DRAFT

Upper Williamson River Watershed Assessment

Prepared for the
Klamath Basin Ecosystem Foundation
Upper Williamson River Catchment Group

in cooperation with the
Upper Klamath Basin Working Group and
the Klamath Watershed Council

DAVID EVANS AND ASSOCIATES INC.

August 16, 2004

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CONTRIBUTORS AND ACKNOWLEDGEMENTS

To those who live, work and play in the Upper Williamson, and to all who have had a hand in putting this document together, our sincerest thanks. You should thank yourselves, too, because after all, the document is yours.

PREFACE

Despite our best attempts at objectivity, the stories we tell always have a point and a purpose. If they didn't there would be no reason to tell them. This Watershed Assessment is one of those stories, and while it is meant to be the truth, it is also meant to be a tool. The job we are trying to do with this tool is twofold.

One the one hand we are trying to understand, as best we can, how the specific, particular natural systems we depend on function (and what happens when they don't). This includes trying to understand, with as much emotional detachment as we can muster, all of the various and, oftentimes, conflicting assertions people have made with regard to the functioning of these systems.

But at the same time that we are trying to get a handle on how these systems work, we are also trying to invite, and advance, a new kind of conversation within our communities. These conversations happen in particular places, with real people facing each other right there in the landscapes they love. When they work, these conversations harness the energy we sometimes squander on strife, and redirect it toward getting things fixed. When these conversations work, we find a way to stop pushing against each other and start pushing together in the same direction, at least long enough to get a problem solved.

One of these goals is relatively technical, and the other is more social and cultural. So often we try, with lots of help from experts and specialists, to segregate our attempts to understand technical issues from our attempts to understand social and cultural issues. But in recent decades many have come to understand that we simply can't understand one without the other. We've come to understand that even with healthy, sincere, and dedicated local communities we can do serious damage to natural systems if we don't know how they work. And, on the other hand, a flawless technical understanding of the functioning of natural systems is largely useless without the deep – and usually quite non-technical – commitment of the folks who live and work within particular landscapes.

There is little doubt that the natural systems of the upper Williamson River watershed would function differently were it not for the influence of human activities. Native American activities appear to have influenced the functioning of those systems in various ways for millennia, and the arrival of industrial technologies in the late nineteenth century had rather more dramatic and sustained effects. Depending on what one may believe to be important, one could argue one way or the other whether those effects have been negative or positive.

It is a primary premise of this document that determinations with respect to the positive or negative impacts of human actions – whether geared toward resource use or habitat restoration – should be made with reference to specific sites and systems. At the same time, the part these specific sites play in the functioning of larger scale systems – sub-basins, watersheds, or even ecoregions – must also be given due consideration.

The natural systems of the upper Williamson are infinitely complex, and constantly changing. Likewise, the culture and communities of the upper Williamson are infinitely complex and ever-changing. When we acknowledge that these two complex systems are inextricably intertwined with each other, it becomes clear that "understanding" is a relative term, and that "fixing things" is not something we do once and then we're done with it. The goal is not some form of ecological "perfection." Our goal is to keep our communities healthy while respecting, openly and honestly, the water, the land, and the other lives we depend on. Our challenge is to hone the skills we possess for working with the land, and to learn the hard lessons that come from working against it. The challenge we face, in short, is to find a way to live that will *last.*

This document is only a success if it helps to make that happen.

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Glossary and Abbreviations

ac	acre(s)
adfluvial	migrating between lakes and streams
af	acre feet
ammocoete	lamprey life stage between the larval and adult stages
anadromous	fish that migrate between fresh and salt water, such as salmon
benthic	pertaining to the bottom of a body of water
cfs	cubic feet per second
cm	centimeter(s)
lentic	referring to still water
meristic	referring to body part variation
mi	mile(s)
mi^2	square mile(s)
mi/mi^2	miles per square mile
mm	millimeter(s)
pyroclastic	pertaining to the rock material that is formed by a volcanic explosion
redd	nest in which fish spawn

To be completed with the help of reviewers.

Acronyms

CHT	Channel Habitat Type
DEM	digital elevation model
DEQ	Oregon Department of Environmental Quality
ECSI	(DEQ) Environmental Cleanup Site Information
ENSO	El Niño/Southern Oscillation
ERO	Ecosystem Restoration Office (of the U.S. Fish and Wildlife Service)
FLIR	Forward Looking Infrared Radiometry
GLO	General Land Office
HSU	Humboldt State University
IAU	Individual Assessment Unit
KBEF	Klamath Basin Ecosystem Foundation
LRMP	Land and Resource Management Plan
NCDC	National Climatic Data Center
NF	National Forest
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWCC	National Water and Climate Center
NWR	National Wildlife Refuge
OAR	Oregon Administrative Rules
OCS	Oregon Climate Service
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
OIT	Oregon Institute of Technology
OSU	Oregon State University
OWEB	Oregon Watershed Enhancement Board
OWRD	Oregon Water Resources Department
PDO	Pacific Decadal Oscillation
POR	Period of record
RCU	riparian condition unit
REO	Regional Ecosystem Office
SWE	snow water equivalent
(%) TIA	(percent of) total impervious area
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TRS	Timber Resource Services
USBR	U.S. Bureau of Reclamation
USDI	U.S. Department of Interior
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Service
WAB	water availability basin
WDNR	Washington Department of natural Resources
WFPB	Washington Forest Practices Board
WPN	Watershed Professionals Network
WQMP	Water Quality Management Plan

1 INTRODUCTION

They say a landscape is a reflection of the people that live within it. The upper Williamson River subbasin is a place of both breathtaking and subtle beauty: Crater Lake, the dance of the sandhill cranes in the meadows, and the redband trout lurking at the bankline. But the upper Williamson is also tough. The summers are dry, the winters can be unyielding and the winds are often fierce.

Compared to the many brutalized landscapes of the west, the upper Williamson River subbasin has been shaped in a relatively gentle manner. But it has been shaped. For many years, this landscape has been altered and adapted by humans to provide for their agricultural and forestry needs. Now, the people of the upper Williamson River are working together, as the Upper Williamson Catchment Group, to minimize their impact and to benefit their landscape.

This Watershed Assessment (Assessment) has been prepared for the Klamath Basin Ecosystem Foundation (KBEF), the Upper Williamson River Catchment Group, and the people that live and work in the upper Williamson River subbasin. The purpose of this Assessment is to characterize the historical and existing conditions within the subbasin and to provide a broad foundation for effective ecosystem restoration. By compiling existing information on the subbasin, this Assessment is intended to reveal research needs and potential data gaps. And with this evaluation of the overall health of the subbasin, the community can identify and prioritize restoration opportunities to improve environmental conditions within the subbasin.

This Assessment follows the framework provided by the *Oregon Watershed Assessment Manual* (Manual) of the Oregon Watershed Enhancement Board (OWEB) (WPN, 1999). This Assessment focused on the components outlined in the Manual and are arranged into the following chapters:

- Historical Conditions
- Channel Habitat Typing
- Hydrology and Water Use
- Riparian
- Wetlands
- Sediment Sources
- Channel Modifications
- Water Quality
- Fish and Fish Habitat

Each chapter is organized by the following sections: Introduction, Methods, Results and Discussion, Confidence Evaluation, Recommendations and Restoration Opportunities.

The Confidence Evaluation rates the overall confidence in each technical chapter of the Watershed Assessment. This section evaluates the analysis by considering the number of resources available, the quality of the available resources, and whether the information in those resources were consistent or not. The Recommendations section describes known data gaps for each technical component and the recommendations for filling those gaps. The Restoration Opportunities section considers all of the technical evidence brought forward in the Results and Discussion section and suggests restoration actions that could benefit the watershed.

The information provided in each of these chapters is then woven together and summarized in the last chapters (to be written once technical chapters have been reviewed), which describe the recommendations and data gaps and the potential restoration scenarios intended to benefit the subbasin. These restoration scenarios can be used by KBEF and the Upper Williamson River Catchment Group to evaluate, to prioritize, and eventually to implement the restoration opportunities.

STUDY AREA

This Watershed Assessment has been conducted as part of a broader Watershed Assessment effort for the entire Upper Klamath Basin. The Assessment techniques described in the OWEB Manual are generally intended for 5th-field watersheds; however, because of time and resource constraints, it was not reasonable to conduct Assessments on each individual 5th-field within the Upper Klamath Basin. It was much more pragmatic to cover the entire Basin by delineating five or six areas as Individual Assessment Units (IAUs) that are generally focussed on the 4th-field or subbasin level. The IAU chosen as the first Watershed Assessment area was upper Williamson River subbasin.

The upper Williamson River subbasin is located in south central Oregon along the eastern flank of the southern Cascades (Figure 1-1). It falls almost entirely in Klamath County, with just a sliver along the east edge of the subbasin occurring within Lake County. The area covered by this Assessment has been defined as the area contributing to the Williamson River, upstream of Kirk Reef, as illustrated in Map 1-1 (at the end of this section). Although the Williamson River 4th field hydrologic unit (18010201) extends from the headwaters of the Williamson River to the mouth at the Williamson River Delta, Kirk Reef was designated as the southern boundary of the Assessment area because it demarcates changes in water sources, hydrologic trends, and patterns of land use and ownership. Kirk Reef also serves as the southern boundary for the Upper Williamson Catchment Group.

Figure 1-1. Location of the Upper Williamson River Subbasin

The Assessment area is approximately 1,300 square miles in size, ranging in elevation from approximately 4,500 feet at Kirk Reef to 9,182 feet at the summit of Mount Thielsen along the northwest boundary of the Assessment area. In addition to the horseshoe-shaped Williamson River, notable features within the subbasin include the Winema National Forest, Crater Lake National Park and the Klamath Marsh National Wildlife Refuge. Primary roads include Highway 97, cutting north-south through the middle of the subbasin; Highway 62, which takes travelers to Crater Lake; the Williamson River Road, accessing the eastern portion of the subbasin; East Diamond Lake Highway, heading towards the western portion of the study area; and Military and Silver Lake Roads, which cut across Klamath Marsh and head toward the northeast. Aside from the small town of Chemult (population approximately 300), located along Highway 97 at the north edge of the study area, there are no population centers within the subbasin. Chiloquin (population approximately 800), is located approximately 10 miles south of the study area, while Klamath Falls, the primary population center of the region, with a population of approximately 19,000 within the city limits, is located approximately 60 miles south.

The assessment area includes the following five 5th-field watersheds, as illustrated in Map 1-1 (at the end of this section):

- Upstream of Klamath Marsh (Hydrologic Unit Code: 1801020101)
- Klamath Marsh/Jack Creek (1801020102)
- Northwest of Klamath Marsh (1801020103)
- West of Klamath Marsh (1801020104)
- Downstream of Klamath Marsh (1801020105) (This 5th-field extends below Kirk Reef but only the portion upstream of Kirk Reef is included in this Assessment).

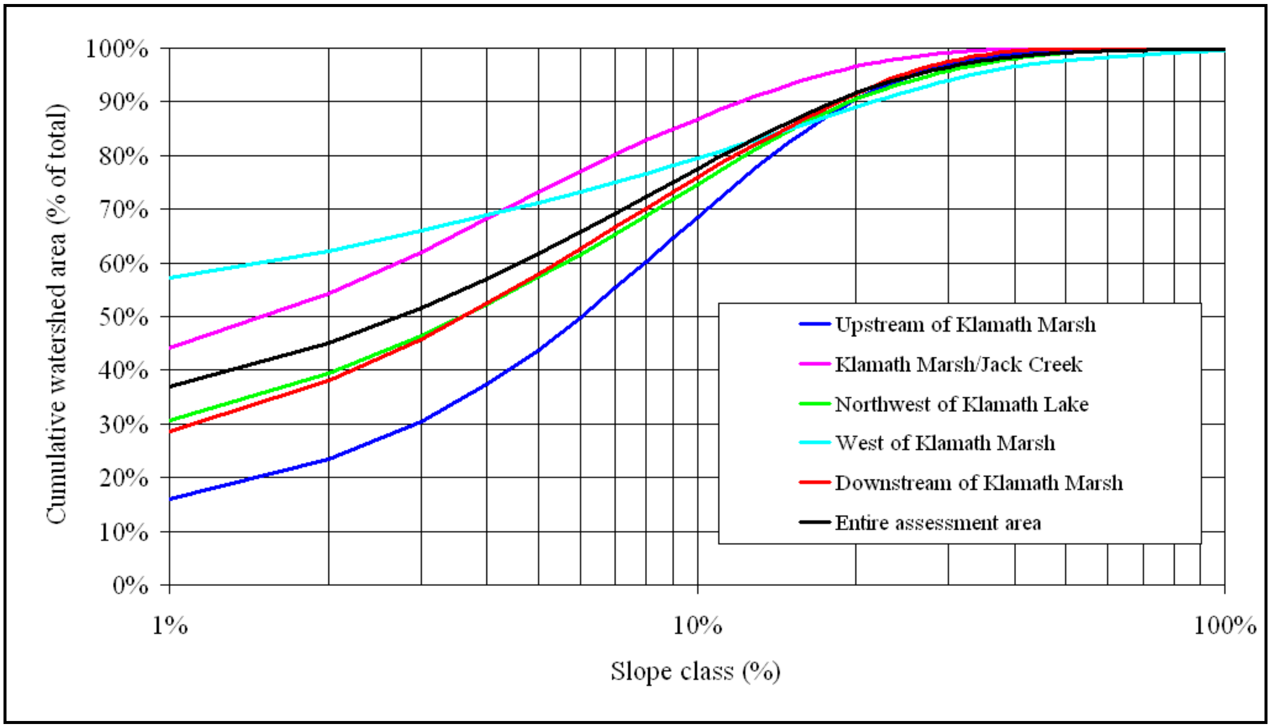
The general 5th-field (watershed) characteristics are provided in Table 1-1. The boundaries for these 5th-field hydrologic units were derived from the U.S. Forest Service (USFS) Regional Ecosystem Office; however, they are similar to those represented by the U.S. Geological Survey (USGS) and others.

Table 1-1. General Characteristics of the Upper Williamson River Subbasin and 5th-Field Watersheds.

		Elevation (feet)		
Watershed	**Area (mi^2)**	**Mean**	**Min**	**Max**
Upstream of Klamath Marsh	268	5,189	4,544	8,180
Klamath Marsh/Jack Creek	304	4,917	4,508	7,067
Northwest of Klamath Lake	313	5,339	4,610	9,182
West of Klamath Marsh	324	5,099	4,511	8,934
Downstream of Klamath Marsh	117	4,896	4,502	6,608
Entire Assessment Area	**1,326**	**5,114**	**4,502**	**9,182**

Data source: USGS (2004a)

Mean elevation, which averages approximately one mile above sea level, is similar among the five watersheds (Table 1-1). The Klamath Marsh/Jack Creek watershed has the lowest relief of all five watersheds, with approximately three-quarters of the watershed area having slopes less then 5%, and 97% of the watershed area having slopes less then 20% (Figure 1-2). The West of Klamath Marsh watershed is unusual in that a large portion of the watershed is relatively flat (57% of the watershed area has 1% slopes or less), but it also has the highest proportion of steep terrain (Figure 1-2). This is due to the high proportion of highly permeable pumice/ash deposits and lake/wetland area in the middle and eastern portion of the watershed, and areas of high relief associated with Mt. Mazama in the western portion.



Data source: USGS 2004a

Figure 1-2. Cumulative Watershed Area by Slope Class

COMMUNITY INVOLVEMENT

An effective Watershed Assessment must be a product of the local community, directly involving the people who make important decisions affecting habitat conditions. In order for a Watershed Assessment to lead to successful watershed enhancement, the people who live and work in the local community should share a conviction that, on a fundamental level, this is *their* Assessment. For this reason, special attention has been paid throughout this process to establishing and maintaining consistent and broad-based community involvement in all aspects of the assessment.

This Watershed Assessment is the first of several Assessments that will cover the Upper Klamath Basin. At the beginning of the Assessment process, a public outreach strategy and framework were developed to guide the outreach efforts for all of the Assessments. The primary goals for the public outreach efforts were to:

- Inform people about the way Watershed Assessments work
- Gather input, solicit guidance, and ensure direct and sustained participation
- Help build a strong sense of stewardship toward the landscape, the habitats, and the various communities of the upper Williamson River subbasin and in the Upper Klamath Basin as a whole.

These outreach efforts were intended to be iterative, encouraging the public to provide comment on outreach techniques and their effectiveness. The first step in developing the outreach strategy was to identify the tools that would be most effective in meeting the outreach goals. These tools, and a brief description of how each was (or wasn't) used is provided below.

Develop and update a mailing list of contacts. A mailing list was prepared that included existing members of the Upper Williamson Catchment Group, as well as all owners of property within 200 feet of a stream in the upper Williamson subbasin. The mailing list was used for notifying individuals of upcoming Catchment Group meetings as well as other important meetings. The mailing list was updated as needed to include other interested individuals.

Prepare and distribute a Watershed Assessment information pamphlet. At the beginning of the Assessment process, a pamphlet was prepared to educate people about the intent of the Assessment and how to get involved. The pamphlet was mailed out to individuals living and/or working in the Upper Klamath Basin and was handed out at meetings early on in the Assessment process.

Design, develop and update an Assessment web page. A web page was developed with the intent of making current Assessment information easily accessible to people with computer access. The web page includes links to the Upper Klamath Basin Working Group, the Oregon Watershed Enhancement Board, and the Klamath Watershed Council.

Develop and foster a positive relationship with the media. The Outreach Committee developed a list of media contacts that were used in distributing information related to the Assessment process.

Conduct a "kick-off" meeting. A kick-off meeting was held the evening of January 29, 2004 at the Klamath Falls Yacht Club. This meeting was intended to educate people about Watershed Assessments in general, and specifically, the Upper Klamath Basin Watershed Assessment process, and to encourage their participation. This meeting also introduced the public to the groups coordinating and conducting the Watershed Assessment and helped to build the general Assessment mailing list. There were approximately 50 people in attendance, all hailing from different parts of the Upper Klamath Basin.

In addition to the "kick-off" meeting, a workshop was held during the Upper Klamath Basin Watershed Conference on February 24, 2004. This workshop was also intended to educate people about the Assessment and to encourage their participation in the process. The workshop was attended by approximately 60 people. To engage attendees in the Assessment process, they were asked to respond to two questions: 1) what concerns you most about this particular process? and 2) If this assessment could turn out the way you want, what would it look like? The responses to these questions were then used to illustrate particular community concerns and to help guide the Assessment process. In addition to answering the two questions, the audience was enlisted to draft a list of issues particular to the upper Williamson River subbasin, which also helped to guide the Assessment process.

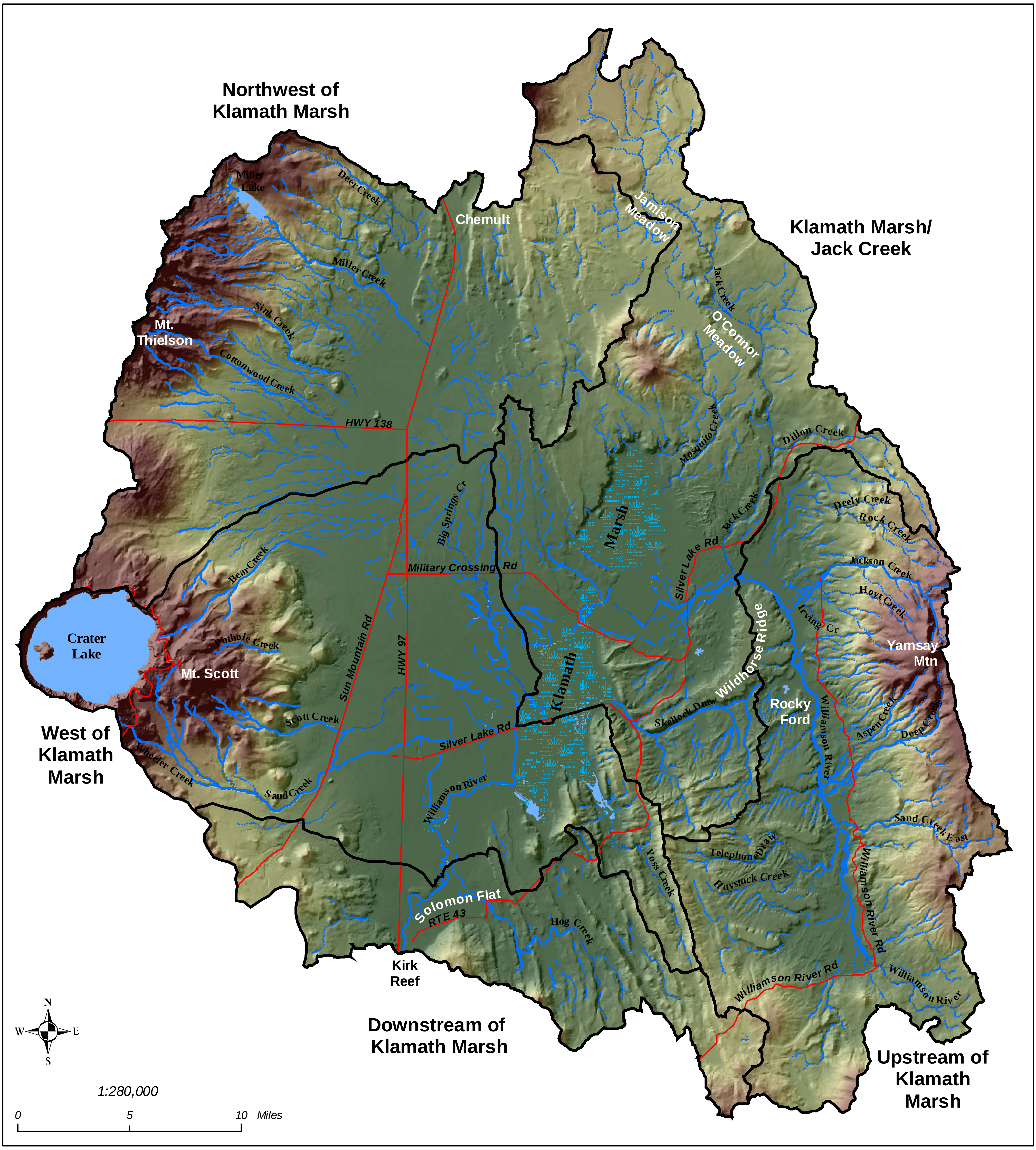
Inform the public of Assessment progress through newsletters. KBEF provided Assessment updates within its regular, seasonal newsletter.

Conduct small, intimate meetings and one-on-one interviews with community. The Upper Williamson Catchment Group meets on the third Tuesday of every month. The Catchment Group meetings were used as an opportunity to share information about the Assessment process, to learn about the issues that are significant to the people that live and work in the subbasin, and to take informative field trips to different parts of the subbasin. These meetings and field trips were always very well attended (probably because of the good food) and usually led to very powerful conversations about work, life and restoration in the subbasin.

In addition to the Catchment Group meetings, several interviews were held with long-time residents of the subbasin in order to gain a better perspective on the history and changes in the area.

Conduct other public meetings at project milestones. Because the combination of the kick-off meeting, the workshop, and the monthly Catchment Group meetings resulted in engaging a broad spectrum of the public in the Watershed Assessment process, no additional public meetings have been required to date. It is anticipated that a larger public meeting will be held to discuss the findings of the Assessment and to elicit discussion of the restoration opportunities.

LIST OF MAPS – SECTION 1



Upper Williamson River Watershed Assessment

Map 1-1: Upper Williamson River Subbasin

Legend

- Perennial stream
- Non-perennial stream
- Major road
- Marsh
- 5th-field watershed boundary

Sources:
Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)

DAVID EVANS AND ASSOCIATES INC.

August 13, 2004
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2 EXISTING DATA AND BASELINE CONDITIONS

GIS BASEMAP

A significant amount of data (written studies and GIS data layers) has been collected that is relevant to the upper Williamson River subbasin. All of the relevant material collected to date is listed in the Bibliography (Section 15) at the end of this document. GIS data from over 20 agencies and organizations has been collected and compiled (See list of GIS data at end of Bibliography). Primary sources of information include the U.S. Geological Society (USGS), USFS, the U.S. Bureau of Reclamation (USBR), the Ecosystem Restoration Office (ERO) of the U.S. Fish and Wildlife Service (USFWS), The Nature Conservancy (TNC) and the Oregon Institute of Technology (OIT). Data has also been obtained from Timber Resource Services, Crater Lake National Park, and various individuals and long-time residents of the area.

The GIS data acquired were of various scales and spatial reference systems, and contained information pertaining to a wide range of subjects. Each dataset was evaluated to determine spatial and content accuracy, appropriate scale of use, and spatial registration. In many cases, data was re-projected from its native coordinate system to a more standard coordinate system to make it easier to use in conjunction with other datasets. Data sources are addressed more specifically in each of the following sections and chapters.

PREVIOUS REPORTS

A number of Watershed Analyses have been conducted on portions of the upper Williamson River subbasin that have been very useful in preparing this Watershed Assessment. These analyses are summarized below.

Assessment of the Jack and Mosquito Creek Watersheds. Undated, approximately 1994.

This document was prepared by a USFS assessment team to provide a general description of ecosystem structure, process, and function occurring within the combined Jack and Mosquito Creek watersheds. This Assessment was not intended as a decision-making document, but rather, to provide the foundation for proposed changes in land management. This Assessment focuses on the following questions:

1. How has the character of the subwatershed changed over time and how does this affect sustainability of key habitats and vegetation?
2. What role have natural disturbance processes had in the function and conditions of the area (particularly as it relates to vegetative and channel conditions)?
3. How has water availability changed over time and how do changes in vegetation stocking levels affect stream flow?

4. How have stream channels changed over time and what activities or events are likely to affect further trends?

Hog, Yoss and Skellock: An Assessment of the Hog Creek, Yoss Creek and Skellock Draw Subwatersheds. February, 1995a.

The intent of this Assessment was the same as the Jack and Mosquito Creek Watershed Assessment and followed the same general format. The analysis area included 86,402 acres of Winema National Forest, 5,932 acres of private land and 1,590 acres of State Forest. This assessment focussed on the following issues:

1. Stream channels, soil productivity, and basic hydrologic functions have changed from the reference era (pre-1875) conditions in the Hog, Yoss and Skellock drainages.
2. Fire exclusion, grazing, timber harvest, road and railroad construction and other management activities have changed the biological and physical characteristics of the landscape from the reference condition.
3. The current risk of stand replacement events from wildfire, insets and disease appears to be increasing.
4. Vast portions of the watershed have experienced potential soil compacting activities.

Mazama Watershed Analysis. July 11, 1996.

This Watershed Analysis was written to help guide project planning during the implementation of the Northwest Forest Plan on the Chemult Ranger District of the Winema National Forest. The analysis area included the upper reaches of seven watersheds: Sand Creek (west), Scott Creek, Pothole Creek, Bear Creek, Cavern Creek, Lost Creek and Wheeler Creek. The analysis was conducted using the Federal Agency Guide for Watershed Analysis, Version 2.2 (REO 1995), which uses a six step process to meld social values, biological capabilities, and physical characteristics of the landscape at the watershed level. Based upon a scoping process, the Analysis addressed the following issues:

1. Clean water for domestic use
2. Diversions may have disconnected streams in the watershed from the Williamson River.
3. Riparian hardwoods and other unique riparian habitats are disappearing.
4. Stream systems are very vulnerable to disturbance.
5. Roads are influencing hydrologic function.
6. Vegetative health and sustainability are at risk in parts of the watershed.
7. Populations of several wildlife species are declining.
8. Roads provide access to Crater Lake for illegal hunting and mushroom picking.

Upper Williamson Watershed Analysis. August, 1996.

This Analysis blended the formats used in the Jack and Mosquito Creek and Hog, Yoss and Skellock Watershed Assessments with the format suggested by the Federal Guide for Watershed Analysis, Version 2.2 (REO 1995). The analysis area included 137,306 acres of Winema National Forest, 16,233 acres of private land, 39,001 acres of Weyerhaeuser (Currently Timber Resource Services) and 7,703 acres of State Forest, for a total analysis area of 200,243 acres. This Analysis is contained generally within the "Upstream of Klamath Marsh" watershed but also includes a small portion of the Klamath Marsh/Jack Creek watershed. Within this Analysis, the assessment team focussed on the following issues/questions:

1. Erosion processes – Road systems, downcutting channels, wind erosion following fires, and compaction
2. Hydrology and stream channels – The hydrologic function of the upper Williamson River has changed over time, resulting in less water being retained in the system later in the year.
3. Vegetation – How and why have the upland and riparian vegetation components changed?
4. Soils – Portions of the watershed have been subjected to activities that may have detrimental impacts to soils.
5. Water quality – Water quality has been affected by increased human usage of the watershed.
6. Species and habitat – How have important and/or listed species, and their habitats, been affected?
7. Human uses – What are the major human uses, or items of importance in the watershed, and how do they affect the watershed as a whole?

Aquatic Module: Mega Williamson Watershed Analysis (Everything that flows into Klamath Marsh). Undated, approximately 1997.

As the title suggests, this document addresses aquatic issues for all waters flowing into Klamath Marsh. This document appears to be a preliminary draft for the aquatic portions of the "Big Bill" Watershed Analysis (as described below). The analysis in this particular document appears to cover much of the upper Williamson River subbasin, but only addresses water quality and fish and fish habitat.

Big Bill – The Williamson River Basin Watershed Analysis. 1998.

The "Big Bill," as it is commonly called, addresses the entire upper Williamson River subbasin above Kirk Reek, which is the same area addressed by this Watershed Assessment. The "Big Bill" was prepared by a watershed analysis team that consisted primarily of personnel from the Oregon State office of USFS. The format is similar to that described for the Mazama and Upper Williamson Watershed Analyses and addresses the issues as described above.

Deep, Sand, Aspen and Coyote Watershed Analysis. Weyerhaeuser. January 1996.

Weyerhaeuser conducted a Watershed Analysis of the Deep, Sand, Aspen and Coyote Creek watersheds following a format that is similar to that described for the USFS Watershed Analyses. The Coyote Creek watershed lies east of the upper Williamson River subbasin, in the Sprague River watershed. The assessment team consisted of Weyerhaeuser team of technical specialists who used the *Standard Methodology for Conducting Watershed Analysis (Version 2.1)* (Washington Forest Practices Board 1994) to prepare the document. Fieldwork for this analysis was conducted in the low flow period of October 1995. Module reports address mass wasting, surface erosion, hydrology, riparian functions, stream channel assessment and fish habitat.

Upper Klamath Basin Subbasin Assessments, Natural Resources Conservation Service (NRCS). 2004.

NRCS prepared the Rapid Subbasin Assessments on the Upper Klamath Basin “in response to a request from the Klamath Soil and Water Conservation District and the Lava Beds/Butte Valley Resource Conservation District for timely information with which to make urgent decisions regarding conservation opportunities for restoring and protecting natural resources on private, agricultural land” (USDA/NRCS 2004). Specifically, the Conservation Districts were facing complex decisions that would affect their ability to secure a reliable supply of water for agriculture by 1) reducing water demand, 2) increasing water storage, 3) improving water quality, and 4) enhancing fish and wildlife habitat. Eight Rapid Subbasin Assessments, covering the entire 5 million acres of the Upper Klamath Basin, were conducted in 18 months using existing information, field reconnaissance, and frequent discussions with knowledgeable members of the community. Each subbasin assessment includes 1) descriptions of current, private land use and levels of management; 2) alternative resource management systems and conservation opportunities; and 3) estimates of the effects of conservation on the Conservation Districts’ resource concerns/objectives.

OWNERSHIP

Information on ownership within the upper Williamson River subbasin was obtained from the Winema National Forest database. Ownership boundaries are illustrated in Map 2-1 (at the end of this section), while ownership is summarized by 5th-field watershed in Table 2-1.

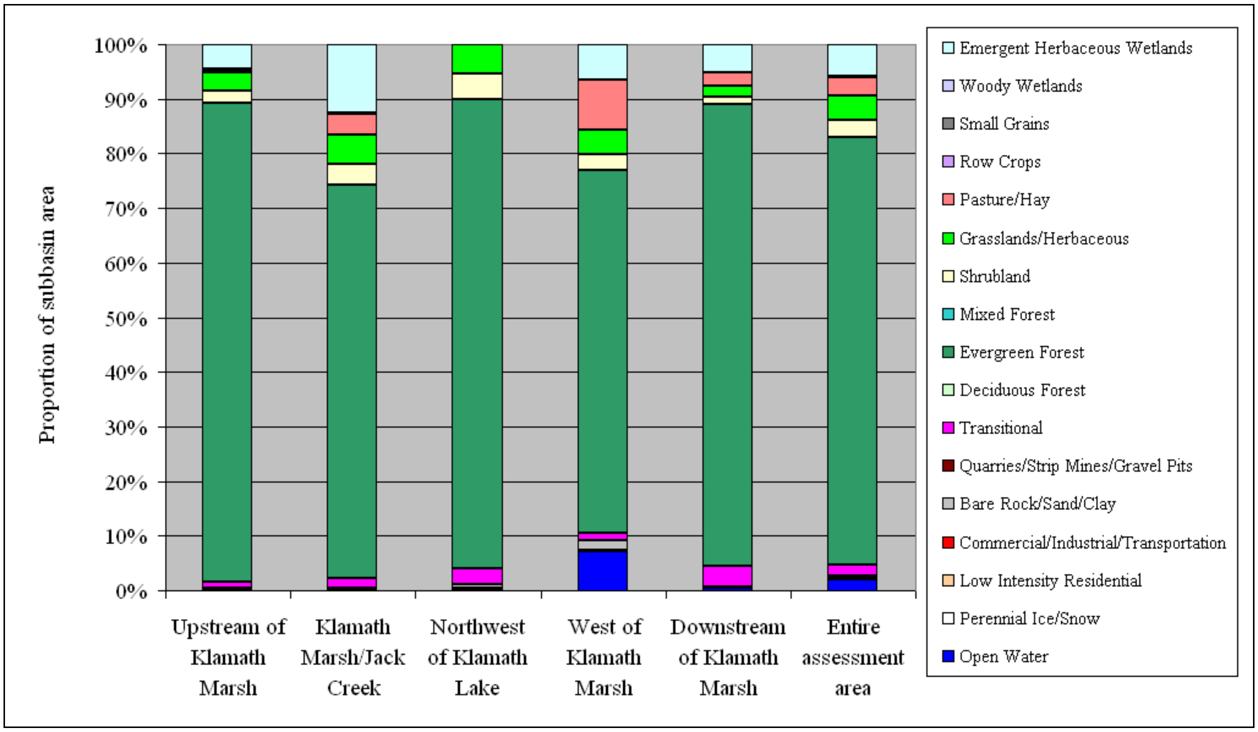
Table 2-1. Summary of Ownership

5th-Field Watershed	USFS		NPS		USFWS		Private	
	Acreage	**%**	**Acreage**	**%**	**Acreage**	**%**	**Acreage**	**%**
Upstream of Klamath Marsh	119,340	70%	0	0	0	0	52,055	30%
Klamath Marsh/Jack Creek	134,474	69%	0	0	25,420	13%	34,803	18%
Northwest of Klamath Lake	120,291	61%	21,959	11%	0	0	56,037	28%
West of Klamath Marsh	66,568	33%	37,622	19%	15,470	8%	82,668	41%
Downstream of Klamath Marsh	59,493	82%	640	1%	0	0	12,159	17%
Total for Subbasin	500,166	60%	60,221	7%	40,890	5%	237,722	28%

The study area is characterized by USFS land (primarily the Winema forest, but also including a sliver of the Fremont National Forest along the east edge of the subbasin), the Klamath Marsh National Wildlife Refuge, Crater Lake National Park, large private timber holdings, and large ranches. Ownership in the subbasin is closely tied to the land cover and land uses, as described in the following section.

LAND COVER/LAND USE

Current land cover/land use within the assessment area was estimated using GIS coverages available from the U.S. Geological Service (USGS) (USGS 1999; Map 2-2). The USGS data is part of the National Land Cover Dataset, and was compiled from Landsat satellite images captured in the early 1990s, and supplemented by other data where available. The data has a spatial resolution of approximately 30 meters. Current land cover/land use conditions are summarized by watershed in Figure 2-1 below. Forest (almost exclusively evergreen forest) covers the majority of the total land area in all watersheds (Figure 2-1). The areas identified as "Transitional" are primarily regenerating forest harvest units. Wetlands and/or open water make up a large portion of all watersheds, with the exception of the "Northwest of Klamath Lake" watershed (Figure 2-1). Areas of pasture/hay are found primarily around Klamath Marsh (Map 2-2). Developed uses (Low Intensity Residential and Commercial/Industrial/Transportation uses) make up less then ¼ of 1% of the total area in any watershed.



USGS 2000

Figure 2-1.Summary of Land Cover Within the Upper Williamson Assessment Area

WATER FEATURES

The Williamson River is the predominant surface water feature within the subbasin. The source of the Williamson River is located southwest of Yamsay Mountain, but the river picks up flow from a group of springs at an elevation of 4,600 feet. From these springs, the river meanders northward to Wildhorse Ridge, where it then swings westward. In this area, the river has been modified by diversions and becomes ditched and channelized as it flows into the Klamath Marsh National Wildlife Refuge. At Military Crossing the channelized river discharges into the Klamath Marsh, where the channel is no longer defined. Once the river leaves the marsh, the channel is redefined. In the Kirk Reef area, below the marsh, the river forms prominent rapids across lava flows during the wet parts of the year but usually dries up during low water periods. Photo 2-1 illustrates the Williamson River at the Road 43/Kirk Bridge during April, when surface flows are present, and Photo 2-2 provides an example of the river in June, when low water has eliminated surface flows.

Photo 2-1. Williamson River at Kirk Reef, April 2004

Photo 2-2. Williamson River at Kirk Reef, June 2004

The river returns to a perennial flow again approximately one-mile downstream of this area, where springs and other sub-surface flows contribute to recharge the river.

The streams network and associated water features for this Watershed Assessment are derived from The Nature Conservancy dataset. A number of stream network data sources were available, but this source was used because it includes field verification, as well as the approval of the various Watershed Councils and Catchment Groups in the Upper Klamath Basin. The water features within the subbasin are summarized in Table 2-2.

Table 2-2. Summary of Water Features

Feature		Upstream of Klamath Marsh	Klamath Marsh/Jack Creek	NW of Klamath Marsh	West of Klamath Marsh	Downstream of Klamath Marsh	Subbasin Totals
Perennial Streams	(miles)	70	23	57	96	14	259
Non-perennial Streams	(miles)	280	264	260	136	39	979
Perennial Ditches	(miles)	1	24	0	11	5	41
Non-perennial Ditches	(miles)	16	13	0	24	4	56
Perennial Lake/ Pond/Reservoirs	(acres)	44	89	519	13,925	0	14,577
Non-perennial Lake/Pond/Reservoirs	(acres)	0	54	0	37	0	91

As indicated in Table 2-2, there are approximately 259 miles of perennial stream and 979 miles of non-perennial streams within the subbasin. The majority of the streams are non-perennial due to the unique geology of the area, and do not have a surface connection to the Williamson River.

Because it was not practical to provide an analysis of all waterways within the study area, key streams were identified based upon their flow, fish distribution, and the amount of available information. These key streams are summarized by 5th-field in Table 2-3 and are identified by name on all of the maps. The Williamson River is a key stream that occurs within each of the watersheds.

Table 2-3. Key Streams by Watershed

5th-Field Watershed	Key Streams	
Above Klamath Marsh	Sand Creek (East)	Hoyt Creek
	Deep Creek	Jackson Creek
	Aspen Creek	Deely Creek
	Irving Creek	Rock Creek
Klamath Marsh/Jack Creek	Jack Creek	Skellock Draw
	Dillon Creek	
NW of Klamath Marsh	Deer Creek	Sink Creek
	Miller Creek	Cottonwood Creek
West of Klamath Marsh	Bear Creek	Wheeler Creek
	Pothole Creek	Sand Creek (West)
	Scott Creek	Yoss Creek
Below Klamath Marsh	Hog Creek	

The hydrology of the subbasin is addressed in much greater detail in Section 5 on Hydrology and Water Use.

ECOREGIONS

The ecoregion data was obtained from the Level III and IV Ecoregion Descriptions of Oregon (Bryce and Woods 2000). Ecoregions denote areas of general vegetation, geologic, land use and climatic similarity. Map 2-3 illustrates the ecoregions identified for the upper Williamson River subbasin. The upper Williamson River is located primarily within the Pumice Plateau Forest ecoregion; while Klamath Marsh is characterized by the Cold Wet Pumice Plateau Basins ecoregion, and the western edge of the subbasin is located within the High Southern Cascades Montane Forest ecoregion, with the higher elevations along the west side falling in the Cascade Subalpine/Alpine ecoregion. Following are brief descriptions of these ecoregions, adapted from Bryce and Woods (2000).

Pumice Plateau Forest: This ecoregion is a high volcanic plateau that is thickly covered by Mt. Mazama ash and pumice. Its residual soils are highly permeable. Prevalent water features are spring-fed creeks, marshes, and a few lakes. Forests of ponderosa pine are common on the slopes; colder depressions and flats are dominated by lodgepole pine. Winters are consistently cold and precipitation falls mainly as snow. Summers tend to be mild.

Cold Wet Pumice Plateau Basins: These areas function as cold air catch-basins during the winter and have lower minimum temperatures than the Pumice Plateau Forest. These marshy areas are important habitat for migratory waterfowl.

High Southern Cascades Montane Forest: This ecoregion consists of an undulating, glaciated plateau punctuated by volcanic buttes and cones. This mixed coniferous forest is dominated by mountain hemlock and Pacific silver fir. Grand fir, white fir, Shasta red fir, and lodgepole pine also occur and become more common toward the south and east.

Cascade Subalpine/Alpine: These areas are generally high, glaciated, volcanic peaks that rise above subalpine meadows. Elevations range from 5,600 to 12,000 feet. Active glaciation occurs on the highest volcanoes and decreases from north to south. The winters are very cold and the growing season is extremely short. The vegetation that occurs in these high elevation areas include herbaceous and shrubby subalpine meadow species and scattered patches of mountain hemlock, subalpine fir and whitebark pine.

GEOLOGY AND SOILS

The upper Williamson River subbasin is characterized by interesting geological events and features that have defined the landscape. The geology of the subbasin was obtained from the Spatial Digital Database for the Geology of Oregon (USGS 2002) and is illustrated in Map 2-4. Information for the Map 2-4 legend is provided in Appendix A. The western edge of the basin follows the crest of a series of irregularly spaced high volcanic peaks dotting the eastern flank of the Cascade Range. These peaks, which were all formed in the recent Pliocene and Pleistocene eras, are Mt. Thielsen (elevation 9,182 feet), Mt. Scott (elevation 8,926 feet) and Crater Peak (elevation 7,265 feet). Notable along the western rim is the Crater Lake caldera, which was formed by the eruption of Mt. Mazama approximately 7,700 years ago (USFS 1998). Mt. Mazama, which is thought to have been greater than 12,500 feet in elevation, erupted and collapsed to form the crater, which subsequently filled with water (Baldwin 1964 in USFS 1998). This eruption removed the upper third of the mountain, and a cloud of pumice poured over the landscape. Airborne pumice was carried towards the northeast, and a thick blanket of pumice was deposited as far north as Bend. At Chemult, in the north portion of the subbasin, pumice deposits over 40 feet deep are common (USFS 1998).

The hydrogeology of the subbasin is dominated by two factors: the distribution of bedrock geologic units and faults. Pyroclastic-flow and -fall deposits from Mount Mazama are present throughout the subbasin. Although highly porous, the pumice in pyroclastic-fall deposits hold water and reduce the amount that migrates into streams and wetlands. In low precipitation years, most of the annual precipitation is probably tied up in the pumice deposits, leading to little recharge of ground water and no stream flow (Cummings and Melady 2002). The pumice substrate explains why many of the streams flowing east from the flanks of the Cascades disappear below the surface (retreat in to the pyroclastic deposits) and do not make it to the Williamson River. It is the abundance of this pumice material that has inspired the understanding that the upper Williamson River subbasin is the area where water sinks and rocks float.

Klamath Marsh bore the brunt of the Mt. Mazama eruption. The marsh existed prior to the eruption, but water levels were raised by the large volume of pumice that entered the area following the eruption. In addition, a lake formed behind a dam composed of pyroclastic-flow debris that blocked the Williamson River canyon (Cummings and Meladay 2000). The lake reached an elevation of 4,600 feet and a surface area of approximately 220 square miles before catastrophically draining by overtopping the debris dam.

The eastern slopes of the subbasin are bounded by a series of low ridges formed along a series of northwest trending faults. In the central portion of the subbasin, late Miocene to early Pliocene volcanic rocks are overlain by Pliocene lakebeds, portions of which were subsequently buried by a thick layer of basaltic lava as much as 1,000 feet deep (Baldwin 1964 in USFS 1998). Late in the Pliocene and early in the Pleistocene, the area was fractured by a series of northwest trending faults. Volcanic cones such as Sugarpine Mountain (elevation 6,393 feet) in the north of the subbasin, Yamsay Mountain (elevation 8,196 feet) on the east edge of the subbasin, and Solomon Butte (elevation 5,763 feet) on the southeast developed along these fault lines (USFS 1998).

Soils information is not complete for the upper Williamson River subbasin. Two surveys cover a portion of the subbasin. The results of these surveys are illustrated in Map 2-5. The keys associated with the legend for Map 2-5 are provided in Appendix B. One of the soils surveys was conducted for Crater Lake National Park and the other was conducted for the Winema National Forest. Although there is a soils survey for the southern portion of Klamath County (USDA Soils Conservation Service 1985), the survey for the northern portion of the County has not yet been completed. NRCS is currently in the process of preparing a soils survey for the northern portion of the County, which includes the assessment area (Sue Malone, NRCS, and Eric Nicita, USFS, personal communications).

CLIMATE

General

The upper Williamson River subbasin is located within Oregon Climate Zone 5 – the High Plateau (OCS, 2004a). Given the generally high elevations, the High Plateau experiences cool temperatures and significant snowfall. Its distance from the coast, along with its location downwind of the Cascades, results in lower annual precipitation than in the mountainous areas to the west. As air moves over the Cascades and descends it becomes drier, the degree to which air loses moisture being proportional to the amount it descends. The result of the Cascade crest being lower in elevation in the High Plateau than farther north, and the high elevation within the Plateau itself, results in a lesser "rain shadow" effect than is seen farther north. For example, air parcels reaching Bend to the north must descend approximately 4,000 feet from the Cascade crest and are normally quite dry, whereas similar air parcels moving into the High Plateau drop only approximately 2,000 feet. The result is that average annual precipitation in the Bend area is only about 12 inches, while the High Plateau receives more than 20 inches.

Climatic Records

Climatic records are available from several sources within the upper Williamson River subbasin. USBR, USFS, NRCS, and numerous other federal, state, and local agencies maintain climatic station throughout the area. Data from these stations are generally available through two separate sources; the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) cooperative station network, and the NRCS National Water and Climate Center (NWCC). Seven NOAA Co-op stations, and five NRCS SNOTEL*1* stations, are located within or adjacent[2] to the upper Williamson River subbasin (Map 2-6). Station data inventories are summarized in Table 2-4.

Table 2-4. Station Information for Climate Stations in the Vicinity of the Upper Williamson River Subbasin

Station ID	Station Name	Elev.	Start date	End date	Temp	Precip	Snowpack
351546	Chemult 2 N	4,750	Jul-48	May-50	X	X	
		4,760	May-50	Jun-71	X	X	
		4,760	Jun-71	Present	X	X	
351548	Chemult 20 SE	4,540	Apr-63	Oct-64	X	X	
351574	Chiloquin 7 NW	4,150	Jun-80	Oct-85	X	X	
		4,160	Oct-85	Oct-86	X	X	
		4,160	Oct-86	Present	X	X	
351946	Crater Lake Natl Park HQ	6,480	Jul-48	Jan-82	X	X	
		6,470	Jan-82	Present	X	X	
352313	Diamond Lake Lodge	5,200	Jul-48	Sep-53		X	
357533	Sand Creek	4,680	Jul-48	May-50	X	X	
357815	Silver Lake 15 W	5,000	Nov-67	Dec-68	X	X	
22G06S 1000	Annie Springs	6020'	Oct-01	Present	X	X	X
21F22S 395	Chemult Alternate	4760'	Oct-80	Present	X	X	X
22F18S 442	Diamond Lake	5315'	Oct-80	Present	X	X	X
21F12S 756	Silver Creek	5720'	Oct-80	Present	X	X	X
21G03S 810	Taylor Butte	5100'	Oct-78	Present	X	X	X

Data sources: EarthInfo (1996), NRCS (2004), NOAA (2004)

Precipitation

The Oregon Climate Service (OCS, 1998) has published digital maps of mean annual and monthly precipitation for the western United States, based on available precipitation

1 *For SNOpack TELemetry*
2 *Within 10 miles of the Upper Klamath Basin boundary*

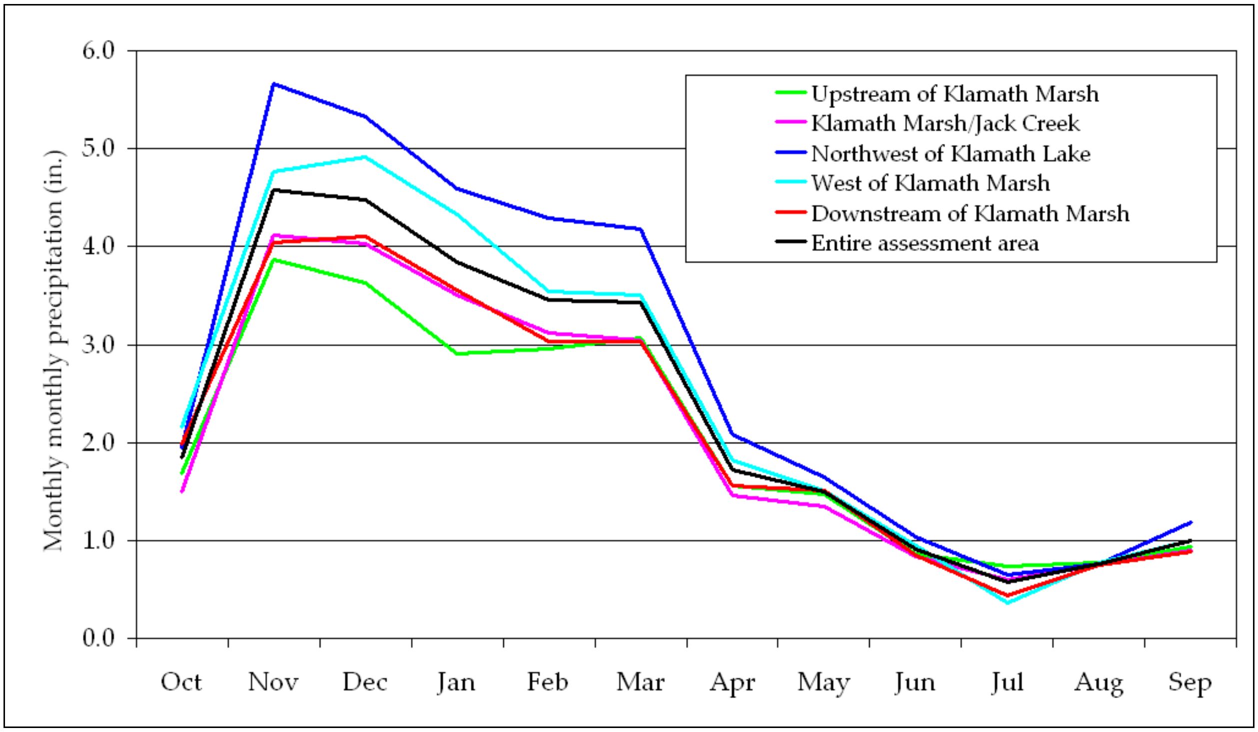
records for the period 1961-1990. The OCS maps were produced using techniques developed by Daly and others (1994), that use an analytical model that combines point precipitation data and digital elevation model (DEM) data to generate spatial estimates of annual and monthly precipitation. As such, the precipitation maps available from the OCS incorporate precipitation data from the local stations shown in Map 2-6. Mean annual precipitation within the subbasin varies with elevation, and from east to west (Map 2-6). Mean annual precipitation ranges from 17 to 69 inches within the Upper Williamson, and is 28 inches overall (as indicated in Map 2-6). Precipitation is lowest in the central portion of the assessment area, in the vicinity of Klamath Marsh, and greatest along the Cascade Crest (Map 2-6).

Table 2-5. Mean Annual Precipitation (inches) in the Upper Williamson River Subbasin

5th–Field Watershed	Area – Weighted		
	Mean	Min	Max
Upstream of Klamath Marsh	24.6	17	41
Klamath Marsh/Jack Creek	25.1	17	43
Northwest of Klamath Marsh	33.3	23	67
West of Klamath Marsh	29.6	19	69
Downstream of Klamath Marsh	25.8	19	47
Subbasin Total	28.1	17	69

OCS, 1998

Mean monthly precipitation for each watershed was also estimated using data available from the OCS (1998) (Figure 2-2). Variation in mean monthly precipitation among the watersheds is reflected in elevational differences and distance from the Cascade crest. Mean monthly precipitation is lowest in the month of July for all watersheds (Figure 2-2), ranging from 0.4 inches in the West of Klamath Marsh watershed to 0.7 inches in the Upstream of Klamath Marsh watershed. November and December are the months with the highest values of mean monthly precipitation, ranging from 3.9 inches in the Upstream of Klamath Marsh watershed to 5.7 inches in the Northwest of Klamath Lake watershed.

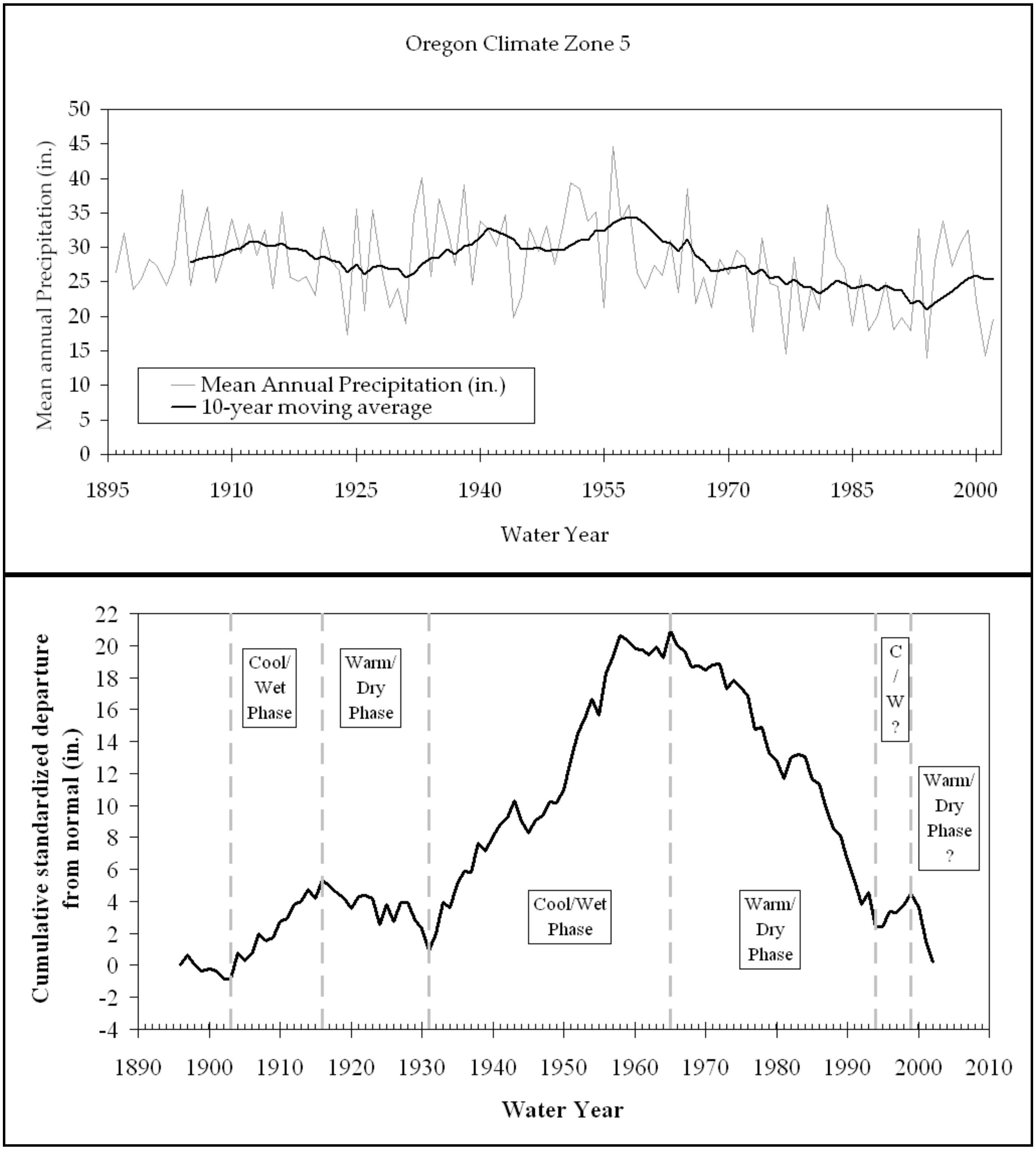


OCS, 1998

Figure 2-2. Mean Monthly Precipitation by Subbasin Within the Upper Williamson River Subbasin

Year-to-year variability in precipitation was assessed using long-term composite precipitation produced by the Oregon Climate Service (2004b) for Climate Zone 5 (the High Plateau). The long-term records produced by the OCS use values from all climate stations within the region, and cover the period from 1895 to present. Total monthly precipitation data were used to calculate total precipitation by water year[3] (Figure 2-2; top graph).

3 *Water year is defined as October 1 through September 30. The water year number comes from the calendar year for the January 1 to September 30 period. For example, Water Year 1990 would begin on October 1, 1989, and continue through September 30, 1990. This definition of water year is recognized by most water resource agencies*



Local PDO cycles are shown as vertical dashed lines.

OCS 2004b

Figure 2-2. Composite Annual Precipitation Record for Oregon Climate Zone 5 (top graph), and Cumulative Standardized Departure from Normal Of Annual Precipitation for Oregon Climate Zone 5 (bottom graph).

The two primary patterns of climatic variability that occur in the Pacific Northwest are the El Niño/Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). The two climate oscillations have similar spatial climate fingerprints, but very different temporal behavior: PDO events persist for 20- to 30-year periods, while ENSO events typically persist for 6 to 18 months (Mantua, 2001). Changes in Pacific Northwest marine ecosystems have been correlated with PDO phase changes. Warm/dry phases have been correlated with enhanced coastal ocean productivity in Alaska and decreased productivity off the west coast of the lower 48 states, while cold/wet phases have resulted in opposite patterns of ocean productivity (Mantua, 2001). Several studies (Mantua et al., 1997; Minobe, 1997; and Mote et al., 1999) suggest that five distinct PDO cycles have occurred since the late 1800s:

- 1890-1924 (cool/wet)
- 1925-1946 (warm/dry)
- 1947-1976 (cool/wet)
- 1977-1995 (warm/dry)
- 1995-present (cool/wet)

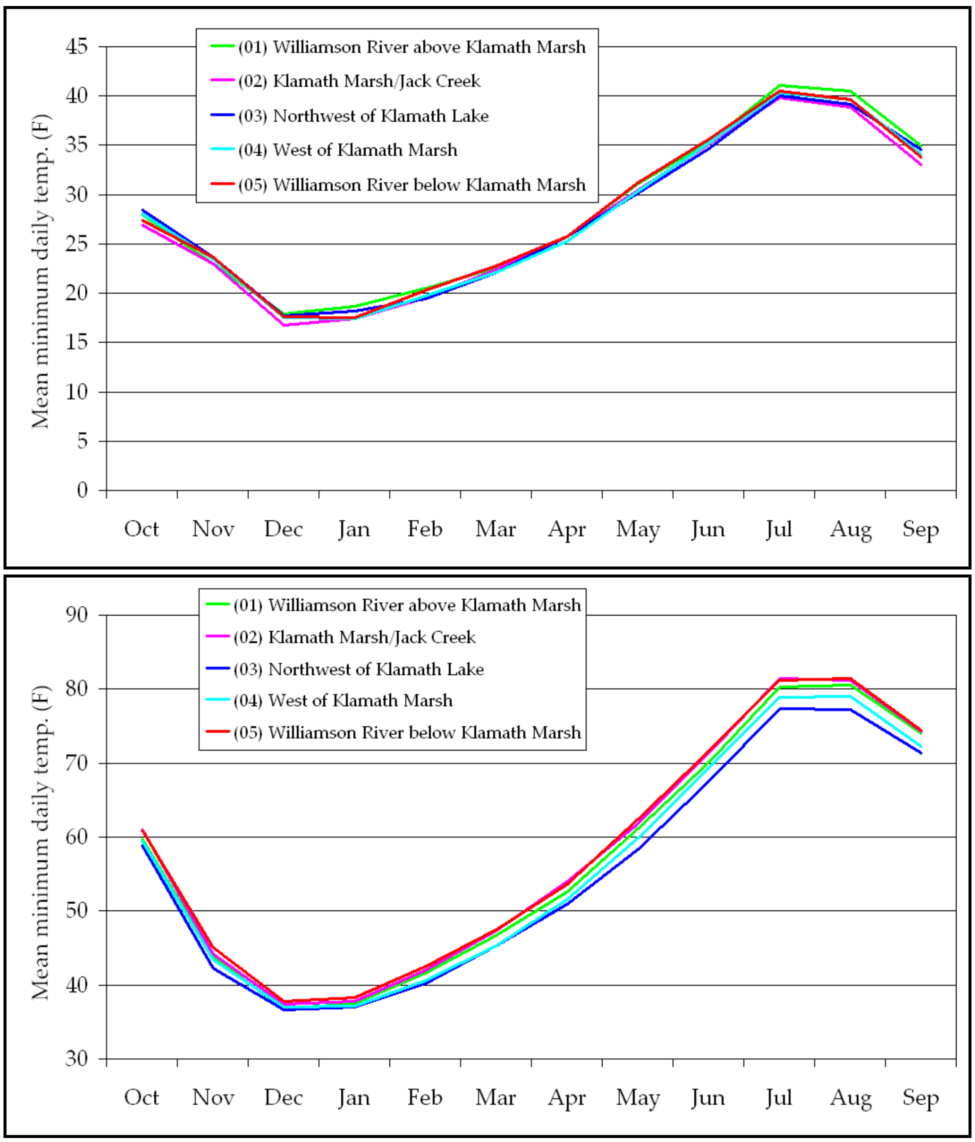
The long-term composite precipitation records produced by the Oregon Climate Service (2004b) for Climate Zone 5 was used to evaluate whether or not local trends follow the documented PDO cycles. These data were processed as follows:

1. The mean and standard deviation were calculated for annual precipitation in each zone over the period of record.
2. A standardized departure from normal was calculated for each year by subtracting the mean annual precipitation from the annual precipitation for a given year, and dividing by the standard deviation.
3. A cumulative standardized departure from normal was then calculated by adding the standardized departure from normal for a given year to the cumulative standardized departure from the previous year (the cumulative standardized departure from normal for the first year in a station record was set to zero).
4. This approach of using the cumulative standardized departure from normal provides a way to better-illustrate patterns of increasing or decreasing precipitation over time by reducing year-to-year variations in precipitation, thus compensating for the irregular nature of the data set. Values for the cumulative standardized departure from normal increase during wet periods and decrease during dry periods.

Results for Climate Zone 5 are given in Figure 2-2 (bottom graph). Precipitation patterns from the composite records do not generally follow the regional trends discussed above. There appears to have been a cool/wet phase from 1903-1916, followed by a warm/dry phase that lasted until the early 1930s. A long cool/wet phase then followed, which continued up to the mid 1960s. A warm/dry phase followed which lasted until the mid-1990s. There appears to have been a brief cool/wet phase from the mid to late 1990s after which there appears to be a warm/dry phase through the end of water year 2002.

Air Temperature

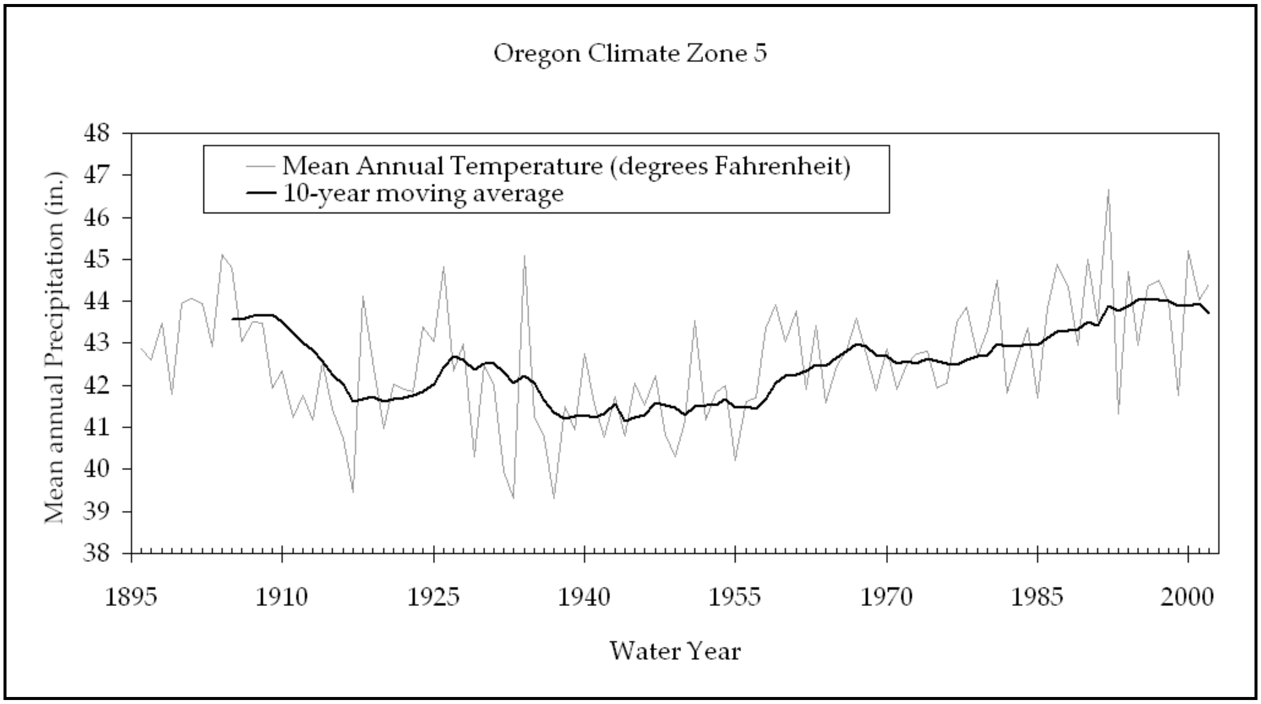
The Oregon Climate Service has also published digital GIS data sets of minimum and maximum mean monthly air temperature for the United States, based on available air temperature records for the period 1971-2000 (OCS, 2004c). The OCS maps were produced using techniques similar to those discussed for precipitation in the previous section. As such, these data sets incorporate temperature data from the local stations shown in Map 2-6. Mean minimum and maximum temperatures within the upper Williamson River subbasin also vary with elevation. Mean minimum air temperatures (Figure 2-3; top graph) occur in the month of December 17° to 18°F), and mean maximum air temperatures (Figure 2-3; bottom graph) occur in the month of August (77° to 81°F).



