permanently decommissioned due to the backwater effect of the new Rocky Reach reservoir (Lake Entiat). Operation of this gage through 9/30/58 provided for one year of data overlap with a new gage established on the Entiat at RM 18.0 in September 1957 (Entiat River near Ardenvoir; USGS Gage #12452800). The latter gage, referred to locally as the Stormy gage, has been operated continuously since WY1958, providing a long-term flow record critical to water resource management in the Entiat subbasin.

A USGS miscellaneous measurement site was established in 1971 on the lower Entiat River at Keystone Bridge (RM 1.5) in order to provide flow data (tape-down measurements) for the WDOE long-term water quality monitoring station at that location. USGS and WDOE personnel took miscellaneous flow measurements at this site through 1996. In March 1996, the Entiat CRMP group sponsored installation of a continuous recording gage just above the Keystone Bridge (Entiat River near Entiat; USGS Gage #12452990) in response to the growing need to collect flow data for watershed plan development and project implementation. This gage is known locally as the Keystone gage, and has been operated continuously since installation, providing invaluable data on total runoff from the subbasin.

In the early to mid 1960's, the Forest Service established a nationwide network of watersheds on National Forest System lands for the purpose of collecting baseline data needed to illustrate how climatic variables interact with watersheds to yield runoff with particular characteristics of quantity, quality and timing. In 1965, the Entiat Barometer Watershed was established as part of this network to be representative of forest land on the east slope of the Cascade Range in Washington State.

Table 4-1. Summary* of Entiat and Mad River gaging sites, types of data collected, and periods of record.

Mainstem Entiat and Mad River Gaging Sites					
Site name	Agency	Gage type	Record type	Period of record	Site ID
Entiat River at Entiat	USGS	Recorder[1]	Continuous	11/1910-9/1925	12453000
	USGS	Recorder[1]	Continuous	6/1951-9/1958	12453000
Entiat River near Entiat (Keystone)	USGS	Recorder[3]	Continuous	3/1996-present	12452990
	USGS	Tape down stage	Misc. Measurements	10/1971-3/1996	
Entiat River near Ardenvoir (Stormy)	USGS	Recorder[3]	Continuous	10/1957-present	12452800
Entiat River at Dill Creek Bridge	WDOE/CCCD	Recorder[3]	Continuous	9/2002-present	46A110
Entiat River at Tommy Creek Bridge	WDOE/CCCD	Recorder[3]	Continuous	9/2002-present	46A150
Entiat River below Entiat Falls	WDOE/CCCD	Recorder[3]	Continuous	9/2002-present	46A160
	USFS	Recorder[2]	Continuous	10/1966-9/1978	
Entiat River at North Fork CG	WDOE/CCCD	Recorder[3]	Continuous	9/2002-present	46A170
	USFS	Recorder[2]	Continuous	10/1966-9/1978	
Mad River at Ardenvoir	USGS	Recorder[4]	Continuous	4/2002-present	12452890
Mad River above Camp Nine	WDOE/CCCD	Recorder[3]	Continuous	9/2002-present	46C100

** This summary is not exhaustive and does not include all miscellaneous measurement sites within the WRIA.*
1 = Strip Chart, 2 = punch tape, 3 = digital with telemetry, 4 = digital only

Hydrometeorological data were collected by Forest Service personnel in the Entiat Barometer Watershed from 1966 through 1978. Parameters measured included streamflow, water temperature, precipitation (including snow course and aerial snow stadia surveys) and other climatic related data. Continuous-recording, streamflow gaging stations were constructed and operated on the Entiat River above the North Fork confluence and below Entiat Falls (RM 33.8) in order to supplement mainstem data being collected by the USGS at the Ardenvoir gage. By 1978, Regional emphases for soil and water funding began to shift. The Barometer gages and other monitoring sites were deactivated at the end of the 1978 water year. A report compiling the data collected during operation of the Entiat Barometer Watershed was prepared in November 1978 (Copenhagen 1978). The completeness and high quality of the Entiat Barometer Watershed data are a tribute to Mr. Art Johnson, an Entiat local, who was the Ranger District employee responsible for locating, installing and operating the Barometer monitoring sites through fires and floods.

Miscellaneous flow measurements for the Mad River began in 1935 with a single flow measurement made by the Bureau of Fisheries during a habitat survey. Beginning in 1967, the USGS and the USFS began taking additional miscellaneous measurements in the lower Mad River. In 1992, the USFS installed a staff gage at the Mill Camp Bridge on the lower Mad and began taking more frequent miscellaneous measurements. In 1999, the CCCD contracted with the USGS to maintain an official miscellaneous measurement site on the Mad River at Mill Camp. In April 2002, the CCCD sponsored installation of a USGS continuous recording gaging station on the Mad River just below the Mill Camp Bridge (Mad River at Ardenvoir; USGS Gage #12452890). This new gage has already provided critical flow data for this significant tributary to the Entiat River.

In 2002, the WDOE received funds to enhance stream flow gaging in the subbasin. By September 2002, the WDOE and the CCCD had jointly installed four continuous recording gages on the mainstem Entiat River and one on the middle Mad River above Camp Nine (about RM 9). Three additional continuous recorders were also installed on tributaries (see Tributary gaging on page 4-4). These new continuous recording telemetered gages collect water stage, air and water temperature data at fifteen minute intervals. The record being compiled upstream of Camp Nine on the Mad River compliments data being collected from the USGS gage at the Mad River mouth. The importance of the upper Mad River as bull trout habitat reinforces the significance of this site. All four mainstem Entiat continuous recorders were placed upstream of the previously discussed USGS gages, and have supplied valuable information on the behavior of the upper Entiat River. The upper two gages - Entiat River below Entiat Falls and Entiat River at North Fork Campground - were installed in the USFS Barometer Watershed gage houses and have in effect reactivated those sites. The lower two gages were installed at accessible locations above and below the confluences of Fox, Burns and McCrea Creeks, in an effort to frame the Entiat Experimental Forest.

The McCrea, Burns and Fox Creek drainages comprise the Entiat Experimental Forest (EEF), an area in the subbasin on National Forest System lands allocated to forest research activities. In 1957, Forest Service scientists at the Wenatchee Forest Science Lab began measuring streamflow, precipitation and other weather and water quality variables in the three drainages. The original objective of the proposed study was to apply a paired watershed approach to evaluate the effects of road building and timber harvest on the quantity, quality and timing of runoff. Fox Creek was designated as the control watershed (no treatment). The calibration (or pre-treatment) period was almost complete when the study area was hit by wildfire in 1970. The study objective was then changed to evaluate the effects of fire and revegetation on soil and water resources in the study area. Post-fire flooding also damaged study sites.

Scientists soon recognized that post-fire recovery in the EEF would be gradual and that continuous flow and related measurements were not needed in order to define recovery trends. In the mid 1970's, a plan was implemented to measure flow and other factors for one more year and then reactivate the study sites every 3 to 5 years to obtain trend data. Measurements were phased out over the period from 1975-1977. About two years after all measurements stopped, the research mission at the Wenatchee Forest Science Lab changed, personnel who had worked on the project transferred, and plans for intermittent reactivation of the EEF study sites were never implemented.

A great deal of valuable information was collected between 1957 and 1977. Between 1970 and 1980, over 25 research papers were published based on EEF data. In 1999, in cooperation with the Wenatchee Forest Science Lab, J. David Helvey and William B Fowler (retired FS researchers who had worked on the study) completed a compilation of selected EEF data to prevent loss of information stored on various media. Their report summarizes data on streamflow, stream temperature, monthly precipitation, air temperature and humidity for the three EEF drainages (Helvey and Fowler 1999).

Recently, the Wenatchee Forest Science Lab established a staff group working on research questions with an aquatic emphasis. The Lab plans to reactivate the EEF study sites in

2004 in order to evaluate water quantity and quality conditions given over 34 years of recovery since the 1970 wildfire. Quantifying their contribution to the mainstem Entiat River will provide a valuable check to any future streamflow data collected.

4.1.2 Tributary gaging

As mentioned earlier, the USFS collected long-term streamflow data from Fox, Burns and McCrea Creeks from 1960-1977 as part of the EEF project. Numerous miscellaneous flow measurements related to various projects have also been collected by the USFS on Entiat and Mad River tributaries. The USGS collected peak flow data at crest gage sites on Tillicum Creek from 1965 to 1975, and an ephemeral Columbia River tributary, located south of the Entiat-Columbia River confluence, from 1954 to 1972.

The USFS has active continuous stage recorders (Aqua-Rods) on both Potato and Tillicum Creeks. As part the WDOE/CCCD enhanced stream flow gaging effort, continuous digital telemetered recorders were installed on Lake, Roaring and Tillicum Creeks in September 2002. Lake Creek is a major annual contributor to the upper Entiat; Roaring Creek, which occasionally supports small numbers of steelhead trout, is a perennial tributary to the lower Entiat River. Tillicum Creek is a principal tributary to the Mad River. Staff-gage-only sites were also installed on Mud, Potato, Stormy, Preston, Tommy and Pope Creeks. Table 4-2 on page 4-5 summarizes past and current tributary gaging efforts in the WRIA.

Table 4-2. Summary* of WRIA 46 tributary gaging sites, types of data collected, and periods of record.

Site name	Agency	Gage type	Record type	Period of record	Site ID
Entiat River Tributary Gaging Sites					
Mill Canyon Creek at 5210 road crossing	USFS	Staff gage	Monthly Q msmt.	5/1995-10/1996	9408
Mud Creek at mouth	USFS	Staff gage	Monthy Q msmt.	5/1995-10/1996	9404
Roaring Creek below Cada diversion	WDOE/CCCD	Recorder[1]	Continuous	9/2002-present	46B060
Mud Creek at Bisping Canyon Road	WDOE/CCCD	Staff gage	Misc. Measurements	9/2002-present	46E070
Potato Creek at FS Road culvert	WDOE/CCCD	Staff gage	Misc. Measurements	1999-present	46F060
	USFS	Recorder[2]	Continuous	1999-present	
Potato ds of North Fork	USFS	Staff gage	Monthy Q msmt.	5/1995-10/1996	9405
Stormy Creek	WDOE/CCCD	Staff gage	Misc. Measurements	9/2002-present	46G060
Stormy @ valley road	USFS	Staff gage	Monthy Q msmt.	5/1995-10/1996	9406
Preston Creek	WDOE/CCCD	Staff gage	Misc. Measurements	9/2002-present	46H050
	USFS	Staff gage	Monthy Q msmt.	5/1995-10/1996	9407
McCrea Creek	USFS	Flume with stage recorder	Continuous	1961-1975	n/a
Burns Creek	USFS	Weir with stage recorder	Continuous	1960-1977	n/a
Fox Creek	USFS	Flume with stage recorder	Continuous	1960-1975	n/a
Lake Creek	WDOE/CCCD	Recorder[1]	Continuous	9/2002-present	46K050
Tommy Creek below USFS quarry	WDOE/CCCD	Staff gage	Misc. Measurements	9/2002-present	46J080
Pope Creek	WDOE/CCCD	Staff gage	Misc. Measurements	9/2002-present	46L050
Mad River Tributary Gaging Sites					
Tillicum Creek at Tillicum Fan	WDOE/CCCD	Recorder[1]	Continuous	9/2002-present	46D050
Tillicum Creek	USGS	Crest gage	Peak	1965-1975	12452880
	USFS	Recorder[2]	Continuous	1999-present	12452880
Columbia River Tributary Gaging Sites					
Borrow Pit	USGS	Crest gage	Peak	1954-1972	12453600

** this summary is not exhaustive and does not include all miscellaneous measurement sites within the WRIA.*
1 = digital with telemetry, 2 = AquaRod stage recorder

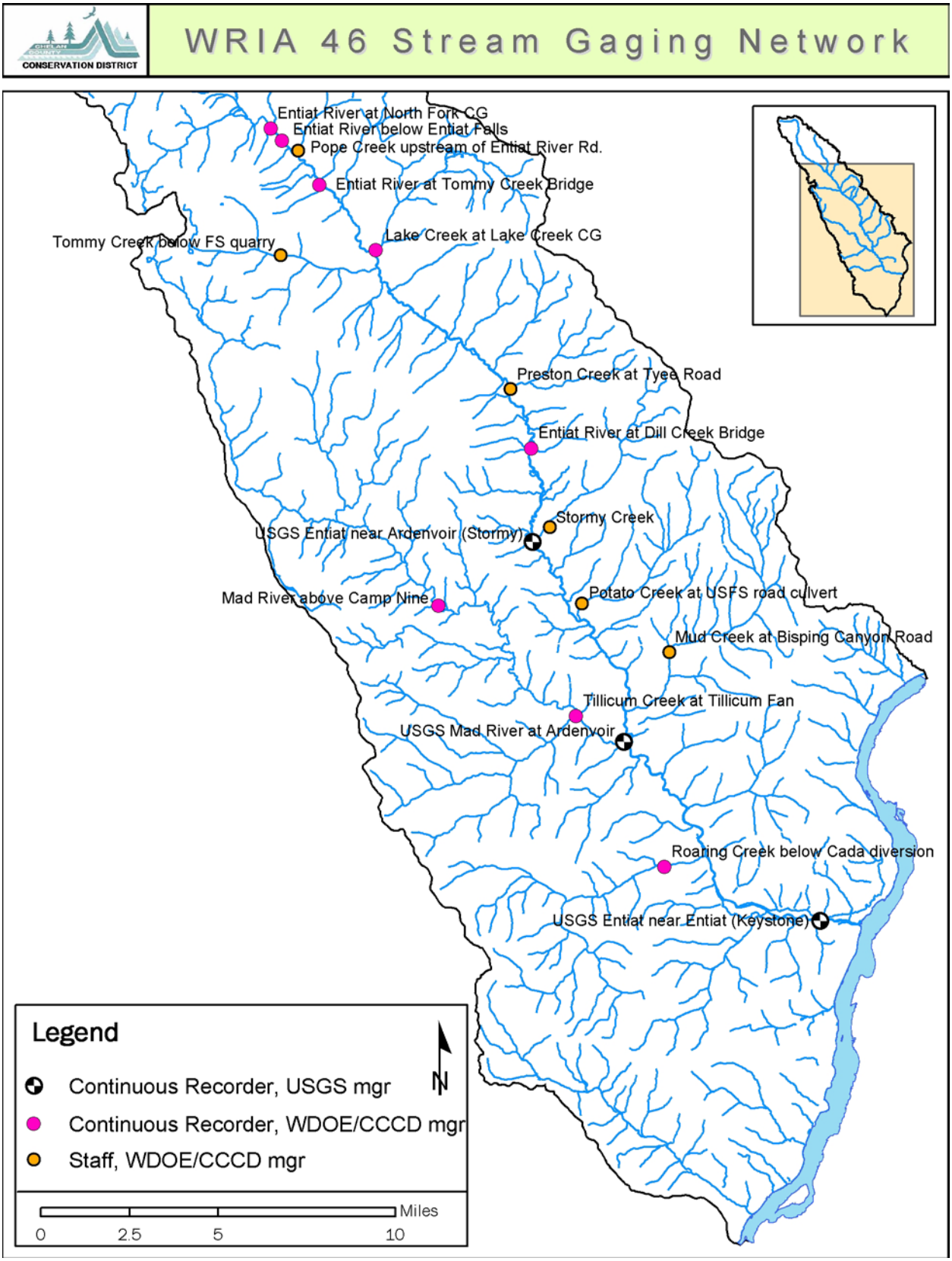


Figure 4-1. Location and types of streamflow gaging sites in the Entiat WRIA.

4.2 STREAMFLOW RECORDS SYNTHESIS

In an effort to facilitate various watershed planning efforts requiring statistical analysis of long-term discharge records, a water resources contractor worked with the USFS Entiat RD hydrologist to examine existing continuous streamflow records, and synthesize daily mean streamflows for multiple gaging sites within the subbasin. The cornerstone of this effort was the continuous record (WY 1958-present) from the USGS gage near Ardenvoir. Records from other continuous gaging sites (with shorter-term records) that temporally overlapped the Ardenvoir record made correlation possible. The water quantity and instream flow subcommittees, as well as ENTRIX personnel involved with the Entiat instream flow study, reviewed the synthesized datasets and determined they had been refined to the greatest extent possible given the measured flow data available. Discrepancies between synthesized daily mean flows and actual measured values recorded for the same time period generally fell within measurement uncertainties, particularly at low and intermediate flows. A detailed discussion of the methods applied and the limitations of the results are contained in the Flow Synthesis Data Summary Sheets (Rhodus and Edwards 2003).

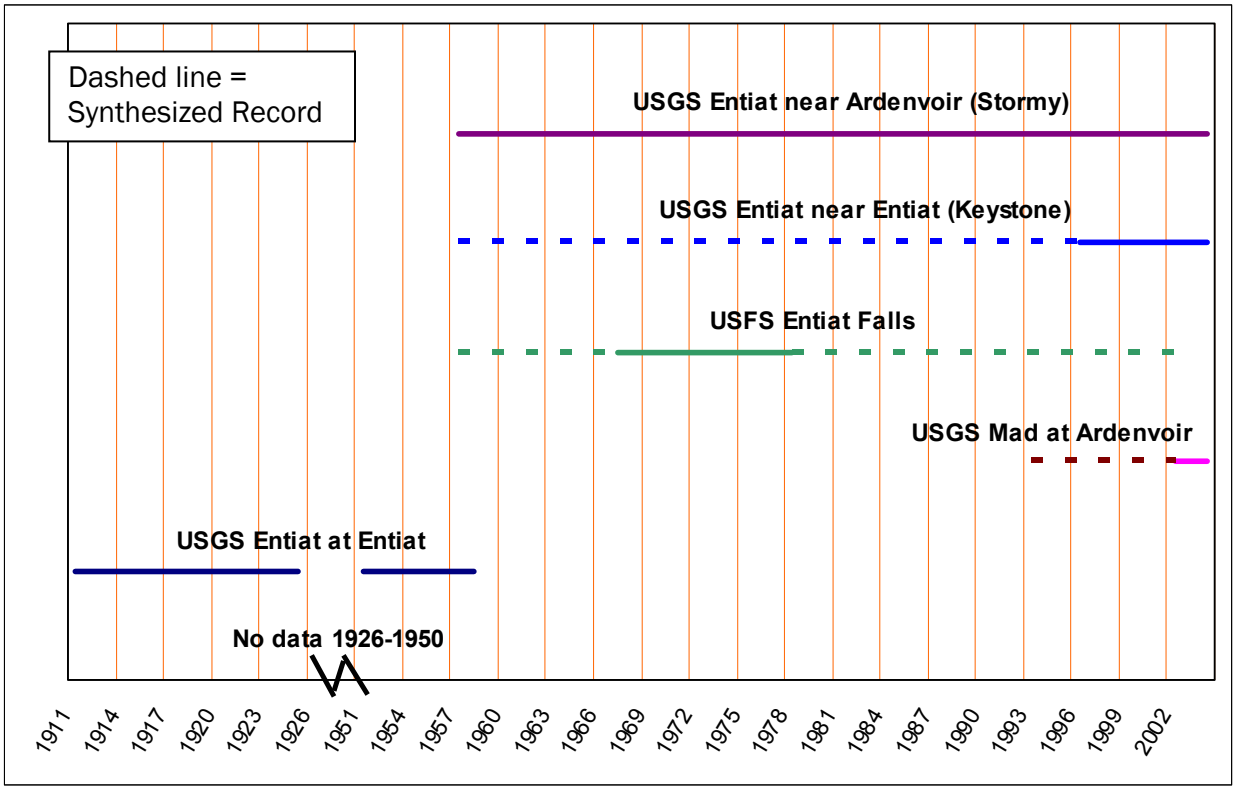


Figure 4-2. Timeline showing the periods covered by composite daily flow records at gaging stations on the mainstem Entiat and Mad Rivers.

Figure 4-2 shows the stations and periods of record for which synthesized daily mean flows were produced. The synthesized data filled important temporal gaps in the streamflow record; "splicing" the synthesized records into existing measured records created continuous, composite records of daily mean discharges. The composite records were then used in other efforts such as hydrograph separation, discussed on the following page, and instream flow analyses (see Chapter 5), and stream temperature modeling (see Chapter 8).

4.3 HYDROGRAPH SEPARATION

4.3.1 Introduction

Hydrograph separation is the process of separating a plot of stage or discharge vs. time, known as a stream hydrograph, in order to determine the baseflow and surface runoff components of a stream. Baseflow, the groundwater contribution to total streamflow, occurs when water from local aquifer material moves under the influence of gravity into a stream channel, supplying water to the stream. Surface runoff is water derived from residual snow or ice melt and precipitation.

The WDOE performed hydrograph separation on the Entiat River as part of an effort to evaluate groundwater contribution to total streamflow (baseflow) at active and inactive stream gaging stations throughout Washington State (Sinclair and Pitz 1999). The USGS hydrograph separation software program called HYSEP (Sloto and Crouse 1996) was used to analyze what percentage of total streamflow was contributed by baseflow on a month-by-month basis. HYSEP is based on algorithms that duplicate manual hydrograph separation techniques, improving the consistency of the results and the speed at which they can be produced. HYSEP analyzes daily mean streamflow records and produces monthly mean total streamflow, baseflow and surface runoff values for each year of data.

Hydrograph separation is an established technique for quantifying groundwater contribution to annual streams; however, streams affected by regulation or snowmelt conditions impose inherent limitations on results generated by using this method. HYSEP consistently *over-estimates* baseflow contribution to streams during snowmelt periods. Streams in WRIA 46 are affected by snowmelt from late winter to mid-summer, so although baseflow was calculated monthly for entire water years, only the results for August-February are valid.

The Planning Unit used HYSEP to perform hydrograph separation analyses of the following gaging sites and periods of record:

1. USGS gage 12452990 (Entiat river near Entiat) WY 1997-2001
2. USGS gage 12452990 (Entiat river near Entiat) WY 1958-2001 (composite record)
3. USGS gage 12452800 (Entiat River near Ardenvoir WY 1958-2001
4. USFS gage Entiat River below Entiat Falls WY 1967-1978
5. USFS gage Entiat River below Entiat Falls WY 1958-2001 (composite record)
6. USGS gage Mad River near Ardenvoir WY 1993-2002 (composite record)

4.3.2 Results

Figure 4-3 on page 4-10 shows mean baseflow and surface runoff volumes at the Entiat near Entiat (Keystone) gage. These values were produced using the composite daily mean streamflow record (WY 1958-2001) discussed earlier in Section 4.2. Results from the CCCD HYSEP analysis for Keystone comported well with WDOE HYSEP analysis results produced using records from the Entiat at Entiat and Entiat near Ardenvoir (Stormy) gages.

Table 4-3. Percent contribution of baseflow to total stream flow determined by CCCD HYSEP analysis of Keystone data, WDOE analysis of Entiat at Entiat and Stormy gage data.

	Jan	Feb		Aug	Sep	Oct	Nov	Dec
CCCD - Entiat near Entiat (Keystone)	83%	87%	No data Mar-Jul due to effects of snowmelt	94%	94%	89%	78%	76%
WDOE - Entiat at Entiat	81% - 95%	81% - 95%		81% - 95%	81% - 95%	81% - 95%	81% - 95%	81% - 95%
WDOE - Entiat near Ardenvoir (Stormy)	81% - 95%	66% - 80%		81% - 95%	81% - 95%	81% - 95%	66% - 80%	66% - 80%

Estimation of baseflow and surface runoff values for March-July

March-July monthly mean baseflow values were estimated based on the professional judgment of the CCCD water resources specialist (CCCD 2003a), rather than real data, due to the inability of HYSEP to accurately separate the baseflow and surface runoff components of streamflow during a snowmelt period.

The precise effects of snowmelt runoff on baseflow contribution to the Entiat River are not known; however, data and analytic results from well monitoring and aquifer storage modeling, described in Sections 4.4 and 4.5 respectively, provided clues to the behavior of baseflow during snowmelt. Results showed that annual recharge of the Entiat valley unconsolidated alluvial aquifer begins in March and reaches its peak in June. The aquifer storage model indicated that elevated in-channel water levels cause water to move *out of* the stream and *into* the depleted aquifer materials of the channel banks and valley floor during these months. This movement or "recharge" of water from channel to aquifer from March through June is the reverse of baseflow, and is seen clearly as a decreasing trend in baseflow for that period (see Figure 4-3). The March through July bars in this figure depict where professional judgment, rather than HYSEP model results were used.

Model results indicated that peak aquifer storage in the Entiat valley coincides closely with peak annual flow; the inflection point in baseflow values seen in June was judged to coincide with the inflection points of peak annual flow and aquifer storage (see Figure 4-6 on page 4-16). As peak streamflow recedes, the newly recharged aquifer begins to discharge to the channel once again, providing an increasing contribution to overall stream flow for the remainder of the year; thus, the aquifer is in a depleted state in late winter just prior to the onset of snowmelt.

Calculation of daily values

HYSEP does not produce daily values for baseflow or surface runoff. The monthly mean baseflow values estimated for March-July, described in the preceding section, were used in these calculations. Daily baseflow and surface runoff values were calculated thus:

(Monthly Mean BF/SF) x Daily Mean SF = Daily BF

Daily Mean SF – Daily Mean BF = Daily Mean SRO

BF = Baseflow; SF = Streamflow; SRO = Surface Runoff

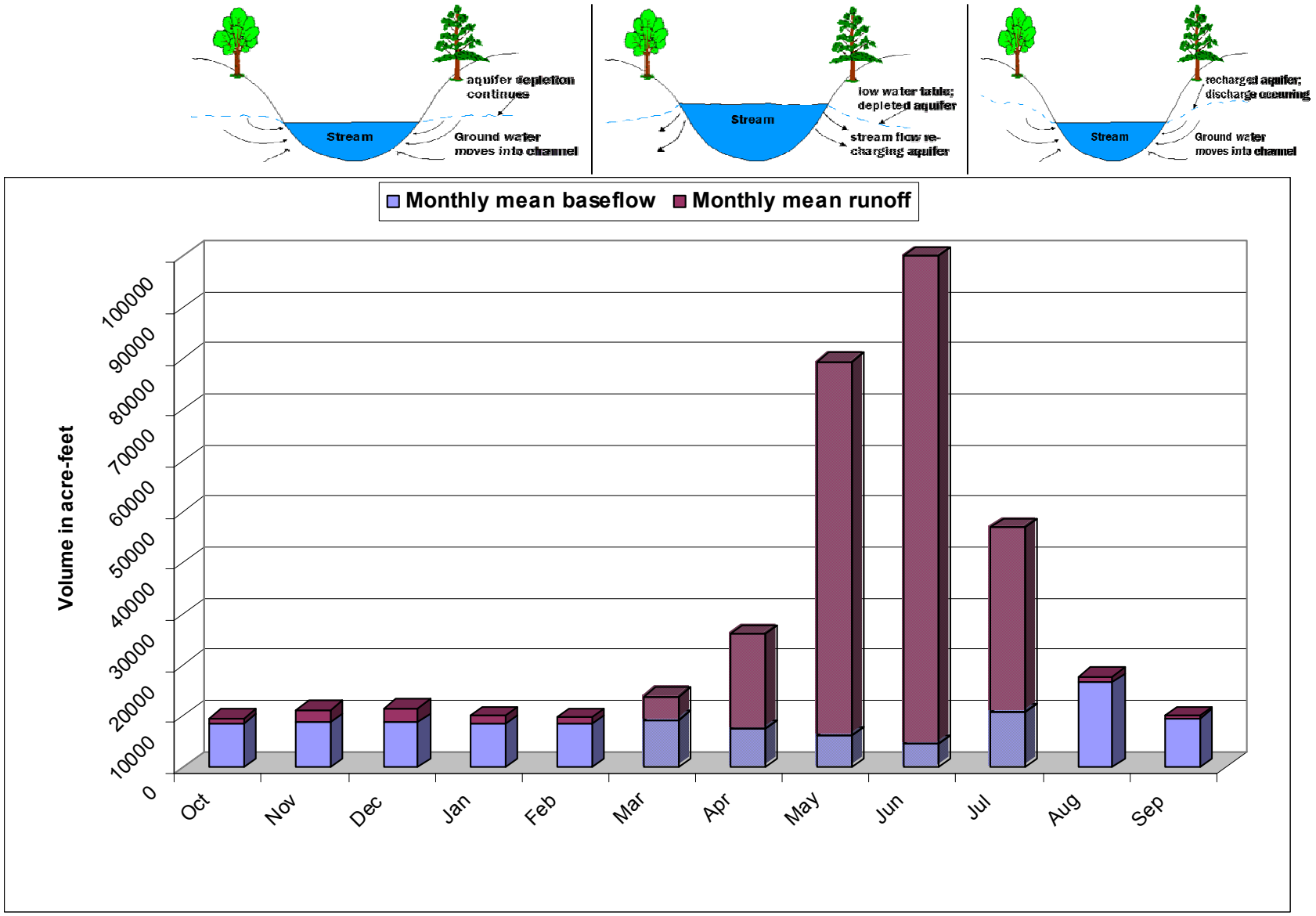


Figure 4-3. Monthly mean baseflow and surface runoff contributions (ac-ft) to the Entiat River based Keystone composite data.

**Note: Professional judgment was used in March through July rather than HYSEP model results.*

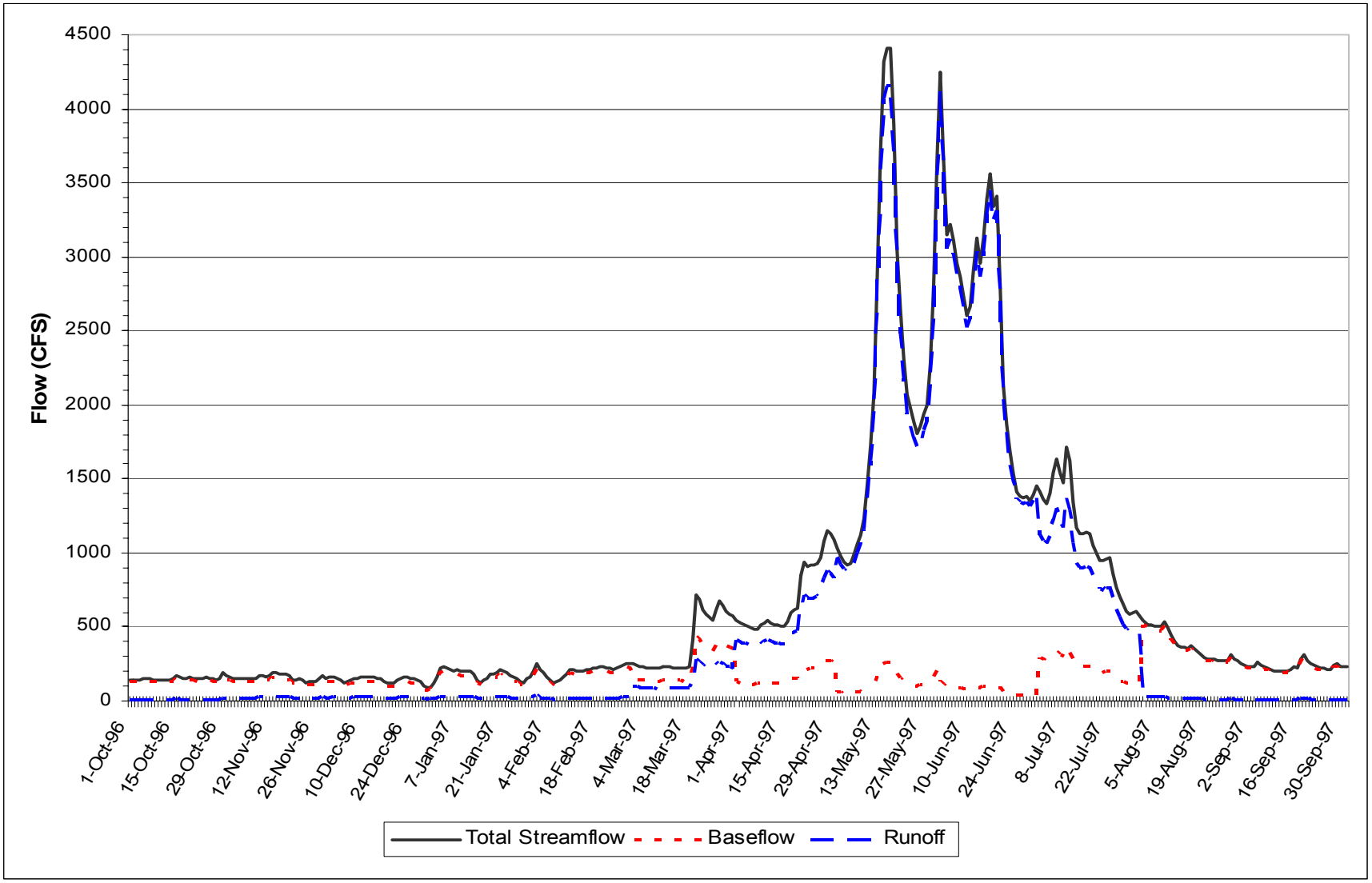


Figure 4-4. Baseflow and surface flow contribution to annual streamflow recorded at the Entiat near Entiat (Keystone) gage, WY 1997.

**Note: Professional judgment was used for March through July rather than HYSEP model results*

Figure 4-4 on page 4-11 shows the annual hydrograph at the Keystone gage for WY 1997, divided into baseflow and surface runoff components, and illustrates the daily variability of streamflow and these components. Again, the March through July lines indicate where professional judgment was used to estimate baseflow / surface runoff values due to the inability of HYSEP to calculate them because of the effects of snowmelt. The figure also shows the range of discharges occurring in the system over the course of a water year (1997 was a "wet" year; the same graph for WY 2001, a very "dry" year, would show the same pattern but with much lower overall discharge values) and depicts the hypothesized relationship of baseflow to surface runoff during the snowmelt-dominated period.

Use of measured and composite streamflow records

As mentioned earlier, HYSEP analyses were performed using both measured and composite daily mean streamflow records at the Keystone and Entiat Falls gages (CCCD 2003a). The goal of using both types of record was to compare the results obtained, and determine how significant the differences in results were. Use of the longer composite records eliminated some short-term climatic variability associated with the shorter measured records; however, the range of values was not great. Use of composite records did not result in consistently higher or lower baseflow estimates; during some months the baseflow/total streamflow ratio was higher and in other months it was lower. For a detailed description of the methods and results for all the HYSEP analyses for WRIA 46, refer to the HYSEP report (CCCD 2003a) and appendices.

4.4 WELL MONITORING

In 2001, the EWPU initiated a domestic well monitoring effort in order to collect data on groundwater levels within the unconsolidated alluvial aquifer, and examine hydraulic continuity within the Entiat valley. Planning Unit LSC members identified willing individuals within the WRIA to volunteer for the monitoring program, and letters of solicitation were sent out late in 2001. Electronic and paper copies of all exempt well logs for the Entiat area and created a database of summary statistics in support of this effort. Beginning in January 2002, the Planning Unit began monthly monitoring of 29 wells. Static water levels and ambient air temperatures were measured for all wells and well water temperature was measured whenever possible. In addition, ambient air and water temperatures were measured at a series of bridges along the mainstem Entiat River. In January 2003, the EWPU determined that another year of data collection would be beneficial, and that additional well monitoring participants should be sought. The EWPU renewed 24 of the original 29 wells for an additional year of monitoring (Jan-Dec 2003).

All wells currently monitored within the Entiat WRIA are permit exempt domestic wells. Initially, a high-capacity non-exempt well at the Entiat National Fish Hatchery was also monitored; however, it became impossible to obtain static water levels because the well was put online and continuously pumped. Monitoring wells are located from approximately RM 1.5 to RM 20. An attempt was made to select wells so that they were spatially distributed throughout the WRIA; however, due to the demographics of the area they are somewhat concentrated within the lower 12 miles of the Entiat valley.

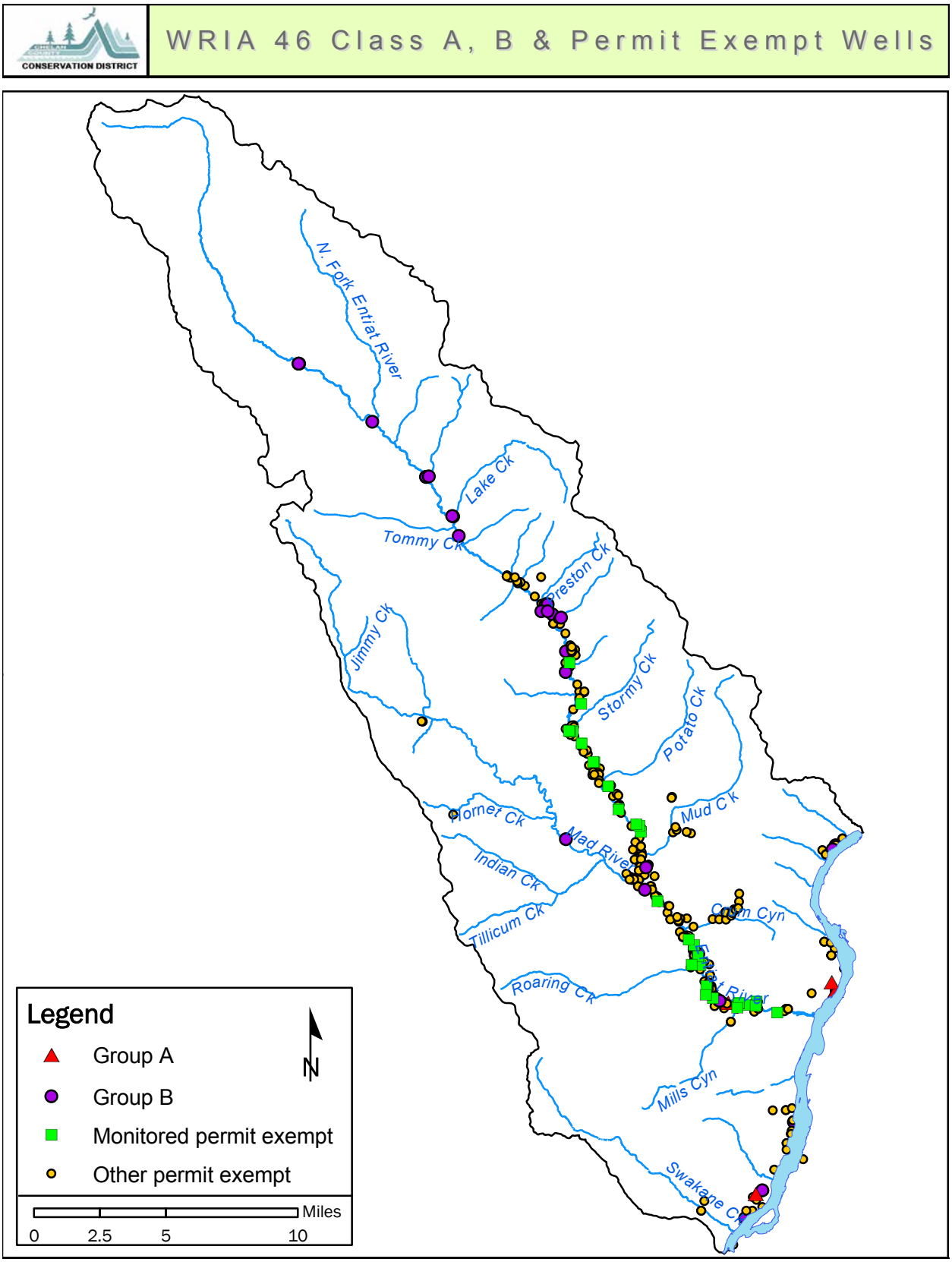


Figure 4-5. WRIA 46 Class A, B, and Permit Exempt Well locations.

Figure 4-5 on page 4-13 depicts the permit exempt well monitoring sites, as well as the location of other permit exempt, Class B, and Class A wells found within the WRIA based on WDOE well log and Department of Health Class A and Class B well data.

All but two of the monitored wells draw water from the shallow, unconfined and unconsolidated alluvial aquifer of the Entiat River. Aquifer data are discussed in detail in Section 4.5. Well monitoring data indicate a high degree of connectivity of this aquifer to flow in the Entiat River, with seasonal variations in streamflow being reflected in static water levels within the wells. Stream and well water temperatures commonly vary only a few degrees Celsius and are similar to mean annual air temperatures.

Data from the Entiat well monitoring program are maintained in paper and electronic format by the CCCD and are available upon request. These data provided the basis for the aquifer storage modeling project (Dixon 2003) discussed below.

4.5 AQUIFER STORAGE MODEL

The Entiat River valley aquifer system is bounded by igneous and metamorphic bedrock. The unconfined aquifers within the watershed are composed of glacial, colluvial, fluvial and alluvial cobbles, gravels, sands, some silts and discontinuous clays. Recharge to the unconfined aquifer is derived primarily from precipitation and potentially from irrigation return flows, but is largely dependent on surface water exchange with the Entiat River. As a result, a high degree of hydraulic connection between the Entiat River and the alluvial aquifer is recognized.

Within an alluvial system such as that described above, groundwater storage is defined as the volume of water that could be theoretically extracted if the aquifer were completely drained. Assuming that the surficial extent of the aquifer represents the lateral extent of the aquifer at depth, groundwater storage within an unconfined aquifer can be estimated by multiplying the aquifer surface area by the saturated thickness of the aquifer and the specific yield of the aquifer materials. An unconfined aquifer is one that lacks an upper confining layer; that is, the water level within the aquifer may rise and fall without restriction. Specific yield refers to the volume of water that can be withdrawn from aquifer materials relative to their total volume (due to the surface tension of water, not all the water can be withdrawn; some will always cling to the solid particles of the aquifer material). Different materials such as gravels of various sizes, sand, clay, fractured and un-fractured bedrock all have unique specific yield values. The saturated thickness of an unconfined aquifer is the vertical distance from the top of the groundwater surface (water table) to the base of the aquifer. In the case of the Entiat valley alluvial aquifer, the thickness or depth of the aquifer is assumed to be the depth to bedrock.

Change in storage volume, commonly referred to as annual recharge, is the defining factor used to determine the sustainability of a groundwater resource. A change in storage volume can be expressed as a volume flux per surface area of the aquifer due to seasonal changes in precipitation, temperature, and other factors, such as withdrawals from wells. On an annual basis, most systems display steady state conditions; e.g., discharge is approximately

equal to recharge, and the net annual change in volume is zero (Hoos 1990). When groundwater extraction combined with losses due to evapotranspiration exceeds annual recharge, water level declines should be expected; however, due to the high degree of connectivity between the Entiat and the alluvial aquifer any expected groundwater declines would be compensated for by aquifer recharge from the river.

Data from 25 monitored wells in the unconsolidated/unconfined alluvial aquifer were used to define aquifer depth (top of the bedrock surface), the top of the water table, and the aquifer's saturated thickness (Dixon 2003). Interpreted well log stratigraphy was used in conjunction with the Washington Department of Natural Resources' (WDNR's) 1:100,000 scale surficial geology Geographic Information System (GIS) data to help determine specific yield values.

A GIS was used to digitize polygons that delineated the surface area of the unconfined aquifer. A polygon in this context refers to a set of straight lines used to enclose and define a specific area of the Earth's surface that has some unique characteristic; in this case, the polygons enclosed areas of equal aquifer depth. Polygon delineation was based on similarities in well depths and surface elevation, as well as the lateral extent of the unconsolidated aquifer material. Aquifer depths were assigned to the aquifer polygons using data recorded in well logs. In instances where depth to bedrock was unknown, a conservative depth was assigned based on the deepest well occurring within that polygon. When no well data were available, aquifer depth was estimated based on data from adjacent polygons and/or geologic and topologic characteristics of the valley.

Once aquifer depths, acreages, and specific yield values were determined for all 205 polygons, a saturated thickness value was assigned to each polygon. Monthly static water levels had only been measured for 25 wells representing 25 polygons distributed spatially throughout the basin; therefore a ratio of measured water depth to total aquifer depth was calculated based on data from the 25 polygons. This ratio was assigned to adjacent polygons and used to calculate monthly saturated thickness for the remaining 180 polygons (Dixon 2003, *draft*). An estimate of groundwater storage volume was then calculated for each polygon, and the sum of storage volumes for all polygons yielded an estimate of storage volume for the entire aquifer. The lowest storage volume was subtracted from the highest storage volume to provide an estimate of total annual change in storage. This change in storage volume could also be evaluated for each individual polygon on a month by month basis by calculating the fluctuation in water levels.

Using the methods described above, the total area of the mainstem Entiat River valley aquifer was estimated to be 10,732 acres (Dixon 2003). During 2002 the saturated thicknesses within the unconfined valley aquifer ranged from 10 feet to 151 feet, with an average aquifer depth of 52 feet. Aquifer polygons ranged in size from 2 acres to as large as 3,210 acres with an average size of 52 acres. Figure 4-7 and Figure 4-8 on pages 4-18 and 4-19 depict modeled aquifer depth in the upper and lower Entiat River. Exclusion of the 3,210 acre outlier polygon, which defines the uppermost headwater aquifer for which no well data were available, reduced the average aquifer polygon size to 37 acres with a maximum polygon size of 467 acres.

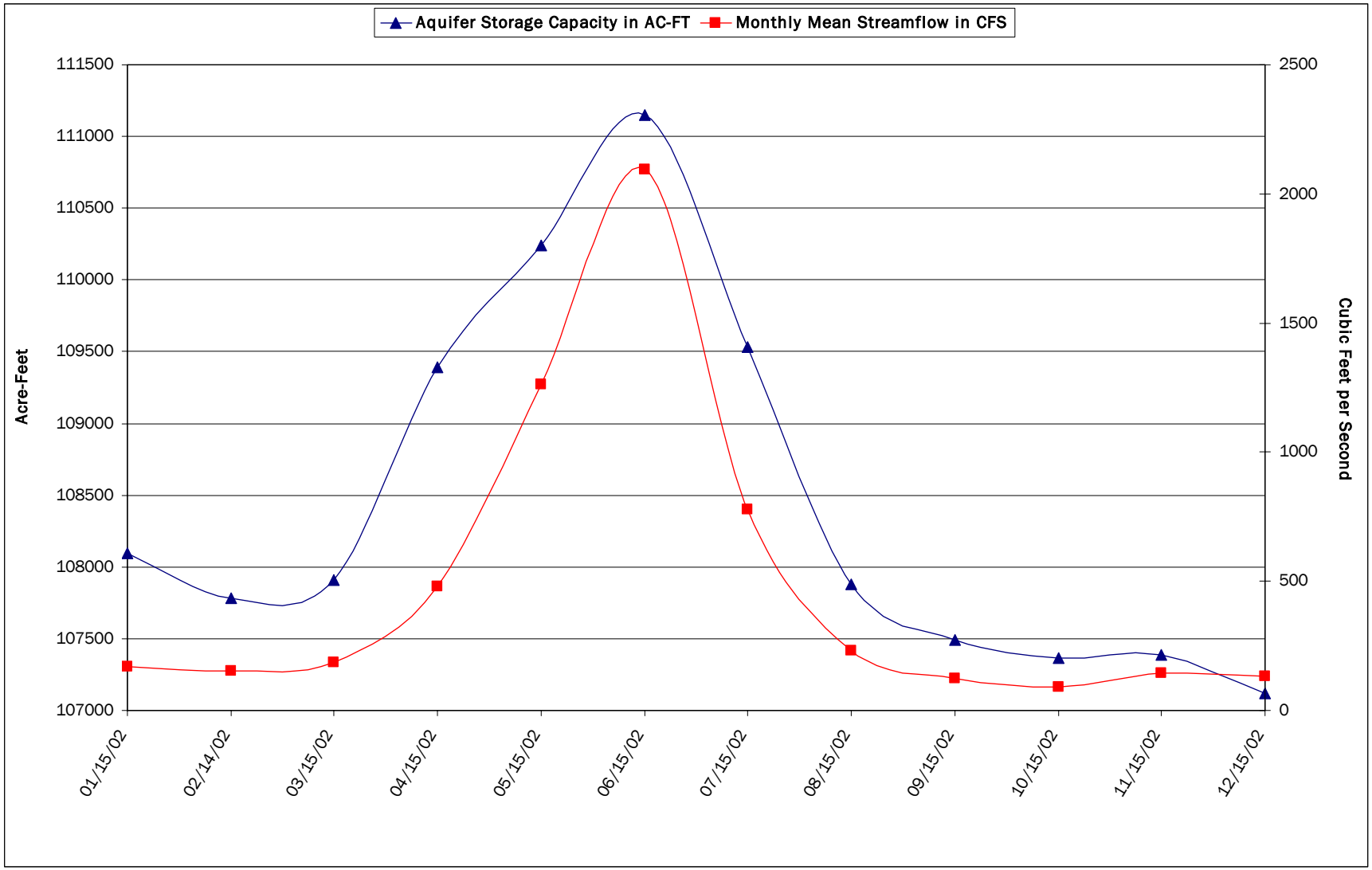


Figure 4-6. 2002 Entiat valley aquifer storage (ac-ft) vs. mean monthly streamflow (cfs) (Dixon 2003).

Figure 4-6 on page 4-16 shows 2002 groundwater storage volumes within the Entiat River valley mainstem aquifer were estimated to range from a high of 111,153 acre feet in June to a low of 107,122 acre feet in December (Dixon 2003). The change in groundwater storage volume (June high minus December low) or annual recharge for 2002 was estimated to be 4,031 acre feet. A temporal comparison of monthly aquifer storage values with mean monthly streamflow showed a strong correlation between the rise in streamflow and the rise in groundwater volumes within the Entiat valley. Refer to the draft aquifer storage report (Dixon 2003) for more information.

4.6 GAIN-LOSS ANALYSIS

A gain-loss study (also referred to as a seepage run or synoptic flow study) involves the direct measurement, over a discrete time period, of all surface water inputs to and outputs from a stream system, as well as multiple mainstem measurements that break the stream into reaches. Once these flow measurements are complete it is possible to construct a simple surface water budget for the stream, and identify (and quantify) gaining or losing reaches. A gain-loss study is best conducted when the stream is at or near "baseflow" condition, i.e. when most or all of the flow in the system is derived from groundwater sources as opposed to precipitation runoff or snowmelt. Baseflow condition in the Entiat system generally occurs in the fall, after the annual snowpack has entirely melted and the subbasin has been without substantial precipitation for some time.

USFS, USGS and CCCD staff cooperated in a gain-loss study of the Entiat River from just above the North Fork confluence downstream, and in the lower Mad River up to the Tillicum Creek confluence near RM 2, during September 25-28, 2002. The project was planned, organized and supervised by the USFS Entiat RD Hydrologist. Many willing landowners granted access to sites to make this study possible. All tributaries with surface flow and all irrigation diversion intakes/outfalls were measured. Mainstem locations identified through geological interpretation as likely areas of changing surface-water/ground-water interchange based on alluvial aquifer depth, proximity to alluvial fans, bedrock pinch points and faults were also measured (R. Dixon, J. Monahan and R. Hendrick, WDOE, pers. comm. September 2002). Additionally, all sites with long-term or recently installed continuous recording stream gages were measured. For more detail, see the 2002 Entiat/Mad River gain-loss study report (2003b).

The gain/loss figures on pages 4-18 and 4-19 show all mainstem measurement reaches, reach gain or loss in cubic feet per second (cfs), and the net rates of gain/loss per unit channel length. It is clear that the Entiat River experiences significant and widely varying ground-water / surface-water interchange within its identified reaches. Two lower mainstem Entiat reaches had a net gain in discharge per unit channel length greater than 10 ft^3/sec/mile; the overall net increase in discharge due to groundwater contribution on the mainstem Entiat River was 11.51 ft^3/sec. Overall, areas of measured gains and losses agreed well with predictions based on geologic interpretation. The Mad River also showed significant groundwater/surface water interchange within the study reaches.

