CHAPTER 5. KLAMATH RIVER TMDLs – ALLOCATIONS and NUMERIC TARGETS

5.1 Introduction

This chapter presents the numeric targets, loading capacity, and load and waste load allocations for the Klamath River in California. This chapter consists of three sections. Section 5.1 describes the numeric targets, loading capacity, load and waste load allocations, and margin of safety associated with the temperature, dissolved oxygen, and nutrient-related water quality impairments of the Klamath River in California. Section 5.2 presents the specific temperature-related numeric targets, and load and waste load allocations for the Klamath River by river reach and associated source areas. Section 5.3 presents the specific dissolved oxygen and nutrient-related numeric targets, and load and waste load allocations for the Klamath River by river reach and associated source areas. Table 5.1 summarizes the temperature, dissolved oxygen, and nutrient-related numeric targets and allocations.

5.1.1 Numeric Targets

Numeric targets are the numeric water quality conditions that represent attainment of the water quality standards. Numeric targets serve as the goal post from which TMDLs and associated load and waste load allocations are developed. Numeric targets refer to the desired water quality conditions, and serve as good indicators of progress towards TMDL compliance and beneficial use support. In some cases numeric targets can equal a numeric water quality objective. In other cases, numeric targets are a numeric interpretation of the conditions that meet a narrative water quality objective. Numeric targets are typically instream water quality measures, but in some cases are measures of landscape conditions that effect instream water quality conditions. Targets are set at levels associated with well-functioning stream systems. In all cases numeric targets are used in the calculation of a TMDL.

5.1.1.1 Temperature Numeric Targets

The primary temperature numeric targets for the Klamath River temperature TMDL are monthly average temperatures calculated from the estimated natural temperature regime of the Klamath River, and are presented in Section 5.2. In addition, secondary targets are established for riparian shade and sediment related channel alteration, also presented in Section 5.2. The riparian shade targets are expressed as effective shade, which is a measure of the percentage of total daily direct beam solar radiation that is blocked by vegetation or topography before reaching the ground or stream surface, and takes into account the differences in solar intensity that occur throughout a day. Instream and watershed targets are established associated with sediment related channel alteration.

The instream target associated with *Substantial Human-Caused Sediment-Related Channel Alteration* is:

0 miles of substantial human-caused sediment-related channel alteration.

Table 5.1: Summary of Klamath River TMDLs Numeric Targets and Allocations

Location	Parameter	Target	Allocation
Watershed-wide	Temperature	Riparian Shade: site-potential effective shade. Effective shade is a measure of the percentage of total daily direct beam solar radiation that is blocked by vegetation or topography before reaching the ground or stream surface, and takes into account the differences in solar intensity that occur throughout a day (Approximated in Figures 5.4, 5.5, and 5.6) Instream Target: 0 miles of substantial human-caused sediment-related channel alteration <1% of all road-stream crossings divert or fail as a result of a 100-year or smaller flood Decreasing trend of road related landslides	Riparian Shade: the shade provided by topography and full potential vegetation conditions at a site, with an allowance for natural disturbances such as floods, wind throw, disease, landslides, and fire Human-caused discharges of sediment: zero temperature increase caused by substantial human-caused sediment-related channel alteration
Stateline	Temperature	Estimated natural temperature, expressed as monthly average (See Table 5.5)	Zero increase above natural temperature
	Dissolved Oxygen	Dissolved oxygen concentrations at 85% saturation under natural temperature conditions expressed as monthly average and monthly minimum concentrations (See Table 5.9)	N/A
	Nutrients/ Organic Matter	N/A	Allocations to TN, TP, and CBOD expressed as monthly average concentrations (See Table 5.10)
Reservoirs	Temperature /Dissolved Oxygen	Overlapping temperature and dissolved oxygen conditions within layers in Copco 1 and 2 and Iron Gate Reservoir, where dissolved oxygen = 85% saturation and temperature = natural (~18.7 ^{o} C) during summer (May - October)	Temperature and dissolved oxygen "Compliance Lens": dissolved oxygen instantaneous mass in Copco = 32,398 lbs; dissolved oxygen instantaneous mass in Iron Gate = 47,624 lbs
	Nutrients/ Organic Matter	TP, TN, and CBOD concentrations expressed as monthly means at mid-point reservoir locations (Table 5.13) and reservoir tailraces (Table 5.12) Chlorophyll-a – growing season average of 10 µg/L *Microcystis aeruginosa* cell density $\leq$ 50% of the blue-green algae biomass, or $\leq$ 20,000 cells/L (which ever is lower) Microcystin toxin < 4 µg/L	Zero nutrient loading from reservoir bottom sediments
	Temperature	Estimated natural temperature at reservoir tailrace – expressed as monthly average temperature (See Table 5.6)	Temperature increase expected to naturally occur in the river reach occupied by the reservoirs (See Table 5.7)
	Dissolved Oxygen	DO concentrations at 85% saturation at reservoir tailraces expressed as monthly mean and minimum (See Table 5.11)	N/A
Iron Gate Hatchery	Temperature	Expressed as monthly average temperatures at Iron Gate Hatchery discharge (See Table 5.8)	Zero increase above natural temperature
	Dissolved Oxygen	Expressed as monthly mean and minimum dissolved oxygen concentrations at Iron Gate Hatchery discharge (See Table 5.14)	N/A
	Nutrients/ Organic Matter	TP, TN, and CBOD concentrations expressed as monthly mean concentrations at Iron Gate Hatchery discharge (See Table 5.15)	Zero net increase of nutrient and organic matter loads between influent water (intake) and effluent (discharge).
Tributaries	Dissolved Oxygen	Expressed as monthly mean and minimum concentrations equal to 85% saturation below Salmon River (See Table 5.16)	N/A
	Nutrients/ Organic Matter	Expressed as monthly mean concentrations of TP, TN, and CBOD below the Salmon River (Table 5.17) Reach-averaged maximum density of 150 mg of chlorophyll-a /m^2 below the Salmon River	Zero increase above natural nutrient and organic matter concentrations. TN, TP, and CBOD concentrations expressed as monthly mean concentrations (See Table 5.18 and 5.19)

The watershed target for *Stream Crossings with Diversion Potential or Significant Failure Potential* is:

> <1% of all stream crossings divert or fail as a result of a 100-year or smaller flood.

The watershed target associated with *Road-Related Landslides* is:

> Decreasing trend.

5.1.1.2 Dissolved Oxygen and Nutrient-Related Numeric Targets
The numeric DO targets are monthly average and monthly minimum DO concentrations calculated at 85% DO saturation under natural temperatures, and are presented in Section 5.3. Numeric targets are also established for nutrients (TN and TP) and organic matter (CBOD) for the reservoirs, and are expressed as monthly average concentrations in Section 5.3. Additional numeric targets are established to reflect compliance with the narrative biostimulatory substances and toxicity objectives. These additional numeric targets are set for suspended algae chlorophyll-a, benthic algae biomass, *Microcystis aeruginosa* cell density, and microsystin concentration. The suspended algae chlorophyll-a numeric target is 10 µg/L. The benthic algae biomass numeric target is 150 mg chlorophyll-a / m^2. The targets for *Microcystis aeruginosa* and microsystin are 20,000 cells/mL and 4 µg/L, respectively.

5.1.2 Loading Capacity, Allocations, and Margin of Safety

The *loading capacity* refers to total amount of pollutant loads that a waterbody can receive and meet water quality standards. In order to achieve the loading capacity (i.e. the Total Maximum Daily Load [TMDL]), allocations are attributed to the natural background, non-point sources, and point sources of the applicable pollutants. *Waste load allocations* are contributions of a pollutant from permitted point sources while *load allocations* are contributions from management-related non-point sources.

The starting point for the load allocation analysis is the equation that describes the Total Maximum Daily Load or loading capacity:

$$\text{TMDL} = \text{Loading Capacity} = \Sigma\text{WLAs} + \Sigma\text{LAs} + \text{Natural Background} + \text{MOS}$$

where Σ = the sum, WLAs = waste load allocations, LAs = load allocations, and MOS = margin of safety.

A margin of safety in a TMDL is required in the Clean Water Act to account for uncertainty and to assure that the TMDL will achieve water quality standards. The Clean Water Act directs states to develop a margin of safety “which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality.” TMDLs can be developed with explicit and/or implicit margins of safety. An explicit margin of safety is established by withholding an explicit fraction of the loading capacity available for allocation. An implicit margin of safety is established by incorporating conservative assumptions in the calculation of the loading capacity.

5.1.2.1 Temperature Loading Capacity, Allocations, and Margin of Safety

For the temperature TMDL, two separate water quality objectives apply, as described in Section 2.2.1.2. The temperature objective for *interstate* waters prohibits the discharge of elevated temperature waste, whereas the *intrastate* temperature objective states that temperatures must be maintained as natural, unless a proposed increase is less than 5 ^{o}F and doesn't adversely impact the beneficial use. Because water temperatures in Klamath basin streams already adversely affect the beneficial uses during critical time periods, the natural receiving water condition becomes the temperature objective.

The loading capacity provides a reference for calculating the amount of pollutant load reduction required to bring a water body into compliance with standards. Because the applicable objectives do not allow for the discharge of elevated temperature waste, or increases in water temperature, the temperature loading capacity equals the natural receiving water condition, and in turn no increase is permissible and all sources are allocated a temperature load of zero.