OCS, 2004c

Figure 2-3. Mean Minimum (top chart) and Maximum (bottom chart) Daily Temperatures by Month for the Watersheds within the Upper Williamson River Subbasin

Long-term composite air temperature records are also available from the Oregon Climate Service (2004b) for Climate Zone 5 (the High Plateau). As with the precipitation records discussed above, these long-term records use values from all climate stations within the region, and cover the period from 1895 to present. Mean monthly air temperature data were used to calculate mean annual air temperature values by water year (Figure 2-4). The ten-year moving average values suggest an increasing trend in annual air temperatures since at least the mid-1950s.

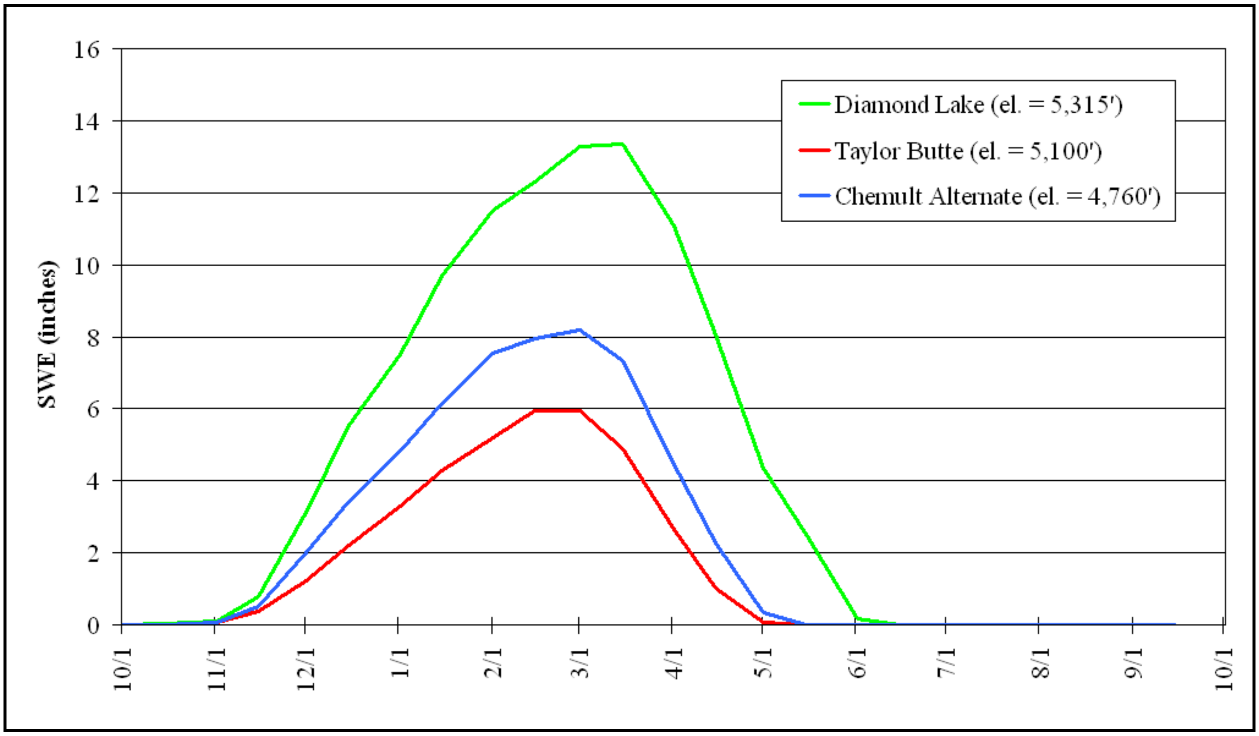


OCS 2004b

Figure 2-4. Composite Mean Annual Air Temperature Record for Oregon Climate Zone 5

Snowpack

Data on snowpack (i.e., depth of snow on the ground, expressed in terms of snow water equivalent or SWE) are available for several stations in the vicinity of the upper Williamson River subbasin (Map 2-6, Figure 2-5). Mean 1st and 15th of the month snowpack values for three of these stations are given in Figure 2-5. Mean snowpack values at the three stations show a stronger relationship to distance from the Cascade crest than to elevation. Snowpack is present on average from the beginning of November to the beginning of May-June, and is greatest in the month of March (Figure 2-5). The time series of March 1st snowpack for the three stations is given in Figure 2-6. March 1st snowpack at all three stations has generally been somewhat higher for the past ten years than for the preceding 10-year period.



Values are inches of snow-water equivalent.

Figure 2-5. Mean 1st and 15th of the Month Snowpack at Three Climate Stations in the Vicinity of the Upper Williamson River Subbasin

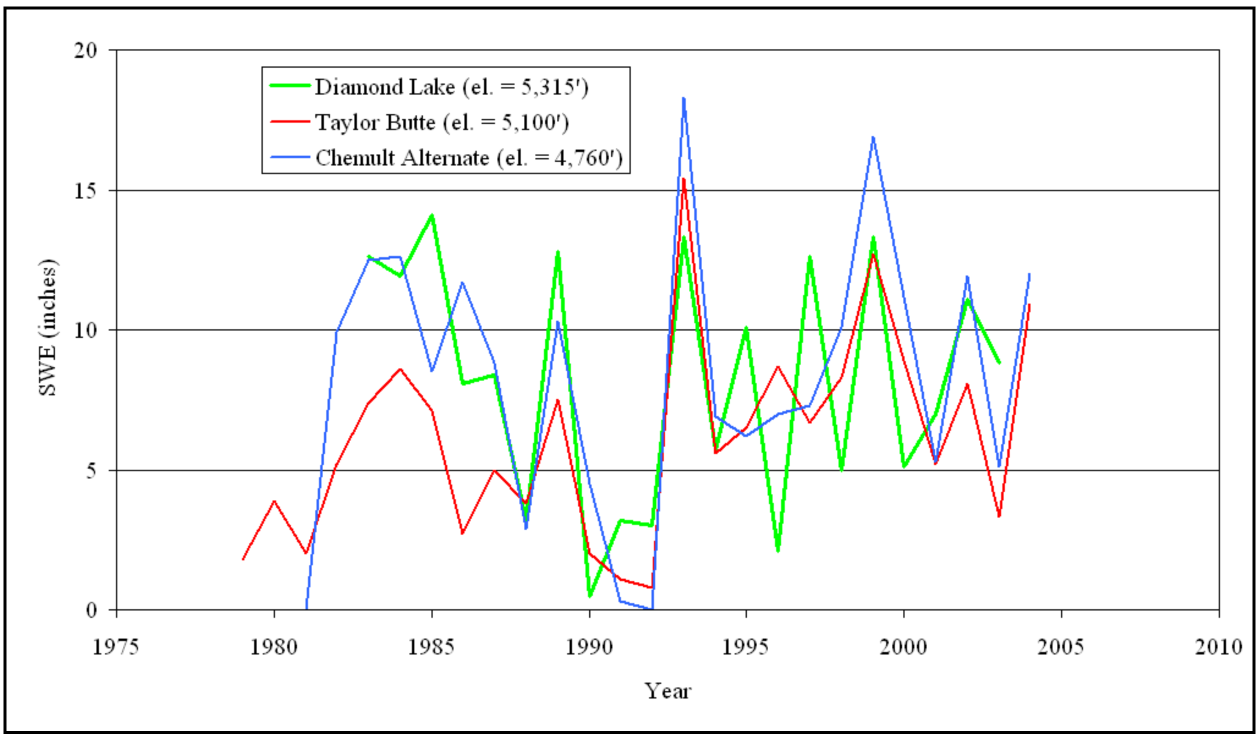
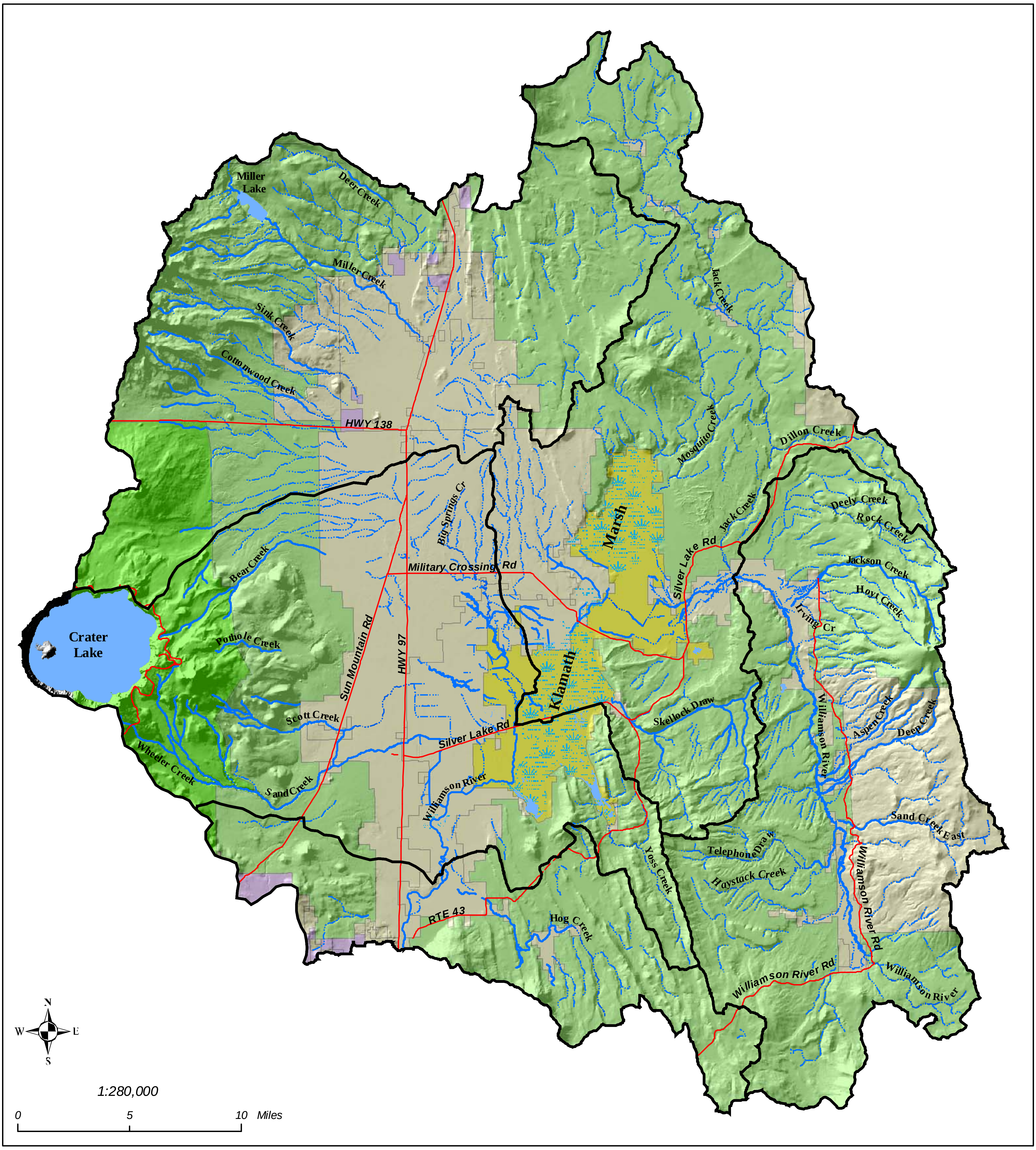


Figure 2-6. Time Series of March 1st Snowpack

LIST OF MAPS



Upper Williamson River Watershed Assessment

Map 2-1: Ownership

Legend

Owner:

- USFS - Winema National Forest
- NPS - Crater Lake National Park
- Private
- State
- USFWS - Klamath Marsh National Wildlife Refuge

- Perennial stream
- Non-perennial stream
- Major road
- Marsh
- 5th-field watershed boundary

Sources:
Ownership -USFS (Winema NF)
Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)

DAVID EVANS AND ASSOCIATES INC.

August 13, 2004
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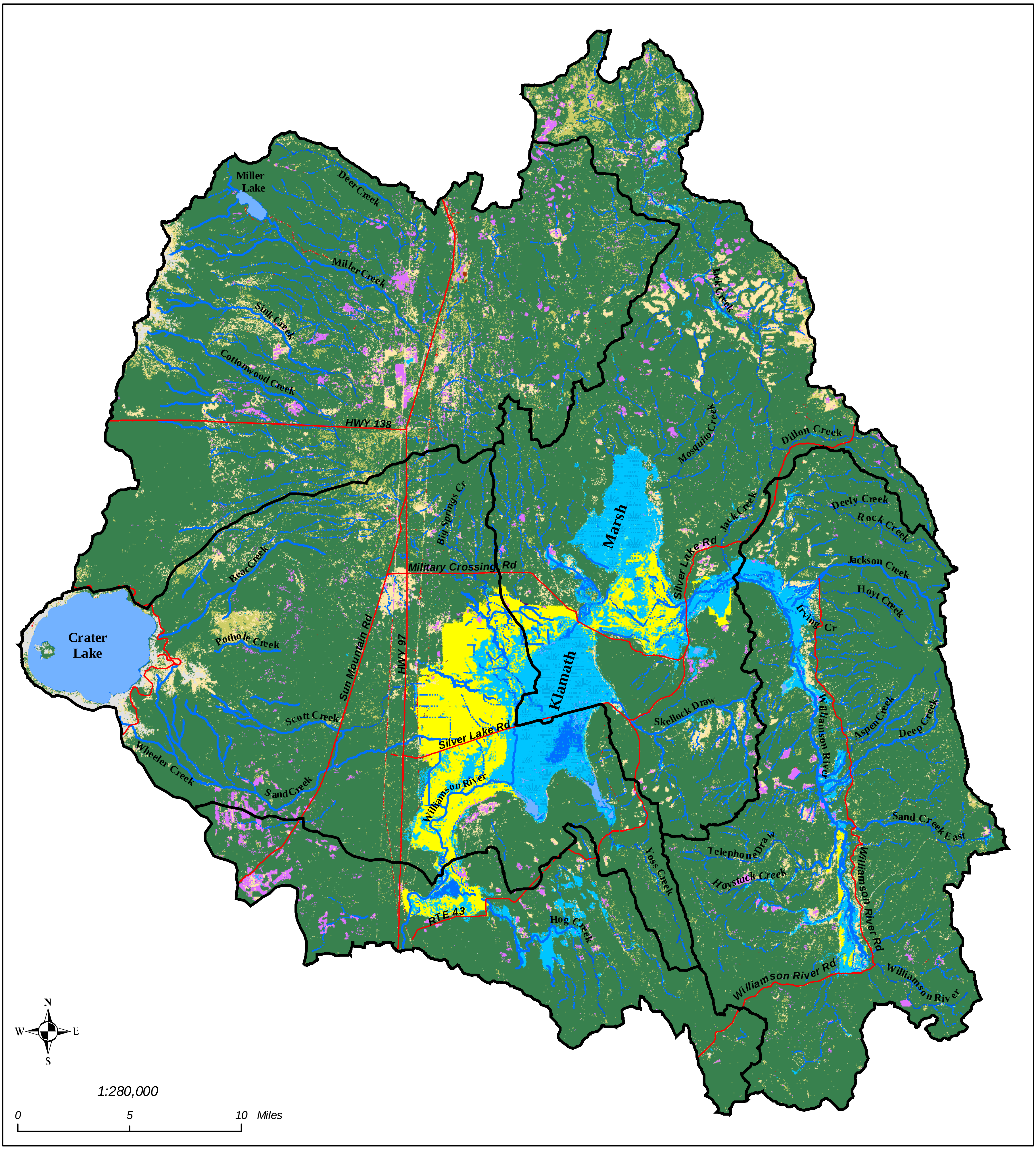

Upper Williamson River Watershed Assessment

Map 2-2: Land Cover / Land Use

Legend

Land Cover/Land Use:

- Open Water
- Ice and Snow
- Low Intesity Residential
- Commercial / Industrial / Transportation
- Bare Rock / Sand / Clay
- Quarries
- Transitional
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrubland
- Grassland / Herbaceous
- Pasture / Hay
- Row Crops
- Small Grains
- Urban Recreational Grasses
- Woody Wetlands
- Emergent Herbaceous Wetlands

- Perennial stream
- Non-perennial stream
- Major road
- Marsh
- 5th-field watershed boundary

Sources:
Land Cover/Land Use -USGS (National Land Cover Dataset)
Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)

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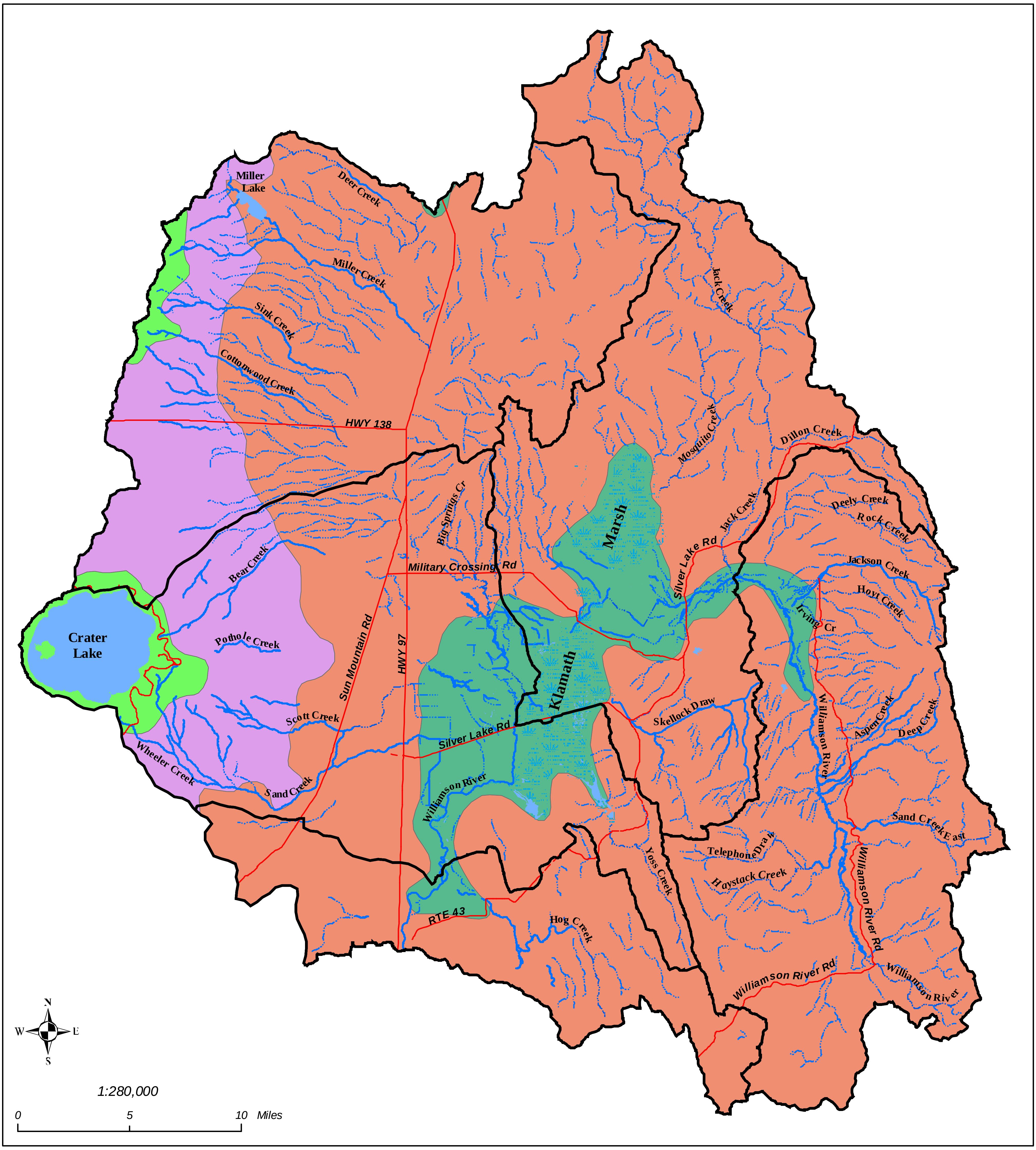

Upper Williamson River Watershed Assessment

Map 2-3: Ecoregions

Legend

Ecoregion:

- Cold Wet Pumice Plateau Basins
- Pumice Plateau Forest
- Cascade Subalpine/Alpine
- High Southern Cascades Montane Forest

- Perennial stream
- Non-perennial stream
- Major road
- Marsh
- 5th-field watershed boundary

Sources:
Ecoregions -OGDC (ORNHP/ODFW)
Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)

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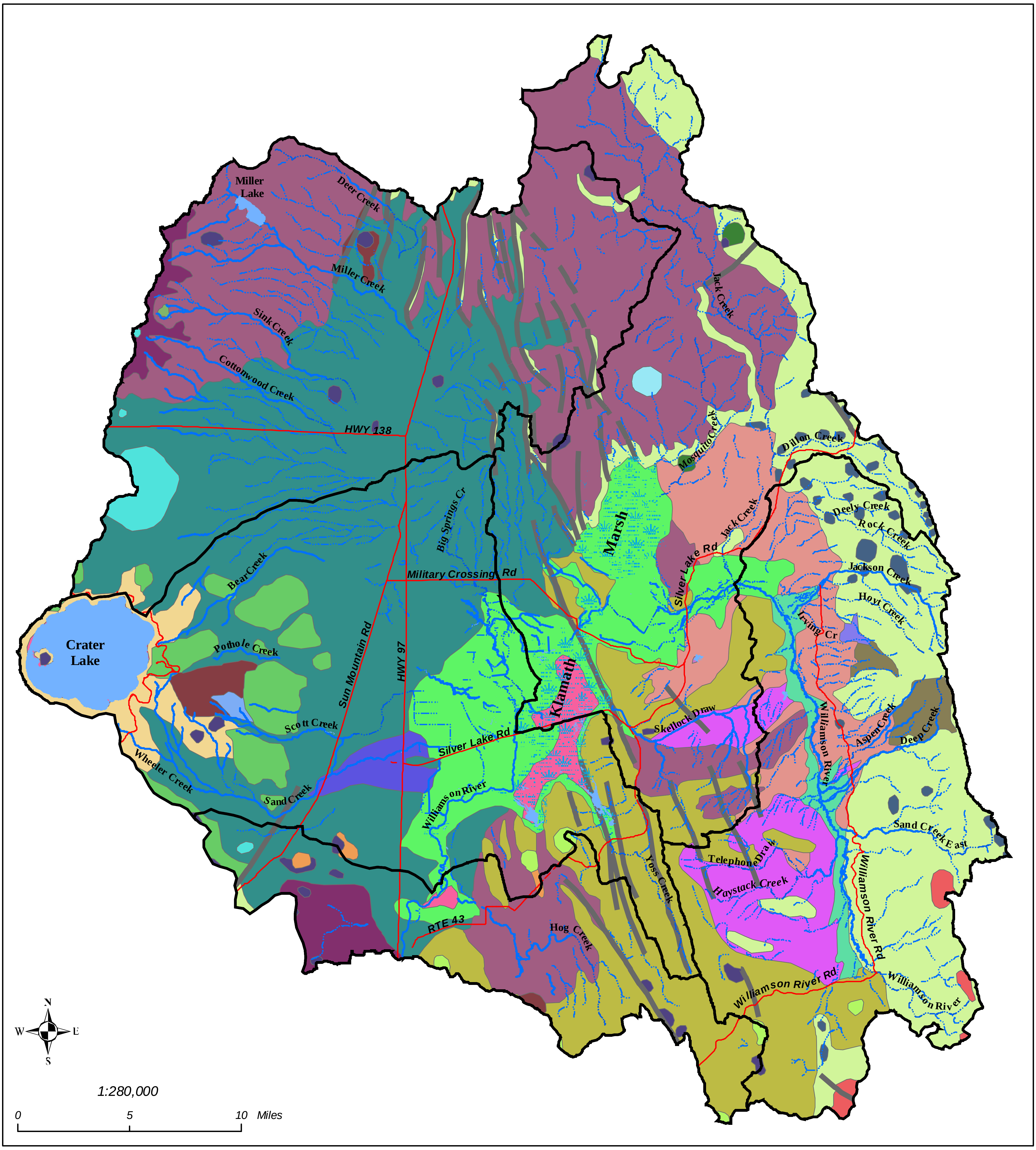

Upper Williamson River Watershed Assessment

Map 2-4: Geology

Legend

Normal fault

Geologic Unit:

QTb, QTba, QTib, QTmv, QTp, QTps, QTs, QTvm, Qa, Qal, Qb, Qba, Qf, Qg, Qma, Qmp, Qrd, Qs, Tb, Tmv, Tob, Tp, Trb, Trh, Ts, Tvm, water

Perennial stream

Non-perennial stream

Major road

Marsh

5th-field watershed boundary

Sources:
Geology -USGS (Walker and MacLeod)
Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)

DAVID EVANS AND ASSOCIATES INC.

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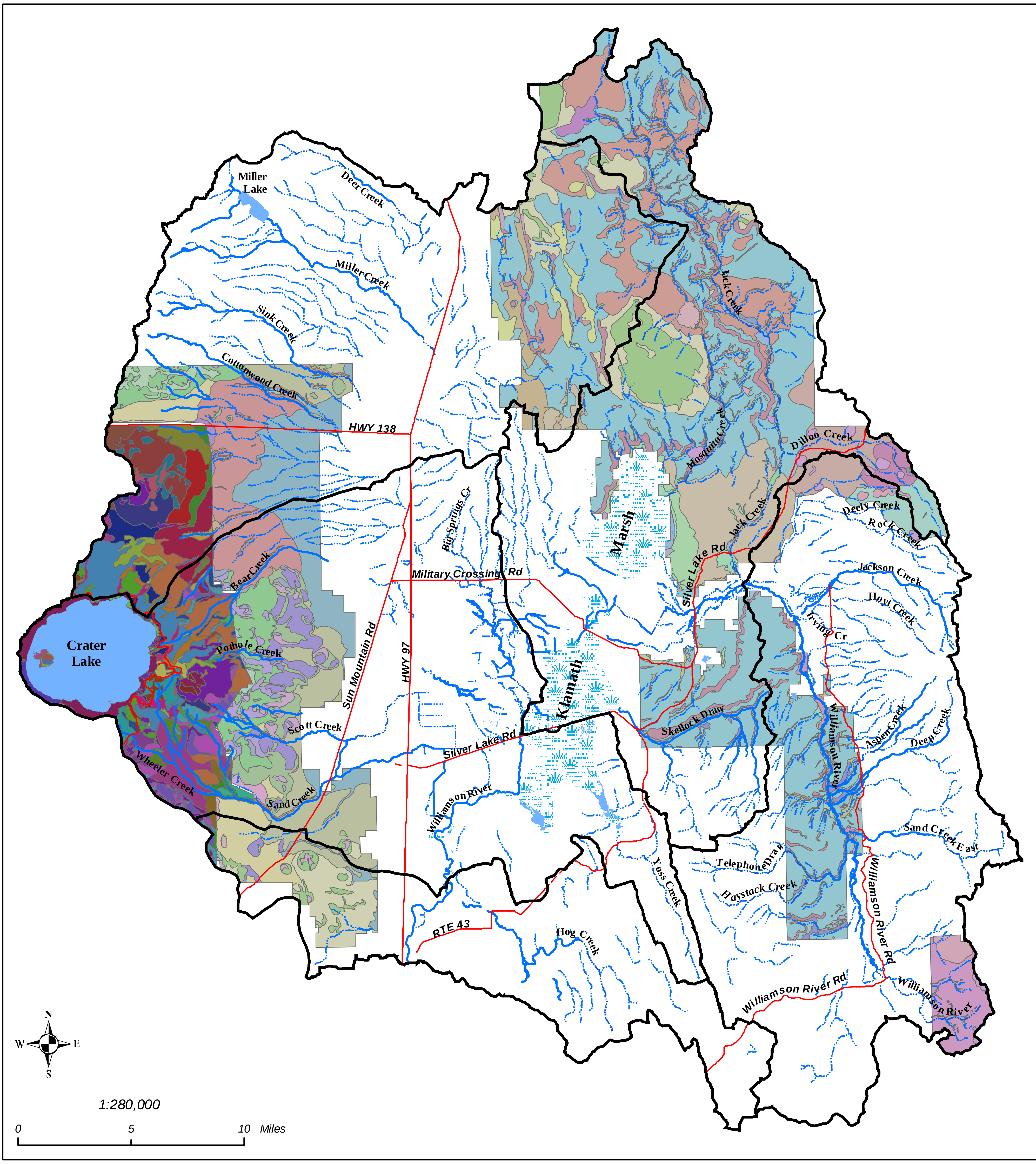


Legend

Soils Crater Lake NP:

1, 12, 13, 14, 15, 16, 18, 19, 20, 23, 26, 27, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 4, 40, 41, 42, 45, 46, 47, 5, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 6, 60, 61, 63, 64, 65, 66, 67, 68, 7, 8, 9

Soils Winema NF:

1220, 1000, 1003, 1004, 1009, 1013, 1014, 1016, 1018, 1023, 1025, 1026, 1031, 1050, 1051, 1052, 1053, 1054, 1055, 1057, 1058, 1059, 1060, 1061, 1090, 1207, 1214, 1217, 1218, 1220, 1227, 1235, 1247, 1281, 1316, 1388, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2012, 2017, 2018, 2019, 2020, 2025, 2030, 2031, 2033, 2034, 8334, 9045, 9201, 9215, 9218, 9231, 9244, 9266, 9281, 9312, 9315, 9325, 9326, 9327, 9328, 9336, 9344, 9388, 9681

- Perennial stream
- Non-perennial stream
- Major road
- Marsh
- 5th-field watershed boundary

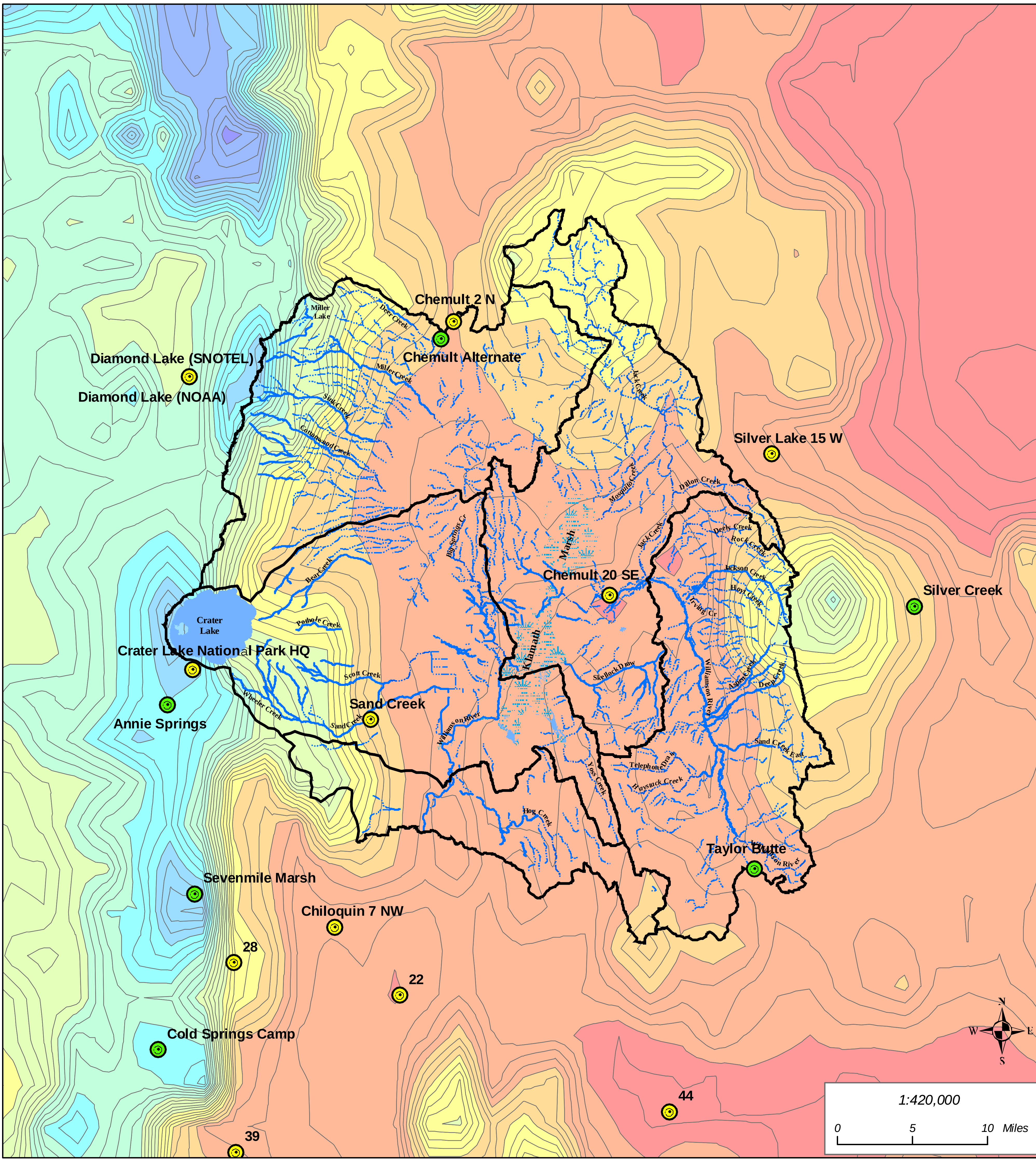
Upper Williamson River Watershed Assessment

Map 2-5: Soils

Sources:
Soils (Winema NF) -NRCS/USFS (Winema NF)
Soils (Crater Lake NP) -NRCS
Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)

DAVID EVANS AND ASSOCIATES INC.

August 13, 2004
n:/gis/kbef0001/arcmap/williamson_report/map2_5_soils.mxd



Upper Williamson River Watershed Assessment

Map 2-6:
Climate Stations and Annual Precipitation

Legend

- NOAA cooperative climate station
- NRCS SNOTEL climate station

Average Annual
Precipitation* (Inches):

- 9.000 - 17.000
- 17.001 - 25.000
- 25.001 - 31.000
- 31.001 - 39.000
- 39.001 - 49.000
- 49.001 - 57.000
- 57.001 - 63.000
- 63.001 - 71.000
- 71.001 - 79.000
- 79.001 - 91.000

- Perennial stream
- Non-perennial stream
- Marsh
- 5th-field watershed boundary

Sources:
Climate stations -NOAA, NRCS
Precipitation -OCS (PRISM)
Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)

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**Average Annual Precipitation based on measurements recorded 1961-1990.*

August 13, 2004
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3 HISTORICAL CONDITIONS

HISTORICAL NARRATIVE

> Bad as our prospects were yesterday they are worse today. It snowed all night and day. If this snow does not disappear our express men will never reach us…. There is a general gloom prevailing in camp with all in a starving condition, so that plots are forming…. Should we not find animals our horses will fall to the kettle. I am at a loss as to how to act. I intend to take the nearest route I can discover into the Clammitte Country.
>
> *-- Peter Skene Ogden, November 1826 (Binns 1967)*

Two weeks after making this entry in his journal, Ogden led his "Snake Country Expedition" into the Upper Williamson watershed. Two months earlier they had left The Dalles with a group of Warms Springs scouts, twelve other men, two boats, and a hundred horses – many of which, they soon learned, turned out to be wild. He also brought along his wife, Julia, and their two children.

They were to search for beaver, first in the "Sylvaille" (Silvies) River country where Antoine Sylvialle had reported many, and then down in what came to be known as Klamath country, where Finan McDonald, the previous year, had not found any at all. Many found it hard to believe that Mr. McDonald's reports were accurate, and Ogden was sent to see for himself. Neither he nor McDonald could have known that much of the Upper Klamath Basin had for many years been included in one of the larger Spanish land grants, and was therefore part of California. It is entirely likely that, by the time McDonald showed up, the region had already been trapped out by Spanish or French trappers coming up from the south. Regardless, Ogden's expedition had little to no luck with beaver until they worked their way down into the canyons that cut through the Siskiyou Mountains.

Beavers cannot be found in the area today, but we know that beaver inhabited the area until roughly 40 years ago (USFS undated). Beaver depend on small-diameter willow and aspen, and the current riparian vegetation (primarily grasses) does not provide adequate habitat for the beaver. Beavers alter the low gradient streams both functionally and biologically. Their dams reduce the channel gradient, dissipate water energy, allow sediments to settle out, and reduce peak discharge during high flow events. The ponds created by their dams create habitat for fish, amphibians, bats, and waterfowl. Current riparian conditions would not support beaver re-introduction at this time, but it should be evaluated further.

The expedition did not start off too well, as we have seen, and in the days before they crossed into the upper reaches of the Klamath watershed, they had all come to be in pretty poor shape. Several horses had already fallen "to the kettle," as had quite a few dogs. They had finally met up with their expressmen, but when they found them they had not eaten for fourteen days, and not had a drink for nine. They were very nearly dead.

When Ogden's expedition reached the banks of the Upper Williamson on the 28th of November, they encountered a "strange fortified town in the river":

> It was composed of 20 tents built on the water, surrounded by water approachable only by canoes, the tents built of large logs shaped like block houses, the foundation stone or gravel made solid by piles sunk 6 ft. deep. Their tents were constantly guarded. They regretted we had opened communication from the mountains. They said, "The Nez Perces have made different attempts to reach our village but could not succeed…. Now they will have your road to follow. We have no fire arms. Still we fear them not." They have only one horse. In winter they live on roots. In summer on antelope and fish.
>
> *-- Peter Skene Ogden, November 1826 (Binns 1967)*

In this remarkable passage, Ogden has documented a critical moment in the transformation of native cultures in response to the arrival of Euro-Americans. These cultures, and their associated economies, were rooted in a relatively detailed knowledge of local landscapes, and of the capacity of those landscapes to produce the food and shelter they needed to survive. Over centuries, native communities had evolved strategies and patterns of use aimed at maximizing survival in this region, given the level of technology they had at their disposal. Ogden encountered this native Klamath settlement – built for safety's sake in the middle of the Williamson River – at the precise historical moment when the introduction of new technologies was fundamentally altering the way native communities functioned internally, and the way distinct native communities interacted with each other.

At this point in time, the Nez Perce, being closer to trading centers and Euro-American settlements, already had access to guns and horses, making them dramatically more effective in terms of both hunting and warfare. The Klamaths, when Ogden encountered them, did not yet have access to these technologies, and so were at a dramatic disadvantage with regard to ancient rivalries with neighboring tribes. But they were very much "in the market," so to speak, and as the description of their settlement indicates, the presence of these new technologies was already changing the way they lived.

A decade later a group of French-Canadian trappers crossing through Klamath headed for The Dalles would bring several native Klamaths along for the trip, and from then on the Klamaths had substantially more contact with the world outside the Klamath watershed. They began to make longer and more frequent forays, either for trade or battle, outside their traditional territory. And within a decade or so, settlers from distant parts of the world would begin to arrive in the watershed in significant numbers. The Klamath watershed was, as they said then, "opened up."

Indigenous Resources and Native American Subsistence

It is important to note that there was no single "Klamath Tribe" when Euro-American explorers and settlers began to arrive in the upper Klamath Basin. The native people of the basin, from the headwaters of the Williamson and the Sprague to the marshlands of Tule and Lower Klamath Lakes, constituted a roughly homogenous language group, largely due to topographical features that inhibited contact with other regions. But despite the relative linguistic uniformity, there were many distinct communities in different parts of the watershed. Modoc cultures inhabited the south and southeast, Yahooskin Paiute inhabited the periphery to the north and east, and the Klamaths dominated territory in the north and around Upper Klamath Lake. In the Upper Williamson, the "Klamath Marsh" band of the Klamaths maintained dense settlements along the banks of the Williamson River and around the shores of Klamath Marsh. In the entire upper Klamath Basin, the total population of native people – including both Klamath and Modoc – has been estimated at between 1,200 and 2,000 people. Out of this, approximately 800 to 1,200 were Klamaths. The Klamath Marsh band was the largest of the Klamath bands, outnumbering all of the rest combined (Stern 1965).

Historic photographs taken in 1902 show native Indian use of present day refuge lands. The campsite pictured here was used by Klamath Indians while harvesting Wocus seed.

Photo 3-1. Klamath Indian Camp (1902)

The native communities of the Upper Williamson River watershed shifted their activities with the seasons (Stern 1965). But the need to ensure adequate foodstuffs to last the long winter months was a dominant concern throughout the year. During the spring and summer months, food was harvested, and then processed to preserve it for later use. The

Klamath Marsh band of the Klamaths relied on many different sources of food, including fish, roots, berries, waterfowl, eggs, and mammals.

Also significant, perhaps, were various techniques that natives may have used to enhance the productivity of desirable plant and animal species. Although very difficult to document, it is likely that Upper Williamson natives, like others throughout North America used fire, in particular, to encourage open understory within forested regions, or to flush game in grassland areas.

One of the most important food sources for all the Klamaths was the wocus, or yellow pond lily, as evidenced by the fact that the month in which the wocus is harvested, August, marks the beginning of the Klamath year (Stern 1965). Wocus grow on open, shallow water within marshlands, and the Klamaths' reliance on the wocus would seem to indicate the presence of a substantial amount of appropriate wetland habitat in the upper Williamson. Some estimates run as high as 10,000 acres of wocus-dominated wetland in the Klamath Marsh area alone. The wocus ripened in late summer and early fall, and often different tribal communities would come together to harvest the wocus in reed or dugout canoes. The wocus could be eaten in a variety of ways, but much of it was ground into flour and stored for winter use.

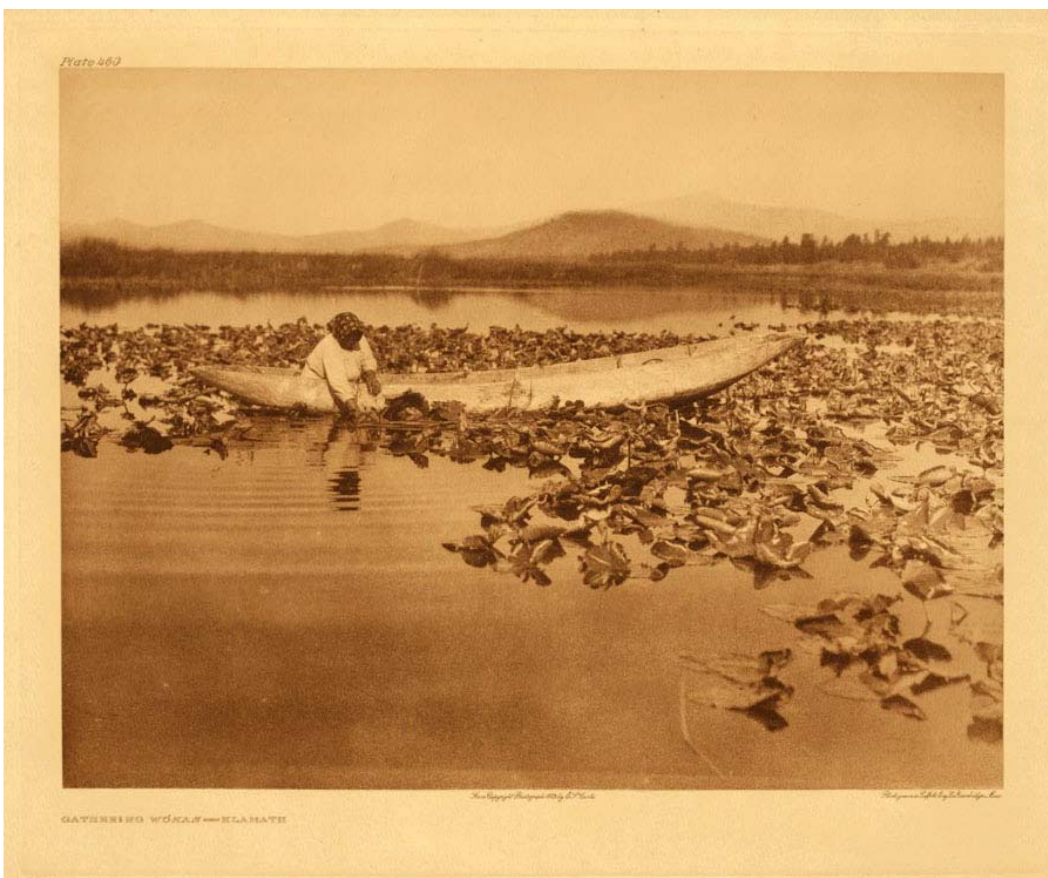

Photo 3-2. Wocus Harvest

The other critically important staple for native communities was fish, and among the various fish species they relied upon, the suckers were the most important. After an often brutal and deadly winter, the suckers were the first to run in the spring. And as early accounts indicate, these runs were often very dramatic in terms of numbers of fish. After subsisting on the barest of rations, the arrival of the suckers, the first fresh food they had seen in months, was a particular cause for celebration. Suckers were caught and eaten fresh throughout the spring, and fish of all kinds, including salmon, were dried and stored for use during the winter months.

As spring progressed and the fish runs played out, the large gatherings of people broke up into groups of three or four families, which spread out over the territory, searching the meadows for roots such as yampa root (*Carum gairdneri*), camas, arrowroot and others, which were eaten fresh, or baked in stone-lined earth ovens for winter storage. They also harvested tule and cattail roots, as well as the eggs of swan and other waterfowl. As spring turned to summer, the wocus began to ripen, and people began coming together again in anticipation of the harvest. While the women busied themselves with the wocus, men headed into the high ground to hunt deer, elk, or mountain goat, or went out into the marshes to hunt waterfowl. After the wocus harvest, the women joined the men in the higher ground, harvesting huckleberries, serviceberries, currants, chokecherries, and wild plums. For the most part, these fruits were dried and stored for winter use.

Given the population estimates cited above, it is reasonable to assume that there were only 500 to 1,000 native people depending upon the resources of the Upper Williamson River watershed for their subsistence. Furthermore, there were, of course, no substantial demands placed upon the watershed's resources by outside markets, due to the absence of the necessary transportation and communication technologies. Given these factors, it is very likely true that the Klamath Marsh band of Klamath Indians lived a life of relative abundance in the Upper Williamson, except of course during the sometimes brutal weather of the winter months, when conditions often imposed unimaginable hardships.

At times, it was no doubt a very difficult life by contemporary standards. And harvest techniques like the mass driving of game or netting of fish certainly must have had some transitory effect on the localized population dynamics of certain species. But in general terms, the relatively low demand placed on the biological productivity of the watershed -- due to limited harvest technologies and limited access to broader markets – meant that the anthropogenic depletion or degradation of resources within the watershed was, in all likelihood, not a significant issue during the period preceding Euro-American settlement.

The Reservation

There is simply no way to accurately characterize the historical development of land use, or the evolution of ecological conditions, in the Upper Williamson watershed without acknowledging the critical influence of the Klamath Indian Reservation. The Upper Williamson watershed is almost entirely within the boundaries of the reservation, which was established by treaty in 1864, and then dissolved ninety years later through a process called "termination." A historical timeline is included at the end of this chapter.

Following a pattern that had been repeated throughout North America in the 18th and 19th centuries, the arrival to Klamath country of settlers from other parts of the world resulted in considerable conflict and bloodshed. Both the new arrivals and the natives understood that it was not in their interest for the conflict to continue. There were significant exceptions to this rule, including some settlers who sought to exterminate the natives, and some natives who sought to do the same to the settlers. But eventually even persistent warriors like the Modoc chief Sconchin would say, with considerable resignation, that

> I thought that if we killed all the white men we saw, that no more would come. We killed all we could, but they came more and more like new grass in the spring. I looked around and saw that many of our young men were dead and could not come back to fight. My heart was sick. My people were few. I threw down my gun. I said, "I will not fight again." I made friends with the white man.
>
> *Stern 1965*

And in 1857 James W. Denver, Commissioner of Indian Affairs, argued that

> I know of no alternative to the present unsatisfactory and dangerous state of things but the adoption of early measures for the extinguishment of Indian title, and their colonization on properly located reservations…. The losses and damages to the government and to the citizens resulting from another general outbreak on the part of these Indians would probably fully equal, if not exceed, in amount what would be necessary to buy out and colonize them…."
>
> *Stern 1965*

For good or ill, the solution advanced was the designation of the reservation covering a significant portion of the Williamson and Sprague River watersheds.

The ratification of the Treaty of 1864, establishing what would come to be known as the "Klamath Tribe," and the resulting designation of the Klamath Indian Reservation, marked a fundamental shift in land use and management in the Upper Williamson watershed. There emerged an explicit imperative to discourage traditional subsistence strategies and encourage reliance on more intensive development of the watershed's natural resources. J. W. Perit Huntington, Superintendent of Indian Affairs for Oregon at the time, explained that "[I]n determining the boundaries of the reservation, I sought primarily to secure a tract of country which had local advantages for supporting a colony of Indians by industrial pursuits…. (Stern 1965) And the Agents locally in charge of supervising tribal affairs were guided by a mission "to promote the well-being of the Indians, advance them in civilization, and especially agriculture…." (Stern 1965)

The General Allotment Act of 1887

The General Allotment Act of 1887, sometimes referred to as the "Dawes Act," is a good example of a politically and socially-motivated decision that had dramatic, if unintended, consequences with respect to the use and management of natural resources. And although the Allotment Act was national in scope, its effects were particularly acute within the Upper Williamson watershed.

Since the ratification of the Treaty of 1864, the reservation had been a single political, economic, and geographic unit, owned in trust by the federal government and managed, to some degree, by cooperative arrangement between the Indian Service and tribal leadership. In 1887 the federal government, in a law that was explicitly promoted as a counterpart to the Homestead Act of 1862, passed the General Allotment Act. The object of the act was to "individualize the Indian by assigning him a private tract, to be held in trust for at least twenty-five years, and by granting him citizenship" (Stern 1965).

In addition to the profound impacts the Act had on the watershed's basically communal native cultures, this change also had fundamental implications for the management and use of the watershed's natural resources. The Allotment Act, like the Homestead Act before it, was intended to foster self-sufficiency and other desirable character traits by rooting individuals on their own bounded tracts of private property. But, again like the Homestead Act, it didn't always work out in practice because the Allotment Act also allowed for the leasing, and eventually the sale, of the individual allotments. It also allowed individual allottees to contract for the harvest of timber on their allotments.

The Reservation and Shifting Patterns of Land Use

Initially, there was a sincere conviction within the Indian Service that it would be possible to establish a local agricultural economy based on field and row crops, including beets, carrots, beans, turnips, peas, onions, and artichokes (Stern 1965). Joseph Emery, a professor from the [Oregon] State Agricultural College, argued that while "I have not been able to depress the mountains nor lower our altitude above the sea, yet I believe that agriculture can be made a comparative success on the Klamath Agency…. If I had plus to loan, I could set 100 Indians to work this spring tilling the soil" (Stern 1965). Predictably, late frosts and summer droughts helped prove this impractical, and in 1867 Agent O.C. Knapp found it necessary to "urge upon the Department [of the Interior] the uselessness of trying to make this an agricultural reservation…. The Indians should be supplied with cattle and sheep, and they would soon become self-sustaining" (Stern 1965).

As we know today, the Upper Williamson watershed is vastly more suited to stock raising than row crops, and once the focus shifted to raising livestock, many natives took advantage of opportunities to establish their own operations. By 1883, Agent Linus Nickerson reported that there were "several" large Indian ranches, and that buyers from as far away as San Francisco traveled to the reservation, offering as much as $40 a head

(Stern 1965). By 1886 Agent Joseph Emery reported 1,485 head of cattle, 3,640 head of horses, 340 mules, and 195 hogs (Stern 1965).

Logging, also, was an important component of the reservation economy from the very beginning. The first mill was built in 1870, and right away enterprising natives began felling timber and selling it at a profit, despite the federal government's insistence that they had no right to do so, based on a 1873 Supreme Court ruling which held that the timber was owned in trust by the government, and not by the Indians. It was apparently quite lucrative, as well, as evidenced by the fact that, when budget cuts threatened the employment of the agency miller, the Indians decided to pay him themselves (Stern 1965). By 1896, the sale of timber was estimated to exceed a quarter of a million board feet. Although certainly significant, these sales were exclusively local, and constrained by the limited demand of local markets. Soon, with the coming of the railroad and the passage of the General Allotment Act, logging activities in the Upper Williamson watershed would expand explosively, and timber harvest would dominate the local economy and land use for nearly a century to come.

The Uplands: Timber Harvest

At the turn of the 20th century, the Klamath Indian Reservation contained one of the single most extensive and high-quality stands of ponderosa pine to be found anywhere in North America. The Reservation was estimated to hold up to eight billion board feet of merchantable timber, and within the Indian Service there was considerable interest in supporting the welfare of the native people, not to mention the Indian Service's own administrative budget, through the harvest and sale of these resources. There was also substantial pressure to harvest an estimated billion board feet of timber contained within a large privately-owned tract, later known as the "Long-Bell Tract," which had been carved out of the northeast corner of the reservation. But as was the case with timber throughout Klamath country prior to the coming of the railroad and the passage of the General Allotment Act, harvest feasibility and market value of the timber was severely limited by the lack of any practical way to transport the timber to distant markets.

But in 1909, the Southern Pacific Railroad arrived at Klamath Falls. Because timber companies had been preparing harvests and developing facilities in the years preceding the railroad's arrival, an explosive boom ensued as soon as the first train rolled into town. E.H. Harriman, who controlled both the Southern and Union Pacific Railroads at the time, saw Klamath Falls not as the end of the line, but as a stopping point on the way north to a point near Crescent Lake, where the southern line would meet two others coming from the east and west. Construction continued through Klamath Falls until it arrived, in 1911, at a settlement called Kirk, at the southern end of the Klamath Marsh. And there it would stop. For twelve years, until the fall of 1923, the railroads would be caught up on an anti-trust lawsuit that would prevent further progress toward connecting the northbound and southbound lines. For those same twelve years, Kirk would boom as few other towns in the west had ever boomed before, as the Indian Service and private timber companies built their own temporary railroads out into every corner of the Upper Williamson watershed.

For several years before the railroad arrived at Kirk, there had been mounting pressure on the Indian Service to offer reservation timber for sale. And although a few smaller sales were made, forest managers within the Indian Service knew that the stumpage value – at the time around $2.00 per million board feet – would go up considerably once the rails were in place. These managers also resisted pressure from large timber companies to offer sales in very large tracts, which they felt would encourage domination by the large companies, resulting in reduced competition and lower revenues for the Tribes and Indian Service administration. As it turned out, they were right on both counts, and over the next two decades prices for reservation timber would rise dramatically. J.P. Kinney, who served as one of the Klamath Agency's foresters during the first decades of the 20th century, claimed that

> The increase in the prices received for pine stumpage on the Klamath Reservation [during this period] is one of the outstanding facts in the development of the timber industry in the Pacific Northwest…. There was no comparable rise in stumpage prices bid for pine, Douglas fir, or other species, throughout the northwest.
>
> *Kinney 1950*

But even in those early days, there was considerable disagreement with regard to the management and harvest of the timber resources. The management of Reservation timber provides a good example.

J.P. Kinney and his colleagues took considerable pride in the prices they were able to secure on behalf of the Klamath Indians. And although managers like Kinney believed very strongly that they were acting in the best interest of tribal people, it also seems clear that they did their best to accommodate the needs of timber harvesters. Kinney himself attributes the high demand for Klamath timber, in part, to their avoidance of "any restrictions that would be of secondary advantage to the Indians and yet would cause substantial expense and considerable annoyance to those engaged in removing timber from Indian lands" (Kinney 1950). On the other hand, Klamath Agency foresters defended against accusations that they were abandoning sound silvicultural practices:

> Through the cutting of trees close to the ground and the taking of tops to a diameter of eight inches, or even less, if smooth and merchantable, the timber was fully utilized. In western yellow [ponderosa] pine cuttings, all slash was piled and burned where this could be accomplished without the killing of so many young trees as to do more harm than good. From 70 to 90 percent of the merchantable volume was removed, depending upon conditions existing on each area being cut over.
>
> *Kinney 1950*

Some critics of Agency harvest practices complained, sometimes bitterly, that “too much of the original stand was removed in logging operations on Indian lands” (Kinney 1950). The issue of harvest levels, like so many other issues, was complicated by the effects of the General Allotment Act, which created a situation in which there was little incentive to conserve timber resources on individual allotments. While average harvest levels of “70 to 90 percent” on unalloted lands might certainly be described as excessive, agency foresters claimed that, when it came to individual allotments, they were often the voice of restraint. On allotment lands, agency foresters claimed, individual allottees “desired, and often demanded” that even more than that be cut (Kinney 1950).

So far we have seen how two main factors – developments in transportation technology and transformations in land tenure systems – had a direct impact on resource use and management, and thus on habitat conditions. The arrival of the Southern Pacific mainline at Kirk, and the ability to build railroad lines quickly and efficiently into the Upper Williamson watershed, established for the first time a connection between the resources of the watershed and distant urban markets where demand was seemingly boundless. And the transformation of the reservation, through the General Allotment Act, from a single legal entity into an agglomeration of relatively small fee simple holdings facilitated the transfer of ownership – of both resources and the land itself – by way of free market transactions. The latter change had particularly significant implications with regard to the grazing and hay ground in the lower elevations of the watershed.

The Lowlands: Cattle Country

> When as a boy I came to know Mamie, she was a plump jolly woman in her forties, given to flowered tents of dresses, and big picture hats flowing with gay ribbons. On a quiet night, her laughter still rings from the rafters…. She had the best of both worlds, being white and Indian at the same time.
>
> *Hyde 1971*

Mamie Farnsworth was one of the many tribal members who, as a result of the General Allotment Act, ended up property owners on the lush bottom ground of the Upper Williamson watershed. As we have seen, the Upper Williamson watershed, and the Klamath Marsh in particular, was a critically important area for Klamath Indians for both spiritual and subsistence reasons, so that when allotments were made available, the riparian meadows and wetlands of the Upper Williamson were some of the first to be allotted.

Mamie had a reputation as being shrewd when it came to money. She had quite a bit of it which attracted the attention of a steady stream of suitors, earning her the nickname “The Cleopatra of the Reservation.” She could work as hard as any man, and harder than many, including her white husband Al, who “ranked close to being the laziest man in the world” (Hyde 1971). She ran a tight cattle operation, and the homestead she built on the lower end of Deep Creek was a “showplace” by anyone’s standards. Throughout the 1920s and

1930s, Mamie bought up several of the adjoining allotments from fellow tribal members who preferred life in the towns, and she maintained ownership until the end, except for a fairly sizable upstream parcel that she gave, in a divorce settlement, to Al. Soon thereafter Al sold the property – some say out of spite – to Mamie's rival up the river, Buck Williams, who by the 1930s had pieced together a good-sized ranch out of allotments he had bought from various tribal members. Buck Williams' ranch would come to be known as "Yamsi," after the mountain that dominates the local landscape.

As we have seen, cattle and other livestock production was, for short period during the late 19th and early 20th centuries, the dominant economic activity pursued by natives on the Klamath reservation. But as income to individual tribal members from reservation timber revenues began to outpace income from agriculture, and as interest in the Upper Williamson country grew among non-Indian livestock producers, the grazing and hay grounds of the Upper Williamson gradually came to fall out of Indian ownership. Mamie Farnsworth, along with Orie Summers and others down on the Klamath Marsh, was one of a few significant exceptions to this rule.

> It was work that can be thought of as craftsmanlike, both artistic and mechanical, creating order according to an ideal of beauty based on efficiency, manipulating the forces of water and soil, season and seed, manpower and equipment, laying out functional patterns for irrigation and cultivation on the surface of our valley. We drained and leveled, ditched and pumped, and for a long while our crops were all any of us could have asked…. We constructed a perfect agricultural place, and it was sacred, so it seemed.
>
> *Kittredge 1987*

It was the 1930s and the Kittredge family had already set itself up on about 20,000 acres of drained swampland in the Warner Valley, east of Lakeview, Oregon. So they knew how to get it done. Bill Sr., the patriarch who had built the ranch, had relatives in Klamath Falls, where the family sometimes wintered. On trips from the Warner Valley to Klamath Falls, they crossed the Upper Williamson River and traveled through the Klamath Marsh.

Never one to miss an opportunity to buy more land, Bill Sr. began, like Buck Williams, to buy up allotments around the Klamath Marsh from individual Indians. Eventually the Kittredges acquired good number of acres, extending from the big bend where the Williamson River begins to turn south, out into the marshlands to Rocky Point and Military Crossing, and north up until the marsh rises up to meet the timbered uplands. As with their Warner Valley operation, a complex system of drains, pump stations, ditches, and diversions allowed for control of the water table within the ranch boundary, and for the optimization of productivity for cattle and hay production.

Like many ranches in the western United States, the operations of the upper Williamson depended on a combination of private and public resources. The privately-owned bottom grounds were used for irrigated pasture or hay production, and often for feeding and calving if the livestock remained in the country over the winter. There were also a good number of leases on the Klamath Marsh used by upriver ranches for hay production. These arrangements were established during the early part of the century when the grasslands around the Marsh were Indian allotments, and most continued to be honored after the hay grounds became either part of the Kittredge Ranch or the National Wildlife Refuge (which was designated in 1961, see Historical Timeline at the end of this chapter). Haying on the Refuge continues to this day, and management of the hay grounds has become a significant issue in recent years.

Another important component of livestock operations in the Upper Williamson was leased summertime grazing in the forested uplands. Again, many leasing arrangements were established while these uplands were either Indian allotments, or part of the unallotted lands of the Klamath Indian Reservation. Leasing arrangement were also made with the series of owners of the 87,000-acre tract of private land in the northeastern corner of the Reservation, often referred to as the Long-Bell Tract. When the Reservation was terminated in 1954, and the unallotted portion became the Fremont and Winema National Forests, the leases continued to be honored, with their administration transferred from the Bureau of Indian Affairs to the U.S. Forest Service. On the Long-Bell Tract, grazing was continued up until the present day, with significant reductions in numbers and duration taking place in the early to mid-1990s. The Forest Service, too, has paid closer attention to grazing management in recent decades, seeking to address to tendency of livestock to gather and linger near water sources, leading to disproportionate impacts to relatively sensitive riparian and meadow systems.

Termination, The Refuge, and the National Forests

After the Termination of the Klamath Tribes in 1954, the marshlands south of Military Crossing Road became the Klamath Forest National Wildlife Refuge (today the Klamath Marsh National Wildlife Refuge). Since the Refuge was established, like Mamie Farnsworth, Buck Williams, and Bill Kittredge before them, Refuge managers have actively sought to expand the territory under their management. In the mid-90s, descendants of the Kittredge family sold the ranch holdings west of the Silver Lake Highway to the U.S. Fish and Wildlife Service, nearly doubling the size of the Wildlife Refuge. Land Acquisition is, to this day, one of the top management and budget priorities for the Klamath Marsh Refuge.

With such acquisitions, management emphasis has shifted from livestock and hay production to relatively less commercial habitat values. The Refuge has become a highly-valued destination for visitors interested in birding, sightseeing, and other recreational activities. These shifts in management have had direct and indirect impacts on adjacent agricultural operations, and in recent years concerns have been raised about the effect of Refuge management on hydrologic and habitat conditions downstream of Kirk Reef.

These issues have become a significant source of conflict within and outside of the Upper Williamson watershed.

In the late 1960s, as part of the Termination process, the unalloted forested uplands of the former reservation were offered up for sale in eleven separate parcels. No bids were made on any of the parcels, with the single exception of the Antelope Desert Unit, in the north-central portion of the Reservation, which was bought by Crown-Zellerbach, and is currently owned by Crown-Pacific, which manages it for industrial timber production. The remaining unsold parcels were transferred to the U.S. Forest Service, to become the Winema and Fremont National Forests. Today these lands are managed for multiple uses, with a gradual transition in recent decades from commercial resource harvest toward management for general forest health and other habitat-related values.

Conclusion

For about ten thousand years, the natural systems of the Upper Williamson watershed have functioned under the influence of human activities. For most of that time the influence was relatively subtle, with some significant exceptions, like the use of fire. During the late nineteenth and throughout most of the twentieth centuries, the influence of human activities became dramatically more significant. Equally important is the fact that the human activities themselves – whether economic, political, social or cultural – became vastly more complex, functioning not just at the local scale, but at local, regional, national, and even global scales simultaneously.

To the extent that these human activities and interactions resulted in negative impacts to the functioning of natural systems we depend upon, it is critically important that we attempt to understand those impacts with explicit reference to the general historical context within which they occurred.

KLAMATH MARSH AND THE HYDROLOGIC REGIME

Klamath Marsh has always been a dynamic system, changing in size in response to local climate changes. There is clear evidence in the historic record that the hydrology of Upper Klamath Marsh and its associated effects on marsh plant communities was notably different during the late 1800s from what it is today. Historically (i.e. late 1800s), water levels were higher, there was a greater area of open water, willow thickets were more prevalent, and the extent of the deep water wocus plant community was much greater than is the case in present times (USFS 1998, USFS 1997, Weddel et al 1998). It is readily accepted that human intervention with the landscape has played a role in these changes. What is less clear is the extent to which natural climate cycles have played a participating role in this change.

Many hypotheses have been put forth regarding the root cause of changes in the marsh. Increased stocking levels of timber affecting evapotranspiration rates and timing of runoff, increased sedimentation rates resulting from grazing and road building, fire suppression (which allows peat to develop), and water diversions for irrigation are a few examples of human activities that may very well affect water levels in the marsh. When investigating these hypotheses, it is important that natural climate variability be taken into account.

One of the earliest descriptions of the marsh, by Williamson and Abbot in August 1857, described the marsh as "a strip of half submerged land, about twelve miles long and seven miles broad … covered by clumps of tule and other aquatic plants separated by sheets of water" (USFS 1997). Map 3-1 illustrates the areas of the Upper Williamson River subbasin that were covered by Government Land Office (GLO) notes and maps in 1892 and 1893. Map 3-2 and Map 3-3 show the historic GLO maps overlain onto current day USGS quadrangle maps (Military Crossing and Wildhorse Ridge quadrangles). GLO notes associated with these maps indicate the edge of open water at an elevation of 4,515 feet in the vicinity of Military Crossing, where water depths were observed to be between 2 to 4 feet (USFS 1997). The GLO information was recorded when water levels were at their lowest during the course of the year, suggesting that this area of open water was permanent. Coville estimated that in 1902 the marsh contained a solid growth of 10,000 acres of wocus (Coville 1904 from Weddell et al 1998). This is indicative of a large area of water too deep for emergent vegetation to develop, as wocus prefer water depths from approximately 3 to 8 feet (USFS 1997). An example of a wocus plant community is shown in Photo 3-2, a historic photo of the wocus harvest. Coville provided the following description of the wocus plant community.

