FINAL TECHNICAL REPORT

Klamath Hydroelectric Project
(FERC Project No. 2082)

Analysis Of Potential Klamath Hydroelectric Project Effects On Water Quality Aesthetics

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Contents

ANALYSIS OF POTENTIAL KLAMATH HYDROELECTRIC PROJECT EFFECTS ON WATER QUALITY AESTHETICS

1. INTRODUCTION

This technical report describes the methods and results of a study to assess the potential effects of the Klamath Hydroelectric Project (Project) on water quality-related aesthetic conditions. The rationale, approach, and methods for this study are based on a study plan developed by PacifiCorp (PacifiCorp 2003) in consultation with the Oregon Department of Environmental Quality (ODEQ), the California State Water Resources Control Board (SWRCB), and other stakeholders to the Project's FERC relicensing process.

The Project is located along the upper Klamath River in Klamath County, south-central Oregon, and Siskiyou County, north-central California. Water quality upstream of the Project in the Klamath River, Upper Klamath Lake, and the Klamath Straits Drain is poor, particularly during summer, with warm, nutrient-rich water that creates the potential for adverse aesthetic conditions as it flows through the Project and further downstream.[1]

In this report, we present measurements of six water quality characteristics that may be associated with aesthetic-related conditions – turbidity, total suspended solids, water color, Secchi disk depths, light extinction, and chlorophyll-a. Summaries and graphs of the water quality data are used to draw inferences on the potential effects of the Klamath Hydroelectric Project on these characteristics. In addition, we present the results of a survey of recreational users' aesthetic perceptions of waters in the Project area[2].

2. METHODS

Available data were compiled on the six types of water quality characteristics that may be associated with aesthetic-related conditions in the Klamath River, including:

- Turbidity
- Total suspended solids
- Water color
- Secchi disk depths

[1] In 2002, the U.S. Environmental Protection Agency approved ODEQ's total maximum daily loads (TMDLs) for the Upper Klamath Lake Subbasin to control low dissolved oxygen and excessive temperature, pH, and chlorophyll-a. The TMDLs include long-term controls to reduce thermal and nutrient inputs into the lake. Similarly, ODEQ has listed the Klamath Straits Drain (a tributary of the Klamath River) and the Klamath River upstream of J.C. Boyle Reservoir under subsection 303(d) of the Clean Water Act as water quality limited for low dissolved oxygen, and excessive temperature, chlorophyll-a, pH, and other pollutants. (ODEQ has listed the Klamath River from the California border to upstream of J.C. Boyle Reservoir only for temperature.) ODEQ currently expects to develop TMDLs for the Klamath River from Upper Klamath Lake to the California border in 2005.

[2] This technical report does not evaluate the Project's compliance with specific Oregon and California water quality criteria, including narrative water quality criteria for aesthetics. PacifiCorp will evaluate the Project's compliance with state water quality criteria in its forthcoming section 401 certification applications to ODEQ and SWRCB.

- Light extinction
- Chlorophyll-a

2.1 Turbidity

The scattering of light in water by suspended materials, such as clay, silt, finely divided organic material, plankton, and other inorganic material is known as turbidity. Turbidity is a measure of how much material suspended in water scatters light as it passes through the water, and thereby provides an estimate of the muddiness or cloudiness of the water. As such, turbidity may be associated with adverse aesthetic conditions.

PacifiCorp collected turbidity samples monthly from April to November 2003 at several sites between the mouth of Link River (RM 253) and the Klamath River below Iron Gate dam (RM 189.5). Samples were collected using the grab-sample method. Turbidity was analyzed in the laboratory by a turbidimeter using the Nephlometric Method (Standard Methods, Method 2130B). This method is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the intensity of scattered light, the higher the turbidity. Formazin polymer is used as the primary standard reference suspension. Turbidimeter readings are made in Nephlometric Turbidity Units (NTU).

Some stakeholders requested that PacifiCorp also analyze whether changes have occurred in water quality aesthetics since 1980. PacifiCorp chose to examine potential changes since 1980 based solely on turbidity data because much more historic data since 1980 was available for turbidity than for the other aesthetic-related parameters.

Historic turbidity data from various sources collected between January 1980 and March 2001 was obtained from the database of existing water quality data developed by PacifiCorp as described in Chapter 2 of the Water Resources Final Technical Report submitted as part of PacifiCorp's Final License Application to FERC (PacifiCorp 2004a). The database contains turbidity data at approximately 46 sample sites throughout the Klamath River from Link River to the mouth. Consistent year-to-year collection of turbidity data occurred at several of these sites along the river, for which data is presented in Section 3.1.

2.2 Total Suspended Solids

Total suspended solids (TSS) are solids in water that can be trapped by a filter (of 0.45-micron pore size). TSS can include a wide variety of material, such as silt, decaying plant and animal matter, and planktonic organisms.

PacifiCorp collected TSS samples monthly from April to November 2003 at several sites between the mouth of Link River (RM 253) and the Klamath River below Iron Gate dam (RM 189.5). Samples were collected using the grab-sample method. TSS was analyzed in the laboratory by filtering water samples through a pre-weighed 0.45-micron filter. The residue retained on the filter was dried in an oven at 103 to 105° C and weighed. The net increase in weight of the filter was used to calculate TSS (Standard Methods, Method 2540D).

2.3 Color

Color in water may result from the presence of natural metallic irons (iron and manganese), humus and peat materials, plankton, or colloidal and suspended particulates. Water color is typically caused by a combination of dissolved organic matter, which absorbs visible light, and suspended colloidal and particulate matter, which scatters light. The “apparent color” refers to color from both dissolved substances in solution and suspended matter, and is due to both light absorption and light scattering. The “true color”, as was sampled for this study, refers to the color from dissolved substances only, and is measured in samples from which turbidity has been removed. Organic matter, which absorbs light within the 300 to 400 nm wavelengths, and fluoresces in the range of 200 to 400 nm, creates the appearance of true color in water. For example, dissolved organic materials such as humic acids from decaying leaves, and dissolved minerals can give water a reddish brown "tea" color.

Grab samples for water color analysis were collected by PacifiCorp in August 2004 at several locations in the Klamath River from below Keno dam (RM 232) to above the confluence with the Trinity River (RM 43.5). Samples were analyzed in the laboratory for true color using EPA Method 110.2 Colorimetric-Platinum Cobalt (EPA 1971). Color was measured in Platinum-Cobalt units (PCU). Samples were not processed within the 48-hour hold time due to field logistics. However, all samples were maintained on ice and/or refrigerated until delivery to the laboratory.

2.4 Secchi Disk

Secchi disk measurements provide a direct measure of water transparency. A Secchi disk is a circular 20-cm disk that is used to measure relative transparency of water (especially in lakes and reservoirs) by lowering the disk into the water until it is no longer visible.

PacifiCorp collected Secchi disk readings during reservoir sampling in 2001, 2002, and 2003. Locations included Link River at the mouth (RM 253), Keno reservoir at the Highway 66 bridge (RM 234), J.C. Boyle reservoir (RM 224.8), Copco No. 1 reservoir (RM 198.7), and Iron Gate Reservoir (RM 190.2).

2.5 Light Extinction

The ratio between irradiance at a certain depth with the irradiance at the surface of the water body is called the light extinction coefficient. Solar radiation diminishes in approximately exponential fashion with increasing depth in the water column. This exponential decrease is mathematically represented by k_d, the vertical extinction (or attenuation) coefficient. The extinction coefficient is generally related to the amount of particulate and dissolved matter in the water column – the lower the value of the coefficient the deeper light will penetrate in the water column. More matter in the water, generally means a larger extinction coefficient. For example, an extinction coefficient of 0.35 m^{-1} will have light penetrating much deeper than a coefficient of 0.90 m^{-1}.

Light intensity measurements were collected from several locations in the Klamath River in August 2003, July 2004 (in cooperation with the North Coast Regional Water Quality Control Board), and August 2004. During the first two trips, only sites on the lower Klamath River (between Iron Gate dam and the confluence with the Trinity River) were sampled. During the August 2004 trip, upper Klamath River sites were sampled in addition to lower Klamath River sites.

Light extinction rates were measured with a LI-COR 192SA underwater Quantum Sensor to measure Photosynthetically Available Radiation (PAR) in the visible wavelength range (400-700nm). PAR is defined as photon flux density (the number of micromoles of photons per second per square meter in the radiant energy between 400nm and 700nm). Multiple measurements were taken at fixed intervals from the surface to depths of up to 3.5 feet. Depth versus intensity data were plotted and fit with an exponential function, wherein the exponent, k_d (m^{-1}), represents the light extinction coefficient from the following formulae:

$$I_z = I_o e^{-k z}$$

$$k_d = (\ln I_o - \ln I_z) / z$$

where:

I_o = quantity of light at water surface

I_z = quantity of light at depth z

z = depth in meters

k_d = light extinction coefficient

2.6 Chlorophyll-a

Chlorophyll are complex molecules found in all photosynthetic plants (e.g., the aquatic plants called phytoplankton). Chlorophyll, contained within the plant's cells, allows the plant to utilize sunlight as part of the cell's metabolism. There are different types of chlorophyll pigments identified by slight differences in their molecular structure and constituents. These chlorophyll pigments are labeled -a, -b, -c, and -d. Chlorophyll-a is the principal photosynthetic pigment and is common to all phytoplankton. Chlorophyll-a can thus be used as an estimate of phytoplankton biomass. Phytoplankton biomass is a primary regulator of clarity and color of water in many lakes and reservoirs.

PacifiCorp collected chlorophyll-a samples monthly from March to November 2002 and 2003 at several sites between the mouth of Link River (RM 253) and the Klamath River below Iron Gate dam (RM 189.5). Samples were collected using the grab-sample method. Chlorophyll-a was analyzed in the laboratory using fluorometric determination of chlorophyll-a (Standard Methods, APHA (1989), Method 10200 H). A well-mixed sample is filtered through a standard glass fiber filter. Pigments are extracted from the retained residue with aqueous acetone and the optical density (fluorescence) of the extract is determined with a fluorometer.

2.7 Recreational Visitor Survey

PacifiCorp conducted a Recreation Visitor Survey through the use of a questionnaire to assess the attitudes, preferences, and characteristics of the primary visitor user groups in the study area. This survey focused on Project-related visitors, including boaters, shoreline day users, campers, and anglers. The questionnaire obtained basic information about the respondents' visit, including areas visited, length of visit, and other trip characteristics. Sections of the survey addressed the specific issues and concerns of recreational users, including if water quality affected their visit to the study area.

Recreational visitor surveys were distributed to visitors at study area recreation sites on pre-selected dates during 2001 and 2002. The survey period for 2001 began in late June and continued through late September, while the survey period for 2002 began in early May and continued through early September. Survey dates were stratified to ensure that visitors from different areas and in different seasons throughout the survey periods were sampled proportionally to actual use levels. Details on the methods of the overall Recreation Visitor Survey are provided in the Recreation Resources Final Technical Report (PacifiCorp 2004c).

3. RESULTS

3.1 Turbidity

Minimum, maximum, and average turbidity values at several sample sites in the Klamath River from Link River to Orleans are summarized in Table 3.1-1 for the periods 1980 to 1986 (from the historic database), 1995 to 2001 (from the historic database), and in 2003 (from PacifiCorp sampling data). The turbidity measurements indicate a general trend of increasing water clarity in the downstream direction on an average basis (Table 3.1-1). Maximum and average turbidity values are highest at the Link River mouth sampling site, probably reflecting the high loading of algae and organic matter to the river from hypereutrophic Upper Klamath Lake, particularly during summer.

Time-series graphs of 2003 turbidity data from sites at the outflow of Link River, and J.C. Boyle, Copco, and Iron Gate reservoirs further indicate a general trend of increasing water clarity in the downstream direction (Figure 3.1-1). Also shown is a strong seasonal trend in turbidity at the Link River site associated with the algal growing season, during which peak algal growth occurs in summer (Figure 3.1-1). For example, the high July and August 2003 turbidity values (at or above about 20 NTU) occurred on dates coincident with very high chlorophyll-a values (230-250 ug/l).

The reduction in turbidity from Link River to Iron Gate dam during 2003, particularly in summer, is probably attributable to two main factors: (1) dilution effects of flow accretion between these two locations (from RM 234 to RM 189.5), and (2) settling or sedimentation of a portion of the organic load in the river during transit through Project reservoirs. For example, about 250 cfs of high-quality spring flows discharge directly to the Klamath River between the J.C. Boyle dam (RM 224) and powerhouse (RM 220). The turbidity of these high-quality spring flows is unknown, but is likely very low, and the flows are assumed to contribute to improved water clarity in the bypass reach downstream of J.C. Boyle dam.

Table 3.1-1. Minimum, maximum, and average turbidity values at sample sites in the Klamath River from Link River to Orleans from 1980 to 1986 (from historic database), 1995 to 2001 (from historic database), and in 2003 (PacifiCorp data). (NA = not sampled during the time period listed under.)