The Klamath River watershed temperature TMDL addresses the heat loads that arise from seven sources:

1. Conditions of Klamath River water crossing the Oregon-California border.
2. Thermal discharges from Copco 2 and Iron Gate dams.
3. The impoundment of water in the reservoirs.
4. Temperature effects of Iron Gate Hatchery.
5. Temperature effects of major tributaries on Klamath River temperatures.
6. Effects of excess solar radiation.
7. Effects of excess sediment loads.

The TMDL equation for temperature is:

Temperature TMDL = Loading Capacity = ΣWLAs + ΣLAs + Natural Background + MOS

The Klamath River temperature TMDL for California relies on an implicit *margin of safety*. As stated in Section 2.2.1.2, the intrastate Water Quality Objective for Temperature allows for temperature increases of up to 2.8 ^{o}C (5 ^{o}F) if beneficial uses of water are not adversely affected. For most of the year the Klamath River is too hot to accommodate more heat without beneficial uses of water being adversely affected. There are periods in the winter and spring months, however, when temperatures increases of 2.8 ^{o}C (5 ^{o}F) or less may occur without beneficial uses of water being adversely affected. The timing of those periods changes from year to year and is difficult to predict. Therefore, this TMDL takes a conservative approach, allocating no temperature increases year-round. This conservative approach constitutes an implicit *margin of safety*.

Substitution of the allocations results in the following temperature TMDL for the Klamath River watershed in California:

Temperature TMDL = Loading Capacity
= 0 increase above natural background
= 0 anthropogenic heat load at Stateline
+ 0 heat load discharged from Copco 2 and Iron Gate Reservoirs
+ 0 heat load discharge from Iron Gate Hatchery
+ 0 heat load from excess solar radiation
+ 0 heat load from anthropogenic sediment loads
+ natural background.
= natural background

Section 5.2 details the load and waste load allocations for these sources.

5.1.2.2 Dissolved Oxygen, Nutrient and Organic Matter Loading Capacity, Allocations, and Margin of Safety

The TMDLs addressing dissolved oxygen and nutrient-related water quality impairments are closely interrelated because of the strong relationship between biostimulatory conditions, decomposition of organic matter, and resulting dissolved oxygen conditions. The DO targets are the primary driver in establishing the nutrient and organic matter loading capacity for the Klamath River in California. Allocations for nutrients (TN and TP) and organic matter (CBOD)[1,2] were set to ensure that Basin Plan dissolved oxygen objectives[3] are met. In addition, the numeric targets set for suspended algae chlorophyll-a, benthic algae biomass, *Microcystis aeruginosa* cell density, and microsystin concentration also influenced the calculation of the loading capacity for nutrients and organic matter.

The loading capacity and associated load and waste load allocations for total phosphorus (TP), total nitrogen (TN), and organic matter (CBOD) for the Klamath River in California are presented in Figures 5.1, 5.2, and 5.3, respectively. These figures present

[1] The Monitoring Plan (Chapter 7) specifies analytic methods for evaluation of compliance with TMDL allocations and numeric targets for nutrients and organic matter.
[2] The allocations for organic matter are expressed as CBOD, and refer to CBOD- ultimate. The water quality models represent CBOD as organic matter; it is converted to CBOD-ultimate for TMDL allocation calculations.
[3] The Regional Water Quality Control Board will consider a proposal to update the salmonid life cycle requirements contained in the Basin Plan for dissolved oxygen (DO) to include 7-day moving averages of the daily mean as an augmentation of the existing daily minimum objectives (e.g., 8.0 mg/L in the water column throughout the year and 8.0 mg/L in spawning gravels during spawning and early development). In addition, it will consider the inclusion of a "natural conditions clause" to replace most Basin Plan Table 3-1 site specific DO minima with an alternate method for establishing site-specific background conditions using percent saturation and natural temperatures (e.g., 85% DO saturation calculated using natural temperatures and applied as daily minima) in those waterbodies where salmonid life cycles requirements can not be achieved due to natural conditions. In any event, a 6.0 mg/L daily minimum will apply.

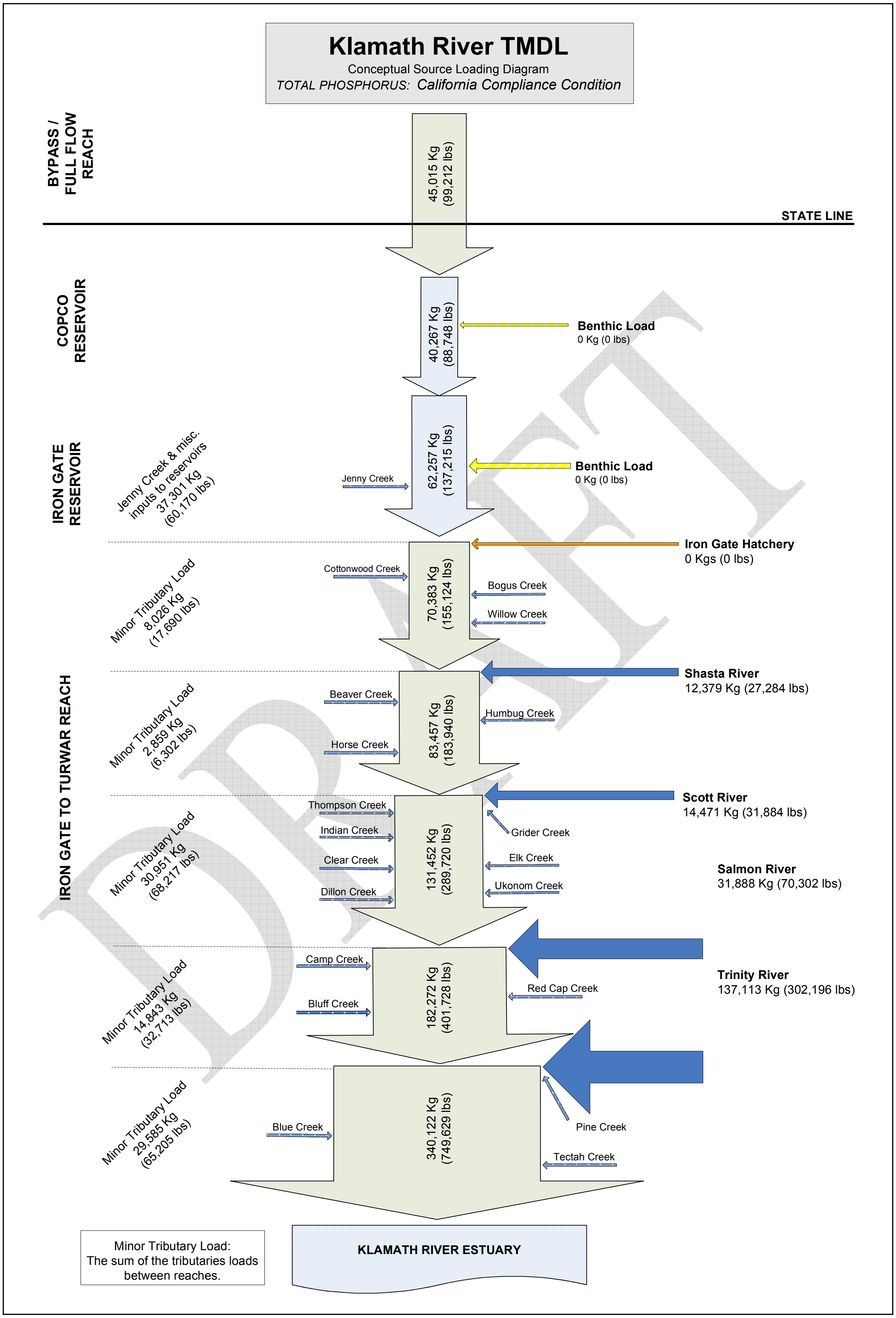

Figure 5.1: Total Phosphorous Loading Capacity and Allocations for the Klamath River Consistent with Assimilative Capacity and Beneficial Use Support.

