CHAPTER 1. INTRODUCTION

1.1 Overview

The purpose of this report is to present the Total Maximum Daily Loads (TMDLs) calculated by California to protect and restore beneficial uses of water in the Klamath River downstream of the Oregon border and in portions of the Klamath River watershed in California. The purpose is also to present the recalculated Site Specific Objectives (SSOs) for dissolved oxygen (DO) for the mainstem Klamath River in California (see Appendix 1). The California Klamath TMDLs are comprised of two distinct parts: the Staff Report and the Action Plan. This document is the Staff Report that contains information and findings to support the recommended Action Plan to the North Coast Regional Water Quality Control Board (Regional Water Board). It also contains, in Appendix 1, the staff report for the proposed Basin Plan Amendment to incorporate into the Water Quality Control Plan for the North Coast Region (Basin Plan) the recalculated SSOs for DO.

The Klamath River basin[1] is 12,680 square miles in area. The Klamath River originates in southern Oregon and flows through northern California to meet the Pacific Ocean at Requa in Del Norte County, California. Forty-four percent of the watershed lies within the boundaries of Oregon, while the remaining 56% of the basin lies within the boundaries of California. Figure 1.1 is a map of the Klamath River basin.

The Klamath River basin is of vital economic and cultural importance to the states of Oregon and California, as well as the Klamath Tribes in Oregon; the Hoopa, Karuk, and Yurok Tribes in California; the Quartz Valley Indian Reservation in California, and the Resighini Rancheria in California. It provides fertile lands for a rich agricultural economy in the upper basin. Irrigation facilities known as the Klamath Project owned by the U.S. Bureau of Reclamation support this economy as does hydroelectric power provided via a system of five dams operated by PacifiCorp. The basin is the home spawning grounds of a once vast Tribal, sport, and commercial fishery and provides other aquatic resources of cultural significance to the local Indian Tribes. The watershed supports an active recreational industry, including activities that are specific to the Wild and Scenic portions of the river designated by both the state and federal governments in both Oregon and California. Finally, the watershed continues to support what were once more significant mining and timber industries.

A decline in the fisheries has signaled deep impacts on the ecology of the basin. Congress passed Public Law 99-552 (Klamath Act) in 1986 to establish the Klamath River Basin Conservation Area Restoration Program with the intention of rebuilding the river's dwindling fish resources. Since that time, however, several of the fish species endemic to the basin have been listed by federal and state agencies as threatened or endangered. Impairments to water quality have been identified as one of the factors

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1 For the purposes of this report, the terms "basin" and "watershed" are synonymous and will be used to refer to the area that drains flows to the Pacific Ocean at Requa.

contributing to the continued decline of native fish populations. This has led to water quality assessments by the States of Oregon and California and the listing of the Klamath

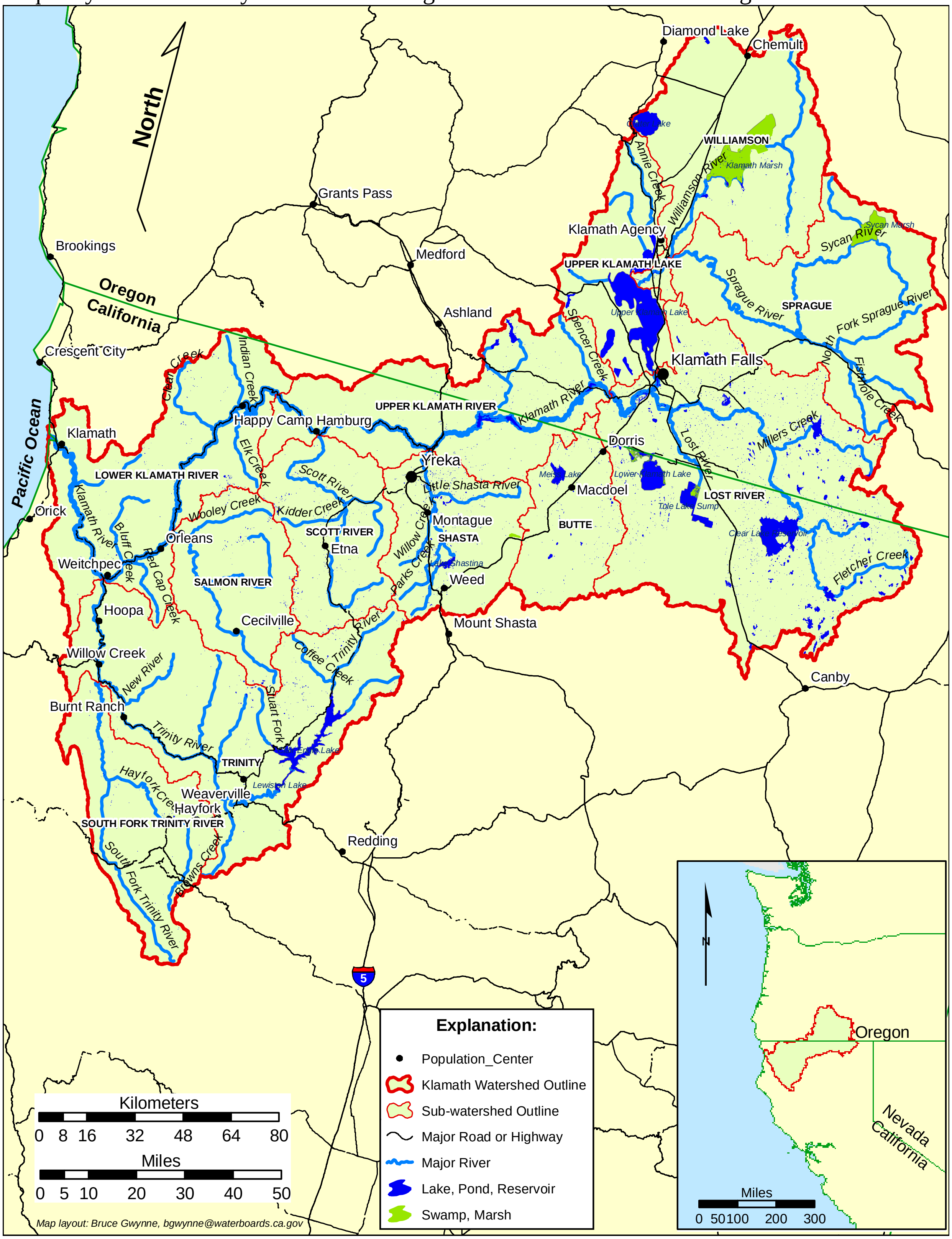

Figure 1.1: Klamath River basin showing rivers, lakes and reservoirs, population centers, and major roads

River as impaired under section 303(d) of the federal Clean Water Act (CWA). It has also led to the recalculation of the SSOs for DO in the mainstem Klamath River as contained in the Basin Plan.

The Oregon Department of Environmental Quality (ODEQ) and the Regional Water Board are working cooperatively to develop TMDLs for the water quality impaired waterbodies in the Klamath Basin, including the Lost River and the Klamath Straits Drain, and the Klamath River from Link River to the Pacific Ocean. The States of Oregon and California are responsible for calculating the TMDL of each of the pollutants of concern that can be discharged to the river while still protecting the fisheries and other beneficial uses of the waters within their respective jurisdictions. California has recalculated the SSOs for DO using data generated by the TMDL development team.

California has listed the portions of the Klamath River within its jurisdiction (from the CA/OR Stateline to the mouth) for impairments due to elevated water temperatures, elevated nutrients, and organic enrichment/low dissolved oxygen. In addition, the portion of the Klamath River watershed downstream of the Trinity River, partially within the Yurok Reservation, is listed for sedimentation/siltation impairment. Finally, in March 2008, the U.S. Environmental Protection Agency (USEPA) added the reach of the Klamath River that incorporates Copco 1 and 2 and Iron Gate Reservoirs to the 303(d) List for the blue-green algae toxin microcystin. Table 1.1 and Figure 1.2 summarize the waterbody-pollutant combinations for the Klamath River in California as identified on the current (2006) section 303(d) List[2]. The Klamath River TMDLs reported here address the water quality impairments and geographic areas summarized in Table 1.1, with the exception of sedimentation/siltation in the Klamath Glen HSA. Table 1.2 summarizes the status of the TMDLs for the entire Klamath River basin in California.

A consent decree entered into by the USEPA in March 1997 (*Pacific Coast Federation of Fishermen's Associations et al. v. Marcus*) establishes the date by which TMDLs for 17 California northcoast watersheds must be completed. The Klamath River TMDLs for the listed temperature and nutrient impairments were scheduled for completion by 2007. Negotiations between USEPA and the plaintiffs resulted in an extension of that deadline to 2010.

The current TMDLs for the Klamath River in California reported here, address temperature, dissolved oxygen, nutrient, and microcystin water quality impairments for the Klamath River Hydrologic Unit, Middle HA (Oregon to Trinity River) and Lower HA, Klamath Glen HSA (Trinity River to Pacific Ocean). These TMDLs do not explicitly address the sedimentation/siltation impairments in the Lower HA, Klamath Glen HSA. Addressing DO in the mainstem Klamath River required not only the development of a TMDL but, the recalculation of the SSOs for DO, as well. The SSOs for DO in the mainstem Klamath River have been recalculated because conditions of barometric pressure, salinity and natural receiving water temperatures at equilibrium

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2 Figure 1.2 identifies the water quality impairments for the entire Klamath River basin in California, as depicted in the 2006 Clean Water Act Section 303(d) List.

(e.g., 100% DO saturation) do not consistently allow for attainment of the existing SSOs for DO. Further, the *Klamath TMDL model*, as described in detail throughout the rest of this report, indicates that under natural conditions, the DO concentrations achieved in the mainstem Klamath are periodically less than the existing SSOs for DO, particularly during the summer months. For a detailed analysis of DO conditions in the mainstem Klamath River, including the recalculation of the SSOs, please see Appendix 1.

