BUILDING A FOUNDATION FOR COORDINATED WATER QUALITY MONITORING IN THE KLAMATH RIVER BASIN

by

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ABSTRACT

Building a Foundation for Coordinated Water Quality Monitoring in the Klamath River Basin

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The Klamath River basin encompasses 10 million acres in Northern California and Southern Oregon. Salmon decline, coupled with impacts to other beneficial uses, have prompted regulatory agencies to list several rivers as impaired under the Federal Clean Water Act. The 303(d) listing and the subsequent Total Maximum Daily Load (TMDL) development and implementation for improving water quality in the basin have been challenging because coordinated water quality monitoring was lacking within the basin. In response, The North Coast Regional Water Quality Control Board with support from the U. S. Environmental Protection Agency and California Non-point Source Program proposed a contract to facilitate development of a coordinated monitoring plan and a multi-agency water quality monitoring organization within the Klamath basin. The Klamath Watershed Institute, an affiliate of Humboldt State University, was chosen as a neutral party to facilitate the effort. I developed the Klamath Basin Monitoring Plan that identified and mapped the organizations collecting water quality monitoring data, developed a network of monitoring locations for long-term water quality tracking, and identified gaps in current monitoring. Using participatory methods, I facilitated development of a multi-agency organization, the Klamath Basin Monitoring Program, and the collaborative development of a cohesive organizational structure including a shared mission and vision, and gradients of agreement. I identified lessons learned including effective participatory GIS methods and challenges to data sharing. I explored

ways of enhancing monitoring efforts using the National Hydrography Dataset – Plus system to provide resource managers with a GIS-based water quality tracking tool and an appropriate scale of resource management.

ACKNOWLEDGEMENTS

The journey toward my master's degree began many years ago while working at National Marine Fisheries Service. It was there that I first saw the inextricable link between water quality and in-stream salmonid habitat, a link often lost in bureaucracy of fisheries management. From there, I brought my curiosity to Humboldt State University, where I met Dr. Andrew Stubblefield. Dr. Stubblefield was instrumental in every aspect of my success as a graduate student. Without his support I would not have been admitted, let alone a Dillard-Bailey Scholarship recipient for promising graduate student and Klamath Watershed Institute team member. It was under Dr. Stubblefield's guidance that the Klamath Basin Water Quality Monitoring Plan was developed, a plan that aims to foster stewardship, protection, and restoration of all beneficial uses within the Klamath River watershed.

One of the integral tools that made the Klamath Basin Water Quality Monitoring Plan possible was the application of Geographic Information System (GIS). GIS was not only a critical tool, but a passion, largely due to Dr. Steven Steinberg's engaging lectures, class projects, and ability to change the way one looks at the landscape. I am especially grateful for the use of Dr. Steinberg's Institute for Spatial Analysis, an asset to any project.

The project would not have been complete without the biological view point. Dr. Alison O'Dowd brought into focus the application of the Klamath Basin Water Quality Monitoring Plan for biota of the Klamath basin. Her experience in the basin was instrumental in developing a viable monitoring plan.

I would also like to thank my family and husband, Todd Krider, for their patience and support over the past few years. Lastly, I would like to thank the members of the Klamath Basin Monitoring Program; they are the real backbone of this work.

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INTRODUCTION

The focus of this thesis was to develop a coordinated water quality monitoring plan for the Klamath basin. My objective was to craft a water quality monitoring plan that addressed water quality issues in the Klamath basin with contribution and support from stakeholders basin-wide. This thesis was part of a larger project conducted by the Klamath Watershed Institute, an affiliate of Humboldt State University, to develop a formalized water quality monitoring coordination group.

In this thesis I describe and critique the process through which I worked in with a collaborative watershed stakeholder group to create a coordinated water quality monitoring plan for the Klamath basin. The Klamath basin offered a unique set of challenges for developing a coordinated watershed management plan due to its size, complexity of water quality issues, number of water quality monitoring entities, and sociopolitical climate.

Many water bodies within the Klamath basin do not meet national Clean Water Act standards (NCRWQCB 2004, 2005a, 2005b, 2006a, 2008, 2009, ODEQ 2002, USEPA 2001, 2008). The bulk of the problem lies in non-point source degradation of water bodies throughout the basin. The Klamath basin is a patch-work of landuses and stakeholders making determination of pollution sources difficult to pinpoint, as well as determining responsibility, and implementing remediation. Part of the solution to understanding water quality issues facing the Klamath basin was to develop a coordination group, bringing together water quality monitoring entities in an effort to identify problems, develop solutions, and forge a multi-agency partnership.

I began this thesis work by examining the interplay between landscape and water resources. To better understand the nested ecological and sociopolitical constructs facing the Klamath basin, I utilized various approaches to collaborative watershed management. Face-to-face meetings, targeted surveys, and small work groups were key to developing a collaborative basin-wide monitoring plan. I also explored methods for improving the current monitoring strategy using the National Hydrography Dataset Plus (USEPA 2009) framework for targeted water quality monitoring. I present the National Hydrography Dataset Plus framework as a case study for potential identification of non-point sources of sediment in the Salmon River basin under post-fire conditions.

Challenges to development of a basin-wide monitoring program for the Klamath basin are typified by complex water quality issues, variable and overlapping resource allocation, diversity of monitoring entities with inconsistent goals and objectives, and lack of a basin-wide understanding of water quality issues. Isolation of water quality monitoring programs in the Klamath basin has led to variable procedures and inconsistent quality assurance and control, making it difficult to compare data at a basin-wide level. Lack of collaboration among organizations in the Klamath basin makes restoration of beneficial uses a challenge. However, before discussing specific water quality issues, it is important to present the context of water quality impairment and interplay between the landscape, water resources, and the sociopolitical climate in the Klamath basin.

The Klamath River basin spans two states, California and Oregon (Figure 1). Thirty-six percent (1,456,868 ha) of the Klamath basin lies within Southern Oregon and sixty-four percent (2,589,988 ha) lies within northern California. The Klamath River

Figure 1: Map of the Klamath Basin and subbasins, cities, tribal lands and dams.

originates in the upper basin at the outlet of Upper Klamath Lake and flows approximately 250 miles from Oregon through California to the Pacific Ocean. The main tributaries to the Klamath River are the headwater rivers of the Williamson and Sprague above Upper Klamath Lake, and the Lost, Shasta, Scott, Salmon and Trinity Rivers below Upper Klamath Lake.

The 4,046,856 hectare basin is renowned for its lakes, rivers, hunting, fishing and agriculture (NRC 2008). Within the basin there are several National Wildlife Refuges, Parks and Forests. Historically, the Klamath River basin had the third largest salmon run on the West Coast after the Columbia and Sacramento Rivers (NCRWQCB 2008b). The Klamath basin is home to a diverse base of stakeholders including six federally recognized tribes, federal, state, local and private entities.

The Klamath River received national attention in recent years due to conflicts concerning water allocations, water quality and endangered species issues. Limited water allowances to farmers in 2001 were followed by reduced water allocation for fish in 2002. In 2002, low flows and high temperatures resulted in a massive fish die-off of an estimated 33,000 fish (CDFG 2003). The four lower dams on the Klamath River (JC Boyle, Copco I & Copco II and Iron Gate) are currently the subject of settlement talks among federal, state, county, tribal and non-governmental organization entities working on an agreement for removal by 2020. The removal would open-up the historic salmonid spawning range within the basin. Coupled with this proposed dam removal is the Klamath Basin Restoration Agreement (NCRWQCB 2009b). The goals of the Klamath Basin Restoration Agreement are: 1) restore and sustain natural fish production;

2) provide for full participation in harvest opportunities of fish species throughout the Klamath basin; and 3) establish reliable water and power supplies which sustain agricultural uses and communities and National Wildlife Refuges (KBRA 2010)

Toxic algae blooms in the Klamath basin have also drawn national attention and continue to be a public health threat. Algae blooms of *Microcystis aeruginosa* occur annually within several of the reservoirs (Copco I, Iron Gate and Dwinnell). Documented levels of toxicity, sometimes 10-100's times levels considered a moderate health risk by the World Health Organizations, occur annually (Kann 2006). These factors coupled with declining water quality throughout the basin over the past few decades have led to the listing of several waterbodies within the Klamath basin as impaired under section 303(d) of the federal Clean Water Act, prompting Total Maximum Daily Load development. Under section 303(d) of the Clean Water Act, 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 (Clean Water Act 1972, NCRWQCB 2009a). Placement of a water body on the 303(d) list triggers development of a Total Maximum Daily Load for water body pollution / stressor combination.

Regulation and compliance monitoring, such as sedimentation or toxic algae, are governed by the federal Clean Water Act (NCRWQCB 2007). The Clean Water Act establishes a structure for regulating discharges of pollutants into waters of United States and regulating quality standards for surface waters. Except for waters located within Tribal reservations, the quality of surface and ground water in the North Coast Region of

California is governed by the Water Quality Control Plan of the North Coast Region (Basin Plan) as developed and implemented the State Water Resources Control Board and nine regional water quality control boards. The Basin Plan identifies existing and potential beneficial uses of water within the north coast region and water quality objectives necessary to protect those uses. Together water quality objectives, beneficial uses, and the antidegradation policy are known as water quality standards (NCRWQCB 2007). The anitdegradation policy requires states and tribes to follow a follow a three-tiered program aimed to maintain and protect existing uses and water quality conditions necessary to support beneficial uses. The subsequent development of an implementation plan to achieve Total Maximum Daily Load goals may result in an amendment to the state Basin Plan.

A Total Maximum Daily Load is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. Total Maximum Daily Loads also provide an analytical basis for planning and implementing pollution controls. The Total Maximum Daily Load Implementation process can take the form of regulatory actions (e.g. pollution control permits), non-regulatory actions (e.g. self-determined pollution control), or amendments to the states' Water Quality Control Plan. California and Oregon through their respective Water Quality Control Plans, in concert with Tribal Water Quality Control Plans, set the water quality standards to which waterbodies are compared. The Water Quality Control Plan for the North Coast Region (Basin Plan) (NCRWQCB 2007), in the case of California, identifies the existing and potential beneficial uses of water within the North Coast Region and the water quality objectives necessary to protect those uses. The aim of Total Maximum Daily Load development and implementation are ultimately to restore the capability of waterbodies to support beneficial uses within the Klamath Basin.

Total Maximum Daily Load development has been an ongoing process in the Klamath basin since 1998, with the South Fork Trinity Total Maximum Daily Load, marking the first effort toward the management of impaired water quality (USEPA 2001). Subsequently, every subbasin with the exception of the Butte subbasin has been listed under the 303(d) section of the Clean Water Act for impaired water quality see Table 1 for a list of Total Maximum Daily Load parameters specified for each subbasin.

Table 1: Total Maximum Daily Loads (TMDL) in the Klamath basin by subbasin and lead agency responsible for establishing TMDL thresholds.

Subbasins	**Total Maximum Daily Load Parameters**	**Lead Agency**
Sprague and Williamson River	Dissolved oxygen, chlorophyll-a, and pH, temperature	Oregon Department of Environmental Quality
Upper Klamath and Agency Lakes	Dissolved oxygen, chlorophyll-a, pH	Oregon Department of Environmental Quality
Lower Lost River (OR)	DO, pH, ammonia, temperature (in the Lower Lost tributaries)	Oregon Department of Environmental Quality
Lower Lost River (CA)	CBOD, dissolved inorganic nitrogen	U. S. Environmental Protection Agency
Klamath River (CA)	Nutrients, temperature, dissolved oxygen, sediment, microcystin	North Coast Regional Water Quality Control Board
Klamath River (OR)	Dissolved oxygen, pH, ammonia, temperature, chlorophyll-a	Oregon Department of Environmental Quality (In Progress)
Shasta Subbasin	Temperature, dissolved oxygen	North Coast Regional Water Quality Control Board
Scott Subbasin	Temperature, sediment	North Coast Regional Water Quality Control Board
Salmon Subbasin	Temperature	North Coast Regional Water Quality Control Board
Trinity and South Fork Trinity Rivers	Sediment	U. S. Environmental Protection Agency

Source: USEPA 2008, Klamath Basin Monitoring Program 2009

While water quality impairments throughout the basin have been identified, a unified effort to track water quality concerns at a basin-wide level has yet to be implemented. As a result, many organizations in the Klamath basin developed water quality monitoring programs in isolation, addressing water quality issues on a subbasin-scale. The isolation of water quality monitoring programs resulted in variable standard operating procedures and inconsistent quality assurance and control, making it difficult to compare data at a basin-wide level. Lack of shared resources and collaboration among organizations has made Total Maximum Daily Load implementation and the restoration of beneficial uses a challenge. Currently water quality monitoring is conducted by approximately 23 diverse and discrete organizations including tribes, non-profit organization groups, federal, state and local governments, and watershed groups (Table 2).

Table 2: Organizations that collect water quality data in the Klamath

Organization	**Type**
California Department of Water Resources	State
City of Yreka	City
Hoopa Tribe	Tribal
Karuk Tribe	Tribal
Klamath Tribes	Tribal
Oregon Department of Environmental Quality	State
PacifiCorp	Private
North Coast Regional Water Quality Control Board	State
Quartz Valley Indian Reservation	Tribal
Resighini Rancheria	Tribal
Salmon River Restoration Council	Non-profit
Scott River Conservation District	County
Shasta Valley Resource Conservation District	County
The Nature Conservancy	Non-profit
Timber Products Company	Private
Timbervest	Private
Trinity River Restoration Program	Non-profit
U. S. Bureau of Reclamation	Federal
U. S. Bureau of Land Management	Federal
U. S. Fish and Wildlife Service	Federal
U. S. Forest Service	Federal
U. S. Geological Survey	Federal
Yurok Tribe	Tribal

The diversity of goals, objectives, resources and regional understanding of water quality issues generate a unique sociopolitical climate in the Klamath basin. Designing an acceptable set of basin-wide water quality sites and parameters for a varied group of organizations, it became importing to understand each monitoring entities' view point.

The diversity of monitoring organizations' goals and objectives and regional territory are also factors that limit collaboration and coordination in the Klamath basin. The goals and objectives of individual monitoring organizations often influence the type of monitoring preformed. For example, tribal water quality monitoring organizations highlight the importance of cultural use (YTEP 2004), while PacifiCorp and the BOR target project specific water quality issues. Coupled with a monitoring entity's goals and objectives is the geographic monitoring region, which are jurisdictional in nature. For Example, PacifiCorp, a utility company, owns several dams on the Klamath River. Two of PacifiCorp's reservoirs harbor toxic algae during the summer months, posing a public health threat. Monitoring by PacifiCorp is generally restricted to the reservoir region, limiting the understanding of toxic algae to the reservoir region in the absence of downstream collaboration.

Disjunct resource allocation is one of the driving factors limiting collaboration and coordination in the Klamath basin. The Klamath Hydrologic Settlement Agreement monitoring program is an example of a single funding source driving unified monitoring (KHSA 2010). As part of the Klamath Hydrologic Settlement Agreement Monitoring Program, $500,000 each year for the next ten years is dedicated to collection of baseline data, public health and fish tissue monitoring on the Klamath River from Link Dam to the

Estuary (KHSA 2010). A positive outcome of the Settlement Agreement is the collaboration of the U.S. Bureau of Reclamation, PacifiCorp, Karuk Tribe, and Yurok Tribe working together using a unified set of standard operating procedures and quality assurance and quality control procedures. However, subbasins that fall outside of the Klamath River mainstem are dependent on multiple funding sources, often competing for grants. As a result, organizations may duplicate monitoring efforts, sometimes monitoring at the same location for the same parameter, due to lack of coordination and data sharing.

The rationale and regulatory authority behind individual organizations conducting water quality monitoring are also varied. Water quality monitoring generally occurs on the basis of regulatory authority, permitting, research, assessment, compliance and restoration. For example, Tribal entities such as the Karuk Tribe conduct water quality monitoring to:

"Protect, promote, and preserve the cultural, resources, natural resources, and ecological processes upon which the Karuk People depend. This mission requires the protection and improvement of the quality and quantity of water flowing through Karuk ancestral territory and Tribal trust lands" (Kaurk 2009).

Nearly all of the federally-recognized tribes located in the Klamath basin have received "treatment as a state" from EPA for purposes of conducting water quality monitoring. As such, these tribes are authorized to conduct water quality monitoring under Section 106 of the Clean Water Act for all waters located within the boundaries of their respective reservations, and are subject to EPA's quality assurance and quality control requirements.

In a bi-state system, such as the Klamath basin, efforts must be made to reconcile the regulation of water quality in the Klamath River mainstem on a regional level. Oregon and California are in the process of developing a bi-state Klamath River mainstem Total Maximum Daily Load for nutrients, temperature, dissolved oxygen, sediment, and microcystin. The North Coast Regional Water Quality Control Board and the Oregon Department of Environmental Quality are currently developing Total Maximum Daily Loads and implementation strategies for the Klamath River (NCRWQCB 2009b). Currently the draft Klamath River Total Maximum Daily Load Implementation plan includes several primary elements for successful restoration of water quality conditions on the mainstem: 1) reduction of point and nonpoint source nutrient loads in Oregon and California; 2) protection of thermal refugia; 3) addressing the water quality impacts form the Klamath Hydroelectric Project (NCRWQCB 2009b). Also included is a reference to a basin-wide monitoring plan, which is intended for this monitoring plan (NCRWQCB 2009b).

The impetus for a basin-wide monitoring plan originated from a collective concern among organizations regarding water quality issues in the Klamath basin. Members of various water quality monitoring organizations initiated annual meetings to discuss findings, develop working relationships, and forge collaboration. In 2004, after many years of informal meetings, participating organizations attempted to formalize an organization, however, because the lack of resources and the complexity and severity of the water quality problems facing the Klamath basin, development of a coordinated and sustainable monitoring program was unsuccessful.

In 2006, The North Coast Regional Water Quality Control Board with support from the U. S. Environmental Protection Agency and the California Non-point Source Program proposed a contract to facilitate the development of the coordinated monitoring and assessment plan within the Klamath basin. The rationale behind supporting of the project was to: 1) create a comprehensive and consistent monitoring strategy; 2) develop effective and efficient ways of using resources; 3) generate a holistic picture on the health of the basin; and 4) create interagency partnerships to improve the health of the basin (NCRWQCB 2006b). The Klamath Watershed Institute, an affiliate of Humboldt State University, was chosen as the neutral party to develop a multiagency organization and water quality monitoring plan.

The contract included several key elements aimed at fostering a basin-wide collaborative approach: 1) facilitation of group meetings attended by water quality monitoring organizations; 2) development of a communication plan; 3) development of a basin-wide multi-agency water quality monitoring plan; 4) establishment of a centralized data clearinghouse; and 5) creation of a strategic plan for long-term support of on-going collaboration and coordination (NCRWQCB 2006b). Item three was the basis of my thesis work.

Before embarking on the development of the monitoring plan, it became apparent that lessons learned in other watershed could be applied to Klamath basin. The hurdles of inconsistent water quality monitoring objectives, resources, quality assurance, rational, and lack of data sharing are not unique to the Klamath basin.

The geographic, political, and environmental challenges advocates of watershed restoration face are often based largely on the sociopolitical climate rather than the water quality issues themselves. Watershed groups often struggle with decision support and analysis regarding complex stakeholder (Stickney et al. 2001, Hermans et al. 2007) and ecological recovery issues (Hartig et al. 1996, Norton et al. 2009) more so than addressing physical causes of water quality degradation. In the case of the Lake Champlain Basin Program, water quality issues in Lake Champlain were phosphorus pollution, toxic contaminants, and invasive species (Stickney et al. 2001). Stakeholders in the basin founded the Lake Champlain Basin Program by extending partnerships encompassing the peaks of the Adirondack Mountains in New York to the Vermont mountains, and Quebec, Canada. The success of this program was rooted in partnerships, collaboration, and a multiple stakeholder approach (Stickney et al. 2001). An essential element of the multi-stakeholder process was the *Memorandum of Understanding on Environmental Cooperation on the Management of Lake Champlain*, an agreement to encourage the exchange of information and cooperative planning for lake protection (Stickney et al. 2001).