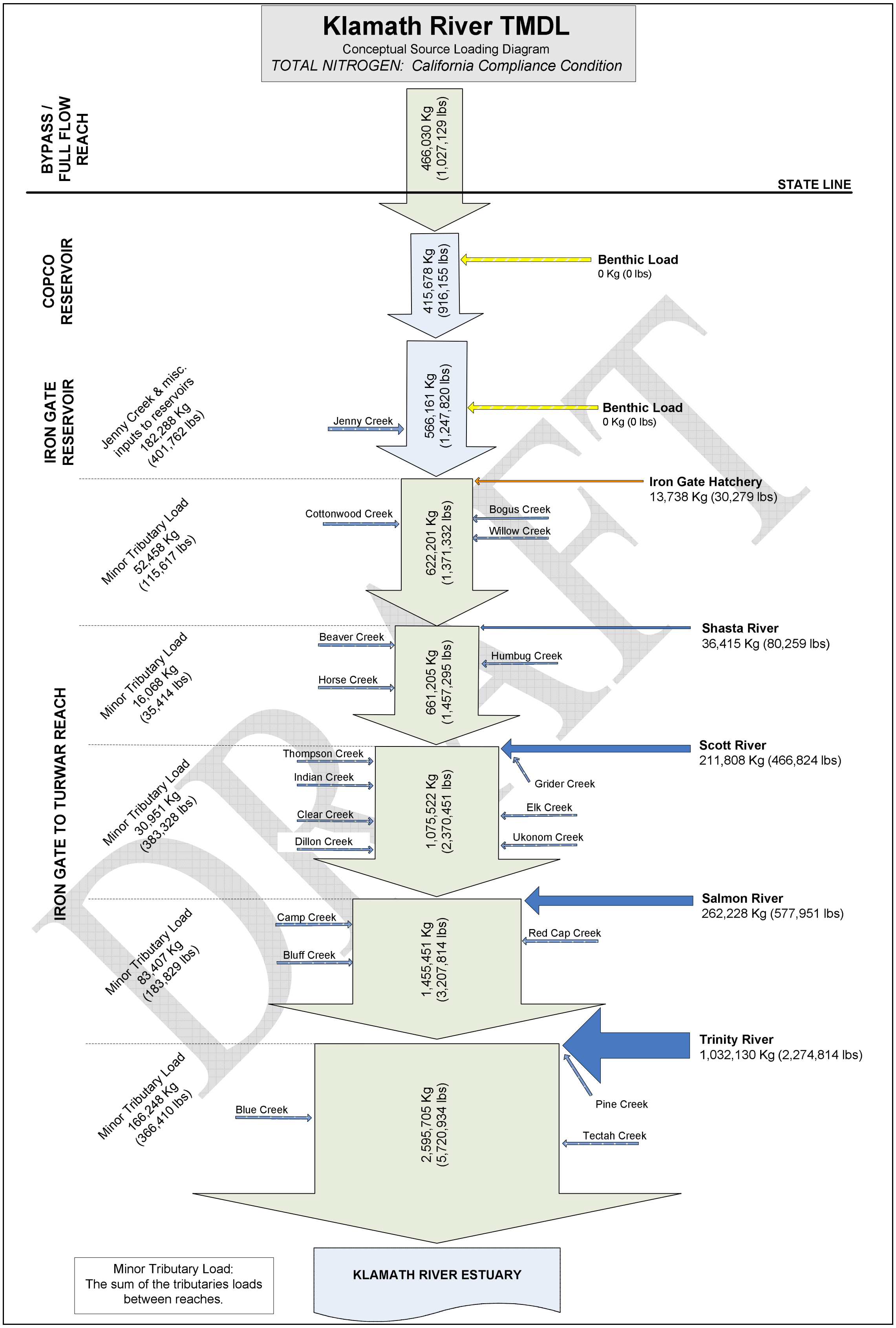

Figure 5.2: Total Nitrogen Loading Capacity and Allocations for the Klamath River Consistent with Assimilative Capacity and Beneficial Use Support.

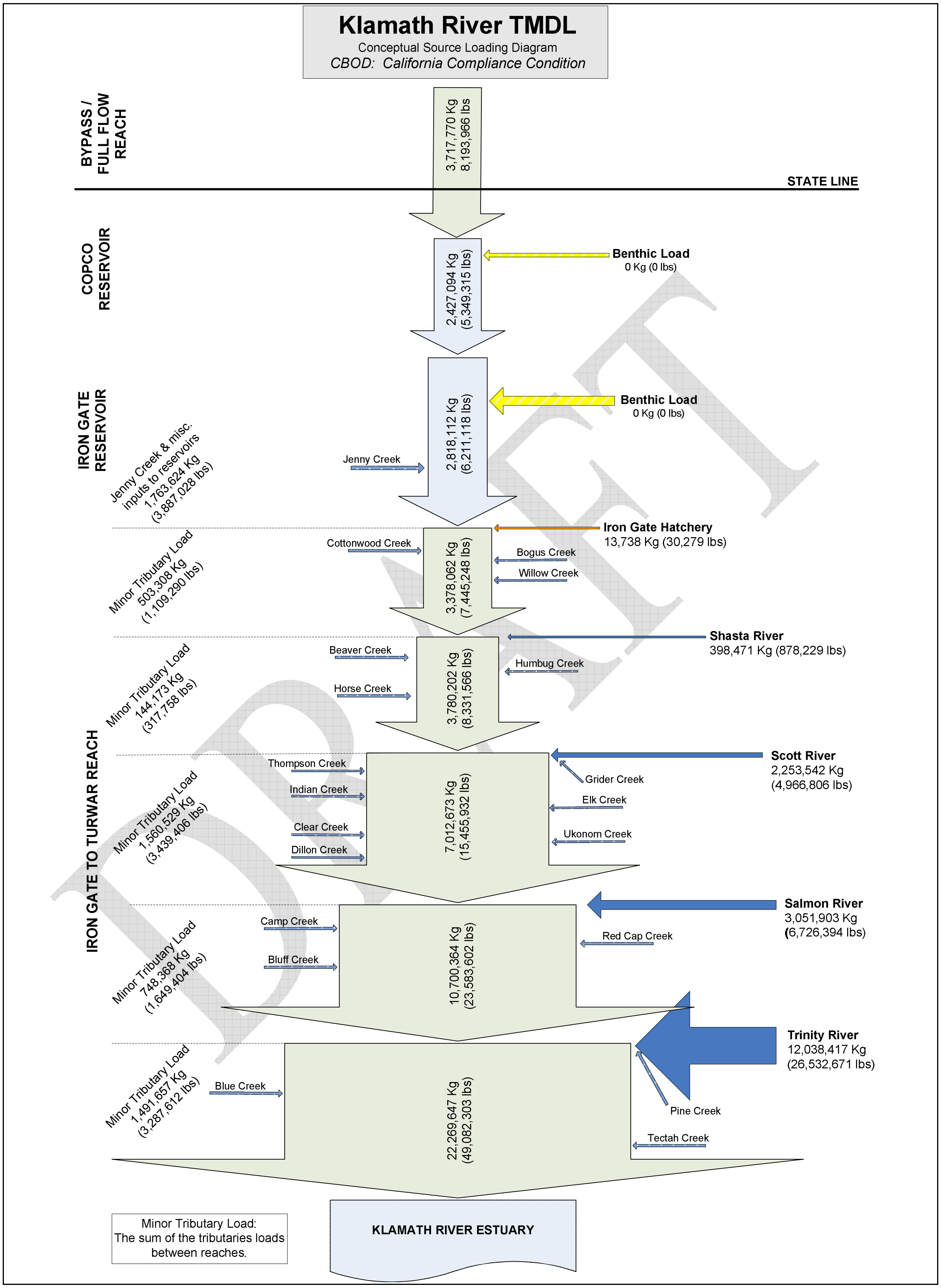

Figure 5.3: Organic Matter Loading Capacity and Allocations for the Klamath River Consistent with Assimilative Capacity and Beneficial Use Support.

the loading capacities divided into various reaches of the Klamath River in California, and also present the load and waste load allocations assigned the different sources necessary to achieve the loading capacity. For most Klamath River compliance locations allocations have been set as monthly mean concentrations for nutrients (TP and TN) and organic matter (CBOD). In order to summarize the Total Maximum Daily Load for these parameters, the allocations are also expressed as daily loads (concentration x flow = mass). The contribution of natural background nutrient and organic matter loads is incorporated into the compliance load for each source area.

Achievement of the nutrient and organic matter allocations will not result in compliance with the DO and temperature targets within Copco 1 and 2 and Iron Gate Reservoirs during periods of thermal stratification. Therefore, additional temperature and dissolved oxygen load allocations are assigned to the reservoirs for the period of May through October, as described in Section 5.3.

The Klamath River nutrient, organic matter, and dissolved oxygen TMDLs for California rely on an implicit *margin of safety*. An implicit margin of safety was deemed appropriate because uncertainty was greatly reduced in the analysis by applying a comprehensive, dynamic numerical model. The model takes advantage of available data collected over multiple years, and deterministically represents the cause-effect relationship between discrete sources and water quality conditions throughout the Klamath's riverine, reservoir, and estuarine portions. By representing conditions in great detail spatially and temporally, the model effectively considers a spectrum of conditions that may be overlooked by a simpler analysis. It was determined that the largest source of uncertainty in this system is the highly variable and dominant loading from Upper Klamath Lake rather than the numeric water quality model. Conservative assumptions that make up the implicit margin of safety are as follows:

- The numeric model used to predict the impact of allocations assumes that sediment oxygen demand (SOD) does not improve in the riverine sections following upstream load reductions. The magnitude of SOD will likely decrease with the decrease of organic loading allocated by the TMDL and result in a shorter season of DO concentrations less than numeric criteria.

- Predicted conditions in the Klamath River are strongly influenced by the predicted variable conditions of the Upper Klamath Lake TMDL. Conservative allocations were set by using a combination of the predicted conditions. The timing of the allocations within Oregon is based on the scenario which represents the greatest loading from Upper Klamath Lake (i.e. results in the longest period of water quality not meeting numeric criterion). The magnitudes of the allocations are based on median loading conditions from Upper Klamath Lake. This is conservative because allocations are based on the difference from a baseline condition. The closer the concentration or temperature is to the numeric criteria, the less loading is necessary to cause a measurable degradation.

- Allocations to non-point source (NPS) are for all nutrients (N, P, OM), not just the predicted limiting nutrient.
- Year 2000 flows are less than more recent flow requirements (i.e. USBR Klamath Project Operations and PacifiCorp Klamath Hydro Project biological opinion flows).

The TMDLs for total phosphorous, total nitrogen, and organic matter (CBOD) to the Klamath River in California are the sum of waste load allocations, load allocations, and natural background for each parameter. The only waste load allocations assigned for these TMDLs is to the Iron Gate Hatchery. The contribution of natural background total phosphorus, total nitrogen, and organic matter (CBOD) loads is incorporated into the load allocations for each source area. Accordingly, the TMDL equations for total phosphorous is:

Total phosphorus TMDL = Loading Capacity = ΣWLAs + ΣLAs

The load and waste load total phosphorus allocations for the Klamath River in California are presented in Table 5.2.

Table 5.2: Total Phosphorus TMDL (lbs.)