> The plant is so vigorous and has such a habit of growth as usually to occupy an area suited to it to the complete exclusion of other characteristics and conspicuous marsh plants, such as tule and cattail. Certain plants associate themselves habitually with the waterlily [wocus], but these plants are for the most part submerged in the water, are inconspicuous, and subsidiary in their relationship to the waterlily, and in no effective or important way contest its spread. The principal of these latter plants are bladderwort (*Utricularia vulgaris*), mare's tail (*Hippuris vulgaris*), and pondweed (*Potamogetan natans*) and other species.
>
> *Coville 1904 from Weddell et al 1998*

A 1912-1913 report prepared by the Bureau of Indian Affairs (BIA) estimated the area of the marsh at 30,000 acres and described it as being "engulfed with water at all times" and covered with tule, slough grass (*Beckmannia syzigachne*), and wocus growths (BIA in Clyde-Criddle-Woodward, Inc. 1976 as cited in Weddell et al 1998). Average water depths in tule and wocus areas were estimated at less than two feet, with channels of greater depth located throughout the marsh. A ring of wet meadow community dominated by sour marsh grass was also observed (BIA in Clyde-Criddle-Woodward, Inc. 1976 as cited in Weddell et al 1998). Map 3-2 and Map 3-3 show that the marsh of the late nineteenth century, in many places, extended far beyond its current boundaries. The GLO maps also show sizeable willow thickets, particularly where streams enter into the marsh.

According to climatic records (described in detail in Section 2), many of the historic descriptions were recorded during a cool/wet climate cycle, which began in the early 1900s and lasted until approximately 1916). In contrast, the period between 1916 and 1931 was a warm/dry climate cycle characterized by drought. The effects of this drought period on the marsh are telling. For example, USFS (1997) reported that Big Springs Creek completely dried up during a drought in the early twentieth century. A narrative report during this time period (circa 1930) describes the drought as follows:

> [The marsh is in] a sad state. Ranchers and livestock men were compelled to put down wells and otherwise provide water. Grasshoppers and rodents plagued the then dry marsh. It was possible to travel by saddle horse and automobile over much of the present marsh area.
>
> *USDI Fish and Wildlife Service 1960 as cited in Weddell et al 1998*

Kirk Reef

Some sources describe Kirk Reef as a natural control structure for water levels in Upper Klamath Marsh (USFS 1998, USFS 1995a) and there is some debate as to whether it was lowered in the past with the intent of lowering water levels in the marsh. In their Big Bill Watershed Analysis, USFS (1998) indicated the reef was lowered around 1908 by an estimated 5 to 10 feet from its estimated historic elevation of 4,528 feet mean sea level (USFS 1995a).

However, in a separate Watershed Analysis, USFS (1997) states that "channel morphology upstream from the control point at Kirk does not support the idea that any potential modification of the Kirk Reef had affected marsh surface elevation." Whether or not Kirk Reef was intentionally lowered is still a question; however, there is no readily observable evidence to support the idea that modifications to the Kirk Reef have affected water levels in the marsh.

From the mid-1920s to 1930 (during the known period of drought) the quantity of permitted irrigated land acreage in the Upper Williamson River basin (i.e., above confluence with the Sprague River) increased from less than 1,000 acres to approximately 10,000 acres (Risley and Laenen 1999). This significant increase in irrigation may have been a result of an increase in land available for agriculture due to the marsh drying up, or it may have been the result of an increased need for irrigation due to drier conditions.

Following this period of drought, there was a long wet/cool climate cycle that extended from the early 1930s to the mid-1960s. A 1955 USFWS report described the marsh as containing 9,900 acres of shallow marsh and 15,000 acres of deep marsh (USDI Fish and Wildlife Service 1955, as cited in Weddell et al 1998). This description of marsh conditions is very similar to those for the marsh at the beginning of the 1900s, both in overall acreage and habitat types. The comparison between these two time periods is notable because the period from the early 1900s through the 1940s was a period of substantial agricultural development within the marsh area (USFS 1998). This agricultural development included the construction of the Kittredge Canal, a major water diversion feature that was dug during the 1940s (Walt Ford pers. comm. 2004). This canal was used to pump water from the north end of the marsh to the south end of the marsh during the spring high water season. This allowed for cattle grazing of the north marsh area. Later in the year, when water levels were naturally lower, a secondary canal diverted water back to the north end in order to irrigate pasture grasses and provide water for cattle (Walt Ford pers. comm. 2004). Although the refuge stopped this practice in the 1990s and the pumps have since been removed, the ditch system still remains (Walt Ford, pers. comm 2004).

A new warm/dry cycle began in the mid-1960s and has continued to the present day (although there may have been a brief cool/wet cycle during the late 1990s). As in previous years, it appears this climate trend may be affecting water levels in the marsh. A 1975 Draft Conceptual Plan for the Klamath Forest Wildlife Refuge provided the following description of refuge lands:

> …present refuge vegetation is dominated by dense stands of hardstem bulrush, [while] open water-vegetation interspersion is virtually non-existent with an estimated 10 percent of the marsh consisting of open water.
>
> *Anon. 1975 as cited by Weddell 1998*

Historic Fish Distribution

Historically, especially during particularly wet periods, redband trout may have been able to access marsh tributary streams such as Sand Creek (west), Scott Creek (west), and Big Springs Creek, and possibly Hog and Yoss Creeks (USFS 1998 and USFS 1997). Tributary streams of the Williamson River above Klamath Marsh, such as Jackson, Irving, Sand (east), and Deep Creeks, may also have been, at least partially, accessible to fish, and probably provided spawning habitat for redband trout during wet climate cycles (USFS 1997).

Current marsh conditions are reflective of this general 1975 description. Open water on the Refuge is limited, and is primarily confined to Big and Little Wocus Bays in the south, with excavated canals providing some additional area. Areas of the Refuge previously used for pasture in the north end of the marsh have since been converted from grazed pasture to tule and cattail marsh (Walt Ford pers. comm. 2004). Water is now diverted to this area through the Rock Island diversion structure, the Refuge's primary diversion structure for delivering water to various sectors of the marsh.

It is difficult to determine, with any accuracy, how the marsh habitats have changed in size over the course of the past century because habitat descriptions/classifications are not consistent from one document to the next. In general, it is clear that there has been a shift from deep-water, wocus dominated plant communities to shallower, emergent vegetation communities. It is also clear (as shown in Map 3-2 and Map 3-3) that water levels are lower, which has decreased the overall size of the marsh, regardless of habitat type. Well log data have recorded long-term groundwater elevation fluctuations of as much as twenty feet within the marsh during the twentieth century, with seasonal fluctuations of one to two feet (Leonard and Harris 1974 as cited by USFS 1997). Based upon the climatic cycles, it is possible that the current, dry marsh condition may not be static, and that wetter conditions may likely ensue when the climate cycle shifts again to a cool/wet cycle. The following quote from USFS (1997) sums up this climatic cycle and its effects on marsh conditions:

> The consequence of climate variation on the marsh is biologically profound. Because of the low topographical relief of the marsh, wet and dry era environments are drastically different. During wet periods marsh production is dominated by forms such as phytoplankton, submerged and floating-leafed aquatic plants, and aquatic fauna such as fish. Drought cycles favor emergent aquatic vegetation and wetland plants which support more terrestrial fauna.
>
> *USFS 1997*

Historic Fish Distribution, Continued...

Deep Creek, the only tributary perennially connected to the Williamson River, is still accessible to redband trout and may provide some spawning habitat (USFS 1997).

Redband trout would have likely used the marsh area for juvenile rearing habitat and also as a feeding area for adults, except during late summertime, when water temperatures would probably have been too high. Based on the potential historic use, it is likely that there were different stocks of redband that used different tributaries for spawning. This may have resulted in a higher degree of genetic diversity among upper Williamson redband than currently exists today. The loss of access between lakes, marshes, and streams has been noted as a problem common to systems containing Oregon basin redband trout, with the result being an interference of migratory life histories and diminished gene flow between populations (ODFW 2004b). Numerous water diversion structures and irrigation canals have been constructed over the course of the 1900s. These features may preclude use of some historic redband trout habitat, even when/if the local climate shifts back to a cool/wet cycle and overall water levels are higher.

Historic Fish Distribution, Continued...

Other native fish species, such as Miller Lake lamprey and the Klamath large-scale sucker, may also be similarly affected.

It is difficult to determine, with any accuracy, how the marsh habitats have changed in size over the course of the past century because habitat descriptions/classifications are not consistent from one document to the next.

In general, it is clear that there has been a shift from deep-water, wocus-dominated plant communities to shallower, emergent vegetation communities. It is also clear (as shown in Map 3-2 and Map 3-3) that water levels are lower, which has decreased the overall size of the marsh, regardless of habitat type. Well log data have recorded long-term groundwater elevation fluctuations of as much as twenty feet within the marsh during the twentieth century, with seasonal fluctuations of one to two feet (Leonard and Harris 1974 as cited by USFS 1997). Based upon the climatic cycles, it is possible that the current, dry marsh condition may not be static, and that wetter conditions may likely ensue when the climate cycle shifts again to a cool/wet cycle. The following quote from USFS (1997) sums up this climatic cycle and its effects on marsh conditions:

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>
> *USFS 1997*

HISTORICAL TIMELINE

1848: Oregon Territory is established (USFS 1998).

1850: Oregon Donation Land Act is passed, whereby each adult United States citizen could get 320 acres of free land in the Oregon Territory (USFS 1998).

1864: Central and Eastern portions of the basin were set aside as the Klamath Indian Reservation under the Klamath Indian Treaty of 1864. The treaty set aside 1,196,872 acres for the exclusive use of Indian peoples, and had the affect of removing Indians from about 20 million acres so that they could be used for non-Indian settlement and agriculture (USFS 1998).

1880s and 90s: Settlers, sheep herders, and timber companies begin to have a notable affect on timber resources, particularly on west side of the basin (USFS1998).

1893: Unclaimed forestlands on west side of basin were set aside as part of the Cascade Range Forest Reserve, under control of the Department of the Interior. Objectives centered on restricting settlement, regulating sheep grazing, wildfire suppression, and timber resource preservation (USFS 1998).

1900 to 1940: A large percentage of marshes and wetlands located on private lands were converted to agricultural uses during this time (USFS 1998).

1902: Crater Lake National Park was established "as a pleasure ground for the benefit of the people of the United States" (Greene 1984:99 as cited in USFS 1998).

1902: A study by Coville (1902:728 as cited in USFS 1998) estimated Klamath Marsh to contain approximately 10,000 acres of solid growth of wokus. Wokus (water lily) seeds were an important food staple of the native peoples.

1903: Starting in 1903, grazing on Forest Reserve lands is regulated through use of a permitting system, which controlled the numbers of animals and season of use (USFS 1998). A similar system was put in place for the Klamath Reservation; however, effective regulation was more difficult and came later. According to Winema National Forest (1998), "the historical affects of grazing throughout the Williamson River Watershed are apparent today. Grazing has reduced or eliminated hardwood communities that are associated with live water sources, either developed or natural. Water diversion, to both drain wetlands and irrigate pastures, has contributed to lowering of water tables, changing plant communities, and reducing the extent of riparian plants and natural wetlands."

1905: Cascade Range Forest Reserve lands transferred to the Department of Agriculture and managed by the newly formed Forest Service (Winema National Forest 1998). Forest lands were initially included as part of the Crater National Forest, then the Rogue River

National Forest, and ultimately the Winema National Forest in 1961 (Winema National Forest 1998).

1909: Commercial timber harvest on National Forest, Klamath Reservation, and large privately owned timberlands becomes significant with the arrival of the Southern Pacific Railroad, which opens the Klamath basin to outside markets (USFS1998).

1918: Approximately 13,000 head of Indian-owned cattle and 30,000 head of non-Indian privately owned cattle were located on Klamath Indian Reservation lands (Moore 1945:4-5 as cited in USFS 1998). Trespass of non-Indian sheepherders and ranchers was common practice starting in the 1860's through the thirty's (USFS 1998).

1918 to 1958: More than 4.4 billion board feet of virgin timber was harvested from the Williamson River watershed (USFS 1998).

Mid-1920s to 1930: The quantity of permitted irrigated land acreage in the Upper Williamson River basin (i.e. above confluence with the Sprague River) shows a notable increase from less than 1,000 acres to approximately 10,000 acres during this time period (as interpreted from Figure 18 of Risley and Laenen 1999). Little to no increase in permitted acreage occurs after this period until the mid-1950's.

1929 to 1948: Lamm Mainline Railroad serves as a common carrier for several lumber companies within the basin. The railway crosses Skellock Draw and could pose potential difficulties for future watershed restoration activities in this area. Portions of the historic railway are eligible for the National Register of Historic Places (USFS 1995).

Mid-1950 s to 1980: The greatest rate and overall change in irrigated agricultural acreage took place during this time period (Risley and Laenen 1999). Irrigated acreage changed from a little over 10,000 acres at the beginning of this period to approximately 52,000 acres at the end of the period (as interpreted from Figure 18 of Risley and Laenen 1999).

1954: The Klamath Termination Act of 1954 terminates federal supervision over the property of the Klamath Tribe. Adult members were given the option to hold their interests in common under state law or converting them to cash. Through an election held in 1958, 77 percent of tribal members decide to convert their assets to cash. Proportionate shares of tribal assets were acquired by the federal government. Approximately 144,000 acres remained as tribal member lands held in trust by the U.S. National Bank of Portland (USFS 1998).

1960: Most virgin timber stands have been harvested from the Williamson River watershed. Emphasis shifts to second growth stands on private and newly created Winema National Forest lands in 1961. Overall volumes are much lower than in the past (USFS 1998).

1961: Winema National Forest is established from forestlands under other National Forest management (USFS 1998).

1961: Klamath Forest National Wildlife Refuge is created (USFS 1998).

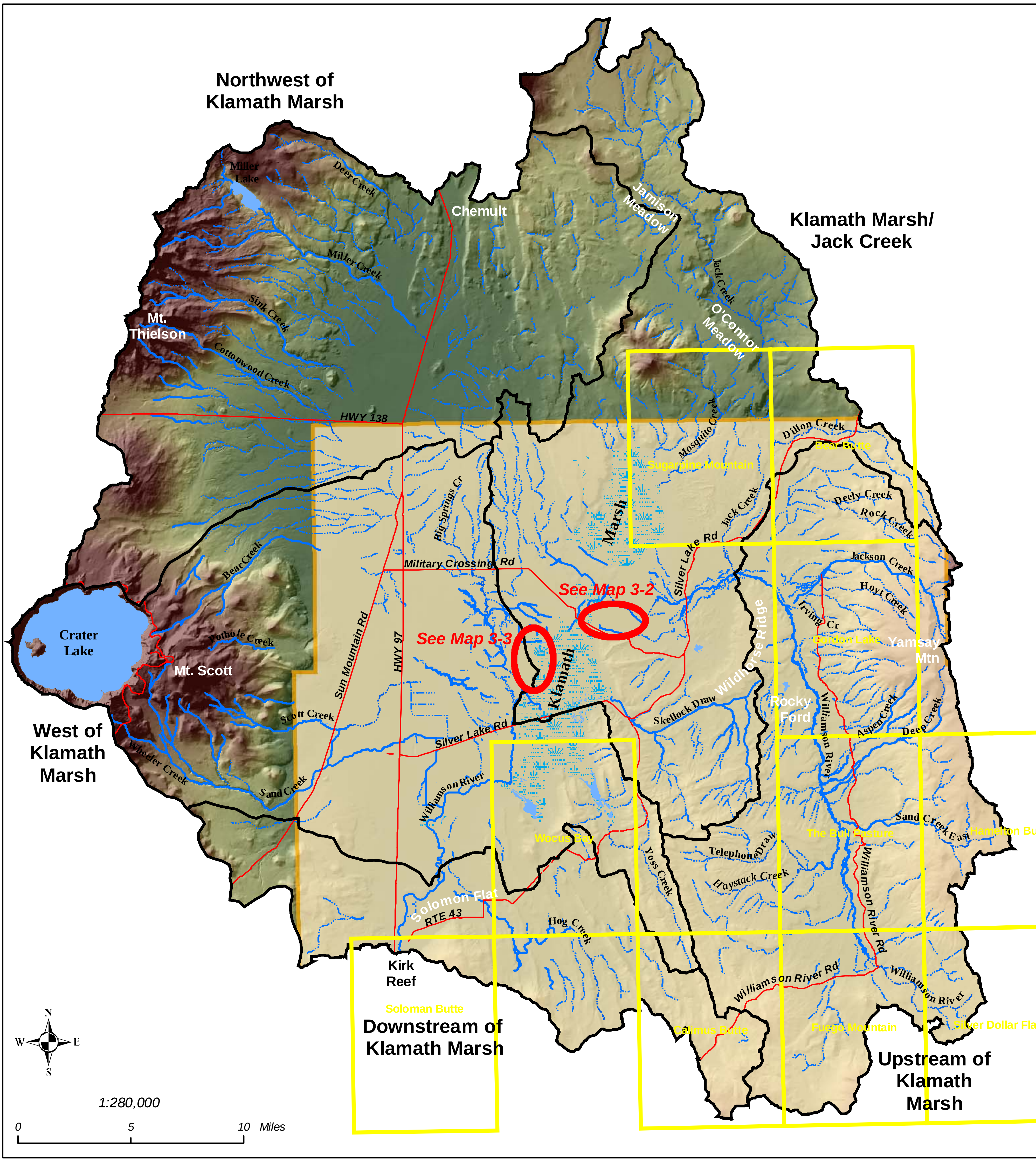
1969: Remaining Klamath Tribe members with land holdings elect to terminate the trust, and in 1974 the lands became part of the Winema National Forest (USFS1998).

1970s through mid-80s: Timber harvesting increases within the Williamson River basin once again. The Yamsay Tract (also known as the Long-Bell Tract), owned at the time by Weyerhaeuser Company, was heavily harvested during this time (USFS 1998).

1986: Klamath Tribes were restored as a federally recognized tribe; although, reservation lands were not. Treaty rights to hunt, fish, trap, and gather plants were retained on former reservation lands. The Klamath Tribe also play a role in protection of cultural sites, maintenance of plant collection areas, maintaining unrestricted use of summer camps, and for access to religious sites (USFS 1998).

1990s: Timber supplies become tighter within the basin, resulting in private landowners playing a more prominent role in supplying harvestable timber than in the past (USFS 1998).

LIST OF MAPS



Upper Williamson River Watershed Assessment

Map 3-1:
Historical Conditions

Legend

- Transcribed GLO Note Locations (by USGS 7.5 Minute Quad)
- Klamath Indian Reservation Boundary (1888)
- Perennial stream
- Non-perennial stream
- Major road
- Marsh
- 5th-field watershed boundary

Sources:
GLO Notes -Oregon Institute of Technology
Reservation Boundary -USFS (Winema NF)
Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)

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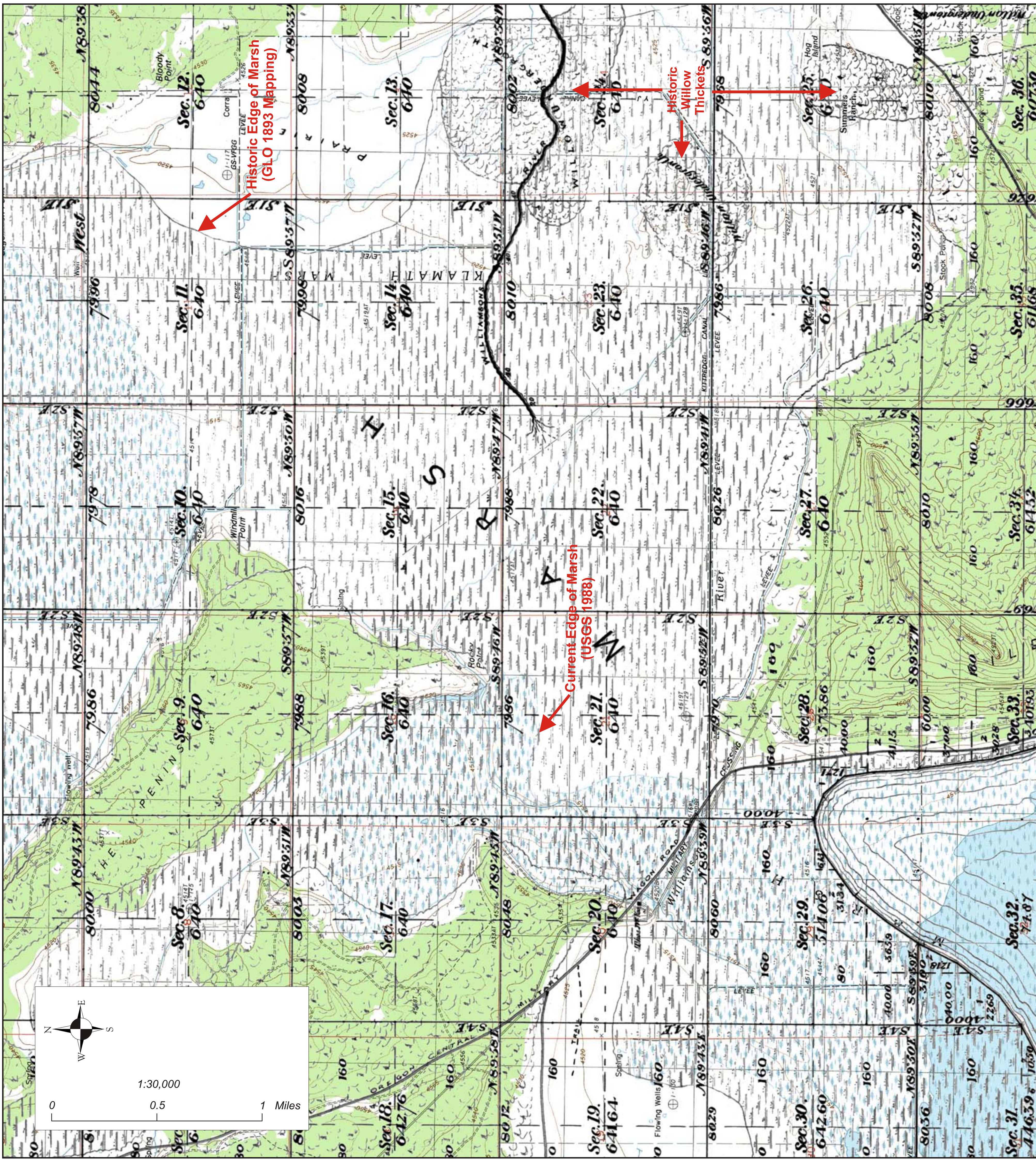

Upper Williamson Watershed Assessment

Legend

GLO information shown as black lines and text.

USGS information shown as color background layer *(some black line work and text is also present)*.

Sources:
GLO Maps - University of Oregon Library Website.
Township 30 South, Range 9 East
(Oct 22 - Nov 3, 1892 survey dates)
USGS Quads - Military Crossing, Oregon (1988),
Wildhorse Ridge, Oregon (1988)

Map 3-2: Overlay of 1892 GLO Map with USGS Quad Map at Military Crossing and Where Williamson River Enters Upper Klamath Marsh

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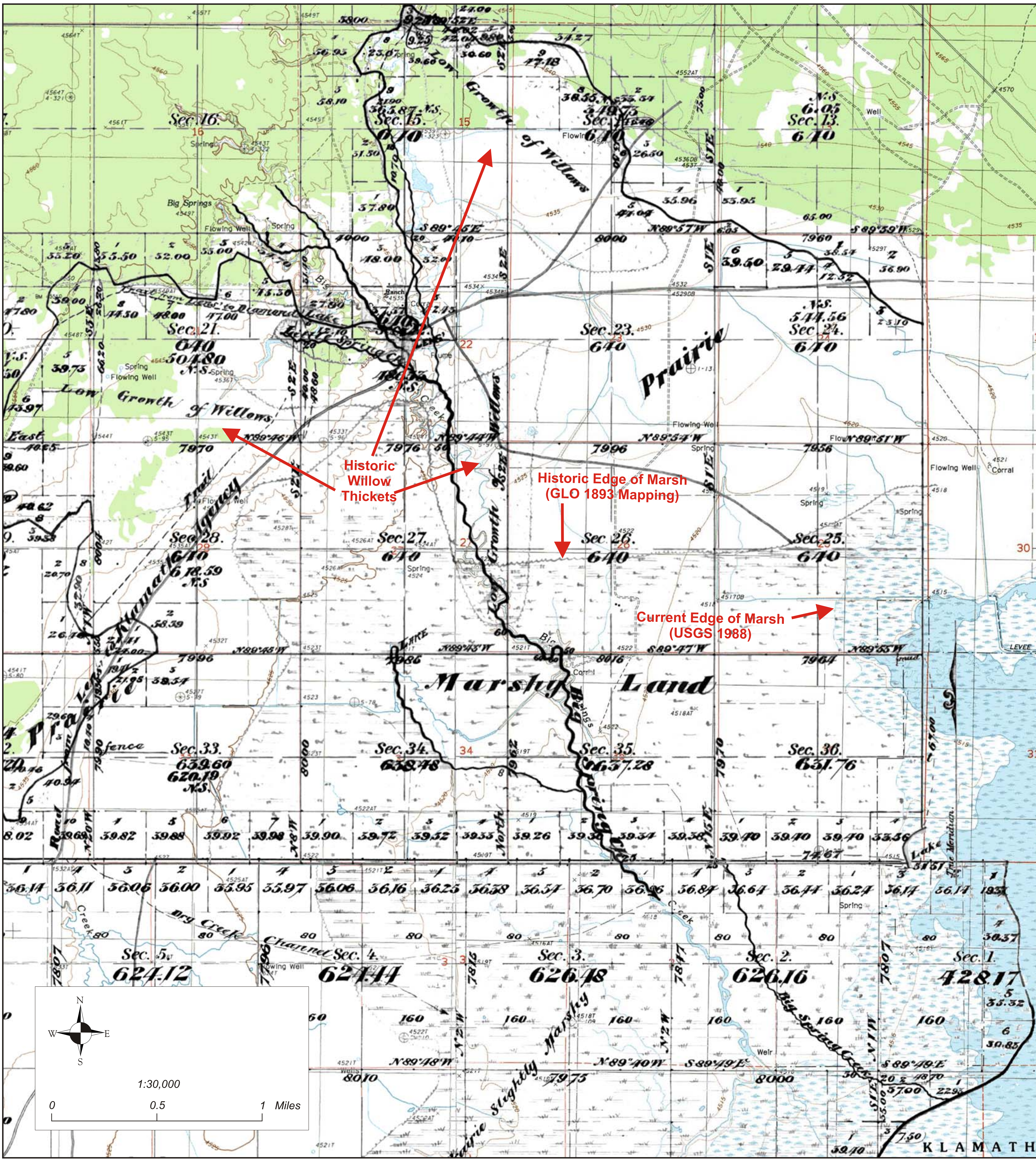

Upper Williamson Watershed Assessment

Map 3-3:
Overlay of 1892 GLO Map with USGS Quad Map at Big Springs Creek and West Side of Marsh

Legend

GLO information shown as black lines and text.

USGS information shown as color background layer *(some black line work and text is also present)*.

Sources:
GLO Maps - University of Oregon Library Website.
Township 30 South, Range 8 East (Aug 19-24, 1893 survey dates)
Township 31 South, Range 8 East (Aug 10-19, 1893 survey dates)
USGS Quads - Military Crossing, Oregon (1988),
Lenz, Oregon (1988)

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4 CHANNEL HABITAT TYPING

INTRODUCTION

Classification of stream channels within a watershed is an important part of understanding the inherent spatial variation in aquatic habitat conditions and is important for prioritizing and understanding the limitations to possible restoration activities. The underlying assumption in any channel-typing scheme is that the morphological channel characteristics are the result of geologic, climatic, and vegetative interactions. Furthermore, similar channel types can be expected to respond in a similar manner to natural or human-caused changes within a watershed in the supply of water, sediment, or wood inputs. The intent of this chapter is to differentiate the channel habitat types within the upper Williamson River subbasin and to address the following two critical questions:

1. What is the distribution of channel habitat types throughout the subbasin?
2. What is the location of channel habitat types that are likely to provide specific aquatic features, as well as those areas that may be the most sensitive to changes in watershed conditions?

METHODS

Because there are approximately 1,300 miles of mapped stream within the assessment area, it was determined that this assessment would use an abbreviated form of the Channel Habitat Type (CHT) classification scheme included in the Oregon Watershed Assessment Manual. The classification scheme used in this analysis is based on the Rosgen methodology (Rosgen 1996). The Rosgen methodology utilizes a hierarchical approach to channel classification. The most extensive classification within the methodology, the Level I classification, is based on broad-scale features that can be remotely derived (Table 4-1).

Table 4-1. General Stream Type Descriptions

Stream type	General description	Entrenchment ratio	W/D ratio	Sinuosity	Slope	Landform/soils/features
Aa +	Very steep, deeply entrenched, debris transport streams.	< 1.4	< 12	1.0 to 1.1	>0.10	Very high relief. Erosional, bedrock or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with/deep scour pools; waterfalls.

Stream type	General description	Entrenchment ratio	W/D ratio	Sinuosity	Slope	Landform/soils/features
A	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.	< 1.4	< 12	1.0 to 1.2	0.04 to 0.10	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step-pool bed morphology.
B	Moderately entrenched, moderate gradient, riffle dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.4 to 2.2	> 12	> 1.2	0.02 to 0.039	Moderate relief, colluvial deposition and/or residual soils. Moderate entrenchment and W/D ratio. Narrow, gently sloping valleys. Rapids predominate with occasional pools.
C	Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well defined floodplains	> 2.2	> 12	> 1.4	< 0.02	Broad valleys with terraces, in association with floodplains, alluvial soils. Slightly entrenched with well-defined meandering channel. Riffle-pool bed morphology.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks.	N/A	> 40	n/a	< 0.04	Broad valleys with alluvial and colluvial fans. Glacial debris and depositional features. Active lateral adjustment, with abundance of sediment supply.
DA	Anastomosing (multiple channels) narrow and deep with expansive well vegetated floodplain and associated wetlands. Very gentle relief with highly variable sinuosities. Stable streambanks.	> 4.0	< 40	Variable	< 0.005	Broad, low-gradient valleys with fine alluvium and/ or lacustrine soils. Anastomosed (multiple channel) geologic control creating fine deposition with well-vegetated bars that are laterally stable with broad wetland floodplains.
E	Low gradient, meandering riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander width ratio.	> 2.2	< 12	> 1.5	< 0.02	Broad valley/meadows. Alluvial materials with floodplain. Highly sinuous with stable, well vegetated banks. Riffle-pool morphology with very low width/depth ratio.
F	Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio.	< 1.4	> 12	> 1.4	< 0.02	Entrenched in highly weathered material. Gentle gradients, with a high WjD ratio. Meandering, laterally unstable with high bank-erosion rates. Riffle-pool morphology.
G	Entrenched "gulley" step/pool and low width/depth ratio on moderate gradients.	< 1.4	< 12	> 1.2	0.02 to 0.039	Gulley, step-pool morphology with moderate slopes and low W\D ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials; i.e., fans or deltas. Unstable, with grade control problems and high bank erosion rates.

Rosgen, 1996

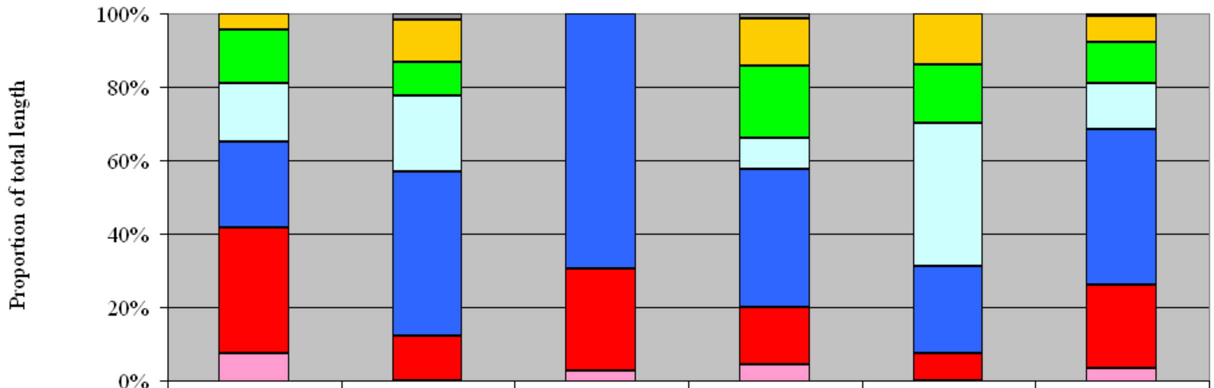
The Rosgen level I approach is based primarily on four factors: the stream entrenchment ratio, which is the ratio of the flood-prone area to the bankfull channel width; the bankfull channel width to bankfull depth ratio; channel sinuosity; and channel gradient or slope. All these parameters, with the exception of the width-depth ratio, can be estimated based on remote sensing data.

Channel gradient was estimated using digital elevation model (DEM) data with a pixel resolution of approximately 10 meters (USGS, 2004a). Sinuosity was estimated for each stream segment within GIS as the ratio of the valley length[4] to channel length. Entrenchment ratio (ratio of the flood prone area to the bankfull channel width) was estimated by this analyst for each segment using digital topographic quadrangle maps (to visualize valley width and channel confinement) and digital ortho photographs (to evaluate human-disturbance to the channel segment, and channel size).

A first approximation of channel type was made using gradient and sinuosity alone. As can be seen from Table 4-1, all channels having gradients greater then 10% can be initially classified as type “Aa+” channels, and all channels with gradients of 4% to 10% as class “A” channels. Similarly, channels having gradients of 2% to 4% were initially classified as type “B/G” channels, indicating that they are either “B” or “G” channel types. The remaining low-gradient channels (<2%) will fall within either the “C”, “E”, or “F” types (type “D” channels are unlikely to be found in the assessment area). This last grouping was initially broken out into two groups, based on channel sinuosity. Those channel segments having a sinuosity of 1.5 or greater were initially grouped as type “E/F” channels, indicating that they are either type “E” or type “F,” depending on the level of entrenchment and width-to-depth ratios. Similarly, segments having a sinuosity of <1.5 were initially grouped as type “C/F” channels.

These initial classifications were modified based on inspection of the topographic maps and ortho photographs, which resulted in the reclassification of many segments (e.g., many segments initially classified as “C/F” were subsequently changed to “B” types). However, because of the limitations of remote sensing and the inability to perform field verification, the channel groupings were not further subdivided. The spatial distribution of Rosgen channel types is shown in Map 4-1 and summarized in Figure 4-1.

[4] *Approximated by calculating the vector distance from the channel segment start point (X_1, Y_1) to the end point (X_2, Y_2).*



	Upstream of Klamath Marsh	Klamath Marsh/Jack Creek	Northwest of Klamath Lake	West of Klamath Marsh	Downstream of Klamath Marsh	Entire assessment area
Connector	-	5	-	4	-	9
Ditched	16	37	-	35	9	97
E/F	54	30	-	52	10	146
C/F	57	67	-	23	24	172
B/G	87	144	221	101	14	566
A	126	40	88	41	5	299
Aa+	27	-	8	12	-	47

Figure 4-1. Summary of Rosgen Channel Types in the Upper Williamson River Subbasin

RESULTS AND DISCUSSION

Type Aa+ Channels:

The Aa+ stream types are very steep streams (>10% channel gradient) located exclusively in headwater areas on the periphery of the assessment. Type Aa+ streams occur on the slopes of the Cascade Mountains to the west, and on the flanks of Yamsay Mountain and Booth Ridge to the east (Figure 4-1). Transport processes dominate in these reaches, as they are often source areas for downstream deposition. Type Aa+ channels are found primarily within the Upstream of Klamath Marsh watershed (7% of total channel length), as well as in the Northwest of Klamath Lake (3%) and West of Klamath Marsh watersheds (4%). Type Aa+ channels make up 4% of the total channel length within the assessment area (Figure 4-1).

Type A Channels:

Channel type A is similar to the Aa+ classification, the primary difference being that these channel types are lower gradient (4% to 10%). Consequently, these channel types tend to be located immediately downstream of the type Aa+ channels (Figure 4-1).Type A channels are found within all watersheds, and range from 8% of the total channel length in the Downstream of Klamath Marsh watershed to 34% of the channel length in the Upstream of Klamath Marsh watershed. Type A channels make up 22% of the channel length in the entire assessment (Figure 4-1).

Type B/G Channels:

The B/G channel designation indicates that these channels are either Rosgen type B or type G channels, but there is insufficient information available to split the two groupings out. This grouping is often positioned downstream of type A channels, but in the Upper Williamson these channels also are widespread in headwater positions within gently sloping terrain (Figure 4-1). Both the B and G channels are moderate in gradient (2% to 4%). Although type B channels are morphologically dominated by hillslope (as opposed to floodplain) processes, they often contain some areas of floodplain development and may be both transport and depositional reaches. Rosgen type G or "gullied" channels are narrow, entrenched, non-meandering channels that are often downcut within alluvial deposits. Although there are undoubtedly naturally-occurring G channels within the assessment area, it may be reasonable to think of the B channels as representing functioning channel types, and the G channels as representing the degraded condition.

Type B/G channels are the predominant type found within the assessment area (42% of total channel length overall), and range from 24% of the total channel length in the Upstream of Klamath Marsh and Downstream of Klamath Marsh watersheds to 70% of the total length in the Northwest of Klamath Lake watershed (Figure 4-1).

Although many of the B/G channels shown to the northwest of Klamath Marsh (Map 4-1) actually classify as lower-gradient streams, because of their probable entrenchment into the highly porous parent material, it seemed more reasonable to classify these streams as type B/G.

Type C/F Channels:

The C/F channel designation indicates that these channels are either Rosgen type C or type F channels; however, there is insufficient information available to split the two groupings out. Rosgen type C channels consist of relatively low-gradient streams with well-developed floodplains and are typically highly responsive to sediment and wood inputs. Type F channels are similar in gradient, and may have a similar planform geometry (thus the difficulty in differentiating these from type C channels using remotely-sensed data), but the type F channels are entrenched, have a high width-depth ratio, and may have high bank erosion rates. For this analysis it is reasonable to think of the C channels as representing functioning channel types, and the F channels as representing the degraded condition.

Type C/F channels are found within all watersheds (with the exception of the Northwest of Klamath Lake watershed), and occur primarily below headwater channels along the mainstem of the principal tributaries (Map 1-1). Type C/F channels range from 9% of the total channel length in the West of Klamath Marsh watershed to 39% of the total length in the Downstream of Klamath Marsh watershed (Figure 4-1).

Type E/F Channels:

The E/F channel designation indicates that these channels are either Rosgen type E or type F channels; however, there is insufficient information available to split the two groupings out. Rosgen type E channels consist of low-gradient, meandering streams with a low width/depth ratio, and often are characteristic of meadow systems. Type F channels are similar in gradient, and may have a similar planform geometry (thus the difficulty in differentiating these from type C channels using remotely-sensed data), but the type F channels are entrenched, have a high width-depth ratio, and may have high bank erosion rates. For this analysis it is reasonable to think of the E channels as representing functioning channel types, and the F channels as representing the degraded condition.

Type E/F channels are found within all watersheds with the exception of the Northwest of Klamath Marsh watershed, and occur primarily within meadow-dominated areas along the mainstem of the principal streams (Map 4-1). Most of these channels occur in areas of intensive agriculture or grazing. Type E/F channels range from 9% of the total channel length in the Klamath Marsh/Jack Creek watershed to 20% of the total length in the West of Klamath Marsh watershed (Figure 4-1).

Ditched Channels:

During the course of the assessment it became apparent that there is a small but significant group of channels that are so highly modified that it would be impossible to place them within any of the Rosgen channel types. These channels occur primarily in the vicinity of Klamath Marsh (Map 4-1), and consist of either natural streams that have been excavated and straightened for drainage, or completely new drainage ditches. These channel are found within all watersheds with the exception of the Northwest of Klamath Marsh watershed, and range from 4% of the total channel length in the Upstream of Klamath Marsh watershed to 14% of the total length in the Downstream of Klamath Marsh watershed, and are 7% of the total stream length in the assessment area overall (Figure 4-1).

CONFIDENCE EVALUATION

Overall the confidence in the channel typing is low to moderate. The assessment was based exclusively on remotely sensed data (channel gradient from DEM data; valley confinement interpreted from DEMs, ortho photos, and topographical maps; and channel modifications interpreted from ortho photos) with no field-verification. Additional material from several USFS watershed analyses was incorporated as a check to the initial channel type assignments. Significant data gaps remain which must be filled before a meaningful prioritization of channel restoration can be completed. Implementation of the recommendations would result in a high confidence in the subsequent assessment.

RECOMMENDATIONS / DATA GAPS

Based upon the results and known data gaps, the following recommendations are made:

1. Refine understanding of channel conditions. As discussed in the Methods section, the channel typing performed for this assessment was based exclusively on remotely sensed parameters, specifically, channel gradient and valley confinement. Additional information on channel entrenchment, channel substrate is required to refine our understanding of the existing channel types, extent of habitat degradation, and possible restoration opportunities. It is recommended that an assessment of stream channel conditions on private lands occur. The focus should be the low-gradient type "C/F", "E/F" and "Ditched channels" (Map 4-1).

2. Identify locations of, and feasibility of removing, channel modifications. This analysis should evaluate the feasibility of removing or modifying existing levies, berms, dikes etc. that impede the natural meander pattern. This evaluation can be incorporated into the channel survey needs identified above.

RESTORATION OPPORTUNITIES

This section provides restoration opportunities that have been made evident during the channel habitat typing investigation.

1. Protect channels that currently provide proper functioning condition. Those channels that are currently in a proper functioning condition should be protected from future degradation. Given the current data gaps on channel conditions (described above) it is not possible to identify all channel reaches that are in proper functioning condition. However, as a first approximation, those channels that currently have good riparian vegetation should be considered as the primary candidates for protection (see Chapter 6, Riparian Assessment).

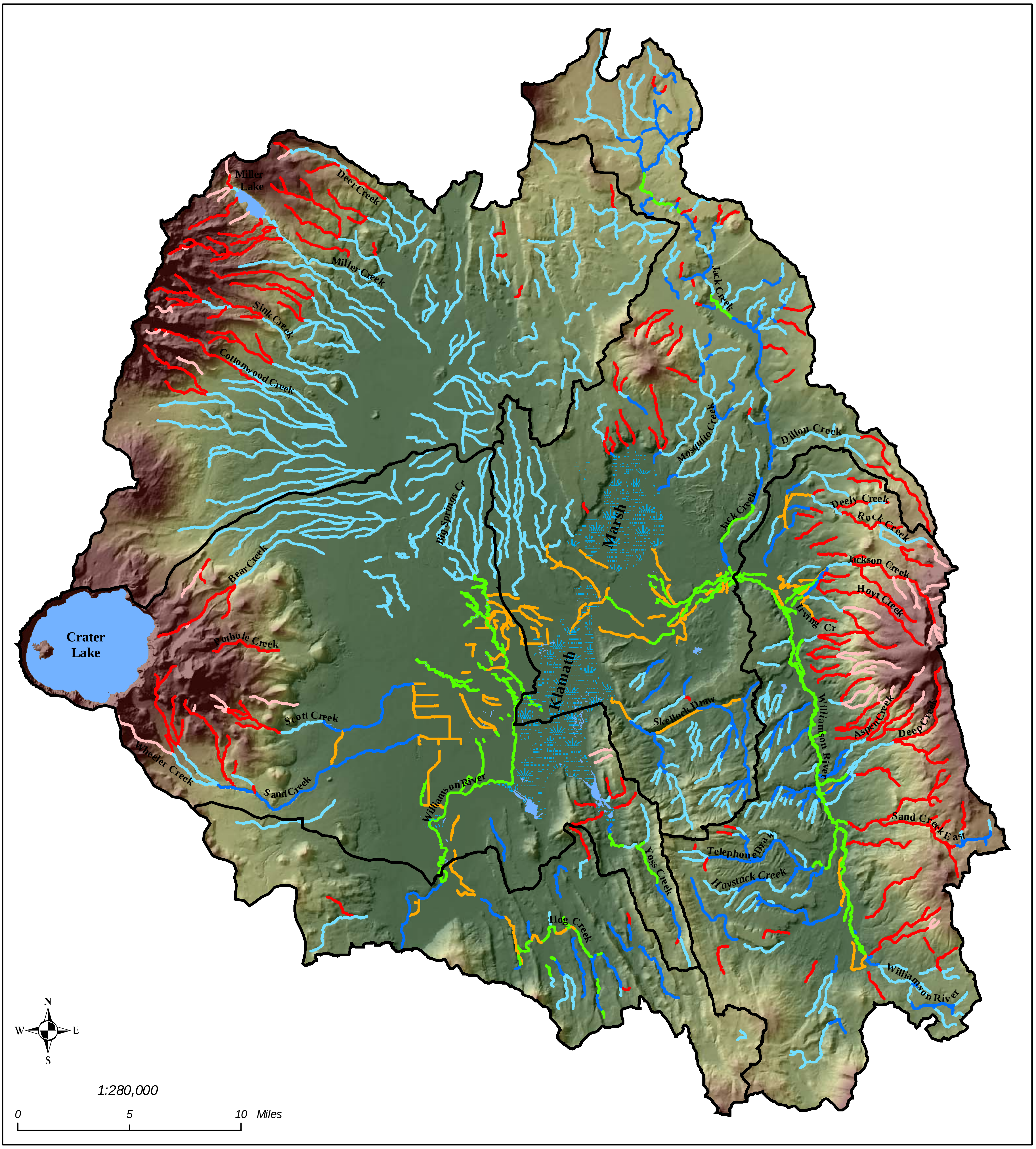
2. Prevent future infrastructural encroachment on channels; remove existing impacts. In many portions of the assessment area roads (and former railroad grades) impact the natural function of stream channels by occupying a portion of the naturally occurring floodplain. Where possible, these impacts should be removed or mitigated, and future impacts should be prevented. Priority for removal should be given to low-gradient unconfined channels (i.e., "C/F", "E/F" channels; Map 4-1).

3. Restore floodplain connections and natural channel form in low-gradient unconfined reaches. In many of the mainstem and larger tributaries (i.e., "C/F", "E/F" channels; Map 4-1), channel downcutting, direct disturbance from livestock, and degradation of riparian vegetation has combined to change the physical attributes of the stream, resulting in aquatic habitat degradation. Many streams have likely widened and become shallower, with a loss of pool habitat. In other streams, particularly smaller channels, streams have downcut and become isolated from their floodplains. Through a combination of grazing management, control of sediment inputs, and riparian recovery, the geomorphic processes that create channel conditions will begin to improve aquatic habitat. With respect to riparian recovery, fencing to control livestock access to the stream channel has proven to be one of the most successful land management activities. Improvements in channel and habitat conditions will likely be most effective in the low-gradient unconfined reaches (i.e., “C/F”, “E/F” channels; Map 4-1).

4. Monitor the effectiveness of channel enhancement actions. Ongoing and future channel enhancement actions will need to be monitored to identify those activities and locations where enhancement yields the greatest benefit. This should begin with an inventory of enhancements that are already in place. A monitoring program should be developed that incorporates the following “tiered” approach:

- Implementation monitoring – Did the agencies, landowners, and managers implement the management guidelines? Implementation monitoring is sometimes viewed as an administrative accounting of actions.
- Effectiveness monitoring – Did the management guidelines have the expected results? Effectiveness monitoring is viewed as tracking results as a specific outcome of management activities.
- Validation monitoring – Are the scientific assumptions underlying the management guidelines correct? Validation monitoring is viewed as testing the scientific basis for the management guidelines, and may entail research.

LIST OF MAPS



Upper Williamson River Watershed Assessment

Map 4-1: Rosgen Level 1 Channel Types

Legend

Rosgen type:

- Aa+
- A
- B/G
- C/F
- E/F
- Ditched
- Marsh
- 5th-field watershed boundary

Sources:

Channel types -Salminen
Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)

DAVID EVANS AND ASSOCIATES INC.

August 13, 2004
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5 HYDROLOGY AND WATER USE

INTRODUCTION

The purpose of this section is to summarize existing information sources, identify data gaps that may require further study, and identify opportunities for improving stream flow conditions. The assessment uses existing information to summarize what is known about streamflow patterns, water use, and land use effects on streamflow in the upper Williamson River subbasin. The results are followed by recommendations on future monitoring needs to fill data gaps and steps that can be taken to improve streamflow conditions.

METHODS

The Hydrology and Water Use assessment methodology outlined in the *Oregon Watershed Assessment Manual* (WPN 1999) is designed around a series of critical questions that form the basis of the assessment. These critical questions are:

1. What land uses are present in the watershed?
2. What is the flood history in the watershed?
3. Is there a probability that land uses in the basin have a significant effect on peak and/or low flows?
4. For what beneficial use is water primarily used in the watershed?
5. Is water derived from a groundwater or surface-water source?
6. What type of storage has been constructed in the basin?
7. Are there any withdrawals of water for use in another basin (interbasin transfers)? Is any water being imported for use in the basin?
8. Do water uses in the basin have an effect on peak and/or low flows?

In general, the methodology used in this assessment follows the outline presented in the *Oregon Watershed Assessment Manual* (WPN, 1999). Critical question 1, "What land uses are present in the watershed?" was addressed in Chapter 2. This Methods section includes a description of the overall hydrologic regime and a summary of existing streamflow data available for the assessment area. The Results section describes the flood history of the area and characterizes the water use among the subwatersheds. The Discussion section considers the effects that current land use may have on streamflow in the watersheds. The Recommendations section outlines information gaps and monitoring needs and gives the restoration priorities.

RESULTS

Hydrologic Regime

The purpose of this section is to characterize the hydrologic regime in the various portions of the upper Williamson River subbasin. General descriptions of the overall hydrology of the area are summarized from La Marche (2004a). Nine stream gages are, or were (as described below), active within the assessment area. In addition, USFS has miscellaneous flow measurements from four additional sites. The locations of gages and flow measurement sites are shown in Map 5-1 and summarized in Table 5-1. Monthly stream flow statistics were calculated for the seven gages in Table 5-1 having the longest flow record, and are discussed below. Statistics calculated for each gage includes median monthly flow and the 80- and 20-percent exceedance flows.[5]

Table 5-1. Gages and Flow Measurement Sites in the Upper Williamson River Subbasin

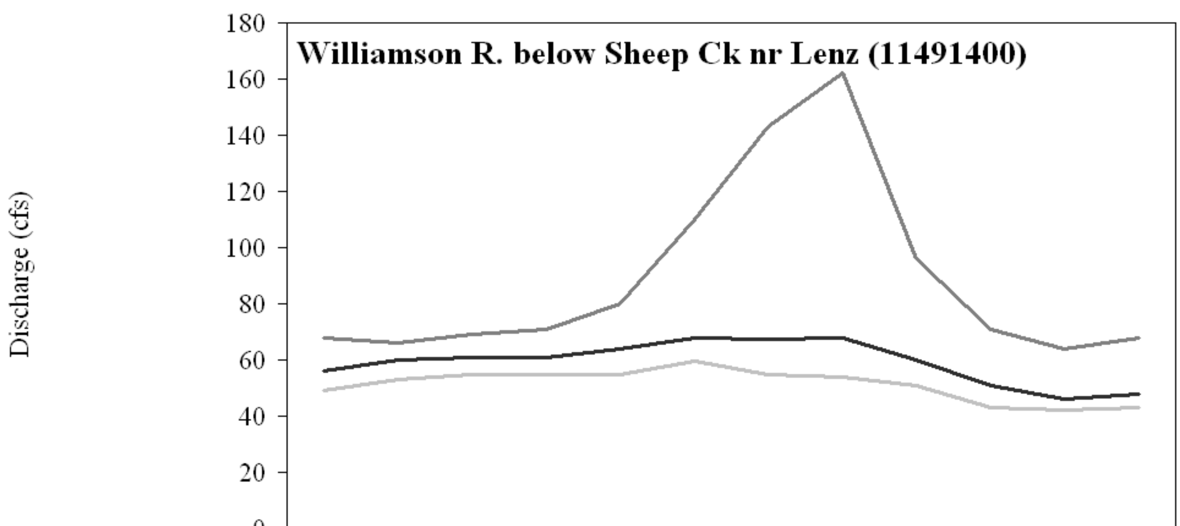
Map #	ID #	Description	Drainage area (mi^2)	Gage elev. (ft)	Period of record: Mean daily flow	Period of record: Peak flows (water years)	Current status/ responsible agency
1	11491400	Williamson River below Sheep Creek, near Lenz	197	4550	10/1973 - 9/2000	1973-2000	Discontinued/ OWRD
2	11491800	Mosquito Cr Nr Shevlin	2	4920	N/A	1964-1981	Discontinued/ USGS
3	11492100	Williamson River at Military Crossing, near Lenz	513	4410	10/1995 - 9/1997		Discontinued/ USGS
4	11492400	Big Springs Creek below Lenz Ranch, near Lenz	397	4560	5/1992 - 10/1995		Discontinued/ USGS
5	11493500	Williamson River near Klamath Agency	1290	4483	10/1954 - Present	1909-Present	Active/ USGS
6	61420101	Cottonwood Creek near Diamond Lake Junction	6	4870	10/1992 - 9/2001		Discontinued/ USFS
7	61420102	Miller Creek near Beaver Marsh	20	5200	10/1992 - 9/2001		Discontinued/ USFS
8	61420103	Sand Creek near Sand Creek Junction	28	4730	10/1992 - Present		Active/ USFS
9	61420104	Sink Creek near Diamond Lake Junction	10	5450	10/1992 - Present		Active/ USFS
10	N/A	Deep Creek					
11	N/A	Irving Creek					
12	N/A	Jackson Creek					
13	N/A	Scott Creek					

[5] *The median, or 50% exceedance stream flow, is the stream flow that occurs at least 50% of the time in a given month. The 80% exceedance stream flow is exceeded 80% of the time, and can be thought of as the stream flow that occurs in a particularly dry month. Conversely, the 20% exceedance stream flow is exceeded only 20% of the time, and can be thought of as the stream flow that occurs in a particularly wet month.*

The majority of the upper Williamson River subbasin consists of a forested plateau located between Mt. Mazama and Yamsay Mountain. Klamath Marsh, located near the center of the basin, significantly influences the hydrology of the basin, as do the highly permeable pumice/ash fall from Mt. Mazama that covers the plateau to the west and north of the marsh (La Marche, 2004a). This high permeability results in relatively low drainage density as compared with the neighboring Sprague River subbasin.

The Williamson River originates from springs near Taylor Butte, and flows north through a wide, sediment-filled valley for 35 miles. Groundwater discharge occurs directly into the Williamson River at several large springs above Rocky Ford, with Wickiup Spring being the largest single contributor (La Marche, 2004a). Flow within this area is best represented by the Williamson River below Sheep Creek stream gage (Figure 5-1, Gage #1 on Map 5-1). Median flows at this gage are relatively constant throughout the year, and there is little difference between the median and 80% exceedance flows. However, spring snowmelt influences high flows during the late winter and spring (as represented by the 20% exceedance flow; Figure 5-1).

Monthly stream flow statistics were calculated for the seven gages in Map 5-1 having the longest flow record. Statistics calculated for each gage includes median monthly flow and the 80- and 20-percent exceedance flows.



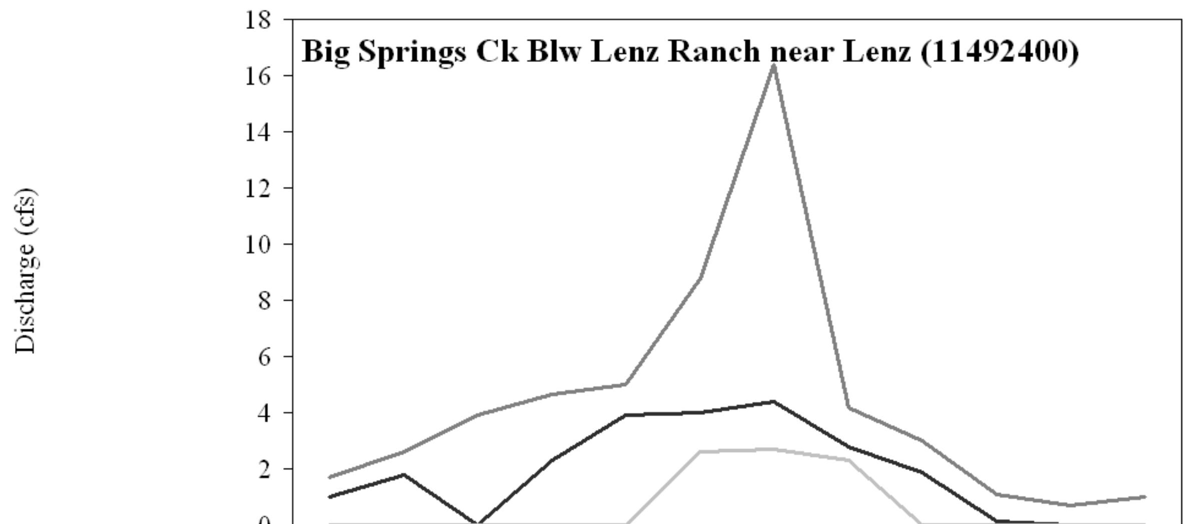
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Median	56	60	61	61	64	68	67.5	68	60	51	46	48
80% exceedance flow	49	53	55	55	55	59.4	55	54	50.8	43	42	43
20% exceedance flow	68	66	69	71	80	110	143	162	96	71	64	68

Gage #11491400 (Gage #1 on Map 5-1); Table 5-1

Figure 5-1. Monthly Streamflow Statistics for the Williamson River below Sheep Creek

Downstream of Rocky Ford the Williamson River turns west for five miles, then enters Klamath Marsh. Historically, the Williamson River spread over a wide delta when it entered Klamath Marsh, but the natural channel has been diked and diverted to supply water to drier portions of the marsh (La Marche, 2004a). Most of the tributaries in this portion of the Williamson River originate from Yamsay Mountain and Booth Ridge and are ephemeral, flowing only during spring snowmelt. The significant spring contributions in the upper portion of the Williamson River result in steady year round baseflow, as well as a pattern of spring runoff.

Big Springs Creek is the only perennial tributary with a surface water connection to Klamath Marsh, although this creek may even go dry during successive drought years (La Marche, 2004a). Despite being spring-fed, Big Springs Creek also shows a relatively flashy response to snowmelt and rainfall events (as represented by the 80% exceedance flow; Figure 5-2), probably due to local runoff from saturated areas adjacent to the stream. Data from the Big Springs Creek gage must be interpreted with caution, as it represents a very short time period (approximately three years; Table 5-1).



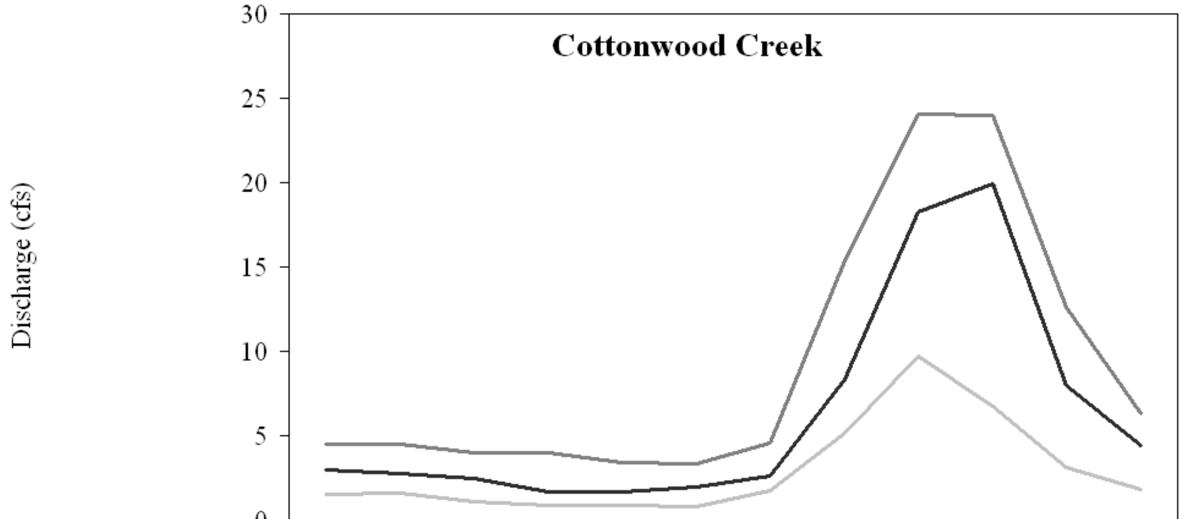
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Median	0.98	1.8	0.01	2.3	3.9	4	4.4	2.8	1.85	0.15	0.015	0.015
80% exceedance flow	0	0	0	0	0	2.62	2.68	2.32	0.02	0	0	0
20% exceedance flow	1.7	2.62	3.9	4.66	5	8.8	16.4	4.18	3	1.1	0.714	1

Gage #11492400 (Gage #4 on Map 5-1); Table 5-1

Figure 5-2. Monthly Streamflow Statistics for Big Creek below Lenz Ranch

Most of the perennial streams that drain the eastern side of the Cascades infiltrate into the pumice plain before reaching Klamath Marsh. Sand and Scott Creeks would reach the marsh, but are diverted to irrigate pasturelands on the western edge of the marsh. The USFS maintains gages on four streams draining the eastern side of the Cascades (Figure

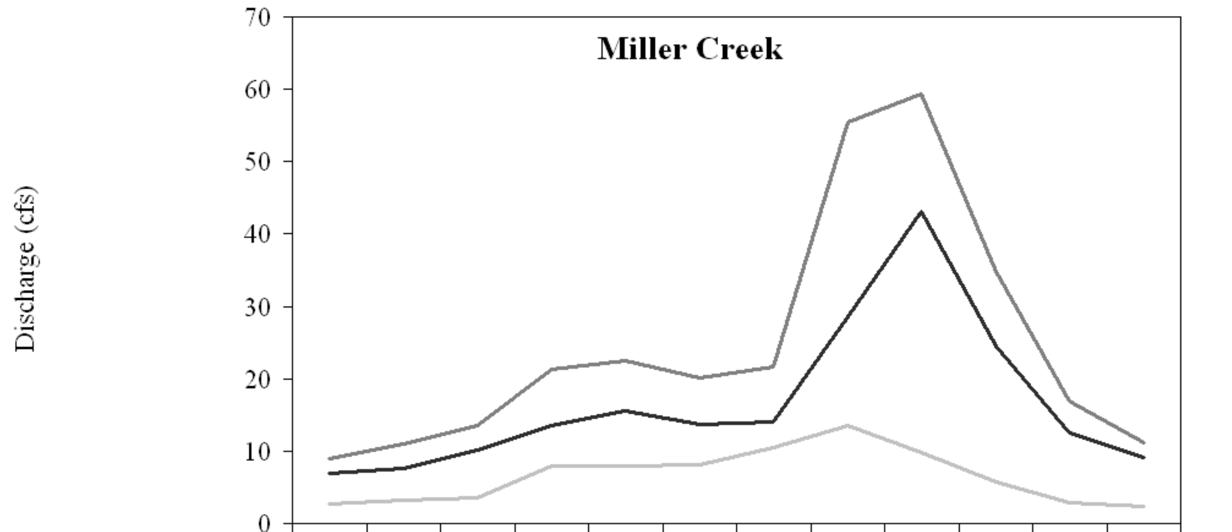
5-3 through Figure 5-6). All four gages show a pronounced snowmelt hydrograph, with the highest monthly flows occurring in June and July.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Median	2.946	2.77	2.434	1.632	1.661	1.948	2.602	8.313	18.29	19.95	8.003	4.406
80% exceedance flow	1.528	1.578	1.108	0.847	0.876	0.822	1.728	5.136	9.718	6.759	3.097	1.842
20% exceedance flow	4.509	4.477	3.963	3.993	3.386	3.34	4.555	15.4	24.03	23.98	12.61	6.279

Gage #61420101 (Gage #6 on Map 5-1); Table 5-1

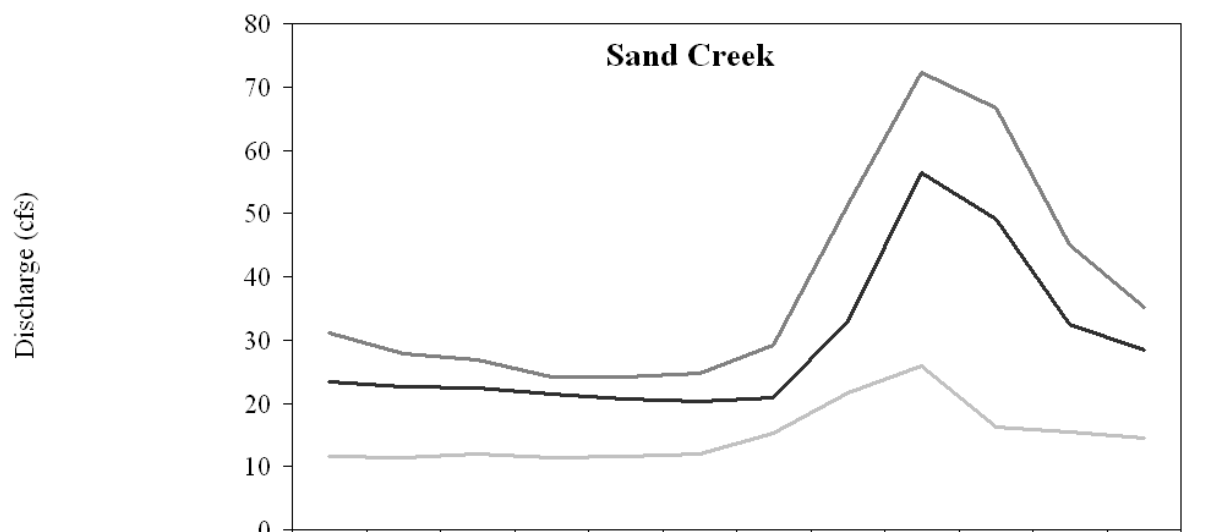
Figure 5-3. Monthly Streamflow Statistics for the Cottonwood Creek Gage



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Median	6.862	7.559	10.15	13.55	15.61	13.68	14.02	28.64	43.13	24.53	12.46	9.213
80% exceedance flow	2.68	3.187	3.579	7.872	7.88	8.107	10.41	13.56	9.831	5.771	2.903	2.384
20% exceedance flow	9.014	11.07	13.59	21.3	22.41	20.16	21.63	55.38	59.3	34.86	16.94	11.24

Gage #61420142 (Gage #7 on Map 5-1); Table 5-1

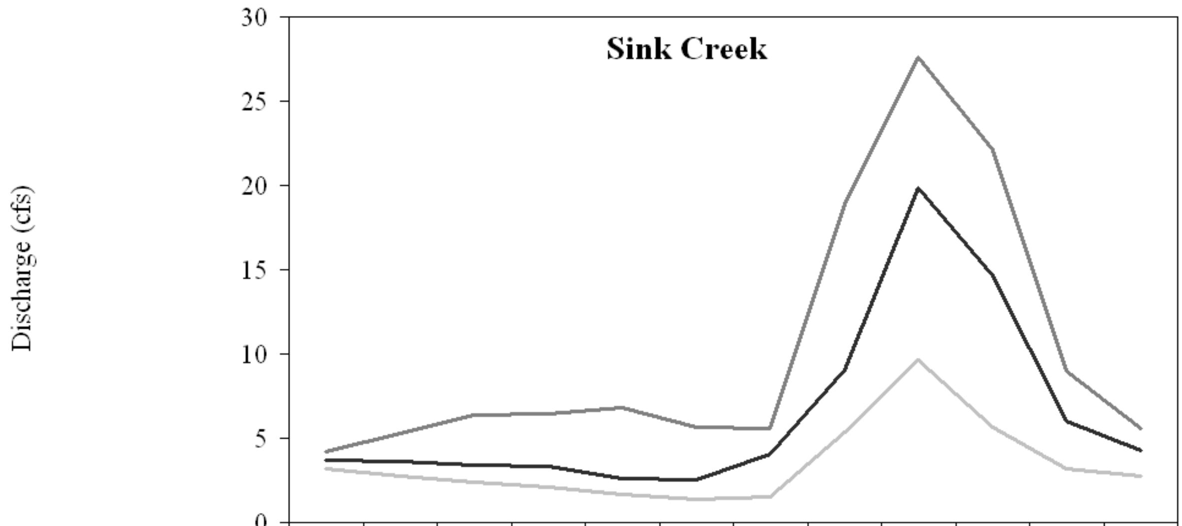
Figure 5-4. Monthly Streamflow Statistics for the Miller Creek Gage



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Median	23.42	22.69	22.4	21.41	20.61	20.32	20.95	32.99	56.51	49.01	32.4	28.4
80% exceedance flow	11.62	11.35	11.94	11.37	11.67	11.95	15.2	21.65	25.91	16.3	15.5	14.42
20% exceedance flow	31.05	27.86	26.94	24.13	24.1	24.74	29.24	51.45	72.21	66.72	45	35.12

Gage #61420143 (Gage #8 on Map 5-1); Table 5-1

Figure 5-5. Monthly Streamflow Statistics for the Sand Creek Gage



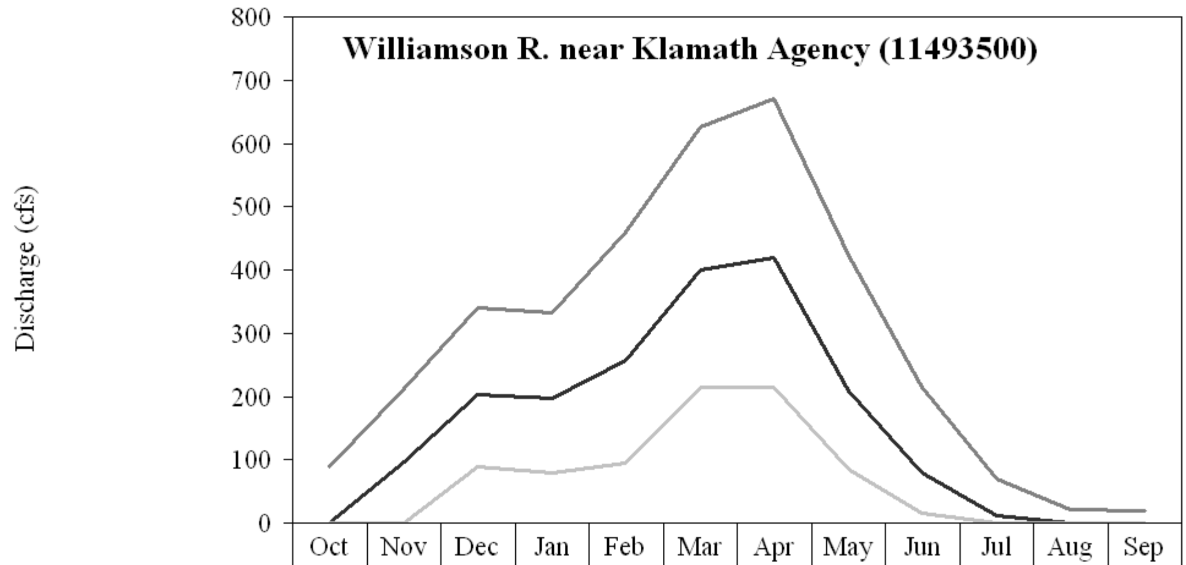
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Median	3.716	3.658	3.38	3.314	2.611	2.524	4.081	9.073	19.88	14.64	6.017	4.245
80% exceedance flow	3.166	2.728	2.408	2.126	1.702	1.382	1.497	5.375	9.646	5.634	3.187	2.78
20% exceedance flow	4.217	5.296	6.344	6.442	6.817	5.675	5.611	18.93	27.58	22.1	8.966	5.567

Gage #61420144 (Gage #9 on Map 5-1); Table 5-1

Figure 5-6. Monthly Streamflow Statistics for the Sink Creek Gage

The Williamson River downstream of Klamath Marsh[6] (Figure 5-7) has a more pronounced runoff response than upstream of the marsh, probably due to inflow from ephemeral tributaries and direct runoff from the surrounding area (La Marche, 2004a). As described briefly in Chapter 2, surface flow downstream of the marsh is controlled primarily by the presence of a basalt sill (Kirk Reef) at the marsh outlet. In most years, flow is quite low at the marsh outlet in the late summer, as the water level drops below Kirk Reef due to diminished surface, groundwater inflows, and evapotranspiration losses from the marsh. Note that median stream flows are zero for the months of August – October (Figure 5-7), until Klamath Marsh recharges and water can once again flow over Kirk Reef.

