Lost River, California
Total Maximum Daily Loads

Nitrogen and Biochemical Oxygen Demand
to address
Dissolved Oxygen and pH Impairments

Established by

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date

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Acknowledgements and Contact Information

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CHAPTER 1: INTRODUCTION

1.1 OVERVIEW OF THE TMDL PROGRAM

The purpose of the Clean Water Act's (CWA's) Total Maximum Daily Load (TMDL) program is to assure that water quality standards are attained and maintained in waters that are now impaired. The water quality problems addressed in this report – reduced dissolved oxygen, elevated pH, and excessive algal and macrophyte growth caused, in part, by excessive discharges of nitrogen and organic matter – are partly responsible for degradation of aquatic habitat conditions in the Lost River basin.

The TMDL process involves identifying *impaired* or polluted waterbodies on the state section 303(d) list, and developing pollutant control plans called TMDLs for each polluted water identified on the section 303(d) list. These TMDLs for the Lost River in California are being established under section 303(d) of the CWA subsequent to their listing by the state of California. Under section 303(d), the state of California periodically identifies "those waters within its boundaries for which the effluent limitations... are not stringent enough to implement any water quality standard applicable to such waters." In 1992 EPA added the Klamath River basin, which includes the Lost River system, to California's section 303(d) impaired water list due to elevated nutrients and temperature. California has continued to identify the Lost River Hydrologic Area (HA)[1] as impaired due to nutrients and temperature in subsequent biennial listing cycles. Specifically, within the Klamath River Hydrologic Unit, Lost River Hydrologic Area, the state listed the Tule Lake and Mount Dome Hydrologic Sub Areas (HSAs) for nutrients (see Figure 1-1); and Tule Lake and Lower Klamath Planning watersheds for pH.

This TMDL addresses the impaired waterbodies in the Lost River HA and Mount Dome and Tule Lake HSAs. For the purposes of this document, the *Lower Lost River* refers to the waterbodies in the Lost River HA. TMDL allocations are calculated to meet water quality standards in those segments.

1.2 OVERVIEW OF TMDLs IN THE KLAMATH BASIN

In preparation for developing these TMDLs, EPA and the state of California reviewed the record supporting the prior listings for the Lost River system. The state of California determined that available data and information did not support the continued listing of Upper Lost River (upstream from Malone Dam) for nutrients or temperature, nor for temperature in the portion of the Lost River downstream of Anderson Rose Dam in the state of California. California removed the section 303(d) listings for temperature for both the Upper Lost River and for Lower Lost River in October 2006; therefore, no temperature TMDLs are being developed for the Upper Lost River or the Lower Lost River in California.

[1] Natural hydrologic boundaries are defined in the Regional Board's Basin Plan and include the Klamath River Basin hydrologic unit, which is divided into smaller units called hydrologic areas (including the Lost River hydrologic area) and even smaller hydrologic subareas (i.e., Tule Lake and Mount Dome hydrologic subareas).

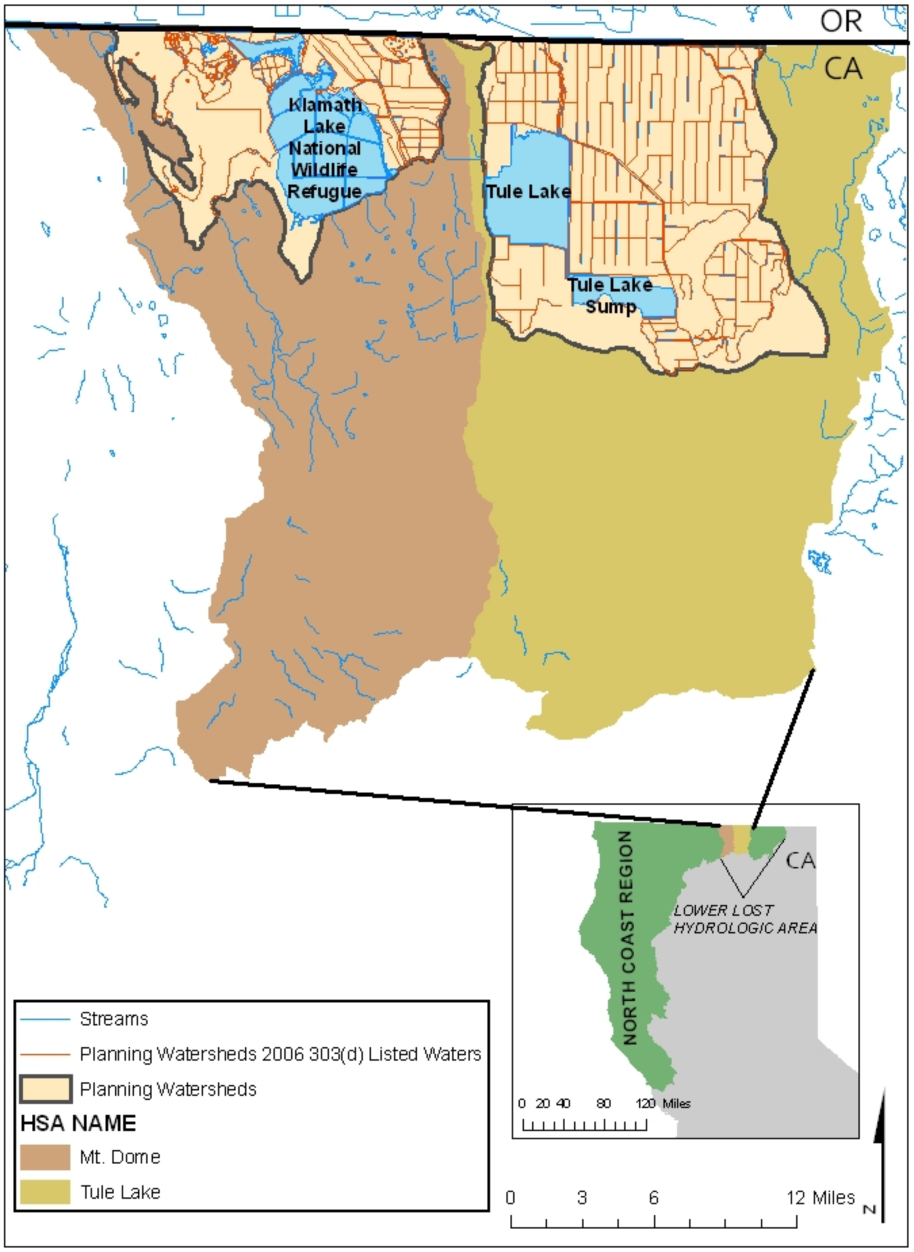

Figure 1-1. Location of the Lost River Hydrologic Area (HA), Hydrologic Sub-areas (HSAs) for Mt. Dome and Tule Lake, and Planning Watersheds (PWS) for Tule Lake and Lower Klamath Lake.

In addition, the state determined that the available data and information supported the continued listing of the Tule Lake and Mt. Dome HSAs for nutrients, and the Tule Lake and Lower Klamath Planning Watersheds for pH.

In accordance with a consent decree (*Pacific Coast Federation of Fishermen's Associations, et al. v. Marcus, No. 95-4474 MHP, 11 March 1997*), requiring the establishment of TMDLs for certain impaired waters in Northern California, TMDLs remaining to be completed under the consent decree include the California portion of the Klamath River and the California portion of the Lost River from Tule Lake to the Oregon border (also known as the *Lower Lost River*).

Under the Consent Decree, the TMDLs necessary for the California Lower Lost River were to be completed by 2007. In December 2007, a *Notice of Agreement to Modify Schedule for Establishment of Total Maximum Daily Loads* was filed in U.S. District Court for the Northern District of California, extending the deadline for establishment of the Lower Lost River TMDLs for nutrients to December 31, 2008.

These TMDLs address the Lost River HA listings, which are for nutrients in waters in the Mt. Dome and Tule Lake HSAs, and pH in waters in the Tule Lake and Lower Klamath Planning Watersheds. Because the state of California will not be adopting TMDLs for the Lost River system by the December 31, 2008, deadline, EPA is establishing these TMDLs. EPA has worked closely with the North Coast Regional Water Quality Control Board (North Coast Regional Board) in developing these TMDLs.

Since 2003, EPA Regions 9 and 10 have been working collaboratively with the North Coast Regional Board and Oregon Department of Environmental Quality (ODEQ) on the development of TMDLs for section 303(d) listed impairments for both the Lost River and the Klamath River. The technical team, supported by Tetra Tech, Inc., has been working together toward the development of coordinated TMDLs for the Oregon and California portions of both the Klamath and Lost Rivers. In a Memorandum of Agreement memorializing this collaboration on TMDL development, the agencies agreed that, for the interstate waters, each state would deliver water quality at the border that meets the downstream state's water quality standards.

Table 1-1 summarizes the TMDLs being completed, the lead agency, and the impairments being addressed in the TMDL.

Table 1-1. Summary of TMDLs being completed

TMDLs	In Oregon	In California
Lost River	ODEQ (DO, pH, Ammonia toxicity, and Temp in Lost River tributaries only)	EPA Region 9 (pH, nutrients)
Klamath River	ODEQ (DO, pH, Ammonia toxicity temp, chlorophyll *a*)	NCRWQCB (Organic enrichment/low DO, temp, nutrients)

EPA Region 9 is developing TMDLs to address impairments in the California portion of the Lost River (pH and nutrients), and ODEQ is developing TMDLs to address impairments for the Oregon portion of the Lost River (low dissolved oxygen, pH, ammonia and temperature). As mentioned above, the California portion of the Lost River was delisted for temperature in the 2006 update to the state's section 303(d) list. Nonetheless, despite the variation in the listed parameters, the agencies undertook a comprehensive analysis for the full Lost River watershed with an emphasis on meeting applicable Lost River basin water quality standards on both sides of the border.

In addition, this interagency collaborative TMDL development effort addresses the many interconnections between the Lost and Klamath Rivers, as well as the contribution of nutrient loadings from the Lost River HA to the Klamath River. Sources of pollutants that may be contributed to the Klamath River by tributaries, including the Lost River, will be addressed in the TMDLs for the receiving waterbody (i.e., the influence of the Lost River inputs to the Klamath River via Klamath Straits Drain will be addressed in the ODEQ TMDLs for the Klamath River).

TMDLs for the Klamath River, addressing nutrients, temperature, and organic matter/low dissolved oxygen are under development by the states of California and Oregon. The North Coast Regional Board is expected to release its Klamath River TMDLs and implementation plan (referred to as an *Action Plan*), for public review in 2009. ODEQ is also slated to jointly release the Oregon Klamath River and Lost River TMDLs for public review in 2009. The Consent Decree schedule for TMDL development calls for EPA approval of the California Klamath River TMDLs by December 2010; Oregon TMDLs are not subject to this Consent Decree.

Several TMDLs have already been developed for tributaries to the Klamath River to address listed impairments. These waterbody locations are illustrated in Figure 1-2, and a summary of these completed TMDLs is presented in Table 1-2. In California, TMDLs have been completed for the Salmon River, Scott River, Shasta River, South Fork Trinity River, and mainstem Trinity River (Table 1-2). ODEQ completed TMDLs[2] in 2002 for Upper Klamath Lake (to address dissolved oxygen, chlorophyll *a*, and pH impairments) and waters that are tributary to Upper Klamath Lake, including the Sprague River subbasin (for dissolved oxygen, pH, and temp impairments), and the Williamson River subbasin (impaired by temperature).

[2] For more information on these ODEQ TMDLs, see http://www.deq.state.or.us/wq/tmdls/docs/klamathbasin/ukldrainage/tmdlwqmp.pdf.

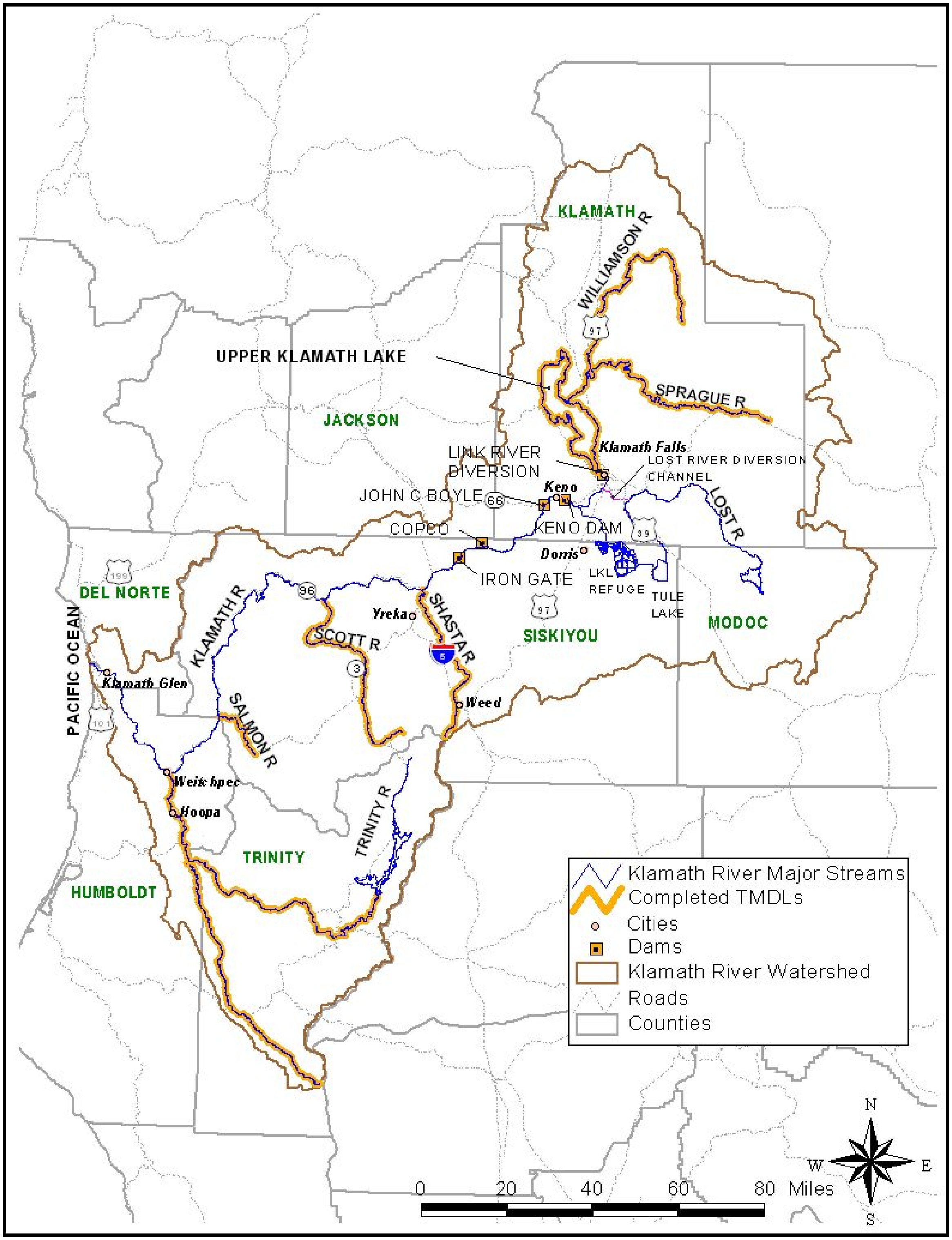

Figure 1-2. Waterbodies in the Klamath River basin that have completed TMDLs.

Table 1-2. TMDLs in the Klamath River basin

Subbasins	TMDL(s)	Year	Agency
Sprague River, Williamson River, and Upper Klamath Lake	Dissolved oxygen, chlorophyll *a*, and pH	Final, 2002	ODEQ
Upper Lost River (CA)	Temperature, nutrients	Delisted, 2006	--
Lower Lost River (OR)	DO, pH, Ammonia toxicity, and Temp (in Lost River tributaries only)	TMDL in progress	ODEQ
Lower Lost River (CA)	Nutrients and pH	Final, 2008	EPA
	Temperature	Delisted, 2006	--
Klamath River (CA)[3]	Nutrients, temperature, organic enrichment/dissolved oxygen	TMDL in progress	North Coast Regional Board
Klamath River (OR)	DO, pH, Ammonia toxicity temp, chlorophyll *a*	TMDL in progress	ODEQ
Shasta River HU1	Temperature, dissolved oxygen	Final Technical TMDL and Implementation Plan, 2007	North Coast Regional Board
Scott River HU	Temperature, sediment	Final Technical TMDL and Implementation Plan, 2006	North Coast Regional Board
Salmon River HU	Temperature	Final Technical TMDL, 2005	North Coast Regional Board
	Nutrients	Delisted, 2006	--
Trinity River	Sediment	Final Technical TMDL, 2001	EPA
South Fork Trinity River	Sediment	Final Technical TMDL, 1998	EPA

These Lower Lost River TMDLs in California have been developed to meet the specific North Coast Regional Board Basin Plan water quality objectives for the Lost River HA. The North Coast Regional Board has responsibility for implementing the TMDLs developed for waterbodies in the North Coast Region. When it adopts the TMDLs for the California Lower Lost River into the Water Quality Control Plan for the North Coast Region (Basin Plan), the North Coast Regional Board has an obligation to consider state laws, including California's Porter Cologne Act, California Environmental Quality Act (CEQA), and the California Endangered Species Act, before incorporating the Lost River TMDLs and a State Implementation Plan into the North Coast Basin Plan. As such, the North Coast Regional Board staff may propose recalculation of or modifications to these Lower Lost River TMDLs as necessary to account for new information. Such information may include the following:

- Load allocations from ODEQ's TMDLs for the Lower Lost River in California;

3 In May 2008, in response to a lawsuit, EPA added microcystin toxins as an additional cause of impairment in Iron Gate and Copco Reservoirs, as part of California's section 303(d) list. This listing is in addition to the original listings of the Klamath River for nutrients, organic enrichment/low dissolved oxygen, and temperature impairments. The TMDLs being developed by the North Coast Regional Board will not directly address the microcystin listing.

- Load allocations from ODEQ's TMDLs for the Klamath Straits Drain to accomplish the Klamath River TMDLs; and
- Additional monitoring data such as that from individual landowners or tributary discharge.

1.3 SUMMARY OF LOWER LOST RIVER TMDLs

These Lower Lost River TMDLs identify the maximum amount (or load) of nitrogen (specifically, dissolved inorganic nitrogen, or DIN)[4] and biochemical oxygen demand (BOD) (specifically, carbonaceous BOD, or CBOD) that can be delivered to the Lost River such that the water quality standards applicable to the Lost River basin for nutrients, dissolved oxygen, and pH can still be met. Modeling and data analysis conducted for this TMDL determined that the most significant nutrient-related impairment in the system is low dissolved oxygen levels; hence, the TMDLs are designed principally to ensure attainment of California's numeric dissolved oxygen water quality standard. This analysis also found that DIN and CBOD reductions sufficient to attain the dissolved oxygen standard will also be sufficient to attain the pH standards. These TMDLs were also developed to ensure that the water that flows downstream across the state line into Oregon meets Oregon's Lost River subbasin dissolved oxygen standards.

The total allowable DIN and CBOD loads are allocated among the sources of DIN and CBOD loading in the watershed. The TMDLs, when implemented, are expected to result in achieving the applicable water quality standards for nutrients (i.e., *biostimulatory substances),* dissolved oxygen, and pH for the Lower Lost River in California. By implementing actions to reduce overall loads, the state is expected to achieve an improving trend in water quality conditions in the Lower Lost River basin. To assist the North Coast Regional Board in developing an implementation plan and in identifying the pollutant controls necessary to meet the TMDLs, EPA is including in this TMDL document a mosaic of recommendations for potential implementation actions, including adaptive management and monitoring programs. EPA expects the North Coast Regional Board to incorporate these TMDLs into its Basin Plan and to develop implementation plans for necessary pollutant controls in accordance with the requirements of federal regulations at Title 40 of the *Code of Federal Regulations* (CFR) section 130.6.

In its section 303(d) list, the state lists the Klamath River Hydrologic Unit, Lost River Hydrologic Area, Tule Lake and Mount Dome Hydrologic Sub Areas (HSAs), as impaired for nutrients. In the North Coast Basin Plan (e.g., Water Quality Objectives, Table 3-1), this area is broken down into specific areas, including the Lower Lost River, Tule Lake, Lower Klamath Lake, other streams, and groundwaters. Additionally, on the section 303(d) list, the Tule Lake and Lower Klamath Lake *Planning Watersheds* (PWS) are listed as impaired for pH.

[4] Dissolved inorganic nitrogen, or DIN, is composed of nitrate, nitrite, and ammonia and is the form of nitrogen most bioavailable to aquatic plants and algae.

For this TMDL analysis, EPA has subdivided the HSA and PWS areas addressed by state's section 303(d) listings into four impaired segments: (1) Lower Lost River from the Oregon Border to Tule Lake Refuge, (2) Tule Lake Refuge (including the sumps and surrounding leased lands), (3) Lower Klamath Refuge, and (4) Klamath Straits Drain from Stateline Highway to the Oregon Border (still within the boundary of the Lower Klamath National Wildlife Refuge).

These four segments are fully within the HSAs listed as impaired for nutrients, as well as within the PWS areas listed for pH on California's 2006 section 303(d) list, and include the small segments of the Ady Canal, Klamath Straits Drain, and drains in the agricultural areas of the PWS areas occurring in California. Figure 1-1 shows the areas in the Mt. Dome and Tule Lake HSA and the PWS areas.

1.4 PHYSICAL SETTING AND HYDROLOGY

The Lost River watershed, traversing the states of Oregon and California, encompasses an area of approximately 2,996 square miles (Figure 1-2). The watershed includes portions of Klamath and Lake counties in Oregon, and Modoc and Siskiyou counties in California. Approximately 56 percent of the watershed (roughly 1,667 square miles) lies in California, while 44 percent (roughly 1,328 square miles) is in Oregon. Figure 1-3 presents general information regarding land use in the Klamath River Basin, including the area of the Lower Lost River. Land use in the HSAs primarily includes the U.S. Bureau of Reclamation's (USBR's) Klamath Project, the Tule Lake and Lower Klamath National Wildlife Refuges (NWRs), surrounded by Bureau of Land Management, National Forest Service and Lava Beds National Monument lands.[5]

The climate of the Lost River watershed is generally characterized by dry summers with high temperatures and wet winters with moderately low temperatures. Precipitation in the watershed occurs mainly during the winter months as rain and snow, with about two-thirds of annual precipitation falling as snow between October and March. Total average snowfall at Klamath Falls, Oregon is about 41 inches. Mean yearly total precipitation measured at Klamath Falls from 1961 to 1990 was 13.5 inches. A portion of this runoff is retained in reservoirs, including Clear Lake and Gerber Reservoir on the upper Lost River (USBR 2000). In addition, water is imported from the Klamath River basin, including diversions from Upper Klamath Lake and Keno Reservoir.

The Lost River originates in California at the outlet of Clear Lake, and flows north into Oregon, near the Malone Dam (Figure 1-4). This portion of the Lost River in California upstream of the Malone Dam, is referred to here as the *Upper Lost River*. Because California removed this from the 2006 section 303(d) list all listings for Upper Lost River in California, EPA is not establishing any TMDLs for the Upper Lost River in California.

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[5] This information is included for general information purposes only and should not be considered definitive or conclusive for any purpose. Further analyses should be conducted as part of TMDL implementation.

From the Oregon border, the Lost River (referred to here as the *Lower Lost River*) continues downstream of Malone Dam, flowing northwest, where it receives substantial inflow from Gerber Reservoir, and then turns westward toward the Harpold Dam. Beyond the Harpold Dam, the Lost River receives inflow of Klamath River water by way of the A-Canal and Lost River Diversion Channel (Figure 1-4). The Lost River Diversion Dam can also divert water to the Klamath River.

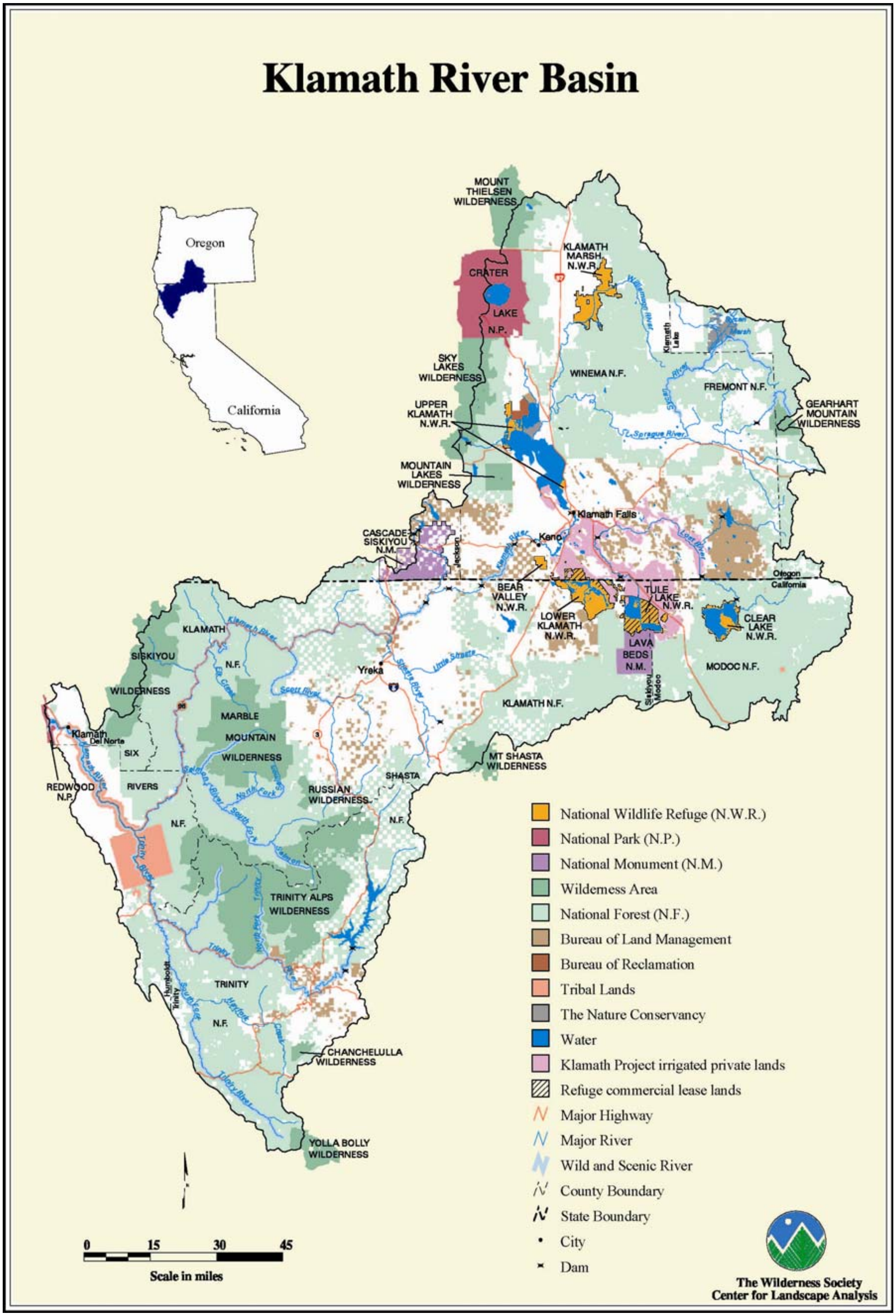

Figure 1-3. Land use in the Klamath River basin.

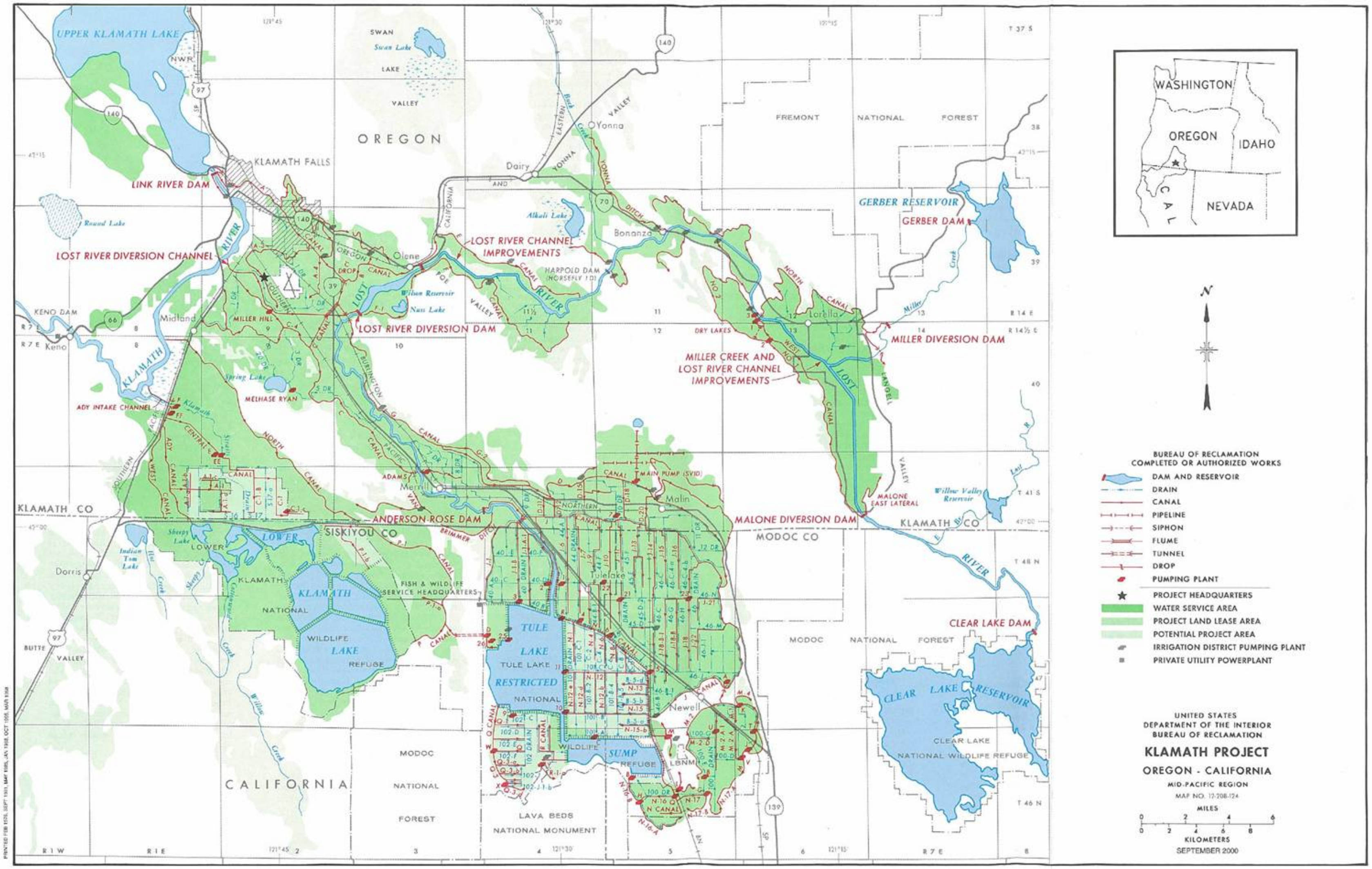

Figure 1-4. Map of the Lost River and Klamath project, showing the path of the Lost River (used with permission from USBR).

Turning southward, the Lower Lost River then reaches the Anderson Rose Dam just before crossing into California. However, most of the water discharging from Anderson Rose Dam is diverted into the J canal.

Again in California, the Lower Lost River continues for approximately 6 miles south to Tule Lake NWR, referred to from this point forward as Tule Lake Refuge. Historically, the Lost River terminated in Tule Lake (discussed further later in this section). Outflow from Tule Lake Refuge is pumped via the *D* Pumping Plant through Sheepy Ridge to the P-Canal and the Lower Klamath Refuge. Pumping from Tule Lake Refuge via the D Plant is conducted to maintain water levels in the refuge to remove excess water while also meeting wildlife needs and requirements.[6] According to Danosky and Kaffka (2002) only approximately 40 percent of the water entering the Tulelake Irrigation District (TID) area (Figure 1-5) is diverted to the Lower Klamath Refuge.

The California portion of the Lower Klamath NWR (aka Lower Klamath Refuge) also receives Klamath River water via the Ady Canal. (North Canal provides Klamath River water to the Oregon portion of the Lower Klamath Refuge). The Lower Klamath Refuge outflows to Klamath Straits Drain, downstream from Lower Klamath Lake; after approximately one-quarter mile in California, Klamath Straits Drain reenters Oregon. Waters in Klamath Straits Drain are then pumped via pump stations E and F toward and discharged into the Klamath River.

1.4.1 Historical Setting

The entire Lost Basin is a significantly altered hydrologic system, with most of the alterations being constructed in the first half of the twentieth century. Historically, the Klamath basin, including Tule Lake and Lower Klamath Lake, contained about 185,000 acres of shallow lakes and freshwater marshes (Figure 1-6).

The Lost River terminated in a vast wetland in the vicinity of Tule Lake, and Lower Klamath Lake had no hydrological connection to the Lost River. Tule Lake area varied in size from 55,000 to 110,000 acres depending on runoff, seasonal flooding, and evaporation; the Klamath River used to spill into the Lost River basin via the Lost River Slough during high-flow events, causing Tule Lake to swell to upwards of 110,000 acres. The Lost River's flow is now determined by water use priorities including the irrigation needs in the basin. As a result, most of the historic fluctuation in lake and marsh habitat in this area has been lost (NRC 2004).

Lower Klamath Lake was an extensive, shallow lake and wetland area that received water from the Klamath River during spring flood events. Wetlands and open water in Lower Klamath Lake once included approximately 30,000 acres of open water habitat, and with the marshes and peat bogs covered 85,000 to 94,000 acres.