Sample Site	**River Mile**	**Minimum/Average/Maximum Turbidity Values, in NTUs (Number of samples in parentheses)**		
		1980-1986	**1995-2001**	**2003**
Link River at Mouth (Klamath Falls)	253	3/9.6/19 (41)	5/15.5/65 (40)	6.9/13.8/22.5 (8)
Klamath River at Highway 66 (Keno)	234	2/8.7/20 (37)	2/13.9/76 (28)	4.6/8.0/13.1 (8)
Klamath River above J.C. Boyle Reservoir	228	NA	NA	3.4/8.1/13.4 (8)
Klamath River below J.C. Boyle Dam	224	NA	NA	2.9/7.1/14.4 (8)
Klamath River below J.C. Boyle Powerhouse	221	NA	1/13.3/76 (32)	NA
Klamath River above Shovel Cr.	206.4	NA	NA	2.0/5.2/11.4 (8)
Klamath River below Copco 2 Dam	196.5	NA	NA	1.7/4.3/7.0 (8)
Klamath River below Iron Gate Dam	189.5	0/7.1/42 (97)	NA	1.4/3.1/6.1 (8)
Klamath River near Seiad Valley	128	1/7.3/170 (120)	NA	NA
Klamath River at Orleans	59	0/4.7/35 (117)	NA	NA

Reservoirs have been shown to remove significant amounts of sediments and nutrients from river inflows, depending on factors such as inflow sediment character and reservoir flushing rates (Baxter 1977, Dendy et al. 1973, Larson 1980, Marzolf 1984, Soltero et al. 1973). Simple comparisons of turbidity values in the 2003 inflow vs. outflow samples from J.C. Boyle, Copco, and Iron Gate reservoirs were used to determine differences. These differences are assumed indicative of reservoir influence on particulate materials that contribute to turbidity. The calculated differences are shown in Figure 3.1-2, where a negative difference represents a reduction in turbidity and a positive difference suggests an increase in turbidity. The differences vary over time and across location, but indicate that the reservoirs mostly act to reduce turbidity during reservoir transit.

3.1.1 Turbidity During Maintenance Activities

As described above, there is general improvement of turbidity conditions in the downstream direction through the Project area, indicating that the Project does not appear to be a net source of turbidity under normal operations. However, regular or emergency maintenance on Project facilities may be a potential source of increased turbidity.

During maintenance activity at Link dam in May 2002, turbidity was measured at two locations: 200 feet downstream from the dam in the Link River bypass reach, and farther downstream in the Link River reach below the East Side powerhouse. Average turbidity increased at both sites during the maintenance spill, from 12.3 NTU to 54.0 NTU at the site below the dam, and from 10.2 to 14.9 NTU at the site below the powerhouse. The elevated turbidity was largely confined to the bypass reach.

Turbidity was measured immediately below J.C. Boyle dam and near the downstream end of the J.C. Boyle bypass reach during maintenance activity at J. C Boyle dam in September 2002. Background data collected at both sites averaged 6.5 and 2.3 NTU, respectively. Average turbidity values increased at both sites during maintenance, from 6.5 to 12.4 NTU at the site near the dam and from 2.3 to 5.8 NTU near the bottom of the bypass reach. Turbidity increased at the upper site following spill for a period of 8 hours before receding to background values. The lower site showed an increase above the average background values for 15 hours, although the actual values are lower than those recorded in the upper section of the reach for the same period. No effect on turbidity attributable to the maintenance activity was observed in the Klamath River near Shovel Creek, approximately 15 miles downstream.

One potential source of turbidity attributable to the Project is the emergency spillway for the power canal to J.C. Boyle powerhouse. When in use, discharge from the spillway can cause erosion of the canyon wall resulting in a probable increase in turbidity in the river, depending on the amount of spill flow. However, PacifiCorp has proposed bypass valves for the J.C. Boyle powerhouse in the Final License Application, which would alleviate use of the spillway.

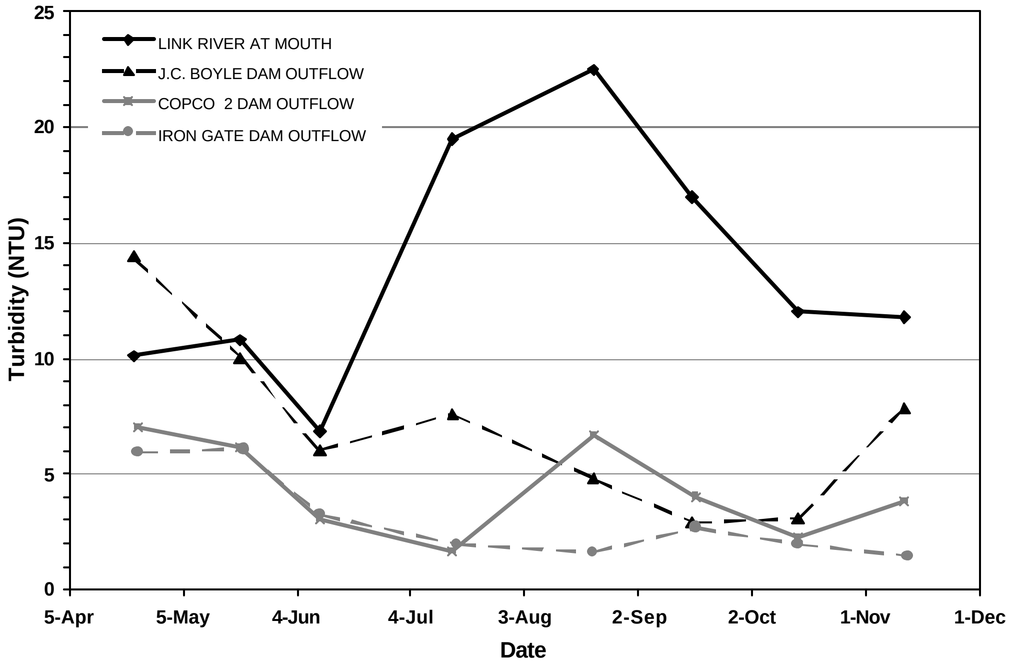

Figure 3.1-1. Turbidity values from samples taken during April-November 2003 at the mouth of Link River (RM 253), the Klamath River below J.C. Boyle dam (RM 224), the Klamath River below Copco No. 2 dam (RM 196.5), and the Klamath River below Iron Gate dam (RM 189.5).

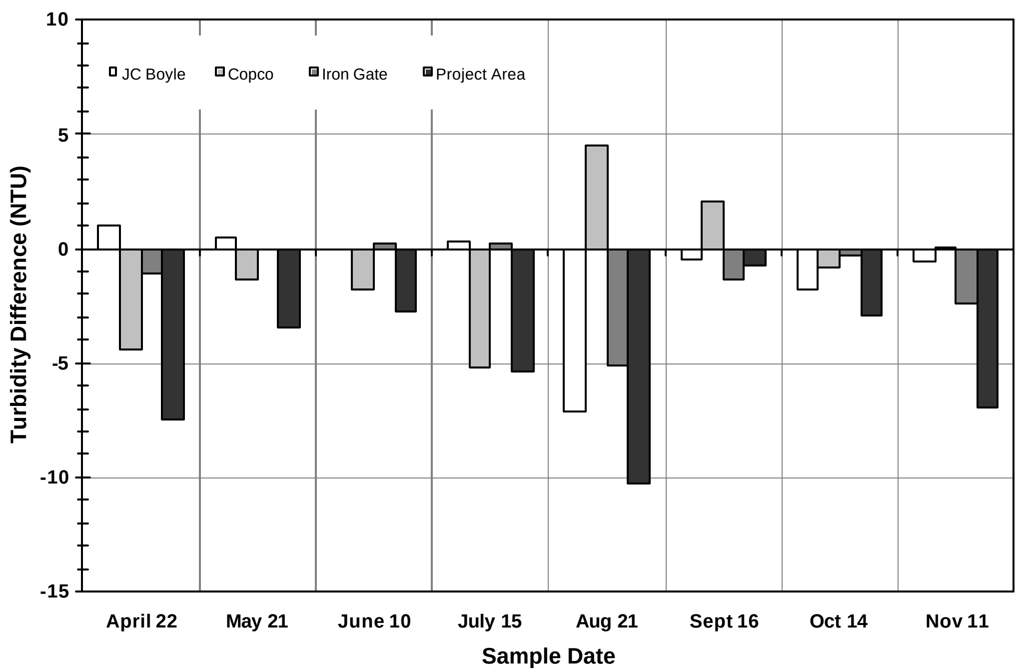

Figure 3.1-2. Differences in turbidity samples taken during April-November 2003 above and below J.C. Boyle, Copco No. 1, and Iron Gate reservoirs, and for the Project area (above J.C. Boyle reservoir to Iron Gate dam outflow).

3.1.2 Turbidity Differences Since 1980

Some stakeholders requested that PacifiCorp also analyze whether changes have occurred in water quality aesthetics since 1980. PacifiCorp examined available turbidity data since 1980 to determine if there are any obvious trends in this data over that period.

Time-series graphs of the historic turbidity data at each of six key sample sites in the Klamath River from Link River (RM 253) to Orleans (RM 59), and the Klamath Straits Drain (which joins the Klamath River at about RM 240.5) are included in Appendix A, Figures A-1 to A-7. Also added to these graphs is the data collected by PacifiCorp at four of the seven sample sites from Link River to Iron Gate dam (RM 189.5) during April to November 2003.

The time-series graphs indicate that turbidity values have been quite variable over time (including within and between years) at all locations. At the Link River, Klamath Straits Drain, Keno, and J.C. Boyle sites (Figures A-1, A-2, A-3, and A-4, respectively), the data show consistently higher annual maximum values during the late 1990's compared to prior years. At the Iron Gate dam, Seiad Valley, and Orleans sites (Figures A-5, A-6, and A-7, respectively), turbidity is not available during the late 1990's to assess this potential trend.

Factors contributing to higher annual maximum values during the late 1990's are not obvious, but may be related to river flow levels. Annual high flows in the river, particularly during winter and spring months, increased during the late 1990's from the late 1980's and early 1990's (Appendix A, Figure A-8 to A-11). This increase in flows during the late 1990's coincides with the observed higher annual maximum turbidity values. However, annual maximum turbidity values were not as high in the early 1980's when flows of higher magnitude similar to the late 1990's also occurred.

Graphs comparing turbidity and flow data (based on mean daily discharge on the date of turbidity sampling) were used to assess potential correlation at two example sites: the mouth of Link River (Appendix A, Figure A-12), and in the river downstream of the J.C. Boyle powerhouse (Appendix A, Figure A-13). These graphs indicate that the turbidity data is not correlated with flow at the mouth of Link River, and weakly correlated with flow (R^2 = 0.32) in the river downstream of the J.C. Boyle powerhouse. These results suggest that flow is not a predominant factor affecting turbidity in the river in these examples.

We assume that turbidity at the mouth of Link River is driven primarily by the discharge of algae and organic matter to the river from hypereutrophic Upper Klamath Lake, particularly during summer. However, a subsequent graph comparing turbidity and chlorophyll-a data at the mouth of Link River (when both were taken on the same date of sampling) indicates only a weak correlation (R^2 = 0.24) with chlorophyll-a (an indicator of algal biomass) (Appendix A, Figure A-14). This suggests that other factors are also contributing to water clarity and transparency, such as other organic or inorganic matter, particulates, and color, which are not captured by chlorophyll-a measurements.

The time-series graphs of turbidity data since 1980 show that turbidity entering the Project area from the Link River, Klamath Straits Drain, and Keno sites had consistently higher annual maximum values during the late 1990's than within or downstream of the Project area. In addition, as previously described, comparisons of inflow vs. outflow turbidity values during 2003 indicate that the reservoirs mostly act to reduce turbidity during reservoir transit. These trends suggest that the presence of the Project in the Klamath River between Keno dam and Iron Gate dam has not caused systematic net increases in turbidity since 1980.

3.2 Total Suspended Solids

Minimum, maximum, and average values of TSS samples obtained monthly at seven key sites in the Klamath River from Link River to Iron Gate dam from April through November 2003 are summarized in Table 3.2-1. Time-series graphs of TSS data from sites at the outflow of Link River, and J.C. Boyle, Copco, and Iron Gate reservoirs are shown in Figures 3.2-1.

The TSS measurements indicate a general trend of decreasing suspended material in the downstream direction on an average basis (Table 3.2-1). In addition, maximum TSS values are highest at the Link River mouth sampling site, probably reflecting the high loading of algal and organic matter to the river from Upper Klamath Lake, particularly during summer. The time-series graphs of TSS data also reflect the general decreasing downstream trend in TSS, with some variability over time and from site-to-site (Figures 3.2-1). This trend corresponds to the general decreasing downstream trend observed with turbidity as described in Section 3.1.

Table 3.2-1. Minimum, maximum, and average values of total suspended solids samples obtained monthly in the Klamath River from Link River to Iron Gate dam, April to November 2003.

Sample Site	River Mile	N	Minimum/Average/Maximum TSS Values (mg/l)
			2003
Link River at Mouth (Klamath Falls)	253	8	3.6/16.7/46.0
Klamath River below Keno Dam	233.3	8	2.0/10.8/32.4
Klamath River above J.C. Boyle Reservoir	228	8	2.4/7.5/18.0
Klamath River below J.C. Boyle Dam	224	8	1.0/6.0/14.0
Klamath River above Copco Reservoir	206.4	8	1.0/5.1/12.0
Klamath River below Copco Reservoir	196.5	8	1.0/3.0/5.0
Klamath River below Iron Gate Dam	189.5	8	0.0/2.3/7.0

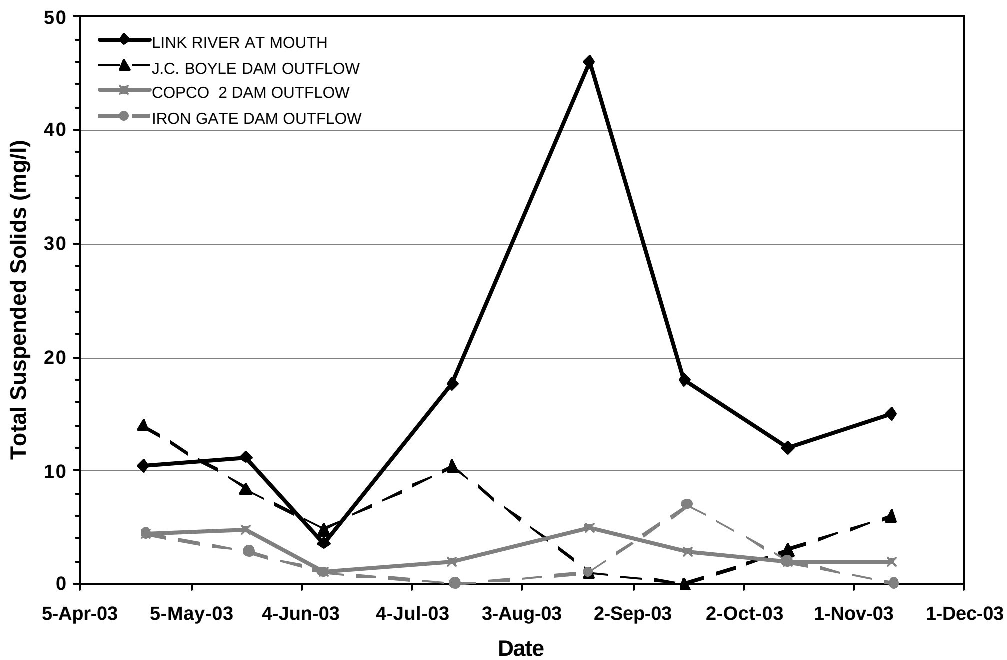

Figure 3.2-1. Total suspended solids values from samples taken during April-November 2003 at the mouth of Link River (RM 253), the Klamath River below J.C. Boyle dam (RM 224), the Klamath River below Copco No. 2 dam (RM 196.5), and the Klamath River below Iron Gate dam (RM 189.5).