[6] *This gage is located at Kirk Reef*



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Median	0	97	202	197	257	400	420	209	79	11	0	0
80% exceedance flow	0	0	89	79.8	94	214	213.6	85	16	0	0	0
20% exceedance flow	89	212.2	340.2	333	459	625.2	671	422.6	214.2	69	22	20

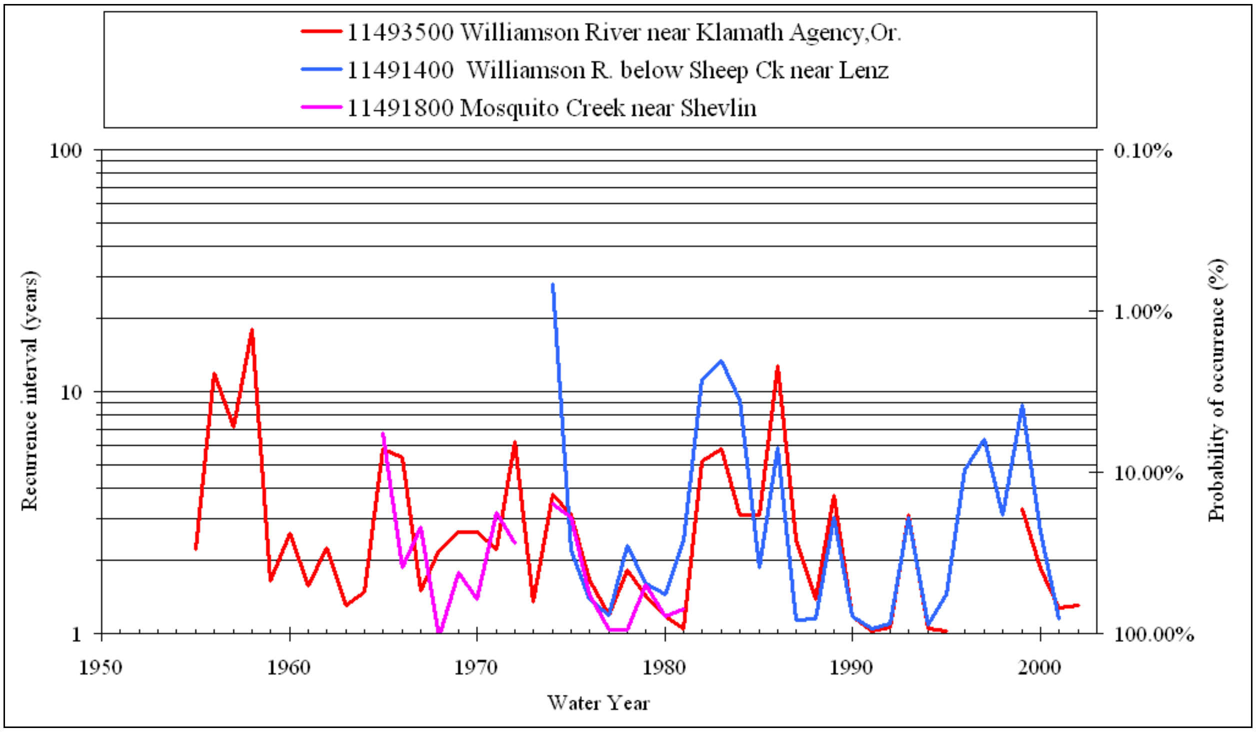
Gage #11493500 (Gage #5 on Map 5-1); Table 5-1

Figure 5-7. Monthly Streamflow Statistics for the Williamson River near Klamath Agency

Flood History

This section addresses critical question 2: What is the flood history in the watershed?

A time series of annual flood peaks was assembled for the three gages located within the area above Klamath Marsh. The long-tem annual peak flow history provides context to recent channel disturbances (or lack thereof) observed throughout the area. Of the stream gages located within the assessment area (Table 5-1), the three having peak flow records were used for this analysis. For purposes of comparison, the data are presented as a time series showing the recurrence interval of the annual flow event (Figure 5-8). This approach allows for a comparison of events from a wide variety of watershed sizes. Recurrence intervals were calculated for the period of record at each station using techniques described by the Interagency Advisory Committee on Water Data (1982). Peak flow magnitude was next plotted against probability (i.e., 1/recurrence interval) on log-probability paper. Recurrence interval was then interpolated for each event from the plotted values.



USGS, 2004c

Figure 5-8. Recurrence Interval Associated with Annual Peak Flow Events at Four Stream Gages in the Upper Klamath Basin

The record presented in Figure 5-8 illustrates the variability in peak flow response that can occur within a single relatively small subbasin. Six peak flow events, having a recurrence interval of ten years or greater, are estimated to have occurred over the period of record. However, in years where more then one gage was active, the 10-year or greater event at one gage was paired with a much smaller event at the other sites. This varied response is probably due to variations in snowpack and other climatic factors, as well as the relatively greater influence of natural storage (e.g., in Klamath Marsh) in parts of the upper Williamson River. For example, the 1974 event is estimated to have had a recurrence interval of approximately 30 years at the Williamson River below Sheep Creek gage, but only a 4-year recurrence interval at the Williamson River near Klamath Agency gage, and a 6-year recurrence interval at the Mosquito Creek gage. Furthermore, the dates on which these four events occurred are far enough apart (4/10/1974, 5/9/1974, and 3/15/1974 respectively) that we can conclude that different storm events or snowmelt conditions were responsible for the flood responses.

Water Use

This section addresses the following critical questions:

- Critical Question 4: For what beneficial use is water primarily used in the subbasin?
- Critical Question 5: Is water derived from a groundwater or surface-water source?

- Critical Question 6: What type of storage has been constructed in the subbasin?
- Critical Question 7: Are there any withdrawals of water for use in another basin (interbasin transfers) or is any water being imported for use in the subbasin?
- Critical Question 8: Are there any illegal uses of water occurring in the subbasin?

Data available from the Oregon Water Resources Department (OWRD 2004b) were used to identify locations and characteristics of water use in the upper Williamson River subbasin. Only those water rights whose current status is given as "non-cancelled" were included in this evaluation.

Overview of Water Rights

Water rights entitle a person or organization to use the public waters of the state in a beneficial way. Oregon's water laws are based on the principle of prior appropriation (OWRD 2001). The first entity to obtain a water right on a stream is the last to be shut off in times of low stream flows. In times when water is in short supply, the water right holder with the oldest date of priority can demand the water specified in their water right regardless of the needs of junior users. The oldest water right within the Upper Williamson assessment area has a priority date of 5/22/1902, and the newest a priority date of 5/30/1997 (OWRD 2004b).

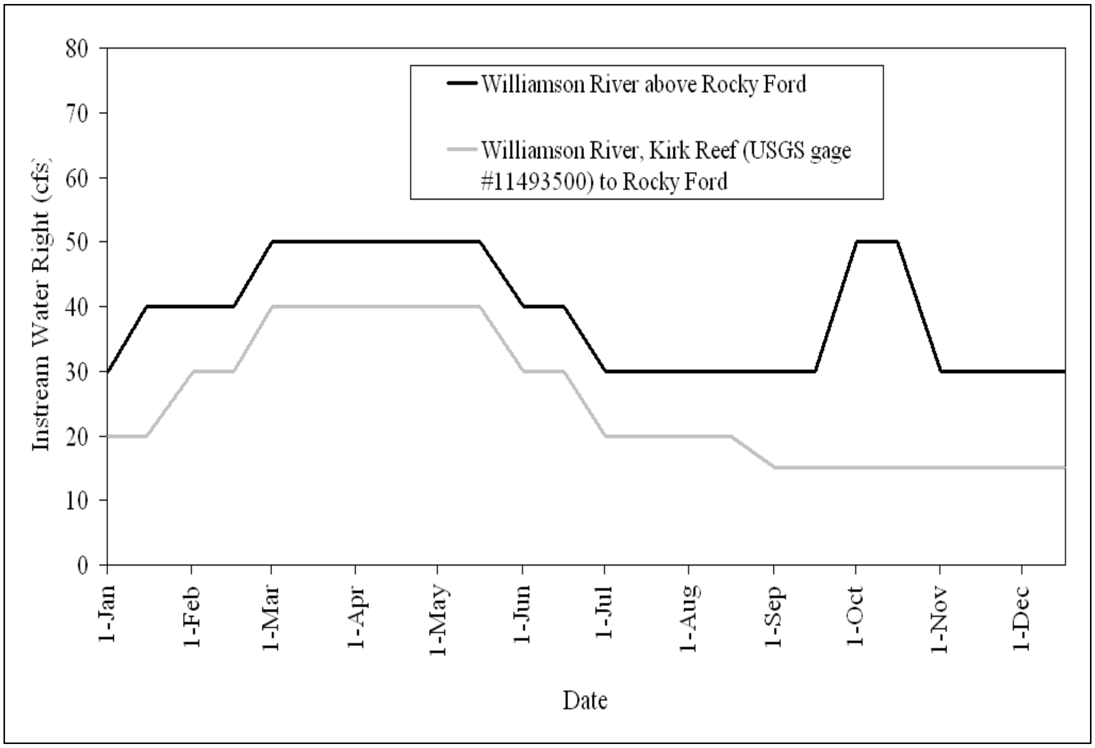
Certain water uses do not require a water right (OWRD 2001). Exempt uses of surface water include natural springs that do not flow off the property on which they originate, stock watering, fire control, forest management, and the collection of rainwater. Exempt groundwater uses include stock watering, less than one-half acre of lawn and garden watering, and domestic water uses of no more than 15,000 gallons per day.

In Oregon, any entity wanting to use the waters of the state for a beneficial use has to go through an application/permit process administered by OWRD. Under this process, an entity applies for a permit to use a certain amount of water, and then establishes that the water is being used for a beneficial use. Once the beneficial use is established, and a final proof survey is done to confirm the right, a certificate is issued.

OWRD also approves instream water rights for fish protection, minimizing the effects of pollution, or maintaining recreational uses (OWRD 2001). Instream water rights set flow levels to stay in a stream reach on a monthly basis, have a priority date, and are regulated the same as other water rights. Instream water rights do not guarantee that a certain quantity of water will be present in the stream: under Oregon law, an instream water right cannot affect a use of water with a senior priority date (OWRD 2001).

Two instream water rights exist within the Upper Williamson assessment area. Instream Water Right #70828 covers the portion of the mainstem Williamson River, from Rocky Ford downstream to beyond the assessment boundary at Kirk Reef, and the stated purpose of the right is "Anadromous And Resident Fish Rearing" (OWRD 2004b).

Instream Water Right #70824 covers the portion of the mainstem from Rocky Ford upstream to the head of the river, the stated purpose being "Anadromous And Resident Fish Habitat" (OWRD 2004b). Both instream water rights have priority dates of 10/26/1990. Instream water rights at both locations vary with date over the course of the year (Figure 5-9).



OWRD 2004b

Figure 5-9. Instream Water Rights by Date at Two Locations Within the Upper Williamson River Subbasin.

Locations of Water Withdrawals

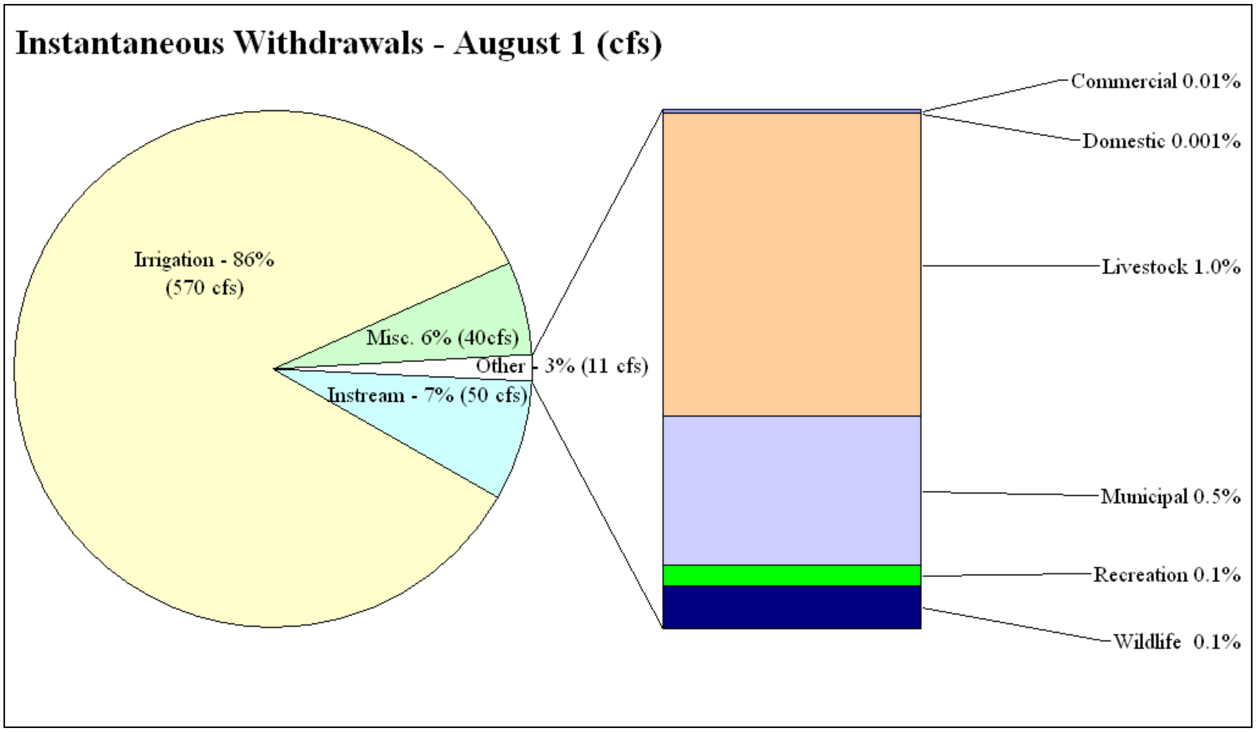
OWRD identifies 412 points[7] of diversion for water rights within the upper Williamson River subbasin (OWRD 2004b). The approximate locations of these points of diversion are shown in Map 5-2 (OWRD 2004b). Points of diversion for water rights are found within all watersheds (Map 5-2). The majority (72%) of the points of diversion are from surface waters, the remainder being from groundwater sources (11%) and reservoirs (17%).

Withdrawal Rates

Information on withdrawal rates associated with water rights within the upper Williamson River subbasin is available through OWRD (2004b). In the OWRD data, the rate of withdrawal is expressed as an instantaneous rate (i.e., cubic feet per second [cfs]),

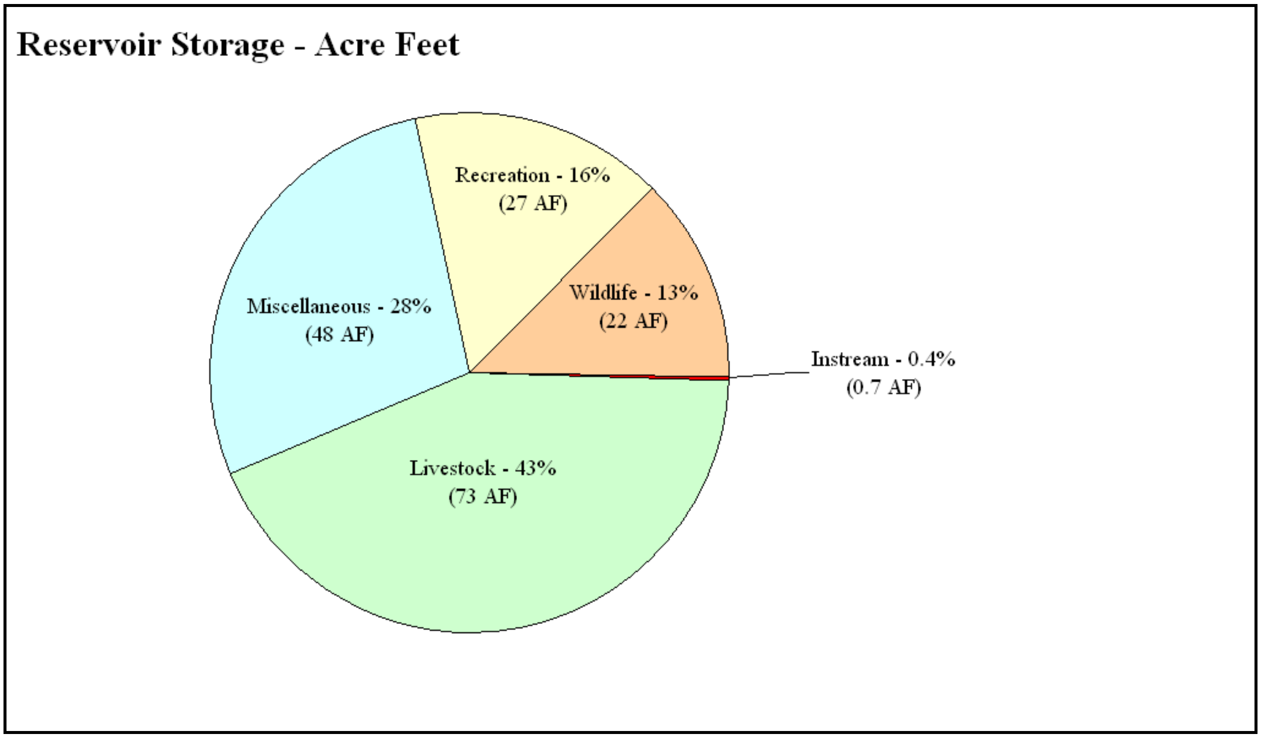
[7] *The actual number of physical locations where water is diverted may be considerably less then 412, as several different water rights may be attached to a single point of diversion.*

except for reservoir storage, which is expressed as a total yearly volume (i.e., acre-feet [af]). In addition, the withdrawal rate for many water rights changes by season (e.g., the allowable withdrawal rate may be lower in the summer months). Withdrawal rates for the entire assessment area are summarized in Figure 5-10 and reservoir storage is summarized in Figure 5-11. August 1 was chosen as the date for this summary because this is typically the low flow period in the assessment area.



OWRD 2004b

Figure 5-10. Summary of Instantaneous Withdrawal Rates Within the Upper Williamson Assessment Area on August 1



OWRD 2004b

Figure 5-11. Summary of Reservoir Storage Within the Upper Williamson River Subbasin

Instantaneous withdrawal for irrigation is the primary use of water on August 1 within the assessment area (86%) (Figure 5-10). Irrigated lands are found primarily along the mainstem Williamson River, primarily in the vicinity of Klamath Marsh (Map 5-2). Instream water rights make up an additional 7% of total water rights on August 1 (Figure 5-10 and Figure 5-11). Miscellaneous uses (including forest management, fire protection, road construction, and storage) make up an additional 6% of total water rights on August 1 (Figure 5-10). The remaining uses collectively make up only 3% of the total August 1 instantaneous withdrawal rate (Figure 5-10). Reservoir storage within the assessment area is primarily for the purposes of livestock, recreation wildlife, and “miscellaneous” uses, which is listed within the OWRD data base as generic “storage” (Figure 5-11).

Land Use Effects on Flow Regime – Water Withdrawals

This section addresses Critical Question 8: Do water uses in the basin have an effect on peak and/or low flows?

Two pieces of information are needed to estimate the net effects of water use on stream flows at any given location: 1) an estimate of the natural stream flow volume, and 2) an estimate of the consumptive portion of all upstream water withdrawals. OWRD has estimated natural monthly stream flows at the mouths of two water availability basins

(WABs[8]) within the upper Williamson River subbasin: the Williamson River at Kirk Reef and the Williamson River at Rocky Ford (OWRD 2004a). The natural streamflow estimates available from OWRD are the monthly 50% and 80% exceedance flows. The 50% exceedance stream flow can be thought of as representing a "normal" stream flow for that month. The 80% exceedance stream flow can be thought of as the stream flow that occurs in a dry month. These exceedance stream flow statistics are used by OWRD to set the standard for over-appropriation: the 50% exceedance flow for storage and the 80% exceedance flow for other appropriations (OWRD 2004a). OWRD used statistical models derived from multiple linear regressions to produce these estimates of natural monthly stream flows.

A consumptive use is defined as any water use that causes a net reduction in stream flow (OWRD 2004a). These uses are usually associated with an evaporative or transpirative loss, or the water may be withdrawn from the system. OWRD recognizes four major categories of consumptive use: irrigation, municipal, storage, and all others (e.g., domestic, livestock). OWRD bases its estimates of the consumptive use for irrigation on estimates made by USGS, including estimates from the 1987 Census of Agriculture, estimates from the Oregon State University (OSU) Cooperative Extension Office, 1989-90 Oregon Agriculture and Fisheries Statistics, and an OSU Study of Crop Water Requirements (OWRD 2001). Irrigation uses are not estimated to be 100% consumptive. Consumptive use from other categories of use is obtained by multiplying a consumptive use coefficient (e.g., for domestic use, the coefficient is 0.20) by the maximum diversion rate allowed for the water right. The OWRD assumes that all of the non-consumed part of a diversion returns to the stream from which it was diverted. The exception is when diversions are from one watershed to another, in which case the use is considered to be 100% consumptive (i.e., the consumptive use equals the diversion rate). Consumptive use estimates available from the OWRD (2004a) for the Williamson River at Kirk Reef and the Williamson River at Rocky Ford were used in this analysis.

The net effect of water withdrawals on monthly stream flows were estimated at the two Williamson River locations in the following manner:

1. The estimated monthly natural stream flows for average and dry years (represented by the 50% and 80% exceedance flow, respectively) were first plotted for each location.
2. The portion of all water withdrawals that do not return to the stream (i.e., the consumptive uses) was added to water diverted for storage for each month and plotted on the same graph.
3. Instream water rights for the watershed were also shown on the graph.

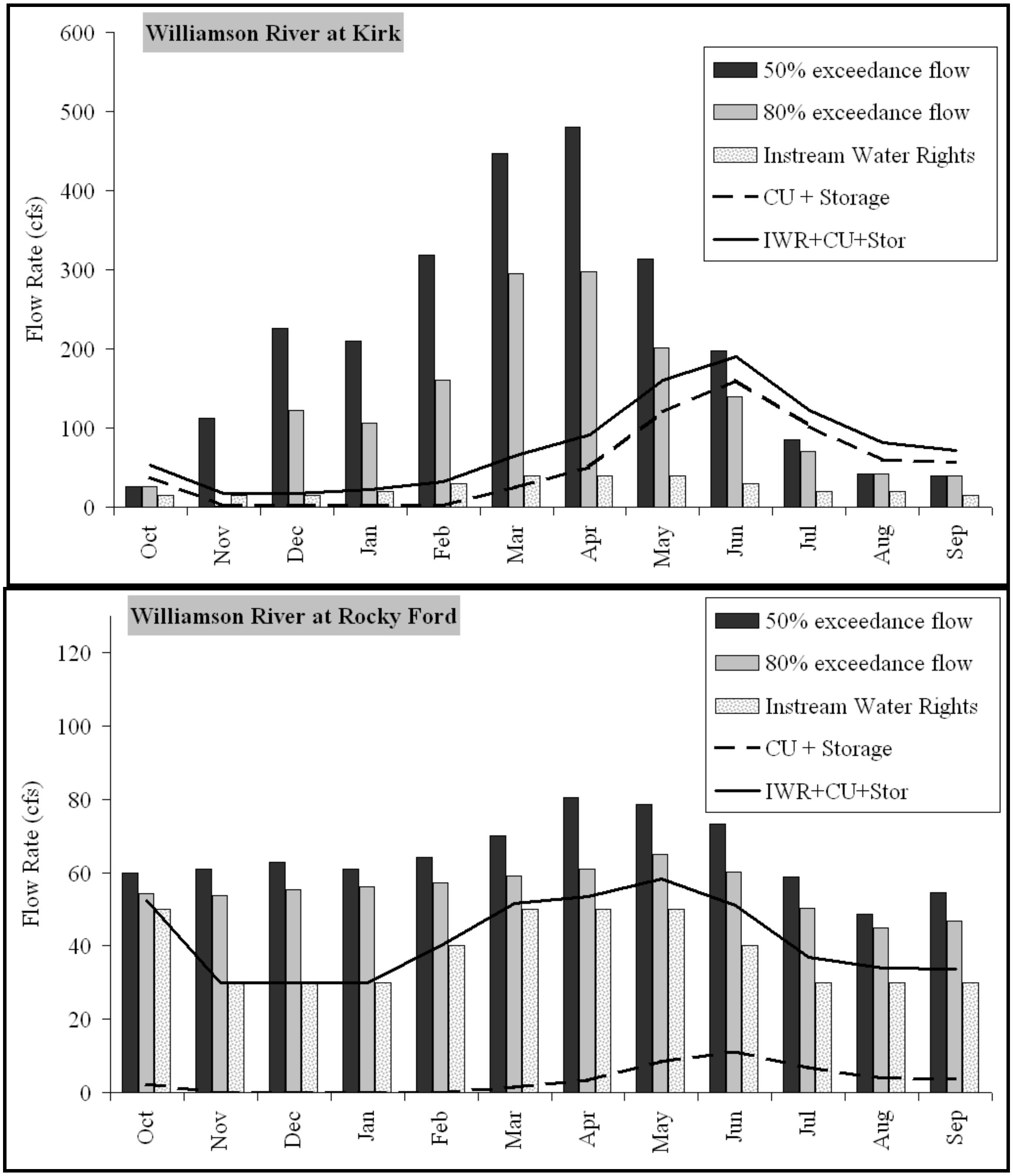
[8] *Locations where the Oregon Water Resources Department has calculated natural stream flow and water availability statistics.*

4. Finally, the sum of instream water rights, consumptive uses, and storage was plotted on the graph.

The estimated net effect of water withdrawals on monthly stream flow is shown for the Williamson River at Kirk Reef (Figure 5-12; top graph), and the Williamson River at Rocky Ford (Figure 5-12; bottom graph).

The estimated values for the Williamson River at Kirk Reef (Figure 5-12; top graph) indicate that consumptive water use plus storage exceeds the estimated volume of natural stream flow in the months of July through October in average years (50% exceedance flows), and for the months of June through November in dry years (80% exceedance flows). In other words, if all of the consumptive water rights were fully used, there would be *no* remaining streamflow at Kirk Reef during the months of July through October in an average year, or for the months of June through November in a dry year, and the instream water rights would not be attained.

The estimated values for the Williamson River at Rocky Ford (Figure 5-12; bottom graph) show a different story. Given the relatively constant hydrograph throughout the year, and the relatively small amount of consumptive water use, it appears that instream flow levels can be maintained in both average and dry years.



Shown are estimated natural stream flows for average and dry years (50% and 80% exceedance flows); the sum of consumptive uses (CU) and water storage; instream water rights; and the sum of instream water rights (IWR), consumptive uses (CU) and storage (STOR). Data source: OWRD (2004a).

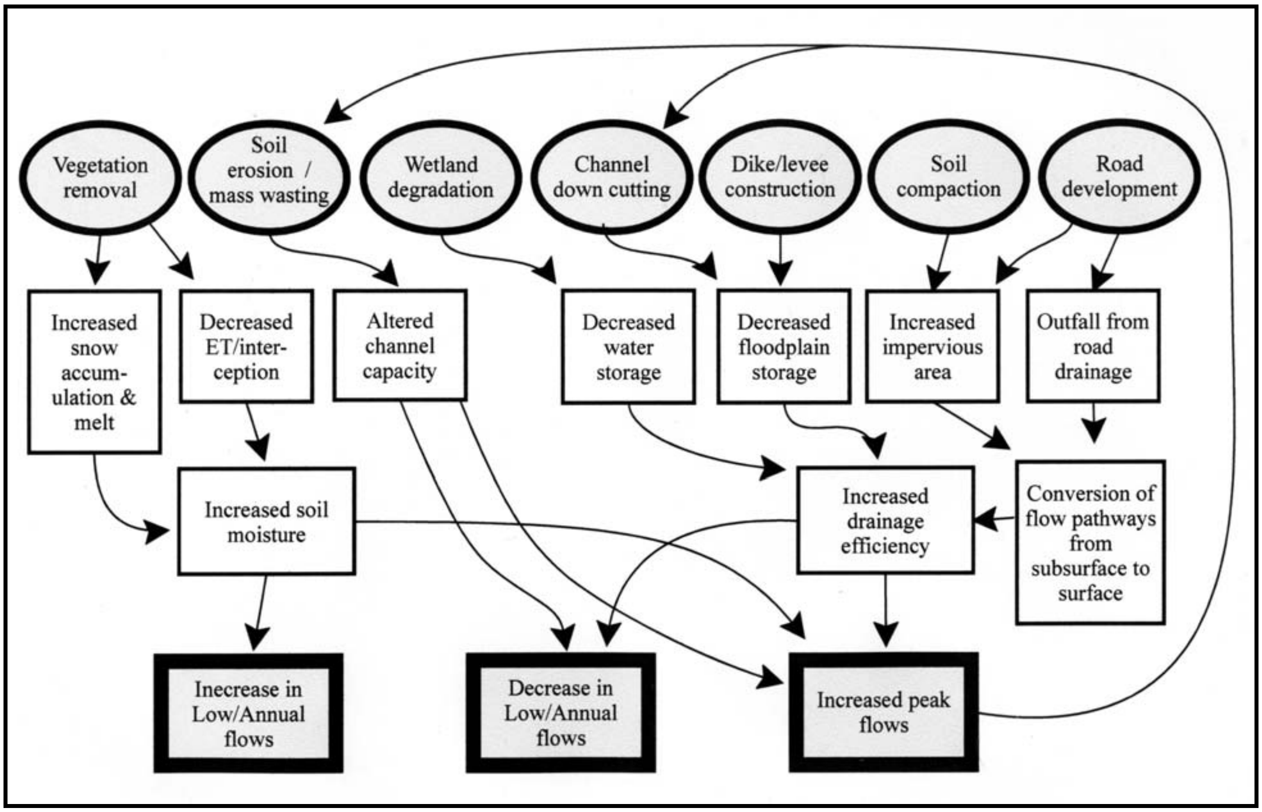
Figure 5-12. Estimated Net Effect of Water Withdrawals on Monthly Stream Flows on the Williamson River at Kirk Reef and at Rocky Ford

Land Use Effects on Flow Regime – Other Land Uses

This section addresses Critical Question 3: Is there a probability that land uses in the basin have a significant effect on peak and/or low flows?

Background Information on Land Use Effects on Stream Flow

Figure 5-13 is a generalized diagram showing the primary interactions between land uses found in the Upper Williamson area and changes in peak, annual, and low stream flows. Note that Figure 5-13 does not include "top-level" land uses (e.g., urbanization, agriculture, forest management, etc.). The reason for this is that there is considerable overlap between top-level land uses and the underlying hydrologic processes that they affect. For example, both urbanization and agricultural practices have the ability to affect vegetation removal, soil erosion/mass wasting, wetland degradation, channel downcutting, dike/levee construction, soil compaction, and road development. Rather than discussing impacts by top-level land uses, it is preferable to discuss land use impacts in terms of the underlying processes.



adapted from Ziemer, 1998

Figure 5-13. Generalized Diagram of the Primary Interactions Between Land Uses and Changes in Peak, Annual, and Low Stream Flows

Vegetation Changes

The primary mechanism by which vegetation removal may increase peak flow is through increased snow accumulation and melt during wintertime rain-on-snow events (WFPB, 1997; Figure 5-13). Rain-on-snow is the common term used to describe wintertime conditions when relatively warm wind and rain combine to produce rapid runoff. Rain-on-snow flood events may occur in areas having significant wintertime snow packs, and are independent of land use. Removal of the forest canopy can augment rain-on-snow peak flows by increasing snow accumulation in openings and increasing the rate of snowmelt by increasing the effective wind speeds at the snowpack surface. The extent to which forest removal may augment rain-on-snow peak flows is a function of the amount of harvesting within the elevation range that defines the rain-on-snow zone. At low elevations (below the rain-on-snow zone) winter temperatures are generally too warm to allow for significant snow accumulation, and at higher elevations wintertime precipitation generally falls as snow. As discussed previously, rain-on-snow is probably an important process in peak flow generation within the Upper Williamson assessment area.

A secondary mechanism by which vegetation removal may increase peak and/or low flows is through changes in evapotranspiration and canopy interception (Dunne and Leopold 1978; Figure 5-13). Vegetation can intercept a portion of the precipitation falling on a watershed, a further portion of which is evaporated back to the atmosphere during or after a storm event, thereby reducing the net precipitation reaching the soil. Evapotranspiration by vegetation removes moisture from the soil profile and returns it to the atmosphere. Increases in peak flow observed in some situations following harvest of trees are presumed to be the result of loss of canopy interception and evapotranspiration (Ziemer, 1998). Several studies have shown that the water yield increases throughout the year, with the largest relative increases occurring during the summer and early fall months following logging. These studies have reported increases in summer flows ranging from 15 to 148%.

Both increased snow accumulation and melt, and decreased evapotranspiration and canopy interception, can increase levels of soil moisture, resulting in increased peak flows, low flows, and annual stream flow volumes. Conversely, the expansion of western juniper communities may have the effect of reducing water yields. Gedney et al. (1999) documented a fivefold increase in juniper forests (defined as areas having at least 10% juniper crown cover) from 1936 to present. The expansion of juniper in eastern Oregon may be linked to a reduction in fire frequency; which is itself linked to fire suppression practices, natural drought-free climatic cycles, and the introduction of large numbers of livestock that led to a loss of fine fuels through grazing (Gedney et al., 1999; Belsky, 1996; Miller and Rose, 1999). Juniper can have a significant effect on the amount of precipitation reaching the soil through canopy interception and loss through evaporation or sublimation, year-round transpiration, and through its extensive root networks, which occupy a relatively greater area than other species (Gedney et al., 1999).

Although the potential exists for juniper to reduce stream flows through canopy interception and removal of soil moisture, little quantitative research is available that proves this to be the case. Most of the applicable water yield studies have been conducted in the southwestern United States on watersheds dominated by piñon-juniper woodlands. Most of these studies found no increase in water yield following piñon-juniper removal

(Belsky, 1996). Several reasons explain why increases in water yield following removal of juniper may not be realized (the following is taken from Belsky, 1996):

- In arid and semi-arid climates, most snowmelt and rainwater simply recharges the soil column; little excess is available to move downslope to streams.
- Herbaceous plants and shrubs that replace trees also intercept rain and snow, reducing the amount of water reaching the ground.
- Replacement plants also transpire and deplete soil water.
- Tree removal exposes the soil and understory plants to direct sunlight, causing elevated temperatures and increased evapotranspiration.
- Tree removal exposes soils and understory plants to more wind, which increases evapotranspiration.
- In areas where water is in excess of that needed to recharge the soil, this water may go to shallow aquifers rather than to streams.

No actual studies exist on changes in stream flow resulting from changes in vegetation in the upper Williamson River subbasin. USFS has considered the effects of vegetation changes on flow as part of several watershed analyses that were conducted in the Upper Williamson area (USFS: 1996a, 1996b, 1996c, 1998, and undated). The synopses of these analyses are as follows:

- Increases in vegetative cover and density due to wildfire suppression likely has some (unquantified) effect on total water yields in the Upper Williamson, however, vegetation is a relatively minor factor in total water yield. A water balance conducted for the Chiloquin area, for the period 1942-1971 (USFS 1998), identified a moisture deficit during the growing season (April through October), indicating that inputs to the soil moisture pool are less than the plants could use. Any gains in water yield from removal of vegetation will tend to reduce the period of moisture deficit. Although vegetation removal may make some additional groundwater available for release to streams in the months of April and/or October, summer stream flows are not likely to change significantly.
- Changes in forest cover are likely having a significant (though unquantified) effect on snow accumulation and the timing of snowmelt; and therefore on the timing of peak flows and late summer base flows. The analyses conclude that a reduction in vegetative cover on the order of 50% over the majority of a watershed may cause an initial increase in peak flows a few weeks earlier in the spring melt season.

Soil Erosion and Mass Wasting

Soil erosion and mass wasting can increase quantities of sediments transported in stream systems. Deposition of both coarse and fine sediments in stream channels can result in a decrease in channel conveyance capacity, leading to an effective increase in frequency of flooding (Dunne and Leopold 1978; Figure 5-13). In addition to the effects on peak flows, increases in aggradation of coarse sediments can increase the proportion of streamflow that travels subsurface, resulting in a reduction of effective summer low flows. Furthermore, as shown in Figure 5-13, increased peak flows can further exacerbate sedimentation problems through increased bank erosion and mass wasting.

The gentle slopes, porous nature of the soils, low and moderate intensity precipitation events, dominance of snow, and extended spring melt period result in the relatively low susceptibility of the upper Williamson River subbasin to soil erosion and mass wasting (USFS 1998). The conclusions of the USFS watershed analyses (as summarized in USFS 1998), and of the sediment source assessment included as part of this analysis (see Section 8) is that erosion is not a major issue in the area, but that the following factors are the primary contributors to erosion in the watershed:

- Bank erosion
- Road Systems
- Downcutting channels
- Wind erosion following wildfires

Although erosion processes have been identified, and recommendations made on the prioritization of erosion treatments (see USFS, 1998), no quantitative data is available on the effects of increased sedimentation on channel and flow conditions within the upper Williamson River subbasin.

Wetland Degradation

Wetlands have the ability to intercept and store storm runoff, thereby reducing peak flows (Mitsch and Gosselink 1986). This water is released over time and may be important to augment summertime low flows (Figure 5-13). Loss of, or modifications to, wetlands may therefore have a significant impact on stream flows.

Normally, a comparison of existing wetlands areas (as shown on the NWI) to areas of hydric soils provides a better understanding of modifications to wetlands; however, because there is no adequate soils layer for the subbasin, it is not possible to do this type of wetlands analysis.

No actual studies exist on the amount of wetland loss or degradation that may have occurred within the assessment area, or on the impacts that these changes may have had to stream flows. USFS has considered the effects of wetland loss/degradation on flow as part of several watershed analyses that were conducted in the upper Williamson River subbasin (USFS 1996a, 1996b, 1996c, 1998, and undated). Synopses of these analyses are as follows:

- Drainage of former marshlands (in combination with water diversions for irrigation purposes) has reduced the extent of deep-water marsh.

- Grazing practices and development of pasture lands have contributed towards lowering water tables. Most of these activities occurred during the first half of this century.
- Many former marshes and wetlands located on private lands were converted to agricultural uses between 1900 and 1940. These actions resulted in the most significant changes to wetlands in the area surrounding Klamath Marsh and the lower Williamson River, and the lower reaches of most major streams tributaries.

Channel Downcutting and Channelization

Channel downcutting and channelization have the same effect on the stream system – decreasing the amount of water that can be stored in channel banks and the floodplain (Figure 5-13). The difference between the two processes is that channel downcutting occurs without direct human assistance in response to changes in water volume and sediment loads, whereas channelization occurs through conscious human design through the construction of dikes and levees. Potential disadvantages to dikes and levees include loss of floodwater storage within the floodplain, which can result in higher downstream peak flows, reduced groundwater recharge, and subsequently lower summertime base flows.

No actual studies exist on the extent of channelization or channel downcutting that has occurred within the watershed. Areas of obvious manipulation were noted as part of the discussion in Section 4, Channel Habitat Typing, but additional areas of disturbance probably exist. USFS has considered the effects of channel modifications as part of several watershed analyses that were conducted in the Upper Williamson area (USFS 1996a, 1996b, 1996c, 1998, and undated). Synopses of these analyses are as follows:

- Effects of improper grazing practices on channel downcutting are concentrated on Rosgen C and E channel types, located primarily in the Williamson River Valley, Klamath Marsh, and the meadow sections of tributary streams. Direct effects from grazing include soil compaction, exposure of bare soil to erosion processes, destabilization of stream banks by removing the deep-rooted vegetation, and physical breakdown of bank structure, all of which have resulted in channel downcutting and widening, and the creation of the unstable G and F channel forms. The effects of these disturbances on stream flow has not been quantified.
- The Haystack, Telephone, and Skellock draws, along with the Bull Pasture, Jack, Mosquito, Big Spring, Yoss, and Hog Creek drainage systems, have segments of downcut channels. Downcut channels in these areas are believed to be due to a combination of heavy grazing use, vehicle traffic in the meadows, drought, and heavy runoff or high-intensity storm events. Changes in grazing practices in the last several years, along with the easing of drought conditions, have allowed many of these channel segments to begin recovery.

Soil Compaction

Soil compaction can increase the amount of impervious area occurring in a watershed. Increases in the amount of impervious area result in increased peak flow magnitudes by eliminating or reducing infiltration of precipitation, thereby shortening the travel time to stream channels (Dunne and Leopold 1978; Figure 5-13). In addition to the effects on peak flows, increases in impervious area also reduce summer low flows by reducing groundwater recharge (Dunne and Leopold 1978).

May et al. (1997), in a summary of several previous studies, suggest that impairment begins when percent total impervious area (% TIA) in a watershed reaches 10%. May et al. (1997) developed a relationship between % TIA and road density (expressed in miles of road/mi^2 watershed area). Watershed % TIA of 5% and 10% equates to a road density of 4.2 and 5.5 miles/ mi^2 respectively. USFS estimates that road densities[9] within the non-wilderness, non-wetland portion of the Upper Williamson area range from 3 to 5 mi/mi^2 (USFS 1998). Based on the indices of May et al. (1997), it is possible that impervious area may be impacting flows within the assessment area; however, no quantitative analysis has been performed.

No actual studies exist on the extent of soil compaction within the watershed, or the effects of compaction on stream flows. USFS has considered the extent of soil compaction as part of several watershed analyses that were conducted in the Upper Williamson area (USFS 1996a, 1996b, 1996c, 1998, and undated). Synopses of these analyses are as follows:

- Grazing is currently, and has been for over a hundred years, a significant and widespread land use throughout the assessment area. Grazing intensity was much greater in the late 19th and early 20th centuries than it is at present. Beginning in the 1980s, grazing practices on public lands have undergone dramatic changes, including reductions in numbers of animals, reductions in duration of use, and exclusion of grazing in sensitive areas. Although unquantified, it is likely that compaction effects due to grazing have occurred.
- Due to the extensive timber harvest that has occurred on all non-wilderness, non-National Park Service lands within the assessment area, compaction is likely to have occurred in most forested areas. Although most of the study area has measurable compaction, very little of that compaction is showing an obvious detriment to either plant vigor (riparian areas are an important exception.) or hydrologic processes.

[9] *In addition to roads, the USFS estimates that there are more than 700 miles of former logging railroad grade on the Winema National Forest, much f which is located within the assessment area.*

Outfall from Road Drainage

In addition to increasing soil compaction, road networks have the potential to affect watershed hydrology by changing the pathways by which water moves through the watershed. Road networks affect flow routing by interception of subsurface flow at the road cutslope and through a reduction in road-surface infiltration rates, resulting in overland flow (Figure 5-13). The net result may be that surface runoff is routed more quickly to the stream system if the road drainage network is well-connected with the stream channel network.

No actual studies exist on the connection of the road drainage network to the stream network within the Upper Williamson area, or the effects of road drainage on stream flows. Given the high road densities discussed above, it would be wise to further evaluate possible impacts to streams.

CONFIDENCE EVALUATION

Confidence in the Hydrology/Water Use assessment is moderate. The availability of reasonable flow records, combined with an evaluation of consumptive water use available from the OWRD, provide a good foundation for the assessment. However, the lack of any quantitative information on land use impacts to peak and base flows limit the confidence in that portion of the assessment. Implementation of the recommendations identified below would result in a high confidence in the subsequent assessment.

RECOMMENDATIONS / DATA GAPS

1. Maintain all currently operational continuous stream flow gages, reestablish discontinued gages, establish additional gages in key locations. Efforts to characterize stream flow were aided by the existence of continuous flow records from several locations within the assessment area; however, several of these gages have been discontinued (Table 5-1), and certain parts of the assessment area (e.g., Jack Creek) are completely without flow records. Continuous stream flow data is essential to understanding peak flow history, estimating natural stream flows, and providing calibration data for any future modeling activities, and promotes better understanding of the effects of water use within the subwatersheds. Maintaining existing gages, and reinstalling discontinued gages, leverages existing data sets.

2. Investigate historical extent of wetlands within the watershed. Existing data sets were inadequate for evaluating the extent of wetland loss and/or modification within the assessment area. Further analysis is needed to define the historic extent of wetland area within the watershed, and to evaluate possible deleterious effects of wetland loss on hydrologic function.

3. Perform functional assessment of wetlands within the watershed. More information on wetland condition and function is needed in order to identify and prioritize any wetland enhancement efforts.

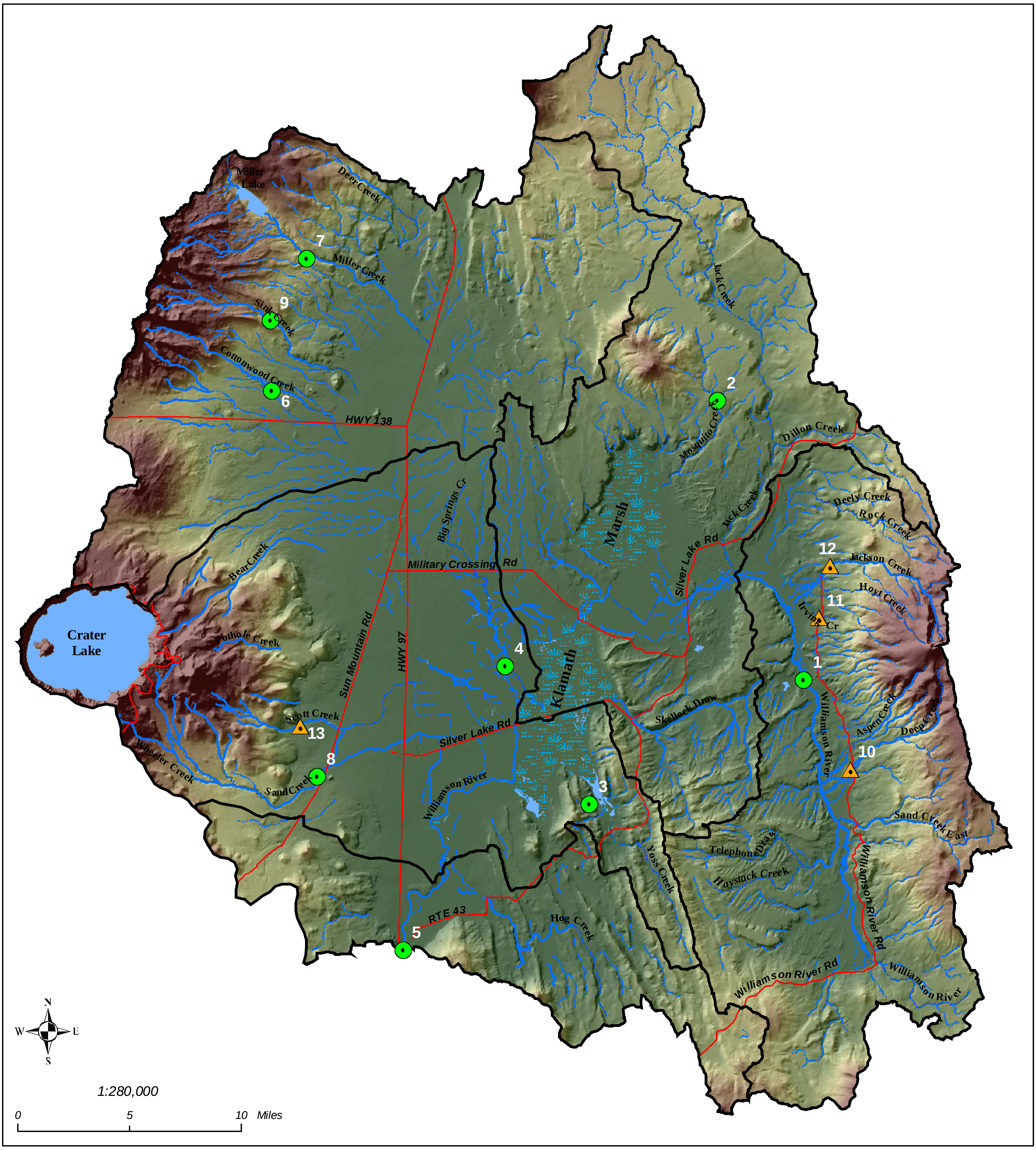
4. Support efforts to better understand the true nature of the effect of juniper expansion on low flows. Although the potential exists for juniper to reduce summertime stream flows through canopy interception and removal of soil moisture, the current state of knowledge does not support wide-scale juniper removal. Ongoing efforts to better understand the effects of juniper expansion are recommended.

5. Implement watershed-wide evaluation of land use effects on peak flows. Information from various USFS watershed analyses (summarized above) suggest that changes in vegetative cover, soil compaction, road densities and drainage, wetlands, and other factors, may be having some as yet unjustified effects on both peak and base flows. A robust modeling tool (such as the Distributed Hydrology-Soil-Vegetation Model developed by the University of Washington and Battelle Pacific Northwest Research Labs) should be used to evaluate the possible effects of past activities on current conditions, as well as to evaluate the possible impacts of future management scenarios. Such a modeling effort should include an evaluation of all items included in Figure 5-13.

RESTORATION OPPORTUNITIES

1. Implement improvements in summertime stream flows through increased water use efficiency, transfer of water rights to instream uses, and other voluntary actions. Despite some uncertainty in the exact magnitude of the problem, it appears that consumptive use of water for irrigation exceeds the estimated volumes of natural stream flow during the summer months at the outlet of the assessment area. Withdrawals contribute to an inability to meet instream water rights in the portion of the Williamson River downstream of Klamath Marsh. Voluntary measures such as an increase in the efficiency of water distribution and application to irrigated areas will help improve summertime flow conditions. However, further reductions in withdrawals through voluntary transfer of water rights (either temporarily or permanently) to organizations such as the Oregon Water Trust is recommended.

LIST OF MAPS



Upper Williamson River Watershed Assessment

Map 5-1: Stream Gages and Miscellaneous Streamflow Collection Sites

Legend

- Stream gage
- Miscellaneous measurement site
- Perennial stream
- Non-perennial stream
- Major road
- Marsh
- 5th-field watershed boundary

Sources:
Gages -OWRD, USGS, USFS
Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)

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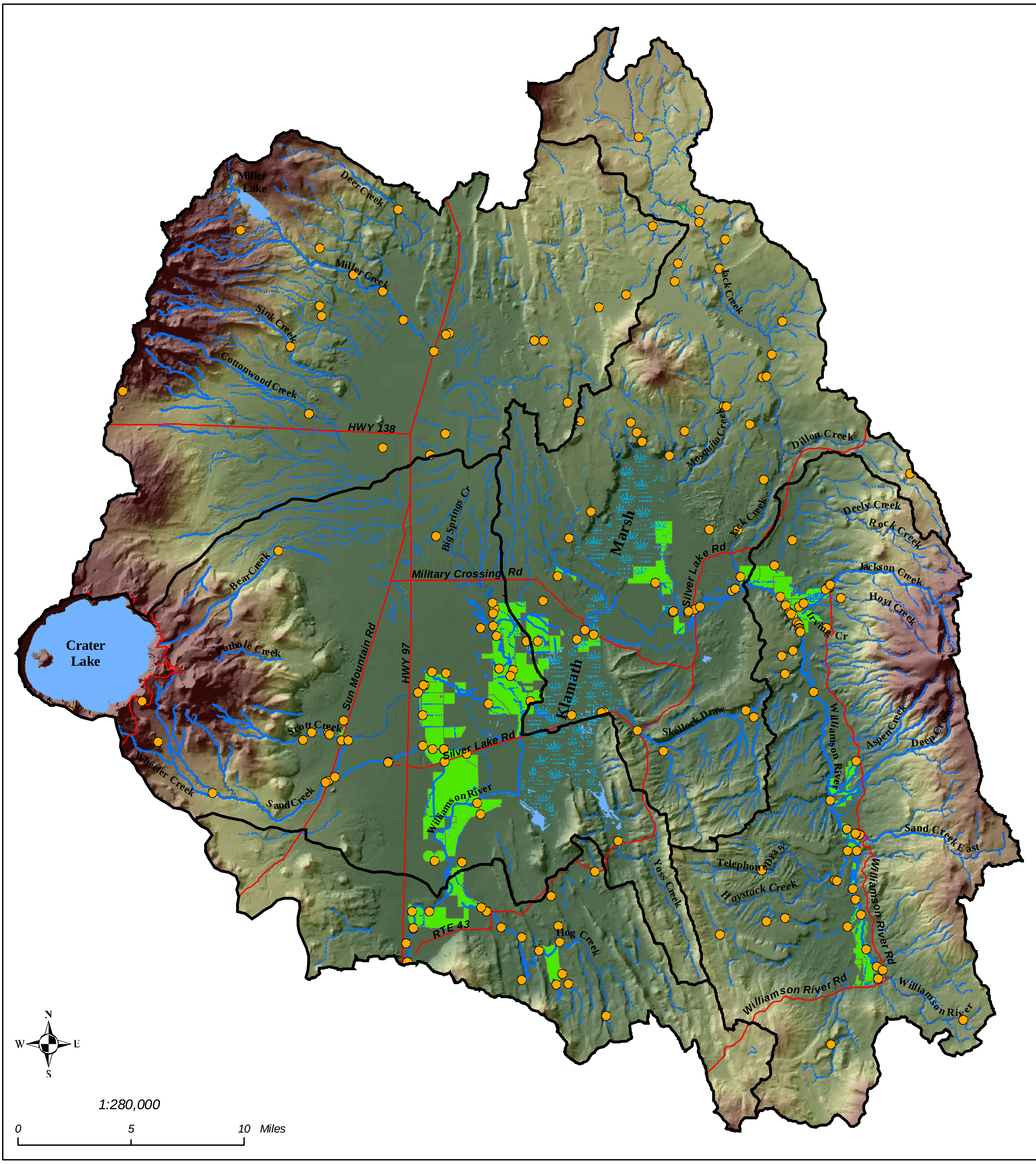

Upper Williamson River Watershed Assessment

Legend

- Point of diversion
- Irrigated area
- Perennial stream
- Non-perennial stream
- Major road
- Marsh
- 5th-field watershed boundary

Map 5-2:
Points of Diversion for Water Rights and Locations of Irrigated Areas

Sources:
PODs and Irrigated Areas -Oregon Water Resources Department
Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)

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6 RIPARIAN ASSESSMENT

INTRODUCTION

Riparian vegetative condition has a dramatic impact on subbasin hydrological performance. Riparian vegetative condition is a site-specific condition which, viewed in aggregate, can have regional impacts on the subbasin. Physical factors affected by riparian vegetative condition include water quality, erosion and bank stability, sedimentation rates, shading and stream temperature control. Biological factors affected by riparian vegetative condition include large wood recruitment for gravel aggradation and nutrient inputs, fish habitat creation and cover, and terrestrial habitat connectivity. The critical questions addressed in this section are:

1. What are the current conditions of riparian areas in the subbasin?
2. How do the current conditions compare to those potentially present or typically present for this ecoregion?
3. How can the current riparian areas be grouped within the subbasin to define patterns that increase our understanding of what areas need protection?
4. What might be the appropriate restoration/enhancement opportunities?

METHODS

Generalized riparian conditions were assessed for each 5th-field watershed. Key subbasin reaches were analyzed by watershed on the basis of their hydrological and biological contributions to the subbasin. Reaches within each watershed were divided into two subsets for the purposes of this assessment: mainstem/adjacent tributary reaches, and upland tributary reaches. This division was based on key differences between the two types and differences in the quality and availability of data for each type.

Potential /Historic Riparian Conditions Assessment

Potential riparian conditions are those conditions most likely to be found in riparian zones, and with the greatest potential to become established in the riparian zone. The potential riparian condition of the subbasin was determined by analyzing level IV ecoregion descriptions of the subbasin (Bryce and Woods, 2000). This information was balanced against information on hydrological, geological, topographical, and climactic factors from historical resources, including historic vegetation maps derived from General Land Office (GLO) survey data, written accounts, and stakeholder interviews. From this combined data, the range of potential conditions that could exist in the project area was extrapolated.

Current Riparian Conditions Assessment

The evaluation of current riparian condition used the two subsets – mainstem riparian conditions and upland tributary riparian conditions. Along the mainstem, high quality landcover data had been hand-digitized from digital ortho quads by the Oregon

Department of Environmental Quality (DEQ) on each side of the Williamson River. The riparian condition of the upper Williamson River was evaluated using an adapted methodology similar to the OWEB Manual's suggested assessment of Riparian Condition Units (RCUs). This adapted methodology divided the Williamson River into 11 discrete RCUs that shared similar land use traits, as illustrated in Map 6-1. Each of these riparian condition units (RCUs) was then evaluated by OWEB assessment methods for vegetation type and stem size in order to characterize stream shading along the reaches. The quality of this data provides for a clear evaluation of mainstem riparian condition at the scale and scope of this analysis.

Data for the upland riparian areas is more scarce. It was necessary to pull together multiple sources of information to assess the riparian condition of the upland tributaries. Available sources included a basin-wide aerial photo library, public and private riparian forestry management policies and practices, USFS watershed analyses, limited site visits, and interviews. These sources were used to analyze key subbasin reaches and to qualitatively assess upland riparian conditions for patterns in vegetation type, shading, and large wood recruitment. Occasionally, more detailed riparian condition information was found for specific reaches, which was included in the analysis when it contributed to understanding the riparian vegetative function and performance in the reach.

RESULTS

Overall Historic/Potential Riparian Condition

An assessment of the four ecoregion types included in the area shows the variety of typical land cover conditions across the entire subbasin (Bryce and Woods, 2000) (Map 2-3). Within these ecoregions, the riparian areas differ from the uplands because of different soil, hydrologic, and topographic factors. Quaking aspen (*Populus tremuloides*), alder (*Alnus rubra*), and even lodgepole pine (*Pinus contorta*) occupy the wooded riparian areas in the Pumice Plateau Forest and High Southern Cascades Montane Forest, because they are typically more tolerant of seasonally wet conditions than ponderosa pine (*Pinus ponderosa*) (Franklin and Dyrness, 1973, Mazama Watershed Analysis, 1996). Meadows in flatlands and depressions along riparian channels, found in the mid-elevations along gently-sloped reaches, may be wet enough to prevent overstory vegetation altogether, and be composed of a mixture of grasses and willows (USFS Jack/Mosquito Creek WA, 1996). Historically areas adjacent to riparian zones were typically characterized by open stands of large-diameter trees, sparsely distributed on the landscape. The open, park-like quality of these mature stands was periodically maintained by fires, that killed most young tree below the canopy while leaving the large, mature trees undisturbed (Sanborn, personal communication, 2004).

Historically, the condition of the Upper Williamson River lowlands was very different than it is today. Generally the mainstem was "narrower and deeper, with well vegetated banks. Willows were a common riparian plant and bank erosion rates were a small fraction of the current rates" (USFS 1996c). Historic accounts of the area indicate the mainstem upstream of Klamath Marsh may have been abutted by up to ½ mile of willow plant community on either side (Catchment Group meeting 2004; Weyerhaeuser Company 1996). This is consistent with topographic cues, which indicate a concentration of flow to a relatively confined valley, providing water table and soil moisture conditions conducive to willow growth. "Beaver dams may have been present in some upper reaches, aiding in the flooding of adjacent valley segments," reducing channel power and stage flow." (USFS 1996c). These conditions would have been conducive to willow and hardwood growth in the low-elevation areas of the mainstem and adjacent tributaries. As the mainstem emptied into the broad Klamath Marsh valley, high flows were able to dissipate over a broad floodplain. This floodplain is also present along the mainstem downstream of the marsh, and willows likely dominated the riparian areas toward Kirk Reef.

Current Riparian Conditions

This section describes conditions and characteristics that are shared by all 5th-fields.

Extremely porous subsoil and high infiltration rates dramatically affect the hydrologic patterns in the subbasin. These conditions challenge the definition of "riparian area" in the subbasin. Riparian zones, while functioning as significant drainages for water conveyance, may not hold surface water during certain times of the year, if ever. However, some plant species can still access much of the percolating subsurface interflow. As a result, unique riparian vegetative communities are found along drainages, serving as signatures for the location of riparian zones in the subbasin (Sanborn, personal communication, 2004).

The upland and lowland riparian conditions within the subbasin are remarkably different. In general, USFS forested upland streams are well vegetated and have been recently protected, after decades of logging. This forested riparian landscape condition is broadly characterized by dense stands of young trees, interspersed with occasional large diameter mature trees (Sanborn pers. comm. 2004). "There is now more 'forest' vegetation in riparian areas than ever before, as a result of fire suppression, cattle grazing, etc. While upland logging activity overall is intense across the watershed, the majority of the Forest Service riparian areas have had very little harvesting" (USFS 1996c). As a result, USFS property has a relatively high degree of riparian cover and buffer in forested areas, resulting from guidelines that restrict activity in riparian areas.