[6] For USBR Proposed Klamath Project Operations from 2008 to 2018, see USFWS 2008 Biological Opinion: http://www.usbr.gov/mp/kbao/operations/klamath_project_2008_fws_bo_final.pdf.

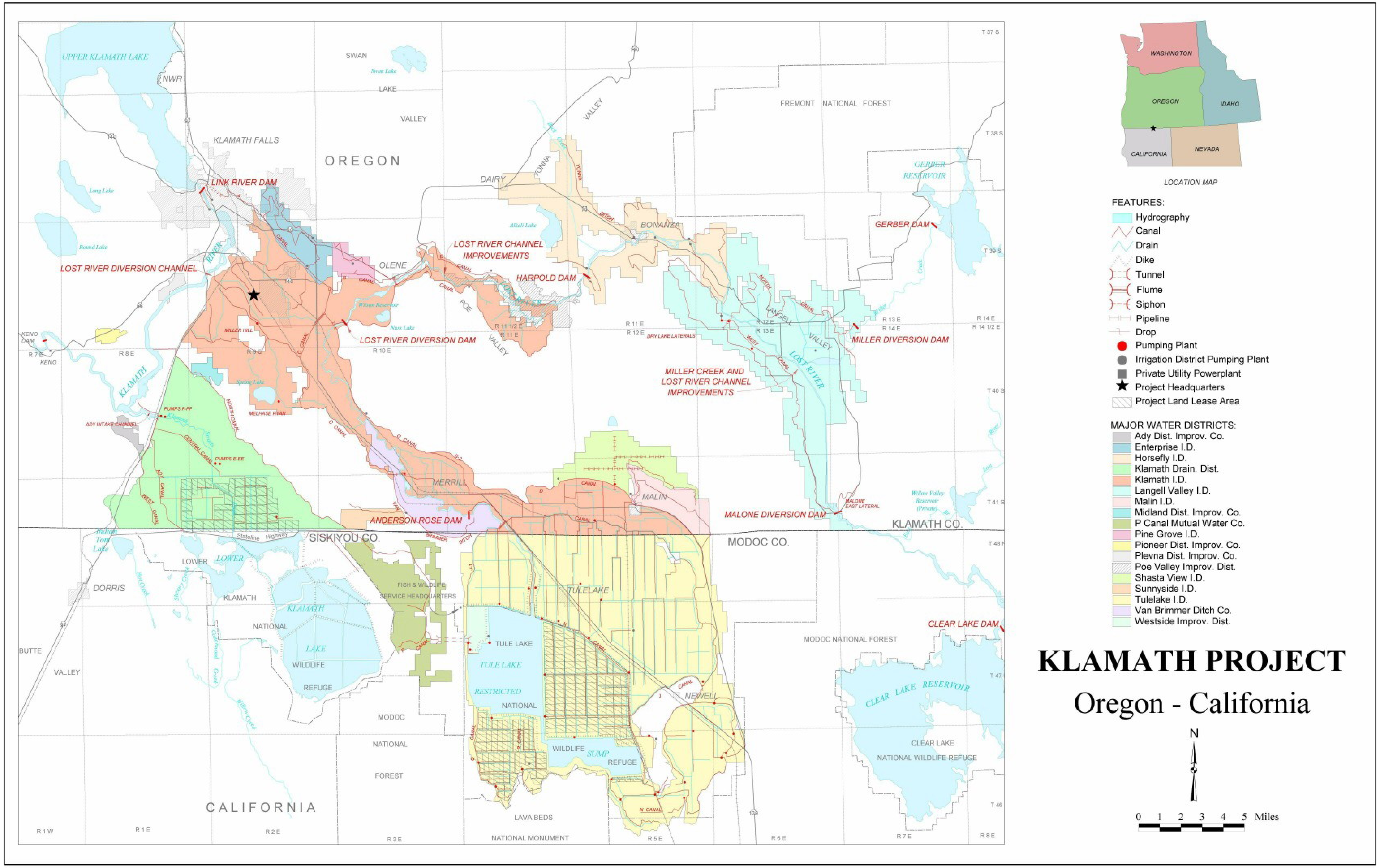

Figure 1-5. Klamath Project showing areas of major water districts (Used with permission of the USBR).

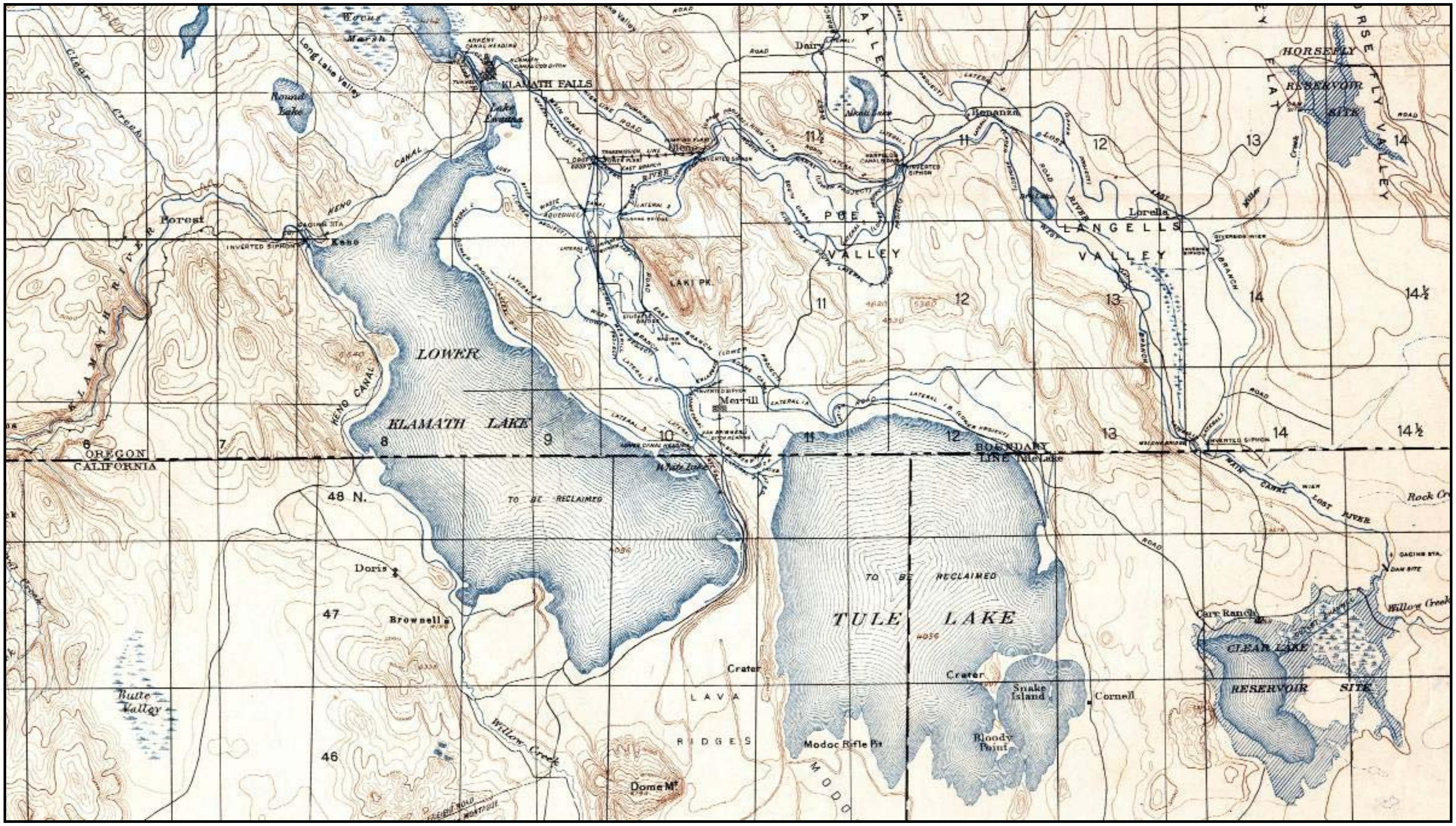

Figure 1-6. 1905 map showing pre-Klamath Project water features in the Lost River and Lower Klamath subbasins. (Source: USFWS Klamath Project BiOp 2008)

The Lower Klamath Lake before settlement has been described as larger than Upper Klamath Lake, with flat-bottomed, steam-driven paddle-wheel boats able to cross 50 miles of open water from Klamath Falls to the railroad to the south (NRC 2004).

1.4.2 Klamath Project History

The USBR's Klamath Project was authorized in 1905 to drain and reclaim lakebed lands of the Lower Klamath and Tule Lakes; to store water from the Klamath and Lost Rivers, including storage in Lower Klamath and Tule Lakes; to divert irrigation supplies; and to control flooding of the reclaimed lands. In 1905, the states of Oregon and California ceded to the United States the lands under the historical Lower Klamath Lake and Tule Lake. Various project facilities on the Klamath and Lost Rivers were built, through 1966.

Also in 1905, the Secretary of Interior authorized the U.S. Reclamation Service (now the USBR) to reclaim the lands beneath both lakes for the primary purpose of homesteading. Thus, the lands formerly inundated by Tule and Lower Klamath lakes were dewatered and reclaimed. Lands were first leased for farming, and then were open for homesteading, beginning in 1917 through 1948. About 44,000 acres were homesteaded in the Tule Lake area (USBR 2000).

Klamath Project work began in 1906 with construction of the A Canal (Figure 1-7). In 1907 the California Northeastern Railway Company constructed a railroad line between the Klamath River and Lower Klamath Lake, which also served as a dike to prevent overflow from the Klamath River into Lower Klamath Lake. Clear Lake Dam, on the Upper Lost River, was constructed in 1910 (and replaced in 2003), initiating drainage of historic Tule Lake. The Lost River Diversion Dam and the Lost River Diversion Channel, which diverts water from Lost River to Klamath River, were constructed in 1912. The Lost River Diversion Channel (enlarged, most recently in 1948) is designed so that water can flow in either direction, depending on operational requirements. Ady Canal, also constructed in 1912, diverts water from the Klamath River into the Lower Klamath Refuge area (USBR 2000).

Anderson Rose Dam on the Lower Lost River just north of the California border was constructed in 1921. That same year, the Link River Dam on the Klamath River was constructed; Klamath River water taken from the Link River Dam is provided to the Lost River in the summer months via the A Canal. Gerber Dam, on Miller Creek (a tributary to the upper Lost River) was constructed in 1926, and Harpold Dam and Malone Diversion Dam were constructed in 1923 (USBR 2000).

Although the Lost River basin historically was usually isolated from the Klamath River, the alterations converted the system into a functional tributary to the Klamath River.[7]

[7] See USBR, *Klamath Project - Historic Operation*, November 2000.

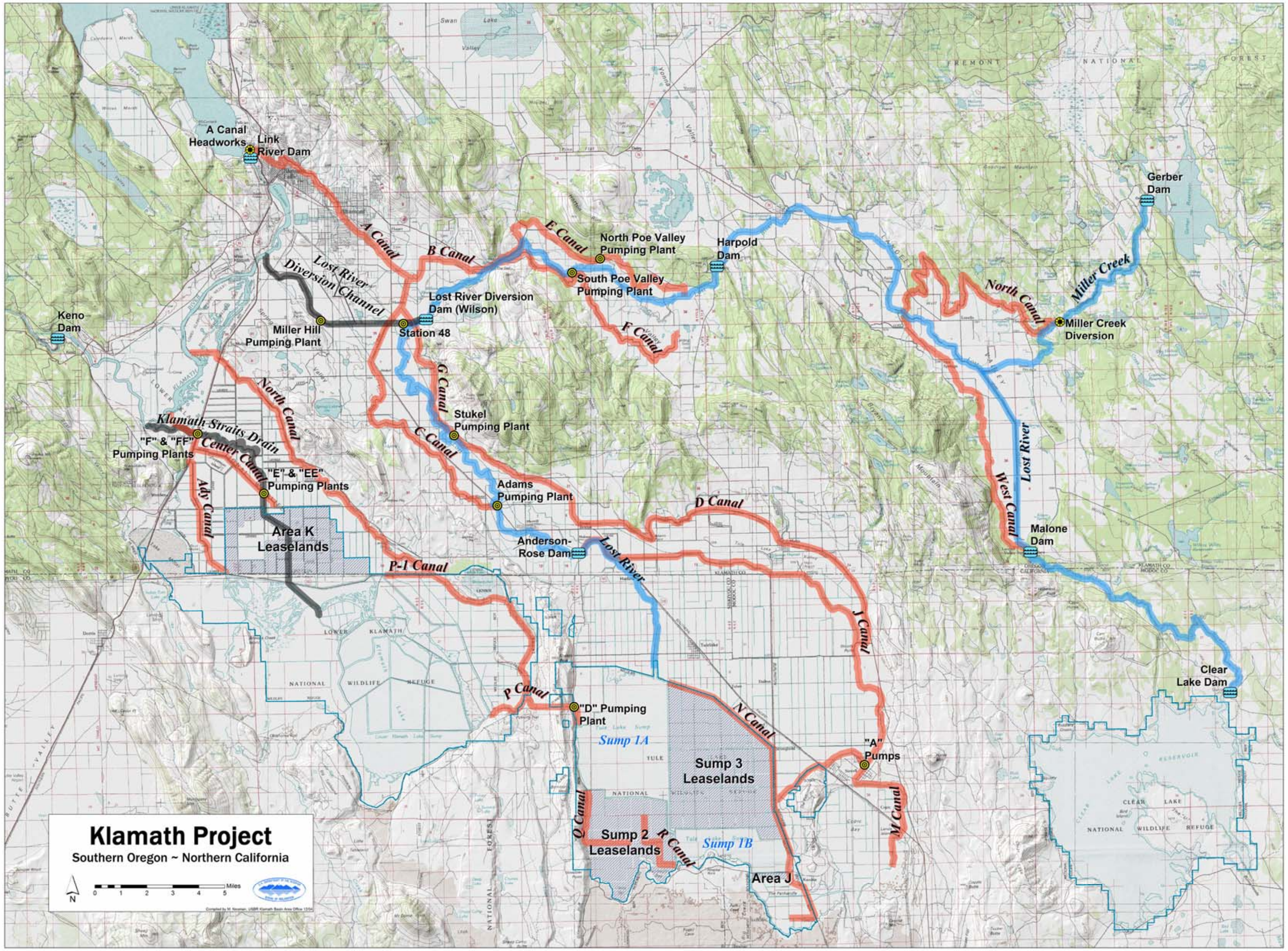

Figure 1-7. Map of Klamath Project highlighting major canals and drains (Used with permission of USBR).

The P Canal System, which consists of the Tule Lake Tunnel and several P canals, was built in 1942 to enable water to be pumped from Tule Lake through Sheepy Ridge and into Lower Klamath Refuge. Klamath Straits Drain, constructed at about the same time, drains Lower Klamath Refuge to the Klamath River via pumping plants (USBR 2000).

The Lost River connection to the Klamath River—pumping through Sheepy Ridge by way of the D Pumping Plant, to the Lower Klamath Refuge and Klamath Straits Drain—is described in *Klamath Project Historic Operation* (USBR 2000) as follows:

> It is important to note that the Klamath River Basin Compact (Compact) recognizes that the Lost River has been made a tributary to the Klamath River via the Project operation (see Klamath River Basin Compact, Article II—Definition of Terms[3]). The Compact was ratified by both California and Oregon and consented to by the United States (August 30, 1957; 71 Stat. 497).
>
> > [[3] Congress consented to the negotiation of the Klamath River Basin Compact (between the States of Oregon and California) by the Act of August 9, 1955, 69 Stat. 613 and to the Compact itself by the Act of August 30, 1957, Public Law 85-222, 71 Stat. 497.] (Page 7)
>
> The Tule Lake National Wildlife Refuge receives water from the Tule Lake area and from the Lost River. Since the Lost River is in a naturally closed basin, Reclamation has constructed a pump and tunnel system (pump "D") from Tule Lake to Lower Klamath National Wildlife Refuge. Return flows from irrigation accrue to Tule Lake and are reused for irrigation before the water is ultimately passed through the pump system and to the Lower Klamath Lake area, where it is used on agricultural and refuge lands. Finally, the water is returned to the Klamath River via the Straits Drain. (Page 23)
>
> P Canal System…is operated to transport water to and through the Lower Klamath Refuge. Pumping Plant D removes water from the Tule Lake Sump and discharges into the Tule Lake Tunnel. The water is then used by individuals or the Refuge, or discharged to the Klamath Straits Drain and thence to the Klamath River. (Page 27)

A conceptual diagram of the Klamath Project created by these construction efforts is presented in Figure 1-8.

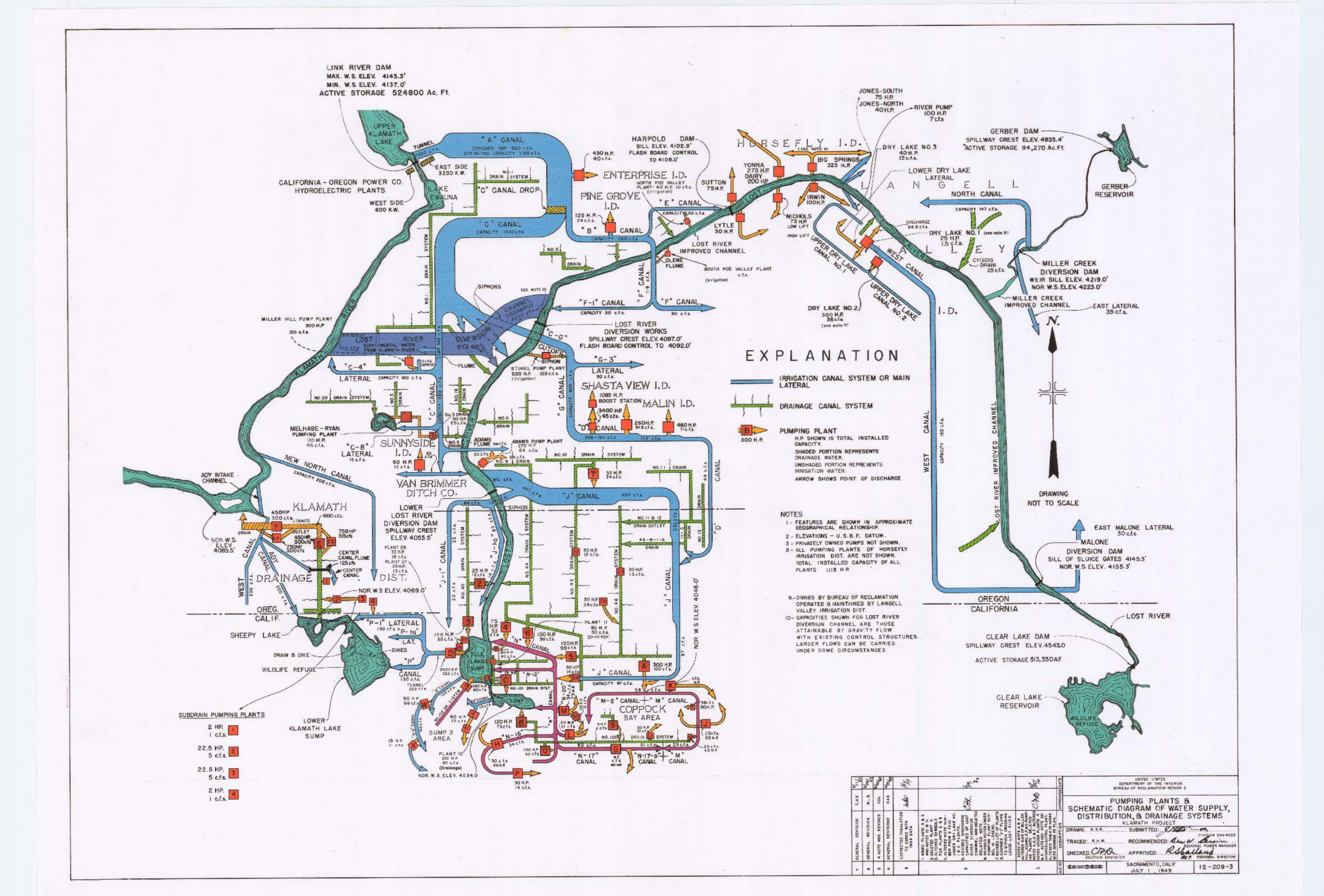

Figure 1-8. Conceptual diagram of Klamath Project; *Pumping Plants and Schematic Diagram of water supply, Distribution & Drainage systems; Klamath Project* updated 9/11/87 (Source: USBR).

The Klamath Project has significantly modified the structure and hydrology of the Lost River. As described by the National Research Council's Committee on Endangered and Threatened Fishes in the Klamath River Basin, "(a)quatic habitats have been modified throughout the upper Klamath basin, but the Lost River watershed has been particularly altered by the development of the Klamath Project…According to the U.S. Fish and Wildlife Service (USFWS), the Lost River 'can perhaps be best characterized as an irrigation water conveyance, rather than a river. Flows are completely regulated, it has been channelized in one 6-mi reach, its riparian habitats and adjacent wetlands are highly modified, and it receives discharges from agricultural drains and sewage effluent. The active floodplain is no longer functioning except in very high water conditions.'" (NRC 2004)

1.4.3 Klamath Project Operations

The current Klamath Project includes approximately 240,000 acres of irrigable lands, and about 23,000 acres of lands within Tule Lake and Lower Klamath Refuges. The Klamath Project is operated to control flows of waters (from the Lost and Klamath rivers) except in some flood periods (USBR 2000). According to the Klamath Project Interim 2008 Operations Plan (USBR 2008), the project is operated to achieve the following:

- Water elevations required by USFWS in Upper Klamath Lake and Tule Lake Refuge;
- Operational criteria for flows at Iron Gate Dam (pending a new National Marine Fisheries Service (NMFS) biological opinion, expected to provide flow requirements);
- Water supply for irrigation; and
- Water supply for the refuges.

The 2008 Operations Plan states that it was developed on the basis of expected hydrologic conditions and to be consistent with the biological opinions issued by the USFWS and anticipated from NMFS.

Project water from Upper Klamath Lake and the Klamath River are delivered, under contract, to water districts operating in the Lost River Basin (see Figure 1-4).

Water diversion to Lost River from Upper Klamath Lake through the A Canal usually begins in spring, gradually increasing in quantity, with maximum flow in early summer, then gradually dropping off in early fall, supporting a similar spring-to-fall irrigation pattern. During summer months very little water originating in the Lost River watershed flows past Harpold Dam (~15 cubic feet per second) and the Lost River downstream of this point is composed of Upper Klamath Lake and Klamath River waters, diverted via the Lost River Diversion Channel (using a pumping plant) to the Lost River. Winter flows come from runoff from all lands throughout the watershed. Water releases are not made from Lost River reservoirs from the time the irrigation season ends in

October until it begins the following April, unless very high inflows occur at Gerber and spill over the spillway occurs (which happens approximately 1 in 10 years).

During winter floods, most water from Lost River above the Lost River Diversion Dam is diverted to the Klamath River, to provide flood protection for irrigated lands downstream; water in the Lost River downstream of the Lost River Diversion Dam is almost entirely runoff from the surrounding lands. In very high floods, water is bypassed into the Lost River.

Most of the remaining water from the Lost River that is not diverted upstream is diverted into the J Canal at the Anderson Rose Dam. Some drainage continues farther downstream into California in the Lost River or by way of agricultural drainage systems ultimately discharging to the Tule Lake Refuge in California (USBR 2000).

Water delivery to the area south of the Oregon border is contracted to the TID. Tule Lake Refuge typically receives water as return flows from agricultural field drains. Danosky and Kaffka (2002) identified three types of agricultural field drainage systems in this area:

- Ditches—A deep ditch along one end of a field, pumped periodically to a master drain. This is reportedly the most common drainage system in the TID area, bordering most fields. In addition to field drainage, such ditches receive input from bank erosion and wildlife and biological production inputs.
- Sump-type drains—A combined series of collector tiles feeding a common sump that also intercepts water in an irrigation supply canal passing along one side of the field. These are typically on privately owned land, serve to reduce back flow from irrigation canals, and address other drainage problems. Waters in these drains are reported to have nutrient levels similar to that found in drainage canals (as opposed to being similar to tile drains).
- Individual tile lines—These subsurface tile drains drain directly into surface drains at the ends of fields. They are used in the Lease Lands area of the Tule Lake Refuge.

TID also operates D Pumping Plant to reduce surplus water levels in the Tule Lake Sumps when needed.

Water delivered to Lower Klamath Refuge is primarily pumped from Tule Lake Refuge (e.g., when there is surplus beyond levels required in the Refuge, or for higher water delivery priorities downstream), and approximately one-third of the water received in the Lower Klamath Refuge comes from Ady Canal (owned and operated by the Klamath Drainage District), primarily in the June to October period. Generally, the area is subject to winter flooding beginning in late fall; irrigation deliveries continue throughout the year, with a smaller quantity of water delivered in the summer. Water from the refuge is discharged to the Klamath River via Klamath Straits Drain (USBR 2000).

1.4.4 Tule Lake and Lower Klamath Refuges

USFWS owns and manages the Tule Lake Refuge and Lower Klamath Refuge. Lower Klamath Refuge was the nation's first waterfowl refuge, established in 1908, and encompasses about 47,000 acres of shallow freshwater marshes, open water, grassy uplands, and croplands that are managed to provide habitat for waterfowl and other water birds (USFWS 2008a). The Tule Lake Refuge was established in 1928, adding another 39,000 acres of mostly open water and approximately 17,000 acres of croplands leased by the USBR. USFWS permit holders farm another 1,900 acres (USFWS 2008b).

The Tule Lake and Lower Klamath NWR are entirely within the area of the USBR Klamath Project. The boundaries for the Tule Lake and Lower Klamath Refuges are illustrated in Figure 1-9 and can be seen in Figure 1-5 as well. With the development of the Klamath Reclamation Project, Lower Klamath Lake was replaced with a system of managed wetland impoundments. Similarly, historical Tule Lake has been replaced by two interconnected sumps.

USFWS manages the Tule Lake and Lower Klamath Refuges, and USBR operates the Klamath Project in accordance with the federal Kuchel Act (1964), as well as by many other state and fereral mandates. Under the Kuchel Act, Tule Lake and Lower Klamath Refuge "shall be administered by the Secretary of the Interior for the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith…. [and] The areas of sumps 1(a) and 1(b) in the Klamath Project lying within… the Tule Lake National Wildlife Refuge shall not be reduced by diking or by any other construction to less than the existing thirteen thousand acres." Tule Lake Refuge contains approximately 15,000 acres of open water and marsh, and 17,000 acres of commercial croplands administered as lease lands. Within the Lower Klamath Refuge, Lease lands are limited to Area K in the Oregon portion of the refuge. Additional information on the lease lands and Kuchel Act is at the USBR Mid-Pacific Region Web page: http://www.usbr.gov/mp/kbao/operations/land_lease/.

When surplus water is not available after fulfilling higher water delivery priorities, Tule Lake sumps and Lower Klamath Refuge receive primarily return flows, other project waters, and precipitation runoff. Surplus water beyond what is required to maintain the level of Tule Lake Refuge sumps is pumped to Lower Klamath Refuge via the D pumping plant when necessary. TID is responsible for maintaining water levels in the Tule Lake Sumps. As TID improves the efficiency of operations and reduces return flows to Tule Lake Refuge, pumping to relieve flooding in Tule Lake Refuge and the surplus flows pumped to Lower Klamath Refuge are also expected to be reduced.

Approximately 60 percent of the water received in Lower Klamath Refuge is pumped from Tule Lake Refuge with the remaining coming from Ady Canal, owned and operated by the Klamath Drainage District. Once in California, Ady Canal flows under Stateline Highway and enters the northwestern area, referred to as Unit 2, of the Lower Klamath Refuge. In accordance with the water delivery priorities, Lower Klamath Refuge may be directed by USBR to pass through to Klamath Strait Drain (via the P canal or through the refuge) as much as 100 percent of waters from Tule Lake Refuge for higher priority allocations downstream. If water is not needed downstream by higher water delivery priorities, USFWS can use the water from Tule Lake Refuge in Lower Klamath Refuge. Additionally, there are times when USFWS cannot discharge excess water because the project conveyances (e.g., Klamath Strait Drain) are full from other discharges.

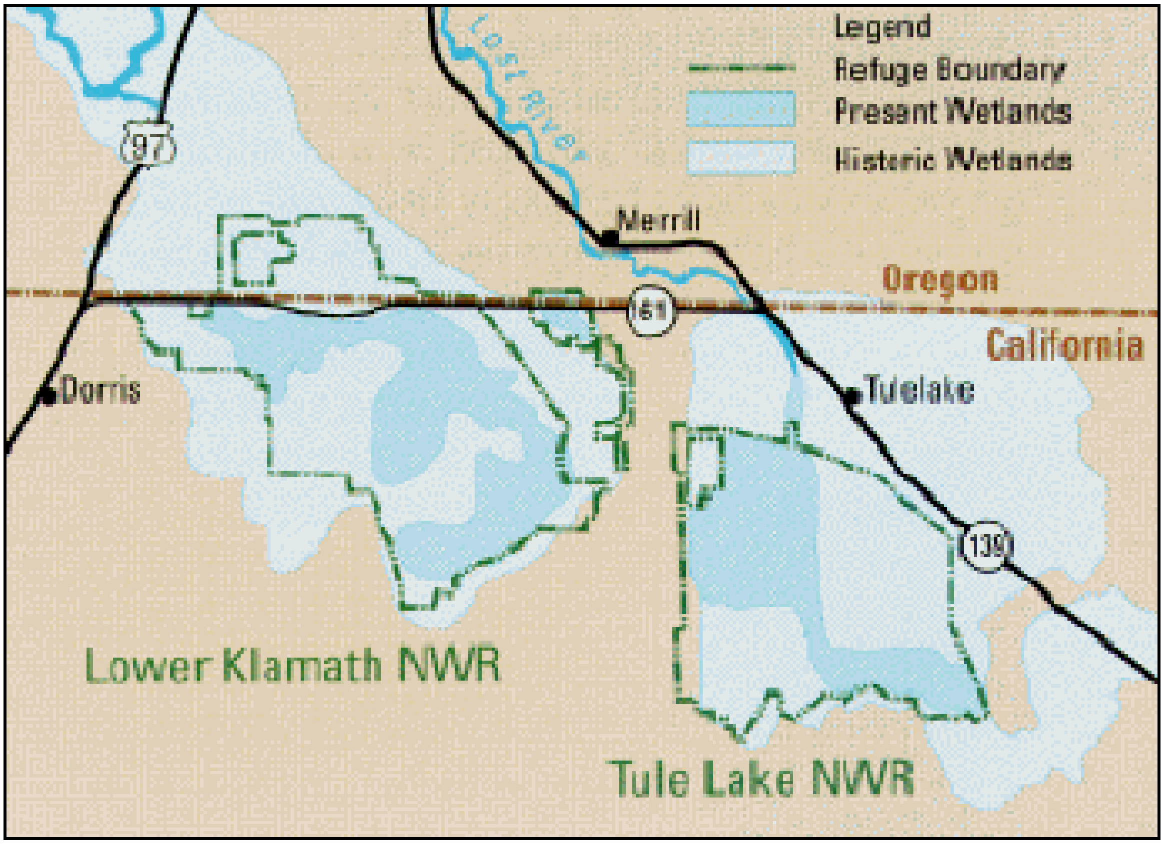

Figure 1-9. Historic wetland areas in Lower Lost River basin (Source: USFWS, Klamath Basin NWRs).

USFWS is working to improve operations at the Tule Lake Refuge by increasing open water areas, rotating wetland areas, and creating marsh/wetland buffers to farming areas; goals include stabilizing water levels, improving water quality and reducing siltation by having a quarter to a third of the agricultural lands in the wetland stage in any given year, in addition to the two large sumps. The USFWS, USBR, and TID work cooperatively to identify lands in the Tule Lake Refuge for flooding. The rotation of wetlands is reported to be improving land fertility and facilitating the transition to organic agriculture when the flooded areas are returned to agriculture, thus reducing chemical input and improving water quality. This work is conducted under the *Environmental Assessment for an Integrated Pest Management Program for Leased Lands at Lower Klamath and Tule Lake National Wildlife Refuges.* Additional information on the program is available on the USFWS Web page for the Klamath Basin NWR Complex: http://www.fws.gov/klamathbasinrefuges/mgmt.html.

In Fall 2008, USFWS initiated the development of Refuge Management Plans for Lower Klamath and Tule Lake Refuges. The management plans for these refuges, addressing a 15-year planning period, are expected to address various parameters including water quality and flooding plans using available water.

1.5 SUMMARY OF WATER QUALITY MODELING

As a first step in developing an understanding of current water quality conditions in the Lost River system, data were obtained from numerous sources and multiple water quality monitoring events. EPA obtained the most current and comprehensive data to support water quality model development, application, and analysis. The technical analysis used to develop the TMDLs made use of best available data and provides a framework that can be readily updated in the future as more data become available. Using available information, a hydraulic and water quality model was developed to (1) analyze the available data; (2) simulate water quality dynamics in the system, and (3) predict conditions that attain water quality criteria. Modeling results indicate that water quality standards can be attained by reducing loading of nitrogen[8] and associated BOD.

To support TMDL development for the Lost River in both Oregon and California, the U.S. Army Corps of Engineers' CE-QUAL-W2 (W2) model was used for the Lost River system from Malone Dam through the Lower Klamath Refuge, as well as the Klamath Straits Drain. The water quality and hydraulic model was developed for the entire Lower Lost River (Oregon and California reaches) to support a comprehensive analysis of nutrient issues in the Lost River system and to support development of TMDLs in both states.