3.3 Color

The measurements of color taken in the Project area during August 9-11, 2004 are shown in Figure 3.3-1. The results indicate a consistent declining trend in color, from highly colored[3] water (80 PCU) in the Klamath River below Keno dam (RM 234), to moderately-colored water (34 PCU) below Iron Gate dam (RM 189.5), to low-colored water (14 PCU) in the Klamath River above the confluence with the Trinity River (RM 43.5). The highly colored water (80 PCU) in the river below Keno dam is not surprising given the high organic loading to the river from hypereutrophic Upper Klamath Lake and Lake Ewauna/Keno reservoir, particularly during summer.

The relatively low-colored water (27 PCU) in the Klamath River in the lower end of the bypass reach above the J.C. Boyle powerhouse reflects the substantial spring flow accretion in the bypass reach. During diversion of flow to the J.C. Boyle powerhouse, flows in the bypass reach consist of about 100 cfs of water released from J.C. Boyle dam

[3] Waters are considered highly colored at color concentrations greater than about 50 PCU (Klein 1962). U.S. secondary drinking water regulations establish a secondary maximum contaminant goal of 15 PCU in public drinking water systems.

and about 250 cfs of spring flow accretion. The spring-fed inflows are assumed to consist of very low-colored water (on the order of about 10 PCU[4]).

The appreciable reduction in color from Keno dam (80 PCU) to Iron Gate dam (34 PCU) cannot be fully explained by the dilution effects of flow accretion between these two locations (from RM 234 to RM 190). USGS gage records show that average flows during August 9-11, 2004 were approximately 350 cfs at the Keno gage and 615 cfs at the Iron Gate gage. If accretion inputs between these locations were assumed to have a color of 10 PCU (as back-calculated for bypass reach spring inflows), a conservative calculation of color at Iron Gate equates to about 50 PCU. Even if accretion inputs between these locations were assumed to have no color (zero PCU), a conservative calculation of color at Iron Gate equates to about 45 PCU[5]. Comparison of these theoretical, conservative estimates to the actual measured value below Iron Gate dam (34 PCU) suggests that Project operations in the Klamath River between Keno dam and Iron Gate dam are not causing an increase in water color, and may in fact act to reduce color, perhaps via reduction of color-causing organic materials in the river during reservoir transit.

Downstream of Iron Gate dam, the continued reduction in color can be mostly attributed to the dilution effects of basin flow accretion. USGS gage records show that average flows during August 9-11, 2004 were approximately 615 cfs at the Iron Gate gage and 1420 cfs at the Orleans gage (RM 59). If accretion inputs between these locations were assumed to have a color of 10 PCU (as back-calculated for bypass reach spring inflows), a conservative calculation of color at Orleans equates to about 20 PCU. Color was not actually measured at Orleans. However, this estimate compares closely to, and falls within, the nearest upstream color measurement of 21 PCU above the Salmon River (RM 68) and the nearest downstream measurement of 14 PCU above the Trinity River (RM 43.5).

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[4] Color of spring inflows can be estimated at about 10 PCU by back-calculation by taking the product of color and flow as measured in the bypass reach (say, C_BQ_B), subtracting the product of color and flow as measured below J.C. Boyle dam (C_DQ_D), and then dividing the remainder by the spring accretion quantity (Q_s).

[5] A theoretical, conservative estimate of color at Iron Gate can be estimated by taking the product of color and flow as measured at Keno (say, C_KQ_K), adding the product of assumed color and flow of accretion (C_AQ_A), and then dividing the sum by the flow as measured at Iron Gate (Q_{IG}). By conservatively assuming that color of accretion flows is zero, the second term (C_AQ_A) also is zero, and can be dropped in the formulated estimate.

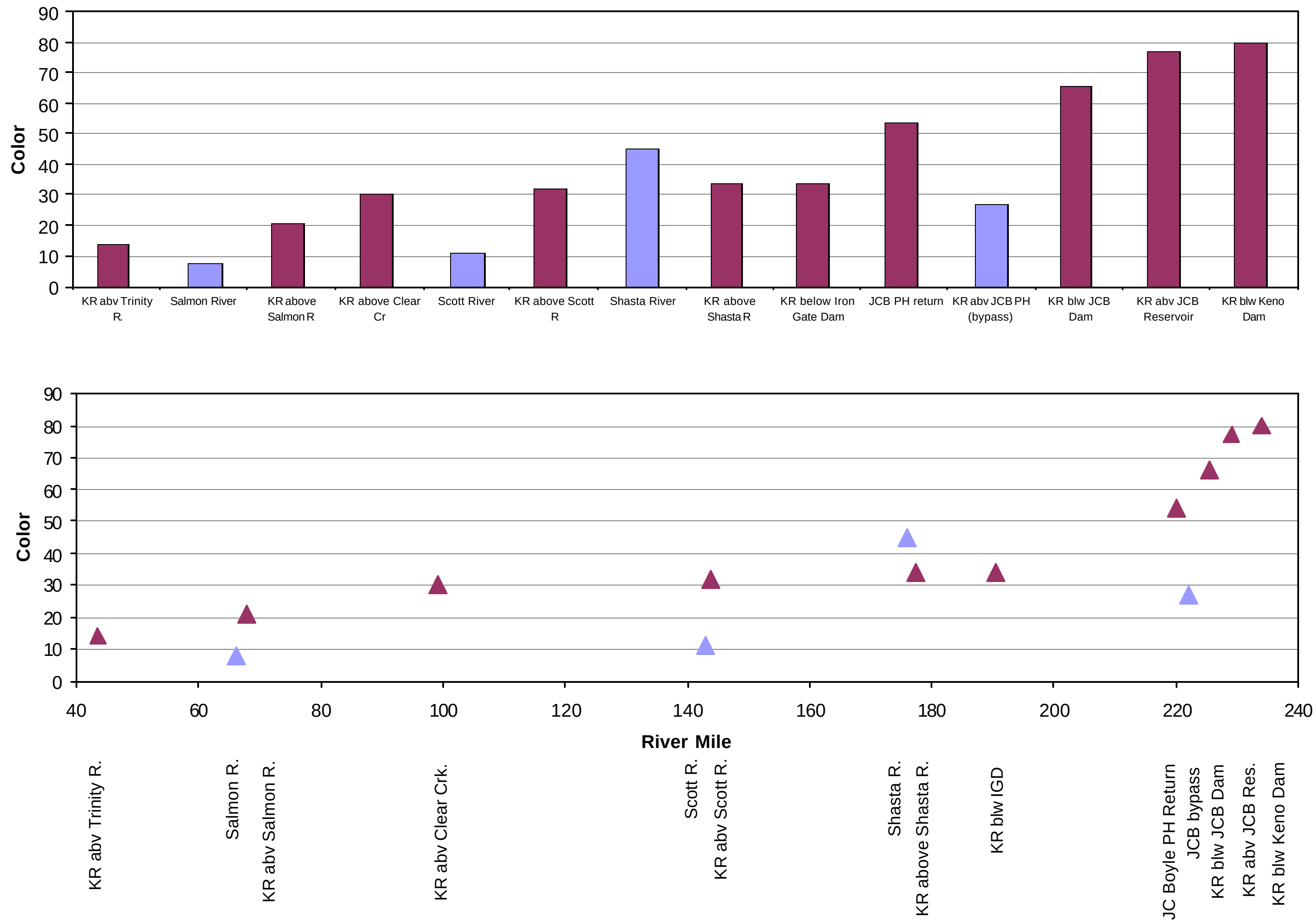

Figure 3.3-1. Color in water (Platinum-Cobalt units) at various locations in the Klamath River measured during August 9-11, 2004.

3.4 Secchi Disc

Minimum, maximum, and average Secchi disk depths (m) during 2001 to 2003 are summarized in Table 3.2-1 for five locations in the Klamath River. Locations include Link River at the mouth, Keno reservoir at the Highway 66 bridge, J.C. Boyle reservoir, Copco No. 1 reservoir, and Iron Gate Reservoir. Table 3.4-1 summarizes the minimum, average, and maximum values measured at each location. Graphs of Secchi disc data collected in the Klamath Basin in 2001 to 2003 are included in Figure 3.4-1.

Secchi disk readings typically vary seasonally with changes in photosynthesis and therefore, algal growth (Welch 1992). In most lakes and reservoirs, Secchi disk readings begin to decrease in the spring, with warmer temperature and increased algal growth, and continue decreasing until algal growth peaks in the summer. The natural color of the water also affects the readings. In most lakes and reservoirs, the impact of color may be insignificant. But some lakes and reservoirs are highly colored, which may result in low Secchi readings even if algae content may be relatively low.

Table 3.4-1. Number of available Secchi disk measurements, and minimum, average, and maximum values at five locations in the Klamath River in 2001 to 2003.

Site Name	N	Minimum/Average/Maximum Secchi Disc Depth (meters)
Link River mouth (RM 253)	8	0.6/0.7/1.0
Keno Reservoir at Hwy 66 Bridge (RM 234)	14	0.4/1.0/1.6
J.C. Boyle Reservoir (RM 224.8)	17	0.4/1.2/2.0
Copco No. 1 Reservoir (RM 198.7)	25	0.5/1.9/3.4
Iron Gate Reservoir (RM 190.2)	25	0.9/2.3/4.2

The Secchi disk values by location indicate a general trend of increasing transparency in the downstream direction. This general trend corresponds to similar decreasing downstream trends observed with turbidity, TSS, and water color as described in previous sections.

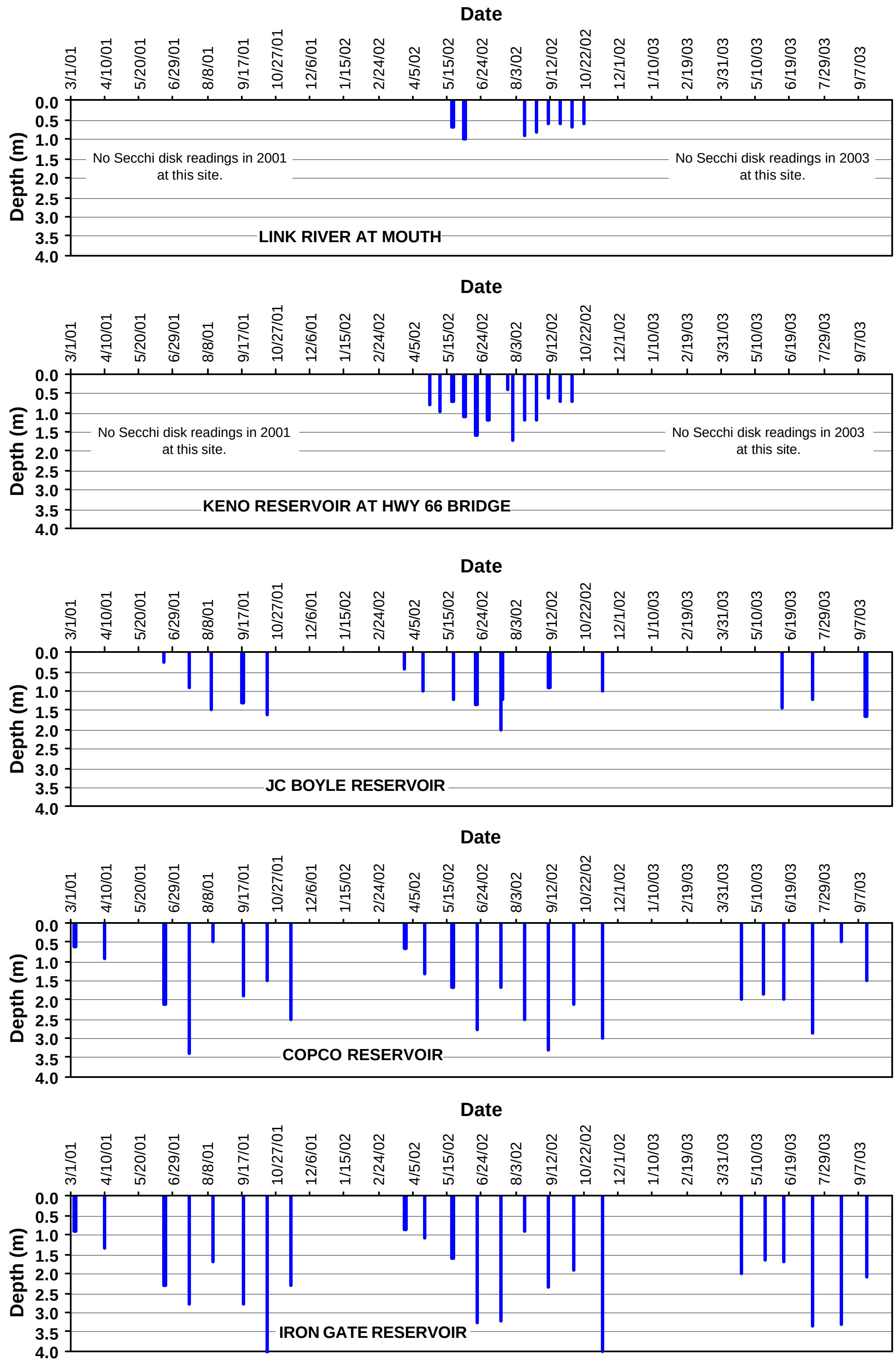

Figure 3.4-1. Graphs of Secchi disc depth (m) data collected at five sites in the Klamath Basin in 2001 to 2003.