Another successful strategy is the formation of collaborative groups, or regional monitoring programs. This approach has had success for San Francisco Bay with the development and implementation of the San Francisco Estuary Institute Regional Monitoring Program. The key to San Francisco Estuary Institute’s success is a stable funding source, namely the regulated point-sources. The San Francisco Estuary Institute developed an estuary-wide monitoring plan aimed at addressing regional water quality issues including mechanisms to distribute information to the public and policy makers (San Francisco Estuary Institute 2009). The Regional Monitoring Program has combined shared financial support, direction, and participation by regulatory agencies and the regulated community. The Regional Monitoring Program provides an open forum for interested parties to communicate about contaminant issues facing the San Francisco Bay.

Several watershed groups have exhibited solutions to key concerns such as, inconsistent water quality monitoring objectives, resources, quality assurance, rational, but a fundamental issue remains, namely a unified water quality monitoring effort in concert with the identification of non-point sources. The successful identification of impacts to water quality hinges on treating the landscape, not a jurisdictional patchwork, but an interconnected hydrologic system, a watershed.

A watershed is defined as the area that, on the basis of topography, contributes all the water that passes through a given cross section of a stream (Dingman 2002). A watershed can be viewed as a natural landscape unit, integrated by water flowing through the landscape. A watershed perspective is an essential component of water quality assessment and mitigation; however, political boundaries do not generally follow watershed boundaries. Constructs often govern the scope and extent of monitoring, such as state and county boundaries, do not necessarily align with water quality issues at hand.

The interconnectedness of a watershed is often overlooked by the political, social, and regulatory entities that govern natural resource management and use. While early voices, such as Wesley Powell of the U. S. Geological Survey Department, advocated dividing the western United States into hydrographic basins, the division of land was largely based on township and county systems (Worster 1985). Historically, watersheds and water resources were exploited by successive piecemeal projects based on characteristics of the land, hydrologic regime, and access points for exploitation (Molle 2009). The drive to harness the west's vast water resources in order to "make the desert bloom", (Worster 1985) in the case of the California water project, became the overwhelming call, drowning out the concerns regarding functional integrity of watersheds and downstream impacts.

In the wake of pollution and salmon decline, from the late 1970's to the early 1990's, the importance of unified watersheds was partially reinstated. Pollution was tracked through the treatment of point-source impacts rather than "unified basin management" (Molle 2009). In the 1990's, a philosophy of managing the water resources of a catchment in an integrated manner, known as Integrated Water Resource Management gained momentum, this approach relies on the recognition that components of the hydrological cycle are intimately linked (Molle 2009). The cornerstone of Integrated Water Resource Management was the scale at which resources may be managed. Catchments are the smallest units that contribute to the overall watershed. The manageable size allows for inclusion of bio-regionalism, emphasizing civic responsibility and stewardship at a local scale. As a result, local watershed groups flourished, uniting watersheds the across federal, state, and local boundaries (Molle 2009).

One potential solution for identifying non-point sources of water quality impairment is to move toward a hypothesis driven and repeatable sampling method by utilizing scalable units of watersheds. Watersheds are composed of smaller units called catchments. Catchments are defined as the portion of the land surface that drains into a stream segment. Catchments are a systems approach to the management of natural resources, particularly water resources. Catchments are also small enough to adapt to any system by capturing localized events or can be scaled up to address basin wide issues. Catchments also generate bio-regionalism, emphasizing stewardship at a local scale as in the Integrated Water Resource Management approach, managing the water resources of a catchment in an integrated manner (Molle 2009). Using catchments in combination with Geographic Information System (GIS) allows for the integration of all spatial data sources including, hydrology, land use, land cover, and land ownership to be assessed at any location or across the landscape at a variety of spatial scales. One example of an effective use of catchments is the National Hydrography Dataset Plus system (Luzio et al. 2002).

Traditionally hydrologic regions were identified at a 1:100,000-scale (low-resolution) and 1:24,000-scale (high-resolution) by the U. S. Geologic Survey in an effort to catalog the Nation's watersheds. This system of inventorying was known as the National Hydrography Dataset system which divided and sub-divided hydrologic areas into successively smaller units. The hydrologic areas, commonly known as watersheds, were classified into four levels: regions, sub-regions, accounting units, and cataloging units (aka subbasins). The hydrologic units are arranged within each other, from the smallest (cataloging units) to the largest (regions). Each hydrologic unit was identified by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system (Seaber et al. 1987).

Recently, The National Hydrography Dataset system has been improved with the integration of the National Elevation Dataset and the National Watershed Boundary Dataset, titled National Hydrography Dataset Plus (National Hydrography Plus 2009) The product is an integrated suite of hydrographic networks connected to the landscape. The National Hydrography Dataset Plus system functions as a network, integrating directionality to flow allowing for routing of the stream network.

Tracking and monitoring water quality concerns across a complex landscape has been a challenge for many regulatory agencies (NCRWQCB 2009b). The National Hydrography Dataset Plus has been an instrumental part of many water quality monitoring programs including local watershed groups and state and federal agencies (Davis et al. 2004, Brakebill and Preston 2003). For example, the Adopt-A-Stream program utilizes the National Hydrography Dataset system for volunteer coordination and monitoring planning (Yates 2004). It has also been used for federal water quality database management (Llieve et al. 2001, Davis et al. 2004). It has been used for BASINS (Better Assessment Science Integrating Point and Nonpoint Sources) developed by the U.S. Environmental Protection Agency for Total Maximum Daily Load development (Luzio et al. 2002). The BASINS software enables users to assess agricultural and urban management scenarios based on models generated by the USDA.

The National Hydrography Dataset is also utilized for the Incident Command Information Tool which has the capability to track contaminants in realtime; the primary function of the Incident Command Information Tool is protection of public drinking water (Samuels and Ryan 2004).

The benefit of establishing a National Hydrography Dataset Plus water quality network lies in the ability to track trends in water quality from the regional extent of a basin, and identify potential cause-and-effect relationships in water quality impairments. Currently, while Total Maximum Daily Load Implementation plans are developed for each subbasin, this piece-wise approach lends itself to a disjunct understanding of the water quality dynamics throughout the Basin. The utility of this comprehensive approach lies in the ability to support the Klamath Basin Monitoring Program in the tracking of the water quality basin-wide, aiding the Total Maximum Daily Load and implementation progress goals and assessing water quality conditions supporting beneficial uses.

To investigate the potential application of this method to the Klamath basin's specific issue, I conducted a pilot study utilizing the National Hydrography Dataset Plus to track the effects of post-fire erosion on salmon habitat. The Salmon River subbasin, one of the major tributaries to the Klamath River, is home to a fall run and a remnant spring run of Chinook salmon. The presence of both runs signifies the importance of the Salmon River subbasin as a refuge in the Klamath basin that is otherwise becoming increasingly uninhabitable for salmonids (NRC 2008). The Klamath National Forest comprises most of the Salmon River subbasin, with less than 2% private ownership (Elder et al. 2002). Since the watershed is predominantly forested, forest fires are one of the largest threats to aquatic habitat. While fires are a natural part of the ecosystem, large and intense fires increase erosion and sediment entering the river and its tributaries. Excessive sediment has been documented to interfere with salmon feeding and egg incubation (NCRWQCB 2009b).

Targeted water quality monitoring in the Salmon River subbasin may aid in efforts to ensure persistence and a source population for recolonization of Chinook after dam removal. By identifying and delineating regions of concern, in association with salmon habitat, targeted monitoring may provide an accurate picture of the stream environment and identify regions in need of restoration.

MATERIALS AND METHODS

The development of the monitoring plan included the following phases: 1) research successful monitoring organizations; 2) assemble monitoring entities into an organization and utilizing regional expertise; 3) develop an inventory of existing monitoring; 4) research Total Maximum Daily Load listings for each subbasin; 5) solicit regional expertise regarding current water quality issues and gaps in monitoring; 6) develop goals and objectives for the monitoring plan; and 7) frame the water quality monitoring plan and circulate it to stakeholder for comments and revision.

Reviewing work done by other watershed management groups was an important component in development of the Klamath Basin Water Quality Monitoring Plan. In particular, the San Francisco Estuary Institute, with over a decade of regional planning and water quality analysis developed an innovative Regional Plan involving a diverse group of stakeholders (San Francisco Estuary Institute 2009).

The success of the San Francisco Estuary Institute can be largely attributed to steady funding through pollution control permits. I drew heavily from the San Francisco Estuary Institute when developing The Klamath Basin Water Quality Monitoring Plan organizational structure, monitoring plan amendments, and special studies adoption process. Coordinated monitoring plans developed by U. S. Geological Survey for the Deschutes River Basin (Anderson 2000) as well as meaningful stakeholder involvement from Pierce County, Washington (Smolko 2002) were evaluated. However, given the unique nature of the water quality issues facing the Klamath basin and the inherent need for a coordinated and consensus-based water quality monitoring effort, the bulk of the Klamath Basin Water Quality Monitoring Plan was developed with input from stakeholders, in an effort to build consensus and address specific needs of the basin.

The first of five face-to-face meetings, facilitated by the Klamath Watershed Institute, was held in Yreka, California in December 2008. This meeting was designed to develop the foundation for the Klamath Basin Monitoring Program. Prior to the Yreka meeting, Klamath basin water quality meetings consisted of presentations and discussions of field and laboratory techniques, with little discussion of organizational structure. Facilitators began the meeting with a group exercise using each agency's mission and vision statement. Through the exercise, trends began to emerge, illuminating commonalities among otherwise polarized organizations. It was also during the first meeting that Klamath Watershed Institute initiated the development of meeting guidelines and gradients of agreement (Appendix A), a keystone for group decision making.

Over the course of two years, the group expanded membership to include additional members, expanding participation from the lower basin to the upper basin. It was also during this period that I began to work with the group to develop the Klamath Basin Water Quality Monitoring Plan. The purpose of the Klamath Basin Water Quality Monitoring Plan was to serve as a collaborative and comparable plan for sampling and analyzing water quality laboratory samples collected throughout the Klamath basin. Using a comprehensive approach, I attempted to include all agencies and organizations engaging in water quality monitoring in the Klamath basin. The Klamath Basin Water Quality Monitoring Plan was not intended to replace individual water quality monitoring efforts or autonomy, but rather to expand coordinated monitoring to that benefit long-term coordination and collaboration in the Basin. The Klamath Basin Water Quality Monitoring Plan was intended to be voluntary, initially setting minimum quality assurance and quality control standards for inclusion of all monitoring organizations, and eventually migrating toward a uniform set of quality assurance and quality control procedures.

Before the monitoring entities could collaborate regionally, subbasins were delineated in an effort to identify monitoring boundaries. Members of Klamath Basin Water Quality Subcommittee, a subset of members, identified the CalWater system (Figure 2) as the most accurate depiction of subbasin delineation (CalWater 2006). The CalWater system differs from the traditional U.S. Geological Survey subbasin delineation (i.e. Hydrologic Unit Code) in that administrative boundaries as well as hydrologic boundaries are used to delineate subbasins. In particular, the Middle Klamath subbasin was not represented in the U.S. Geological Survey subbasin delineation scheme (Seaber et al. 1987). The Middle Klamath is seen as an important subbasin by the Mid Klamath Watershed Council and the Karuk Tribe. The Middle Klamath in the Calwater system was delineated at the upper border by Iron Gate Dam and at the lower border by the mouth of the Salmon River (Figure 2). For consistency, the CalWater subbasin schema was employed throughout the Klamath Basin Water Quality Monitoring Plan.

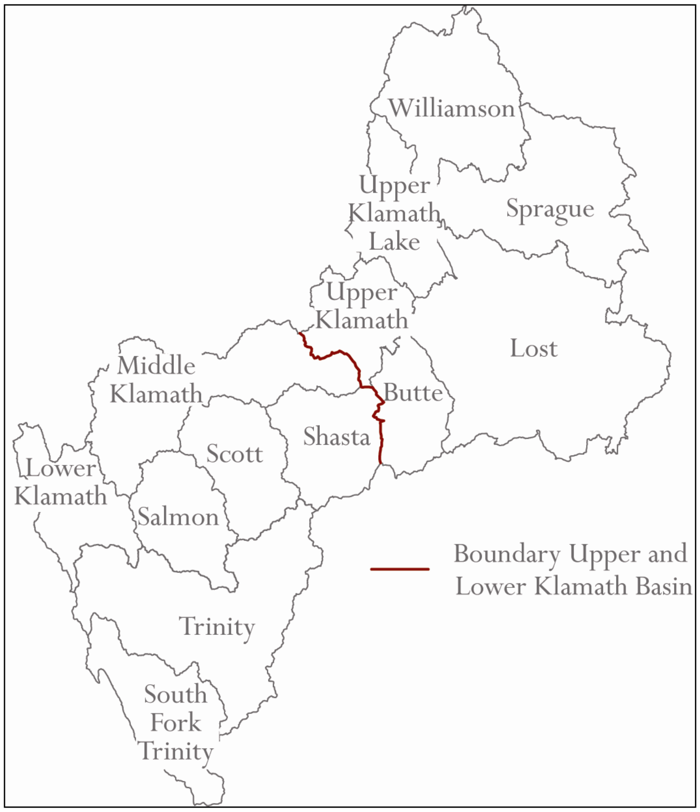

Figure 2: Klamath basin subbasin boundaries.

Along with subbasin delineation, subbasin captains were identified for each subbasin and served as water quality subcommittee members. Subcommittee members represent the diversity of agencies and organizations engaged in the collection of water quality information within a particular subbasin. Subbasin captains contributed to the Klamath Basin Water Quality Monitoring Plan by responding to a set of questions (IRB # 07-05) regarding baseline water quality monitoring, gaps in current monitoring, impacts of land and water management on water quality, and specific beneficial uses impacted by poor water quality (Appendix B). At the request of the water quality subcommittee members, a blog was developed to track responses to the questions. This forum allowed for transparency and collaboration during the process. Regional expertise brought by subbasin captains was instrumental in crafting each section of the monitoring plan. This format allowed for each subbasin to be addressed independently. Along with the unique water quality issues for each subbasin, I also incorporated Total Maximum Daily Load development and compliance and trend monitoring.

As the water quality subcommittee addressed key water quality issues within their respective subbasin, all water quality monitoring organizations in the basin were surveyed for the locations, parameters, sampling frequency, and sampling season of water quality monitoring using an Excel (Microsoft) template. Additional information was gathered using public participation GIS. Public participation GIS is an effective method of soliciting public's thoughts, ideas, and actions as part of a process (Steinberg and Steinberg 2006). During the group meetings, members were asked mark sampling locations on prepared maps and indicate monitoring details. I then mapped, digitized, and cataloged the information using Arc 9.1 (ESRI) GIS (decimal degrees, WGS 84). Along with sampling location, additional information was collected, including frequency of monitoring, season of sampling and parameters monitored. Additional information about the monitoring organization was collected as well; this included a contact person, address, and telephone number. These details were input into a database management system (Oracle, 10.1.0.2.0) using Structure Query Language (SQLplus, 11.1.0.6.0) (Appendix C). The result was an up-to-date inventory of existing water quality monitoring throughout the Klamath basin.

Once key issues for each subbasin had been identified and an inventory of water quality monitoring was completed, the Klamath Basin Monitoring Program members focused on developing a set of basin-wide monitoring goals and objectives. The first goal of the monitoring plan was to develop a network of long-term monitoring sites with the capability to capture status and trends of selected indicators throughout the Klamath basin over time and space. From the inventory of existing water quality monitoring locations, sites were selected for inclusion in this monitoring network. Sites were selected based on key parameters (Appendix D) monitored at the particular site and the length of time the site had been in operation. Key parameters were selected by the subbasin captains for baseline monitoring (i.e. stations monitoring for 303(d) listed impairments or compliance and trend monitoring). Sites situated near U.S. Geological Survey gauging stations were also prioritized. The product was a searchable multiagency network of monitoring locations throughout the Klamath basin (Figures 3-13).

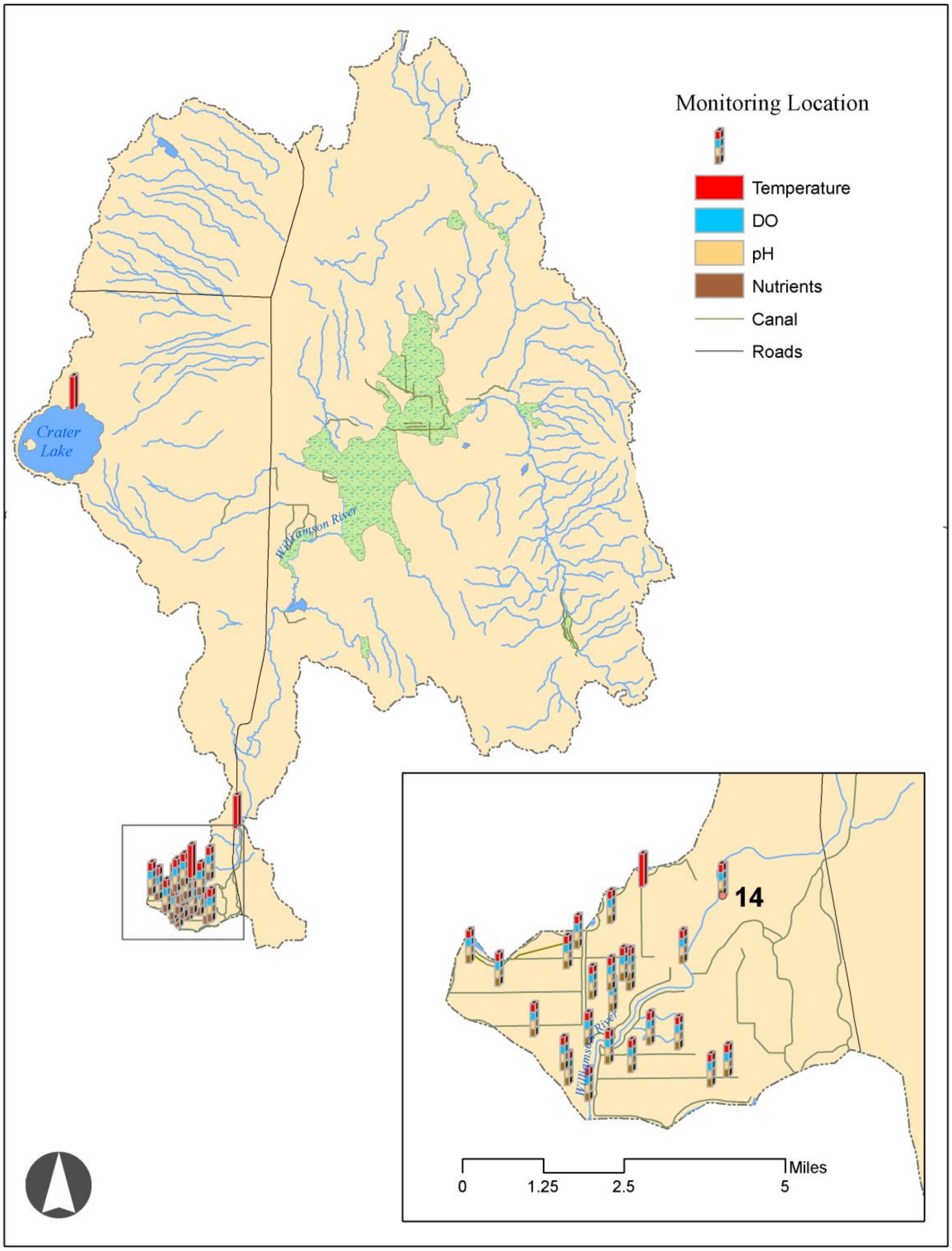

Figure 3: Williamson subbasin with locations of water quality monitoring sites and corresponding 303(d) listed parameters. Not all parameters are illustrated. Number indicates monitoring network site. Inset of Willamson Delta. (Data source Klamath Basin Monitoring Program 2009)