For TMDL modeling, the Lost River was divided into 12 waterbody segments on the basis of the presence of major hydraulic features and the location of monitoring data in the system (Figure 1-10). Linkages between the Klamath River and Lost River system are addressed in the model; tributaries are addressed within the appropriate modeled segments, and incorporate flow and water quality parameters. For example, tributaries to segment 5 (extending from Lost River Diversion Dam to Anderson Rose Dam) include inflows from the Klamath River by way of the A Canal and the Lost River Diversion Channel (e.g., Station 48). Similarly, for segment 9 (Lower Klamath Lake) inflows from the Klamath River via the Ady Canal are addressed as tributary inputs.

These TMDLs for the Lower Lost River in California focus on modeled segments 6 (Anderson Rose Dam to Lost River before Tule Lake), 7 (Tule Lake), 8 (P-Canal), 9 (Lower Klamath Lake) and a small portion of 10 (Klamath Straits Drain). Upstream

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[8] As part of the technical modeling analysis for the Lost River TMDLs, a sensitivity analysis was performed in which contributions of both nitrogen and phosphorus in the Lost River were evaluated, and the analysis suggested that dissolved oxygen levels in the system were not sensitive to phosphorus reductions. Therefore, the Lost River TMDL modeling was developed to address nitrogen loading, and reductions were not made to phosphorus. Oregon's Klamath River TMDLs will result in allocations to the Lost River for discharges into the Klamath River, and these allocations may address reductions in phosphorus loads in addition to nitrogen.

(modeling segments 1 through 5) and downstream (modeling segments 11 and 12) segments will be addressed by ODEQ in its TMDLs for the Lower Lost River.

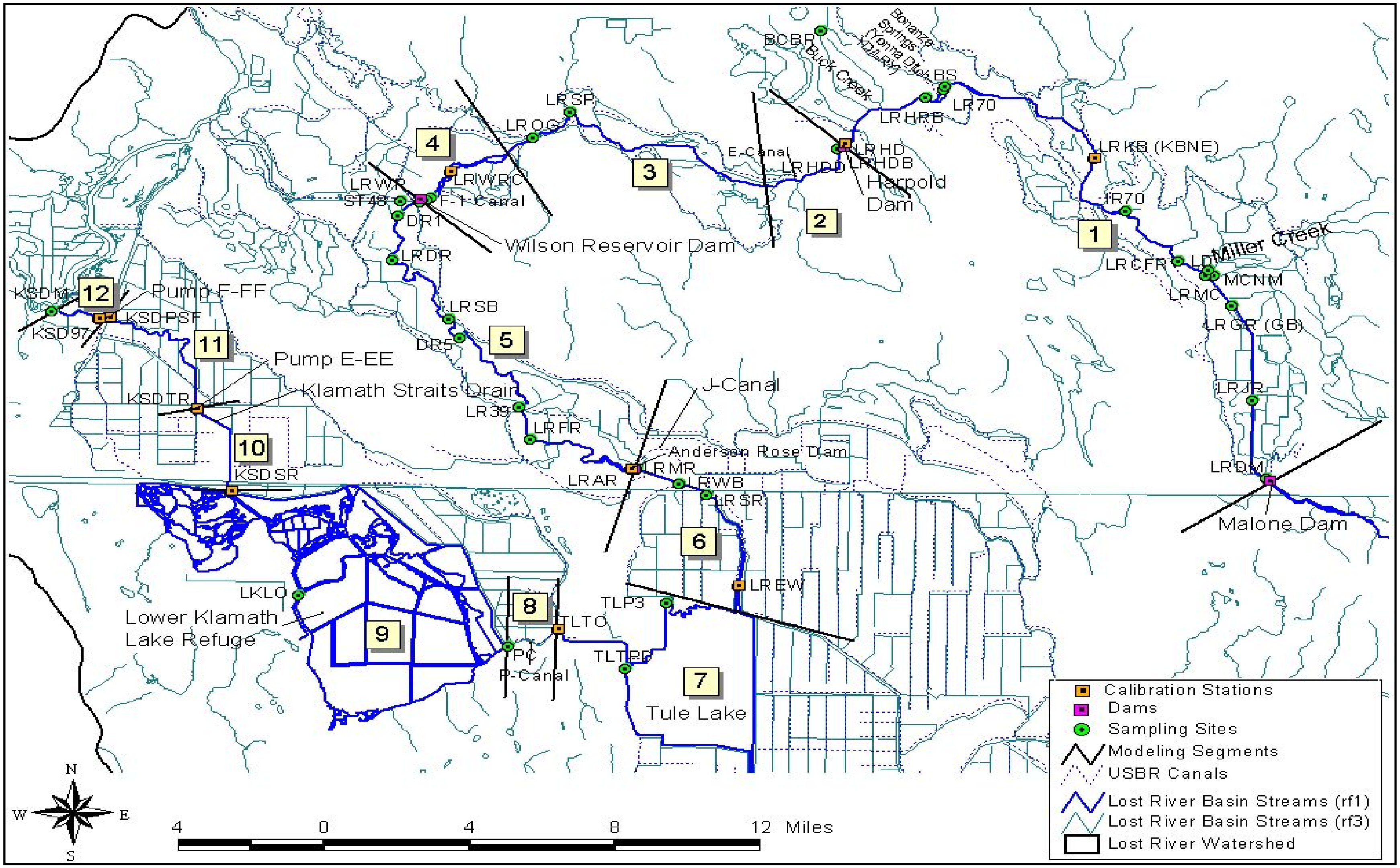


Figure 1-10. Map of modeled segments.

Chapter 5 further describes the model used for these Lost River TMDLs. Additionally, complete documentation of modeling configuration, model input, and calibration is presented in *Model Configuration and Results Lost River Model for TMDL Development* (Tetra Tech 2005), included as Appendix A of this report.

In general, the Lost River model is used to represent the overall water quality trends in response to external loading and internal system dynamics, and addresses transfers to and from the Klamath River. It is not intended to mimic highly localized features (e.g., spatial and temporal distribution of agricultural return flows and pump operations) or short-term variations in water quality from local loadings (e.g., watershed return flows). The model predicts the general response of the river and its impoundments to load inputs and evaluates the impact of hypothetical load changes to evaluate water quality for development of TMDLs.

1.6 EPA ESTABLISHING TMDLS

EPA is proceeding to establish these TMDLs for the Lost River in California, in a time frame to meet its obligations under the Consent Decree. The TMDLs are being established by EPA pursuant to CWA section 303(d) and federal regulations at 40 CFR 130.7.

This document also includes recommendations for implementation to assist the North Coast Regional Board, together with local stakeholders, in identifying and targeting actions necessary to address suspected causes of water quality impairment in the Lost River system. These implementation recommendations, contained in Chapter 7 of this document, are not part of the TMDLs in Chapter 6 that are being established by EPA pursuant to the CWA. The implementation recommendations are strictly advisory and are not required to be implemented under federal law. We encourage the state and local stakeholders to consider these implementation recommendations to guide future water quality protection efforts in the basin.

The North Coast Regional Board has stated that it will consider Oregon's Lost River TMDLs, the Klamath River TMDLs, and any other additional data when it considers incorporating the Lost River TMDLs into the Basin Plan. At that time, North Coast Regional Board staff may propose modifications to EPA's TMDLs as necessary to account for new information. The North Coast Regional Board will provide opportunities for public comment for any proposed revisions to the TMDLs at that time. Additionally, federal TMDLs are not subject to state laws. EPA expects that the North Coast Regional Board will meet its obligation to consider state laws, including California's Porter Cologne Act, CEQA, and the California Endangered Species Act, before incorporating the Lost River TMDLs and a State Implementation Plan into the North Coast Basin Plan. EPA retains the authority to review and approve any new or revised TMDLs.

1.6.1 Tribal Trust Responsibilities

EPA has a trust responsibility to protect and maintain rights reserved by or granted to recognized tribes and individual Indians, by treaties, statutes or executive orders. The trust responsibilities require federal agencies to take all actions reasonably necessary to protect trust assets, including the fishery resources of the Indian tribes in the Klamath River and Lost River basins.

EPA recognizes that improving conditions in the Lost River is necessary to achieve water quality standards, thereby supporting fisheries and Native American cultural beneficial uses, in the Lost and Klamath rivers.

Development of the Lost River and Klamath River TMDLs has included ongoing tribal and interagency consultations, beginning in 2003, and including coordination between tribal technical staff and the TMDL technical development team (EPA, ODEQ, North Coast Regional Board, and federal resource agencies).

1.6.2 Endangered Species Act Consultations

EPA has an obligation to consult with federal wildlife agencies on any action that may affect the wildlife trust responsibilities of these agencies. EPA has determined that the adoption of these TMDLs “may affect, but is not likely to adversely affect” listed species subject to the jurisdiction of the USFWS (the federally endangered shortnose suckers (*Chasmistes brevirostris*) and Lost River suckers (*Deltistes luxatus*)), and has received concurrence with that determination from the USFWS (December 9, 2008). EPA is also consulting with the National Marine Fisheries Service (NMFS) on the effect of this action on coho salmon or its critical habitat.

The North Coast Regional Board is expected to fulfill wildlife trust responsibilities by adopting implementation actions that restore and maintain pollutant levels protective of the wildlife trust responsibilities. EPA retains the discretion to revise the TMDLs if the consultations identify deficiencies in the TMDLs or allocations.

1.7 TMDL DOCUMENT ORGANIZATION

This report is divided into eight chapters. Chapter 2 (Problem Statement) describes the nature of the environmental problems addressed by the TMDLs—nutrient and BOD-related effects on aquatic habitat and associated water quality standards violations. Chapter 3 (Numeric Targets) describes the water quality indicators used in the analysis that represent attainment of applicable water quality standards. Chapter 4 (Source Analysis) describes estimates of nitrogen and BOD loading in the watershed. Chapter 5 (Loading Capacity Linkage Analysis) describes the modeling and data analysis used to evaluate the effects of nitrogen and BOD loading in the Lost River system and determine level of pollutant reductions necessary to attain applicable water quality standards. Chapter 6 (TMDLs and Allocations) describes the TMDLs and associated allocations based on the linkage analysis. This chapter also describes how the TMDL analysis provides the requisite margin of safety and addresses seasonal variations and critical conditions. Chapter 7 (Implementation and Monitoring Recommendations) contains recommendations to allocation holders and the state regarding implementation and monitoring of the TMDLs. Chapter 8 (Public Participation) describes public participation in the development of the TMDLs and implementation recommendations.

CHAPTER 2: PROBLEM STATEMENT

This chapter includes a description of the water quality standards applicable to the Lost River HA and the causes of the water quality impairments being addressed by the Lost River TMDLs. In summary, water quality in the Lost River system is impaired by low dissolved oxygen concentrations and elevated pH caused by excessive BOD and nutrient loading that causes excessive algal growth.

2.1 WATER QUALITY STANDARDS

In accordance with the CWA, TMDLs are set at levels necessary to achieve the applicable water quality standards. Under the federal CWA, water quality standards consist of designated uses, water quality criteria to protect those uses, and an antidegradation policy. California uses slightly different language (i.e., beneficial uses, water quality objectives, and state antidegradation policy). This section describes the state water quality standards applicable to the Lost River TMDLs.

The beneficial uses and water quality objectives for the Lower Lost River are designated in the Water Quality Control Plan for the North Coast Region (Basin Plan), as amended (NCRWQCB 2005). As described in Chapter 1, these TMDLs actually address both the Mt. Dome and Tule Lake HSAs in the Lost River HA. The Clear Lake or Boles Hydrologic Subareas, found in the upper part of the Lost River basin, were not identified as impaired on California's 2006 section 303(d) list of impaired waterbodies and are, therefore, not addressed.

2.1.1 Beneficial Uses

Beneficial uses, as specified in the North Coast Basin Plan, for the Mt. Dome and Tule Lake HSAs are presented in Table 2-1.

Table 2-1. Beneficial uses of the Mt. Dome and Tule Lake HSAs, Lost River HA

Beneficial use	Designation for Mt. Dome HSA	Designation for Tule Lake HSA
Rare, Threatened or Endangered Species (RARE)	Existing	Existing
Agricultural Supply (AGR)	Existing	Existing
Industrial Service Supply (IND)	Potential	Potential
Industrial Process Supply (PRO)	Potential	Potential
Groundwater Recharge (GWR)	Existing	Existing
Freshwater Replenishment (FRSH)	Existing	Existing
Migration of Aquatic Organisms (MIGR)	Existing	Existing
Municipal and Domestic Supply (MUN)	Potential	Potential
Hydropower Generation (POW)	Potential	--
Cold Freshwater Habitat (COLD)	Existing	Potential
Water Contact Recreation (REC1)	Potential	Potential
Non-Contact Recreation (REC2)	Existing	Existing
Commercial & Sport Fishing (COMM)	Potential	Existing
Warm Freshwater Habitat (WARM)	Existing	Existing
Wildlife Habitat (WILD)	Existing	Existing
Aquaculture (AQUA)	Potential	Potential
Spawning and Reproduction (SPWN)	Existing	Existing

2.1.2 Water Quality Objectives

The North Coast Regional Board Basin Plan includes both narrative and numeric water quality objectives designed to protect designated beneficial uses. Water quality objectives for dissolved oxygen, nutrients, and pH are relevant to these TMDLs. Water quality data indicate significant exceedance of the water quality objectives for these parameters, and the California portion of the Lower Lost River is listed as impaired for nutrients and pH on the state's section 303(d) list. The water quality objectives for *other streams* and *groundwaters* in the Lost River HA have been added for context.

<u>Dissolved Oxygen - Numeric Objectives</u>

Waterbodies	Objectives
Lower Lost River Tule Lake PWS Lower Klamath PWS	Greater than or equal to 5.0 mg/L (absolute minimum)
Other Streams	Greater than or equal to 7.0 mg/L (absolute minimum). 50% or more of monthly means must be greater than or equal to 8.0 mg/L.

<u>Biostimulatory Substances (Nutrients) - Narrative Objective (applicable to all waters)</u>

> Waters shall not contain biostimulatory substances (nutrients) in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.

pH - Numeric Objectives

Waterbodies	Objectives
Lower Lost River Tule Lake PWS Lower Klamath PWS	Minimum of 7.0 and not to exceed 9.0
Other Streams	Minimum of 7.0 and not to exceed 8.4
Groundwaters	Minimum of 7.0 and not to exceed 8.5

2.1.3 Stressors

Nutrients and Phytoplankton

In July 2004, a survey was conducted to determine the nature of the aquatic plant communities in the river system (Eilers 2005). Ten sites were evaluated throughout the course of the Lost River of Oregon and California, including impoundments. Figure 2-1 shows the sampling locations. Species found in the Lost River were those common to eutrophic lakes and slow-moving waters and that are tolerant of high turbidity. The dominant aquatic plant species in the Lost River was identified as non-nitrogen fixing *Ceratophyllum demersum* (coontail). Also common to many of the sites were *Lemna minor* (duckweed), several species of pondweed (*Potamogeton pectinatus, P. crispus, and P. nodosus*), *Elodea canadensis*, and *Heteranthera dubia*. *Cladophora* sp., a filamentous alga also common in nutrient-rich waters. Macrophyte coverage (presented as average plant coverage per transect) at sampling locations in or near the California portion of the Lost River found: 21 percent coverage upstream of Anderson Rose Dam; 14.8 percent coverage at East-West Road, just north of the Tule Lake Refuge; 40.8 percent coverage in the P-Canal along stateline; and 1.4 percent coverage in Klamath Straits Drain at Township Road.

Plants were analyzed for several parameters, including nitrogen to phosphorus ratios (N:P). Sites upstream of the Lost River Diversion Channel indicated “macrophyte communities with a net deficiency of nitrogen, whereas the sites further downstream have N:P ratios near the expected values for plants,” that is, higher N:P ratios. Similarly, algal biovolume generally increased at downstream sampling locations.

Aphanizomenon flos-aquae (AFA), a nitrogen-fixing phytoplankton, was identified in significant amounts at only two of ten sampling locations; one being the site at East-West Road, just north of the Tule Lake Refuge. AFA was not a dominant species at the other sampling locations in or near the California portion of the Lost River (upstream of Anderson Rose Dam, P-Canal at stateline, or Klamath Straits Drain at Township Road). Regarding these locations, Eilers (2005) reported the following:

> The last three sites sampled in the Lost River system, LREW [Lost River at East-West Road], PC [P Canal], and KSDTR [Klamath Straits Drain], were among the least similar to the upstream sites and were very different from one another. The LREW was the site with the clearest water and also contained extensive beds of Typha extending from the banks on both sides of the channel. The sites contained a relatively diverse macrophyte community extending across much of the channel as well as floating macrophytes, especially Lemna, derived from upstream. The

> PC site was dominated by *P. pectinatus*, with a minor amount of Cladophora attached to the macrophytes. The KSDTR had few attached macrophytes. Most of the plants appeared to be drifting in the canal. This site was notable for an algal sheen on the surface…and for relatively high light extinction.

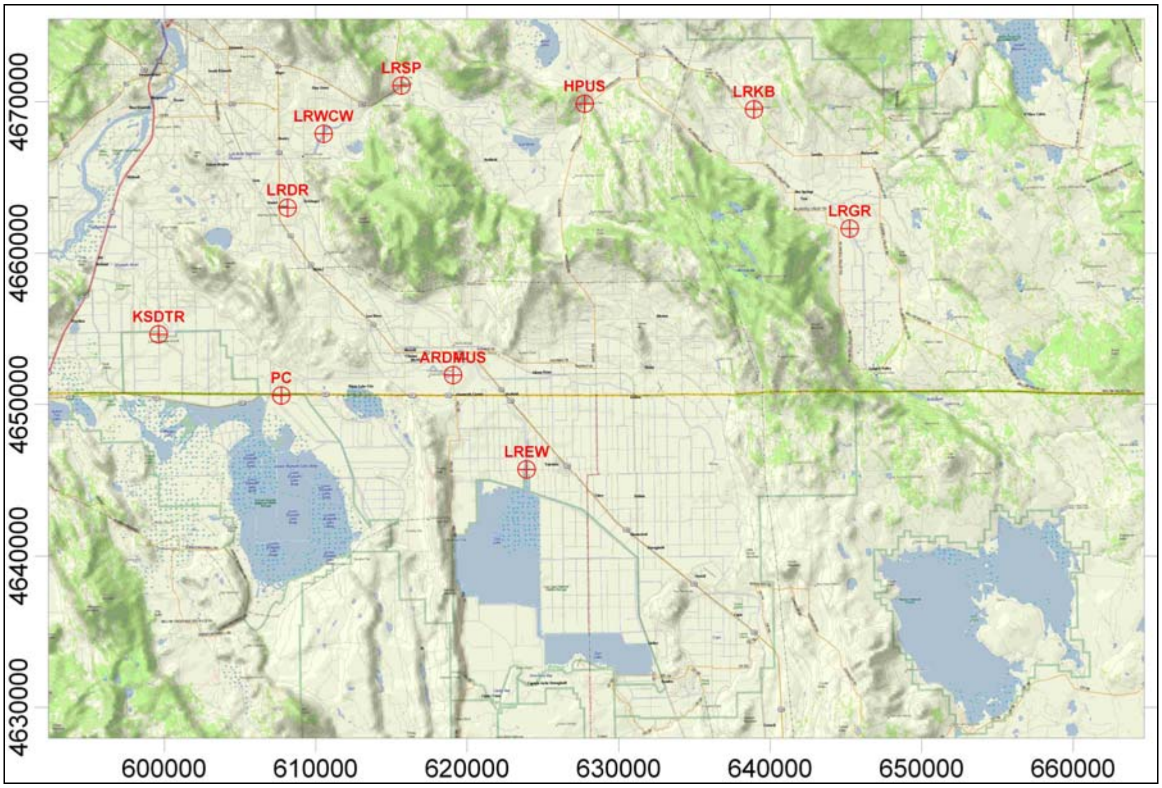


Figure 2-1. Lost River vegetation study sampling locations (Eilers 2005) (Axes are UTM coordinates).

While AFA might have localized impacts, available data do not suggest that nitrogen fixation by AFA is a dominant factor in the California portion of the Lost River.

Biological productivity, including nutrient uptake and release by aquatic plants, is explicitly represented in the TMDL model framework that is built around the dominant (non-nitrogen fixing) aquatic plant species present in the river. A more detailed characterization of the amount of nitrogen contributed to the system by the various phytoplankton species in the Lower Lost River system would be needed to further estimate the effects of phosphorus and nitrogen reductions on water quality conditions. Thus, additional monitoring to better understand and quantify contributions from phytoplankton is included in the recommendations for further work (see Chapter 7). In the future, should sufficient, quantitative data become available, the model could be updated to explicitly consider phytoplankton and macrophytes.

Lost River and Shortnose Suckers

The habitat-related beneficial uses for the Lower Lost River are of concern in these TMDLs because of the potential adverse impact that depressed dissolved oxygen and elevated pH levels could have on native fish in the Klamath basin including the shortnose sucker (*Chasmistes brevirostris*) and Lost River sucker (*Deltistes luxatus*). Both sucker species were listed as endangered in 1988 under the federal ESA (USFWS 2007a, 2007b).

In 2007 the USFWS completed 5-year reviews for the Lost River and shortnose sucker. That review considered information on population trend data, effects of threats on long-term survival, adequacy of existing regulatory mechanisms and conservation measures, and management and conservation planning information. The review reached the following conclusions: the Long River and shortnose suckers are both endangered, shortnose sucker is at risk of extinction and should remain listed as endangered, and the Lost River sucker is not at risk of extinction in the foreseeable future and should be reclassified as threatened. The ESA should continue to protect both species. USFWS has not yet taken action to change the regulatory status of the Lost River sucker.

In April 2008, USFWS completed a Biological Opinion (BO) on the effects of the USBR's proposed Klamath Project Operations for 2008 to 2018. Future proposed actions developed by USBR to respond to this BO and protect the suckers will be reviewed by USFWS. The BO primarily addresses suckers in Upper Klamath Lake areas; however, it includes requirements for the TID to maintain minimum water levels in Tule Lake Refuge to support an *orphan* population of suckers (believed to have accessed the area via supply canals), along with other requirements to protect that population. The final USFWS BO is on the USBR Web site:
http://www.usbr.gov/mp/kbao/operations_planning.html

The most recent USFWS Recovery Plan for Lost River and shortnose suckers was completed in 1993; USFWS has initiated an update of that document, and is using its Klamath Falls Office Web site to post information on the process (e.g., calendar of meeting dates; notes from recovery team, public, and stakeholder meetings; contact information; press releases; relevant technical documents; and other related information). USFWS has convened a recovery team and contracted with the Desert Research Institute to prepare a draft plan over the next year with assistance from the recovery team, stakeholders, and the public. For additional information on the Sucker Recovery Plan development, see http://www.fws.gov/klamathfallsfwo/suckers/suc_rec.htm.

The following presents a brief summary of habitat and spawning requirements for both Lost River and shortnose suckers and then presents a summary of the status of the suckers in the Lower Lost River. This information was abstracted from the most recent 5-year review documents (USFWS 2007a) and the USFWS Web sites that includes species fact sheets for Lost River and shortnose suckers:

- Lost River: http://www.fws.gov/oregonfwo/Species/Data/LostRiverSucker/
- Shortnose: http://www.fws.gov/oregonfwo/Species/Data/ShortnoseSucker/

Lost River Sucker

Lost River suckers were found in Upper Klamath Lake and tributaries, Lost River and Clear Lake, and in one or more Klamath River reservoirs below Keno Dam at the time of the original USFWS listing. A small, previously unreported Lost River sucker population has since been found in the Tule Lake Sumps.

Currently, most Lost River sucker habitat (80 percent) occurs in Upper Klamath Lake, with the remainder primarily in Clear Lake. Some Lost River suckers are found in the Upper Klamath Lake tributaries and in the Lost River, although those populations may not be self-sustaining. Habitat degradation is considered the primary cause of diminished adult populations; there is ongoing concern about lack of age-class diversity, although it is thought that the breeding population numbers have been relatively stable in the last decade. “Loss of streambank vegetation due to overgrazing, logging activities, agricultural practices, and road construction has also led to increases in stream temperatures, high levels of nutrients (which encourages the buildup of excess algae and bacteria), and serious erosion and sedimentation problems in streams” (USFWS 2008c). Significant habitat, approximately 150,000 acres of spawning and rearing habitat, was lost with the development of the Klamath Project and the draining of Tule Lake and Lower Klamath Lake.

Lost River suckers live in the deeper water of lakes, preferring emergent vegetation that can provide cover from predators and invertebrate food sources. They are a long-lived sucker that can live to more than 40 years of age. They grow rapidly in their first 5 or 6 years, reaching up to 1 meter long. Lost River suckers typically begin to reproduce at 9 years, when they first participate in spawning migration, and can spawn multiple times during their life. Most spawning occurs from late February to early May in upstream springs or tributaries along riffles or runs with gravel or cobble substrate and abundant aquatic vegetation. Some spawning occurs in lakes. Larvae emerge from late March to early June and immediately move downstream to the reservoirs toward shallow, near-shore vegetation in lake and river habitat.

Lost River suckers are relatively tolerant of water quality conditions that are unfavorable to other fishes, including higher pH, higher temperature and un-ionized ammonia concentrations. However, depleted dissolved oxygen in Upper Klamath Lake from large algae blooms and die-offs has caused documented fish die-offs and reduced reproductive capacity of the lake. The possibility of prolonged drought is also a concern (USFWS 2007a).

Shortnose Sucker

Similar to the Lost River suckers, the range of shortnose suckers is primarily Upper Klamath Lake and Clear Lake. Two previously unreported populations have been found in the Tule Lake sumps and they are now known to also occur in Gerber Reservoir (although there are current investigations to determine whether the populations in Gerber Reservoir and Clear Lake are genetically shortnose sucker). Population numbers of shortnose suckers are also thought to be in decline. A population consisting of a few hundred shortnose suckers in the Tule Lake sumps is isolated from upstream spawning sites by a series of dams, indicating that it is likely not self-sustaining (USFWS 2007b). Hybridization was also identified as a threat to the shortnose sucker when it was listed, and those concerns continue today. Some studies appear to indicate that hybridization could be occurring between shortnose suckers and Klamath largescale suckers (*Catostomus snyderi*) in Gerber Reservoir and Clear Lake and possibly in the Lost River.

Habitat loss was a major factor in the listing of the shortnose sucker. Historically, habitat loss and alteration were especially pronounced in the Tule Lake and Lower Klamath Lake areas, where approximately 150,000 acres, or over 75 percent of spawning and rearing habitat, were lost when the two lakes were drained. Shortnose suckers prefer shallow, turbid, and highly productive lakes that are cool, but not cold, in summer (15–25 degrees Celsius (ºC)), with dissolved oxygen above 4 milligrams per liter (mg/L) and moderate alkalinity.

Shortnose suckers also grow rapidly in their first 5 years and reach sexual maturity between their fourth and sixth years. Spawning occurs primarily from early April to early May in the gravel substrates in the larger tributaries, particularly where springs occur along the shorelines. A few shortnose suckers reportedly spawn along the Upper Klamath Lake shoreline. Like Lost River suckers, shortnose suckers can spawn multiple times during their lives. Larvae emerge from April to early June and move immediately downstream to lakes, preferring shallow, vegetated water in Upper Klamath Lake, and shallow, unvegetated areas in Clear Lake and Gerber Reservoir. Sucker larvae tend to occur at higher densities around emergent vegetation, which provides food and cover from predators. Juveniles use relatively shallow and unvegetated shoreline (1.2 meters), whereas adults prefer slightly greater depths (1.5 to 3.4 meters) (USFWS 2007b).

Lake suckers, similar to shortnose suckers, are relatively tolerant of water quality conditions that are unfavorable for many other fishes. They tolerate elevated pH, temperature, un-ionized ammonia concentrations, and lower dissolved oxygen; however they are still adversely affected by poor summer water quality in Upper Klamath Lake and the Lost River Basin. Poor water quality could also lead to mortality of young suckers and physiological impairment short of death, and loss of substantial portions of young age classes (e.g., due to massive die-off) is believed to limit recruitment (USFWS 2007b).

Low water levels and adverse water quality are also concerns. Sucker populations have been unstable, although considerable progress has been made on habitat restoration in Upper Klamath Lake, including fish passage improvements such as screening and fish ladders and fencing. Localized population increases have been observed in restored areas (USFWS 2007b).

Lost River Populations

Historically, both Lost River and shortnose suckers migrated from Tule Lake to spawn in the upper Lost River watershed, but these runs were cut off from spawning sites with the construction of the Klamath Project. Although the Lost River probably never supported a large population, historical spawning runs from Tule Lake were large. Both Modoc Indians and white settlers captured suckers during these migrations for consumption, livestock, food, oil and other uses. A small remnant population might still exist and sucker spawning has been documented in a small riffle below Anderson Rose Dam when releases or spillover occurs at the dam. USFWS and TID recently entered into an agreement to provide releases during the spawning season, but survival of eggs and larvae have been limited. Tule Lake populations are now just a remnant of historical levels. Recent limited spawning observations in Tule Lake suggest a small population exists there; however, this population probably numbers in the hundreds with very little recruitment and is likely not self-sustaining. There are no fish passage facilities at the dam, and there are numerous unscreened diversions around the Tule Lake Sumps (USFWS 2008e).

Tule Lake water quality varies seasonally and is dependent on inflow and sump conditions. During the irrigation season, the primary source of water to the Lost River is Upper Klamath Lake water that is delivered via the Lost River Diversion Channel and A Canal. During the summer, water quality is characterized by high temperatures and pH, low dissolved oxygen levels, elevated un-ionized ammonia and nutrient concentrations, and filamentous green algae growth. During the winter, most inflow to Tule Lake is from localized runoff below Wilson Reservoir. Water quality conditions during the winter are often relatively good, except during periods of prolonged ice cover, which causes dissolved oxygen levels to decline (USFWS 2008e).

The long-term survival of suckers in Tule Lake is considered unlikely because of the lack of adult rearing habitat at depths greater than 3 feet and a lack of flows and spawning habitat. The Tule Lake population of Lost River suckers could be crucial to recovery of that species because it represents one of only three Lost River sucker populations. Spreading the risk of extirpation among three populations rather than two could significantly decrease the threat of extinction risk to the species. Tule Lake has been proposed as Critical Habitat for the Lost River and shortnose sucker, and the USFWS has also identified two Reasonable and Prudent Measures: minimize take of Lost River and shortnose suckers, as a result of (1) entrainment by project facilities and (2) reduced in-stream flows below Anderson Rose Dam (USFWS 2008e).

2.2 DISCUSSION OF WATER QUALITY STANDARD VIOLATIONS

This section presents a discussion of observed water quality standard impairments for the Lower Lost River to provide a more comprehensive analysis of existing conditions. Figure 2-2 and the following text provide a brief overview of how to read box-plots. Box plots are used to illustrate the distribution of samples through time or space. The box shows the median, the 25th percentile, and 75th percentile. In example 1 (top of Figure 2-2), the top of the box is the 75th percentile; 75 percent of the sample values are lower than the line corresponding to a value of 15. The bottom of the box represents the 25th percentile and shows that 25 percent of the values are lower than 5. By definition, the median is the 50th percentile, with 50 percent of values lower and 50 percent of values higher than 10. In the box plot figures that follow, the numbers given below each box plot are the sample sizes (number of sample values used in developing the plot).

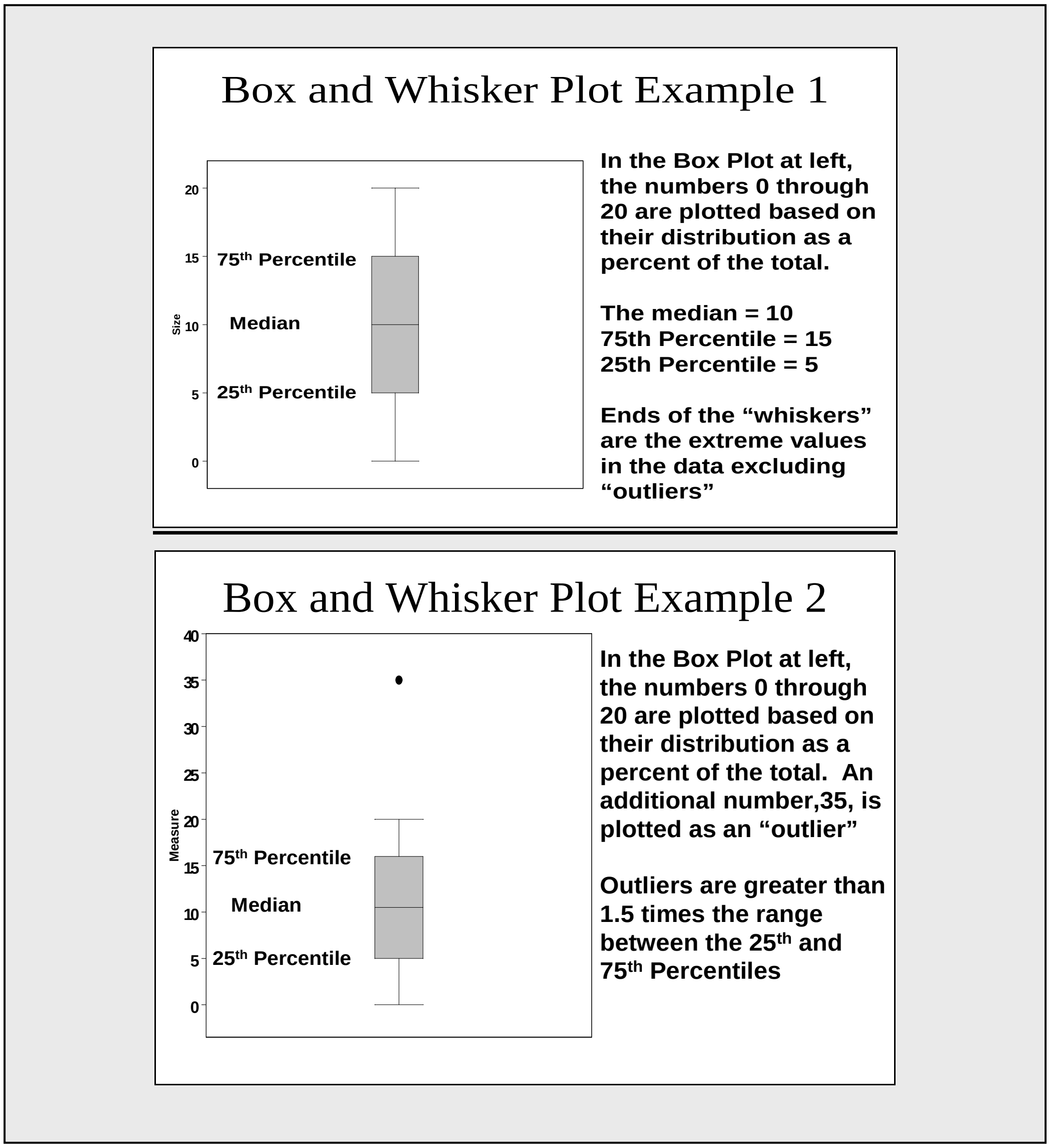


Figure 2-2. Reading box plots.