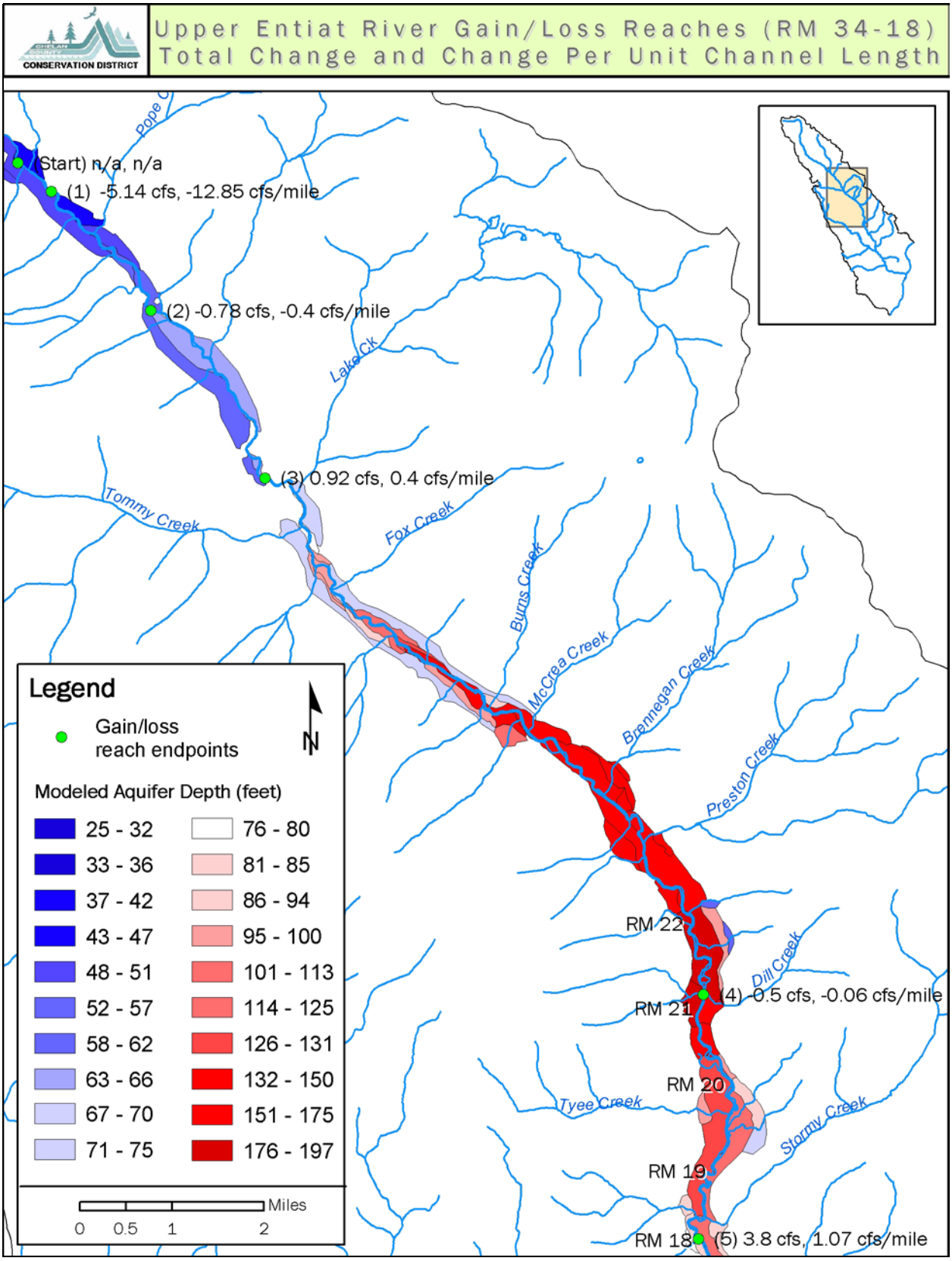


Figure 4-7. Upper Entiat River gain/loss reaches and measurements September 2002.

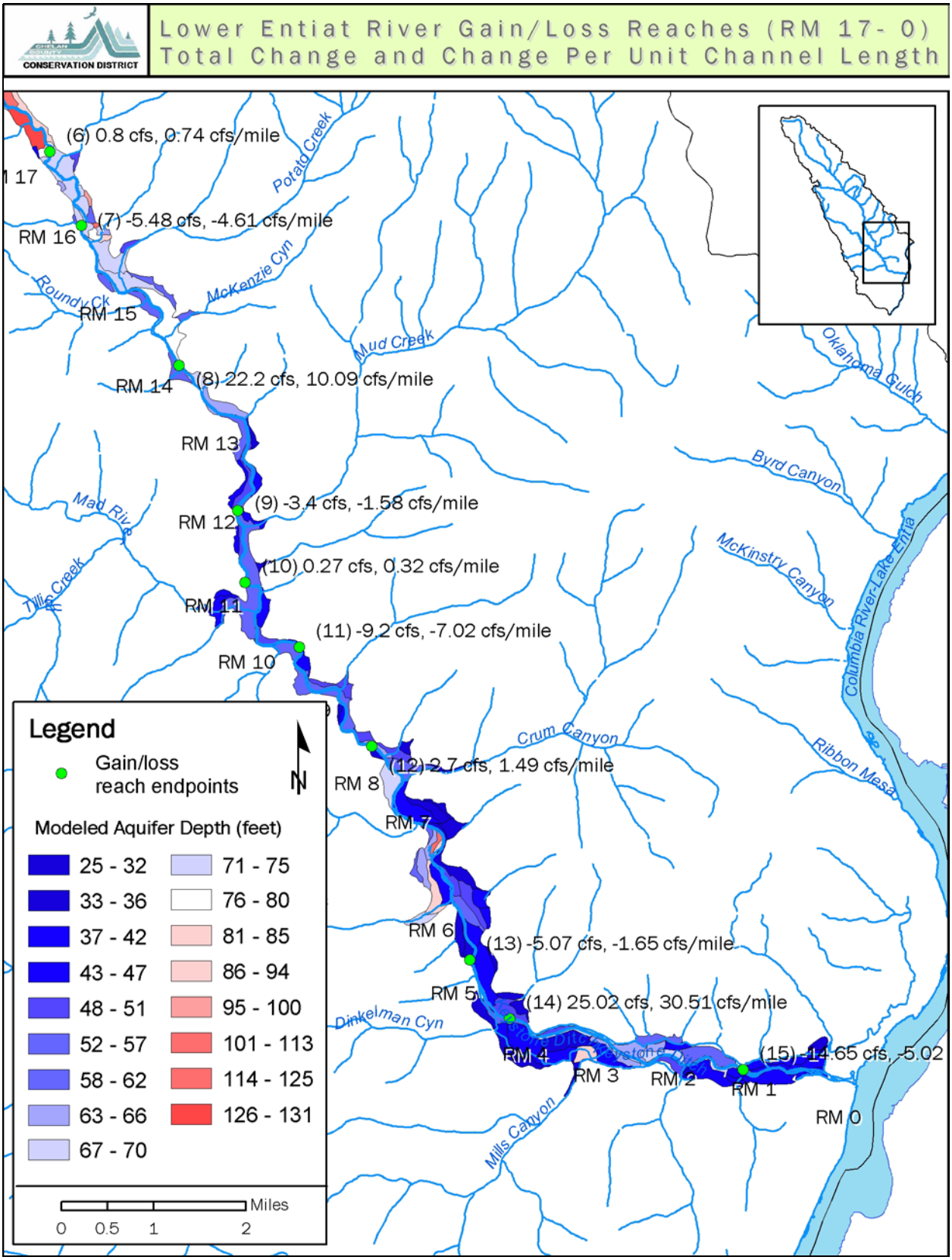


Figure 4-8. Lower Entiat River gain/loss reaches and measurements September 2002.

The results of this study are an important component of efforts to quantify ground water and identify areas of ground-water/surface-water interaction within the Entiat subbasin. The two mainstem Entiat reaches with a net gain in discharge per unit channel length of greater than 10 ft^3/sec/mile occurred in the lower portion of the river, where most land is privately owned. These gaining reaches act like "filling stations" and it is due to their large groundwater contributions that the Entiat River had an overall net gain in flow of 11.51 ft^3/sec from the North Fork confluence (approximately RM 34) to the mouth. It is not clear whether the groundwater entering the stream in these reaches is derived exclusively from the shallow alluvial aquifer, irrigation return flows, or coming from deep groundwater sources due to regional and local geology. If the latter is the case, gaining reaches may be linked to hydro-climatic conditions spatially and temporally removed from local conditions, and therefore unpredictable. Additional gain-loss and aquifer studies in other months would help to refine our understanding of aquifer/stream interactions on the Entiat and Mad Rivers.

4.7 WATER RECHARGE AREAS

Chapter 90.82.070 RCW requires watershed planning units to provide "an identification of the areas where aquifers are known to recharge surface bodies of water and areas known to provide for the recharge of aquifers from the surface". The most important and obvious cases of these relationships in WRIA 46 are the interactions between the Entiat River and the Entiat valley unconsolidated alluvial aquifer. These are discussed at length in sections 4.3 through 4.6; Figures 4-7 and 4-8 on the previous pages show details of gaining and losing (aquifer discharging and recharging, respectively) reaches of the mainstem Entiat River in late September 2002. All findings discussed in the aforementioned sections indicate that water interchange between the Entiat alluvial aquifer and Entiat River in-channel flow fluctuates both seasonally and spatially. A great deal of further study in the form of additional gain-loss analyses, continued and expanded well monitoring, and refinement and updating of the aquifer storage GIS model would be needed to adequately define reach- and season-specific areas of aquifer/river recharge.

In an attempt to identify areas of groundwater - surface water interchange not associated with the Entiat River, its tributaries and the Entiat alluvial aquifer, the Planning Unit examined USFWS National Wetlands Inventory (NWI) and USFS Land Type Association (LTA) GIS data. The USFS LTA data identified likely areas of *upwelling*; i.e., the likelihood of near surface groundwater contributing to seeps, springs, etc. An area of upwelling exhibits, to a greater or lesser degree, the expression of all the site factors affecting near surface groundwater movement and storage. Specific geologic formations, such as the Tenas Basalt and Dick Mesa basalt cap, also serve as mini-aquifer areas with several springs seeping out at or near their contact with bedrock (see Chapter 3, Section 3.3.3, Geology). During their land use study, Central Washington University classified some land uses in the subbasin as sub-irrigated pasture. An area along the Entiat River approximately 20 acres in size near the mouth of Mills Canyon (approximately RM 3.5), and additional sites between RM 19 and RM 22 were identified, indicating other likely areas of groundwater upwelling.

4.8 WATER RIGHTS, CLAIMS AND APPLICATIONS

The WDOE's Geographic Water Information System (GWIS), a GIS-based tool for display and query of water right type, location and volume information, was used to estimate the amount of water in WRIA 46 represented by water right permits and certificates, and claims. The Planning Unit analyzed water right and claim data contained in GWIS, and grouped the information according to the type of document (permit/certificate or claim), water source (surface water or groundwater withdrawal), source of water withdrawal (Mad, Entiat, or minor Columbia River tributaries), and primary beneficial use. Existing water rights within the Entiat subbasin that are conditioned by instream were also summarized, as well as water right applications. Data contained in the tables below and on the following pages were taken from water right and claim documents as reported. It is important to note that cfs values represent a maximum potential instantaneous rate of withdrawal, not a continuous withdrawal rate.

Table 4-4. Summary of surface water certificates and permits.

Source Area	# of Records	Sum of CFS	# of Records Reporting CFS	Sum of Ac-Ft	# of Records Reporting Ac-Ft	Calculated Ac-Ft[3]
Columbia River & Minor C. R. tributaries	27	210,022.2[1]	26	390,719.2[1]	16	752.2
Entiat River watershed	84	73.7	81	1,392.6	37	2,563.6
Mad River watershed	4	70.2	4	19.5	4	25.0
Totals	**115**	**210,166.1**	**111**	**392,131.3**	**57**	**3,340.8**

Table 4-5. Summary of surface water claims.

Source Area	# of Records	Sum of CFS	# of Records Reporting CFS	Sum of Ac-Ft	# of Records Reporting Ac-Ft	Calculated Ac-Ft[3]
Columbia River & Minor C. R. tributaries	28	506.5	17	5,676.7	23	2,399.2
Entiat River watershed	133	4,885.4[2]	70	377,282.4[2]	109	15,012.8
Mad River watershed	12	0.1	5	815.0	8	815.0
Totals	**173**	**5,392.0**	**92**	**383,774.1**	**140**	**18,227.0**

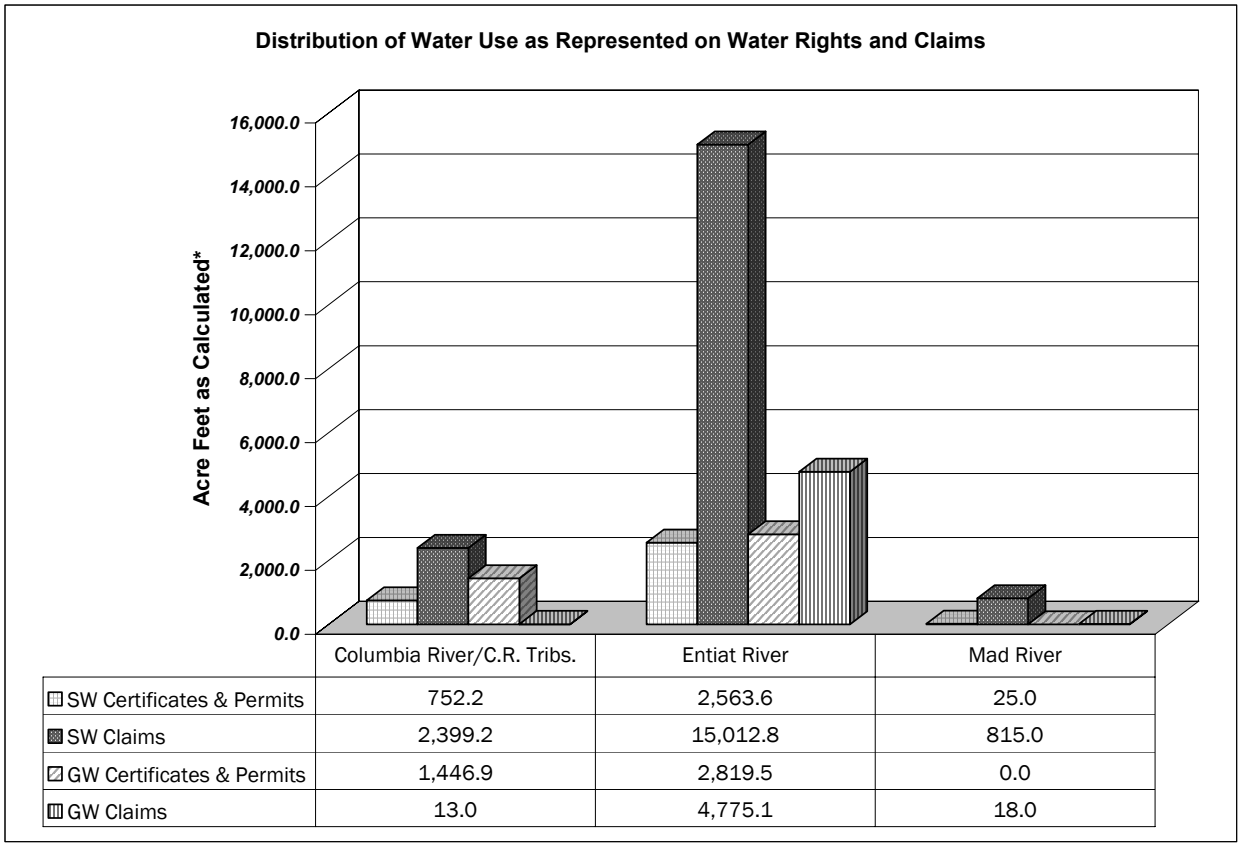
1. Includes a reported 210,000 cfs and 390,000 ac-ft for power generation.
2. Includes numerous claims with questionable reported values totaling 3,400 cfs & 370,213 ac-ft.
3. Calculated acre-feet values for surface water rights and claims are based on irrigated acres reported multiplied by 4.0 acre-feet per acre plus reported values for non-irrigation uses.

Table 4-6. Summary of ground water certificates and permits.

Source Area	# of Records	Sum of CFS	# of Records Reporting CFS	Sum of Ac-Ft	# of Records Reporting Ac-Ft
Columbia River & Minor C. R. Tributaries	13	8.2	13	1,446.9	13
Entiat River watershed	25	14.0	25	2,819.5	25
Mad River watershed	0	0.0	0	0.0	0
Totals	**38**	**22.2**	**38**	**4,266.4**	**38**

Table 4-7. Summary of ground water claims.

Source Area	# of Records	Sum of CFS	# of Records Reporting CFS	Sum of Ac-Ft	# of Records Reporting Ac-Ft
Columbia River & Minor C. R. Tributaries	9	0.2	7	13.0	7
Entiat River watershed	152	15.0	109	4,775.1	105
Mad River watershed	11	0.2	6	18.0	7
Totals	**172**	**15.4**	**122**	**4,806.1**	**119**



**Calculated acre-feet for surface water are based on irrigated acres reported multiplied by 4.0 acre-feet per acre plus reported values for non-irrigation uses.*

Figure 4-9. Geographic distribution of WRIA 46 water use as represented on rights & claims.

Table 4-8. Surface water certificates, permits and claims by primary beneficial use.

	Columbia River & Minor C. R. tributaries		Entiat River watershed		Mad River watershed	
Primary Use	Certificates & Permits	Claims	Certificates & Permits	Claims	Certificates & Permit	Claims
Commercial/Industrial	1	0	0	0	0	1
Single Domestic	1	0	4	0	2	0
Multiple Domestic	1	0	2	0	0	0
General Domestic	0	6	0	5	0	1
Frost Protection	0	0	2	0	0	0
Fish Propagation	0	0	2	0	0	0
Heat Exchange	1	0	0	0	0	0
Irrigation	14	18	63	106	2	5
Mining	0	0	0	2	0	0
Municipal	0	0	1	0	0	0
Power	3	0	0	0	0	0
Stock Watering	6	3	8	19	0	5
Wildlife Propagation	0	1	0	0	0	0
Use Not Listed	0	0	2	1	0	0
Totals	**27**	**28**	**84**	**133**	**4**	**12**

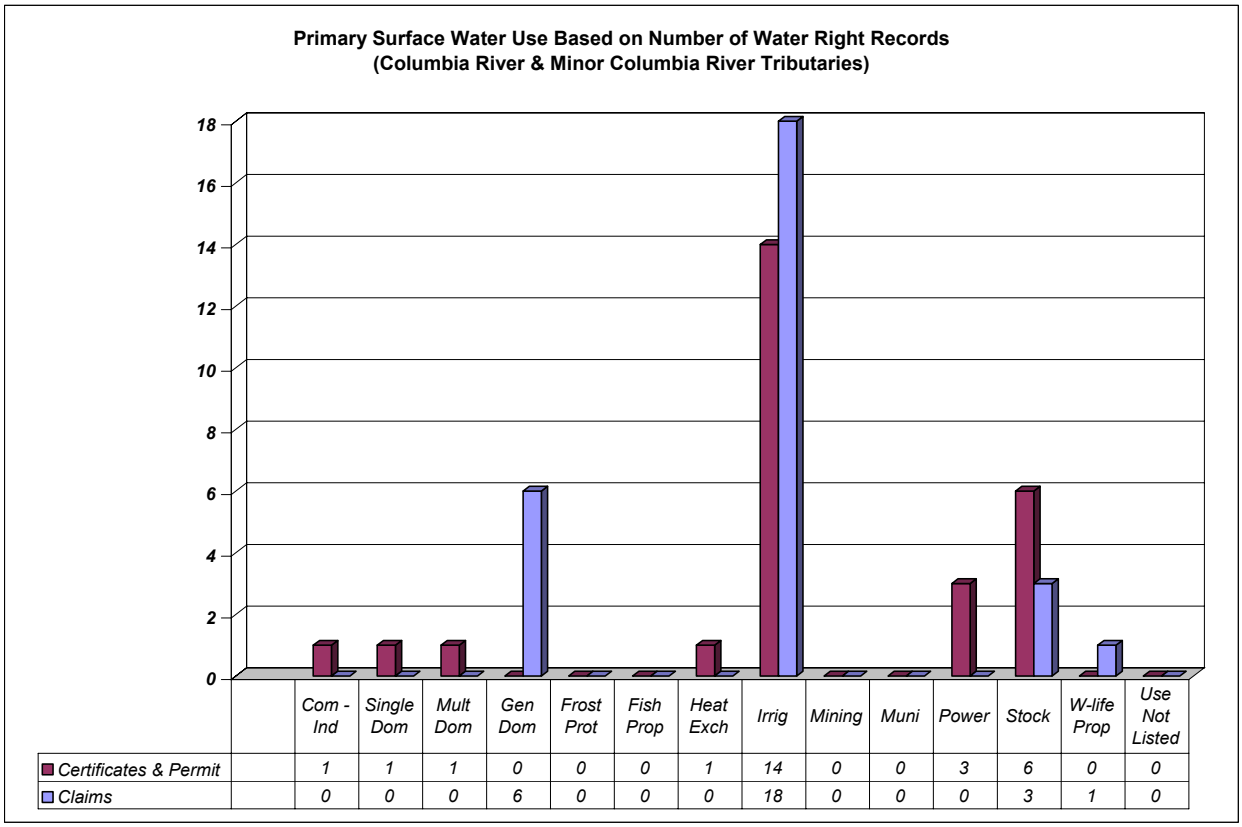
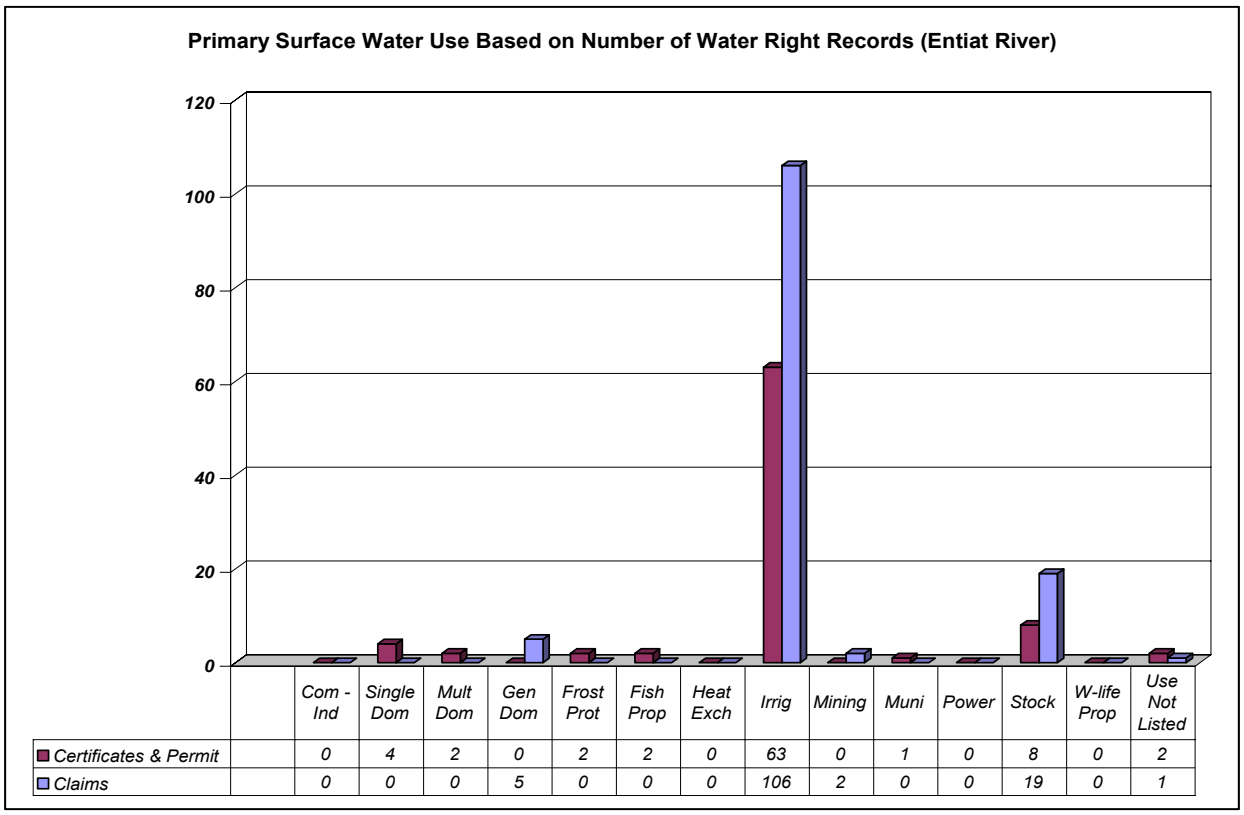
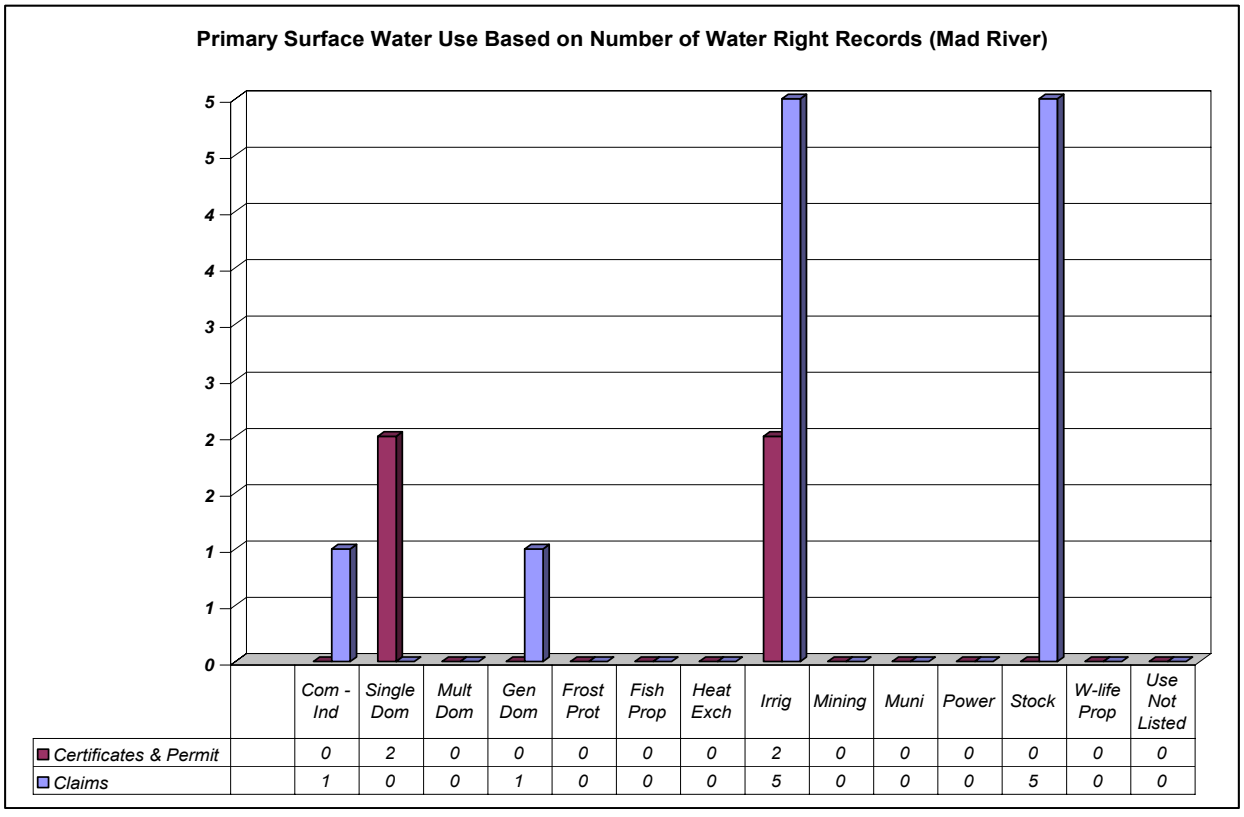


Figure 4-10. Columbia River & minor C.R. tributaries primary surface water beneficial use.



	Com - Ind	Single Dom	Mult Dom	Gen Dom	Frost Prot	Fish Prop	Heat Exch	Irrig	Mining	Muni	Power	Stock	W-life Prop	Use Not Listed
Certificates & Permit	0	4	2	0	2	2	0	63	0	1	0	8	0	2
Claims	0	0	0	5	0	0	0	106	2	0	0	19	0	1

Figure 4-11. Entiat River watershed primary surface water beneficial use.



	Com - Ind	Single Dom	Mult Dom	Gen Dom	Frost Prot	Fish Prop	Heat Exch	Irrig	Mining	Muni	Power	Stock	W-life Prop	Use Not Listed
Certificates & Permit	0	2	0	0	0	0	0	2	0	0	0	0	0	0
Claims	1	0	0	1	0	0	0	5	0	0	0	5	0	0

Figure 4-12. Mad River watershed primary surface water beneficial use.

Table 4-9. Ground water certificates, permits and claims by primary beneficial use.

	Columbia River & Minor Col. R. Tributaries		Entiat River watershed		Mad River watershed	
Primary Use	Certificates & Permits	Claims	Certificate & Permits	Claims	Certificate & Permits	Claims
Commercial/Industrial	0	0	1	1	0	0
Single Domestic	0	0	2	1	0	0
Multiple Domestic	4	0	1	7	0	0
General Domestic	0	7	0	82	0	6
Frost Protection	0	0	0	0	0	0
Fish Propagation	0	0	2	0	0	0
Heat Exchange	0	0	0	0	0	0
Irrigation	8	2	19	51	0	5
Mining	0	0	0	0	0	0
Municipal	1	0	0	0	0	0
Power	0	0	0	0	0	0
Stock Watering	0	0	0	10	0	0
Wildlife Propagation	0	0	0	0	0	0
Not Reported	0	0	0	0	0	0
Totals	**13**	**9**	**25**	**152**	**0**	**11**

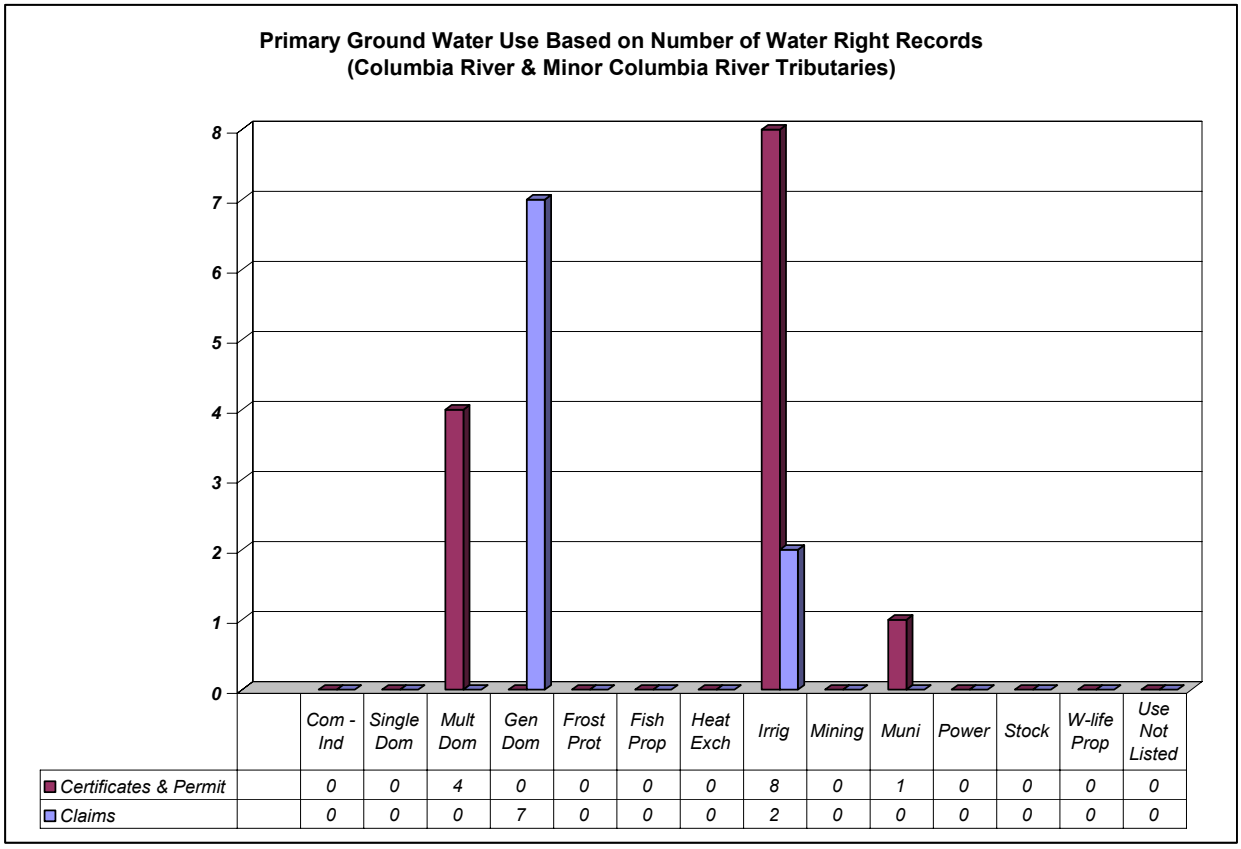
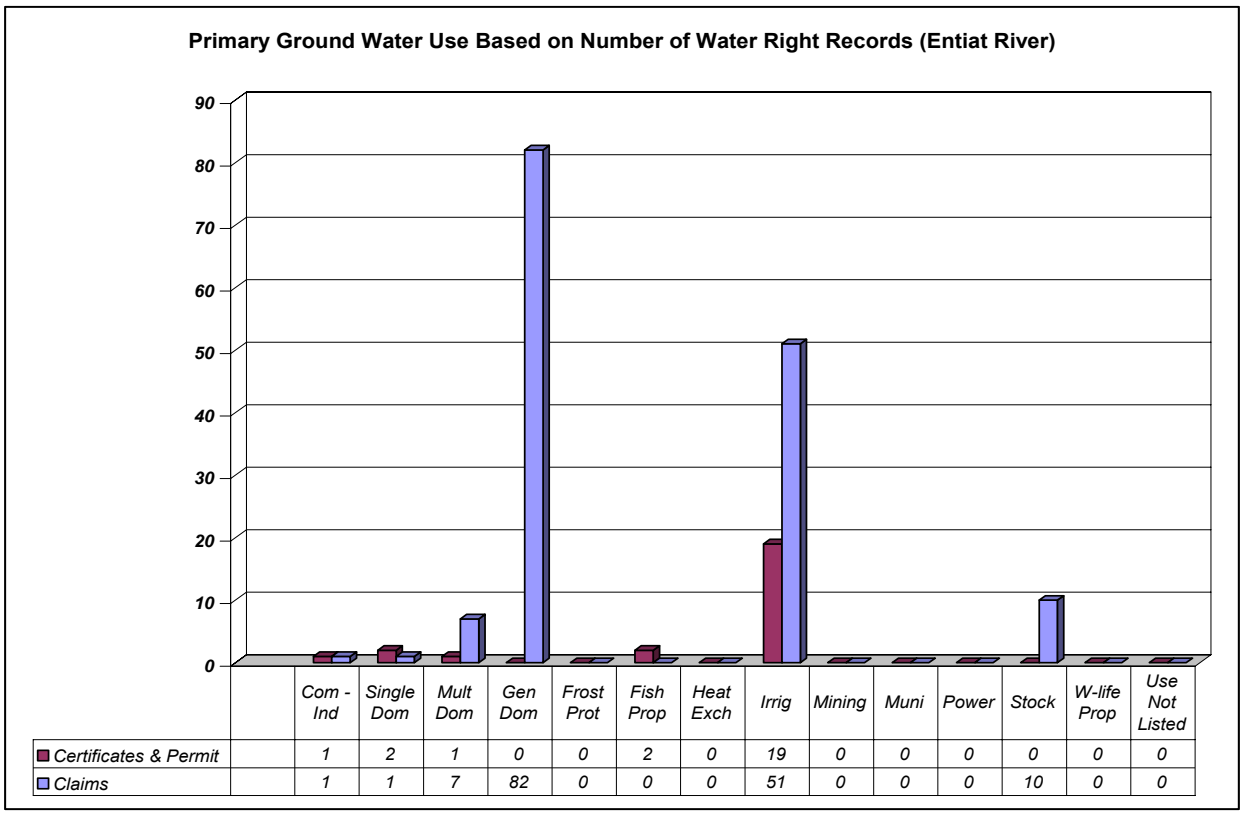
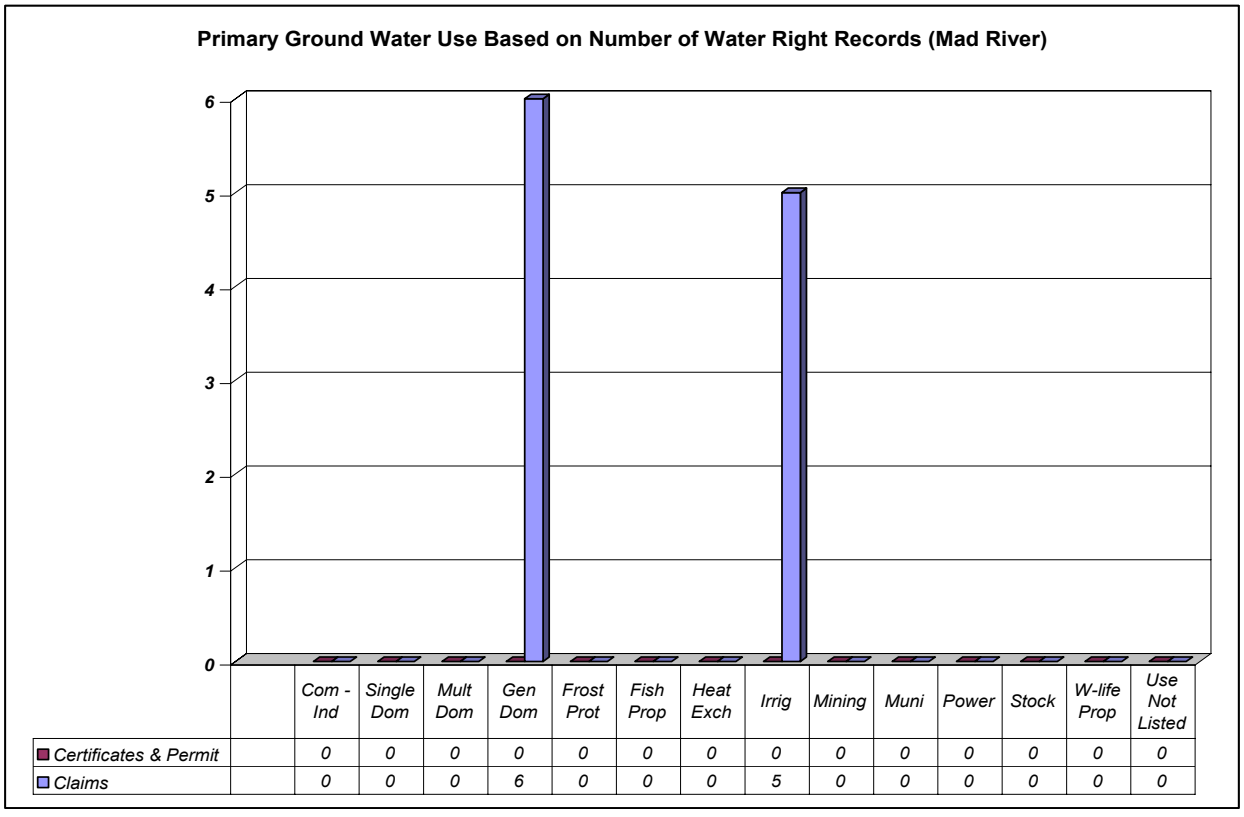


Figure 4-13. Columbia River & minor C.R. tributaries primary ground water beneficial use.



	Com - Ind	Single Dom	Mult Dom	Gen Dom	Frost Prot	Fish Prop	Heat Exch	Irrig	Mining	Muni	Power	Stock	W-life Prop	Use Not Listed
Certificates & Permit	1	2	1	0	0	2	0	19	0	0	0	0	0	0
Claims	1	1	7	82	0	0	0	51	0	0	0	10	0	0

Figure 4-14. Entiat River watershed primary ground water beneficial use.



	Com - Ind	Single Dom	Mult Dom	Gen Dom	Frost Prot	Fish Prop	Heat Exch	Irrig	Mining	Muni	Power	Stock	W-life Prop	Use Not Listed
Certificates & Permit	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Claims	0	0	0	6	0	0	0	5	0	0	0	0	0	0

Figure 4-15. Mad River watershed primary ground water beneficial use.

Analysis of the WDOE water rights registry revealed that 11 permits and one certificate issued for water use in the Entiat watershed since March 1993 are conditioned to some degree by minimum instream flows (for a complete explanation and discussion of minimum instream flows, refer to Chapter 5, Instream Flows).

Table 4-10. Conditioned surface and ground water certificates and permits.

Source Area	# of Records	Sum of CFS	# of Records Reporting CFS	Sum of Ac-Ft	# of Records Reporting Ac-Ft	Sum of Reported Irrig. Acres
Entiat River watershed *Surface water*	8	2.6	8	139.1	8	51.0
Entiat River watershed *Ground water*	4	0.0	0	115.9	4	36.5
Totals	**12**	**2.6**	**8**	**255.0**	**12**	**87.5**

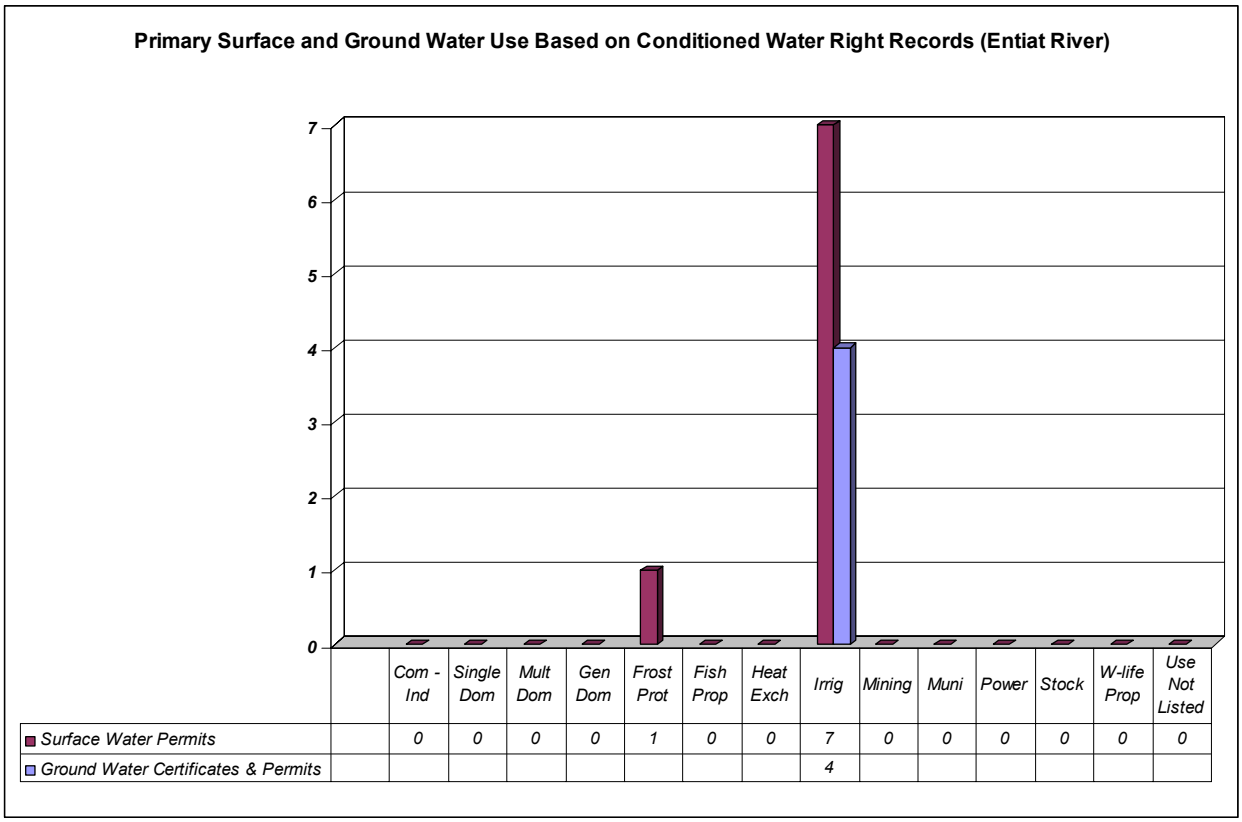


Figure 4-16. Primary surface and ground water use reported in conditioned water rights.

Language in the 12 conditioned water rights stipulates that "The irrigation portion [April 1 to October 31]…is subject to the recommendations of the Department of Fish and Wildlife minimum instream flow provisions", such that "No diversion of water…shall take place when the flow of the Entiat River falls below 116 cfs during November 1 through August 31, and 77 cfs during September 1 through October 31 as measured at the Ardenvoir gage". The minimum instream flows by which the water rights are conditioned were determined by the WDFW based on application of the Tennant Method for stream flow requirements. Stream flow exceedence values calculated based on flows recorded at the Ardenvoir gage for the

months of April - October show that sufficient water will likely be present 90% or more of the time from April through July; however, certainty of water availability decreases during the months of August-October, as evidenced by the flow exceedence values (see Table 4-11). The Record of Decision, which is part of the legal record, provides additional detail about the review process, calculations and considerations that led to these water right decisions.

Table 4-11. Minimum instream flows associated with conditioned water rights, and flow exceedence values by month based on Entiat near Ardenvoir (Stormy) gage data.

	Apr	May	Jun	Jul	Aug	Sep	Oct
Minimum Instream Flow (cfs)	116	116	116	116	116	77	77
Percent flow exceedence at Ardenvoir	90	99.5	100	100	84	63	68

The WDOE Water Rights Application Tracking System (WRATS) showed that 34 applications have been filed for water rights in WRIA 46 since 1991. Although surface water applications showed cfs, and ground water applications reported a pumping rate in gallons per minute (gpm), no acre-feet calculations were reported by either due to the fact that this volume is determined during application processing. Thus, only calculated acre-feet values are shown.

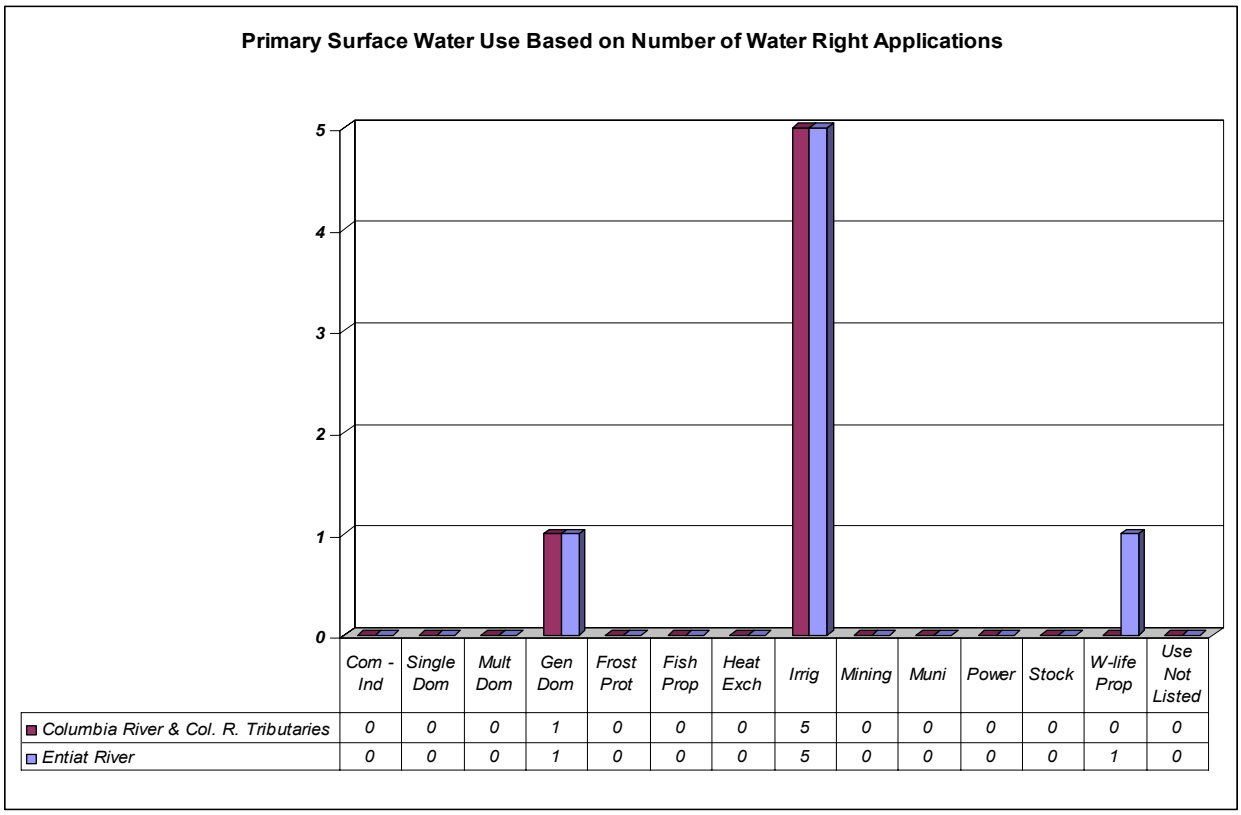
Table 4-12. Surface water right applications.

Source Area	# of Records	Sum of CFS	# of Records Reporting CFS	Sum of Reported Irrigated Acres	Calculated Irrigation Ac-Ft[1]	Sum of Reported Domestic Units	Calculated Domestic Ac-Ft[2]
Columbia River & Minor C. R. Tributaries	6	0.5	6	11.68	46.7	1	0.1
Entiat River watershed	7	0.9	7	23.00	92.0	2	0.2
Totals	**13**	**1.4**	**13**	**34.70**	**138.7**	**3**	**0.3**

Table 4-13. Ground water right applications.

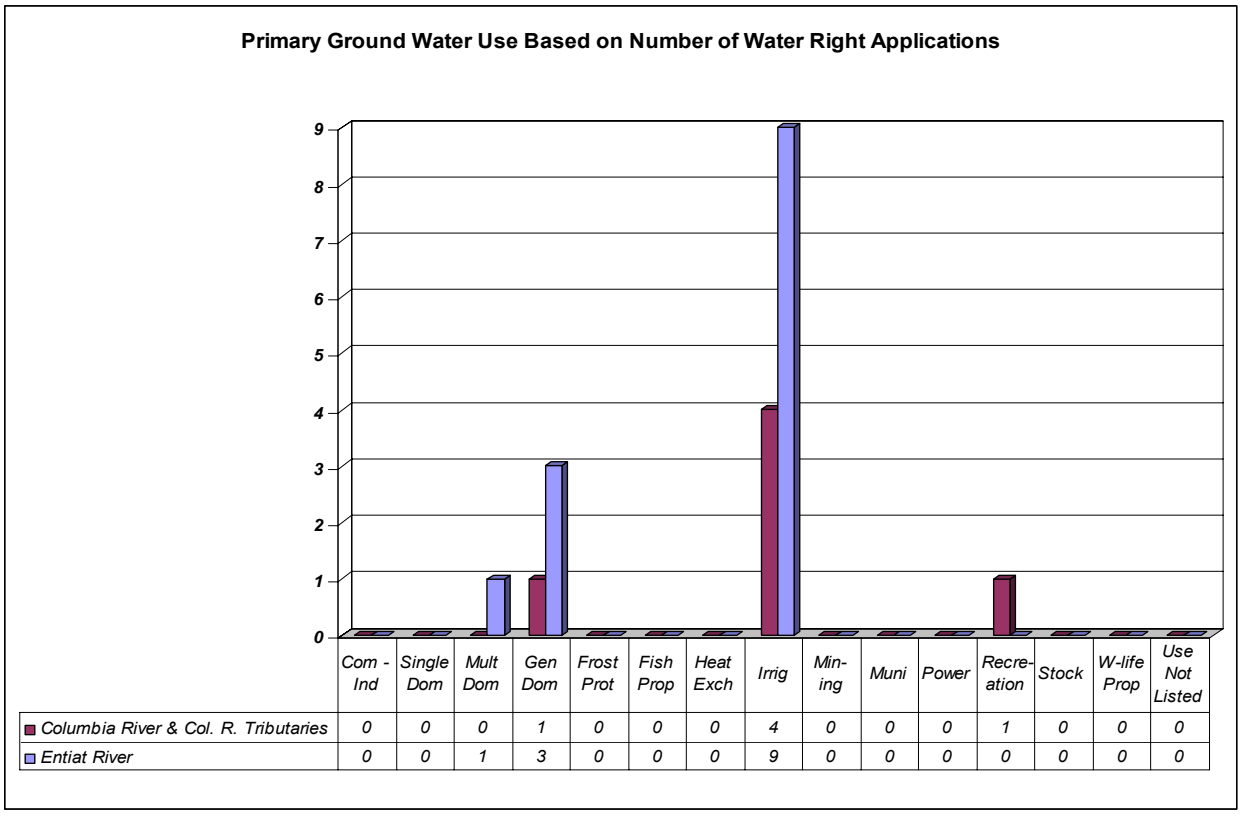
Source Area	# of Records	Sum of gpm	# of Records Reporting gpm	Sum of Reported Irrigated Acres	Calculated Irrigation Ac-Ft[1]	Sum of Reported Domestic Units	Calculated Domestic Ac-Ft[2]
Columbia River & Minor C. R. Tributaries	6	1,530	6	76.4	305.6	82	8.7
Entiat River watershed	13	1,376	13	135.50	542.0	26	2.8
Totals	**19**	**2,906**	**19**	**211.9**	**847.6**	**108**	**11.5**

1. *Calculated irrigation acre-feet values for water right applications are based on irrigated acres reported multiplied by 4.0 acre-feet per acre. Although the Planning Unit has developed irrigation water use estimates for tree fruit and lawn/pasture, 4 ac-ft was used because applications did not specify type of irrigation water use that would occur. For more information see Section 4.19, Irrigation Water Use.*
2. *Calculated domestic acre-feet values for water right applications are based on domestic units reported x 2.71 people per household x 35 gallons per capita per day net water use x 365 days in a year, and converted to acre-feet using the standard 1 acre-foot = 325,850 gallons. For more information on per capita per day domestic net water use estimates, see Section 4.9.2, Domestic In-House Net Water Use.*



	Com - Ind	Single Dom	Mult Dom	Gen Dom	Frost Prot	Fish Prop	Heat Exch	Irrig	Mining	Muni	Power	Stock	W-life Prop	Use Not Listed
Columbia River & Col. R. Tributaries	0	0	0	1	0	0	0	5	0	0	0	0	0	0
Entiat River	0	0	0	1	0	0	0	5	0	0	0	0	1	0

Figure 4-17. Primary surface water use reported in water right applications.



	Com - Ind	Single Dom	Mult Dom	Gen Dom	Frost Prot	Fish Prop	Heat Exch	Irrig	Min-ing	Muni	Power	Recre-ation	Stock	W-life Prop	Use Not Listed
Columbia River & Col. R. Tributaries	0	0	0	1	0	0	0	4	0	0	0	1	0	0	0
Entiat River	0	0	1	3	0	0	0	9	0	0	0	0	0	0	0

Figure 4-18. Primary ground water use reported in water right applications.