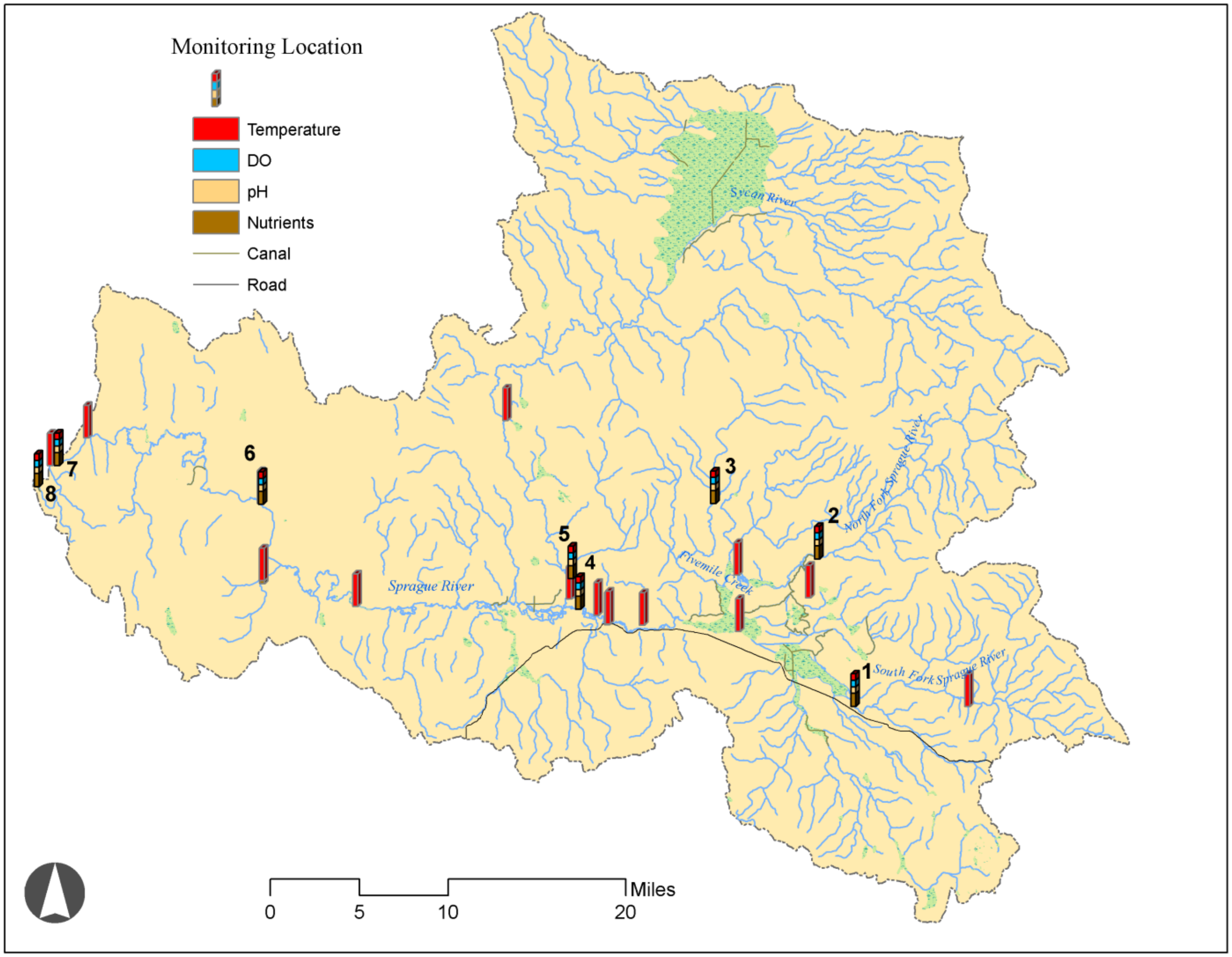

Figure 4: Sprague subbasin with locations of water quality sites and corresponding 303(d) listed parameters. Not all parameters are illustrated. Numbers indicate monitoring network site. (Data source Klamath Basin Monitoring Program 2009)

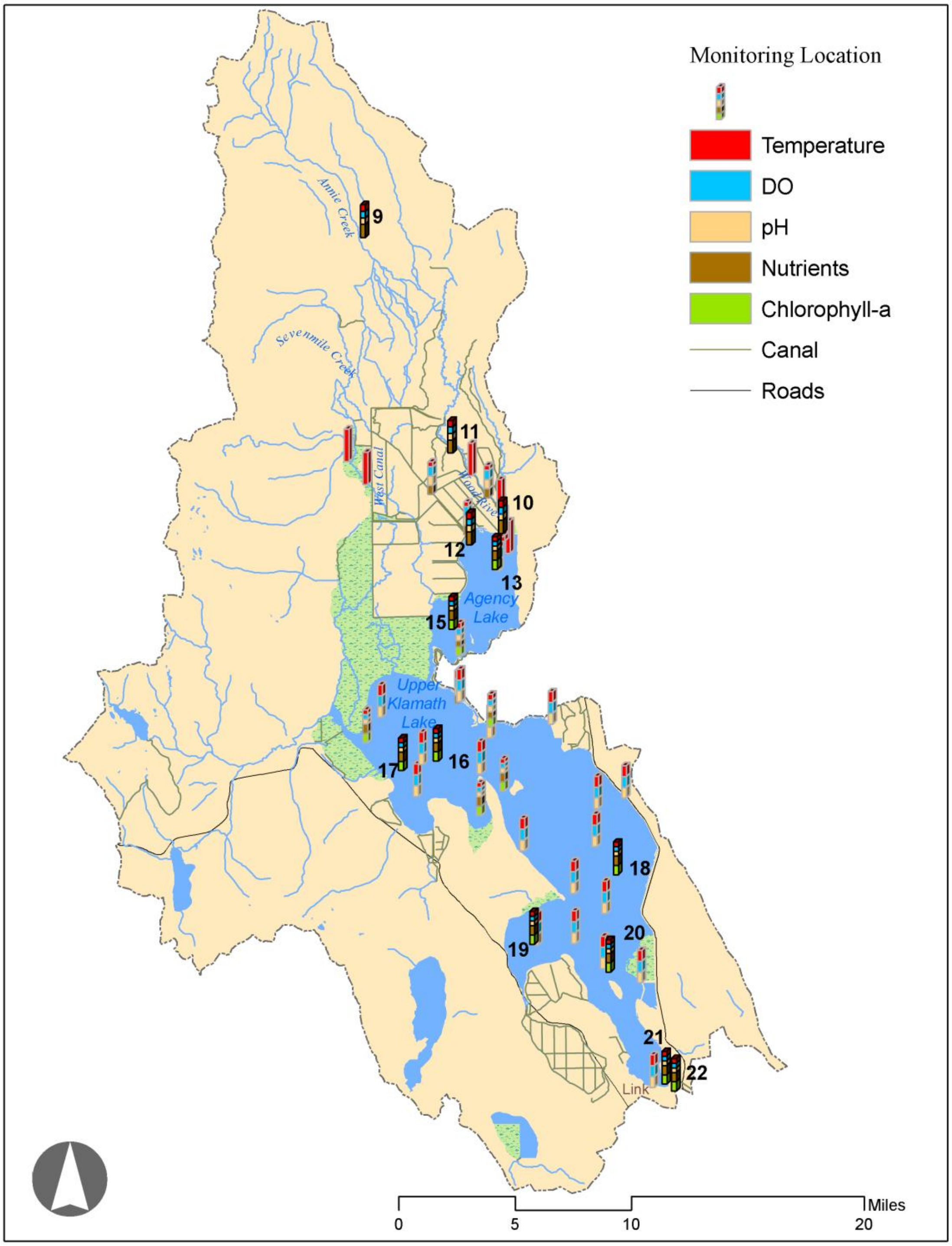

Figure 5: Upper Klamath Lake subbasin with locations of water quality sites and corresponding 303(d) listed parameters. Not all parameters are illustrated. Numbers indicate monitoring network site. (Data source Klamath Basin Monitoring Program 2009)

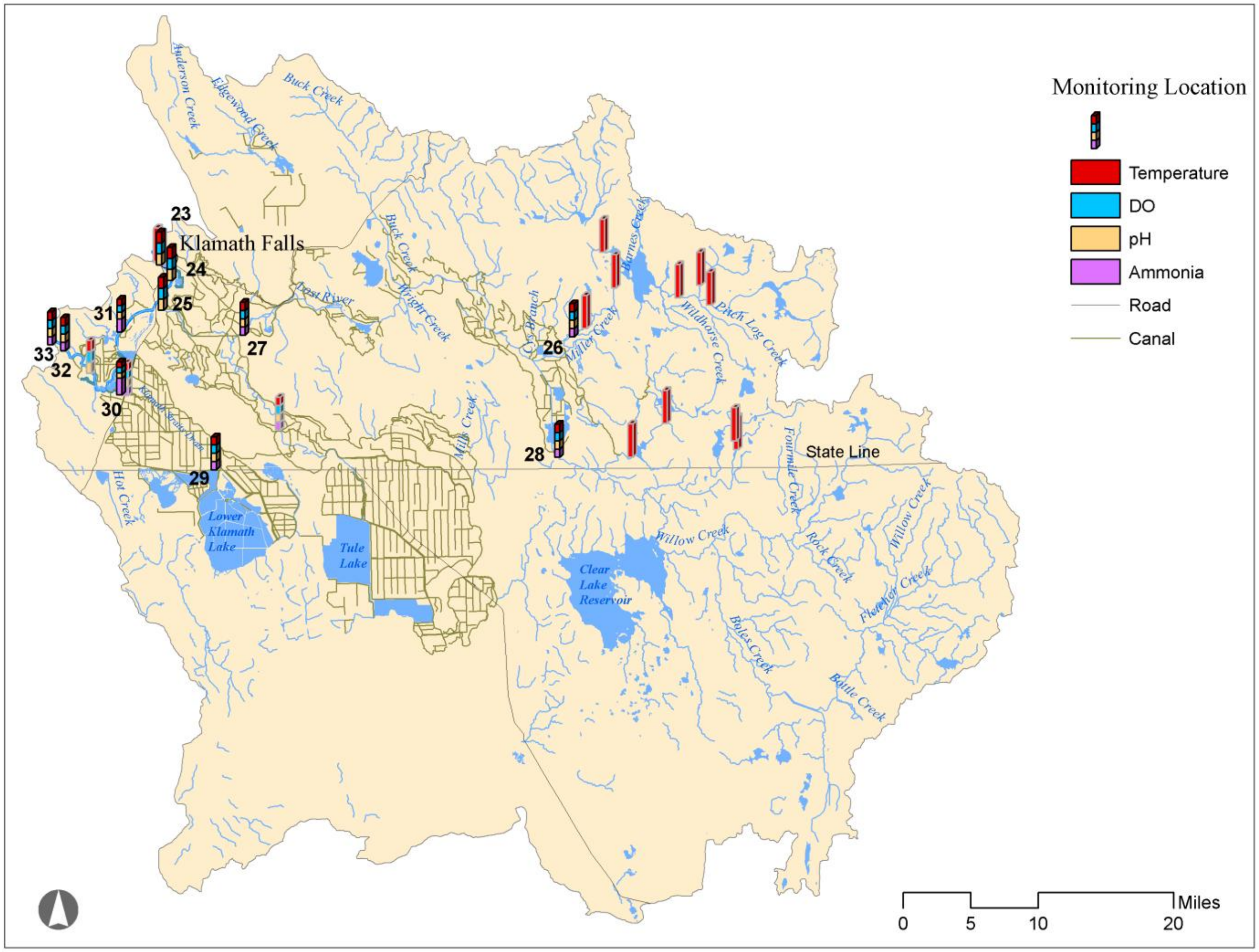

Figure 6: Lost subbasin with locations of water quality sites and corresponding 303(d) listed parameters. Not all parameters are illustrated. Numbers indicate monitoring network site. (Data source Klamath Basin Monitoring Program 2009)

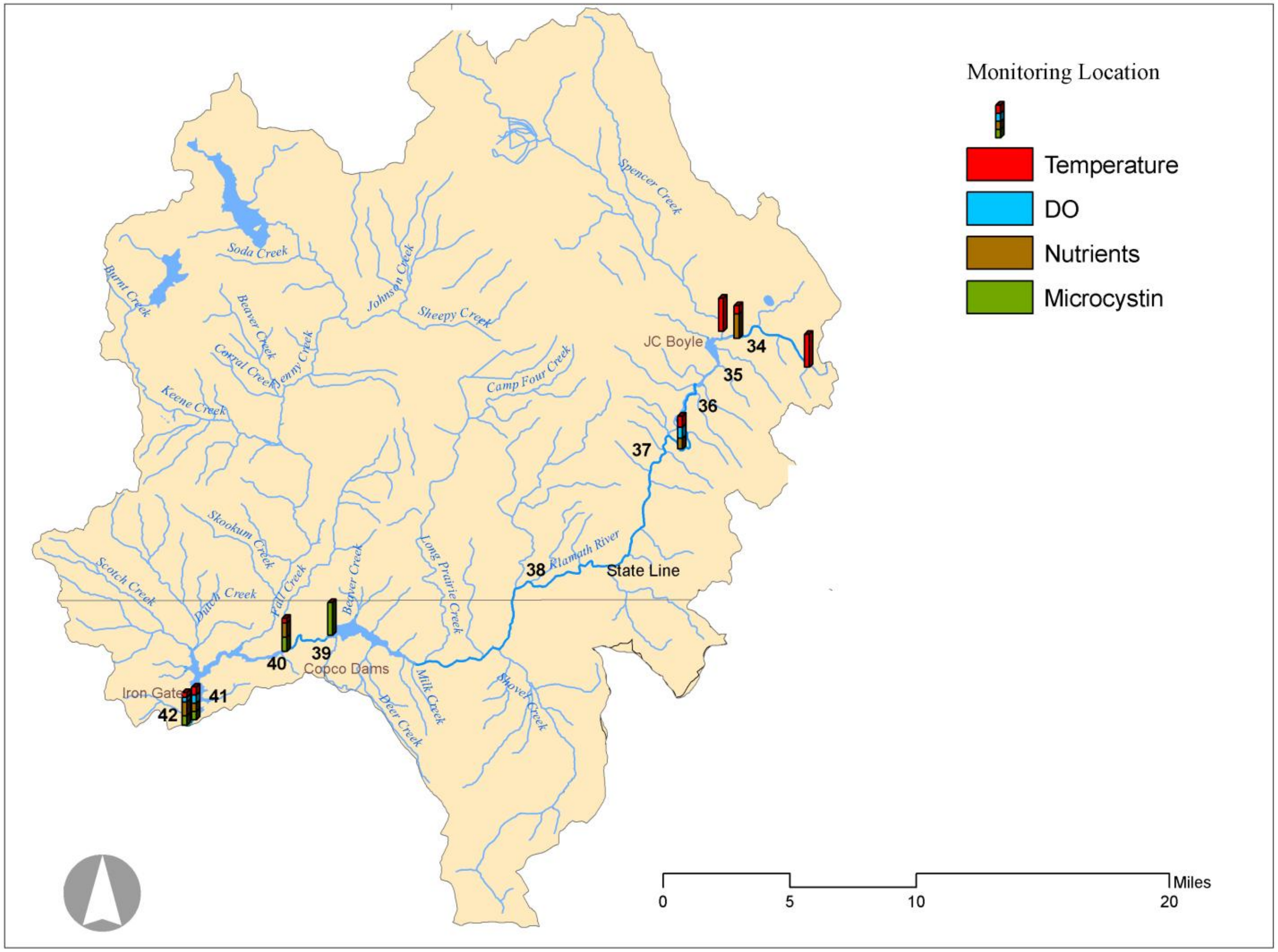

Figure 7: Upper Klamath subbasin with locations of water quality sites and corresponding 303(d) listed parameters Not all parameters are illustrated. Numbers indicate monitoring network site. (Data source Klamath Basin Monitoring Program 2009)

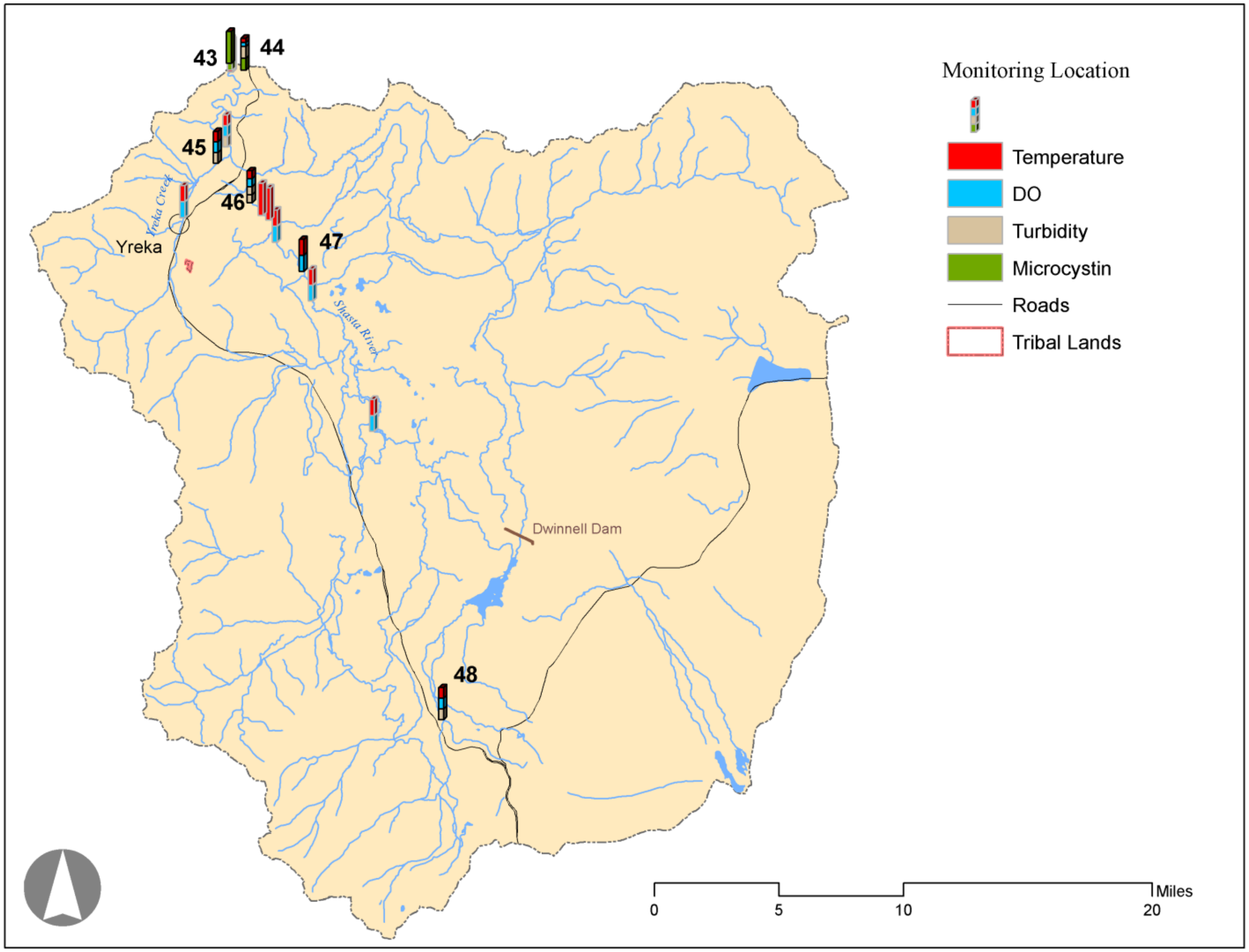

Figure 8 :Shasta subbasin with locations of water quality sites and corresponding 303(d) listed parameters. Not all parameters are illustrated. Numbers indicate monitoring network site. (Data source Klamath Basin Monitoring Program 2009)