2.2.1 Irrigation and Other Agricultural Practices

Relationships between agricultural practices and surface water quality in the TID were studied by Danosky and Kaffka (2002), over a 2-year period, and focused on nitrogen and phosphorus concentration and mass transfers. This study found "irrigation and other agricultural practices in the… Klamath Project may result in impaired surface water quality, reducing its use for wildlife and fish in important national wildlife refuges that receive drainage water from farms, and in the Klamath River."

Among other findings, nutrient content in surface water increased nearly threefold moving through the watershed from the Lost River at Anderson Rose Dam and the J Canal diversion, through the refuges and out through the Klamath Straits Drain. Figure 2-3 shows total nitrogen values to be lower in the upstream locations (see 14—J Canal; 19—Lost River at Stateline, and 32—Ady Canal) than in downstream locations (see 18—D-Pump, 21—Lower Klamath Refuge at Stateline Highway, 33—Klamath Straits Drain at County line Road, and 20—Klamath Straits Drain at Highway 97). Similarly, as shown in Figure 2-4, tile drains in the northern portion of the TID and closer to supply canals (see locations 2, 5, and 6 north of Tule Lake Refuge) had values similar to those measured in surface waters and significantly lower than values measured in tile drains farther from input canals (e.g., locations 23, 24, 25, 28). Table 2-2 presents location descriptions for each of the numeric locations identified on the X axis of Figures 2-3 and 2-4.

Table 2-2. Surface water and subsurface tile drains location descriptions

Surface water (Figure 2-3)	
Location	**Location description**
14	J Canal
19	Lost River at Stateline south of Anderson-Rose Dam
18	D-Pump at Sheepy Ridge
21	Lower Klamath Refuge at Stateline highway
33	Klamath Straits Drain at County line Road (Oregon)
20	and Klamath Straits Drain at Highway 97 (Oregon)
32	Ady Canal
Subsurface tile drains (Figure 2-4)	
Location	**Location description**
1 and 37	West side of Tule Lake, sub surface tile line – sump type
2, 5, and 6	North and east of Tule Lake Refuge, sub surface tile line – sump type
22	Northeast corner of Tule Lake Refuge near N Canal, sub surface tile drain – sump type
23, 24, and 28	Lease lands in Tule Lake Refuge east of sump 1A, subsurface tile line
25 and 27	Lease lands in Tule Lake Refuge south of sump 1A, subsurface tile line

Overall, the tile drain samples from Tule Lake Refuge Lease Lands contained higher levels of nutrients than those found in ditches, which were similar to most surface water samples from the Lost River or Tule Sump. However, surface waters were not affected by tile drain contributions, as tile drains reportedly do not discharge directly to the Tule sumps. "The differences in water quality between tiles and drainage ditches suggest that the ditches and water management infrastructure itself has a role in regulating nutrient transfers and can contribute nutrients (especially TP) to the system: from internal hydrologic cycles present in the ditches and canals, from agitation of sediments, from the death and decay of aquatic plants, from N fixation by blue green algae, and from N fixation of sediments due to pumping and transfer of water" (Danosky and Kaffka 2002).

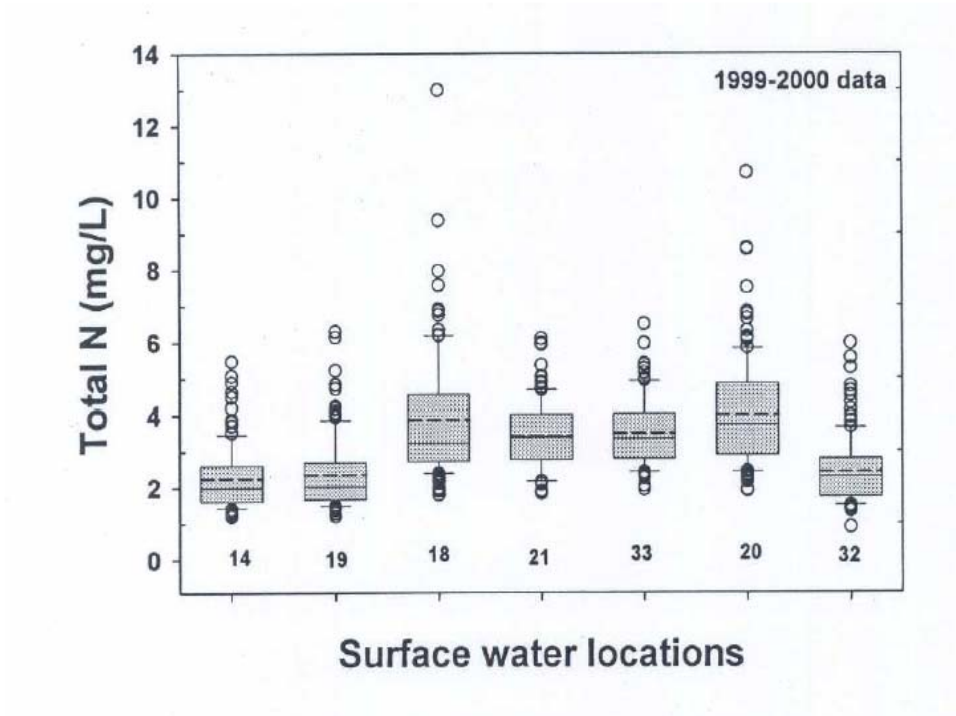


Figure 2-3. Box plots for total nitrogen for surface water locations (Source: Danosky and Kaffka 2002).

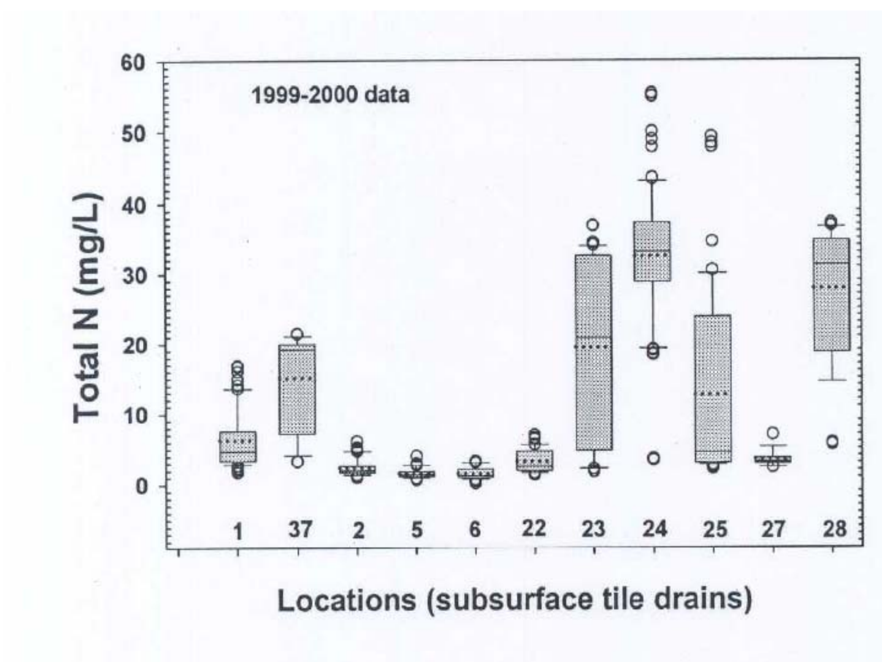


Figure 2-4. Box plots for total nitrogen in subsurface agricultural tile drains (Source: Danosky and Kaffka 2002).

2.2.2 Longitudinal Variations in Water Quality

Using available data results from 1995 to 2004 for summer months (July, August and September), longitudinal plots were generated for several parameters.

Overall, the Lost River, from Malone Dam to the outlet at Klamath Straits Drain, is impaired for low dissolved oxygen. Figure 2-5 shows a general degradation of conditions in the downstream direction compared to the applicable Oregon criteria and California objectives. (Note that the dissolved oxygen criteria in Oregon vary seasonally and are higher than California's objectives in some months and lower in others.[9]) The segment of the graph labeled *Tule and L. Klamath Lake* shows that California's dissolved oxygen objectives for the Lost River are violated. In the left box plot of the two in this segment, the lower half of the box-plot—and thus, nearly half the sample values—fall below the dissolved oxygen objective (minimum value of 5.0 mg/L). For the box plot on the right, only a small number of samples (the lower *whisker)* fall below the objective. The box-plots for the next downstream segment, Klamath Straits Drain, also show nearly half the sample values falling below the dissolved oxygen standard.

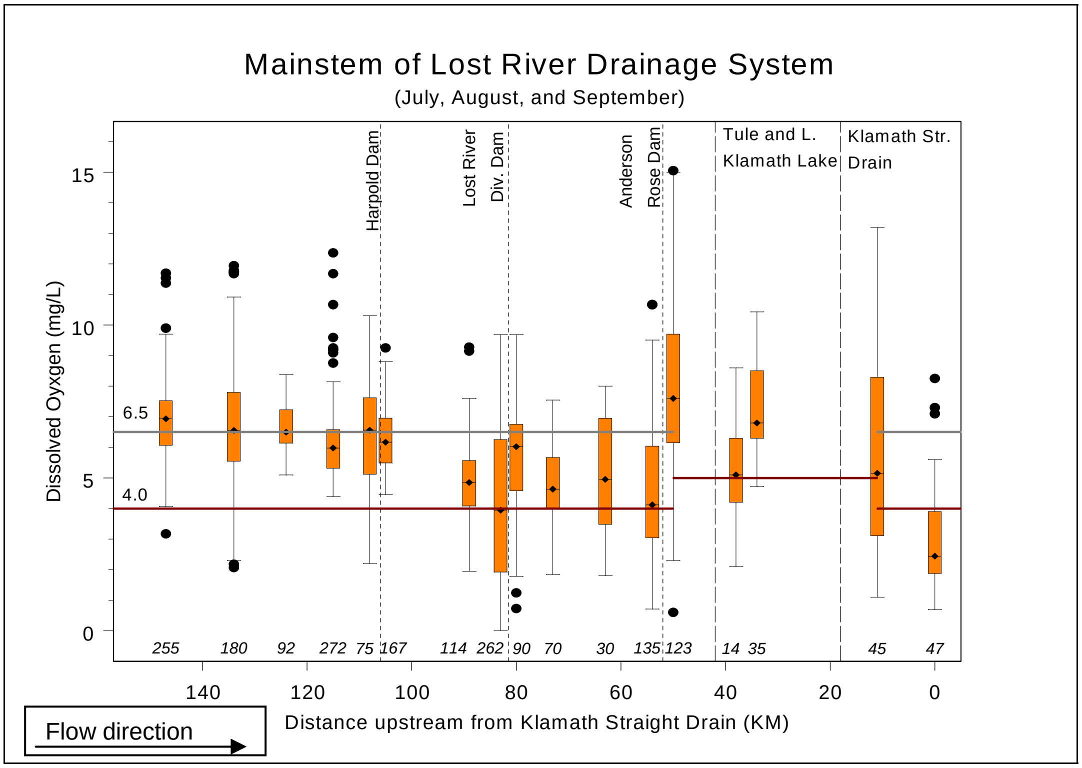


Figure 2-5. Longitudinal variation of the dissolved oxygen concentrations during summer months. (Applicable standards in Oregon and California are denoted by the horizontal bars).

[9] More information concerning Oregon water quality standards is at: http://www.deq.state.or.us/WQ/standards/wqstdshome.htm.

Impairments to pH appear to be limited to downstream of Anderson Rose Dam (Figure 2-6). Values in the Tule Lake Refuge consistently exceed the maximum numeric objective (pH < 9), and a significant number of values in the upstream Klamath Straits Drain box plot also show exceedences of the maximum numeric objective.

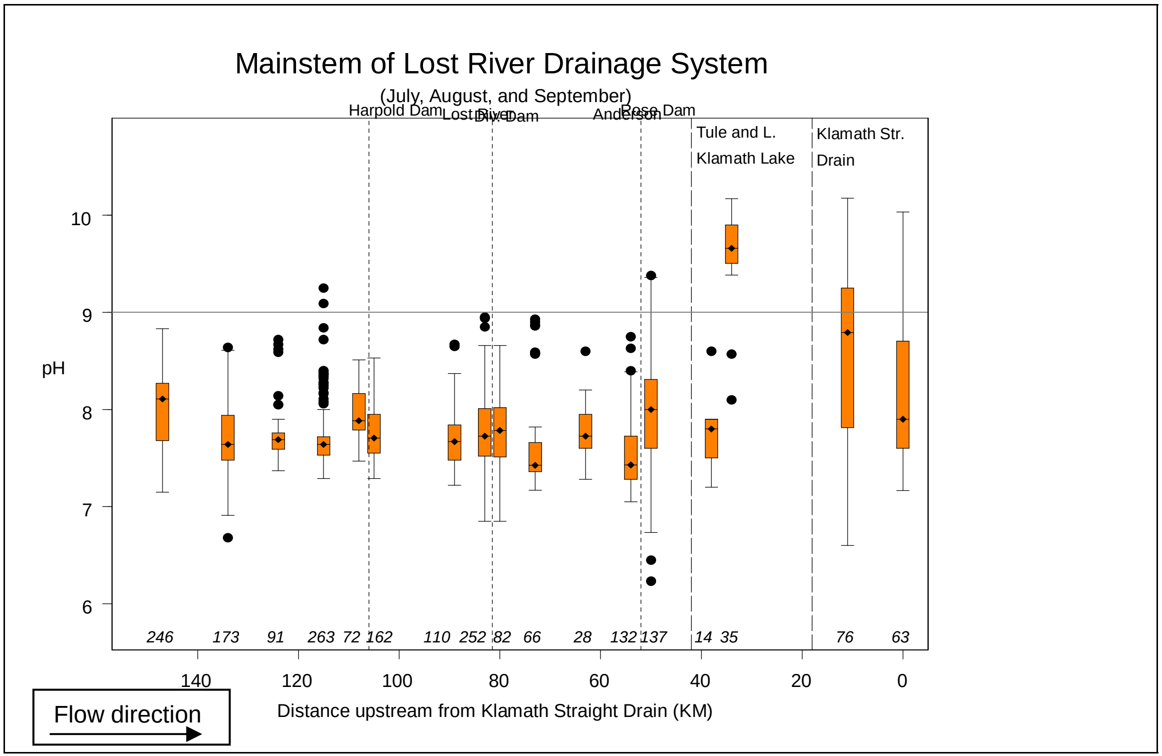
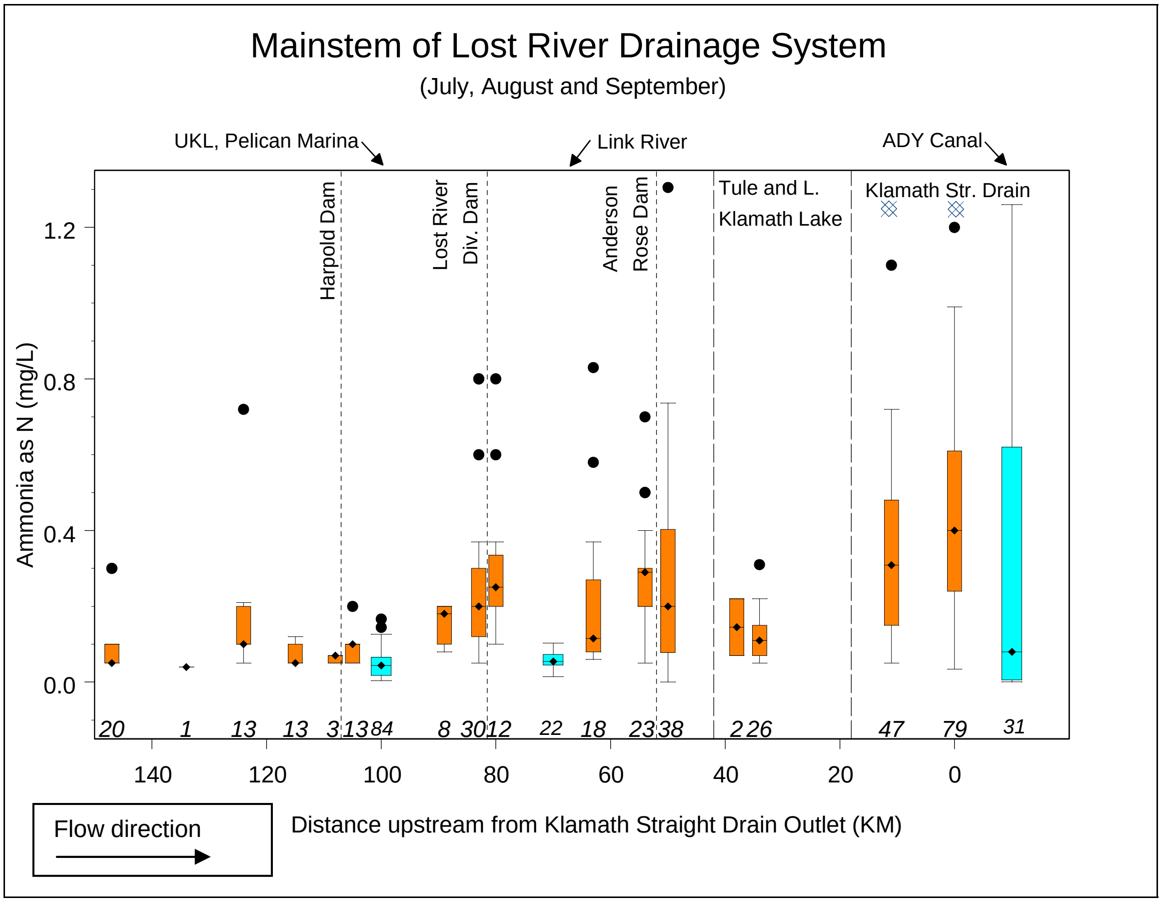


Figure 2-6. Longitudinal variation of pH during the critical summer months. (The applicable standard is denoted by the horizontal line.)

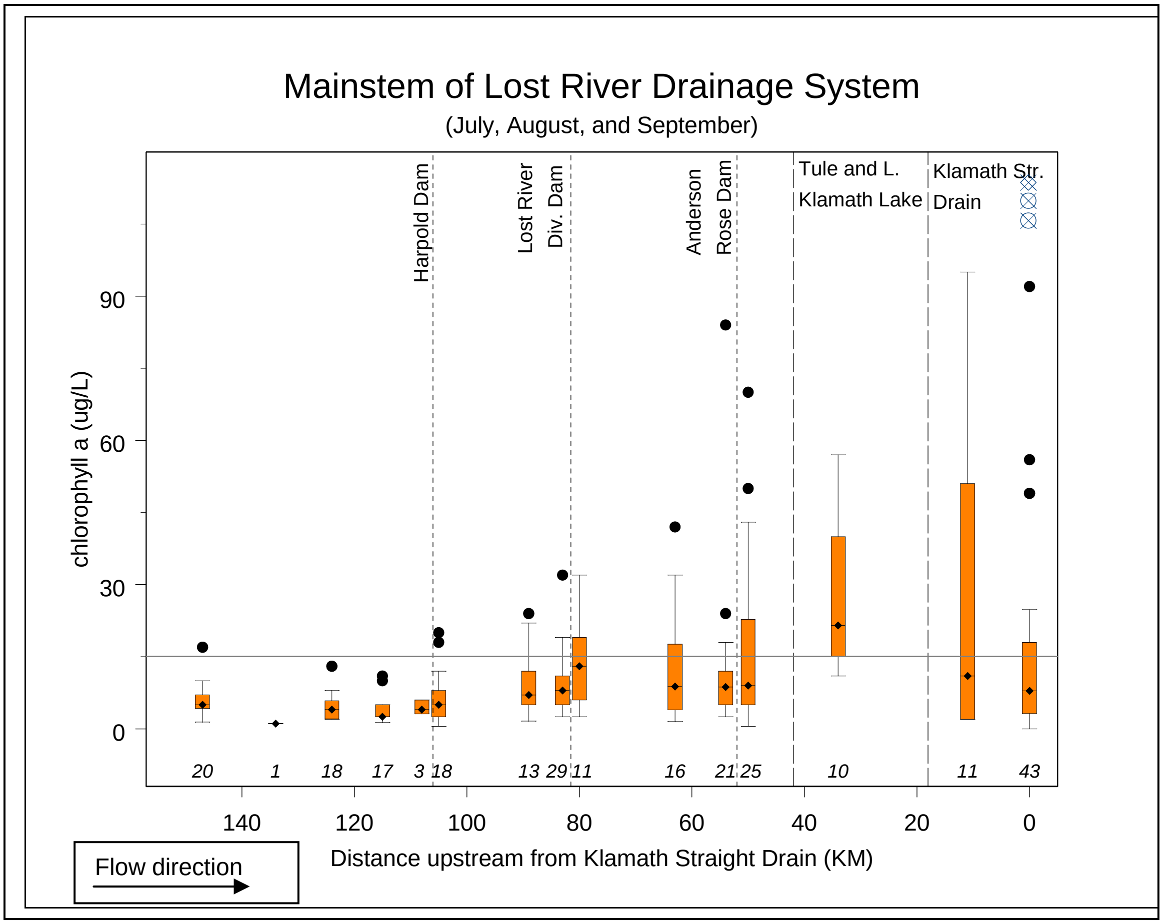
Ammonia (NH_3) concentrations show a moderate increasing trend in the downstream direction (Figure 2-7). No violations of California's narrative water quality objective that addresses water column toxicity were observed, and there is no current evidence of ammonia-caused violations in California. However, values for Klamath Straits Drain and Ady Canal (shown in blue) were notably higher and exceed applicable Oregon water quality criteria.



(Box-plots for other waterbodies are shown in blue and are identified at the top. Blue diamond with an X indicates that there are values, not plotted, that were greater than the Y-axis range.)

Figure 2-7. Longitudinal variation of ammonia during the critical summer months.

Trends for chlorophyll *a* levels show a clear and steady increase in the Lost River in the downstream direction (Figure 2-8). Downstream of Anderson Rose Dam, a significant number of samples were above the Oregon nuisance level of 15 migrograms per liter (µg/L), with Tule Lake Refuge and Klamath Straits Drain showing the highest levels.

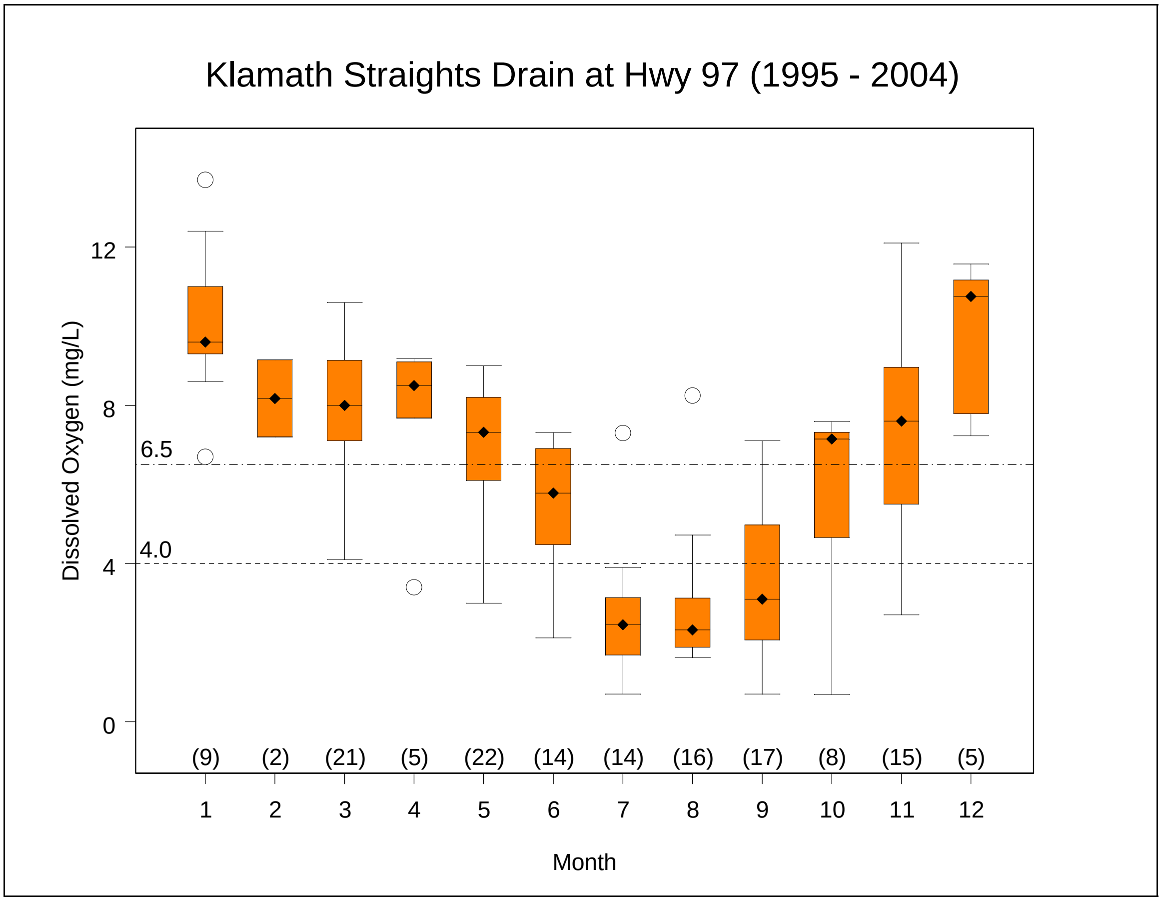


The Oregon nuisance level (15 µg/L) is shown for comparison. Blue diamonds at the top indicate values, not plotted, that exceed the Y-axis range.

Figure 2-8. Longitudinal trends for Chlorophyll *a* during the critical summer months.

2.3 ANNUAL VARIATIONS AND CRITICAL CONDITIONS

Critical levels of dissolved oxygen and pH occur predominantly during the summer: from June through September. Consequently, the critical period for this TMDL analysis is the 122-day period from June 1st to September 30th. Klamath Straits Drain, one of the most impacted and regularly sampled monitoring locations, was chosen to show the seasonal variation of dissolved oxygen levels (Figure 2-9). July and August appear to be the most impaired months for dissolved oxygen, but minimum values have been measured that are lower than the criteria from May to November. Exceedances of the dissolved oxygen criteria are more frequent between June and September. Similarly (but not shown), exceedances above the pH criteria occurred in June. The summer period holds the highest potential for excessive aquatic plant and algae growth because nutrient and BOD loads are relatively high, air and water temperatures are high, and more sunlight is available during the long daylight hours to stimulate plant and algae growth. However, nutrients and organic material discharged during the winter and spring can remain in the system for several months; thus, it is important to include data on nitrogen and BOD loads throughout the year.



The horizontal lines denote the upper and lower range of Oregon's applicable dissolved oxygen standards.

Figure 2-9. Seasonal excursion frequencies below water quality standards for dissolved oxygen, Klamath Straits Drain at Highway 97.

CHAPTER 3: NUMERIC TARGETS

3.1 NUMERIC TARGETS

Numeric targets are established for water quality indicators on the basis of applicable water quality standards. These targets represent the goals of the TMDL and provide a basis for evaluating the future effectiveness (e.g., via monitoring) of DIN and CBOD reductions in achieving water quality standards.

As described in Chapter 2, these TMDLs are being developed to address violations of California's applicable numeric water quality objectives for dissolved oxygen and pH and for narrative nutrient standards. The Basin Plan specifies numeric objectives for both dissolved oxygen and pH; thus, these numeric objectives are used as the numeric targets for the TMDL analysis. These targets are applicable for the entire Lost River system in California, including the following:

- Lost River from the Oregon border to Tule Lake Refuge,
- Tule Lake Refuge,
- Lower Klamath Refuge, and
- Klamath Straits Drain from Lower Klamath Refuge to the Oregon border.

The numeric targets are specified in Table 3-1.

Table 3-1. Numeric targets

Indicator	Numeric target value
Dissolved oxygen	Greater than or equal to 5.0 mg/L (daily minimum)
pH	No higher than 9.0 as daily maximum or lower than 7.0 as a daily minimum

Low dissolved oxygen and elevated pH conditions are associated with excessive loads of DIN and CBOD to the Lost River system. The TMDL modeling analysis was designed to identify the DIN and CBOD reductions needed to attain the dissolved oxygen and pH standards. While it would be desirable to specify maximum DIN and CBOD targets to supplement the dissolved oxygen and pH targets, it was infeasible to do so for these TMDLs because there is substantial spatial and temporal variability in how nitrogen and organic matter loads affect oxygen and pH levels. Chapter 5 presents plots of the modeled annual variability of these parameters for selected locations.

3.2 OVERVIEW OF NUTRIENT AND ORGANIC MATTER PROCESSES

Biological processes associated with cycling of excessive nitrogen and organic material loads (and associated growth of aquatic plants) are responsible for short-term (e.g., diel) swings in dissolved oxygen and pH levels that can cause violations of applicable dissolved oxygen and pH water quality standards.

Dissolved oxygen in waterbodies can fall below healthy levels for a number of reasons including CBOD in the water column, nitrogenous biochemical oxygen demand (NBOD, also known as nitrification), algal respiration, zooplankton respiration, and sediment oxygen demand (SOD). Dissolved oxygen in the water column can also be reduced by high water temperatures, which decrease oxygen solubility and increase rates of nitrification and organic matter decay.

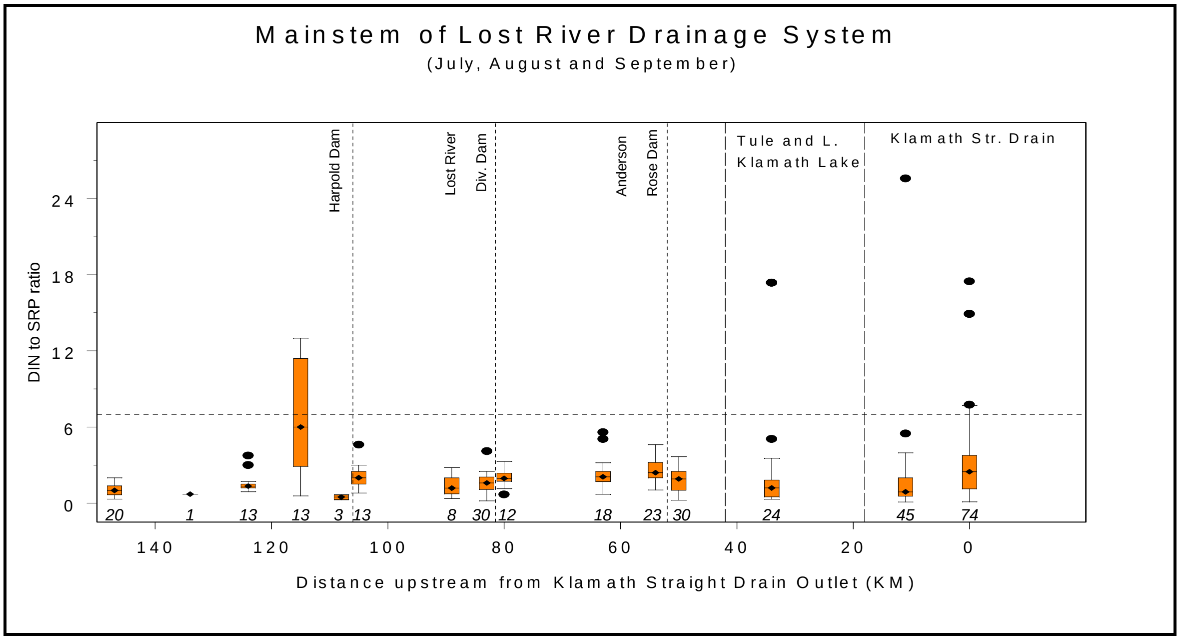
3.2.1 Nutrients

There are a number of natural processes that can increase nutrient loads to a river: leaching from the soil, degradation of plant material, and fish defecation and carcass decay. Elevated loads of nutrients promote the growth of plants and algae; preferred nutrient forms are inorganic phosphorus (measured as dissolved orthophosphate as P or soluble reactive phosphorus) and inorganic nitrogen (composed of ammonia, nitrite, and nitrate).

As plants and algae grow, they consume phosphorus and nitrogen. As algae die off, nutrients are released back into the river. Algae consume nitrogen and phosphorus at a fixed ratio. Therefore, if either nutrient is in short supply, it will often limit the growth of algae regardless of the concentration of the other nutrient. The growth of attached algae and phytoplankton (free-floating algae) can also be limited by light, temperature, and the availability of suitable substrate.

High consumption of oxygen by algae and plants can have several effects. At nighttime, algal biomass can consume high levels of oxygen, causing or contributing to nocturnal sags in dissolved oxygen levels. Similarly, bacteria can consume high levels of oxygen as excess plant material decays. The reduced levels of oxygen remaining in the water can cause chronic problems (e.g., stress, reduced growth, and reduced fecundity) for aquatic organisms, and in severe circumstances, death.