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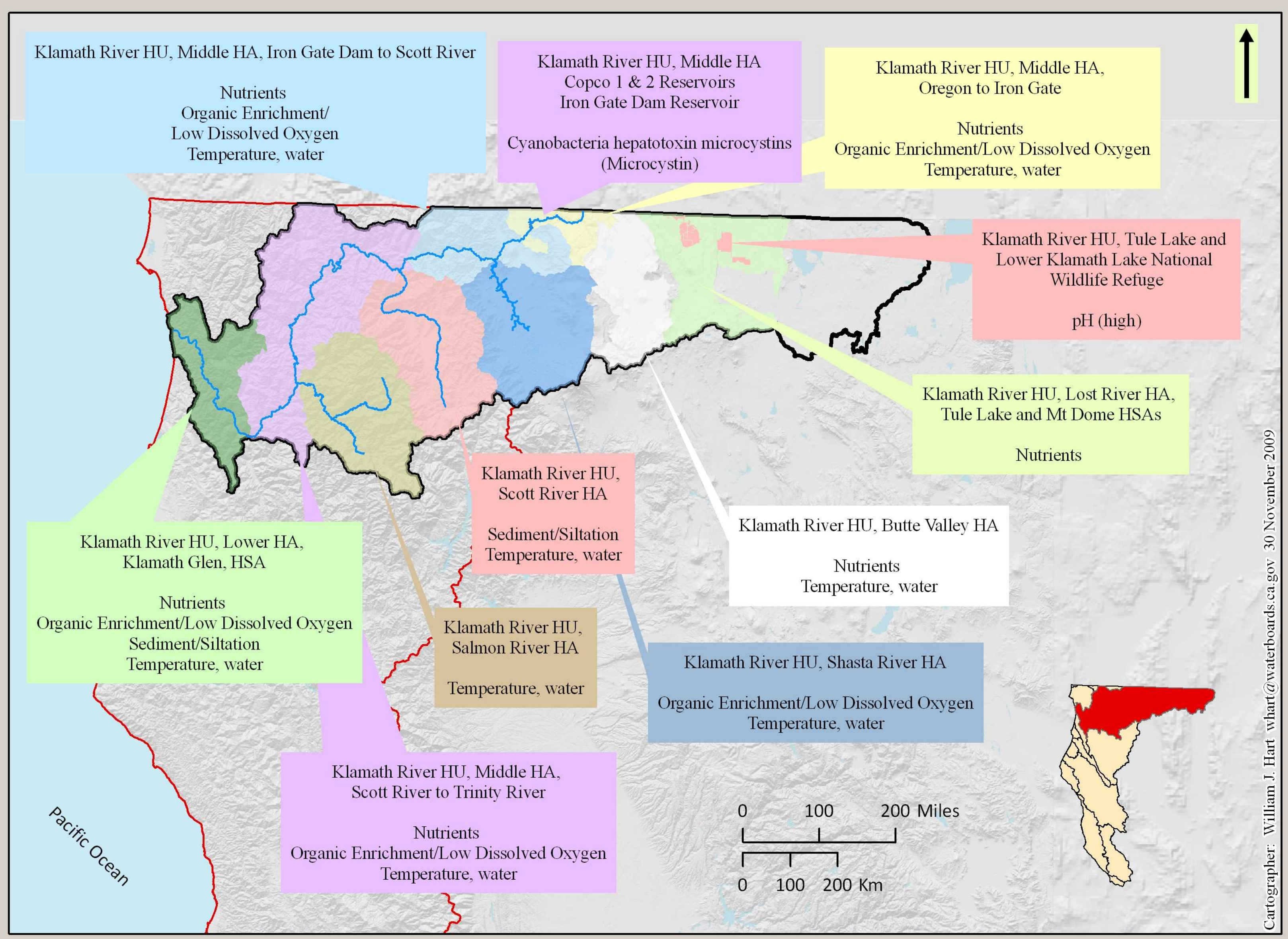

Figure 1.2: 2006 Clean Water Act Section 303(d) List of water quality limited segments in the Klamath River hydrologic unit in California

Table 1.1: Klamath River water quality impairments in California from the 2006 Clean Water Act Section 303(d) List

Hydrologic Area (HA)[3]	**CalWater Watershed**	**Pollutant/Stressor(s)**	**Hydrologic Sub Areas (HSAs**[2]**) Included in Listing**
Middle HA, Oregon to Iron Gate	10530000	Temperature Nutrients Organic enrichment/ low dissolved oxygen	Iron Gate HSA 115.37 Copco HSA 105.38
Middle HA, Copco 1 and 2 and Iron Gate Reservoirs	NA	Microcystin	N/A
Middle HA, Iron Gate Dam to Scott River	10530000	Temperature Nutrients Organic enrichment/ low dissolved oxygen	Beaver Creek HSA 105.35 Hornbrook HSA 105.36
Middle and Lower HAs, Scott River to Trinity River	10500000	Temperature Nutrients Organic enrichment /low dissolved oxygen	Orleans HSA 105.12 Ukonom HSA 105.31 Happy Camp HSA 105.32 Seiad Valley HSA 105.33
Lower HA, Klamath Glen HSA, Trinity River to Pacific Ocean	10511000	Temperature Nutrients Organic enrichment/ low dissolved oxygen Sedimentation/Siltation	Klamath Glen HAS 105.11

Table 1.2: Status of TMDLs in the Klamath River basin in California.

Subwatershed	**TMDL(s)**	**Year**	**Agency**
Upper Lost River	Temperature, nutrients	Delisted, 2006	-
Lower Lost River	Nutrients	Technical TMDL, 2008	USEPA
	Temperature	Delisted, 2006	-
Shasta River	Temperature, dissolved oxygen	Final Technical TMDL and Implementation Plan, 2007	Regional Water Board
Scott River	Temperature, sediment	Final Technical TMDL and Implementation Plan, 2006	Regional Water Board
Salmon River	Temperature	Final Technical TMDL, 2005	Regional Water Board
	Nutrients	Delisted, 2006	-
Trinity River	Sediment	Final Technical TMDL, 2001	USEPA
South Fork Trinity River	Sediment	Final Technical TMDL, 1998	USEPA
Klamath River	Nutrients, temperature, organic enrichment/low dissolved oxygen, microcystin	TMDL in progress	Regional Water Board

Oregon and California have formed a technical team in conjunction with USEPA and its contractor Tetra Tech, Inc. to develop a uniform water quality model of the basin and conduct joint analyses to ensure compatible TMDLs. However, the states will establish

[3] Hydrologic Area (HA) is the terminology used in the CalWater watershed delineation system to identify a sub-unit of a watershed. Similarly, Hydrologic Sub Area (HSA) identifies a smaller hydrologic unit within a HA.

independently the TMDLs for those portions of the basin within their respective jurisdiction. Oregon is not bound by the deadlines associated with the above referenced consent decree. Further, California proposes the recalculation of the SSOs for DO as contained in the Basin Plan, as an additional action not applicable in Oregon.

California has listed separately several of the major tributaries to the Klamath River as impaired; these are identified in Table 1.2. Each tributary watershed is listed for its own site-specific list of pollutants but generally include: elevated water temperature, elevated nutrients, depressed dissolved oxygen levels and excess sediment. Either technical TMDLs or TMDLs with Action Plans have been developed and approved for each of the major tributary watersheds.

1.2 Report Organization

As noted above, this document is the Staff Report supporting the Action Plan. Appendix 1 includes a separate staff report for the recalculation of the SSOs for DO in the mainstem Klamath River. This report contains several standard elements (summarized below) including:

- Chapter 1 – Introduction
- Chapter 2 – Problem Statement
- Chapter 3 – Analytic Approach
- Chapter 4 – Pollutant Source Analysis
- Chapter 5 – Klamath River TMDLs - Allocations and Numeric Targets
- Chapter 6 – Implementation Plan
- Chapter 7 – Reassessment Monitoring Program
- Chapter 8 – Antidegradation Analysis
- Chapter 9 – California Environmental Quality Act (CEQA) Environmental Analysis
- Chapter 10 – Economic Analysis
- Chapter 11 – Public Participation

Chapter 1 describes the regulatory framework for the Klamath River TMDLs and recalculation of the SSOs for DO in the mainstem Klamath River, and presents an overview of the Klamath River basin. Chapter 2 provides the assessment framework for the TMDL and recalculation of the SSOs for DO; assesses water quality conditions in the basin; and documents impairments. Chapter 3 describes the TMDL model and its use in developing the source analysis and allocations for the TMDL as well as its use in the recalculation of the SSOs for DO. Chapter 4 assesses the sources of water quality impairment in the basin and their relative contribution to the overall load of pollutants. Chapter 5 assigns pollutant load and waste load allocations and establishes numeric targets consistent with water quality standards. Chapter 6 describes a program of implementation and includes measures necessary to achieve the Klamath River TMDLs and recalculation of SSOs for DO in California. Chapter 7 describes the monitoring necessary to assess the degree of success associated with the TMDLs, the recalculation of the SSOs for DO and their implementation. Chapter 8 briefly describes the state and federal antidegradation policies and how they apply to the Action Plan. Chapter 9 describes the steps Regional Water Board staff have taken to comply with CEQA, and presents the findings of the CEQA analysis. Chapter 10 analyzes the potential economic benefits and costs that may result from the adoption and implementation of the proposed Action Plan. Chapter 11 describes some of the opportunities that have been made available to the public for comment on and participation in the development of the Klamath River TMDL Staff Report and Action Plan. See Appendix 1 for a discussion of the opportunities for public review associated with the Proposed Site Specific Dissolved Oxygen Objectives for the Klamath River in California (Klamath River DO Staff Report).

1.3 TMDL Development and Adoption Process

Regional Water Board staff submitted a Peer Review Draft Staff Report to outside scientific peer reviewers for review of the technical elements associated with the TMDL. (See Appendix 1 for discussion of the peer review process associated with the Klamath River DO Staff Report). Staff prepared a response to the peer review comment document and revised the Staff Report accordingly. Staff released a Public Review Draft Staff Report for public review and comment in June 2009. The Staff Report accompanied a TMDL Action Plan that summarizes the findings of the TMDLs and describes in detail the proposed plans for implementation, monitoring, and adaptive management. During the summer 2009 public review period, staff conducted public and Board Workshops to present the TMDL and receive oral comments. In December 2009, a revised Staff Report and TMDL Action Plan was released, incorporating revisions based on public comments. Finally, the Staff Report and Action Plan are presented before the Regional Water Board at a public hearing for the purpose of adopting the Action Plan as an amendment to the Basin Plan. Once the Regional Water Board has adopted the TMDL Action Plan, the State Water Resources Control Board (State Water Board) holds a workshop and hearing to confirm the decision of the Regional Water Board. California's Office of Administrative Law provides a final legal review before the TMDL Staff Report and Action Plan are forwarded to USEPA. USEPA approves only the technical TMDL, not the implementation plan components.