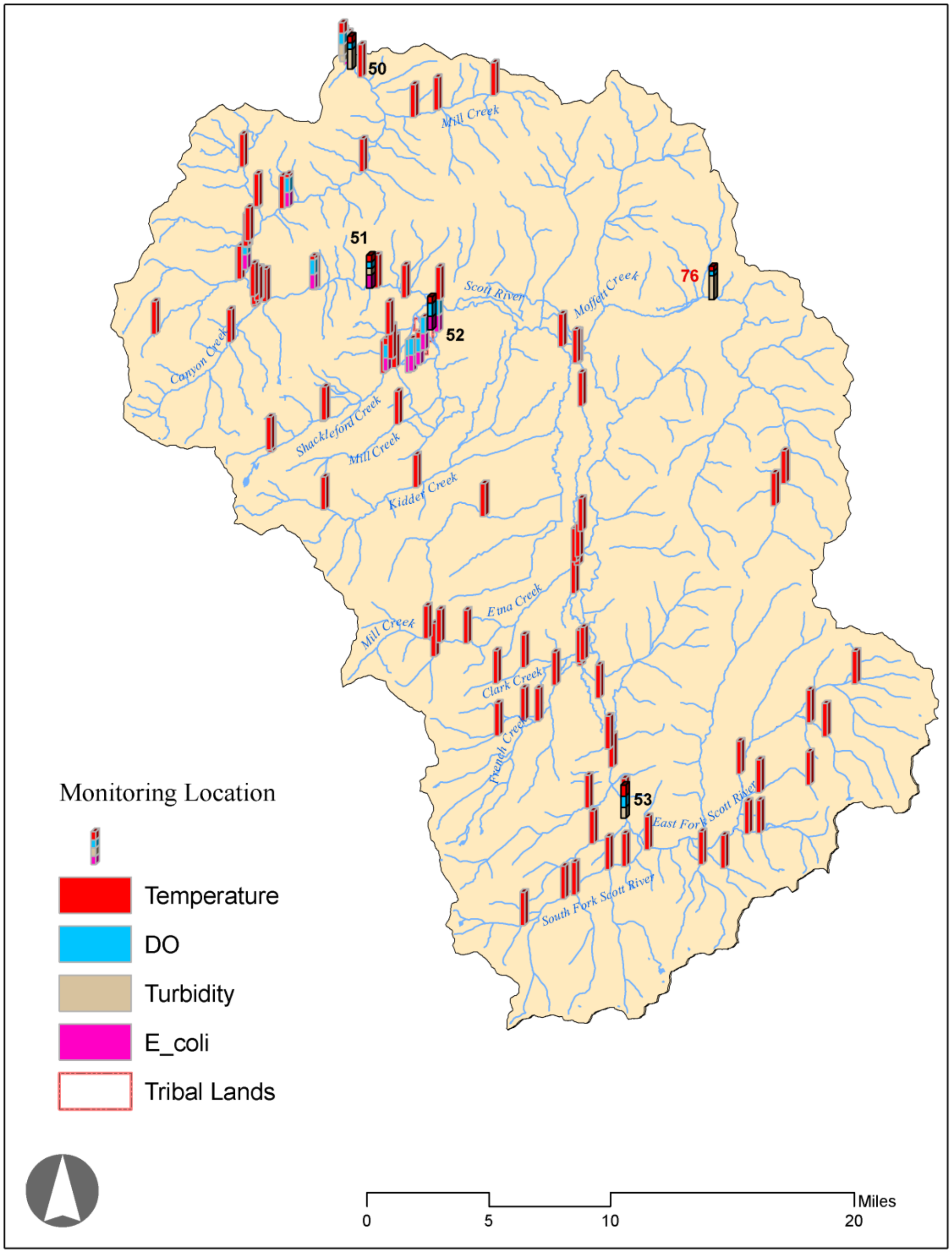

Figure 9: Scott subbasin with locations of water quality sites and corresponding 303(d) listed parameters. Not all parameters are illustrated. Numbers indicate monitoring network site. (Data source Klamath Basin Monitoring Program 2009)

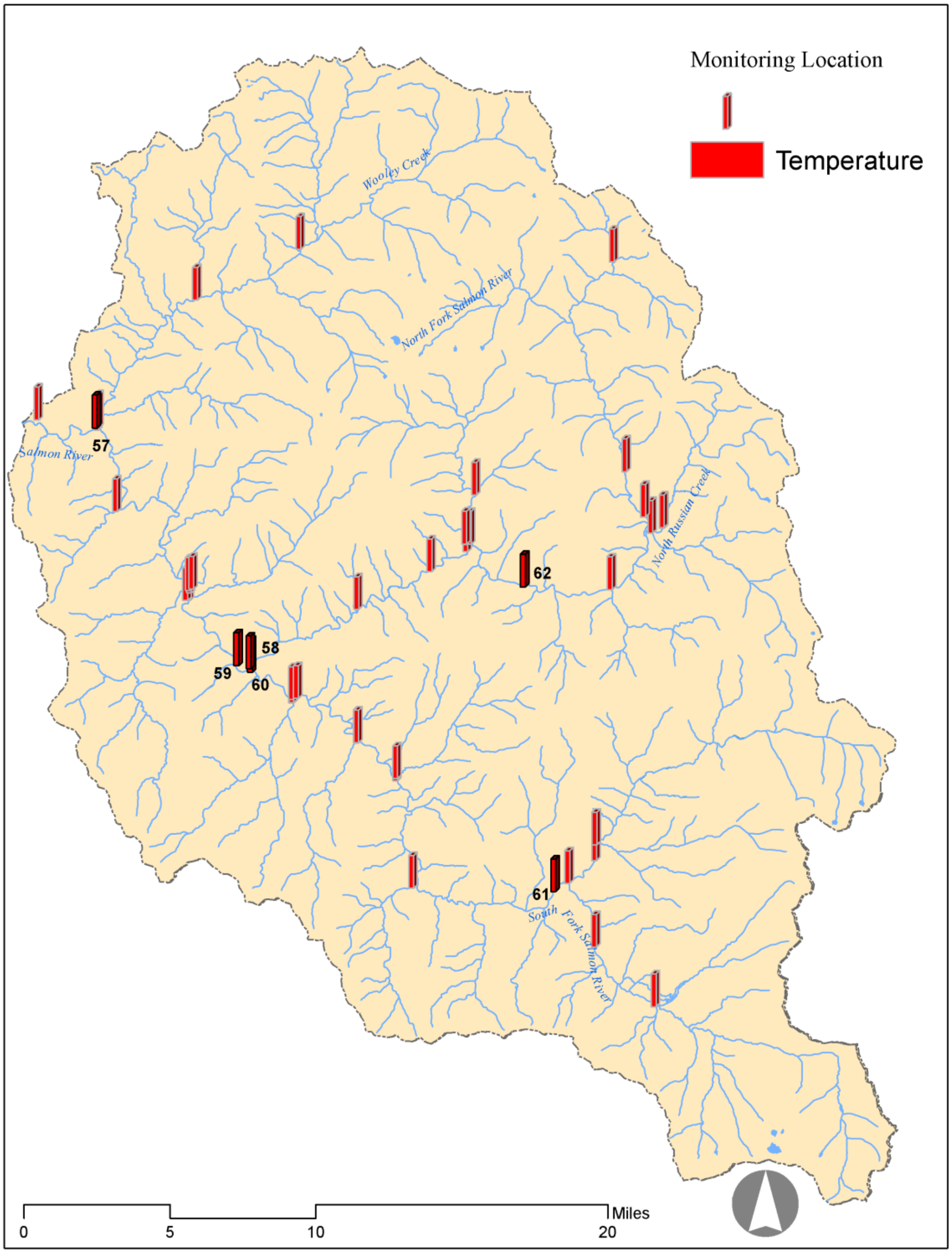

Figure 10: Salmon subbasin with locations of water quality sites and corresponding 303(d) listed parameters. Not all parameters are illustrated. Numbers indicate monitoring network site. (Data source Klamath Basin Monitoring Program 2009)

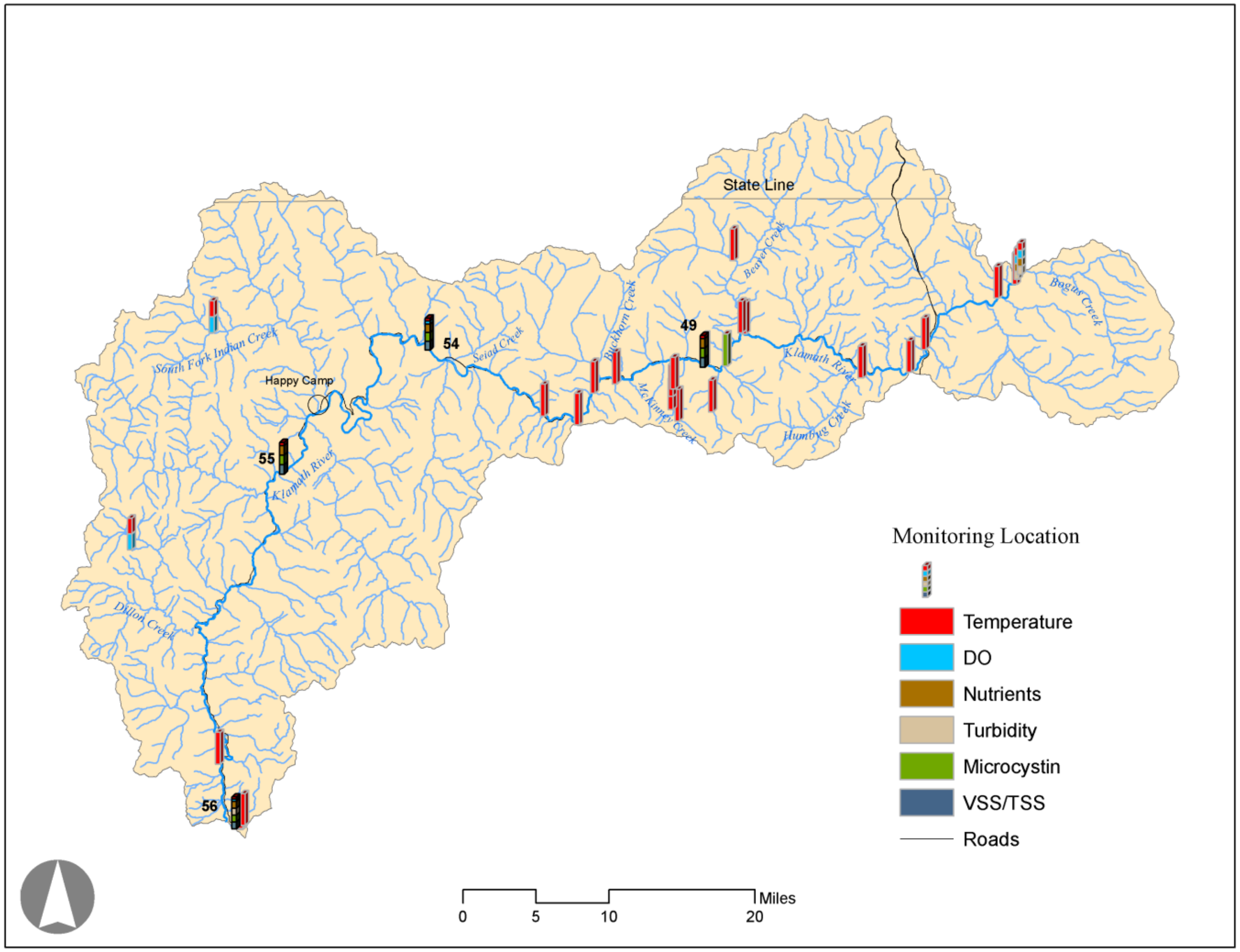

Figure 11: Middle Klamath with locations of water quality sites and corresponding 303(d) listed parameters. Not all parameters are illustrated. Numbers indicate monitoring network site. Volatile Suspended Solids / Total Suspended Solids (VSS/TSS) (Data source Klamath Basin Monitoring Program 2009)

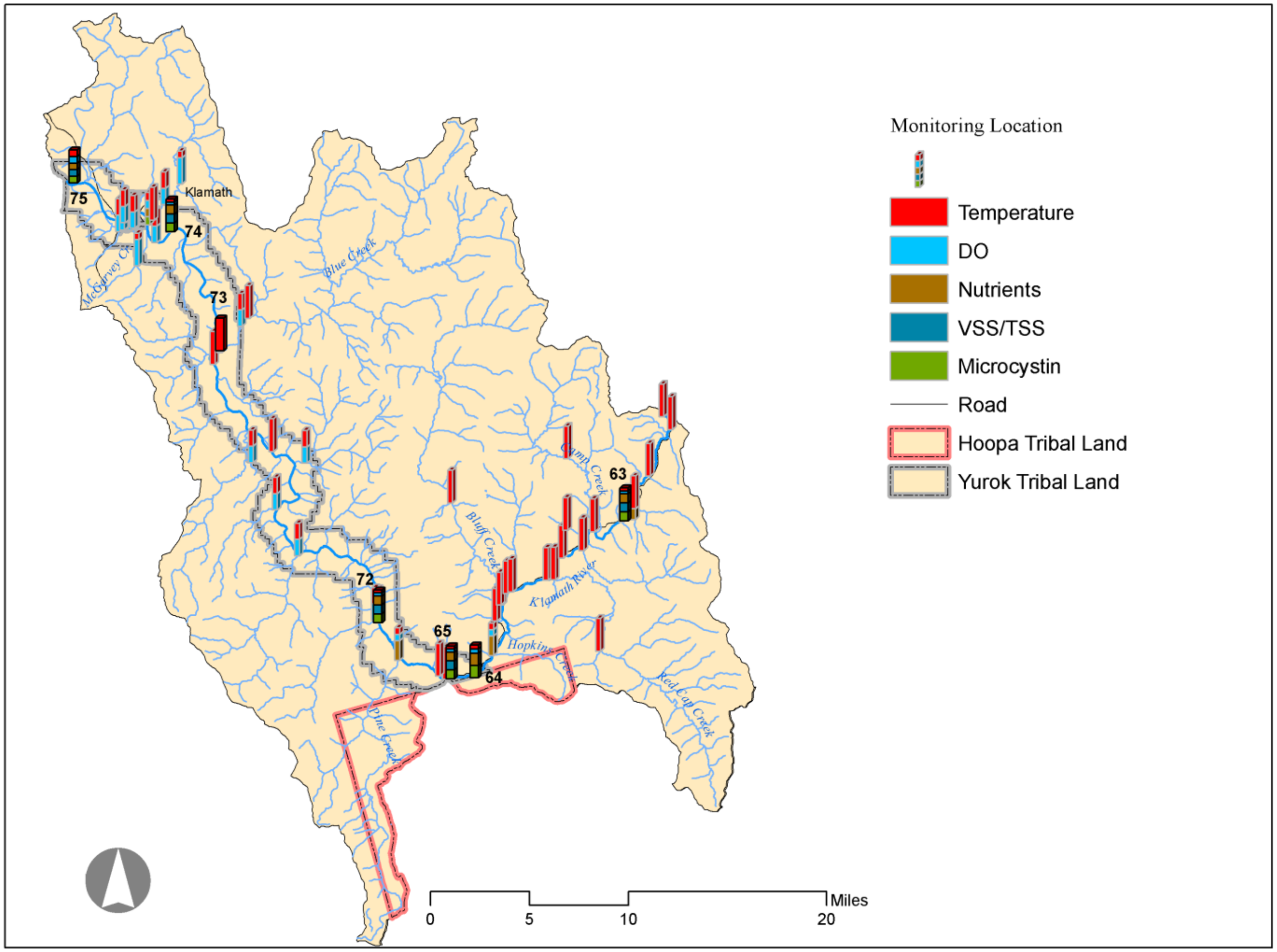

Figure 12: Lower Klamath with locations of water quality sites and corresponding 303(d) listed parameters. Not all parameters are illustrated. Numbers indicate monitoring network site. Volatile Suspended Solids / Total Suspended Solids (Data source Klamath Basin Monitoring Program 2009)

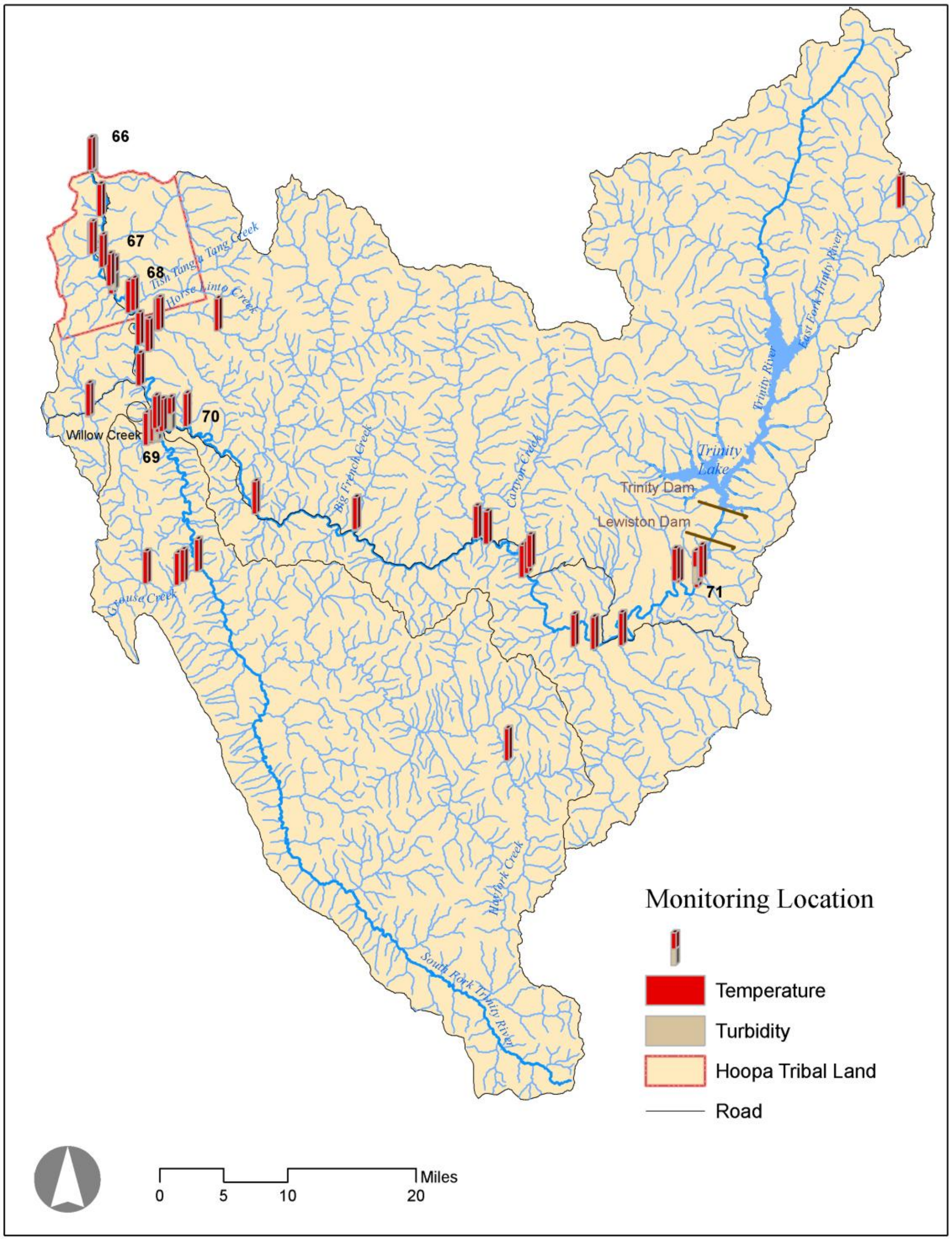

Figure 13: Trinity and South Fork Trinity with locations of water quality sites and corresponding 303(d) listed parameters. Not all parameters are illustrated. Numbers indicate monitoring network site. (Data source Klamath Basin Monitoring Program 2009)

Sensitive beneficial uses were determined to be part of the selected indicators tracked by the monitoring network along with 303(d) listed impairments. Sensitive beneficial uses were identified by the Klamath and Williamson, Sprague, and Upper Klamath Lake Total Maximum Daily Loads. Beneficial uses as defined by the Clean Water Act are social uses, as determined by the state and federal governments that should be attained in the waterbody. Examples include, warm water aquatic ecosystems, public water supply, and recreational fishing (EPA 2009). The most sensitive beneficial uses from the standpoint of water quality management are municipal, domestic drinking water supply, contact recreation, (ODEQ 2002) and uses associated with maintenance of rare, resident and anadromous fisheries and cultural uses and practices (NCRWQCB 2009b). For each location within the monitoring network corresponding sensitive beneficial uses were identified by review of Total Maximum Daily Load documentation and regional expertise. Tables outlining sensitive beneficial use, and key parameters monitored by water quality monitoring location, can be found in Appendix E and F.