For these TMDLs, available data was used to analyze N:P. Ratios around 7 to 10 are generally considered optimal for plant growth. Ratios generated using Lost River DIN and soluble reactive phosphorus (SRP) data were found to consistently be well below 7, indicating that nitrogen is the nutrient most limiting growth in the Lost River (Figure 3-1). Modeling analyses found that moderate reductions in nitrogen loads were effective in reducing excess algal growth and maintaining acceptable dissolved oxygen levels. In contrast, modeled reductions in phosphorus loads had little, if any, effect on plant and algal growth rates; therefore, these TMDLs to address dissolved oxygen deficits focus on reducing nitrogen sources. (When extremely high reductions to phosphorus are evaluated, there is some effect on growth rates; however, the system is much more sensitive to nitrogen concentrations.) If TMDL implementation is successful and nitrogen concentrations are reduced, phosphorus could become a limiting, or co-limiting, factor in the future.



The horizontal line represents a ratio of 7. Points above this line indicate possible phosphorus limitation, whereas points below this line indicate possible nitrogen limitation.

Figure 3-1. Longitudinal plot of the ratio of DIN to SRP.

The movement of nitrogen between the atmosphere, soil, water, and organisms is a process called the nitrogen cycle (Figure 3-2). In waterbodies, nitrogen is found in several compounds including ammonia (NH_3), nitrate (NO_3), and nitrite (NO_2), as well as in carbon-containing molecules. Nitrogen-containing compounds are needed as part of a healthy aquatic food web, but excessive nitrogen inputs to a waterbody can increase plant and algae growth to unhealthy levels.

The major sources of nitrogen contributions (loads) to waters in the Lost River watershed include agricultural return flows and runoff, municipal wastewater, failing septic systems, animal waste runoff, and watershed runoff. Internal contributions of nitrogen can be from bed sediments, wildlife and waterfowl waste, and nitrogen fixation. Routes of nitrogen input to the Lost River include tributaries, canals, drains, shallow and deep groundwater discharges, and atmospheric deposition of organic matter. Nitrogen loading quantified by input source is presented in Chapter 4.

High nutrient and organic matter loadings in the Lost River system promote the production of aquatic plants and algae (macrophytes, epiphyton, periphyton, and phytoplankton), resulting in violations of numeric water quality objectives for dissolved oxygen and pH, and narrative nutrient objectives. During the growing season, the growth of aquatic plants and algae in the Lost River appears to be limited by the available nitrogen. BOD, in the water column and sediment, also contributes to the dissolved oxygen limitation. High nitrogen and BOD loads come principally from water diversions into the Lost River system, agricultural return flows, and cycling of nutrients and organic matter from waterbody bottom sediments.

The nitrogen cycle consists of five major transformations of nitrogen and nitrogen-containing compounds: mineralization, nitrification, immobilization, denitrification, and nitrogen fixation (Table 3-2). Two of these processes are important when considering excess nitrogen, namely nitrification and denitrification (Novotny and Olem 1994). Nitrogen fixation—the conversion of atmospheric nitrogen gas to ammonia (NH_3) and then to organic forms usable by plants—can occur by two main processes: lightning and biological fixation. As described in Chapter 1, nitrogen-fixing phytoplankton was not identified as one of the dominant aquatic plant species present in the river in California. While AFA was identified in samples collected in the Lost River at East-West Road (north of Tule Lake Refuge), and might have localized impacts, available data do not suggest that nitrogen fixation by AFA is a dominant factor in the Lower Lost River.

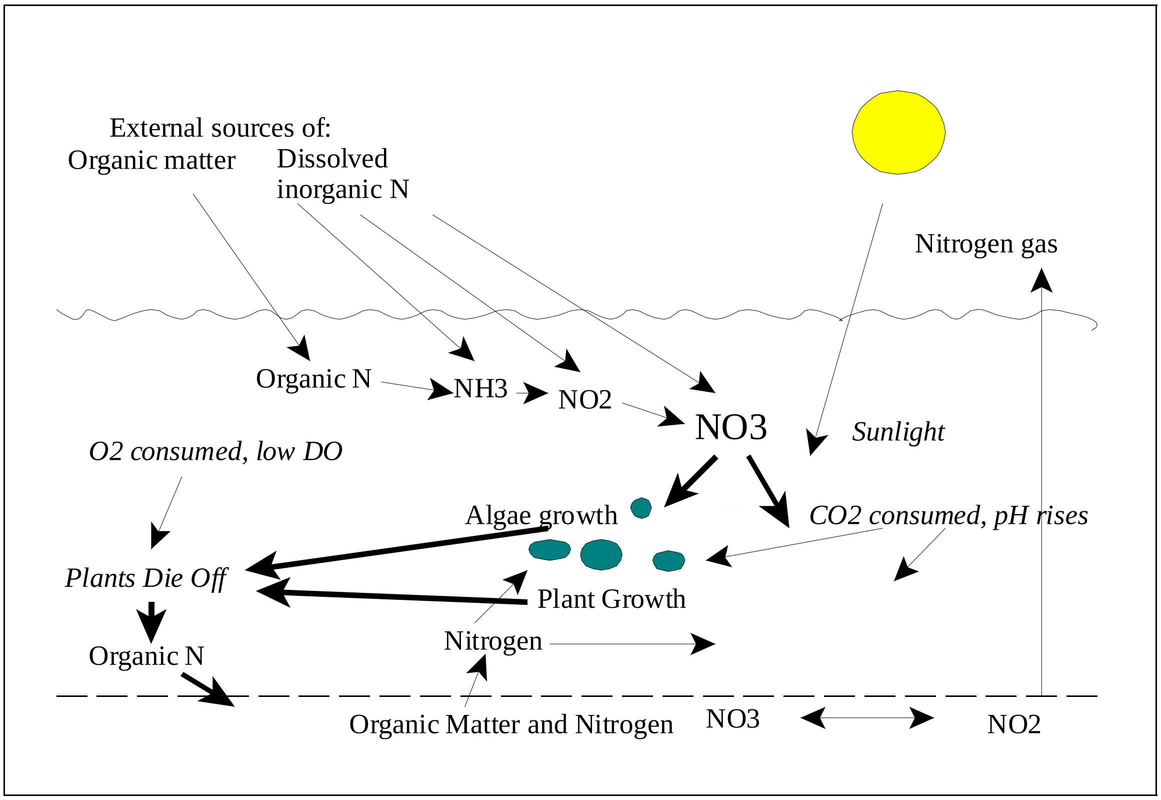


Figure 3-2. The nitrogen and BOD cycle in the Lost River.

Table 3-2. Nitrogen cycle processes

Reaction	Summary	Formula	Environment	Biological mediator
Mineralization	Bacteria convert organic nitrogen (e.g., plant and animal waste) into ammonia	organic N ↔ NH_3, NH_4	Anaerobic and Aerobic	Bacteria
Nitrification	Nitrifying bacteria convert ammonia to nitrites (NO_2^-), and other bacteria convert the nitrites into nitrates (NO_3^-).	$NH_4 \leftrightarrow NO_2^- \leftrightarrow NO_3^-$	Aerobic	Bacteria
Immobilization	Plants and bacteria use ammonia and nitrates to make organic nitrogen	NO_3^-, NH_4^- ↔ organic N	Aerobic	Plants, bacteria
Denitrification	Bacteria convert nitrates to nitrogen gases (NO, N_2O, N_2)	$NO_3^- \leftrightarrow NO_2^- \leftrightarrow N_2$	Anaerobic	Bacteria
Fixation	Bacteria convert gaseous nitrogen into forms usable by living organisms	N_2 ↔ organic N	Aerobic	Bacteria

Denitrification is the process whereby certain species of facultative and anaerobic organisms reduce nitrate and nitrite to molecular nitrogen or nitrogen oxides. Denitrifying bacteria occur in wetlands and poorly drained soils; under these anaerobic conditions, nitrates are subject to high rates of denitrification.

Mineralization is the conversion of organic nitrogen to ammonia.

The process called nitrification is the biological oxidation of ammonium (NH_4^+) to nitrite (NO_2^-) and then to nitrate (NO_3^-). Ammonium and nitrite exist in soils but are unstable molecules that readily accept oxygen, leaving nitrate as the dominant form of nitrogen in aerated soils. Soil nitrate remains soluble in aqueous solutions and available for plant root update. Consequently, nitrate is the most important form of nitrogen for agricultural purposes. However, because nitrate is readily water soluble, it is subject to high rates of leaching out of the soil and into groundwater and streams.

Available data indicate that a significant amount of nitrogen in the Lost River system is in particulate (organic) form. Mineralization and nitrification processes decompose it to release dissolved inorganic nitrogen. DIN, composed of nitrate, nitrite, and ammonia, is the form of nitrogen most bioavailable to aquatic plants and algae. These TMDLs focus on controlling dissolved inorganic nitrogen. Although particulate forms of nitrogen and phosphorous are believed to be less important influences on growth of aquatic plants, these TMDLs indirectly account for particulate nutrients by also targeting excess loads of organic materials that could contain particulate nutrients.

3.2.2 Biochemical Oxygen Demand

When organic material is discharged into a waterbody, bacteria in the water work to break 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 that is exerted by the organic material. Water quality analyses of the Lost River system indicate that CBOD is a major cause of dissolved oxygen depletion.

Similarly, when solids that contain organic matter settle to the bottom of a stream, they may decompose anaerobically (with no oxygen present), or aerobically (in the presence of oxygen), depending on conditions. The oxygen consumed in aerobic decomposition of these sediments, the SOD, represents a loss of dissolved oxygen for a stream. SOD is an important cause of decreased oxygen levels in water, particularly in impoundments where water velocities are low. The SOD can continue to reduce dissolved oxygen for a long period of time after the pollution discharge ceases. For example, organic-containing sediment deposited as a result of rain-driven runoff may remain a problem long after the rain event has passed. In contrast, CBOD and nitrification processes are typically short term.

External sources of organic sediments, that is, sources of organic matter (OM) from the Lost River watershed but from non-aquatic sources, include runoff and return flows from farms, rangeland, forest, urban lands and wastewater treatment plant upsets. Internal sources include dead and dying aquatic plants and algae that have settled, wetland decomposition products, and waterfowl excretion. Additionally, organic matter enters the Lost River watershed from upstream sources including particulate organic carbon in water diversions from Upper Klamath Lake and the Klamath River, and from AFA production that occurs in the Oregon portion of the Lost River watershed. AFA production has been noted at various locations in the Lost River watershed including Gerber, Harpold, and Anderson Rose reservoirs. AFA was identified as the dominant algal taxa at Wilson Reservoir in Oregon, as well as at East-West Road in California (Eilers 2005).

It is not feasible to precisely quantify the organic sediment sources for this project given the complexity of the Lost River and limitations in some loading data. Control of the sources that deliver nitrogen and CBOD to the Lost River will also reduce the loading of settleable organics that cause SOD. The TMDL modeling analysis indicates that actions taken to reduce CBOD and nitrogen loading will sufficiently reduce loads of settleable organic materials such that all applicable water quality standards can be attained.

In summary, as described earlier in this chapter, low dissolved oxygen and elevated pH conditions are associated with excessive loads of DIN and CBOD to the Lost River system. The TMDL modeling analysis was designed to identify the DIN and CBOD reductions needed to attain the dissolved oxygen and pH standards.

CHAPTER 4: SOURCE ANALYSIS

4.1 OVERVIEW OF SOURCE ANALYSIS

As described in Chapter 1, the Lost River was partitioned into segments for modeling purposes; the California portion of the Lower Lost River includes five modeling segments (see Figure 1-10). One of the modeling segments, the P Canal connecting Tule Lake Refuge to Lower Klamath Refuge, was not retained as a segment for loading analysis, because it represents a tunnel through Sheepy Ridge, and inputs and losses are not known to occur. For purposes of presenting loading estimates and the associated TMDLs and allocations, the remaining four divisions are used (Figure 4-1), and are as follows:

- Segment 1 - Lower Lost River from the Oregon Border to Tule Lake Refuge,
- Segment 2 - Tule Lake Refuge (including the sumps and leased lands),
- Segment 3 - Lower Klamath Refuge, and
- Segment 4 - Klamath Straits Drain from Stateline Highway to the Oregon Border (still within the boundary of the Lower Klamath Refuge).

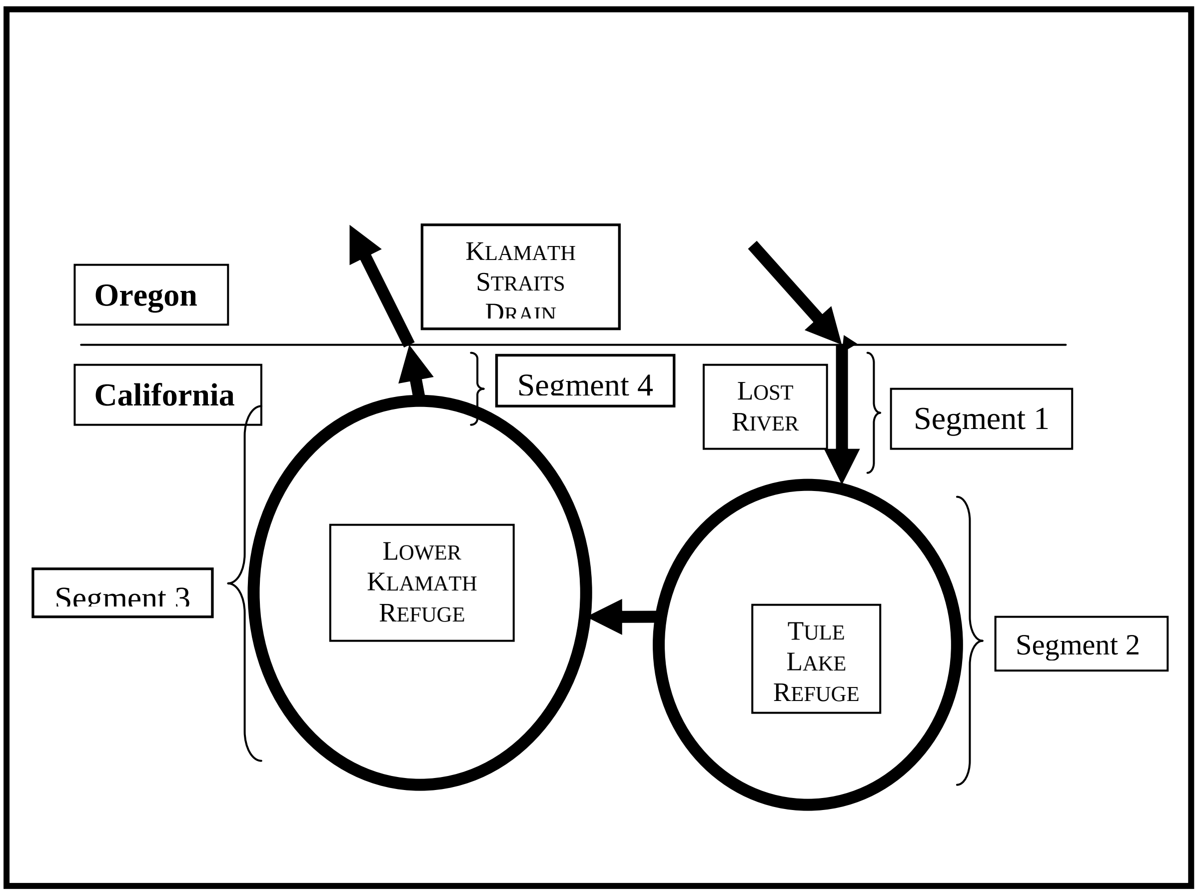


Figure 4-1. Lost River TMDL segments.

Estimates of nitrogen (as DIN) and organic matter (expressed as oxygen demand, or CBOD) loads were developed for discrete sources in the Lower Lost River system in California; Chapter 6 identifies the load reductions (in the form of load and wasteload allocations) for these sources. Loading sources and the methods used to estimate loads are discussed below. Table 4-1 presents the loading estimates for each segment.

These load estimates were based on modeling results and analysis of water quality data that examined DIN and CBOD levels in the Lower Lost River in California. The TMDL analysis focused on 1999 as the *baseline* year, which represented the most extensive of the available data sets and also was a year in which water quality impairment was particularly pronounced. The analytical basis for these estimates—that is, the use of the model for establishing allocations—is summarized in Chapter 1, discussed in more detail in Chapter 5, and presented fully in Appendix A.

Upstream inputs (i.e., inputs representing loads transferred from the upstream modeling segment) are identified for each segment. These *upstream inputs* for each segment are generally equivalent to the sum of the loads for the prior segment. However, between segments 2 and 3, only a portion of the waters in Tule Lake Refuge (segment 2) are pumped to Lower Klamath Refuge (segment 3). Thus, the load being conveyed to segment 3 represents only a portion of total load in segment 2 (Tule Lake). Additionally within each segment, in the refuges particularly, there are biological processes (including losses) that affect DIN and CBOD levels (e.g., settling processes in Tule Lake and Lower Klamath Lake) that modify downstream load contributions. As a result, the upstream loads identified for segments 3 and 4 are not equal to the total load for the prior segment.

The largest loads in each segment are from anthropogenic sources (excluding the upstream inputs). These anthropogenic loads are dominated by agricultural and refuge drainage loads, with one exception; in segment 3 (Lower Klamath Refuge) tributary inputs from the Ady Canal are nearly equivalent to the agricultural/refuge drainage loads.

Additional sources of nitrogen and organic matter in the Lost River system include internal loading from bed sediments and waterfowl and wildlife excrement inputs. Internal loading from bed sediment is explicitly included in the model. Waterfowl and wildlife excrement loading is inherently considered in each modeled segment in the depiction of water quality boundary conditions assigned. Because these sources are largely uncontrollable, specific loads for waterfowl and wildlife inputs are not identified, and neither sediment nor waterfowl/wildlife load allocations are developed in Chapter 6 to identify specific reductions for these sources. However, while waterfowl and wildlife sources are not addressed separately, the allocations still include those sources.

Table 4-1. Nitrogen and CBOD loading estimates (based on 1999 data)

Segment	Source	DIN loads (metric tons/yr)	C-BOD loads (metric tons/yr)
1 Lost River	Lost River at Stateline Road (OR Border)	55.5	108.5
	Agricultural drainage loads to Lost River between Stateline Road and Tule Lake Refuge	2.3	34.9
	CalTrans Roads and Facilities to Lost River between Stateline Road and Tule Lake Refuge	0.1	0.2
2 Tule Lake Refuge	Upstream load from Lost River	57.9	143.6
	Agricultural and refuge drainage loads to Tule Lake Refuge	72.3	506.6
	CalTrans Roads and Facilities to Tule Lake Refuge	0.1	0.2
	City of Tulelake Treatment Plant	2.0	7.0
3 Lower Klamath Refuge	Upstream load from Tule Lake Refuge[a]	38.8	491.8
	Agricultural and refuge drainage loads to Lower Klamath Refuge	7.8	78.7
	Load from Ady Canal to Lower Klamath Refuge	8.8	78.7
	CalTrans Roads and Facilities to Lower Klamath Refuge	0.1	0.2
4 Klamath Straits Drain from Stateline Road to OR Border	Upstream load from Lower Klamath Refuge[b]	40.3	386.5
	Agricultural drainage loads to Klamath Straits Drain	3.0	21.0

[a]Upstream Load from Tule Lake Refuge—only a portion of the waters from Tule Lake Refuge are pumped to Lower Klamath Refuge. Additionally, the model assumes that Tule Lake Refuge is a single mixed segment; to avoid transferring uncertainties associated with the coarse spatial resolution to the next downstream segment, monitoring data collected at the D Pumping Plant intake was used as upstream inputs for the next segment.
[b]Because the model assumes that Lower Klamath Refuge is a single mixed segment, water quality inputs to the next segment were based on monitoring data collected at Klamath Straits Drain at Stateline Highway.

4.2 DESCRIPTION OF SOURCE CATEGORIES

In this section, sources of the pollutant loads are identified, generally as locations in the applicable segment. The responsible entity is presented below, where there is sufficiently detailed information to identify the source; however, this identification is preliminary and informational only and should be confirmed as part of the implementation process.

The California portion of the Lower Lost River includes input sources from Oregon (e.g., Lost River and Ady Canal). As described in Chapter 1, Oregon is developing TMDLs for DIN and CBOD for the Lost River in Oregon, which will include the Ady Canal, and is expected to release a public review draft in 2009. Through the Oregon TMDL process, allowable loads from individual pollutant loading sources in Oregon will be identified through the allocation process.

Additional information on the analytical basis for these estimates is in Appendix A and Tetra Tech (2006), both available at EPA's Web site for the Lost River TMDLs: http://www.epa.gov/region09/water/tmdl/progress.html.

Upstream Loads at Oregon/California Border (Segment 1)

ODEQ has identified the Lost River in Oregon on its CWA section 303(d) list as failing to meet certain Oregon water quality standards. Accordingly, ODEQ intends to issue, in 2009, and implement TMDLs for DIN and CBOD for the Lost River in the state of Oregon. These Oregon-issued TMDLs will be based on Oregon's water quality standards. Because these TMDLs (and their anticipated load allocations and wasteload allocations) are being developed by Oregon as part of a comprehensive multistate analysis of pollutant loadings to the entire Lost River, they are also being designed to meet California water quality standards at the Oregon/California border. It is appropriate for EPA to account for these anticipated upstream load reductions in Oregon when developing the TMDLs for the segments of the Lost River that are downstream in California. For ease of reference, these anticipated reductions in Oregon-source loads are identified in this TMDL as load allocations that reflect anticipated water quality at the California/Oregon border once the Oregon TMDLs are fully implemented.

Agricultural Drainage Discharges to segment from Oregon Border to Tule Lake Refuge (Segment 1)

Agricultural drainage discharges to the Lost River between the Oregon Border and Tule Lake Refuge were estimated by calculating the difference between model-derived DIN and CBOD loads in Lost River at the Oregon border and at the beginning of Tule Lake Refuge. This approach assumes pollutant levels are conservative. Inputs to this segment are from lands and drains within the TID, and, to an unknown extent, inputs (water supply and drain water) from drains originating in the Klamath Irrigation District (KID) facilities immediately to the north in Oregon (see Figure 1-4). The modeling analyzed the entire segment from Anderson Rose Dam to Tule Lake, crossing the Oregon-California border. The loadings to the segment in California are calculated to represent that portion of the segment that is in California, which is two-thirds of the segment total (see Tetra Tech 2006). Additional water quality and flow monitoring of the supply and drainage systems are needed to more accurately characterize the relative loading contributions from the different irrigation districts to this segment of Lost River, and are included in Chapter 7 as recommended actions.

Agricultural and Refuge Drainage Discharges to Tule Lake Refuge (Segment 2)

Agricultural and refuge drainage discharges to Tule Lake Refuge were derived through the modeling process. Loads for this segment were estimated by calculating the difference between DIN and CBOD loads entering and leaving (by way of the D Pumping Plant) the Tule Lake Refuge area. This approach is conservative, assuming the difference is composed of loads from agricultural drainage and refuge operation discharges and that those loads are retained in the Refuge. Internal nutrient loadings to this segment (e.g., benthic sources, waterfowl/wildlife sources) are also included in this total and are not separately quantified.

Inputs to this segment are from agricultural lands and drains (part of the TID) and other refuge operations. This area also receives water supply and drain water from KID facilities in Oregon, contributing an unknown portion of the DIN and CBOD load discharges to Tule Lake Refuge. Pollutant loads, from TID (and KID) and refuge operations are not distinguished from benthic and waterfowl or wildlife inputs.

The refuge is owned and operated by the USFWS and includes agricultural lease lands served by TID. As discussed in Chapter 7, additional water quality and flow monitoring in the supply and drainage system would facilitate more refined characterization of the relative loading contributions from the different irrigation districts and from operations of Tule Lake Refuge. Chapter 7 also includes recommendations to refine characterization of the relative loading contributions from the benthic and waterfowl/wildlife inputs.

City of Tulelake Wastewater Treatment Plant (Segment 2)

The city of Tulelake operates a 0.16 million gallon per day (mgd) wastewater treatment plant (WWTP) that discharges to a drain that is tributary to Tule Lake Refuge. Existing CBOD loads were estimated using existing National Pollutant Discharge Elimination System (NPDES) permit limitations. Existing DIN loads were estimated on the basis of facility monitoring data (St. John 2006).

Loadings from Tule Lake Refuge (Segment 3)

Estimates of loads from Tule Lake Refuge (segment 2) to Lower Klamath Refuge (segment 3) are based on monitored flow and pollutant concentration data collected at the D Pumping Plant to the P Canal. As described in Chapters 1 and 5, monitoring data were used to calibrate the water quality model and determine the *upstream* loads coming into the Lower Klamath Refuge. It appears there are no direct loadings to P Canal other than pumping from Tule Lake Refuge. Therefore, the P Canal has no separate load allocations, and thus is not further analyzed in this document.

Agricultural and Refuge Loadings to Lower Klamath Refuge (Segment 3)

Agricultural and refuge drainage discharges to Lower Klamath Refuge were derived through the modeling process by calculating the difference between DIN and CBOD loads entering Lower Klamath Refuge (from the D Pumping Plant) and leaving Lower Klamath Refuge (via Klamath Straits Drain at Stateline Highway). The difference was attributed to loads from Lower Klamath Refuge operations, agricultural drainage discharges (very little, if any), and waterfowl/wildlife inputs. This evaluation included characterization of internal benthic sources of nutrients. Internal nutrient loadings to Lower Klamath Refuge were captured by the model but are not individually quantified in this analysis.

The owner and operator of the Lower Klamath Refuge is the USFWS. Sources of agricultural loading to Lower Klamath Refuge are not known, but could come from the area (e.g., from the P Canal Mutual Water Company area) to the northeast of the Lower Klamath Refuge. Insufficient data and information are available to distinguish relative loading contributions from agricultural operations, other refuge operations, and waterfowl/wildlife inputs. As discussed in Chapter 7, additional monitoring is recommended to distinguish the contributions of loadings from these different sources.

Loadings from Ady Canal to Lower Klamath Refuge (Segment 3)

The Ady Canal was constructed in 1912 by the Klamath Drainage District to divert water from Keno Reservoir on the Klamath River to agricultural operations and to the Lower Klamath Refuge. Loads from Ady Canal to the Lower Klamath Refuge, estimated on the basis of flow and loading data, do not meet California water quality standards, and thus constitute a source of impairment to segment 3. Ady Canal is owned by the Klamath Drainage District.

Loadings from Lower Klamath Refuge (Segment 4)

Estimates of loads from Lower Klamath Refuge into Klamath Straits Drain are based on monitored flow and pollutant concentration data collected at the outlet of Lower Klamath Refuge. These values were used to calibrate the water quality model as discussed in Chapter 5 and set the upstream loads included in Klamath Straits Drain segment. Loads from the Lower Klamath Refuge are considered sources to the Klamath Straits Drain.

Agricultural Drainage Loads to Klamath Straits Drain in California (Segment 4)

Two agricultural field drains enter Klamath Straits Drain at Highway 161 (Stateline Highway) and south of the Oregon-California border approximately one-quarter mile to the north. These drains are believed to primarily receive input from Area K leased lands. The loads to Klamath Straits Drain were estimated by calculating the difference between DIN and CBOD loads at Klamath Straits Drain Pump Station E (in Oregon) and loads from Lower Klamath Refuge, assuming the difference is composed of loads from agricultural drainage discharges. Estimated loadings to this segment of Klamath Straits Drain in California are proportional to the length of the modeled segment located in California (approximately 10 percent of segment length) as compared to the full segment stretching from Lower Klamath Refuge to Pump Station E in Oregon (approximately 12 miles north of Lower Klamath Refuge).

Stormwater Discharges from Caltrans Facilities (Segments 1, 2, and 3)

Stormwater discharges from roads and other facilities managed by Caltrans (California Department of Transportation) are regulated under a statewide NPDES permit. Although two state highways are present in the TMDL project area, their spatial extent is very limited, and nitrogen and BOD discharges are expected to be relatively insignificant. A rough estimate of loads was developed on the basis of best professional judgment, and wasteload allocations are provided in each of the TMDLs to account for these very small pollutant contributions.

CHAPTER 5: LOADING CAPACITY LINKAGE ANALYSIS

This chapter discusses the use of water quality models to evaluate nutrient and BOD loads and effects in the Lost River system and to determine the capacity of the system to receive loadings of DIN and CBOD and attain the applicable water quality objectives for dissolved oxygen and pH.

Federal regulations define *loading capacity* as "the greatest amount of loading that a water can receive without violating water quality standards" (40 CFR 130.2(f)). The load capacity analysis serves to link water quality goals with pollutant loading information to determine necessary loading reductions.

5.1 DATA AND MODELING ANALYSIS

As described in Chapter 1, to support the development of TMDLs for the Lost River system, available monitoring data were compiled and evaluated to identify the extent, location, and timing of water quality impairments. Subsequently, a technical approach to analyze the relationship between sources and waterbody responses was developed. These steps are detailed in *Data Review and Modeling Approach – Klamath and Lost Rivers TMDL Development* (Tetra Tech 2004)[10].

For the Lost River TMDLs, a modeling effort was undertaken to develop a predictive model that, using best available data, would provide a reasonable representation of the physical, chemical, and biological processes occurring in the Lost River. CE QUAL W2 (W2), is a two-dimensional, longitudinal/vertical (laterally averaged) model integrating water hydrodynamics and water quality interactions (Cole and Wells 2003). The hydrodynamic portion of the model predicts water surface elevations, velocities and temperature; the water quality portion simulates dissolved oxygen, nutrients, phytoplankton interactions, macrophytes, and pH, as well as other constituents.

To address the complex hydrology of the Lost River caused by free-flowing riverine segments and relatively stagnant reservoirs/ponds, a number of enhancements to the W2 model were made for the Lost River TMDL analyses. These include the following:

- Enabling the model to run as a series of interlinked segments. This allows modeling activities on only selected segments of interest or on all waterbodies in the system.
- Addressing diffuse (or distributed) flows such as surface-runoff, return flows, and withdrawals, which are not represented by tributaries or other common functions.
- Refining the representation of SOD to more reasonably approximate the natural processes in the Lost River system.

[10] Available on the North Coast Regional Board Web site, under *Klamath River TMDLs – Supporting Information*: http://www.swrcb.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/

- Improving representation of macrophyte dynamics to address substrate availability and flow velocity.
- Modifying the denitrification rate to the lower end of the potential range, to represent diminished denitrification capacity associated with channelized rivers.

The Lost River model was first calibrated using data from 1999, a year that had good data availability. 1999 was also a year that exhibited significant water quality impairment during the summer critical period, providing an excellent basis for testing the model's capability of capturing extreme conditions, which are of concern for TMDL development. The model calibration was then corroborated using data for 2004 from a supplemental summer sampling effort conducted by ODEQ, North Coast Regional Board, and EPA Regions 9 and 10, to support model development. Using data for two separate years (1999 and 2004) increases the model's reliability. Other sources of data (e.g., Danosky and Kaffka 2002) were used for the testing and refining of the model. The database for the Lost River basin is maintained by the North Coast Regional Board and includes data used for this modeling effort and additional data subsequently received by the North Coast Regional Board.

5.1.1 Model Configuration

Each of the 12 waterbody segments (see Figure 1-10) was characterized within the model. Tule Lake Refuge (including the Sumps 1-A and 1-B) and the Lower Klamath Refuge were each treated as single waterbodies for purposes of the TMDL analysis. Output from an upstream segment was generally used as the input for next segment, with the exceptions of the two refuges in California. Modeled output from waterbody 7 (Tule Lake) was not used as the input for waterbody 8 (P Canal); instead, monitoring data at the Tule Lake outlet (referred to as station TLTO) was used to configure the incoming water quality for waterbody 8. Tule Lake model results contain uncertainties resulting from insufficient data to fully represent heterogeneities in the area of Tule Sumps 1A and 1B. Because of this lack of data, it was necessary to treat this large waterbody as a well-mixed segment in the model; that is, loads entering Tule Lake were consider to be instantly diluted by the lake's significant volume, while in reality, significant spatial gradients likely exist. To avoid transferring the uncertainties associated with this coarse spatial resolution to the next downstream segment, monitoring data were used as upstream inputs. Similarly, the modeled output from waterbody 9 (Lower Klamath Lake) was not used to represent the upstream boundary conditions for waterbody 10 (Klamath Straits Drain); and, instead, monitoring data from Klamath Straits Drain at Stateline (station KSDSR) were used to configure the water quality conditions.

Within the W2 model, each computational segment has multiple layers associated with it. The layers are horizontal *slices* of the water column from top to bottom that assist the model to accurately characterize nutrient, BOD, and dissolved oxygen flux at different waterbody depths. Each modeled segment had from two to five layers. For this study, layer thicknesses were set to approximately 1 meter (and ranged from 0.84 meters to 1.15 meters) for the 12 waterbodies (Table 5-1). As previously described, Tule Lake and Lower Klamath Refuges were represented in the model as single computational segments. For more information about lake segmentation, see Appendix A, p. 13.