Guidelines in four recent management documents have determined riparian conditions on the Forest Service landbase. Areas managed from 1989 to 1995 are subject to Winema National Forest Land and Resource Management Plan (LRMP) guidelines, which state that areas within at least 100 feet of Forest-designated Class I fish-bearing and Category II streams, and within 50 feet of Class III streams, shall be protected from timber harvest (USFS 1990). Areas managed after 1995 are subject to the Inland Native Fish Strategy riparian protection guidelines and LRMP Amendment 8 (Haugen pers. comm. 2004).

These guidelines generally require riparian buffer widths of two potential site trees or 300 feet on each side for fish bearing streams, and one potential site tree or 150 feet for permanently flowing non fish bearing streams, and (USFS, 1995b, USFS, 1995c) A relatively minor proportion of the land base is under the guidance of the Northwest Forest Plan, which further buffers riparian areas in designated Riparian Reserve Units (USDA/USDI 1994). In areas falling under multiple guidelines under these management documents, the strictest, or most protective, riparian buffer requirements apply (Haugen pers. comm. 2004). These prescriptions are intended to improve riparian and aquatic habitat function, including water quality stream shading, and long-term instream wood recruitment as trees mature in age.

Grazing is another resource activity that occurs on USFS lands in the subbasin. In the USFS lands in the upper portions of the subbasin, the Forest Service manages low density grazing allotments on both upland and riparian areas. Both the timbered canopy and the open riparian meadows are considered in these grazing allotments. Of these allotments, by annual unit month 40% are sheep-grazed, and 60% are cattle-grazed (Nevill pers. comm. 2004). Sheep prefer upland forage, especially bitterbrush, and typically enter riparian areas only for crossing or watering. Cattle, which are grass feeders, tend to forage in riparian areas. All allotments, including those in open riparian meadows and timbered riparian reaches, are managed on a deferred rotation, which prescribes that cattle will not graze a given part of an allotment at the same time of year over a sequential two-year period (Nevill pers. comm. 2004). This ensures that species within the herbaceous plant community that have different flowering, seeding and setting times over the course of these year have the opportunity to produce seed free from foraging pressure to contribute to the seed bank and plant base. Less than two percent of the USFS riparian land base is open riparian meadow, which is typically composed of aquatic sedges in saturated areas, with Kentucky blue grass (*Poa pretensis*) and kusicks bluegrass (*Poa cusickii*), preferred by grazing cattle, on the periphery (Nevill pers. comm. 2004). Generally, the guidance for these open meadow allotments is to keep cattle out of sensitive saturated areas on USFS lands as much as possible, though in practice this can be difficult to regulate (Nevill pers. comm. 2004).

Private lands, though heavily logged, generally have a minimum riparian buffer characteristic of Oregon Forest Practices Act requirements, which require a 50- to 100-foot buffer for fish-bearing streams (based on stream size), and a 50- to 70-foot buffer for non-fish-bearing perennial streams (also based on stream size) (Johnson pers. comm. 2004, Logan 2002). (See further discussion in Section 11, Fish and Fish Habitat Assessment.) Logging is allowed under certain conditions iin these zones, but target basal area retention standards and other restrictions apply (Logan 2002). Aerial analyses and interviews with employees indicate that the large-lot timber companies meet or exceed these logging requirements (Johnson pers.comm. 2004).

In contrast to upland riparian areas, much of the mainstem and the low elevation tributary reaches has little or no riparian cover. In the lowland areas, which are mostly privately owned, intensive grazing has dramatically altered vegetative conditions over time. "Long term agricultural use of the grasslands along the Williamson River and its tributaries has resulted in activities that have removed forest and riparian vegetation from the near-stream area…." (USFS 1996c). Most of the willows and hardwoods that once occupied the lowland riparian vegetative zone are now gone. Absence of vegetation in these areas results in poor stream shading and lack of large wood recruitment along the mainstem. A riparian vegetative analysis of the mainstem found an average of only 19% canopy cover over the Williamson River. The remaining cover was 68% grass, 1% brush, and 11% non-vegetated. In general, the Williamson River upstream of Klamath Marsh had greater riparian cover than the mainstem below the marsh (Map 2-2).

The grassy meadow lowland riparian zones are also at risk of encroachment by other vegetative types. Lack of fire has resulted in favorable lowland conditions for establishment of lodgepole pine and other woody species. These species are intolerant of fire, and fire suppression has removed this control from their advancement into open riparian meadow areas. Along these lowland riparian areas, many young pines are growing at the margins of riparian meadows, with mature pines behind them. The spread of these species into meadow areas is also exacerbated by long-term drought conditions, which drive water tables deeper, thereby creating more favorable conditions for the moisture-intolerant lodgepole pine and other opportunistic species (Weyerhaeuser, 1996). On the east side of the subbasin, mountain meadows, which are found in depressions along riparian channels, are also subject to such encroachment. As a result, currently very few riparian stands are composed of only hardwoods such as aspen or alder. These factors combine to set the trend in the watershed toward successional replacement of riparian hardwoods over time (USFS no date).

Site visits indicate that portions of the mainstem channel banks are severely incised and/or slumping, and not conducive to volunteer plant growth. This is likely due to a combination of geologic subsoil characteristics, land use impacts, and seasonal hydrologic patterns. The result is a lowered water table, which encourages invasion by species tolerant of drier conditions.

Existing Conditions by Watershed

The following sections describe the unique riparian conditions within each 5^{th}-field watershed by mainstem and tributary reaches.

Upstream of Klamath Marsh

Mainstem

The mainstem area is unique to this watershed in that it is closely surrounded by forested slopes. The steep topography, which constricts the channel and concentrates runoff in the lowlands, also creates optimal moisture conditions for riparian vegetative growth.

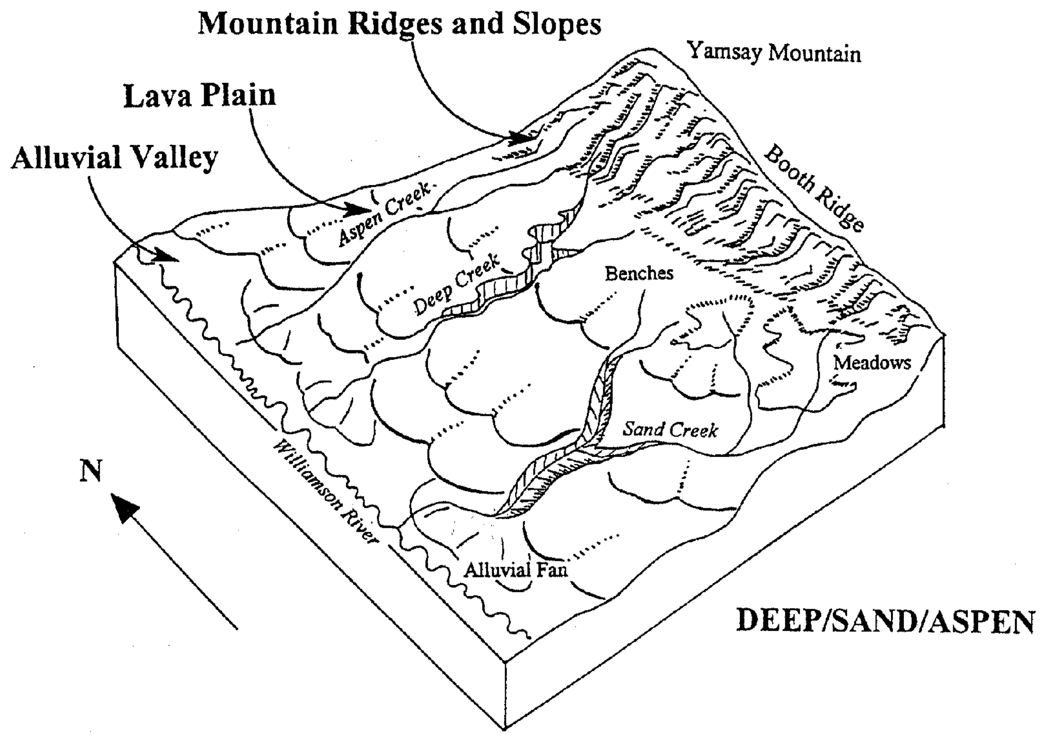
The low-lying areas that once contained a willow thicket are now periodically flooded to water livestock and to maintain water tables to enhance the growth of pasture grasses. Vegetation along the channels in this area is usually a mixture of native and non-native grasses encouraged for forage, with some sedge and rush species growing at the margins of the channel toe (Anderson pers. comm. 2004; site observation).

Most of the private lands along the mainstem are managed for grazing. Mainstem riparian areas owned by the Winema National Forest are also typically leased as grazing allotments, although with a generally lower grazing pressure than on private lands (Ragan pers. comm. 2004). As a result, aerial photographs show that much of the riparian areas on private lands along the mainstem has very low vegetative cover, if any, compared to the cover typical in this subbasin .

RCUs 1 through 8 of the analysis pass through the Upstream of Klamath Marsh watershed. The prominent vegetation type is pasture cover, which averages 65% cover along the mainstem in these units. Most of this cover is pasture grasses, which typically abut the river channel, giving way to sparse native hydrophytic species at the toe of the channel slope. Conifers, the only significantly represented canopy cover in the mainstem above Klamath Marsh, had an average cover of only 25%. These confiers mostly represent vegetation perched on drier slopes adjacent to riparian bottoms, not the riparian zones adjacent to streams in particular. Willows and other brush species, which at one time were a major riparian structural component, now only occupy 1% of the watershed (Map 6-1).

Tributaries

Key tributaries in the Upstream of Klamath Marsh watershed include Deep, Sand, Aspen, and Jackson creeks, and to a lesser extent Hoyt, Deeley, Rock, and Irving creeks. Their steep headwater reaches flow west down the headwater slopes of Yamsay Mountain and Booth Ridge, then cut down the Piedmont and Lava Plains through geologically young soils, as illustrated in Figure 6-1. The streams continue to drain west through the lava plains zone down intermediate slopes. A slower hill gradient in the middle elevation, in combination with coarse pumice substrates, can cause some streams not supplemented by springs to go dry during the descent due to infiltration. The streams ultimately enter the Williamson River riparian corridor as alluvial fans (Figure 6-1). They are fed by a combination of snowpack runoff and isolated springs that typically provide surface water flow along the stream length year-round.



Deep, Sand, Aspen and Coyote Watershed Analysis. Weyerhaeuser. January 1996.

Figure 6-1. Schematic Block Diagram of Upstream of Klamath Marsh and Coyote Creek Watersheds

Most areas above the floodplain are managed by the Winema National Forest in this watershed. Riparian areas on these lands are managed to “protect soil, water, wetland, floodplain, wildlife, and fish resource values associated with riparian vegetative communities” (USFS 1990). Reaches on either side of the watershed pass through either Forest Service General Forest Management Units, which are managed for timber production; Proposed Old Growth Management Units, which are managed for old-growth habitat; or Upper Williamson Management Units, which are managed for visual quality and habitat. The forest service buffer policy, as described above, is corroborated by aerial analysis of timberlands, which shows that USFS timber harvest patterns appear to carefully avoid riparian areas in this watershed.

The perennial headwater reaches running through the USFS areas appear to be overtopped with significant stands of conifer and hardwood trees (aerial photo observations). Based upon the aerial photo review, these areas likely have a relatively high degree of stream shading. Streams reaches that pass through older stands of trees, particularly those in Proposed Old Growth Management Areas and Upper Williamson Management Areas, are most likely to encounter opportunities for large wood recruitment than in reaches that pass through younger stands of trees in General Forest Management areas. Many of the intermittent and ephemeral streams hold significant stands of aspen, which will grow on sites where the water table runs beneath the surface (Weyerhaeuser, 1996). As a result, the aspen can often provide large wood and shading along the riparian edge (Weyerhaeuser, 1996).

Private timber companies in this watershed manage their lands for timber production along the Booth Ridge slopes. Analysis of recent aerials indicates that most of this property has been logged in the last 10 years. Oregon Forest Practices Act guidelines require minimum buffers, especially on perennial, fish-bearing streams. These buffers protect Jackson Creek and Deep Creek in particular. Analysis of Deep Creek riparian buffers indicates over 70% shading on these headwaters (Weyerhaeuser 1996; Map 6-2). Data from a stream habitat survey indicates that Jackson Creek has a varying degree of shade, decreasing from a high of 67% shade in the upper reaches to 0 to 20% near the end of the lava plains reaches and the beginning of the alluvial fan portion of the stream (Humboldt State University [HSU] Data 1998; Map 6-3). The ODFW stream survey data was compared to ODFW habitat benchmarks provided in *Appendix IX-A* of the *Oregon Watershed Assessment Manual* (WPN 1999). These habitat benchmarks recommend greater than 40% stream shading on Central Oregon stream reaches, which appears to be maintained on most of Upper Jackson Creek and Upper Deep Creek based on the mapped data. Based on aerial photo interpretation, Sand Creek likely has similar shading characteristics, though shading is limited in the upland meadow benches through which the headwaters pass before they descend west. The streams are covered by a brushy understory and groundcover layer, leaving the channels generally stable and well-protected, but with some incision due to undercutting of shallow root masses (Weyerhaeuser, 1996). Streams on private lands that receive adequate buffers in these zones also have a high likelihood of wood recruitment.

On privately owned forestlands, non-fish-bearing streams, and especially the small ephemeral drainages, appear to receive marginal logging buffer protection, if any. Many of these riparian areas have been included in the clearcut treatments of the surrounding uplands.

As the tributaries continue west and drop into the Williamson River floodplain, they lose the overhead canopy more common on the upland slopes, decreasing opportunities for large wood recruitment. Similar to reaches along the mainstem, lower perennial stream reaches in the valley have been heavily grazed for many years. Aerial analysis indicates that very little vegetation remains on these stretches. This lack of vegetation, in combination with fine-grained erodible soils, causes stream-side slumping and erosion, which over time makes the channel shallower, wider, and more susceptible to solar inputs affecting temperature (Weyerhaeuser, 1996). This condition is consistent with low-elevation tributaries with grassy lowlands, such as Skellock Draw, Telephone Draw, and Haystack Draw.

Klamath Marsh/Jack Creek

Mainstem

A small portion of the Williamson River, as it drains into Klamath Marsh, is contained within the Jack Creek Watershed. Reach 8 of the mainstem is composed of 86% grasses, most of which appears to be pasture grasses (Figure 6-1). One percent of the reach is composed of brush, which is likely to contain willow species. Some deciduous hardwoods do exist in the reach at the westernmost edge, but in small numbers.

Tributaries

The key tributaries in this watershed include Dillon Creek, Jack Creek, and Mosquito Creek. Dillon Creek and Jack Creek drain to the Williamson River, while Mosquito Creek drains directly to Klamath Marsh. Overall, information on the riparian characteristics of this watershed is limited. The most is known about Mosquito Creek drainage, of which approximately 12% (2,765 acres) is designated as riparian area. About 7% (4,600 acres) of the Jack Creek drainage area is classified as riparian area (USFS no date).

Like all of the watersheds in the subbasin, the Klamath Marsh/Jack Creek watershed is composed of wooded upland slopes and grassy lowlands. The watershed differs in that its generally more gentle slopes allow for development of large upland riparian meadows, shrub, and hardwood communities on the flatter stream benches. Almost all of the upland slopes are managed by the Winema National Forest as General Forest Management units. Aerial analysis of the watershed shows intensive management of forested stands, some of which have been logged three or four times since settlement (USFS no date).

Riparian areas, however, have generally been protected during recent forestry logging operations, with buffers at or above guidelines (USFS 1990). Because of this degree of protection, it is likely that, at the watershed scale, most streams are relatively shaded. The best opportunities for large wood recruitment occur when streams pass through isolated mixed-age stands that are periodically encountered in the forest matrix.

The best studied drainage system in this watershed is Mosquito Creek. Aerial and topographic analysis of Mosquito Creek indicates that its riparian condition is generally representative of the watershed. It is an intermittent system fed by a combination of snowmelt, groundwater, and a single spring. A longitudinal profile study of the Mosquito Creek channel shows a combination of steeper wooded channels broken by flatter segments holding grassy meadow plant communities (USFS no date; Figure 6-2). Wooded areas appear to have a high potential for large wood recruitment and riparian shading, although the small tree size limits the potential to recruit wood (USFS no date). The meadow zones, by virtue of their vegetative composition, probably provide little opportunity for large wood recruitment or shading. Overall, the canopy composition of the Mosquito Creek drainage is 60% moist lodgepole pine, 31% hardwoods, 6% meadow, and 3% moist mixed conifer (USFS no date). Aerial analysis indicates that similar communities exist across the watershed, although meadows and hardwood communities are proportionally higher in the Jack Creek and Dillon Creek drainages than Mosquito Creek Drainage.

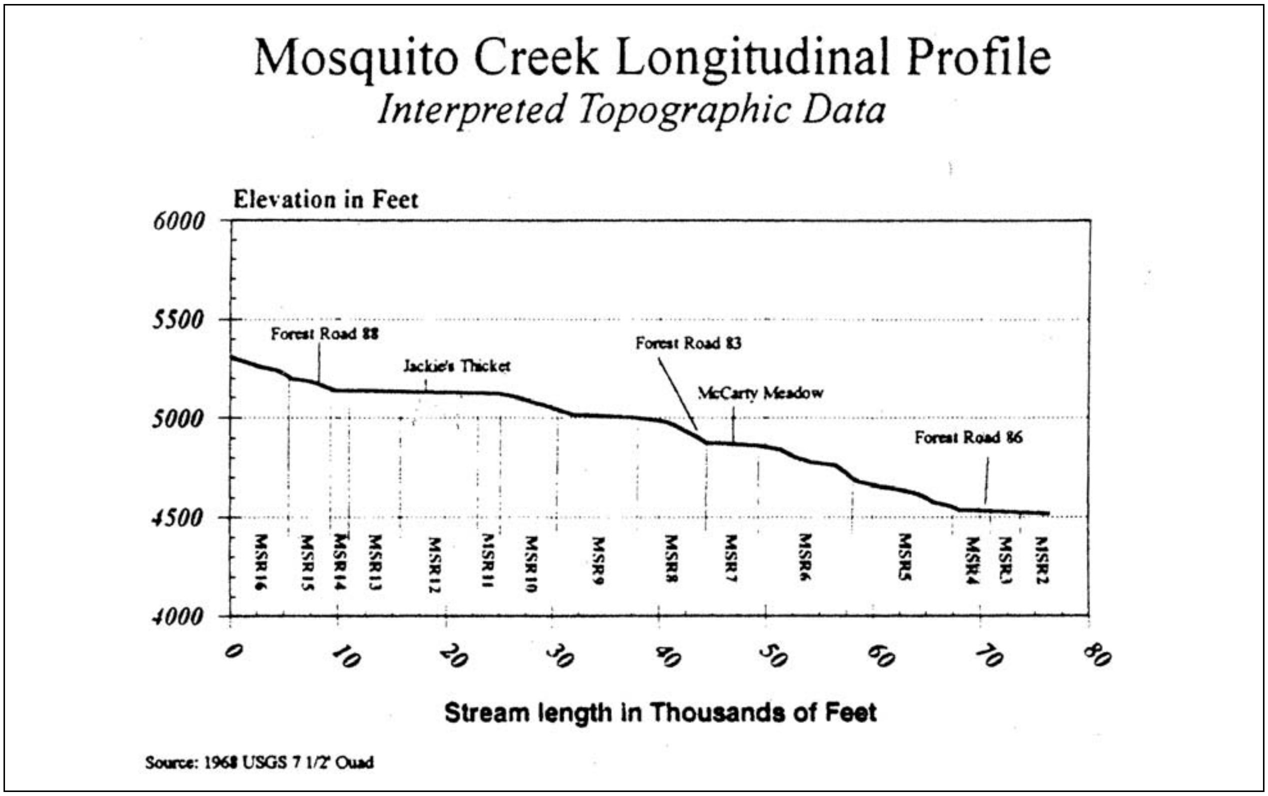


Figure 6-2. Representative Watershed Stream Profile (Mosquito Creek Example)

In the flatter, ephemeral riparian areas, grassy meadows also include stands of aspen and willow along the periphery (USFS no date). Alder and black cottonwood are likely present in smaller proportions. Historical and current beaver activity in these meadows has been observed (USFS no date). Beavers depend on aspen and willow for food and habitat, and by damming and flooding areas create conditions that sustain their growth. It can be inferred that the historically higher populations of beavers in the area increased water retention and flooding, and likely supported higher populations of riparian aspen compared to the prevalent conditions today.

Northwest of Klamath Marsh

Mainstem

An unusual trait of this watershed is that no surface water ever leaves its boundaries. All the water that enters the watershed as precipitation is completely absorbed into the highly permeable soils, and never reaches the mainstem via surface flow. It is likely, however, that much of this water eventually reaches the river by subsurface inputs through Klamath Marsh.

Tributaries

The key perennial tributaries in this watershed are Deer Creek, Miller Creek, Sink Creek, and Cottonwood Creek. With the exception of Deer Creek, all of these reaches originate from the USFS, Mt. Thielsen Wilderness and drain east through General Forest Management lands. Their riparian characteristics appear to be very similar to the streams in the West of Klamath Marsh watershed (as described below), as they drain through NPS and USFS lands. Data from a stream habitat survey indicates that stream shading in Miller Creek on average falls below the ODFW habitat benchmark of 40% stream shading (HSU data 1998, Map 6-2, WPN 1999). Stream shading, timber stocking, vegetative communities, and potential for large wood recruitment is likely very similar to this survey condition in the upper and middle portions of the watershed.

As these streams pass from federal property in the upper reaches onto private lands, they reach the end of the Cascades slope. Private lands in the area are intensively managed for timber. As the tributaries flow towards the bottom of the subbasin, they slow down, become intermittent tributaries, and then ultimately vanish. None of the tributary surface flows continues much beyond Highway 97, except for Miller Creek, which remains perennial to Highway 97. This is the only creek that receives perennial drainage protection along its entire length through the private timberlands. The other streams, as they reduce in class and size with dwindling water flows, receive smaller and smaller buffers on private lands. Streams in the eastern part of the watershed are also ephemeral, and likewise receive little or no buffer protection on the private timberlands through which they pass.

West of Klamath Marsh

Mainstem

In this watershed the Williamson River channel reforms at the southern end of Klamath Marsh. There is very little canopy or brush cover on this stretch of the mainstem as it flows toward Kirk Reef, which includes Reach 9 and most of Reach 10 of the mainstem (Map 6-1). Reach 9 is composed of 82% grass, with no canopy or brush cover. Reach 10 is composed of 75% grass with about 4% canopy cover, most of which lies outside this watershed boundary in the Downstream of Klamath Marsh watershed. The composition of grasses is unknown, but it is presumed to be a mixture of non-native pasture grasses and native meadow. Below the confluence with Sand Creek (west), the river has virtually no willows or other riparian vegetation (USFS 1996c).

Tributaries

USFS refers to the West of Klamath Marsh watershed as the Mazama Watershed. The key small-to-mid-sized perennial streams flowing from the east side of Crater Lake National Park include Sand, Scott, Bear, Pothole, and Wheeler creeks. Yoss Creek enters the mainstem from the east through Wocus Bay. Generally the area has a low drainage density, simple drainage patterns with few intermittent streams, and relatively small stream catchment areas USFS 1996b). The sparse drainage network can be attributed to the high infiltration rates caused by the underlying pumice material. This geology distinguishes this watershed from the east side of the subbasin by creating a steeper headwaters zone and a longer alluvial plain for possible infiltration and water diversions. These factors ultimately prevent water from reaching the Klamath Marsh via surface flow in this watershed. However, thick basaltic bedrock underneath provides opportunity for occasional springs along drainages, preserving mesic riparian vegetation communities.

In this watershed, the NPS owns most of the headwaters zones and perennial creeks, and manages their associated riparian areas for large buffers in a “natural” or “near-natural” state (NPS 2004; Map 2-1). Wheeler, Lost, Cavern, Sand, and Bear Creeks all originate on NPS property. Aerials indicate that the headwaters of these streams all have extensive riparian cover and buffers free of timber or vegetative management. Subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmanni* Parry ex. Engelm.) typically dominate upper riparian zones, with few hardwoods. Sitka alder (*Alnus viridis*), thinleaf alder (*Alnus incana*), and Pacific willow (*Salix lucida* spp. *lasiandra*) become more common at middle and lower elevations of NPS ownership (NPS 2004). Remote sensing indicates that riparian wood recruitment and shading are likely excellent in this portion of the watershed. The ability for large wood to contribute to stream morphological pool and scour characteristics may be limited by steep topography in this zone.

The sideslope areas below the NPS boundary are managed by the USFS Chiloquin Ranger District. Stream surveys of Sand (west) and Scott Creeks indicate that their riparian zones are well-stocked (and possibly overstocked) with young, thick stands of regenerating timber following extensive historical logging (USFS 1996b). A few large trees are found scattered amongst the young riparian sapling/shrub stands, including red fir (*Abies magnifica* var. *shastensis*) and mountain hemlock (*Tsuga mertensiana*) in the higher elevations and white fir (*Abies concolor*) in the lower elevations. Tree densities are lower at high elevations as they mixed with grass/forb communities (USFS 1996b). Scott Creek passes through late successional reserve and riparian reserve areas managed specifically for stream cover and shading. Sand Creek and Wheeler Creek lack this vegetation due to steep canyons, especially as Sand Creek passes through the Pinnacles Special Management Unit (USFS 1996b).

Pothole Creek passes through Northwest Forest PlanRiparian Reserve Management units as it flows through USFS property. The riparian buffer in this area appears to be wide and well stocked. Bear Creek, as it passes through General Forest Management units, is protected by a riparian reserve buffer through the upper elevations. Similar to neighboring creeks in the area, the riparian tree canopy appears to be young but well-stocked through the Bear Creek riparian reserve. Shading is likely adequate in this area, but large wood recruitment may be limited due to the young stand age and class characteristics. As streams pass through the lower parts of USFS management, they generally have less riparian canopy cover due to more sparsely growing trees. Sparse canopy growth is also observed north of Bear Creek over Silent Creek and other ephemeral and intermittent drainages in the northern part of the watershed.

Private timberlands lying downstream of forest boundaries have been subject to intensive logging for decades. Streams appear to have received only minimum buffers during the harvest phase. Fish-bearing streams appear to have greater buffer widths. Riparian vegetative community composition likely is composed of lodgepole pine in drier areas, with limited hardwoods in wetter areas.

Downstream of Klamath Marsh

Mainstem

There is very little canopy or brush cover along this stretch of the Williamson River as it flows toward Kirk Reef, which includes reach 11 and portions of reach 10. 75% of reach 10 is covered with only grasses(Map 6-1). Sideslopes constrict the channel floodplain as it flows down toward Kirk Reef through Reach 11. Nearby slopes generate conditions dry enough for conifers, which occupy 71% of the total landcover. The change in moisture condition associated with this topography leads to a reduction in grasses, with room for minimal willows to grow in the riparian edge margins.

Tributaries

Hog Creek is the key tributary in this watershed. The vegetation along its channel ranges from mixed riparian conifer stands in the uplands to wet riparian marsh communities as the creek empties into Soloman flat adjacent to the Williamson River (USFS 1996a, aerial analysis). Most of this watershed is managed by Winema National Forest, which manages wooded riparian areas for stream shading and large wood recruitment. Aerials of forested riparian slopes show generally contiguous forest cover. As the creek descends, low-cover meadow openings along the channel become larger and larger. USFS has undertaken several restoration projects along Hog Creek, with deliberate efforts to improve channel stability, vegetative structure, and vegetative diversity (Sanborn, personal communication, 2004).

Discussion

The upper Williamson River provides important economic and recreational benefits for residents and visitors, and has been doing so for many years. However, these services do not come without a cost. Decades of intensive logging, grazing, and road building have taken a toll on the region’s riparian areas. These communities perform important ecosystem services to the watershed, including protection of streambanks, maintenance of fisheries, and improvement of lowland-upland terrestrial riparian connectivity, water quality and discharge functions.

Winema National Forest manages over 60% of the subbasin. Its management prescriptions, applied across the subbasin upper elevations, have important effects on the health of the watershed. Remote sensing has indicated that most of the riparian areas have been recently protected by buffers that mitigate impacts of otherwise intensive logging activity. At the watershed scale, it appears that private timberlands in the upper elevations of the subbasin have maintained a minimum buffer on identified streams as required by state regulation.

Historically, much of the upper elevation areas were composed of open, savanna-like stands of large, low density mature trees. The onset of fire suppression, which allowed young shoots to sprout unchecked amidst these sparse trees, in combination with originally low densities of mature trees and a subbasin wide history of logging them, has resulted in a riparian areas overstocked with a high proportion of young overstory trees. This condition may aid in stream-shading, but it doesn't necessarily lend itself to large wood recruitment opportunities. The historical landscape condition as described indicates that large wood may have provided a limited role in stream riparian character to begin with. In riparian areas where logging has removed these low density trees, the potential for large wood recruitment is even further limited.

In an effort to address these upper elevation riparian conditions, the Klamath Tribes have proposed a management plan that emphasizes broad-scale restoration of late-successional conditions (Johnson et al 2003). This management plan identifies priorities for management of the "Klamath Reservation Forest," which is now part of the Winema and Fremont National Forests. One of these priorities is restoration and protection of the forested riparian landbase through eventual restoration of the large tree component in riparian areas, and restoration of hardwood patches along streams, marshes, springs and seeps (Johnson et al 2003). To achieve this restoration goal, the plan proposes that riparian areas currently managed under the Northwest Forest Plan continue with Riparian Reserve Unit protections, limiting logging activity within a minimum of one tree-length from the stream channel. The plan proposes that management of riparian areas outside designated Northwest Forest Plan Riparian Reserve units, which compose most of the lands identified in the Klamath Reservation Forest, should meet or exceed the buffer width, goals, and management guidelines recommended by the USFS Inland Native Fish Strategy (INFISH) (Johnson et al, 2003, USFS 1995b). In addition, open meadow and hardwood riparian areas would be maintained by removal of encroaching lodgepole pine as needed (Johnson et al 2003).

Land ownership changes as the streams move down the subbasin, and so does the riparian condition. Most areas below USFS land are owned by private landowners, who manage large expanses of meadow with occasional upland forested slopes. Some of this land is managed for timber production, but grazing and cattle production are very important land uses as well.

Cattle, as primary consumers in the food chain, have a tremendous ability to alter vegetative conditions. It is apparent that meadow riparian vegetative conditions have been dramatically affected by grazing. Conversion of meadows to feed-oriented plant communities has limited the ability for riparian areas to serve the bank stabilization, water quality, and biodiversity services they usually provide to the watershed. Fire suppression perpetuates the negative effects of these changes, while limiting potentially beneficial effects of these conditions. Initiatives that address riparian vegetative land management choices on private lands stand to have profound benefits to the entire subbasin.

These observations indicate that land use is the key indicator for determining patterns that help to identify areas in need of protection or restoration. Considering these land uses in an evaluation of landscape functions helps to identify and group these areas in terms of their potential for protection or restoration. Within this context, landscape patterns can be separated into three main groups, as illustrated in Table 6-1: best functioning riparian condition areas, fair functioning riparian condition areas, and poor functioning riparian condition areas.

Table 6-1. Land Use and Riparian Functions

BEST Riparian Functioning Condition	FAIR Riparian Functioning Condition	POOR Riparian Functioning Condition
• Streams in National Park Service lands • Streams in Klamath Marsh National Wildlife Refuge • Streams in USFS Old Growth Ecosystem Units (MC 07/07OG) • Streams in USFS Upper Williamson Management Area Units (MC 15) • Northwest Forest Plan Riparian Reserve Units on USFS lands	• Streams in USFS General Forest Management Units (MC 12) • Perennial and fish-bearing streams privately managed for timber • Intermittent streams privately managed for timber • Streams in properly managed riparian range lands	• Private timberland ephemeral streams • Streams in overgrazed riparian range lands

Best functioning riparian areas are riparian areas that, through regulatory requirements or voluntary practices, provide the riparian vegetative buffer necessary for proper stream shading and potential large wood recruitment. Often this buffer is relatively wide, and it may hold some large diameter trees compared to similar stream reaches. These streams are typically found on federal timberlands where management strategies limit resource extraction activities in riparian areas, or in privately owner areas where state regulations require a significant no-activity buffer due to sensitivity of a resource (i.e., fish-bearing streams).

Fair riparian functioning condition areas are riparian areas that, through regulatory requirements or voluntary practices, likely provide the riparian buffer necessary for proper stream shading, but have limited opportunities for large wood recruitment (timberlands) or bank stability (range lands). On timber-producing lands, these stream reaches are typically found where federal or state regulations require a mid-sized no-activity buffer on private lands due to fair sensitivity of a resource, but may not currently contain large trees for woody debris recruitment. Range lands that are being managed with riparian function in mind (i.e., rotationally grazed or stubble-height management minimums) also fall into this category.

Poor riparian functioning condition areas are riparian areas, through lack of regulatory requirements or voluntary practices, do not provide the riparian protection necessary for proper stream shading, large wood recruitment, or bank stability protection. These areas typically include private timberland ephemeral streams and overgrazed riparian grassland meadows.

Functioning riparian condition is an important tool for determining the contributions riparian areas make to the subbasin. The characteristics of each condition may not apply to all sites in all areas identified, but it does provide a broad overall picture of the landscape pattern. These patterns help us determine which areas are best suited for riparian protection and restoration efforts.

CONFIDENCE EVALUATION

Because of the scale of the project, the riparian assessment relied heavily on remote sensing techniques for determining subbasin riparian vegetative condition. This is a data-limited approach, and gaps in knowledge exist as a result. However, an extensive search of all available information on the sub-basin was conducted, and the most relevant of this information was compiled and reviewed during the writing of this assessment. To the limits of available data and approach, the analysis revealed key patterns in the watershed as they address topics outlined in the critical questions for this assessment component. As this information is considered for implementation on the ground, it will be important to verify that site conditions reflect the watershed-scale patterns observed by remote-sensing.

RECOMMENDATIONS/DATA GAPS

The research process uncovered little site data describing riparian conditions in the upland areas. Land cover analysis similar to the DEQ Total Maximum Daily Load (TMDL) data (DEQ 2002a) would be very helpful in determining the riparian health of these upland areas. This is especially true for the Northwest of Klamath Marsh watershed and the Jack Creek/Klamath Marsh watershed. Similar studies on representative streams in the watersheds would help eliminate data gaps and improve understanding of riparian function and performance.

In addition to resolving the above data gaps, monitoring is needed to determine the degree and extent to which riparian meadows are suffering from riparian encroachment. It is unknown which upland meadow areas are in greatest need of treatments to improve them for grazing and habitat.

RESTORATION OPPORTUNITIES

Thoughtful placement of riparian community recovery efforts can also have dramatic benefits to water quality, water temperature, sediment loading, aquatic habitat, time of concentration, discharge, and property protection. Restoration planning however, should always be viewed with a critical eye: cost-benefit analyses, as a balance of opportunity and strategy, are important to the success of a given project. Therefore, based on the understanding that upper-elevation riparian vegetation policies are in place, and that lower elevation areas would most benefit from riparian vegetation enhancements, the following recommendations are made.

1. Concentrate riparian recovery initiatives on private property. Some of the best candidates for restoration occur on private lands. Many landowners are already interested in restoring their property. Not everyone needs to participate in order to have an impact. Restoration projects on private lands have more funding available and are generally implemented more quickly than on public lands. Involving landowners builds community, and sets up the momentum necessary for making the subbasin work for both the people, and the resource.

While restoration on public lands is important to the subbasin, much of it is already being implemented, or is planned for implementation soon. These efforts should be encouraged and monitored for important lessons that could be applied to projects on private land.

2. Concentrate riparian recovery initiatives on areas that are already functioning or have key habitat value. Build restoration efforts out from areas that already contain important resources. The larger the vegetative stand (i.e., a patch of trees or willows) is, the more resilient it becomes, and the greater its contributions to the surrounding area. Examples of these areas could be found in the Best Riparian Functioning Category. It is also likely that areas with functioning, yet vulnerable riparian systems, have other resource assets, including functioning fish habitat, low water temperature, and stable channels to build on. These may be in the Fair Riparian Functioning Category.

It is recommended that the community direct their restoration efforts towards portions of the mainstem that already have significant stands of riparian vegetation to build out from. At the watershed scale, these areas are concentrated in Reaches 2, 3, and 5 in the Williamson River Upstream of Klamath Marsh watershed, and Reach 11 along the Williamson River below Klamath Marsh (Table 6-1).

Tributary junctions along the mainstem, are very important for key ecological and hydrological reasons. They provide the initial point of connectivity between lowland and upland areas, and should also be focused on for improvement and recovery.

Klamath Marsh National Wildlife Refuge may be considered a Best Riparian Functioning area. Involving adjacent landowners along the marsh in riparian recovery initiatives would compound the beneficial impacts of this resource.

Restoring upland communities can also benefit mainstem and low-elevation riparian areas. These upland areas include fish-bearing perennial streams, especially those with existing or historical connections to the Williamson River. These streams include Jackson Creek, Jack Creek, Aspen Creek, Hog Creek, and Deep Creek. Enhancing riparian vegetative condition along these key streams will benefit fish habitat. Other upland areas that also deserve attention are the upland meadows found in the Jack Creek/Klamath Marsh watershed, including Jack Creek and Mosquito Creek, and meadows in the southeast portion of the Upstream of Klamath Marsh Watershed. These meadows once helped their watersheds by storing water in the uplands for slow release over the course of the year. Now they are suffering from the result of lowered water tables as a result of a combination of factors, and need help to maintain meadow riparian community vegetation. Interventions (check dams) that improve water retention in these meadows should also be considered on a site-by-site basis.

3. Consider restoration management projects as well as restoration design projects.

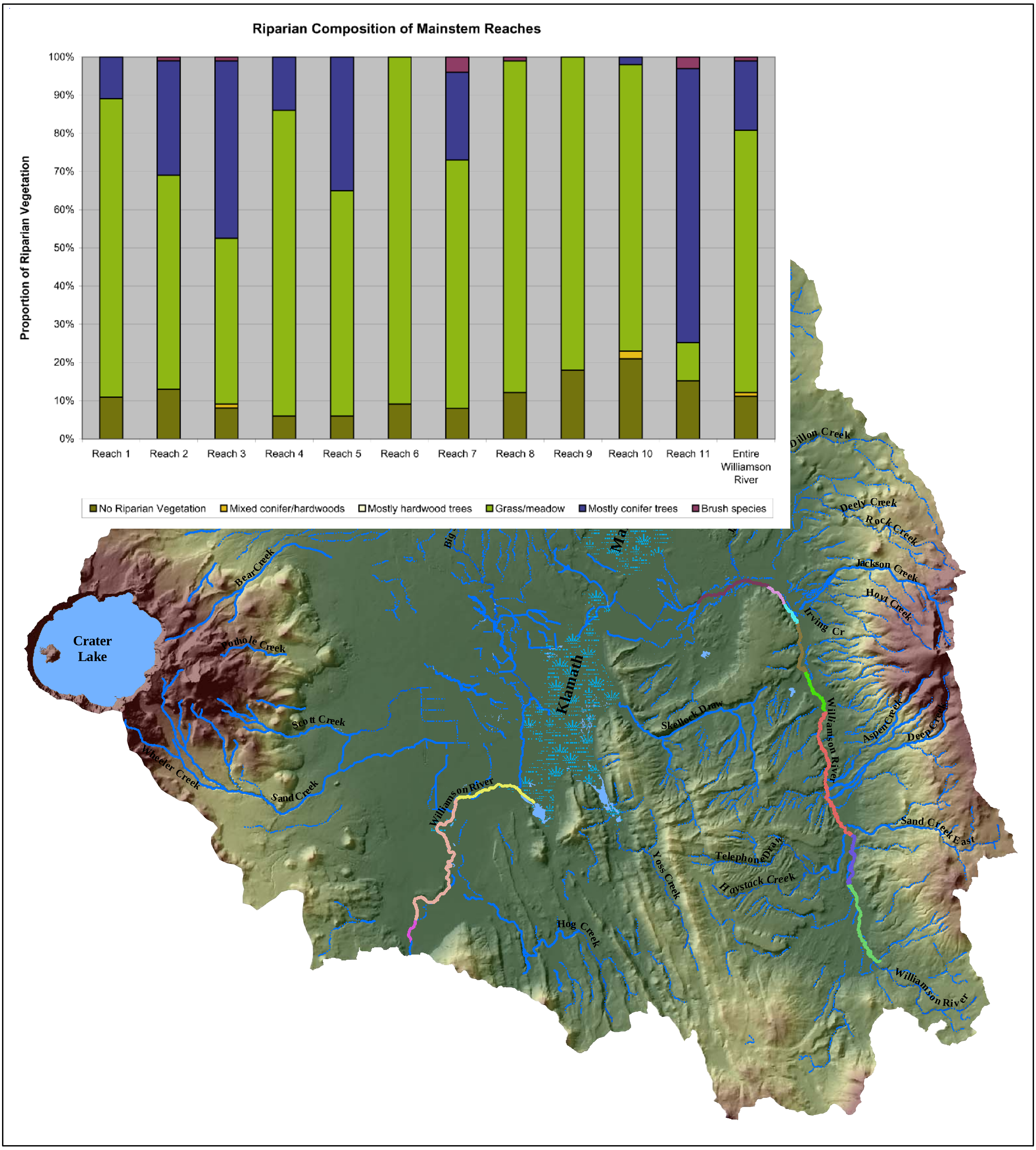
Not every riparian community needs riparian plantings to improve. Often, changes in management strategy will allow the existing communities to recover and provide riparian benefit. Examples include rotational grazing to allow cattle in areas when stubble height is adequate, and coordination of water diversion between landowners to maintain stable water levels so plants can adapt. Often, a combination of management and design can provide more significant benefits to riparian vegetation. For example, construction of a water gap to water cattle shifts grazing pressure away from streambanks, while allowing other areas to recover and thrive.

It is also important to protect investments by making sure areas that are restored are compatible with management strategies. For example, willows may need to be fenced for the first few years in order to ensure that they are not consumed by grazing cattle.

4. Consider fire management or other measures that control lodgepole pine and other mesic encroachment in meadows. Reversal of the effects of channel incision throughout the subbasin is a long-term project that will take place over many years. USFS efforts to improve upper-elevation riparian conditions may ultimately reverse this condition. In the meantime, lowered water tables associated with channel incision are allowing lodgepole pine and others species that favor drier conditions to take over meadows. A burning strategy that controls fire-intolerant species will mitigate eventual loss of these meadows to lodgepole pine stands. If burning places resources at risk or is not preferred in certain areas, manual removal of encroaching species can also slow meadow loss.

5. Choose the right types of vegetation for the right places. On a site-by-site basis, consider adjacent vegetation, historical vegetation, slope, successional patterns, and annual moisture cycles when choosing plant communities to restore. In some places, especially portions of the upper Williamson River, willows are the best choice over taller canopy. In other areas, canopy cover will provide the greatest benefit to the riparian area and its associated assets.

LIST OF MAPS



Upper Williamson River Watershed Assessment

Map 6-1:
Williamson River Riparian Vegetation

Legend

Reach:
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11

- Perennial stream
- Non-perennial stream
- Marsh

Sources:
Riparian Vegetation -DEQ
Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)

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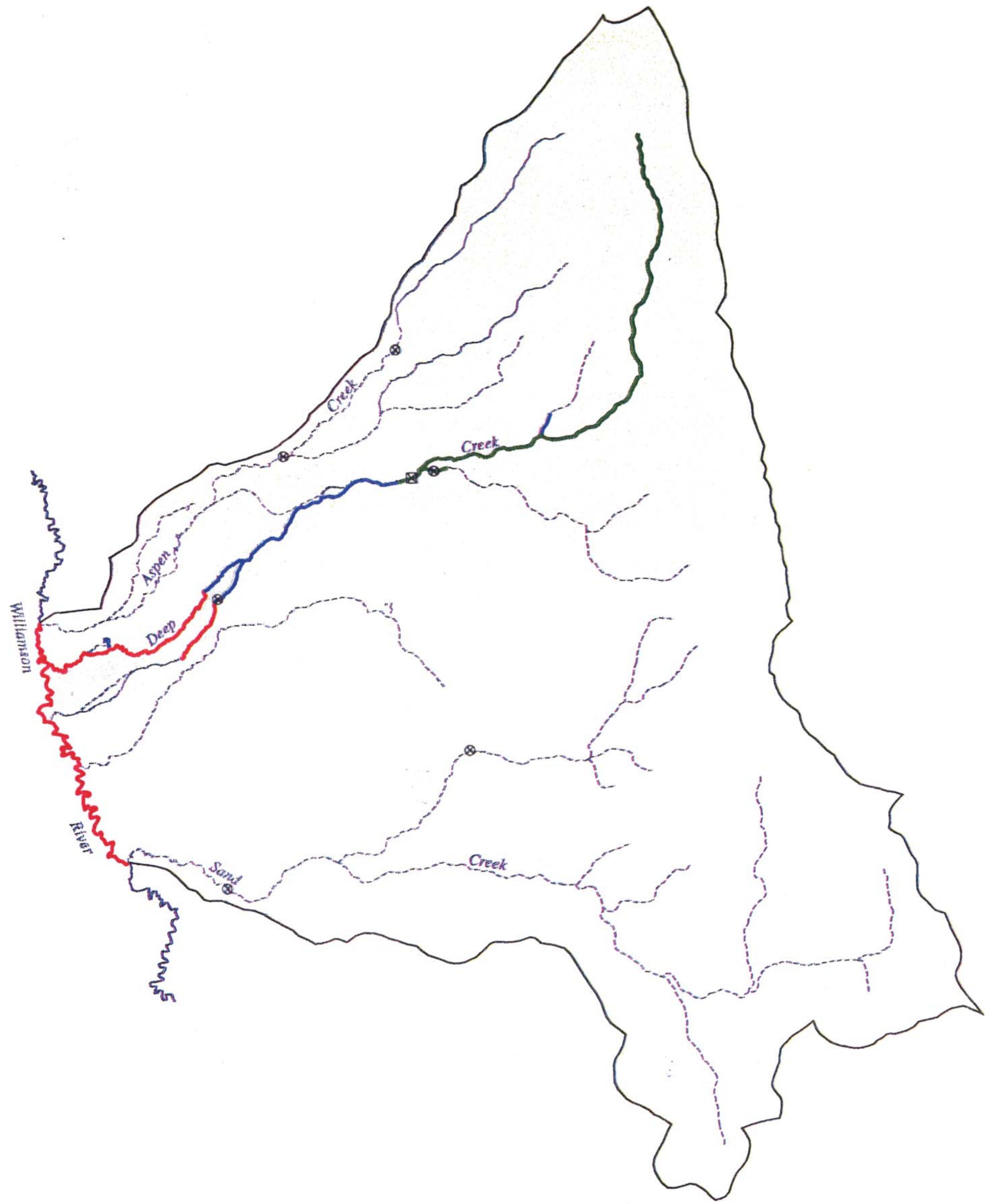
MAP 6-2

Deep Creek and Mainstem Williamson River

Riparian Shading



Stream Channel Shading

- Low: 0-40%
- Moderate: 40-70%
- High: >70%
- Stream temperature station
- Air and stream temperature station
- Perennial Stream
- Seasonal Stream

Note: Only data from fishbearing streams are displayed on this map

N

Scale 1:75,000

1 0 1 2

Statute Miles

Map projection: State Plane Oregon South

Weyerhaeuser

EcoLogic

Deep, Sand, Aspen and Coyote Watershed Analysis. Weyerhaeuser. January 1996.

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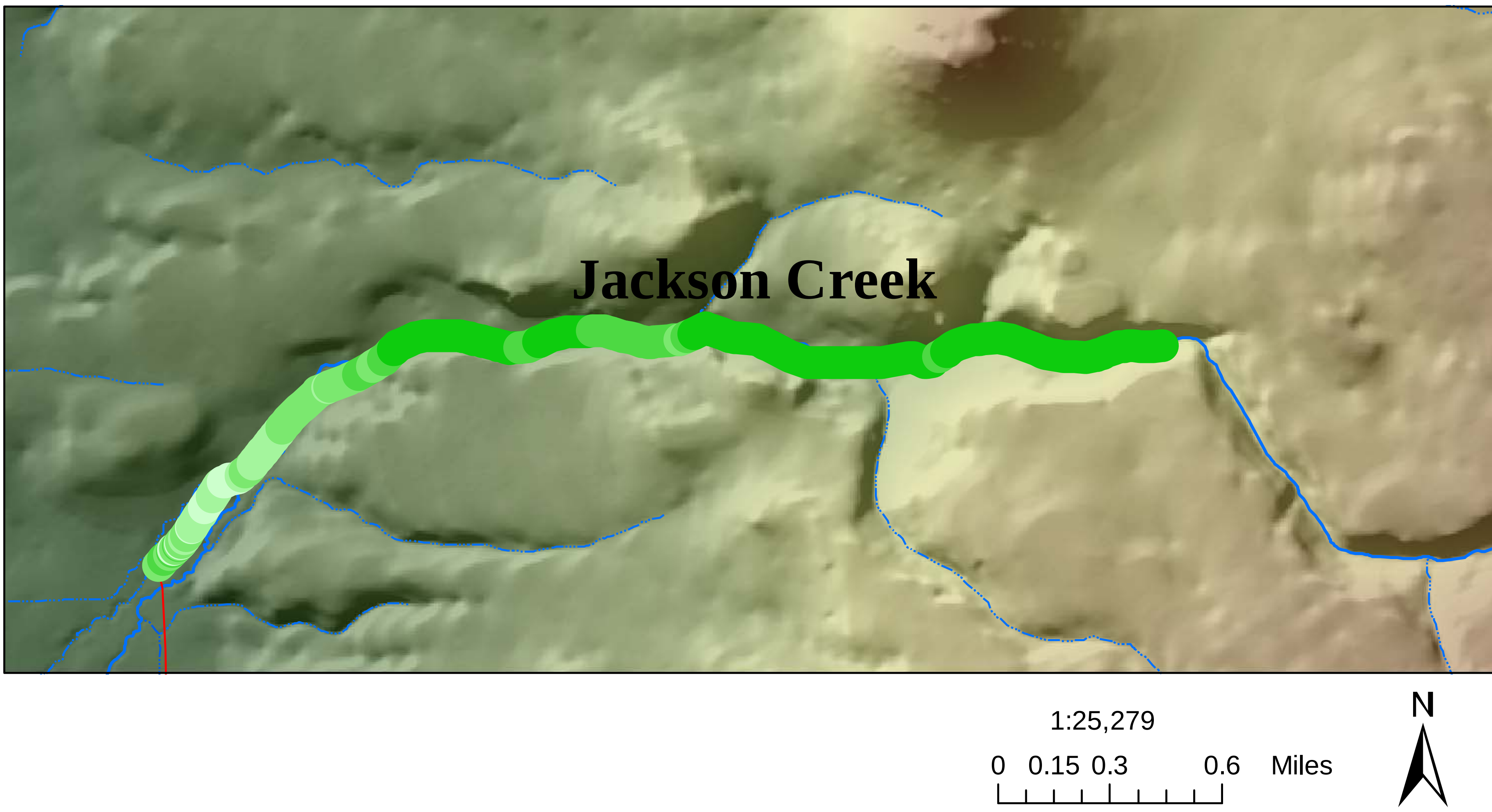

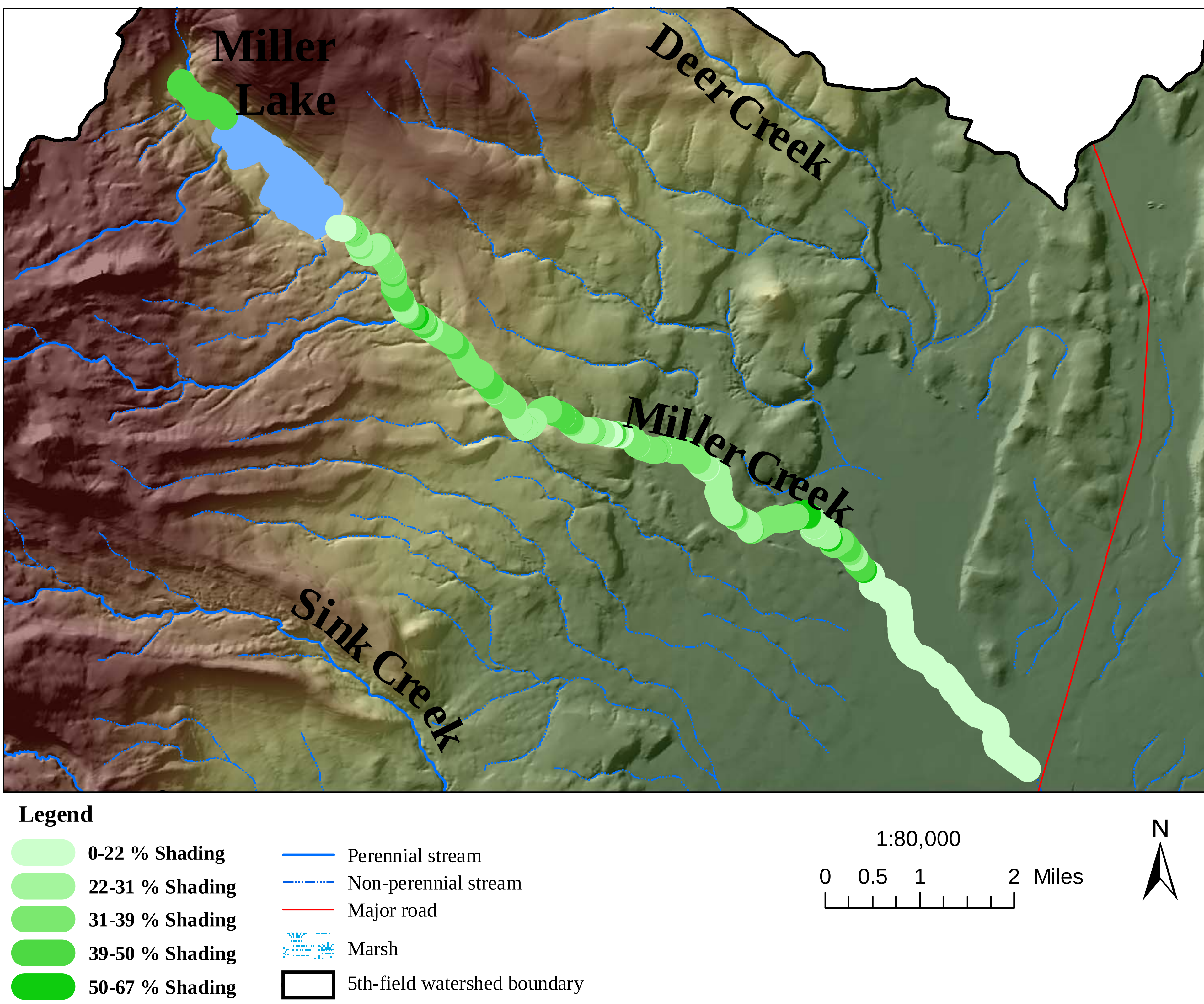

Upper Williamson River Watershed Assessment

Map 6-3:
Stream Shading: Jackson and Miller Creeks

Sources:
Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)
Stream Shading -ODFW (Aquatic Inventories Project)

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7 WETLANDS ASSESSMENT

INTRODUCTION

The purpose of this section is to identify the location of wetlands in the upper Williamson River subbasin and to characterize the nature of these wetlands at a subbasin scale. This information helps determine how wetland characteristics have changed over time, and provides insights about potential locations for restoration or enhancement of the wetlands in the subbasin.

Critical questions that are addressed in this part of the assessment are as follows:

1. Where are the wetlands in the subbasin?
2. What are the general characteristics of wetlands within the subbasin?
3. What opportunities exist to restore wetlands in the subbasin?

METHODS

The location and condition of the wetlands in the subbasin was evaluated using the most current digital National Wetland Inventory data generated by USFWS (USFWS, 1981). All wetlands were evaluated based on the Cowardin Classification Code (Cowardin, 1992). Due to the size of the assessment area, it was not pragmatic to address each individual wetland area. According to this classification code, wetlands in the subbasin were distinguished by the System, Subsystem, and Class modifiers in a database, then characterized by watershed.

Information from landowner and agency interviews was also incorporated into the discussion.

RESULTS

Wetlands are defined by Cowardin (1992) as “lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water.” In order to be defined as a wetland, the area in question “must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year” (Cowardin, 1992). All of the parcels discussed below meet this definition. The definition used to determine state or federal jurisdictional wetlands is different from the Cowardin definition; therefore, this section should not be used to identify jurisdictional wetlands or waters.

A characterization of wetland types using the Cowardin system shows twelve types of wetlands occurring in the subbasin (Figure 7-1). Of these twelve, four main types of wetlands comprise the vast majority of the wetlands in the subbasin. These types are palustrine emergent wetlands, palustrine forested wetlands, palustrine scrub-shrub wetlands, and lacustrine limnetic unconsolidated bottom wetlands.

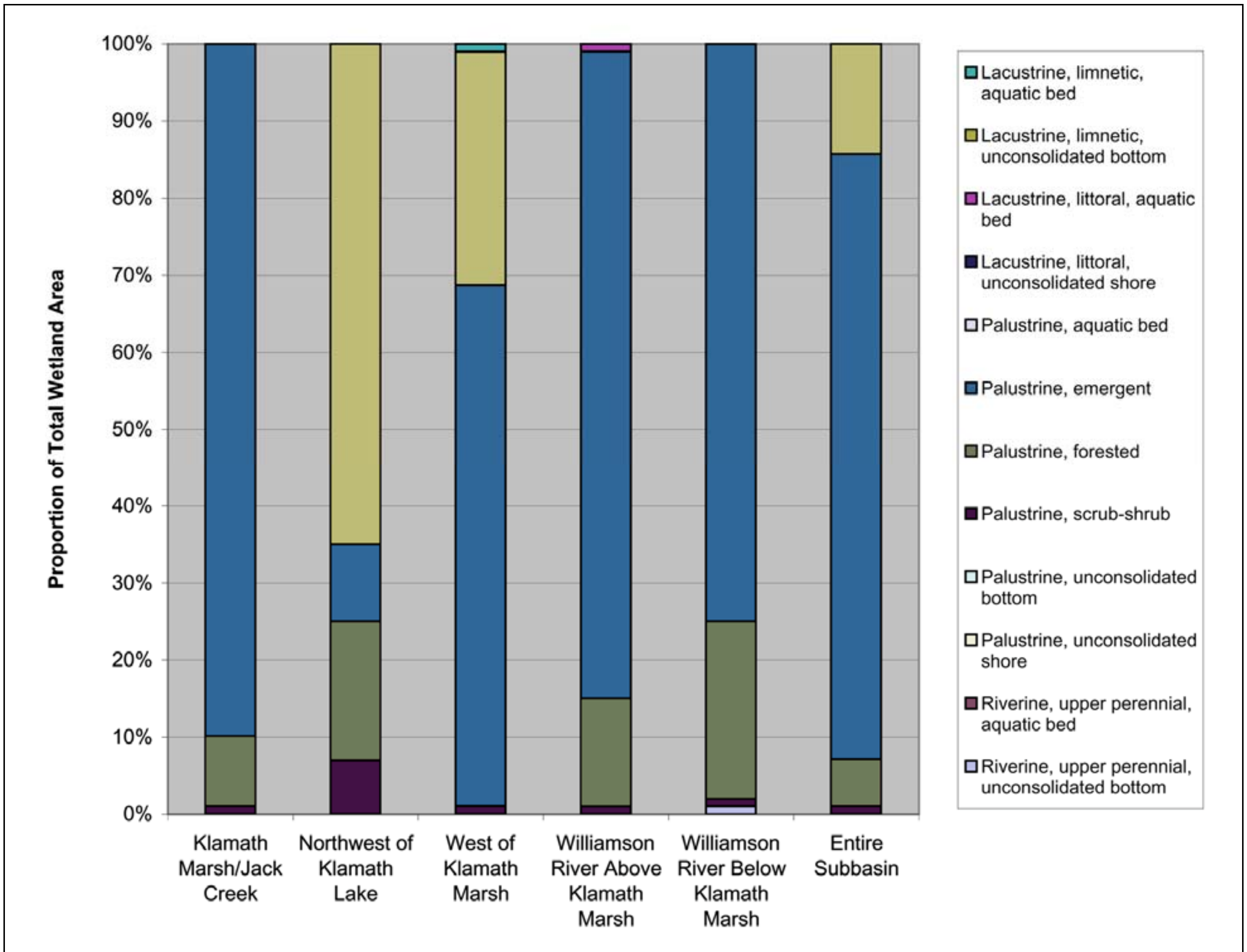


Figure 7-1. Types and Prevalence of Wetlands in the Watersheds

Three of the four main types of wetlands are defined as palustrine wetlands. Palustrine wetlands is the name for a group of wetlands traditionally referred to as a marsh, swamp, bog, fen, or prairie (Cowardin, 1992). They typically have a water depth of less than approximately 6½ feet at low water (Cowardin, 1992). Except for watersheds with large lakes, almost all wetlands in the subbasin are palustrine wetlands (Figure 7-1)

Palustrine wetlands can be further defined by subsystem and class. Palustrine *emergent* wetlands are palustrine wetlands containing emergent vegetation, which includes sedges, rushes, and other grasses typically found in wet areas. In most years, this vegetation is present throughout the growing season. (Cowardin, 1992). Most of the palustrine wetland types in the subbasin are palustrine emergent wetlands (Figure 7-1). Palustrine *scrub-shrub* wetlands are dominated by woody vegetation less than approximately 20 feet tall, including shrubs and small trees. Palustrine *forested* wetlands are dominated by trees greater than 20 feet tall. These three types of wetlands are sometimes referred to as "swamps" or "bottomland hardwoods" (Cowardin, 1992).

The fourth most common wetland type, the lacustrine-limnetic unconsolidated bottom wetland, consists of deep-water habitats lacking vegetation over 30% of its area, which must exceed 20 acres. These relatively large, deepwater habitats have bottoms with more than 25% of their particles smaller than stones, which is typical the lakes represented in the subbasin (Cowardin, 1992). Such wetlands include permanently flooded lakes and reservoirs.

The following sections describe wetland conditions within each watershed.

Upstream of Klamath Marsh

This watershed has the greatest amount of wetlands, excluding Klamath Marsh. Most of the wetlands in this watershed are concentrated in the low elevations of the first segments of the Williamson River, or in the low elevation reaches of its western tributaries. 84% of all wetlands found in this watershed are palustrine emergent wetlands, and most are located near the mainstem (Figure 7-1). The largest expanse of palustrine wetlands is located at the headwaters of the Williamson River, where the floodplain is broader than in other parts of this watershed.

About 14% of all wetlands in this watershed are classified as palustrine forested (Figure 7-1). These forested wetlands are generally concentrated near the headwaters of the western tributaries of the mainstem, and to a lesser extent along thin bands of some streams that drain from the east to the mainstem. Palustrine forested areas also dot the palustrine emergent matrix in the lowland areas adjacent to the Williamson River.

Two large, upper-elevation wetland areas of note are located on the west-facing slopes of Yamsay Mountain and Booth Ridge (Map 1-1). One is southeast of the headwaters of the Williamson River and is associated with some of its low-gradient riparian tributaries. Most of the area is palustrine forested wetland with some palustrine emergent patches. The second area is on a shallow bench of Booth Ridge east of Deep Creek. Where water can pool in these relatively flat areas, palustrine emergent wetlands create a highland meadow. Palustrine forested wetlands are more closely associated with streams below these meadows. Also located in these higher elevations are a couple of palustrine scrub-shrub wetlands, a wetland type that occurs very infrequently in this watershed and in the subbasin in general.

Klamath Marsh / Jack Creek

Klamath Marsh is the primary wetland feature within the subbasin, with a portion of it occurring in this watershed. About 89% of the wetlands in this watershed are composed of palustrine emergent wetlands, of which the Klamath Marsh is the largest example (Figure 7-1).

This watershed is unique to the subbasin in that many of its main tributaries, including Jack Creek, Mosquito Creek, and to a lesser extent Dillon Creek, are composed of palustrine wetlands. About 9% of the wetlands in the watershed are forested wetlands (Figure 7-1), and most of these can be found in the headwaters along these creeks and some of the smaller tributaries to the west. Jackie's Thicket, at the headwaters of Mosquito Creek, harbors a large palustrine forested wetland. The first order tributaries to Mosquito Creek are also notable for their streamside network of palustrine forested wetlands. East of Mosquito Flat are two large palustrine forested wetland matrices, interspersed with palustrine emergent habitat and the largest representation of palustrine scrub-shrub wetland habitat in the watershed. Above these wetlands are O'Connor Meadow and Jamison Meadow, which are the two most significant upland palustrine emergent meadows in the subbasin (Map 1-1 and Map 7-1).

Northwest of Klamath Lake

Of the five watersheds, this one has the least amount of wetland area. Miller Lake, which is identified as a lacustrine-limnetic unconsolidated bottom wetland, is the largest wetland in the watershed, accounting for 65% of the total wetland area in this watershed. Most of the remaining wetlands in the watershed are palustrine forested (18%), palustrine emergent (10%), and palustrine scrub-shrub (7%) wetland types, which are distributed along the periphery of the stream riparian areas draining east (Figure 7-1). The greatest concentrations of these wetlands are located along the relatively shallow upper reaches of Deer Creek, in the northwest portion of the watershed, and along the lower reaches of Miller Creek as it transforms from a perennial to intermittent stream in the low-gradient bottomlands of the subbasin.

West of Klamath Marsh

The West of Klamath Marsh watershed can be characterized in terms of two major wetland areas. These are Crater Lake, identified as a lacustrine-limnetic unconsolidated bottom wetland (30% of total wetland area), and the western reaches of Klamath Marsh (67% of total wetland area) (Figure 7-1). Klamath Marsh is almost entirely a palustrine emergent marsh, aside from a large piece of palustrine scrub-shrub wetland at the southwestern end of the marsh.

Aside from the clusters of forested and emergent marsh at the mouth of Yoss Creek as it drains into Klamath Marsh, wetland areas are scarce in this watershed.

Downstream of Klamath Marsh

Over 75% of the wetland area in this watershed is palustrine emergent wetland, almost all of which lies outside of the Klamath Marsh National Wildlife Refuge (NWR) boundary (Figure 7-1). Most of this emergent wetland runs along the Williamson River. The rest of the palustrine emergent wetland habitat type is interspersed with palustrine forested wetland units (23% of total wetland area) along the mid- to lower reaches of Hog Creek and its tributaries. Small units of palustrine scrub-shrub wetlands, which make up about

1% of the total wetland area in the watershed, are also mixed into this matrix (Figure 7-1). Wetland habitats are very limited in this watershed beyond the Hog Creek drainage and adjacent parts of the Williamson River floodplain.