TMDL Parameter	Source Area	Daily Load (lbs.)
Total phosphorus TMDL =		
Loading Capacity (1852.5 lbs.) =		
	Δ Iron Gate Hatchery	0 +
	Stateline	271.8 +
	Stateline to Iron Gate inputs	164.8 +
	Iron Gate to Shasta tributaries	48.5 +
	Shasta River	74.8 +
	Shasta to Scott tributaries	17.3 +
	Scott River	46.7 +
	Scott to Salmon tributaries	186.9 +
	Salmon River	131.9 +
	Salmon to Trinity tributaries	89.6 +
	Trinity River	641.6 +
	Trinity River to Turwar tributaries	178.6+
	Total	**1,852.5**

The TMDL equation for total nitrogen is:

Total nitrogen TMDL = Loading Capacity = ΣWLAs + ΣLAs

The load and waste load total nitrogen allocations for the Klamath River in California are presented in Table 5.3.

Table 5.3: Total Nitrogen TMDL (lbs.)

TMDL Parameter	Source Area	Daily Load (lbs.)
Total nitrogen TMDL =		
Loading Capacity (10,839 lbs.) =		
	Δ Iron Gate Hatchery	0 +
	Stateline	2,814 +
	Stateline to Iron Gate inputs	1,101 +
	Iron Gate to Shasta tributaries	317 +
	Shasta River	220 +
	Shasta to Scott tributaries	97 +
	Scott River	655 +
	Scott to Salmon tributaries	1,050 +
	Salmon River	775 +
	Salmon to Trinity tributaries	504 +
	Trinity River	2,303 +
	Trinity River to Turwar tributaries	1,004 +
	Total	**10,839**

The TMDL equation for organic matter is:

Organic matter TMDL = Loading Capacity = ΣWLAs + ΣLAs

The load and waste load organic matter (CBOD) allocations for the Klamath River in California are presented in Table 5.4.

Table 5.4: Total Organic Matter TMDL (lbs.)

TMDL Parameter	Source Area	Daily Load (lbs.)
Total organic matter TMDL =		
Loading Capacity (156,154 lbs.) =		
	Δ Iron Gate Hatchery	0 +
	Stateline	22,449 +
	Stateline to Iron Gate inputs	10,649 +
	Iron Gate to Shasta tributaries	3,039 +
	Shasta River	2,406 +
	Shasta to Scott tributaries	871 +
	Scott River	10,357 +
	Scott to Salmon tributaries	9,423 +
	Salmon River	18,459 +
	Salmon to Trinity tributaries	4,519 +
	Trinity River	64,975 +
	Trinity River to Turwar tributaries	9,007 +
	Total	**156,154**

5.2 Temperature-Related Numeric Targets and Allocations

This section presents the temperature-related numeric targets, and load and waste load allocations for the Klamath River by river reach and associated source areas.

5.2.1. Watershed-Wide Temperature-Related Targets and Load Allocations in California

There are two temperature-related load allocations that apply watershed-wide, i.e. to the entire Klamath River watershed, including all tributaries, in California. These allocations are for excess solar radiation and human-caused discharges of sediment. For clarity of presentation the numeric targets are presented after presentation of these allocations.

5.2.1.1 Riparian Shade

Regional Water Board staff have concluded that the load allocation for excess solar radiation assigned in previous TMDLs (e.g. Navarro, Mattole, Scott, Shasta, and Eel River Temperature TMDLs), is also an appropriate allocation for excess solar radiation in the Klamath River watershed in California. The load allocation for solar radiation is expressed as its inverse: shade. Accordingly, the **temperature load allocations for shade** are equal to:

> the shade provided by topography and full potential vegetation conditions at a site, with an allowance for natural disturbances such as floods, wind throw, disease, landslides, and fire.

The targets for riparian shade are expressed as effective shade. Effective shade is a measure of the percentage of total daily direct beam solar radiation that is blocked by vegetation or topography before reaching the ground or stream surface, and takes into account the differences in solar intensity that occur throughout a day. The effective shade curves in Figures 5.4, 5.5, and 5.6 graphically present the levels of effective shade that are expected to naturally occur for a given type of vegetation, aspect, and stream width. These curves constitute the numeric targets for riparian shade within the Klamath River in California.

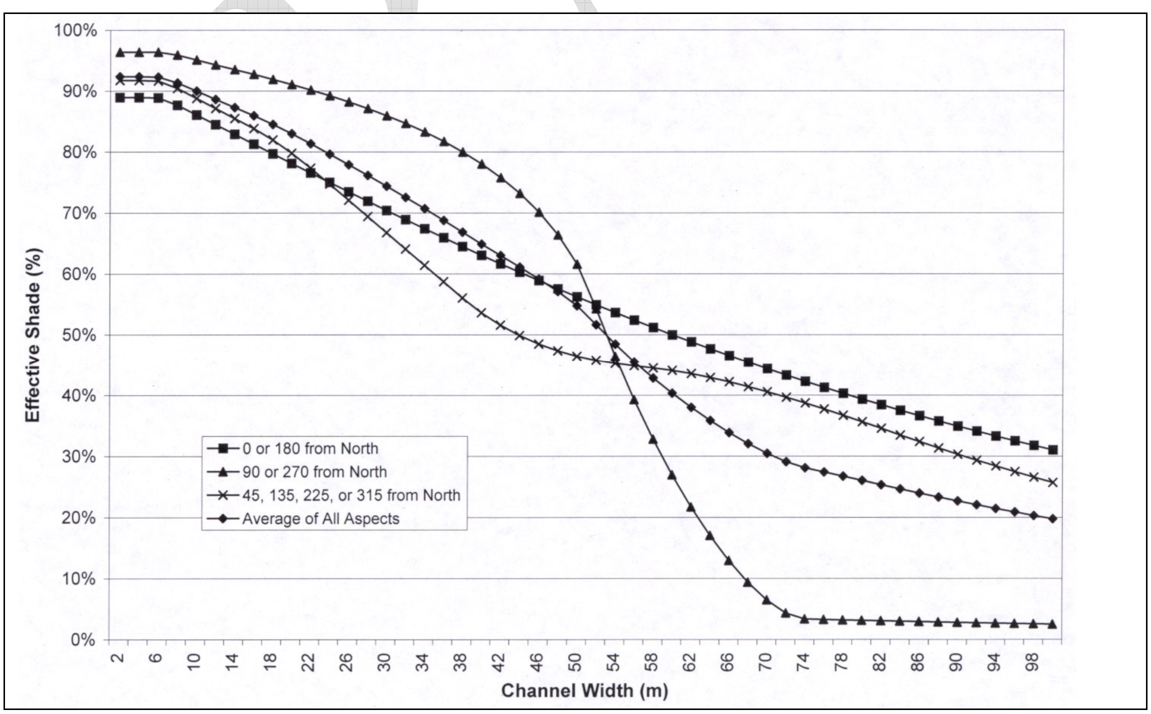

Figure 5.4: Effective shade vs. channel width for various channel orientations, Douglas Fir and mixed hardwood-conifer forests. Assumed vegetation height = 40 meters (131.2 feet).

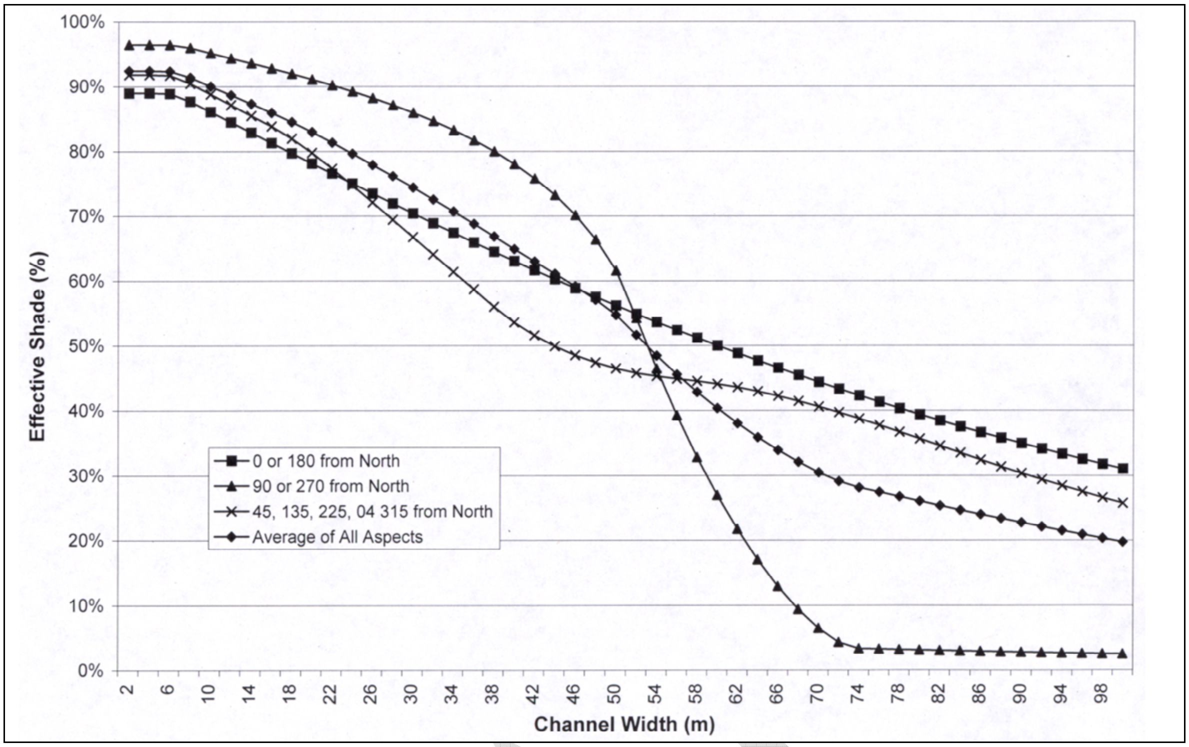

Figure 5.5: Effective shade vs. channel width for various channel orientations, Klamath mixed conifer and Ponderosa Pine forests. Assumed vegetation height = 35 meters (114.8 feet).