1.4 Regulatory Framework and Purpose of the TMDL

The quality of surface and ground waters in the North Coast Region of California is governed by the Water Quality Control Plan for the North Coast Region (Basin Plan) as developed and implemented by the Regional Water Board. The North Coast Region is defined as those waters draining into the Pacific Ocean from the California-Oregon state line to the southern boundary of the watershed of the Estero de San Antonio and Stemple Creek in Marin and Sonoma Counties. The Basin Plan identifies the existing and potential beneficial uses of water within the North Coast Region and the water quality objectives necessary to protect those uses. Together water quality objectives, beneficial uses, and the anti-degradation policy are known as water quality standards. The Basin Plan also prohibits certain activities and requires certain other activities as necessary to achieve water quality standards.

With respect to the Klamath River basin, the Basin Plan prohibits point source waste discharges to surface waters. Point sources are sources of pollutants discharged through a known conveyance, such as an outfall pipe. This prohibition does not apply to point source waste discharges to land, such as discharges to evaporation or percolation ponds. Similarly, the prohibition does not apply to nonpoint source discharges which are the more dispersed flow of pollutants through stormwater runoff.

Under section 303(d) of the CWA, states are required to develop a list of water bodies where legally required pollution control mechanisms are not sufficient or stringent enough to meet water quality standards applicable to such waters. The 303(d) List also includes the pollutant/stressor causing the impairment and a time schedule for addressing the water quality impairment. Placement of a water body on the 303(d) List triggers the development of a TMDL, for each water body-pollutant/stressor combination. The specific requirements for TMDLs are described in the United States Code of Federal Regulations (CFR) Title 40, sections 130.2 and 130.7 (40 CFR § 130.2 and 130.7), and section 303(d) of the federal CWA.

A TMDL is in essence a planning and management tool intended to identify, quantify, and control the sources of pollution within a given watershed such that water quality objectives are achieved and the beneficial uses of water are fully protected. A TMDL is defined as the sum of individual waste loads allocated to point sources, load allocations assigned to non-point sources, and loads assigned to natural background conditions. Loading from all pollutant sources must not exceed the loading or assimilative capacity (TMDL) of a water body. To account for uncertainty, CWA section 303(d) requires that TMDLs are established with a margin of safety.

The USEPA has federal oversight authority for the CWA section 303(d) program and may approve or disapprove TMDLs developed by the states. Under the terms of the consent decree (*Pacific Coast Federation of Fishermen's Association, et. al. v. Marcus*), if USEPA disapproves the Klamath River TMDLs as developed by the Regional Water Board, then USEPA must itself establish the TMDLs by the date specified in the decree.

The Regional Water Board, under the state's Porter-Cologne Water Quality Control Act, has the obligation to establish an Action Plan by which TMDLs are implemented. Action Plans are adopted by the Regional Water Board and incorporated as an amendment into the Basin Plan. USEPA, on the other hand, does not have this obligation. TMDLs developed by USEPA include the technical analysis only, and are then forwarded to the Regional Water Board for implementation. The States of Oregon and California utilize their authority to implement TMDLs by different methods. See <http://www.oregon.gov/DEQ/WQ/index.shtml> for information on Oregon's TMDLs and implementation planning methods.

The purpose of the Klamath River TMDLs is to estimate the assimilative capacity of the system with respect to the total loads of nutrients and organic matter that can be delivered to the Klamath River without causing an exceedance of the water quality objectives for nutrients and dissolved oxygen. The TMDLs must also establish the amount of protection from solar radiation and cold water withdrawals necessary to meet water quality objectives for water temperature.

Assessing the assimilative capacity of the system begins with an estimate of water quality under natural baseline conditions. Having simulated the natural baseline conditions, anthropogenic sources of nutrient and organic matter loads are incrementally added back into the models until that point at which water quality objectives are just being met. A somewhat different but similar approach is used for temperature to assess the assimilative capacity of the river for solar radiation and cold water withdrawals. This then forms the basis for the TMDLs. The geographic scope of these TMDLs includes the entire Klamath River hydrologic area[4] (HA) in California, not including those reaches of the Klamath River that lie within the Hoopa Valley Indian Reservation and Yurok Reservation.

1.5 Other Ongoing Regulatory Processes in the Klamath River Basin

TMDLs must consider other ongoing regulatory processes in the basin. Already described is the recalculation of the SSOs for DO in the mainstem Klamath River. Of additional relevance to water quality are:

- The Tribal Trust responsibilities of the United States government to Tribes and individual Indians.
- The need for consultation under the federal Endangered Species Act with the National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries) and U.S. Fish and Wildlife Service on projects affecting listed species occurring in the Klamath River and its watershed, and
- The relationship between the TMDL process and the water quality certification process under section 401 of the CWA associated with the relicensing application submitted by PacifiCorp to FERC for the operation of hydroelectric facilities on the Klamath River mainstem.

1.5.1 Tribal Trust Responsibilities

The United States has a trust responsibility to protect and maintain rights reserved by, or granted to, federally recognized Tribes and individual Indians, by treaties, statutes, and executive orders. The trust responsibility requires that federal agencies take all actions reasonably necessary to protect trust assets, including the fishery resources of the Indian Tribes in the Klamath River basin. The Regional Water Board must consider federal Tribal Trust responsibilities in the Klamath River basin since TMDLs are subject to the approval of the USEPA. The Regional Water Board will assist USEPA in fulfilling Tribal Trust responsibilities by adopting an Action Plan that restores and maintains pollutant levels that are protective of anadromous fish and other beneficial uses related to

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4 Hydrologic Area is the terminology used in the CalWater watershed delineation system to identify a sub unit of a watershed, involving a major river.

the Tribes of the Klamath River in California, including the Hoopa, Karuk, Quartz Valley, and Yurok Tribes and the Resighini Rancheria to the degree that natural conditions allow.

1.5.2 ESA Consultation

The USEPA and Regional Water Board initiated an informal consultation process with the United States Fish and Wildlife Service (USFWS) and NOAA Fisheries on the Klamath River basin TMDLs in California. USEPA and Regional Water Board staff have used this process to provide information and updates on the TMDLs in the Klamath River basin (e.g., the Salmon, Scott, Shasta, Lower Lost, and Klamath River TMDLs). USEPA has an obligation to consult with federal wildlife agencies on any action that may affect the wildlife trust responsibilities of these agencies. The Regional Water Board must consider the federal wildlife trust responsibility in the Klamath River basin since TMDLs are subject to USEPA approval. The Regional Water Board will assist USEPA in fulfilling wildlife trust responsibilities by adopting an Action Plan that restores and maintains pollutant levels that are protective of threatened or endangered species including anadromous fish, and other cold water species, and their habitat.

1.5.3 Water Quality Certification

PacifiCorp currently operates hydroelectric facilities on the Klamath River in southern Oregon and northern California. On February 23, 2004, PacifiCorp transmitted its application for a new 50-year license for the Klamath Hydroelectric Project to the Federal Energy Regulatory Commission (FERC). Associated with its application for a new license is the obligation to submit documentation under section 401 of the CWA to the State Water Board and ODEQ that demonstrates compliance of the proposed project with state water quality standards. The State Water Board then reviews the documentation and issues its water quality certification (401Certification) if the information indicates that water quality standards will be met. The certification can include conditions in order to ensure that water quality standards are met. A certification is denied if water quality standards will not be met by the project as proposed.

As a result of its review of the submitted documents, the State Water Board issued a letter on February 26, 2007 indicating that PacifiCorp had not adequately documented its assertion that water quality will be protected by the relicensing of the hydroelectric facilities. Additional studies of several areas of concern are required before 401 Certification can be issued. In addition, an environmental impact review under the CEQA is required before a certification can be issued. A key question under consideration in the certification review process is whether or not the proposed project will meet the TMDLs.

1.5.4 Klamath Basin Restoration Agreement, Agreement in Principal, and Klamath Hydroelectric Settlement Agreement

The Klamath Basin Restoration Agreement (KBRA) is a negotiated settlement agreement between as many as 26 different parties designed to settle long-standing disputes in the Klamath River basin. It focuses on water allocations in the upper basin, provides for fisheries restoration and is structured around the central assumption that an agreement to remove the lower four Klamath River Dams will be reached. On November 13, 2008, an Agreement in Principle (AIP) to remove four Klamath River dams was announced after negotiations between the federal government, representatives from the state of California, the state of Oregon, and PacifiCorp. Regional Water Board staff were not a party to the KBRA or AIP negotiations. On September 30, 2009, a draft Klamath Hydroelectric Settlement Agreement (KHSA) was released. The final KBRA and KHSA agreements may affect the TMDL implementation schedule, which relies on the FERC relicensing process and subsequent water quality certification by the State Water Board. As currently drafted, the KHSA contemplates federal legislation that would allow PacifiCorp to remain on annual licenses from FERC, thereby indefinitely delaying the 401 certification and Clean Water Act compliance. See Chapter 6 for additional discussion.

1.6 Physical Setting

It is useful to orient the reader to the physical setting within which the TMDLs for the Klamath River basin are developed as a way of establishing the background conditions influencing pollutant levels in the system. The topography of the basin, the bedrock geology, soils, vegetation and climate each play a role in shaping the particular surface water and ground water hydrology of the basin. Similarly, these factors play a role in the fate and transport of instream pollutants. More detailed descriptions of the physical setting of the Klamath River basin have been reported extensively in numerous available publications including:

- Federal Energy Regulatory Commission. 2007. Final Environmental Impact Statement for the Klamath Hydroelectric Project. Docket No. P-2082-027. November 18, 2007. U.S. DOE, FERC, Washington D.C.
- National Research Council of the National Academies (NRC). 2004. Endangered and Threatened Fishes in the Klamath River Basin. Washington, D.C. National Academies Press.