3.5 Light Extinction

The light extinction coefficients calculated in the Project area from measurements taken during August 9-11, 2004 are shown in Figure 3.5-1. The results indicate a general declining trend in light extinction coefficients, from 2.6 m^{-1} in the Klamath River below Keno dam (RM 234), to 1.2 m^{-1} below Iron Gate dam (RM 189.5), to 0.8 m^{-1} in the Klamath River above the confluence with the Trinity River (RM 43.5)[6]. This general downstream increase in light penetration corresponds with similar general trends of downstream reductions in turbidity, TSS, and water color, and downstream increases in Secchi disk depths as described in previous sections.

The lower light penetration (2.6 m^{-1}) in the river below Keno dam is not surprising given the high organic loading to the river from hypereutrophic Upper Klamath Lake and Lake Ewauna/Keno reservoir, particularly during summer. The relatively high light penetration (0.9 m^{-1}) in the Klamath River in the lower end of the bypass reach above the J.C. Boyle powerhouse reflects the dominance of substantial spring flow accretion in the bypass reach. During diversion of flow to the J.C. Boyle powerhouse, flows in the bypass reach consist of about 100 cfs of water released from J.C. Boyle dam and 250 cfs of clear, non-turbid spring flow accretion.

Downstream of Iron Gate dam, the light intensity coefficient generally decreases through the lower reaches of the Klamath River. This continued increase in light penetration is probably mostly attributable to the dilution effects of basin flow accretion, as previously shown for water color (see Section 3.3). Light intensity measurements were taken in the lower Klamath River below Iron Gate dam and tributaries during all three sampling periods (August 2003, July 2004, and August 2004) (Figures 3.5-2 and 3.5-3), whereas Upper Klamath River sites were sampled only in August 2004 (Figure 3.5-1). Each of the three data sets indicate that light penetration generally increases through the lower reaches of the Klamath River. The Salmon and Scott Rivers add fairly clear, high quality water, while the Shasta River may add relatively more turbid water to the Klamath River.

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[6] The extinction coefficient is generally related to the amount of particulate and dissolved matter in the water column – the lower the value of the coefficient the deeper light will penetrate in the water column. More matter in the water, generally means a larger extinction coefficient. For example, an extinction coefficient of 0.35 m^{-1} will have light penetrating much deeper than an extinction coefficient of 0.90 m^{-1}.

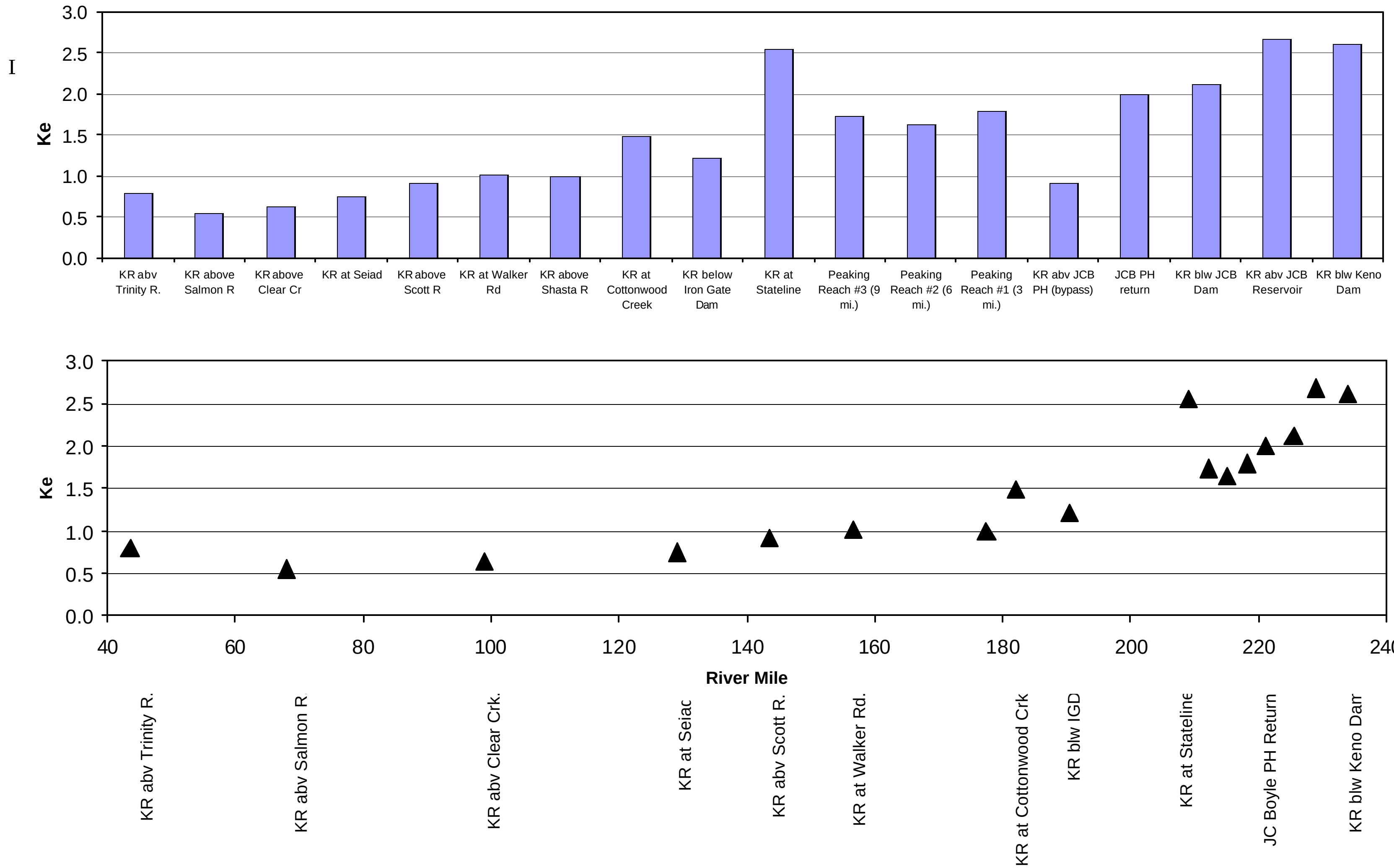

Figure 3.5-1. Light extinction coefficients (Ke; 1/m) at various locations in the Klamath River measured during August 9-11, 2004.

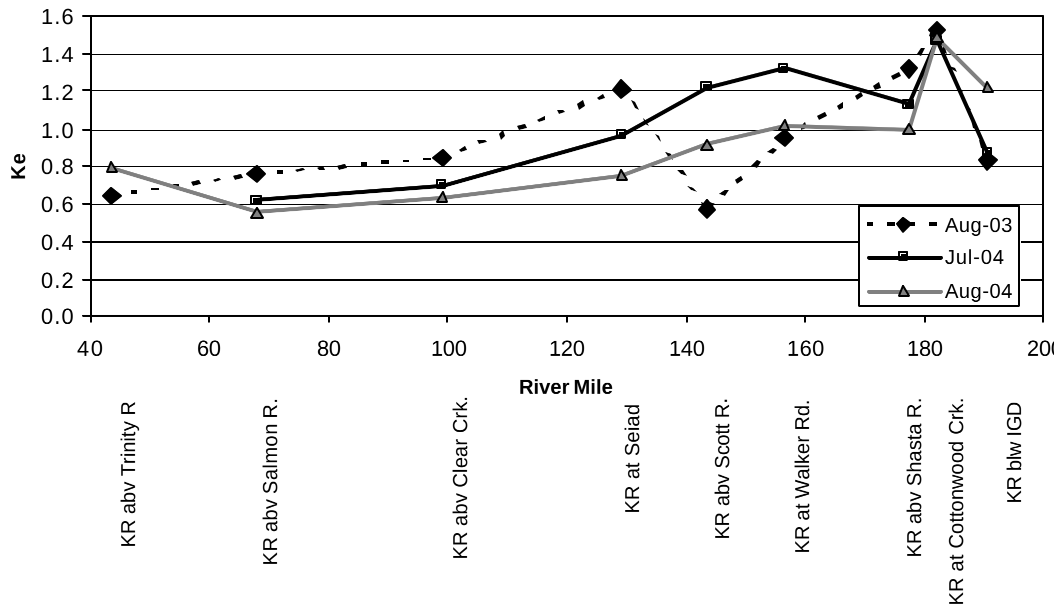

Figure 3.5-2. Light extinction coefficients (Ke; 1/m) at the lower Klamath River downstream of Iron Gate dam measured during August 18–21, 2003; July 7-8, 2004 (in cooperation with the North Coast Regional Water Quality Control Board); and August 9-11, 2004.

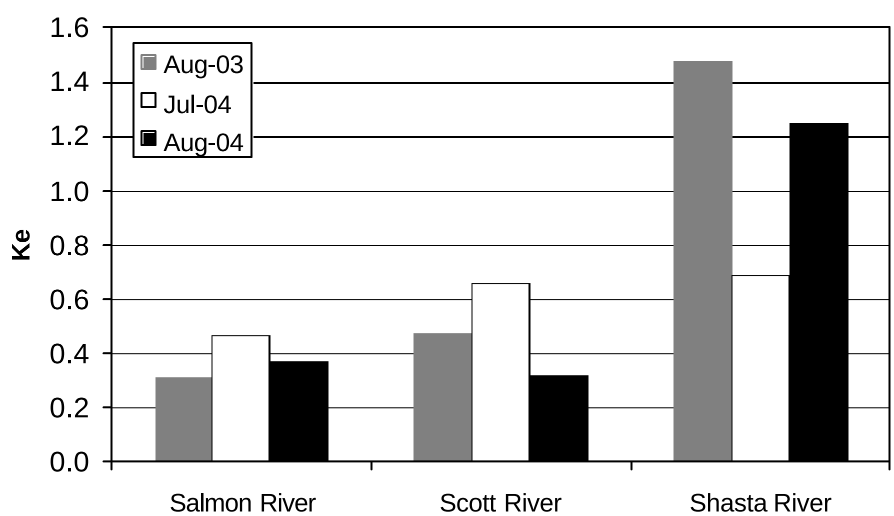

Figure 3.5-3. Light extinction coefficients (Ke; 1/m) measured in key tributaries to the lower Klamath River during August 2003; July 2004 (in cooperation with the North Coast Regional Water Quality Control Board); and August 2004.

3.6 Chlorophyll-a

Minimum, maximum, and average values of chlorophyll-a samples obtained monthly at five key sites in the Klamath River from Link River to Iron Gate dam from March to November 2002 and March to November 2003 are summarized in Table 3.6-1. Time-series graphs of the chlorophyll-a data from sites at the outflow of Keno, J.C. Boyle, Copco, and Iron Gate reservoirs are shown in Figure 3.6-1.

The chlorophyll-a measurements indicate a general trend of decreasing algal biomass in the downstream direction. The data indicate that chlorophyll-a decreases in the downstream direction on an average basis (Table 3.6-1). In addition, maximum chlorophyll-a values are much higher at the Link River mouth sampling site, reflecting the high organic loading to the river from hypereutrophic Upper Klamath Lake, particularly during summer. As expected, chlorophyll-a has a strong seasonal trend associated with the algal growing season, during which peak algal growth occurs in summer (Figure 3.6-1).

This general trend of downriver decline in chlorophyll-a corresponds to similar trends observed with turbidity, TSS, water color, Secchi disk, and light extinction observations. However, the chlorophyll-a trend is more variable over time and from site-to-site. As a result, there are occasions when phytoplankton production in J.C. Boyle, Copco, and Iron Gate reservoirs contributes to increased chlorophyll-a concentration in reservoir outflows to the river (Figure 3.6-1).

Table 3.6-1. Minimum, maximum, and average values of chlorophyll-a samples obtained monthly in the Klamath River from Link River to Iron Gate dam, March to November 2002 and March to November 2003.