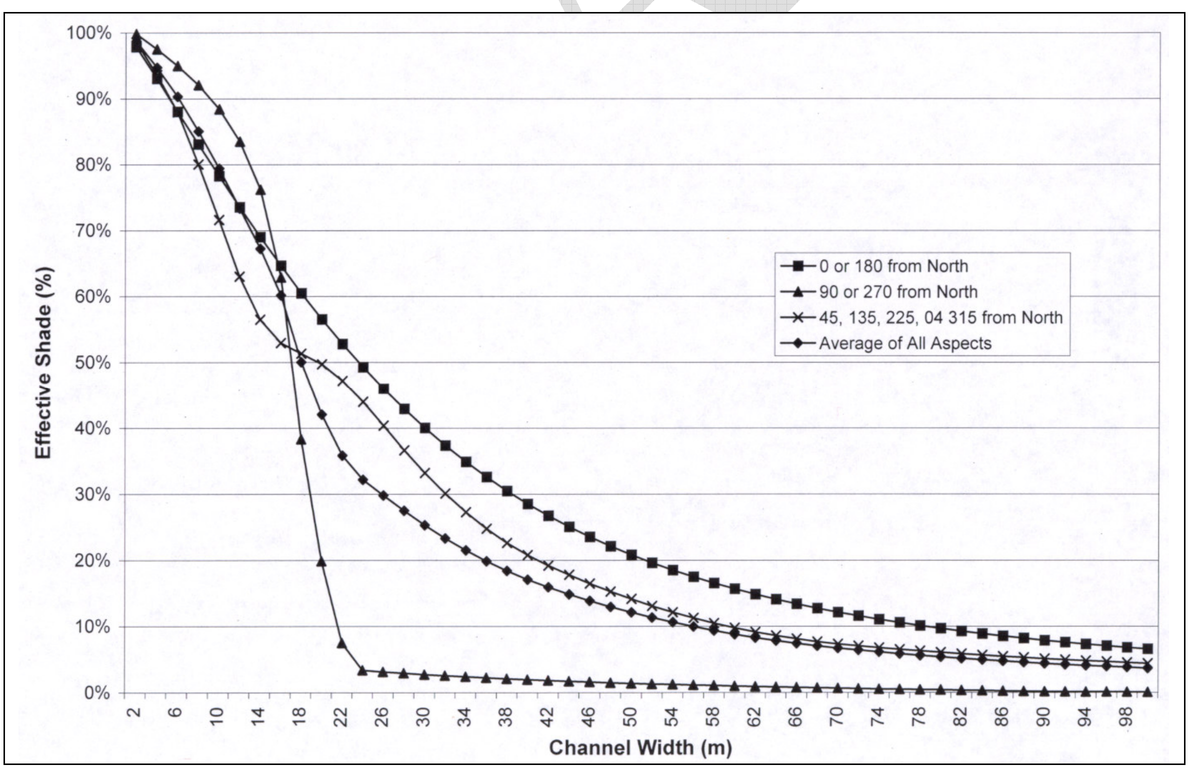

Figure 5.6: Effective shade vs. channel width for various channel orientations, oak woodland forest. Assumed vegetation height = 20 meters (65.6 feet).

5.2.1.2 Excess Sediment

Regional Water Board staff have concluded that stream temperature increases in the Klamath River watershed cannot be accommodated without adverse effects to beneficial uses. Therefore, stream temperature increases that result from human-caused discharges of sediment constitute an exceedence of the water quality objective for temperature. Accordingly, the **temperature-related load allocation for human-caused discharges of sediment** equals:

> zero temperature increase caused by substantial human-caused sediment-related channel alteration.

For this purpose, the following definition is used to define *substantial human-caused sediment-related channel alteration*:

> Substantial human-caused sediment-related channel alteration: "A human-caused alteration of stream channel dimensions that increases channel width, decreases depth, or removes riparian vegetation to a degree that alters stream temperature dynamics and is caused by increased sediment loading"

Two types of targets are designated for this category, an instream target and watershed targets.

The instream target associated with *Substantial Human-Caused Sediment-Related Channel Alteration* is:

> 0 miles of substantial human-caused sediment-related channel alteration.

The watershed target for *Stream Crossings with Diversion Potential or Significant Failure Potential* is:

> <1% of all stream crossings divert or fail as a result of a 100-year or smaller flood.

Most roads, including skid trails, cross ephemeral or perennial streams. Crossings are built to capture the stream flow and safely convey it through, under, or around the roadbed. However, stream crossings can fail, adding sediment from the crossing structure (i.e., fill), or from the roadbed, directly into the stream. Stream crossing failures are generally related to culverts that are undersized, poorly placed, plugged, or partially plugged. When a crossing fails, the total sediment volume delivered to the stream usually includes both the volume of road fill associated with the crossing and sediment from collateral failures such as debris torrents that scour the channel and stream banks.

Diversion potential is the potential for a road to divert water from its intended drainage system across or through the road fill, thereby delivering road-related sediment to a watercourse. Generally, less than one percent of stream crossings have conditions where modification is inappropriate because it would endanger travelers or where modification is impractical because of physical constraints (D. Hagans, pers. comm., 1998, in USEPA 1998a).

The watershed target associated with *Road-Related Landslides* is:

Decreasing trend.

Since road failures usually occur many years after roads are constructed and are often unpredictable, it is expected that the rate of road-related landslides is not likely to decrease until roads in problem areas are treated or decommissioned. Appropriate location, design, construction and maintenance of roads is expected to result in a reduction of the rate of road failures.

5.2.2 Temperature Numeric Targets and Load Allocations at Stateline

The ODEQ has identified the Klamath River in Oregon on its CWA section 303(d) list as failing to meet Oregon temperature criteria. Accordingly in 2009, ODEQ intends to issue, in 2009, and implement TMDLs for temperature for the Klamath 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 Klamath River, they are also being designed to meet California water quality standards at the Oregon/California border. It is appropriate for the Regional Water Board to account for these anticipated upstream load reductions in Oregon when developing the TMDLs for the segments of the Klamath River that are downstream in California. For ease of reference, these anticipated reductions in Oregon-source loads are identified in this TMDL in California as load allocations that reflect anticipated water quality at the Oregon/California border once the Oregon TMDLs are fully implemented. Thus, the temperature allocations at Stateline identified in Table 5.5 reflect an understanding and acknowledgement that improvements in water quality in Oregon represent a critical part of the solution in meeting water quality objectives in California.

The temperature targets at Stateline are expressed as monthly average temperatures and are presented in Table 5.5.

Table 5.5: Temperature Numeric Targets (°C) at Stateline, Expressed as Monthly Averages.

May	June	July	August	September	October
13.7	17.3	18.7	18.0	14.0	9.7
November	**December**	**January**	**February**	**March**	**April**
3.9	2.6	3.4	6.2	8.8	11.2

The allocation for temperature at Stateline is zero increase above natural, in accordance with water quality objectives.

5.2.3 Temperature Numeric Targets and Load Allocations to Copco 2 and Iron Gate

The numeric temperature targets assigned to Iron Gate and Copco 2 tailraces are calculated from the California compliance scenario, and are expressed as monthly average temperatures in Table 5.6.

Table 5.6: Temperature Numeric Targets for Iron Gate and Copco Reservoir Tailrace Waters, Expressed as Monthly Averages.

	May	June	July	August	September	October
Copco 1&2	14.1 °C 57.4 °F	17.7 °C 63.9 °F	19.1 °C 66.4 °F	18.4 °C 65.1 °F	14.3 °C 57.7 °F	9.8 °C 49.6 °F
Iron Gate	14.5 °C 58.1 °F	18.0 °C 64.3 °F	19.5 °C 67.1 °F	18.8 °C 65.9 °F	14.7 °C 58.4 °F	10.0 °C 50.0 °F
	November	**December**	**January**	**February**	**March**	**April**
Copco 1&2	3.8 °C 38.8 °F	2.5 °C 36.5 °F	3.3 °C 37.9 °F	6.2 °C 43.2 °F	8.8 °C 47.8 °F	11.0 °C 51.8 °F
Iron Gate	3.7 °C 38.7 °F	2.4 °C 36.3 °F	3.3 °C 37.9 °F	6.1 °C 43.0 °F	8.9 °C 48.0°F	10.9 °C 51.6 °F

Iron Gate and Copco Reservoirs discharge elevated temperature waste, as defined by the Thermal Plan. The discharge of elevated temperature waste to the Klamath River is prohibited by the Thermal Plan. Furthermore, temperature alterations caused by the reservoirs adversely effect beneficial uses. Thus, there is no allowable temperature increase that can be allocated to Iron Gate and Copco 1 and 2 Reservoirs. Accordingly, the temperature load allocation for these reservoirs equals zero temperature increase above natural temperatures.

The determination of compliance with water quality objectives for temperature is complicated by the fact that under current conditions the temperature of water entering Copco 1 Reservoir (the most upstream California reservoir) carries an anthropogenic heat load from upstream sources. The upstream heat sources are also allocated temperature loads through the State of Oregon's Klamath River TMDL, although these allocations are expected to be achieved gradually over time. Because the upstream heat loads are outside of the control of the dam operators (PacifiCorp), the allocations apply to the condition of the water as it enters the reservoirs.