Table 5-1. Model configuration

Waterbody number	Location	Number of segments	Segment length (m)	Layers	Thickness of layers (m)
1	Malone to Harpold	80	483.0	5	1.0
2	Harpold to RM 27	10	489.7	4	0.96
3	RM 27 to Wilson Reservoir	30	505.3	4	0.84
4	Wilson Reservoir	9	506.4	5	1.0
5	Lost River Diversion Dam to Anderson Rose Dam	55	534.5	5	1.0
6	Anderson Rose Dam to Tule Lake	24	502.9	4	1.0
7	Tule Lake	1	8008.0	2	1.0
8	P-Canal	8	502.6	3	1.0
9	Lower Klamath Lake	1	11,898.0	2	1.0
10	Klamath Straits Drain at Pump E	13	507.2	5	1.15
11	Klamath Straits Drain at Pump F	15	538.1	5	0.93
12	Klamath Straits Drain D/S Pump F	6	503.2	5	0.93

5.1.2 Model Boundary Conditions and Linkages

To run the dynamic W2 model, external forcing factors (known as boundary conditions) and internal linkages must be specified for the system. These boundary conditions are a critical component in the modeling process and have direct implications on the quality of the model's predictions. External factors include a wide range of dynamic information:

- Upstream external inflows, temperature, and constituent boundary conditions (US)
- Tributary inflows, temperature, and constituent boundary conditions (TRIB)
- Distributed tributary inflows, temperature, and constituent boundary conditions (DST)
- Withdrawals (WD)
- Atmospheric conditions (including wind, air temperature, solar radiation)

The US, TRIB, DST, and WD boundary conditions were specified for the Lost River model (Figure 5-1) based on all available data. Upstream external inflows represent the inflow at the model's *starting* point. Tributary inflows represent the major tributaries that feed into the Lost River. Distributed tributary inflows represent the combination of all diffuse contributions to each of the waterbodies (i.e., anything that is not considered a major tributary inflow, such as irrigation return flow). All water removed from the system is combined within the Withdrawals category.

Data were not sufficient to support a detailed differentiation between distributed flows/inputs (i.e., agricultural irrigation withdrawals, irrigation return flows, wildlife excrement, and groundwater interactions); thus, these sources were represented as a single combined source in each waterbody segment. Similarly, various external loadings including storm water runoff were not individually represented in the Lost River TMDL model; however the model boundary conditions do include contributions from these sources. For example, storm water was not represented as a separate and explicit source in the model (i.e., just storm water by itself), but it was explicitly represented in each segment of the model through the boundary conditions.

The model also must account for linkages within the system between the 12 waterbodies. Modeled internal linkages include the following:

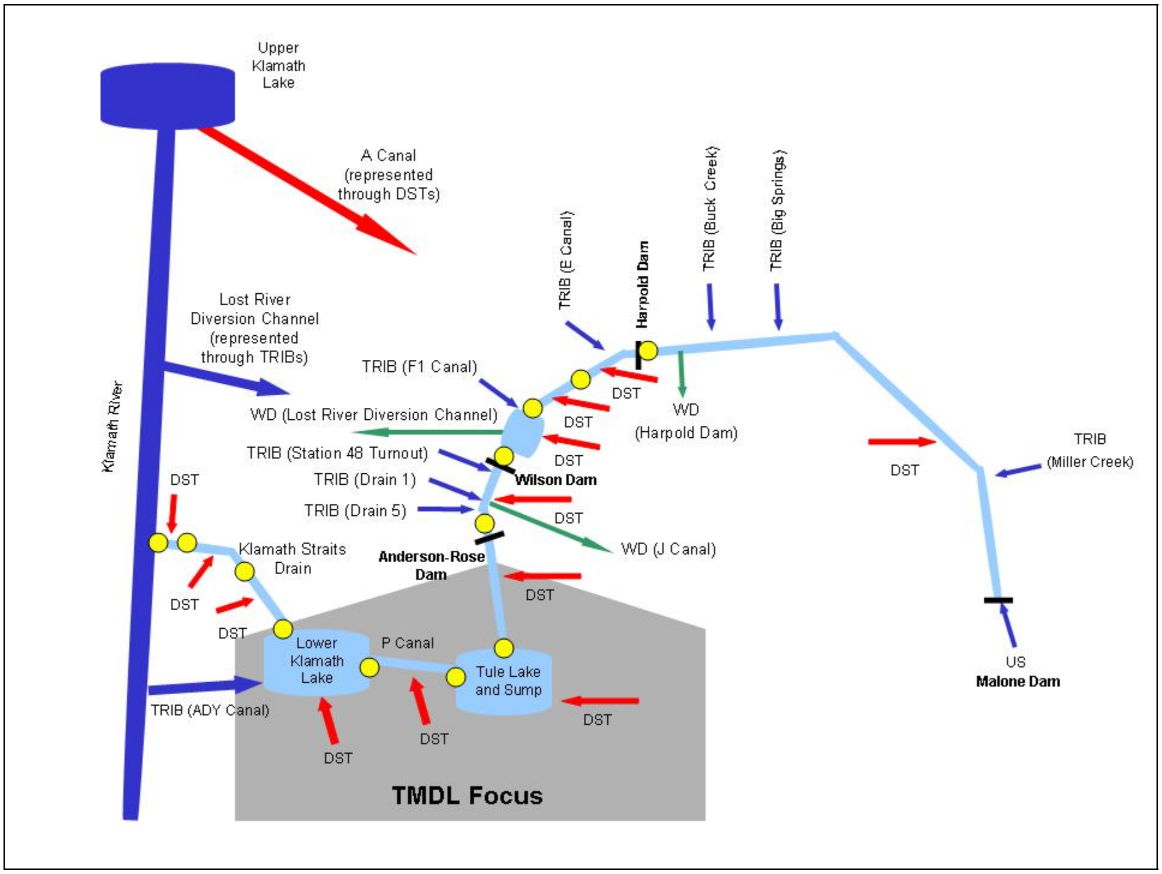
- Downstream weir-based boundary conditions (DSW)
- Upstream internal flow, temperature, and constituent boundary conditions (USIFB)
- Downstream internal head boundary conditions (DSIH)
- Upstream internal head boundary conditions (USIH)

5.1.3 Model Assumptions

All mathematical water quality models are a simplified representation of the very complex real world. The Lost River system is certainly no exception. It is a highly modified environmental system driven largely by irrigation operations, and it exhibits tremendous biological activity. Because of the limited quantitative data to describe aspects of the system, several key assumptions were made during model development. The following key assumptions are associated with the Lost River model development:

- Un-gauged inflows and outflows can be estimated using a water balance that is based on measured flows, inflows, and outflows.
- Where quantitative data were unavailable for characterizing agricultural pumping, return flow, and other unknown sources and sinks, it was assumed that the water quality associated with these distributed flows is similar to the water quality in the Lost River where the distributed flow discharges.
- One phytoplankton species and one macrophyte species are sufficient for representing the overall primary production and nutrient interactions in the system.
- The water quality gradients within Tule Lake and Lower Klamath Lake are insignificant; therefore, each can be considered as a single, mixed segment.

Modeling assumptions and limitations are specified in the document *Lost River Model for TMDL Development* (Tetra Tech 2005), presented in Appendix A.



Gray shading represents portion of Lost River addressed in these TMDLs. Yellow circles represent waterbody divisions. Blue arrows represent tributary (TRIB) and upstream (US) inputs. Red arrows represent distributed (DST) inputs. Green arrows represent withdrawals (WDs).

Figure 5-1. Model boundary conditions and linkages.

5.1.4 Model Performance and Limitations

The capability of a model is constrained by the availability and quality of data. The Lost River model can be used to represent overall trends in water quality in response to external loading and internal system dynamics; it is also capable of evaluating loading and water quality responses. Thus, it is appropriate to use to develop the TMDLs. However, the model is not expected to be able to mimic the exact timing and location of all water quality conditions or flow from return flows.

The model has reproduced the observed low dissolved oxygen concentrations (both in magnitude and timing) and trends for other parameters.

The model predicts that some water quality standards could be exceeded under the TMDL scenario; these exceedences are due to model and boundary condition uncertainty. For example, ammonia toxicity and pH model predictions were found to exceed criteria during the spring at two California locations upstream of Tule Lake Refuge—Lost River at Stateline Road (both parameters) and Lost River at East-West Road (pH); additional pH exceedences were predicted in October. However, a review of the monitoring data for this period indicates that there were no apparent ammonia toxicity issues in the Lost River in

California. Thus, EPA believes that these high values are likely an artifact of the model construction, which was based on sparse data during the spring and are not representative of actual water quality conditions.

Consistent with the findings of Mayer (2005), the TMDL model demonstrates that Tule Lake and the Lower Klamath Refuge are nutrient sinks. In the TMDL model, approximately 70 percent of inorganic nitrogen is retained by Tule Lake and the Lower Klamath Refuge.

The model also indicates that segments of the Lost River are limited more by nitrogen than by phosphorus for macrophyte development, which requires about six times more nitrogen than phosphorus for growth, and that macrophytes are the dominant factor controlling diel dissolved oxygen and nutrient fluctuations and minimum dissolved oxygen levels. However, the model appears to underpredict macrophyte growth in California at two locations: LREW (north of Tule Lake Refuge) and the P Canal.

In general, however, the model does a very good job of representing water quality responses to changes in loads of nutrients and organic matter. The model is a reliable tool and provides a sound framework for developing TMDLs and allocations.

5.2 EVALUATION OF LOAD REDUCTION SCENARIOS

The W2 model was used to evaluate load reductions needed for attaining water quality objectives in the Lower Lost River. Modeling results found that the dissolved oxygen objectives were the most difficult standards to attain. Consequently, if the dissolved oxygen objectives were met in the system, the water quality objectives for pH and nutrients would also be attained for the California segments (Lost River, Tule Lake Refuge, Lower Klamath Refuge, and Klamath Straits Drain).

Starting from a depiction of 1999 conditions, source loading was iteratively reduced through several pollutant reduction modeling scenarios until water quality criteria were achieved in the Lower Lost River. The modeling scenario that achieved the standards, and thus serves as the basis for the TMDL and allocation decisions, is referred to as *Scenario 1D* (Tetra Tech 2005 and 2005b).

Graphical depictions of modeled predictions from Scenario 1D are presented for dissolved oxygen and pH for each of the following three locations:

- LRSR – Lost River at Stateline, south of Anderson Rose Dam
- LREW – Lost River at East-West Road, slightly north of Tule Lake Refuge
- KSDSR – Klamath Straits Drain at Stateline Road

Figures 5-2 through 5-4 present dissolved oxygen predictions and Figures 5-5 through 5-8 present pH predictions from Scenario 1D.

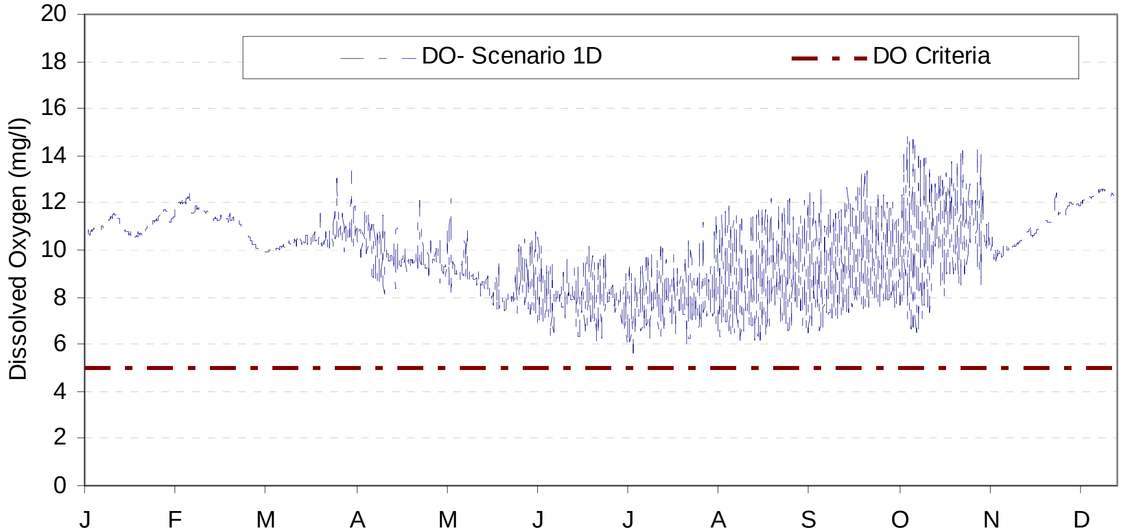


Figure 5-2. Dissolved oxygen standard compliance – Lost River at Stateline Road (LRSR).

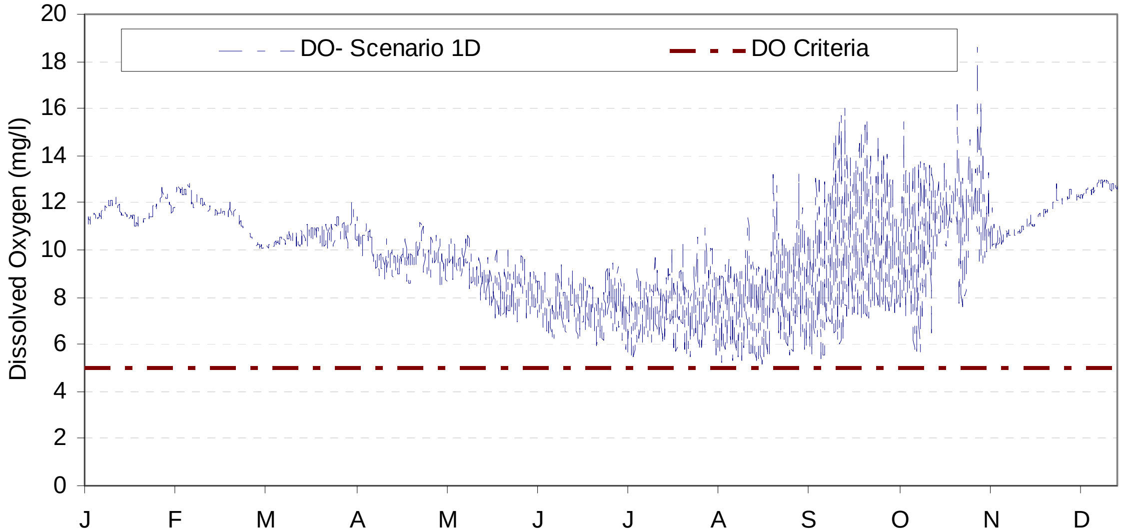


Figure 5-3. Dissolved oxygen standard compliance – Lost River at East- West Road (LREW).

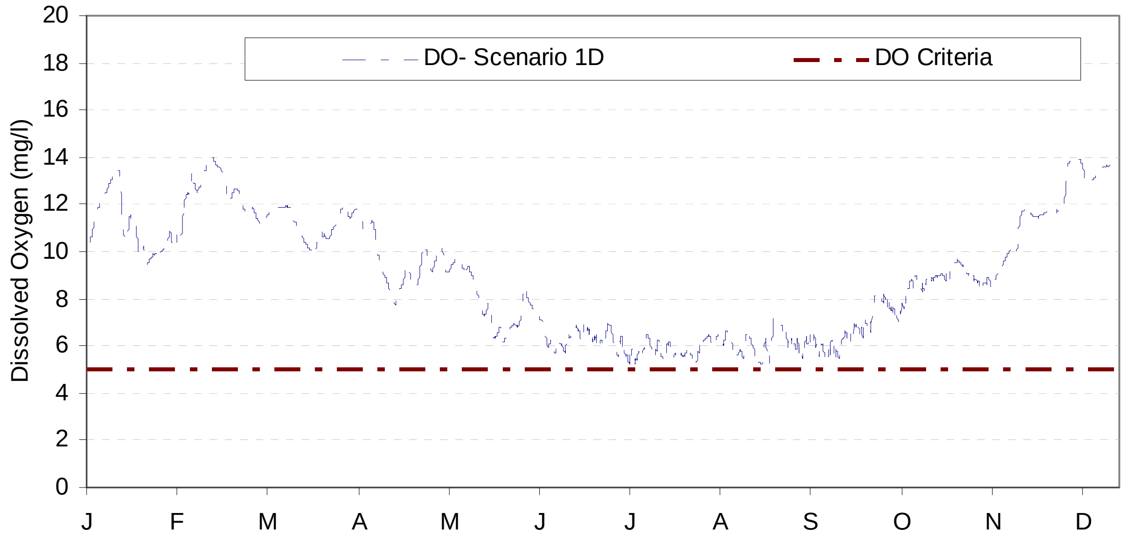
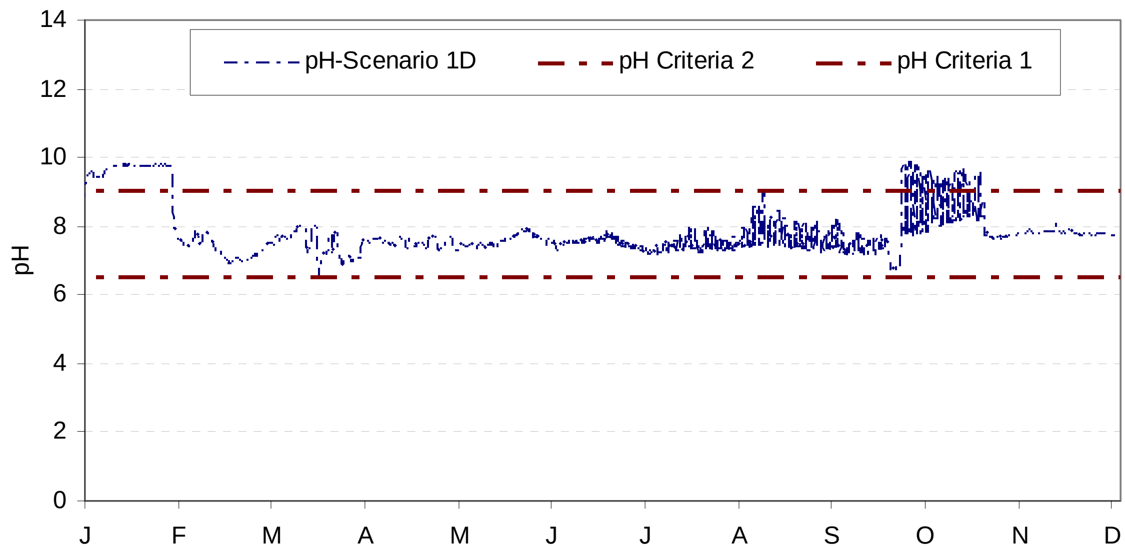


Figure 5-4. Dissolved oxygen standard compliance – Klamath Straits Drain at Stateline Road.



Exceedances of the 9.0 criteria in the winter and spring are believed to be artifacts of the coarse nature of the model boundary conditions.

Figure 5-5. pH standard compliance – Lost River at Stateline Road.

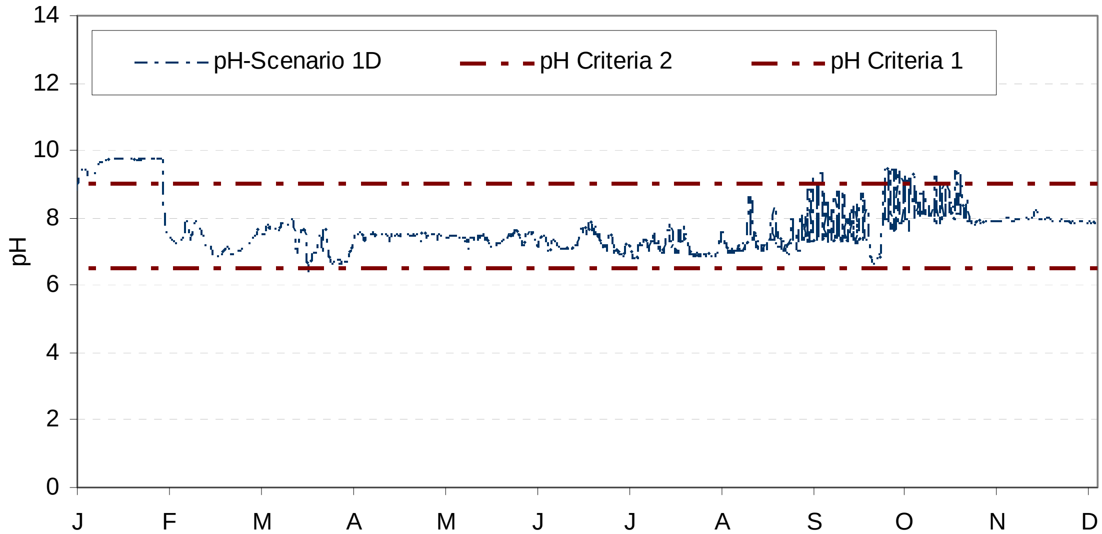


Figure 5-6. pH standard compliance – Lost River at East- West Road (LREW).

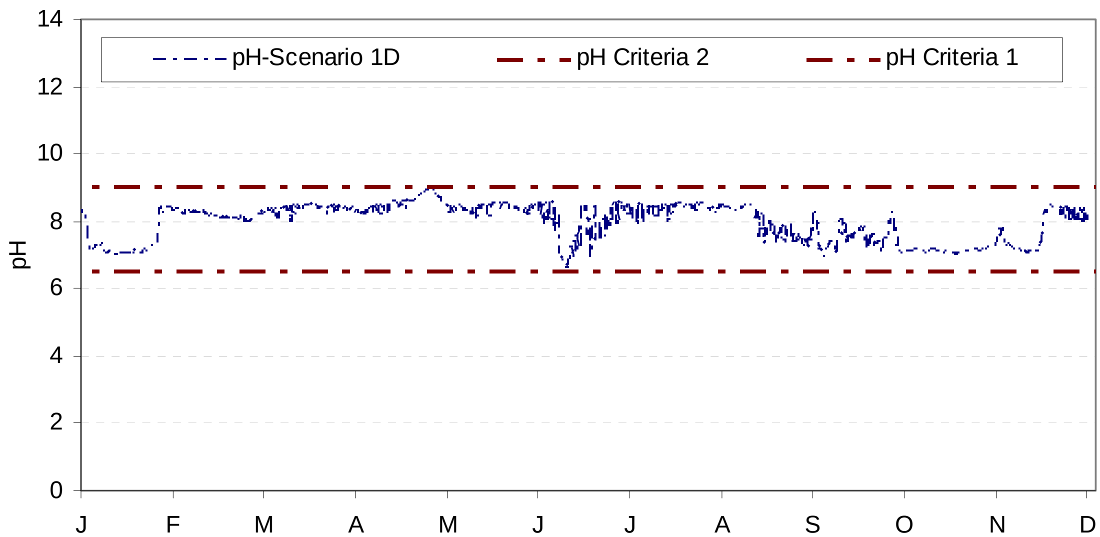


Figure 5-7. pH standard compliance – Klamath Straits Drain at Stateline Road.

Additionally, modeled predictions for CBOD and DIN concentrations at these same locations are presented in Figures 5-9 through 5-13. While the TMDL model is capable of predicting DIN and CBOD concentrations throughout the modeling segments, there is significant spatial and temporal variability in DIN and CBOD concentrations. Thus, different DIN and CBOD concentrations might be necessary to achieve the dissolved oxygen and pH targets (which are the primary goal of this TMDL) at different times of year and for different years. Addressing these constituents by designating allocations in terms of loads more appropriately accounts for temporal and spatial variability. Additionally, because of data limitations associated with the highly variable spatial and temporal nature of source inputs to the river, the model is more reliable for relative comparisons than for specific time and place DIN and CBOD concentration predictions.

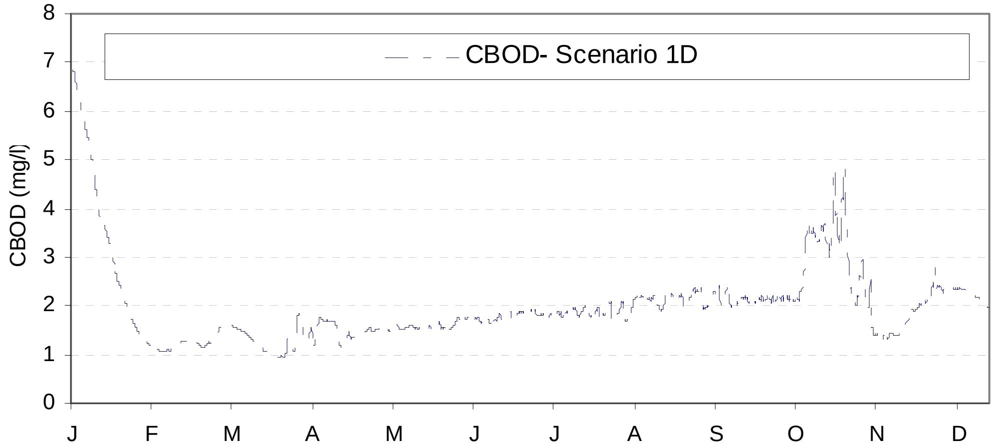


Figure 5-8. CBOD concentrations – Lost River at East-West Road.

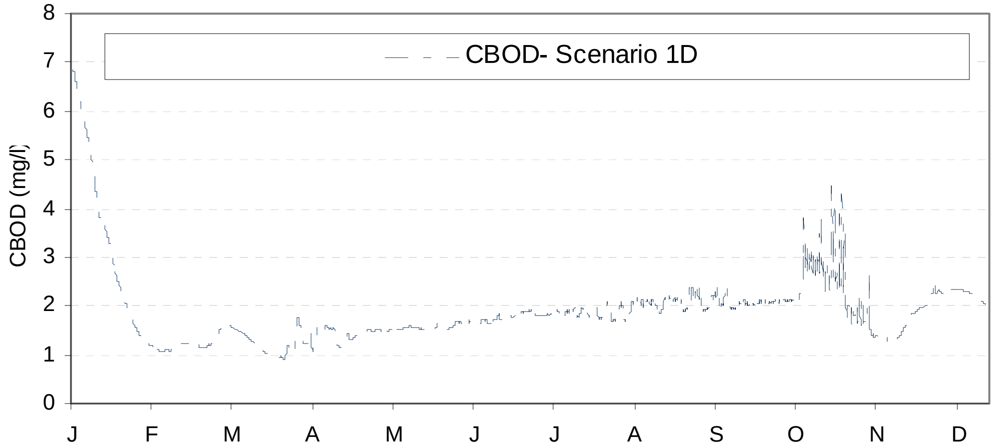


Figure 5-9. CBOD concentrations – Lost River at Stateline Road (LRSR).

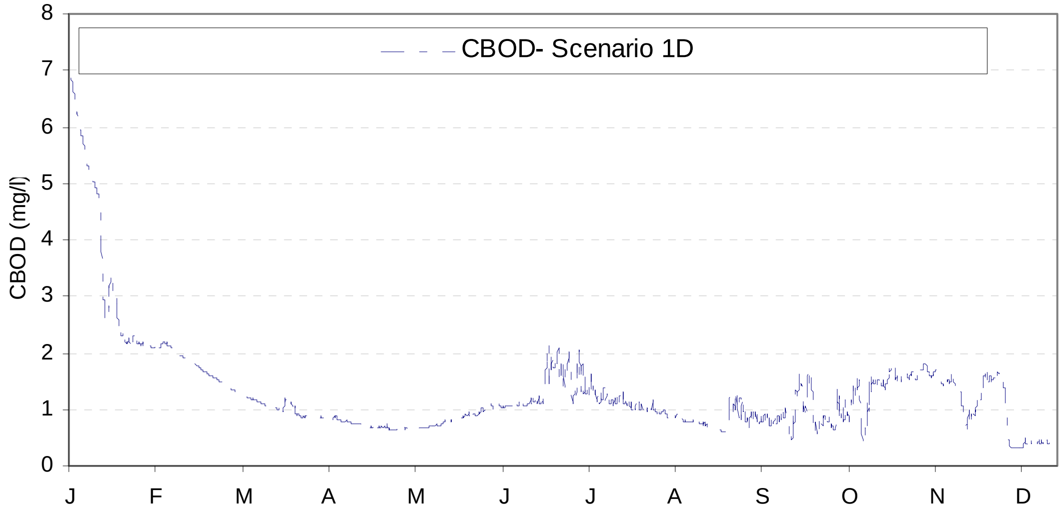


Figure 5-10. CBOD concentrations – Klamath Straits Drain at Stateline Road.

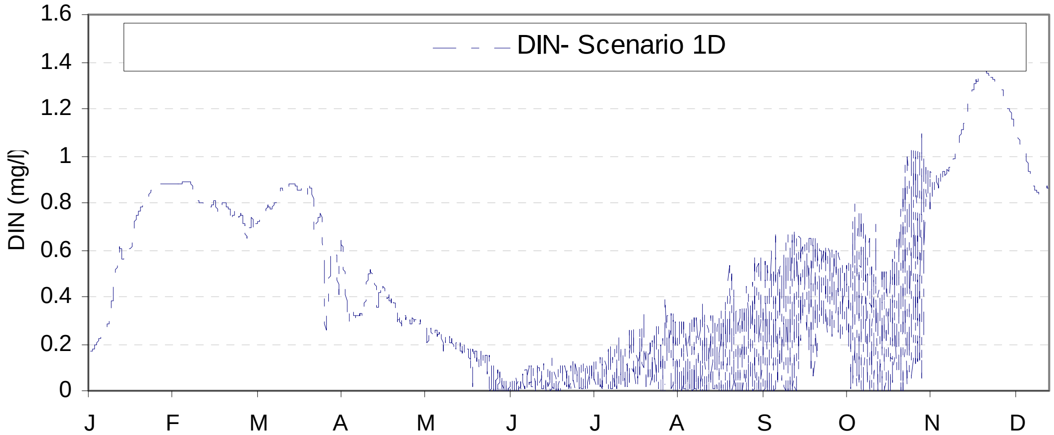


Figure 5-11. DIN concentrations– Lost River at Stateline Road (LRSR).

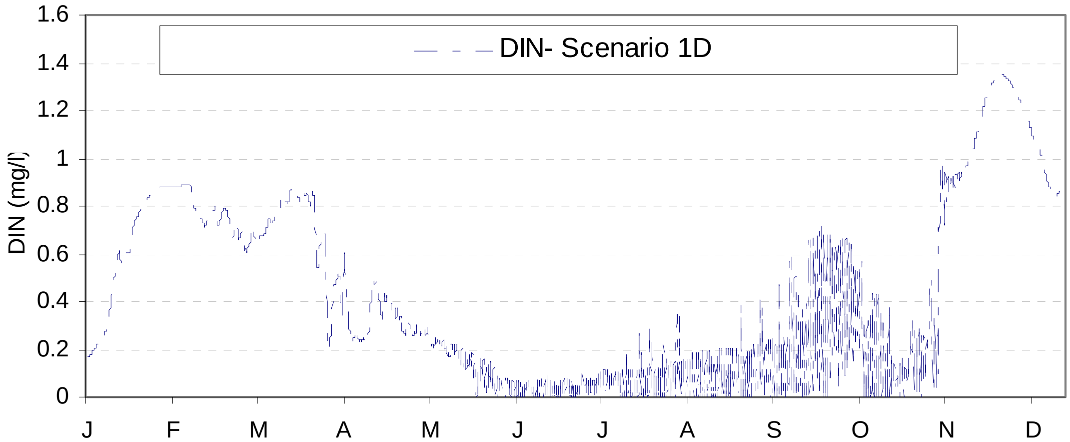


Figure 5-12. DIN concentrations– Lost River at East- West Road (LREW).

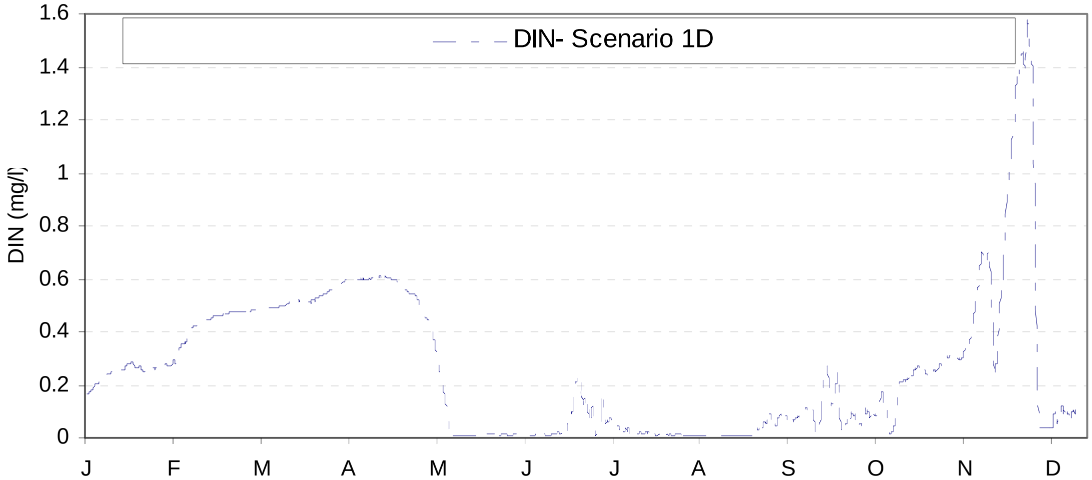


Figure 5-13. DIN concentrations– Klamath Straits Drain – Stateline Road.

5.3 ESTIMATION OF LOADING CAPACITY

As stated above, W2 modeling evaluation Scenario 1D achieved water quality standards for dissolved oxygen and pH at all locations in California. Load reductions between segments varied as needed to meet standards; however, within each segment of the river, the nitrogen and BOD levels were reduced equally. Calculations for downstream segments assumed that the water quality for upstream inputs achieved the identified DIN and BOD load reductions.

In general, the dissolved oxygen criteria were the most stringent objectives, and other objectives (such as that for pH) were achieved once dissolved oxygen objectives were met. Under Scenario 1D, DIN and CBOD inputs are reduced by 50 percent from the 1999 baseline levels throughout the Lost River system in California. Therefore, the loading capacity of Lost River in each of the four evaluated segments is 50 percent of estimated loads presented in Table 4-1. These loading capacity estimates are used in Chapter 6 to define the TMDLs and associated allocations for each segment.

CHAPTER 6: TMDLS, ALLOCATIONS, AND MARGIN OF SAFETY

6.1 TMDLS AND ALLOCATIONS

The pollutant loading capacities established in Chapter 4 represent the maximum amount of DIN and CBOD that can be discharged such that the Lower Lost River in California can still attain the applicable water quality standards for dissolved oxygen and pH. The TMDLs are normally set equal to the loading capacity for each pollutant; this is the case with these Lost River TMDLs.