Many WRIA 46 water right claims contained in the WDOE registry were incomplete. Some did not list an annual volume in acre-feet, some listed a beneficial use but no volume information, some were missing both beneficial use and volume information, and some irrigation water rights were missing acres irrigated values. Additionally, there is no assurance that all of the aforementioned rights are still in use, or that the volumes contained within the paper record accurately depict water use within the WRIA. Therefore, the values contained in the preceding tables, which were generated directly from information contained in the water right documents, do not represent an accurate accounting of actual water use in the Entiat WRIA; rather, the tables presented are a summary of the information as reported in the paper water right record. The validity and extent of claims can only be determined through a general adjudication in the Superior Court of Chelan County, therefore the record will remain incomplete until they are included in a general adjudication.

4.9 ACTUAL WATER USE

Obvious inconsistencies exist between the amount of water use reported in the paper record (Section 4.8) and what is observed at gaging stations in the subbasin (see Section 4.1). Thus, the EWPU employed a variety of methods and data sources to generate estimates of actual irrigation and in-house domestic water use, which are detailed in this section.

4.9.1 Irrigation Water Use

In 2002, the CCCD contracted members of the Central Washington University (CWU) Geography and Land Studies Department to assess private land use and associated irrigation water use along the Entiat and Mad Rivers. CWU analyzed color stereopairs from 1992 and digital 1m resolution black and white orthophotographs of the valley from 1998, both provided by the USFS Wenatchee National Forest Supervisor's Office, and classified land use in the Entiat and Mad River watersheds as irrigated orchard (IO), irrigated residential (IR), non-irrigated residential (NIR), irrigated pasture (IP), non-irrigated pasture (NIP), sub-irrigated pasture (SIP), or building (BLD). Areas of pulled orchard (PO) were also classified, and project staff performed ground-truthing to verify photograph interpretation. On screen digitizing and analysis in a GIS was done to produce a land use polygon shapefile containing acreage estimates, land use type, irrigation water use, irrigation, and pulled orchard attribute data (Lillquist and Erickson 2002). In the spring of 2003, the Planning Unit performed supplemental orthophotograph interpretation and field checks to generate irrigated orchard information for the minor Columbia River tributaries area of the WRIA. A GIS was used to digitize and add these land use polygons to the original shapefile created by CWU.

Central Washington University's estimates of total tree irrigation water use were developed using information contained in the document "Irrigation Requirements for Washington: Estimates and Methodology" (James et al. 1982). This publication lists 40 locations that can be used to estimate irrigation requirements for 30 different crops, as well as return values (a 2-year return period value will be adequate, on average, one out of every two years; a 20-year return period value will be adequate, on average, 19 out of 20 years). Omak and Winthrop were the nearest locations listed in the publication for which data were

available. CWU used Omak crop irrigation requirement data to estimate irrigation water requirements in the Entiat valley, because its elevation and precipitation more closely mirrored conditions in Omak. CWU also used 20-year return period values for apples/cherries with cover and pasture/turf to provide a conservative water use estimate, and applied a 70% irrigation efficiency rate in their estimates of crop irrigation water requirements (Lillquist and Erickson 2002).

The EWPU determined that local data could be used to refine CWU's crop irrigation water use calculations and more accurately reflect irrigation water use in the Entiat valley. The Planning Unit used data collected by the WSU Cooperative Extension Program at the WSU Tree Fruit Research Center in Wenatchee to revise irrigation requirement estimates. WSU Cooperative Extension has annually recorded water use by month in acre-inches for fruit trees with cover since 1972. Data from this 31-year period of record (1972-2002) were used to determine average monthly fruit tree water requirements in acre-inches from April through September. Refer to Table 4-14 on page 4-32 for a summary of monthly tree water use data.

Due to the fact that WSU has not collected much data on tree water use in the month of October, miscellaneous data and input from WSU Cooperative Extension agent Tim Smith were used to estimate fruit tree irrigation water requirements in October at two acre-inches (T. Smith, pers. comm., April 8, 2003). Based on discussions with EWPU landowners and NRCS Resource Conservationist Gary Mitchell, the 70% application efficiency level used in CWU's calculations was changed to 65% in order to better reflect overall irrigation water application efficiency levels in the Entiat valley, and provide a more conservative estimate of irrigation water use.

Estimates of the total amount of irrigation water used in acre-feet during each month of the effective growing season (April-October), with 65% application efficiency, were made using WSU's tree water use data and CWU's irrigated orchard acreage estimates in the following formula:

$$\{[(\text{Tree Water Requirement } \textit{in ac-in} \times \text{Acres of Orchard}) / 65] \times 100\} / 12$$

WSU does not collect data on pasture/turf (lawn) irrigation water requirements. The best available information on local pasture/turf irrigation water requirements is published in USDA SCS document "State of Washington Irrigation Guide". This guide contains a value for pasture/turf irrigation water requirements in Wenatchee; it also contains data on fruit tree water use in Wenatchee. A ratio was developed using the State of Washington Irrigation Guide's published season water requirement for apples with cover and the published season value for pasture/turf to determine what percentage of fruit tree irrigation water is required to support pasture/turf. Calculations showed that pasture/turf requires 85% of the volume of water required for fruit trees with cover. The following formula was applied to the monthly average tree fruit water requirements listed in Table 4-14 to estimate monthly pasture/turf water requirements in acre-feet with 65% irrigation efficiency:

$$\{[(\text{Fruit Tree Water Requirement } \textit{in ac-in} \times 0.85 \times \text{Acres of Pasture/Turf}) / 65] \times 100\} / 12$$

Table 4-14. Monthly tree water use[1] (ac-in) at WSU Tree Fruit Research Center, 1972-2002.

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT[2]	SEASON TOTAL
1972	2.03	5.18	7.47	9.20	8.03	4.43	2.00	38.34
1973	2.28	5.40	9.22	11.48	9.80	4.60	2.00	44.78
1974	1.74	4.57	8.69	9.21	8.95	5.21	2.00	40.37
1975	1.72	5.26	8.33	10.49	8.88	4.66	2.00	41.34
1976	1.84	2.82	7.86	10.04	6.71	4.84	2.00	36.11
1977	1.69	4.49	6.67	8.32	5.43	4.32	2.00	32.92
1978	1.92	5.18	8.07	10.20	8.25	4.63	2.00	40.25
1979	2.10	3.78	8.11	9.45	8.31	3.28	2.00	37.03
1980	1.66	4.52	6.25	9.72	7.06	3.61	2.00	34.82
1981	1.61	4.26	6.19	8.53	7.63	3.76	2.00	33.98
1982	1.61	4.60	7.18	8.06	6.74	3.22	2.00	33.41
1983	1.44	5.20	6.66	7.18	6.53	3.89	2.00	32.90
1984	1.47	3.92	6.42	9.86	7.89	3.26	2.00	34.82
1985	1.72	5.18	8.34	10.71	7.93	3.13	2.00	39.01
1986	1.74	4.65	7.69	8.56	7.97	4.08	2.00	36.69
1987	1.88	4.75	7.30	8.28	8.09	4.46	2.00	36.76
1988	1.56	4.22	6.38	10.06	7.57	4.16	2.00	35.95
1989	1.79	4.47	7.65	9.40	7.13	4.43	2.00	36.87
1990	1.78	3.91	6.69	9.39	6.83	4.55	2.00	35.15
1991	1.87	4.21	6.41	10.00	7.42	4.48	2.00	36.39
1992	2.08	6.34	8.58	8.75	7.65	4.22	2.00	39.62
1993	1.10	4.75	6.36	7.46	7.20	3.90	2.00	32.77
1994	1.69	4.74	8.23	12.41	8.53	4.67	2.00	42.27
1995	1.47	5.28	7.90	10.52	7.90	4.66	2.00	39.73
1996	1.53	4.34	8.54	11.02	9.58	4.65	2.00	41.66
1997	1.14	4.27	7.22	9.16	7.30	3.48	2.00	34.57
1998	1.49	3.66	7.81	9.52	8.29	4.75	2.00	37.52
1999	1.60	4.57	8.03	9.31	7.26	4.00	2.00	36.77
2000	1.65	4.38	8.02	9.85	8.56	3.66	2.00	38.12
2001	1.39	4.98	7.06	10.23	7.65	4.35	2.00	37.66
2002	1.49	4.12	7.69	9.83	7.82	3.81	2.00	36.76
MO. AVG. SINCE 1972	1.68	4.58	7.52	9.55	7.77	4.17	2.00	37.27 ac-in

1. Data have already been adjusted using pan evaporation & KC value to approximate orchard tree water use.
2. The October value of 2 acre-inches was estimated based on miscellaneous October measurements provided by the WSU Tree Fruit Research Center, and conversations with Tim Smith, WSU Cooperative Extension. April through Sept values are based on data collected by T. Smith.

**Note: Actual irrigation rates must be 10 to 40% higher than tree use, depending on irrigation efficiency*

Table 4-15 shows the 'base' average monthly and seasonal water use values in acre-inches, and the 65% efficiency correction values that were used in the formulas listed in the Irrigation Water Use section to calculate tree fruit and pasture/turf water use estimates.

Table 4-15. Average monthly tree and pasture/turf irrigation water use (ac-in) estimates.

Description of Value	Apr	May	Jun	Jul	Aug	Sep	Oct	Season (Ac-In)
Average tree fruit water use by month, based on 1972-2002 WSU data	1.68	4.58	7.52	9.55	7.77	4.17	2.00	37.27
Average tree water use by month, with 65% application efficiency	2.58	7.05	11.57	14.69	11.95	6.42	3.08	57.34
Average Pasture/Turf water use by month (85% of WSU tree fruit water use avg. value)	1.43	3.89	6.39	8.12	6.60	3.54	1.70	31.68
Average Pasture/Turf water use by month, with 65% efficiency	2.20	5.99	9.83	12.49	10.16	5.45	2.62	48.74

Table 4-16 on page 4-34 summarizes land use acreage and irrigation water use estimates for WRIA 46. Estimates made for the minor Columbia River tributaries portion of the WRIA were based on the limited land use data generated for this area by CWU, and additional land use classification work and ground-truthing performed by the Planning Unit. The supplemental work done for the minor Columbia River tributaries area of the WRIA was focused primarily on documenting acres of irrigated orchard and larger areas of irrigated pasture/turf, due to the fact that water resource management for the Columbia River and its minor drainages is governed by Chapter 173-563 WAC (see Appendix L). Therefore, it is important to note that land and water use estimates for this portion of the WRIA are not thoroughly representative of the minor Columbia River tributaries area, especially with respect to irrigated residential land use. Land use in this area is currently very dynamic; therefore, estimates would likely have changed in the near future. It should also be noted that the minor Columbia River tributaries area data include acres of irrigated land along the lower Entiat River that are supplied by the Entiat Irrigation District, which obtains its water from the Columbia River.

Table 4-16. WRIA 46 estimated average monthly/seasonal irrigation water use in ac-ft, assuming 65% application efficiency.

Land Use	Estimated Acres	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Season (ac-ft)
Entiat River watershed above ~RM 18														
Irrigated Residential (IR)	20	0	0	0	3.63	9.88	16.23	20.61	16.77	9.00	4.32	0	0	80.43
Non Irrigated Residential (NIR)	90	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00
Sub Irrigated Pasture (SIP)	102	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00
Non Irrigated Pasture (NIP)	54	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00
Totals	**266**	**0**	**0**	**0**	**3.63**	**9.88**	**16.23**	**20.61**	**16.77**	**9.00**	**4.32**	**0**	**0**	**80.43**
Entiat River watershed below ~RM 18														
Irrigated Orchard (IO)	835	0	0	0	179.84	490.29	805.02	1022.33	831.78	446.40	214.10	0	0	3989.77
Irrigated Residential (IO)	201	0	0	0	36.88	100.54	165.08	209.65	170.57	91.54	43.91	0	0	818.17
Non Irrigated Residential (NIR)	82	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00
Irrigated Pasture (IP)	206	0	0	0	37.72	102.83	168.84	214.42	174.45	93.62	44.90	0	0	836.79
Sub Irrigated Pasture (SIP)	19	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00
Non Irrigated Pasture (NIP)	345	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00
Totals	**1688**	**0**	**0**	**0**	**254.44**	**693.66**	**1138.94**	**1446.40**	**1176.81**	**631.57**	**302.91**	**0**	**0**	**5644.73**
101 acres of current NIP was formerly orchard; 10 acres of current IR/IP was formerly orchard.														
Mad River watershed														
Irrigated Orchard (IO)	21	0	0	0	4.56	12.42	20.40	25.90	21.07	11.31	5.42	0	0	101.08
Irrigated Residential (IR)	15	0	0	0	3.26	8.90	14.61	18.56	15.10	8.10	3.89	0	0	72.42
Non Irrigated Residential (NIR)	16	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00
Non Irrigated Pasture (NIP)	1	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00
Totals	**53**	**0**	**0**	**0**	**7.82**	**21.32**	**35.01**	**44.46**	**36.17**	**19.41**	**9.31**	**0**	**0**	**173.51**
Minor Columbia R. tributaries Area[1]														
Irrigated Orchard (IO)	571	0	0	0	122.98	335.26	550.46	699.06	568.76	305.24	146.40	0	0	2728.17
Irrigated Residential (IR)[2]	65	0	0	0	11.94	32.54	53.42	67.85	55.20	29.62	14.21	0	0	264.78
Non Irrigated Residential (NIR)	13	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00
Irrigated Pasture (IP)	12	0	0	0	2.25	6.13	10.06	12.77	10.39	5.58	2.67	0	0	49.85
Non Irrigated Pasture (NIP)	22	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00
Totals	**683**	**0**	**0**	**0**	**137.16**	**373.92**	**613.95**	**779.68**	**634.36**	**340.45**	**163.28**	**0**	**0**	**3042.79**
31acres of current NIR/NIP was formerly orchard; 12 acres of current IR/IP was formerly orchard.														

1. Water use estimates for Minor Columbia River tributaries area irrigated lands in the lower Entiat River that receive water from the Entiat Irrigation District, which draws its water from the Columbia River.

2. Irrigated residential values in this area of the WRIA are based on polygons originally created by CWU, and a few additional lawn polygons created by the CCCD. Time was not spent trying to capture all irrigated residential use in the minor Columbia River tributaries area because this water is drawn from the Columbia River.

4.9.2 Domestic In-house Net Water Use

Almost all of the water pumped from the Entiat valley alluvial aquifer by permit exempt wells for in-house domestic use returns to the groundwater supply via septic system drain fields, or directly through the soil. Arguably, a small portion of the water withdrawn for domestic purposes does not return to the system, e.g., water for drinking or cooking food, water that is removed from clothes in the dryer, water used by house plants.

Although most of the groundwater withdrawn by wells does return to the system, the rate of return is not instantaneous; thus, a certain volume of water is not immediately available to be withdrawn again from groundwater supplies. The EWPU decided the term "Net Water Use" should be used to describe the amount of water that is not immediately returned to the system and available for reuse. The term Net Water Use, rather than "Consumptive Use", will be used throughout the remainder of this discussion in recognition of the fact that very little water withdrawn from the Entiat valley aquifer for in-house use is truly consumed and not returned to groundwater and/or the river system over time.

The Planning Unit utilized records from the City of Entiat's municipal water system to formulate its estimates of per capita per day (pcpd) net water use. The City obtains water for its municipal system from wells adjacent to the Columbia River. Municipal wastewater is processed by the City's treatment plant and discharged back to the Columbia River. The City reports volumes of water pumped and treated in millions of gallons per day (mgd); an average daily volume is also calculated for each month. The EWPU used the City's year 2000 records to develop pcpd net water use estimates. The year 2000 records were used because they were more accurate[1] than 2001 and 2002 data, and 2000 population and household size data for the City were available from the US Census.

It was assumed that the difference between the City's average daily pumped and average daily treated water volumes represented basic municipal net water use; however, the City serves both residential and commercial/industrial customers. In order to estimate the amount of water being pumped and delivered to residences, discussions were held with the City Public Works Department. It was estimated that about 75% of the total annual volume of water that the City pumps is dedicated to residences (B. Whitehall, pers. comm. April 2003).

Average daily pumped values for each month were multiplied by 0.75 to estimate *water flowing to residences* each month. Each monthly residential estimate was divided by the number of days in the month, and then divided by the City's 2000 population to arrive at an estimate of the average amount of water flowing each day to each person during different months of the year. It was estimated that 73 gallons flow each day to each person during the months of October through March. Average daily treated volumes for each month were then subtracted from average daily pumped values and multiplied by 0.75 to estimate *average daily residential net water use* each month. Residential net water use estimates were divided by the City of Entiat's 2000 population to provide an estimate of pcpd net water use. It was estimated that during the months of October through March, pcpd net

[1] The City of Entiat pump experienced technical difficulties in 2001/2002 (B. Whitehall, pers. comm. 2003).

water use was approximately 35 gallons. Refer to Table 4-17 on page 4-37 for a summary of City of Entiat data and per capita per day net water use calculations.

The City pumps surplus water during the months of April through September for cooling and flushing water lines, filling pools, construction projects, etc. The additional water that is pumped is not returned to the City's wastewater plant, making it difficult to estimate net water use values for this period. In order to address this issue, a sample of bi-monthly meter records from different sized households was obtained from the City for March/April, May/June, July/August, and September/October. The sample of meter records showed that, even when the highest household volumes recorded for each two month period were used, the average amount of water flowing to each person each day during this period was 73 gallons. Refer to Table 4-18 on page 4-38 for bi-monthly record data and calculations. Notably, there was not an increase in domestic water use during spring and summer months as one might expect. This can be explained by the fact that the Entiat Irrigation District provides water to the City and its residents for irrigation, outdoor use, etc. during this time period.

In-house net water use analyses were focused on the area *within* the Entiat subbasin that fell *outside* of the City Urban Growth Area (UGA), as water used in the UGA and the minor Columbia River tributaries area of WRIA 46 is obtained from either the City of Entiat or other sources in hydraulic continuity with the Columbia River. Furthermore, a water resources program for the Columbia River has already been developed (see Appendix L, Chapter 173-563 WAC, Instream Resources Protection Program for the Main Stem Columbia River in Washington State). The Planning Unit obtained and analyzed 2000 census tract and block GIS data to determine which census blocks containing people and/or households fell within the subbasin. Two census blocks included data for both the minor CRTs area and the lower Entiat River; one showed 24 people and 7 households, the other 58 people and 16 households. The block with 7 households was included in the analyses, while the block with 16 households was excluded based on known population distribution patterns within these blocks, and the fact that the majority of the excluded block area fell within the minor CRTs region of the WRIA.

Table 4-17. Summary of City of Entiat municipal water system data and per capita per day water use estimates.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Gallons pumped monthly for 390 hookups	2518000	2268400	2749000	3636000	4086700	4664800	5838300	5937200	4104800	3562200	2960900	3028700	
Avg. pumped daily	81226	78221	88677	121200	131829	155493	188332	191523	136827	114910	98697	97700	
Avg. treated daily	45000	47000	53000	56000	60000	57000	64000	67000	59000	57000	48000	43000	
Difference (*Avg. net water use daily)*	36226	31221	35677	65200	71829	98493	124332	124523	77827	57910	50697	54700	
Avg. flow to homes daily *(75% of pumped daily)*	60919	58666	66508	90900	98872	116620	141249	143642	102620	86182	74023	73275	**Oct.-Mar. Daily Avg.**
Avg. flow to each person daily *(flow to homes daily / City pop*)*	64	61	69	95	103	122	148	150	107	90	77	77	**73**
Avg. home net water use daily *(75% of net water use daily)*	27169	23416	26758	48900	53872	73870	93249	93392	58370	43432	38023	41025	
Average pcpd net water use *(home net use / City pop.)*	28	24	28	51	56	77	97	98	61	45	40	43	**35**

** 2000 City of Entiat population = 957. Data provided by US Census Bureau.*

Table 4-18. Sample of City of Entiat water meter data for 19 household connections, in gallons per month*.

People per housing unit	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Highest flow to each person	Bi-monthly period
4	5550	5550	6100	6100	5450	5450	6050	6050	51	May/Jun
4	5850	5850	5100	5100	3950	3950	4550	4550	49	Mar/Apr
4	6200	6200	6250	6250	8300	8300	6550	6550	69	Jul/Aug
4	8400	8400	5700	5700	6750	6750	10250	10250	85	Sep/Oct
4	9750	9750	7900	7900	9300	9300	9100	9100	81	Mar/Apr
4	10600	10600	10850	10850	10150	10150	10250	10250	90	May/Jun
4	15250	15250	10850	10850	15550	15550	12900	12900	130	July/Aug
4	11750	11750	9050	9050	6250	6250	7250	7250	98	Mar/Apr
3	5850	5850	4500	4500	5600	5600	5150	5150	65	Mar/Apr
3	5650	5650	6200	6200	5700	5700	4550	4550	69	May/Jun
2	4700	4700	2700	2700	2750	2750	2750	2750	78	Mar/Apr
2	2500	2500	4150	4150	4450	4450	3850	3850	74	Jul/Aug
2	2200	2200	1650	1650	2500	2500	2450	2450	42	Jul/Aug
2	5650	5650	4500	4500	5200	5200	3550	3550	94	Mar/Apr
2	2850	2850	2700	2700	3000	3000	2700	2700	50	Jul/Aug
2	4350	4350	3500	3500	3900	3900	3500	3500	73	Mar/Apr
2	2350	2350	2200	2200	2700	2700	3150	3150	53	Sep/Oct
2	4200	4200	3900	3900	3750	3750	4100	4100	70	Mar/Apr
2	4550	4550	2950	2950	2100	2100	2450	2450	76	Mar/Apr
Total people = 56 Avg. people per unit=2.9									**Avg. of highest flows = 73**	
Total flow by month to 19 units	118200	118200	100750	100750	107350	107350	105100	105100		
Average flow by month to each unit	6221	6221	5303	5303	5650	5650	5532	5532		
Average flow by month to each person	2111	2111	1799	1799	1917	1917	1877	1877		
Average flow daily to each person	70	70	60	60	64	64	63	63	**March-Oct daily avg. flow = 64**	

** Meter readings are taken every two months. The total volume from each bi-monthly reading was divided in half to estimate monthly values.*

Data from the select census blocks showed there were 470 housing units. Of these, 310 were reported as supporting the year-round population of 829 people, indicating an average of 2.71 people per household in the subbasin. Vacation or part time residences comprised the remaining 160 units. As these could become full time at any point, and there is no seasonal water use restriction on the permit exempt wells associated with these homes, they have the imminent potential for year-round water use. Accordingly, all 470 units were treated as full time, year-round residences during the development of in-house water use estimates for the subbasin. The equations used to estimate total daily net water use were as follows:

470 housing units x 2.71 people per unit = 1274 people
1274 people x 35 gallons pcpd = 44,590 gallons net water use per day

Daily net water use was multiplied by the number of days in each month to approximate monthly net water use (31-day mo. = 1,382,290 gallons; 30-day mo. = 1,337,700 gallons; 28-day mo. = 1,248,520 gallons). Monthly in-house net water use estimates were converted to acre-feet using the standard 1 ac-ft = 325,850 gallons. Thus, current domestic net water use ranges from 3.8 to 4.2 ac-ft per month. The standard 1cfs for 1 day = 1.9835 ac-ft was used to convert ac-ft volumes to cfs. It was estimated that total domestic in-house net water use in the Entiat and Mad watersheds is approximately 0.07 cfs on an average monthly basis.

4.10 RESERVE WATER

It is important to note that water for homes, commercial enterprises, and other uses in the Entiat subbasin is not currently provided by a municipal water system, but via withdrawals occurring under permit exempt wells, water rights and claims. Thus, all future water withdrawals in the subbasin, whether associated with new water rights or permit exempt wells, would be conditioned by codified minimum instream flows. Codification of the Administrative Instream Flow regime proposed in Chapter 5, or for that matter the Planning Unit Flow regime (whose monthly flow exceedence values were usually higher than those of the Administrative Flow regime), would not provide a reliable year-round water supply sufficient to support new growth and associated water use in the valley. Recognizing this, the Planning Unit agreed to explore negotiation of a "Reserve" of water that would be senior to codified minimum instream flows.

The development of a Reserve was encouraged by the WDOE in recognition of the fact that a key part of Planning Unit's vision for the Entiat WRIA includes "...a balance between natural resources and human use, both current and projected; the coexistence of people, fish and wildlife while sustaining lifestyles through planned community growth, and maintaining and/or improving habitats; [and ensuring] ...economic stability in balance with natural resources". Additional rationale for the creation of a Reserve is that, in order to balance community needs with aquatic resource needs, some "unconditioned" water should be available to allow for and support future moderate growth and economic expansion in the Entiat valley. Providing the opportunity for growth to occur is integral to maintaining and enhancing the social and economic viability of the community, and augmenting the small

core property tax base from which essential community services (fire department, schools) are funded. If codified, the special Reserve would allow for future beneficial uses that require guaranteed water (available as needed), e.g. for homes, commercial agriculture, other businesses, etc.

A Reserve of 5 cfs was negotiated based on the Planning Unit's future water supply estimates and requirements discussed in Section 4.11, as well as evaluation of the potential impact of additional withdrawals. Biologists and resource specialists involved with creation of the Administrative [minimum] instream flow and Planning Unit flow recommendations described in Chapter 5 agreed that the Entiat system could support additional withdrawals up to 5 cfs without significantly impacting aquatic resources/existing beneficial uses.

The Reserve will only become "real" upon completion of the water resources management rule making process for the Entiat. Under Washington Water Law, the date on which rule making concludes will be the priority date associated with the Reserve. The Reserve will be given the same as the priority date that will be given to minimum instream flows (see Chapter 5, Administrative Instream Flows, for discussion related to the priority date of minimum instream flows). Thus, the Reserve will make water available for qualifying future beneficial uses that will be uninterruptible/unaffected by codified minimum instream flows.

As part of its preliminary discussions of criteria for qualifying future beneficial uses, the Planning Unit has proposed partitioning the Reserve so that discrete volumes may be allocated into the following general categories:

- New Residential
    - Exempt wells serving single and up to six residential units, including gardens, lawns up to ½ acre in size, and stock watering
    - Larger non-exempt residential developments
- Agriculture
    - Commercial orchard/vineyard, other commercial livestock / farming operations
- Commercial and Light industrial
    - Businesses
    - Process water / "value added" operation component of enterprises using or selling agricultural products
    - Clean industries

Partitioning has been proposed to help facilitate management of the Reserve. Additionally, the Planning Unit recognizes that new water appropriated from the Reserve for future agricultural, commercial/light industrial uses should be limited to the lower Entiat River (below RM 16.2) in order to help protect the important "stillwater" area. However, new residential development and associated water use will continue to be allowed in and above the stillwater reach.

The EWPU intends to continue its work to develop specific language for inclusion in Chapter 173-546 that will detail how:

- conditioned water rights and pending water right applications should be addressed;
- transfer of water between reserve categories may occur if warranted (e.g. if residential development occurred at a higher than anticipated rate, water from one of the other reserve categories could be used to meet additional domestic water needs);
- water use decision making institutions may be established or organized for management of the Reserve; and
- additional criteria may be used by WDOE and partners for the management of the Reserve so that this water will help to achieve community goals for the Entiat valley.

The Planning Unit is also exploring how water right banking/leasing, transfers, etc. can be used in lieu of Reserve water to satisfy new uses, so that future appropriation of Reserve water only happens after all other options have been exhausted.

Water in excess of the 5 cfs Reserve may also be available in the future through implementation of storage, water-for-water mitigation and out-of-kind mitigation options. Implementation of the management recommendations proposed in Chapter 9 (changes to channel geometry, water conveyance efficiency improvements, water conservation measures, etc.) are examples of out-of-kind mitigation.

4.11 FUTURE WATER SUPPLY REQUIREMENTS

In recognition of the fact that the City of Entiat, Entiat School District have suffered financial losses associated with the construction of Rocky Reach dam (ECONorthwest 2003), and that additional community and economic growth is essential to support the schools and facilities that serve the community, the EWPU has proposed that a Reserve of water be available for new beneficial uses that help to achieve the Planning Unit's long term vision for the valley. The Planning Unit selected a 22-year planning horizon for making their water reserve estimates in order to coincide with Chelan County's comprehensive planning horizon.

4.11.1 Future Population Estimates

Under the Growth Management Act (GMA; RCW 36.70A), Chelan County and its cities designated Urban Growth Areas (UGAs) designed to include areas and densities sufficient to permit the urban population growth that is projected to occur over a 20-year planning horizon. The planning period used by the Chelan County for its comprehensive plan is 22 years into the future, or through the year 2025. Between now and the year 2025, a goal of Chelan County and the City of Entiat is encourage development and future population growth within the Entiat UGA.

The county and cities of Wenatchee, Chelan, Cashmere, Leavenworth and Entiat used the Chelan County 'High Series' population projection for the year 2025 (101,859 people), provided by the Washington State Office of Financial Management (OFM) on January 25, 2002, as the basis for their future population predictions. They distributed the projected population among each of the seven County Census Divisions (CCDs) based on the historical contribution of each CCD to total county population. Weighted averaging was used to assign

more emphasis to recent census data. The following weighting factors were used: 1970 census, 10%; 1980 census, 20%; 1990 census, 30%; 2000 census, 40%.

Using the aforementioned methodology, it was estimated that the Entiat CCD will account for 3117 out of the 101,859 people projected to be living in the county in 2025. Year 2000 census data reported the Entiat CCD population at 2042 and City of Entiat population at 957 (US Census Bureau 2001b, 2001a). Chelan County estimated that the population living in the greater Entiat UGA in the year 2000 was 1017 (C. Wavra, pers. comm. July 30, 2003); thus, the remaining 1025 people were estimated to be living in the rural area of the Entiat CCD.

The county and City of Entiat split the projected Entiat CCD population (3117) between the UGA and the rural area using the estimate that 65% of the projected population may live in the UGA (2026 people) and 35% may live in the rural area (1091 people). If population growth and settlement patterns in the Entiat CCD occurred along these lines, the UGA would experience a 2.795% average annual rate of growth, and the rural area would grow by an annual average rate of 0.25% over the next 22 years. Stated differently, the UGA population would expand by up to 1009 people, from 1017 to 2026, and the rural area would grow by 66 people, from 1025 to 1091, between now and the year 2025.

As mentioned earlier, Chelan County and City of Entiat's projections for population growth and distribution among the urban and rural areas of the Entiat CCD are tied to goals associated with planning under the GMA, which include the efficient provision and utilization of public facilities and services, and reducing inappropriate conversion of undeveloped land into sprawling, low density development. The GMA also requires the rural element of the Chelan County comprehensive plan to provide for a variety of rural densities, uses, essential public facilities, and rural governmental services needed to serve the permitted densities and uses (Chapter 36.70A.070(5)(b) RCW). Accordingly, the county zoning designations for the Entiat CCD were designed to control the level of rural growth that can occur in this area over the next 22 years; however, even with zoning in place a number of privately held parcels of land in the subbasin still have the potential to be developed and/or divided.

A goal of the EWPU's water resources planning effort was to estimate what unconditioned reserve volume will likely be adequate to satisfy additional water needs in the Entiat subbasin through the year 2025. In doing so, the Planning Unit made a more liberal projection of the population growth that may through the year 2025. A population larger than what was predicted by the county for the rural area of the Entiat CCD may or may not exist in 2025. Given that uncertainty, the EWPU used a more liberal projection to help assure that adequate unconditioned water will be available for appropriation to beneficial uses in the Entiat valley if growth within this rural area of the Entiat CCD exceeds the county's projections. A more liberal estimate was also made to help ensure that adequate year-round water will be available to help the EWPU meet its long-term vision and goals for the subbasin, which include: providing for the coexistence of people, fish, and wildlife; sustaining lifestyles through planned community growth; and emphasizing local culture and economic stability in balance with natural resources.

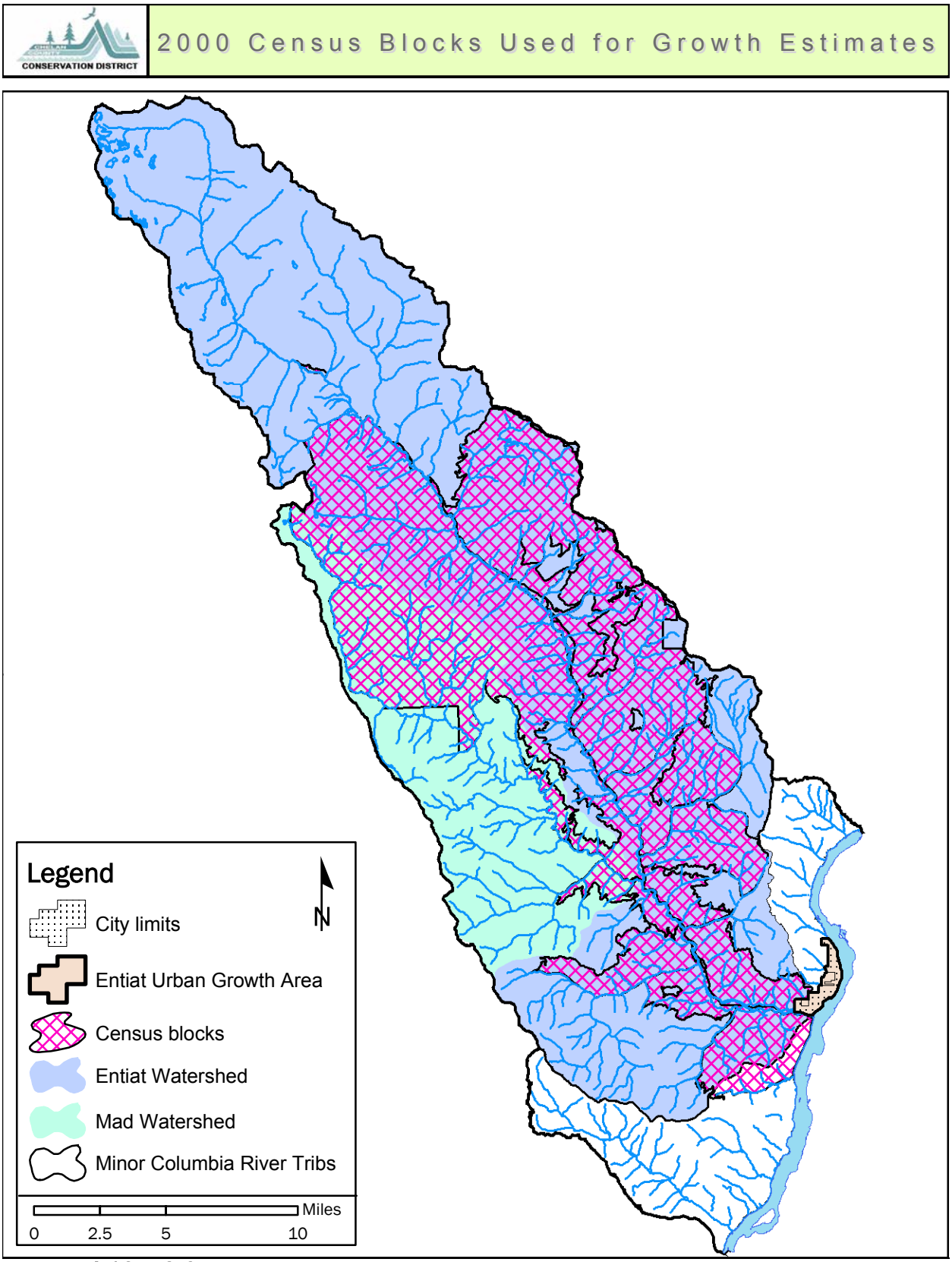


Figure 4-19. US Census blocks within the Entiat subbasin (excluding city) reporting people and houses used for future population predictions.

In an effort to estimate what population was living solely in the Entiat and Mad watersheds in the year 2000, the Planning Unit used a GIS to select census blocks from the Entiat CCD that fell entirely or largely within the Entiat and Mad River watersheds, but outside of the UGA. Refer to Figure 4-19 on page 4-43 for a depiction of the US Census blocks selected. Entiat CCD census blocks that included people living in the Entiat UGA or the minor Columbia River tributaries area were excluded from consideration. Data showed that approximately 839 people were living in the subbasin in the year 2000 (US Census Bureau 2001b).

To project what future Entiat subbasin population may require water appropriated from within this area of the WRIA, the Planning Unit analyzed census block data from 1990 and 2000. Population in the Entiat and Mad River watersheds grew from 739 to 839 people during the period 1991-2000 (US Census Bureau 1991, 2001). Thus, the average annual rate of growth in the subbasin over this decade was 1.156%. As mentioned previously on page 25 of this Chapter, the EWPU determined that all of the 470 residences reported in the 2000 census should be treated as year-round occupancy for the purpose of estimating water use (US Census Bureau 2001b). The 1.156% average annual rate of population growth was applied to the year 2004 potential population of 1274 people (470 housing units x 2.71 people per household = 1274) to derive a future population estimate of 1641 people total, or up to 367 additional people living in the Entiat and Mad watersheds in 2025.

4.11.2 Future Domestic Water Use Estimates

Domestic In-House Water

An estimate of the water needed for in-house net water use by 367 additional people was calculated using the following formula:

367 people x 35 gallons pcpd = 12,845 gallons net water use per day.

Daily net water use in gallons was multiplied by the number of days in each month to approximate monthly net water use (31-day month = 398,195 gallons; 30-day month = 385,350 gallons; 28-day month = 359,660 gallons). Monthly domestic net water use estimates were converted to acre-feet using the standard of 1 ac-ft = 325,850 gallons. Future residential net water use by 367 additional people ranges from 1.1 to 1.2 acre-feet per month, depending on the number of days in the month. Monthly acre-foot estimates were converted to cfs using the standard of 1 cfs for 1 day = 1.9835 acre-feet. It was thus estimated that 0.02 cfs of water may be necessary to satisfy future domestic in-house net water use needs through the year 2025.

Domestic Irrigation Water

The average of 2.71 people per household reported by the 2000 census was used to estimate how many new housing units may exist in the subbasin in 2025:

367 new people / 2.71 people per household = 135 new housing units.

It was assumed that each new housing unit may irrigate up to ½ an acre of lawn, with an average of 24 acre-inches, or 2 acre-feet of water required per half acre of lawn during the seven month April-October irrigation season (24 ac-in is half of the per acre value for pasture/turf in Table 4-15 on page 4-33). It is important to maintain defensible space around residences in rural areas like the Entiat subbasin for wildfire protection; therefore, it was assumed that lawn watering will occur even in 'drought' years when suburban water conservation measures may have been put into effect elsewhere. Subsequently, up to 270 acre-feet of water may be necessary between April and October to irrigate the 68.5 additional acres of lawn potentially associated with 135 new housing units. New lawn irrigation water use in July, the most consumptive month, may total approximately 71 acre-feet, or an instantaneous amount of about 1 cfs. Thus, it was estimated that about 1 cfs will likely be sufficient to accommodate future domestic in-house, irrigation and stock water needs in the Entiat and Mad River watersheds through 2025 if population growth in the subbasin continued at the rate experienced over the period 1991-2000.

4.11.3 Future Commercial Agriculture Irrigation Water Estimates

In order to help promote future agricultural economic enterprises in the Entiat subbasin, the EWPU estimated what amount of reserve water might be requested by the valley community for future appropriation for new commercial livestock operations, orchards, vineyards, etc. Water right applications for the subbasin and non-irrigated pasture acres identified by the CWU land use study were analyzed in an attempt to estimate the current/potential demand for water for commercial agriculture, and how many larger tracts of irrigable land exist in the subbasin.

The Planning Unit used a GIS to identify non-irrigated pasture parcels in single, private ownership that were shown as greater than or equal to five acres in size, and which had not been classified by the CWU land use assessment as pulled orchard. Parcels greater than or equal to five acres in size were targeted because it was assumed that smaller areas would not be commercially viable; non-irrigated pasture lands coded as pulled orchard were excluded because there were already irrigation water rights associated with these areas. Non-irrigated pasture lands much upstream of the Potato Creek confluence were also ruled out due to the fact that topography and climate shorten the effective growing season in this part of the Entiat watershed; length of growing season in the lower part of the subbasin averages about 150 days (USDA 1979). It was estimated that approximately 150 acres of non-irrigated pasture could conceivably be put into commercial agriculture in the future, if parcel owners so desired.

Estimates of how much water would be necessary to support this additional commercial agriculture were made based on the tree water use in July 1973, the highest tree water use month/year out of the 31-years of data collected by the WSU Tree Fruit Research Laboratory. The highest water use month in the highest water use year was used in order to estimate the greatest instantaneous amount of water that may be required in the future by new orchards (refer back to Table 4-14 on page 4-32 for July 1973 tree water use in ac-in). The EWPU estimated that if 150 acres of orchard were planted, about 220 acre-feet of water would be needed during a very dry year in July. This volume translated into a maximum rate of approximately 3.6 cfs. Members of the Planning Unit recognized that

grapes/vineyards and other less consumptive crops may be planted in lieu of or in combination with orchards, and that not all of the estimated acres of non-irrigated pasture may be put into commercial agriculture in the future; therefore, they determined that a reserve of approximately 3 cfs of water should be available via future water rights for commercial agriculture in the Entiat subbasin.

4.11.4 Future Commercial/Light Industrial Water Estimates

The EWPU estimated that approximately 1 cfs of water should be placed in reserve for appropriation to future commercial and light/clean industrial uses in the subbasin. This estimate was made based on discussions with the LSC and other members of the EWPU about the desire to assure that water is available to support future economic growth in the valley. Although it is likely that many, if not all new small commercial uses will draw water from permit exempt wells, new exempt well water withdrawals will be conditioned by minimum instream flows. Therefore, it was necessary estimate what amount of unconditioned reserve water may be needed to allow future commercial enterprises to operate consistently and over the long-term.

The Title 11 "Zoning Resolution" of the Chelan County Code provides examples of enterprises that are either permitted outright in the subbasin or permitted as conditional and/or administrative uses, dependent on zoning. Such activities include, but are not limited to: bed and breakfasts; the development of tourist/recreational uses; wineries; agricultural tourism related businesses; and value added operations. Chapter 11.04 of the Chelan County Code defines a value added operation as any activity or process that allows farmers to retain ownership and that alters the original agricultural product or commodity for the purpose of gaining a marketing advantage (Res. 2002-08 (part), 1-15-02). Water from this Reserve category would be used to support the value-added part of commercial agricultural operations include bagging, packaging, bundling, pre-cutting, food service etc., whereas crop irrigation water would be appropriated from the Commercial Agriculture Irrigation Water portion of the overall reserve.

4.12 WATER BANKING/LEASING OPPORTUNITIES

The 1991 Water Resources Management Act and the 1989 Yakima Basin Trust Water Rights Act created a mechanism for WDOE to acquire water rights from willing water right holders through leases, water conservation projects, donations, and other appropriate means. Some of the following legislative provisions apply to trust water rights:

- Trust water rights retain their priority date during the time they are held in trust and are not subject to relinquishment due to lack of use;
- A water right expressly conditioned to limit its use to instream purposes must be used as a trust water right in compliance with that condition;
- The trust water program can redirect the use of conserved water within a specific reach for other purposes.

The EWPU agreed to provide information to water right holders in the Entiat and Mad River watersheds about the State Trust Water Program and similar water banking/leasing programs available to prevent the relinquishment of existing water rights due to non-use, especially when orchard/agricultural land conversion occurs, and encourage use of such programs. Public outreach will also be used to explain how water banking/leasing will work in conjunction with the Reserve to satisfy future water right applications. For example, a goal is to use 'banked' rights (especially seasonally conditioned trust rights) to satisfy future water right applications for irrigation/commercial agriculture, and other beneficial uses that do not require guaranteed year round water. A review of trust water rights will be done prior to consideration of a Reserve water allocation so that, if possible, Reserve water would be used solely for appropriation to new uses that require year-round water.

4.13 WATER STORAGE OPPORTUNITIES

The EWPU determined that once Administrative Flow numbers have been met during a given month, the opportunity for water storage should be available. The Administrative Flows recommended for the beginning, middle and end of the spring freshet (approximately May 1 through July 15) were developed to protect channel maintenance flows and natural variability in the range of flows experienced by the system. WDOE also made a preliminary determination of water availability for the May 1 – July 15 time period so that a certain portion of flows that exceed recommended minimum instream flow numbers could be stored, based on the following semi-monthly basis:

Semi-Monthly Period (total 76 days)	Storage Potential
May 1 – May 15	Up to 100 cfs
May 15 – May 31	Up to 100 cfs
June 1 - June 15	Up to 100 cfs
June 16 – June 30	Up to 100 cfs
July 1 – July 15	Up to 67 cfs

During the May 1 – July 15th period in 1997 (a representative 'wet' year), proposed semi-monthly Administrative instream flow values were exceeded by a minimum of 443 cfs in each period. Using the rough estimate that 1 cfs for 1 day = 2 acre-feet, approximately 14,210 acre feet of water would have been available for storage during the 76 day period May 1 – July 15th in 1997. In 2001 (a representative 'very dry' year), proposed semi-monthly Administrative instream flow recommendations would not have been met at any time, based on an average of the mean daily flows experienced during each period. However, an examination of *daily* mean flow values showed that water would still have been available for storage on 14 days out of the 76 day period, totaling approximately 2316 ac-ft.

Refer to table 4-19 on the following page for a summary of days and amounts of water that would have been available in 2001.

Table 4-19. Water that would potentially have been available for storage in 2001, given proposed Administrative instream flows for the lower Entiat River.

Date	Daily Storage Potential (cfs)	Daily Storage Potential (ac-ft)
5/12/2001	20	40
5/13/2001	100	200
5/14/2001	100	200
5/15/2001	100	200
5/16/2001	2	4
5/23/2001	100	200
5/24/2001	100	200
5/25/2001	100	200
5/26/2001	100	200
5/27/2001	100	200
5/28/2001	100	200
5/29/2001	100	200
5/30/2001	100	200
5/31/2001	36	72
Total volume available in 14-day period = 2316 ac-ft		

5.0 INSTREAM FLOWS

5.1 INSTREAM FLOW INVESTIGATIONS

As stated in Chapter 1, Section 1.2.1, watershed planning units have the option of collaborating with the Washington Department of Ecology (WDOE) to develop and recommend minimum instream flows under the Watershed Planning Act (see sections 040, 060, 080 of Chapter 90.82 RCW). In 1998 the initiating governments and the EWPU decided to include the development of minimum instream flow recommendations as part of the Entiat WRIA planning process.

The term "minimum instream flow" refers to an instream stream flow regime that has been put into rule, or codified, and used for two main water management purposes:

- determining the availability of water for new out-of-stream uses and regulating those new uses; and
- defining stream flows that are needed to protect and preserve instream resources and values.

The instream flow regime recommended by the Planning Unit for codification as a "minimum instream flow" in Chapter 173-546 WAC will be used by the WDOE to help determine the availability of water for issuance of *new* water rights. In essence, a minimum instream flow regime becomes a legal water right for the river to protect the instream resources and beneficial uses/values it supports. A minimum instream flow is "junior" to all existing valid (senior) water rights, and therefore has *no effect* on these water rights and out-of-stream uses; however, the minimum instream flows will be "senior" to all water rights issued after they are codified. Essentially, minimum instream flows say that water is available for new beneficial uses only if a certain flow is present in the river.

The first step in setting minimum instream flows is to identify and assess the stream flow needs for a given watershed, and then to identify which of the instream resources and environmental values are required by existing state law to be protected by those flows within the watershed. Adequate instream flows are important not only for fish, but for irrigation, wildlife, recreation, aesthetics, navigation, stock watering, and water quality needs. Data, such as information relating to the biology (specifically fish and aquatic habitat), hydrology, water quality, and geomorphology of the watershed are gathered.

The planning unit must use a collaborative process to develop minimum instream flow recommendations. Data must be summarized, analyzed, and reviewed by all interested parties. An instream flow regime must consider the temporal and geographic range of stream flows needed to protect and preserve instream resources and environmental values. It includes a set of specific stream flow numbers (usually set as cubic feet per second (cfs)) for a given time-step (week, month, etc.), and time period (spring, summer, fall, winter) tied to a certain location that is needed to assure that enough water is available to protect and preserve the aforementioned resources. The last step of the process involves proceeding with a formal review and codification of the recommendations as "minimum instream flows" in the Washington Administrative Code (WAC).

For more information on instream flows please review the publication, "*A Guide for Instream Flow Setting in Washington State"* (WDOE and WDFW 2003). The full report may be accessed by clicking the following link: http://www.ecy.wa.gov/pubs/0311007.pdf. Information is also available from the following web-site: http://www.ecy.wa.gov/programs/wr/instream-flows/isfhm.html

5.1.1 Previous Instream Flow Work in WRIA 46

In 1992 the WDOE and WDFW collected instream flow data as part of a statewide watershed assessment process. They established transects within representative reaches of the lower and mid-Entiat River (RM 1.0 and 16.2, respectively) and the lower Mad River (RM 0.2). Data on four key measurable elements of fish habitat (depth, velocity, substrate and cover) were collected at each transect for use in a Physical Habitat Simulation (PHABSIM) analysis (Caldwell 1995). PHABSIM analysis is a nationally approved tool for estimating habitat available in a river for different species and different life stages of fish at various stages of flow, and is the most commonly used analysis tool for instream flows in Washington State.

Estimates of spawning and juvenile fish habitat availability for Chinook, steelhead and bull trout were generated by the PHABSIM computer model and calibrated based on several stages of flow at the two study locations in the Entiat. A full analysis of the Mad River data was deferred. A report entitled, "Entiat and Mad Rivers Fish Habitat Analysis Using the Instream Flow Incremental Methodology" (Caldwell 1995) contains the results of the PHABSIM assessment (see the 1995 assessment in the Reports folder on the CD). The title of the report is somewhat misleading as PHABSIM is only a component of the full Instream Flow Incremental Methodology (IFIM) decision-making framework (see Section 5.2).

Instream flows recommended by WDOE and WDFW were presented to the Entiat community on March 23, 1995. During this meeting, the WDOE presented findings from the Initial Watershed Assessment, Entiat River Watershed (Kirk et al. 1995). The minimum instream flow recommendations presented were generated without utilization of a full collaborative decision-making process like IFIM to identify issues, develop and implement a study plan, generate alternatives, and solicit input from multiple stakeholders. As a result, the recommendations were not well understood or received, and not codified. Members of the Entiat CRMP Technical Advisory Committee reviewed the information and concluded that the habitat estimates reasonably approximated the relationship between habitat and flow levels for the study segments. However, the EWPU identified data gaps in the assessment; thus they chose to utilize a more collaborative approach to developing instream flow recommendations and took on the optional instream flow component as part of its collaborative watershed planning effort.

5.2 INSTREAM FLOW INCREMENTAL METHODOLOGY (IFIM)

The Instream Flow Incremental Methodology was developed in the 1980s by an interdisciplinary team of scientists from various federal and state agencies and academia under the leadership of the USFWS (Bovee 1998). Notably, IFIM is a *process* designed to help solve multiple-use water resource allocation issues, such as setting instream flows. It is a decision-support system designed to help determine the benefits and consequences of different water management alternatives within a given river and/or watershed. IFIM is made up of a combination of problem solving tools and integrated computer models, such as PHABSIM, as well as steps intended to involve all stakeholders. It consists of four interrelated phases:

- Phase I: Problem identification and diagnosis,
- Phase II: Study planning,
- Phase III: Study implementation, and
- Phase IV: Alternatives analysis/problem resolution.

The Planning Unit decided to use the IFIM process to develop minimum instream flow recommendations for the Entiat and Mad Rivers for a number of reasons. First, the IFIM framework complemented the collaborative problem solving process already established via the group's past use of the NRCS' Coordinated Resource Management Plan framework, and current Planning Unit structure. Second, since IFIM based studies are considered "flexible" and can be tailored to fit the individual needs of a watershed, use of IFIM enabled the specific goals of the EWPU to be included in the process to develop instream flow recommendations. Finally, IFIM was selected because its framework allows consideration of how given water management alternatives may affect human resources. By employing IFIM, the Planning Unit was able to choose what methods, models, and public involvement procedures were best suited to solving instream flow issues within the Entiat subbasin. For more information regarding the IFIM, please refer to the following links:
http://www.fort.usgs.gov/products/software/ifim/5phases.asp
http://www.fort.usgs.gov/products/publications/3910/3910.asp

5.3 EWPU APPLICATION OF IFIM

In preparation for developing minimum instream flow recommendations, the Planning Unit and WDOE sponsored a three-day IFIM training in March 2000 to educate interested parties on the IFIM process and instream flow setting in Washington State. Subsequently, at their June 2000 meeting, the EWPU agreed to use a robust application of IFIM as their approach to addressing instream flow issues. The group also agreed to apply for FY 2001 Salmon Recovery Funding Board (SRFB) money to help fund the EWPU IFIM process. The Planning Unit successfully obtained SRFB funding, and the consulting firm ENTRIX, Inc. (ENTRIX) was hired in September 2001 to work with the EWPU and the instream flow subcommittee on this issue.

