BOX CANYON HYDROELECTRIC PROJECT
FERC No. 2042

INTERIM TEMPERATURE MANAGEMENT PLAN

Prepared for

Public Utility District No. 1 of Pend Oreille County
Newport Washington

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1.0 INTRODUCTION

The Washington Department of Ecology (WDOE) issued a 401 water quality certification for the Box Canyon Hydroelectric Project (FERC No. 2042), as an amended order dated February 21, 2003. As a condition of certification, the Public Utility District No. 1 of Pend Oreille County (District) shall prepare an interim temperature management plan. The draft plan shall be submitted to WDOE within thirty days of the date FERC issues a new license for the project. The FERC issued a new license for the Box Canyon Project July 11, 2005. This plan is being submitted to the WDOE as part of the compliance with the 401 certification.

1.1 Water Quality Standards

The Washington State Water Quality Standards, set forth in Chapter 173-201A of the Washington Administrative Code, include designated beneficial uses, water body classifications, and numeric and narrative water quality criteria for surface waters of the state. A revised version of the standards was adopted in 2003 and is currently awaiting approval by U.S. Environmental Protection Agency (EPA).

Under the new standards the mainstem Pend Oreille River is protected for "non-core salmon and trout." The new standards contain a special condition of temperature.

Temperature shall not exceed a 1-day maximum (1-DMax) of 20.0°C due to human activities. When natural conditions exceed a 1-DMax of 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3 °C; nor shall such temperature increases, at any time, exceed $t=34/(T+9)$. ("T" represents the background temperature as measured at a point, or points, unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.)

This new condition is identical to that listed in the previous standards (Chapter 173-201A of the Washington Administrative Code).

1.2 Background

The District has monitored water temperature in the Box Canyon Reservoir, downstream of Box Canyon Dam and in tributaries to the reservoir (District 2000; DE&S 2001a; DE&S 2001b; FADES 2002; EESC 2003; EESC 2005). The District has also researched and reported the limited historical temperature data for Box Canyon Reservoir (DE&S 2000), which document that historical temperatures prior to construction of Box Canyon Dam are very similar to today's water temperatures in the reservoir.

The District modeled with- and without-project water temperatures using the 2-dimensional model, CE-QUAL-W2, developed by the Corps of Engineers. CE-QUAL-W2 was originally developed by Edinger and Buchak (1975). The model was subsequently modified by U.S. Army Corps of Engineers Waterway Experiments Station (Cole and Buchak, 1995) and Portland State University (Cole and Wells, 2000). CE-QUAL-W2 is a vertical two-dimensional hydrodynamic and water quality model for reservoirs, lakes, rivers and estuaries. The CE-QUAL-W2 model has been under development for many years and is a public-domain code maintained by the Corps of Engineers, Waterways Experiments Station (WES), located in Vicksburg, Mississippi. The current version, Version 2 (Cole and Buchak 1995), has been superceded by Version 3 developed by WES and Wells (1997). Version 2 of the model has been successfully used in more than 200 river and reservoir applications. Version 3 has undergone rigorous testing and has been successfully applied to many river basin systems. Primary physical processes modeled by CE-QUAL-W2 include surface heat transfer, short-wave and long-wave radiation and penetration, convective mixing, wind and flow induced mixing. The CE-QUAL-W2 (ver. 3.0) model was selected because it has good hydrodynamic and full thermal dynamic modeling capability. It is a public domain model that is in wide use for similar applications, and is very well suited for application to narrow and long reservoirs, like the one at the Box Canyon Project.

The model was calibrated using 1997 and 1998 observed temperature data. Model results showed very good agreement with the observed data. The model successfully reproduced the seasonal and daily variations of temperature in the reservoir. Model simulations showed that the primary factors controlling temperatures in BCR are the upstream boundary condition (inflow temperature from Albeni Falls) and meteorological forcing.

The calibrated model was applied to simulate the "without project" condition to evaluate the effect of the hydroelectric project on the temperature distributions in the reservoir. Model results indicate that project operation results in slight temperature cooling in the reservoir. The only period of note when the "without" project water temperatures were significantly cooler than the "with" project temperatures was August 5-7, 1998. Modeled water temperatures at Ione were, on average, 1°C warmer for the "with" project scenario. During this period, the total river flow at Box Canyon was rapidly decreasing from approximately 27,700 cfs to about 22,900 cfs. The modeled water surface elevation at Ione without the project dropped about 3.8 ft as opposed to 0.8 ft with the project. Air temperatures were seasonably warm but cooling through this period. It is hypothesized that the smaller water mass without the project was able to respond faster to the short-term cooling climate conditions. The trend in water temperatures; however, reversed itself and the "without" project water temperatures were again slightly warmer than "with" project condition by August 8, 1998. At other times, when cooling air temperatures and dropping flow did not coincide, the "with" project temperatures were cooler; i.e., the trend reversal is dependent upon both contributing factors coinciding with the descending limb of the peak in the heating season. The District concludes that the CE-QUAL-W2 modeling for Box Canyon demonstrates that the project has little to no effect on water temperatures within the Box Canyon Reservoir when model uncertainty is taken into account. A full description of modeling methods and model results is reported in (EESC 2002) and is provided in this plan as Appendix A.