1.6.1 Population and Land Ownership

The human population in the Klamath River basin was estimated in the 2000 US Census to be about 114,000 (United States Census Bureau [USCB] 2000). The largest population concentrations lie in the upper Klamath agricultural area, the Shasta River Valley, and Scott Valley. The largest population center is Klamath Falls in Oregon (19,462 people in 2000) followed by Yreka, California (7,290 people). The Klamath River basin can generally be characterized as a rural watershed with limited population-related water quality issues.

More than two thirds of the Klamath River watershed is in federal ownership. Figure 1.3 shows, among other things, federal lands managed as National Forests, National Wildlife Refuges, and National Parks, in addition to Bureau of Land Management (BLM) land. The largest blocks of private ownership are agricultural areas in the upper Klamath watershed and agricultural and timber properties in the Shasta and Scott Valleys and adjacent areas of the mainstem. Also, much of the Klamath River Valley near the mouth of the river is privately owned.

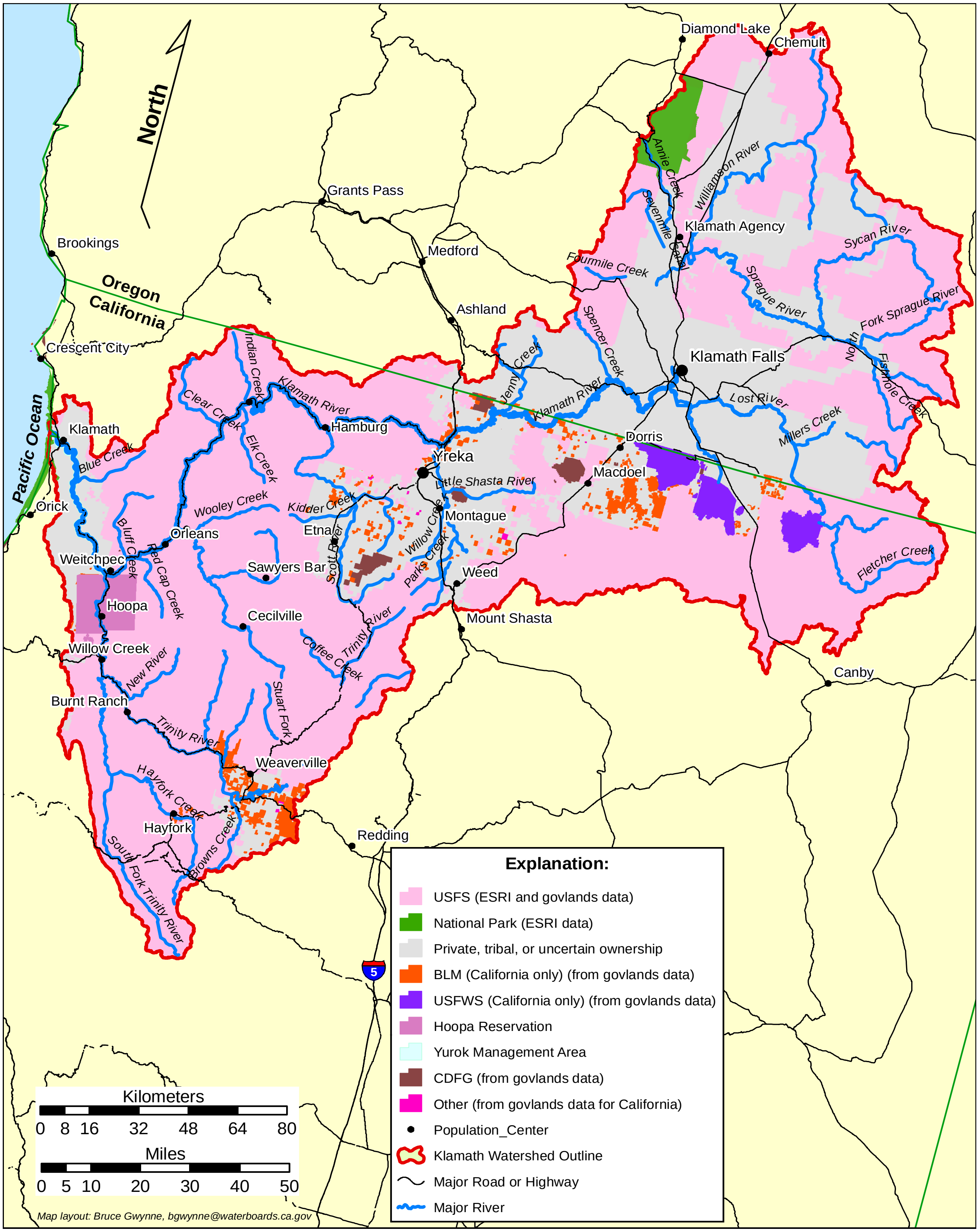

Figure 1.3: Land ownership in the Klamath River basin

The Hoopa Valley Tribe owns land, 12 miles by 12 miles, primarily in the Trinity River watershed but intersecting the Klamath River at Saints Rest Bar upstream of the confluence with the Trinity. The Yurok Reservation's lands extend from 1 mile on each side from the mouth of the Klamath River and upriver for a distance of 44 miles. The Karuk Tribe owns 800 acres of tribal trust land along the Klamath River between Orleans and Happy Camp, and in Yreka, California. The Quartz Valley Indian Reservation is located near Fort Jones and encompasses 174 acres along the Scott River. The Resighini Rancheria spans 228 acres along the south shore of the mouth of the Klamath River.

1.6.2 Topography, Geology and Soils

Topography in the Klamath River watershed varies between steep mountains and flat and rolling valley bottoms with little in between (Figure 1.4). Elevations range from sea level at the river mouth to 14,179 feet (4,322 meters) feet at the summit of Mount Shasta. The Klamath River watershed crosses four recognized geomorphic provinces, each of which is defined and shaped by its unique geologic history. From east (upstream) to west (downstream) these provinces are the Modoc Plateau, Cascade Range, Klamath Mountains, and Coast Ranges (Figure 1.5). These geomorphic provinces, defined by Oakshott (1978), are the result of the different structure and composition of the underlying rocks and different times of uplift and volcanism.

Headwaters of the Klamath gather in the Modoc Plateau, an area of geologically young lava flows (Pliocene and Pleistocene – less than fifteen million years) and flat valleys punctuated by volcanic cones. The rolling valley bottoms are at about 4000 to 5000 feet (1219 to 1524 meters) elevation and the volcanic cones rise a thousand feet higher. While drainage in this young landscape is through-flowing, many depressions contain shallow lakes, most of which have been augmented by dams. Although rainfall is low, the flat and rolling valley bottoms of rich volcanic and organic soils combine with abundance of water entering from higher surrounding country to create historically vast freshwater wetlands. Much of these have been converted to farmland. The volcanic soils are naturally rich in phosphorus, a nutrient of concern in these TMDLs. Similarly, the conversion of wetlands to farmland and other land uses has exposed the nutrient and organic rich soils to oxidation, resulting in the release to the water column of nitrogen and phosphorus previously stored in the soil and wetland vegetation (Snyder and Morace, 1997).

The transition between the Modoc Plateau and Cascade Range provinces is not sharp, so that a line on a map is by necessity a bit arbitrary (Figures 1.5, 1.6). The Cascade Range province is a belt of mainly volcanic rocks that are younger than rocks of most of the Modoc Plateau and form higher relief. The Cascade Range is defined by a chain of active and potentially active volcanoes that stretches from Mount Lassen, east of Redding, northward through Oregon and Washington into Canada. The most prominent mountain in the Klamath region is Mount Shasta, a composite volcano that rises at the head of Shasta Valley, and which last erupted about 1786. Crater Lake, in the northeast, fills the collapse crater of a volcano that erupted cataclysmically about 7,000 years ago.