5.3.1 Instream Flow Work Plan (IFWP) Development

An EWPU instream flow technical subcommittee field trip and a Landowner Steering Committee (LSC) meeting were held in September and October 2001, respectively, to initiate instream flow issue scoping (Phase one of IFIM: Problem Identification). These sessions, combined with input received from the EWPU habitat subcommittee and subsequent landowner meetings, provided stakeholder input for the development of the IFWP (Phase II of IFIM: Study Planning). As stated in the IFWP, the goals of the EWPU were to:

1. **Develop instream flow recommendations for the Entiat and Mad Rivers** (with contingency planning) for the purpose of: (a) addressing future water right decision-making and (b) addressing flows necessary for protection and restoration of habitat for threatened and endangered salmonids and other species of interest within the context of existing water use. The flow recommendations will be associated with key life stages of target fish species (Chinook salmon, steelhead and bull trout) within distinct stream segments of the Entiat and Mad Rivers.
2. **Establish the micro and macrohabitat data platform necessary to conduct status and trend monitoring** of key reaches in the Entiat River watershed for the purpose of evaluating the success of habitat restoration efforts associated with listed species.
3. **Conduct a simultaneous application of the Instream Flow Incremental Methodology and the Ecosystem Diagnosis and Treatment** (EDT) process on a relatively small-scale, data-rich watershed for the purpose of demonstrating the degree of compatibility of the two procedures in facilitating the development, implementation and monitoring of a comprehensive watershed restoration strategy.
4. **Conduct a robust application of the IFIM as a demonstration of a problem solving process**, directed at the local level, that utilizes an efficient combination of both existing data (e.g., 1995 PHABSIM analyses) and new information (e.g., site-specific assessment of passage conditions) to develop instream flow recommendations under the guidance of the Washington State Watershed Planning Act.

5.3.2 IFIM Study Scope and Data Inputs

The EWPU instream flow and habitat subcommittees worked with ENTRIX to define segments of the Entiat and Mad Rivers with similar characteristics for the purpose of identifying where field data should be collected (see Figure 5-1 on page 5-5). Stream flow, land ownership, channel condition, habitat composition, and aquatic habitat utilization data, as well as data from the EDT effort and WDOE/WDFW PHABSIM report (Caldwell 1995), were used to delineate instream flow study segments. The EWPU technical subcommittee determined how new study sites would compliment the previous PHABSIM assessment transects, and how data from both analyses would be used to craft instream flow recommendations. Field reconnaissance was performed on July 31, 2002, by ENTRIX, EWPU instream flow subcommittee members, and WDFW staff involved with the 1995 PHABSIM study in order to discuss the utility of data collection sites and transects proposed in the IFWP, and assure there was no duplication of effort between the 1995 study and ENTRIX's data collection efforts.

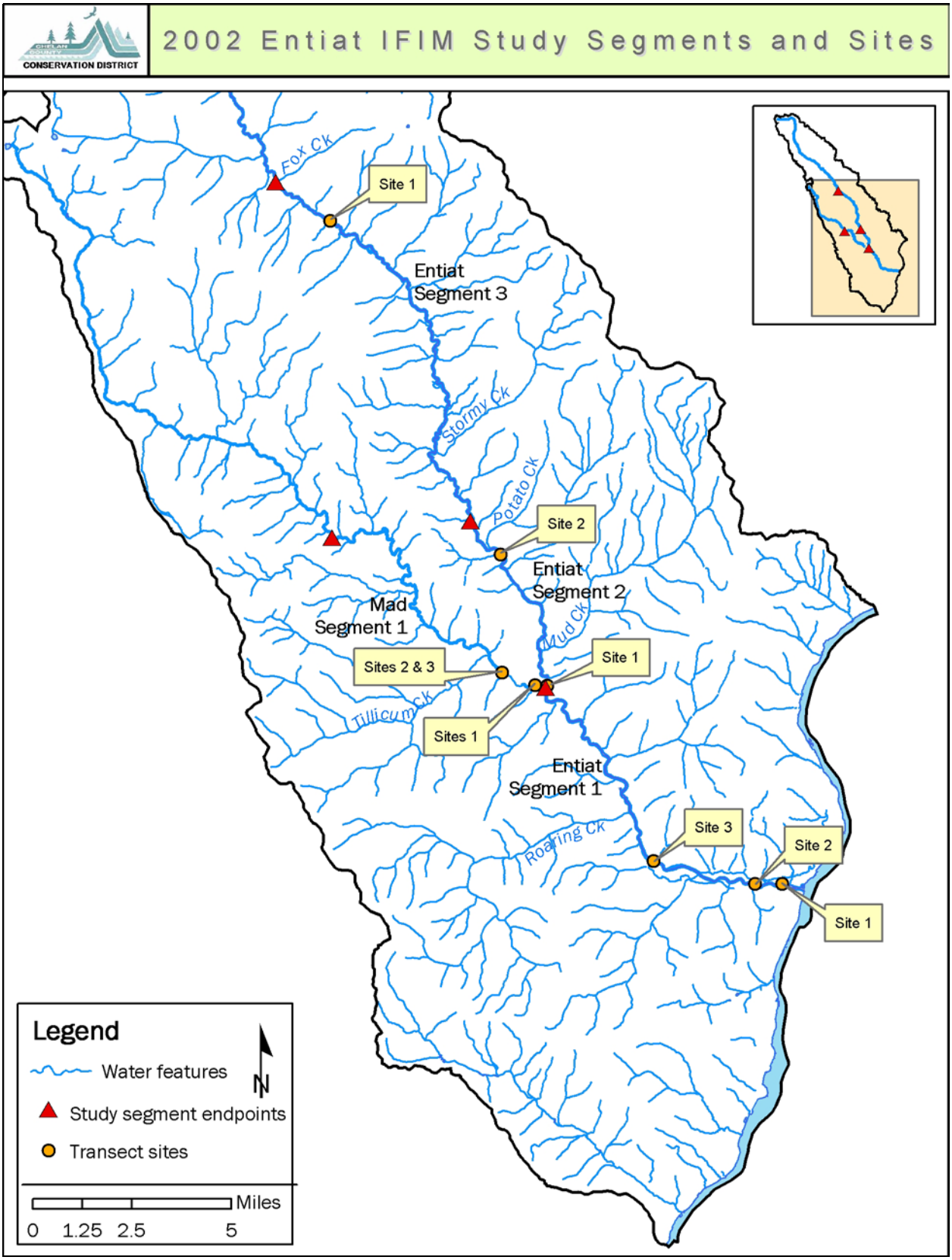


Figure 5-1. Entiat 2002-2003 IFIM study segments and transect sites.

ENTRIX's field data collection focused within three segments of the Entiat River and the lower Mad River in order to balance total study cost against the utility of results from reach-specific instream flow studies. Only segments downstream of RM 28.5 (Fox Creek) were studied in detail due to cost considerations and the very limited potential for future out of stream water use above the Forest Service boundary at RM 26.3. Stream flow measurements for Segments 1 and 2 were correlated to the Keystone gage (USGS gage 12452990); stream flow measurements for Segment 3 were indexed to the Stormy gage (USGS gage 12452800). The Mad River was evaluated as a single study segment with the primary focus being the lower two miles. Mad River stream flow measurements were correlated to USGS gage 12452890 near the mouth of the Mad.

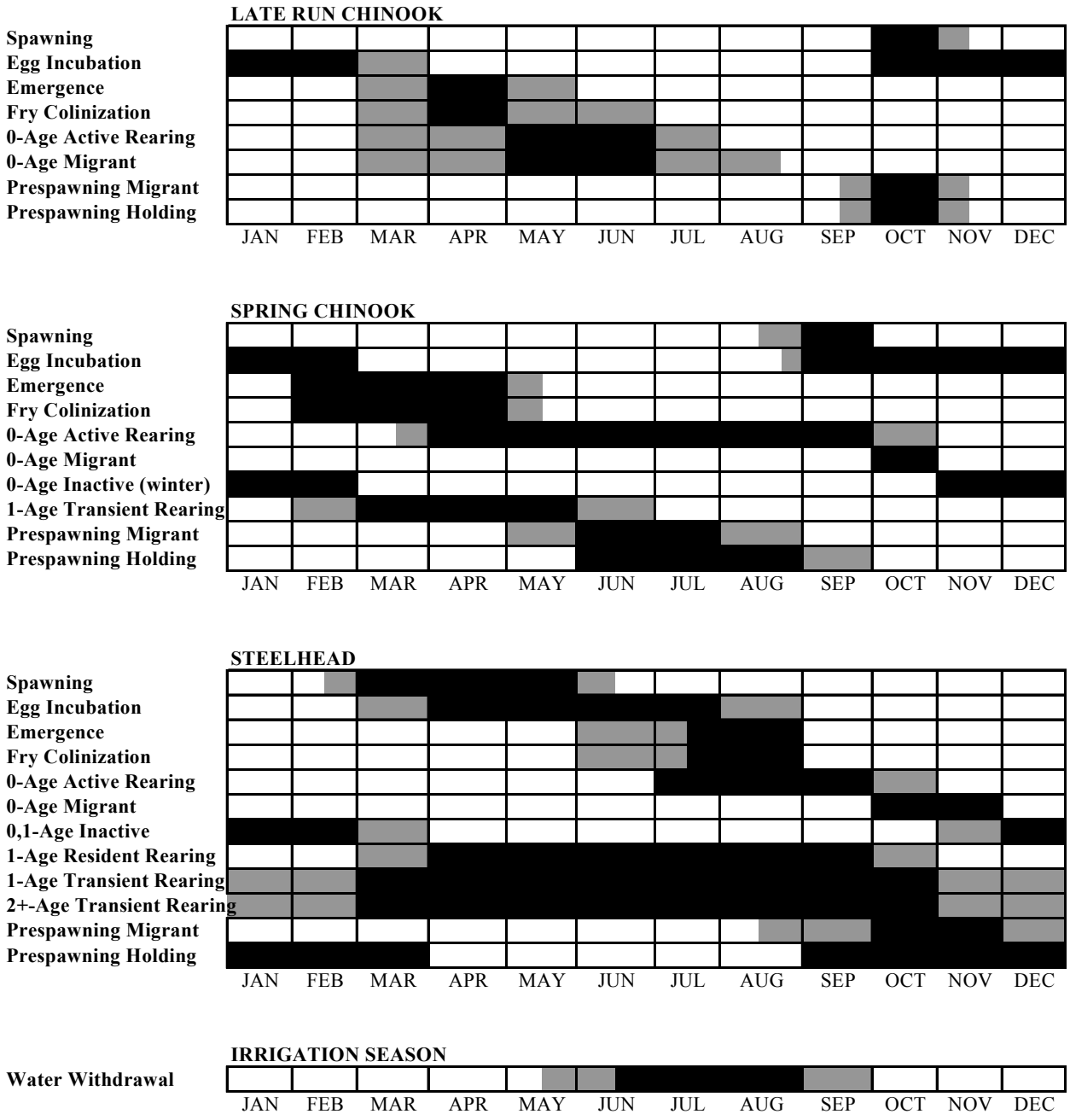
Table 5-1. Summary of 2002-2003 Entiat IFIM segment, sites, transects and selection rationale.

Segment	Site/R.M.	Transect	Purpose	Description	Field Observations 8/02, 9/02, 10/02
Entiat Segment 1	R.M. 0.8 Site 1	1	Spawning	1 chosen for Chinook spawning. 2&3 chosen for steelhead spawning; "no Chinook". Transects are located on right bank channels	Active spawning 10/02.
		2	Spawning /Passage		No passage into side channel at lower flows.
		3	Spawning		
		4	Flow	In combination with the average of 2&3, provides total flow measurement.	Spawning activity observed downstream 10/02.
	R.M. 1.3 Keystone		Spawning /Passage	Chosen because of spawning in previous years and potential passage issues at low flow	Spawning 9/02 and 10/02.
	R.M. 4.5 Dinkleman		Passage	Concern expressed that cross vane may create potential passage issues at low flow.	Adults holding in scour pool downstream of cross vane, all 3 visits. No passage problems.
Mad River	R.M. 0.2	1	Passage	The transect captures a potential passage issue; however, a more likely passage issue is located just upstream of the transect on private property. No permission to enter.	
	R.M. 1.2	2	Spawning	Spawning in previous years.	Chinook redd in 9/02.
	R.M. 1.3	2	Spawning	Spawning in previous years.	Steelhead redds in 7/02. Chinook redd on transect in 9/02.
Entiat Segment 2	R.M. 10.6	Lower	Passage/ Aesthetic	Chosen for potential passage issues and aesthetics viewpoint.	
	R.M. 14.9	Upper	Passage/ Aesthetic	Chosen for potential passage issues and aesthetics viewpoint.	
Entiat Segment 3	R.M. 25.8	1	Spawning	Chosen because of spawning in previous years. Segment 3 typically has the most spawning of the studies segments.	
		2	Spawning		Good cover along right bank.
		3	Spawning		Redd on right bank.

The EWPU habitat subcommittee worked with ENTRIX to document the phenology of Chinook and steelhead within the Entiat and Mad River watersheds in order to determine when field data should be collected. The landowner steering committee provided information about quantity and timing of irrigation water use to help define which months are critical with respect to water demand. Although steelhead, spring Chinook and late run Chinook utilize different segments of the Entiat and the Mad Rivers to different degrees, no difference was observed in the timing of a particular species' life history activity across stream segments. Thus, the timing of life history activities presented in Figure 5-2 on page 5-8 was deemed applicable to all stream segments addressed by the Entiat IFIM.

ENTRIX collected data at transects within each study segment during August, September and October 2002 in order to assess Chinook and steelhead spawning and passage stream flow requirements. Additional steelhead spawning flow data were collected at the upper two transects in the Mad River by USFS Entiat RD fish biologists on April 8, 2003 to record flows during a known steelhead spawning event. Weighted Usable Area (WUA) curves for Chinook, steelhead and bull trout habitat produced by WDOE/WDFW as part of their previous PHABSIM work were also utilized in the development of instream flow recommendations. Habitat Time Series analysis was done combining WUA and Flow Time Series data to examine bull trout habitat in the Mad River and upper Entiat River. ENTRIX paid particular attention to the juvenile habitat WUA curves, as they were only contracted to collect new data on spawning and passage flow issues as part of the Entiat IFIM process. Planning Unit thermograph data and winter habitat condition information in the lower Entiat River were used in conjunction with data from a study on summer/fall Chinook salmon incubation and survival success (BioAnalysts, Inc. 2002a) to guide development of instream flow recommendations for the winter months. For more information on winter habitat conditions and effects on fish, see Chapter 7, Habitat.

As mentioned in Chapter 4, Water Quantity, the Planning Unit and consultant Gran Rhodus compiled and review all historic and current USGS and USFS stream flow records for the Entiat and Mad Rivers (Rhodus and Edwards 2002). Continuous gage records from the three main USGS gages were used, and appropriate correlation analyses were performed to estimate stream flow data and fill the gaps in these records as needed. In order to expand the daily stream flow record at each gage, composite stream flow records were created to tie together both measured and synthesized stream flow data (refer to Chapter 4, Section 4.2).



Stream Use Key:
Black Areas = Periods of Heaviest Use
Grey Areas = Periods of Moderate Use
Blank Areas = Periods of Little or No Use

Note: Light irrigation water use occurs mid-April through mid-May and during the first half of October.

Figure 5-2. Phenology chart for Chinook salmon and steelhead in the Entiat subbasin.

ENTRIX used the composite stream flow records[1] to prepare representative hydrographs for Entiat Segments 1 through 3 and the Mad River to depict the time of year stream flows are the highest and lowest. Four sets of annual and monthly stream flow duration curves were also generated to illustrate the likelihood of a particular magnitude stream flow occurring during a particular month of interest. Composite flow values generated for the Stormy, Keystone, and the Mad River at Ardenvoir gages were plotted by month using their exceedence value. An "exceedence value" represents the probability that a particular flow will be met or exceeded a specific percentage of time during a month. For example, at the Keystone gage a flow of 608 cfs during the month of July has an exceedence value of 50%, meaning that a stream flow of 608 cfs in the lower Entiat River in July is likely to be met or exceeded 50% of the time, or roughly one out of every two years. It is important to note that a 50% exceedence value does not guarantee that this flow will be met or exceeded in July at that gage every one out of two years; it only represents the probability that a flow of at least this magnitude will occur. Exceedence flow values were used to describe water availability (stream flow magnitude) on a monthly basis because these statistics provide a more reliable indication of the amount of water that typically exists in the system during a particular time period.

5.4 INSTREAM FLOWS

Between February and October 2003, six professionally facilitated meetings were held to bring stakeholders together to craft instream flow recommendations for the Entiat and Mad Rivers. Significant effort was made to ensure that interested stakeholders not participating as regular Planning Unit members were either present at the table or informed of the EWPU's efforts.

During facilitated sessions, the EWPU determined that it should develop non-regulatory biological/management flows in addition to instream flows for codification in Chapter 173-546 WAC. This was done to help meet the vision and goals of the group, which include optimizing the quantity and quality of water to achieve a balance between natural resources and human use both current and projected, gaining certainty under the Endangered Species Act through habitat conservation planning under Section 10(A)(1)(b) of the ESA and providing habitat sufficient to eventually provide harvestable and sustainable populations of fishes and other aquatic resources.

During the third and fourth facilitated sessions, the EWPU determined that the terms ***Planning Unit Instream Flows*** and ***Administrative Instream Flows*** should be used to describe the two instream flow regimes during subsequent discussions and the development of instream flow work products. This was done to differentiate between the two, provide clarity regarding their purpose and legal standing, and to avoid confusion often associated with the phrase "Minimum Instream Flow".

[1] During instream flow work negotiations, the WDFW, WDOE, and EWPU instream flow subcommittee determined that the composite records adequately represented the flow regimes of the Entiat and Mad Rivers.

The EWPU agreed that:

1) Approved Planning Unit Instream Flows will serve as non-regulatory management tool for:
   - monitoring the effectiveness of future water conservation efforts;
   - monitoring the effectiveness of channel restoration efforts;
   - guiding the Upper Columbia Salmon Recovery Board's efforts to develop a salmon recovery plan;
   - supporting Wenatchee National Forest Plan revisions; and
   - measuring progress towards compliance with the Clean Water Act.

2) Approved Administrative Instream Flow recommendations will be codified in Chapter 173-546 WAC as legal minimum instream flows, and used by WDOE to help manage future water right appropriations within the Entiat and Mad River watersheds. Instream flows on National Forest system lands require a Forest Plan amendment and line officer decision. The Forest Service will use the analyses completed by the Planning Unit when determining instream flows for National Forest System streams.

5.4.1 Planning Unit Instream Flows

As mentioned earlier, the Planning Unit and ENTRIX developed three biologically-based Planning Unit flow regimes for subbasin management and monitoring purposes. Planning Unit flows were developed for the lower Entiat River (RM 0-16.2; Segments 1 and 2), upper Entiat River (RM 16.2-25.8; Segment 3), and the Mad River (RM 0-4) (see Figure 5-1). Planning Unit flow regimes were developed to identify monthly flow needs for Chinook and steelhead, given existing water and land use, and provide benchmarks for monitoring the effects of future water use, water conservation, stream channel restoration or salmon/steelhead recovery efforts in the Entiat subbasin.

- The primary species and life history concerns identified for Entiat Segments 1 and 2 were summer Chinook spawning and incubation (Oct-Dec), as well as steelhead and spring Chinook rearing (Jul-Sept).
- The primary concerns in Entiat Segment 3 were spring Chinook spawning and incubation (Sept-March), steelhead spawning and incubation (April-June), and steelhead juvenile rearing (July and August).
- The primary concerns in the Mad River were steelhead passage (March), spawning (April and May), incubation (June and July), juvenile rearing (August), and fall/winter base flows.

Each flow regime was indexed to an established USGS stream gage and applies to a specific life history phase of the priority fish species utilizing that segment of the Entiat or Mad Rivers. Refer to Table 5-2, Table 5-3, and Table 5-4 for proposed lower Entiat, upper Entiat and Mad River Planning Unit instream flow regimes, respectively.

ENTRIX (2003) noted that several other species of fish and much of the upper portion of the Mad and Entiat Rivers may or may not benefit from these suggested flow regimes, and

suggested that additional focused studies would be required to determine what benefit might exist or whether modification of the suggested flow regimes would be necessary in order to benefit these other fish species. ENTRIX felt that significance should be assigned to accommodating the general magnitude of the suggested monthly instream flow rather than on replicating specific monthly values. ENTRIX reported that a 5 or 10 cfs departure from a suggested monthly flow value would result in little measurable difference to instream hydraulics or fish habitat conditions in a river as large as the Entiat (ENTRIX, Inc. 2003).

Aesthetic flow recommendations were provided for Entiat River Segment 2 (ENTRIX, Inc. 2003; see Table 5-2 on page 5-13). These flows were defined for May through September, which coincides with the period of highest recreational use and includes the major summer holidays. Aesthetic values were incorporated to reflect local desires for a visually pleasing stream, recreation benefits and the economic benefits of tourism. Recommended aesthetic flows ranged between the 50th and the 70th percentile of flow exceedence for the months of interest (ENTRIX, Inc. 2003).

The average annual peak flows required for channel maintenance were not defined by ENTRIX as part of the Planning Unit Instream Flow regime. They reported that although the dynamic nature of year to year snowmelt floods in erodible stream channels (such as Entiat's stillwater reach) is of paramount importance to maintaining their character and condition, and associated riparian vegetation, high streamflows can also cause low rates of incubation success and fish recruitment.

The relationship between high streamflows, channel condition and fish production in the Entiat subbasin has not been fully investigated and explained; however, snowmelt runoff is, for the most part, unaltered and channel condition in Entiat Segment 3 and further upstream is quite natural. As such, ENTRIX recommended maintaining the current high degree of natural variability in streamflow patterns during the snowmelt season by restricting new streamflow withdrawals from the Entiat River during this time to between 75 to 100 cfs, until further study demonstrated that additional diversions would not impair the long-term quality or productivity of off-channel and main channel habitats in Entiat River Segment 3 (ENTRIX, Inc. 2003).

High flow relationships with habitat and channel conditions have not been studied in the Mad River either. However, it is known that naturally occurring peak flows in the Mad River are, for the most part, unaltered; that steelhead production is "good" in the lower 4 or 5 miles; and that bull trout production is "good" above River Mile 12. ENTRIX (2003) reported that there appears to be a positive relationship between high streamflow, channel condition, and fish production in the Mad River, although this relationship has not been studied in detail. Thus, they advised that new water diversions from the Mad River during May and June should be restricted to 20 or 30 cfs until further study demonstrates that additional water could be withdrawn without adversely affecting current channel conditions or levels of fish production.

Although each of the suggested Planning Unit flow regimes was based upon the best hydrologic, biologic, and water use data available, professional judgment was a primary component of considerable portions of the suggested flow regimes. None of the suggested

Planning Unit flow regimes were recommended by ENTRIX for inclusion in a habitat conservation plan (HCP), as additional study, re-evaluation and modification of the flow regimes would be required for such an effort. Instead, the suggested regimes should serve well as an initial benchmark by which to begin monitoring the success of future salmon recovery efforts. These regimes also provide a sound starting point for the discussion of Chinook and steelhead biological flow requirements when habitat conservation planning is initiated for the Entiat WRIA. The "Rationale" column in each of the following tables provides a brief statement and/or reference related to each flow recommendation. Detailed explanation of the analysis process and the associated professional judgment is provided in the Entiat Watershed Planning Unit Flow Study Report (ENTRIX 2003) and associated appendices.

Table 5-2. Proposed Planning Unit Instream Flows for Entiat Segment 1 (RM 0.0-10.6) and Segment 2 (RM 10.6-16.2), to be monitored at the Keystone gage (USGS gage #12452800, Entiat near Entiat).

Month	Species / Life History Stage of Concern	Fish Flow Range (cfs)	Percent exceedence for fish flow	Segment 2 Aesthetics flow (cfs)	Percent exceedence aesthetic flow	Rationale for Planning Unit flow regime
January	Summer Chinook incubation and juvenile Chinook /steelhead overwintering	**130** (130-145)	56-46	Not defined[2]	---	130 = 80% of spawning flow 145 = approx. winter base flow
February		**130** (130-145)	65-52	Not defined	---	
March		**130** (130-145)	84-72	Not defined	---	
April	Chinook fry dispersal	**250** (260-290)	73-68	Not defined	---	Twice the incubation flow for fry dispersal.
May	Chinook outmigration	**474**[3]	90	815	70	The Planning Unit selected this number to correspond to recommended Admin. Flow
June		**540** (520-580)	97-95	1156	70	Twice the fry dispersal flow for outmigration.
July	Chinook and steelhead rearing	**165**	99	426	70	Figure 4-8 and 4-10 in ENTRIX flow study report. 91% Chinook and steelhead rearing WUA (1995 WDOE report).
August		**165**	89	198	70	
September		**165**	42	140	70	
October	Summer Chinook spawning	**165** (150-185)	27	Not defined	---	Summer Chinook and redd count scattergrams, Figure 5-6 and 5-6 in ENTRIX flow study report.
November	Summer Chinook rearing and juvenile Chinook/steelhead overwintering	**130** (130-145)	73-56	Not defined	---	130 = 80% of spawning flow 145 = approx. winter base flow
December		**130** (130-145)	59-42	Not defined	---	

NOTES: ENTRIX did not identify high flows for channel maintenance.

A full discussion of the flow rationales for fisheries and aesthetics is presented in the EWPU Flow Study Report (ENTRIX, Inc. 2003). The aesthetic assessment was limited to Segment 2 and focused on determining adequate flows to maintain natural appearing views of the river. Aesthetic and recreational values are considered a beneficial use in the watershed and study was required to meet the goals of the EWPU.

[2] Aesthetic flow recommendations for these months were not determined to be relevant by the Planning Unit and ENTRIX.
[3] ENTRIX's recommendation for May was 540 cfs.

Table 5-3. Proposed Planning Unit Instream Flows for Entiat River Segment 3 (RM 16.2-26.5), to be monitored at the Stormy gage (USGS gage #12452990, Entiat near Ardenvoir).

Month	Steelhead life history stage	Steelhead flow range (cfs)	Steelhead rationale	Spring Chinook life history stage	Spring Chinook flow (cfs)	Spring Chinook rationale	Percent exceedence for Chinook flow
January	Juvenile overwintering	120	110-130 cfs = 25%-30% exceedence value	Incubation	**120** (110-130)	Incubation for Chinook should be the same or slightly lower than spawning.	26
February							29
March							48
April	Spawning and incubation	300 (240-325)	240-325 cfs = 80%-90% WUA for steelhead spawning (1995 WDOE report). Figure 4-10 in the ENTRIX flow study report.	Fry dispersal	**240** (240-325)	Twice the incubation flow; 80% WUA for steelhead spawning (1995 WDOE report).	57
May		325 (240-325)		Juvenile outmigration	**375**	Twice the fry dispersal flow. Steelhead spawning WUA is decreasing, but still high.	82
June	Incubation and rearing	260-300	80% of spawning flow in May. Steelhead incubation.		**325**		95
July	Juvenile rearing	275	99% juvenile WUA (1995 WDOE report).	Juvenile rearing	**275**	93% WUA for Chinook rearing (1995 WDOE report).	80
August	Juvenile rearing	180	89% juvenile WUA (1995 WDOE report).	Juvenile rearing	**180**	100% WUA for Chinook rearing (1995 WDOE report).	49
September	Juvenile rearing	125	75% juvenile WUA (1995 WDOE report).	Spawning	**125** (120-135)	Spring Chinook redd count scattergrams, Figures 5-8 and 5-8 in the ENTRIX flow study report.	30
October	Juvenile rearing	120	73% juvenile WUA (1995 WDOE report).	Incubation	**120** (110-130)	Incubation for Chinook should be the same or slightly lower than spawning.	16
November	Overwintering		Arithmetic average of the 25%-30% exceedence flows at Ardenvoir gage.				27
December							26

Flows identified in **BOLD** are suggested flows; flows for spring Chinook were selected because they are listed as endangered and Segment 3 of the Entiat River has been identified as a primary production area in the subbasin for this species.

NOTES: ENTRIX did not identify high flows for channel maintenance

Table 5-4. Proposed Planning Unit Instream Flows for the Mad River (RM 0-4), to be monitored at USGS gage #12452890, Mad at Ardenvoir.

Month	Steelhead Life History Stage of Concern	Fish Flow Range (cfs)	Percent exceedence for fish flow	Rationale for Planning Unit flow regime
January	Steelhead passage	25 (20-30)	56 (93-20)	Winter base flow.
February			68 (94-19)	
March		31 (30-35)	53 (53-46)	Figure 4-7 in the ENTRIX flow study report.
April	Steelhead spawning	70	74	Data collected in April 2003, 93% WUA (1995 WDOE report), and Figure 4-11 in the ENTRIX flow study report.
May		70	97	
June	Steelhead incubation	55	91	80% of spawning flow.
July		55	69	
August	Steelhead juvenile	40	45	To ramp down between July and September flows, the arithmetic average was calculated (55+25/2) = 40. 40 cfs = 80%-90% WUA for juvenile steelhead and Chinook (1995 WDOE report).
September		25 (20-30)	59 (100-24)	Winter base flow.
October		25 (20-30)	45 (94-12)	
November		25 (20-30)	52 (92-23)	
December		25 (20-30)	46 (92-22)	

NOTES: ENTRIX did not identify high flows for channel maintenance.
A full rationale for all flows is available in the full Entiat Flow Study Report (ENTRIX, Inc. 2003).

5.4.2 Administrative Instream Flows

The Planning Unit also developed Administrative Instream Flow recommendations for codification as minimum instream flows in Chapter 173-546 WAC. Three flow regimes were developed and tied to USGS gages:

- lower Entiat River, tied to the Keystone gage (USGS #12452800, Entiat near Entiat);
- upper Entiat River, tied to the Stormy gage (USGS #12452890, Entiat near Ardenvoir;
- Mad River, tied to USGS #12452990, Mad at Ardenvoir.

Under the Watershed Planning Act, minimum instream flows "…set by rule of the department [of ecology] shall have a priority date of two years after funding is first received from the department … unless determined otherwise by a unanimous vote of the members of the planning unit but in no instance may it be later than the effective date of the rule adopting such flow" [Chapter 90.82.080, sub-section 2(a)]. As Entiat Planning Unit first received funds on September 16, 1998, "Administrative" instream flows recommended in this document would receive a priority date of September 16, 2000 "…unless determined otherwise by a unanimous vote of the members of the planning unit".

As the Reserve of water described in Chapter 4, and recommended for implementation in Chapter 9 was intended by the Planning Unit to be a non-interruptible source of water for qualifying new beneficial uses, the Planning Unit recognized the benefit of clarifying the relationship of instream flow and Reserve priority dates. Thus, at the April 13 meeting of the Planning Unit, the group elected to specify, by unanimous vote, that the priority date of proposed instream flows be the date of rule adoption. In this way, instream flows and the Reserve would have the same priority date. As authorized under Chapter 90.82.080 2(a) of the Watershed Planning Act and consistent with instream flow and water resource management programs established under the Water Resources Act of 1971 (Chapter 90.54, RCW) and other state laws, the EWPU voted unanimously on May 17, 2004 to make the priority date of minimum instream flows the date of rule adoption.

Refer to Table 5-5, Table 5-6, and Table 5-7 on the following pages for proposed lower Entiat, upper Entiat and Mad River Administrative instream flow regimes. The priority species and life history stage, biological rationale and flow exceedence value for each period/flow are also presented in the tables. Figure 5-3, Figure 5-4, and Figure 5-5, which are based on the numbers in Tables 5-6, 5-7 and 5-8, respectively, depict the proposed Administrative [minimum] instream flows and compare them to representative 10%, 50%, and 90% flow exceedence hydrographs developed using historic USGS gage #12453000, Entiat at Entiat, data.

Table 5-5. Proposed Administrative Instream Flows for lower Entiat River (RM 0.0-16.2), to be monitored at the Keystone gage (USGS gage #12452800, Entiat near Entiat).

Monthly / semi-monthly period	Administrative instream flow (cfs)	Priority species and life history stages	Biological rationale	Percent flow exceedence
January 1-31	**185**	Chinook egg incubation, steelhead and Chinook juvenile rearing plus adult steelhead adults immigrating.	Incubation – flows at least 2/3 of spawning flows present mid-August thru October (90-300 cfs), Juveniles – best balance of 1995 study habitat flows gives 95% of peak habitat for steelhead and 85% of peak habitat for Chinook. Provide stable flows for juveniles.	25
February 1-28	**185**	Same as above plus Chinook fry emerging.	Same as above.	32
March 1-15	**185**	Same as above.	Same as above.	46
March 16-31	**250**	Steelhead spawning, steelhead and Chinook juveniles rearing and outmigrating, plus steelhead egg incubation.	Juveniles becoming more active and outmigrants need more flow. 1995 study – 93% habitat for steelhead spawning, 98% for steelhead juveniles,	35
April 1-15	**250**	Same as above.	Same as above.	65
April 16-30	**350**	Steelhead spawning peak, steelhead and Chinook juveniles plus steelhead egg incubation.	From 1995 study – 100% habitat for steelhead spawning, 80% habitat for steelhead juveniles, 48% habitat for Chinook juveniles. Plus juvenile outmigration flows should be increased.	72
May 1-15	**474** Plus a 100 cfs limit on total new rights.	Channel maintenance flows and steelhead and Chinook juvenile rearing and outmigration, plus steelhead spawning and egg incubation plus adult Chinook immigration.	To better protect channel maintenance flow and variability of flows, limit the total quantity of new water that can be given away during these periods. *	90
May 16-31	**720** Plus a 100 cfs limit.	Same as above.	Lesser priority is given to spawning since the majority of spawning is in the upper Entiat River reach.	90
June 1-15	**898** Plus a 100 cfs limit.	Same as above.		90
June 16-30	**617** Plus a 100 cfs limit.	Same as above.	Outmigration of juvenile salmonids is a high priority during this high flow time of year.	90
July 1-15	**359** Plus a 67 cfs limit on new water rights.	Channel maintenance, steelhead and chinook juvenile rearing and outmigration, steelhead egg incubation, and adult Chinook immigration.	Another high priority is providing the typical channel forming flows to maintain the shape of the channel, the substrate and woody debris, and connecting the side channels by using at least the 90% exceedence flows.	90
July 16-31	**268**	Same as above.		90

Monthly / semi-monthly period	Administrative instream flow (cfs)	Priority species and life history stages	Biological rationale	Percent flow exceedence
August 1-31	**185**	Steelhead and Chinook juveniles, Chinook spawning and egg incubation.	From 1995 study –95% habitat for steelhead juveniles, 85% habitat for Chinook juveniles and 90% habitat for Chinook spawning.	85
September 1-30	**185**	Same as above.	Same as above.	29
October 1-31	**185**	Chinook spawning and egg incubation, steelhead and Chinook juveniles, steelhead adults immigrating.	From 1995 study – 90% habitat for Chinook spawning, 95% habitat for steelhead juveniles, 85% for Chinook juveniles. Plus incubation is at least 2/3 of spawning flows in August and September.	15
November 1-30	**185**	Chinook egg incubation, steelhead and Chinook juveniles, steelhead adults immigrating.	Same as above but Chinook spawning over.	26
December 1-31	**185**	Same as above.	Same as above.	24

* The instream flow was chosen using the 90% exceedence flow instead of the 250 and 350 cfs IFIM flows needed for steelhead spawning because the lower reach is more important for juvenile outmigration and for juvenile rearing in side channels than for spawning. Additionally, because of uncertainty around the flows needed for fish outmigration, side channel connectivity, and for maintenance of the channel and floodplain, biologists felt that flows around the 100 % exceedence level were too low to protect those functions but that flows around the 90% exceedence level would help reduce that uncertainty when combined with a limit of 100 cfs on the quantity of water available for granting new water rights. This could lower the typical channel maintenance flow of 2500 cfs in May to 2400 cfs; however, biologists felt the channel maintenance flow would still be sufficient.

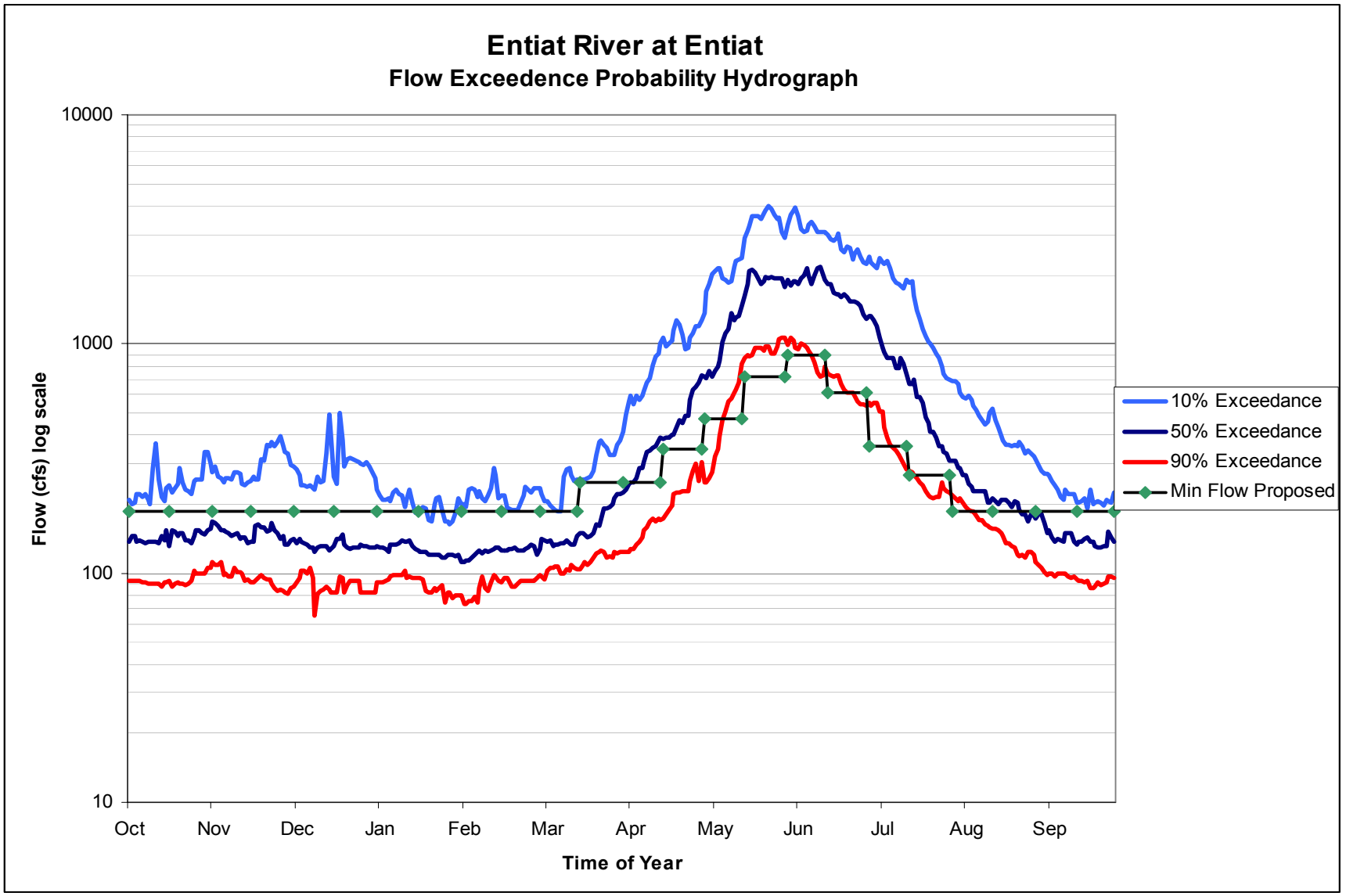


Figure 5-3. Proposed Administrative instream flows for lower Entiat River and 10%, 50% and 90% flow exceedence values recorded at historic USGS gage #12453000, Entiat at Entiat.

Table 5-6. Proposed Administrative Instream Flows for the upper Entiat River (RM 16.2-25.8), to be monitored at the Stormy gage (USGS gage #12452990, Entiat near Ardenvoir).

Monthly / semi - monthly period	Administrative instream flow (cfs)	Priority species and life history stages	Biological rationale	Percent flow exceedence
January 1-31	**175**	Chinook egg incubation, steelhead and Chinook juvenile rearing, steelhead adults immigrating.	Provides a stable juvenile rearing flow and incubation flow. Flows rarely go above 175 cfs and stability is more important in winter for juvenile rearing and egg incubation than changing flows to gain a small amount of habitat.	12
February 1-28	**175**	Same as above plus Chinook fry emerging.		15
March 1-15	**175**	Same as above.		19
March 16-31	**285**	Steelhead spawning starting, steelhead and Chinook juveniles rearing plus juvenile outmigration and Chinook fry emerging	Juveniles becoming more active, flow provides 78% of habitat for steelhead spawning, 94% of habitat for steelhead juveniles. Limited flow to 10% exceedence level.	10
April 1-15	**325**	Steelhead spawning and egg incubation, steelhead and Chinook juveniles rearing plus juvenile outmigration.	Flow provides 91% of habitat for steelhead spawning, and 98% of habitat for steelhead juveniles.	18
April 16-30	**375**	Steelhead spawning peak and egg incubation, steelhead and Chinook juveniles rearing plus juvenile outmigration.	Flow provides 100% of habitat for steelhead spawning, 100% for steelhead juveniles, and 71% for Chinook juveniles.	45
May 1-15	**375** Plus a 100 cfs limit on allocation on total new water rights.	Steelhead spawning and egg incubation, steelhead and Chinook juveniles rearing and outmigrating, plus adult Chinook immigration and channel maintenance.	We decided a 100 cfs limit on the quantity of new water rights would be a better way to protect the channel maintenance flow than using the 1800 cfs, 1.5 year interval bank full flow. Spawning is a higher priority in this reach than downstream so we kept the 325 to 375 1995 numbers for spawning and rearing even though the exceedence values were 90-99%.* Flow provides 91 to 100% of habitat for steelhead spawning, 98 to 100% for steelhead juveniles, and 71 to 80% for Chinook juveniles.	90
May 16-31	**375** Plus a 100 cfs limit on new water rights.	Same as above.		90
June 1-15	**325** Plus a 100 cfs limit on new water rights.	Same as above.		99.5
June 16-30	**325** Plus a 100 cfs limit on new water rights.	Same as above.		99.5

Monthly / semi - monthly period	Administrative instream flow (cfs)	Priority species and life history stages	Biological rationale	Percent flow exceedence
July 1-15	**275** Plus a 67 cfs limit on new rights.	Steelhead egg incubation, steelhead and Chinook juveniles rearing and outmigrating, plus adult Chinook holding in the river and channel maintenance.	We decided the priority would still be incubation and juvenile rearing but use a 67 cfs limit on new rights to protect the channel maintenance flow.*	80
July 16-31	**275**	Steelhead and Chinook juveniles rearing and outmigrating, plus adult chinook holding in the river	Flow provides 92% of habitat for steelhead juveniles and 91% for chinook juveniles.	80
August 1-31	**275**	Chinook spawning and egg incubation, steelhead and chinook juvenile rearing.	Flow provides – 91% of habitat for chinook spawning, 92% of habitat for steelhead juveniles, and 91% of habitat for chinook juveniles.	22
September 1-30	**175**	Chinook spawning and egg incubation, steelhead and chinook juvenile rearing.	Flow above 175 cfs is better for spawning but rarely occurs, so we lowered the flow to 10% exceedence. Incubation flow should about 2/3 of the August spawning flow.	10
October 1-31	**175**	Chinook egg incubation, steelhead and Chinook juvenile rearing, and steelhead adult immigration.	Provides a stable juvenile rearing flow and incubation flow. Flows rarely go above 175 cfs and stability is more important in winter for rearing and incubation than changing flows to gain a small amount of habitat.	5
November 1-30	**175**	Same as above.		15
December 1-31	**175**	Same as above.		16

*This could possibly lower the typical channel maintenance flow of 1800 cfs in May to 1700 cfs, but biologists felt the channel maintenance flow would still be sufficient to do its job. The 100 cfs allocation limit on new rights was proposed for May and June because it was about 10% of the median flow, and 67 cfs was proposed for the first half of July because it was about 10% of the median flow. The numbers were kept the same for allocation in both the upper and lower Entiat for ease of regulating. These numbers are for a cumulative total for upstream and downstream combined, not a separate 100 cfs from each reach.

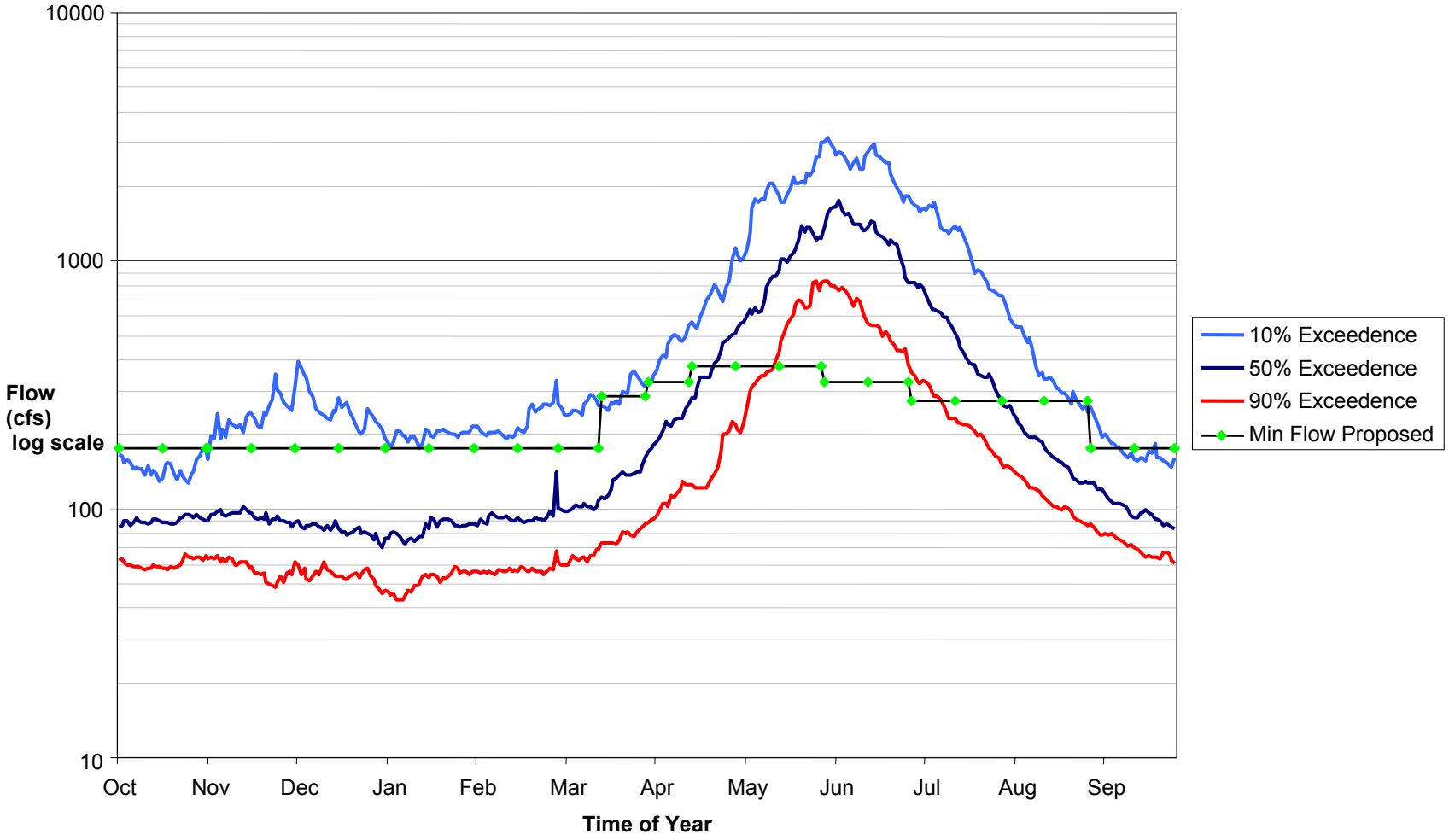


Figure 5-4. Proposed Administrative instream flows for the upper Entiat River and 10%, 50%, and 90% flow exceedence values recorded at the Stormy gage (USGS gage #12452990, Entiat near Ardenvoir).

Table 5-7. Proposed Administrative instream flows for the Mad River (RM 0-4), to be monitored at USGS gage #1245890, Mad at Ardenvoir.

Monthly / semi - monthly period	Administrative instream flow (cfs)	Priority species and life history stages	Biological rationale	Percent flow exceedence
January 1-31	32	Chinook egg incubation; steelhead, Chinook, and bull trout juvenile rearing, and steelhead adult immigration.	Provides a stable juvenile rearing flow and incubation flow. Flows above 32 cfs would provide more habitat but flows rarely go above 32 cfs and stability is more important in winter for juvenile rearing and egg incubation than changing flows to gain a small amount of habitat. Provides 74% of habitat for steelhead juveniles and 86% of habitat for Chinook juveniles.	16
February 1-28	32	Same as above plus Chinook fry emerging.		16
March 1-15	32	Same as above.		33
March 16-31	68	Steelhead spawning starting; steelhead, Chinook, and bull trout juveniles rearing plus juvenile outmigration and chinook fry emerging.	More flow needed for juveniles outmigration. Flow provides 93% of habitat for steelhead spawning, 90% for steelhead juveniles, and 99% for chinook juveniles.	33
April 1-15	100	Steelhead spawning and egg incubation; steelhead, Chinook, and bull trout juveniles rearing plus juvenile outmigration.	Flow provides 100% of habitat for steelhead spawning, 100% for steelhead juveniles, and 99% for Chinook juveniles.	46
April 16-30	100 Plus 25 cfs limit on new water rights.	Steelhead spawning peak and egg incubation, steelhead and Chinook juveniles rearing plus juvenile outmigration	Flow provides 100% of habitat for steelhead spawning, 100% for steelhead juveniles, and 99% for Chinook juveniles.	75
May 1-31	100 Plus a 25 cfs limit on new water rights.	Steelhead spawning and egg incubation, steelhead and Chinook juveniles rearing and outmigrating, plus adult Chinook immigration and channel maintenance.	A 25 cfs limit on the quantity of new water rights would protect the channel maintenance flow. 25 cfs is 10% of the median flow in May.	90
June 1-30	100 Plus a 25 cfs limit on new water rights.	Same as above.		99.5

Monthly / semi - monthly period	Administrative instream flow (cfs)	Priority species and life history stages	Biological rationale	Percent flow exceedence
July 1-31	68	Steelhead egg incubation; steelhead, Chinook, and bull trout juveniles rearing and outmigration.	Flow provides 90% of habitat for steelhead juveniles and 99% of habitat for Chinook juveniles. Provides 2/3 of 100 cfs spawning flow for incubation.	80
August 1-15	68	Steelhead, Chinook, and bull trout juvenile rearing.	Flow provides 90% of habitat for steelhead juvenile and 99% for Chinook juveniles.	22
August 16-31	51	Chinook spawning and egg incubation; steelhead, Chinook, and bull trout juvenile rearing.	Would prefer flows over 51 cfs but they rarely occur so we used the 10% exceedence value as an upper limit.	10
September 1-30	32	Same as above.	Would prefer flows over 32 cfs but they rarely occur so we used the 10% exceedence value as an upper limit. Provides a stable juvenile rearing flow and incubation flow. Flows rarely go above 32 cfs and stability is more important in winter for juvenile rearing and egg incubation than changing flows to gain a small amount of habitat.	10
October 1-31	32	Chinook egg incubation; steelhead, Chinook, and bull trout juvenile rearing, and steelhead adult immigration.		5
November 1-30	32	Same as above.		15
December 1-31	32	Same as above.		16

*This could possibly lower the typical channel maintenance flow of 500 cfs in May to 475 cfs, but I feel the channel maintenance flow would still be sufficient to do its job. The 25 cfs allocation limit on new rights was proposed for mid-April through June because it was about 10% of the median flow for May. This allocation number is for a cumulative total for the whole river combined; not a separate 25 or 100 cfs from each reach or tributary of the river.