Discussion

Klamath Marsh, which lies the bottom of the subbasin, is the most significant wetland feature in the subbasin. Here, most of the water in the subbasin collects to create one of the largest wetland features in eastern Oregon. It is a provides a diversity of wetland types and plant communities, and is a major stopover for waterfowl and marsh birds. The hydrology of the marsh is driven by a combination of surface and subsurface flow. A large portion enters the marsh as surface flow from the Williamson River above Klamath Marsh.

In general, Klamath Marsh can be divided into the northern and southern portions of the marsh. Historically, it appears that discharge from the Williamson River drained into the northern portion of the marsh, pooled there, then flowed south towards the marsh (Walt Ford, personal communication, 2004). This general trend created saturated conditions on both halves of the marsh that made grazing and haying difficult. The Kittredge Canal was created in the early 1900s to drain the wetlands in the north half of the marsh and the waters of the south half of the marsh for grazing and haying activities. Pumps were installed in the 1950s-1960s period (exact date not recorded) to facilitate dewatering of these areas marsh (Walt Ford, personal communication, 2004). Each year in the spring, water was pumped south along the canal network to dewater the northern half of the marsh, and then allowed back north through control structures in the canal network in the summer to irrigate grazing and planting areas. In 1989, the pumps were shut off. They were removed in 2002, where the ditches remain, allowing free flow of water via the ditches marsh (Walt Ford, personal communication, 2004).

Water is now allowed to meander in a fashion similar to historic conditions, with the additional free-flow conveyance via the canal. There is some diversion for maintenance of optimal marsh waterfowl habitat conditions in the Klamath Marsh National Wildlife Refuge, as well as diversion for adjacent private land uses via the Mitchell Ditch in spring and fall (Walt Ford, personal communication, 2004). Recently, adjacent areas outside the marsh have been flooded during high-flow months. It is unknown whether this is a historic condition. It is likely that these areas are relatively low in elevation compared to the rest of the marsh, and are consequently flooded during periods of excess flow. It has been speculated that this recent flooding condition may be exacerbated by road and land management activities in the basin, but no conclusive data is currently available to confirm or deny this assertion at this time (Watershed Council Field Trip Discussion, 2004)

Throughout the subbasin, wetland areas are limited due to a combination of highly permeable substrates and steep topography. Currently, they may also be limited by water management activities and the recent drought. Generally, most of the wetland areas found outside of Klamath Marsh are located in close proximity to the mainstem Williamson River, where the water table is relatively high compared to the rest of the subbasin. Smaller pockets of wetlands can also be found along tributary stream systems, where water collects at the bottom of drainages. The largest wetland areas are found at the base of these drainages with relatively low gradients, which often occurs at the lower reaches of tributary streams to the Williamson River.

Palustrine emergent wetland is the most prevalent wetland type in the basin. This may not have been the predominant wetland condition of the subbasin in the past. In at least parts of the subbasin, willow scrub-shrub wetlands and wooded wetlands were historically present in much more significant proportions in the watershed. Anecdotal evidence indicates that a large fire came through the headwaters region of the subbasin around the time of settlement, wiping out most of the willows within the floodplain. This occurrence coincided with the introduction of cattle to the area, which prevented re-growth of the willows. Due to widespread grazing, the floodplain has been relatively void of willows ever since (Upper Williamson River Catchment Group meeting April 20, 2004). The young shoots of vegetation in scrub-shrub wetlands, and especially willow wetlands, are palatable to cattle. In some areas continued grazing along the river banks and within scrub-shrub wetlands may have eventually limited the replacement of older willow stands with younger plants as plants mature and die. Over time, the presence of scrub-shrub and possibly forested wetlands may have diminished as a result. Palustrine emergent wetlands are much better adapted to grazing, at least during parts of the year, because they can regenerate (albeit with less vigor and biodiversity) from the roots once grazed. They are constantly maintained as emergent wetlands by grazing, as young shrub and tree shoots are utilized as forage by cattle.

CONFIDENCE EVALUATION

National Wetlands Inventory data was used extensively for present-day wetland conditions and evaluation. NWI data is a nationally utilized data source generated by USFWS to identify sites across the country with wetland characteristics. The data was generated via aerial photo interpretation, and attempts to document all photointerpretable wetlands within its spatial database (USFWS 1981). It is likely that not all wetlands were mapped during this process. Most farmed wetlands are not mapped, and partially drained wetlands have been conservatively mapped to the limits of aerial photo interpretation (USFWS 1981). The data does not represent exact wetland boundaries in ways that formal, on-the-ground wetland surveys and delineations do. Shown boundaries should be considered generalized interpretations of wetland locations and sizes and should in no way be used to make jurisdictional determinations (USFWS 1981).

These data limitations, in combination with data gaps in historical wetland data described below, place limits on the accuracy of the subbasin wetland condition. The climate, geology, land use practices, and wetland vegetation types for this region make it likely that wetlands in the area are not documented in NWI database. The lack of a good record of historical wetland locations, or of soil indicators of wetland status, makes it difficult to identify trends in wetland condition and representation that are important for determining opportunities for wetland restoration.

That said, by concentrating the analysis of wetland conditions at large scales (i.e., watershed and subbasin), large amounts of data could be analyzed during the wetlands assessment. This has the benefit of balancing out site-scale deficiencies in data accuracy by using a large database of information. Viewed in aggregate, this data allowed the identification of clear patterns that exist at large scales, especially with respect to general wetland type and relative proportion.

RECOMMENDATIONS / DATA GAPS

Information on hydric soils within the subbasin would have been helpful for evaluating potential historic wetland areas; however, as discussed in Section 2, there is a lack of an adequate or continuous soils basemap for the subbasin. This information would have been helpful for identifying areas with hydric soils, an important indicator of potential wetland restoration opportunities.

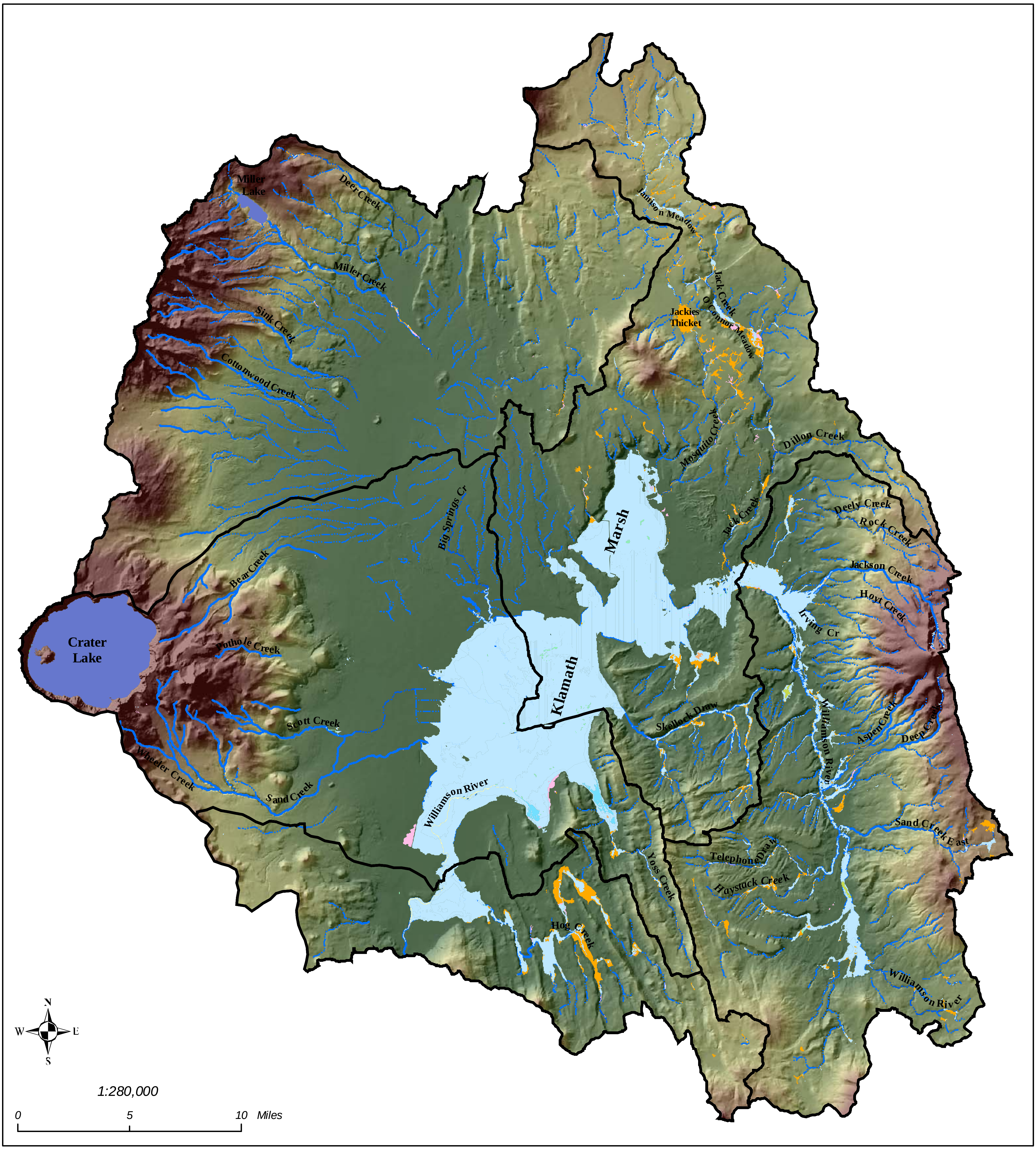
Studies of effects of riparian grazing on wetland vegetative composition and character would be needed to conclusively determine whether continued grazing will maintain a high proportion of palustrine emergent wetland vegetation to other wetland communities.

RESTORATION OPPORTUNITIES

1. Increase the proportion of palustrine scrub-shrub communities within the subbasin. Scrub-shrub communities may have been historically dominant in the watershed, but are now greatly diminished (Catchment Group meeting, May 19, 2004). Scrub-shrub communities, while relatively rare in the subbasin, perform important services to the watersheds within which they reside. They provide habitat structure and forage for a number of bird species that depend on them, and also conserve bank stability along nearby channels. This could be achieved by working with landowners who have significant wetland areas to restore them in a manner compatible with their land use efforts.

2. Build out from Klamath Marsh. In general, the Klamath Marsh National Wildlife Refuge functions as a healthy matrix of palustrine emergent, palustrine scrub-shrub, and other wetland types. Efforts could be made to expand on this functioning matrix by generating cooperative management agreements to improve wetland structure and function between adjacent areas owned by the Refuge, Winema National Forest, and private landowners.

LIST OF MAPS



Upper Williamson River Watershed Assessment

Figure 7-1:
National Wetlands Inventory: Wetland Types

Legend

Wetland Type:

- Lacustrine-limnetic, aquatic bed
- Lacustrine-limnetic, unconsolidated bottom
- Lacustrine-littoral, aquatic bed
- Lacustrine-littoral, unconsolidated shore
- Palustrine, aquatic bed
- Palustrine, emergent
- Palustrine, forested
- Palustrine, scrub-shrub
- Palustrine, unconsolidated bottom
- Palustrine, unconsolidated shore
- Riverine-upper perennial, aquatic bed
- Riverine- upper perennial, unconsolidated bottom

- Perennial stream
- Non-perennial stream
- 5th-field watershed boundary

Sources:
Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)
NWI - US Bureau of Reclamation

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8 SEDIMENT SOURCES ASSESSMENT

INTRODUCTION

This section describes the process used to evaluate possible sources of sediment within the Upper Williamson River subbasin and presents the results of these analyses. The sediment source assessment encompasses three primary components: (1) evaluation of the dominant geomorphic processes that deliver sediment to the various stream channels in the watershed through field inventory, and review of pertinent documents; (2) indirect measurement of various parameters, such as road length and number of water course crossings, using GIS methods; and (3) observation of bank and road erosion sites during a reconnaissance of the subbasin.

Sediment production, delivery, transport, and deposition are natural processes that occur in all watersheds. The timing, magnitude, and significance of these processes vary over time and across the watershed. Erosion that occurs near streams and on surrounding slopes is a natural part of any watershed. Fish and other aquatic organisms in a region are adapted to deal with a range of sediment amounts that enter streams. The amount of erosion in a watershed and the sediment load in the streams vary considerably both during the year and between years, with most sediment moving during the few days that have the highest flows. The most significant land-forming or channel-shaping events may occur during precipitation or snowmelt events that happen only once every decade or more.

In addition to natural levels of erosion, human activities can alter sediment-related processes (production through deposition) in various ways. Separating human-induced erosion from natural erosion can be difficult because of the highly variable nature of natural erosion patterns. Furthermore, human-caused erosion may also be highly variable in timing and spatial pattern. While it is nearly impossible to specify when a human-induced change in sediment is too much for a local population of fish and other aquatic organisms to handle, in general, the more a stream deviates from its natural sediment levels the greater the chance that the fish and other aquatic organisms are going to be affected. Sediment in streams can have a human dimension, affecting beneficial uses of water (such as domestic water supply, agricultural water, etc.) in a variety of ways.

An assessment of erosion and sediment within a watershed requires three steps. First, an inventory of erosion sources is needed, preferably one that identifies sources during different time periods. This exercise may include locating and mapping landslide scars, road washouts, or areas with extensive gullying. The second step is to identify and map areas or situations for which erosion and movement of sediment into streams is likely to occur in the near future. This exercise may include such tasks as locating and mapping high-risk sections of road, undersized but still-intact culverts at stream crossings, or areas where inappropriate cropping techniques occur on highly erodible soil. The third step is to summarize information in a way that allows identification of human-caused erosion problems for which there is a high priority for developing remedies.

The purpose of this section is to summarize existing information sources, identify data gaps that may require further study, and identify opportunities for reducing sediment delivery to stream channels. The assessment uses existing information to summarize what is known about sediment sources in the Upper Williamson subbasin, as well as data collected as part of this study. The results are followed by recommendations on future assessment and monitoring needs to fill data gaps and steps that can be taken to reduce erosion and sediment delivery.

METHODS

Initial Screening

The Sediment Sources assessment methodology outlined in the Oregon Watershed Assessment Manual (OWEB 1999) is designed around a series of critical questions that form the basis of the assessment. These critical questions are:

1. What are important current sediment sources in the watershed?
2. What are important future sources of sediment in the watershed?
3. Which erosion problems are most severe and qualify as high priority for remedying conditions in the watershed?

In general, the methodology used in this assessment follows the outline presented in the *Oregon Watershed Assessment Manual* (WPN, 1999), although many of the sediment sources seen in other watersheds are not applicable to the unique setting and characteristics of the upper Williamson River subbasin. In addition, due to the large size of the basin, some changes to the methodology presented in the manual are necessary. Specific deviations from the methods presented in the Manual are discussed under each of the identified sediment sources.

The first step was to identify which sediment sources are the most important in the study watershed, (i.e., address Critical Question 1). Eight potential sediment sources that have significant impacts on watershed conditions have been identified by the Oregon Watershed Enhancement Board (WPN 1999). Not all are present in every watershed, and they vary in influence depending on where and how often they occur. The potential sediment sources include slope instability, road instability, rural road runoff, urban area runoff, crop land, range or pasture lands, burned areas, and other identified sources.

In this watershed, rural road runoff and streambank erosion were determined to be the most significant sediment sources. This screening process is outlined in the OWEB watershed assessment manual (WPN 1999). Existing information, primarily from the various planning documents prepared by the USFS (watershed analyses from the 1990s listed in Section 2), combined with personal, local knowledge, was used to make the judgments shown in Table 8-1 regarding important sediment sources.

Table 8-1. Screening for Sediment Sources in the Upper Williamson River Watershed

Upper Williamson River Source	Questions	Response	Priority
Source 1: Road instability			Not an issue
	Are rural roads common in the watershed?	Yes	
	Do many road washouts occur following high rainfall?	No	
	Are many new roads or road reconstructions planned?	No	
Source 2: Slope instability (not related to roads)			Not an issue
	Are landslides common in the watershed?	No	
	Are there many high-sediment, large-scale landslides?	No	
Source 3: Rural road runoff			**2nd**
	Is sediment-laden runoff from rural roads and turbidity in streams common?	No	
	Is there a high density of rural roads?	Yes	
Source 4: Urban runoff			Not an issue
	Are many portions of the watershed urbanized?	No	
	What is the importance of these tributaries to the Watershed Council?	Low	
Source 5: Surface erosion from cropland			Topic is not a high priority
	Is there much cropland in the watershed?	Low	
	Is there much evidence of sediment in streams flowing through cropland?	Little	
Source 6: Surface erotion from rangeland			Topic is not a high priority
	Is there much rangeland in the watershed?	Some	
	Is there evidence of sediment in streams flowing through rangeland?	Yes	
Source 7: Surface erosion from burned land			Topic is not a high priority
	How man burns occurred recently (last 5 years), especially hot fires:	Few	
	Was much sediment created by these burns?	Low	
Source 8: Other discrete sources of sediment			
	Streambank erosion due to channel instability / lack of vegetation	High	**1st**
	Timber harvest ground-distrubing activities	Some	**3rd**

Shallow landslides and deep-seated slumps, while common in the Oregon Coast Range, are almost non-existent in the subdued volcanic terrain of the Upper Williamson River watershed. Streamside landslides and slumps can be major contributors of sediment to streams, and shallow landslides frequently initiate debris flows. Rural roads are a common feature of this watershed. Washouts from rural roads contribute sediment to streams, and sometimes initiate debris flows. The density of rural roads, especially unpaved gravel and dirt roads, indicates a high potential for sediment contribution to the stream network.

Urban runoff and surface erosion from crop and range or pasture lands were not analyzed in this assessment. Agricultural lands are mostly located in the valley bottom of the Williamson River and its most significant tributaries and adjacent to the Klamath Marsh. Streambank erosion from agricultural operations is, however, a significant source of sediment. There is virtually no development in the watershed. It is likely that industrial timberland operations have increased sediment yields through both road and hillslope erosion, though relatively little information is available regarding this source.

Subsequent Sediment Source Investigations

Following the initial screening, more detailed evaluations of the primary sediment sources in the watershed were conducted, through a combination of collecting and evaluating existing information, as available, and field investigations in the watershed. This work involved collection of related information from existing watershed documents, a road-based reconnaissance of road-related sediment sources, and a field assessment of channel stability and bank erosion along the Williamson River and significant tributaries (where access was obtained).

GIS Road Investigation

A lack of comprehensive road inventory data necessitated changes to the standard methodology. For example, the level of detail concerning road-related sediment presented in the Manual requires a road inventory or detailed field surveys. Data collection constraints in this assessment document, combined with the lack of existing road survey information, limited the ability to fully assess the role of roads in the overall sediment picture. As a surrogate for these data, however, information concerning road miles and crossings associated with key stream channels, based on GIS analyses of existing datasets, has been summarized. In addition, GIS analyses were performed to identify those portions of the road network within the standard 200-foot buffer from a stream channel (i.e., riparian roads), because of the much greater delivery potential from these sections of the road network.

Road Investigation

During the road-based sediment source investigation, approximately 800 miles of roads in the watershed were driven and evaluated at a reconnaissance level (no detailed quantitative road inventory data were collected). Field personnel identified and mapped all observed erosional features along the roads traveled and took photographs of each site. Each road-related erosional feature had the following data recorded: (1) type of sediment source, (2) area, thickness and volume of erosion, and (3) an estimate of the percentage of sediment delivered to the stream. Unfortunately, the nature of the soils (loose pumice) tends to fairly rapidly mask erosional features.

Unlike surface erosion from exposed hillslopes where revegetation usually occurs within a few years, road surfaces can continue to erode as long as the road is used. The road cutslopes and fillslopes tend to revegetate, reducing erosion from those sources over time. However, road-running surfaces continue to provide fine-grained sediments over the life of the road.

Since it was not realistic to visit every road segment in every watershed, the road system was stratified, to the extent possible, to enable representative portions of the roads to be sampled. Due to the timing of the road investigation (May-June 2004), access to many higher elevation areas was restricted due to snow, and generally only the main roads could be assessed with limited resources.

Gully erosion on roads can occur when surface runoff is concentrated along the tread or ditch for long distances. The most common causes of gully erosion are plugged culverts, undersized culverts, or steep unsurfaced roads (over 10% grade). Because gully erosion is often episodic (e.g., in response to a blocked culvert that causes a stream to flow down or across the road tread) it is difficult to obtain a reasonable quantitative estimate of gully erosion. Instead, a qualitative estimate of how severe the problem is in different areas of the basin or on different road slopes was made during road field-verification. When gullying was seen in the field, data were recorded including the location, cause, and approximate dimensions of the gully to help determine the relative amount of sediment produced by this mechanism.

Other Data Sources

The only existing source of detailed information on sediment sources in the subbasin comes from the watershed analysis conducted by Weyerhaeuser on the Deep, Sand, Aspen, and Coyote creeks in 1996.

Channel Stability and Bank Erosion Investigation

Streambank erosion is a component of the sediment budget that must be evaluated based on considerable fieldwork. Most bank erosion, except large-scale changes in alluvial reaches, cannot be mapped from aerial photography. The main channel of the Williamson River was either floated (Yamsi Ranch to Rocky Ford) or walked (Rocky Ford to Klamath Marsh) where access was available. Portions of tributary channels were also evaluated when access was available. Photographs were taken throughout the reaches, but quantitative evaluation of streambank erosion rates or volumes proved impractical in the time available.

Sediment Transport Data

Limited sediment transport data have been collected by USGS at the Williamson River below Sheep Creek, near the Lenz, Oregon, gage. These data were compiled and used to estimate and evaluate sediment transport rates in the river upstream of the marsh.

RESULTS

GIS Road Analysis

Road data were developed from various sources and compiled into the project GIS. USFS coverages provided much of the base data.

According to the GIS road coverage developed in this study, there are currently 4,577 miles of roads in the upper Williamson River subbasin, which translates to a basin-wide road density of 3.45 mi/mi^2. Table 8-2 shows the existing road network distributed by 5th-field watershed. Road densities range from 2.45 to 4.71 mi/mi^2.

All roads within the Upper Williamson River Watershed were also evaluated to determine the length of streamside or riparian roads in the study area. To determine the location of riparian roads, all stream channels were buffered by 200 feet on either side. All roads segments within this buffer were considered riparian. From 3.55 to 7.8% of all roads are located adjacent to stream channels.

Table 8-2. Road Length and Density in the Upper Williamson River Subbasin

ALL ROADS

Watershed	Watershed Area (mi^2)	Road Miles (mi)	Road Density (mi/mi^2)
Klamath Marsh / Jack Creek	304	1,096	3.61
Northwest of Klamath Lake	313	907	2.90
West of Klamath Marsh	324	801	2.47
Williamson River above Klamath Marsh	268	1,262	4.71
Williamson River below Klamath Marsh	117	511	4.37
Total:	**1,326**	**4,577**	**3.45**

RIPARIAN ROADS (within 200 feet of stream channel)

Watershed	Watershed Area (mi^2)	Riparian Road Miles (mi)	Percentage of Total Road Miles (%)
Klamath Marsh / Jack Creek	304	64.4	5.9%
Northwest of Klamath Lake	313	67.0	7.4%
West of Klamath Marsh	324	43.6	5.4%
Williamson River above Klamath Marsh	268	98.7	7.8%
Williamson River below Klamath Marsh	117	18.0	3.5%
Total:	**1,326**	**291.7**	**6.4%**

In addition, the number of road crossings over the key streams data layer was also assessed. Table 8-3 shows the number of key stream crossings for the existing road network distributed by fifth field sub-watershed. The largest number of key stream crossings is in the Williamson River above Klamath Marsh. It must be remembered that there are actually many more stream crossings than this analysis implies, since there are many stream channels beyond those included in the key stream layer.

Table 8-3. Number of Key Stream Road Crossings in the Upper Williamson River Watershed

Watershed	Watershed Area (mi^2)	Key Stream Road Crossings (#)	Key Stream Road Crossing (#/mi^2)
Klamath Marsh / Jack Creek	304	28	0.09
Northwest of Klamath Lake	313	17	0.05
West of Klamath Marsh	324	34	0.10
Williamson River above Klamath Marsh	268	61	0.23
Williamson River below Klamath Marsh	117	8	0.07
Total:	**1,326**	**148**	**0.11**

GIS Slope Analysis

Because erosion rates are generally related to slope steepness, a GIS analysis was also conducted to define the distribution of slope classes within each fifth field watershed. shows the percentage of fifth field sub-watershed area within 9 slope classes along with the cumulative percentage. It is readily apparent that slopes are very low in the vast majority of the watershed, with most sub-basins having about 90% of their area in slopes less than 20%.

Table 8-4. Distribution of Slope Classes in the Upper Williamson River Watershed

	Klamath Marsh/Jack Cr		NW of Klamath Marsh		West of Klamath Marsh		Williamson Above Klamath Marsh		Williamson Below Klamath Marsh	
Slope Class	% in Class	Cumulative %	% in Class	Cumulative %	% in Class	Cumulative %	% in Class	Cumulative %	% in Class	Cumulative %
0-10%	84.98%	84.98%	71.76%	71.76%	78.1%	78.09%	64.6%	64.59%	73.21%	73.21%
10-20%	11.10%	96.07%	17.87%	89.63%	10.2%	88.29%	24.7%	89.28%	17.30%	90.51%
20-30%	3.00%	99.08%	5.83%	95.47%	5.3%	93.60%	7.4%	96.63%	6.68%	97.19%
30-40%	0.74%	99.82%	2.43%	97.90%	2.8%	96.41%	2.3%	98.92%	2.21%	99.40%
40-50%	0.14%	99.96%	1.17%	99.06%	1.2%	97.63%	0.8%	99.67%	0.52%	99.92%
50-60%	0.03%	99.99%	0.53%	99.59%	0.6%	98.24%	0.2%	99.89%	0.07%	99.99%
60-70%	0.01%	100.00%	0.21%	99.80%	0.5%	98.73%	0.1%	99.95%	0.01%	100.00%
70-80%	0.00%	100.00%	0.10%	99.90%	0.4%	99.10%	0.0%	99.98%	0.00%	100.00%
> 80%	0.00%	100.00%	0.05%	99.95%	0.3%	99.37%	0.0%	99.99%	0.00%	100.00%

Field Reconnaissance of Road Erosion and Stream Crossings

In the approximately 800 miles of roads driven in the subbasin, relatively few obvious sediment sources were observed. A total of 23 sites were found that appeared to be locations of active road erosion. Most of the sites were small gullies that developed due to the concentration of flow. Additional surface erosion would likely occur from road tread runoff during storm events, but this type of erosion was not evaluated.

During the road reconnaissance, 43 stream channel crossings were also observed and field notes and pictures were taken. The sites contained a selection of both perennial and ephemeral channels. Most of the sites showed minimal to no active erosion, although some bank erosion was identified at several sites. Photo 8-1 through Photo 8-6 illustrate the various channel conditions throughout the subbasin.

Photo 8-1. View of Diversion and Unstable, Eroding Banks on Jackson Creek

Photo 8-2.Gully along Steep Section of Road that Contributes Directly to Stream Channel

Photo 8-3. View of Stable River Channel at Yamsi Ranch

Photo 8-4. View of Typical Bank Erosion between Deep Creek and Rocky Ford

Photo 8-5. View of Incised Channel and Outside Bend Bank Erosion Downstream of Rocky Ford

Photo 8-5. View of Williamson River Channel at Silver Lake Highway

Photo 8-6. Channelized Section of Williamson River in the Klamath Marsh

Previous Erosion Evaluations

The watershed analysis conducted by Weyerhaeuser in 1996 for the Deep, Sand, and Aspen watersheds (Coyote drains into the Sycan River), is the only quantitative analysis of erosion sources and rates in the Upper Williamson River subbasin. This document found no mass wasting in the Upper Williamson portion of the assessment area (two landslides were found in Coyote Creek), and risk of future mass wasting was considered low due to gentle slopes, thin soils, and low precipitation, which mostly falls as snow. Hillslope and road surface erosion rates were quantified to the extent possible and subdivided into background and management-related sources. Hillslope erosion was estimated to be relatively limited compared to road sediment yields, due to low slopes, low drainage densities, and porous soils. Surface erosion sites were observed on recently harvested areas, but were only observed to deliver sediment to stream channels when the disturbance was in close proximity to channels.

Total road sediment yield was computed to be 5 to 20 times greater than background rates, with by far the greatest yield coming from the Sand Creek watershed.

Field Evaluation of Streambank Erosion

The field investigation found substantial reaches of the mainstem Williamson River that have relatively high percentages of actively eroding banks. Most of the upper reaches from Yamsi Ranch down to nearly Sand Creek were observed to have well-vegetated stable banks. From Sand Creek downstream to Rocky Ford, the amount of bank erosion increased substantially, until the outside of nearly every bend was found to have at least some bank erosion. From Rocky Ford downstream to the vicinity of Jackson Creek, similar and extensive amounts of bank erosion were observed. In the areas around Silver Lake Highway and into the marsh, little bank erosion was observed.

Evaluation of Sediment Transport

In 1996 USGS collected five measurements of both suspended sediment and bedload transport at the stream gage at Rocky Ford (Williamson River below Sheep Creek near Lenz, Oregon). These data are shown in tabular form in Table 8-5 and graphically in Figure 8-1.

Table 8-5. Upper Williamson River – 1996 USGS Sediment Transport Data (Williamson River Below Sheep Creek near Lenz, Oregon)

	SUSPENDED LOAD			BEDLOAD		TOTAL LOAD
Date	**Concentration (mg/L)**	**Discharge (cfs)**	**Sediment Load (tons/day)**	**Sediment Load (tons/day)**	**Bedload as % of Suspended Sediment**	**Sediment Load (tons/day)**
2/15/1996	21	94.8	5.38	1.34	24.9%	6.72
3/8/1996	15	84.4	3.42	0.81	23.7%	4.23
3/12/1996	12	89.2	2.89	2.05	70.9%	4.94
3/21/1996	18	92.4	4.49	1.51	33.6%	6.00
4/16/1996	14	103.0	3.89	1.54	39.6%	5.43

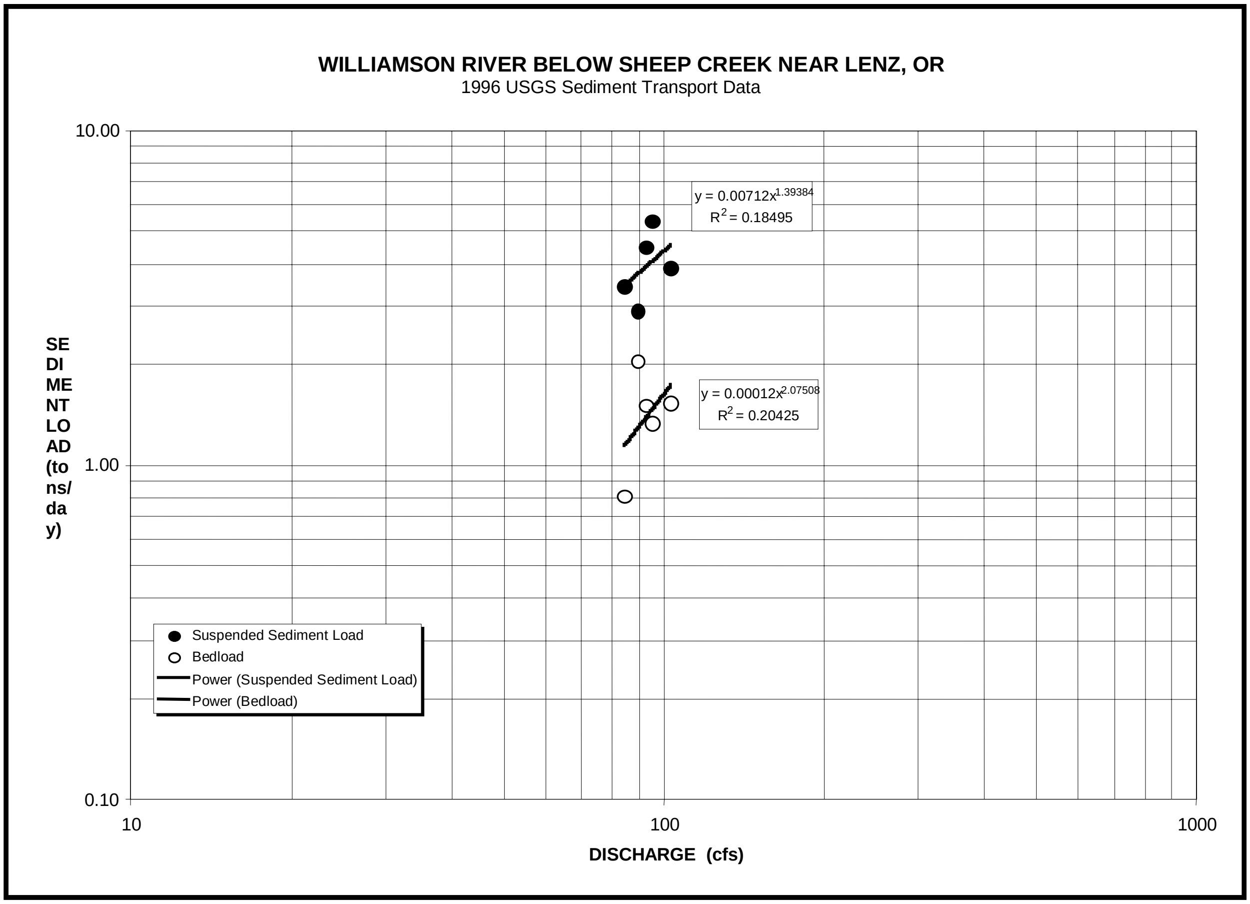

Figure 8-1. Williamson River Below Sheep Creek – 1996 USGS Sediment Transport Data

These data provide a glimpse of sediment transport relationships in the Upper Williamson River above the marsh. The transport rates are quite low, although bedload is a much higher percentage of suspended load than is commonly found. It is likely that the low density of the pumice sands allows higher bedload rates than would be expected in this low gradient system. As a simple exercise to approximate sediment transport rates, the power equations shown in Figure 8-1 were applied to the 28-year daily flow record for the gaging station and then averaged to come up with an average annual transport rate. The computed values, 950 tons/year of suspended load and 320 tons/year of bedload, are extremely low, translating to a unit area yield of only 6.2 tons/mi^2/year.

Discussion

Geomorphic Setting

All previous erosion investigations have identified the relatively low sediment yields of the Upper Williamson are the result of a combination of subdued volcanic terrain which has mostly gentle slopes less than 20%, porous volcanic ash and pumice soils, and the relatively low precipitation which comes mostly as snow. This subdued relief, combined with the porous volcanic soils and relatively low rainfall rates (as compared to snowfall), indicate the low energy nature of this watershed. While this means that natural erosion rates are low, it also means that sediment transport rates are low, so that when sediment accumulates in the stream channels, it has a difficult time being transported through the system.

Sediment, particularly sand-sized grains (0.0625 to 2 millimeters [mm]), has been identified as a primary factor in the reduction in fisheries habitat in the Upper Williamson River basin. Accelerated surface erosion related to road and land use changes, combined with extensive streambank erosion along the channel of the Williamson River, has resulted in sediment accumulation in the mainstem channel, as the river was no longer capable of transporting sediment downstream. These accumulations filled pools, covered spawning riffles and over-wintering areas, and impacted rearing areas, thereby reducing sensitive fish habitat. Simplification of the natural longitudinal profile complexity by sedimentation is closely linked to a reduction in fish populations and biomass (L. Dunsmoor, Klamath Tribes, pers. comm.)

Road Evaluation

Accelerated surface erosion from land management activities is well recognized. Erosion from road surfaces is often a persistent source of sediment in logged basins due to the large network of dirt roads associated with harvest activities and the increased connectivity of the roads to the stream channels. Numerous studies have documented the role of road construction in increased sediment yields (e.g., Reid and Dunne 1984, Rice et al. 1979). Road-related sediment is a major factor in most watersheds. The location of roads on basin slopes (near stream, mid-slope, and ridgetop) can have major effects on both fluvial and mass wasting processes (Jones et al. 2000).

In the Upper Williamson, virtually all roads are un-surfaced, which produces high fine sediment yields. Although midslope roads produce the highest volume of fine sediment in the watersheds inventoried by Weyerhaeuser (1996), this is a function of their number and mileage. Higher yields per unit length of road come from riparian roads, but they only comprise 7% to 12% of the road network.

Bank Erosion

Bank erosion is prevalent along much of the Upper Williamson River above the marsh. Riparian zones along the mainstem and lower alluvial reaches of major tributaries have been grazed for over one hundred years, resulting in loss of woody vegetation. As a result of the loss of the stabilizing influence of riparian vegetation, bank erosion is extensive. Substantial efforts have been made in many areas over the past 20+ years to install riparian fencing, and replant woody riparian vegetation (with varying degrees of success), although it is unlikely that these actions alone can fully restore the river. Channel incision along the Upper Williamson River between the marsh and Rocky Ford exacerbates bank stability issues from a lack of riparian vegetation (as illustrated in Photo 8-7).

Photo 8-7. View of Upper Williamson River at Rocky Ford
Channel incision is more pronounced downstream (left side of picture) of the bridge.

Summary of Results

Two significant sources of sediment have been identified: (1) bank erosion along the mainstem Williamson and lower portions of larger tributaries, and (2) road erosion from the extensive road network. Low transport capacity in the mainstem Williamson River due to its spring fed nature and low gradient makes the residence time of elevated sediment levels long, with substantial impacts to fishery resources and water quality. The low energy nature of this system suggests that the ability of the system to fully "heal" itself (recover to a narrower, deeper and more complex channel form) is quite low, though improvements in bank stability through riparian fencing and planting have been underway for quite some time.

CONFIDENCE EVALUATION

The methods used to identify and characterize sediment sources have a significant number of limitations, primarily based on lack of data, and this assessment is considered only an approximation based on the presently available information.

RECOMMENDATIONS / DATA GAPS

Significant data gaps exist in regard to being able to evaluate potential sediment sources in this watershed and the effect of altered sediment transport relationships on the various stream channels in the watershed. In particular, lack of a comprehensive road inventory makes it difficult to assess the significance of roads within the watershed as sediment sources and to compare road-related sediment to other sources, such as bank erosion. Lack of a comprehensive sub-basin road inventory also prevents prioritization of road treatments to reduce these management related sediment yields. In addition, lack of a detailed hydrologic and geomorphic analysis of the marsh and impacts on the mainstem of the Williamson River above the marsh prevent the development of detailed prescriptions.

1. Comprehensive Road Inventory. A comprehensive road inventory is a high priority for the sub-basin. If a comprehensive inventory cannot be conducted, then efforts should be focused on the road network upstream from the marsh, as this has the most direct effect on mainstem channel conditions. Prioritization of road erosion sites could then be undertaken.

2. Geomorphic Analysis to Guide Restoration Options. A thorough geomorphic analysis of the mainstem Williamson River above the marsh needs to be completed to determine the extent and specific nature of the channel instability between Sand Creek and the marsh. With this analysis, specific recommendations for restoration could be developed and implemented. In the absence of such an analysis, it is likely that piecemeal actions that may not address the root problem are likely to continue.

3. Baseline Monitoring. A hydrologic and geomorphic monitoring program should be established to provide baseline data, to allow for trend monitoring, and to provide feedback into the effectiveness of restoration actions as they are implemented. Such a program would include monitoring streamflow and sediment transport at key sites, and geomorphic monitoring of channel geometry.

Trend monitoring of channel geometry can provide insight into changes to the river channel due to specific events (typically large floods) and to longer-term adjustments and recovery from these flood events. Channel geometry is most often monitored through cross section and profile surveys, both of which are two-dimensional representations of channel shape, with the cross section perpendicular to the flow direction, and the longitudinal profile parallel.

LIST OF MAPS

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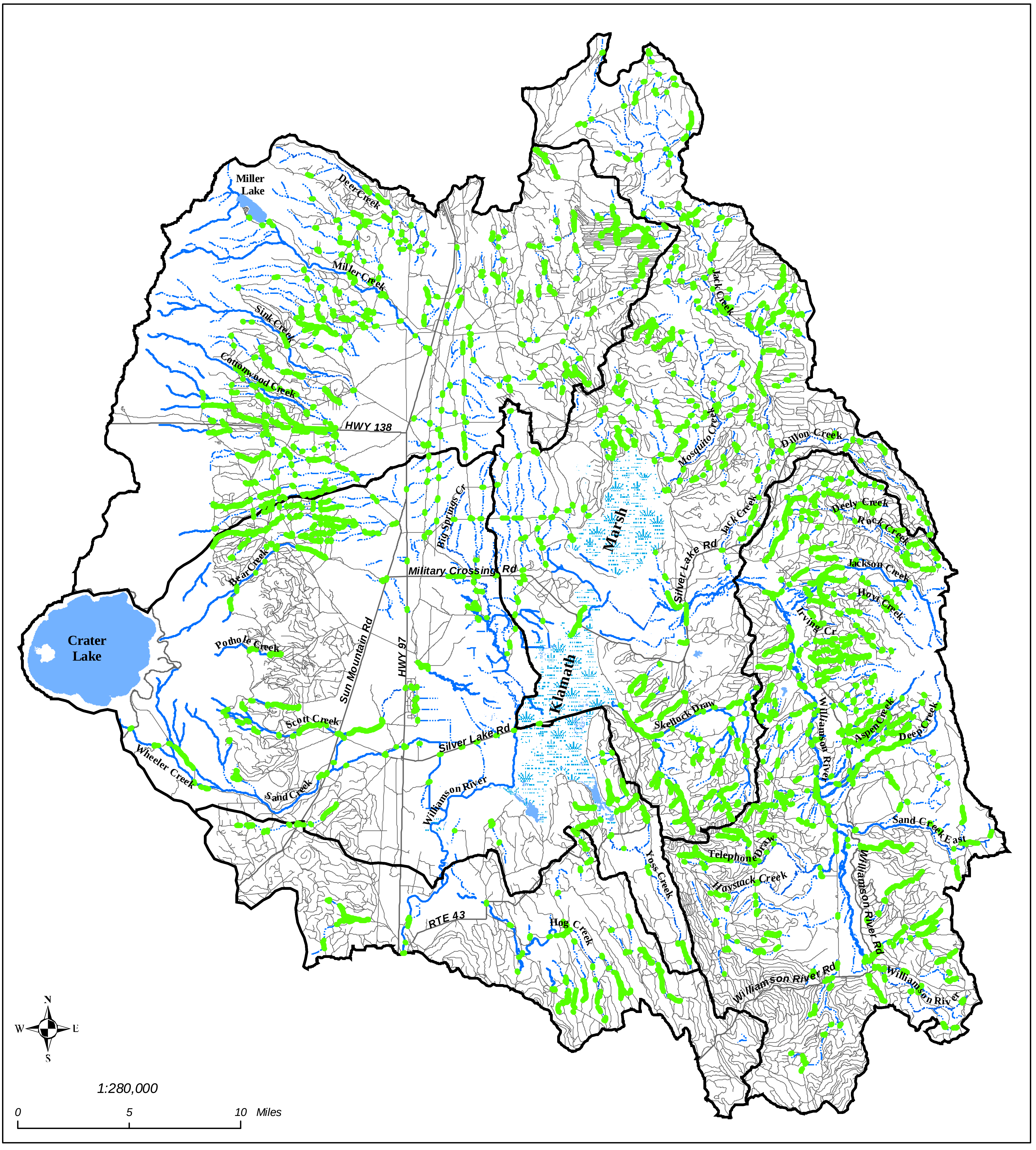

Upper Williamson River Watershed Assessment

Map 8-1:
Riparian Roads

Legend

- Road within 200' of stream
- Perennial stream
- Non-perennial stream
- Road
- Marsh
- 5th-field watershed boundary

Streams -*The Nature Conservancy (24k)*
Roads -*USFS (Winema NF)*
Waterbodies -*BLM (Lakeview Dist)*
Watersheds -*REO/DEA (REO HUCs, modified by DEA)*

DAVID EVANS AND ASSOCIATES INC.

August 13, 2004
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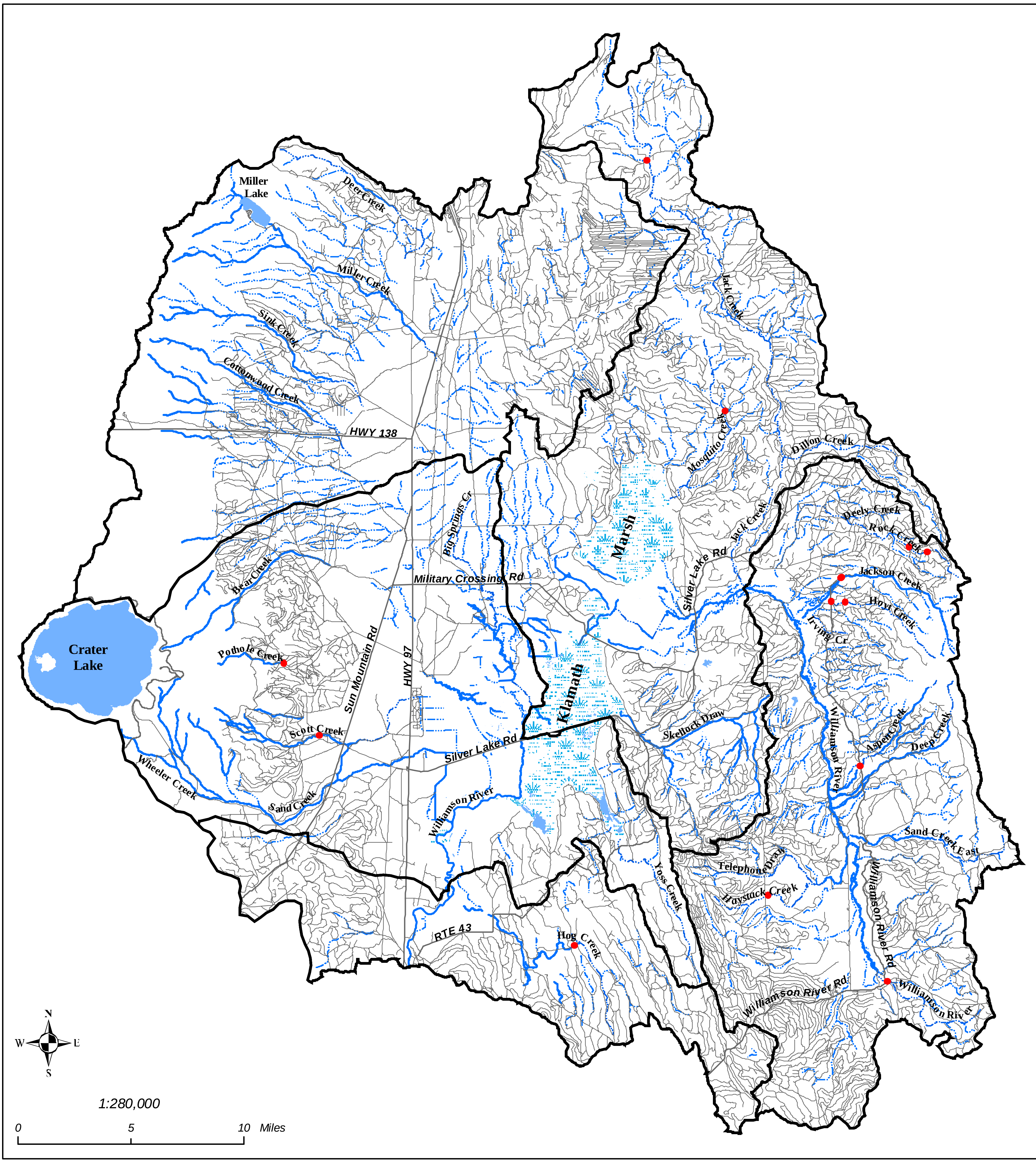

Upper Williamson River Watershed Assessment

Map 8-2: Stream Crossings

Legend

- Road-stream crossing (key streams)
- Perennial stream
- Non-perennial stream
- Road
- Marsh
- 5th-field watershed boundary

Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)

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9 CHANNEL MODIFICATION ASSESSMENT

INTRODUCTION

A channel modification is a human-caused alteration that influences channel geomorphology and often disrupts biotic function. Direct modifications include channelization, dams, roads, bridges, riprap, ditches, culverts, instream mining, dredging, levee building, and other bank stabilization efforts. Channel disturbances can move a stream from its natural channel, affect water velocities, reduce available habitat for aquatic organisms, and change water temperature. In addition, the effects of channel modifications may often cause geomorphic adjustments that may impact a given channel for significant distances, both upstream and downstream of the original action. This is often observed, for example, with actions that initiate a geomorphic response that includes channel incision or downcutting. Further, once channel instability is initiated, the area of disturbance can then propagate downstream as the excess sediment from bed or bank erosion is deposited in downstream reaches causing additional instability and habitat impacts. Identification of these indirect, off-site effects of channel modifications is often difficult.

The purpose of this chapter is to identify current and historic channel modifications in the upper Williamson River subbasin, including both public and private lands, to the extent feasible.

The Channel Modification assessment methodology outlined in the *Oregon Watershed Assessment Manual* (WPN 1999) is designed around a series of critical questions that form the basis of the assessment. These critical questions are:

1. Where are channel modifications located?
2. Where are historic channel disturbances, such as dam failures, splash damming, hydraulic mining, and stream cleaning, located?
3. What channel habitat types have been impacted by channel modification?
4. What are the types and relative magnitude of past and current channel modifications?

METHODS

Data on the location, timing (mostly not able to be identified), and nature of channel modifications were gathered from a variety of agencies and sources, but primarily from the USFS watershed analyses. Aerial photographs were examined and limited field reconnaissance was conducted.

RESULTS

The Upper Williamson River has a long history of human activity. By the 1860s, stockmen had been utilizing the watershed, starting a legacy of ranching that continues today. In the 1880's, the first irrigation systems were installed to increase the grazing potential of floodplain areas along the mainstem and lower portions of significant tributaries. Road building and timber harvest occurred in the watershed. These activities have affected channel conditions in a number of ways. The following discusses some of the more obvious channel modifications and their impact to channel and aquatic habitat conditions.

Perhaps the most significant “modification” to channel conditions over time has been an indirect result from the specific actions detailed below. Changes to overall channel condition have been brought about by a combination of land management activities in the watershed. This issue is addressed in the Discussion section.

Locations of Channel Modifications and Disturbances

Almost all channel modifications are located in low gradient, alluvial reaches of the Upper Williamson River and its major tributaries, and in the vicinity of the Klamath Marsh (see Map 4-1). Since virtually all of the channel modifications have occurred in the low gradient alluvial reaches, the impacted channel habitat types are primarily C and E channel types.

Limited information was developed on historic channel disturbances. References to one splash dam were found, otherwise no other information on dam failures, splash damming, hydraulic mining, or stream cleaning was found. Riparian vegetation has decreased significantly along the upper Williamson River upstream of Klamath Marsh, probably as a result of extensive grazing.

Types and Magnitude of Modifications

Channel modifications in the subbasin include:

- Modifying the Klamath Marsh, including road construction, channelization, potential modification of the hydraulic control of the marsh, and canal construction intended both to facilitate seasonal draining of wetlands or irrigation for agricultural purposes
- Installing roads, culverts, and bridges across streams
- Installing railroad grades along and across streams and meadows
- Splash dams
- Instream dams and ponds
- Water diversions and ditch construction
- Removal of woody debris and riparian vegetation
- Instream Habitat Projects and Riparian Fencing

Alteration of the Klamath Marsh: Although quantitative data on the extent of modification of the Klamath Marsh is generally lacking, there is general agreement that significant alterations of the Marsh have occurred since the early 1900s. Some documents have indicated that the hydraulic control of the marsh was greatly altered around 1910 by blasting. One document (USFS 1996) suggests that this caused as much as 5 to 10 feet of change in the elevation of the control at Kirk Reef, although other accounts suggest that any blasting at Kirk Reef would not have had any impact. In any case, GLO maps and other historic descriptions of the area indicate a much more extensive marsh, with up to 10,000 acres of open water wocus habitat (Colville 1902). The river channel in the portions of the marsh has been dredged and straightened, and drainage/irrigation canals have been built to modify the hydrology of the marsh and vicinity to better accommodate agriculture. It has been hypothesized that channel modifications on the east side of the marsh may have initiated a headcut that has migrated as far upstream as Rocky Ford, causing channel incision and instability (USFS 1998 and L. Dunsmoor, pers. comm.). Lack of quantitative data, such as surveyed long profiles of the river and its floodplain, precludes definitive evaluation of such theories.

Channelization: This modification involves channel straightening, relocation, and excavation and has occurred in the marsh and other natural channels. These activities were done for a number of reasons, including water delivery for irrigation purposes, seasonal draining, and realignment to ease agricultural operations. The data source for identifying these channels are existing digital coverage obtained from TNC and USGS, it is highly probable that additional reaches of channelized streams occur in the watershed, particularly short reaches too small to appear on the map. Channelization has occurred over the last 80 years, with the precise dates of most of the work unknown. Channelization has a direct effect on habitat conditions in the affected reach. Simplification of aquatic habitat is the primary impact, as the stream structure that produced pools, riffles, and steps is removed. In addition, downstream reaches can be affected as flow velocities increase and sediment delivery rates and timing are altered.

Road Construction: There is little information on the extent of channel modification caused by road construction in the basin, although thousands of miles of roads have been built in the watershed (see Chapter 7), and at least 7% of these roads are located within 200 feet of a stream channel.

Railroad Construction: There are over 700 miles of historic railroad grades in the watershed, with most constructed in the 1910 to 1935 period, when most timber harvest was conducted via railroads (USFS 1996). Numerous spurs were constructed along the tributary drainages along the east and west sides of the marsh. Few railroad grades were developed in the northern or eastern portions of the watershed. After 1940, most timber was hauled by trucks and many of the railroad grades were converted to roads. In places, such as Skellock Draw, construction of railroad grades has been identified by USFS as having a significant impact on adjacent stream channels (USFS 1996), by constricting the floodplain and concentrating flow.

Splash Dams: A splash dam is a constructed impoundment used to store a large volume of water, that when rapidly released provides sufficient flow and water depth to float timber that has been stored in the impoundment to downstream areas, where it can be retrieved and hauled to mills. At least one splash dam (Williamson River at Williamson River Campground) has been identified in the watershed. Others probably were constructed and operated, although the nature of the land ownership (Klamath Tribal land), timber harvest history (large sales), and volume of water may suggest that there were relatively few.

Instream Dams and Ponds: A number of instream dams have been constructed, particularly in the upper mainstem above Sand Creek, for stock watering, irrigation, and to provide fishing areas. The overall impact to the aquatic resources of all of these structures are unknown.

Water Diversions and Ditch Construction: Many low gradient areas suitable for grazing (in and adjacent to the marsh, along the Williamson River, and in tributaries with meadow areas) have been impacted by water diversions and ditch construction. This has affected most of the significant tributaries to the river and the marsh, by reducing instream flows and spreading flows out to the extent that some channels do not reach the mainstem.

Removal of Woody Debris and Riparian Vegetation: The dense willow thickets between the marsh and Rocky Ford described in the GLO surveys have been largely eradicated by both active (removal) and passive means (grazing prevents recruitment). In recent years, riparian fencing is allowing some areas to begin to see the reestablishment of woody vegetation.

Instream Habitat Projects and Riparian Fencing: A variety of public and private partners have been undertaking instream habitat projects, riparian planting, and riparian fencing in the assessment area since at least 1973 (USFS 1996). Quantification of the impact of these improvements on channel morphology and aquatic habitat is not possible. In most cases, the impact of the fencing and structures has not been monitored, and only a qualitative assessment concerning the impact can be made. Field reconnaissance suggests that riparian fencing is working in many areas that are showing signs of recovery.

Discussion

In general, channels that are most sensitive to changes are low gradient (<2%) reaches with a developed floodplain (Montgomery and Buffington 1993). These alluvial channels generally lack geomorphic controls such as bedrock, boulders, or confining terraces or hillslopes. Alluvial valley reaches in river systems often act as “response reaches,” since they are areas of temporary (in a time frame of 10s to 100s of years) sediment storage that adjust their storage and the stream channel geometry traversing these areas in response to changes in streamflow and sediment discharge. Thus, episodic events such as large floods may cause the channel location to change, sometimes dramatically, in response to the energy of high flows that exceed the resisting forces of the stream channel banks and riparian vegetation. In a similar manner, large influxes of sediment, whether derived in a single large storm event or delivered chronically over a longer time period, may cause changes in channel form in these response reaches as sediment deposition locally overwhelms the capacity of the channel to transport it. In the low gradient reaches of the Upper Williamson River, channel form has adjusted to increased sediment loads, loss of bank stabilizing riparian vegetation, and channel modifications in several ways. In upstream reaches, primarily affected by increased sediment loads and bank erosion, the channel has widened, become shallower and increased its width to depth ratio, reducing aquatic habitat and sediment transport capacity. In downstream reaches more directly affected by channel modification, the channel has incised, widened, and become isolated from its floodplain.

Historic road construction, timber harvest and agricultural practices have significantly altered the marsh and river channel, both upstream and downstream. Unfortunately, virtually no data are available to quantify the extent or impact of these alterations. Quantification of historic changes to the Williamson River and the Klamath Marsh, to the extent possible, could help provide assessment of opportunities for restoration.

CONFIDENCE EVALUATION

Significant data gaps exist regarding the location and extent of channel modifications, and more importantly, regarding their relative impact on aquatic resources. As a result, confidence in the evaluation is moderate. Additional information from personal interviews with long-time property owners would help strengthen this Assessment.

RECOMMENDATIONS / DATA GAPS

1. Geomorphic Analysis to Quantify Impact of Channel Modifications and to Guide Restoration Options. A thorough geomorphic analysis of the Klamath Marsh and the mainstem Williamson River is suggested in order to quantify the extent and specific nature of the channel instability between Sand Creek and the marsh. With this analysis, specific recommendations for restoration could be developed and implemented.

2. Monitor the Effectiveness of Restoration Actions. While much has been done in the watershed to improve channel and habitat conditions, many of these efforts have not been monitored. Without monitoring, identifying and implementing those activities that yield the greatest benefit can not be done. This should begin with an inventory of those improvements that are already in place.

RESTORATION OPPORTUNITIES

1. Restore Natural Geomorphic Processes. In the mainstem and lower reaches of larger tributaries, damage from loss of riparian vegetation and channel incision has combined to change the physical attributes of the stream, resulting in aquatic habitat degradation. Many streams have widened and become shallower, with a loss of pool habitat. Along the mainstem, the channel has downcut and become isolated from its floodplains. This is likely the case in certain tributaries also. Through a combination of reducing sediment yields, specific restoration actions, as well as promoting riparian recovery, the geomorphic processes that control channel conditions will begin to improve aquatic habitat.

LIST OF MAPS

10 WATER QUALITY ASSESSMENT

INTRODUCTION

The purpose of the water quality assessment is to compile and evaluate available information about water quality within the basin, with the purpose of identifying areas of water quality impairment and where restoration efforts may improve water quality. This analysis relies on existing data, primarily from the DEQ, the Winema National Forest, and the USGS. DEQ completed a TMDL analysis for the Upper Klamath Lake basin in 2002, which included the upper Williamson River subbasin (DEQ 2002a). Documentation from this effort was of particular value for this analysis. Critical questions addressed in this section are as follows.

1. What are the designated beneficial uses of water within the subbasin?
2. What are the water quality criteria that apply to the subbasin?
3. Are there stream reaches identified as water quality limited segments on the 303(d) list by the state?
4. Are any stream reaches identified as high-quality waters or Outstanding Resource Waters?
5. Do water quality studies or evaluations indicate that water quality has been degraded or is limiting the beneficial uses?

METHODS

Information regarding designated beneficial uses, water quality criteria, and 303(d) listed waters were obtained from the DEQ website, which provides links to relevant Oregon Administrative Rules and to DEQ 303(d) databases. Both the 2000 and 1998 DEQ 303(d) databases were reviewed.

The TMDL and WQMP (DEQ 2002a) and associated stream temperature analysis (DEQ 2002b) were used to evaluate temperature issues along the Williamson River mainstem. Winema National Forest (NF) water temperature monitoring data were used to analyze sections of the Williamson River mainstem as well as tributary streams throughout the basin (USFS 2004). Data from the U.S. Geological Survey (USGS), which conducted synoptic measurements of water quality parameters in 1992 and 1993 for many of the tributary streams throughout the upper Williamson River sub-basin, was also reviewed (USGS 2004b).

Watershed assessments conducted by the Winema NF (USFS 1998; USFS 1997; USFS 1995a) and other water quality reports were also reviewed and incorporated into the discussion of overall water quality conditions.

RESULTS

Designated Beneficial Uses

In-stream water quality requirements are based on the protection of recognized water uses, referred to as "designated beneficial uses" (OWEB 1999). The State of Oregon designates these uses for each basin within the state. Designated beneficial uses have been designated for the Upper Klamath Basin, which includes the upper Williamson River subbasin. Designated beneficial uses particular to the upper Williamson River basin are provided in Table 10-1.

Table 10-1. Designated Beneficial Uses for the Upper Klamath Lake Basin, Particular to the Upper Williamson River Subbasin

Public Domestic Water Supply	Boating	Wildlife and Hunting
Private Domestic Water Supply	Salmonid Fish Spawning (Trout)	Fishing
Industrial Water Supply	Salmonid Fish Rearing (Trout)	Water Contact Recreation
Irrigation	Resident Fish and Aquatic Life	Aesthetic Quality
Livestock Watering		

OAR 340-41-0180

Water Quality Criteria

Water quality rules contain both narrative and numeric standards. The following OARs provide general statewide narrative standards germane to this assessment. Numeric water quality criteria are provided in Table 10-2.

OAR 340-041-0007(1): "Notwithstanding the water quality standards contained in this Division, the highest and best practicable treatment and/or control of wastes, activities, and flows must in every case be provided so as to maintain dissolved oxygen and overall water quality at the highest possible levels and water temperatures, coliform bacteria concentrations, dissolved chemical substances, toxic materials, radioactivity, turbidities, color, odor, and other deleterious factors at the lowest possible levels."

OAR 340-041-0007(2): "Where a less stringent natural condition of a water of the State exceeds the numeric criteria set out in this Division, the natural condition supersedes the numeric criteria and becomes the standard for that water body."

OAR 340-041-0007(10): "In order to improve controls over nonpoint sources of pollution, federal, State, and local resource management agencies will be encouraged and assisted to coordinate planning and implementation of programs to regulate or control runoff, erosion, turbidity, stream temperature, stream flow, and the withdrawal and use of irrigation water on a basin-wide approach so as to protect the quality and beneficial uses of water and related resources."

Table 10-2. General and Basin Specific Water Quality Criteria and Standards

(Basin-specific criteria are shown in italics, where such criteria have been developed)

Water Quality Attribute	Water Quality Criteria and Standards
Temperature	**Previous Standard**: Rearing; 7-day average maximum temperature not to exceed 17.8° C (64° F). **Current Standard**: Streams containing redband trout; 7-day average maximum temperature not to exceed 20° C (68° F).
pH	**Fresh waters except Cascade lakes:** *pH may not fall outside the range of 6.5 to 9.0. When greater than 25 percent of ambient measurements taken between June and September are greater than pH 8.7, DEQ will determine whether the values higher than 8.7 are anthropogenic or natural in origin*. **Cascade lakes above 5,000 feet altitude:** *pH values may not fall outside the range of 6.0 to 8.5.*
Dissolved Oxygen	**Spawning areas used by native trout (applicable during spawning through fry emergence period):** Dissolved oxygen (DO) may not be less than 11.0 mg/l. However, if the minimum intergravel DO measured as a spatial median, is 8.0 mg/l or greater, then the DO criterion is 9.0 mg/l. Where conditions of barometric pressure, altititude, and termperature preclude attainment of the 11.0 mg/l criteria, DO levels must mot be less than 95 percent saturation. The spatial median intergravel dissolved oxygen concentration must not fall below 8.0 mg/l.
Bacteria	The 30-day log mean of 126 E. coli organisms per 100 milliliters (minimum of 5 samples); No single sample may exceed 406 E. coli organisms per 100 milliliters.
Nuisance Phytoplankton Growth	**Lakes, reservoirs, and streams (excludes ponds and reservoirs less than ten acreas in surface area, and marshes and saline lakes):** In natural lakes that thermally stratify average Chlorophyll a concentrations must not exceed 0.01 mg/l. In natural lakes that do not thermally stratify, reservoirs, and rivers, average Chlorophyll a concentrations must not exceed 0.015 mg/l.

General Water Quality Criteria, OAR 340-041-0001 through -0061;
Basin Specific Water Quality Criteria ,OAR 340-041-0185

Water Quality Limited Streams and the TMDL Process

Section 303(d) of the Federal Clean Water Act requires states to compile a list of waters suffering from water quality impairment. These water bodies are referred to as “water quality limited.” States are required to establish TMDLs for all water quality limited water bodies, with the exception of those that are impaired by natural causes or where pollutants can not be defined (DEQ 2002a). The purpose of the TMDL is to analyze causes for water quality impairment and then establish the measures by which water quality standards will be met in the future. A Water Quality Management Plan (WQMP) is developed to implement these measures. Completion of the written WQMP results in delisting of 303(d) listed waters that fall under the plan, although measures provided in the plan still need to be implemented (Deborah Sturdavich, DEQ, pers. comm. 2004).

In 2002, a TMDL and WQMP were completed for the Upper Klamath Lake basin, including the Williamson River subbasin. The Williamson River was included in the TMDL and WQMP due to its water quality effects on Upper Klamath Lake. However, it was also included because the entire length of the Williamson River was listed on the 1998 state 303(d) list for impaired waters. The river was listed for exceeding the previous temperature standard of 17.8^{o} C (64.0^{o} F), which is set for waters with salmonid rearing as a designated beneficial use. Redband trout is the salmonid species of concern within the Williamson River system. Table 10-3 provides the listing results provided by a search of the 1998 DEQ 303(d) database, available on-line (DEQ 2004). Completion of the Upper Klamath Lake Drainage TMDL and WQMP have resulted in the delisting of the Williamson River from the state 303(d) list. The most recent list produced by the state, compiled in 2002, no longer contains the Williamson River.