In addition to sensitive beneficial uses, the monitoring network was designed to be consistent with other large-scale regional monitoring efforts. The Klamath Hydrologic Settlement Agreement monitoring funded by PacifiCorp, includes monitoring of the Klamath River mainstem (including reservoirs) from Link River dam downstream through the estuary (Figure 1). The Klamath Hydrologic Settlement Agreement monitoring addresses public health monitoring of cyanobacteria and associated toxins, and comprehensive baseline water quality monitoring in the Klamath River. Within the region were two plans (Klamath Hydrologic Settlement Agreement and Klamath Basin

Monitoring Plan) that utilize the same monitoring locations. On the Klamath River mainstem, both plans utilize the same monitoring locations and parameters in an effort to provide continuity and comparability between the two monitoring plans. The Klamath Basin Monitoring Plan differs from the Klamath Hydrologic Settlement Agreement monitoring in that it addresses water quality issues basin-wide.

Although these two plans aim to address large scale baseline monitoring and public health issues, there was additional concern among subbasin captains regarding discrete water quality issues. To address these concerns, several special studies were included in the monitoring plan. Members of the Klamath Basin Monitoring Program used brainstorming techniques to identify potential special studies. Several of the ideas presented by the larger group were then selected by the Steering Committee for inclusion in the monitoring plan. Special studies are defined projects that help improve monitoring measurements or the interpretation of monitoring data, in particular by elucidating cause-effect relationships and enable targeted research into key water quality issues. The criteria for adopting special studies include: 1) it must be consistent with the Klamath Basin Water Quality Monitoring Plan Goals and Objectives; 2) it must address an identified gap in current monitoring; and 3) it must address affected beneficial uses by examining the toxicity or degradation of water quality at a regional or local level (KBMP 2009).

Each version of the monitoring plan was reviewed by the subbasin captains and the larger group. The group reviewed the content of the monitoring plan and mapping products. After each review, necessary revisions were made and the revised plan was resubmitted to the group for a total of four revisions.

In an effort to expand the identified monitoring network to address non-point source impacts such as post fire erosion potential in a the Salmon River subbasin. The Universal Soil Loss Equation (Moor and Burch 1986) in combination with Erosion Risk Management Tool was used to estimate the erosion potential pre and post fire. Fires from 2003 - 2007 were evaluated in relationship to identified salmon habitat within the subbasin. Using the Universal Soil Loss Equation (A=R*K*L*S*C*P) where erosion was estimated in tons/acre/year, various data were utilized. Rainfall-runoff (R) was obtained from the EPA's isoerodent map of Northern California, Soil erodibility (K) was obtained from U.S. Geological Survey's Land Cover dataset, (P), support practice factor, was not evaluated. Pre-fire conditions were calculated using preexisting land USDA's STATSGO soil dataset. Slope length and steepness (LS) were combined using catchments within and upslope of fire polygons in an effort to capture the upslope contributing area using equation $LS = (A/72.60)^{.4}(\sin\theta/.0896)^{1.3}$ (Moore et al. 1986). The cover management (C) was obtained from cover conditions. Pre-fire erosion estimates were calculated in raster calculator (ERSI) (Figure 14).

Fire history from 2003-2007 in the Salmon basin was identified using CalFIRE and mapped (Figure 15). Post-fire erosion was evaluated further using the Universal Soil Loss Equation in combination with Erosion Risk Management Tool. Post-fire estimates were evaluated using the magnitude of erosion potential for high-intensity fire taking into account age of fire disturbance and mean soil type (Robichaud et al. 2006).

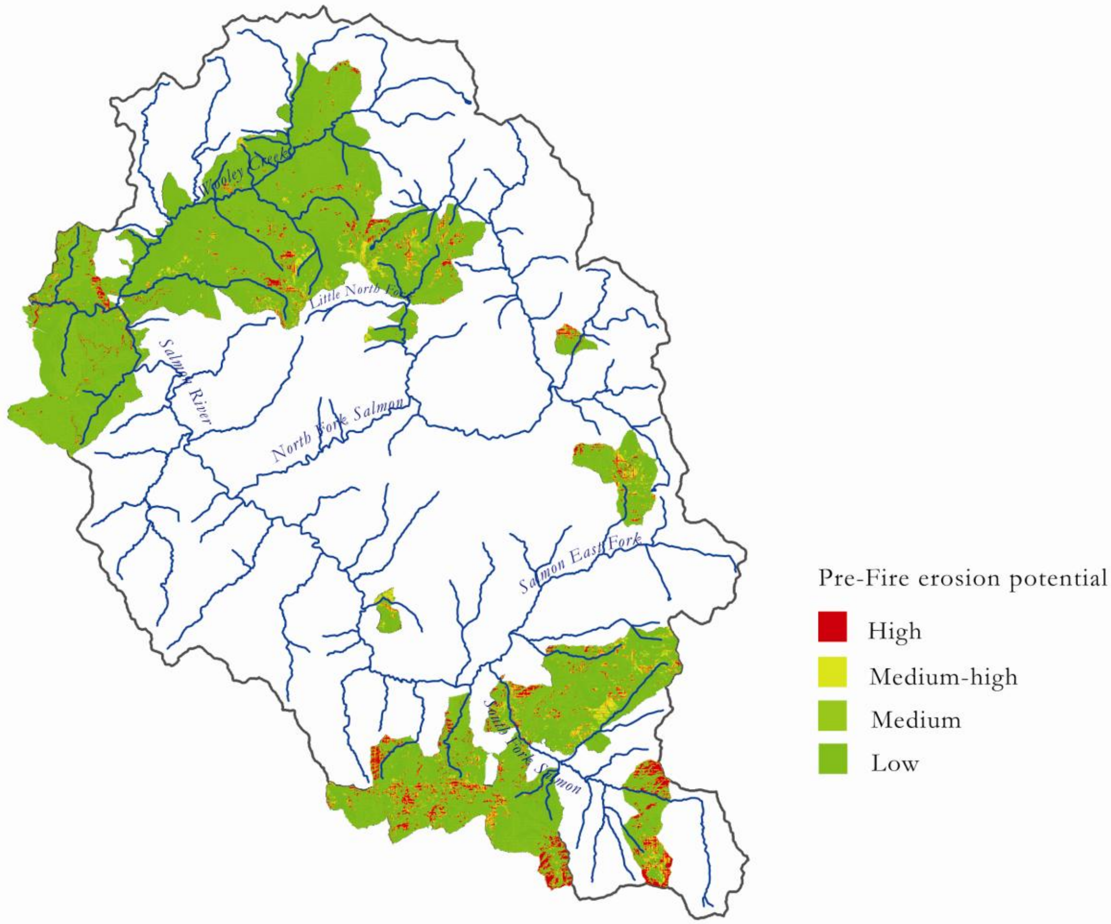

Figure 14: Pre-fire erosion potential in the Salmon River basin.

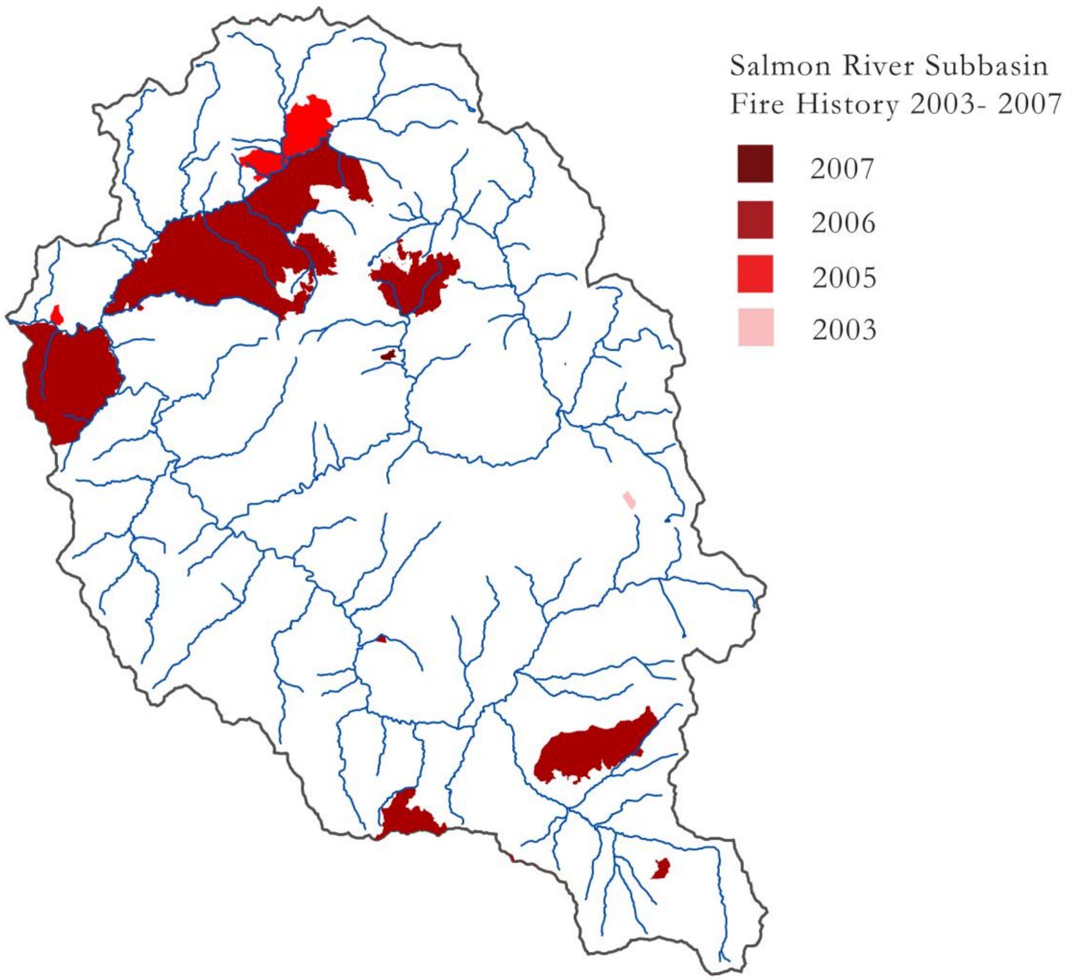

Figure 15: Fire history from 2003 - 2007 for the Salmon River basin.

RESULTS

Two years of facilitated meetings and active involvement of water quality monitoring organizations and regulatory agencies has resulted in successful development of the Klamath Basin Water Quality Monitoring Plan, formation of the Klamath Basin Monitoring Program, and organizational structure (Figure 16). Also during the two year process, membership expanded from approximately 15 core members over 250 active members and interested parties. The collective concern regarding water quality issues among various organizations brought the basin together to address these issues and formalize a collective mission and vision for the multiagency program adopted in October 2009; the mission and vision were stated as:

Mission: The mission of the Klamath Basin Monitoring Program is to implement, coordinate and collaborate on water quality monitoring and research throughout the Klamath Basin. The Klamath Basin Monitoring Program provides guidelines and technical support for monitoring activities and promotes the sharing of high quality data to inform resource management within the basin.

Vision: The Klamath Basin Monitoring Program facilitates the coordination and implementation of water quality monitoring in support of stewardship, protection, and restoration of all beneficial uses within the Klamath Basin watershed, with the ultimate goal of restoring water quality.

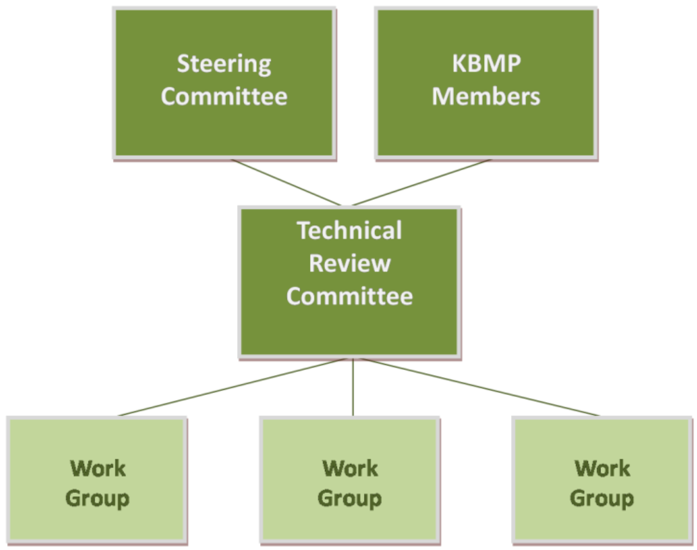

Figure 16: Klamath Basin Monitoring Program Organization Structure

Additionally, through the process of collaborative engagement throughout drafting of the Klamath Basin Monitoring Program and Klamath Basin Water Quality Monitoring Plan organizations members also developed interagency partnerships, by agreeing to common set of monitoring goals and objectives. In April 2010, the Klamath Basin Monitoring Program voted to adopt the Klamath Basin Water Quality Monitoring Plan.

In addition to the adoption of the monitoring plan, several members have agreed to fulfill specific roles in support of the newly formed Klamath Basin Monitoring Program. The structure of the KBMP organization is comprised of the Klamath Basin Monitoring Program members, Steering Committee, and Technical Review Committee and supporting Work Groups (Figure 16). The Steering Committee determines the budget, allocation of funds, track progress, and provides direction to the organization. The Technical Review Committee provides the technical content of the Monitoring Plan and development of special studies, with the assistance of the Work Groups. The Steering Committee and Technical Review Committee operate through consensus and collaboration. Each member has equal voice. The chair and secretary of the committees are elected every year. The role of the chair confers no additional powers or privileges. The role of the chair is to facilitate the meetings and uphold the gradients of agreement. The role of the secretary is to take meeting notes and distribute to members and post on the website, if appropriate. Work Groups are comprised of experts in a particular field (i.e. Tribal Water Quality Work Group, Blue Green Algae Work Group, and Klamath Fish Health Assessment Team) and advise the Technical Review Committee.

The Klamath Basin Water Quality Monitoring Plan brought together regional expertise, Total Maximum Daily Load listings and compliance and trend monitoring locations to develop a basin-wide monitoring network (Figure 17). The monitoring network connected multiple water quality organizations. It will provide a first holistic picture of the health of the Klamath basin under a unified set of monitoring goals and objectives. The goals of the Klamath River Basin Monitoring Plan are: 1) involve all stakeholders in a collaborative process to develop a comparable and consistent basin-wide monitoring plan; 2) Solicit stakeholders to indentify essential baseline parameters and water quality monitoring goals and objectives; 3) develop the monitoring plan to inform TMDL implementation goals and regional water quality concerns; 4) Identify minimum quality control and quality assurance measures consistent with California and Oregon States' guidelines; 5) Identify uniform standard operating procedures; and 6) Identify a long-term monitoring network of sites that may best capture water quality status and trends throughout the basin. The monitoring network addresses the 303(d) listings, sensitive beneficial uses, and baseline monitoring. Using the inventory of monitoring sites and parameters monitored at each location, organizations can better strategize to reduce overlap and conserve resources, monitor water quality exceedences effecting beneficial uses, and target areas in need of restoration.

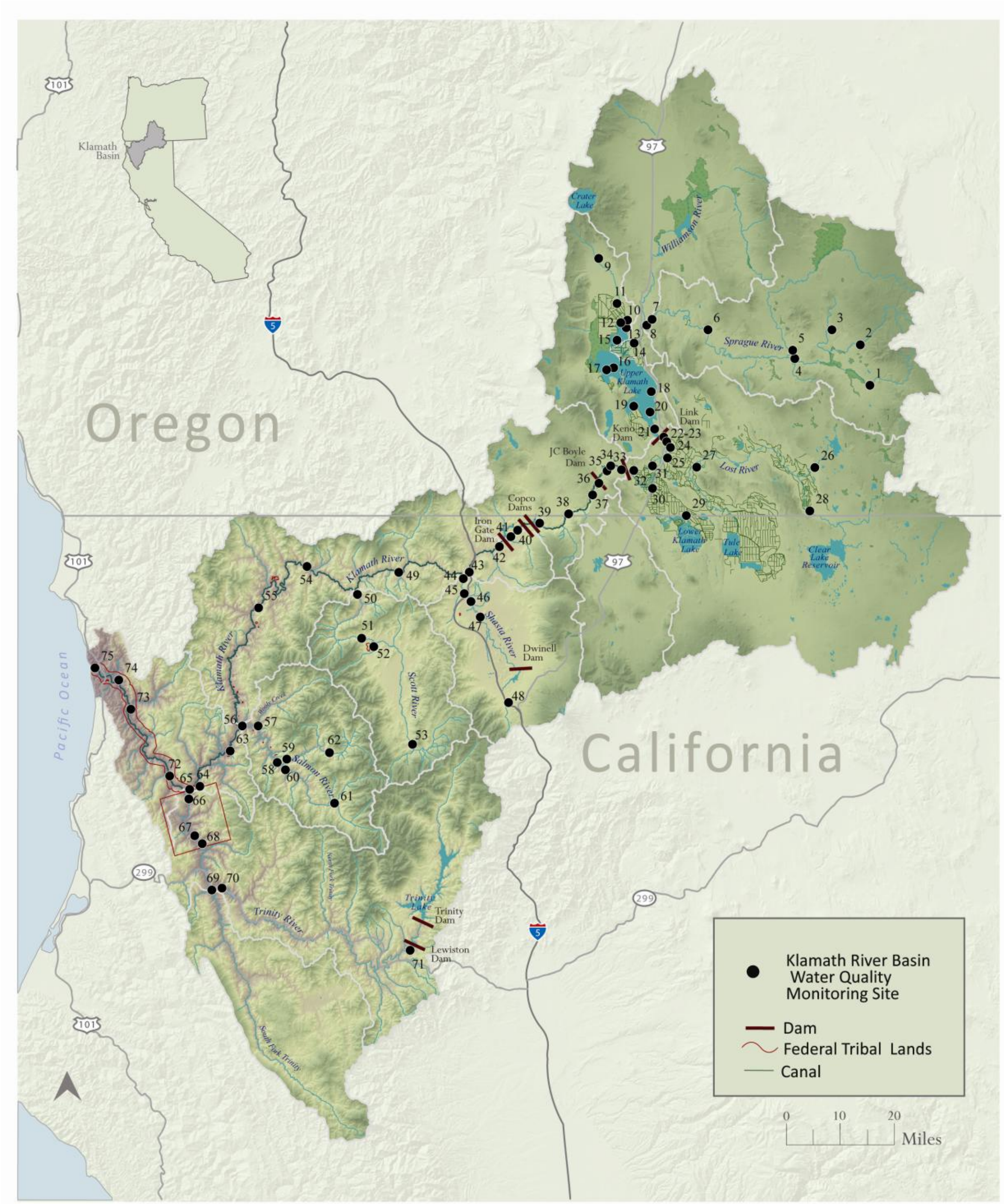

Figure 17: Map of the Klamath Basin and the Water Quality Monitoring Network

The plan is intended to be developed in phases, the current version represents phase one of the multiphase process. Essential components to crafting phase one of the Klamath Basin Water Quality Monitoring Plan were the identification of key water quality parameters, long-term monitoring locations, development of the Klamath Basin Water Quality Plan goals, development of suggested uniform standard operating procedures, and identification of minimum bi-state (California and Oregon) quality assurance and control standards. Phase one of the monitoring plan is available at the following link (http://Klamath Basin Monitoring Program.net/documents).

Phase two of the monitoring plan emphasizes an adaptive management approach to enhance the effectiveness of the existing monitoring plan. Adaptive management is an approach commonly used in resource planning. Adaptive management focuses on learning and adapting, through partnerships of managers, scientists, and other stakeholders who work together to create and maintain sustainable ecosystems (U. S. Department of Interior 2010).

Through annual review of water quality data, the Technical Review Committee may evaluate the relevance or applicability of sites or parameters on a location by location basis and offer recommendations that best support the monitoring needs and requirements necessary to answer management questions and support beneficial uses. The Technical Review Committee makes recommendations for incorporating measures that are coupled to current data, resulting in the addition of sites or parameters to be added to the monitoring network. This also includes the implementation of special studies, and identification of gaps in monitoring by region.

In addition to the annual review process, the plan also outlines several special studies identified by members of the Klamath Basin Monitoring Program. Special studies are designed as targeted research into emerging water quality issues. Special studies are defined projects that may help improve interpretation of monitoring data. The plan outlines special studies authored by experts in particular fields. Special studies include: Spatial and Temporal Variation of Total Suspended Sediment Concentrations, Benthic Biomass (periphyton) in the Trinity, Salmon and Klamath Rivers, Fish Disease and Periphyton Links to Water Quality, and Estuary Water Quality Monitoring.