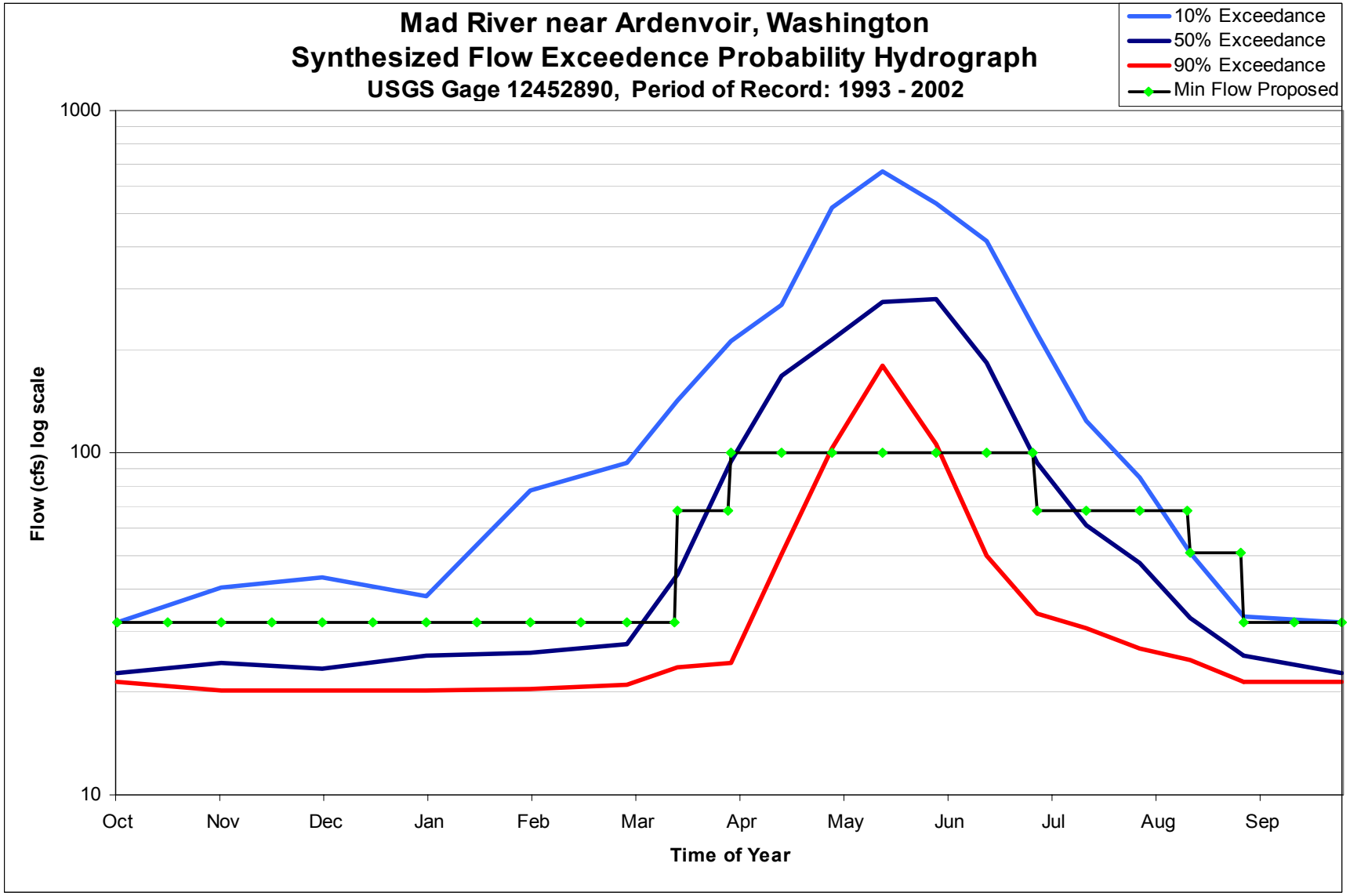


Figure 5-5. Proposed Administrative instream flows for the Mad River and 10%, 50%, and 90% exceedence values recorded at the USGS gage #12452890, Mad at Ardenvoir.

6.0 WATER BUDGET

6.1 INTRODUCTION

In 1998 the Entiat WRIA Planning Unit (EWPU) applied for funds from the State of Washington under Chapter 90.82 RCW, the Watershed Planning Act. In doing so, it agreed to develop a water budget for the Entiat Water Resource Inventory Area (WRIA 46), which comprises the Entiat River watershed, the Mad River watershed, and some minor Columbia River tributaries. A water budget is basically an accounting ledger that contains water credits and debits, i.e. an estimate of water present within the system (credit); what water is needed to accommodate future domestic, commercial and agricultural use (debit); what flows are required to be left in stream for the protection of *existing* beneficial uses, including water for irrigation and fish (debit); and what actual water use is occurring (debit).

The difference between the credit and debit numbers shows what water is available during different months of the year for future appropriation. The information contained in the water budget will allow the EWPU to make management recommendations to WDOE about how much water should be made available in the future for new water rights associated with commercial enterprises, agriculture, residential development, and other beneficial uses. Through the use of its water budget, the EWPU will be able to provide the State the maximum possible input regarding the protection of existing water rights, strategies for water resource management, and issuance of new water rights in WRIA 46.

6.2 WATER BUDGET FORMAT

A primary reason for development of a water budget is to determine at what times of year water resources are scarce and/or require management. Consequently, the EWPU water budget shows flow and water use data by month, with semi-monthly values added as necessary due to administrative instream flow recommendations.

WRIA 46 is composed of two main drainages, the Entiat and Mad River watersheds, as well as an area containing minor Columbia River tributaries. A water budget spreadsheet was developed for each of the major drainage areas in the WRIA (Entiat River, Mad River, and minor Columbia River tributaries); the Entiat River was also split into upper and lower reaches. Dividing the WRIA into four different areas was done to facilitate estimation of the amount of water present and actual water use, as well as the development of instream flow and water management recommendations. Channel geomorphology, fish habitat and use, land and water use, settlement patterns, and the hydrologic connectivity of these areas, as well as where administrative instream flows would be monitored, were all used to help determine how to split the WRIA.

6.3 DATA INPUTS

A number of studies were sponsored by the EWPU to collect data for use in the development of its water budget. Data from a number of sources, including stream gage records, in-field flow measurements, and Geographic Information System (GIS) modeling of aquifer thickness and extent were used. These studies and data have been detailed previously in Chapter 4, Water Quantity.

Entiat and Mad River streamflows were estimated by assembling and analyzing all existing stream flow data from USGS gages, and developing synthesized stream flow records that include modeled flow data for those years in which no data were available. A base flow separation analysis was done to determine what contribution groundwater makes to the total flow in the river at different times throughout the year.

A better understanding of surface and ground water interaction/connectivity in the Entiat and Mad River watersheds was gained by monitoring residential well levels and examining how those levels, especially water levels in wells drilled into the alluvium, responded to changes in stream flow. A gain-loss study was also done to identify stream reaches in which surface-ground water interaction was occurring.

Fruit tree irrigation requirement data and land use acreages were used to estimate current irrigation water use by month occurring within the WRIA. Data on weekly average tree water use over a 25-year period were used to develop a ratio of semi-monthly to monthly water use, which was then applied to monthly tree water use estimates in order to derive select semi-monthly tree water use values.

Population data were used in conjunction with City of Entiat water pumping, use and connection records to estimate daily in-house net water use. Census block information and population projections were used to estimate how much water will be needed in the future to ensure community growth and development.

The Planning Unit and ENTRIX, Inc. developed Planning Unit Instream Flow as well as Administrative Instream Flow recommendations to protect existing resources and beneficial uses, and to help guide issuance of new rights based on all of the aforementioned data. Refer to Chapter 5 for these flow regimes.

6.4 UPPER ENTIAT RIVER BUDGET

Flows for the upper Entiat River are monitored at the Stormy gage (Entiat near Ardenvoir USGS gage, at RM 18). It was estimated that water use occurring upstream of this point is associated with the irrigation of approximately 20 acres of residential property (lawn), and totals only 80 acre-feet annually. Average peak monthly use in July accounts for approximately 20 acre-feet, which is negligible in comparison to the average July monthly volume of stream flow produced by the entire subbasin (46,955 acre-feet, based on composite Keystone gage record).

The tables on pages 6-4 and 6-5 show mean monthly and/or semi-monthly flow recorded at the Stormy gage in cfs and acre-feet, respectively, as well as the estimated water use occurring upstream of this point. The "Naturalized" mean stream flow number is meant to approximate what stream flow would likely be recorded at the Stormy gage if no upstream water use were occurring in the subbasin. The difference between proposed Administrative Instream Flows and monthly mean (or semi-monthly mean) stream flow shows the amount of water that will potentially available for future appropriation if the proposed Administrative Instream flows are codified. In some months, the amount of water potentially available for future appropriation will be limited to a specific number of cfs as recommended by the WDOE.

Table 6-1. Upper Entiat River water budget (cfs), tied to the Stormy gage (USGS gage #12452800, Entiat near Ardenvoir).

	Jan 1-31	Feb 1-28	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30	May 1-31	Jun 1-30	Jul 1-15	Jul 16-31	Aug 1-31	Sep 1-30	Oct 1-31	Nov 1-30	Dec 1-31
"Naturalized" mean streamflow (cfs) at Stormy gage	**106**	**114**	**131**	**167**	**243**	**410**	**1068**	**1431**	**813**	**481**	**219**	**114**	**100**	**129**	**126**
Orchard irrigation water use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lawn irrigation water use - 20 acres	0	0	0	0	0.03	0.09	0.16	0.27	0.34	0.33	0.27	0.15	0.07	0	0
Domestic net water use* - 115 housing units according to census	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Mean streamflow (cfs) at Stormy gage	106	114	131	167	243	410	1068	1431	813	481	219	114	100	129	126
Proposed Administrative MIF	**175**	**175**	**175**	**285**	**325**	**375**	**375**	**325**	**275**	**275**	**275**	**175**	**175**	**175**	**175**
Water potentially available for future appropriation	-69	-61	-44	-118	-82	35	693	1106	538	206	-56	-61	-75	-46	-49
Water available for future appropriation* (cfs)	**0**	**0**	**0**	**0**	**0**	**35**	***100***	***100***	***67***	**206**	**0**	**0**	**0**	**0**	**0**

** Italicized* water amounts will be based on codification of WDOE's determination of water availability during select semi-monthly periods.

Conversions/Assumptions used in calculations:
"Naturalized" = gage discharge + use totals (rounded as appropriate)
1 cfs for 1 day = 1.9835 acre-feet
1 housing unit = 2.71 people per unit
Net water use = 35 gallons per capita per day
325,850 gallons = 1 acre-foot

Table 6-2. Upper Entiat River water budget (acre-feet), tied to the Stormy gage (USGS gage #12452800, Entiat near Ardenvoir).

	Jan 1-31	Feb 1-28	Mar 1-15	Mar 6-31	Apr 1-15	Apr 16-30	May 1-31	Jun 1-30	Jul 1-15	Jul 16-31	Aug 1-31	Sep 1-30	Oct 1-31	Nov 1-30	Dec 1-31
"Naturalized" mean volume (ac-ft) at Stormy gage	**6518.82**	**6332.27**	**3898.08**	**5300.45**	**7231.23**	**12201.78**	**65680.64**	**85168.89**	**24199.30**	**15276.15**	**13483.79**	**6793.57**	**6154.21**	**7677.15**	**7748.59**
Orchard irrigation water use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lawn irrigation water use - 20 acres	0	0	0	0	0.88	2.75	9.88	16.23	10.02	10.59	16.77	9.00	4.32	0	0
Domestic net water use - 115 housing units according to census	1.04	0.94	0.50	0.54	0.50	0.50	1.04	1.00	0.50	0.54	1.04	1.00	1.04	1.00	1.04
Mean volume (ac-ft) at Stormy gage	6517.78	6331.33	3897.58	5299.91	7229.86	12198.53	65669.72	85151.66	24188.78	15265.02	13465.98	6783.57	6148.85	7676.15	7747.55
Proposed Administrative MIF	**10760.49**	**9719.15**	**10760.49**	**17524.22**	**9669.56**	**11157.19**	**23058.19**	**19339.13**	**8181.94**	**8727.40**	**16909.34**	**10413.38**	**10760.49**	**10413.38**	**10760.49**
Water potentially available for future appropriation	-4242.71	-3387.82	-6862.91	-12224.31	-2439.71	1041.34	42611.53	65812.53	16006.85	6537.62	-3443.36	-3629.81	-4611.64	-2737.23	-3012.94
Water available for future appropriation (ac-ft)	**0**	**0**	**0**	**0**	**0**	**1041**	***6149***	***5951***	***1993***	***6538***	**0**	**0**	**0**	**0**	**0**

6.5 LOWER ENTIAT RIVER BUDGET

Flows in the lower Entiat River are monitored at the Keystone gage (USGS gage #1245990, Entiat near Entiat), located approximately 1.4 miles upstream of the Entiat's confluence with the Columbia River. In this portion of the Entiat River watershed irrigation water use accounts for almost all use occurring in the subbasin. Peak net irrigation water use by occurs in July, with average monthly irrigation use totaling 1511 acre-feet (about 25 cfs), or 3% of the average monthly volume of water produced during this month (47,039 acre-feet or approximately 765 cfs). Average net irrigation water use in the months of September and October is approximately 6.5% and 6%, respectively, of the average monthly volume of water produced during these months. Actual gross water use is greater due to water conveyance losses.

As the Keystone gage site is essentially the "pour point" for the entire Entiat subbasin, the water budget tables for the lower Entiat River on pages 6-7 and 6-8 reflect all upstream water uses recorded within the subbasin. Again, the "Naturalized" mean flow approximates what stream flow would be recorded at the Keystone gage were no upstream water use occurring. Additionally, *water use associated with residences found in the lower Mad River was included as part of the lower Entiat River use*, due to the following reasons:

- There is a high degree of connectivity between surface and ground water in the Entiat subbasin;
- There is very minimal private land ownership upstream of RM 2 in the Mad River;
- The primary domestic water source in the lower Mad River is wells; and
- The lower Mad River and area around its mouth are part of an alluvial fan, and therefore groundwater drawn from the lower Mad River is likely a part of the larger unconsolidated alluvial valley aquifer.

Table 6-3. Lower Entiat River water budget (cfs), tied to the Keystone gage (USGS gage #12452990, Entiat near Entiat).

	Jan 1-30	Feb 1-28	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30	May 1-15	May 16-31	Jun 1-15	Jun 16-30	Jul 1-15	Jul 16-31	Aug 1-31	Sept 1-30	Oct 1-31	Nov 1-30	Dec 1-31
"Naturalized" mean flow (cfs)	**164**	**176**	**198**	**248**	**342**	**545**	**1019**	**1571**	**1886**	**1524**	**985**	**607**	**308**	**181**	**161**	**189**	**187**
Upper Entiat orchard irrigation water use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Entiat lawn irrigation water use - 20 acres	0	0	0	0	0.03	0.09	0.15	0.17	0.23	0.32	0.34	0.33	0.27	0.15	0.07	0	0
Upper Entiat domestic net water use - 115 housing units	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Lower Entiat orchard irrigation water use - 835	0	0	0	0	1.46	4.59	7.28	8.62	11.21	15.85	16.70	16.56	13.53	7.50	3.48	0	0
Lower Entiat pasture/lawn irrigation water use - 407 acres	0	0	0	0	0.60	1.90	3.02	3.58	4.65	6.58	6.93	6.49	5.61	3.11	1.44	0	0
Lower Entiat/Mad domestic net water use - 355 housing units	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Mad orchard irrigation water use - 21 acres	0	0	0	0	0.04	0.12	0.18	0.22	0.17	0.40	0.42	0.42	0.34	0.19	0.09	0	0
Mad lawn irrigation water use - 15 acres	0	0	0	0	0.03	0.08	0.13	0.16	0.20	0.29	0.30	0.30	0.25	0.14	0.06	0	0
Mean flow (cfs) at Keystone gage	164	176	198	248	340	538	1008	1558	1869	1500	960	583	288	170	156	189	187
Proposed Administrative MIF	**185**	**185**	**185**	**250**	**250**	**350**	**474**	**720**	**898**	**617**	**359**	**268**	**185**	**185**	**185**	**185**	**185**
Water potentially available for future appropriation	-21	-9	13	-2	90	188	534	838	971	883	601	315	103	-15	-29	4	2
Water available (cfs) for future appropriation	**0**	**0**	**13**	**0**	**90**	**188**	***100***	***100***	***100***	***100***	**67**	**315**	**103**	**0**	**0**	**4**	**2**

Table 6-4. Lower Entiat River water budget (acre-feet), tied to the Keystone gage (USGS gage #12452990, Entiat near Entiat).

	Jan 1-30	Feb 1-28	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30	May 1-15	May 16-31	Jun 1-15	Jun 16-30	Jul 1-15	Jul 16-31	Aug 1-31	Sep 1-30	Oct 1-31	Nov 1-30	Dec 1-31
"Naturalized" mean volume (ac-ft)	**10088**	**9778**	**5893**	**7873**	**10182**	**16211**	**30313**	**49851**	**56099**	**45328**	**29299**	**19269**	**18942**	**10780**	**9913**	**11250**	**11502**
Upper Entiat orchard irrigation water use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Entiat lawn irrigation water use - 20 acres	0	0	0	0	0.88	2.75	4.37	5.51	6.72	9.51	10.02	10.59	16.77	9.00	4.32	0	0
Upper Entiat domestic net water use - 115 housing units	1.04	0.94	0.50	0.54	0.50	0.50	0.50	0.54	0.50	0.50	0.50	0.54	1.04	1.00	1.04	1.00	1.04
Lower Entiat orchard irrigation water use - 835 acres	0	0	0	0	43.37	136.47	216.74	273.55	333.40	471.62	496.83	525.50	831.78	446.4	214.1	0	0
Lower Entiat pasture/lawn irrigation water use - 407 acres	0	0	0	0	17.99	56.61	89.90	113.47	138.29	195.63	206.09	206.09	345.02	185.16	88.81	0	0
Lower Entiat/Mad domestic net water use - 355 housing units	3.2	2.9	1.49	1.59	1.49	1.49	1.49	1.59	1.49	1.49	1.49	1.59	3.2	3.1	3.2	3.1	3.2
Mad orchard irrigation water use - 21 acres	0	0	0	0	1.10	3.46	5.49	6.93	4.92	11.95	12.59	13.31	21.07	11.31	5.42	0	0
Mad lawn irrigation water use - 15 acres	0	0	0	0	0.79	2.47	3.93	4.97	6.05	8.56	9.02	9.54	15.1	8.1	3.89	0	0
Mean volume (ac-ft) at Keystone gage	**10084.11**	**9774.69**	**5891.00**	**7870.53**	**10115.85**	**16006.85**	**29990.52**	**49444.69**	**55607.42**	**47604.00**	**28562.40**	**18502.09**	**17708.69**	**10115.85**	**9592.21**	**11246.45**	**11498.35**
Proposed Administrative MIF	11375.37	10274.53	5504.21	7934.00	7438.125	10413.38	14102.69	22849.92	26717.75	18357.29	10681.15	8505.25	11375.37	11008.43	11375.37	11008.43	11375.37
Water potentially available for future appropriation	-1291.26	-499.84	386.78	-63.47	2677.73	5593.47	15887.84	26594.77	28889.68	29246.71	17881.25	9996.84	6333.32	-892.57	-1783.17	238.02	122.98
Water available for future appropriation (ac-ft)	**0**	**0**	**387**	**0**	**2678**	**5593**	***2975***	***3174***	***2975***	***2975***	***1993***	**9997**	**6333**	**0**	**0**	**238**	**123**

6.6 MAD RIVER BUDGET

Table 6-5. Mad River water budget (cfs), tied to USGS gage #12452890, Mad at Ardenvoir.

	Jan 1-31	Feb 1-28	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30	May 1-31	Jun 1-30	Jul 1-31	Aug 1-15	Aug 16-31	Sep 1-30	Oct 1-31	Nov 1-30	Dec 1-31
Mean streamflow (cfs)	27	37	53	53	135	135	321	250	93	43	43	27	25	29	30
Proposed Administrative MIF	32	32	32	68	100	100	100	100	68	68	51	32	32	32	32
Water potentially available (cfs) for future appropriation	-5	5	21	-15	35	35	221	150	25	-25	-8	-5	-7	-3	-2
Water available (cfs) for future appropriation	0	5	21	0	35	*25*	*25*	*25*	25	0	0	0	0	0	0

Table 6-6. Mad River water budget (acre-feet), tied to USGS gage #12452890, Mad at Ardenvoir.

	Jan 1-31	Feb 1-28	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30	May 1-31	Jun 1-30	Jul 1-31	Aug 1-15	Aug 16-31	Sep 1-30	Oct 1-31	Nov 1-30	Dec 1-31
Mean volume (ac-ft) at Mad gage	**1660.19**	**2054.91**	**1576.88**	**1682.01**	**4016.59**	**4016.59**	**19737.81**	**14876.25**	**5718.43**	**2644.01**	**2644.01**	**1606.64**	**1537.21**	**1725.65**	**1844.66**
Proposed Administrative MIF	**1967.63**	**1777.22**	**952.08**	**2158.05**	**2975.25**	**2975.25**	**6148.85**	**5950.50**	**4181.22**	**4181.22**	**3135.91**	**1904.16**	**1967.63**	**1904.16**	**1967.63**
Water potentially available for future appropriation	-307.44	277.69	624.80	-476.04	1041.34	1041.34	13588.96	8925.75	1537.21	-1537.21	-491.91	-297.53	-430.42	-178.52	-122.98
Water available for future appropriation	**0**	**278**	**625**	**0**	**1041**	***744***	***1537***	***1488***	**1537**	**0**	**0**	**0**	**0**	**0**	**0**

6.7 MINOR COLUMBIA RIVER TRIBUTARIES BUDGET

This water budget addresses the minor, often ephemeral streams above the Entiat River-Columbia River confluence as far north as Oklahoma Gulch and below the confluence as far south as Swakane Canyon (both drainages included). These drainages, though encompassed within the Entiat WRIA, flow directly into the Columbia River. Much of their area is either state (WDFW) or federally (USFS) owned; private property (excluding the City of Entiat) is largely concentrated in a narrow strip along the Columbia River and astride State Highway 97A.

Precipitation in the minor Columbia River Tributaries (CRT) ranges from 8 to 36 inches annually (Daly and Taylor 1998), with the higher values limited to the upper portions of the Swakane Creek drainage, which extends much further west and into higher elevations than the other CRT. Table 6-7 lists the surface area, average (area-weighted) annual precipitation and selected surface water discharges (at or near peak flow conditions) for the minor CRTs.

Table 6-7. Summary of minor Columbia River tributary precipitation and select surface flows.

Drainage Name	Area (acres)	Average Precipitation (inches)	Precipitation volume (ac-ft)	Surface Flow (cfs) 3/27/2003	Annual Runoff (ac-ft)[1]
Oklahoma Gulch	3047	19.2	4887	0.76	549
Byrd Canyon	2243	18.3	3416	0.72	520
McKinstry Canyon	1172	18.9	1849	0.38	275
Spencer Canyon	2816	19.7	4614	N/A	N/A
Tenas George Canyon	3869	22.3	7204	0.13	94
Swakane Canyon	13639	27.9	31662	0.41	296
sub-total	**26785**		**53632**		**1734**
Other CRTs	8736	22.0	16020		
Total	**35521**		**69652**		

[1] Maximum estimated value based on continuous 3/27 flow rate for one year.

It is clear from the table that the vast majority of precipitation falling within the CRT is either lost to evapotranspiration or penetrates into the surface to become groundwater. Although some of the CRTs, notably Oklahoma Gulch, Byrd and McKinstry Canyons, are perennial, the total surface contribution of these streams to the Columbia River (if they were to run at or near peak flow rates all year) would be a very small fraction of total annual precipitation.

Groundwater within or near the CRT has as its source(s): 1) saturated Columbia River alluvial sediment; 2) shallow, localized unconsolidated or bedrock aquifers; or 3) deeper and/or more laterally extensive bedrock aquifers. In any case, such water is not immediately connected to the Entiat subbasin system, nor is any surface flow from these drainages connected to or influenced by the Entiat system. Furthermore, water contributions to the Columbia River from the Entiat WRIA minor CRTs fall under the management and regulatory scope of WAC 173-563 (see Appendix L). For these reasons, and considering the limited potential for future residential/agricultural development of this area, the EWPU did not perform as rigorous an examination of water quantity in the CRTs.

8.0 WATER QUALITY

8.1 INTRODUCTION

The Clean Water Act of 1977 set federal standards for water quality (see Appendix F). In accordance with the Act, and after developing standards that met or exceeded the federal standards, the State of Washington was designated by the US Environmental Protection Agency (EPA) to administer the Washington State water quality program. The WDOE is the state agency with the primary responsibility for water quality management and monitoring. The state established 5 classes of surface water, and defined numeric and narrative water quality criteria designed to protect characteristic uses listed for each classification. Standards define general attributes, characteristic uses, and water quality criteria.

8.1.1 Water Quality Classes

The state water classifications that apply to the Entiat River include:

- Class AA (extraordinary) from the Entiat headwaters to the National Forest Boundary (RM 26). Class AA waters shall have water quality that markedly and uniformly exceeds the requirements for all, or substantially all uses.
- Class A (excellent) from below the National Forest Boundary to the river mouth. Class A waters shall have water quality that meets or exceeds the requirements for all, or substantially all uses.

8.1.2 Characteristic Uses

Characteristic uses include, but are not limited to: water supply (domestic, industrial, and agricultural), stock water, fish and wildlife habitat, recreation and navigation. Refer to Appendix G for a complete discussion of characteristic uses, and state water quality standards and criteria.

8.1.3 Water Quality Parameters and Criteria

Five water quality parameters have associated state criteria: temperature, fecal coliform bacteria, dissolved oxygen, pH, and turbidity. These and nine other water quality parameters of interest (conductivity, flow, ammonia-nitrogen, nitrate-nitrite, dissolved organophosphates, air pressure, suspended solids, total phosphorous and total persulfate nitrogen) are monitored by the WDOE at ambient water quality station 46A070, on the lower mainstem Entiat River adjacent to the Entiat near Entiat (Keystone) USGS gage. State water quality criteria and parameters particularly important for assessment of freshwater ecology are summarized in Table 8-1 on the next page. Refer to Appendix G for additional parameter information and discussion of marine and fresh water quality criteria.

Table 8-1. Summary of select water quality parameters and associated state criteria.

Parameter	Importance	State Class AA Criteria	State Class A Criteria
Temperature	Affects aquatic ecology; cold water fish species such as trout and salmon are particularly sensitive to very high and very low temperatures.	≤ 16°Celsius (60.8° Fahrenheit; Forest Plan standard is 61°Fahrenheit).	≤ 18°Celsius (64.4° Fahrenheit).
Fecal coliform bacteria	Indicative of possible human health risk due to fecal contamination by warm blooded animals.	Geometric mean value ≤ 50 colonies/100mL and not more than 10% of all samples obtained > 100 colonies/100mL.	Geometric mean value ≤ 100 colonies/100mL and not more than 10% of all samples obtained > 200 colonies/100mL.
Dissolved oxygen (DO)	Related to temperature and stream productivity. Low concentrations can stress fish.	> 9.5mg/L	> 8.0mg/L
pH	Dependent on geomorphology and stream productivity. Very low and very high pH can stress fish. PH also affects the solubility of many chemicals.	Within range of 6.5 to 8.5, with human-caused variation within a range of < 0.2 units.	Within range of 6.5 to 8.5, with human-caused variation within a range of < 0.5 units.
Turbidity	A measure of the clarity of the water. High turbidities can affect sight-feeding organisms, including fish, and may be indicative of watershed disturbance.	Turbidity shall not exceed 5 nephelometric turbidity units (NTU) over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10% increase in turbidity when the background turbidity is more than 50 NTU. **Note: No background turbidity values have been established for waters within the Entiat WRIA.**	
Total persulfate nitrogen (TPN) and Total Phosphorous (TP)	Two nutrients most often limiting production in aquatic systems. High levels of nitrogen can result in excessive plant growth and algae growth, which can in turn cause wide fluctuations in DO/pH.	N/A	

8.1.4 Clean Water Act 303(d) List

Section 303(d)(1) of the Clean Water Act requires the State to list and monitor surface water body segments that are not expected to attain water quality standards after implementation of technology-based controls, thus requiring additional management activities (See Appendix F for a copy of Section 303(d)). The first state "303(d) List" was created in 1992 and is updated by WDOE every two years. Types of water quality problems that can lead to 303(d) listings include: water temperature, fecal coliform bacteria, toxic substances, excessive organic waste and/or nutrients.

The Class AA reach of the Entiat River (Headwaters to RM 26) has never been placed on the State's 303(d) list; however, the Class A portion of the Entiat has been listed in the past. The 1996/1998 instream flow listings resulted from instream flow recommendations that were proposed based on the results of a PHABSIM conducted in 1995 (Caldwell 1995).

Table 8-2. Summary of Entiat River Class A reach 303(d) listings.

Biennial List Year	Parameter(s) Listed
1992	pH
1994	pH and temperature
1996	pH, temperature, instream flow
1998	Instream flow
2000	n/a; the EPA did not require states to submit a 303(d) list in 2000
2002/2004 (draft)	No parameters proposed for 303(d) listing; proposed as Category 4b

Following guidance from the EPA contained in the *2002 Integrated Water Quality Monitoring and Assessment Report*, the state's listing process was altered to include a much more comprehensive assessment of Washington's waters. The new listing process and data requirements are described in a recent update to the Water Quality Program Policy 1-11, "Assessment of Water Quality for the Section 303(d) List", which was finalized and submitted to the State Register in September 2002. Five unique assessment categories were used by WDOE as part of their 2002 303(d) listing process:

Table 8-3. 2002 303(d) list assessment categories and definitions.

Assessment Category	Definition
Category 1	Waters that meet tested standards
Category 2	Waters of concern
Category 3	Waters with no data available
Category 4	Impaired waters but one of the following conditions exist: Category 4a. Water has a TMDL Category 4b. Water has a pollution control plan Category 4c. Water is impaired by a non-pollutant
Category 5	The 303(d) list

The WDOE has prepared a 2002/2004 list for submittal to the USEPA; however, until the new list is approved the 1998 list remains in effect. ***The WDOE has proposed to the EPA that the lower Entiat River be classified as a Category 4b stream in 2002/2004*** as a result of the Planning Unit's previous and current efforts.

8.1.5 Total Maximum Daily Load

The Clean Water Act requires that once a water body is placed on the 303(d) list, a Total Maximum Daily Load (TMDL) study be completed. A TMDL can be describes as the calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. In other words, a TMDL helps identify the sources of pollutants that are causing water quality exceedences, quantifies how much of the given pollutant(s) a water body can accept and still meet water quality standards, and recommends actions that should be taken to reduce the pollutant to this level so that the impaired water may meet water quality standards again.

A 1996 needs assessment of the Wenatchee Water Quality Management Area, which includes the Entiat watershed, set priorities for water quality-related actions (WDOE 1996). The development of a TMDL for temperature in the Entiat River was given a low priority. This determination was based largely on the need for further analysis of the specific causes of excursions beyond water quality standards. Since 1996, the USFS Entiat Ranger District has collected additional temperature data and examined the causes of excursions (see Appendix 1-N), and WDOE modeled temperature and various management alternatives for the Entiat River using the Stream Network Temperature (SNTEMP) model (Hendrick and Monahan 2003; see section 8.5).

In 2003 the WDOE modeled heat loads to streams on the USFS Wenatchee National Forest in order to develop a TMDL analysis to address impairment of characteristic uses by elevated water temperatures on the WNF (Whiley and Cleland 2003). The forest was classified the forest into five basins: Chelan (17% of WNF area); Entiat (11%), Wenatchee (33%), Yakima (18%), and Naches (22%). Subsections of each basin that considered elevation, precipitation and primary landscape setting; drainage area; bankfull width and Rosgen Stream Classification were also developed. Temperature data were used to develop an approximation of effective shade for each. A TMDL was then developed to establish forest-wide riparian shade levels (in terms of percent effective shade) to maintain maximum water temperatures at, or below, water quality standards (Whiley and Cleland 2003). For more information about the WNF TMDL, refer to http://www.ecy.wa.gov/biblio/0310063.html

For more information on 303(d) listings, TMDL's, and other Federal Clean Water Act issues in general, please refer to the following sources:
http://www.epa.gov/owow/tmdl/intro.html
http://www.ecy.wa.gov/programs/wq/303d/index.html
http://www.epa.gov/watertrain/cwa/index.htm

8.2 DATA SOURCES

Data from various sources were compiled and examined to assess historic and current water quality in the Entiat WRIA. The WDOE ambient water quality monitoring site provided the longest comprehensive record; data have been collected there since July 1959. The WDOE continues to collect monthly data at this ambient water quality monitoring site. Details about the WDOE Keystone station and parameters monitored may be downloaded directly from:
http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?theyear=&tab=notes&scrolly=1&wria=46&sta=46A070

In addition to monitoring water quality parameters at Keystone, the WDOE currently records water temperature data at eight continuous recording gages that were installed in fall 2002 throughout WRIA 46 by the Planning Unit. The temperature data collected at these sites are considered provisional and have not at this date undergone internal quality control/quality assurance review by the WDOE. Historic WDOE data are also contained in the U.S. Environmental Protection Agency's (EPA) LEGACY national water quality database.

The USFS has conducted water quality monitoring at various sites in the Entiat subbasin both on and off National Forest System lands. Data collected in the Entiat Experimental Forest (1957-1977) focused on water quantity and quality in the three study drainages (McCrea, Burns and Fox Creeks). The Entiat Barometer Watershed program, which operated from 1996-1978, emphasized climatic and streamflow measurements and also included water temperature monitoring at a mainstem Entiat station. Sediment transport data were collected after the 1970 fires and documented in the 1979 Entiat Cooperative River Basin Study. The Forest Service and Chelan County Conservation District collected water quantity and quality data at nine mainstem and tributary stations in 1995 and 1996 in order to characterize conditions after the 1994 Tyee Fire.

Other water quality data collection by the USFS (particularly in the tributaries) has been event or project driven—not intended to assemble a long-term record. These data are spatially dispersed and temporally discontinuous throughout the subbasin. USFS water quality data collected prior to 1995 are contained in the EPA LEGACY database. Forest Service water quality efforts are currently focused on water temperature monitoring at multiple stations and annual measurement of fine sediment in the substrate in reference reaches (see Chapter 7, Habitat, Section 7.1.1 for more information on fine sediment).

The U.S Geological Survey (USGS) has performed very limited water quality sampling at three sites (USGS site numbers 12452800, 12452990 and 12453000) within WRIA 46. USGS gage site 12452990, Entiat River near Entiat, is coincident with WDOE site 46A070 (Keystone). These data were at one time maintained by both USGS and EPA LEGACY; however, USGS water quality data entries have been removed from the EPA LEGACY database. All historic and current water quality data associated with the three USGS gages are now maintained solely by the USGS.

The City of Entiat and the WDOE maintain records associated with a NPDES (National Pollution Discharge Elimination System) permit issued to the city for its wastewater treatment plant. The ENFH also has an NPDES permit associated with hatchery discharges. Although the city and hatchery lie within the Entiat WRIA, point source water quality issues associated with these NPDES permits are currently not known to exist. Refer to Figure 8-1 for a map of historic and current monitoring sites in WRIA 46.

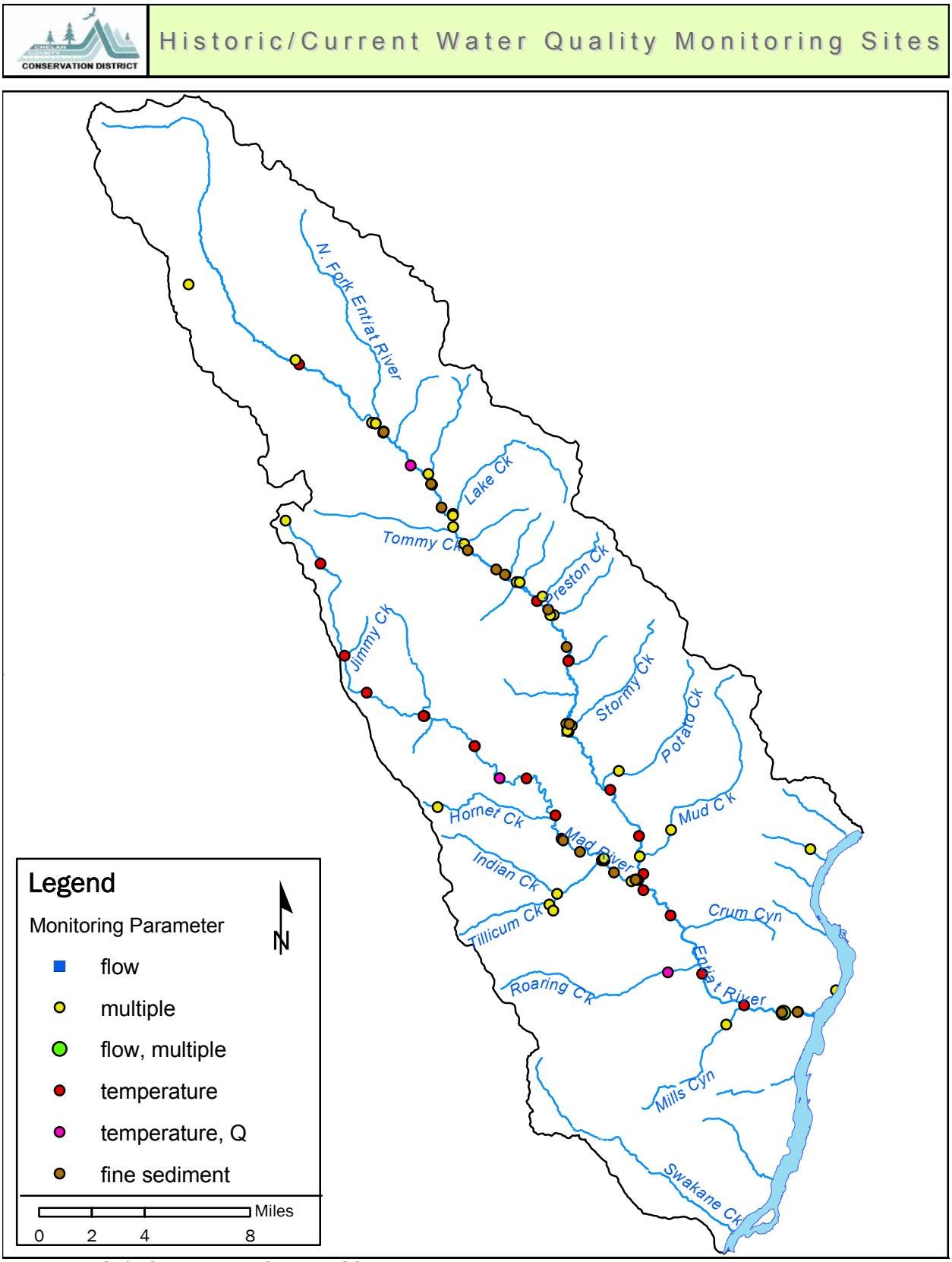


Figure 8-1. Summary of WRIA 46 historic and current water quality monitoring sites and parameters.

8.3 WATER QUALITY FINDINGS

8.3.1 Temperature

Temperature exceedences in the Entiat WRIA occur during late summer when low flows, high air temperatures and high insolation rates coincide. They are usually of short duration and diurnal in nature, a conclusion supported by temperature monitoring performed over the past years by the USFS Entiat RD. A 1994 review of ambient monitoring results by WDOE for Water Years (WY) 1978 - 1991 noted that high water temperature in the afternoon during late-summer and fall was the major water quality standard not met (Ehinger 1994). Ambient water quality data collected at the Keystone site from July 1959 to September 2003 also show a pattern of late summer temperature exceedences occurring during the months of July, August and September. Figure 8-2 and Figure 8-3 on pages 8-8 and 8-9 provide a summary of annual stream temperature data collected at the Keystone site during the 1970s, 1980s, 1990s, and 2000s, and a depiction of the months in these decades during which exceedences of Class A standards (18°C) have occurred. As mentioned previously, the lower Entiat River was included on the 1996 303(d) list of impaired or threatened waters for temperature and instream flows, and is currently listed on the draft 2002 303(d) list for temperature.

USFS Entiat RD thermograph data indicate that exceedences of the Forest Plan water temperature standard (61°F; State Class AA = 60.8°F) most frequently occur in streams at or below 2000 feet in elevation (Archibald and Johnson 2002). In 2002, three locations in the WRIA under 2000 feet in elevation did not exceed Forest Plan standards: the Entiat River at RM31, Indian Creek, and Tillicum Creek. Factors such as topography, geology, groundwater storage landforms, riparian conditions and orientation of the drainages with respect to the surrounding landscape are most likely very influential in maintaining lower water temperatures in these streams (Archibald and Johnson 2002). The EWPU has also examined the influence of the aforementioned factors on summer water temperature exceedence issues in the mainstem Entiat River using the Stream Network Temperature (SNTEMP) model (Hendrick and Monahan 2003). The model, calibrated and run by the EWPU, predicted the effects changes to riparian shade, channel geometry, and stream flows may have on overall stream temperatures. A detailed discussion of SNTEMP methods and results can be found in Section 8.5.

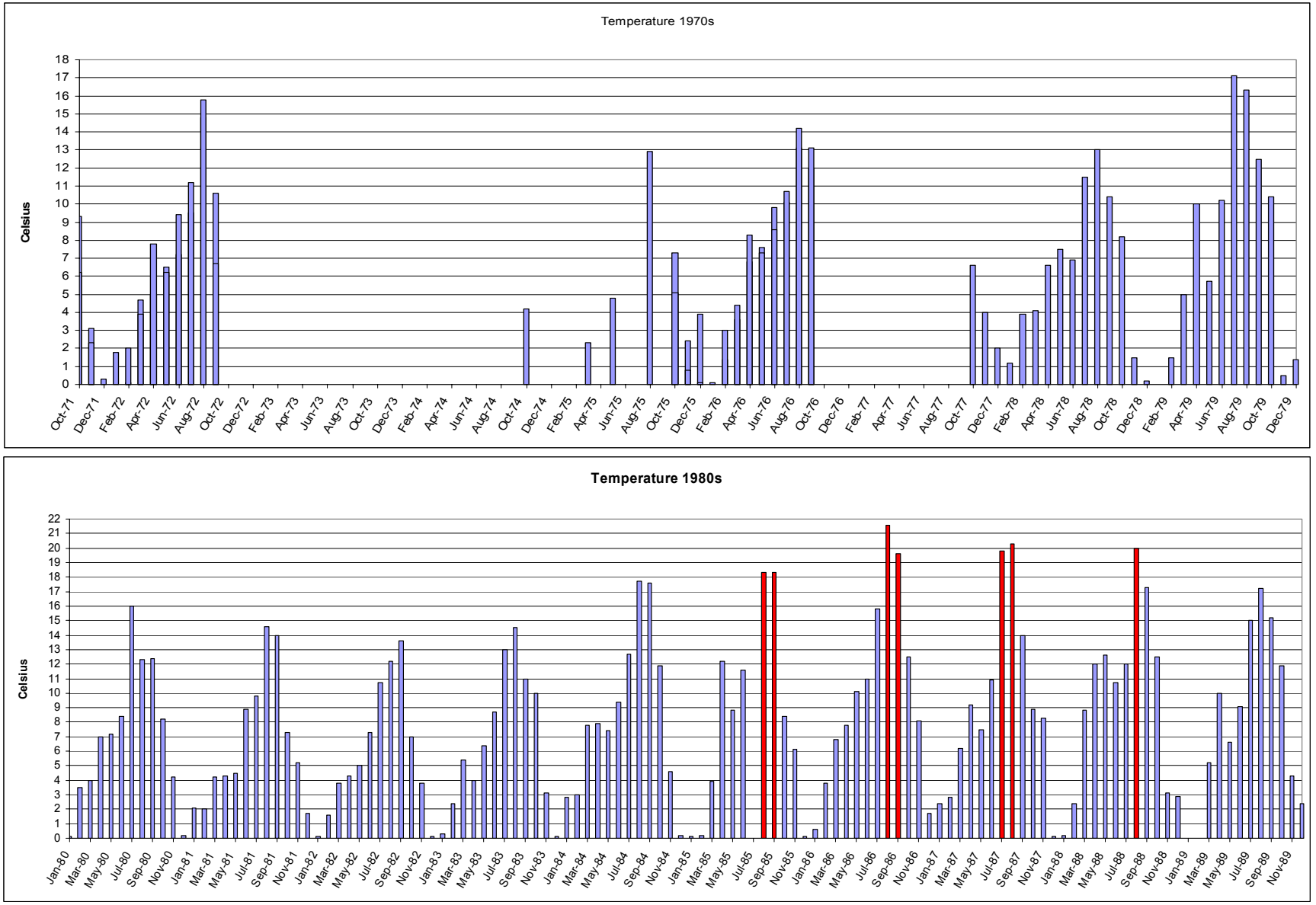


Figure 8-2. Entiat River water temperature data collected at WDOE 46A070 site during the 1970s (above) and 1980s (below).

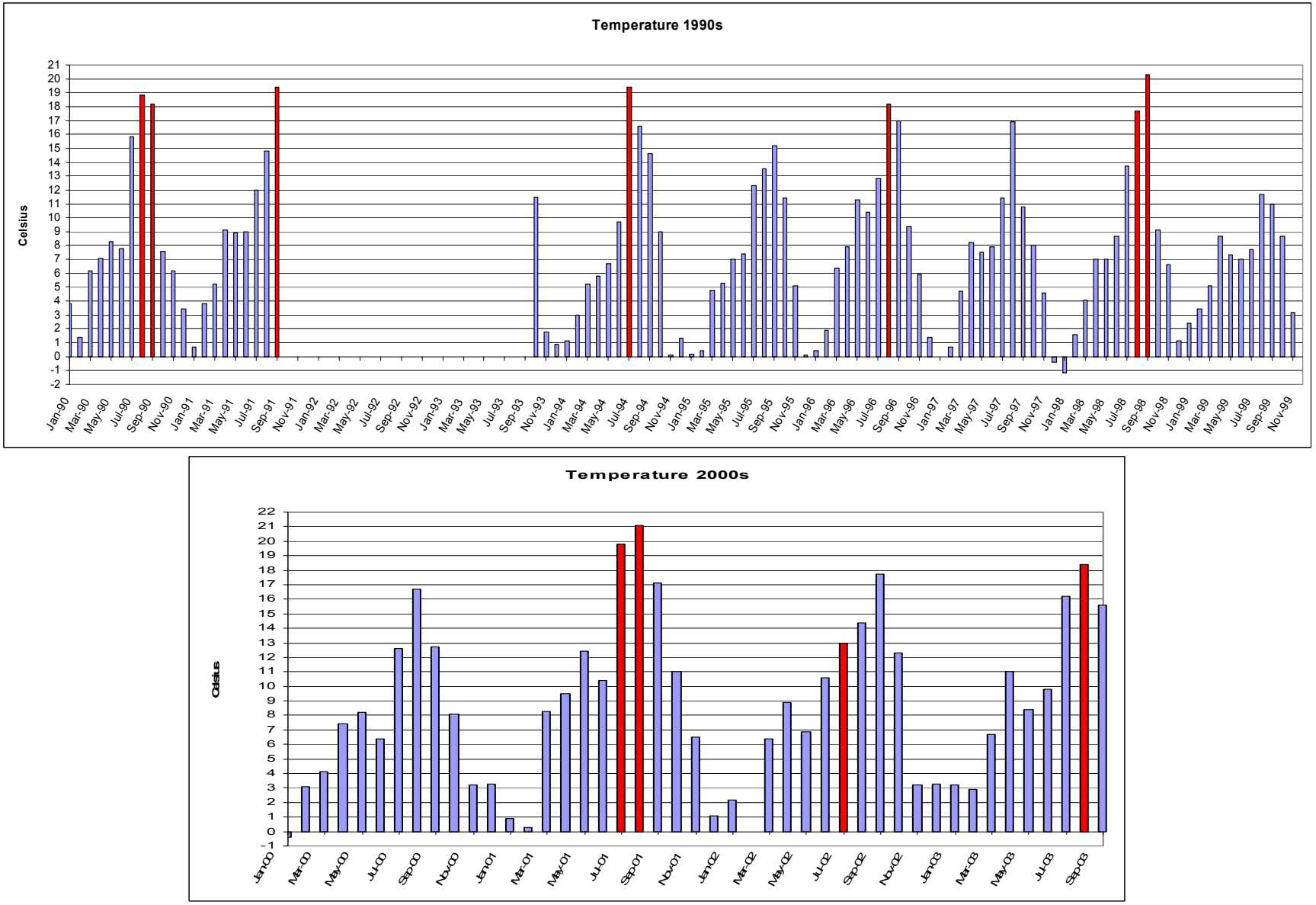


Figure 8-3. Entiat River water temperature data collected at WDOE 46A070 site during the 1990s (above) and 2000s (below).

Thermal Regime in the Entiat River

Archibald and Johnson (2002) observed the following trend in summer stream temperatures based on their analyses of 1999-2002 data:

- The North Fork of the Entiat River near its confluence with the Entiat River tends to be warmer than the mainstem from the middle of July until early September;
- Substantial warming tends to occur between RM 38 (Cottonwood campground) and RM 21 (Dill Creek Bridge);
- A "moderating zone" extends from RM 18 (Stormy gage; USGS Entiat near Ardenvoir) downstream to RM 15 (Roundy Creek confluence) during the hottest part of the summer, with maximum stream temperatures differing by only tenths of a degree from late July to early October;
- Between RM 10.8 and RM 10.2, where the Mad River flows into the Entiat River, stream temperatures tend to be equivalent indicating that the Mad River does not have a great influence on Entiat River water temperatures;
- In 2002, another "moderating zone" extended from RM 8.5 downstream to RM 5.3;
- Stream temperatures gradually warm from RM 5.3 to RM 1.4, with maximum temperatures recorded near the Keystone bridge; and
- Exceedences about RM 20 generally occur from early August to early September; from RM 21 downstream, exceedences are of progressively longer duration, beginning in late July and continuing until mid-September.

Temperature monitoring data, gain/loss analysis results, and information about the Entiat valley's geology and alluvial valley comport well with one another and support hypotheses about stream temperature trends observed in the mainstem Entiat River.

Differences in stream temperatures near the confluence of the North Fork with the Entiat River mainstem are likely related to several factors. First, the mainstem and the North Fork of the Entiat have different primary sources of summer flows. The Entiat mainstem receives summer flows from snowmelt, glaciers and perennial snowfields within the Glacier Peak Wilderness area located farther west and at higher elevation (7000-8000 feet) than the headwaters of the North Fork. In contrast, the North Fork receives summer flows from yearly snow melt and runoff not associated with glaciers or perennial snowfields and the headwaters are at a lower elevation (6000 feet).

Other factors that may have a large influence on North Fork stream temperatures include the aspect of the stream (north-south versus the east-west orientation of the mainstem) and the presence of massive rock outcrops that constrain the channel from RM 0.5 to RM 1 potentially serving as heat sinks during the summer. Additionally, aquifer depth near the mouth of the North Fork Entiat River was modeled at 40 feet and approximately 47 acres in size (Dixon 2003), indicating that the volume of cooler groundwater input to this reach during the months of June through September, which showed a decreasing trend in aquifer storage, would not likely be substantial enough to provide a moderating influence on warmer water temperatures.

In the mainstem Entiat from the North Fork confluence at RM 34 to the USFS monitoring site at RM 26 (Forest Service boundary, near McCrea Creek confluence), stream temperatures would be expected to rise naturally due to the warmer North Fork contributions, an

elevational decline of about 900 feet and the presence of the Box Canyon near RM 29 which confines the channel to a narrow bedrock gorge that likely serves as a heat sink/source as well. Modeled aquifer depth from the North Fork confluence downstream to Box Canyon ranged from 45 to 65 feet, which is still relatively shallow given the range of aquifer thickness estimated in the valley (25 to 197 feet) (Dixon 2003). Although aquifer storage was shown to decrease between July and September, indicating that baseflows are supporting overall stream flow during this period, gain loss data show an overall net loss of 12.85 cfs per mile for the 4.67 mile reach between the North Fork confluence and the top of Box Canyon (CCCD 2003b). Almost all of the loss recorded in the September gain/loss analysis occurred in the 0.4 miles between the North Fork confluence and Entiat Falls (-12.85 cfs per mile). This significant decrease in surface flow may also be contributing to warmer water temperatures in the reach from the North Fork to Box Canyon; however, DNR surficial geology data indicate a pocket of alluvium here, which confounds interpretation of surface/ground water exchange in this area.

From the USFS boundary at RM 26 downstream to RM 18, the river flows through an increasingly wider U-shaped valley where it exhibits increased sinuosity and a lower gradient compared to all other areas of the Entiat River. In this "stillwaters" reach where stream temperatures would be naturally expected to increase as well, a temperature moderating influence was observed in 1999-2002. The moderating zone lies between RM 21 and RM 16, and is most likely related to a ground aquifer created by glacial till. Much of the landform in the upper and mid-Entiat Valley was shaped by a glacier that extended from the west towards the Columbia River ending at about RM 16. The area near RM 16 is a terminal moraine, with a U-shaped valley present above this point and a V-shaped valley downstream. However, movement of the cooling zone downstream during late fall indicates that the area of glacial till serving as groundwater storage may actually extend downstream further than RM 16.

Model data show that alluvial aquifer depth and aquifer polygon size increase significantly in the stillwater reach from RM 26 downstream to the Stormy Creek confluence near RM 18, with the majority of aquifer polygons estimated to be 100 feet or more deep (Dixon 2003). The deepest aquifer polygon (197 feet) and five aquifer areas estimated at over 100 acres in size, and ranging in depth from 129 to 180 feet, are found within this portion of the valley. This supports the hypothesis that the large volume of groundwater stored in this area may provide a moderating influence on stream temperatures. DNR data indicate a large fault between RM 19 and RM 20, which may also contribute cooler subsurface water to this reach.

Predicted aquifer depth begins to decrease around RM 17 although tends to remain between 60 and 80 feet until about RM 14. Two modeled areas of approximately 50 acres and 70 feet deep fell between RM 16 and 15, with a larger polygon of approximately 100 acres in size and 79 feet in depth between RM 14 and 15. Gain/loss data show a gain of 10.09 cfs per mile between RM 16 and approximately RM 14.3, which may be explained by groundwater contributions from these larger, moderately deep aquifer areas (CCCD 2003b). Their presence also contributes to the idea that areas of deeper alluvium and groundwater storage do exist downstream of the terminal moraine.

Stream temperatures in the Mad River near the confluence with the Entiat River were somewhat cooler than those observed at the Entiat RM 10.8 or RM 10.2 during the 11 weeks of data collected during the 2002 Mad River monitoring period (Archibald and Johnson 2002). Overall the Mad River appeared to have a slight (mean = 0.95°F, range = 0.2°F to 2.0°F) cooling influence on mainstem Entiat stream temperatures although the Mad River in August and September generally contributes 10-20% of the Entiat River flow (Archibald and Johnson 2002). Gain/loss data collected in September above and below the Mad River confluence showed a loss of 7.02 cfs per mile in this area (CCCD 2003b), which may also help explain why the Mad has very little moderating influence on temperatures of the mainstem Entiat River in this reach.