As described in Chapters 1 and 4, the Lost River system in California has been subdivided into four segments for purposes of assessing load and determining TMDLs.

Segment 1. Lost River from the Oregon border to Tule Lake
Segment 2. Tule Lake Refuge
Segment 3. Lower Klamath Refuge
Segment 4. Klamath Straits Drain

TMDLs for each segment are represented as the sum of allowable loads, also known as allocations, to each source of nitrogen and CBOD discharging to those segments. Figure 6-1 presents a conceptual diagram of the four segments used for the Lost River system and the sources receiving allocations.

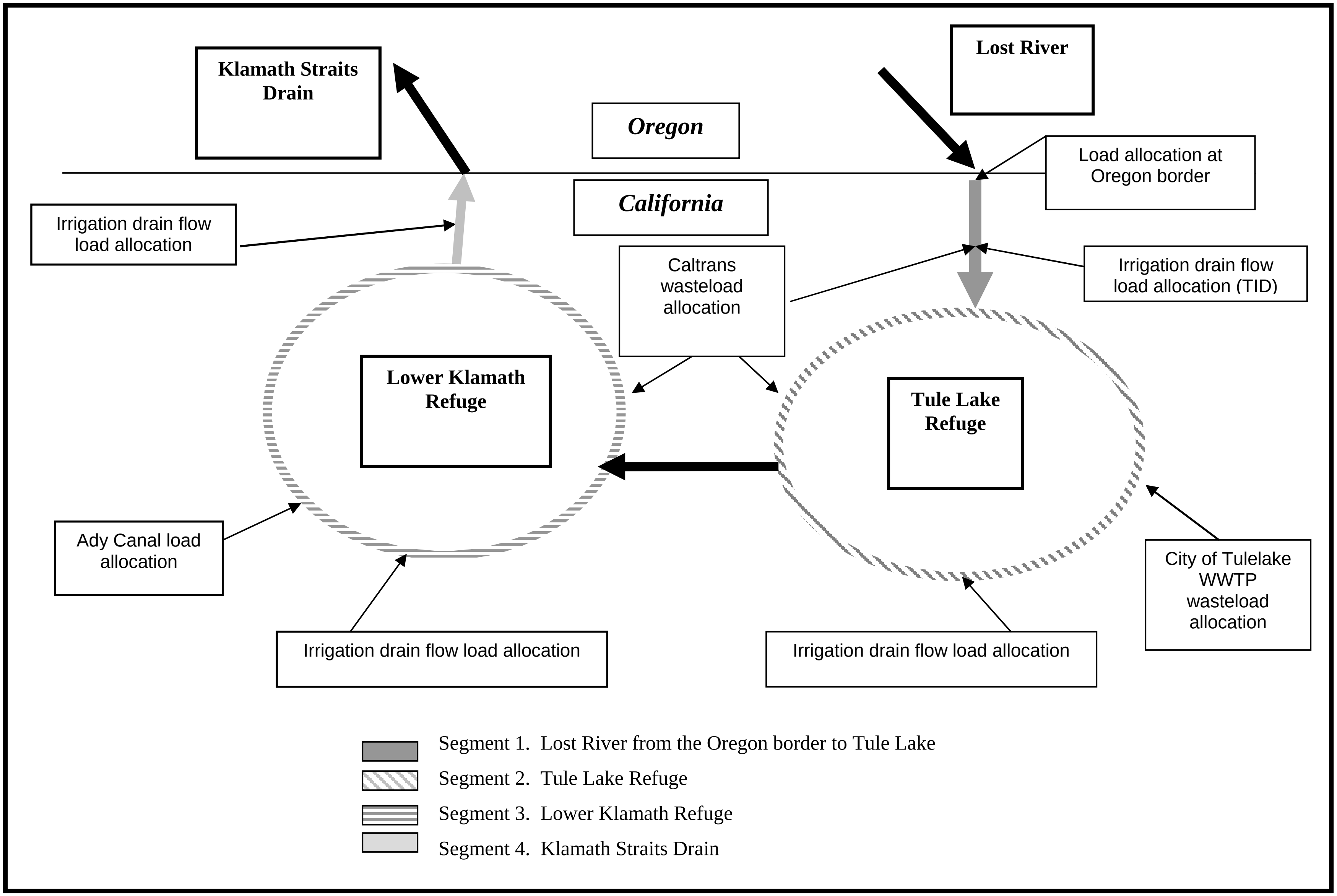


Figure 6-1. Lost River TMDLs schematic diagram.

A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive (loading capacity) and still attain water quality standards. TMDLs are defined as the sum of the individual wasteload allocations (WLAs) and load allocations (LAs) including natural background, with a margin of safety (MOS), such that the loading capacity of a waterbody is not exceeded [40 CFR 130.2(i)].

$$\text{TMDL} = \Sigma\,(\text{WLAs}) + \Sigma\,(\text{LAs}) + \text{MOS}$$

An LA is the portion of a receiving waterbody's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources. A WLA is the portion of a receiving waterbody's loading capacity that is allocated to one of its existing or future point sources of pollution. Chapter 4 describes the sources of DIN and CBOD loading to which allocations are being assigned.

Table 6-1 presents the TMDLs and associated allocations. For each of the four segments for which TMDLs are established, LAs are provided for nonpoint sources that discharge to the segment (termed *irrigation drainage* here and included in *distributed* sources in the modeling analysis). Pursuant to federal regulatory provisions at 40 CFR 130.2(g), LAs in these TMDLs may be expressed as *gross allotments* when insufficient data and information are available to support further delineation of LAs by specific source category. A separate LA is established for Ady Canal, which discharges to Lower Klamath Refuge.

As discussed in Chapter 5, the data and modeling analysis conducted to support these TMDLs found that reductions in DIN and CBOD loadings of approximately 50 percent from the estimated baseline loads from 1999 (which would produce commensurate reductions in SOD) would be sufficient to attain the applicable California water quality objectives for pH and dissolved oxygen. The analysis projects that if the amount of nitrogen and CBOD input to a waterbody is reduced by 50 percent from the 1999 baseline as projected in the TMDLs, the total nitrogen and CBOD loads for that waterbody would also reduced by approximately 50 percent. The baseline year is not relevant to what levels of pollutants the waterbodies are able to assimilate; they merely provide a comparison point for expressing the permissible loads. Thus, each of the LAs in Table 6-1 are set at approximately 50 percent of 1999 estimated loads presented in Table 4-1. LAs to each segment are also established for upstream sources (i.e., the estimated loads that come from sources in the next upstream segment).

LAs are also established to address upstream loads where the Lost River flows into California from Oregon. ODEQ has identified the Lost River as impaired, and intends to issue, in 2009, and implement TMDLs for DIN and CBOD for the Lost River within the State of Oregon, based on Oregon's water quality standards. Developed as part of a comprehensive basinwide analysis of pollutant loadings to the entire Lost River, the Oregon TMDLs (and their anticipated LAs and WLAs) are also designed to meet California water quality standards at the Oregon/California border. EPA has accounted for these anticipated upstream load reductions in Oregon when developing the TMDLs for the segments of the Lost River located downstream in California. For ease of reference, these anticipated reductions in Oregon source loads are identified in this TMDL as LAs that reflect anticipated water quality at the California/Oregon border once the Oregon TMDLs are fully implemented. Thus, the load reductions identified in

Table 6, reflect an understanding and acknowledgement that improvements in water quality upstream represent part of the solution in meeting water quality objectives in California.

WLAs are established for the two point sources that discharge nutrients and BOD in the study area—the city of Tulelake wastewater treatment plant and Caltrans facility stormwater runoff. Because the city of Tulelake is in the process of upgrading its treatment plant, its WLAs are set at 50 percent of estimated current loadings to be consistent with the allocations set for nonpoint sources. EPA believes that these WLAs will be achievable by the new treatment plant. For Caltrans, the WLA is set at a level achievable through implementation of best management practices (BMPs) specified in the existing NPDES permit. These permitted BMPs must be applied in this watershed for these TMDLs to be implemented.

TMDLs, LAs, and WLAs are expressed both in terms of maximum annual and maximum average daily loads. The modeling analysis conducted to support the TMDLs indicates dissolved oxygen and pH levels vary substantially on a seasonal basis but less so on a daily basis. The period between June and September is associated with the most serious water quality violations (e.g., see Figure 2-8). While there is seasonal variability in nitrogen and CBOD loading and effects, nitrogen and organic material discharged to Lost River can have lengthy residence times. As a result, pollutants discharged during the less critical period between late fall to early spring can remain in the system for substantial periods of time and contribute to adverse effects on dissolved oxygen and pH levels during the critical summer period. The TMDLs are set to require year-round pollutant loading reductions, and thus are expressed, in part, in annual terms to reflect this requirement.

The TMDLs are designed to result in attainment of water quality standards at all locations in the receiving waterbody segments. TMDL attainment should be measured by evaluating the following:

1. Are the applicable dissolved oxygen and pH water quality targets met at all monitoring locations?
2. Have DIN and CBOD loads been reduced in comparison with 1999 baseline conditions to meet the allocations reflected in Table 6?

If the follow-up analysis of monitoring data indicate that the applicable water quality targets are regularly met, it would be reasonable to conclude that the TMDL has been attained. If, however, the necessary 50 percent loading reductions have been attained yet the applicable water quality targets are not attained, it might be necessary to review and potentially revise the TMDLs to ensure that sufficient pollutant reductions are being identified. Even if projected load reductions are not met upstream, allocations in Table 6 will still be applicable.

The TMDLs and allocations are also expressed in daily terms to focus attention on the need to avoid large pulses of nutrient loading that could cause or contribute to short-term dissolved oxygen deficits. Daily TMDLs and allocations were calculated by dividing the annual load-based TMDLs and allocations by 365 (the number of days/year). Setting the TMDLs and allocations in daily terms is more reflective of the averaging period specified for the numeric targets (Chapter 3). Finally, the importance of setting TMDLs in daily terms was reinforced by a federal Appeals Court decision in the Anacostia River TMDL case (*Friends of the Earth, Inc. v.*

EPA et al., D.C. Circuit Court of Appeals, No.05-5015, April 25, 2006). On November 16, 2006, EPA issued national policy guidance stating the expectation that TMDLs be set in terms of daily time steps (USEPA 2006). It is permissible to express a TMDL both in daily and non-daily terms. EPA believes that setting both daily and longer-term TMDLs will assist in designing monitoring programs that effectively track progress in reducing pollutant loads and improving water quality. For example, grab sample monitoring results can be more easily compared to average daily allocations than to longer-term allocations. The intent in setting both average daily and annual TMDLs and allocations is to meet TMDL regulatory requirements in a manner that is sensitive to how water quality control and monitoring programs are actually implemented. As bottom sediments in these waterbodies contain substantial reservoirs of nitrogen and CBOD, there could be a significant lag time between reductions of nitrogen and BOD loadings to these waters and full attainment of applicable water quality standards.

It is also important to note that setting allocations for loading sources is different from setting TMDLs. Whereas TMDLs are set to achieve applicable water quality standards *in* the target waterbody, allocations are set for sources discharging to the target waterbody as necessary to meet the applicable water quality standards in the target TMDL waterbody. For example, the portion of Klamath Straits Drain in California is addressed as an impaired segment and TMDL allocations are calculated for inputs to this segment to attain California water quality objectives in that segment. TMDLs for the Oregon portion of the Klamath Straits Drain are being developed by ODEQ as part of the Oregon Lost River TMDLs document, and water quality will be evaluated using the applicable Oregon criteria. Similarly, inputs to the Klamath River (e.g., from Klamath Straits Drain) will be addressed in ODEQ's TMDLs for the Klamath River.

The TMDLs for each segment includes an LA for upstream sources from the segment immediately upstream. It is important to note that the upstream LAs for the Lower Klamath Refuge (representing outflow from Tule Lake Refuge) and for Klamath Straits Drain (representing outflow from Lower Klamath Refuge) do not equal the TMDLs set for those upstream waterbodies. As described in Chapter 4, these quantities are not equivalent, for several reasons including the following:

- Only a portion of water (with its associated DIN and CBOD loads) is pumped, via the P Canal, from Tule Lake Refuge to Lower Klamath Refuge, the next *downstream* TMDL segment.
- Substantial amounts of nitrogen and CBOD entering Tule Lake and Lower Klamath Refuges are consumed in these waterbodies through settling and biological processes, as described in Chapter 3.

Water from the Tule Lake sumps is reused in the fields, and less than half (42 percent) of the water entering the TID area was found to be diverted to the Lower Klamath Refuge (Danosky and Kaffka 2002). (Water from Lower Klamath Refuge is not known to be reused in this way; and water leaving Lower Klamath Refuge goes to Klamath Straits Drain.) Taking into account these factors, the upstream LAs for loading to segment 3, Lower Klamath Refuge, and to segment 4, Klamath Straits Drain, are less than the TMDL for the upstream segment. However, they represent a 50 percent reduction from the upstream loads (monitored nitrogen and CBOD loadings) entering these waterbodies (see Table 4-1).

Table 6-1 identifies the TMDLs, LAs, and WLAs for each of the four segments. Where an allocation is given to a general segment, sources not explicitly identified (e.g., refuge bed sediments, wildlife excrement, or stormwater runoff) are indirectly addressed as components contributing to each segment's boundary conditions and, thus, are indirectly addressed.

6.2 MARGIN OF SAFETY ANALYSIS

The CWA requires the inclusion of an MOS in each TMDL to account for uncertainties concerning the relationship between pollutant loads and in-stream water quality and other uncertainties in the analysis. The MOS can be incorporated implicitly into conservative assumptions used to develop the TMDL, or added as an explicit MOS (established by withholding an explicit fraction of the loading available for allocation). These TMDLs incorporate an implicit MOS through use of conservative assumptions. First, the TMDLs assume year-round reductions in DIN and CBOD reductions are needed although the critical period in which water quality standards violations occur is during the summer months. Second, the W2 model calibration incorporates conservative rates for key water quality parameters (e.g., denitrification rates used, as described in Chapter 5). EPA does not believe that an explicit MOS is warranted in these TMDLs. Therefore, these TMDLs rely on an implicit MOS.

Table 6-1. Lost River TMDLs and allocations by segment

Segment	Source	Dissolved inorganic nitrogen (DIN) (metric tons/yr)	Dissolved inorganic nitrogen (DIN) (average kg/day)	Carbonaceous biochemical oxygen demand (CBOD) (metric tons/yr)	Carbonaceous biochemical oxygen demand (CBOD) (average kg/day)
1	Lost River at Stateline Road (OR Border) Load Allocation	27.8	76.0	54.3	148.6
	Load Allocation for irrigation drainage loads to Lost River between Stateline Rd and Tule Lake Refuge	1.2	3.2	17.5	47.8
	Wasteload Allocation-CalTrans	0.1	0.3	0.2	0.5
Total	Lost River (from border to Tule Lake Refuge) TMDLs	29.0	79.5	71.9	197.0
2	Upstream load - from Lost River	29.0	79.5	71.9	197.0
	Load Allocation for irrigation drainage loads to Tule Lake Refuge	36.2	99.0	253.3	694.0
	Wasteload Allocation-CalTrans	0.1	0.3	0.2	0.5
	Wasteload Allocation City of Tulelake WWTP	1.0	2.7	3.5	9.6
Total	Tule Lake Refuge TMDLs	66.3	181.5	328.9	901.1
3	Upstream load - from Tule Lake Refuge[a]	19.4	53.2	245.9	673.7
	Load Allocation for irrigation drainage loads to Lower Klamath Refuge	3.9	10.7	39.4	107.8
	Load Allocation to Ady Canal	4.4	12.1	39.4	107.8
	Wasteload Allocation - CalTrans	0.1	0.3	0.2	0.5
Total	Lower Klamath Refuge TMDLs	27.8	76.2	324.8	889.9
4	Upstream load from Lower Klamath Refuge[b]	20.2	55.2	193.3	529.5
	Load Allocation for irrigation drainage loads to Klamath Straits Drain	1.5	4.1	10.5	28.8
Total	Klamath Straits Drain (Stateline Highway to border) TMDLs	21.7	59.3	203.8	558.2

[a]Upstream load from Tule Lake Refuge—only a portion of the waters from Tule Lake Refuge are pumped to Lower Klamath Refuge. Additionally, the model assumes that Tule Lake Refuge is a single mixed segment; to avoid transferring uncertainties associated with the coarse spatial resolution to the next downstream segment, monitoring data collected at the D Pumping Plant intake was used as the basis for upstream inputs for this segment.

[b]Because the model assumes that Lower Klamath Refuge is a single mixed segment, water quality inputs to the next segment were based on monitoring data collected at Klamath Straits Drain at Stateline Highway.

CHAPTER 7: IMPLEMENTATION RECOMMENDATIONS

In this chapter, EPA presents implementation recommendations for consideration by the North Coast Regional Board and local stakeholders to assist in targeting actions to address suspected causes of water quality impairment in the Lost River. Regulations for TMDLs developed by EPA do not include developing implementation plans. Thus, the implementation recommendations presented in this chapter are not part of the TMDLs (Chapter 6) that are being established by EPA pursuant to CWA section 303(d) and federal regulations at 40 CFR 130.7. These implementation recommendations are strictly advisory and are not required to be implemented under federal law. Similarly, the time frames for water quality improvements provided in this chapter are recommendations.

Oregon and California are each responsible for implementation plans in their respective states. The North Coast Regional Board has responsibility for implementing the Lost River TMDLs in California. Implementation of TMDLs for the Lost River in Oregon will be addressed under ODEQ's TMDL Program and Implementation Guidelines[11]. EPA strongly encourages stakeholders to participate in the development of these implementation plans.

EPA guidance recommends including the following elements in an implementation plan (USEPA 1991):

- A description of the implementation actions and management strategies
- Legal or regulatory controls
- A time line for implementing the measures
- Time required to attain water quality standards
- Monitoring plans and milestones for attaining water quality standards
- Adaptive Management, periodic review and revision of the plan.

Implementation plans, together with comprehensive implementation of NPDES permits and designation of entities responsible for achieving load allocations, will establish the foundation for achieving the allocations in these TMDLs. It is ultimately the responsibility of dischargers identified in the implementation plan to meet the allocations specified in Chapter 6 by reducing contributions to water quality impairments in the Lost River.

EPA acknowledges and appreciates that there are many factors that affect whether an action is feasible and will be effective toward achieving load reductions. Additionally, EPA recognizes the importance of cumulative water quality improvement efforts for the Lost River in California, as well as coordination of efforts addressing water quality with those for upstream and downstream segments of the Lost River (i.e., in Oregon). Concurrent activities toward achieving allocations throughout the Lost River are recommended to address impairments in all reaches of the waterbodies via state-led implementation plans in the Klamath Basin. Concurrent efforts to

[11] For more information on ODEQ rules that guide its TMDL implementation process, see http://arcweb.sos.state.or.us/rules/OARs_300/OAR_340/340_042.html.

reduce loads in each segment of the Lost River are needed to achieve required improvements in water quality. EPA also encourages coordination of Lost River implementation efforts with those for the Klamath River, where practical and beneficial.

The North Coast Regional Board has stated its intention to develop, in conjunction with stakeholders, an implementation plan (called an *Action Plan)* for the California Lower Lost River TMDLs, that will establish clear targets and time frames and will determine which entities and what measures will best achieve the allocations and the TMDLs. The State Water Resources Control Board adopted a Nonpoint Source (NPS) Policy[12] that requires the North Coast Regional Board to adopt waste discharge requirements, waivers or prohibitions to control nonpoint source discharges. The North Coast Regional Board will develop an implementation plan that is consistent with the statewide policy. The implementation actions required by the North Coast Regional Board's Action Plan may vary from the recommendations offered here.

Additionally, the North Coast Regional Board staff has expressed readiness to work with landowners to ensure proper crediting of early implementation efforts. Before adopting a Lost River Action Plan, a system of monitoring will be needed to determine any reductions achieved toward meeting the load allocations specified in Chapter 6 of this document. For example, monitoring at the load allocation compliance points designated in Chapter 6 could be used to calculate load reductions from the 1999 baseline and could be credited to the entities (e.g., landowners, irrigation districts) contributing to the loading at that point. EPA strongly encourages parties to contact North Coast Regional Board staff[13] for a consultation and assistance in developing implementing management practices, and discuss monitoring needed to demonstrate reduction of loads (from the 1999 baseline) that have already been achieved.

The implementation recommendations presented in this chapter are for the North Coast Regional Board and other stakeholders to consider when developing implementation actions and do not *assign* responsibilities or timelines. EPA believes that these recommendations contain a broad range of valuable suggestions, and their presentation is intended to capture suggestions provided throughout this TMDL development process. EPA encourages the state and local stakeholders to consider these recommendations to guide future water quality protection efforts in the basin.

7.1 RECOMMENDATIONS FOR IMPLEMENTATION ACTIONS

This section presents general strategies intended to promote activities to improve water quality over time, with the ultimate goal of achieving TMDL LAs and meeting water quality standards in the Lower Lost River. Specific recommended actions are included in Table 7-1. Many suggestions were provided in public comments to the 2007 Draft TMDL document. EPA has added to Table 7-1 those suggestions applicable to meeting these TMDLs, providing the North Coast Regional Board and stakeholders with a broad range of possibilities that reflect this input. The actions are organized by general topic.

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[12] The Plan for California's NonPoint Source Pollution Control Program is available at: http://www.waterboards.ca.gov/water_issues/programs/nps/protecting.shtml

[13] Landowners are advised to contact Rich Fadness, Monitoring Coordinator for the Regional Water Board at (707) 576-2220

The following are EPA recommendations for measures to improve or maintain water quality conditions in the Lower Lost River system:

- Coordinating closely with other agencies, and developing Memoranda of Understanding for those efforts
- Convening stakeholders to identify and develop strategies to control discharges, and identify watershed restoration activities and public outreach opportunities
- Coordinating with other agencies during their development of management plans to include measures to protect water quality and the associated beneficial uses
- Developing a monitoring strategy for filling gaps in current data and for ensuring progress with implementation measures
- Utilizing adaptive management approaches to implementation, and refining implementation strategies in response to monitoring data and new technical information.

EPA encourages the North Coast Regional Board to build upon ongoing, proactive restoration and enhancement efforts in developing implementation actions. Actions taken since 1999 may have already initiated reduction of nutrient and BOD loads. EPA encourages all stakeholders to work together with the North Coast Regional Board to identify changes needed for the benefit of water quality, including the management of the Project operations and Refuges.

At the time California considers development and adoption of the Lost River Action Plan, together with these TMDLs, into the Basin Plan, EPA recommends that the state evaluate the degree to which dischargers have initiated implementation of effective pollutant control measures. Consideration should be given to the EPA recommendations below as well as any other relevant efforts to improve water quality in the Lost River basin.

The following presents a discussion of several of the suggested implementation measures that EPA recommends to support achievement of TMDL allocations.

Memoranda of Understanding

EPA suggests two separate groups that could be assembled to facilitate identification of appropriate water quality control measures (regulatory, voluntary, or a combination) and to help identify appropriate parties to implement those measures. A first option would be a bi-state (California and Oregon) TMDL implementation effort limited to the water quality agencies, North Coast Regional Board and ODEQ. A second option is the formation of a larger group including both state and federal regulatory agencies with jurisdiction in the Lost River basin, because operations in the Lost River area are governed by numerous statutory and regulatory programs at both the state and federal level. This second group would also work together cooperatively to identify feasible implementation options. Cooperative agreements, with entities in either or both options, could be implemented before committing to a working group or process, and marked by Memoranda of Understanding.

Stakeholders Working Group

EPA encourages developing a stakeholder working group for the purposes of gathering and evaluating site-specific data related to impairments in the Lost River basin and for identifying workable solutions. Development of a stakeholder working group will increase the potential for success of selected implementation measures and management activities to improve water quality. EPA recommends that such a work group be facilitated by a neutral third party, to encourage participation by all stakeholders and thus optimize the outcome in the implementation process. Stakeholders could include, but are not limited to, tribal representatives, irrigation districts, Klamath Water Users Association, University of California (UC) Cooperative Extension representatives, state and federal agencies, and nongovernmental organizations.

Project and Refuge Management Practices

As described in Chapter 1, USFWS has initiated the development of Refuge Management Plans for Lower Klamath and Tule Lake Refuges for a 15-year planning period. EPA encourages the North Coast Regional Board to work closely with USFWS to identify and coordinate implementation activities into the refuge management planning efforts to address water quality improvements and options for achieving those improvements such as the “walking wetland” program, described below.

Water quality in the refuges benefits from the ongoing Lower Klamath and Tule Lake Refuge management activities referred to as the Walking Wetlands program. Identification of lands for flooding in Tule Lake Refuge is conducted informally under the Integrated Pest Management (IPM) Plan,[14] with approximately 700 acres per year converted to wetlands for 2-year cycles. These lands in Tule Lake Refuge are identified opportunistically (e.g., as leases expire) and cooperatively between the USFWS, USBR, and TID. The percent of lands flooded each year has been increasing and agricultural interests (farmers) are seeing economic benefits. The acreage being used for walking wetlands, as well as the fully flooded areas, provide important wetland habitat and contribute to improved water quality. These improvements are also benefiting farmers returning to lands after flooding by increasing the fertility of soil and reducing the need for pest management; some farmers are choosing to transition to organic agriculture when returning to an area following flooding under the Walking Wetlands program, further improving water quality by reducing chemical inputs.

Restoring proper ecosystem function and natural filtration mechanisms can be an effective and achievable method for reducing pollution in river systems and should be considered in the evaluation of implementation options. Reduction of nutrients and improvement of water quality in the Lost River basin can be achieved through restoration of riparian areas, and wetlands. Buffers along riparian areas and wetlands could be enhanced as ways to reduce nutrient loads. Use of permanent wetlands with fluctuating water levels, to reduce nutrient loads and thus provide water quality benefits, should be used where appropriate and possible.

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[14] For the IPM Plan for the leased lands at Lower Klamath and Tule Lake National Wildlife Refuges, see http://www.fws.gov/klamathbasinrefuges/mgmt.html.

However, it is also important to improve the water quality entering the refuges to meet the beneficial uses of the wetlands.

The North Coast Regional Board staff has indicated that wetland treatment will be considered in the development of implementation plans for the Lost and Klamath River basins. EPA supports exploring how wetlands might be used for improving water quality and recommends convening a public workshop, bringing together scientists and other experts to present information this topic for evaluation. The California State Wetlands and Stream Protection Policy, currently in preparation, is expected to be a proposed amendment to the Water Quality Control Plans (Basin Plans) for the North Coast and San Francisco Bay Regional Boards, and will include measures to protect riparian areas and floodplains.[15]

The National Research Council[16] has recommended expanding the size and depth of Tule Lake and Lower Klamath Lake to restore water quality and sucker species. Refuge managers are continuing to develop flooding activities that benefit water quality and thus other beneficial uses including improvements to sucker habitat.

Agricultural Irrigation Practices

An important part of water quality management in the Lost River basin includes managing agricultural irrigation practices and use of return flows. Return flows are both reused in agriculture and comprise the majority of the water to both of the refuges. As described in Chapter 2, waters coming off agricultural lands farthest from the source canals (e.g., lease lands surrounding Tule Sump) are of worse quality than waters in the source canals or in the sumps, suggesting that implementation measures to reduce nutrient loads in agricultural drainage waters should be a priority for restoring water quality in the Lost River.

The source analysis identified agricultural return flows as a significant source of nutrient and CBOD loading in the Lost River basin. The TMDLs assign a 50 percent load reduction to irrigation drainage loads throughout the study area to achieve water quality objectives. Therefore, the loading of DIN and CBOD in agricultural discharges in the Lost River must be reduced by 50 percent on an annual basis to comply with the TMDLs. The means for achieving these load reductions may be decided by the irrigation districts, or land owners or managers responsible for those discharges. Table 7-1 presents recommendations for management practices that could be implemented to comply with the TMDLs, such as implementation of nutrient organic matter management measures that reduce pollutant loads. The effectiveness of landowner implementation on reducing DIN and CBOD levels in the Lost River should be monitored on a larger scale through in-stream trend monitoring. Under adaptive management (see section 7.3), monitoring results can be used to inform the ongoing TMDL implementation planning process, making revisions as necessary to meet TMDL allocations in the appropriate time frame.

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[15] Stream and Wetland Systems Protection Policy
http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/streamandwetlands.shtml.
[16] *Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery* (NRC 2004).

To comply with the state NPS policy, EPA anticipates the North Coast Regional Board will adopt permits (waste discharge requirements [WDRs] or a conditional waiver) for activities associated with irrigated agriculture, including irrigated pastures used for grazing. Such permits would require dischargers, either individually or as a group, to implement management measures and monitor their effectiveness in improving water quality as described above. Conditional waivers for these activities are currently administered by the Central Coast Regional Board and the Central Valley Regional Board. A waiver program for irrigated lands in the Lost River basin would maintain regulatory consistency among irrigated agriculture communities in California and facilitate adequate and timely implementation. This approach would also be consistent with the approach in the Shasta River TMDL implementation, where irrigators are required to submit annual reports on tailwater return flow management actions taken to comply with the wavier adopted as part of the Action Plan for the Shasta River TMDL.

EPA recommends evaluating options in the technical literature for reducing nutrient loads in tailwater entering the Lost River basin. To reduce the amount of nutrients in the Lost River, Danosky and Kaffka (2002) recommended that diversion of water to farming throughout the system be enhanced to re-utilize return flows as inputs to crop production. Such recycling was characterized as an effective way to reduce the nutrients loads in the Lost River waters passing through Klamath Straits Drain to the Klamath River.

Nearly all the water in Tule Lake Refuge (excepting precipitation and runoff), and most of the water in Lower Klamath Refuge is made up of return flows. Investigating and implementing more efficient irrigation practices—including drip irrigation, sprinkler irrigation and other flood irrigation alternatives—should be evaluated, seeking to balance the benefits of reduced nutrient loading in runoff water with potential decreases in return flows to the Tule Lake Refuge, which could decrease surplus for pumping to Lower Klamath Refuge. Efforts to reduce irrigation return flows in the basin through a voluntary demand reduction program should be coordinated with the USBR and USFWS and focus on measures to improve the water quality of return flows.

Surface and Groundwater Use

Comprehensive measurement of water use has been recommended to determine if the amount of water diverted from surface and groundwater in the Lost River basin impacts water quality, and to address potential effects of TMDL implementation measures on water quality and conservation efforts.

An Environmental Assessment (EA) for the development of groundwater production wells to augment the water supply for the Lower Klamath Refuge was conducted in 2001;[17] however, for various reasons, the project has not progressed.

[17] http://www.fws.gov/klamathbasinrefuges/ccp.html

Several U.S. Geological Survey (USGS) reports[18] provide characterization of groundwater for the Klamath River basin, including the area of the Lost River.

- Water quality and habitat in the Lower Klamath Refuge may be negatively impacted by decreasing flows. Groundwater pumping on lands outside of the refuge in the last 50 years has resulted in smaller quantities of water in springs feeding three creeks (Sheepy, Cottonwood, and Willow Creeks) and thus the refuge (USGS 2006).
- Groundwater from the Tule Lake subbasin may flow out toward the Pit River basin. This may mitigate salinity accumulation in Tule Lake, where less than half of inflows are pumped to Lower Klamath Refuge (USGS 2007).

EPA encourages continued groundwater investigation in the region and monitoring of potential salinity accumulation and associated water quality degradation.

Sucker Habitat

Habitat-related beneficial uses are of concern in these TMDLs because of the potential adverse effect of depressed dissolved oxygen and elevated pH levels on shortnose and Lost River suckers. These TMDLs, once implemented, are intended to improve habitat by improving the dissolved oxygen and pH impairments, known to affect the fish during critical periods present during the summer when water temperatures are warm, dissolved oxygen concentrations fluctuate between very low and very high, and pH values are high.

EPA recommends that the North Coast Regional Board and USFWS jointly identify actions that will both improve water quality and facilitate sucker recovery in the basin. In addition EPA recommends continued monitoring of aquatic invertebrates and fish species as indicators of restored water quality and attainment of beneficial uses.

7.2 MONITORING

EPA recommends that a monitoring program to evaluate water quality trends in the Lower Lost River be developed by stakeholders working with the North Coast Regional Board. Additional monitoring is proposed to better characterize water quality in various areas of the Lost River, to track TMDL implementation, monitor progress toward improving water quality, and provide feedback for modifying implementation actions as necessary to ensure that actions are effective and water quality improvements are being accomplished. Such a monitoring program could also facilitate the collection and subsequent use of additional data to further characterize the role of specific contributing factors including nitrogen fixation by blue-green algae, groundwater influences, and natural riverine denitrification.

[18] USGS Oregon Water Science Center Scientific Investigations Report (2006–5036), *An Evaluation and Review of Water-Use Estimates and Flow Data for the Lower Klamath and Tule Lake National Wildlife Refuges, Oregon and California* http://pubs.usgs.gov/sir/2006/5036/ USGS Scientific Investigations Report 2007-5050, Ground-Water Hydrology of the Upper Klamath Basin, Oregon and California. http://pubs.usgs.gov/sir/2007/5050/pdf/sir20075050.pdf

The first step in developing a monitoring program would be to develop a plan that would identify monitoring objectives, parameters to monitor, sampling procedures and techniques, locations of monitoring stations, frequency and duration of sampling, quality control and quality assurance protocols, methods for establishing benchmark conditions where available, measurable milestones and specific timelines for monitoring, data analysis and time frames for reporting and analysis of results.

The monitoring plan should be developed with the objective to generate data adequate for evaluating progress toward achieving the allocations identified in Chapter 6 of this document and the management measures selected from Table 7-1 for implementation of the TMDLs. The monitoring should track the implementation and effectiveness of management measures on an individual landowner scale as well as water quality trends towards meeting the load allocations. The water quality trends should be tracked on the reach level scale as well as the basin-wide scale.