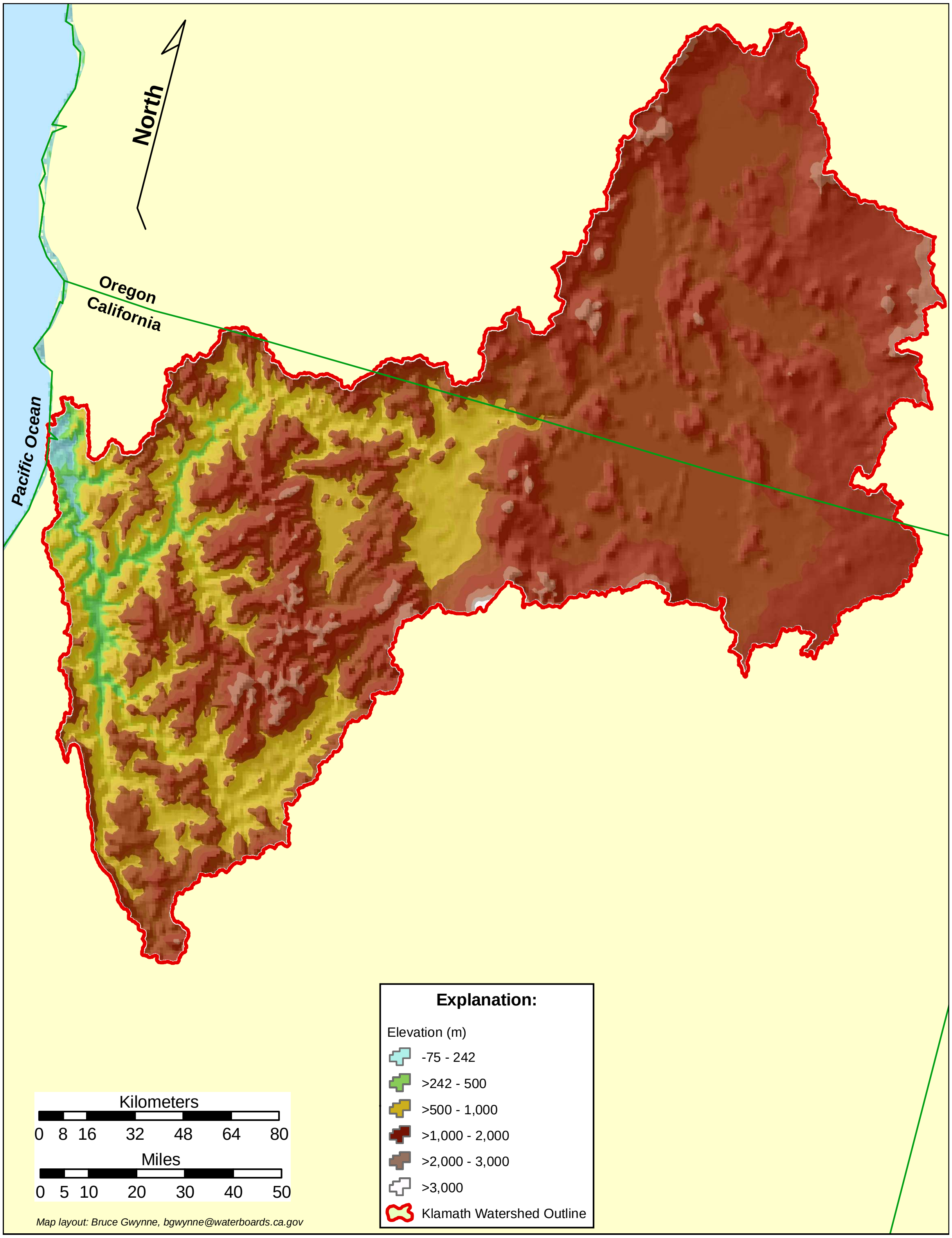

Figure 1.4: Land elevation in the Klamath River basin

Figure 1.5: Geomorphic provinces in the Klamath River basin - Source: Oakshott 1978

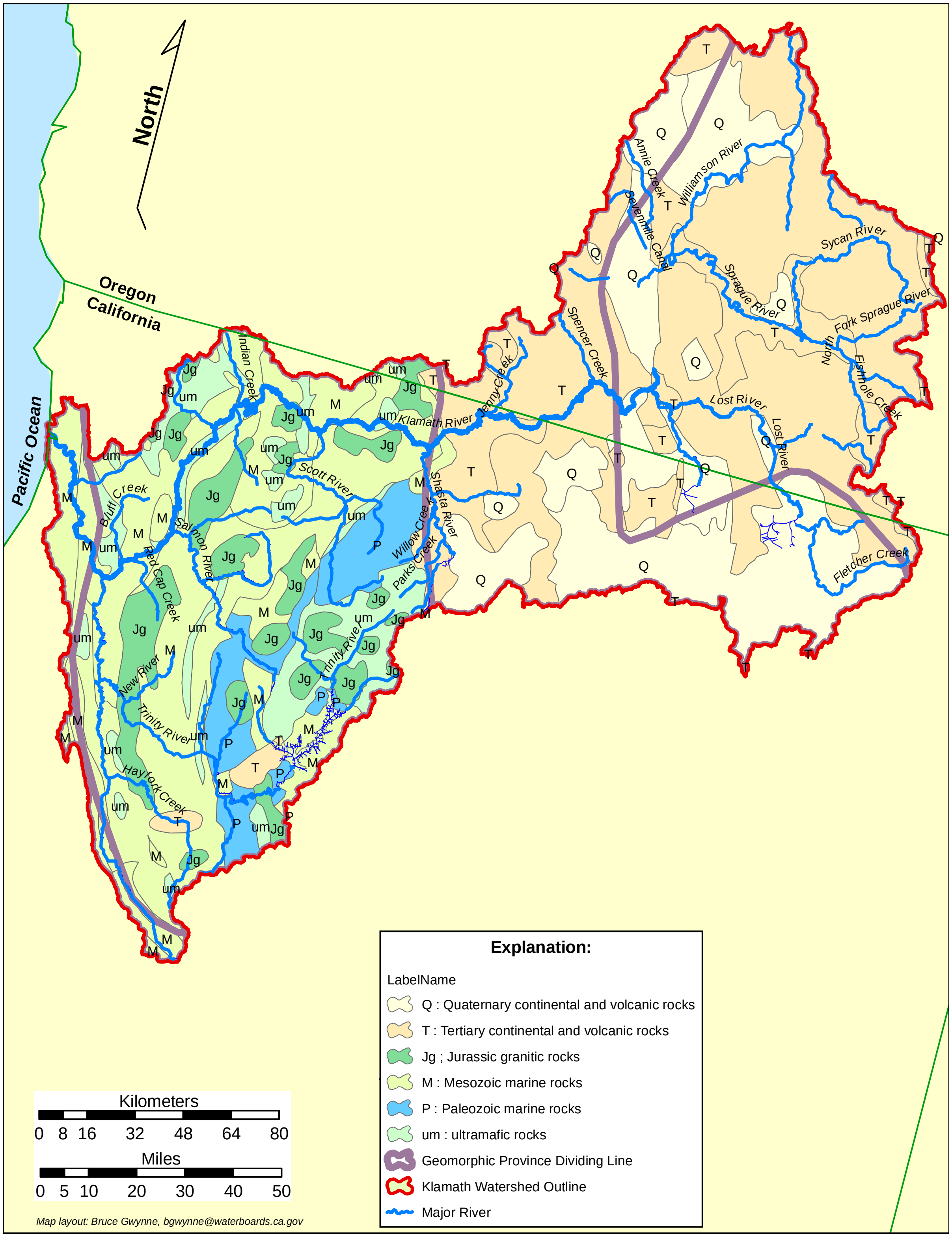

Figure 1.6: Geologic map of the Klamath River basin
Source: Modified from Schruben et al. (1997)

The border between the Cascade province and the Klamath Mountains province is spanned by Shasta Valley and covered by a unique deposit. Most of the floor of this valley is disrupted rolling topography of small hillocks and closed depressions. Crandell (1989) recognized this landscape as the deposits formed by a huge avalanche and debris flow, or series of such events, shed off the north flank of Mount Shasta more than 300,000 years ago.

The Klamath Mountains province is very steep and rugged for the most part and in the Klamath River watershed consists of several irregularly oriented ranges – the Trinity Alps, Scott Bar Mountains, Siskiyou Mountains, and Marble Mountains. Shasta and Scott Valleys have broad flat valley bottoms that support agriculture, but other valleys are narrower and steeper and therefore less developed. Most of the land in the Klamath Mountains province is in federal ownership (Figure 1.3), and this rugged landscape lends itself more to timber harvest and cattle grazing than to crops.

The bedrock geology of the Klamath Mountains province is extremely varied and complex (Figure 1.6) and largely made up of ocean-floor igneous and sedimentary rocks of a large range in ages. Most of the igneous rocks in this province are dark colored mafic and ultramafic rocks of both intrusive and extrusive origin, most of which have been partly or wholly altered to serpentine and otherwise metamorphosed. Younger, light colored granitic rocks have been intruded in some places. Recent uplift has created a landscape of rapidly downcutting streams and steep slopes that are subject to rapid erosion and landsliding. The granitic rocks in particular weather to form loosely consolidated material that sloughs and ravels easily when disturbed.

The Coast Ranges province, the westernmost province (Figure 1.5), forms about 20 miles of the lower Klamath River valley and part of the west side of the valley of the lower Trinity River and South Fork Trinity River. These rivers have exploited the fault zone that forms the geologic boundary between the Klamath Mountains province and the Coast Ranges province. The Coast Ranges are steep, but are generally more rounded and not as high as the mountains of the Klamath Mountains province. Bedrock is the Franciscan Complex, which is structurally deformed and highly varied. The mix of sedimentary rocks includes sandstone, siltstone, shale, conglomerate, greywacke, and chert. Parts of the complex have been metamorphosed and include blueschist and greenschist as well as low grade mica schist. Some areas are mélange, which is geologic terrain that has been deformed and mixed by prolonged and complex tectonic movement, and lacks continuity of structure, rock type, or age.

The gradient profile of the Klamath River is anomalous for a large river in that it is generally low gradient in the headwaters in the Modoc Plateau and steeper farther downstream (Figure 1.4). This unusual gradient is largely the result of geologic uplift in the upstream portion of the river basin in recent geologic time.

1.6.3 Vegetation

Vegetation in the Klamath varies greatly with elevation, precipitation, and degree of disturbance. Figure 1.7 shows the major classifications of vegetation (Thematic Mapper

GIS database). Conifers dominate in the steep mountains and the higher elevations. Hardwood forest and shrubs are more abundant in the lower country, which tends to be warmer and dryer. In many parts of the region a transition zone of mixed conifer and hardwood separates areas classified as conifer forest and hardwood.

1.6.4 Climate

The great geographic extent and topographic relief of the Klamath River watershed combine to produce a wide variety of climate conditions (Figure 1.8). On average, the climate is characterized by dry summers with high daytime temperatures and wet winters with moderate to low temperatures. About three quarters of the annual precipitation falls between October and March, producing a snowpack in the higher mountain ranges that feeds streamflow in many lower areas through the summer. As major storms move in from the Pacific Ocean, the moisture-laden air rises over the coastal mountain ranges and condenses as rain and snow (California Department of Water Resources [CDWR] 1986). Further inland, in the valleys of major tributaries and over the lower terrain of the upper Klamath basin, a rain shadow effect is created, and less moisture falls (Figure 1.8).