Table 10-3. 1998 303(d) Listing Information for Project Reaches of Williamson River

River Segment	303(d) Listing Information (from 1998 list)
Williamson River from Sprague River to Klamath Marsh (DEQ Segment ID: 43B-Will11)	**Parameter:** Temperature **Criteria:** 17.8^{o} C (64.0^{o} F) **Season:** Summer **Basis for Listing Consideration and Supporting Data:** NPS Assessment-segment 18, 19, and 20: moderate (DEQ 1988). USFS data (Site 34S-7E-2swnw): 7 day average of daily maximum of 22.4^{o} C (72.3^{o} F) with 106 days exceeding temperature standard 17.8^{o} C (64.0^{o} F) in 1994.
Williamson River from Klamath Marsh to Headwaters (DEQ Segment ID: 43B-Will49)	**Parameter:** Temperature **Criteria:** 17.8^{o} C (64.0^{o} F) **Season:** Summer **Basis for Listing Consideration and Supporting Data:** NPS Assessment-segment 21, 22, and 23: severe/moderate (DEQ 1988). USFS data (Site 31S-10E-12nwne, RM70): 7 day average of daily maximum of 23.7/21.9/23.0^{o} C (74.7/71.4/73.4^{o} F) with 113/67/105 days exceeding temperature standard 17.8^{o} C (64.0^{o} F) in 1992/1993/1994, respectively.

Since completion of the Upper Klamath Lake Drainage TMDL and WQMP, a new water temperature standard has been adopted for the Williamson River subbasin. The new standard came about as a result of improved understanding of redband trout's ability to tolerate warmer water temperatures compared to most other salmonid species. The new standard is 20.0^{o} C (68.0^{o} F). Data provided in Table 10-3 suggest that even if this new standard had been in place during preparation of the 1998 303(d) list, the upper Williamson River would have still been listed as water quality limited.

The Williamson River and associated tributaries have not been listed as water quality impaired for any other water quality parameters. It is therefore assumed that these other parameters (pH, dissolved oxygen, etc.) are all within state standards.

Basin Characterization

This section provides a basin-wide characterization of water quality conditions. The discussion is broken up by hydrologic functional groups (i.e., tributary streams, Williamson River mainstem, and Klamath Marsh) rather than by 5th-field watershed because it is these functional groups that differ with respect to physical, chemical, and biological components of water quality. The following discussion focuses primarily on water temperature conditions within the upper Williamson River subbasin, because temperature is the primary water quality parameter of concern, particularly for the mainstem Williamson River. Other water quality parameters or issues will be discussed briefly, where appropriate.

The Winema NF has operated water temperature monitoring stations for many of the key streams within the upper Williamson River Map 10-1 (*Note: USFS gage stations are to be added to map later*.) These stations recorded water temperature on an hourly basis, 24 hours a day, for several months to a year, over the course of several years. The earliest gage stations began recording data in 1992, and most had stopped recording data by 2002. Representative temperature graphs were created from this data and are provided in the ensuing discussion. Data from the 1999 calendar year were used, when available, because most stations recorded data during this year and because it is the year in which research data specific to the TMDL development process was recorded.

Tributary Streams

Temperature

Tributary streams throughout the upper Williamson River Subbasin typically contain cool water, as a result of groundwater inputs, and a moderate to high degree of shading by riparian vegetation. The lowest reaches of some tributaries likely experience notable warming where they leave forested areas (i.e., heating caused by increased exposure to solar radiation due to lack of shading) and are often diverted for irrigation purposes (author's assumption –no data available). Although no tributary streams were listed on the 1998 303(d) list, several factors have the potential to cause adverse water quality impacts. These include the potential for increased sediment load due to runoff from forest roads and bare land surfaces (i.e., construction zones and freshly logged areas prior to vegetation reestablishment), nutrient enrichment from animal wastes, and water temperature issues due to irrigation diversions and loss of riparian cover.

Temperature graphs for Sand (West), Miller, Jack, Jackson, and Deep Creeks, produced from Winema NF data (USFS 2004), are provided in Figure 10-1 through Figure 10-5. These graphs are representative of general water temperature conditions in tributary streams throughout the upper Williamson River subbasin. Although only data from one year are presented, with only one location for each creek, it can be seen that water temperatures in tributary streams are generally well below the previous water temperature criteria of 17.8^{o} C and obviously even further below the current criteria of 20.0^{o} C. Jack Creek peaked above these criteria for roughly a one-week period in July 1999. The 7-day average of the hottest daily temperature exceeded the 17.8^{o} C criteria during this time period, but fell just short of exceeding the 20.0^{o} C criteria. Water temperature monitoring conducted by Weyerhaeuser on Sand Creek (East) in 1995 showed that Sand Creek occasionally had single day exceedances of these criteria (Weyerhaeuser 1995).

However, the 7-day average of the hottest daily temperature for the hottest period exceeded only the lower of these two criteria. Jack Creek contains introduced trout species but does not contain native redband. Sand Creek (East) does not contain fish (Weyerhaeuser Company 1996).

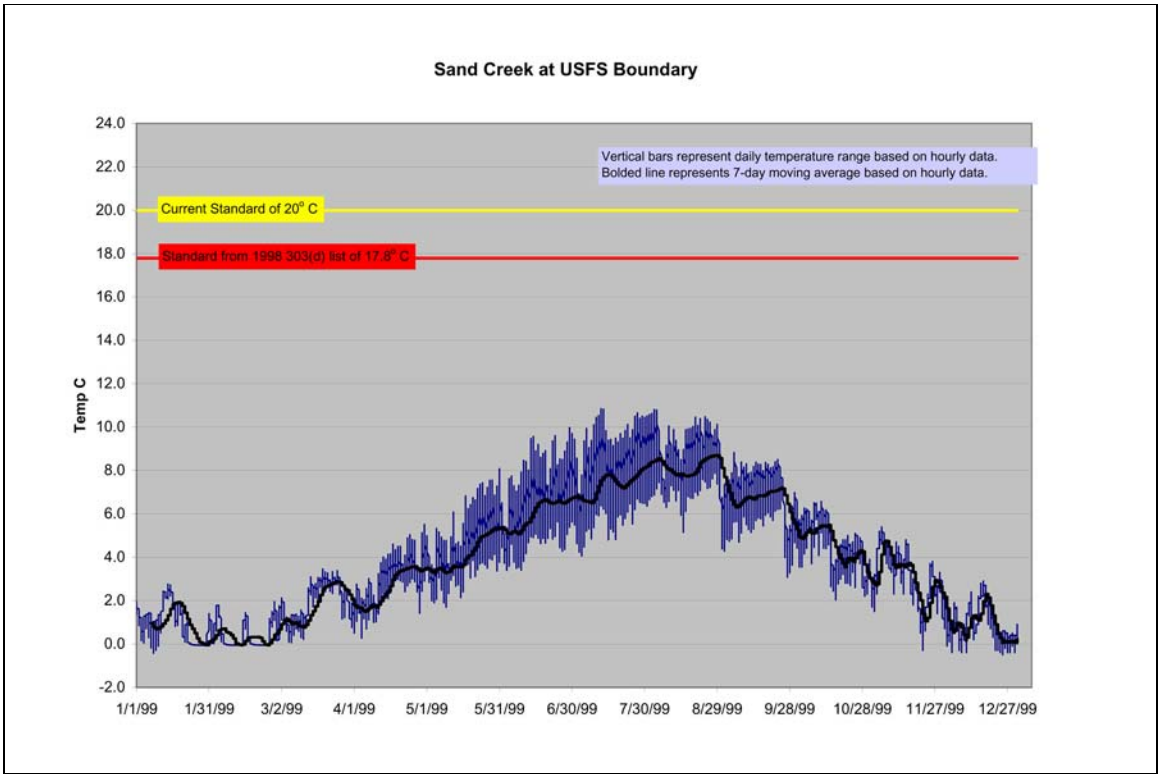


Figure 10-1. Temperature Graph for Sand Creek (West of Klamath Marsh 5th-Field)

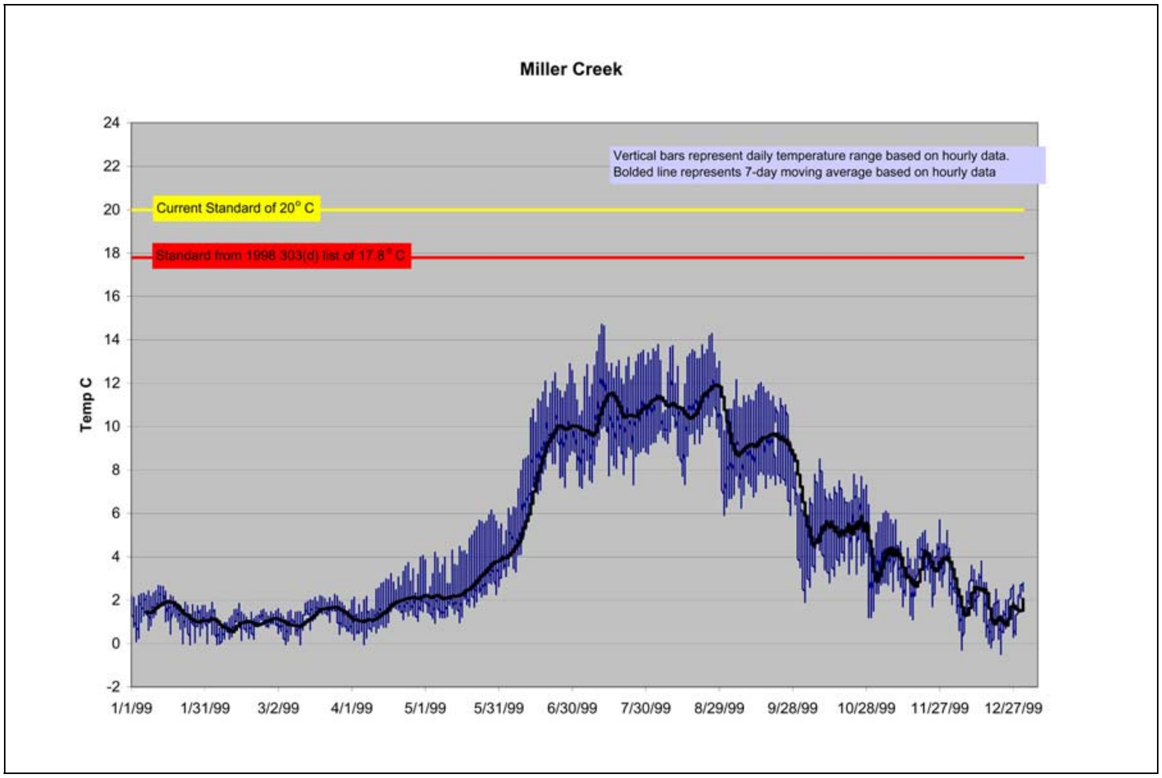


Figure 10-2. Temperature Graph for Miller Creek (Northwest of Klamath Marsh 5th-Field)

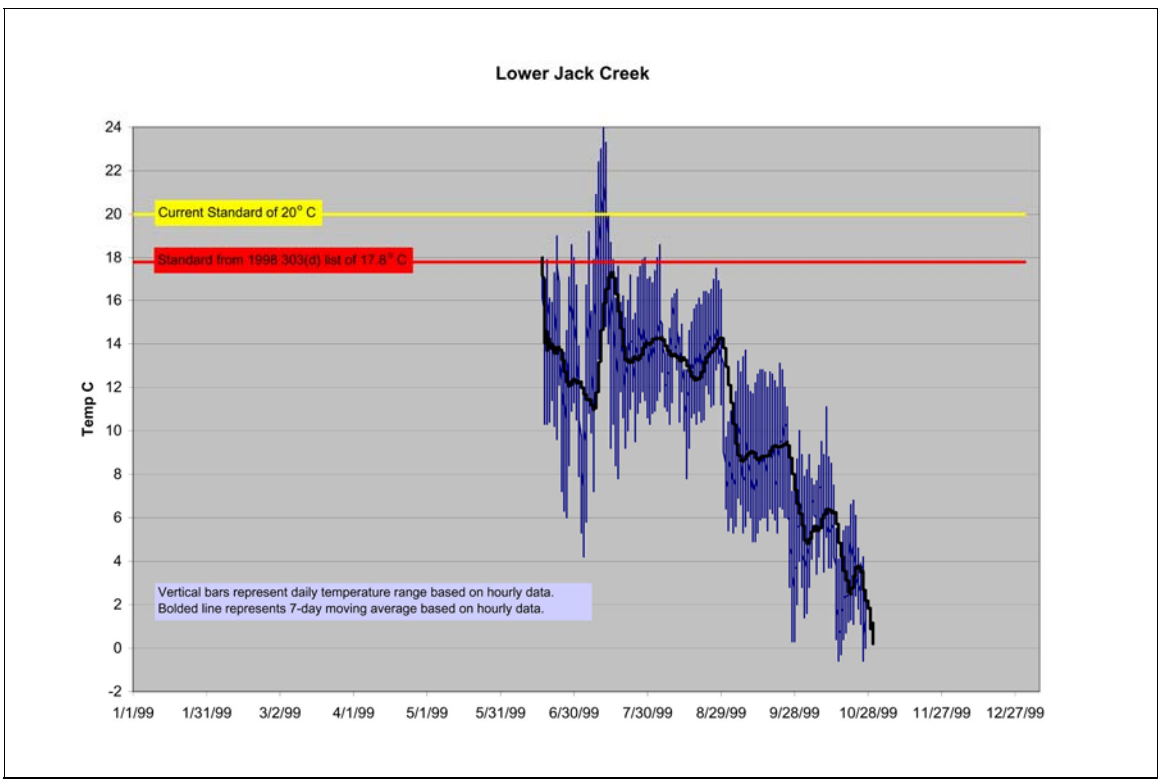


Figure 10-3. Temperature Graph for Jack Creek (Klamath Marsh/Jack Creek 5th-Field)

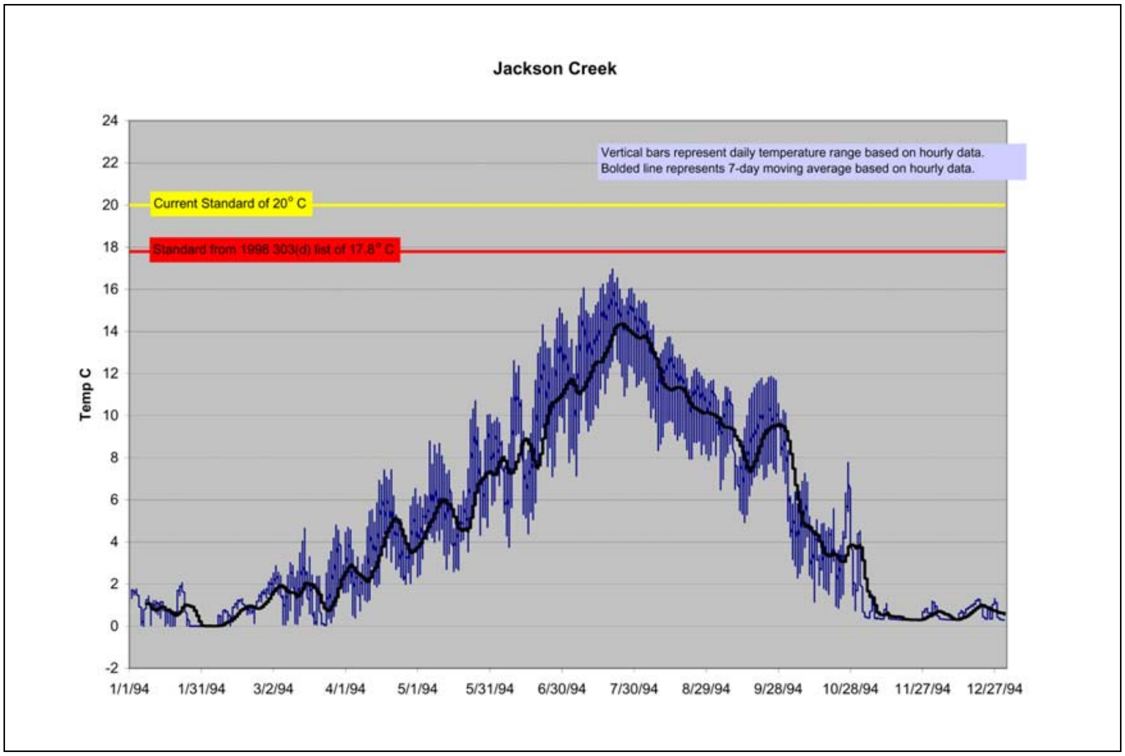


Figure 10-4. Temperature Graph for Jackson Creek (Williamson River Upstream of Klamath Marsh 5th-Field)

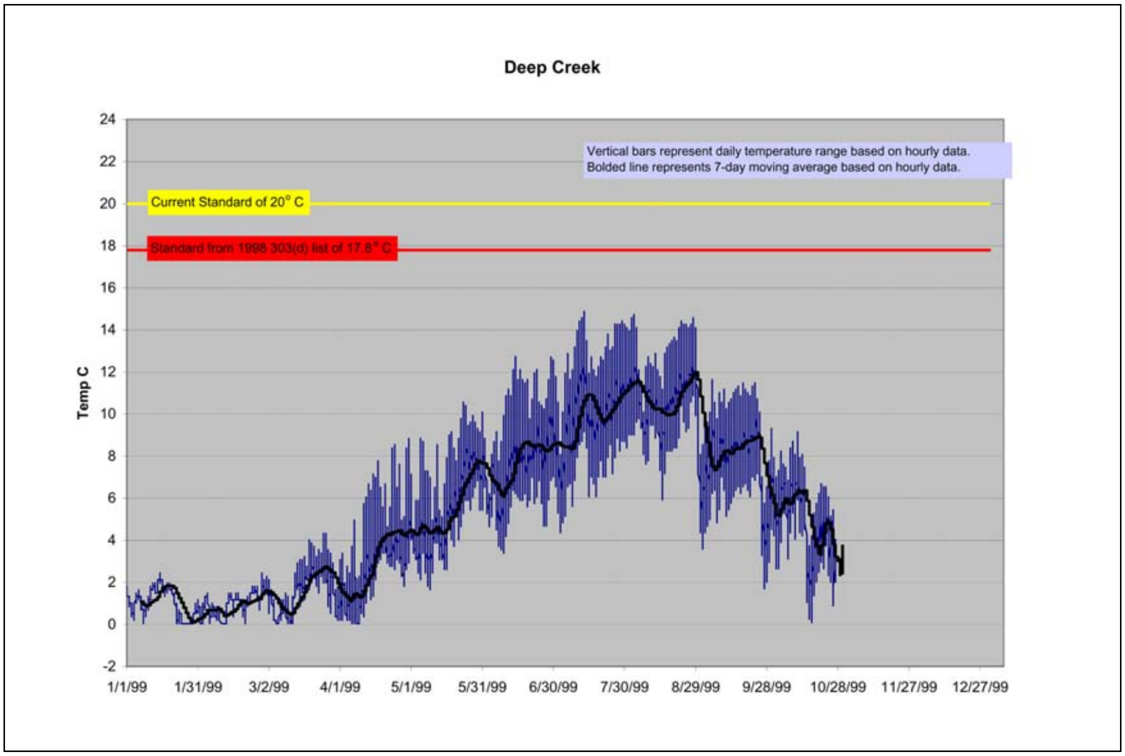


Figure 10-5. Temperature Graph for Deep Creek (Williamson River Upstream of Klamath Marsh 5th-Field)

Other Water Quality Parameters

USGS conducted synoptic measurements of water quality parameters in 1992 and 1993 for many of the tributary streams throughout the upper Williamson River subbasin (USGS 2004b). Orthophosphate, a readily available form of phosphorous for aquatic vegetation, typically ranged in concentration from less than 0.01 to 0.03 milligrams per liter (mg/l). Orthophosphate concentrations in Sand Creek (West) below the Sand Creek Ditch were as high as 0.04 mg/l. Big Springs Creek showed the highest orthophosphate concentrations recorded by the USGS, at 0.05 mg/l. Concentrations of 0.01 mg/l are known to support algal growth; however, a level of 0.08 to 0.10 mg/l is typically necessary to cause algal blooms (Dunne and Leopold 1978). Orthophosphate concentrations typical of natural waters in undisturbed forested basins range from 0.005 to 0.05 mg/l (Dunne and Leopold 1978). Upper Williamson River tributary streams appear to lie within this range.

Williamson River

Temperature

Temperature monitoring on the upper Williamson River mainstem shows a general pattern of cold water in the upper reaches of the Williamson River, with increasing temperatures as one moves downstream. This pattern is portrayed in the water temperature graphs in Figure 10-6 through Figure 10-8, which are based on the Winema NF data (USFS 2004). Cool water springs help to reduce temperatures, particularly at discrete locations along the river's length. The larger and more influential springs tend to be more prevalent upstream in the system than downstream in the system. Water diversions and impoundments tend to cause increased heating, the first by reducing the volume of water within the mainstem that needs to be heated, and the latter by spreading out and stagnating water, which allows for increased surface area and time for heating to occur. Specific examples of the effects of these features on river water temperature are provided below and are displayed in Figure 10-9 and Figure 10-10.

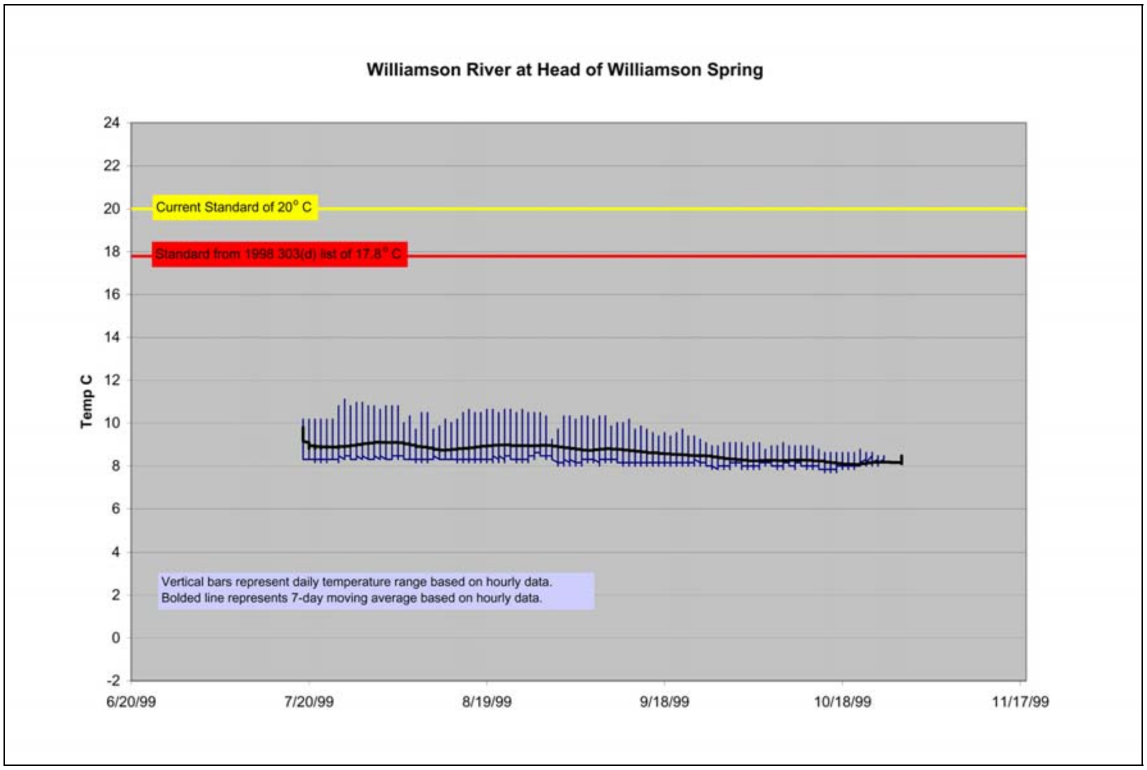


Figure 10-6. Temperature Graph for Williamson River at Head of Williamson Spring

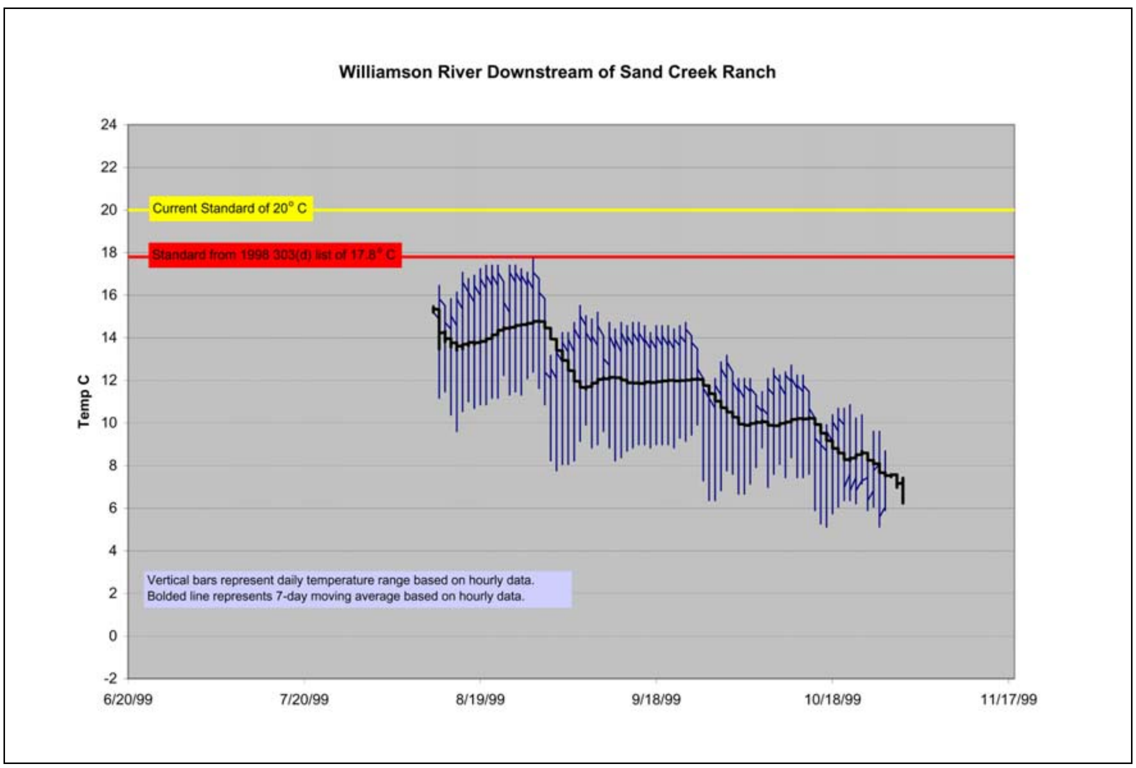


Figure 10-7. Temperature Graph for Williamson River Downstream of Sand Creek Ranch

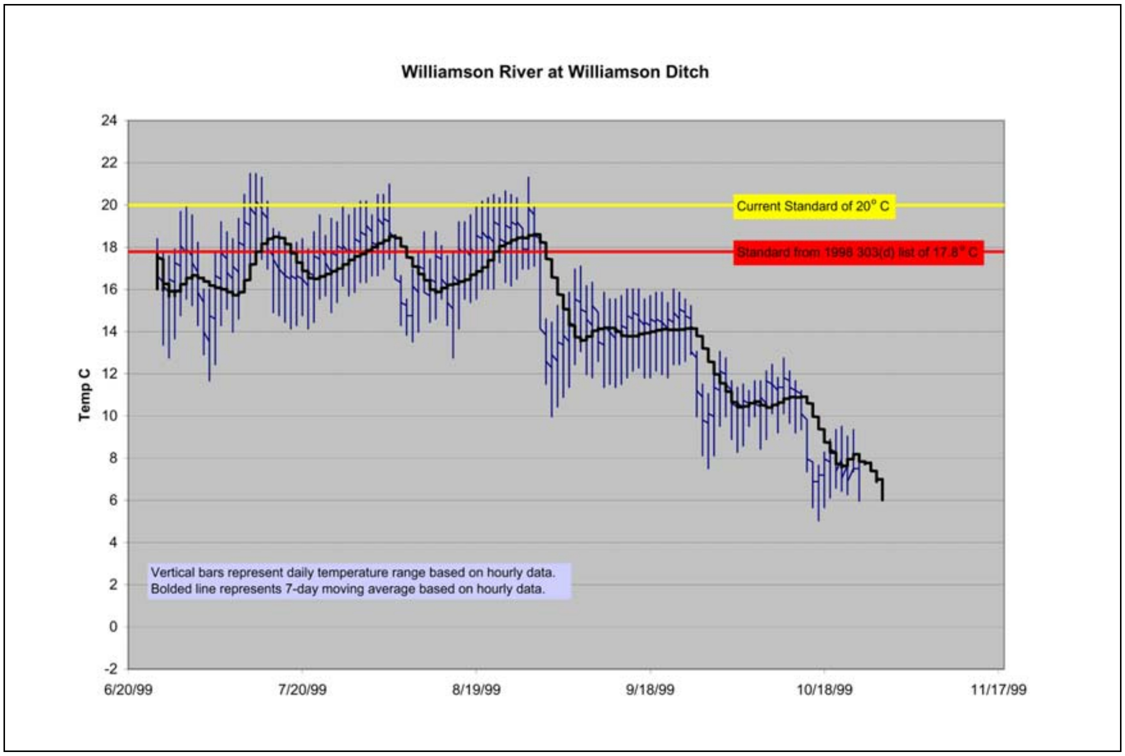
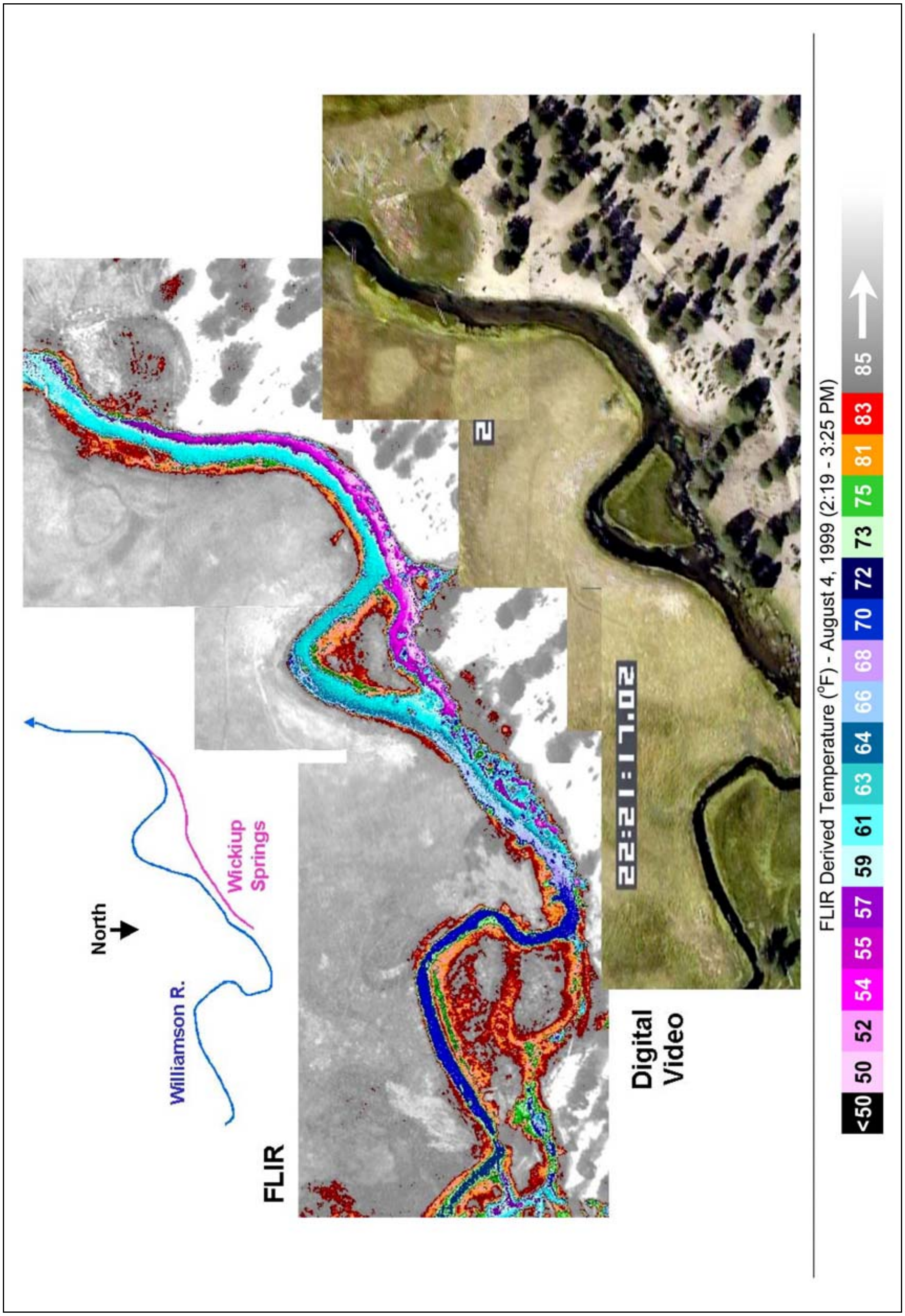


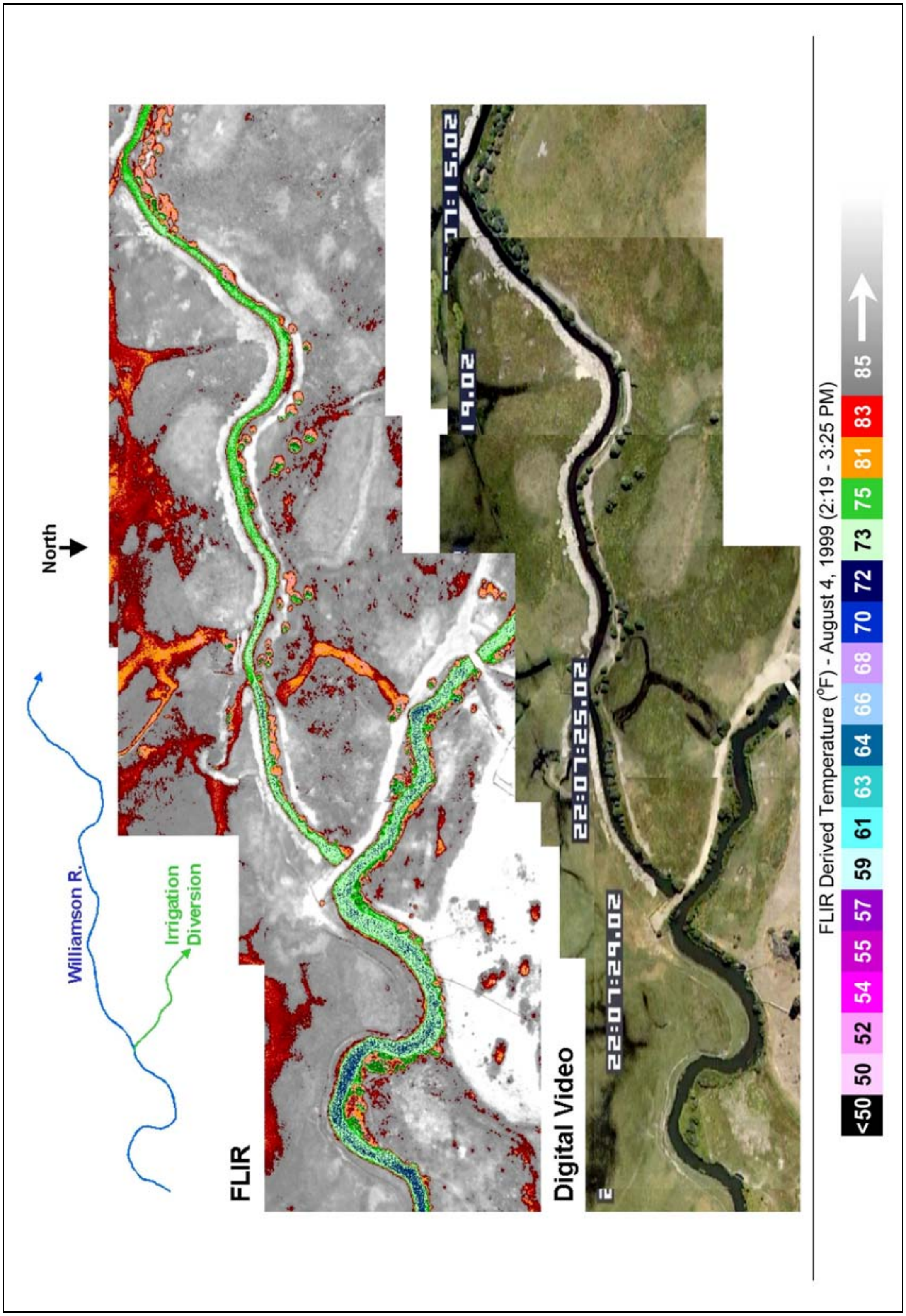
Figure 10-8. Temperature Graph for Williamson River at Williamson River Ditch

Several impoundments in the headwaters appear to result in rapid heating of the river; however, inputs from Williamson Spring and Wickiup Spring, both major sources of flow to the river, play an important role in cooling the river. The cooling influence of Wickiup Spring on river water temperatures is readily observed in Figure 10-9. This figure shows the Wickiup Spring area in both true color and with infrared imagery recorded by DEQ in an August 4, 1999, fly-over of the Williamson River with Forward Looking Infrared Radiometry (FLIR) remote sensing equipment (DEQ 2002b). Figure 10-10 shows the heating effect of a water diversion on the Williamson River located between River Mile (RM) 56.53 and 56.20.



DEQ 2002b

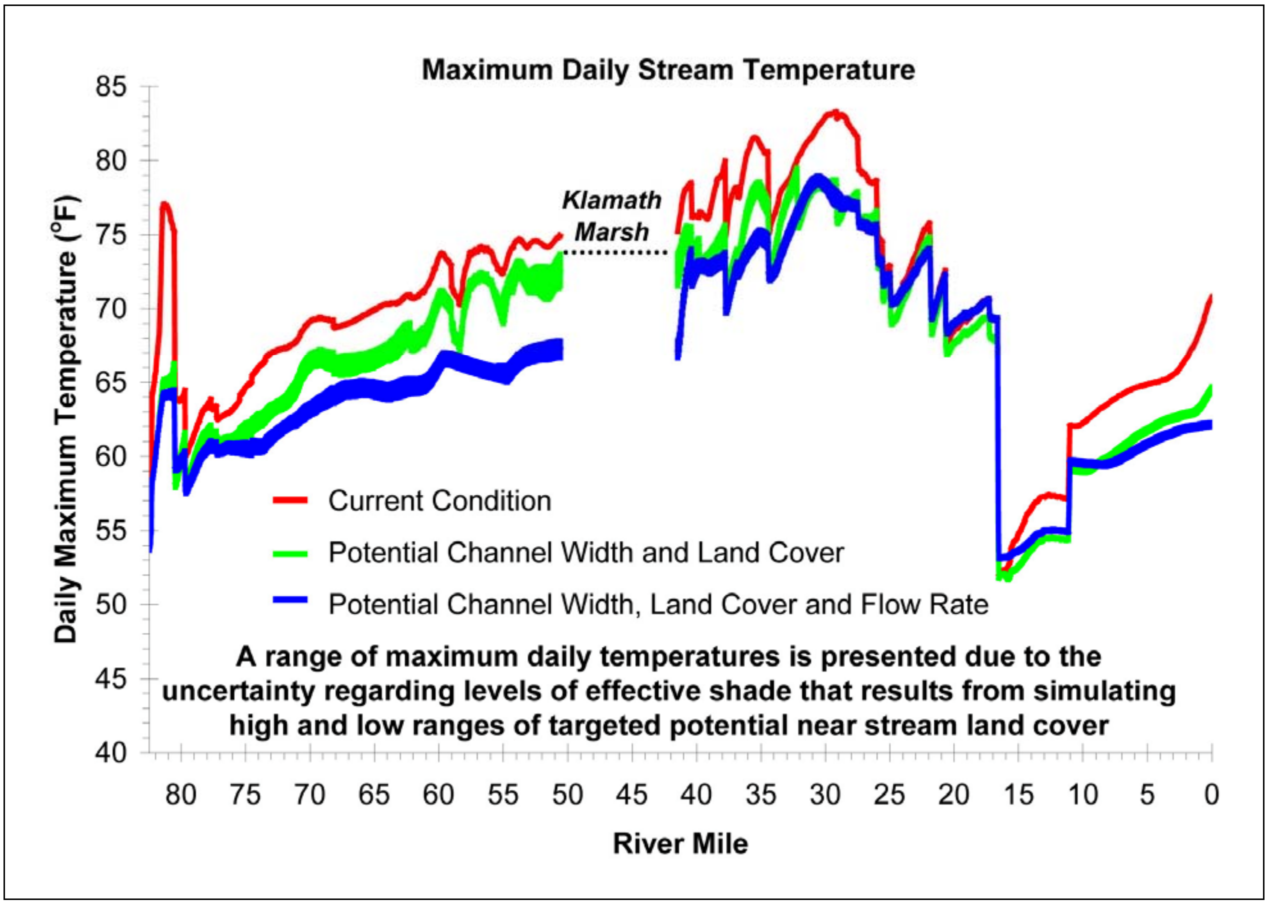
Figure 10-9. True Color and FLIR Imagery of Wickiup Spring Area Showing Cooling Effect on River Temperatures, River Miles 80.65 to 80.41



DEQ 2002b

Figure 10-10. True Color and FLIR Imagery of River Miles 80.65 to 80.41, Showing Water Diversion Effect on River Heating

Figure 10-11 provides a profile graph of the Williamson River from mouth to headwater, showing modeled DEQ FLIR derived maximum daily stream temperature along the length of the river (DEQ 2002a). DEQ also modeled the potential effects of restorative action scenarios on water temperature conditions. The first scenario included restorative actions to restore historic channel width (i.e., narrowing of channel) and restore historic land cover (i.e., reestablish riparian vegetation to full potential). The second scenario included actions taken in the first scenario plus restoration of river flow rates. The results of these modeled scenarios are also shown on. As evidenced by the modeling results, both scenarios have the potential to notably reduce average water temperature within the river, with the second scenario (restoration of channel width, land cover, and flow) having the greatest effect.



DEQ 2002a

Figure 10-11. Williamson River Profile Modeled Maximum Daily Temperatures Under Current Conditions and Under Two Restorative Action Scenarios

Other Water Quality Parameters

Orthophospate concentrations within the mainstem Williamson River ranged from 0.01 to 0.02 mg/l (USGS 2004b). As discussed in Section 5.1.2, these concentrations are well within accepted norms for natural systems.

Klamath Marsh

Klamath Marsh has experienced extensive alteration over the past century, including construction of levees, roads, ditching, and rerouting of natural flows. This has likely had an effect on the internal nutrient cycling and other water chemistry dynamics of the marsh. Unfortunately, no direct studies of internal marsh processes have been performed. Perdue et al (1981) conducted an investigation that looked at the chemical and biological impact of the marsh on the Williamson River. However, this investigation focused primarily on water chemistry of waters flowing in and then out of the marsh, but with little investigation of what happens inside the various regions and different aquatic habitats of the marsh itself. The following discussion is therefore general in nature and based primarily on generally accepted principles of aquatic chemistry.

Although temperature data were not available for the marsh, the Winema NF Watershed Analysis of the Upper Williamson Subbasin (USFS 1998) notes summertime marsh water temperatures reaching into the range of 25 to 30^{o} C (77 to 86^{o} F). This was likely the case in the past as well, even before significant human alteration of marsh hydrology. It is possible that some of the remaining deeper water areas may become thermally stratified in summer, which would result in a cooler layer of water occurring at depth. Additionally, inputs from springs, groundwater, and cold water tributaries should have the effect of creating localized areas of cooler water. With tributary diversions for irrigation, these cool water inputs may be reduced relative to historic conditions.

Nutrient cycling dynamics within the marsh are highly complex, with the marsh playing a notable role in altering the chemistry of in-flowing and out-flowing waters. Nutrients carried into the marsh from the Williamson River and other tributaries, in the form of simple organic and inorganic bioavailable compounds, are modified into organic humic substances (USFS 1998). These substances lock nutrients into their structure, making them relatively unavailable for aquatic primary production. Perdue et al (1981) found that nutrient concentrations in the Williamson River were lower at the downstream end of the marsh than the upstream end. Within the marsh itself, it was noted that spring inputs from Big Springs Creek appeared to have a localized effect of elevating nutrient levels where it enters the marsh (Perdue et al 1981). Humic substances can also have an antiseptic quality, which retards bacterial breakdown of organic matter, thus further limiting biological productivity due to the slower recycling of nutrients than would occur otherwise (Wetzel 1983). The present marsh is believed to contain a greater percentage of emergent marsh habitat (relative to open/deep water habitat) than is did under historic conditions. It is believed that emergent flora, which typically contain a higher lignin content, is a greater source of humic compounds than submerged hydrophytes (Wetzel

1983). Given this, it is possible that concentrations of humic compounds may be higher today than under historic conditions. If this is the case, in-water biological productivity may be lower today than under historic conditions. Tannin-stained waters also inhibit light penetration into the water column, further reducing photosynthesis by submerged aquatic vegetation and algae. Photo 10-1, taken at the Kirk bridge, provides an example of the dark, tannin-stained waters coming out of the marsh.

Photo 10-1. Photo of Tannin-Stained Water Flowing from Klamath Marsh, Taken at Kirk Bridge Crossing of Williamson River

Dissolved oxygen concentrations are often undersaturated in lakes highly stained with humic substances (Wetzel 1983). This is due in part to the chemical oxygen demand resulting from the breakdown of these substances (Wetzel 1983). Wind blowing across the surface of open water areas can help to re-oxygenate waters through improving the water circulation, which results in a greater volume of water that can interact with the atmosphere (i.e., increased potential for diffusion of oxygen from the atmosphere into the water column). These competing processes no doubt affect dissolved oxygen concentrations in waters of the Klamath Marsh. With the ratio of open water area to emergent marsh area much lower than believed to have been the case historically, reoxygenation of marsh waters through windblow is likely much less prominent than in the past. This may result in overall marsh water dissolved oxygen concentrations being lower in present time than they were historically.

Marsh outflows to the Williamson River (at Kirk Reef) cease during the summer months. This leaves a reach of the river approximately one-half mile long dry until springs and groundwater return flows back to the channel further downstream. This cessation of flows has a notable effect on transport of iron, total organic carbon, amino acids, and absorbance (related to aquatic humus concentration) to downstream reaches of the Williamson River (Perdue et al 1981). Concentrations of these substances in the Williamson River below Kirk Reef are notably lower during the summer months, when flows from the marsh no longer occur (Perdue et al 1981). Perdue et al (1981) noted a high correlation between the timing of the cessation of these flows with the onset of algal blooms in Upper Klamath Lake. The Williamson River is a major contributor of flows to Upper Klamath Lake, which experiences regular nuisance blooms caused by blue-green algae, particularly *Aphanizomenon flos-aquae*. Perdue et al (1981) appropriately noted that this correlation does not necessarily mean causation and that further research is needed to determine if the influx of humic-rich waters acts to control nuisance blooms of *Aphanizomenon flos-aquae*, or if this correlation is caused by other factors. Algal populations within the Williamson River itself are notably different upstream and downstream of the marsh, with total cell densities in the Williamson River upstream of the march being six times greater than downstream of the marsh (Perdue et al. 1981). Algal species composition changes as well.

Outstanding Resource Waters

The Outstanding Resource Waters policy is carried out by DEQ. This policy is governed under OAR 340-041-0004. This OAR states that "where existing high quality waters constitute an outstanding State or national resource such as those waters designated as extraordinary resource waters, or as critical habitat areas, the existing water quality and water quality values must be maintained and protected, and classified as Outstanding Resource Waters of Oregon." No Outstanding Resource Waters have been designated for the upper Williamson River subbasin (Loretta Pickerell, DEQ, pers. comm. 2004).

Hazardous Materials Review

An on-line search of the DEQ Environmental Cleanup Site Information (ECSI) database was conducted for the Upper Williamson Subbasin (DEQ404b). This search identified three registered hazardous material sites within the basin. These include the Cavenham Forest Industries Site, the former site of the Chemult Bulk Plant, and the USFWS Klamath Forest-Cow Dip Pit site. These sites are shown on Map 10-1. Details of the database search for these sites are provided in Table 10-4.

Table 10-4 DEQ Environmental Cleanup Site Information (ECSI) Database Search Results

Site Name: Cavenham Forest Industries **DEQ Site ID:** 606

Other Site Name: none

Contamination Information: Low-level PCB-contaminated sawdust and soil placed in shallow excavated depression west of mill site with DEQ approval. Covered with at least 1 foot of soil and stabilized with grass or native vegetation. PCB levels ranged from 6.8 to 10 ppm in soils, and 5.2 ppm in sawdust. Voluntary disclusure of contamination. Site was dropped from inventory as PCB concentration was 10ppm or less.

Site Name: Chemult Bulk Plant (former) **DEQ Site ID:** 2699

Other Site Name: Wirtz Union Oil Bulk Plant

Contamination Information: Site added to database in 2000 for tracking purposes; active bulk plant, site screening recommended in 2003. No contamination information available.

Site Name: US DOI FWS Klamath Forest –Cow Dip Pit **DEQ Site ID:** 2292

Other Site Name: USDOI FWS Klamath Forest NWR Toxaphene Cow Dip Pit

Contamination Information: Site is located on east side of Klamath Marsh near the intersection of Military Crossing Road and Silver Lake Highway. FWS personnel indicated that the site was last used in January of 1979 to treat cattle for an outbreak of scabies. Previously, the site had been used annually until 1976 from an unspecified year to treat cattle for pests. A mixture of water and toxaphene appears to have been used; however, DDT, DDT metabolites (DDE and DDD), and lindane were detected in several soil pits as well. Some groundwater contamination was noted to have occurred. Record of decision in 2002 approved remedial actions to include: removal of impacted soil to above 1ppm in soil from surface to 3 feet below ground surface (bgs) and the removal of impacted soil above 75 ppm from 3 feet to depth. Soil less than 75 ppm would be placed at depths below 3 feet and capped with 6 feet of clean fill. Remdial action was conducted in summer of 2002.

Discussion

Overall water quality conditions throughout the Upper Williamson sub-basin are good and do not limit beneficial uses. When viewed with respect to DEQ water temperature standards for streams with redband trout, the redband trout fishery of the Williamson River mainstem may be negatively affected by high water temperatures. However, anecdotal evidence suggests that there is a healthy sport fishery within the Williamson River. Nonetheless, improved temperature conditions could still result in an improvement of this beneficial use.

CONFIDENCE EVALUATION

Confidence in the water quality evaluation is moderate to high with respect to the parameter of concern (i.e., water temperature). Water temperature data is available for many of the Klamath Marsh tributary streams, including the Williamson River itself. Additionally, extensive modeling of the Williamson River mainstem was conducted by DEQ as part of the development of the TMDL and WQMP for the Upper Klamath Drainage basin. Since the basin does not appear to be suffering from major nutrient enrichment and related water quality impacts, it is assumed that nutrient data is sufficient for these streams as well.

RECOMMENDATIONS / DATA GAPS

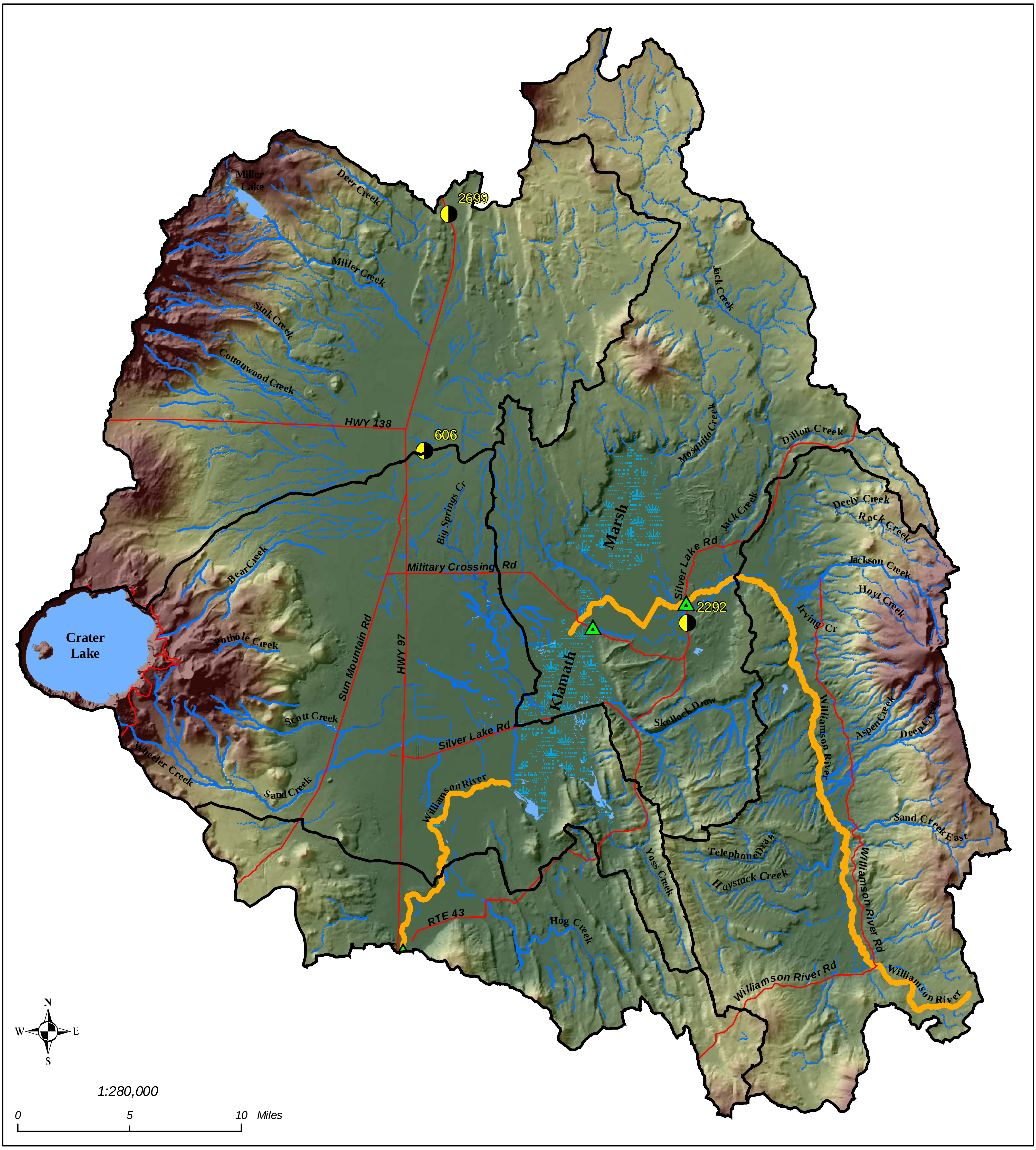
Data and research on internal marsh water quality and chemistry dynamics is lacking. Such research is highly recommended and will likely be needed for updating of the Upper Klamath Marsh Refuge Plan.

RESTORATION OPPORTUNITIES

As indicated by DEQ (DEQ 2002a), improvement of water temperature conditions on the Williamson River mainstem could take the form of restoration of riparian vegetation, channel form, and flow regimes. The following restoration opportunities are based on these three forms of restoration.

- Critical springs site protection plan(s) could be produced for each landowner who has a spring that provides important cold water flow inputs to the Williamson River mainstem. The goal would be protection of these direct flows to the river during critical periods.
- Exclosure fencing of riparian areas would allow riparian vegetation to reestablish. This would allow the river to begin to restore its channel form naturally by reducing stream bank erosion processes. Undercut banks would form, which would provide areas of cooler water refugia for redband during critically hot periods.
- Nutrient management plans for agricultural lands would help to prevent nutrient enrichment of waters from becoming a problem.
- Providing stock watering areas away from river would prevent direct release of animal excrement into river and eliminate trampling of riverbanks and associated vegetation.

LIST OF MAPS



Upper Williamson River Watershed Assessment

Map 10-1: Water Quality

Legend

- DEQ Hazmat site
- DEQ temperature monitoring station
- Water quality listed for temperature (1998)
- Perennial stream
- Non-perennial stream
- Major road
- Marsh
- 5th-field watershed boundary

Sources:
Water Quality and Hazmat -DEQ
Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)

DAVID EVANS AND ASSOCIATES INC.

August 13, 2004
n:/gis/kbef0001/arcmap/williamson_report/map10_1_water_quality.mxd

11 FISH AND FISH HABITAT ASSESSMENT

INTRODUCTION

The purpose of the fish and fish habitat assessment is to compile and evaluate available information about fish populations, distribution, habitat, and migration barriers. The following critical questions are addressed:

1. What fish species are documented in the subbasin? Are any of these currently state- or federally-listed as endangered or candidate species? Are there any fish species that historically occurred in the watershed which no longer occur there?
2. What is the distribution, relative abundance, and population status of salmonid species in the subbasin?
3. Which salmonid species are native to the subbasin, and which have been introduced?
4. Are there potential interactions between native and introduced species?
5. What is the condition of fish habitat in the subbasin according to existing habitat data?
6. Where are potential barriers to fish migration?

METHODS

The following data sources were reviewed to determine fish species presence and distribution within the study area and were used to prepare the fish distribution map (Map 11-1).

- Excel spreadsheet, dated May 5, 2004, prepared by ODFW in cooperation with others listing fish distribution within the Upper Klamath Basin (ODFW 2004a). This list covers streams that have been sampled through electroshocking or angling, and is noted as being incomplete. Distribution of redband trout in Jack and Jackson Creeks is based on Wendell Stout (1977) and is noted as possibly being based on professional opinion and not on documented occurrences. This spreadsheet was noted as being the most up-to-date source of information regarding fish distribution in the Upper Williamson at the time that this watershed assessment was being prepared (Neil Anderson, Winema NF, pers. comm. 2004; Roger Smith, ODFW, pers. comm. 2004).
- Oregon Department of Forestry (ODF) fish presence/absence maps (annotated USGS quadrangle maps) were available for portions of the watershed. Original copies were obtained directly from ODF, as well as transcribed copies provided by Timber Resource Services (TRS) (ODF/TRS date unknown). A total of 28 USGS quadrangle maps were obtained between these two sources, whereas 38 USGS quadrangle maps are located at least partially within the study area. Complete coverage was not possible because several maps were missing from ODF's files (Gress, ODF, pers. comm. 2004).

The analysis of fish habitat conditions relied on existing data and reports, data produced by other sections of this watershed assessment, several brief site visits, and communications with resource agency staff. Due to the scope of this assessment, most streams have not been visually surveyed and none of the streams were physically surveyed (i.e., extensive measurements taken); however, stream survey data was available from ODFW for Miller Creek, Evening Creek, and Jackson Creek.

Additional methodology is provided as needed in the following "Results" subsections.

RESULTS

Map 11-1 shows fish presence/absence and known species distribution within the study area. This figure was prepared by compiling information from the available hardcopy ODF fish presence/absence maps (ODF/TRS date unknown) and data from the recently-produced ODFW fish distribution spreadsheet. Table 11-1 provides a list of streams identified on Map 11-1 as containing fish.

Table 11-1. Streams/Waterbodies Mapped as Containing Fish

5^{th}-Field	Stream
West of Klamath Marsh	Sand Creek (West)
	Sand Creek Ditch
	Scott Creek
	Big Springs Creek
Northwest of Klamath Lake	Miller Lake
	Miller Creek
	Cottonwood Creek
	Sink Creek
	Deer Creek
Klamath Marsh/Jack Creek	Jack Creek
	Williamson River

5th-Field	Stream
Upstream of Klamath Marsh	Jackson Creek
	Deep Creek
	Williamson River
	Rock Creek
	Deely Creek
	Dillon Creek
	Knight Creek
	Irving Creek
	Aspen Creek
Downstream of Klamath Marsh	Williamson River

Table in Table 11-1 is based on available ODF maps, and ODFW data (ODFW 2004a). Other streams may contain fish, but were not explicitly noted as such by these data sources.

Table 11-2 provides a list of documented fish species for the upper Williamson River basin.

Table 11-2. Documented Fish Species Within the Upper Williamson River Basin

Native Species		Non-Native Species	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Redband Trout	*Oncorhynchus mykiss newberri*	Brown Trout	*Salmo trutta*)
Speckled Dace	*Rhinichthys osculus klamathensis*	Brook Trout	*Salvelinus fontinalis*
Blue Chub	*Gila coerulea*	Introduced Rainbow Trout	*Oncorhynchus mykiss irideus*
Tui Chub	*Gila bicolor*	Kokanee Salmon	*Oncorhynchus nerka kennerlyi*
Klamath Largescale Sucker	*Catostomus Snyderi*	Brown Bullhead	*Ameirus nebulosus*
Miller Lake Lamprey	*Lampetra minima*	Fathead Minnow	*Pimephales promelas*
Other lamprey species	*Lampetra* spp.		

Based on available ODFW information

Sensitive, Threatened and Endangered Fish Species

Under the Federal Endangered Species Act (ESA), the term ``threatened species" means any species (or subspecies or distinct population segment for vertebrate organisms) that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range (Federal Register 2000). The term ``endangered species" means any species that is in danger of extinction throughout all or a significant portion of its range (Federal Register 2000). The principal considerations in the determination of whether a species warrants listing are the threats that currently confront the species and the likelihood that the species will persist in the foreseeable future. Thus, listing of a species may be warranted when the species still occupies much of its historic range but confronts significant, widespread threats (Federal Register 2000). In contrast, if not confronted by significant threats, a species occupying only a small portion of its historic range may be considered to be neither threatened nor endangered (Federal Register 2000).

Currently, there are no proposed, candidate, or listed threatened or endangered fish species within the upper Williamson River basin. In March of 2000, a petition to list Great Basin redband trout as threatened or endangered was determined to be not warranted (Federal Register 2000). Great Basin redband trout are a distinct population segment of redband trout, separate from redband trout within the upper Williamson River basin. No similar petition to list has occurred for the redband of the upper Williamson River basin.

Species Profiles

Focal Species

Redband Trout

Oregon basin redband trout occupy remnant streams in seven Pleistocene lake beds in Oregon, including the Klamath basin (i.e. Lake Modoc) (ODFW 2004b). Desiccation of the prehistoric lakes resulted in the formation of stream/marsh/lake systems, which redband trout adapted to by establishing adfluvial life histories. The fish would migrate from the highly productive rearing areas in the lakes and marshes to spawning areas in streams (ODFW 2004b). During severe drought episodes, which could cause complete desiccation of the lakes and marshes, streams provided refuge for populations that would later return to the lakes and marshes when they refilled (ODFW 2004b). This general description of Oregon basin redband trout is likely what historically occurred within the upper Williamson River system, including Klamath Marsh and its tributary streams. The Klamath basin is the only one of the seven former Pleistocene lake bed systems that has an outlet to the ocean. The other six systems are closed basins. Redband within these closed basins are referred to as “Great Basin redband trout.” Redband trout of the upper Williamson River are referred to as the “upper Williamson River group”.

The upper Williamson River group redband trout shows ancient redband morphologies and has unique allozyme characters (i.e., unique enzyme form due to differing amino acid sequence) (ODFW 2004b). This suggests that it may be a remnant from the original Lake Modoc redband trout (Buchanan and Currens unpublished data as cited in ODFW 2004b) and may constitute a unique subspecies (ODFW 2004b). The upper Williamson River group is distinguished from the Klamath Lake group (i.e. redband located below Kirk Reef), as it is not resistant to the disease *Ceratomyxa. shasta*, which is found in the lower Williamson River.

Redband trout within the upper Williamson River spawn in the late winter through early spring (Neil Anderson pers. comm. 2004; Weyerhaeuser Company 1996). Females typically select redd sites in gravel substrates at the head of a riffle or downstream edge of a pool (Orcutt et al. 1968 as cited in Weyerhaeuser Company 1996). Hatching of fry occurs within 30 to 40 days and is partly dependent on water temperature (Scott and Crossman 1973 as cited in Weyerhaeuser Company 1996). The fry emerge from the gravels within approximately two weeks, where they then stay near stream margins through the summer and over winter in shallow areas with good cover (Weyerhaeuser Company 1996). Following the first winter, juveniles move to deeper and faster water as they grow (Everest and Chapman 1969 as cited in Weyerhaeuser Company 1996). Following the second winter they seek larger pools and are typically reproductively mature by the following spring (Holton 1953 as cited in Weyerhaeuser Company 1996). Adult redband prefer water temperatures between 12.8 and 18.3^{o} C (55 and 65^{o} F) (Cherry et al. 1977 as cited in Weyerhaeuser Company 1996). Growth rate slows above 20.0^{o} C (68^{o} F) and is believed to stop at 25.0^{o} C (77^{o} F) (Hokanson et al 1977 as cited in Weyerhaeuser Company 1996). Rodnick et al (2003) noted that, for Great Basin redband trout, adults (large individuals) were more susceptible to the negative effects of elevated temperature than smaller redband trout. This may be the case for the upper Williamson River group of redband as well. Weyerhaeuser Company (1996) notes that redband may use available tributary streams in which gradients are up to four percent. This conclusion was based on observations of redband presence in Deep Creek, a tributary of the upper Williamson River.

Miller Lake Lamprey

The following discussion of the Miller Lake lamprey is a summary of an ODFW published report, *Oregon Lampreys: Natural History Status and Problem Analysis* (Kastow 2002). Direct citations of the Kastow (2002) report are not provided below, as this was the primary document source for the summary below; however, citations provided by Kastow are noted.

The Miller Lake lamprey was previously believed to be endemic to the Miller Lake subbasin. Historically, the only other fish present in Miller Lake is believed to have been the tui chub, which acted as a host species to the parasitic adult form of Miller Lake lamprey (Kan 1975 and Lee et al 1980 from Kastow 2002). Both the lamprey and tui chub were intentionally extirpated from Miller Lake through chemical treatment with toxaphene by ODFW in 1958. This was done because the lamprey were scaring trout that had been released into the lake, which resulted in complaints by fisherman. The species was declared extinct in 1973 by Bond and Kan (1973 from Kastow 2002), only to be rediscovered in the 1990s in separate incidences by Oregon State University and the USFS. The species was soon after declared extant (still in existence) with an expanded range that covers the Miller Lake basin, Upper Klamath Marsh, the Williamson River above the marsh, Sycan Marsh, and the Sycan River.

Life history of lampreys tends to be generalized across all species due to a lack of species specific information (Potter 1980; Moore and Mallatt 1980; both from Kastow 2002). Lamprey eggs are deposited in redds (spawning nests) and are then covered with sand and gravel. The egg incubation period lasts between ten to twenty days and may be influenced by temperature and perhaps the individual species of lamprey. Larva spend roughly one week to a month in the redd after hatching, after which they leave the redd at night and migrate downstream to areas with fine silt deposits and a mild current. They then burrow into the silt and survive as filter feeders, feeding on algae, from between three to seven years. The best spawning grounds tend to be riffle/gravel areas in close proximity to pools or other silt deposits. At this stage of their life they are referred to as ammocoetes. The ammocoetes will gradually move downstream seeking courser sand and silt substrates and deeper water as they grow.