Another complicating factor is that even without the presence of the reservoirs the Klamath River would be expected to naturally change temperature through the reaches currently occupied by the reservoirs. Thus, to account for natural processes, the temperature load allocation for the reservoirs includes an allowance for natural temperature increases. The allowable temperature increase was developed from model data that predicts the natural temperature increases through the free flowing river reaches occupied by the reservoirs for the year 2000.

The temperature increase that would be expected to occur in the reach of the Klamath River occupied by the Copco 1 and 2 Reservoirs is presented in Figure 5.7. These results indicate that the daily average temperature would naturally increase by approximately 0.3 °C (0.5 °F) through the Copco reach. Similarly, the results indicate that the daily maximum temperatures periodically increase slightly; however, from approximately June through December the daily maximum temperature actually decreases through the Copco reach. The increase in daily average temperatures, coupled with a decrease in daily maximum temperatures indicates a reduced daily range of temperatures. The reduced daily range may be due to more topographic shading in this reach in comparison to upstream reaches.

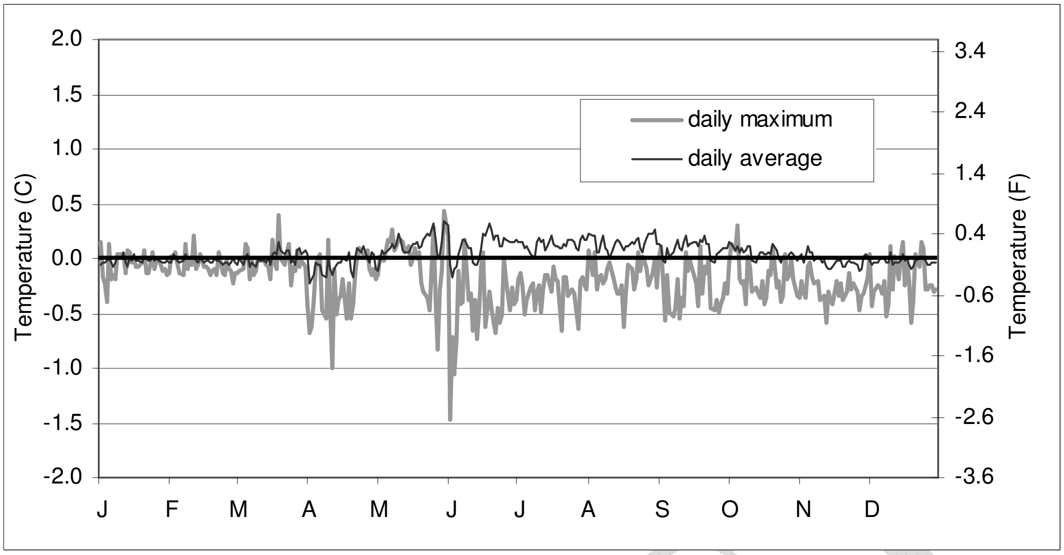

Figure 5.7: Natural temperature change through the Copco Reservoir reaches. Calculated as difference of downstream and upstream daily maximum and daily average temperatures; a positive value indicates warming through the reach.

The temperature increase that would be expected to occur in the reach of the Klamath River occupied by Iron Gate Reservoir is presented in Figure 5.8. These results indicate that the daily average temperature would naturally increase by approximately 0.1 ^{o}C (0.2 ^{o}F) through the Iron Gate reach. Similarly, the results indicate that the daily maximum temperatures would naturally increase by approximately 0.1 ^{o}C (0.2 ^{o}F) in the same reach.

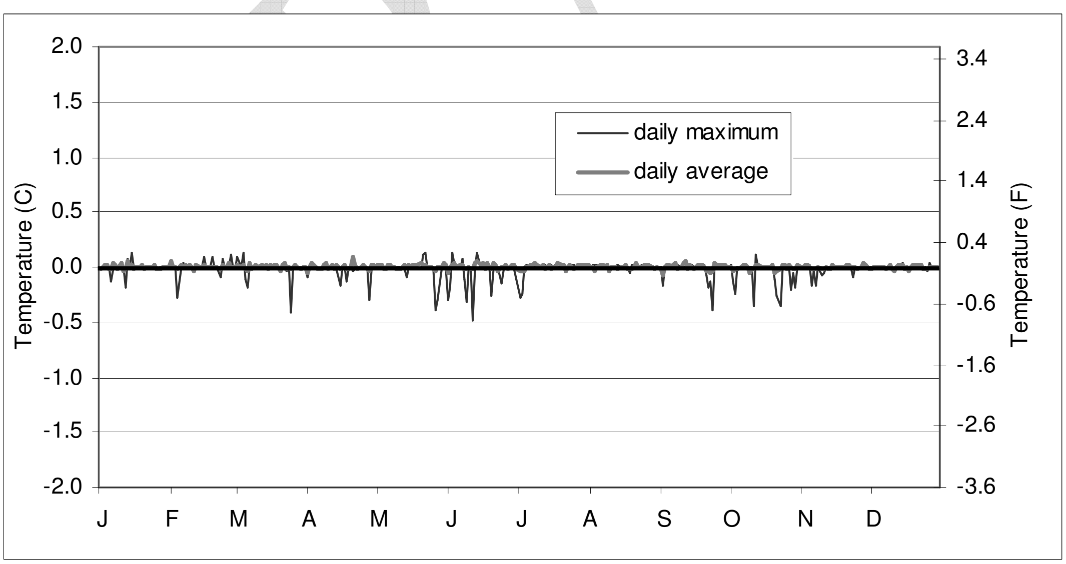

Figure 5.8: Natural temperature change through the Iron Gate Reservoir reach. Calculated as difference of downstream and upstream daily maximum and daily average temperatures; a positive value indicates warming through the reach.

Given that the water quality objectives for temperature do not allow for temperature increases above natural, the water released from Iron Gate and Copco 2 Reservoirs to the

Klamath River are allocated temperature increases that correspond to natural temperature increases, as presented in Table 5.7. The temperature allocation is intended to be added to the in-flowing temperature of the river immediately upstream of each reservoir.

Table 5.7: Temperature Load Allocations for Reservoir Tailrace Waters, Expressed as Increase Relative to Inflow

Facility	Daily Average	Daily Maximum
Iron Gate	0.1 °C (0.18 °F)	0.1 °C (0.18 °F)
Copco 1 & 2	0.3 °C (0.54 °F)	0.5 °C (0.9 °F)

5.2.4 Temperature Numeric Targets and Waste Load Allocations to Iron Gate Hatchery

The numeric temperature targets assigned to the Iron Gate Hatchery (Table 5.8) are expressed as monthly average temperatures, equal to the temperatures associated with the Klamath River downstream of Iron Gate Dam, and are calculated from the California compliance scenario.

Table 5.8: Temperature Numeric Targets for Iron Gate Hatchery, Expressed as Monthly Averages.

May	June	July	August	September	October
14.5 °C 58.1 °F	18.0 °C 64.3 °F	19.5 °C 67.1 °F	18.8 °C 65.9 °F	14.7 °C 58.4 °F	10.0 °C 50.0 °F
November	**December**	**January**	**February**	**March**	**April**
3.8 °C 38.8 °F	2.5 °C 36.5 °F	3.3 °C 37.9 °F	6.2 °C 43.2 °F	8.8 °C 47.8 °F	11.0 °C 51.8 °F

The discharge of elevated temperature waste to the Klamath River is prohibited by the state Thermal Plan. Iron Gate Hatchery discharges elevated temperature waste when the hatchery discharge is warmer than the Klamath River. Thus, there is no allowable temperature increase that can be allocated to Iron Gate Hatchery. Accordingly, the temperature load allocation for the Hatchery equals zero temperature increase above natural temperatures.

5.3 Dissolved Oxygen and Nutrient-Related Numeric Targets and Allocations

This section presents the dissolved oxygen and nutrient-related numeric targets, and load and waste load allocations for the Klamath River by river reach and associated source areas.

5.3.1 Dissolved Oxygen and Nutrient-Related Numeric Targets and Load Allocations at Stateline

The ODEQ has identified the Klamath River in Oregon on its CWA section 303(d) list as failing to meet certain Oregon water quality standards. Accordingly in 2009, ODEQ intends to issue and implement TMDLs for chlorophyll-a, dissolved oxygen, organic matter, and ammonia for the Klamath 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

Klamath River, they are also being designed to meet California water quality standards at the Oregon/California border. It is appropriate for the Regional Water Board to account for these anticipated upstream load reductions in Oregon when developing the TMDLs for the segments of the Klamath 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 at Stateline that reflect anticipated water quality at the Oregon /California border once the Oregon TMDLs are fully implemented. Thus, the load reductions identified in Figures 5.1, 5.2, and 5.3 and the following allocations and numeric targets reflect an understanding and acknowledgement that improvements in water quality upstream represent a critical part of the solution in meeting water quality objectives in California.

Allocation values are based on model output and significant digits have been set based on consideration of analytical method detection limits and criteria / objective reporting requirements. The following convention has been used for each of the following parameters: dissolved oxygen (DO) – tenths of mg/L; nutrients (total nitrogen and total phosphorous) – thousandths mg/L; and whole units for carbonaceous oxygen demand (CBOD).

The dissolved oxygen targets at Stateline are expressed as monthly average and monthly minimum DO concentrations (Table 5.9). These dissolved oxygen targets are consistent with the DO concentrations at Stateline under the California compliance scenario and achieve 85% saturation under natural temperature conditions.