Landowners could be encouraged to organize into local groups to monitor progress towards the TMDL allocations; this approach is currently being used under the Central Valley Regional Board's Irrigated Lands Program. These groups may establish their own monitoring plans, coordinated with their implementation activities, to provide feedback on the effectiveness of implementation. The group monitoring plans could feed into the larger TMDL monitoring effort.

At a minimum, the monitoring plan should answer the following questions (taken from Chapter 6):

- Are the applicable dissolved oxygen and pH water quality targets met at all monitoring locations?
- Have DIN and CBOD loads been reduced by 50 percent or more in comparison with 1999 baseline conditions?

If the follow-up analysis of monitoring data indicate the applicable water quality targets are regularly met, it would be reasonable to conclude the TMDL has been attained. If, however, the necessary 50 percent loading reductions have been attained yet applicable water quality targets are not attained, it may be necessary to review and potentially revise the TMDLs to ensure sufficient pollutant reductions are being identified.

EPA also encourages the North Coast Regional Board to coordinate the Lost River monitoring with the monitoring efforts in the Klamath basin to ensure that water quality parameters relevant to achieving the Klamath River TMDLs are part of the monitoring plan for the Lost River TMDLs. EPA, along with the North Coast Regional Board, is participating in the Klamath basin Water Quality Institute's Monitoring Coordination Group, developing a monitoring plan for the entire Klamath River Basin in California and Oregon. Lost River TMDL compliance could be a stated goal in that monitoring plan and the data collected from that effort used to support the assessment of implementation activities in the Lost River basin and the appropriateness of the TMDL allocations.

7.3 ADAPTIVE MANAGEMENT

Through the recommendations presented above, EPA has proposed mechanisms for implementing water quality improvements. To evaluate if measurable improvements in water quality are being accomplished in the Lower Lost River toward the overall goal of attaining needed LAs and targets, time frames for progress toward and final achievement of TMDLs are necessary. EPA guidance also recommends that the schedule include a time frame within which water quality standards are expected to be met.

As recognized in EPA guidance[19] "[d]etermining the reasonable period of time in which water quality standards will be met is a case-by-case specific determination considering a number of factors including, but not limited to: behavior and ubiquity of pollutants of concern; type of remediation activities necessary; available regulatory and non-regulatory controls; and individual State or Tribal requirements for attainment of water quality standards."

The Lower Lost River system is unique, fragile and known to be highly dynamic; recovery from nutrient loads and inputs could take time. Therefore, a reasonable time frame is recommended for achieving final TMDL LAs, while also identifying an adaptive management approach for implementing the TMDL, with interim targets. This approach provides appropriate check points to assure that actions are resulting in load reductions and that water quality conditions in the basin are improving. Suggested time frames are presented in Table 7-2.

The goal of this proposed schedule is to establish a time frame within which actions for improving water quality will be carried out, monitoring will occur to determine the effectiveness of these actions, and a periodic analysis of the collective effect of the actions and review of TMDL goals will occur. These actions will also be informed by any additional or improved information that might become available. The collected information (including linkages to Oregon TMDLs) would then be used to determine whether the TMDL LAs need to be revised.

Stakeholders are encouraged to work with the North Coast Regional Board in tracking implementation efforts, schedules and report on progress, to ensure water quality improvements are attained.

[19] EPA Great Lakes Water Quality Guidance, Appendix F to 40 CFR part 132 (60 *Federal Register* 15416, March 23, 1995).

Table 7-1. Recommendations for implementation actions

Topic	Appropriate parties	Recommended actions to address nutrient loadings	Outcomes
(1) Development of Nutrient and residue management plans for agricultural lands to minimize agricultural nonpoint source releases	Growers/ Individual Irrigators	Develop "nutrient and residue management plans" to reduce nutrient releases to waters and achieve TMDL LAs. A nutrient and residue management plan assists growers to manage commercial fertilizer and animal manure input costs by planning how growers or a group of growers will manage the amount, source, placement, form and timing of the application of nutrients and soil amendments. It will also help to improve surface water quality. The purposes of a nutrient management plan are to: • supply adequate nutrients for plant production; • properly utilize manure or organic by-products as a plant nutrient source; • minimize agricultural nonpoint source pollution to surface and ground water resources; and • maintain or improve the physical, chemical and biological condition of soil.	Develop nutrient and residue management plans. Collaborate with partners to establish and implement bi-annual trend monitoring plans.
	Tulelake and Klamath Irrigation Districts Natural Resource Conservation Service (NRCS) and Resource Conservation Districts	• Provide guidance and support for development and implementation of nutrient and residue management plans. • Provide assistance and input to work group to establish coordinated trend monitoring plans, and review plans bi-annually for revision. • Provide assistance for implementation of monitoring plan.	
(2) Establish working group to refine implementation recommendations	Stakeholders Neutral third party facilitator UC Intermountain Research and Extension Center	• Facilitate development of a working group to refine implementation recommendations that will result in the achievement of the TMDL LAs. • Promote collaboration with Tribal representatives and other interested partners to establish a Lower Lost River-specific TMDL implementation plan with roles and responsibilities building on the existing recommendations in this document. • Under adaptive management, periodically update implementation plan, incorporating data reflecting progress (e.g., results of trend monitoring).	Facilitate establishment of a working group.
(3) Reduce/revise on-farm fertilizer application	Growers/ Individual Irrigators	• In conjunction with developing nutrient and residue management plans, evaluate methods to reduced fertilizer needs. Appropriate crop nutrition management decisions might include: - Conduct yearly soil sampling to determine plant nutrient needs	Investigate of feasibility of reducing fertilizer needs. Document results fertilizer

Topic	Appropriate parties	Recommended actions to address nutrient loadings	Outcomes
		- Evaluate potential use of other sources that contribute nitrogen and phosphorous to the soil - Evaluate crops/varieties requiring less fertilizer inputs - Apply the appropriate form of nitrogen fertilizer to reduce leaching from and to avoid over-fertilization of target fields - Time the applications to coincide with maximum crop uptake - Calibrate equipment at least annually to ensure that the recommended amount of fertilizer is spread - Use alternative application techniques for optimal fertilizer placement (e.g., subsurface application to the root zone) instead of a surface broadcast fertilizer, to enhance plant nutrient uptake and minimize losses • Document and maintain records of fertilizer use • Collaborate with other parties (e.g., growers, irrigation districts, USBR) to secure access for monitoring efforts • Use monitoring data and fertilizer use records to determine if reductions in application are benefiting water quality	use relative to monitoring results. Develop and facilitate the implementation of water conservation plans that will increase water quality benefits. Document NRCS water conservation activities already underway.
	Tulelake Irrigation District	• Assist growers with developing mechanisms to implement reduction of fertilizer application	
	UC Intermountain Research and Extension Center NRCS and Resource Conservation Districts	• Provide planning support, training and technical support to growers to assist with matching fertilizer applications to crop needs. • Offer training and education on innovative techniques that can minimize the use of fertilizers, while maintaining or increasing yields. • Assist with the development and implementation of on-farm management plans. • Provide guidance to other parties (e.g., growers, irrigation districts, USBR) to establish monitoring to determine if the reduction in fertilizer use results in decreased nutrient loads.	
(4) Irrigation practices to reduce nutrient loads	Growers / Individual Irrigators	Develop water conservation plans including drip and sprinkler irrigation alternatives to flood irrigation: • Identify resources to modify irrigation systems to reduce nutrient leaching and concentrations in the collection and tile drains, and to combat the increase in energy rates. • Research and consider implementation of more efficient irrigation practices including drip and sprinkler irrigation systems to reduce water consumption per acre. Initial capital costs for installation of irrigation systems (including pumps, piping, delivery devices, soil moisture monitoring devices and possibly automated computer controls) can be	Develop and implement water conservation plans and identify opportunities for recycling.

Topic	Appropriate parties	Recommended actions to address nutrient loadings	Outcomes
		relatively high, but could be offset by NRCS EQUIP funds. With several million in EQIP funds spent in the Klamath basin, on irrigation efficiencies, the bulk of water quality benefits may have been achieved. Evaluate additional methods to conserve water that could have ancillary benefits of achieving LAs: • If pre-irrigated, farmers could grow a cereal crop even if water deliveries are cut off during drought years. Juniper control on rangelands may yield additional water. • During years that alfalfa fields are rotated to grain, winter flooding or pre-season irrigation could be used to reduce water demand. • On hay and croplands, upgrade existing irrigation systems and improve irrigation water management to decrease water demand. Subsurface drainage could be added before re-establishing alfalfa stands, permitting better control of water table and soil moisture levels. • Implement mechanisms to measure the effect of water conservation efforts on nutrient LAs.	
	NRCS and Resource Conservation Districts	• Document water conservations activities already taken or underway and identify resources to determine if the conservation activities have lead to improved water quality. • Evaluate water quality benefits of water conservation and distribution of equipment and funds installed post 1999. • Implement before and after monitoring of tile drains to ensure best management practice efficiency. • Continued trend monitoring to illustrate improvements and the effectiveness of sprinkler irrigation. • Evaluate benefits of a voluntary irrigation demand reduction program. • Provide education and planning support on effective water conservation opportunities.	Document conservation activities already underway. Implement conservation outreach.
	Tulelake Irrigation District UC Intermountain Research and Extension Center	Improve Irrigation uniformity • Assist with developing improvements in the manner of flood irrigation and scheduling to ensure better matching of amounts of water delivered to crop needs as a way to reduce nutrient loads. • Conduct pump testing replacing nozzles as needed, to increase energy efficiency of irrigation systems and assist with uniformity. • Provide education, planning and support to improve irrigation uniformity.	Collaborate with operators and resource partners to modify schedules and water usage as necessary.

Topic	Appropriate parties	Recommended actions to address nutrient loadings	Outcomes
(5) Reduce volume of and improve water quality of return flows	Growers/ Individual Irrigators	• Manage irrigation water efficiency by using delivery systems (e.g., lined ditches and gated pipes) and reuse systems (e.g., field drainage recovery ponds) to efficiently capture sediment and nutrient loads. • Conduct assessments of tailwater return flows and water quality. • Identify and promote opportunities to reuse return flows where feasible to improve water quality. • Manage tailwater return flows so that entrained constituents, such as fertilizers, are not discharged to nearby watercourses. This could include modifications to irrigation systems that optimize tailwater reuse (e.g., use of off-stream retention basins, active pumping and/or passive tailwater recapture/ redistribution systems).	Identify resources for opportunities to optimize tailwater recovery and water quality.
	Tulelake Irrigation District	• Assist growers with developing mechanisms to implement reduction of fertilizer application and tailwater return flows.	
	UC Intermountain Research and Extension Center NRCS and Resource Conservation Districts	• Assist with developing recommendations for improved tailwater return flow activities. • Identify resources and establish study opportunities for increased recycling of tailwater onto crop lands, and improving water quality of return flows.	
(6) Aquatic plant removal in canals and open-ditch management	Growers / Individual Irrigators	• Establish methods to reduce the amount of aquatic plant growth in canals. Harvesting, the backbone of aquatic plant management, efficiently manages plants in large areas, removes some nutrients and reduces the need for chemical herbicides. However, machine or hand harvesting requires expensive equipment and harvesters do not remove roots so regrowth and reharvesting is often necessary, sometimes within the same season. • Maximize fertilizer availability for plant growth and reduce adverse surface water quality impacts by focusing efforts to reduce or prevent fertilizers and other chemicals from leaving fields and entering canals/ditches. • Implement other approaches for vegetation management, such as ditch geometry.	Investigate feasibility and benefits of aquatic plant removal.

Topic	Appropriate parties	Recommended actions to address nutrient loadings	Outcomes
	Tulelake Irrigation District	• Evaluate efficiency of installation of the conveyor belt systems to remove excess aquatic plant growth and share lessons learned.	Transfer technology and lessons learned through conveyor belt systems.
	NRCS and Resource Conservation Districts	• Conduct research and educational outreach on practices and resources available for aquatic plant removal, open ditch management and algae removal/management. • Identify resources, determine the effectiveness and establish a plan for open-ditch management.	Facilitate and provide support for aquatic plant removal and open-ditch management strategies.
	Bureau of Reclamation	• Provide assistance with aquatic plant removal. • Develop monitoring to determine if the aquatic plant removal has decreased nutrient loads to help meet TMDL LAs.	Establish monitoring to determine if the algae removal has assisted in achieving TMDL LAs.
(7) Enhanced nutrient removal in the Tule Lake and Lower Klamath Refuge areas	US Fish and Wildlife Service	• Investigate opportunities to expand the Walking Wetlands program beyond the existing acreage in the Refuge. • Determine if the Lower Klamath Refuge could be utilized for water quality treatment. • Document how the two Refuge areas are managed, for example, water temperatures, depth, etc. and investigate ability to modify wetland structure and/or water flow. • Study possibilities to configure water delivery and drainage system in the Lower Klamath Refuge so that existing wetlands satisfy wildlife habitat requirements and are optimally used for water quality treatment. • Increase organic and coop farming in the Tule Lake Refuge, to decrease nutrient loads. In the coop farm, ¼ of the crop is utilized for birds and harvesting and ¾ limited to small grains. • Expand ways to reduce nutrient loads, provide wildlife habitat, and improve sustainability of farming in the Tule Lake Refuge (e.g., use of walking wetlands). • Investigate and identify ways to use existing and future wetlands to provide wildlife habitat and improve water quality with the goal of achieving LAs, as part of the development of the larger Comprehensive Conservation Plan for the Klamath basin • In the Refuge Management Plan, currently under development, the objective of improving water quality toward meeting TMDL allocations. • Continue to evaluate potential for wetlands management activities to improve water quality and pursue activities that will promote denitrification (e.g., monitor wetland enhancement projects within Tule	Increase Walking Wetlands acreage. Evaluate waterfowl discharge and determine applicability of National Wildlife Refuge areas for water quality treatment. Explore opportunities for monitoring water quality treatment in the Lower Klamath Refuge.

Topic	Appropriate parties	Recommended actions to address nutrient loadings	Outcomes
		Lake Refuge to determine impact on nutrient loads). • Promote fertilizer management plans on leased lands to achieve TMDL LAs. • Explore opportunities to recycle water (and nutrients) in the Refuge areas.	
	Tulelake Irrigation District UC Intermountain Research and Extension Center	• Seek opportunities to create new wetlands to reduce nutrient loadings in the Lost River. • Determine whether techniques such as walking wetlands have applicability on private lands. • Evaluate and determine what changes in configurations, if any, could be made to enhance denitrification in the Tule Lake Refuge. • Evaluate percent of nutrient contributions to Refuge loads from waterfowl excrement. EPA's BASINS analysis software could be used to estimate source contributions for internal nutrient loading[a].	
(8) Management of Agricultural Practices	UC Intermountain Research and Extension Center	• Encourage use of BMPs and development of generic nutrient and residue management plans.	Develop revised experimental lease language.
	US Fish and Wildlife Service (for leased lands)	• Promote use BMPs and development of nutrient and residue management plans. • Establish language in leases to achieve TMDL LAs on an experimental or demonstration basis on leased lands, similar to the pesticide residue analysis already underway.	
(9) Monitoring & Evaluation	Bureau of Reclamation	• Establish basin-wide water quality monitoring program with trend monitoring stations to: - determine water quality improvements and progress towards achieving LAs; - better understand and quantify contributions from phytoplankton species, including AFA; - include monitoring of aquatic invertebrates and fish species (e.g., suckers) as indicators of restored water quality and attainment of beneficial uses; and - better characterize water quality in Tule Lake and Lower Klamath Refuges. • Monitor water use, distinguishing between surface and groundwater resources used. • Work with growers, individual irrigators and other interested parties to gain permission for access, as needed to collect monitoring data.	Develop monitoring plan and implement trend monitoring.

Topic	Appropriate parties	Recommended actions to address nutrient loadings	Outcomes
		• Issue annual monitoring data reports. • Collaborate with workgroup to identify monitoring resources/funding and establish efficient methods to achieve TMDL LAs. • Evaluate benefits of further characterizing contributions to internal loading (e.g., waterfowl contributions) and to improve characterization of water quality in sumps and drain inputs.	
(10) Water Treatment and Recycling	Bureau of Reclamation	• Study methods to treat or reuse/recycle agricultural return flows from the Klamath Project service area. • Investigate whether more reuse/recycling will assist in achieving TMDL LAs. • Evaluate the Klamath Project operations for possibly water quality improvements, such as through water reuse in the Lost River together with other water management actions, to achieve TMDL allocations for the Oregon Lost River and Klamath River TMDLs.	Research feasibility of irrigation water reuse/recycling and/or treatment.

Topic	Appropriate parties	Recommended actions to address nutrient loadings	Outcomes
(11) Memoranda of Understanding	North Coast Regional Board and ODEQ	State water quality agencies outline a bi-state coordinated effort to achieve TMDL LAs.	Establish MOU.
	EPA USBR USFWS	Federal agencies with jurisdiction in the Lost River basin to outline appropriate roles and responsibilities, and identify joint funding for monitoring, to achieve TMDL LAs.	
(12) Agricultural Waivers, WDR and/or prohibitions for agricultural operations	North Coast Regional Board	• The statewide non-point source policy states that all current and proposed discharges must be regulated under waste discharge requirements or waivers. In 1999 the state was tasked with reviewing and either renewing Irrigated Agriculture runoff waivers or replacing them with waste discharge requirements. The amendment requires the State's enforcement of conditions in waivers and the re-adoption of waivers every five years. Then in 2003 the State Board was tasked with establishing fees for waivers. The North Coast Regional Board has no immediate plans to adopt generic agricultural waivers, but may do so to implement TMDLs. • Utilize recommendations in this implementation plan as a framework for specific waivers when implementing waiver provisions. • Assess implementation progress when establishing a framework for the agricultural waivers. • Collaborate with other state and federal partners and stakeholders to develop an inclusive monitoring plan to achieve TMDL LAs and ensure monitoring plans for the Lower Lost River discharges are established and implemented. • Publicize grant funding opportunities for implementation activities.	Collaborate with other state and federal partners and stakeholders to develop an inclusive monitoring plan to achieve TMDL LAs. Ensure monitoring plans for the Lower Lost River discharges are established and implemented.

[a]BASINS (Better Assessment Science Integrating Point & Nonpoint Sources) analysis software is available at http://www.epa.gov/waterscience/basins/

Table 7-2. Suggested timeline for implementation recommendations

Appropriate parties	Year 1–2: 2009–2010
EPA and North Coast Regional Board	• Consider non-regulatory measures including development of memorandum of understanding with implementing organizations and possible incentives to control waste discharges and conduct watershed restoration activities. • Convene and participate in working group, as appropriate, to refine implementation plan.
North Coast Regional Board and ODEQ	• Evaluate a bi-state coordinated effort to implement TMDL actions.
Klamath Water Users Association	• Participate in working group to refine implementation recommendations contained in this document.
Growers / Individual Irrigators NRCS and Resource Conservation Districts	• Collaborate to develop nutrient and residue management plans to achieve TMDL LAs.
Tulelake Irrigation District	• Transfer technology and lessons learned through conveyor belt system for aquatic plant removal.
Growers / Individual Irrigators NRCS and Resource Conservation Districts UC Intermountain Research and Extension Center	• Investigate and document results of feasibility for reduced fertilizer needs. • Identify resources and establish study opportunities for tailwater recovery. • Develop and implement water conservation plans that will increase water quality benefits. • Document NRCS water conservation activities already underway. • Implement water conservation outreach.
USBR	• Develop trend monitoring plan with input from partners, which considers filling gaps in current data and for ensuring progress with implementation measures. • Identify resources for monitoring with assistance from various partners. • Implement monitoring in areas where water quality improvements are expected due to post 2001 water conservation activities. • Investigate feasibility of treatment and/or recycling of irrigation return flows from Project Area.
USFWS	• Identify actions to improve water quality as part of the development of the Refuge Comprehensive Conservation Plan and Refuge Management Plan
EPA, USFWS, USBR	• Establish a Memoranda of Understanding to implement TMDL actions.

Appropriate parties	Years 3-5: 2011-2013
Workgroup	Collaborate with interested partners and establish a Lower Lost River-specific TMDL implementation plan with roles and responsibilities building on the existing recommendations in this document
All appropriate parties	Start implementation actions.
Growers / Individual Irrigators	Establish and implement improved irrigation systems.
Growers / Individual Irrigators UC Intermountain Research and Extension Center Natural Resource Conservations Districts	Investigate studying impacts from return flows and appropriate measures to enhance water quality of return flows.
Tulelake Irrigation District UC Intermountain Research and Extension Center	Collaborate with operators and resource partners to modify schedules and water usage as necessary.
USBR	• Prepare bi-annual monitoring reports evaluating if aquatic plant removal and other recommended actions have assisted in achieving TMDL LAs. • Pursue funding for implementation of feasible treatment or recycling options.
USFWS	• Evaluate waterfowl discharge and determine applicability of Refuge areas for water quality treatment. • Increase walking wetlands acreage. • Explore opportunities for water quality treatment in the Lower Klamath Refuge.
	Years 6-8: 2014-2016
USBR, USFWS, Klamath Water Users Association and all appropriate parties	• Report on implementation actions and monitoring results. • Evaluate and refine implementation actions. • Evaluate and refine time frames for achieving LAs based on effectiveness of implementation actions, feasibility, and new scientific information.
	Years 9-11: 2017-2019
USBR, USFWS, Klamath Water Users Association and all appropriate parties	Document achievement of TMDL LAs through monitoring results (note: this is an initial estimate of time needed to meet LAs and could be changed based on evaluations conducted in years 6-8.

7.4 POTENTIAL FUNDING SOURCES

This section discusses potential federal and state sources of funding that might be available to assist in implementation of control actions.

Natural Resources Conservation Service

The Environmental Quality Incentives Program (EQIP), administered by the NRCS, was reauthorized in the Farm Security and Rural Investment Act of 2002 (Farm Bill) to provide a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land. EQIP offers contracts with a minimum term that ends one year after the implementation of the last scheduled practices and a maximum term of ten years. These contracts provide incentive payments and cost-shares to implement conservation practices. Persons who are engaged in livestock or agricultural production on eligible land may participate in the EQIP program. EQIP activities are carried out according to an environmental quality incentives program plan of operations developed in conjunction with the producer that identifies the appropriate conservation practice or practices to address the resource concerns. The practices are subject to NRCS technical standards adapted for local conditions. The local conservation district approves the plan. EQIP may cost-share up to 75 percent of the costs of certain conservation practices. Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive. For more information, see http://www.nrcs.usda.gov/programs/eqip/

State Water Resources Control Board/Regional Water Quality Control Board

The Water Boards provide funding from State Bonds and the federal CWA to address nonpoint source water quality problems. Some of these funds have been specifically focused on addressing concerns related to irrigated agricultural lands and supporting related water quality monitoring. Most funds give priority consideration to TMDL waterbodies. The funds are available to eligible applicants (e.g., RCDs, local government, non-profit organizations, etc.) to implement projects that reduce the discharge of pollutants and to address California's need for water quality monitoring, which will further assist to define and identify the source of water quality problems. The funding amounts vary from year to year. The funding is typically available yearly; however, the next Request for Proposals (RFP) is not likely to be released until Fall 2009. EPA encourages applicants for CWA section 319 funds to work together with Farm Bill funding. In addition, section 319 funds must be used for projects implementing TMDLs and watershed plans, which include the following:

- Explicit short- and long-term goals, objectives and strategies to protect surface and groundwater
- Strong working partnerships and collaboration with appropriate state, interstate, tribal, regional, and local entities (including conservation districts), private sector groups, citizens groups, and federal agencies

- A balanced approach that emphasizes nonpoint source solutions and on the ground management of the watershed where waters are impaired or threatened
- Abate known water quality impairments resulting from nonpoint source pollution and prevent significant threats to water quality from present and future activities
- An identification of waters and watersheds impaired or threatened by nonpoint source pollution and a process to progressively address these waters
- Review, upgrade and implement program components required by section 319 of the CWA and establish flexible, targeted, iterative approaches to achieve and maintain beneficial uses of water as expeditiously as practicable
- An identification of objectives which are not managed consistently with state program objectives
- Efficient and effective management and implementation of nonpoint source programs in the watershed, including necessary financial management
- A feed back loop whereby there are reviews, evaluations and revisions to nonpoint source assessments and management programs at least every five years

For more information, see http://www.waterboards.ca.gov/water_issues/programs/grants_loans/#request.

U.S. Environmental Protection Agency

EPA's Wetland Program Development Cooperative Agreements and Grants are for states, tribes and local governments to aid in developing wetland protection programs. The program requires a 25 percent nonfederal match and funds can be used to build and refine any element of a comprehensive wetland program, with priority given to developing a comprehensive monitoring and assessment program, improving the effectiveness of compensatory mitigation and refining the protection of vulnerable wetlands and aquatic resources. For more information, see http://www.epa.gov/owow/wetlands/grantguidelines/

EPA's Wetlands, Oceans, and Watersheds provides technical tools for watershed management to EPA regions, states, local governments and their contractors to provide access to technically defensible approaches that can be used in the development of TMDLs, WLAs, and watershed protection plans. See http://www.epa.gov/owow/watershed/tools/. Additionally, EPA's Council for Regulatory Environmental Modeling (CREM) was established in 2000 to promote consistency and consensus among environmental model developers and users. See http://epa.gov/crem/.

EPA provides funding through the establishment of a State Revolving Fund (SRF) loan program. The program is funded by federal grants, state funds, and revenue bonds. The purpose of the SRF loan program is to implement the CWA and various state laws by providing financial assistance for the construction of facilities or implementation of measures necessary to address water quality problems and to prevent pollution of the waters of the state. The SRF loan program provides low-interest loan funding for construction of publicly-owned wastewater treatment facilities, local sewers, sewer interceptors, water reclamation facilities, as well as, expanded use projects such as implementation of nonpoint source projects or programs, development and implementation of estuary Comprehensive Conservation and Management Plans, and storm water treatment. See http://www.waterboards.ca.gov/water_issues/programs/grants_loans/srf/.

The Volunteer Monitoring Program helps volunteer water monitors build awareness of pollution problems and increase the amount of water quality information available to decision-makers at all levels of government. See http://yosemite.epa.gov/water/volmon.nsf.

U.S. Bureau of Reclamation

The USBR's Hydraulic Investigations and Laboratory Services Group performs research to improve USBR efforts including fish protection/screening, fish passage, reservoir release water quality, river restoration and wetlands. See www.usbr.gov/pmts/hydraulics_lab.

U.S. Geological Survey

USGS National Water Information System (NWIS) provides water data, including real time water data, surface water flow measurements and water quality measurements. USGS is available to support development of TMDLs. See the following websites: http://water.usgs.gov/pubs/fs/FS-130-01, http://waterdata.usgs.gov/nwis, and http://water.usgs.gov/nawqa.

U.S. Fish and Wildlife Service

USFWS's Partners for Fish and Wildlife provides technical and financial assistance for habitat restoration projects on lands not owned by a state or federal government to provide watershed management, conservation easements and river restoration in cooperation with voluntary landowners. USFWS develops a cost-sharing agreement with the partner typically 50 percent is required and funding provided after completion of the project. Technical assistance is also available. See www.fws.gov/partners.

CHAPTER 8: PUBLIC PARTICIPATION

EPA offered several opportunities for interested stakeholders to participate in TMDL development for the Lower Lost River. EPA defines *stakeholders* as community members, other agencies, tribes, environmental groups, community and business organizations, landowners and others with interest in the watershed. Continued stakeholder involvement is important to this project to ensure pertinent information about the Lost River is shared and to ensure that interested stakeholders have an opportunity to identify, address, and receive information about Lower Lost River projects as related to the TMDL implementation.

In February and March 2004, the North Coast Regional Board, ODEQ, and EPA Regions 9 and 10 held joint public meetings, signifying the beginning of the collaborative TMDL effort, on the development of both the Klamath and Lost River TMDLs. Meetings were held in Yreka, California; Klamath Falls, Oregon; and Fortuna, California. EPA also held a series of informational meetings on the Lost River TMDLs in June 2006 and September 2006 to provide an opportunity for various stakeholders to understand and respond to EPA's role in the TMDL development and recommendations for the Lower Lost River Implementation Plan. EPA scheduled targeted outreach meetings with stakeholder groups such as the TID, Resource Conservations Districts, University of California Extension Service, Klamath Water Users Association and individual farmers.

EPA provided a formal comment period for the public to review the draft Lost River TMDLs. EPA released the Draft Lost River TMDL document for public review on March 15, 2007, for a 90-day public review period closing on June 15, 2007; the public review period was subsequently extended until July 6, 2007. EPA published a Public Notice about the availability of the Draft TMDL document in the March 15, 2007, edition of the *Klamath Falls Herald and News*, and distributed the Public Notice electronically and by mail. The Draft TMDL document, supporting documents and the Public Notice were also made available on EPA's Web site. EPA held a public meeting on June 25, 2007,[20] in Tulelake for interested parties to learn more about the proposed TMDLs and to facilitate the public commenting on the Draft TMDL document.

Stakeholders' Roles and Responsibilities

- EPA Region 9 has worked with EPA Region 10, ODEQ, and the North Coast Regional Board to coordinate the development of TMDLs for the Lost River, as well as for the related Klamath River TMDLs. EPA will monitor the progress of the TMDL implementation actions and continue to work with the North Coast Regional Board to achieve compliance.
- North Coast Regional Board will, at some future date, consider incorporating the Lost River TMDLs into the North Coast Basin Plan. At that time, North Coast Regional Board staff may propose modifications to EPA's TMDLs as necessary to

[20] The meeting was originally scheduled for June 6, 2007, but was subsequently rescheduled for June 25, 2007.

account for new information. The North Coast Regional Board will provide opportunities for public comment for any proposed revisions to the TMDLs at that time. There are several mechanisms available to the state to implement the actions necessary to meet a TMDL. These mechanisms include non-regulatory actions, such as third-party agreements and self-determined pollutant control; a Memorandum of Understanding to describe the specific regulatory actions to be taken; and regulatory actions such as a permit, waiver, or an enforcement order.

- ODEQ will collaborate with the North Coast Regional Board and EPA to ensure that Lost River waters entering California will meet the specified objectives of the TMDL to meet the load allocations of 50 percent reductions from 1999 baseline conditions. ODEQ is developing TMDLs for the Lost River in Oregon concurrently with the TMDLs for Klamath River to be completed in 2009.
- TID was established in 1956 when homesteaders organized under California law to manage parts of the Klamath Project that service their farms. Today, the district provides water through 37 pumping plants to more than 63,000 acres and approximately 600 growers.
- KID is tasked with promoting the protection and use of water rights and the wise stewardship of water resources in Oregon. The District will work with ODEQ and the North Coast Regional Board to ensure that water crossing the California border meets the specified objectives of the TMDLs.
- USBR’s Klamath Basin Area Office employs 30 staff who assist in the management of the Klamath Project, a federal storage project built in the early 1900s to provide irrigation for about 240,000 acres. More than 1,400 miles of canals and drains provide service to water users in the Klamath and Lost River watersheds. In addition, four national wildlife refuges also receive water and are adjacent to or within the service area. Project facilities operated by the USBR include Klamath Straits Drain.
- USFWS owns and operates the Tule Lake and Lower Klamath Refuges. USFWS manages these refuges to enhance wildlife and to support the local agricultural economy that is dependent upon refuge lands. USFWS and USBR have signed an agreement under which they coordinate agricultural and water management programs.

The following organizations are available to assist growers, individual irrigators, landowners and operators who are responsible for recommended implementation actions on fields to develop and devise plans for achievement.

- Klamath Water Users Association (KWUA) represents private rural and suburban irrigation districts and ditch companies within the Klamath Project, along with private irrigation interests outside the project in both Oregon and California in the Upper Klamath basin. KWUA is governed by a board of directors elected from supporting irrigation districts, private irrigation interests, and the business community and represents more than 5,000 water users on 1,400 family farms.
- Natural Resource Conservation Service (NRCS) is providing technical assistance under an adaptive management strategy through various Farm Bill programs. NRCS

technical standards, quality criteria, and planning policies are designed to ensure effective on-farm practices and to provide the necessary resources to address agricultural concerns. Rapid subbasin assessments provide information that will assist in prioritizing the application of conservation practices in the basin recognizing the need to evaluate cumulative impacts beyond the farm boundaries and to determine the extent that their conservation activities effectively address basin-wide resource issues such as water quality. NRCS recognized the cumulative impact analysis needs to be done in partnership with organizations and groups in the basin.

- Resource Conservation Districts can assist growers/individual irrigators to develop and implement management practices that minimize, control, and prevent discharges of nutrients into the Lower Lost River and assist to develop and implement monitoring plans to evaluate and document implementation and effectiveness of actions executed.
- The University of California (UC) Tulelake Research and Extension Center in the Klamath Basin just 4 miles south of the Oregon border, has been a vital local link to UC's scientific resources and supports UC research in field and vegetable crops and resource.
- Environmental Organizations: Pacific Coast Federation of Fishermen's Associations, Environmental Protection Information Center, Klamath Riverkeeper and Endangered Species Groups

As mentioned above, EPA provided a formal comment period for the public to review the draft Lost River TMDLs. EPA received written comments from sixteen entities during the comment period (March 15–July 6, 2007). EPA considered comments received during the comment period and made revisions to this document, as appropriate, based on those comments. EPA has prepared a Response to Comments document articulating its response to written comments on the March 2007 Public Review Draft TMDLs; that document is available on EPA's Web site: http://www.epa.gov/region09/water/tmdl/final.html

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Appendix A
Lost River Model and TMDL Development.
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This document is also available at http://www.epa.gov/region09/water/tmdl/lost-river/model-report-8-29-2005.pdf.