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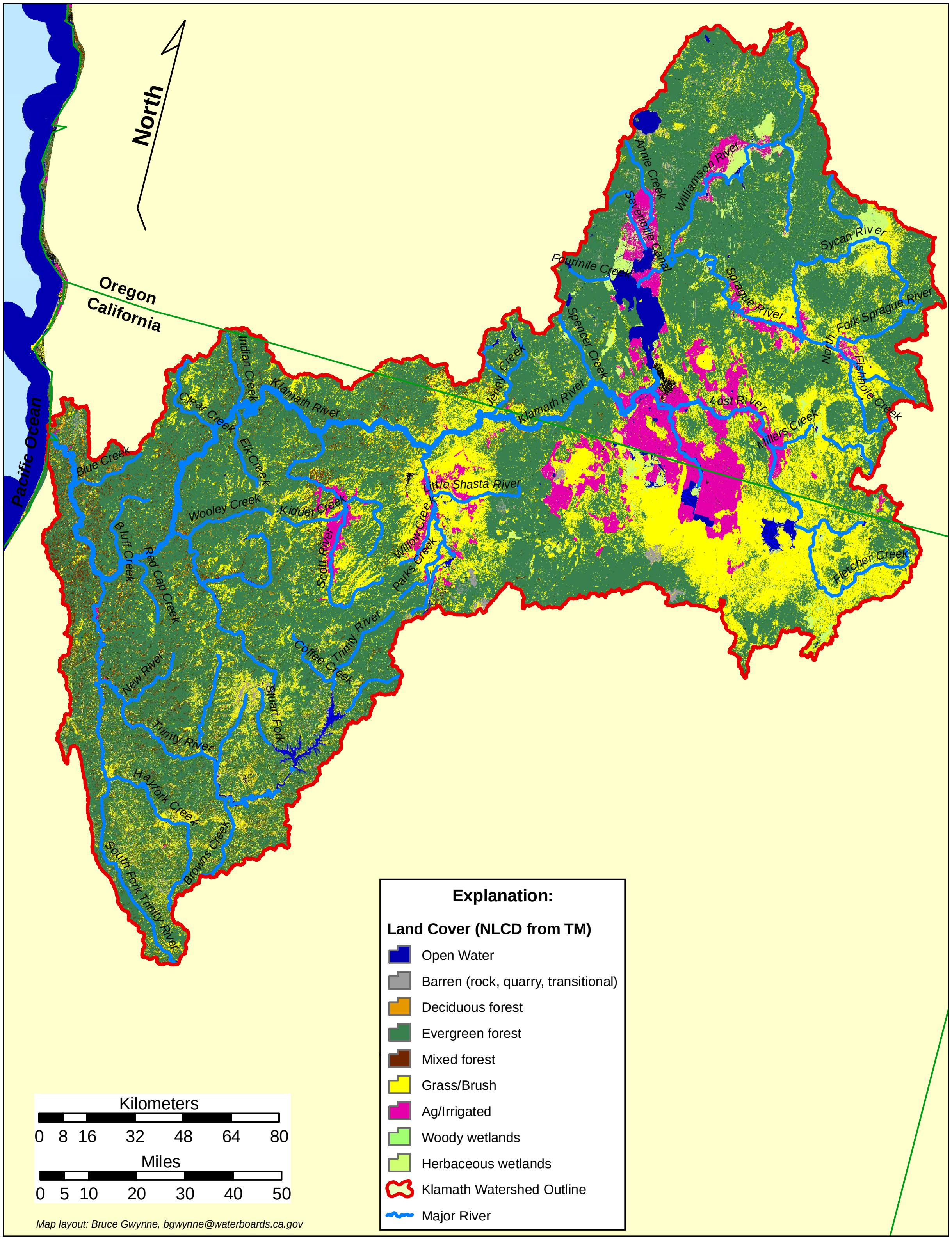

Figure 1.7: Vegetation and land cover of the Klamath River basin

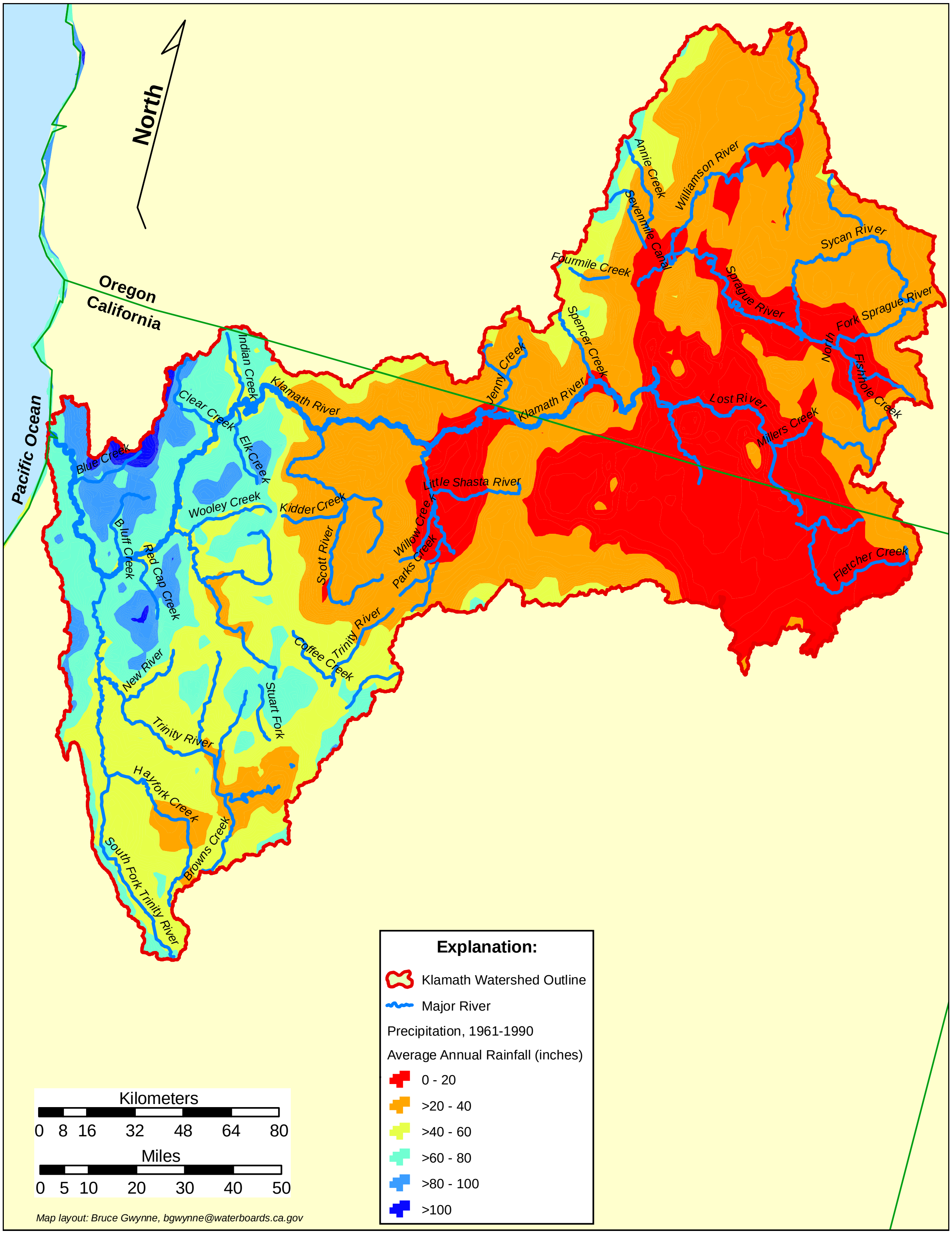

Figure 1.8: Average annual rainfall in the Klamath River basin
Source: United States Department of Agriculture (USDA) Undated

Figure 1.9 provides a comparison of monthly precipitation values from Orleans, California in the mountainous country of the lower Klamath basin and Klamath Falls, Oregon in the broad valley of the upper Klamath basin as an illustration of rainshadow effect. The mean annual precipitation in the Klamath River watershed is about 32 inches (CDWR 1986); but, local averages range from more than 80 inches in the high elevations to 10 inches in the broad inland valleys (CDWR 1986; United States Forest Service [USFS] 1996).

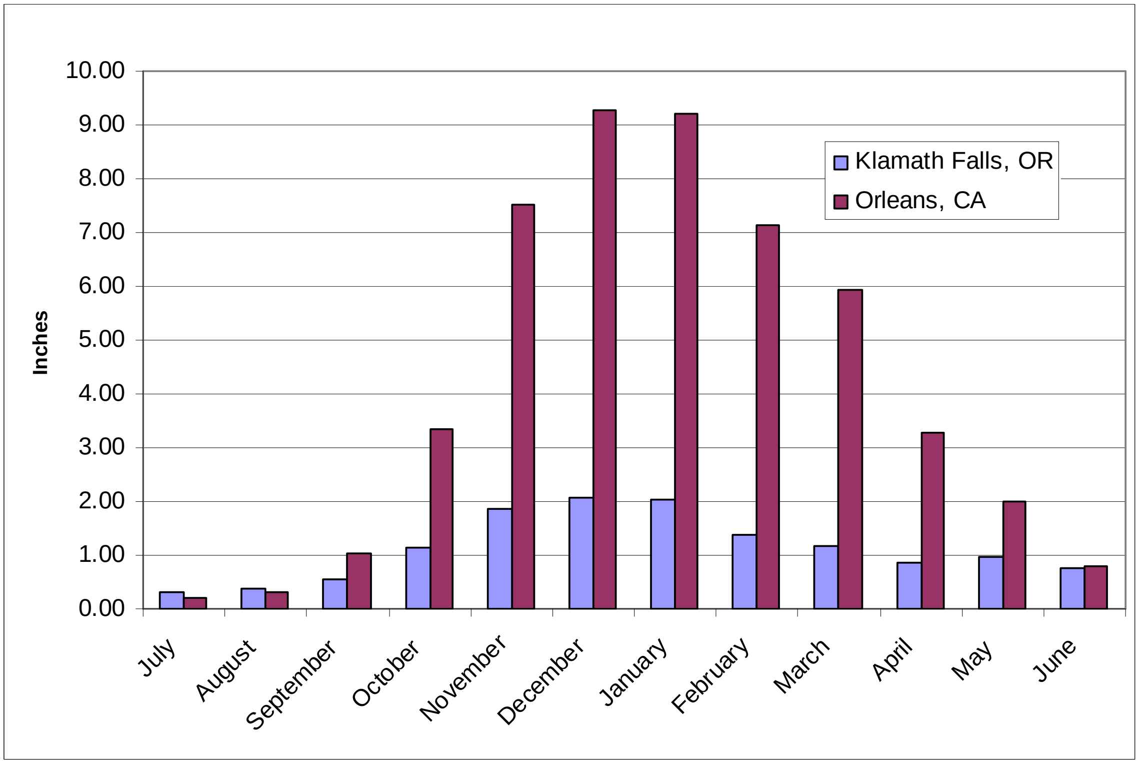

Figure 1.9: Average Monthly Precipitation, 1905-2003, in Klamath Falls, Oregon and Orleans, California
Source: California Data Exchange Center [CDEC] 2006; Oregon Climate Service [OCS] 2006

In the 20th century the Klamath River watershed was characterized by a pattern of floods and droughts. This pattern is discussed by The Klamath River Basin Fisheries Task Force [KRBFTF] (1991, p. 2-3 to 2-7). During a drought in 1976-77, precipitation was only 20 percent of normal in the Scott River watershed and 40 percent of normal in the upper Klamath River basin. The largest floods occurred when relatively warm storm systems melted a pre-existing snow pack such as occurred in 1861, 1955, 1964, 1974 and 1997 (USFS 2000, p.3-3). Many areas of the Klamath River watershed, mostly in the middle third of the basin, are susceptible to these rain-on-snow events.