Apart from the monitoring plan, the Strategic Plan (Appendix G) is aimed at providing budget estimates for special studies and gaps in monitoring identified by the subbasin captains (Table 3). The Strategic Plan attempts to ensure the long-term success of the monitoring plan by identifying fundable components and potential funding sources. The Strategic Plan outlines a Klamath Basin Monitoring Program organizational structure and step-wise approach for full staff support. Currently, the Klamath Basin Monitoring Program is supported on a volunteer basis by Klamath Basin Monitoring Program members. There is concern that without staff support and funding the Klamath Basin Monitoring Program may lose momentum, as it did prior to the contract with the Klamath Watershed Institute.

Table 3: Water quality monitoring parameter gaps by subbasin

Subbasin	**Parameter**
Williamson, Sprague, and Upper Klamath Lake	Nutrients Loading
Williamson, Sprague, and Upper Klamath Lake	Phytoplankton Interaction
Lost	Bacteria
Lost	Algae
Lost	Nutrients
Lost	Water Chemistry*
Shasta	Bacteria
Shasta	Sediment
Scott	Algae
Scott	Water Chemistry*
Salmon	Bacteria
Salmon	Algae
Salmon	Sediment
Salmon	Invertebrates
Middle Klamath (Seiad Valley to Orleans & Seiad Valley to Weitchpec)	Algae / Periphyton
Middle Klamath (Seiad Valley to Johnsons Riffle)	Invertebrates
Middle Klamath (Seiad Valley to Orleans)	Nutrients
Middle Klamath	Sediment
Middle Klamath (Seiad Valley to Orleans)	Water Chemistry*
Middle Klamath (Seiad Valley to Orleans)	SONDE
Lower Klamath (Estuary)	Bacteria
Lower Klamath	Sediment
Lower Klamath (Estuary)	Atmospheric
Trinity / SF Trinity	Bacteria
Trinity / SF Trinity	Algae
Trinity / SF Trinity	Invertebrates

*Water chemistry – pH, dissolved oxygen, conductivity, temperature

As part of the contract with the Klamath Watershed Institute, an effort is also underway to enhance communication among monitoring organizations through the development of interactive maps of the region and a central water quality monitoring data clearinghouse. It is the intent of Klamath Basin Monitoring Program members to develop a comprehensive water quality database including of all monitoring organizations collecting water quality data in the Klamath basin. It is hoped these communication tools (interactive map and database) with the guidance of the Klamath Basin Water Quality Monitoring Plan will foster enhanced understanding and collaboration among regulatory agencies, monitoring organizations, federal and state agencies and the public.

In addition to the development of the monitoring plan, methods for improving non-point source estimates from post fire erosion were evaluated. Elevated erosion levels were observed post fire for all four years (2003, 2005, 2006, and 2007) evaluated (Figure 18). The region of greatest concern was Wooley Creek, a region of high total erosion, active salmon utilization, and limited sediment monitoring. Further analysis in needed to quantify the upslope erosion by catchment at each potential sampling location under variable hydrologic conditions. Using the catchments as a spatial reference, additional layers may be evaluated such as soil erosivity due to unpaved roads, timber harvesting, land ownership, and legacy mines. Throughout the basin, the utility of National Hydrography Dataset Plus as a watershed management tool lies is its ability to enable the user to query the spatial relationship of upslope water quality stressors to downstream sampling locations. The National Hydrography Dataset Plus may become an instrumental part of the Klamath Basin Water Quality Monitoring Program, aiding the Klamath Basin

Monitoring Program members in developing a repeatable approach to rapid assessment evaluations and targeted monitoring.

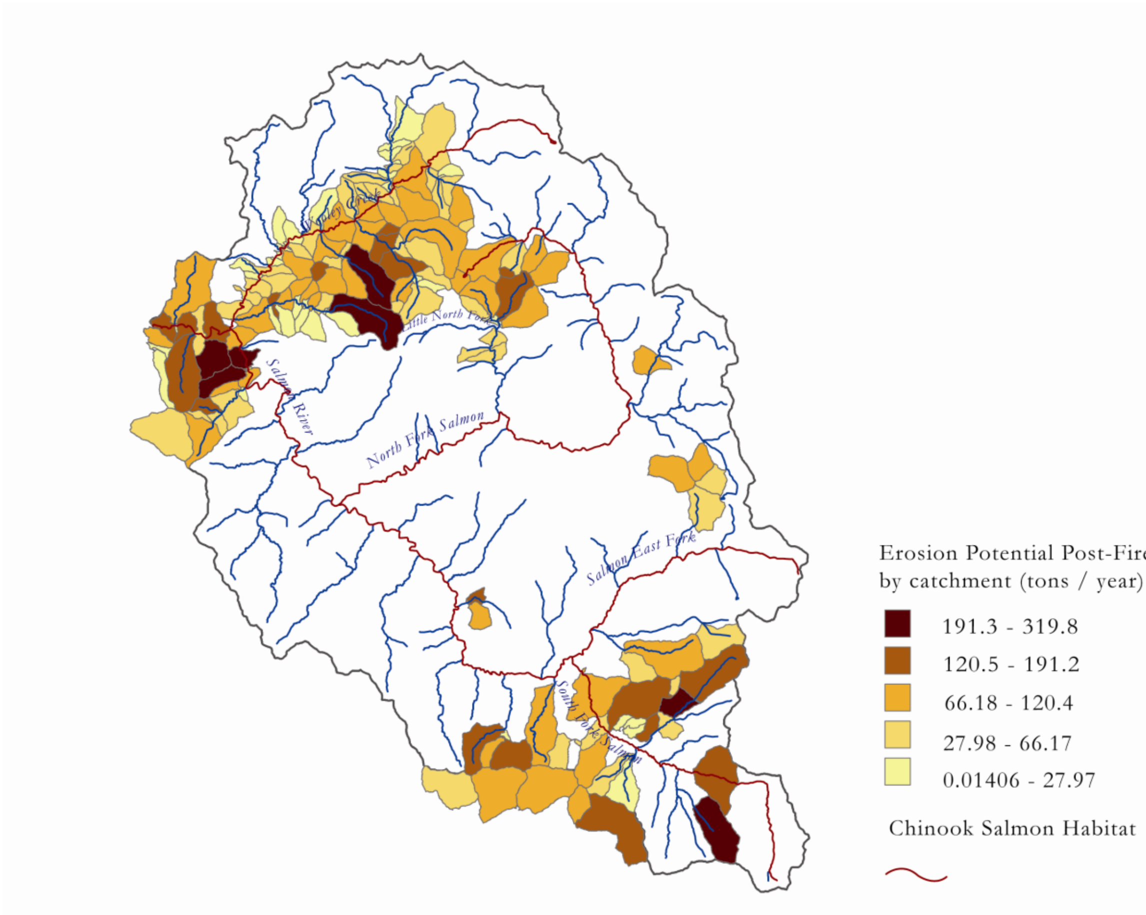

Figure 18: Estimated post-fire erosion potential for the Salmon River basin.

DISCUSSION

The Klamath Basin Water Quality Monitoring Plan represents a first step toward basin-wide water quality monitoring and coordination in the Klamath basin. The Klamath Basin Monitoring Plan has yielded positive results in the form of a mutually agreed upon monitoring network, suite of parameters, and goals and objectives. The process has also yielded the formation of a multi-agency group, the Klamath Basin Monitoring Program. With the support of the water quality monitoring entities basin-wide, and a collective mission and vision, the Klamath Basin Monitoring Program has acquired momentum toward sustainability as an organization. With the Klamath Basin Monitoring Plan and tools for decision making and monitoring framework, a unified water quality monitoring effort is in sight. While many milestones were achieved during the two-year process, external basin-wide events, stakeholder engagement, and entrenched monitoring methods in some cases has proved to be obstacles to the process.

The timeline for development of the Klamath Basin Monitoring Program overlapped with other large-scale events such as, the Klamath Hydrologic Settlement Agreement, the Klamath Basin Restoration Agreement, and Total Maximum Daily Load development for the Klamath River mainstem. Some of the participating members were involved in multiple processes. As a result, the time members could commit to drafting documents was limited. The Klamath Watershed Institute took the lead in drafting the majority of work products, such as the monitoring plan. Using member expertise, published data, and Total Maximum Daily Loads, several initial drafts were presented to the group for suggestions and edits. Members were given the opportunity to shape the monitoring plan without the burden of developing it from scratch. By initially framing the project deliverables, the group was able to accomplish a great deal despite other time commitments and busy schedules.

Stakeholders made an effort to attend several of the five meetings. Face-to-face meetings were a critical component to the development of the Klamath Basin Monitoring Program and monitoring plan. Several attempts were made to solicit the involvement of water quality monitoring organizations throughout the basin, as an invitation to participate in the process. Soliciting the involvement of monitoring entities was a critical step in forging ownership of the outcomes of the process. Members were able to discuss material in a social setting, brainstorm options, and discuss alternatives. Facilitators utilized small group discussion techniques in an effort to enhance participation. Small group discussion was usually followed by large group discussion and synthesis. During large group discussions, the facilitators tracked trends and highlighted common themes as products emerged. The process allowed for complex issues to be discussed and distilled into work products. Work products were then taken before the Steering Committee and Technical Review Committee for inclusion in the monitoring plan and other final documents.

To reflect the diversity of stakeholders, every effort was made to have wide representation among committee members. Committees were composed of federal, state and regional regulatory agencies as well as local monitoring organizations. As the process moved forward, the participation of the Steering Committee became an instrumental in the development of meeting agendas and leading group discussion.

Neutral facilitation of the stakeholders was also critical to development of the Klamath Basin Monitoring Program. Members were often reluctant to follow direction from other members of the group. The power dynamics and historical relationships among members of the group presented issues when leading the group; some members would limit their participation when some members were pushing an organizational-based agenda on the rest of the members. Facilitators were more effective at introducing decision and structure-based topics to the group. Members were able to adopt the gradients of agreement and membership guidelines because it was proposed by a neutral party.

Some of the less successful approaches included watershed analysis of contributing factors to water quality impairments, development of consistent quality assurance and quality control and standard operating procedures, reducing monitoring duplication, and expanding the monitoring network. The watershed analysis was presented at a stakeholder meeting using large-format paper worksheet for sketching potential sources of water quality impairment. Each worksheet was of one subbasin, which illustrated the stream network, overland flow, soil erodeability, and landuse within the subbasin. Every table at the meeting has a worksheet for a total of twelve worksheets. The design was that each member, based on regional expertise, would sketch the sources of impairment from sources such as cattle ranching, forest fire, or timber harvesting on the maps. The information gathered would allow for a targeted assessment of contributing factors to impaired water quality. The sources could then be addressed by expanding the monitoring network to include new monitoring locations.

The exercise was received with little enthusiasm, in part due to the way the boundaries for the subbasins were delineated. For subbasin delineation, the U.S. Geological Survey hydrography dataset was employed. The U.S. Geological Survey delineation failed to take into account administrative boundaries that the group felt were important, such as the Iron Gate Dam. The Iron Gate Dam is seen as the border between the upper and lower basin and represents a dramatic shift in hydrology and water quality on the Klamath mainstem. Readily identifiable landmarks such as, highways, major roads, and towns were also absent. Since the group could not identify with the subbasin divisions, the exercise received little attention and yielded little useful information. Despite the result of this exercise, other uses of geospatial tools in the process did play important roles helping the group to track complex information across a dynamic landscape.

Using GIS, members were able to visualize monitoring locations from every entity within the basin along with parameters and sampling season. This visualization aided the identification of key sampling locations and gaps in current monitoring. The database was essential to organizing communication among members as well as tracking water quality sampling efforts throughout the basin. Future efforts in expanding the monitoring network include the utilization of National Hydrography Dataset Plus, a repeatable, hypothesis-driven approach for selecting monitoring locations. The National Hydrography Dataset Plus enables water quality concerns to be tracked across a complex landscape and can be coupled with a relational database, allowing for ad hoc queries regarding water quality concern and their impact on beneficial uses.

However, the current monitoring network is based on legacy sites, not targeted hypotheses. This framework may not lend itself to answering questions or understanding processes. The issue with the existing monitoring network identified in the monitoring plan is that it is based on existing sites. Based on member input regarding the watershed analysis, it appears that members have not considered the upslope sources of water quality impairment. Existing locations may be based on access and historical monitoring locations rather than targeting sources of impairment or monitoring sensitive beneficial uses. While existing sites may represent long-term baseline data, emerging water quality issues may be ignored. For example, climate change affects the timing of spring snowmelt, seasonal hydrography and salmonid habitat. The reduction of spring run-off and reduction in water storage affects agricultural needs in the upper basin. Groundwater, an important source of water for upper basin farmers, is all but overlooked. While the special studies aim to address specific issues identified by the Klamath Basin Monitoring Program members, a great number of monitoring locations are redundant, wasting resources that could be redirected to better serve goals to understand water quality issues basin-wide.

Monitoring duplication in the basin wastes resources and narrows the understanding of basin-wide water quality issues. There are several monitoring entities in the Klamath basin that collect data at some of the same sites. These locations are usually associated with U.S. Geological Survey gauging stations. The duplication of effort stems from the lack of data sharing and coordination. Although a database has been developed as part of the work conducted by the Klamath Watershed Institute, there has been resistance among monitoring entities in populating the database. One explanation may be that monitoring entities lose the ability to represent their own data, leaving the data to be misused. Another explanation may be the battle over turf. Relinquishing a monitoring location to another agency may be viewed as losing turf. Also, monitoring entities throughout the basin have developed unique goals and objective particular to their programs. Each monitoring entity frames the monitoring objectives in the light of their individual monitoring program; other monitoring programs may not reflect the same ideals.

National Hydrography Dataset Plus network offers the capability to track non-point source related impairments, generate spatially referenced database for improving collaboration and reducing monitoring redundancy. The Salmon River basin post-fire erosion potential case study presents a compelling reason to develop the National Hydrography Dataset Plus network for use in the Klamath basin. National Hydrography Dataset Plus offers resource managers to a tool to implement targeted monitoring by catchment.

In addition to the spatially referenced catchements, hydrography is also incorporated into the National Hydrography Dataset Plus system using linear features and a complex coding system. When a quality sampling site is addressed in the National Hydrography Dataset Plus network, the upslope contributing area can be identified. By identifying upslope contributing area, potential sources of water quality impairments may be targeted. This method of addressing water quality sampling sites to a spatially referenced network was used by the U. S. Geological Survey in the Chesapeake Bay watershed to track and statistically relate nutrient sources and land-surface characteristics to nutrient loads in streams (Brakebill and Preston 2003). The approach employs a methodology called SPARROW (Spatially Referenced Regression on Watershed) relating measured stream nutrients loads to nutrient sources via nonlinear statistical regression models. This approach may be integrated into a web-based database clearing house offering researchers and the public an opportunity to gain greater understanding of the water quality issues. This method was particularly important in tracking water quality exceedences that affect sensitive beneficial uses. Using established thresholds for sensitive beneficial uses, water quality may be evaluated as supporting, or failing to support, identified beneficial uses, adding resource managers in assessing Total Maximum Daily Load implementation goals.

In addition to the difficulty of monitoring established thresholds and targeted monitoring, Total Maximum Daily Load implementation has been slowed due to variable quality assurance and control procedures. Total Maximum Daily Load development has progressed throughout the basin over the years; many organizations have developed water quality monitoring programs in isolation, addressing water quality issues at variable scales. The variable quality assurance and quality control and standard operating procedures made water quality data comparability an issue. Although a comprehensive basin-wide quality assurance and quality control and standard operating procedures were some of the major goals of the monitoring plan, resistance over adopting one method over another resulted in a stalemate. There was concern among members regarding altering procedures and potentially loosing comparability to internal historical data. The compromise was to suggest the implementation of the California Surface Water Ambient Monitoring Program standards and set minimum criteria for quality assurance and quality control. The rationale for the minimum criteria was to be inclusive of all monitoring entities, with the hope that collaborative programs like the Klamath Hydrologic Settlement Agreement monitoring would prove to be a model for water quality data sharing. There was also an expectation that in the future California may require Surface Water Ambient Monitoring Program protocol as a funding requirement.

Other stakeholder groups attempting to create similar programs could benefit by using key factors that led to the success of the Klamath Basin Monitoring Program. The key factors that led to successful development of the Klamath Basin Monitoring Program included: interactive and inclusive collaboration; involving the group in leadership roles; neutral facilitation; framing project deliverables; and development of interactive geospatial tools.

At the core of the Klamath Basin Monitoring Program are the individuals and organizations who participated in the early days of the effort. These partnerships will be continued beyond the completion of this monitoring plan. The Klamath Basin Monitoring Plan still actively seeks alliances to ensure long-term support. The future of the Klamath Basin Water Quality Monitoring Program is dependent upon the participation of the Klamath Basin Monitoring Program members and the support of the California and Oregon regulatory agencies, and the U. S. Environmental Protection Agency. It is hoped that the coordinated monitoring effort will support decisions regarding resource management in the Klamath basin and expedite the recovery of impaired beneficial uses for the benefit of all California and Oregon residents and Tribal communities.

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APPENDICES

Appendix A.Gradients of agreement for polling

1	2	3	4	5
STRONGLY SUPPORT	SUPPORT WITH RESERVATIONS & SUGGESTIONS FOR TAILORING PROPOSAL	ABSTAIN	DO NOT SUPPORT, BUT WILL NOT REGISTER A MINORITY OPINION	DO NOT SUPPORT & WILL REGISTER MINORITY OPINION

Voting Round 1

1.1 Bring the proposal to the full group.

1.2 Clarify and discuss the proposal.

1.3 Call the question.

1.4 Poll the group using the gradients of agreement.

- Lead: process decision maker.*
- Who: Voting members in good standing.**
- Decision rule: Consensus is 80 % of those voting register a 1 or a 2 on gradients of agreement scale. 3s do not count towards the total number of members polled.

1.5 If there is consensus, then the proposal moves forward.

1.6 If there is NOT consensus, then vote to vote.

- Lead: process decision maker.*
- Who: Voting members in good standing.**
- Decision rule on vote to vote is 50% + 1
- What: Members vote on whether they want to (1) modify the proposal or (2) make decision on the existing proposal.

1.7 If vote to modify the proposal, then move on to round 2.

1.8 If vote to make a decision on the existing proposal, then take a straight vote (yes, no, abstain).

- Lead: process decision maker.*
- Who: Voting members in good standing.**
- Decision rule: 80% super majority of those voting needed to adopt the proposal. (The total number of voters would include proxy votes. Abstentions do not count towards the total number of voters; they are *not* equivalent to a "no" vote.)

1.9 If the proposal gets less than 80% "yes" votes, then the proposal dies or the group must start over with a new proposal.

Voting Round 2 (*NOTE: Steps 2.2-2.9 are the same steps as 1.2-1.9, but with a modified proposal.*)

2.1 Modify the proposal.

2.2 Clarify and discuss the revised proposal.

2.3 Call the question.

2.4 Poll the group using the gradients of agreement.

- Lead: process decision maker.*
- Who: Voting members in good standing.**

- Decision rule: Consensus is 80 % of those voting register a 1 or a 2 on gradients of agreement scale. 3s do not count towards the total number of members polled.

2.5 If there is consensus, then the proposal moves forward.

2.6 If there is NOT consensus, then vote to vote.

- Lead: process decision maker.*
- Who: Voting members in good standing.**
- Decision rule on vote to vote is 50% + 1
- What: Members vote on whether they want to (1) modify the proposal or (2) make decision on the existing proposal.

2.7 If vote to modify the proposal, then move on to round 3.

2.8 If vote to make a decision on the existing proposal, then take a straight vote (yes, no, abstain).

- Lead: process decision maker.*
- Who: Voting members in good standing.**
- Decision rule: 80% super majority of those voting needed to adopt the proposal. (The total number of voters would include proxy votes. Abstentions do not count towards the total number of voters; they are *not* equivalent to a "no" vote.)

2.9 If the proposal gets less than 80% "yes" votes, then the proposal dies or the group must start over with a new proposal.

Voting Round 3 (Final round. *NOTE: Steps 3.2-3.9 are the same steps as 1.2-1.9, but with a modified proposal*.)