Sample Site	**River Mile**	**Minimum/Average/Maximum Chlorophyll-a Values, in ug/l (Number of samples in parentheses)**	
		2002	**2003**
Link River at Mouth (Klamath Falls)	253	2.7/57.3/162 (16)	2.4/64.3/257 (9)
Klamath River below Keno Dam	233.3	2.0/30.4/88 (9)	2.2/20.6/76 (8)
Klamath River below J.C. Boyle Dam	224	1.0/11.8/31 (9)	5.8/12.4/38 (9)
Klamath River below Copco Reservoir	196.5	1.0/7.7/33 (9)	1.0/14.3/82 (9)
Klamath River below Iron Gate Dam	189.5	2.7/11.7/29 (8)	2.0/9.6/20.4 (9)

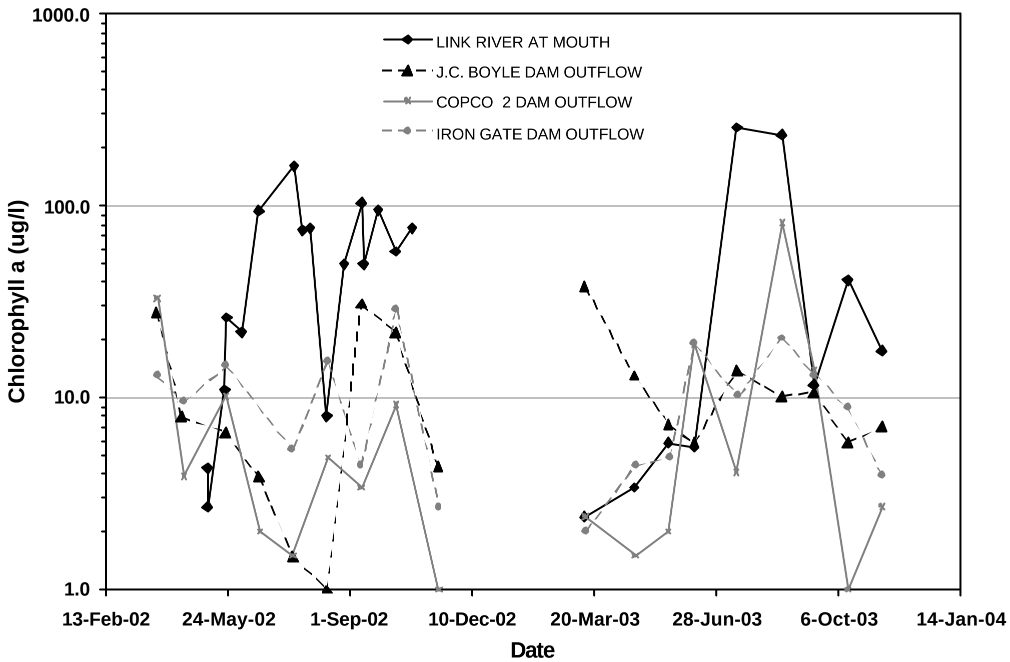

Figure 3.6-1. Chlorophyll-a values from samples taken during March-November 2002 and 2003 at the mouth of Link River (RM 253), the Klamath River below J.C. Boyle dam (RM 224), the Klamath River below Copco No. 1 dam (RM 197), and the Klamath River below Iron Gate dam (RM 189.5). Note that Chlorophyll-a values are on a logarithmic scale.

3.7 Recreational Visitor Survey

The following text is focused on the results of the Recreation Visitor Survey that are pertinent to water quality. Details on the results of the overall Recreation Visitor Survey are provided in the Recreation Resources Final Technical Report (PacifiCorp 2004c). It should be noted that water quality condition was only one of many factors that recreational users were asked about in the survey. In addition, the survey was not designed to correlate user responses on water quality conditions to specific, quantified water quality conditions at the time of the response.

During the 2001 and 2002 survey periods, 1,461 visitors were given the opportunity to complete a survey. In total, 694 completed surveys were returned, which corresponds to a 48 percent response rate. This response rate to the visitor survey was lower than anticipated[7], but consisted of a sufficient number of completed surveys to achieve a 95 percent confidence level and a sampling error of 5 percent for the entire study area (Table 3.7-1). Additionally, a sufficient number of completed surveys were returned to achieve a 95 percent confidence level with a sampling error of 10 percent at all resource areas except Copco reservoir (Table 3.7-1).

Table 3.7-1. Completed surveys by resource area and corresponding sampling error.

Resource Area	Returned Surveys	Percent of Total	Sampling Error (Low Variance)[1]
Link River/Lake Ewauna/Keno Reservoir	98	14	± 7.9
J.C. Boyle Reservoir	141	20	± 6.6
Upper Klamath River/Hell's Corner Reach	63	9	± 9.9
Copco Reservoir	30	4	± 14.3
Iron Gate Reservoir	318	46	± 4.4
Other[2]	44	6	N/A
Study Area (Total)	**694**	**100**	**± 2.9**

Source: PacifiCorp (2004c)

[1] Low variance in responses (e.g., 80 percent true and 20 percent false in response to a True/False questions) is characteristic of more homogenous populations.

[2] Corresponds to surveys in which a primary location could not be identified for a variety of reasons (location notation was torn off, location line was not filled in, etc.). Several of these surveys are likely to be from Sportsman's Park.

Among the many questions contained in the survey, visitors were asked if water quality ever affected their visit to the study area. Overall, 38 percent of the survey respondents replied that water quality had affected their visit to the study area (Table 3.7-2). In addition, approximately one-third of respondents at each resource area (except the Upper Klamath

[7] Researchers have noted a national trend of declining survey participation in recent years.

River/Hell's Corner reach), also replied that water quality had affected their visit to their respective resource area.

Table 3.7-2. Perceived effect of water quality on recreational visits in the study area (yes/no).

SURVEY QUESTION: *Has water quality ever affected your visit to the Klamath River area?*		
Resource Area	**Yes (percent)**	**No (percent)**
Link River/Lake Ewauna/Keno Reservoir	32	68
J.C. Boyle Reservoir	39	61
Upper Klamath River/Hell's Corner Reach	61	39
Copco Reservoir	35	65
Iron Gate Reservoir	32	68
Study Area (Total)	**38**	**62**

Source: Source: PacifiCorp (2004c)

Slightly more than 60 percent of survey respondents in the Upper Klamath River/Hell's Corner reach felt that water quality had affected their visit to the area. This may suggest that whitewater river users are more cognizant than reservoir users of water quality conditions. However, when asked to explain how water quality affected their visit, many of the respondents in this area cited insufficient or inconsistent flows, rather than poor water quality.

Respondents who replied that water quality had affected their visit to the study area were asked (on a scale from "Detracts a lot" to "Adds a lot") how water quality had affected their visit. About 36 percent of these respondents felt that water quality had detracted a lot from their visit to the study area, and about 33 percent felt that water quality had detracted a little from their visit (Table 3.7-3) (the remaining 31 percent felt that water quality either did not detract from, or added to their visit). As a percentage of all survey respondents (i.e., including those who indicated that water quality did not affect their visit per Table 3.7-2), about 14 percent of all survey respondents indicated that water quality had detracted a lot from their visit to the study area, and about 13 percent indicated that water quality had detracted a little from their visit (Table 3.7-3).

Survey respondents were also asked to write-in where, when, and how water quality had potentially affected their visit. Table 3.7-4 summarizes responses to "where, when, and how" questions about water quality in the study area. Only those respondents who replied that water quality had affected their visit to the study area were asked to complete this question. Responses are grouped by the area each respondent indicated was the location of their water quality issue. The most-often cited factors affecting respondents perception of water quality include algae, "dirty" water conditions, flow conditions, and smell.

Table 3.7-3. Perception of how much water quality affected recreational experiences in the study area.

SURVEY QUESTION: *Please indicate how reservoir or river water quality has affected the quality of your experience?*				
	Respondents who replied that water quality had affected their visit		**Including All Respondents**	
Resource Area	**Detracts a Lot (percent)**	**Detracts a Little (percent)**	**Detracts a Lot (percent)**	**Detracts a Little (percent)**
Link River/Lake Ewauna/Keno Reservoir	48	33	15	11
J.C. Boyle Reservoir	30	41	12	16
Upper Klamath River/Hell's Corner Reach	55	36	34	22
Copco Reservoir	60	10	21	4
Iron Gate Reservoir	32	38	10	12
Study Area (Total)	**36**	**33**	**14**	**13**

Source: Source: PacifiCorp (2004c)

Table 3.7-4. Perceived water quality issues in the study area. (Note: the percentages in this table are based only on the number of persons who said that water quality affected the quality of their visit, not on the number of total respondents.)

SURVEY QUESTION: *Has water quality ever affected your visit to the Klamath River area? If yes, please explain….*		
Where (n)	**When (percent)**	**How (percent)**
Link River/Lake Ewauna/Keno Reservoir (20)	• Summer (30 percent) • Always (25 percent) • Last year—2001 (10 percent)	• Algae (40 percent) • Smell (15 percent))
J.C. Boyle Reservoir (16)	• Summer (25 percent) • Always (25 percent) • Now (19 percent)	• Algae (56 percent) • Dirty (31 percent)
Upper Klamath River/Hell's Corner Reach (19)	• Summer (32 percent) • Now (16 percent) • Always (11 percent) • Last year—2001 (11 percent)	• Not enough water (32 percent) • Inconsistent flows (32 percent) • Algae (26 percent)
Copco Reservoir (8)	• Always (38 percent) • Summer (25 percent) • Last year—2001 (25 percent)	• Dirty (38 percent) • Algae (25 percent)
Iron Gate Reservoir (56)	• Summer (38 percent) • Late summer/fall (30 percent) • Last year—2001 (9 percent) • Spring (7 percent)	• Algae (48 percent) • Low water (11 percent) • Dirty (7 percent) • Smell (5 percent)
Below Iron Gate Dam (4)	• Summer (50 percent) • Winter (25 percent)	• Low water (50 percent) • High water (25 percent)

Source: Source: PacifiCorp (2004c)

4. DISCUSSION

The results as described in Chapter 3 indicate that water quality characteristics that may be associated with aesthetic conditions (turbidity, total suspended solids, water color, Secchi disk depth, light extinction, and chlorophyll-a) are poorest at the upper end of the study area (e.g., at the Link River, Klamath Straits Drain, and Keno sites), and generally improve in the downstream direction. The consistently higher turbidity, TSS, and chlorophyll-a at the upper end of the study area is likely driven primarily by the discharge of algae and organic matter to the river from hypereutrophic Upper Klamath Lake, particularly during summer.

The general improvement in these water quality characteristics in the downstream direction is attributed to two main factors: (1) dilution effects of flow accretion in the downstream direction; and (2) settling or sedimentation of a portion of the organic load in the river during transit through Project reservoirs. For example, with respect to accretion, about 250 cfs of high-quality spring flows discharged directly to the Klamath River between the J.C. Boyle dam and powerhouse noticeably enhances water clarity in the bypass reach downstream of J.C. Boyle dam. With regard to reservoir settling effects, comparisons of turbidity values in the 2003 inflow vs. outflow samples from J.C. Boyle, Copco, and Iron Gate reservoirs indicate that the reservoirs mostly act to reduce turbidity during reservoir transit. Reservoirs have been shown to remove significant amounts of sediments and particulate matter from river inflows, depending on factors such as inflow sediment character and reservoir flushing rates (Baxter 1977, Dendy et al. 1973, Larson 1980, Marzolf 1984, Soltero et al. 1973).

Like the other parameters, chlorophyll-a data show a general trend of downriver decline. However, the chlorophyll-a trend is more variable over time and from site-to-site. As a result, there are occasions when phytoplankton production in J.C. Boyle, Copco, and Iron Gate reservoirs contributes to increased chlorophyll-a concentration in reservoir outflow to the river (Figure 3.6-1).

Also, although there is general improvement in turbidity in the downstream direction through the Project area, occasional maintenance activities on Project facilities may be a potential source of increased turbidity. Monitoring of such maintenance activities (as described in Section 3.1) indicates that increased turbidity has been episodic and confined to the river reach where the activity has occurred.

The recreational user survey information indicates that about one quarter of respondents stated that water quality in the Project area affected their visit. About 14 percent of all survey respondents indicated that water quality had detracted a lot from their visit to the study area, and about 13 percent indicated that water quality had detracted a little from their visit. Algae, "dirty" water conditions, and flow were the most-often cited adverse conditions.

Some stakeholders requested that PacifiCorp also analyze whether changes have occurred in water quality aesthetics since 1980. Turbidity values since 1980 have been quite variable over time (including within and between years), but the data show consistently higher annual maximum values during the late 1990's compared to prior years. The cause of consistently higher annual maximum values during the late 1990's is not obvious. Both flow and algal matter (represented by chlorophyll-a) appear to be factors, although correlation of these factors with turbidity is not strong, suggesting that factors affecting water clarity and transparency are variable and complex in this system.

The time-series graphs of turbidity data since 1980 show that turbidity entering the Project area from the Link River, Klamath Straits Drain, and Keno sites had consistently higher annual maximum values than within or downstream of the Project area. In addition, as previously described, comparisons of inflow vs. outflow turbidity values during 2003 indicate that the reservoirs mostly act to reduce turbidity during reservoir transit. These trends suggest that the presence of the Project in the Klamath River between Keno dam and Iron Gate dam has not caused systematic net increases in turbidity since 1980.

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Appendix A

Turbidity Time-Series (1980-2003) Data Graphs

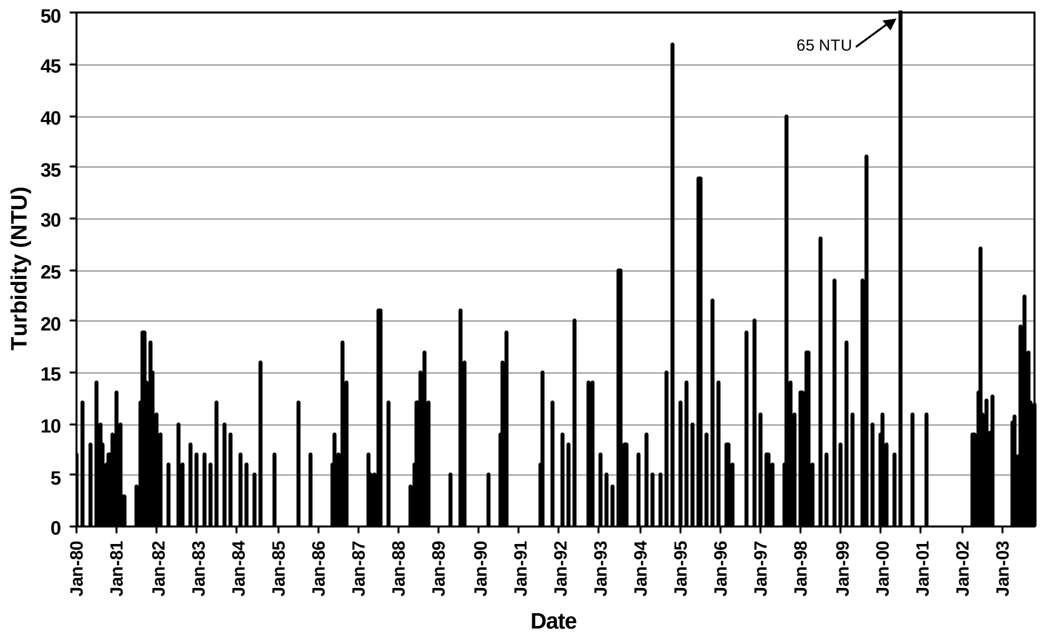

Figure A-1. Turbidity values from samples taken at the mouth of Link River (RM 253), January 1980 to December 2003.