Klamath Basin air and water temperature data indicate that air and water temperatures have been steadily increasing since at least the 1960s. Bartholow (2005) analyzed air and water temperature records distributed throughout the Klamath basin and evaluated water temperatures simulated using a computer-based water temperature model. The results of Bartholow's analysis strongly suggest a trend of water temperature increases of approximately 0.5 °C per decade since the 1960s.

1.6.5 Hydrology

Drainage density in the Klamath River watershed is affected by infiltration capacity, tectonics, and underlying bedrock. Figure 1.10 shows dense drainage networks in the steep, recently uplifted ranges to the west and in the volcanic mountains to the east. The lower, flatter country in the upper Klamath, in the region of Klamath Falls, has a much lower drainage density and is punctuated by lakes and wetlands associated with local tectonic subsidence.

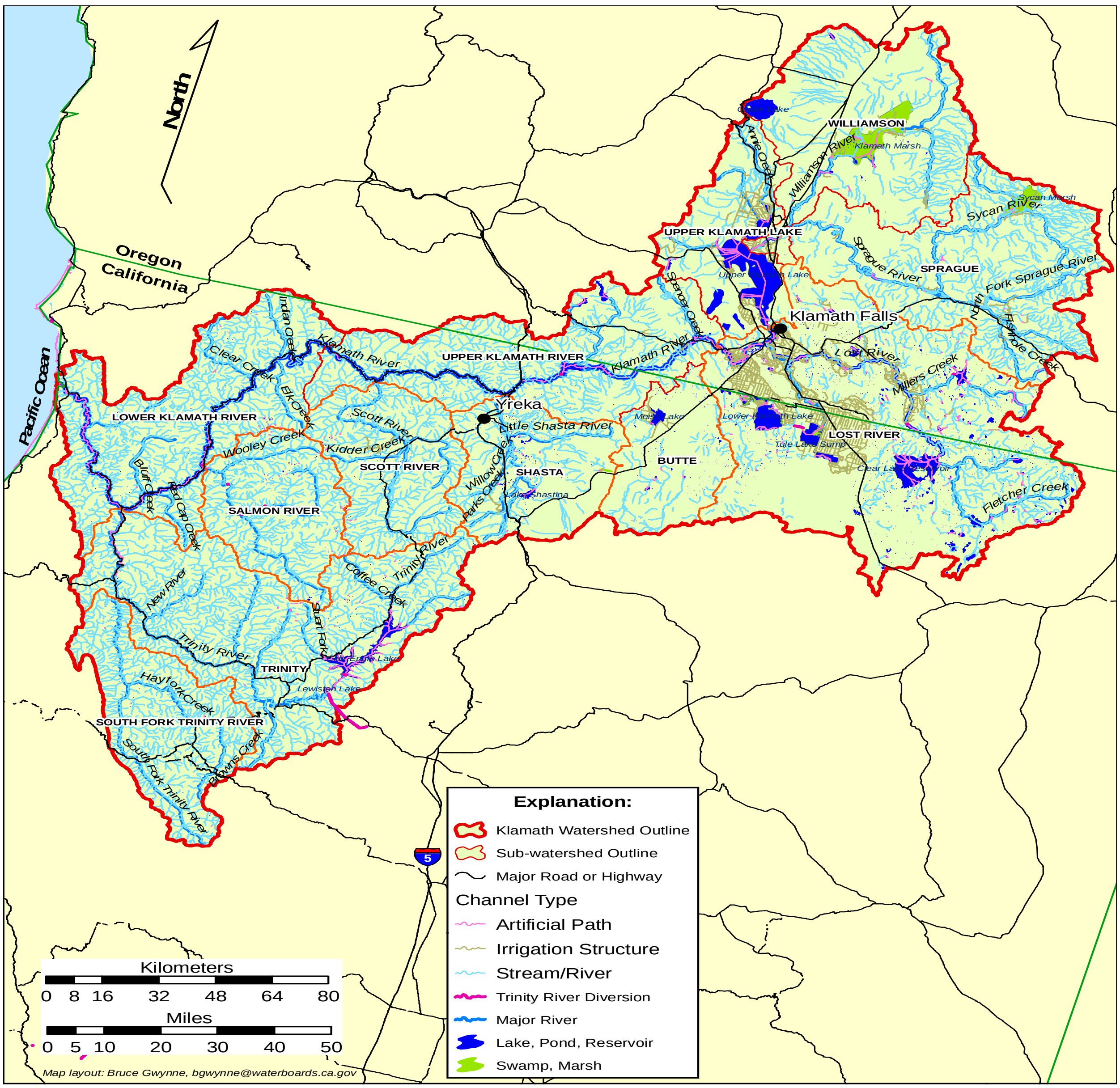

Figure 1.10: Map of Klamath River basin emphasizing subbasins and surface drainage

Water yield in the Klamath basin varies by watershed setting. As illustrated in Figure 1.11, approximately half of the February flow measured in the lower watershed at Klamath, California is drained from that portion of the basin from Orleans, California to Klamath, California, representing about a third of the basin's area. Conversely, only 7 percent of the flow originates in the upper one third of the basin. This pattern is not as dramatic in the summer months when water yield is more generally proportional to drainage area. It is important to recognize that the data presented in Figure 1.11 shows the pattern of flow associated with a history of consumptive use (e.g., Klamath Project in the upper basin) and altered flow timing (e.g., controlled releases from Upper Klamath Lake). However, these factors do not affect the above observations with respect to winter flows.

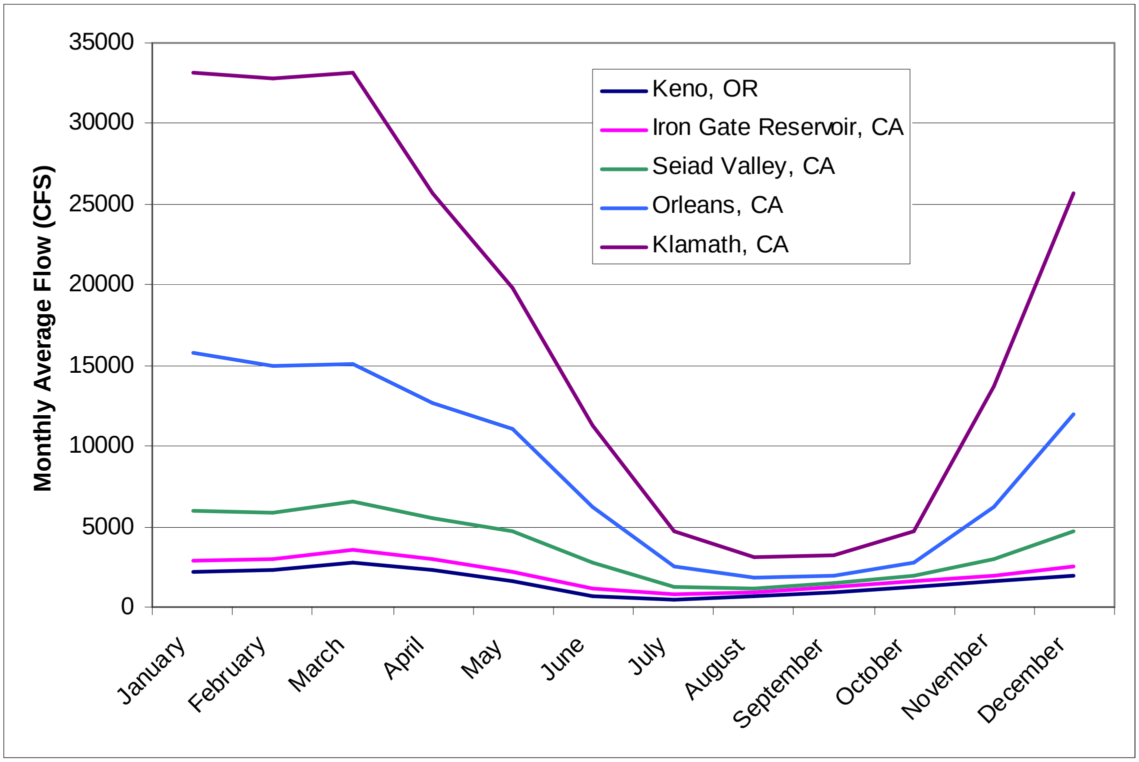

Figure 1.11: Monthly average flows at five Klamath River locations, water years 1963-2005
Source: United States Geological Survey [USGS] 2006

1.6.6 Water Use

There exist in the Klamath River basin numerous dams and diversions associated with power generation and irrigation. The histories of many of these are well documented and the effects on water yield quantified. The effects of diversions granted under riparian rights and groundwater withdrawals, however, are not well understood. Beginning around 1850, small dams and diversion ditches were built on smaller tributaries for use in mining and irrigation. Starting out small and temporary in nature, some became more fixed as established use persisted. As early as 1930, these more permanent diversion structures were creating barriers to fish migration (KRBFTF 1991, p.2-40, 2-62). Among the mining dams, some were left in place after cessation of mining, creating additional barriers (KRBFTF 1991, p.2-62).

Beginning in the 1890s, hydroelectric power facilities were installed, first on the Shasta River, then on the Link River. California Oregon Power Company (COPCO) built Copco Number 1 Dam and Copco Number 2 Dam between 1917 and 1925. These comprise the first major hydroelectric facilities built on the mainstem of the Klamath River (KRBFTF 1991, 2-62 to 2-64).