The moderating zone that lies between RM 8.5 and RM 5.3 may be related to groundwater aquifers created by glacial Lake Missoula flood deposits located at the mouth of Roaring Creek (C. Narcisco, pers. comm. 2003). Aquifer model data show an area approximately 92 feet deep near the mouth of Roaring Creek, which supports the notion of a deeper deposit and the potential influence of groundwater in that area. Gain/loss data also indicated a net gain of 0.02 cfs over the 0.9mi stretch from just above the Roaring Creek alluvial fan to its mouth.

"In addition to the glacial outwash gravels there are geologic controls, both bedrock and structural features likely contribute to the occurrence of groundwater in the area. A wedge of the Mad River schist extends from the headwaters of the Mad River down to the Columbia. It begins to thicken in plan view near Dinkelman Canyon, and mid to lower Roaring Creek is largely underlain by this rock type. It weathers to a finer textured soil than is common with the granitic or gneissic bedrock in the area with potential for clay intergrades. This rock is the same as that seen on the southwest slope of the Mad River, where the large and seepy slumps occur. Additionally, there is a (thrust) fault contact within this unit and the Swakane biotite gniess which crosses the mid drainage of Roaring Creek and near the mouth of Mills Canyon" (C. Narcisco, pers. comm. 2003). DNR data also show three normal faults oriented towards the mainstem Entiat contacting a Napeequa unit and Entiat Pluton in the Saunders Canyon area (between RM 5 and RM 4). Fault zones can serve as conduits which transmit increased groundwater; gain/loss data show a tremendous increase in flow (30.51 cfs per mile) between Dissmore and Dinkelman Canyons (approximately RM 5.2 to 4.3) (CCCD 2003b). Another potential factor is that the foliation plane in both the Mad River schist and the Swakane gneiss (in this area) dips toward the Entiat valley and could provide for some recharge of groundwater to the aquifer" (C. Narcisco, pers. comm. 2003).

From RM 5.3 to the river mouth, warming continued at a rate similar to that between RM 21 and RM 31. This is likely related to changes in stream morphology and reduced riparian cover in the most populated segment of the river (Archibald and Johnson 2002).

Figure 8-4 on page 8-13 depicts the aforementioned thermal regime in the Entiat River in longitudinal profile, and the relationship of stream temperatures to land type associations, channel gradient, stream flow, and fish distribution within the watershed.

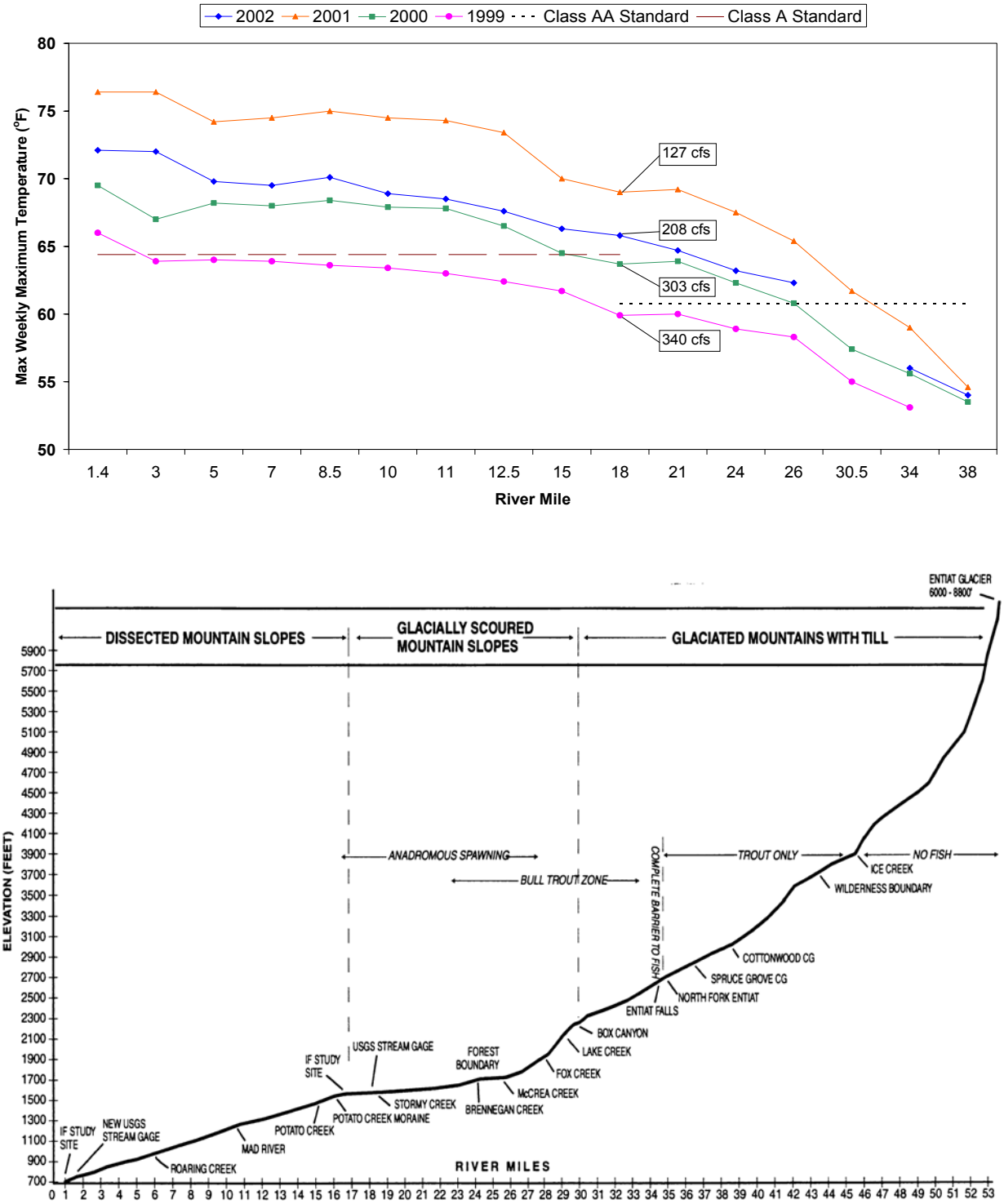


Figure 8-4. Relationship between weekly maximum water temperatures (°F) for the Entiat River, land type associations, channel gradient, stream flow and fish distribution.

Thermal Regime in the Mad River

The Mad River temperature data set spans 63 years, making it the longest-term record available for the Entiat subbasin. As the Mad River is essentially unaffected by direct management of riparian and valley bottom vegetation from RM 4.0 to the headwaters, a distance of nearly 20 miles, it represents a possible "reference" stream useful for assessing "natural variability" and may provide an important piece of information for natural water temperature regimes in similar land type associations.

Thermograph data collected by the USFS Entiat RD from 1993-2002 indicate that maximum water temperatures in excess of 61°F in the lower Mad River occur consistently. In 1997 fisheries biologists at the Entiat RD identified the following trend in Mad River summer water temperatures:

- At Mad Lake where the river originates, stream temperatures are substantially warmer at the outlet of this high elevation (5900 feet) shallow lake;
- Stream temperatures gradually cool going downstream until reaching the Cougar Creek area (3400 feet);
- Re-warming progressively occurs from Cougar Creek downstream to Tillicum Creek (1400 feet); and
- Tillicum Creek then provides a cooling influence evidenced by lower stream temperatures at the confluence with the Entiat River than those observed just above the Tillicum confluence.

Three historic sources of Mad River water temperature data (stream surveys from 1935-36 Bureau of Fisheries), 1972 (Holtby WNF), and 1990 (Haskins WNF), were reviewed to provide context and support for the observed trend; all historic data coincided with and reinforced the trend hypothesized in 1997. Thermal Infrared (TIR) imagery data for the Mad River collected during a flight on August 12th, 2001 helped to explain observed trends (Watershed Sciences, LLC 2001). The TIR imagery showed that cold water inputs from springs and tributaries contributed to the observed spatial temperature variations in the Mad River, and analysis revealed that reach-scale patterns may influence downstream heating in five identified “response” reaches (Faux and Archibald 2002).

The Mad River originates relatively warmer at the small (5 acres) and shallow (<20 feet deep) Mad Lake. It then flows through high elevation meadows with little shading from vegetation or topography. TIR imagery revealed that the temperature pattern in this reach (Reach 1, RM 26 to RM 20.5) is characterized by rapid increases in temperature over relatively short spatial scales due to direct solar radiation; however, stream temperatures in this reach also respond dramatically to tributary and spring inputs as a result of relatively low flow conditions, (Faux and Archibald 2002). Thus, a high degree of spatial thermal variability exists from Mad Lake downstream to this point.

Reach 2 (RM 20.5 to RM 17.4) showed an overall cooling trend. A spring was detected near RM 20.5, and vegetative shading also increases. Most importantly, the valley bottom consists of deep glacial till which stores and cools groundwater that contributes to Mad River streamflow. The combination of ground water influx, topographic and vegetative shading reduces the warming effects of direct solar radiation in this reach (Faux and Archibald 2002).

Reach 3 (RM 17.4 to 14.3) temperatures remained consistently cool, although no longer showed a general cooling trend. Deposits of glacial till are also present in this reach indicating the continued contribution of ground water as a buffer to stream warming; however, cooling influences decrease as the glacial till ends below Cougar Creek. The river also has an easterly aspect through this reach, which may also increase the amount of solar radiation. Downstream of this reach, Mad River temperature begins to increase again.

In Reach 4 (RM 14.3 to RM 10), from below Cougar Creek to around Camp Nine, a rapid increase in the heating rate was observed that accounted for most of the warming observed over the full length of the profile (Faux and Archibald 2002). The likely explanation is the transition from glacial till and associated groundwater inputs to more exposed steep bedrock along the north side of the Mad River valley. The vegetation is also less dense in this reach due in part to the 1994 Tyee Fire. It is tempting to attribute some of the warming to the 1994 Tyee Fire which killed most overstory riparian vegetation in the vicinity of Young Creek and Camp Nine. Although the magnitude of temperature increases may be a result of the Tyee Fire, the warming trend was observed in the 1930's, 1972, and 1990, when the riparian canopy was intact. The visible band color images also showed both vegetative and topographic shading at the time of the August 2001 survey (Faux and Archibald 2002), indicating that the mass of bedrock outcroppings likely acts as a heat sink which warms the Mad River by conduction and possibly by reflection as the sun declines from its zenith in the months of July and August.

Reach 5 (RM10 to mouth) showed a slight warming trend with some local spatial variability at several points. A marked cooling in temperature was noted at around RM 8.7 where the channel gradient increases over the next two miles, suggesting possible groundwater upwelling in this area. Tillicum Creek (about RM 2) has also been identified as a cooling source to the Mad River.

Figure 8-5 on page 8-16 depicts the longitudinal temperature profile and aforementioned thermal regime in the Mad River, and the relationship of stream temperatures to land type associations, channel gradient, stream flow, and fish distribution within the watershed.

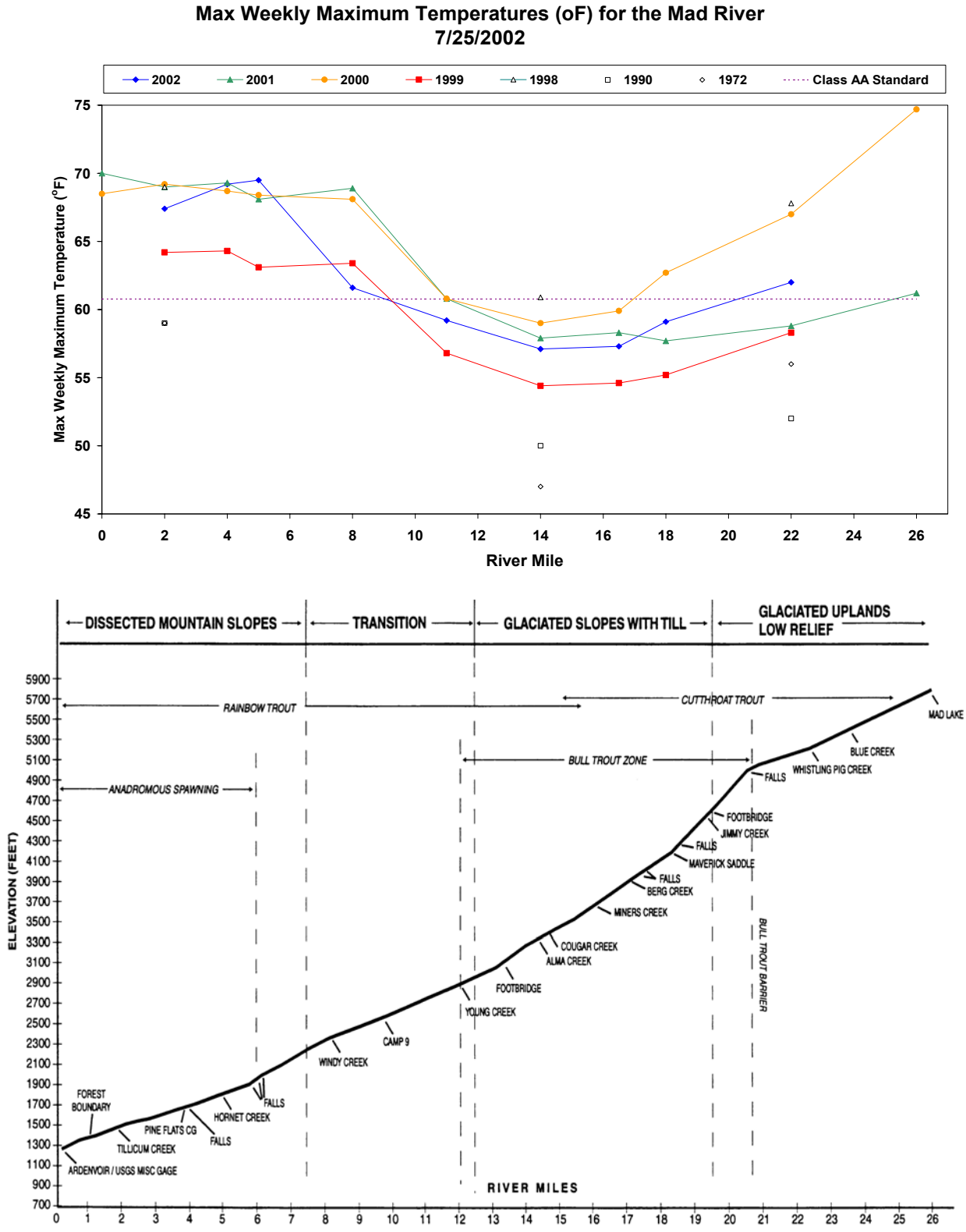


Figure 8-5. Relationship between maximum weekly maximum water temperatures (°F) for the Mad River, land type associations, channel gradient, stream flow and fish distribution.

8.3.2 Fecal Coliform Bacteria

The Planning Unit examined fecal coliform water quality data collected at the Keystone ambient water quality monitoring site by WDOE from November 1971 to September 2003; Class A criteria apply to this site. Fecal coliform colony samples were generally well within state water quality standards for Class A and even Class AA streams (see Table 8-1 on page 8-2). A previous review of Keystone ambient data 1978-1991 also noted that fecal coliform counts were usually low Ehinger (1994).

Occasional historic exceedences above Class A standards exist but are infrequent, exhibit no particular pattern, and have thus far not posed a water quality concern. The most recent exceedence of Class A standards occurred in April 1981, and only two excursions for fecal coliform above Class AA standards have been measured in the mainstem Entiat River since October 1996. Some elevated values for fecal coliform were measured in the tributaries (Mud and Potato Creeks) during post-Tyee Fire water quality sampling in 1995 and 1996; however, values for the mainstem Entiat were well within expected ranges. Although fecal coliform counts have been and continue to be low, future growth in the Entiat valley may present the potential for water quality problems associated with septic systems. Similarly, although no fecal coliform problems associated with livestock inputs have been noted, monitoring and Best Management Practices (BMPs), e.g. limiting livestock access to streams, should be used to help protect water quality. Figure 8-6 on this and the following page provides a summary of fecal coliform data collected at Keystone during the 1970s, 1980s, 1990s and 2000s, and compares data to Class A (and Class AA) water quality criteria for this parameter.

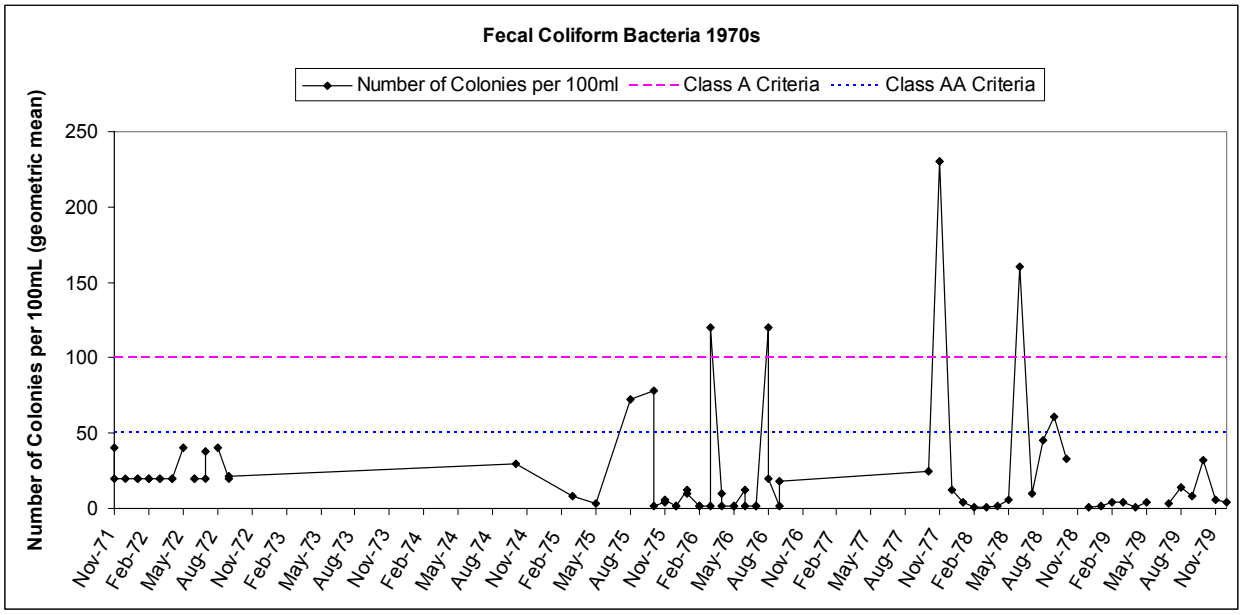


Figure 8-6a. Summary of Entiat River fecal coliform bacteria data collected by the WDOE at monitoring station 46A070 during the 1970s.

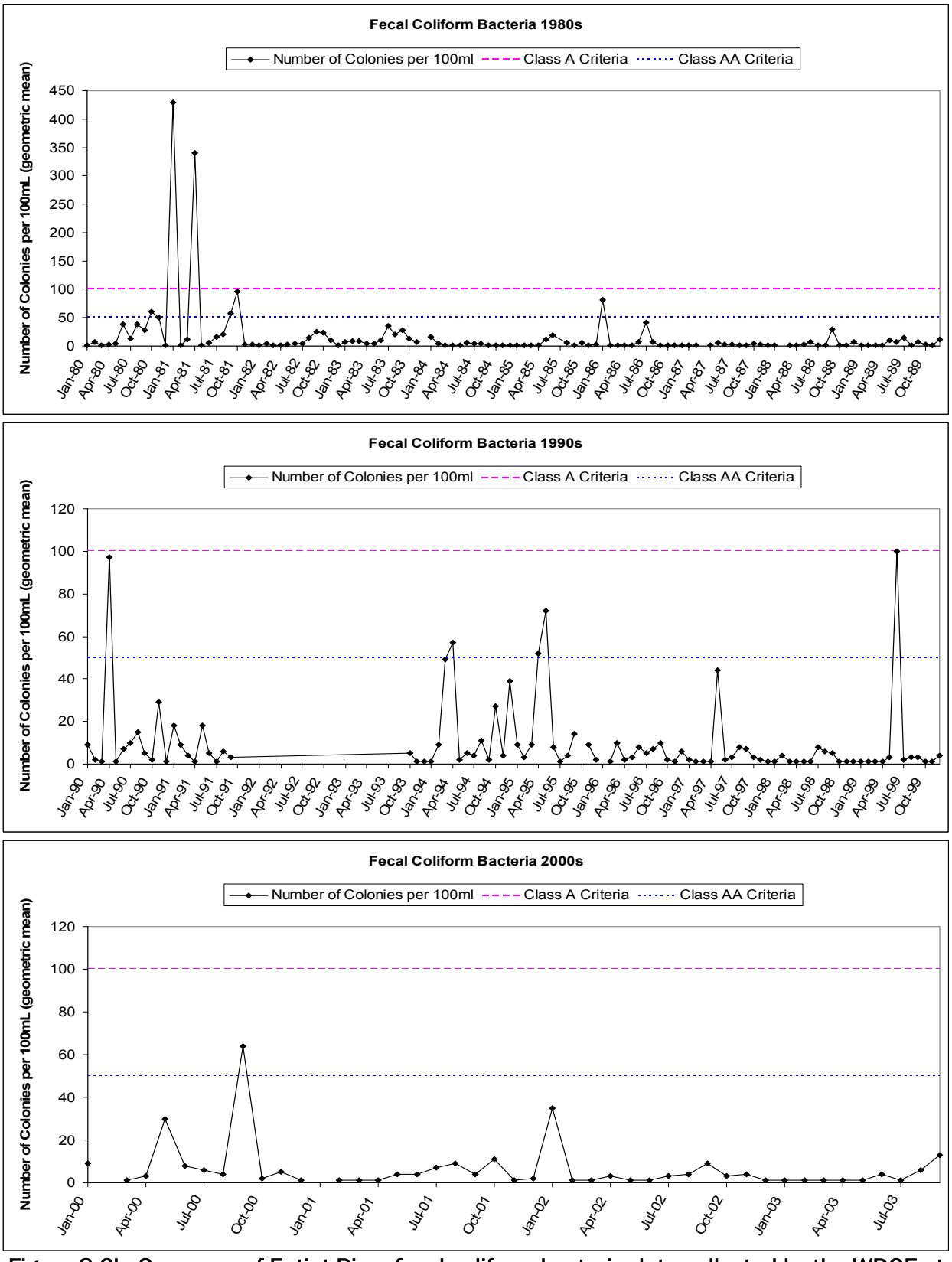
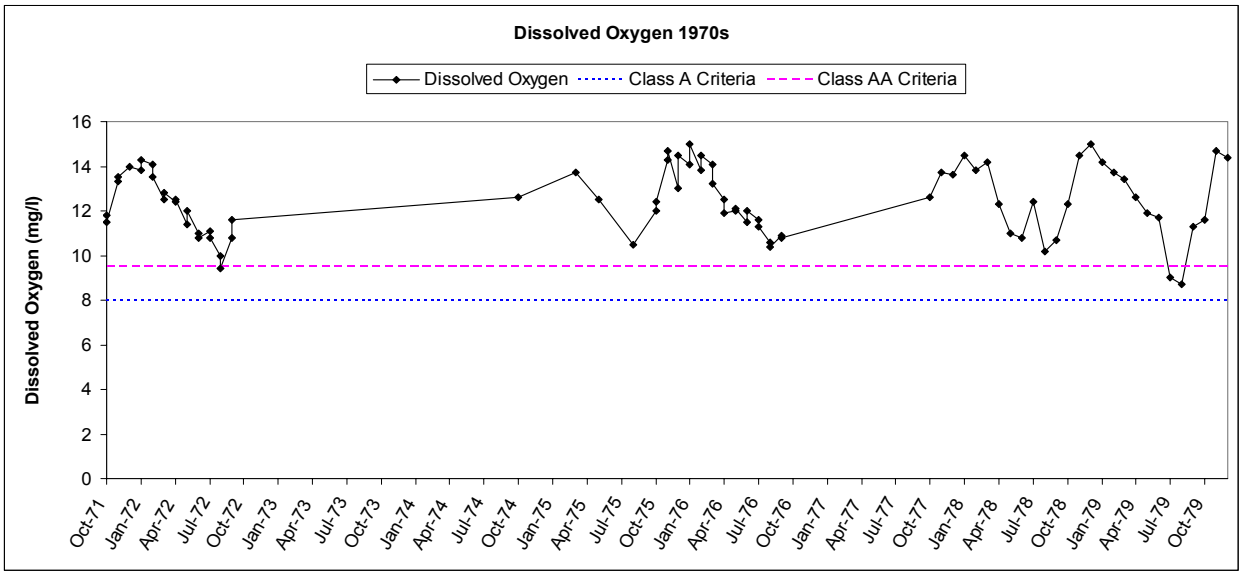


Figure 8-6b. Summary of Entiat River fecal coliform bacteria data collected by the WDOE at monitoring station 46A070 during the 1980s, 1990s, and 2000s.

8.3.3 Dissolved Oxygen

Entiat River ambient water quality data collected at the Keystone site from October 1971 to September 2003 show that the Class A water quality standard for dissolved oxygen has never been exceeded. Only one to two dissolved oxygen samples per decade have not met the standard for Class AA streams. Post-1994 Tyee Fire water quality sampling data collected in 1995 and 1996 showed that dissolved oxygen levels were well within expected ranges for the mainstem Entiat River. Refer to Figure 8-7 below and on the following page for a summary of dissolved oxygen data.



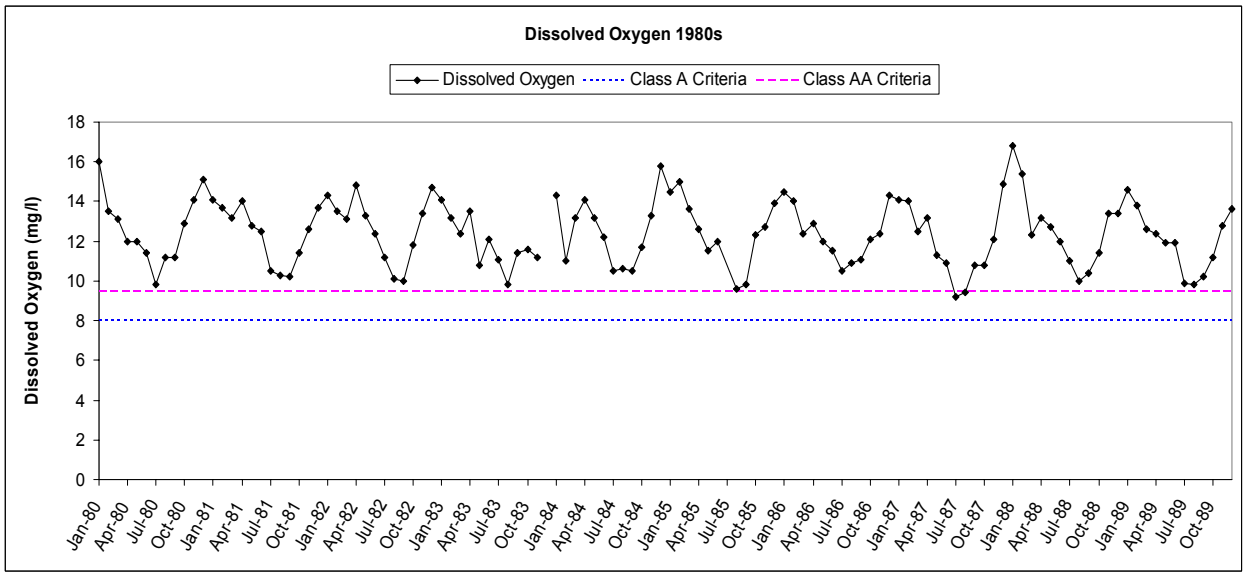


Figure 8-7a. Summary of Entiat River dissolved oxygen data collected by the WDOE at monitoring station 46A070 during the 1970s and 1980s.

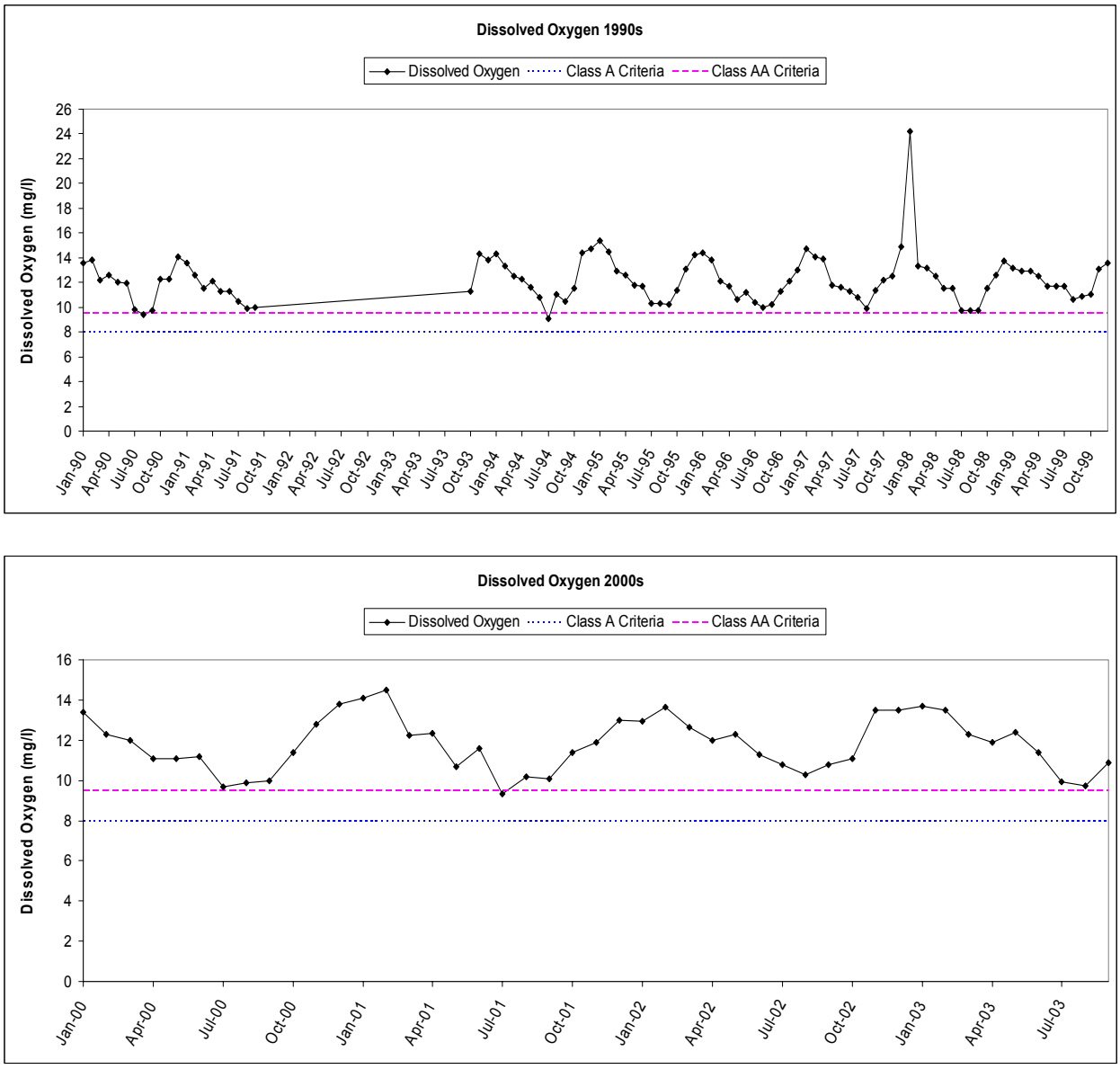


Figure 8-7b. Summary of Entiat River dissolved oxygen data collected by the WDOE at monitoring station 46A070 during the 1990s and 2000s.

8.3.4 pH

A 1994 review of ambient monitoring results by WDOE for Water Years (WY) 1978 - 1991 noted that pH excursions above 8.5 were relatively infrequent (Ehinger 1994). A Planning Unit review of Keystone data from October 1971 to September 2003 noted that occasional pH excursions above Class A/AA standards have occurred; however, values are generally within both Class A and Class AA criteria. WDOE hydrolab data collected in August 1998 showed that pH fluctuations were diurnal in nature and probably a result of photosynthetic activity; elevated pH levels typically peaked in late afternoon, coinciding with maximum insolation of the stream. Insufficient data are available to conclude that pH excursions recorded in other months and years are also a result of diurnal oscillations.

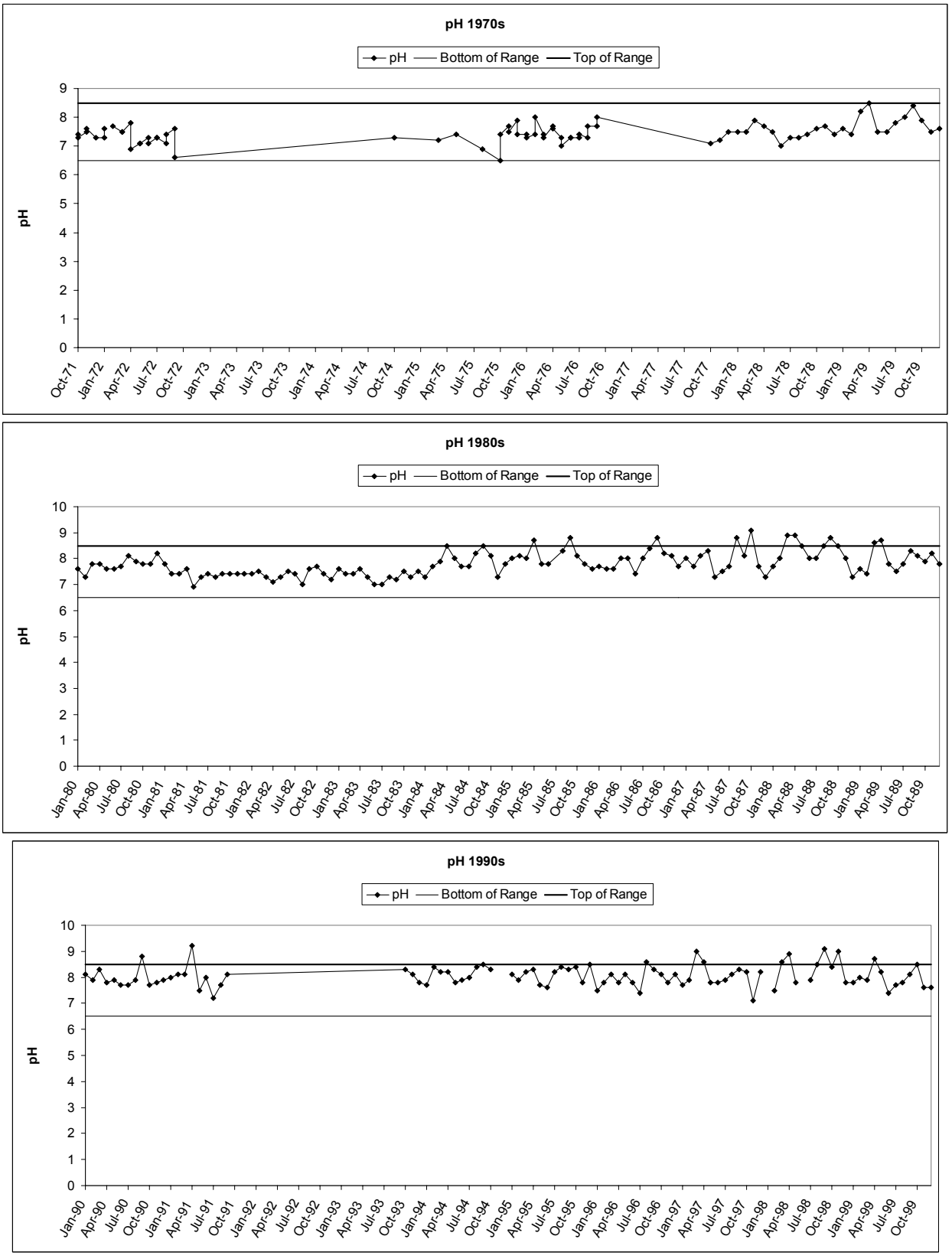


Figure 8-8a. Summary of Entiat River pH data collected by WDOE at monitoring site 46A070 during the 1970s, 1980s and 1990s.

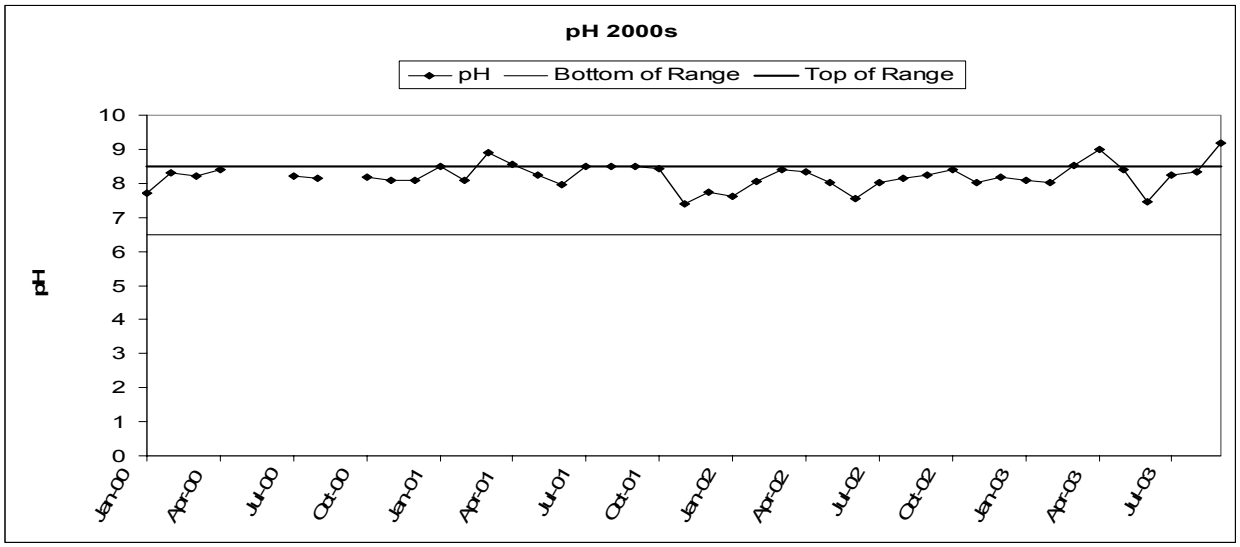


Figure 8-8b. Summary of Entiat River pH data collected by WDOE at monitoring site 46A070 during the 2000s.

8.3.5 Turbidity

Reviews of Keystone data by Ehinger (1994) and the Planning Unit noted that there have been infrequent spikes in turbidity levels; however, these turbidity spikes have occurred during high flow periods with resultant sediment transport. It is important to note that no background turbidity value has been officially determined for the Entiat River. Data showed a correlation between increased turbidity and suspended solids levels.

8.3.6 Suspended Solids

Suspended solids are also monitored at the WDOE Keystone site. May 1995 post-Tyee Fire data showed extremely high suspended solid concentrations, reflecting an initial flush of fine material as streamflow began to rise the first spring after the fire. Subsequent suspended solids data reflect a similar concentration versus flow relationship for both pre- and post-fire monitoring; however, the sampling frequency is limited for this event-dependent parameter (B. Ehinger, pers. comm. 1995).

8.3.7 Nutrients

A 1994 review of nutrient data collected by the WDOE at Keystone noted that ammonia-N, total phosphorus and soluble reactive phosphorus levels were generally low, with nitrate/nitrite-N concentrations well within the range expected of natural conditions and decreasing (Ehinger 1994). Post-1994 Tyee Fire water quality sampling data collected by the USFS, CCCD and WDOE in 1995 and 1996 showed annual nitrate loads exceeded 30,000 kg/year, compared to an estimated pre-fire annual load of 10,000 kg/year. Although post-fire nitrate concentrations were elevated, maximum concentrations did not increase notably and stayed within the natural range experienced in similar watersheds. Increased nitrate loading was associated with increased, sustained streamflows and expected post-fire release. Soluble phosphorus levels showed no change, suggesting that

the phosphorus being transported was attached to sediment. Given the low availability of phosphorus, stimulation of algal growth as a result of increased nitrate levels after the fire was considered unlikely (B. Ehinger, pers. comm. 1995). No trend was seen that indicated a general increase in nutrient concentrations.

Current nutrient concentrations in the mainstem Entiat River are well within the range of expected natural conditions. Increased use of "soft" agricultural practices, like application of coddling moth mating disruption pheromones, indicates that nutrient levels from that source are not likely to increase in the future. WRIA 46 lies within U.S.Environmental Protection Agency (EPA) level III Ecoregion 10 (Columbia Plateau), a subdivision of Nutrient Ecoregion III (arid portions of the northwestern United States). The EPA has published regional numeric reference standards for nitrogen and phosphorus levels specific to both regions; however, the EPA recommends that local entities refine these criteria to reflect local conditions. Criteria have not been refined to reflect local reference conditions for WRIA 46. Thus, although nitrogen and phosphorus levels in the Entiat River and its tributaries have occasionally exceeded EPA criteria, it is difficult to ascertain the significance of these exceedences. Figure 8-9 on this and the following page and Figure 8-10 on page 8-25 summarize nutrient data collected from the Entiat River during the past three and a half decades.

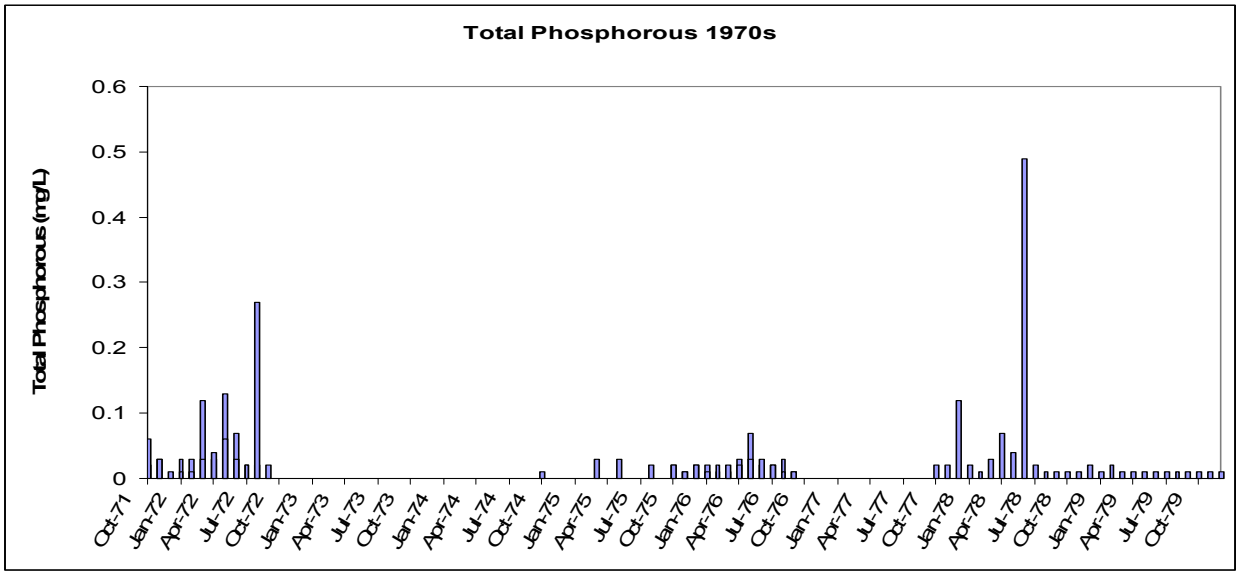


Figure 8-9a. Summary of Entiat River total phosphorous data collected by WDOE at monitoring site 46A070 during the 1970s.

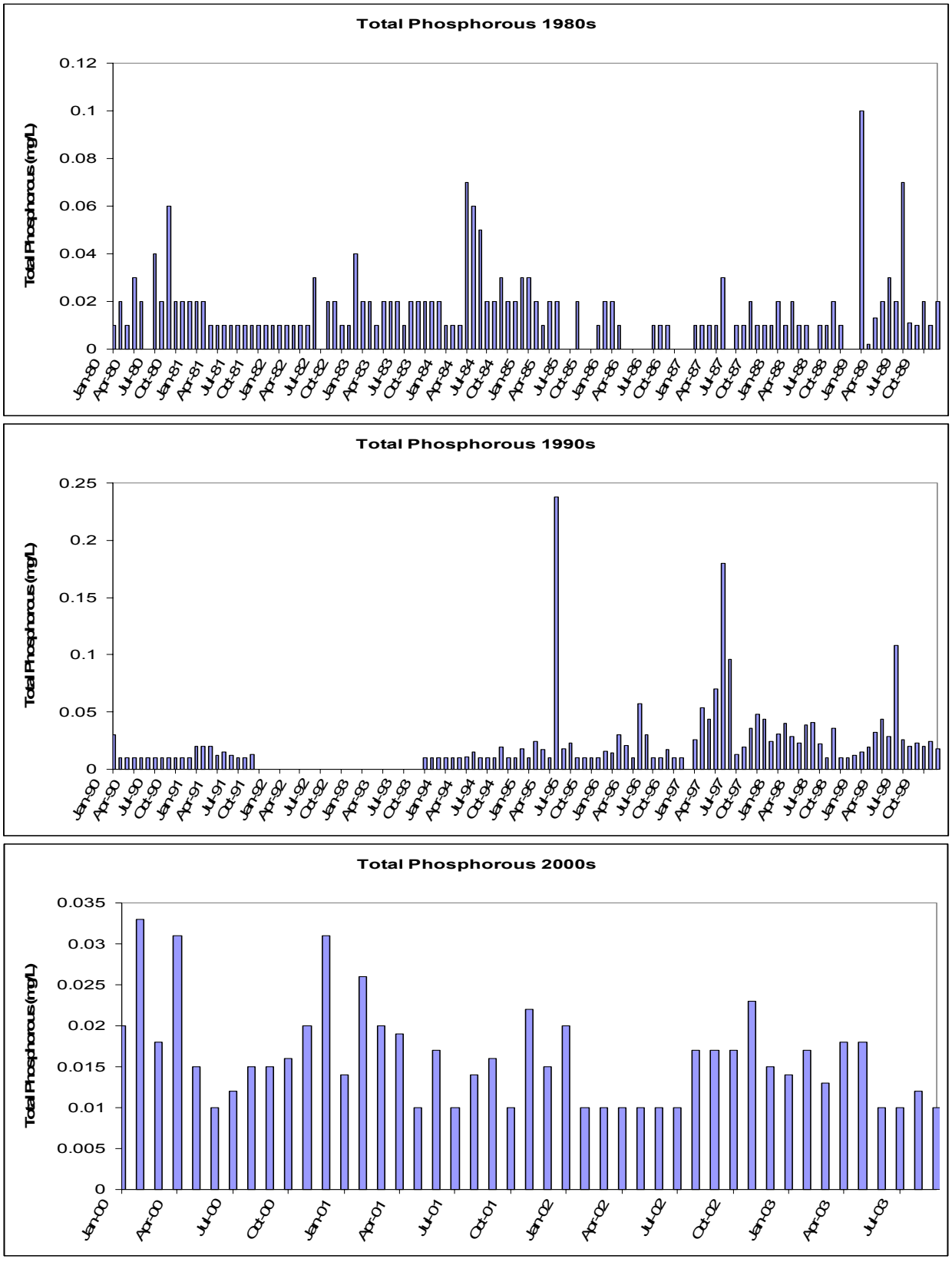
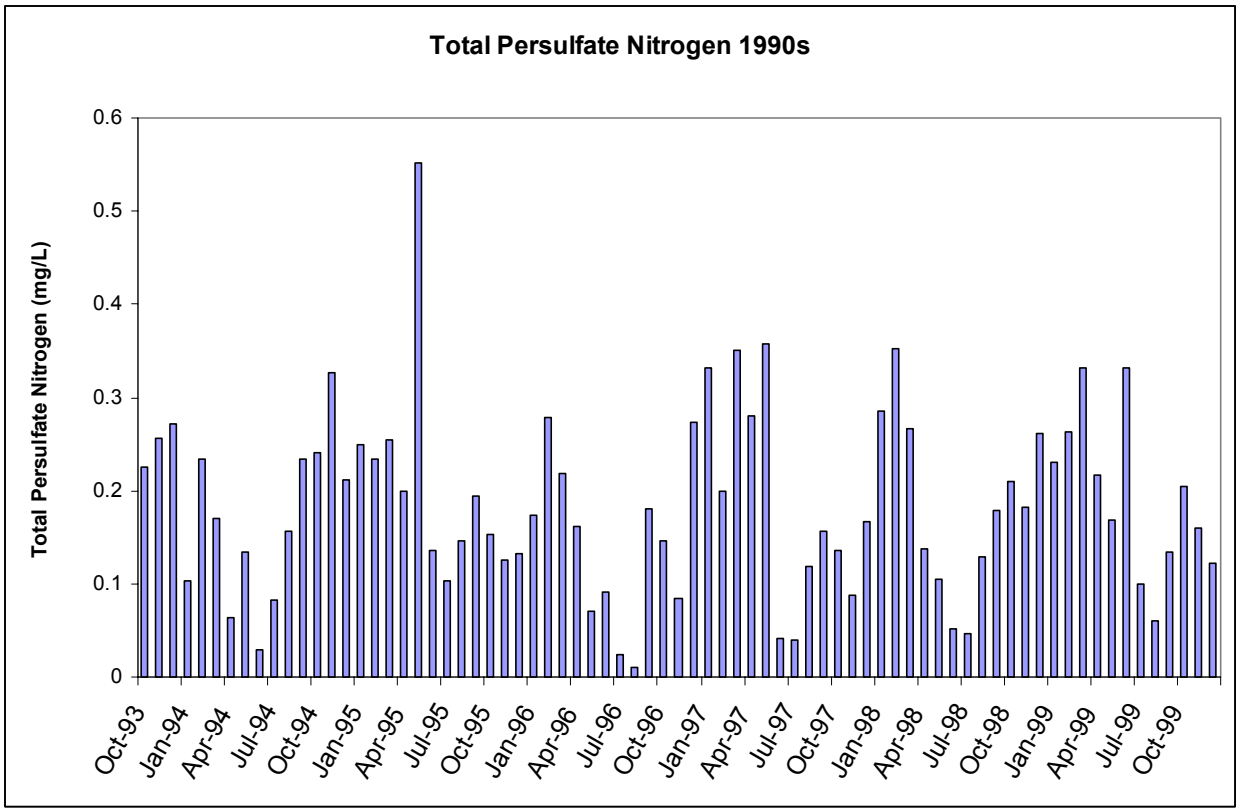


Figure 8-9b. Summary of Entiat River total phosphorous data collected by WDOE at monitoring site 46A070 during the 1980s,1990s and 2000s.



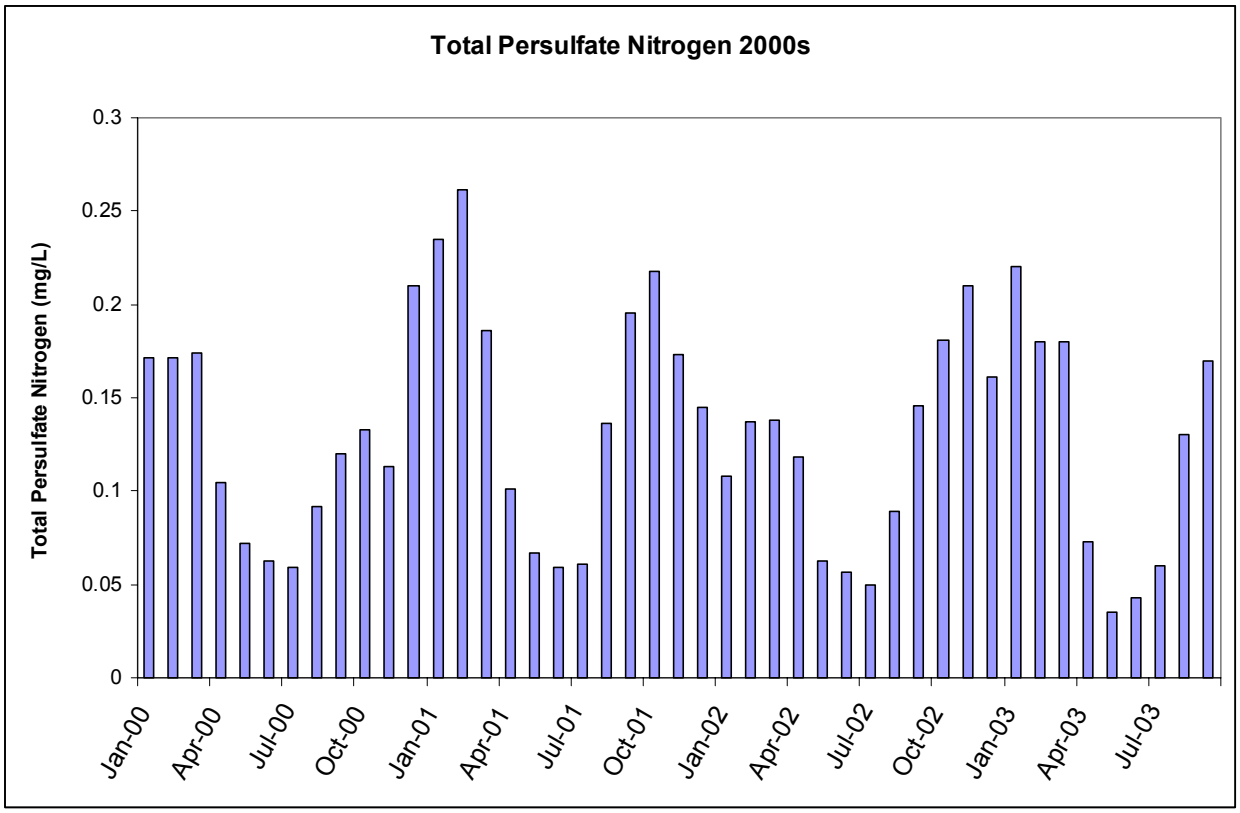


Figure 8-10. Summary of Entiat River total persulfate nitrogen data collected by WDOE at monitoring site 46A070 during the 1990s and 2000s.