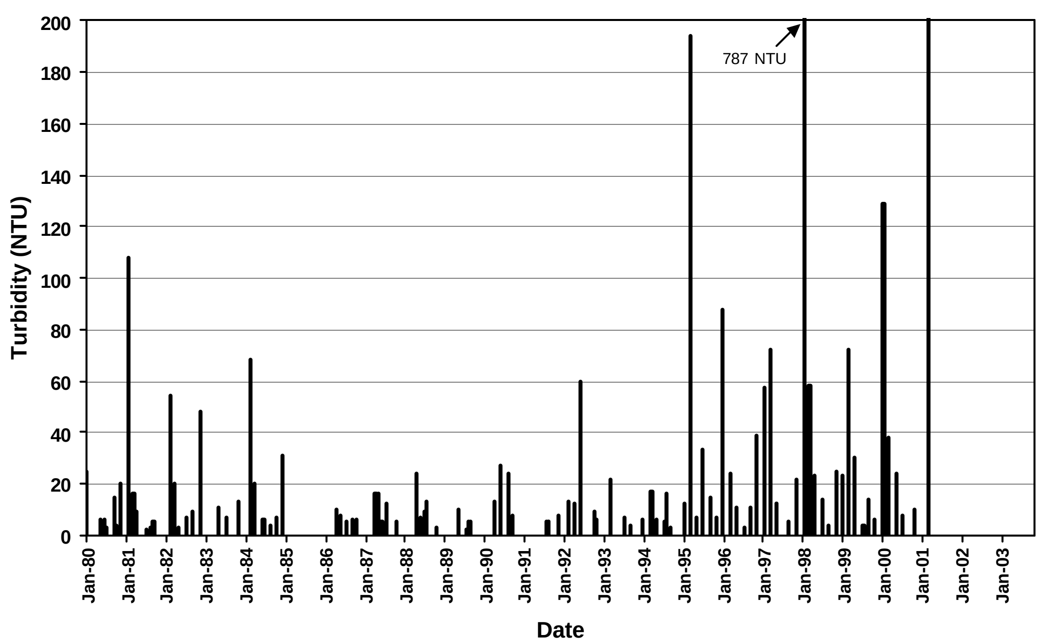

Figure A-2. Turbidity values from samples taken in the Klamath Straits Drain at Pump Station F (RM 240.5), January 1980 to December 2003. Note that no data is available at this site after 2001.

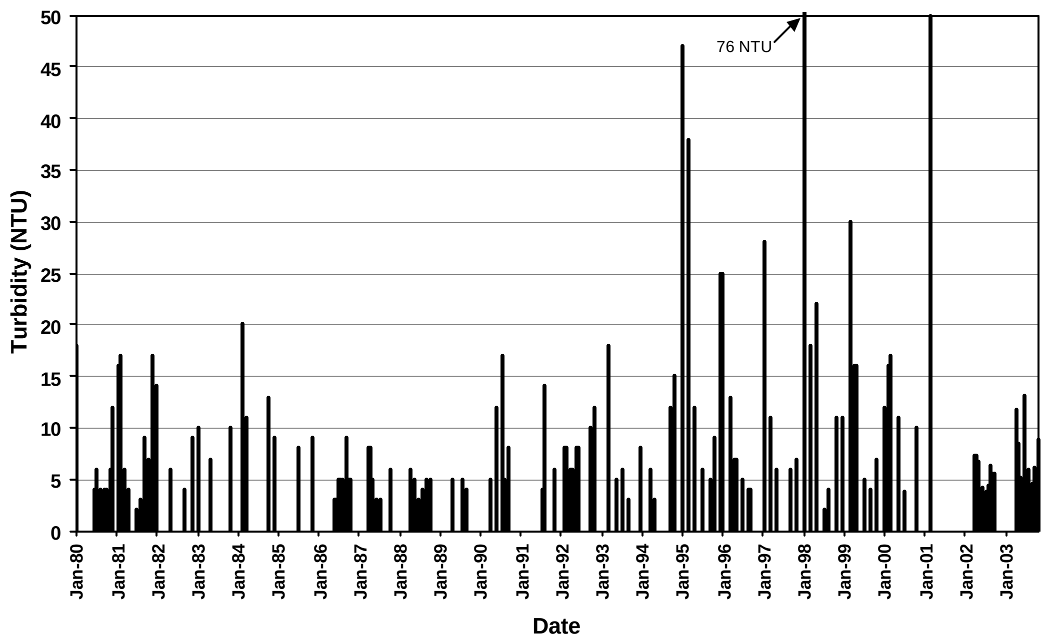

Figure A-3. Turbidity values from samples taken in the Klamath River at Highway 66 near Keno (RM 234), January 1980 to December 2003.

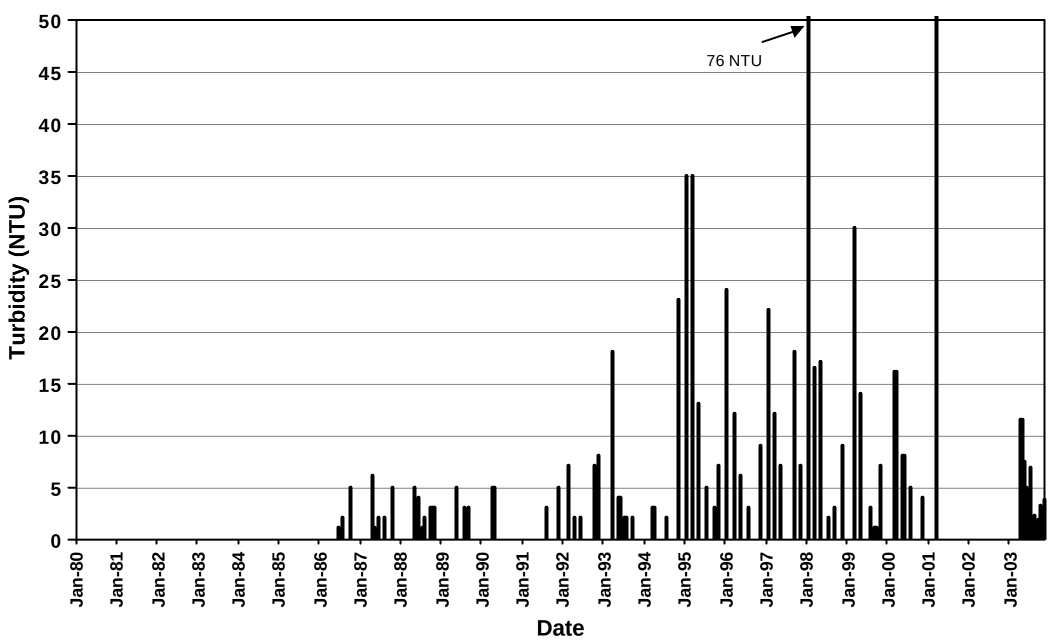

Figure A-4. Turbidity values from samples taken in the Klamath River downstream of the J.C. Boyle powerhouse (RM 221), January 1980 to December 2003. Note that no data is available at this site from 1980 through 1985, and in 2002.

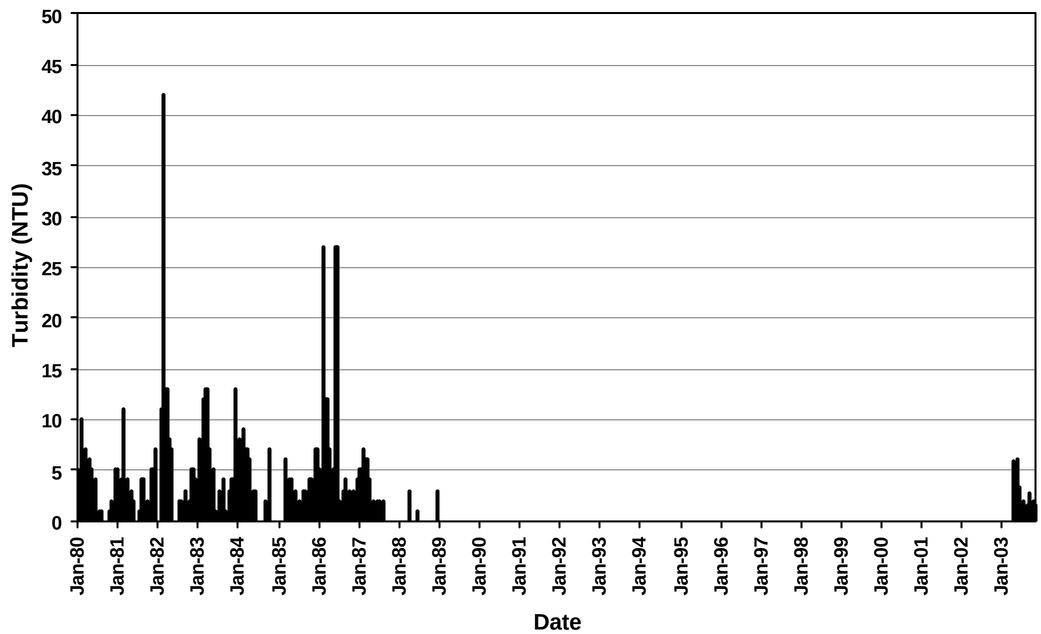

Figure A-5. Turbidity values from samples taken in the Klamath River below Iron Gate dam (RM 189.5), January 1980 to December 2003. Note that no data is available at this site after from 1989 through 2002.

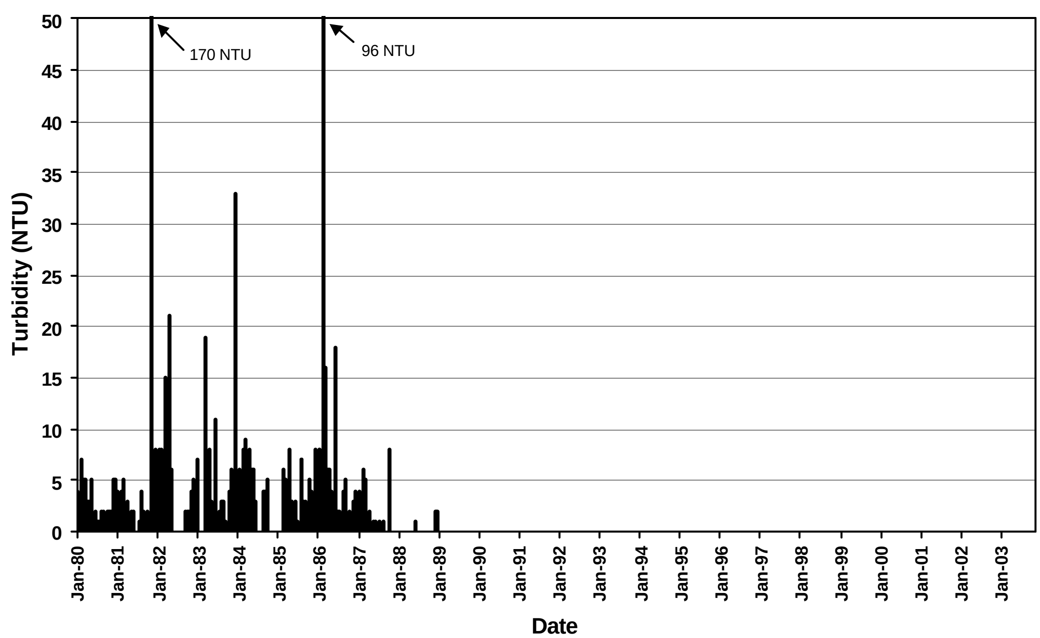

Figure A-6. Turbidity values from samples taken in the Klamath River at Seiad Valley (RM 128), January 1980 to December 2003. Note that no data is available at this site after 1988.

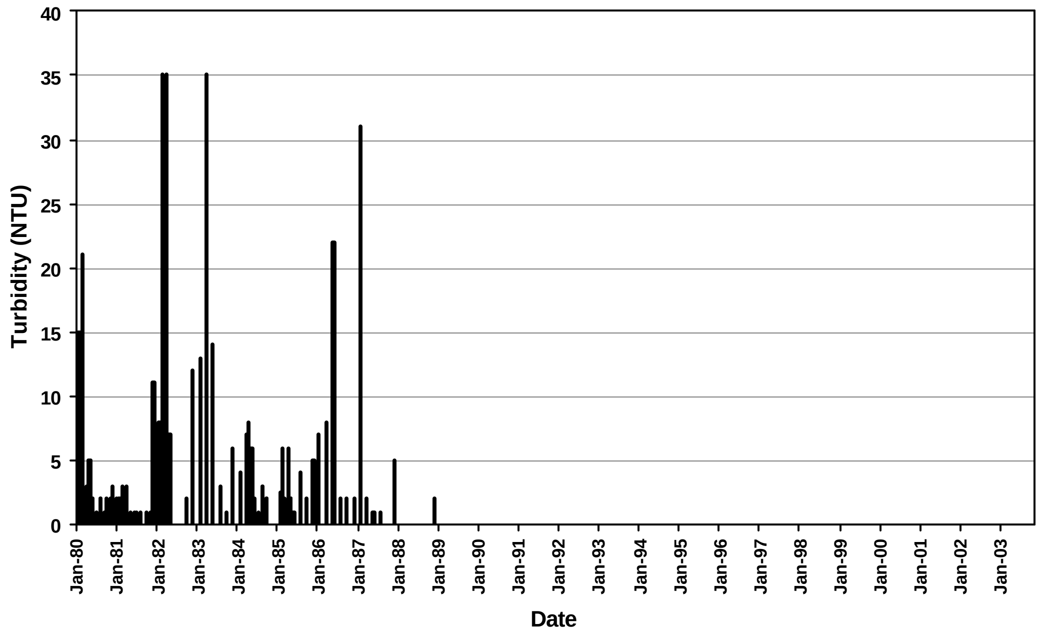

Figure A-7. Turbidity values from samples taken in the Klamath River at Orleans (RM 59), January 1980 to December 2003. Note that no historical data is available at this site after 1988.