3.1 Modify the proposal.

3.2 Clarify and discuss the revised proposal.

3.3 Call the question.

3.4 Poll the group using the gradients of agreement.

- Lead: process decision maker.*
- Who: Voting members in good standing.**
- Decision rule: Consensus is 80 % of those voting register a 1 or a 2 on gradients of agreement scale. 3s do not count towards the total number of members polled.

3.5 If there is consensus, then the proposal is adopted.

3.6 If there is NOT consensus, then vote to vote.

- Lead: process decision maker.*
- Who: Voting members in good standing.**
- Decision rule on vote to vote is 50% + 1
- What: Members vote on whether they want to modify the proposal again or make decision on the existing proposal.

3.7 If vote to modify the proposal, then move on to another round.

3.8 If vote to make a decision on the existing proposal, then take a straight vote.

- Lead: process decision maker.*
- Who: Voting members in good standing.**
- Decision rule: 80% super majority of those voting needed to adopt the proposal. (The total number of voters would include proxy votes. Abstentions do not count towards the total number of voters; they are *not* equivalent to a "no" vote.)

3.9 If the proposal gets less than 80% "yes" votes, then the proposal dies or the group must start over with a new proposal.

3.10 Declare the outcome of the vote and final decision on the proposal.

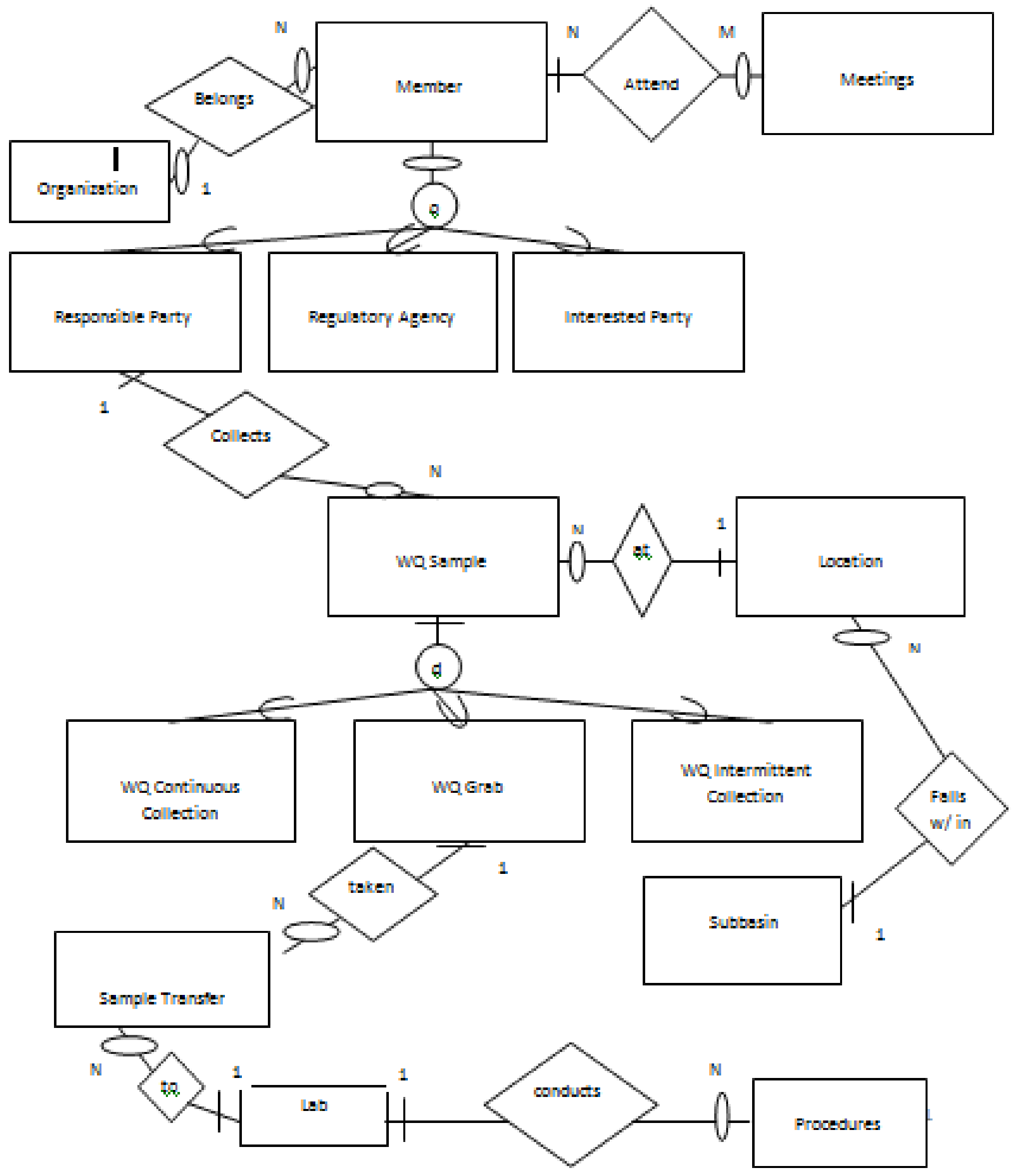
**PROCESS DECISION MAKER: Either the chair of the meeting or a person selected by the group operates as process decision maker. This person reads the polling information and determines if there is consensus or the need for additional discussion and consensus building. The process decision maker also calls for the vote or additional rounds of discussion at steps 1.6, 2.6 and 3.6.*

***For an organization to be a member in good standing, a representative from each member organization must attend one of the two regularly scheduled face-to-face Klamath Basin Monitoring Program meetings per year (one pre-monitoring season, one post-monitoring season). (See Membership Agreement Form p. 3.)*

Appendix B. Subbasin lead survey questions

1) What are the baseline trends?
2) Does water quality support beneficial uses?
3) How is the water quality affected by climate change?
4) What are the effects of regulatory actions on water quality?
5) What are the effects of land and water management actions on water quality?

Appendix C. Database structure entity-relationship



Appendix D. Justification of analytes

- **Temperature -** controls rate reactions in aquatic system and can be a stressor to aquatic life.

- **Dissolved Oxygen -** is important to aquatic ecosystem function. Low concentrations can be a stressor to certain aquatic life.

- **pH -** conditions are important for aquatic life, with typical acceptable pH concentrations in a range of 6 to 9. At elevated pH, unionized ammonia can be toxic to aquatic life, a condition exacerbated by elevated temperatures.

- **Conductance -** represents ions that are in solution. This parameter is often used as a conservative constituent and to identify inputs or affects of land use practices.

- **Inorganic/Organic N (ammonia, nitrate, nitrite, organic N) -** Inorganic nutrients (ammonia, nitrite, nitrate) are readily available for primary production. Nitrate is a component of fertilizers, sewage, and manure. Total nitrogen (organic plus inorganic forms) is an indicator of overall status of an aquatic system. It is important to collect and assess/consider both organic and inorganic forms. Ammonia can be toxic to fish and other aquatic life at relatively low levels (unionized ammonia) when elevated pH and temperature conditions are present. The conversion of ammonia to nitrite and nitrate consumes oxygen.

- **Inorganic/Organic P (orthophosphate, organic P) -** Inorganic nutrients (orthophosphate) are readily available for primary production. Total phosphorus (organic plus orthophosphate) is an indicator of overall status of an aquatic system. It is important to collect and assess/consider both organic and inorganic forms.

- **Particulate and Dissolved C (particulate and dissolved organic carbon) -** This is a measure of the organic matter within the system, and is necessary for the partitioning of organic matter fractions into particulate, dissolved, labile, and refractory. Organic matter consumes oxygen during decay and releases nutrients. Elevated levels of total organic carbon can cause an increase in biological oxygen demand, decreasing D.O. in the water column resulting in unfavorable conditions for aquatic life. Analysis of organic carbon is used to determine organic matter loads. Special studies will be used to identify stoichiometry of organic matter (C, N, and P fraction) and to partition particulate and dissolved matter into refractory and labile forms.

- **TSS/VSS (total and volatile suspended solids) -** TSS and VSS together define the organic (VSS) and inorganic (TSS-VSS) fraction of suspended material. Total Suspended Solids in the water column can impact aquatic life by clogging fish gills, decreasing foraging success, and ultimately can result in decreasing growth rates of fish inhabiting water with high levels of suspended solids. This provides insight on bulk organic matter loads, and coupled with inorganic suspended solids can be used to estimate light extinction.

- **Alkalinity -** Understanding alkalinity, helps to identify the buffering capacity of waters and the ability of an aquatic system to resist changes in pH (e.g., in response to primary production). Elevated pH levels my cause stressful conditions for aquatic life.

- **Water Column Chl-A/Pheo -** This measure of Chlorophyll-a and Phaeophytin-a (a breakdown product of chlorophyll-a) are indirect measurements of primary production, and can be used to estimate productivity. This parameter is well a recognized index of nutrient pollution (U.S. EPA, 2000).

- **Phytoplankton species -** Sampling is needed to identify species presence and absence. Determination of population variations can provide insight into trophic status, nutrient availability, BGA species, potential toxins and health advisories. Consideration should be given to further reducing the sampling frequency in mid-winter.

- **Microcystin -** The California 2006 Section 303(d) list identified microcystin as an impairment in the segment from and including the Copco Reservoirs down to Iron Gate Dam, including the segment of Klamath River between those reservoirs. California's 2008 *Public Review Draft Staff Report for the 2008 Integrated Report for the Clean Water Act Section 305(b) Surface Water Quality Assessment and the 303(d) List of Impaired Waters* (Regional Water Board 2008) recommends that the mainstem Klamath River from downstream of Iron Gate Dam to the confluence of the Trinity River be listed as impaired for microcystin (Klamath River from Iron Gate Dam to Scott River - Middle Klamath River HA, and from Scott River to the Trinity River - Middle & Lower Klamath River HA).

- **CBOD -** Carbonaceous Biological Oxygen Demand (CBOD) is associated with bacteria in the water breaking down the organic material through chemical processes that consume oxygen from the water column. The amount of oxygen potentially consumed by this process is referred to as the CBOD (EPA, 2008). CBOD loading are calculated as part of the Klamath TMDL.

Appendix E. Rational and purpose table

Location	Site Number	State	WQCP	AIP	Other	Rational / Purpose	Sensitive Beneficial Uses
S. F. Sprague	1	OR			•	Track nutrient loading, support spawning habitat	SPWN, RARE, COLD, REC-1, CUL, FISH
N. F. Sprague	2	OR			•	Track nutrient loading, support spawning habitat	SPWN, RARE, COLD, REC-1, CUL, FISH
Five Mile	3	OR			•	Track nutrient loading, support spawning habitat	SPWN, RARE, COLD, REC-1, CUL, FISH
N. F. Sprague @ Godowa Rd	4	OR			•	Track nutrient loading, support spawning habitat	SPWN, RARE, COLD, REC-1, CUL, FISH
Sycan R. @ Drews Rd	5	OR			•	Track nutrient loading, support spawning habitat	SPWN, RARE, COLD, REC-1, CUL, FISH
Sprague R. @ Lone Pine	6	OR			•	Track nutrient loading, support spawning habitat	SPWN, RARE, COLD, REC-1, CUL, FISH
Sprague @ Chiloquin Ridge Rd.	7	OR			•	Track nutrient loading, support spawning habitat	SPWN, RARE, COLD, REC-1, CUL, FISH
Kirchers Bridge	8	OR			•	Track nutrient loading, support spawning habitat	SPWN, RARE, COLD, REC-1, CUL, FISH
Annie Creek	9	OR			•	Track nutrient loading, support fish habitat	RARE, COLD, CUL, FISH
Wood R. @ Dike Rd	10	OR			•	Track nutrient loading, support fish habitat	RARE, COLD, CUL, FISH
Wood R. Weed Rd.	11	OR			•	Track nutrient loading, support fish habitat	RARE, COLD, CUL, FISH
7-Mile Canal @ Dike Rd	12	OR			•	Track nutrient loading, support fish habitat	RARE, COLD, CUL, FISH
Agency North	13	OR			•	Track nutrient loading, phytoplankton / zooplankton communities, support fish habitat	RARE, COLD, REC-1, FISH, CUL
Williamson R	14	OR			•	Track nutrient loading, phytoplankton / zooplankton communities, support fish habitat	RARE, COLD, REC-1, FISH, CUL
Agency South	15	OR			•	Track nutrient loading, phytoplankton / zooplankton communities, support fish habitat	RARE, COLD, REC-1, FISH, CUL
Mid North	16	OR			•	Track nutrient loading, phytoplankton / zooplankton communities, support fish habitat	RARE, COLD, REC-1, FISH, CUL
Coon Point	17	OR			•	Track nutrient loading, phytoplankton / zooplankton communities, support fish habitat	RARE, COLD, REC-1, FISH, CUL
Mid Lake	18	OR			•	Track nutrient loading, phytoplankton / zooplankton communities, support fish habitat	RARE, COLD, REC-1, FISH, CUL
Wocus Bay	19	OR			•	Track nutrient loading, phytoplankton / zooplankton communities, support fish habitat	RARE, COLD, REC-1, FISH, CUL
North Buck Island	20	OR			•	Track nutrient loading, phytoplankton / zooplankton communities, support fish habitat	RARE, COLD, REC-1, FISH, CUL
Pelican Marina	21	OR			•	Track nutrient loading, phytoplankton / zooplankton communities, support fish habitat	RARE, COLD, REC-1, FISH, CUL
Link Dam	22	OR			•	Continuous water quality monitoring of: water temperature, pH, dissolved oxygen, and specific conductance, to comply with ESA requirements.	CUL, AGR, MUN, MIGR, REC-1, COMM
				•		Blue-Green Algae (BGA) monitoring	
				•		Nutrient monitoring including CBOD	
				•	•	Data will be used to continue to refine UKL outflow quality understanding	
				•	•		
Below Link Dam above Lake Ewauna	23	OR			•	Support TMDL activities	CUL, AGR, MUN, MIGR, REC-1, COMM
Klamath R. at RR Bridge at Lake Ewauna	24	OR			•	Support TMDL activities	CUL, AGR, MUN, MIGR, REC-1, COMM
Lost River Diversion Channel	25	OR			•	Support Lost TMDL activities	CUL, AGR, MUN, MIGR, REC-1, COMM
Miller Creek @ N. Canal Diversion	26	OR			•	Support Lost TMDL activities	CUL, AGR, MUN, MIGR, REC-1, COMM
Lost @ Wilson Reservior	27	OR			•	Support Lost TMDL activities	CUL, AGR, MUN, MIGR, REC-1, COMM
Lost River @ Malone Dam	28	OR			•	Support Lost TMDL activities	CUL, AGR, MUN, MIGR, REC-1, COMM
Klamath Straits Drain @ Stateline Rd	29	OR			•	Support TMDL activities (UKL, Lost River, and Klamath River)	CUL, AGR, MUN, MIGR, REC-1, COMM
Klamath Straits Drain nr Hwy 97	30	OR			•	Support TMDL activities (UKL, Lost River, and Klamath River)	CUL, AGR, MUN, MIGR REC-1, COMM
Keno Reservoir – at Miller Island	31	OR			•	Continuous water quality monitoring at 1.0 meters below the surface and 1.0 meter above the bottom of: water temperature, pH, dissolved oxygen, and specific conductance, to comply with ESA requirements.	CUL, AGR, MUN, MIGR, REC-1, COMM
				•		Nutrient monitoring including CBOD	
					•	Keno reservoir experiences complex flow and water quality conditions, and a separate sampling effort should be used to quantify the individual effects of the TMDL efforts through time. For example, inputs from the Lost River diversion channel and the Klamath Straits Drain should be quantified, municipal and industrial compliance tracked, comprehensive monitoring of water quality prescriptions (e.g., return flows from treatment wetlands, non-point source control BMP's). Sampling conducted by USBR will include vertical profiles (e.g., top and bottom observations) located at two to three longitudinal locations.	
				•		Blue-Green Algae (BGA) monitoring	

Appendix E. Rational and purpose table (continued)

Location	Site Number	State	WQCP	AIP	Other	Rational / Purpose	Sensitive Beneficial Uses
Klamath Rier at Keno	32	OR			•	Support Lost TMDL activities	CUL, AGR, MUN, MIGR,REC-1, COMM
Klamath River below Keno Dam	33	OR		•	•	Support TMDL activities (UKL, Lost River, and Klamath River)	CUL, AGR, MUN, MIGR, REC-1, COMM
				•		CBOD – see rationale for Link River below Link Dam	
				•		Blue-green algae monitoring	
Klamath River above J.C. Boyle Reservoir	34	OR		•		Implement and maintain water quality management plans for J.C. reservoir, wherein inflows, outflows, and in-reservoir sampling are desirable.	CUL, AGR, MUN, MIGR, REC-1, COMM
				•		Support TMDL activities	
J.C. Boyle Reservoir	35	OR		•		Supports implementation and assessment of in-reservoir water quality activities associated with reservoir water quality management plans.	CUL, AGR, MUN, MIGR, REC-1, COMM
				•		Support TMDL activities – Nutrient monitoring	
				•		Blue-Green Algae (BGA) monitoring	
Klamath River below J.C. Boyle Dam	36	OR		•		This reservoir outflow point will support TMDL activities in Oregon regarding conditions in J.C. Boyle reservoir.	CUL, AGR, MUN, MIGR, REC-1, COMM
				•		reservoir	
				•		Combined with the sampling point below the J.C. Boyle powerhouse, these data can be used to assess conditions in the bypass reach.	
				•		Dam removal baseline	
Klamath River below USGS Gage	37	OR		•		the last point in Oregon where compliance would be assessed. Access to stateline from the Oregon side of the border is challenging.	CUL, AGR, MUN, MIGR, REC-1, COMM
				•		Blue-Green Algae (BGA) monitoring	
				•		Dam removal baseline	
Klamath River above Shovel Creek	38	CA		•		entities as the Klamath River above Shovel Creek for several years.)	COLD, RARE, MIGR, SPWN, CUL, COMM, FISH, REC-1, MUN
				•		CBOD – see rationale for Link River below Link Dam, Blue-Green Algae (BGA) Monitoring	
				•		Dam removal baseline	
				•		Assess TMDL activities in California.	
Copco Reservoir	39	CA		•		Support TMDL activities	COLD, RARE, MIGR, SPWN, CUL, COMM, FISH, REC-1, MUN
				•		Support reservoir management activities (e.g. nutrients)	
				•		Blue-Green Algae (BGA) monitoring	
				•		Dam removal baseline	
Klamath River below Copco Dam	40	CA		•		Support reservoir management plan activities (e.g., nutrients)	COLD, RARE, MIGR, SPWN, CUL, COMM, FISH, REC-1, MUN
				•		Blue-Green Algae (BGA) monitoring	
				•		Dam removal baseline	
Iron Gate Reservoir	41	CA		•		Blue-Green Algae (BGA) monitoring	COLD, RARE, MIGR, SPWN, CUL, COMM, FISH, REC-1, MUN
				•		Dam removal baseline	
				•		Support reservoir management activities (e.g. nutrients)	
				•		Location to support TMDL activities	
Klamath River below Iron Gate Dam	42	CA		•		Support reservoir management plan activities	COLD, RARE, MIGR, SPWN, CUL, COMM, FISH, REC-1, MUN
			•	•		Blue-Green Algae (BGA) monitoring	
				•		Dam removal baseline	
			•	•		Support TMDL activities	
Klamath River at I-5 Rest Area	43	CA			•	Blue-Green Algae (BGA) monitoring	COLD, RARE, MIGR, SPWN, CUL, COMM, FISH, REC-1, MUN
Shasta River near Mouth	44	CA		•	•	Major tributary contribution: nutrient and sondes	COLD, RARE, MIGR, SPWN, COMM, REC-1
Yreka Creek at Anderson Rd	45	CA			•	Support Shasta TMDL Activities	COLD, RARE, MIGR, SPWN, CUL, COMM, FISH, REC-1, MUN
Shasta River near Yreka	46	CA			•	Support Shasta TMDL Activities	COLD, RARE, MIGR, SPWN, COMM, REC-1
Shasta River @ Mont-Green Rd	47	CA			•	Support Shasta TMDL Activities	COLD, RARE, MIGR, SPWN, COMM, REC-1
Shasta River near Edgewood	48				•	Support Shasta TMDL Activities	COLD, RARE, MIGR, SPWN, COMM, REC-1