8.3.8 Toxic Substances (DDT and metabolites)

In 1994, the WDOE initiated a composite sampling effort for 43 pesticides and breakdown products, as well as seven polychlorinated binphenyl mixtures (PCBs), using fish tissue and sediment samples from six sites in the state. Whole samples of bottom feeding fish (largescale suckers) were collected to assess potential wildlife impacts, while sport fish were collected to evaluate potential risk to human health (Davis and Serdar 1996). As part of the study, two replicate samples of large-scale suckers *(Catostomus sp)* were obtained from the Entiat River about one-half mile upstream from the mouth; no sport fish were obtained from this site for fillet analysis (Davis and Serdar 1996). Elevated levels of total[1] DDT and its breakdown products were the main contaminants found in the Entiat River sucker samples, with low levels of HCB and PCBs also detected.

Given that samples were taken from fish inhabiting the lower portion of the Entiat River near its confluence with Lake Entiat on the Columbia River, the data may not be representative of Entiat River resident fish populations. Furthermore, the risk to human health is unknown because no sport fish were sampled. The WDOE toxics monitoring program identified the Entiat River as a potential site for resampling in order to help verify 1994 t-DDT data and collect additional information (D. Norton, pers. comm. 2002); however, the priority assigned to such a re-sampling effort is low and it is not likely to receive additional funding. Additional sampling from a site further upstream is warranted to clarify results and contaminant source, as well as determine potential risk to human health. Davis and Serdar (1996) also recommended collection of additional whole fish samples to confirm DDT contamination levels and fillet sampling to evaluate potential human health risks.

8.4 SUMMARY

The Entiat River is classified as a Class A (excellent) stream from its confluence with the Columbia River to the boundary of the Wenatchee National Forest at approximately RM 26, and as a Class AA (extraordinary) stream from the National Forest boundary to its headwaters. It supports beneficial uses including domestic, industrial and agricultural water supply and primary contact recreation. Overall water quality at WDOE ambient water quality monitoring station 46A070 (Keystone) met or exceeded expectations in water year 2002, and is of lowest concern according to WDOE's Water Quality Index (WQI). For more information on the Entiat River's overall WQI score, and scores for individual parameters and months, see the following link: http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?theyear=&tab=wqi&scrolly=0&mapscale=935&wria=46&sta=46A070. Refer to http://www.ecy.wa.gov/pubs/0203052.pdf for a detailed description of the WQI methodology.

Water quality in the Entiat River has been affected in the past by practices including flood control, logging and related roading, livestock grazing, and past agriculture practices. Significant positive changes and/or reductions have been made in several of these land uses. Logging and grazing in the watershed has declined significantly, and agricultural

[1] Total DDT refers to the sum of 4,4'- and 2,4'-isomers of DDT, DDD, and DDE.

practices have improved significantly with new technology. Watershed restoration emphasizing road rehabilitation has become a major focus of federal land managers. Furthermore, the amount and type of flood rehabilitation and control measures used and/or financed by federal agencies earlier in the century will probably not re-occur, due to a better understanding of the environmental sensitivity of the watershed.

With the exception of the post-1994 Tyee Fire sampling, and ongoing USFS temperature data collection, very little of the available tributary data are more recent than the mid-1980s. Temperature exceedences are the most common type of water quality issue in the tributaries, with infrequent excursions for dissolved oxygen, fecal coliform and pH also occurring. No increasing trends were seen.

There is no indication of any significant degradation within the WRIA with respect to fecal coliform, dissolved oxygen, pH, or turbidity. Temperature exceedences in the summer months have been identified throughout the record, beginning in 1960. Occasional temperature exceedences may have occurred naturally prior to settlement of the Entiat valley; however, it is impossible to determine the magnitude or frequency of this type of historic exceedence given the existing data record. It is likely that the number and frequency of exceedences has increased due to a combination of historic manipulation of channel geometry and removal of riparian plants, coupled with natural flood and wildfire events, which have also affected streamside vegetation.

Ongoing monitoring of water quality by the WDOE ensures that any trends indicating degradation of the Entiat River will be quickly identified. Maintaining current efforts and practices, and the future implementation of specific projects aimed at improving water quality will ensure that the Entiat River and its tributaries continue to regularly meet or exceed state standards in the foreseeable future.

8.5 STREAM NETWORK TEMPERATURE MODEL (SNTEMP)

The Following discussion is a summary of the report: *"An assessment of Water Temperatures of the Entiat River, Washington Using the Stream Network Temperature Model (SNTEMP)"* (Hendrick and Monahan 2003).

8.5.1 Introduction

As mentioned in section 8.3.1, water temperature excursions have been measured at various locations in both the Entiat and Mad Rivers. The Class A reach of the Entiat River was listed on the 303(d) list in 1996 as exceeding water temperature standards based on ambient water quality samples collected at WDOE monitoring station 46A070 (Keystone) (see section 8.1.4 for 303(d) list information). Although the Entiat was delisted for temperature in 1998, the draft 2002 303(d) list again lists the Class A segment of the Entiat River as exceeding water temperature standards. Therefore, the EWPU was interested in treating water temperature issues as a key part of the water quality component of its watershed plan. The EWPU specifically requested the development of a means to evaluate

what actions can be taken to reduce water temperatures in the Entiat River watershed during critical high temperature periods.

The EWPU Water Quality subcommittee recommended to the EWPU that water temperatures in the Entiat watershed be assessed and evaluated using a stream network temperature model like the United States Fish and Wildlife Service's (USFWS) Stream Network Temperature (SNTEMP) model (Theurer et al 1984). SNTEMP is a one dimensional heat transport model that can, as a function of stream distance and environmental heat flux, predict daily mean and maximum water temperatures based on a dynamic temperature-steady flow equation (Bartholow 1989). Results from the modeling work were used to evaluate the effectiveness of different management actions, and develop strategic recommendations to reduce water temperatures in the Entiat River watershed during critical high temperature periods.

8.5.2 Methods

SNTEMP requires information defining the hydrology, geomorphology, climate, and observed water temperatures within the watershed being modeled. Data defining these processes within the Entiat watershed were collected from the numerous agencies performing other watershed management studies within the Entiat watershed, including the USFS, USGS, CCCD, NRCS, ENTRIX Inc., and WDOE. Figure 8-11 shows a longitudinal profile of the Entiat River node network used for this application of SNTEMP. A node is defined as a location along the river system to which some type of modeling information is assigned, such as hydrology or geomorphology data. Points along the profile depict categories of node type including headwater (H), change (C), validation (V), branch (B), terminal (T) junction (J), and end (E) types.

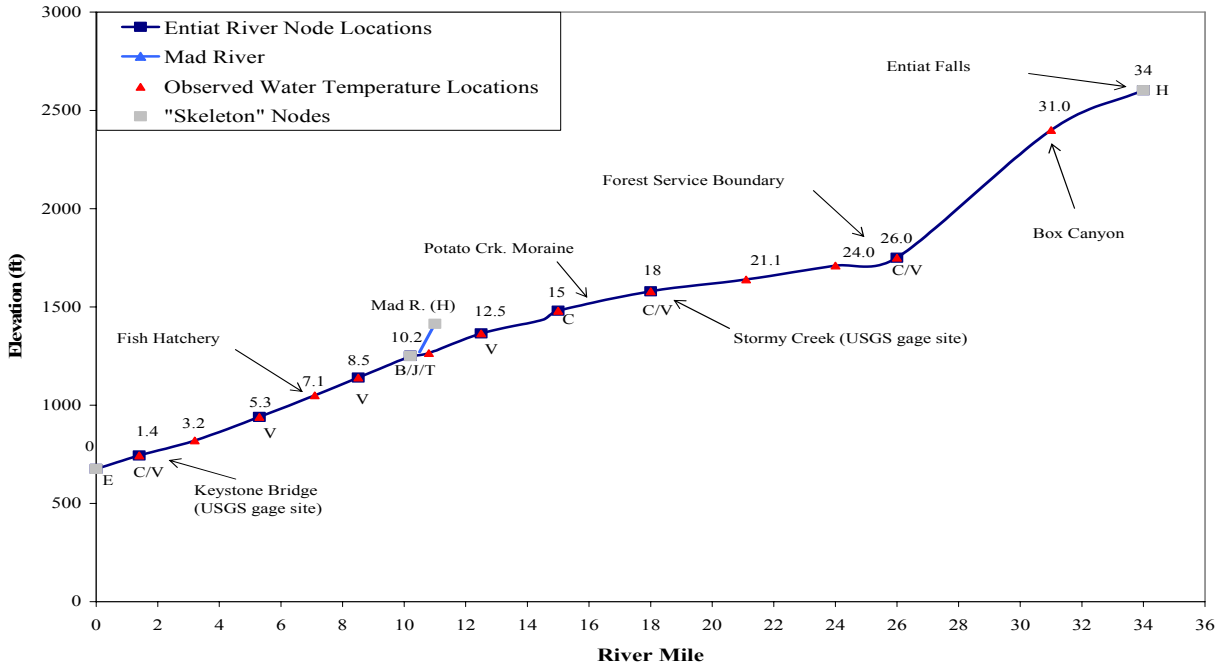


Figure 8-11. Longitudinal profile of the Entiat River illustrating the composite node network of the river and relative river gradient.

The time period August 2 - September 14 during the years 1997-2002 was chosen for modeling based on data availability and model objectives (Hendrick and Monahan 2003). Many years were modeled so that seasonal variability could be captured, assuring that any recommendations based on the results of the modeling effort would be valid for various types of seasons and conditions. After information defining the Entiat River watershed was collected and entered into the SNTEMP model, and a time period was selected, initial calibration model runs were made to assure that the model was accurately and precisely predicting water temperature values, and maximize the reliability of the model in estimating the effects of alternative treatments on water temperature. The model was considered calibrated and therefore accurately and precisely predicting water temperatures, when simulated water temperatures matched observed water temperatures at similar locations for the same time periods within a pre-determined and scientifically accepted range of errors. Figure 8-12 illustrates a linear regression of observed and predicted daily mean water temperatures (˚C) for the Entiat River for the entire modeled period of record. This relationship was evident across the range of temperatures simulated, with close correlation occurring from just below 10 °C to just over 20 °C. The calibrated model showed no trend in error and suggests that it performed well in predicting daily mean water temperatures (Hendrick and Monahan 2003).

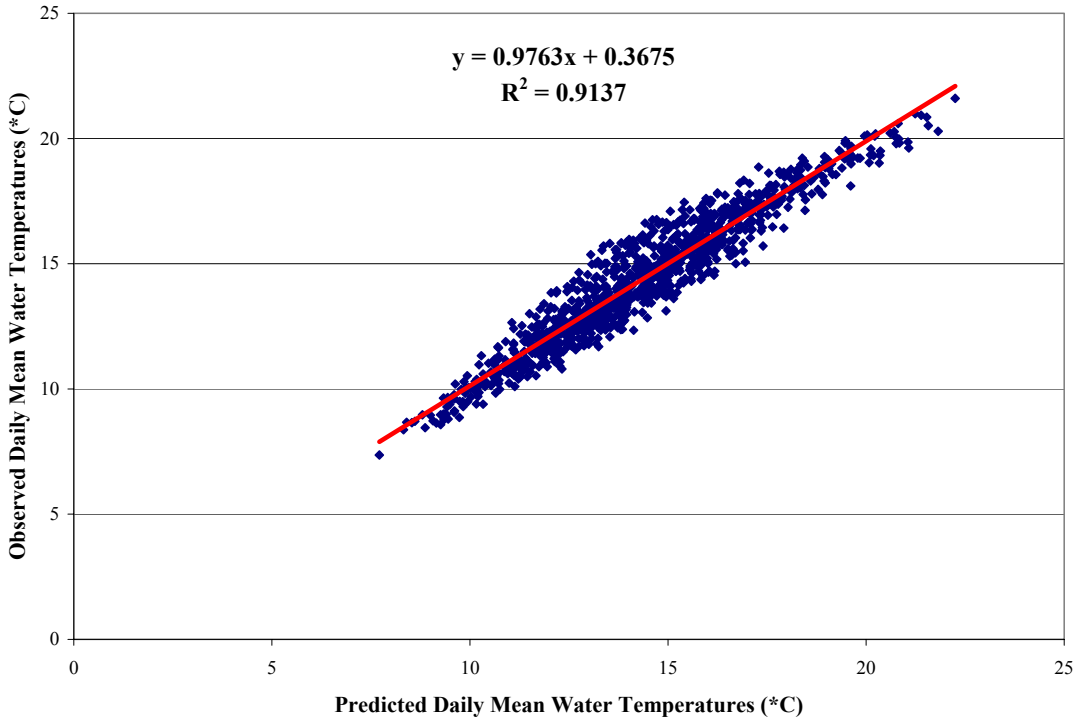


Figure 8-12. Final calibration results showing observed vs. predicted daily mean water temperatures at all validation (V) nodes for all years and time periods simulated.

Table 8-4 on page 8-30 illustrates the summary statistics of the final calibration run. The model performed well and produced a correlation coefficient of 0.9137, a mean error of -0.03°C, a maximum error of -2.34 °C, and a dispersion error of 5.94%. These values are well within the acceptable range of error (see the full SNTEMP Report for more discussion).

Table 8-4. Summary statistics for final SNTEMP model calibration run.

Correlation Coefficient (R^2)	0.9137
Mean Error (°C)	-0.03
Maximum Error (°C)	-2.34
Dispersion Error (%)	5.94

8.5.3 Model Alternatives and Results

With calibration complete, three distinct actions were simulated using SNTEMP: system wide (RM 0-34) increase in streamflow, system wide increase in riparian shade and reduction in stream channel width in the lower river (RMs 0-10) with all other parameters held constant. Ranges of change for each of the alternatives modeled included: increases in streamflow by 10%, 25%, 50%, 150%, 200%, 250%, and 300%; reduction in channel width by 10%, 25%, and 50%; and increases in shade by 10%, 25%, 50%, and 100%. As shade model inputs were already in a percent form, increases in shade were calculated by adding the percent change amount to the observed percent shade condition, Thus, in an area where existing shade was estimated at 10% canopy cover, a 10% increase in shade equates to 10% + 10%, or 20% resultant shade overall. Alternative actions that included combinations of the three actions and ranges of change were also performed to determine which single action or combination of actions best reduced high water temperatures. Alternative actions were developed using guidance from the EWPU and Water Quality subcommittee, and examples from others. Although all aforementioned ranges of change were simulated, not all were considered feasible to implement, e.g. a 25% increase in streamflow, given the current resources and goals of the EWPU.

The SNTEMP model simulated daily maximum water temperatures at 16 nodes over a period of 44 stream-days (08/02 – 09/14) in a year (Hendrick and Monahan 2003). A stream-day is defined as a complete 24 hour period in which daily mean and maximum water temperature data were modeled. Thus, a total of 704 "measurement points" (16 nodes x 44 stream-days = 704) were used to determine the number of temperature exceedences that occurred from 08/02 - 09/14 for each year modeled. Eleven nodes were between RM 0-20 (State water quality Class A, ≤18°C), and five nodes were between RM 20-34 (State water quality Class AA, ≤16°C). Refer to Figure 8-13 on page 8-31 for a depiction of node locations with respect to Class A and Class AA reaches. For each year modeled, the number of times that simulated daily maximum water temperature was above 18°C at each node between RM 0-20, and above 16°C at each node between RM 20-34 was counted, and then compared to the total number of measurement points. For example, in 2001, the number of overall stream-day water temperature exceedences simulated was 510. Therefore, knowing that out of 704 "chances" modeled water temperature exceeded standards 510 times, it can be said that standards were exceeded 72% of the time in 2001 (Hendrick and Monahan 2003).

The total number of temperature exceedences simulated for baseline conditions was compared against the number of exceedences simulated for each "feasible" alternative in order to determine how each alternative action reduced the number of predicted exceedences. Figure 8-14 on page 8-32 summarizes the number of stream day exceedences modeled for select alternative actions. Table 8-5 on page 8-33 shows the

number of stream-day exceedences for the Class AA water quality standard, Class A water quality standard, as well as the system-wide total number (Class AA + Class A) of exceedences for each year simulated (1997-2002). The table also shows the percent value of exceedences. Table 8-6 on page 8-34 shows similar values but is limited to RMs 0-10 in order to illustrate effects of alternative actions in this reach. This was necessary to understand the predicted effects of alternative actions that included reducing channel width in the lower 10 RMs.

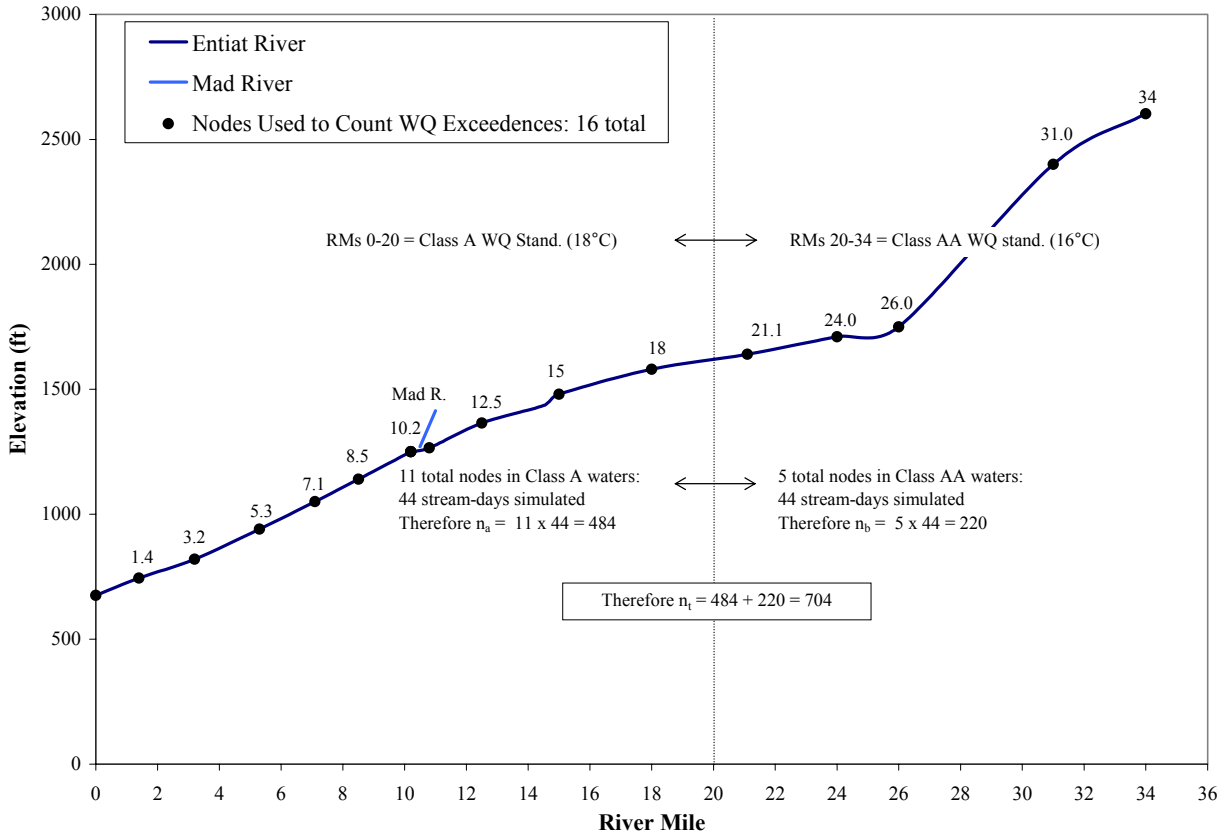
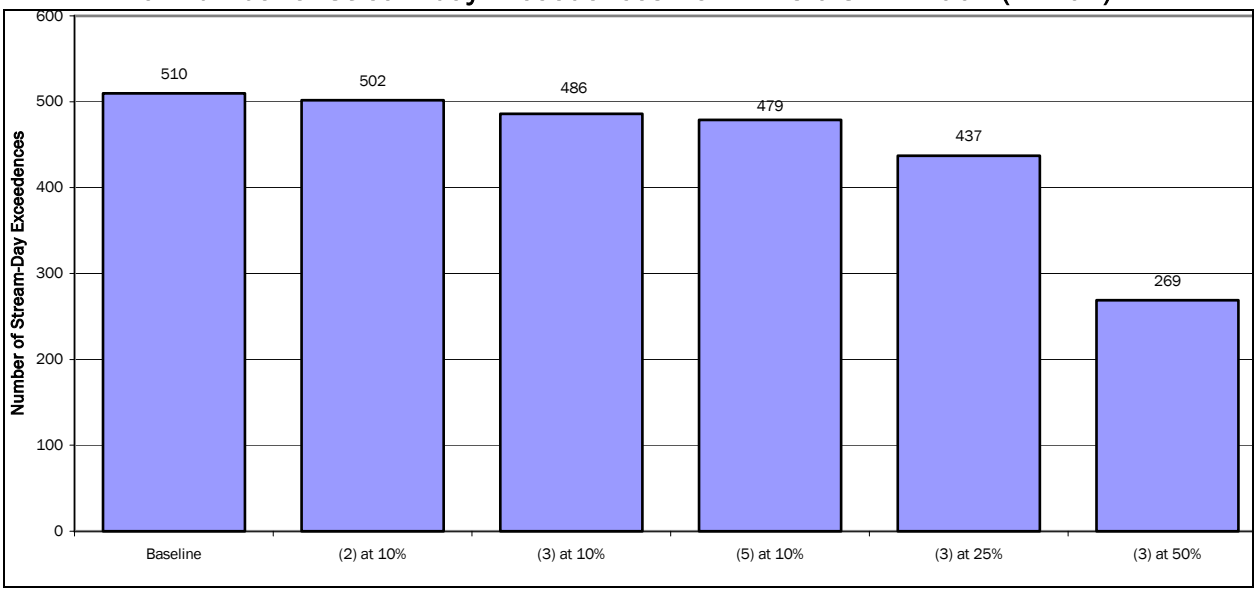


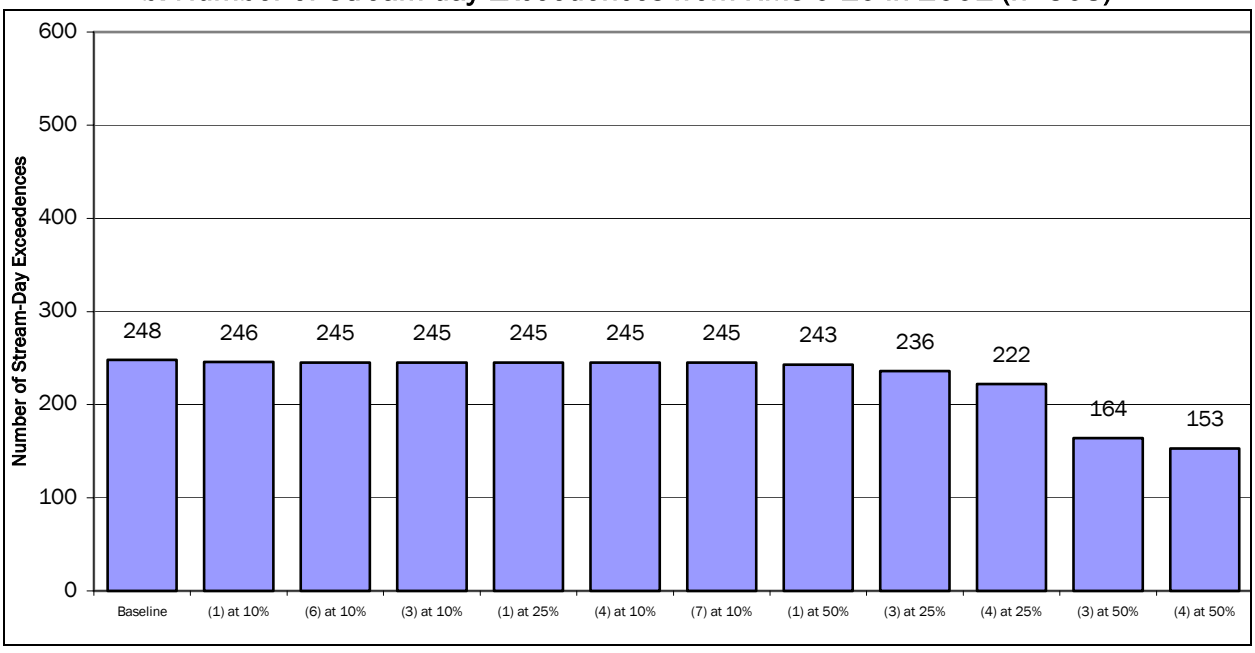
Figure 8-13. Longitudinal profile of Entiat River showing the location and total number of nodes (labeled by RM) used as simulated "measurement points" for counting exceedences for each time period/year simulated.

a. Number of Stream-day Exceedences from RMs 0-34 in 2001 (n=704)



Alternative Action Number Key:
(2) = Increase Streamflow in RMs 0-34
(3) = Increase Riparian Shade in RMs 0-34
(5) = Increase Streamflow AND Riparian Shade in RMs 0-34

b. Number of Stream-day Exceedences from RMs 0-10 in 2001 (n=308)



Alternative Action Number Key:
(1) = Decrease Channel Width in lower 10 RMs; (3) = Increase Riparian Shade in RMs 0-34
(4) = Increase Riparian Shade (in RMs 0-34) AND Decrease Channel Width (in lower 10 RMs)
(6) = Increase Streamflow (in RMs 0-34) AND Decrease Channel Width (in lower 10 RMs)
(7) = Increase Streamflow AND Riparian Shade (in RMs 0-34) AND Decrease Channel Width (in lower 10 RMs)

Figure 8-14. Number of stream-day water temperature exceedences for simulated baseline conditions and alternative actions for RMs 0-34 (a) and RMs 0-10 (b) during the 8/2/01-9/14/01 (44 day) time period.

Table 8-5. Exceedence table showing the number of state water quality exceedences for simulated baseline conditions, percent of exceedences based on total number of "measurement" points (n), and proposed alternative actions system wide (RMs 0-34).

Alt. Action	Exceedences		Alt. Action	Exceedences		Alt. Action	Exceedences		Alt. Action	Exceedences		Alt. Action	Exceedences		Alt. Action	Exceedences	
	#	%		#	%		#	%		#	%		#	%		#	%
Class AA	*n*=220																
1997			**1998**			**1999**			**2000**			**2001**			**2002**		
Baseline	**33**	15.00	Baseline	**146**	66.36	Baseline	**3**	1.36	Baseline	**54**	24.55	Baseline	**141**	64.09	Baseline	**102**	46.36
(2) at 10%	**26**	11.82	(2) at 10%	**141**	64.09	(2) at 10%	**3**	1.36	(2) at 10%	**46**	20.91	(2) at 10%	**137**	62.27	(2) at 10%	**95**	43.18
(3) at 10%	**17**	7.73	(3) at 10%	**133**	60.45	(3) at 10%	**2**	0.91	(3) at 10%	**32**	14.55	(3) at 10%	**130**	59.09	(3) at 10%	**78**	35.45
(5) at 10%	**12**	5.45	(5) at 10%	**125**	56.82	(5) at 10%	**2**	0.91	(5) at 10%	**25**	11.36	(5) at 10%	**126**	57.27	(5) at 10%	**67**	30.45
(3) at 25%	**1**	0.45	(3) at 25%	**94**	42.73	(3) at 25%	**0**	0.00	(3) at 25%	**8**	3.64	(3) at 25%	**109**	49.55	(3) at 25%	**39**	17.73
(3) at 50%	**0**	0.00	(3) at 50%	**29**	13.18	(3) at 50%	**0**	0.00	(3) at 50%	**0**	0.00	(3) at 50%	**60**	27.27	(3) at 50%	**0**	0.00
Class A	*n*=484																
1997			**1998**			**1999**			**2000**			**2001**			**2002**		
Baseline	**194**	40.08	Baseline	**396**	81.82	Baseline	**56**	11.57	Baseline	**226**	46.69	Baseline	**369**	76.24	Baseline	**318**	65.70
(2) at 10%	**174**	35.95	(2) at 10%	**381**	78.72	(2) at 10%	**44**	9.09	(2) at 10%	**217**	44.83	(2) at 10%	**365**	75.41	(2) at 10%	**294**	60.74
(3) at 10%	**155**	32.02	(3) at 10%	**361**	74.59	(3) at 10%	**34**	7.02	(3) at 10%	**194**	40.08	(3) at 10%	**356**	73.55	(3) at 10%	**271**	55.99
(5) at 10%	**137**	28.31	(5) at 10%	**350**	72.31	(5) at 10%	**25**	5.17	(5) at 10%	**175**	36.16	(5) at 10%	**353**	72.93	(5) at 10%	**255**	52.69
(3) at 25%	**88**	18.18	(3) at 25%	**310**	64.05	(3) at 25%	**16**	3.31	(3) at 25%	**129**	26.65	(3) at 25%	**328**	67.77	(3) at 25%	**206**	42.56
(3) at 50%	**12**	2.48	(3) at 50%	**179**	36.98	(3) at 50%	**0**	0.00	(3) at 50%	**34**	7.02	(3) at 50%	**209**	43.18	(3) at 50%	**79**	16.32
Total	*n*=704																
1997			**1998**			**1999**			**2000**			**2001**			**2002**		
Baseline	**227**	32.24	Baseline	**542**	76.99	Baseline	**59**	8.38	Baseline	**280**	39.77	Baseline	**510**	72.44	Baseline	**420**	59.66
(2) at 10%	**200**	28.41	(2) at 10%	**522**	74.15	(2) at 10%	**47**	6.68	(2) at 10%	**263**	37.36	(2) at 10%	**502**	71.31	(2) at 10%	**389**	55.26
(3) at 10%	**172**	24.43	(3) at 10%	**494**	70.17	(3) at 10%	**36**	5.11	(3) at 10%	**226**	32.10	(3) at 10%	**486**	69.03	(3) at 10%	**349**	49.57
(5) at 10%	**149**	21.16	(5) at 10%	**475**	67.47	(5) at 10%	**27**	3.84	(5) at 10%	**200**	28.41	(5) at 10%	**479**	68.04	(5) at 10%	**322**	45.74
(3) at 25%	**89**	12.64	(3) at 25%	**404**	57.39	(3) at 25%	**16**	2.27	(3) at 25%	**137**	19.46	(3) at 25%	**437**	62.07	(3) at 25%	**245**	34.80
(3) at 50%	**12**	1.70	(3) at 50%	**208**	29.55	(3) at 50%	**0**	0.00	(3) at 50%	**34**	4.83	(3) at 50%	**269**	38.21	(3) at 50%	**79**	11.22

Alternative Action (#) Legend
(2) = Increase Streamflow in RMs 0-34
(3) = Increase Riparian Shade Values in RMs 0-34
(5) = Increase Streamflow AND Increase Riparian Shade in RMs 0-34

Table 8-6. Exceedence table showing the number of state water quality exceedences for simulated baseline conditions, percent exceedences based on total number of "measurement" points (n), and proposed alternative actions in the lower 10 RMs.

Alt. Action	Exceedences		Alt. Action	Exceedences		Alt. Action	Exceedences		Alt. Action	Exceedences		Alt. Action	Exceedences		Alt. Action	Exceedences	
	#	%		#	%		#	%		#	%		#	%		#	%
	n=308																
1997			**1998**			**1999**			**2000**			**2001**			**2002**		
Baseline	**171**	55.52	Baseline	**279**	90.58	Baseline	**52**	16.88	Baseline	**191**	62.01	Baseline	**248**	80.52	Baseline	**250**	81.17
(1) at 10%	**158**	51.30	(1) at 10%	**275**	89.29	(1) at 10%	**43**	13.96	(1) at 10%	**187**	60.71	(1) at 10%	**246**	79.87	(1) at 10%	**242**	78.57
(1) at 25%	**145**	47.08	(6) at 10%	**268**	87.01	(1) at 25%	**34**	11.04	(6) at 10%	**177**	57.47	(6) at 10%	**245**	79.55	(6) at 10%	**230**	74.68
(6) at 10%	**144**	46.75	(3) at 10%	**267**	86.69	(3) at 10%	**33**	10.71	(1) at 25%	**174**	56.49	(3) at 10%	**245**	79.55	(1) at 25%	**229**	74.35
(3) at 10%	**140**	45.45	(1) at 25%	**266**	86.36	(6) at 10%	**32**	10.39	(3) at 10%	**168**	54.55	(1) at 25%	**245**	79.55	(3) at 10%	**223**	72.40
(4) at 10%	**132**	42.86	(4) at 10%	**265**	86.04	(4) at 10%	**27**	8.77	(4) at 10%	**160**	51.95	(4) at 10%	**245**	79.55	(4) at 10%	**215**	69.81
(7) at 10%	**114**	37.01	(7) at 10%	**262**	85.06	(7) at 10%	**23**	7.47	(7) at 10%	**149**	48.38	(7) at 10%	**245**	79.55	(7) at 10%	**204**	66.23
(1) at 50%	**101**	32.79	(1) at 50%	**255**	82.79	(1) at 50%	**21**	6.82	(1) at 50%	**146**	47.40	(1) at 50%	**243**	78.90	(1) at 50%	**198**	64.29
(3) at 25%	**87**	28.25	(3) at 25%	**243**	78.90	(3) at 25%	**16**	5.19	(3) at 25%	**121**	39.29	(3) at 25%	**236**	76.62	(3) at 25%	**176**	57.14
(4) at 25%	**57**	18.51	(4) at 25%	**225**	73.05	(4) at 25%	**10**	3.25	(4) at 25%	**93**	30.19	(4) at 25%	**222**	72.08	(4) at 25%	**155**	50.32
(3) at 50%	**12**	3.90	(3) at 50%	**158**	51.30	(3) at 50%	**0**	0.00	(3) at 50%	**34**	11.04	(3) at 50%	**164**	53.25	(3) at 50%	**78**	25.32
(4) at 50%	**0**	0.00	(4) at 50%	**109**	35.39	(4) at 50%	**0**	0.00	(4) at 50%	**8**	2.60	(4) at 50%	**153**	49.68	(4) at 50%	**26**	8.44

Alternative Action (#) Legend
(1) = Decrease Channel Width in lower 10 RMs
(3) = Increase Riparian Shade Values in RMs 0-34
(4) = Increase Riparian Shade (in RMs 0-34) AND Decrease Channel Width (in lower 10 RMs)
(6) = Increase Streamflow (in RMs 0-34) AND Decrease Channel Width (in lower 10 RMs)
(7) = Increase Streamflow AND Increase Riparian Shade (in RMs 0-34) AND Decrease Channel Width (in lower 10 RMs)

The SNTEMP model predicted reductions in water temperatures for all three system-wide alternative actions, suggesting that implementation of any of the three actions will help reduce summer water temperatures to some extent (Hendrick and Monahan 2003). Of the feasible alternatives, SNTEMP predicted the largest reduction in water temperature exceedences when riparian shade was increased over the long term by 50% throughout the system (Alternative Action 3). Alternative Action 4, which included a 50% increase in riparian shade in RMs 0-34[2] *and* a 50% reduction in channel width in the lower 10 miles of the Entiat River, produced the most significant change in the number of temperature exceedences in that portion of the system (Hendrick and Monahan 2003).

Although none of the alternative actions completely reduce water temperatures to or below current state water quality standards during the hottest day of each year simulated (see full report), increasing riparian shade and decreasing channel width (Alternative Actions 3 and/or 4) could produce, in addition to reductions in high water temperatures, other positive effects on the overall health of the Entiat River watershed. Increasing current riparian shade conditions system-wide has the potential to increase biological diversity within the watershed and increase nutrient sources for fish species (Andonaegui 1999). Increases in riparian vegetation and shade could also provide a potential source for large woody debris placement (an important component of fish habitat), refuge from predators and extreme environmental events, and buffer the effects of erosive forces (Andonaegui 1999).

Decreasing channel width in the lower 10 RMs has the potential to improve fish passage, and further enhance the effectiveness of increased riparian vegetation in the summer as well as the winter, when low temperatures are also a concern (CCCD 2002). The Planning Unit installed three rock cross vanes in the lower river in 2001 to help restore habitat complexity (resting pools) and modify channel geometry. Installing additional instream structures to reduce width to depth ratios would also support habitat improvement objectives.

For additional information on riparian condition, channel morphology, temperature and fish habitat conditions, refer to Chapter 7, Habitat.

[2] Due to variation over this 34 mile reach riparian restoration and enhancement efforts will not be applied systematically throughout. The goal is to attain a certain percentage of site potential shade. Sites will be prioritized for planting.

9.0 RECOMMENDATIONS

9.1 INTRODUCTION

This chapter is the heart of the WRIA 46 Management Plan. The Watershed Assessment Entiat Analysis Area (USFS WNF 1996), Entiat River Inventory and Analysis (CCCD 1998), and Final Coordinated Resource Management Plan/First Draft WRIA 46 Plan (CCCD 2002) provide the foundation for this document. Significant issues identified during the watershed assessment work conducted over the last ten years are documented here. This chapter describes existing conditions underlying each of these issues and, most importantly, details recommended actions that best respond to issues. Other management strategies specifically tailored to address resource issues on National Forest System and BLM lands in WRIA 46 are documented in the Chapter 2 Synthesis Summary Tables.

The Planning Unit deems that all of the data, methodologies and assessments contained in this document are the best science available given the time and funding expended to date. Therefore, the EWPU recommends that the results from these studies be used to move forward with the actions contained in this chapter.

Recommendations in this chapter are designed to help attain the community, economic, and ecologic objectives captured in the Vision and Goals of the Planning Unit. This chapter includes recommendations for:

- implementation of actions to address issues;
- monitoring to evaluate resource conditions and the results of our actions; and
- additional studies needed to better understand some priority resource conditions.

Section 9.2, General Recommendations, outlines actions that are needed to maintain the basic framework necessary for implementation of this plan. Sections 9.3 through 9.5 group recommendations by analysis component (water quantity, instream flow, habitat and water quality) and references are provided to the chapter(s) in the plan where supporting information is contained. Section 9.6 includes a set of additional issues that span multiple resource issues.

Although this chapter categorizes recommendations, it is important to recognize that all recommendations are intertwined and compliment one another. An action like changing channel geometry (shape), listed in the “Habitat” section, will improve habitat but also help water quality and instream flow conditions, as well as mitigate for future water uses.

The strength of this plan derives from two fundamental points:

1) ***Development of the plan occurred via a local effort to address both community and ecological issues***. Recommendations have been designed to help meet resident's goals that include retaining the quality of life and rural feel of the Entiat valley, supporting agricultural production, avoiding further reduction of the tax base, and promoting community unity and moderate growth in the years to come; and

2) ***Implementation has been locally driven and collaborative***. The participation of many landowners, agencies, tribes and other stakeholders has enabled the development of strategic partnerships and coordinated action. Projects must continue to be implemented in an informed and coordinated manner, recognizing the many linkages that exist between components in this plan.

Projects proposed in the Entiat WRIA by groups involved with development and implementation of activities stemming from other planning efforts should look to the recommendations provided in this document for overall guidance and strategic direction. It is critical for the successful implementation of this plan that these groups communicate/coordinate their actions with the CCCD/EWPU. Care must be taken not to implement one recommendation independent of the other recommendations without consideration of how singular action may affect other related actions. The Planning Unit hopes to continue serving in an advisory capacity throughout the implementation of this plan in order to assure that future projects are complementary and cost-efficient.

9.1.1 Overarching Principles

The Entiat has a long history of citizen participation in resource management efforts. The Planning Unit recognizes the close connection between community well-being and watershed conditions, and as a result a set of basic principles regarding the past, present and future of WRIA 46 became clear during this planning process. The Planning Unit therefore acknowledges the following overarching principles:

- Continued community participation and involvement with the EWPU is necessary to ensure its future success and achievement of the group's vision and goals;
- Future projects proposed in the WRIA need to be communicated to and coordinated with the CCCD/Planning Unit in order to reduce duplication of effort and assure compatibility with this strategic plan;
- Monitoring and continual feedback are key to the design of future projects and tracking progress towards the achievement of desired results;
- Surface and ground water in the subbasin have a high degree of connectivity; therefore surface and groundwater in the watershed should be treated as one source for all water quality, quantity, habitat and instream flow actions;
- The upper Entiat River watershed from RM 10.5 (Mad River confluence) upstream is highly functioning and the priority should be anti-degradation and protection of existing conditions, particularly in the stillwater reach;

- The lower Entiat River from the Mad River confluence (RM 10.5) downstream has been most influenced by past activities and should be the priority area for active restoration projects; and
- The tributaries to the mainstem Entiat River are in relatively good condition with respect to water quality; however, variability in habitat and water quality conditions exists.

9.2 GENERAL RECOMMENDATIONS

The following general recommendations outline the framework necessary for successful implementation of this plan:

- The base structure for plan implementation (Phase 4) should at a minimum consist of continuing the Planning Unit's role as the overall coordination and advisory group, and the CCCD's role of administrative and project support;
- The EWPU should encourage expansion of participation on the Planning Unit via outreach to other stakeholders/community members in order to assure its continued success and support of plan recommendations;
- The EWPU and CCCD should continue to promote and implement collaborative projects and perform monitoring;
- The CCCD and EWPU should continue their support of legislation, project grant proposals, etc. submitted by others for actions or activities that contribute to achievement of WRIA 46 plan goals and recommendations;
- County planning regarding land use should be coordinated with the EWPU and reflect the science in the Entiat Plan;
- Community vitality of the Entiat valley should be addressed during County land use planning and other land development and protection activities;
- State, Federal, Tribal, Local Government, Foundations, local contributions and other funding sources should be secured to continue to support the Planning Unit coordination, administration and facilitation roles of the CCCD, and to fund District staff technical assistance supporting development and implementation of plan recommendations;
- The CCCD should continue to develop and support the Entiat Geographic Information System (EGIS) and maintain its role as primary clearinghouse for WRIA 46 GIS data;
- The Planning Unit should to continue to use EGIS for information sharing and analysis, and further explore potential of the tool;
- Monitoring in the Entiat River watershed should be done using protocols consistent with Upper Columbia Salmon Recovery Board (UCSRB) Regional Technical Team (RTT) "Monitoring Strategy for the Upper Columbia Basin" (Hillman 2003, *draft*); and
- The CCCD, on behalf of the Planning Unit, should pursue funding to implement monitoring according to the above strategy.

9.3 WATER QUANTITY AND INSTREAM FLOWS

Recommendations in this section are based on information contained in Chapters 4 and 5 of this document, the Entiat Coordinated Resource Management Plan/First Draft WRIA 46 Plan (CCCD 2002) and other supporting technical documents.

1) At present there is no formal program established directing the management of water resources in the Entiat River subbasin. Recognizing the need for a system of managing water resources that balances the instream and out-of-stream needs for water in the subbasin and other resource management objectives, the Planning Unit has developed water resource management recommendations and instream flow recommendations as part of the WRIA 46 watershed planning process. The WDOE, Chelan County and the Planning Unit should work together to implement these recommendations as a complete package:
   - WDOE and the Planning Unit should initiate rule making (Chapter 173-546 WAC and/or other) within one (1) year of adoption of this plan by Chelan County to create a water resource management program that includes a reserve of water for future uses prioritized by use type, qualifying criteria for accessing reserve water, and to establish minimum instream flows in WRIA 46 based on proposed Administrative Instream Flow regimes (see Chapter 5 for biological rationale, percent exceedence values, and additional data pertinent to proposed Administrative Instream Flows listed in the table below);

Recommended Administrative Instream Flows

Time Period	Lower Entiat River, Tied to Keystone Gage	Upper Entiat River, Tied to Stormy Gage	Mad River, tied to Mad at Ardenvoir Gage
January	185	175	32
February	185	175	32
March 1-15	185	175	32
March 16-31	250	285	68
April 1-15	250	325	100
April 16-30	350	375	100 Plus 25 cfs limit on new water rights.
May 1-15	474 Plus a 100 cfs limit on new rights.	375 Plus a 100 cfs limit on new water rights.	100 Plus a 25 cfs limit on new water rights
May 16-31	720 Plus a 100 cfs limit on new water rights.	375 Plus a 100 cfs limit on new water rights.	100 Plus a 25 cfs limit on new water rights
June 1-15	898 Plus a 100 cfs limit on new water rights.	325 Plus a 100 cfs limit on new water rights.	100 Plus a 25 cfs limit on new water rights.
June 16-30	617 Plus a 100 cfs limit on new water rights.	325 Plus a 100 cfs limit on new water rights.	100 Plus a 25 cfs limit on new water rights.

July 1-15	359 Plus a 67 cfs limit on new water rights.	275 Plus a 67 cfs limit on new rights.	68
July 16-31	268	275	68
August 1-15	185	275	68
August 16-31	185	275	51
September	185	175	32
October	185	175	32
November	185	175	32
December	185	175	32

- The WDOE and the Planning Unit should consider rulemaking to implement Planning Unit Instream Flow recommendations and associated habitat and water quality actions to assure compliance with the Clean Water Act, the Salmon Recovery Act and/or other non-water resource management programs and laws; (see Chapter 5 for biological rationale and additional data pertinent to proposed Planning Unit Instream Flows listed in the table below);

Proposed Planning Unit Instream Flows

Time Period	Lower Entiat River Range, tied to Keystone Gage	Upper Entiat River Range, tied to Stormy Gage	Mad River Range, tied to Mad at Ardenvoir Gage
January	130 (130-145)	120 (110-130)	25 (20-30)
February	130 (130-145)	120 (110-130)	25 (20-30)
March	130 (130-145)	120 (110-130)	31 (30-35)
April	270 (260-290)	240 (240-325)	70
May	474	480	70
June	540 (520-580)	480	55
July	165	275	55
August	165	180	40
September	165	125 (120-135)	25 (20-30)
October	165 (150-185)	120 (110-130)	25 (20-30)
November	130 (130-145)	120 (110-130)	25 (20-30)
December	130 (130-145)	120 (110-130)	25 (20-30)

- The State of Washington, Chelan County, and others responsible for administration of water resources in the Entiat River subbasin shall allow continuation of permit-exempt wells and associated uses as a legal means of appropriating water;

- The Planning Unit should continue to work with the WDOE to set priorities for future water allocations and reserve water use; determine method for processing pending applications and handling of previously conditioned water rights; define how State Trust Water Program, USBR water leasing, and other banking options will be used; outline procedures for use of conserved water and use of stored water; and making determination of water availability. This program should be documented in the detailed implementation plan within one (1) year of initiation of implementation plan development;
- The Planning Unit recommends that any reserve established in rule should be split into categories for management and tracking purposes. For example "residential" use should be split between "in-house domestic" and "domestic irrigation" water use components and higher priority should be assigned to "in-house domestic" use to assure certainty of future in-house domestic use well into the future; and
- The Planning Unit recommends that reserve water for new commercial, agricultural and light industrial enterprises should be limited to use in the lower Entiat River, below the stillwater area (RM 16.2), but that residential water use continue to be allowed above this point.

2) There is a great deal of disparity between actual water use and the amount of water represented by rights and claims. Documentation that most closely reflects actual water use is necessary for effective water resource management:
   - A priority action is for the Department of Ecology to work with the planning unit to develop the most defensible means to address uncertainties in the water rights and claims record, such as on a case-by-case basis, general adjudication, or other legal means that may become available to clean up the paper record. The Department of Ecology and Planning Unit should agree to a course of action within one (1) year of initiation of implementation plan development;
   - The WDOE and Planning Unit should host community workshops to share information about the WRIA 46 water rights and claims data, and water resource management goals in the Entiat subbasin;
   - WDOE should continue to provide technical assistance and cost share on equipment for water metering;
   - WDOE should continue to provide education and technical assistance to residents to assure reporting is done in a timely manner, and using formats and procedures to facilitate the rapid transfer of information to interested persons like the members of the Planning Unit;
   - The Planning Unit should promote community water metering to record actual water use and provide a means to monitor gains in efficiency and losses attributable to new uses or changes in system operation;
   - The CCCD, on behalf of the Planning Unit should establish a reporting mechanism / agreement between Chelan County and the CCCD/Planning Unit to share information on permit exempt wells associated with new construction. This should be done within one (1) year of initiation of implementation plan development; and
   - The Planning Unit should work with willing citizens in the watershed to meter single household domestic permit exempt wells throughout a representative cross-section of the watershed to refine in-house domestic water use estimates and plan content.

3) Some water right holders in the Entiat River watershed may not currently be exercising some/all of their water right, yet they want to prevent relinquishment while others need water:
   - The Planning Unit should host and the State of Washington and partners should support a State Trust Water Program workshop, available to all Entiat valley landowners defining the trust water program, water acquisition program, water right lease options, water transfer option, and related opportunities (USBR). This workshop should be held within one (1) year of adoption of this plan by Chelan County, so that a specific program can be included in the detailed implementation plan; and
   - The Planning Unit should work with the Department of Ecology to develop a detailed water conservation, trust water, and water acquisition program for the Entiat River subbasin in order to help assure adequate water for community growth in the future, and include said program in its detailed implementation plan.

4) Water conservation in the Entiat River watershed will help meet management goals and provide additional water for instream and out-of-stream uses:
   - The Planning Unit and local partners should continue to pursue water conveyance efficiency improvements throughout the Entiat watershed;
   - The Planning Unit, U.S. Bureau of Reclamation (USBR), the Natural Resource Conservation Service (NRCS), and the CCCD should continue to work on alternative projects to consolidate the Knapp-Wham and Hanan-Detwiler irrigation ditches ;
   - The Planning Unit should encourage all Entiat River watershed water users to work to convert open irrigation systems to piped systems as assisted by local, state, federal, and tribal partners;
   - The CCCD and Planning Unit should continue to seek funding from USBR and partners to upgrade inefficient/ineffective surface water diversion structures;
   - The Planning Unit should explore use of the voluntary Comprehensive Irrigation District Management Process (CIDMP) and other resources available to Districts, either through the existing Entiat Irrigation District and/or potential new district;
   - The CCCD and Planning Unit should work with the City of Entiat and Entiat Irrigation District to obtain funds for a feasibility study for extending City of Entiat municipal water system and Entiat Irrigation District irrigation distribution systems upstream to serve new uses, and to consolidate existing uses;
   - The Planning Unit recommends that water users in the Entiat River watershed continue conversion of surface water diversions to ground water / well withdrawals when/where feasible;
   - The NRCS and other partners should continue to provide technical and financial assistance to improve on-farm irrigation application efficiency, scheduling, and promote/improve water conservation.
     - Encourage Federal Government to fully fund farm bill programs and other cost-share programs supporting water conservation work;
   - The State should continue to fund Referendum 38 (improvements to public water-supply systems and public irrigation districts);
   - The Planning Unit and partners should promote water efficient landscaping, and host a workshop and/or trade show available to local water users; and

- The City of Entiat and appropriate system managers should solicit training from the Department of Ecology and other appropriate entities, within six (6) months of adoption of this plan by Chelan County, regarding reclaimed water use.

5) While the existing entities responsible for resource management in the Entiat River watershed are working well together through the Entiat WRIA Planning Unit, institutional changes or creation of additional institutions may be necessary to more fully implement water and other natural resource management recommendations in the Entiat subbasin:
   - Local irrigators should explore the potential of consolidating the Knapp-Wham, Hanan-Detwiler, and possibly other systems into a single irrigation district under Chapter 87.03 Revised Code of Washington (RCW). Recommendations regarding organization under Chapter 87.03 RCW should be included in the detailed implementation plan within one (1) year of adoption of this plan by Chelan County; and
   - The Planning Unit recommends that a local water advisory group be established, potentially as a sub-committee of the Planning Unit, to track implementation of the water resources management program, recommended instream flows, and related activities that will be codified in Chapter 173-546 (and/or other chapter) WAC.

6) This plan has determined that if the recommended water resource program is fully implemented, water will be available for storage in the Entiat River subbasin. However, suitable storage sites and feasibility of their construction have not yet been fully explored:
   - The CCCD, on behalf of the Planning Unit, should assure that a study or studies be completed to explore surface water and ground water storage options and identify potential locations either on the surface or in sub-surface confined or unconfined alluvial aquifers, in order to provide additional water for future community growth and beneficial out-of-stream uses; and
   - Any potential storage sites and estimates of costs required to establish the sites should be included in the detailed implementation plan.

7) Areas of surface water-groundwater interchange and subsurface water movement affect the ability of water managers to carefully manage water resources, water quality, instream flow, and habitat programs in the watershed. These interchange and sub-surface flow areas are not fully understood:
   - The CCCD should work with WDOE and other staff to update NWI data to reflect known, field checked wetlands in the WRIA (to help show areas of interaction);
   - The CCCD, on behalf of the Planning Unit, should assure that areas of subirrigated pasture identified by CWU assessment are adequately checked against actual conditions;
   - The CCCD, on behalf of the Planning Unit, should pursue funding of a study of flows through alluvial fans;
   - The CCCD, on behalf of the Planning Unit, should pursue opportunities for additional gain loss study work during July (highest irrigation use month) and October (lowest flow period), prior to rains if possible, to capture data after most irrigation ends;

- The CCCD, on behalf of the Planning Unit, should seek funding for a study of water exiting the watershed as surface water vs. groundwater; and
- The Planning Unit should use the supplemental assessments described above to refine water resource, instream flow, habitat, and water quality recommendations. The CCCD is should continue providing planning unit members new information when collected, convening the Planning Unit, and facilitating and documenting plan revisions.