Table 5.9: Dissolved Oxygen Numeric Targets (mg/L) at Stateline.

	May	June	July	August	September	October
Mean	8.6	8.2	8.2	8.2	8.9	9.7
Minimum	7.9	7.1	6.9	7.0	8.0	8.4
	November	**December**	**January**	**February**	**March**	**April**
Mean	11.2	11.5	11.1	10.2	9.5	8.9
Minimum	9.9	11.0	10.7	9.8	9.0	8.4

Nutrient and organic matter allocations at Stateline are set to control their biostimulatory and oxygen consuming effect on DO and to achieve the DO objective/targets. These allocations are expressed as monthly mean concentrations (mg/L) for total phosphorous (TP), total nitrogen (TN), and organic matter (CBOD) as shown in Table 5.10.

Table 5.10: Nutrient and Organic Matter Monthly Mean Concentrations (mg/L) Allocations at Stateline.

	May	June	July	August	September	October
TP	0.033	0.040	0.044	0.040	0.029	0.028
TN	0.353	0.418	0.434	0.406	0.230	0.265
CBOD	3	3	3	3	1	2
	November	**December**	**January**	**February**	**March**	**April**
TP	0.029	0.031	0.027	0.028	0.029	0.034
TN	0.269	0.300	0.304	0.330	0.338	0.370
CBOD	2	2	2	3	3	3

5.3.2 *Dissolved Oxygen and Nutrient-Related Numeric Targets and Load Allocations to Copco 1 and 2 and Iron Gate Reservoirs*

Dissolved oxygen and nutrient-related numeric targets and load allocations are set for the Copco 2 and Iron Gate tailraces as well as for the reservoirs themselves.

5.3.2.1 Copco 2 and Iron Gate Reservoir Targets

Copco 2 and Iron Gate tailrace targets for dissolved oxygen are calculated from the California compliance scenario, and are expressed as monthly mean and monthly minimum DO concentrations (Table 5.11).

Table 5.11: Dissolved Oxygen Numeric Targets (mg/L) for Copco 2 and Iron Gate Tailraces.

Copco 2 Tailrace						
	May	**June**	**July**	**August**	**September**	**October**
Mean	8.7	8.3	8.2	8.3	9.0	9.8
Minimum	7.8	7.0	6.8	6.8	7.9	8.4
	November	**December**	**January**	**February**	**March**	**April**
Mean	11.4	11.7	11.3	10.3	9.7	9.1
Minimum	10.0	11.2	10.8	9.9	9.1	8.5
Iron Gate Tailrace						
	May	**June**	**July**	**August**	**September**	**October**
Mean	8.9	8.3	8.2	8.2	9.0	9.9
Minimum	7.9	7.3	7.2	7.2	8.1	8.6
	November	**December**	**January**	**February**	**March**	**April**
Mean	11.6	11.9	11.5	10.6	9.9	9.4
Minimum	10.4	11.4	11.0	10.1	9.3	8.7

Numeric targets for nutrients (TP and TN) and organic matter (CBOD) are also established for Copco 1 and 2 and Iron Gate Reservoirs, and are expressed as monthly mean concentrations. These nutrient and organic matter targets are established both for the tailraces of Copco 2 and Iron Gate (Table 5.12) and for mid-point locations with Copco 1 and Iron Gate Reservoirs (Table 5.13).

In addition to receiving high nutrient and organic matter loadings from upstream, the Copco and Iron Gate impoundments also provide slower movement and unshaded water that allow greater expression of nutrient impacts. Environmental conditions within the impoundments create an increased susceptibility to nuisance blooms of suspended algae (e.g., green algae, diatoms, and blue-green algae). Nutrient conditions in Iron Gate and Copco 1 and 2 Reservoirs, along with the physical conditions of the reservoirs, are associated with the formation of summer algal blooms, including the formation of extensive blooms of the blue-green algae *Microcystis aeruginosa*, as detailed in Chapter 2. For the TMDL to be successful in restoring water quality conditions and supporting beneficial uses, numeric targets are set for both suspended algae chlorophyll-a and nuisance blue-green algae blooms (*Microcystis aeruginosa* cell density and associated concentrations of the toxin microcystin), applicable to Copco 1 and 2 and Iron Gate Reservoirs. These targets are both responsive to nutrient loading upstream and controllable environmental factors within the reservoirs. The suspended algae chlorophyll-a numeric target is 10 µg/L. The targets for *Microcystis aeruginosa* and microsystin are:

Table 5.12: Nutrient and Organic Matter Monthly Mean Concentration Targets (mg/L) for Copco 2 and Iron Gate Tailraces.

Copco 2 Tailrace						
	May	June	July	August	September	October
TP	0.025	0.025	0.028	0.030	0.025	0.022
TN	0.251	0.216	0.193	0.201	0.162	0.131
CBOD	2	1	1	1	1	1
	November	December	January	February	March	April
TP	0.023	0.027	0.032	0.023	0.023	0.026
TN	0.170	0.211	0.558	0.258	0.267	0.264
CBOD	1	1	1	2	2	2
Iron Gate Tailrace						
	May	June	July	August	September	October
TP	0.032	0.030	0.031	0.035	0.034	0.028
TN	0.276	0.225	0.202	0.198	0.176	0.135
CBOD	1	1	1	1	1	1
	November	December	January	February	March	April
TP	0.027	0.031	0.044	0.033	0.034	0.040
TN	0.156	0.209	0.751	0.297	0.311	0.322
CBOD	1	1	1	2	2	2

Table 5.13: Nutrient and Organic Matter Monthly Mean Concentration Targets (mg/L) for Mid-Point of Copco 1 and Iron Gate Reservoirs.

Mid-Point Copco 1 Reservoir						
	May	June	July	August	September	October
TP	0.024	0.027	0.023	0.021	0.023	0.024
TN	0.267	0.276	0.223	0.155	0.123	0.130
CBOD	1	1	1	1	1	1
	November	December	January	February	March	April
TP	0.023	0.025	0.028	0.025	0.024	0.027
TN	0.171	0.202	0.423	0.281	0.267	0.276
CBOD	1	1	1	2	2	2
Mid-Point Iron Gate Reservoir						
	May	June	July	August	September	October
TP	0.034	0.030	0.034	0.034	0.034	0.029
TN	0.279	0.206	0.182	0.155	0.170	0.140
CBOD	2	1	1	1	1	1
	November	December	January	February	March	April
TP	0.028	0.002	0.038	0.035	0.035	0.044
TN	0.166	0.012	0.585	0.315	0.320	0.356
CBOD	1	0	1	3	3	3

- *Microcystis aeruginosa* concentrations that are equal to or less than 50% of the blue-green algal biomass or 20,000 cells per liter (whichever is lower); and
- Microcystin toxin levels below 4 µg/L (World Health Organization and the California Blue-Green Algae Work Group Voluntary Guidelines).

See Section 2.3.2.2 for detailed background information regarding the selection of these numeric targets.

5.3.2.2 Copco 1 and 2 and Iron Gate Reservoir Load Allocations

Copco 1 and 2 and Iron Gate Reservoirs, as constructed facilities, are responsible for the flux of nutrients (e.g., ammonia and orthophosphate) from sediments under anoxic conditions during the critical period May through October. The nutrient-related allocation for Copco 1 and 2, and Iron Gate Reservoirs is zero nutrient loading from reservoir bottom sediments.

Achievement of the nutrient and organic matter allocations will not result in compliance with the DO and temperature targets within Copco 1 and 2 and Iron Gate Reservoirs during periods of thermal stratification. Therefore, additional temperature and dissolved oxygen load allocations are assigned to the reservoirs for the period of May through October to ensure compliance with the DO and temperature targets within the reservoirs, and ensure support of COLD. The temperature and DO allocations for waters within Copco 1 and 2 and Iron Gate Reservoirs are dual allocations, wherein achievement of the water quality objective for temperature is dependent on dissolved oxygen conditions and vice versa. Allocations for dissolved oxygen and temperature are equal to a “compliance lens” where both DO and temperature conditions meet Basin Plan objectives for water temperature and DO and are therefore protective of COLD. The concept of the compliance lens where both DO and temperature objectives are met is illustrated in Figure 5.9.

The allocation is for the critical period of May through October and requires overlapping DO concentrations consistent with 85% saturation, at temperatures consistent with natural water temperatures at the point of entry to the reservoirs within a lens throughout the reservoir.

The volume of each reservoir compliance lens is equal to the average hydraulic depth of the river in a free-flowing state for the width and length of the reservoir. The depth at which the compliance lens occurs within the reservoirs will vary. For Copco 1 and 2 and Iron Gate Reservoirs the instantaneous DO mass that achieves the DO allocation equals 39,398 pounds (7.64 mg/L) and 47,624 pounds (7.60 mg/L), respectively[4].

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4 The instantaneous DO mass for Copco and Iron Gate was calculated from the depth within each reservoir at which temperatures achieved California compliance scenario temperatures. The volume within the compliance lens was calculated from the depth at which compliance is achieved to the thickness associated with the reach-average depth of the free-flowing river channel for the entire width of the reservoir at these depths. This volume estimate was then multiplied by the average 85% DO saturation concentration calculated from the California compliance scenario to get the instantaneous DO mass for each reservoir.