Miller Lake lamprey metamorphose into adults in the fall. A distinguishing feature of the Miller Lake lamprey is that unlike other parasitic lampreys, Miller Lake lamprey adults are smaller than late-stage larva (ammocoetes). At the time of metamorphosis into the adult phase, lamprey were observed to be approximately 14 to 15 centimeters (cm) long. By the time they were ready to spawn they were only approximately 9 to 11 cm (Bond and Kan 1973, Kan 1975, Lorion et al 2000, all from Kastow 2002). Miller Lake lamprey are thought to be scavengers and cannibalistic, eating whatever is available. The parasitic adult phase lasts only three to four months during the winter, with spawning occurring in spring. According to Kan (1975 from Kastow 2002), Miller Lake lamprey were primarily a lacustrine species (lake dwelling) with lentic (still water) spawning and ammocoetes rearing in the lake. However, adfluvial forms (migration between lakes and streams) also used Miller Creek. Lamprey are generally believed to die soon after spawning; however, several researchers have noted observing out-migration after spawning of some anadromous lamprey species.

Other Species

Brook, Brown, and Introduced Rainbow Trout (all Non-Native)

Brook trout prefer clear, cool, well-oxygenated water. They are found in creeks, lakes, and small- to medium-size rivers. Brook trout feed on a wide range of organisms, including worms, leeches, crustaceans, insects, mollusks, fishes, and amphibians (Fishbase 2004). Introduced fish in California have been documented to reach 15 years of age (Fishbase 2004).

Brown trout prefer cold, well-oxygenated waters. There tolerance limits are lower than that of rainbow trout. Brown trout favor large streams in mountainous areas with adequate cover in the form of submerged rocks, undercut banks, and overhanging vegetation. They feed on aquatic and terrestrial insects, mollusks, crustaceans, and small fish. The fish mature in 3 to 4 years. Reproduction takes place in rivers, with the female producing approximately 10,000 eggs (Fishbase 2004).

Rainbow trout prefer moderate- to fast-flowing, well-oxygenated water for breeding, but also occur in cold lakes (Fishbase 2004). Adults feed on aquatic and terrestrial insects, mollusks, crustaceans, fish eggs, minnows, and other small fishes (including other trout). The young feed primarily on zooplankton (Fishbase 2004).

Kokanee Salmon (Non-Native)

Kokanee within the Upper Williamson Basin are a non-native stocked species. Kokanee salmon are the landlocked form of sockeye salmon (*Oncorhynchus nerka*) and are confined to lake-stream systems (Fishbase 2004). Spawning may occur along lake shorelines or in stream gravels, with fry migrating to lake environments soon after emergence (ODFW 2004c). The life span of kokanee ranges from 2 to 7 years, depending on the individual stock, with most of that time spent in lake. They feed mostly on plankton, but will also feed on insects and bottom organisms (Fishbase 2004).

Tui Chub (Native)

Tui chub present a very complex and widespread assemblage of subspecies throughout the western states of Washington, Oregon, Nevada, California, and Idaho, occurring in the Columbia and Klamath River systems as well as in the Lahontan, Catlow, and other inland basins (ODFW 2004d). At least 13 subspecies are known, 8 of which occur in Oregon. The subspecies found in the Klamath Basin is *Gila bicolor bicolor*. Tui chub inhabit lakes and quiet, vegetated, mud- or sand-bottomed pools of headwaters, creeks, and small to large rivers (Fishbase 2004).

Blue Chub (Native)

Blue chub are found in rocky pools of creeks and small to large rivers, as well as rocky shores of lakes and impoundments (Fishbase 2004).

Speckled Dace (Native)

The speckled dace is a widespread species native to all major western river drainages from the Columbia River to the Colorado River and south to Mexico (ODFW 2004e). The speckled dace inhabits rocky riffles, runs, and pools of headwater streams, creeks and small to medium rivers (Fishbase 2004). It is rarely found in lakes.

Klamath Largescale Sucker (Native)

The Klamath largescale sucker inhabits lakes, impoundments, and rocky pools, and runs of creeks and small rivers (Fishbase 2004).

Brown Bullhead (Non-Native)

Brow bullhead is native to watersheds of the Atlantic and Gulf Coast states (Pennsylvania Fish and Boat Commission [PFBC] 2004), but is an introduced species within the upper Williamson watershed. Brown bullhead inhabit several habitat types, but are found mostly in ponds and bays of larger lakes, and in slow-moving sections and pools of streams (PFBC 2004). They are bottom-dwellers and are typically found over soft mud or muck in areas with submerged aquatic vegetation (PFBC 2004). Brow bullhead are tolerant of warm water temperatures, high carbon dioxide and low oxygen concentrations, and levels of pollution that other fish often cannot tolerate (PFBC 2004).

Fathead Minnow (Non-Native)

Fathead minnows are a hardy species that can tolerate a wide range of environments from clear water to cloudy water, and extremes of pH and low oxygen levels (PFBC 2004). They prefer slow-moving streams and still water (PFBC 2004).

Interactions Between Native and Non-Native Trout Species

Interactions between native redband trout and non-native trout species could potentially occur through competition for resources, predation between species (particularly adult predation of juveniles), and interbreeding between native and non-native stocks. These potential interactions are discussed below.

Trout are opportunistic feeders that consume a wide variety of food types, preying on organisms that are most available at the time (Behnke 1992). It is only when more than one species of trout are placed together in the same location that genetically based feeding tendencies become apparent, with each species favoring a particular niche (Trojnar and Behnke 1974 from Behnke 1992). By partitioning into different feeding niches, such as riffle versus pool or daytime feeding versus nighttime feeding, competition for food resources is minimized (Behnke 1992). Brook, brown, and redband trout currently coexist in the Williamson River mainstem. The fact that redband populations within the mainstem are healthy is suggestive that potential competition between these species does not occur at a level that negatively affects the overall health of any one species (Neil Anderson pers. comm. 2004; Roger Smith pers. comm. 2004). This is not to say that the overall species mass of any one species wouldn't be greater, if the other species were not present.

Brook trout and redband trout spawn at different times of the year, with brook trout spawning in the early fall (September through October) and redband spawning in winter (December through February) (Neil Anderson pers. comm. 2004). Therefore, competition for spawning sites between these two species is likely to be negligible, if it exists at all (Neil Anderson, pers. comm. 2004; Roger Smith pers. comm. 2004).

With the exception of Miller Lake, which is hydrologically isolated from other parts of the basin, non-native rainbow trout are not stocked in the upper Williamson River basin (Roger Smith pers. comm. 2004). According to ODFW Fish Biologist Roger Smith (pers. comm. 2004) there is little to no evidence to suggest that the upper Williamson River system had historically been stocked with non-native rainbow trout. A study by Tim Currens showed no genetic markers of introduced stock in the present population of redband trout (Roger Smith pers. comm. 2004). In contrast, Great Basin redband trout have been noted as being impacted by interbreeding with introduced hatchery rainbow trout (*Oncorhynchus mykiss irideus*) (ODFW 2004b). This is evidenced by both meristic (i.e., body part variation) and biochemical evidence that such interbreeding has occurred (ODFW 2004b). Coastal rainbow hatchery fish fair poorly in the Great Basin due to the warm and often alkali waters that occur there (ODFW 2004b). This gives the native redband populations a competitive advantage, as they are better adapted to such conditions. When interbreeding occurs, this fitness advantage may be impacted, reducing the overall fitness of the redband fishery (ODFW 2004b).

Fish Habitat Conditions

This section provides a general description of fish habitat conditions within the 5th-field watersheds, which have been grouped by geologic characteristics and landscape position for those areas that contain similar overall stream conditions. The West of Klamath Marsh and Northwest of Klamath Lake watersheds have been grouped together because both subbasins flow off the east side of the Cascades. Jack Creek was broken out from the Klamath Marsh/Jack Creek subbasin and combined with the Upstream of Klamath Marsh watershed because Jack Creek is similar in nature to some of the other tributaries of the Williamson River and because the marsh represents a very distinct habitat type.

West of Klamath Marsh and Northwest of Klamath Marsh 5th-Fields

The West of Klamath Marsh and Northwest of Klamath Marsh watersheds drain the east side of the Cascade Mountains (i.e., west side of the upper Williamson River sub-basin). Streams in these watersheds are typified by moderate to steep headwaters that have carved their way through thick layers of pyroclastic flow deposits produced by the eruption of Mount Mazama (Photo 11-1). The stream courses follow old glaciated valleys that existed prior to the eruption of Mount Mazama and were then filled by the Mazama eruption (USFS 1998). As described previously, the thick ash deposits characterized by high infiltration rates results in a stream system heavily influenced by subsurface flows and ground water inputs. This helps to regulate flows and provide for cool water temperatures throughout the year, particularly in the upper and mid-reaches of these stream systems (USFS 1998). The geology also results in active channels with highly abrasive pumice substrates. In general, middle to upper reaches are moderate to steep and have a greater quantity of gravel and larger substrate than lower stream reaches (USFS 1998). Mid- to upper reach habitat is characterized by pool riffle systems, with large wood and riparian vegetation contributing to channel form (USFS 1998). Lower reaches are low-gradient systems dominated by ash and pumice substrates, with riparian vegetation contributing to channel form (USFS 1998). Stream survey data is limited for these subbasins. However, a generalized characterization for streams within these subbasins can be extrapolated from existing available data. In general, streams in these watersheds are functioning close to their potential (USFS 1998, , personal observations by the author of Sand Creek), however, some drainages may still be recovering from past land management activities (i.e. logging, road construction, grazing). Streams are generally clear, cool, and well shaded by ponderosa pine and mixed conifer forest (USFS

1998). The abrasive pumice sediments and low concentrations of limiting nutrients result in these streams being relatively biologically unproductive (USFS 1998).

Several of the lowest stream reaches, those that make it to the flat bottomland of the sub-basin (i.e., Sand and Scott Creeks), have been affected by human interactions over roughly the past century, with the result likely being a decrease in fish habitat quality. Factors affecting this decrease in habitat quality include loss of riparian cover, channelization, and diversion of stream flows.

ODFW conducted a stream survey for Miller and Evening Creeks in October-November of 1991 and recorded the data in GIS format (ODFW 1999). Evening Creek is a tributary to Miller Lake, and Miller Lake outflows to Miller Creek. This creek system is located in the Northwest of Klamath Lake subbasin. The ODFW stream survey data was compared to ODFW habitat benchmarks provided in *Appendix IX-A* of the *Oregon Watershed Assessment Manual* (WPN 1999). These benchmarks are included in Appendix C of this watershed assessment. Summary results for Evening and Miller Creeks are provided in Table 11-3 and Table 11-4 respectively. Habitat conditons for both creeks rated fairly low overall when compared to the ODFW benchmarks. Reach one of Evening Creek rated the highest; however, even this reach only contained 4 out of 9 benchmarks rated as desirable. In general, these creeks were noted as undesirable relative to the benchmarks due to low pool frequency values and a high percentage of fines (i.e., sand, silt, and organics) in riffle complexes. Four out of the five reaches of Miller Creek that contained available data were noted as having undesirably low percentage shade values. One reach of Evening Creek and two reaches of Miller Creek were also noted as having a low volume of large woody debris. The easily eroded native pumice soils and past logging activity likely play a role in these low benchmark scores. Desirable benchmarks met included the percent gravel content of riffle complexes, particularly in Evening Creek, and the quantity and volume of large woody debris in certain reaches of both creeks.

Table 11-3. Comparison of ODFW Survey Data (ODFW 1999) for Evening Creek with ODFW Benchmarks

			Comparison to ODFW Benchmarks		
Reach #	**Length (ft)**	**Percent of Total Stream Length**	**Undesirable (X out of 9)**	**In-between (X out of 9)**	**Desirable (X out of 9)**
1	2,552	71	2	3	4
2	1,064	29	4	3	2

Table 11-4 Comparison of ODFW Survey Data (ODFW 1999) for Miller Creek with ODFW Benchmarks

			Comparison to ODFW Benchmarks		
Reach #	**Length (ft)**	**Percent of Total Stream Length**	**Undesirable (X out of 9)**	**In-between (X out of 9)**	**Desirable (X out of 9)**
1	15,399	27	No data	No data	No data
2	6,563	11	3	3	3
3	8,295	14	4	2	3
4	10,286	18	7	1	1
5	9,937	17	7	1	1
6	7,521	13	3	4	2

Sand Creek, which is located in the West of Klamath Marsh subbasin, was visually surveyed (non-intensive) by the author at three locations to document characteristics of representative upper, middle, and lower stream reaches. This characterization is described in the following sequence of photos.

Photo 11-1. Upper Reach of Sand Creek

Photo 11-1 (left photo) is representative of an upper reach of Sand Creek, and was taken near a trail head to Crater Lake National Park at the terminus of Road 2304. The photo provides a good example of how the creek has carved its way down through the thick Mazama ash and pyroclastic flow deposits. The steep canyon walls help to shade the creek, further helping to keep stream temperatures cool. Biological production is likely low in this section of creek due to the naturally low amount of adjacent riparian vegetation that would normally provide a source of organic matter to the stream. This is a result of the steep and easily eroded canyon walls and narrow canyon bottom. Heavy shading of the creek may also reduce in-stream primary production. Photo 11-1 (right photo) is located in close proximity to Photo 11-1 (left photo) and shows the thick layer of Mazama ash and pyroclastic deposits present in this portion of the watershed. Sand Creek has carved its way through these deposits.

Photo 11-2: Road 2304 Crossing of Sand Creek

Photo 11-2 was taken at the Road 2304 crossing of Sand Creek, a representative middle reach for this creek. The riparian corridor is dominated by aspen, which contribute large wood for channel forming processes, as well as cover for aquatic organisms. Leaf fall from the hardwood-dominated corridor provides an important source of readily decomposable organic matter that helps feed the food chain in this reach of the creek. Stable but undercut banks were noted and gravel spawning substrate was abundant. The water was clear, cold, and swift-flowing.

Photo 11-3: Lower Reach of Sand Creek

Photo 11-3 shows a lower reach of Sand Creek on the downstream side of Highway 97. The photo shows a partially intact, although highly altered, riparian zone. The creek appears to have been straightened. Despite these alterations this creek segment contained undercut banks, clear and cool water, and abundant gravel substrates. However, further downstream of this photo Sand Creek has been modified for irrigation purposes.

Upstream of Klamath Marsh Including Jack Creek

The tributary streams of the Upstream of Klamath Marsh watershed are somewhat similar to those of the West of Klamath Marsh and Northwest of Klamath Marsh watersheds; however, the former watershed streams received small amounts of air-laid ash from Mount Mazama, whereas the latter received thicker layers of ash and pyroclastic flow material (USFS 1998). The tributary streams upstream of Klamath Marsh are characterized by well-defined channels carved down to parent basalt and dacite (USFS 1998). Exposure of parent material rock likely provides a material source for spawning gravels, with deposition occurring in the more moderately flowing areas. Abundant spawning habitat has been noted for Jackson Creek (Neil Anderson pers. comm.). Channel gradients are moderate. Stream flows are dominated by springs and shading is moderate to high, which results in maintenance of cool water temperatures. Channel segments are more stable and abrasive sediments are less abundant than in the subbasins located on the east side of the Cascades (USFS 1998). These conditions allow for greater levels of benthic primary production relative to the Cascade streams; however, due to low concentrations of critical nutrients, these streams tend to be only low to moderate in biological productivity (USFS 1998). Deep Creek is currently the only tributary that maintains a year-round surface flow connection with the mainstem (USFS 1998); however, historically, several of these streams may have had seasonal surface-water connections with the Williamson River mainstem. In the current day, connections to the mainstem are likely hindered by the long term drought the area is experiencing, as well as a result of water diversions, potential changes in mainstem river morphology resulting in disassociation of the river from the floodplain (USFS 1998), and potential changes in overall basin hydrology resulting from changes in forest management practices.

ODFW conducted a stream survey for Jackson Creek in October-November of 1991 and recorded the data in GIS format (ODFW 1999). The ODFW stream survey data was compared to ODFW habitat benchmarks (ODFW benchmarks provided in Appendix C). Summary results are provided in Table 11-5. Relative to the ODFW benchmarks, most reaches of Jackson Creek rated as moderate. Two out of five reaches contained an equal number of benchmarks rated as undesirable and desirable. Another two reaches had more desirable benchmarks than undesirable benchmarks. Only one reach contained more undesirable benchmarks than desirable. As was the case for Miller and Evening Creeks, the benchmark most commonly identified as rating as undesirable was the percent sand, silt, and organics in riffle complexes. Interestingly, the benchmark most commonly identified as desirable was the percent gravel content of riffle complexes. As with elsewhere in the basin, the erodable pumice soils of the basin may be the cause for the high percentage of sand and silt found in Jackson Creek. It is uncertain how much of this is a result of natural erosion processes and how much is a result of past land management practices (i.e. logging, road development, grazing, etc.). Benchmarks generally rated as desirable included shading and the quantity and volume of large woody debris.

Table 11-5. Comparison of ODFW Survey Data (ODFW 1999) for Jackson Creek with ODFW Benchmarks

			Comparison to ODFW Benchmarks		
Reach #	**Length (ft)**	**Percent of Total Stream Length**	**Undesirable (# out of 9)**	**In-between (# out of 9)**	**Desirable (# out of 9)**
1	3,080	0.19	5	3	1
2	4,251	0.27	3	3	3
3	1,156	0.10	1	4	4
4	3,249	0.21	3	3	3
5	3,709	0.23	1	4	4

A brief visual assessment was conducted at single points along Jackson and Jack Creeks. Results are described in the following sequence of photos and photo captions.

Photo 11-4. Middle Reach of Jackson Creek

Photo 11-4 is a photo of a middle reach of Jackson Creek taken near the Jackson Creek campground adjacent to Road 49. The creek contained moderately swift-flowing cold water. Bottom sediments consisted of sand and silt, with limited gravel and cobbles.

The creek runs through a wet meadow area with a narrow band of alder and aspen growing along each bank of the creek.

Photo 11-5. Middle Reach of Jack Creek

Photo 11-5 is a photo of a middle reach of the Jack Creek riparian zone taken at the Silver Lake Road crossing. Jack Creek is comprised of a narrow channel that runs through a wet meadow riparian community, with a narrow band of willows growing along the creek banks. The creek channel is not visible in this photo.

Williamson River Mainstem

The Williamson River mainstem is considered the most productive stream in the upper Williamson River subbasin (USFS 1998). The stream gradient is low, and substrates are made up almost entirely of pumice sand. Spawning substrates are limited to a few locations, often near springs (Neil Anderson pers. comm. 2004). The primary spawning area is an approximately 1,500-foot reach of river between the mouth of Haystack Draw (Sand Creek Reef) and the mouth of Sand Creek (east) (USFS 1998). Secondary spawning sites are located at the mouth of Deep Creek, near Rocky Ford, and at Wickiup Springs (USFS 1998). Some spawning habitat may also be present in Deep Creek itself (USFS 1998) (Weyerhaeuser Company 1996). Redband often line up in queue waiting for their opportunity to spawn at these sites (Neil Anderson pers. comm. 2004). Despite limited spawning habitat, recruitment appears sufficient to fully stock all available functional habitat (USFS 1998). Riparian vegetation capable of providing shade is typically lacking, resulting in high exposure to solar radiation and subsequent water heating. During the summer months, water temperatures can become elevated, particularly in the lower reach of the river; cold water springs provide important refugia during these periods (Anderson pers. comm. 2004). Although the main channel is relatively stable due to low water velocities, slumping of banks due to a lack of robust riparian vegetation has been noted as a problem, particularly downstream of Haystack Draw (USFS 1998, Smith pers. comm. 2004, Anderson pers. comm. 2004). Biological productivity is primarily driven by phytoplankton production; although in the upper reaches, which have a more stable channel, benthic primary production tends to dominate (USFS 1998). Several water diversion structures and ditch systems, in addition to several private road crossings, are located along the length of the mainstem. These features may be at least partial redband migration barriers, and the ditch systems may result in fish stranding if they are not properly screened (Anderson pers. comm. 2004). Water diversion from the mainstem, if not appropriately timed amongst water users, has the potential to cause lower reaches of the river to go dry (Catchment Group field trip discussion). Upper reaches with more significant flow inputs from springs are less vulnerable.

Photo 11-6 Williamson River at Cholo Fork

Photo 11-6 is a photograph of the point at which the Williamson River mainstem splits to form the Cholo Fork. The Cholo Fork channel is located on left side of photo, with the Williamson mainstem in upper right side of the photo. The river has been affected by the adjacent gravel road and by loss of riparian cover, although some willows are still present along the banks.

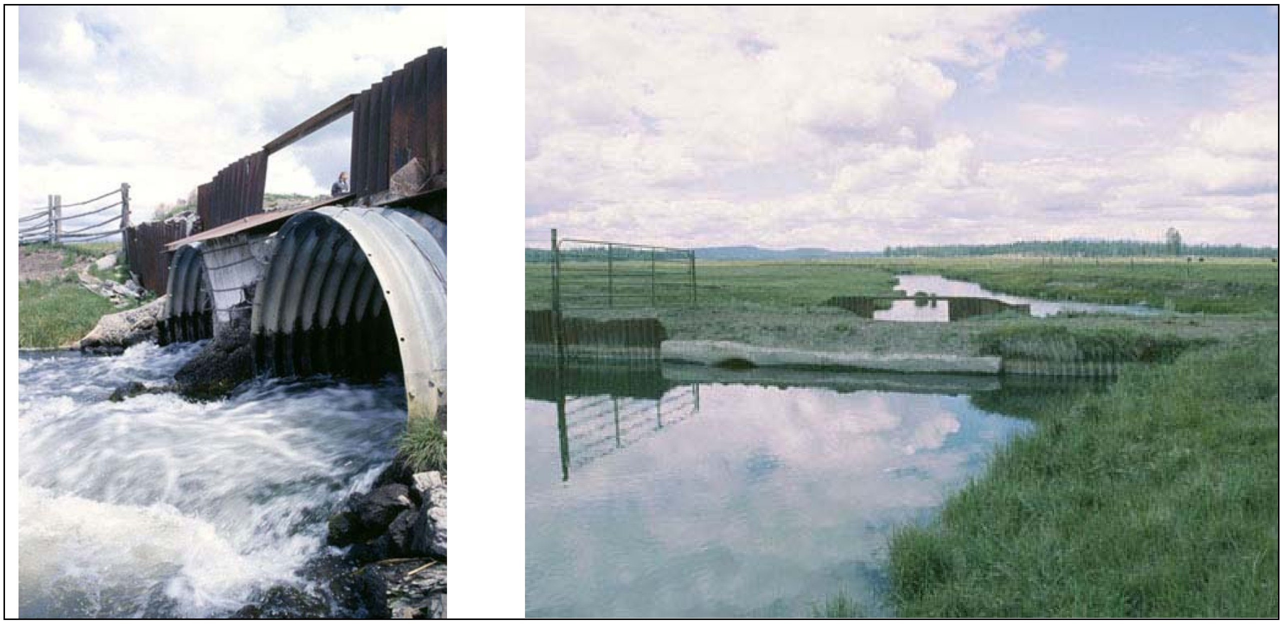


Photo 11-7: Water Impoundment Structure (downstream side and upstream side)

Photo 11-7 (left) is a photo of the downstream end of a water impoundment structure located on the mainstem Williamson River. Photo 11-7 (right) is a photo of the upstream side of this structure. Water is impounded behind this structure and diverted through gravity flow irrigation canals to irrigate pasture areas. This structure may represent at least a partial fish migration barrier.

Photo 11-8. Exclosure Area on Williamson River Mainstem Showing Reestablished Vegetation

Photo 11-8 was taken along a section of the Williamson River mainstem that has had exclosure fencing installed. A sharp sloughed-off bank is visible on left side of photo; however, riparian vegetation is reestablishing itself and should alleviate this problem in the future, likely leading to more stable but undercut banks. Flash grazing is allowed in this area and has been noted as helpful in getting grasses to grow vigorously.

Klamath Marsh

In addition to natural climate cycles extensive hydrologic alterations over the past century have led to lower water elevations in the marsh, which has likely resulted in disconnection of tributaries from the marsh relative to historic conditions. These lower water elevations also result in much less deep-water habitat, and remaining deep-water areas are disconnected from each other. Numerous diversion points create fish migration barriers. These barriers limit migration of redband between the marsh and the Williamson River mainstem above the marsh. Redband trout that are able to migrate from the Williamson River into the marsh during the spring are likely not able to migrate back upstream into the Williamson River when marsh water temperatures become inhospitable during the summer and the trout seek cold water refuge. It is possible that during particularly wet cycles water levels could be sufficiently high enough to allow redband to migrate through or around some of these areas.

Marsh water temperatures become elevated during the summer, reaching into the range of 25 to 30^{o} C (77 to 86^{o} F) (USFS 1998), likely exceeding the preferred temperature regime of redband trout. Tributary drainages may provide some localized cooler water inputs. Rodnick et al (2004) noted the acute critical temperature or T_{crit} (temperature at which a fish becomes incapacitated after being acutely exposed to a constant rate of heating) for three distinct populations of redband trout in south-eastern Oregon averaged 29.4^{o} C plus or minus 0.1^{o} C (84.9^{o} F plus or minus 0.4^{o} F). There is little reason to believe that the thermal tolerance of upper Williamson River redband trout would be any higher than for those of south-eastern Oregon basins.

Historically, especially during particularly wet periods, redband may have been able to access marsh tributary streams such as Sand Creek (west), Scott Creek, and Big Springs Creek, and possibly Hog and Yoss creeks (USFS 1998 and USFS 1997). Redband would have likely used the marsh area for juvenile rearing habitat as well as an important feeding area for adults, except during late summertime, when water temperatures in the marsh would probably have been too high. Based on this potential historic use, it is likely that there were different stocks of redband that used different tributaries for spawning. This may have resulted in a higher degree of genetic diversity among Upper Williamson redband than currently exists today. The loss of access between lakes, marshes, and streams has been noted as a problem common to systems containing Oregon basin redband trout, with the result being an interference of migratory life histories and diminished gene flow between populations (ODFW 2004).

Photo 11-9. Klamath Marsh Refuge Rock Island Diversion Structure

Photo 11-9 was taken at the Rock Island Diversion Structure, a major diversion structure where the Williamson River enters into the Klamath Marsh Refuge. The area actually contains several diversion structures that allow the refuge to divert water to various sectors of the marsh. These structures, as well as other diversion points and water control weirs within the marsh may limit fish migration within the marsh and to the Williamson River mainstem.

Photo 11-10. Klamath Marsh Refuge Deep Water Area near Former Kittredge Canal Pumping Station

Photo 11-10 was taken at Klamath Marsh Refuge near the Peninsula. The photo shows a deep water area associated with the Kittredge Canal. Pipes from the former pumping station can be observed in the photo. Tule marsh can be observed in the background. Segregation of marsh habitat types occurs as a result of past dike and roadway construction.

Photo 11-11. Klamath Marsh Refuge at Silver Lake Road

Photo 11-11 (left and right) were taken along the Silver Lake Road crossing of the Klamath Marsh Refuge. Both of these photos were taken at the same location, but at different camera angles. The left photo is suggestive of historic descriptions of "10,000 acres of Wocus" within the marsh. The photo at right shows that much of the area is now dominated by tule marsh, with deep water areas occurring where past excavation has occurred in conjunction with road and levee building activities. The combination of levees, road crossings, water control structures, and likely reduction in acreage of open water areas likely results in severe impediments to fish migration and dispersal through and within the marsh.

Downstream of Klamath Marsh

The ODFW (2004a) fish distribution database lists redband trout as occurring within the Williamson River mainstem from River Mile 27 to 95. This includes the portion of the mainstem downstream of Klamath Marsh but upstream of Kirk Reef. The river downstream of the marsh primarily consists of dark tannin-stained slow flowing water, particularly during the summer low flow months. Water temperatures become elevated during the summer, likely exceeding the preferred temperature regime of redband trout.

This portion of the river is likely relatively biologically unproductive as a result of the effects of humic substances on water quality (i.e., locking up of nutrients and reduction of light penetration into water column, both vital to in-stream primary production). Tributary streams which may have once provided some limited spawning habitat and cold water refugia for redband have been significantly modified and likely no longer provide these functions (USFWS 1997). The combination of all of the above factors, means that redband trout likely do not reside in this portion of the watershed in any significant numbers, if at all.

BARRIERS TO FISH PASSAGE AND MIGRATION

The Winema National Forest conducted an assessment of fish passage at road crossings for all known fish-bearing streams within the Winema National Forest (NF) (Gorman and Smith 2001). The Winema inventory used a color coding system of green, gray, and red to describe the viability of fish passage at each culvert. Green reflects that conditions are adequate for fish passage; red indicates that fish passage criteria are not met; and gray means that further evaluation is necessary to determine passability. None of the culverts surveyed was classified as green. Table 11-6 provides a summary of the Winema NF results for streams covered by this assessment. These results are also displayed on Map 11-2. The Deep Creek Ditch and Jackson Creek Ditch crossing locations were not identifiable through GIS and are not displayed on Map 11-2.

Table 11-6: Potential Fish Passage Barriers Caused by Road Crossings (Key Streams Only)

Stream	Road #	# Pipes	Fish Passage Rating
Deep Creek	4648-000	1	Grey[1]
Deep Creek Ditch	4648-000	2	Red[2]
Hog Creek	4300-000	2	Red

Stream	Road #	# Pipes	Fish Passage Rating
Irving Creek	4900-000	1	Red
Jack Creek	9418-000	1	Red
	8821-000	3	Red
	8676-000	1	Grey
Jackson Creek	4900-000	2	Red/Grey
Jackson Creek Ditch	4900-000	1	Red
Miller Creek	9771-620	1	Grey
	9772-000	1	Grey
	9770-000	2	Red
Scott Creek	2308-060	1	Red
Sink Creek	9775-000	2	Red
	9777-000	3	Red

[1] Grey rating indicates that further evaluation is necessary to determine passability.

[2] Red rating indicates that fish passage criteria are not met.

Because no similar inventory dataset was available for potential migration barriers outside the Winema National Forest (NF), DEA conducted a preliminary GIS based analysis to determine the presence of other potential fish migration barriers on key streams within the upper Williamson River subbasin. This was done by intersecting a roads layer, provided by Winema NF, with a layer of streams identified as key streams for this assessment. A total of 135 road/stream crossing points were identified. Further analysis is needed to determine if these represent barriers to fish migration. Table 11-7 provides a summary of the number of crossings points located along each key stream. These points were too numerous to plot on Map 11-2.

Table 11-7. Number of Road Crossings of Key Streams Including Those Reviewed by Winema National Forest

Stream	Number of Road Crossings	Stream	Number of Road Crossings	Stream	Number of Road Crossings
Aspen Creek	5	Hog Creek	7	Sand Creek (east)	4
Bear Creek	8	Hoyt Creek	4	Scott Creek	8
Big Springs Creek	3	Irving Creek	2	Sink Creek	2
Cottonwood Creek	5	Jack Creek	9	Skellock Draw	5
Deely Creek	4	Jackson Creek	7	Telephone Draw	1
Deep Creek	4	Miller Creek	6	Wheeler Creek	3
Deer Creek	4	Mosquito Creek	6	Williamson River	12
Dillon Creek	6	Pothole Creek	4	Yoss Creek	3
Haystack Creek	4	Rock Creek	18	**Total**	**148**

In addition to road crossings, numerous water diversion points and ditch systems located throughout the basin lowlands represent potential barriers to fish migration. INFORMATION IS FORTHCOMING AND WILL BE INCLUDED IN FUTURE REVISIONS]

CONFIDENCE EVALUATION

The overall confidence in the fish and fish habitat assessment is moderate; however, several aspects rate as low in confidence and require additional study. Existing data and knowledge of local resource agency personnel is sufficient for a general understanding of fish habitat and fishery conditions within the basin, particularly with respect to redband trout, to determine general protective and restorative measures. However, further investigation is needed in order to better prioritize some of these measures and the actions required in carrying them out. For example, although more data on use of the Williamson River by redband trout may be useful, it is already known that improving riparian conditions along the river will be beneficial to the system as a whole. Therefore, willing landowners should be encouraged and supported in making such improvements, even without additional data. On the other hand, removing or reconstructing fish migration barriers to allow for fish passage can be costly and it is important that such structures are evaluated and designed properly. With respect to fish migration barriers the confidence evaluation is low and additional data gathering is warranted before undertaking such restoration actions.

With respect to fish use and habitat of Upper Klamath Marsh, the confidence evaluation is low due to limited knowledge of fish use and the overall ecology of this area of the watershed.

RECOMMENDATIONS / DATA GAPS

Additional information is needed to better understand how redband utilize the upper Williamson River system, particularly with regard to how human influences may be detrimentally altering this use. Of particular concern is the extent and types of migration barriers, as well as the potential for irrigation diversions to result in fish stranding/ entrapment. Further study of the Upper Klamath Marsh ecosystem is also highly recommended.

The effects of natural climate variation on waterlevels and subsequent effects on the connectivity of tributary streams to the Williamson River mainstem and Upper Klamath Marsh warrants further investigation. Although human induced changes to water levels and flows have occurred, it is important to understand the impact of these changes relative to natural variation, as both sources of variation will need to be taken into account during the restoration design process.

RESTORATION OPPORTUNITIES

The following restoration actions focus primarily on redband trout; however, other aquatic species would also likely benefit. With respect to redband trout, these actions are intended to meet the following goals:

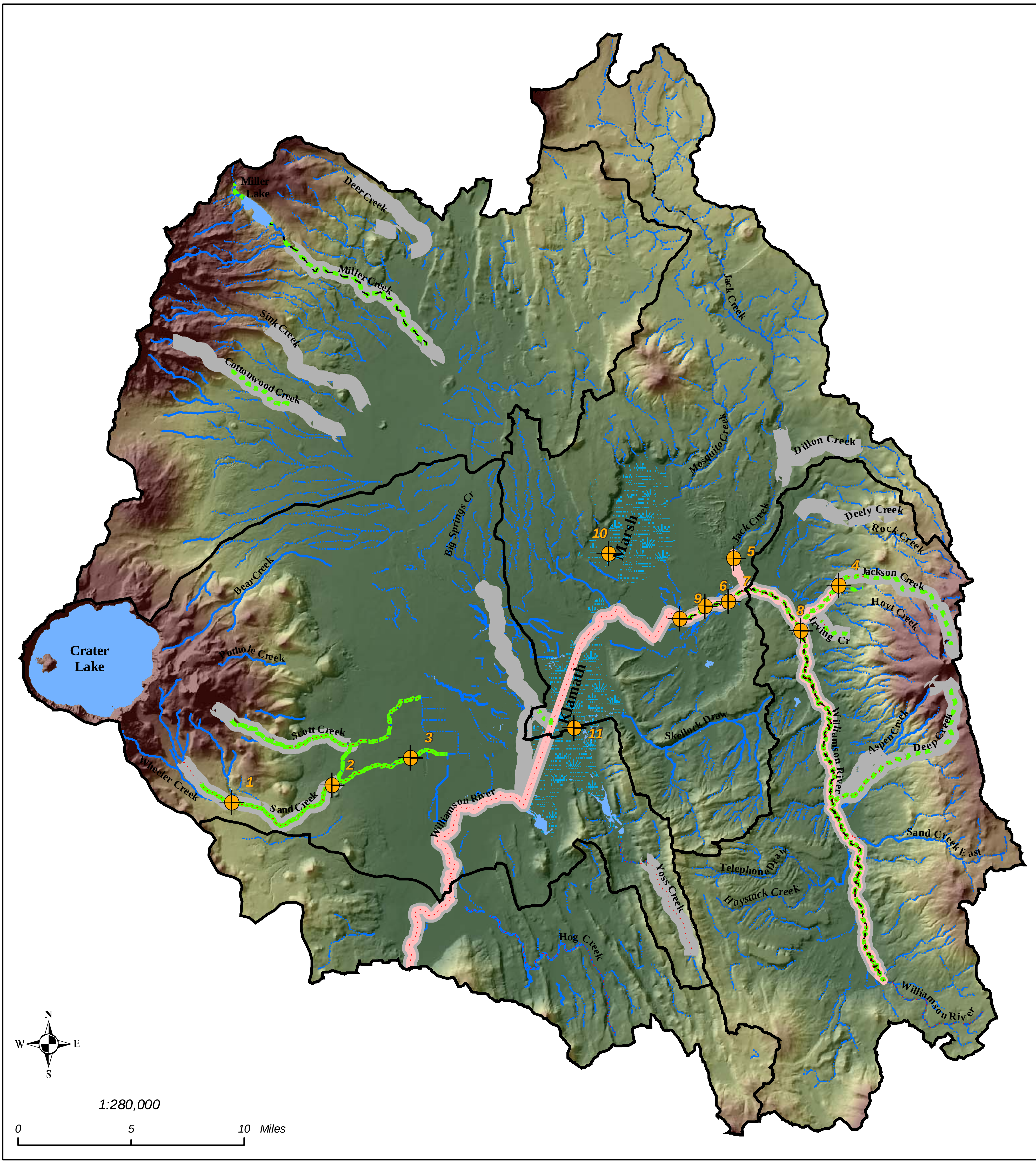
1) Protection of existing limited spawning sites and spring-fed cold water refugia sites.
2) Restore historic connections between the Williamson River and its tributary streams likely to provide spawning habitat.
3) Improve overall aquatic habitat conditions within the Williamson River mainstem.
4) Restore and improve migratory pathways along the Williamson River, within Upper Klamath Marsh, and between the marsh and its tributaries including the Williamson River.

The following are potential restoration actions intended to meet the above listed restoration goals.

- Survey water diversions for need for screening to prevent fish entrapment (Anderson pers. comm. 2004).
- Pit tag/telemetry study of redband trout use of Williamson River system. Will help to better understand redband trout’s ability to migrate through the system, both downstream and upstream, use of marsh habitat, and potential entrapment areas.
- Use exclosure fencing along the Williamson River and its tributaries to encourage vegetation regrowth. Improved bank stabilization will reduce slumping resulting in undercut banks. Improved riparian vegetation will also provide shading and potential food source and substrates for invertebrate food sources.
- Improve communication of water diversion timing along mainstem Williamson to maintain suitable flows.
- Analyze the extent of road networks’ contribution of sediments to tributaries (Anderson pers. comm. 2004).
- Reconnect tributaries to the mainstem Williamson River. Quality spawning habitat is found in several of the tributaries (Anderson pers. comm. 2004). This might require an engineered solution due to modifications of the system over time (channel downcutting resulting in less overflow onto flood plain, which would have allowed for a surface connection between mainstem and tributaries). Or it may be a matter of managing irrigation diversions, particularly during the redband spawning season, when adult redband would likely move up into the tributaries to spawn. Because redband spawning season occurs in winter, which is the non-irrigation season, there should be increased opportunities for managing water for such purposes. Jackson Creek is a primary candidate to be studied for such restoration possibilities (Neil Anderson, based on Watershed field trip discussion).

- Assess opportunities for improving redband habitat within Upper Klamath Marsh Refuge and restoring fish migration corridors between the marsh and the Williamson mainstem. The Watershed Council should have involvement in Refuge Management Plan, which will soon be significantly updated.
- Remove migration barrier on Miller Creek to allow Miller Lake Lamprey to move back into Miller Lake (Anderson pers. comm. 2004).
- Develop spawning site protection plans. Few redband spawning sites are present within the upper Williamson River system. Although these sites appear to be sufficient to fully stock the river, protection is of notable importance since degradation of any one site could result in a significant impact to redband breeding success.
- Critical springs site protection plan(s) could be produced for each landowner that has a spring that provides important cold water flow inputs to the Williamson River mainstem. The goal would be protection of these direct flows to the river during critical periods.

LIST OF MAPS



Upper Williamson River Watershed Assessment

Map 11-1: Fish Distribution

Legend

- Photo point
- Historic Redband Trout presence (USFS)
- Miller Lake Lamprey distribution (ODFW, May 2004)*
- Brown and Brook Trout distribution (ODFW, May 2004)*
- Redband Trout distribution (ODFW, May 2004)*
- Fish presence (ODF)**
- Perennial stream
- Non-perennial stream
- Marsh
- 5th-field watershed boundary

Introduced Rainbow Trout and Kokanee Salmon are present in Miller Lake, but were not documented in Miller Creek. Kokanee use Evening Creek, a tributary to Miller Lake, during fall spawning. According to ODFW (May 2004) database, Red Band distribution in Jackson Creek and Jack Creek were cited by Wendell Stout (1997), but may be based on professional opinion rather than documented ocurrences.

Sources:
Fish -ODF, ODFW, USFS
Streams -The Nature Conservancy (24k)
Roads -USFS (Winema NF)
Waterbodies -BLM (Lakeview Dist)
Watersheds -REO/DEA (REO HUCs, modified by DEA)

**Species distributions based on ODFW database, provided by Winema NF. Data is incomplete, but represents the best available information (Neil Anderson, Winema NF).*

***Data available for approximately 74% of the Williamson Subbasin.*

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August 13, 2004
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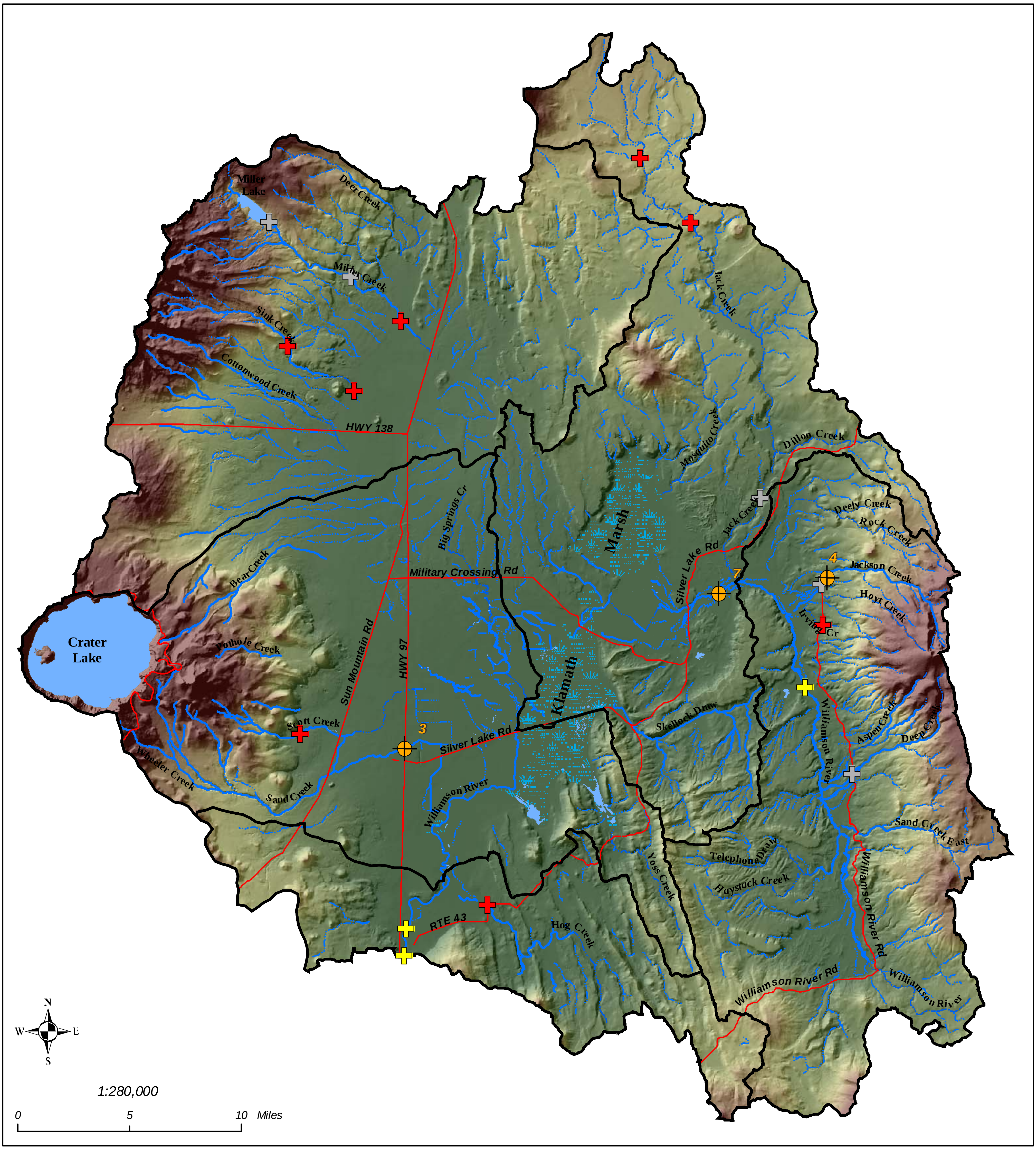

Upper Williamson River Watershed Assessment

Map 11-2: Potential Fish Migration Barriers

Legend

- Culvert requiring additional evaluation (Winema NF)
- Culvert not meeting criteria required to pass fish (Winema NF)
- Potential barrier, structure unknown
- Photo point
- Perennial stream
- Non-perennial stream
- Major road
- Marsh
- 5th-field watershed boundary

There are an additional 135 road crossing of key streams for which the Winema NF does not have maintenence responsibilities. The migration status of these crossings is unknown.

Sources:

Culverts	*-Winema NF*
Potential barriers	*-DEA, derived from DEQ riparian landcover data*
Streams	*-The Nature Conservancy (24k)*
Roads	*-USFS (Winema NF)*
Waterbodies	*-BLM (Lakeview Dist)*
Watersheds	*-REO/DEA (REO HUCs, modified by DEA)*

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12 SUMMARY OF WATERSHED CONDITION

Will be written once technical chapters have been reviewed.

LIST OF MAPS

13 SUMMARY OF RECOMMENDATIONS AND DATA GAPS

Will be written once technical chapters have been reviewed.

LIST OF MAPS

14 PRESERVATION AND RESTORATION OPPORTUNITIES

Will prepare once technical chapters have been reviewed.

Will include a summary of existing habitat improvement projects.

LIST OF MAPS

15 BIBLIOGRAPHY

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GIS METADATA

See table on following pages

GIS Metadata

Category	Layer	Source	Scale	Feature Type	File Type	Spatial Coverage	Origin	Metadata
Basedata	Aerial photography (color)	Department of Environmental Quality	5k	Raster	TIF	Williamson mainstems	DEQ	No
Basedata	Dams	Oregon Department of Fish and Wildlife	100k	Point	Coverage	State	ODFW	Yes
Basedata	Dams (BORC)	Oregon Institute of Technology	24k	Point	Coverage	Basin	Unknown	No
Basedata	Dams (federal)	Oregon Institute of Technology	24k	Point	Coverage	Basin	Unknown	No
Basedata	Dams (state)	Oregon Geospatial Data Clearinghouse	24k	Point	Coverage	State	Unknown	Yes
Basedata	DEM (10 Meter)	Bureau of Land Management	24k	Raster	GRID	State (1-degree cell)	BLM	Yes
Basedata	DEM (30 Meter)	Bureau of Reclamation	24k	Raster	GRID	Basin	BORC	No
Basedata	DOQ	Oregon Institute of Technology	24k	Raster	SID	Basin	USGS	No
Basedata	DRG	Bureau of Land Management	24k	Raster	SID	State (1-degree cell)	BLM	Yes
Basedata	Taxlots	Oregon Institute of Technology	24k	Polygon	Shapefile	Klamath County	Unknown	No
Environmental	103 Year Precipitation	Spatial Climate Analysis Service, Oregon State University	250k	Polygon	Coverage	State	NOAA	Yes
Environmental	Ecological Units	United States Forest Service	24k	Polygon	Coverage	Winema NF	USFS	No
Environmental	Ecoregions	Oregon Geospatial Data Clearinghouse	250k	Polygon	Coverage	State	Oregon Natural Heritage Program	Yes
Environmental	Erosion	United States Forest Service	24k	Polygon	Coverage	Fremont NF	USFS	No
Environmental	Fire history	United States Forest Service	24k	Polygon	Coverage	Winema NF	USFS	Yes
Environmental	Geology	Oregon Geospatial Data Clearinghouse	500k	Polygon	Coverage	State	USGS	Yes
Environmental	Geology (2003)	United States Geological Survey	24k	Polygon	Coverage	State	USGS	Yes
Environmental	Merged National Weltands Inventory	Bureau of Reclamation	24k	Polygon, Point, Line	Geodatabase	Basin	USFW	No
Environmental	Peak flow	Oregon Department of Forestry	500k	Polygon	Shapefile	State	ODF	No
Environmental	Restoration projects	Oregon Water Enhancement Board	24k	Point	Table	Basin	OWEB	No
Environmental	Restoration projects (94-02)	United States Fish and Wildlife	24k	Point	Coverage	Basin	Unknown	No
Environmental	Soils	National Resources Conservation Service	24k	Polygon, Point, Line	Coverage	Klamath County, Crater Lake NP	NRCS	Yes
Environmental	Soils	United States Forest Service	24k	Polygon	Coverage	Winema NF, Fremont NF	USFS	No
Environmental	Wetlands 1905	Oregon Institute of Technology	24k	Polygon	Coverage	Basin	Unknown	No
Environmental	Wetlands 1940	Oregon Institute of Technology	24k	Polygon	Coverage	Basin	Unknown	No
Environmental	Wetlands 1968	Oregon Institute of Technology	24k	Polygon	Coverage	Basin	Unknown	No
Environmental	Wetlands 1989	Oregon Institute of Technology	24k	Polygon	Coverage	Basin	Unknown	No
Fish	Barriers	Oregon Department of Fish and Wildlife	100k	Point	Coverage	State	ODFW	Yes
Fish	Brook Trout	Oregon Department of Fish and Wildlife	100k	Line	Coverage	State	ODFW	Yes
Fish	Bull Trout	Oregon Department of Fish and Wildlife	100k	Line	Coverage	State	ODFW	Yes
Fish	Chum	Oregon Department of Fish and Wildlife	100k	Line	Coverage	State	ODFW	Yes
Fish	Cutthroat Trout	Oregon Department of Fish and Wildlife	100k	Line	Coverage	State	ODFW	Yes
Fish	Fish distribution	Oregon Institute of Technology	24k	Line	Coverage	Basin	Unknown	No
Fish	ODFW 2004 Fish Distribution	United States Forest Service	24k	Line	Table	Basin	ODFW	No
Fish	Rainbow Trout	Oregon Department of Fish and Wildlife	100k	Line	Coverage	State	ODFW	Yes
Fish	Steelhead	Oregon Department of Fish and Wildlife	100k	Line	Coverage	State	ODFW	Yes

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Category	Layer	Source	Scale	Feature Type	File Type	Spatial Coverage	Origin	Metadata
Landcover	1900 Vegetation	Bureau of Land Management	250k	Polygon	Coverage	State	BLM	Yes
Landcover	Historic vegetation	Oregon Geospatial Data Clearinghouse	100k	Polygon	Coverage	State	Oregon Natural Heritage Program	Yes
Landcover	Landcover	Department of Environmental Quality	5k	Polygon	Coverage	Williamson mainstems	DEQ	Yes
Landcover	National Land Cover Data Set	United States Geological Survey	100k	Raster	GRID	State	USGS	Yes
Landcover	Plant Communites	United States Forest Service	100k	Polygon	Coverage	Winema NF	USFS	Yes
Landcover	Vegetation (GAP)	United States Fish and Wildlife	100k	Raster	GRID	Basin	Humboldt State University	No
Landcover	Vegetation 1900	Oregon Department of Forestry	500k	Polygon	Shapefile	State	ODF	No
Landcover	Vegetation 1914	Oregon Department of Forestry	250k	Polygon	Shapefile	State	ODF	No
Landcover	Vegetation 1936	Oregon Department of Forestry	500k	Polygon	Shapefile	State	ODF	No
Political	Klamath Indian Reservation boundary 1888	United States Forest Service	100k	Polygon	Coverage	Basin	USFS	No
Political	Klamath Project	Bureau of Reclamation	24k	Polygon	Shapefile	Klamath Project	UC Davis	No
Political	Land management	Oregon Geospatial Data Clearinghouse	250k	Polygon	Coverage	State	State Service Center for GIS	Yes
Political	Ownership	United States Forest Service	24k	Polygon	Coverage	Winema NF, Fremont NF	USFS	No
Political	Public Land Survey System	Oregon Geospatial Data Clearinghouse	100k	Polygon	Coverage	State	USGS	Yes
Political	Watershed councils	Oregon Geospatial Data Clearinghouse	100k	Polygon	Coverage	State	GWEB	Yes
Transportation	Roads	United States Forest Service	24k	Line	Coverage	Winema NF, Fremont NF	USFS	No
Transportation	Streets	Oregon Institute of Technology	24k	Line	Shapefile	Klamath County	Unknown	No
Water	Flow and temp sites	Department of Environmental Quality	5k	Point	Shapefile	Williamson mainstems	DEQ	No
Water	Lakes	Bureau of Land Management	100k	Polygon	Coverage	State	BLM	Yes
Water	Lakes	The Nature Conservancy	100k	Polygon	Shapefile	Basin	Unknown	No
Water	Perennial streams	Oregon Institute of Technology	24k	Line	Coverage	Basin	OIT	No
Water	Points of diversion	Water Resources Department	24k	Point	Coverage	Basin	WRD	No
Water	Rivers	Oregon Geospatial Data Clearinghouse	100k	Line	Coverage	State	EPA	Yes
Water	Rivers	Oregon Geospatial Data Clearinghouse	250k	Line	Coverage	State	EPA	Yes
Water	Stream gages, compiled	Ed Salminen	24k	Point	Shapefile	Basin	Various	No
Water	Streams	The Nature Conservancy	24k	Line	Coverage	Basin	TNC/OIT	No
Water	Streams	United States Forest Service	24k	Line	Coverage	Winema NF, Fremont NF	USFS	No
Water	Streams	Department of Environmental Quality	5k	Line	Shapefile	Williamson mainstems	DEQ	Yes
Water	Waterbodies	Oregon Geospatial Data Clearinghouse	250k	Polygon	Coverage	State	USGS	No
Water	Watershed boundaries (HUCs 3, 4, 5, 6)	Regional Ecosystem Office	24k	Polygon	Coverage	State	REO	Yes

APPENDICES

APPENDIX A – Key To Map 2-5, Geology

Appendix A – Key to Map 2-5, Geology

MAP UNIT	LITH	DESCRIPTION
QTb	Volcanic	Basalt (Pleistocene and Pliocene)
QTba	Volcanic	Basalt and Basaltic Andesite (Pleistocene and Pliocene)
QTib	Volcanic	Intrusive Basalt and Andesite (Pleistocene, Pliocene, and Miocene)
QTmv	Volcanic	Mafic Vent Complexes (Pleistocene; Pliocene; and Miocene?)
QTp	Volcanic	Pyroclastic Rocks Of Basaltic and Andesitic Cinder Cones: Basaltic and Andesitic Ejecta
QTps	Volcanic	Pyroclastic Rocks Of Basaltic and Andesitic Cinder Cones: Subaqueous Basaltic and Andesitic Ejecta
QTs	Sedimentary	Sedimentary Rocks (Pleistocene and Pliocene)
QTvm	Volcanic	Mafic Vent Deposits (Pleistocene; Pliocene; and Miocene?)
QTvs	Volcanic	Silicic Vent Deposits (Pleistocene and Pliocene)
Qa	Volcanic	Andesite (Holocene and Pleistocene)
Qal	Sedimentary	Alluvial Deposits
Qb	Volcanic	Basalt and Basaltic Andesite (Holocene and Pleistocene)
Qba	Volcanic	Basaltic Andesite and Basalt (Holocene)
Qf	Sedimentary	Fanglomerate (Holocene? and Pleistocene)
Qg	Sedimentary	Glacial Deposits
Qma	Volcanic	Mazama Ash Deposits (Holocene)
Qmp	Volcanic	Mazama Pumice Deposits (Holocene)
Qrd	Volcanic	Rhyolite and Dacite (Holocene and Pleistocene)
Qs	Sedimentary	Lacustrian and Fluvial Sedimentary Rocks (Pleistocene)
Tb	Volcanic	Basalt (Upper and Middle Miocene)
Tmv	Sedimentary And Volcanic	Mafic Vent Complexes (Miocene)
Tob	Sedimentary And Volcanic	Olivine Basalt (Pliocene and Miocene)
Tp	Sedimentary And Volcanic	Pyroclastic Rocks Of Basaltic Cinder Cones (Lower Pliocene? and Miocene?)-Basaltic and Andesitic Ejecta
Trb	Volcanic	Ridge-Capping Basalt and Basaltic Andesite (Pliocene and Upper Miocene)
Trh	Volcanic	Rhyolitie and Dacite (Pliocene? and Miocene)
Ts	Sedimentary And Volcanic	Tuffaceous Sedimentary Rocks and Tuff (Pliocene and Miocene)
Tvm	Sedimentary And Volcanic	Mafic and Intermediate Vent Rocks (Pliocene? and Miocene)
Water	Water	Water Bodies

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APPENDIX B – Key to Soils (Winema NF and Crater Lake NP)

Appendix B – Key to Soils of the Winema National Forest

Map Symbol	Map Unit Name
1051	Alfic Humic Vitrixerands, 2 to 12 percent slopes
2031	Anniecreek, 0 to 2 percent slopes
2030	Aquic Haplocryands, 0 to 2 percent slopes
2018	ashy sandy loam, 0 to 2 percent slopes
1090	Bigtoe Shortnap complex, 0 to 2 percent slopes
1054	Bottlespring, 1 to 4 percent slopes
9315	Castlecrest ashy loamy sand, dry, 0 to 15 percent slopes
1388	Castlecrest ~~ Rocky land with minimal vegetation potential badland complex, 60 to 80 percent slopes
9312	Castlecrest Sunnotch Timbercrater complex, 0 to 10 percent slopes
9326	Castlecrest Timbercrater complex, dry, 2 to 15 percent slopes
1220	Castlecrest Timbercrater Unionpeak complex, 15 to 30 percent slopes
1227	Castlecrest Timbercrater Unionpeak complex, 2 to 15 percent slopes
2008	Chemult, 0 to 2 percent slopes
2000	Chinchallo, 0 to 2 percent slopes
2025	Chinchallo Cosbie complex, 0 to 3 percent slopes
2004	Chocknott, 1 to 4 percent slopes
1247	Collier, 2 to 15 percent slopes
1281	Collier, steep ~~ Rocky land with minimal vegetation potential badland complex, 60 to 80 percent slopes
9215	Collier very gravelly ashy loamy sand, low, 0 to 7 percent slopes
9218	Collier ashy loamy sand, dry, 0 to 10 percent slopes
1235	Collier Lapine Onionpie complex, 15 to 40 percent slopes
1207	Collier Maklak complex, 0 to 4 percent slopes
1217	Collier Maklak Onionpie complex, 2 to 8 percent slopes
2017	Cosbie, 1 to 3 percent slopes
2006	Cosbie Stirfry complex, 1 to 15 percent slopes
1004	Deepdish, 0 to 2 percent slopes
2019	Humic Haploxerands ~~ Dry meadow flood plain ~~ Intermittent streams, rivers riverwash complex, 0 to 2 percent slopes
2007	Intermittent streams, rivers rubble land, gently sloping
1000	Lapine, 0 to 2 percent slopes
1003	Lapine, 1 to 6 percent slopes
1013	Lapine, 35 to 70 percent slopes
1016	Lapine, 2 to 12 percent slopes
1018	Lapine, 12 to 35 percent slopes
9344	Lapine paragravelly ashy loamy coarse sand, 10 to 35 percent slopes
1060	Lapine, fine sand substratum, 2 to 20 percent slopes

1061	Lapine, fine sand substratum, 0 to 2 percent slopes
9328	Llaorock Timbercrater complex, dry, 30 to 60 percent slopes
9201	Maklak, 0 to 10 percent slopes
2001	Mesquito, 1 to 8 percent slopes
2002	Mesquito, 8 to 15 percent slopes
2003	Mighty, 0 to 1 percent slopes
2020	Mightytoo, 0 to 2 percent slopes
2012	Regcrust, 0 to 1 percent slopes
1052	Shukash, 12 to 35 percent slopes
1053	Shukash, 2 to 12 percent slopes
2010	Silverdollar Mighty complex, 0 to 1 percent slopes
1009	Steiger, 1 to 6 percent slopes
9336	Sunnotch, 0 to 35 percent slopes
2033	Terric Cryosaprists, loamy-skeletal, 1 to 15 percent slopes
8334	Timbercrater, 25 to 60 percent slopes
2034	Typic Cryaquands, medial-skeletal, 4 to 8 percent slopes
9266	Umak, 0 to 10 percent slopes
1214	Unionpeak, 2 to 12 percent slopes
2005	Wickiup, 0 to 2 percent slopes
2009	Yamsay, 0 percent slope
1050	Yancy, 1 to 4 percent slopes

Appendix B – Key to Soils of Crater Lake National Park

Map Unit	Description
1	Anniecreek-Stirfry-Riverwash complex, 0 to 2 percent slopes
4	Castlecrest gravelly ashy sandy loam, 2 to 10 percent slopes
5	Castlecrest ashy loamy sand, dry, 0 to 15 percent slopes
6	Castlecrest ashy loamy sand, low, 0 to 7 percent slopes
7	Castlecrest gravelly ashy loamy sand, high elevation, 5 to 45 percent slopes
8	Castlecrest-Badland complex, 60 to 100 percent slopes
9	Castlecrest-Llaorock complex, 2 to 25 percent slopes
12	Cleetwood-Castlecrest complex, dry, 10 to 30 percent slopes
13	Cleetwood-Castlecrest-Llaorock complex, 5 to 30 percent slopes
14	Cleetwood, thin surface-Cleetwood-Dyarock complex, 2 to 20 percent slopes
15	Cleetwood, thin surface-Llaorock-Cleetwood complex, 5 to 30 percent slopes
16	Cleetwood-Sunnotch-Castlecrest complex, high elevation, 15 to 30 percent slopes
18	Collier ashy loamy sand, dry, 0 to 10 percent slopes
19	Collier very gravelly ashy loamy sand, low, 0 to 7 percent slopes
20	Collier-Badland complex, 60 to 100 percent slopes
23	Grousehill-Llaorock complex, 5 to 35 percent slopes
26	Lapine paragravelly ashy loamy coarse sand, 10 to 35 percent south slopes
27	Lapine paragravelly ashy loamy coarse sand, 35 to 55 percent south slopes
30	Lapine-Rock outcrop-Wuksi complex, 30 to 70 percent south slopes
31	Lapine-Steiger-Wuksi complex, high elevation, 2 to 25 percent slopes
32	Lapine-Wuksi-Rock outcrop complex, 30 to 70 percent north slopes
33	Lava flows, 0 to 15 percent slopes
34	Llaorock-Castlecrest complex, 0 to 15 percent slopes
35	Llaorock-Castlecrest complex, 15 to 30 percent slopes
36	Llaorock-Castlecrest-Rock outcrop complex, 30 to 60 percent north slopes
37	Llaorock-Castlecrest-Rock outcrop complex, 30 to 60 percent south slopes
38	Llaorock-Rubble land-Rock outcrop complex, 60 to 90 percent north slopes
39	Llaorock-Rubble land-Rock outcrop complex, 60 to 90 percent south slopes
40	Llaorock-Timbercrater-Rubble land complex, dry, 60 to 90 percent south slopes
41	Maklak paragravelly ashy loamy sand, 0 to 10 percent slopes
42	Maklak paragravelly ashy loamy sand, low, 0 to 10 percent slopes
45	Redcone-Cinder land complex, 30 to 60 percent south slopes
46	Redcone-Rock outcrop complex, 30 to 60 percent north slopes
47	Rock outcrop-Rubble land complex, 60 to 90 percent slopes
50	Sunnotch gravelly ashy sandy loam, dry, 0 to 35 percent slopes
51	Sunnotch-Unionpeak complex, 15 to 35 percent slopes

Map Unit	Description
52	Timbercrater paragravelly ashy loamy sand, dry. 25 to 60 percent north slopes
53	Timbercrater-Castlecrest complex, 0 to 10 percent slopes
54	Timbercrater-Castlecrest complex, dry, 2 to 15 percent slopes
55	Timbercrater-Castlecrest complex, dry, 15 to 30 percent south slopes
56	Timbercrater-Castlecrest-Llaorock complex, 10 to 30 percent south slopes
57	Timbercrater-Llaorock complex, 10 to 30 percent north slopes
58	Timbercrater-Llaorock complex, dry, 30 to 60 percent south slopes
59	Timbercrater-Llaorock complex, high elevation, 30 to 80 percent slopes
60	Timbercrater-Llaorock-Castlecrest complex, 30 to 60 percent slopes
61	Timbercrater-Sunnotch-Castlecrest complex, 0 to 10 percent slopes
63	Umak paragravelly ashy fine sandy loam, dry, 0 to 10 percent slopes
64	Umak paragravelly ashy fine sandy loam, low, 0 to 5 percent slopes
65	Unionpeak-Castlecrest complex, dry, 5 to 15 percent slopes
66	Unionpeak-Castlecrest-Llaorock complex, 15 to 30 percent slopes
67	Unionpeak-Castlecrest-Sunnotch complex, 0 to 15 percent slopes
68	Water

APPENDIX C – ODFW Benchmarks

From *Appendix IX-A* of the *Oregon Watershed Assessment Manual* (WPN 1999)

ODFW HABITAT BENCHMARKS

	UNDESIRABLE	DESIRABLE
POOLS		
Pool Area (% total stream area)	<10	>35
Pool Frequency (channel widths between pools)	>20	5-8
Residual Pool Depth		
Small Streams (<7-m width)	<0.2	>0.5
Medium Streams (≥7-m & <15-m width)		
Low Gradient (slope <3%)	<0.3	>0.6
High Gradient (slope >3%)	<0.5	>1.0
Large Streams (≥15-m width)	<0.8	>1.5
Complex Pools (pools w/wood complexity >3 km)	<1.0	>2.5
RIFFLES		
Width/Depth Ratio (active-channel based)		
East Side	>30	<10
West Side	>30	<15
Gravel (% area)	<15	≥35
Silt-Sand-Organics (% area)		
Volcanic Parent Material	>15	<8
Sedimentary Parent Material	>20	<10
Channel Gradient <1.5%	>25	<12
SHADE (reach average %)		
Stream Width <12 m		
West Side	<60	>70
Northeast	<50	>60
Central-Southwest	<40	>50
Stream Width >12 m		
West Side	<50	>60
Northeast	<40	>50
Central-Southeast	<30	>40
LARGE WOODY DEBRIS* (15 cm X 3 m min. size)		
Pieces/100-m Stream Length	<10	>20
Volume/100-m Stream Length	<20	>30
"Key" Pieces (>60-cm and 10-m long)/100 m	<1	>3
RIPARIAN CONIFERS (30 m from both sides)		
Number >20-in dbh/1,000-ft Stream Length	<150	>300
Number >35-in dbh/1,000-ft Stream Length	<75	>200

* Values for streams in forested basins