9.3.1 Monitoring - water quantity and instream flows

Recommendations in this section are based on information contained in Chapter 4, Water Quantity and Chapter 5, Instream Flows, as well as Chapter 10, Monitoring. These monitoring recommendations pertain specifically to future water resource management in the Entiat subbasin, and are therefore contained as a subsection of 9.3. It is essential to monitor and evaluate water resource actions over time in order to help assure that goals and objectives are being met and determine the efficacy of actions. Additionally, this feedback is necessary for the development of future projects and refinement of plan recommendations.

- The CCCD, on behalf of the Planning Unit, should pursue state, federal, tribal, local, foundation, and other funding to continue monitoring at all existing streamflow and ambient gages. Priority is assigned to assuring that the three (3) USGS streamflow gages (Keystone, Stormy, and Mad at Mill Camp) continue over the long term as administrative and planning unit instream flow recommendations are associated with these gages;
- The CCCD and City of Entiat, on behalf of the Planning Unit, should find funding and willing participants to continue domestic well monitoring and try to fill in geographic gaps in the network with new participants;
- The CCCD, on behalf of the Planning Unit, should continue monitoring population growth on an annual basis using the State of Washington (OFM estimates) and on a decadal basis using federal census data to refine growth, land-use, and water use projections and recommended actions;
- The CCCD, on behalf of the Planning Unit, should track exempt well development annually using WDOE data and proposed County tracking mechanism to assist the to-be-established local water advisory group's efforts to assure full implementation of this plan and to recommend changes as necessary;
- The CCCD, on behalf of the Planning Unit, should monitor new construction occurring using County Planning Department permit data, and provide this information to the to-be-established local water advisory group to assure full implementation of this plan and to recommend changes as necessary;
- The CCCD, on behalf of the Planning Unit, should track new water right applications, permits, certificates, claims and associated geographic and water volumes annually in coordination with WDOE. This information should be provided to the to-be-established local advisory group to assure full implementation of this plan and to recommend changes as necessary;

- The CCCD, EWPU, USFS and partners should support reactivation of the Entiat Experimental Forest project in order to collect additional data, and data collected subsequent to reactivation should by shared with the Planning Unit on an annual basis; and
- Chelan County should reassess land use and the Planning Unit should find funding to reassess water use every 5 years, and the CCCD, on behalf of the Planning Unit, should provide this information to the to-be-established local advisory group to assure full implementation of this plan and to recommend changes as necessary.

9.4 HABITAT

Habitat recommendations contained in this section are based on information in Chapter 7 of this plan, and supporting documents. They incorporate and build upon recommended actions that have already been committed to by the Planning Unit, such as those contained in the Entiat River Inventory and Analysis (CCCD 1998; see Reports folder on the CD) and Final Entiat Coordinated Resource Management Plan (CCCD 2002).

1) Stream channel geometry (shape) in the upper Entiat River (RM 16.2 to RM 33.8) has not been significantly affected by human actions in the watershed. Channel geometry in the lower Entiat River (RM 16.2 to mouth) has been modified by past human activities including bank armoring, channelization, woody debris removal, and removal of riparian vegetation particularly from the Mad River confluence (RM 10.5) downstream to the confluence of the Entiat and Columbia Rivers.
   - The CCCD and partners should seek funding, permitting, means to monitor and otherwise fully implement Ecosystem Diagnosis and Treatment (EDT) Alternative 5, on behalf of the Planning Unit. This alternative incorporates the strategic actions (instream structures, revegetation) outlined in Alternative 4 of the Entiat River Inventory and Analysis, and includes additional steps modeled with EDT such as the reconnection of off channel habitats, placement of large woody debris structures in the stillwater reach of the upper Entiat, and habitat protection (see table below).

EDT Alternative Management Scenarios

Actions	Cross Vanes or other instream structures (Reaches 2-9)	Riparian Plantings (Reaches 2-9)	Log / LWD Placement	Side Channel Connection (Reach 3)	Irrigation Ditch as Habitat	Habitat Protection and Restoration (Reaches 10,11,12)
Alternatives	(structures)	(lineal feet)	(sites)	Yes / No	Yes / No	(sites)
1	20	10,000	5	No	No	No
2	40	20,000	10	No	No	No
3	80	40,000	20	No	No	No
4	80	40,000	20+	Yes / No	Yes / No	Yes / No
5	80	50,000	40	Yes / No	Yes / No	Yes / No

- Habitat protection projects such as the establishment of conservation easements, leases, and other options should first be pursued with willing landowners rather than outright property acquisition (in order to preserve community tax base);
- The CCCD and partners, on behalf of the Planning Unit, should continue active restoration work in the "Bridge to Bridge" reach (~RM 3.2 - 4.5) to capitalize on connectivity to existing instream habitat restoration sites, and proceed upstream from there;
- The CCCD, NRCS, USFWS, BLM, landowners, and partners, on behalf of the Planning Unit, should continue cooperative monitoring of existing instream structures, associated channel geometry, and fish species utilization on an annual basis; and
- The CCCD, NRCS, USFWS, BLM, landowners, and partners should pursue funding and/or use existing partnerships to monitor new habitat improvement projects; and
- Monitoring results should be used to refine management recommendations as necessary.

2) Riparian condition has been altered by natural (fire) and human disturbances. Riparian vegetation is necessary for bank stabilization, large woody debris recruitment, and stream temperature moderation.
   - The CCCD and partners, on behalf of the Planning Unit, should implement targeted riparian restoration and enhancement projects, based on priorities established by the Entiat River Inventory and Analysis data, CWU vegetation community classification study, and ground truthing by CCCD staff as described in this plan (see tables below and on the following page);

General streambank planting recommendations from 1995 NRCS study.

Reach	Length (miles)	Reach Description	Canopy Cover (%)	Potential Planting Sites (feet)	Dominant Plant Community
1	2.3	End of slackwater to Fire Station bridge.	0–10	4700	cottonwood/ red osier dogwood
2	3.0	Fire Station bridge to Old Hatchery bridge.	0–10	5900	cottonwood/ red osier dogwood/ erect willow
3	2.7	Old Hatchery Bridge to Johnson/Steven's bridge.	0–10	3900	cottonwood/ erect willow
4	3.0	Johnson/Steven's bridge to bridge near Mud Creek.	0–10	2900	cottonwood/ alder
5	2.2	Bridge near Mud Creek to Ryan/Small bridge.	10–20	2000	cottonwood/alder conifer/alder
6	2.2	Ryan/Small bridge to terminal moraine at Shorty's	0–10	10,350	mixed conifer/ alder
7	2.2	Terminal moraine at Shorty's to USGS gaging station.	0–10	6600	river birch/ broadleaf sedge
8	2.5	USGS gaging station to USFS boundary (section 14).	20–30	3600	cottonwood/ river birch/ red osier dogwood
Total	20.1			39,950 (7.6 miles)	

Additional priority planting recommendations not previously detailed by 1995 NRCS study.

Approximate location	Description of site/rationale
RM 1.2 - 3.2	Keystone Ranch to Fire Station Bridge near rock cross vane
RM 3-5 and RM6-7	Areas shown by CWU study to have largest decrease in riparian area from 1945-1998.
RM 4.2	Old Naumes warehouse site
RMs 7-9	Near Roaring Creek to Morical Canyon
RM 10.2	Mad River confluence old Mill site
RMs 11-13	Near Mud Creek confluence to Medsker Canyon
RMs 14-16	McKenzie Canyon to Potato Creek moraine -- heavy Tyee Fire effects.

- The CCCD and partners, on behalf of the Planning Unit, should perform public outreach to inform community members about the reasons for and benefits of maintaining riparian vegetation. This work should begin within six (6) months of adoption of this plan by Chelan County;
- The CCCD, on behalf of the EWPU, should inform community members about the Conservation Reserve Enhancement Program (CREP) and other options for cost-share on revegetation projects or easement renting;
- The CCCD and partners, on behalf of the Planning Unit, should develop streamside revegetation partnerships with willing landowners. Documentation of the first of these partnerships should be included in the detailed implementation plan due one (1) year after initiation of implementation planning;
- The CCCD and partners, on behalf of the Planning Unit, should pursue conservation easement, lease, and options other than outright property acquisition (in order to preserve community tax base) with willing landowners to protect larger, undisturbed riparian areas, and include a prioritized list of area in the detailed implementation plan to be completed one (1) year after initiation of implementation plan development;
- The CCCD and partners, on behalf of the Planning Unit, should assure monitoring of streambank planting projects, and report progress to the Planning Unit.

3) Wetlands along the upper mainstem Entiat River adjacent to the reach above the Potato Creek moraine serve important hydrologic and biologic functions in the Entiat River. Wetlands along the lower reach of the river have been modified by flood control work and development and only a few wetlands exist.
   - The County, Corps of Engineers, and State of Washington should assure that landuse actions comply with existing regulations related to wetlands protection, and provide periodic update to the Planning Unit upon request of the Planning Unit;
   - Local, state, federal, and other partners should assist landowners with voluntary maintenance of existing wetlands, or enhancement of the few remaining wetlands and their function; and,
   - Local, State, federal, and other partners should work with the CCCD to assure that updates to existing NWI maps are included in the EGIS.

4) Some existing surface water diversions and culverts in the Entiat River watershed are problematic for fish:
   - The Planning Unit should use information contained in the 1997 WDFW study, and proposed for collection by the WDFW under Bonneville Power Administration funding, to prioritize surface water diversion/withdrawal point corrections. The Planning Unit should include the project identification and prioritization schedule in its detailed implementation plan;
   - The CCCD and Planning Unit should continue to seek funding from USBR, WDFW and other sources to screen and/or upgrade existing screens on pumps/diversion intakes;
   - The Planning Unit should continue to show support for Congress granting the USBR construction authority for screening and barrier removal projects;
   - The Planning Unit should use information contained in the 2000 County culvert assessment, and proposed for collection by the WDFW under Bonneville Power Administration funding, to prioritize culvert corrections; and
   - The County, USFS, WDFW, USFWS, CCCD and partners should continue to seek funds for repairs (or directly fund repairs) of culverts that present fish passage problems.

5) Fish habitat in the Entiat River watershed is adversely affected by excessive fine sediment, which can suffocate redds and cause substrate embeddedness.
   - USFS and partners should continue fine sediment monitoring using McNeil core sampling, and implement probabilistic monitoring described in the UCSRB-RTT "Monitoring Strategy for the Upper Columbia River Basin" (Hillman, T.W. 2003);
   - Reporting of results to the Planning Unit should be continued; and
   - The Planning Unit should use monitoring results to refine management recommendations as necessary.

6) Winter habitat conditions have been identified as a factor limiting salmonid survival in the Entiat River watershed. Of particular concern are the effects of cold water temperatures and anchor ice on egg and fry survival.
   - USFS, WDOE and CCCD, on behalf of the Planning Unit, should continue thermograph deployment and monitoring of winter temperatures, and the effects of anchor ice on salmonid survival. An update of potential causes and actions to remediate effects of cold temperatures on salmonid survival should be provided to the Planning Unit on an annual basis, or on a schedule requested by the Planning Unit so that the Planning Unit can use the information to prioritize plan actions;
   - The CCCD, on behalf of the Planning Unit, should pursue grant funding to implement riparian planting and channel geomorphology restoration projects in the bridge-to-bridge reach and other areas where enhancement of riparian and geomorphic condition might significantly enhance over-winter and other salmonid habitat conditions; and
   - The CCCD and implementing partners, on behalf of the Planning Unit, should monitor the effects of additional riparian vegetation and in-channel projects on winter water temperatures and anchor ice formation. The CCCD and implementing partners should report findings to the Planning Unit to enable re-prioritization of plan actions.

7) The Entiat subbasin is utilized by salmonids protected as threatened and endangered under the Endangered Species Act (ESA). Protection and restoration of fish habitat sufficient to assure adequate habitat for salmonid recovery and to provide certainty for land and water users in the watershed under the ESA are goals of the Planning Unit. Implementation of a comprehensive watershed protection and restoration effort like the program recommended in this plan is intended to work toward, or reach these goals.
   - CCCD, on behalf of Planning Unit, will assure that actions are taken to Implement aforementioned channel geometry and riparian restoration recommendations, irrigation diversion structure improvements, and screening improvements;
   - CCCD, USFS, WDOE, WDFW, USFWS, BLM, Yakama Nation, and other partners, on behalf of the Planning Unit, should continue habitat monitoring (fine sediment, temperature, channel geometry, etc.), and sharing information with the CCCD for inclusion in EGIS and sharing with the full Planning Unit;
   - USFS, USFWS, and the Chelan County PUD, on behalf of the Planning Unit, should continue spring and late run Chinook, steelhead, and bull trout surveys and monitoring in the Entiat River Watershed Monitoring information should be provided to the CCCD for inclusion in EGIS, and distribution to Planning Unit members to assure new information influences prioritization of plan actions to be implemented;
   - USFS, USFWS, and partners, on behalf of the Planning Unit, should continue fish distribution, abundance, and redd mapping in the Entiat River watershed, and provide such information to the CCCD for inclusion in EGIS and distribution to the full Planning Unit. The Planning Unit should use monitoring information to adjust priorities of plan recommendations;
   - The USFWS should continue monitoring of salmonid outmigrants via smolt traps, and potentially expand monitoring efforts consistent with the Upper Columbia Basin monitoring strategy (Hillman, T.W. 2003);
   - Subbasin planning and Upper Columbia Salmon Recovery Unit partners should perform additional EDT model runs for steelhead and other fish species, and provide copies of results to the CCCD for inclusion in EGIS and for distribution to the full Planning Unit. The Planning Unit should use new information to make any necessary adjustments to plan recommendations or priorities as new information becomes available;
   - Current and future regulatory programs developed by the County to protect and restore fish and wildlife habitat and other critical areas should be coordinated with the EWPU, and should take into account current and future restoration and protection projects being undertaken; and
   - The CCCD and partners, on behalf of the Planning Unit, should work to develop a Habitat conservation Plan (HCP) and/or salmon recovery plan to gain certainty under the ESA.

8) It is important to consider not only the habitat requirements of threatened and endangered salmonids and other species when developing a watershed restoration plan, but it is also important to consider the genetic makeup of stocks managed to best understand how to protect the genetic integrity of the species of concern. The genetic makeup of fish currently utilizing the Entiat River watershed is not well understood.

- The USFWS and partners, on behalf of the Planning Unit, should continue annual salmon carcass collection and DNA sampling. Results of genetic analyses should be provided to the CCCD on an annual basis for inclusion in the EGIS and distribution to the full Planning Unit;
- The Planning Unit should support USFWS proposal for bull trout genetic studies;
- The USFWS and USFS should pursue abundance and distribution studies on native fish species of interest (lamprey, cutthroat); and
- The Planning Unit should use genetic stock information to make any necessary adjustments to plan elements or priorities, as appropriate, based on new information received.

9) Watershed and riverine resource management is driven by a number of natural processes including sediment. The sediment budget, bedload transport dynamics, and its relationship to channel geomorphology in the mainstem Entiat River are not completely understood.
   - The Yakama Nation, USFS and partners, on behalf of the Planning Unit, should initiate sediment budget, sediment transport, and/or analysis of bedload dynamics using acceptable methods (e.g. scour chains) to improve our understanding of this aspect of the system. Data should be provided to the CCCD for inclusion in EGIS and distribution to the full Planning Unit;
   - The Planning Unit should continue its support of the ongoing assessment of gravel clusters, and results of the study should be presented to the EWPU; and
   - The Planning Unit should consider this information in its evaluation of efficacy of plan recommendations, and for adjustment of plan recommendations or priorities.

10) Roads on forest lands were built primarily for timber access. Riparian vegetation has been reduced and sediment delivery to streams has increased as a result of many unpaved roads being located close to streams. The rehabilitation of roads by forest land managers is a watershed restoration priority.
   - The USFS, BLM, State, County, Longview Fibre Co., and partners, on behalf of the Planning Unit, should coordinate road management with major land owners in intermingled ownership areas to help reduce erosion and sediment from road sources.

11) Noxious weed infestations are common in disturbed areas throughout the WRIA, especially along roads and right of ways, and in abandoned pastures and cultivated fields. Noxious weeds reduce the biotic integrity and diversity in the watershed effecting quality of life for people, fish, and wildlife.
   - The CCCD, NRCS, USFS, State, County, and partners, on behalf of the Planning Unit, should develop a comprehensive weed control program with landowners, the County Weed Control Board, and State and other federal agencies. Parties responsible for developing the weed control program, and a schedule for implementation should be included in the detailed implementation plan due one (1) year after initiation of implementation plan development;
   - The CCCD and NRCS, on behalf of the Planning Unit, should encourage voluntary landowner efforts to control noxious weeds on their properties; and

- The Planning Unit should explore potential for use of biological agents (e.g., weevils) for noxious weed control, and update management recommendations as necessary.

12) Wildlife species protected as threatened or endangered under the Endangered Species Act use habitat on public lands and some private lands within the Entiat WRIA.
- The Planning Unit should host a workshop providing guidance to landowners in the Entiat River subbasin as to the means to promote land practices that are beneficial for wildlife; protect and restore riparian and terrestrial lands; and provide information about how to mitigate land use actions such that riparian and terrestrial species thrive;
- The CCCD and partners, on behalf of the Planning Unit, should continue to apply for grant funds for priority riparian and terrestrial habitat projects;
- The CCCD and project proponents should continue to monitor the success of habitat improvement projects. Monitoring information obtained should be provided to the CCCD for inclusion in EGIS, and distribution to the full Planning Unit; and
- The Planning Unit should use the new monitoring information to make any necessary adjustment to plan recommendations or priorities.

13) Plant species that are listed under the ESA and/or are species of concern for State and Federal agencies are present within the Entiat WRIA. Plants with cultural resource significance also exist.
- The Planning Unit should provide information to the public regarding the identification, significance, and protection of plant resources in the Entiat WRIA.

14) Benthic macroinvertebrates (aquatic insects) can be a powerful indicator of watershed health, habitat quality, and water quality. Some macroinvertebrate sampling has been done in the Entiat River watershed. In 1992 the USFS sampled one site in the lower Mad River and one site in the lower Entiat River. In 2002 the WDOE sampled one site in the lower Entiat River near Keystone gage. Results indicate that the benthic macroinvertebrate community condition is generally healthy; however, additional sampling is warranted to be able to make stronger inferences about watershed health, habitat quality, and water quality.
- The CCCD and partners, on behalf of the Planning Unit, should seek funding to implement a probabilistic survey (n=50 minimum) of the macroinvertebrate community and other relevant parameters, consistent with UCSRB monitoring protocol to assess overall health of the subbasin (Hillman, T.W. 2003).

9.5 WATER QUALITY

Additional information related to this suite of recommendations may be found in Chapter 8, Water Quality. Analysis of ambient water quality monitoring data collected near the Keystone gage (WDOE station 46A070) and elsewhere throughout the subbasin has shown that overall there are very few water quality problems in the Entiat or Mad Rivers and their tributaries.

1) The WDOE ambient water quality station 46A070 has contributed the most long-term data to the overall water quality record for the subbasin.
   - The WDOE should continue monitoring all water quality parameters for which data are currently collected at this site; and
   - The CCCD, on behalf of the EWPU, should explore implementation of a probabilistic water quality monitoring program within the Entiat subbasin as outlined in the Monitoring Strategy for the Upper Columbia Basin (Hillman, T.W. 2003).

2) Water temperature monitoring has indicated that summer water temperatures in some tributaries (North Fork Entiat, Mad River near Tillicum Creek) and the mainstem Entiat River periodically exceed State standards.
   - The CCCD, WDOE, USFS and partners, on behalf of the Planning Unit, should continue current water temperature monitoring via thermograph deployment and gages to assess conditions and trends;
   - The CCCD and partners, on behalf of the Planning Unit, should use existing FLIR data to help evaluate cold-water influences as thermal refugia for salmonids and other cold-water species during periods of high water temperature within the system, and to enhance technical staff and Planning Unit knowledge of temperature regimes. The CCCD and partners should incorporate finding in EGIS and share finding with the full Planning Unit. The Planning Unit should use new information to make any appropriate changes to plan recommendations or priorities; and
   - The CCCD and partners should pursue funding, permits, etc to fully implement priority items identified with SNTEMP, EDT (Alt 5), and the Entiat River Inventory and Analysis (Alt. 4) to help mitigate summer temperatures and guide improvements including:
     - Any proposed projects that include an aggressive approach to increasing the current riparian shade conditions throughout the watershed to achieve site potential shade, given the natural limitations of climax vegetation;
     - Any projects that work to achieve a 50% increase in canopy cover system-wide over the long term;
     - Any projects that work towards a system-wide goal of 25-30% increase in canopy cover in the short term;
     - Any projects in the upper river where current riparian shade is already estimated to be 20-30% (RMs 18-34), it is probably infeasible to increase these conditions by 50% (thus achieving 80% canopy cover), and therefore the goal in these reaches should be to increase these conditions up to the site potential shade; and
     - If resources are available, any project that results in decreases to channel width in the lower 10 RMs in conjunction with changes in shade (SNTEMP Alternative Action 4) should be implemented; thus, in the lower 10 RMs, the goal is to increase shade 50% and decrease channel width 50% in order to effect the most significant change to water temperatures.

3) Nutrient loading caused by fertilization has not been identified as a problem in the Entiat River; however, the percentage of scraper life-history type macroinvertebrates (32%) indicates that artificially enhanced nutrient-driven periphyton production may be occurring. Although periphyton occurs naturally in the Entiat and other watersheds, exceedingly high levels may lead to pH and other water quality problems.

- The WDOE should continue ambient water quality monitoring of nutrients in the Entiat River at site 46A070 and should report findings to the CCCD on an annual basis for inclusion in EGIS;
- The CCCD should provide regular update to the full Planning Unit so that the Planning Unit can make any necessary adjustments to plan actions and/or priorities; and
- The CCCD/NRCS should inform community members about farm bill programs related to nutrient management and potential cost-sharing.

4) Recent monitoring has indicated that pH levels occasionally exceed State standards in the lower mainstem Entiat River. The pH increases may be related to photosynthetic activity of periphyton communities, although pH excursions above 8.5 were relatively infrequent (Ehringer 1994).
   - The WDOE should continue pH monitoring at ambient monitoring site 46A070 and report findings on an annual basis to the CCCD for inclusion in the EGIS;
   - The CCCD should provide periodic update of pH findings to the full Planning Unit to facilitate any necessary adjustments of plan recommendations or priorities; and
   - The CCCD, on behalf of the Planning Unit, should explore implementation of probabilistic nutrient monitoring (nitrogen, phosphorous) using Upper Columbia protocol (Hillman, T.W. 2003).

5) The Entiat National Fish Hatchery has a National Point-source Discharge Elimination System (NPDES) permit associated with its production facility.
   - USFWS should continue to monitor its water discharges for compliance with NPDES permit guidelines. Monitoring results should be shared with the EWPU on an annual basis; and
   - The Planning Unit should use ENFH hatchery water quality monitoring data as appropriate to update plan management recommendations.

6) In 1994 whole fish samples from two suckers collected approximately 0.5 RM upstream from the mouth of the Entiat River indicated elevated levels of t-DDT and PCBs. No fillet samples were collected to assess human health risks.
   - The WDOE or an appropriate contractor should conduct supplemental studies that include collection of additional whole-fish samples at a site or sites more representative of conditions in the mainstem Entiat to confirm the levels of DDT and PCB contamination. Finding should be reported to the CCCD for inclusion in the EGIS and reporting to the full Planning Unit;
   - The WDOE or an appropriate contractor should collect fillet samples from sport fish from a site or sites representative of the watershed to evaluate potential human health risk. Findings should be reported to the CCCD for inclusion in the EGIS and to be shared with the full Planning Unit; and
   - The Planning Unit should use updated whole-fish and fillet sample information to make any necessary changes to plan recommendations or priorities.

7) Recent federal court decisions have called into question the ability of landowners to use pesticides, and maintain economically viable businesses. Pesticide application practices

have improved significantly over the past several decades but are again challenged by recent changes.

- Landowners should continue use of established standards and best management practices for pesticide applications;
- The Planning Unit should host a workshop regarding pesticide use and recent federal decisions, and potential effects on best management practices in the Entiat River watershed; and
- The CCCD, on behalf of the Planning Unit, should pursue funding for a study of the levels of pesticides of concern that are used in the subbasin. Monitoring results should be used to update management recommendations.

8) Fecal coliform bacteria and nitrate ambient water quality monitoring results do not indicate water quality problems associated with leaking/failing septic systems, or livestock inputs to streams. Compliance with septic upgrade requirements has been good, although the number of septic systems that have been installed in the valley has increased greatly over the past decade. Continued high-density development of private lands may pose a threat to future water quality, as could future increases to livestock if given unrestricted access to streams.

- The CCCD, on behalf of the Planning Unit, should work with County Department of Health and partners to inform the public about sanitation issues, e.g. septic systems and the importance of proper septic location; livestock BMPs (see 9.6, item 2).
- The WDOE should continue ambient water quality monitoring of nitrate and fecal coliform levels in the Entiat River. The WDOE should provide an annual report of findings to the CCCD for inclusion in the EGIS and for distribution to the full Planning Unit;
- The Planning Unit should use monitoring information to make any appropriate changes to plan recommendations or priorities; and
- If septics in need of upgrades are documented, the CCCD and partner agencies should help interested community members identify and secure funding to assist with upgrade costs.

9.6 ADDITIONAL MANAGEMENT ISSUES

This section covers topics that have implications for multiple resource issues; as such, they do not fit directly within one of the previous categories. Supporting information for this section is found throughout the WRIA 46 plan.

1) New residence and subdivision construction along the river is a concern as it has the potential to degrade the condition of streamside areas and alter the land's ability to mitigate flood flows. There are safety problems associated with construction in the floodplain and on alluvial fans. Dense development could also affect water quality and change the rural feel of the Entiat valley. Chelan County Comprehensive Plan (adopted February 2000) zoning designations now determine property minimum lot sizes and sub-divisibility, and other regulations dictate structure and septic placement requirements, riparian setbacks, and other land use restrictions.

- All construction should follow Chelan County Code requirements for zoning, building permits, structure and septic placement, setbacks, and other land uses;
- All future land use changes should follow appropriate comprehensive plan designation amendment procedures;
- Chelan County, FEMA, and partners, on behalf of the Planning Unit, should inform the public about hazards of construction in flood-prone areas, particularly where new construction is in or adjacent flood-prone areas; and
- Agencies/entities should continue enforcement of their respective codes.

2) An assessment done in 1996 indicated that livestock have unrestricted access to streams and mainstem Entiat River in a few locations, which has denuded stream banks and could affect water quality.
   - The CCCD, on behalf of the Planning Unit, should reassess livestock access to streams, map the information, include the information in EGIS, and provide an update to the full Planning Unit;
   - The Planning Unit should use updated information to change and/or re-prioritize plan elements;
   - The CCCD and NRCS, on behalf of the Planning Unit, should encourage and assist landowners to develop comprehensive farm plans including livestock management planning; and
   - The CCCD and NRCS, on behalf of the Planning Unit, should encourage private landowner use of cost-share programs to fence sites where livestock have unlimited access to river, to develop off-stream stock watering sources, or to allow only limited access to streams for watering livestock consistent with comprehensive farm plans.

3) Timber harvest and other silviculture practices on state and private lands are currently at a low level, with little potential for immediate expansion.
   - Timber mangers should comply with State of Washington Forest Practices Act and obtain appropriate permits, should use Best Management Practices (BMPs), and should go through SEPA review as necessary for any proposed projects.

4) Fire in the rural interface posses a threat to public safety, private property, and watershed resources. Wildfires in the valley have occurred regularly in the past, and are expected to continue on a periodic basis in the future.
   - The CCCD, USFS, State, Fire District 8, and partners should provide the public with information regarding fire prevention, planning and protection (e.g. development of a defensible space and fireproofing structures) with priority given to the wildland-urban interface;
   - The CCCD, on behalf of the Planning Unit, and interested community members should apply for community fire prevention/protection grants;
   - The Chelan County Sheriff and other appropriate groups should continue public education of disaster management and evacuation protocols; and
   - The Planning Unit should inform the public about the Columbia Breaks Fire Interpretive Center.

5) Forest road maintenance needs typically exceed annual budgets and there is a concern about federal roads being closed for management and economic reasons. Some roads to private homes are unsafe for firefighter use. Adequate existing road access is needed for firefighting to ensure quick initial attack and safe escape routes.
   - The USFS, BLM, State, Fire District 8, and other partners should continue cooperation with rural fire departments to assure adequate and reasonable road access to homes for wildfire protection; and
   - Chelan County should continue to assure that county roads meet fire access standards.

10.0 MONITORING AND EVALUATION

Monitoring and evaluation each have a distinctly different purpose and scope. Monitoring is designed to gather data necessary for the evaluation of projects, environmental trends, species dynamics, etc. During evaluation, monitoring data are analyzed and interpreted to determine whether goals and objectives are being met. Through the use of adaptive management, information and insights gained from monitoring and data evaluation are used to improve management practices and policies.

The monitoring strategy in Table 10-1 summarizes the type and frequency of monitoring that has gone on to date in the Entiat subbasin; many actions are ongoing. The monitoring strategy identifies the elements to be tracked during implementation of this Plan to ensure:

1) That natural resource trends remain favorable;
2) That habitat improvements are implemented as planned and are effective in addressing key limiting factors;
3) That land use trends do not change significantly from assumed trends, and
4) That the goals and objectives of the Entiat WRIA 46 Management Plan are being met.

The monitoring and evaluation process outlined in this chapter provides landowners and agencies with a summary of what data are necessary to amend/update the WRIA 46 Plan. The monitoring information contained here is not intended to detail all monitoring that is occurring or may occur in the subbasin. Many activities are already being monitored in order to comply with County, State, Tribal and Federal laws and/or regulations, or meet legal responsibilities. Information included in this document relies heavily on such agency information.

As mentioned in the preface, Entiat valley landowners and participating agencies are committed to making this a dynamic document. As such, the monitoring strategy will be amended over time (as necessary) to correspond with the recently developed Monitoring Strategy for the Upper Columbia Basin (Hillman, T.W. 2003) and support regional monitoring efforts.

Table 10-1. Summary of past and ongoing monitoring activities in WRIA 46.

Monitoring Item	Monitoring Element	Units	Suggested Method	Responsible Entity	Frequency
Natural Resources					
Vegetation - Noxious weeds	Area occupied by noxious weeds	Acres	Agency records, visual inspection, mapping (EGIS)	Chelan County and Land Mgt. Agencies	5 years, with some annual
TE&S Plants	Populations	Numbers/Acres	Agency records, visual inspection	WDFW, USFWS, USFS and others	5 years
Water Quantity	Stream flow	Volume (cfs)	Continuous and staff gages	USGS, CCCD, USFS	Ongoing at 3 primary sites
Water Quantity	Stream flow	Volume (cfs)	Continuous and staff gages	WDOE, CCCD, USFS	Ongoing at expanded network
Water Quantity	Wells	Water surface elevation, gallons/gpm	Tape, metering	CCCD, WDOE	Monthly, ongoing
Water Quantity	Surface Water diversions > 1 cfs	cfs	Metering	Water Users, WDOE	Continuous
Water Quality	Water Quality parameters	Varies	Water sampling	WDOE and Mgt. Agencies	Monthly ongoing
Water Temperature	Excursions beyond criteria	Number of excursion days per year	Continuous recording data loggers	WDOE, USFS, Mgt. Agencies	Daily ongoing for select months
Fine Sediment	Exceeds established parameters	Percent fines ($\leq$1 mm) in gravels	McNeil core sampling	USFS, WDOE	Annual ongoing
Riparian & Aquatic Resources	Geomorphology, riparian veg., streambank erosion	Departure from natural condition	Stream surveys, photo points	USFWS, USFS NRCS, and others	10 years
Wetlands	Wetlands	Acres	Wetland Inventory	WDOE, NRCS, USFS	ongoing
TE&S Fish	Trends stable or improving	Fish distribution, species composition, and population levels.	Spawning surveys/redd counts; snorkel surveys; telemetry; smolt traps; dam passage counts	USFS, PUD, NMFS, USFWS and others	Annual ongoing
Wildlife TE&S, State/Federal Species of Concern	Trends stable or improving	Wildlife numbers	Use of ongoing sampling	WDFW, USFS, USFWS and others	5 years
Vegetation	Vegetative recovery past disturbance (e.g. fire)	Trend in site condition	Fixed photo points	USFS and contractors	Varied

Monitoring Item	Monitoring Element	Units	Suggested Method	Responsible Entity	Frequency
Habitat Improvements					
Instream Structures	Rock cross vanes (or other structures) with root wads	Habitat area	Cross-sections with Flow and bench mark photos	NRCS, WDFW USFWS, USFS	1 year 5 years
Riparian plantings	Survival surveys	Percent survival	Random sampling and bench mark photos	NRCS/CCCD and Mgt. Agencies	1 year 5 year
Upland restoration projects	Project and site condition	Trends in site condition	Variable – visual, photos, etc.	USFS, BLM, NRCS, and others	ongoing
Land Uses					
Agriculture	Irrigated Lands	Acres	Air Photo - Ground-truthed	DOE and CCCD	5 years
Livestock Grazing	Class of livestock and location	Numbers by Class	Agency records and field counts	DNR, USFS, BLM	5 years
Timber harvest and associated road building	Logging and road building	Volume harvested / miles of new road	Agency and private ownership records	BLM, USFS, DNR, and Private Owners	5 years
Recreation	Visitor trends	Visitor days	Agency records	USFS et al.	5 years
Residential housing	New development	Number of exempt wells	Agency records	Chelan County WDOE (wells)	Annual
***Economic & Population Trends**					
Entiat Retail Sales	Retail sale trends	Dollars in thousands	Retail records	City, State Dept. of Commerce	Annual ongoing
Population Growth	Population growth trends	Population in hundreds	Annual predictions, 10 year US Census	State Office of Financial Management, US Census Bureau	2001 2011

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12.0 GLOSSARY

303(d) list: A list of stream segments that do not meet Federal/State water quality standards. The list is named after Section 303(d) of the Federal Clean Water Act, which requires states to maintain such a list.

Acre-feet (ac-ft): The volume of water necessary to cover one acre of area with one foot of water. One ac-ft is equal to twelve acre-inches (ac-in).

Alluvial fan: Loose sediment and material deposited via stream flow and/or debris flows at the base of a mountain front, escarpment or valley side, which has the shape of a fan, either fully or partially extended.

Anadromous: Referring to species of fish that are hatched in freshwater, migrate to the ocean to mature, and return to their natal streams to spawn. Salmon and steelhead are some examples.

Anchor ice: Ice that forms along the stream channel bottom via the accumulation of frazil ice on the rough surfaces of bottom sediments and on the lee sides of pebble, cobbles, and boulders.

Aquatic: Of or in the water; living or growing in or on the water.

Bankfull discharge: Water fills a stream channel to the top of its banks just to the point where water begins to overflow onto the adjacent floodplain. Bankfull discharge occurs about once every year or two, and its flows transport the greatest quantity of sediment and bedload over time.

Bank armoring: The process of placing large rocks, vegetation, or engineering materials along stream banks to protect them from flowing water, especially erosion of channel banks or bottoms during runoff events.

Beneficial use: Beneficial uses of water bodies are protected by Washington State statute. (Chapter 173-201 WAC), and include: fish and shellfish rearing; spawning and harvesting; swimming; boating; navigation; irrigation; wildlife habitat; and domestic, industrial, and agricultural water supply.

Board feet: A volume measurement for timber. MBF = 1,000 board feet = Unit of measurement equal to 1,000 feet of wood having a thickness of 1 inch. MMBF = 1,000,000 board feet.

Channelization: Straightening the meanders/bends of a river and simplifying the habitat; often accompanied by bank armoring to stabilize the system.

Confinement: Fixing a channel in its location, restricting and/or removing its ability to migrate.

Cubic foot per second: (ft^3/s; also CFS) The rate of discharge representing a volume of 1 cubic foot passing a given point during 1 second, equivalent to 7.48 gallons per second or 448.8 gallons per minute or 0.02832 cubic meter per second. One cfs flowing for one day is equivalent to 1.9835 acre-feet.

Deciduous: Referring to trees that annually shed their leaves before the cold or dry season, and then regrow them.

Depressed stock: A fish stock whose production is below expected levels based on available habitat and natural variations in survival levels, but above the level where permanent damage to the stock is likely.

Dichloro-Diphenyl-Trichloroethane (DDT): Pesticide used to control mosquitoes, lice, flies, aphids, etc. Speculated to have adverse effects on both human and wildlife populations.

Discharge: The volume of water (or more broadly, volume of fluid plus suspended sediment) that passes a given point within a given period of time.

Dissolved Oxygen (DO): The concentration of free molecular oxygen (a gas) dissolved in water, usually expressed in milligrams per liter, parts per million, or percent of saturation. DO concentration measurements are an indicator of water quality and a water body's ability to support fish and other aquatic life.

Ecosystem: A geographically defined area that encompasses unique physical and biological characteristics. It is the sum of the plant community, animal community (including humans), and environment in a particular region or habitat.

Ecosystem Diagnosis and Treatment (EDT): A methodology designed by Mobrand Biometrics, Inc. to provide a practical, science-based approach for developing and implementing watershed plans. Information is organized in a way that describes a watershed ecosystem so that scientific principles can be applied to better understand that ecosystem; an analytical model is used to analyze environmental information and draw conclusions about the ecosystem; and a step-by-step procedure is used to explain how to apply the conceptual and analytical model to develop plans that achieve goals. The conceptual framework for the EDT method was developed with an aim toward utility for salmon management but also with the important goal of maintaining consistency with an ecosystem approach.

Entiat Experimental Forest (EEF): An area in the subbasin on National Forest System lands allocated to forest research activities.

Endangered species: Any species of animal or plant considered to be in danger of extinction throughout all or a significant portion of its range. Endangered species are designated in the Federal Register, and provided the most stringent protection under the Endangered Species Act of 1973.

Endangered Species Act: A 1973 Act of Congress that mandated the protection and restoration of endangered and threatened species of fish, wildlife and plants.

Erosion: The wearing away of land surfaces by running water, wind, ice, rain, etc.

Escapement: The portion of adult salmon that survive all fisheries to return to spawning grounds or a hatchery.

Fecal Coliform: A group of bacteria passed through the excrement of wildlife, livestock and humans that can enter aquatic environments through the waste from mammals and birds, agricultural and storm runoff, and from untreated human sewage that may enter streams through leaking septic systems or storm water overflows. Fecal coliform by themselves are usually not pathogenic; they are indicator organisms, which means they may indicate the presence of other pathogenic bacteria that can cause infection or disease in humans.

Fine sediment: Sediment with a diameter less than 1mm in diameter, usually reported as a percentage, i.e. percent fines, of total substrate size composition. Fine sediment plays an important role in determining spawning gravel suitability and salmonid egg survival.

Fish screen: Woven, welded or perforated durable material installed at the intake of surface water diversions, e.g. irrigation ditches, hydropower facilities, pumps, in order to protect juvenile fish. Screens must meet certain engineering and design criteria in order to be effective.

Fish passage: An important consideration for the migration of fish species within a river or stream system. Culverts under roads must be engineered such that juvenile salmonids (50 – 120mm) and/or trout 6 inches in length are provided suitable velocity and depth of flow conditions for movement. A range of flow regimes and different fish species and life stage requirements (adult v. juvenile) must all be considered.

Floodplain: Lowland and relatively flat areas adjacent to stream channels susceptible to a one percent or greater chance of inundation/flooding by stream derived waters in any given year.

Flow rate: The rate at which water moves by a given point. In US rivers, it is usually measured in cubic feet per second (cfs).

Forward Looking Infrared (FLIR): Technology available for monitoring and evaluating stream surface temperatures using infrared sensors that detect in the 8-12 micron range of the spectrum.

Frazil ice: Stream ice with the consistency of slush, formed when small ice crystals develop in super-cooled stream water as air temperatures drop below freezing. These ice crystals join and are pressed together by newer crystals as they form.

Fry: Young salmon that have emerged from the redd, absorbed their yolk-sac, and are capable of actively searching for food.

Gaging station: A particular site on a stream, canal, lake, or reservoir where systematic observations of hydrologic data are obtained. Stations in the Entiat are either continuous recording gages or staff gages.

Geographic Information System (GIS): A computer system which allows the input and manipulation of geographic data to allow manipulation, analysis and display of data in tabular as well as map format.

Geomorphology: Geologic study of the configuration and evolution of surface features of the Earth. Geomorphology deals with the general configuration of the earth surface and the changes that take place as landforms develop (history).

Glaciation: Effects on landforms produced by the presence and movement of a glacier.

Gradient: The rate of inclination; change in elevation per unit length of slope.

Gravel scour: The scrubbing or flushing of gravel from a streambed due to increases in stream flow. Especially a concern in salmonid spawning areas, as gravel scour can damage eggs or sweep them downstream.

Groundwater: All water beneath the earth's surface that can be collected with wells, tunnels, or drainage galleries, or that flows naturally to the surface via seeps or springs.

Hatchery: Facility where salmon eggs are hatched and reared..

Hydrology: Natural science related to the waters of the earth, their occurrence, circulation and distribution, their chemical and physical properties, and their reaction with the environment, including their relation to living things.

Infiltration rate: The measure of a soil's ability to absorb and transmit water in a given time, which reveals the likely behavior of the soil under precipitation or flooding. This is important information for irrigation management or flood prevention planning.

Instream flow: The quantity of water maintained in a stream in order to sustain multiple non-consumptive uses, such as: fisheries and wildlife, channel stability and maintenance, riparian habitat maintenance, navigation, recreation, and aesthetics.

Instream Flow Incremental Methodology (IFIM): A methodology developed by the USFWS in the late 1970s, which involves putting site-specific stream flow, and micro- and macrohabitat data, into a group of models collectively called PHABSIM (physical habitat simulation) in order to determine the relationship between flows and fish habitat over space and time. In addition to the PHABSIM models, IFIM may include reviewing water quality, sediment, channel stability, temperature, and other variables that affect fish production. An IFIM approach can be applied to other instream values as well, such as recreation.

Landform: Surface features, the origin of which can be attributed to particular geological processes or structures. A type of land surface that exists as a result of geological activity, such as a plateau, plain, basin, or mountain.

Land Type Association (LTA): One of the most basic ecological units for Forest-wide planning; describes areas of common ecosystem characteristics and generally (but not always) numbering in the thousands of acres. LTA's are defined by similarities in general topography, geomorphic process, geology, soil and potential plant community patterns.

Large Woody Debris (LWD): Any large piece of relatively stable woody material having a diameter greater than 10 cm and a length greater than 3 meters. LWD is an important part of the structural diversity of streams. The nature and abundance of LWD in a stream channel reflects past and present recruitment rates, which are largely determined by the age and composition of past and present adjacent riparian stands.

Moraine: Dirt, rock and debris transported via the advance of a glacier, and then left behind once the glacier recedes. A terminal moraine marks the farthest glacial advance.

Nitrate: One of the forms of nitrogen found in aquatic ecosystems. Elevated nitrate levels can cause changes in the types of plants and animals living in a stream, may lead to low dissolved oxygen, and may cause temperature increases.

Non-point source pollution: Diffuse pollution; not discharged from a pipe. Non-point source pollution can result from land uses such as agriculture and timber harvest, or contamination from septic tanks, etc.

Noxious weed: Undesirable plant that is harmful to agriculture as well as native plant species. Washington State law (17.10 RCW) defines a noxious weed as: "…any plant which, when established, is highly destructive, competitive, or difficult to control by cultural or chemical practices."

Optimum: The best or most advantageous condition, degree, or amount [Webster's Dictionary].

Organic: Containing carbon atoms and carbon-carbon bonds.

Orographic: Related to the physical geography of mountains and mountain ranges.

Parr: Young trout or salmon actively feeding in fresh water, often with large dark spots or bars on their sides for camouflage. Salmon parr usually live in freshwater for 1 to 2 years; usually refers to young anadromous salmonids before they migrate to the sea.

pH *or* pH scale: A measure of the concentration of hydrogen ions in a substance. A pH scale is used to determine the alkaline or acidic nature of a substance. The scale ranges from 1-14 with 1 being the most acidic and 14 the most basic. Pure water is neutral with a pH of 7. Water pH determines the amount of nutrients that can be dissolved in the water and utilized by aquatic life.

Percolation rate: The rate at which a soil will accept water.

Phosphorous: A nutrient essential for plant and animal growth. It may be dissolved or suspended in water. Slight increases may cause numerous undesirable effects, such as accelerated plant growth, algae blooms, low dissolved oxygen, and the death of certain aquatic organisms.

Pinnate: Having a shape like that of a feather.

Polychlorinated biphenyls (PCBs): Mixtures of up to 209 individual chlorinated chemical compounds used as coolants/lubricants in transformers and other electrical equipment until 1977, when the manufacture of PCBs was stopped due to concerns about their harmful environmental and health effects. PCBs do not readily break down in the environment and thus may remain there for very long periods of time. In water, PCBs are taken up by and accumulated in fish and marine mammals, reaching levels that may be many thousands of times higher than in water.

Pool: Portion of a stream with reduced current velocity, often with deeper water and a smooth surface. Essential habitat for young salmonid rearing and adult salmon resting.

Radio telemetry: The process of tracking the movement and location of animals that have been implanted or collared with a radio transmitter. An animal's unique radio signal/frequency is detected using a special antenna, which can be hand held or mounted to a vehicle or airplane.

Reach: A homogenous section of stream or river characterized by uniform channel pattern, gradient, substrate and channel confinement.

Rearing habitat: Areas required for the successful survival to adulthood by young animals.

Redd: A gravel nest dug out of streambed by the adult salmon female, into which eggs are laid and then covered.

Riffle: Stream habitat having a broken or choppy surface (white water), moderate or swift current, and shallow depth.

Riparian vegetation: Vegetation that grows beside rivers, streams and other freshwater bodies and depends on these water sources for soil moisture greater than would otherwise be available from local precipitation.

Riparian zone: The land area and associated vegetation adjacent to a stream or river, identified by soil characteristics and distinctive vegetation. It includes wetlands and those portions of floodplains that support riparian vegetation.

Runoff: Rainfall not absorbed by soil or vegetation.

SaSI (Salmonid Stock Inventory): A list of Washington's naturally reproducing salmonid stocks and their origin, production type, and status. Developed in 1998 as an appendix to SASSI to include bull trout and Dolly Varden; formerly named SASSI.

SASSI (Salmon and Steelhead Stock Inventory): A list of Washington's naturally reproducing salmon and steelhead stocks and their origin, production type, and status; developed in 1992.

Salmonid: Of or belonging to the family Salmonidae, which includes the salmon, trout chars, bull trout, and whitefishes.

Salmon: Common name for species of the family Salmonidae

Sedimentation: The removal, transport, and deposition of detached soil particles by flowing water (or wind). Accumulation of organic and inorganic matter on the stream bottom; usually the result of the reduction in water velocity below the point at which material can be transported in suspended form.

Silviculture: Cultivation, care, and management of forest trees.

Smolt: Young anadromous fish, 1 or more years old, migrating downstream from freshwater to saltwater and undergoing physiological changes that will allow it to change from life in freshwater to life in the sea. The transformation from parr to smolt often involves the loss of spots and change to a silvery color.

Spawning habitat: Areas with specific micro- and macrohabitat parameters (water depth and velocity, substrate, temperature) required for successful redd creation by adult salmonids.

Streamflow: The discharge that occurs in a natural channel.

Subbasin: A subdivision of the largest regional hydrologic unit [basin], i.e. the Columbia River Basin. Examples within Chelan County include the Wenatchee, Entiat and Lake Chelan subbasins.

Substrate: Mineral and organic material forming the bottom of stream or waterbody.

Suspended solids: Items such as soil, algal cells, and plant particles, which can be separated from the water by filtration via a filter with openings of 0.45 microns in diameter. Total suspended solids levels are monitored/regulated to protect water quality.

Thalweg: The path of maximum depth in a river or stream.

Thinning: The process of removing trees to decrease population density and competition between trees in a stand

Threatened species: Any species of animal or plant considered likely to become endangered in the foreseeable future. Threatened species are protected by somewhat less restrictive regulations than endangered species.

Topography: The shape of a portion of the earth's surface, including its elevations and the position of physical and cultural features

Total Maximum Daily Load (TMDL): A calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources.

Tributary: A river or stream that flows into a larger river or stream.

Water Resource Inventory Area (WRIA): Washington State is divided into 62 WRIAs for water and aquatic-resource management planning, e.g. planning done under Chapter 90.82 RCW, the Watershed Planning Act. A Water Resource Inventory Area may include more than one watershed, although the terms "WRIA", "watershed" and “subbasin” are frequently used interchangeably. WRIA 46 comprises Entiat and Mad River watersheds, along with some minor Columbia River tributaries.

Water year: A 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 1992 is called the "1992 water year" [USGS].

Watershed: The entire land area that contributes water to a river, river system, or body of water; also a subdivision of the subbasin. The Entiat and Mad River watersheds collectively form the Entiat subbasin.

Wetland: Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas [RCW 90.58.030].

Width-to-Depth ratio: The ratio of the bankfull surface width to the average depth of the bankfull channel. The width-to-depth ratio is important in understanding a stream's adjustments to the water's energy in its channel, and the ability of various discharges within the channel to move sediment.

Wild and Scenic River: Rivers that receive special protection under the Wild and Scenic Rivers Act.

Wilderness: Undeveloped Federal land retaining its primeval character and influence without permanent improvements or human habitation. Wilderness areas are designated by congressional action under the 1964 Wilderness Act.

13.0 LIST OF ACRONYMS

°F	Degrees Fahrenheit
°C	Degrees Celsius
ac-ft	acre-feet
ac-in	acre-inches
BiOp	Biological Opinion
BLM	Bureau of Land Management
BMP	Best Management Practice
BPA	Bonneville Power Administration
CAA	Clean Air Act
CCD	County Census Division
CCCD	Chelan County Conservation District
CDLT	Chelan-Douglas Land Trust
CRMP	Coordinated Resource Management Plan (or planning)
cfs	cubic feet per second
CRITFC	Columbia River Inter-Tribal Fisheries Commission
CRT	Columbia River Tributaries
CTED	Community Trade and Economic Development
CWA	Clean Water Act
CWU	Central Washington University
CZMA	Coastal Zone Management Act
DDT	Dichloro-diphenyl-trichloroethane
DO	Dissolved Oxygen
EDT	Ecosystem Diagnostic Treatment
EEF	Entiat Experimental Forest
EGIS	Entiat Geographic Information System
EIS	Environmental Impact Statement
ENFH	Entiat National Fish Hatchery
ESA	Federal Endangered Species Act
ESHB	Engrossed Substitute House Bill
ESU	Evolutionarily Significant Unit
EWPU	Entiat WRIA Planning Unit
FCRPS	Federal Columbia River Power System
FLIR	Forward Looking Infrared
FLPMA	Federal Land Policy and Management Act
ft	feet
GCFMP	Grand Coulee Fish Maintenance Project
GIS	Geographic Information System
GMA	Growth Management Act
GWIS	WDOE's Geographic Water Information System
gpm	gallons per minute
HCP	Habitat Conservation Plan
HYSEP	Hydrograph Separation Software Program
IFIM	Instream Flow Incremental Methodology
IFWP	Instream Flow Work Plan
kg/yr	Kilograms per year

LSC	Landowner Steering Committee
LTA	Land Type Association
LWD	Large Woody Debris
m/s	meters per second
mgd	millons of gallons per day
mg/L	milligrams per liter
mi^2	square miles
MIS	Management Indicator Species
mL	milliliters
MPRSA	Marine Protection, Research and Sanctuaries Act
MS	Management Strategy
NCW	North Central Washington
NEPA	National Environmental Policy Act
NFMA	National Forest Management Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
OFM	Washington State Office of Financial Management
PCBs	polychlorinated biphenyl mixtures
pcpd	per capita per day
PHABSIM	Physical Habitat Simulation
PPA	Pollution Prevention Act
PUD	Chelan County Public Utility District
RCW	Revised Code of Washington
RM	River Mile
RNA	Research Natural Area
RPA	Reasonable and Prudent Alternative
ROD	Record of Decision
SaSI	Salmonid Stock Inventory
SASSI	Salmon and Steelhead Stock Inventory
SCS	USDA Soil Conservation Service
SEPA	State Environmental Policy Act
S&M	Survey and Manage
SNTEMP	USFWS's Stream Network Temperature Model
SOC	Species of Concern
SRA	Salmon Recovery Act
SRFB	Salmon Recovery Funding Board
ROS	Recreational Opportunity Spectrum
TIR	Thermal Infrared
T&E	Threatened and Endangered species
TMDL	Total Maximum Daily Load
UCR	Upper Columbia River
UGA	Urban Growth Area
USACE	U.S. Army Corps of Engineers

USBR	U.S. Bureau of Reclamation
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WA	Washington
WAC	Washington Administrative Code
WDNR	Washington Department of Natural Resources
WDOE	Washington Department of Ecology
WDOH	Washington Department of Health
WDFW	Washington Department of Fish and Wildlife
WDOT	Washington Department of Transportation
WNF	Wenatchee National Forest
WPA	Watershed Planning Act (Chapter 90.82 RCW)
WQI	WDOE's Water Quality Index
WRATS	WDOE Water Rights Application Tracking System
WRIA	Water Resource Inventory Area
WSU	Washington State University
WUA	Weighted Usable Area
WY	Water Year