Appendix E. Rational and purpose table (continued)

Location	Site Number	State	WQCP	AIP	Other	Rational / Purpose	Sensitive Beneficial Uses
			•	•		Blue-Green Algae (BGA) monitoring	
Klamath River at Walker Creek Bridge	49	CA		•		Dam removal baseline	COLD, RARE, MIGR, SPWN, CUL, COMM, FISH, REC-1, REC-2, MUN
			•	•		Location to support TMDL activities	
Scott River near Mouth	50	CA	•	•		Major tributary contribution: nutrient and sondes	COLD, RARE, SPWN, MIGR, COMM, CUL
Scott River @ USGS Gauge	51	CA			•	Major tributary contribution: nutrient and sondes, Location to support TMDL activities	COLD, RARE, SPWN, MIGR, COMM, CUL
Shackleford near mouth	52	CA				Support Scott TMDL Activities	COLD, RARE, SPWN, MIGR, COMM, FISH, CUL
Scott River at Callahan	53	CA				Support Scott TMDL Activities	COLD, RARE, SPWN, MIGR, COMM, CUL
			•	•		Blue-Green Algae (BGA) monitoring	
Klamath River below Seiad	54	CA		•		Dam removal baseline	
			•	•		Location to support TMDL activities	COLD, RARE, MIGR, SPWN, CUL, COMM, FISH, REC-1, MUN
			•	•		Blue-Green Algae (BGA) monitoring	
Klamath River near Happy Camp	55	CA		•		Dam removal baseline	
			•	•		Location to support TMDL activities	COLD, RARE, MIGR, SPWN, CUL, COMM, FISH, REC-1, MUN
Salmon River near mouth	56	CA	•	•		Major tributary contribution: nutrient and sondes	COLD, SPWN
Wooley Creek	57	CA			•	Location to support TMDL activities, Support Salmon spawning	COLD, SPWN
Salmon River Below Forks	58	CA			•	Location to support TMDL activities, Support Salmon spawning	COLD, SPWN
N.F. Salmon River	59	CA			•	Location to support TMDL activities, Support Salmon spawning	COLD, SPWN
S. F. Salmon River	60	CA			•	Location to support TMDL activities, Support Salmon spawning	COLD, SPWN
S.F. Salmon near Cecilville	61	CA			•	Location to support TMDL activities, Support Salmon spawning	COLD, SPWN
N.F. Salmon near Sawyers	62	CA			•	Location to support TMDL activities, Support Salmon spawning	COLD, SPWN
			•	•		Blue-Green Algae (BGA) monitoring	
Klamath River near Orleans	63	CA		•		Dam removal baseline	
			•	•		Location to support TMDL activities	COLD, RARE, MIGR, SPWN, CUL, COMM, FISH, REC-1, MUN
Klamath River at Saints Rest Bar	64	CA	•			Location to support TMDL activities, Blue-Green Algae (BGA) monitoring	GWR, COLD, REC-1, WILD, RARE, MIGR, SPWN, CUL
				•		Location to support TMDL activities	
			•	•		Blue-Green Algae (BGA) monitoring	
Klamath River at Weitchpec	65	CA		•		Dam removal baseline	COLD, RARE, MIGR, SPWN, CUL, COMM, FISH, REC-1, MUN
				•		Long-term monitoring station is established at Weitchpec with relatively easier access than Saints Rest Bar. Compare representative	
Trinity River near mouth	66	CA	•	•		Major tributary contribution: nutrient and sondes	GWR, COLD, REC-1, WILD, RARE, MIGR, SPWN, CUL
Trinity River at Hoopa	67	CA	•			Location to support TMDL activities	MUN, GWR, COLD, REC-1, WILD, RARE, MIGR, SPWN, CUL
Tish Tang Creek	68	CA	•			Location to support TMDL activities, Major drainage on Hoopa Valley Indian Reservation	GWR, COLD, REC-1, WILD, RARE, SPWN, MIGR, CUL
Trinity River - South Fork near Salyer	69	CA	•			Location to support TMDL activities	GWR, COLD, REC-1, REC-2, WILD, RARE, MGR, SPWN, CUL
Trinity River at Salyer	70	CA	•			Location to support TMDL activities, Major drainage on Hoopa Valley Indian Reservation	MUN, GWR, COLD, REC-1, WILD, RARE, MGIR, SPWN, CUL
Trinity @ Lewiston	71	CA	•			Location to support TMDL activities	MUN, GWR, COLD, REC-1, WILD, RARE, MGIR, SPWN, CUL
				•		Location to support TMDL activities	
Klamath River below Trinity River / above		CA	•	•		Blue-Green Algae (BGA) monitoring	
	72			•		Dam removal baseline	COLD, MIGR, SPWN, COMM, FISH, REC-1, MUN, CUL
				•		Location to support TMDL activities	
Klamath River above Blue Cr.	73	CA	•			Blue-Green Algae (BGA) monitoring, support TMDL activities	CUL, GW, MIGR, MUN, RARE, REC-1,SPWN, WILD

Appendix E. Rational and purpose table (continued)

Location	Site Number	State	WQCP	AIP	Other	Rational / Purpose	Sensitive Beneficial Uses
Klamath River near Klamath	74	CA	•	•		Blue-Green Algae (BGA) monitoring	COLD, RARE, MIGR, SPWN, CUL, COMM, FISH, REC-1, MUN
				•		Dam removal baseline	
			•	•		Location to support TMDL activities	
Klamath River Estuary	75	CA	•	•		Blue-Green Algae (BGA) monitoring	FRSH, COLD, RARE, MIGR, SPWN, CUL, COMM, FISH, REC-1, MUN
				•		Dam removal baseline	
			•	•		Location to support TMDL activities	

Appendix F. Parameter table.

Site ID	Monitoring Location		Temperature (°C)	Dissolved Oxygen (mg/l)	pH (log[H+])	Conductance (uS/cm)	Inorganic/Organic N (mg/l)	Inorganic/Organic P (mg/l)	Particulate and Dissolved C (mg/l)	Turbidity*	Alkalinity (mg/l)	Water Column chl_a/Pheo (ug/l)	Phytoplankton species	Microcystin (ug/l)	LCMS confirmation	CBOD, mg/l	Sampling Entity	Notes
-	*Sampling Method:*	*Satus*	*T,P*	*P*	*P*	*P*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	-	-
1	S. F. Sprague	CG	H	H	H	H	BW	BW	-	BW[1]	-	-	-	-	-	-	Klamath Tribes	
2	N. F. Sprague	CG	H	H	H	H	BW	BW	-	BW[1]	-	-	-	-	-	-	Klamath Tribes	
3	Five Mile	CG	H	H	H	H	BW	BW	-		-	-	-	-	-	BW*	Klamath Tribes	BOD not CBOD
4	N. F. Sprague @ Godowa Rd	CG	H	H	H	H	BW	BW	-	BW[1]	-	-	-	-	-	-	Klamath Tribes	
5	Sycan R. @ Drews Rd	CG	H	H	H	H	BW	BW	-		-	-	-	-	-	BW*	Klamath Tribes	BOD not CBOD
6	Sprague R. @ Lone Pine	CG	H	H	H	H	BW	BW	-	BW[1]	-	-	-	-	-	-	Klamath Tribes	
7	Sprague @ Chiloquin Ridge Rd.	CG	H	H	H	H	BW	BW	-	BW[1]	-	-	-	-	-	-	Klamath Tribes	
8	Kirchers Bridge	CG	H	H	H	H	BW	BW	-	-	-	-	-	-	-	-	Klamath Tribes	
9	Annie Creek	CG	H	H	H	H	BW	BW	-	-	-	-	-	-	-	-	Klamath Tribes	
10	Wood R. @ Dike Rd	CG	H	H	H	H	BW	BW	-	-	-	-	-	-	-	-	Klamath Tribes	
11	Wood R. Weed Rd.	CG	H	H	H	H	BW	BW	-	-	-	-	-	-	-	-	Klamath Tribes	
12	7-Mile Canal @ Dike Rd	CG	H	H	H	H	BW	BW	-	-	-	-	-	-	-	-	Klamath Tribes	
13	Agency North	CG	H	H	H	H	BW	BW	-	-	-	BW	BW	-	-	-	Klamath Tribes	
14	Williamson R	CG	H	H	H	H	BW	BW	-	-	-	-	-	-	-	-	Klamath Tribes	
15	Agency South	CG	H	H	H	H	BW	BW	-	-	-	BW	BW	-	-	-	Klamath Tribes	
16	Mid North	CG	H	H	H	H	BW	BW	-	-	-	BW	BW	-	-	-	Klamath Tribes	
17	Coon Point	CG	H	H	H	H	BW	BW	-	-	-	BW	BW	-	-	-	Klamath Tribes	
18	Mid Lake	CG	H	H	H	H	BW	BW	-	-	-	BW	BW	-	-	-	Klamath Tribes	
19	Wocus Bay	CG	H	H	H	H	BW	BW	-	-	-	BW	BW	-	-	-	Klamath Tribes	
20	North Buck Island	CG	H	H	H	H	BW	BW	-	-	-	BW	BW	-	-	-	Klamath Tribes	
21	Pelican Marina	CG	H	H	H	H	BW	BW	-	-	-	BW	BW	-	-	-	Klamath Tribes	
22	Link Dam	CG /	VP	VP	VP	VP	M/BM	M/BM	M/BM	M/BM[2]	M/BM	M/BM	M/BM	M/BM	M	M/BM	USBR	
23	Below Link Dam above Lake Ewauna	CG	H	H	H	H	-	-	-	BW[1]	-	-	-	-	-	-	USBR	
24	Klamath R. at RR Bridge at Lake Ewauna	CG	H	H	H	H	-	-	-	BW[1]	-	-	-	-	-	-	USBR	
25	Lost River Diversion Channel	CG	H	H	H	H	-	-	-	BW[1]	-	-	-	-	-	-	USBR	
26	Miller Creek @ N. Canal Diversion	CG	Bi	Bi	Bi	Bi	Bi	Bi	-	Bi[1]	Bi	-	-	-	-	-	USBR	
27	Lost @ Wilson Reservior	CG	Q	Q	Q	Q	Q	Q	-	Q[1]	Q	-	-	-	-	-	USBR	
28	Lost River @ Malone Dam	CG	Bi	Bi	Bi	Bi	Bi	Bi	-	Bi[1]	Bi	-	-	-	-	-	USBR	
29	Klamath Straits Drain @ Stateline Rd	CG	Q	Q	Q	Q	Q	Q	-	Q[1]	Q	-	-	-	-	-	USBR	
30	Klamath Straits Drain nr Hwy 97	CG	H	H	H	H	Q	Q	-	BW[1]	Q	-	-	-	-	-	USBR	
31	Keno Reservoir at Miller Island	CG /	VP	VP	VP	VP	M	M	M	M[2]	M	M	M	M	-	-	USBR	
32	Klamath Rier at Keno	CG	M	M	M	M	M	M	M	M[1]	M	M				BM	ODEQ	BOD not CBOD
33	Klamath River below Keno Dam	CG /	H	M	M	M	M	M	M	M[2]	M	M	M	M	-	M/BM	USBR	

Appendix F. Parameter table. (continued)

Site ID	Monitoring Location		Temperature (°C)	Dissolved Oxygen (mg/l)	pH (log[H+])	Conductance (uS/cm)	Inorganic/Organic N (mg/l)	Inorganic/Organic P (mg/l)	Particulate and Dissolved C (mg/l)	Turbidity*	Alkalinity (mg/l)	Water Column chl_a/Pheo (ug/l)	Phytoplankton species	Microcystin (ug/l)	LCMS confirmation	CBOD, mg/l	Sampling Entity	Notes
-	*Sampling Method:*	*Satus*	*T,P*	*P*	*P*	*P*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	-	-
34	Klamath River above J.C. Boyle Reservoir	CG /	H	-	-	-	M	M	M	M[2]	M	M	M	-	-	-	PacifiCorp	
35	J.C. Boyle Reservoir	CG /	VP	VP	VP	VP	M	M	M	M[2]	M	M	M	M	-	-	PacifiCorp	
36	Klamath River below J.C. Boyle	CG /	H	-	-	-	M	M	M	M[2]	M	M	M	-	-	-	PacifiCorp	
37	Klamath River below USGS Gauge	CG /	H	H	H	H	M	M	M	M[2]	M	M	M	M	-	-	PacifiCorp	
38	Klamath River above Shovel Creek (State	CG /	H	-	-	-	M	M	M	M[2]	M	M	M	M	M	M/BM	PacifiCorp	
39	Copco Reservoir	CG /	VP	VP	VP	VP	M	M	M	M[2]	M	M	M	M	-	-	PacifiCorp	
40	Klamath River below Copco Dam	CG /	H	-	-	-	M	M	M	M[2]	M	M	M	M	-	-	PacifiCorp	
41	Iron Gate Reservoir	CG /	VP	VP	VP	VP	M	M	M	M[2]	M	M	M	M	-	-	PacifiCorp	
42	Klamath River below Iron Gate	CG /	H	H	H	H	M/BM	M/BM	M/BM	M/BM[2]	M/BM	M/BM	M/BM	W/S	M	M/BM	PacifiCorp	
43	Klamath River at I-5 Rest Area	CG/A	-	-	-	-	-	-	-	-	-	-	BW	BW/M			Karuk Tribe	
44	Shasta River near mouth	CG /	H	H	H	H	BW	BW	BW	BW[2/1]	BW	BW	BW	BW/M	-	-	Karuk Tribe	
45	Yreka Creek at Anderson Rd	CG	Ti	Ti	Ti	Ti				Ti[1]							NCRWQCB	Site removed July 09
46	Shasta R near Yreka	CG	Q	Q	Q	Q	Q	Q	-	Q[1]	Q	Q	-	-	-	-	CDWR	
47	Shasta River @ Mont-Green Rd	CG	H	x	-	-	-	-	-	-	-	-	-	-	-	-	SVRCD	
48	Shasta River near Edgewood	CG	Ti	Ti	Ti	Ti	-	-	-	Ti[1]	-	-	-	-	-	-	NCRWQCB	Site removed July 09
49	Klamath River at Walker Creek Bridge	CG /	H	-	-	-	BW	BW	BW	BW[2/1]	BW	BW	BW	BW/M	-	-	Karuk Tribe	
50	Scott River near Mouth	CG /	H	H	H	H	BW	BW	BW	BW[2/1]	BW	BW	BW	BW/M	-	-	Karuk Tribe	
51	Scott River @ USGS Gage	CG	H	H	H	H	BW	BW	-	H[1]	-	-	-	-	-	BW*	QVIR	BOD not CBOD
52	Shackleford near mouth	CG	BW	BW	BW	BW	BW	BW	-	-	-	-	-	-	-	-	QVIR	
53	Scott River at Callahan	CG	Ti	Ti	Ti	Ti	-	-	-	Ti[1]	-	-	-	-	-	-	NCRWQCB	Site removed July 09
54	Klamath River below Seiad	CG /	H	H	H	H	BW	BW	BW	BW[2/1]	BW	BW	BW	BW/M	-	-	Karuk Tribe	
55	Klamath River near Happy Camp	CG /	H	-	-	-	BW	BW	BW	BW[2/1]	BW	BW	BW	BW/M	-	-	Karuk Tribe	
56	Salmon River near mouth	CG /	H	H	H	H	BW	BW	BW	BW[2/1]	BW	BW	BW	BW/M	-	-	Karuk Tribe	
57	Wooley Creek	CG	H	-	-	-	-	-	-	-	-	-	-	-	-	-	SRRC	
58	Salmon River below Forks	CG	H	-	-	-	-	-	-	-	-	-	-	-	-	-	SRRC	
59	North Fork Salmon River	CG	H	-	-	-	-	-	-	-	-	-	-	-	-	-	SRRC	
60	South Fork Salmon River	CG	H	-	-	-	-	-	-	-	-	-	-	-	-	-	SRRC	
61	SF Salmon River near Cecilville	CG	H	-	-	-	-	-	-	-	-	-	-	-	-	-	SRRC	
62	NF Salmon River near Sawyers	CG	H	-	-	-	-	-	-	-	-	-	-	-	-	-	SRRC	
63	Klamath River at Orleans	CG /	H	H	H	H	BW	BW	BW	BW[2/1]	BW	BW	BW	BW/M	-	-	Karuk Tribe	
64	Klamath River at Saints Rest Bar	CG	BM	BM	BM	BM	BM	BM	BM	BM[1]	BM	BM	BM	BM	-	-	Hoopa Tribe	
65	Klamath River at Weitchpec	AIP	H	H	H	H	BW	BW	BW	BW[2/1]	BW	BW	BW	BW/M	-	-	Yurok Tribe	
66	Trinity River near Mouth	CG /	H	H	H	H	BW	BW	BW	BW[2/1]	BW	BW	BW	-	-	-	Yurok Tribe	

Appendix F. Parameter table. (continued)

Site ID	Monitoring Location		Temperature (°C)	Dissolved Oxygen (mg/l)	pH (log[H+])	Conductance (uS/cm)	Inorganic/Organic N (mg/l)	Inorganic/Organic P (mg/l)	Particulate and Dissolved C (mg/l)	Turbidity*	Alkalinity (mg/l)	Water Column chl_a/Pheo (ug/l)	Phytoplankton species	Microcystin (ug/l)	LCMS confirmation	CBOD, mg/l	Sampling Entity	Notes
-	*Sampling Method:*	*Satus*	*T,P*	*P*	*P*	*P*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	-	-
67	Trinity R at Hoopa	CG	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	-	**Q**[1]	**Q**	**Q**	-	-	-	-	**CDWR**	
68	Tish Tang Creek	CG	**H**	**H**	**H**	**H**	**BW**	**BW**	-	**BW**[1]	**BW**	-	-	-	-	-	**Hoopa Tribe**	
69	Trinity River - South Fork near Salyer	CG	**Ti**	**Ti**	**Ti**	**Ti**	-	-	-	**Ti**[1]	-	-	-	-	-	-	**NCRWQCB**	**Site removed July 09**
70	Trinity River at Salyer	CG	**Ti**	**Ti**	**Ti**	**Ti**	-	-	-	**Ti**[1]	-	-	-	-	-	-	**NCRWQCB**	**Site removed July 09**
71	Trinity @ Lewiston	CG	**Ti**	**Ti**	**Ti**	**Ti**	**Ti**	**Ti**	-	**Ti**[1]	-	**Ti**	-	-	-	-	**NCRWQCB**	**Site removed July 09**
72	Klamath River below Trinity / above Tully	CG	**H**	**H**	**H**	**H**	**BW**	**BW**	**BW**	**BW**[1]	**BW**	**BW**	**BW**	**BW/M**	**M**	-	**Yurok Tribe**	
73	Klamath River above Blue Cr.	CG	**H**	-	-	-	-	-	-	-	-	-	-	-	-	-	**Yurok Tribe**	
74	Klamath River near Klamath	CG /	**H**	**H**	**H**	**H**	**BW**	**BW**	**BW**	**BW**[2/1]	**BW**	**BW**	**BW**	**BW/M**	-	-	**Yurok Tribe**	
75	Klamath River Estuary	CG /	**BW**	**BW**	**BW**	**BW**	**BW**	**BW**	**BW**	**BW**[2/1]	**BW**	**BW**	**BW**	**BW/M**	-	-	**Yurok Tribe**	

Key to tables:		
Sampling Method:	Sampling Frequency:	Turbidity* 1 = Turbidity, 2 = TSS/VSS, 3 = Secchi
T - thermistor	H - hourly measurements (in some instances sub-hourly data may be desired)	
P - probe or data sonde	VP - vertical profile at stated sampling frequency (3 depths)	Acronyms:
(minimum seasonal deployment - April to November)	M - monthly sampling	CG - Contiuous / Grab
G - grab sample	M/BM - Bi-monthly (every two months) and monthly sampling the remainder of the year	WQCP - Water Quality Control Plan
	E- Event based monitoring (e.g. samples at the highest flow events of the year)	AIP- PacifiCorp funding monitoring
	M/S - monthly sampling	
	W/S - weekly sampling	
	BW - Bi-weekly	
	Bi - Bi-annually	
	Ti- Tri-annually	
	Q - Quaterly	
	x-unknow sampling frequency	

Appendix G. Strategic plan

http://www.kbmp.net/documents