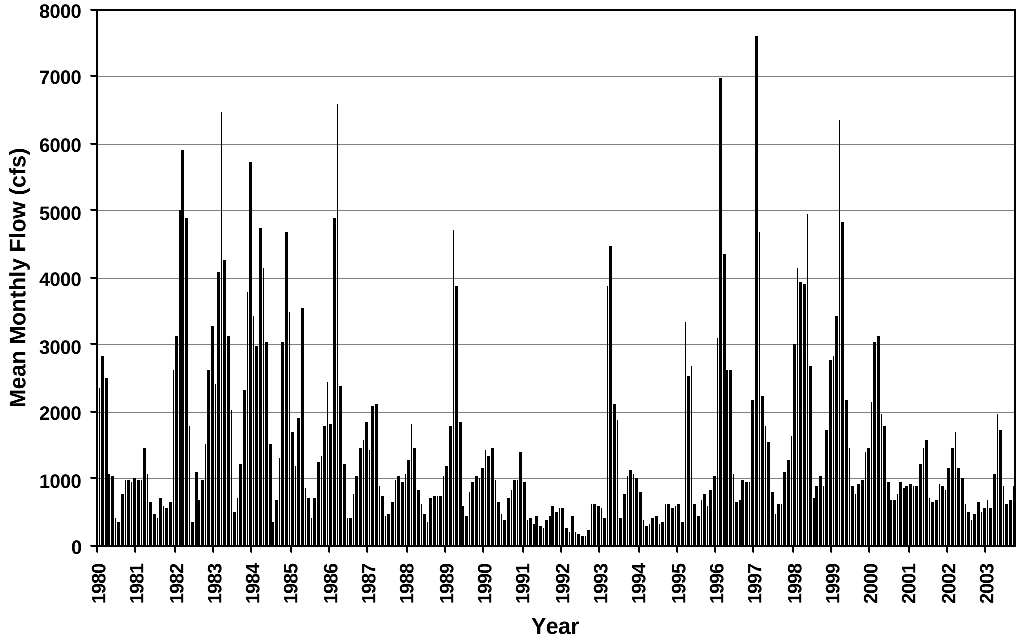

Figure A-8. Mean monthly flows in the Klamath River at Keno (USGS gage 11509500) during 1980 to 2003.

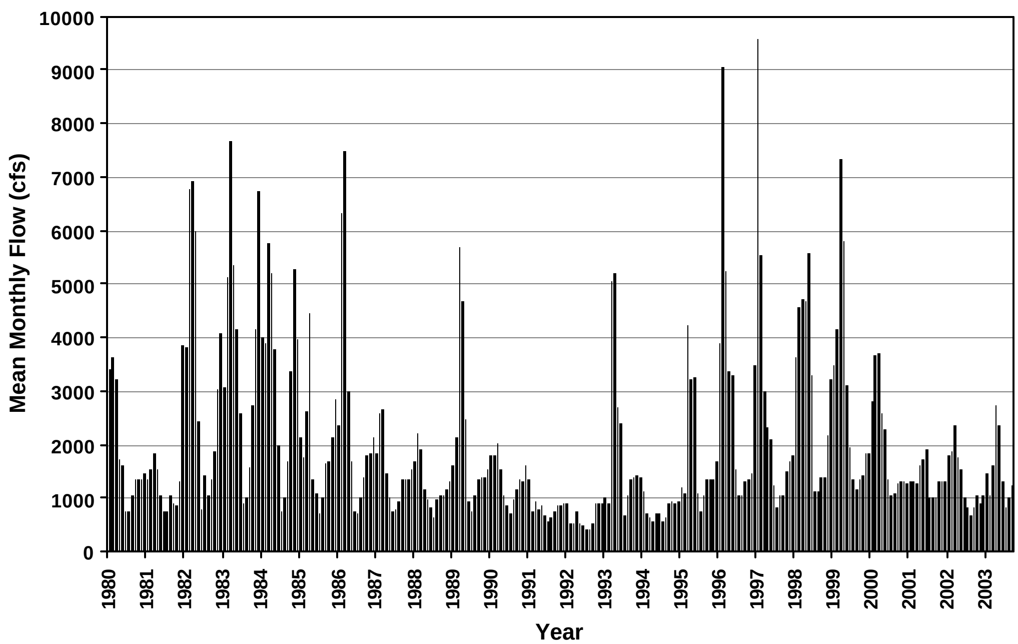

Figure A-9. Mean monthly flows in the Klamath River below Iron Gate dam (USGS gage 11516530) during 1980 to 2003.

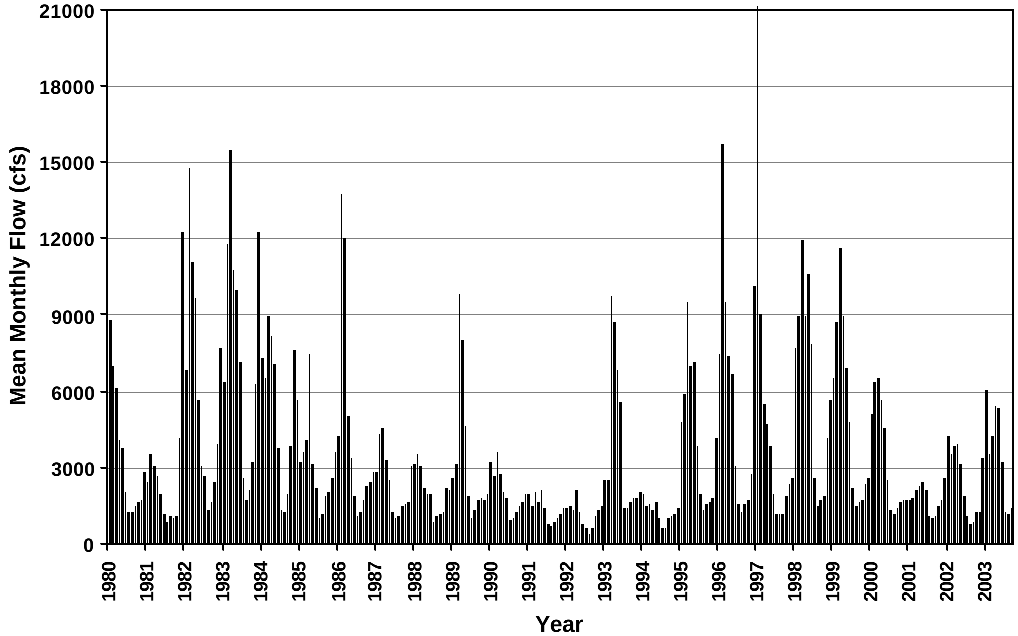

Figure A-10. Mean monthly flows in the Klamath River at Seiad Valley (USGS gage 11520500) during 1980 to 2003.

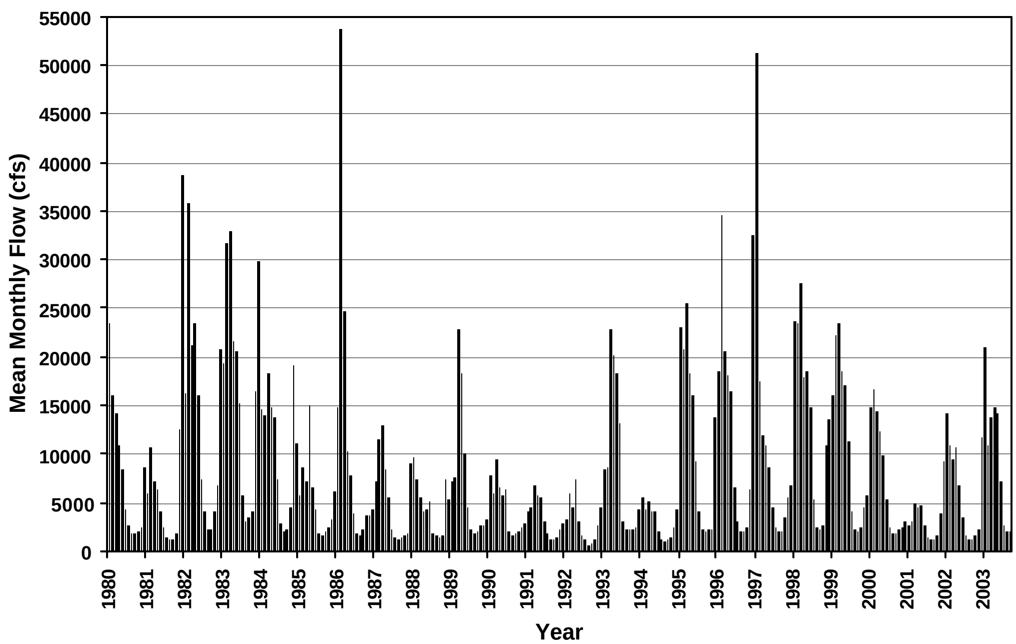

Figure A-11. Mean monthly flows in the Klamath River at Orleans (USGS gage 11523000) during 1980 to 2003.

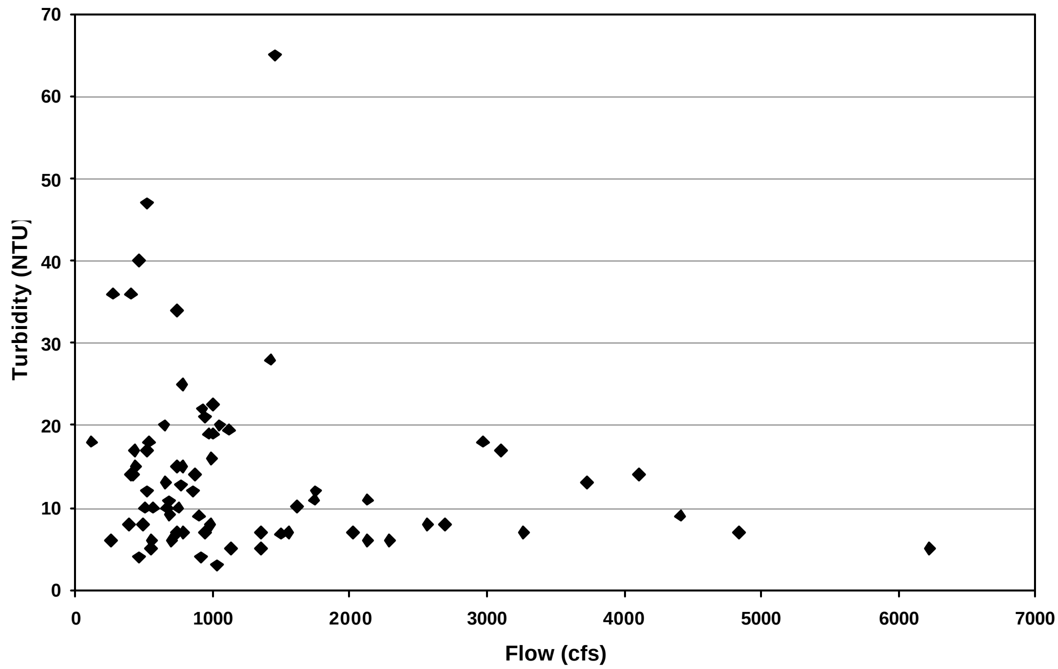

Figure A-12. Turbidity vs. flow at the mouth of Link River (RM 253), January 1980 to December 2003.

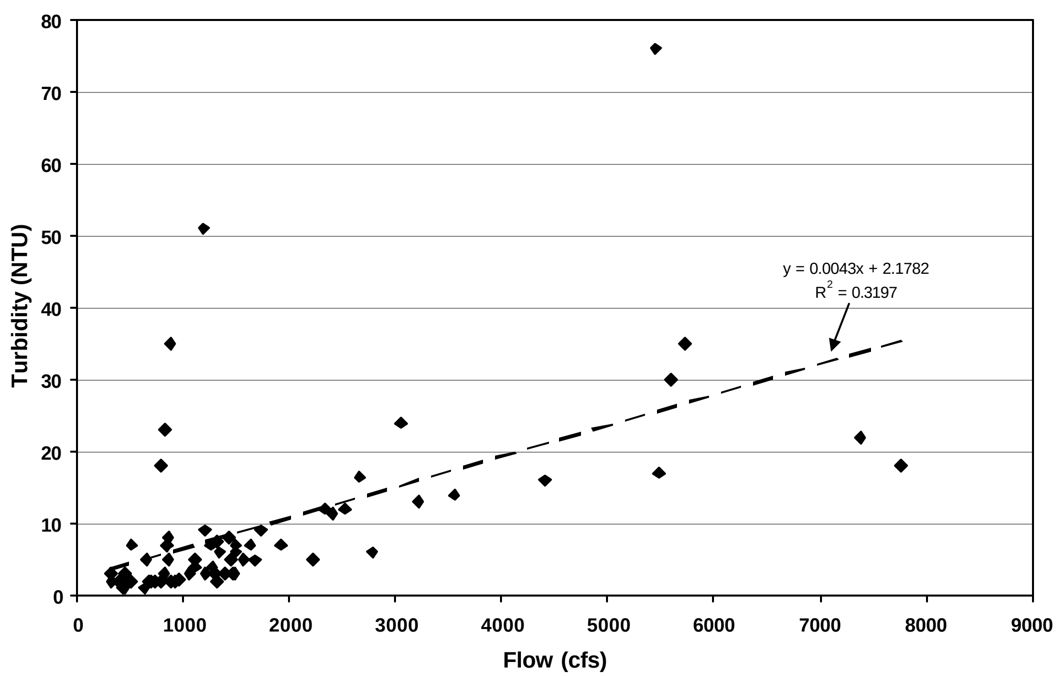

Figure A-13. Turbidity vs. flow in the Klamath River downstream of the J.C. Boyle powerhouse (RM 221), January 1980 to December 2003.