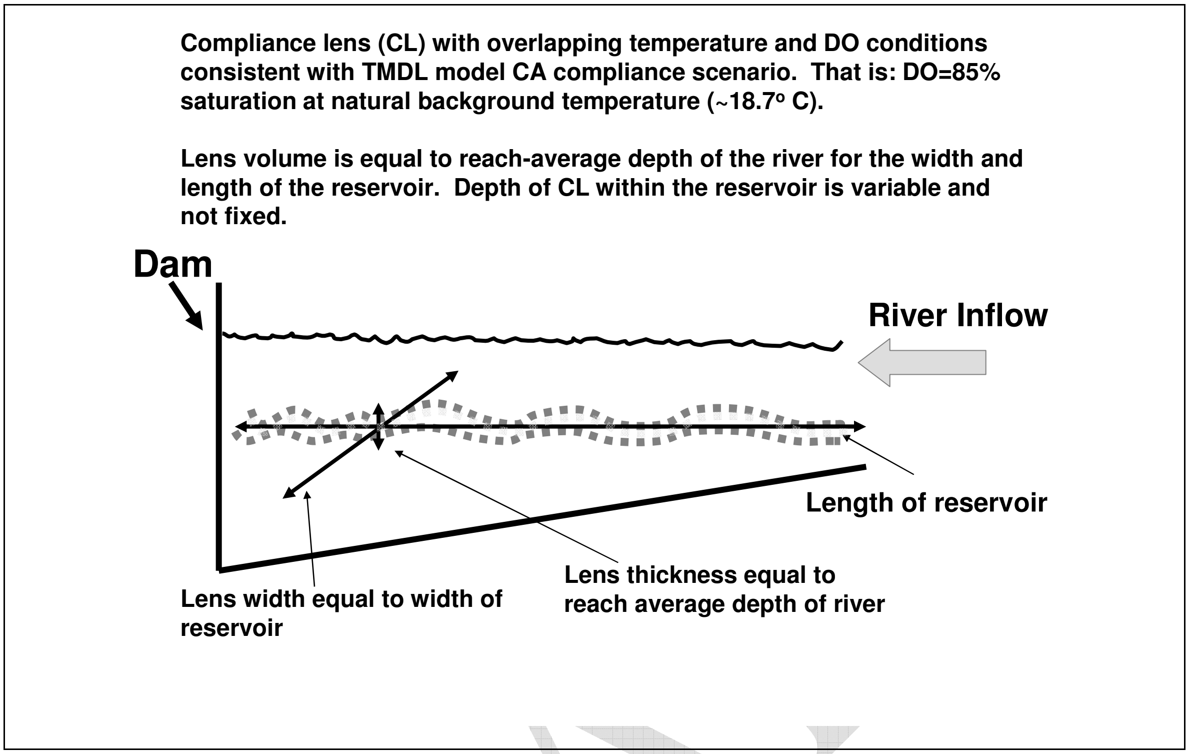

Figure 5.9: Illustrated Conceptual Model of Reservoir Compliance Lens for Temperature and Dissolved Oxygen

5.3.3 Dissolved Oxygen and Nutrient-Related Numeric Targets and Waste Load Allocations to Iron Gate Hatchery

The DO targets for Iron Gate Hatchery discharge are monthly mean and monthly minimum DO concentrations (Table 5.14). The targets apply to the Iron Gate Hatchery discharge location just above the mouth of Bogus Creek. The target concentrations were calculated from the California compliance scenario, and reflect compliance DO conditions immediately downstream of Iron Gate Dam.

Table 5.14: Dissolved Oxygen Numeric Targets (mg/L) for Iron Gate Hatchery Discharge.

	May	June	July	August	September	October
Mean	8.9	8.3	8.2	8.2	9.0	9.9
Minimum	7.9	7.3	7.2	7.2	8.1	8.6
	November	**December**	**January**	**February**	**March**	**April**
Mean	11.6	11.9	11.5	10.6	9.9	9.4
Minimum	10.4	11.4	11.0	10.1	9.3	8.7

Iron Gate Hatchery draws its water from depth within Iron Gate Reservoir. The allocation to this facility is zero net increase of nutrient and organic matter between influent water (intake) and effluent (discharge). The facilities discharge water quality must equal the water quality of the inflow water. Table 5.15 presents the Iron Gate Hatchery nutrient and organic matter targets, expressed as monthly mean concentrations.

These concentration targets reflect California compliance conditions within the Iron Gate Reservoir, at the approximate location where the Hatchery receives its inflow.

Table 5.15 Nutrient and Organic Matter Monthly Mean Concentration Targets (mg/L) for Iron Gate Hatchery.

	May	June	July	August	September	October
TP	0.034	0.030	0.034	0.034	0.034	0.029
TN	0.279	0.206	0.182	0.155	0.170	0.140
CBOD	2	1	1	1	1	1
	November	**December**	**January**	**February**	**March**	**April**
TP	0.028	0.002	0.038	0.035	0.035	0.044
TN	0.166	0.012	0.585	0.315	0.320	0.356
CBOD	1	0	1	3	3	3

5.3.4 Dissolved Oxygen and Nutrient-Related Numeric Targets and Load Allocations to California Tributaries

The primary targets associated with California tributary nutrient and organic matter loadings are dissolved oxygen concentrations within the Klamath River mainstem. The monthly mean and monthly minimum DO targets are calculated from the California compliance scenario. The primary DO target compliance location is located downstream of the Salmon River immediately upstream of the boundary of the Hoopa Valley Indian Reservation; these targets are presented in Table 5.16.

Table 5.16: Dissolved Oxygen Numeric Targets (mg/L) for the Klamath River Mainstem Below the Salmon River.

	May	June	July	August	September	October
Mean	10.0	9.1	8.5	8.4	8.9	10.0
Minimum	9.3	8.1	7.7	7.6	8.2	8.8
	November	**December**	**January**	**February**	**March**	**April**
Mean	11.7	12.4	12.3	11.8	11.4	10.7
Minimum	10.7	11.9	11.9	11.5	10.8	10.3

Nutrient and organic matter numeric targets are also set for the Klamath River mainstem downstream of the Salmon River. The TP, TN, and CBOD numeric targets are expressed as monthly mean concentrations (mg/L); consistent with the California compliance scenario (Table 5.17).

Table 5.17: Nutrient and Organic Matter Monthly Mean Targets (mg/L) for Klamath River Below the Salmon River.

	May	June	July	August	September	October
TP	0.023	0.024	0.026	0.029	0.032	0.029
TN	0.208	0.200	0.185	0.168	0.181	0.163
CBOD	2	2	2	2	1	1
	November	**December**	**January**	**February**	**March**	**April**
TP	0.028	0.027	0.027	0.023	0.025	0.026
TN	0.161	0.170	0.333	0.181	0.199	0.208
CBOD	1	1	1	1	2	2

The final numeric target for the Klamath River mainstem downstream of the Salmon River is for periphyton biomass. The periphyton biomass numeric target selected for the Klamath mainstem at this location is a reach-averaged maximum density of 150 mg of chlorophyll-a / m^2. This value was developed through the California NNE analysis for the Klamath River[5] (Appendix 1, TetraTech 2008).

Allocations for all Klamath River tributaries in California, can be summarized as zero increase above concentrations for TP, TN, and CBOD as defined in the natural baseline conditions scenario. Allocations for minor tributaries are set as monthly mean concentrations (mg/L) that apply year-round. The Shasta, Scott, Salmon, and Trinity Rivers allocations are monthly mean concentrations (mg /L) but are different for wet (November through April) and dry (May through October) seasons. The allocations are calculated from the California compliance scenario, and are summarized in Tables 5.18 and 5.19. The Shasta River TN, TP, and CBOD allocations are consistent with the existing approved Shasta River TMDL. No additional load reductions are required from the Shasta River.

Table 5.18: Nutrient and Organic Matter Seasonal Monthly Mean Concentration Allocations (mg/L) for Tributaries to the Klamath River

Tributary	Season	TP	TN	CBOD
Shasta River	Dry: May – October	0.071	0.21	2
	Wet: November – April	0.071	0.21	2
Scott River	Dry: May – October	0.014	0.21	4
	Wet: November – April	0.016	0.21	3
Salmon River	Dry: May – October	0.010	0.10	2
	Wet: November – April	0.020	0.10	2
Trinity River	Dry: May – October	0.020	0.10	2
	Wet: November – April	0.030	0.10	3

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[5] Compliance with this target shall be assessed by calculating the average periphyton chlorophyll-a from not less than ten samples collected within the Klamath River downstream of the Salmon River and upstream of the Trinity River.

Table 5.19: Nutrient and Organic Matter Annual Monthly Mean Concentration Allocations (mg/L) for Tributaries to the Klamath River

Tributary	TP	TN	CBOD
Willow Creek	0.014	0.077	1
Cottonwood Creek	0.014	0.077	1
Humbug	0.014	0.077	1
Beaver Creek	0.014	0.077	1
Horse Creek	0.014	0.077	1
Grider Creek	0.014	0.077	1
Thompson Creek	0.014	0.077	1
India Creek	0.014	0.077	1
Elk Creek	0.014	0.077	1
Clear Creek	0.014	0.077	1
Ukonom Creek	0.014	0.077	1
Dillon Creek	0.014	0.077	1
Camp Creek	0.014	0.077	1
Red Cap Creek	0.014	0.077	1
Bluff Creek	0.014	0.077	1
Pine Creek	0.014	0.077	1
Tectah Creek	0.014	0.077	1
Blue Creek	0.014	0.077	1

CHAPTER 5 REFERENCES

Tetra Tech. 2008. Nutrient Numeric Endpoint Analysis for the Klamath River, CA. Prepared for U.S. EPA Region 9 and North Coast Regional Water Quality Control Board. May 29, 2008. Tetra Tech, Inc., Research Triangle Park, NC.