Prohibitions on the construction of any obstructions in the Klamath River downstream from the mouth of the Shasta River were enacted as a result of Proposition 11 passed in a statewide election of 1924 (KRBFTF 1991, p. 2-64). This effectively ended the prospective efforts to build major hydroelectric and diversion projects in the Klamath River below the mouth of the Shasta River; though no such protections were afforded the flows above the confluence with the Shasta. In 1958, J.C. Boyle (Big Bend) Dam went online just upstream of the California state line.

In 1962 Iron Gate Dam was built below Copco 1 and 2 at river mile 190. From this point to the ocean the river is protected as free flowing under the National Wild and Scenic Rivers System. Iron Gate Dam was originally built to attenuate flow variations caused by the operations of Copco 1 and 2 Dams. These dams are operated as peak demand generation facilities.

Most of the Klamath River water is used in the Klamath River basin, including the use of water for crop and pasture irrigation within the Williamson River, Sprague River, Lost River, Shasta River, Scott River, and South Fork Trinity River. Facilities built to support consumptive uses in California include the U.S. Bureau of Reclamation Klamath Project (construction began in 1906, first water delivered in 1907) and Lake Shastina (created by the construction of Dwinnell Dam on the Shasta River in 1928). A total of 240,412 acres of irrigable lands, including 235,667 acres of farmland, and 4,745 acres of residential, commercial, and industrial lands, are served by Klamath Project infrastructure.

In addition to in-basin use, however, there are also significant diversions out of the basin maintained for agriculture and power generation: The Lewiston and Trinity Dams were completed in 1964 on the Trinity River to enable a significant transfer of flow out of the Klamath watershed and into the Sacramento River system. An additional, smaller, out-of-basin diversion occurs from the upper tributaries in the Jenny Creek watershed in Oregon and into the Rogue River watershed in Oregon.

The pattern of water use, on the other hand, is nearly the opposite of the pattern in drainage density and water yield. That is, the majority of the diversions in the basin are upstream of Seiad Valley where the least amount of the water is produced. As demonstrated by Figure 1.12, some of the effects of this pattern of water use are to:

- Move the timing of the peak spring flows from mid-April to mid-March;
- Make steeper the decline in the spring hydrograph, thus reducing flows by roughly 65-70% in June and July, 45% in May, 20-25% in April, and 35-40% in August;
- Lower the minimum summer flows; and
- Move the timing of the minimum summer flow from mid-September to mid-July

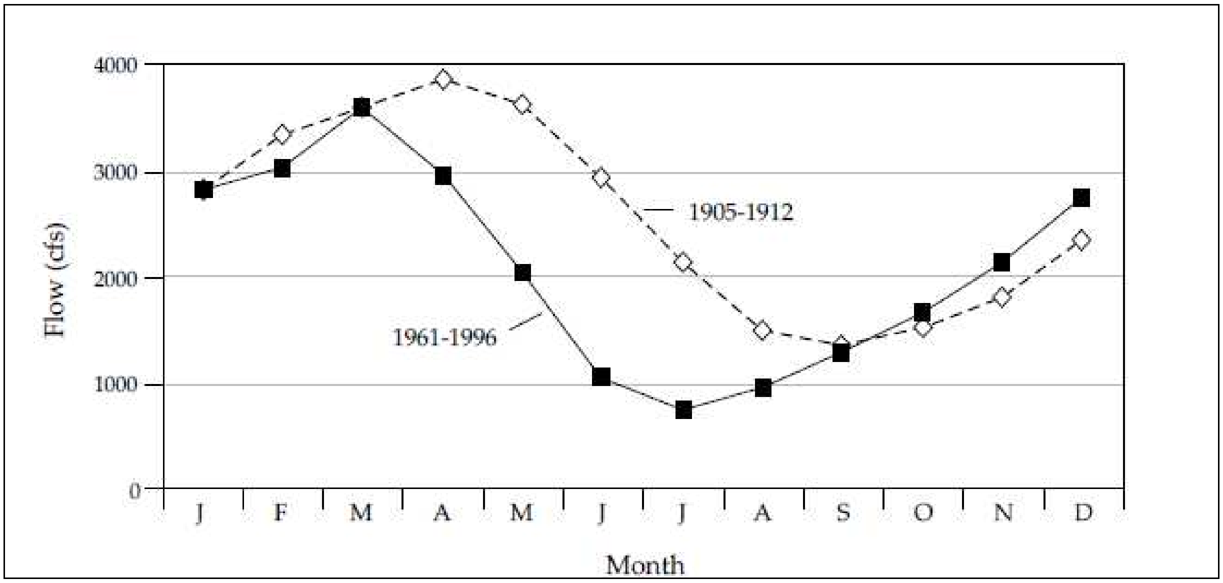

Figure 1.12: Mean monthly flows at Iron Gate Dam in 1961-1996 compared with reconstructed flows for 1905-1912
Source: NRC 2004

The estimated unimpaired flows represented in Figure 1.12 illustrate the magnitude and pattern of flows that would be expected without diversions upstream of Keno, Oregon.

1.6.6.1 Water Rights of the Klamath River Basin, California
Water rights within the State of California are administered by the State Water Resources Control Board, Division of Water Rights (Division of Water Rights) based on three general principles:

- All water belongs to the people of the state;
- Water rights are a right to the use of water;
- Water use must be reasonable and beneficial.

Generally, the appropriative use of surface water after 1914 requires a permit through the Division of Water Rights. Permits identify the maximum amount of water allowed to the user, the timing of permitted use, and the place and purposes of the use. In times of water shortage users with the oldest permits have the first priority to use. Permitting of water rights within the Klamath River basin in California began in June 1916. For the Klamath Basin within California, there are a total of 1614 permitted water rights listed with the Division of Water Rights.

Once all the water within a stream or river has been permitted by the Division of Water Rights for withdrawal, the stream is declared fully appropriated either year-round or during specified months. Table 1.3 lists all the fully appropriated tributaries to the Klamath River in California and below Iron Gate dam, as well as the season during which they are determined fully appropriated. Additionally, the Klamath River itself is determined to be fully appropriated during the entire year.

Table 1.3: Fully appropriated Klamath River reaches and tributaries to the Klamath River in California below Iron Gate Dam

Stream	Tributary	Season Begin-End	Critical Reach
Klamath River	Pacific Ocean	01/01-12/31	From the mainstem about 100 yards below Iron Gate Dam to the Pacific Ocean.
Trinity River	Klamath River	01/01-12/31	The mainstem from 100 yards below Lewiston Dam to the river mouth at Weitchpec.
Salmon River	Klamath River	01/01-12/31	The Salmon River from Cecilville Bridge to the river mouth near Somes Bar.
Scott River	Klamath River	01/01-12/31	The Scott River from the mouth of Shackleford Creek west of Fort Jones to the river mouth near Hamburg.
Shasta River	Klamath River	05/01-10/31	From the confluence of the Shasta River and the Klamath River upstream.
Willow Creek	Klamath River	04/01-11/30	From the York Road Bridge located within Section 8, T46N, R5W, MDB&M upstream.
Seiad Creek	Klamath River	07/01-10/31	From the confluence of Seiad Creek and the Klamath River upstream.
McKinney Creek	Klamath River	03/01-11/30	About 1 ½ miles downstream from the point of diversion on McKinney Creek upstream.
Douglas Creek	Klamath River	06/01-10/31	From a point on Douglas Creek located within the NE 1/4, Section 19, T15N, R7E, MDB&M upstream.

Source: State Water Board 1998, p.8, 13, 56, 57, 58, 64.

The right to use water can under some circumstances be legal without a permit from the Division of Water Rights. Land owners with property adjacent to a waterbody have what is known as a “riparian right” by which they can use water on their river front parcel, so long as the use is reasonable with respect to other users of the waterbody. Groundwater use is also allowed without a permit from the Division of Water Rights if not within the underflow of the river. All water use in California is subject to a constitutional prohibition against waste and unreasonable use or method of diversion.

Table 1.4 summarizes permitted water rights within the Klamath River basin in California, based on the Division of Water Rights, Water Right Information Management System (WRIMS). Table 1.4 groups water rights into reaches of the Klamath River in California including all tributaries. The Shasta, Scott, Salmon, and Trinity Rivers are summarized individually. Summer season (May through August) and winter season (September through April) water rights are summarized and the primary summer season water use is identified. Diversions for the purpose of storage are included in Table 1.4. Uses for stored water include domestic, fire protection, fish culture, irrigation, industrial, incidental power, municipal, power, recreation, stockwatering, and fish and wildlife protection and/or enhancement. The season that water is diverted for the purpose of storage varies from permit to permit. Months of diversion for storage generally occur during the period of November through June. A small portion of permits include the right to divert water throughout the year and only a few allow diversion for storage during the summer months. All values represent the maximum permitted water use.

Table 1.4: Summary of water rights in the Klamath River basin in California below Iron Gate Dam

Reach	Number of Permits	Primary Summer Use	Summer Totals (cfs)	Winter Totals (cfs)	Storage Totals (af)
Klamath River					
Iron Gate to Shasta River	50	Fish Culture	65	49	81
Shasta River to Scott River	76	Domestic	9.6	8.6	0
Scott River to Salmon River	143	Power	25	17	10
Salmon River to Trinity River	66	Domestic	0.006	0.006	160
Trinity River to Pacific Ocean	40	Power	2	2	0
Tributaries					
Tributaries to Iron Gate & Copco	34	Irrigation	72	16	0
Shasta River Watershed	121	Irrigation	982	82	9406
Scott River Watershed	272	Irrigation	255	157	387
Salmon River Watershed	86	Domestic	44	39	6
Trinity River Watershed	726	Municipal	818	593	4442

Source: WRIMS 2006
Note: Summer season is May through August and winter season is September through April.

Dates of permitted water use vary from permit to permit. Table 1.4 groups permitted water rights into summer and winter seasons. Water use permitted during the months of May through August are grouped into the summer totals. Water use permitted during the months of September through April is grouped into the winter totals. Water uses permitted for the entire year are accounted for once in the summer total and again in the winter total.

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