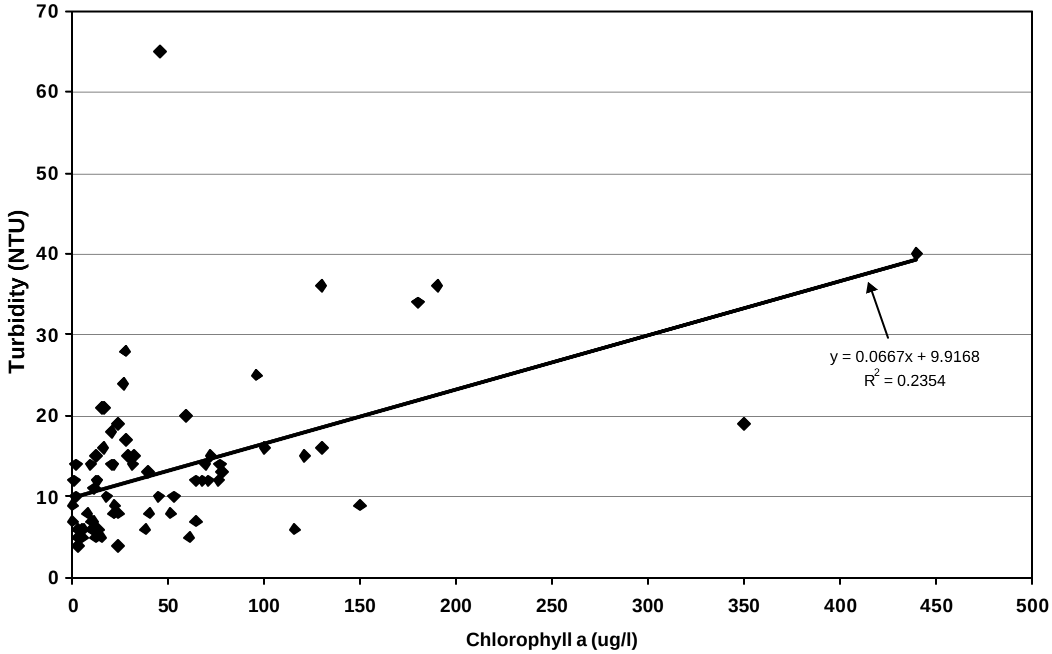

Figure A-14. Turbidity vs. chlorophyll-a at the mouth of Link River (RM 253), January 1980 to December 2003.

Appendix B

Klamath Recreational Survey Water Quality Results

Klamath Water Quality/Aesthetics Survey Responses

GENERAL QUESTIONNAIRE SURVEY
Has water quality ever affected your visit to the Klamath River area?

	Percent	n
NO	57	407
YES	36	250

If YES, please explain….(open-ended responses sorted by area)

Where	When	How
LAKE EUWANA/KENO RESERVOIR		
Keno	Every visit to Keno	cannot swim due to too much algae - So go to other lake to swim. It would be nice if where we visit river was cleaner to swim.
Keno and Lake Ewauna	This year	Bad smell this year
Keno Res.; Klamath Lake	middle summer	algae
Keno Reservoir	going fishing, every time we camp out & walk to water	too much algae
Keno Reservoir	8/11/2001	campsite
Keno River	0	algae smell
Keno, Iron Gate	Late summer	Algae
Klamath	0	lake is so dirty
Klamath Falls	8/25/2001	0
Klamath Lake	0	Stagnant water
Klamath Lake	always	0
Klamath Lake	All year	algae
Klamath Lake	Anytime	Algae
Klamath Lake	0	Algae/dirty
Klamath Lake - too low	0	0
Lake Ewauna Trail	Late spring - early fall	Standing water by trail smells
Lake Ewauna/Veteran's Park	7/1/2001	0
Lake Ewauna/Klamath Falls	Aug-Sept.	0
Miller Island	Last summer	Flotsam
Lake Ewauna	July 1	Smelled-water
J.C. BOYLE RESERVOIR		
JC Boyle	Last year	Saw dead fish in lake
JC Boyle Res.	0	Water Level up and down
near Sportsman's Park	ever since park has been established	0
Topsy	Summer visits	Extremely filthy (also dead fish everywhere)

Where	When	How
Topsy	6/2/2002	Dirty can't swim/leachy
Topsy	Now	Muddy from power boats
Topsy	Late summer	Algae
Topsy	Today	Algae
Topsy	Aug or end of July	Green stuff in the water (mucky)
Topsy	Every time	Vegetation overgrowth/algae
Topsy	Since I was young	There is too much muck & algae
Topsy	all the time	moss/slime
Topsy	0	algae
Topsy	0	gross
Topsy Day Use	This trip (6-23-02)	The seaweed was extremely distracting
Topsy Reservoir	0	Dirty algae
UPPER KLAMATH RIVER/HELL'S CORNER REACH		
Hell Corner	Last 3 years on Labor Day	I do not swim in River due to Color and taste
Hell's Corner	0	Water's too high
Hell's Corner	When water is too high	0
Hell's Corner	0	Level is low then high, and makes fishing impossible.
Hell's Corner	0	Let the water out at night!!
Hell's Corner Reach & below Iron Gate	everytime	0
Hell's Corner Run	This trip	0
Hell's Reach	Occasionally	Water releases not ramped down in eve.
Klamath River	Summer	Water too warm for fishing
Klamath River	June through July	Too low of flows
Klamath River	June through July	Too little water
Klamath river	summer	algae--yuk
Rafting upper Klamath & flows effect trip	0	a lot of algae and "suds"
river	0	we didn't get in the river a lot but boating is ok
Upper Klamath River	Last year	Uneven waterflows
Upper Klamath River	Labor Day Weekend	Flow lines
Upper Klamath River	8/4/2001	Algae
Upper Klamath River	July 6th weekend; Labor day weekend	Timing of water release
Upper Klamath River Campground	8/4/2001	Algae
COPCO RESERVOIR		
Copco	Yearly	Green/Blue Algae Bloom - Weeds

Where	When	How
Copco	Can be anytime during the summer	0
Copco	last summer	0
Copco	0	smug in the water
Copco	always	bad water quality
Copco Lake	In past years	"suds" in the river & lake
Copco, Iron Gate	Summers	Affected our timing
Copco/Lower Klamath	~ Late 91	Slimy, green, foamy - yuck
IRON GATE RESERVOIR		
Horseshoe Ranch/on the river below Iron gate dam	Late Summer	the river drops and it gets nasty
IG Reservoir	0	Smell bad & I don't come up
In the Klamath area	Mid-Sept to June	To cold
Iron Gate	2 weeks ago (end April)	Low water
Iron Gate	0	Low Water
Iron Gate	Summer	Algae bloom
Iron Gate	later in summer	Seaweed
Iron Gate	late summer	Seaweed
Iron Gate	5/6/02-5/12/02	Late turn on
Iron Gate	April 20	Low water
Iron Gate	5/11/2002	Yellow tag - not to use water
Iron Gate	August on	The algae gets to bay
Iron Gate	Late in the summer	Don’t' come
Iron Gate	Late Summer	Gets yucky
Iron Gate	Years past	Pea green soup, algae
Iron Gate	Late 90's	Too much algae
Iron Gate	Late summer	Algae
Iron Gate	Late in the summer	Gets really dirty
Iron Gate	Late Summer	Lots of stuff in water (plants)
Iron Gate	0	0
Iron Gate	Late Aug-Sept.	0
Iron Gate	Late in the year	Algae
Iron Gate	after Mid Aug.	0
Iron Gate	Late summer	plant life in water
Iron Gate	0	Algae clogs jet ski engines
Iron Gate	late in year	gets skunky
Iron Gate & Copco Lakes	Summertime	Too algae filled to enjoy swimming
Iron Gate & Upper Klamath	0	I like the algae in the lakes
Iron Gate Dam to mouth of Klamath River	August, September	Need more water to be released; water too warm for salmon
Iron Gate Lake	Always	Because the algae grows too close to shore

Where	When	How
Iron Gate Res.	7/5/2002	Dirty shoreline; people are slobs
Iron Gate Res.	7/20-7/22/01	0
Iron Gate Res.	Late summer	Algae
Iron Gate Reservoir	August	Poor Water Quality
Iron Gate To I-5	summer	no water!
Iron Gate	Late in summer	Green, thick algae
Iron Gate	Late in summer	Too much algae – jet skis get clogged up
Iron Gate	Late summer	Algae seaweed
Iron Gate	Late summer	Algae is bad
Iron Gate	late in the summer	gets to messy
Iron Gate	end of summer	algae - but I guess that makes less crowds!
Iron Gate	0	too mossy
Iron Gate	Last year	0
Iron Gate	Late summer	too much algae
Iron Gate	Late Summer	0
Iron Gate	Late summer	Green water
Iron Gate	July 0-2001	0
Iron Gate	7/29/2001	0
Iron Gate & Copco	Summer time	Algae, from water temp or cows??; The smell is disgusting...
Iron Gate & Copco	Winter and late summer	0
Iron Gate & Copco	mid-summer	Algae
Iron Gate & Keno	Late summer	Algae
Iron Gate AKA slimegate	August, sometimes July	0
Iron Gate Res.	Late summer	Algae blooms increase - nasty!
Mirror Cove	Summer	Too much seaweed
Iron Gate	From about July on	too much algae
OTHER		
Algae	0	0
Algae	Late summer	Makes water look dirty
All	Year round	Dirty
April	Iron Gate	Low water
Around docks/campgrounds	Late summer	Hydrilla WEEDS; swimming/fishing
Below Iron Gate	Winter	To High Middy
Below Iron Gate	Summer	Klamath too low; fish sick
But H20 quality effects wildlife and would effect it.	0	0
Can't drink it	0	0
Diamond Lake	8/18/2001	0
everywhere	always	the algae

Where	When	How
everywhere	everytime	irrigation pollution
Expectation	0	The trip leaders talked about not wanting to get cut in water because of filth
Fishing on the lower river	0	water levels
Here	Today	Too much seaweed where we like to swim
here	All the time	Moss in water not clean
Here	Now	Weeds Moss Kelp
Lakes	Each Summer	Grass + Water plants
Lower Klamath	Last year	You guys cut our water off. We couldn't farm.
Moss	Summer	Don't come in summer
Not the lake but water in hydrants	0	Its May 11 & still no water or hydrants
off the shore	you can't get on any of the docks	0
Oregon & N. California	0	Low water levels
PPL Park	Last summer	The algae
Sycan, Sprague, Williamson, Klamath River Reservoirs	Last 25 days, next 15 days (Permanent)	Temp., sediments, ague./ Human pollution
Steal gates	Summer of 2001	Protect
The entire basin made useless to both humans & wildlife	Last year	Taking the farmers' water; WE have swam & skied in upper Kl. Lake for 50 years - it's green - but then so is grass.
The lake	0	Too much moss in lake
Too little experience, however, water quality is extremely important to me and I would avoid an area I know is polluted.	0	0
Upper and Lower Klamath River	today, Sept. 3, 2001	0
Upper Klamath	Last summer	Inaccurate & late water flows released
Upper Klamath	every summer	0
upper Klamath	summer	not quality quantity; river doesn't rise 'till Late Afternoon.
Upper Klamath Lake	Late Summer/Fall	Thick Algae
Upper Klamath Lake	Sat, Sun Aug 5, 6	0
Upper Klamath Lake	Late Spring/Summer	0
Upper Klamath Lake/Agency Lake	Late summer	Algae - stinks

Where	When	How
Upper Klamath River System	Warm weather algae	I don't fish or swim in the water.
upper Klamath.	Labor Day 01	polluted
water	0	I don't come as often as swimming in green water is not ideal
Water level too low, Summer '01	0	0
whole Klamath	0	stinks
0	0	When the water smells bad and is too green
0	0	Not enough
0	Early April	0
0	Water warm & is green	0
0	0	Plant growth around lake prevents bank fishing from May-Oct.
0	Last year	0
0	0	Algae
0	0	Need water in hydrants
0	0	Need water faucets
0	0	The algae usually isn' t bad in the river.
0	0	Algae affects skiing enjoyment
0	0	Don't know if water is good
0	0	Too much algae
0	always	prevents swimming
0	0	fishing poor
0	All the time	Dirty water
0	0	Availability of camp water
0	Now	Lots of foam?? River quality
0	Always	Dirty
0	0	Try to do something about algae
0	0	drinking fine - don't care to swim when full of algae
0	0	Algae prohibits good swimming
0	0	It would be nice if the algae could be decreased.
0	0	lots of floating debris
0	0	algae thick
0	Earlier in the day	Need to release water
0	0	Flows
0	0	foamy

If YES, please indicate how reservoir or river water quality has affected the quality of your experience.

	Percent	n
Detracts a lot	36	89
Detracts a little	33	82
No effect	15	38
Adds a little	2	5
Adds a lot	4	12

HELL'S CORNER REACH BOATER/ANGLER INTERVIEW FORM

Did water conditions affect your trip in any way?

	Percent	n
NO	44	8
YES	56	10

If YES, how….

- Warmer water was nice, has lots of algae
- Several people claimed illness as a result of ingestions (accidental) of river water
- Scummy water, lots of foam, definitely not clean water
- Lots of foam/scum
- Water quality is obviously very poor: the abundance of brown foam very negatively affected my experience on the river.
- Dirty
- Too warm, too polluted, too much agricultural runoff
- Water is nasty
- Water cold coming from dam, pollutes agricultural runoff
- The amount of foam gave me the impression that the water was polluted

Of yes respondents….

- All 10 were on commercial rafting trips.