WDOE included the Pend Oreille River on the state's 303(d) list for water temperature higher than the standard. The river is also on Idaho's 303(d) list for temperature. In order to determine the causes of the high river temperatures and correct any human-caused problems, WDOE Idaho Department of Environmental Quality (IDEQ) the EPA and the Kalispel Tribe are in the process of cooperatively determining a Total Maximum Daily Load (TMDL) for the mainstem Pend Oreille River from the outlet of Lake Pend Oreille to the Canadian border, which includes the Box Canyon reach.

WDOE published a Quality Assurance Plan for the temperature TMDL technical study for the Pend Oreille River (Pickett 2004). As part of the technical work for the TMDL, WDOE, IDEQ and the EPA are applying the CE-QUAL-W2 model to the Pend Oreille River from the outlet of Lake Pend Oreille to the Canadian border.

The WDOE 401 certificate for Box Canyon Hydroelectric Project states that this interim temperature management plan shall be in effect only until WDOE completes a temperature TMDL and its associated implementation plan for the Pend Oreille River.

2.0 MITIGATION AND MONITORING MEASURES

No interim mitigation measures for managing water temperature are scheduled or proposed. The District's modeling and a review of historic pre-project water temperature data support a conclusion that the project does not adversely affect summer water temperatures. Although water temperatures exceed the criteria for non-project-related reasons, the District believes that operation of the Box Canyon Project is in compliance with the water quality standard for temperature. In its Biological Opinion (USFWS 2005), the U.S. Department of Interior states that, "little opportunity exists to dramatically lower summer water temperatures since the project operated in a ROR [run of river] mode and minimal vertical stratification occurs within the reservoir."

The District understands that the CE-QUAL-W2 model for the Box Canyon reach is being revised and updated as part of the technical study for the Pend Oreille River temperature TMDL. If modeling and analysis indicate that human influences cause violations of temperature standards, then the agencies with jurisdiction will work with the TMDL advisory group to develop an implementation plan for the TMDL.

The District will be an active member of the advisory group. The District will review those parts of the implementation plan that address any temperature problems determined to be caused by Box Canyon Dam and its operations. The District will implement those parts of the plan that are consistent with the FERC license and State 401 certificate for the Box Canyon Project

The District understands that monitoring will be an element of the temperature TMDL. In support of WDOE's implementation of the TMDL, the District will participate in a cooperative monitoring network set up by the TMDL advisory group. The District commits to be responsible for equipment, maintenance, and analysis of water temperature data for up to four temperature monitoring stations in addition to a monitoring station in the Box Canyon forebay. One of these four monitoring stations will be located in the Calispell River immediately upstream of the District's pumping station. The location of the other three monitoring stations will be identified by the TMDL advisory group; however, these locations will be within the Box Canyon Reservoir or at the mouths of tributaries to the reservoir. If the TMDL determines that additional monitoring points are needed to document the Project's effect on temperature, then the District will work with the TMDL advisory group to identify additional monitoring stations that the District will be responsible for.

The methods listed are intended to be consistent with TMDLs affecting the Box Canyon reach. The methods will be modified upon concurrence by the WDOE, if necessary, to be consistent with future TMDLs. Continuous recording TIDBIT thermographs will be deployed at the selected locations including the forebay. Thermographs will be programmed to record hourly temperature. All thermographs will be set to real time with data reported on the hour to facilitate analysis among sites. All thermographs will be serviced approximately once per every eight-week period. Servicing and downloading will occur at approximately four-week intervals during July through September to minimize the potential of data gaps due to instrument loss or malfunction. A calibration temperature measurement using a hand-held mercury thermometer will be recorded at each servicing. All thermographs will also be subject to a three-point calibration test prior to deployment and at the end of the study period. The Onset Corporation TIDBIT thermographs have an accuracy of $\pm$ 0.16°C and a resolution of 0.28°C. A calibration factor will be applied to data for any thermographs that are not within $\pm$0.3°C of the standardized mercury thermometer used in laboratory calibration.

Thermograph data will be processed through a quality control/quality assurance (QA/QC) procedure. Data from time periods with anomalous patterns, or uncharacteristic spikes will be identified and discarded if data are not reasonable. Thermograph data will be compared to the field and laboratory instrument calibration records. Full documentation of QA/QC procedures, and reasons for not accepting any data, will be provided in the annual water quality monitoring report (see Water Quality Monitoring Plan).

Hourly temperature files will be reduced and analyzed to determine daily and monthly maximum, mean, and minimum temperatures. (Hourly temperature data will still be available for any future modeling application.) In addition, data will be expressed as seven-day averages.

3.0 SCHEDULE

This interim management plan will be implemented upon approval by WDOE and remain in effect until the WDOE completes the TMDL and its associated implementation plan for the Pend Oreille River. Water temperature monitoring is scheduled for April 1 through October 31 of each year the interim plan is in effect.

A draft of the annual report will be filed with the WDOE and FERC no later January 31, which describes activities and monitoring results for the previous field season. A final report will be filed within 60 days of comments received from the WDOE.

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Appendix A

Analysis of Water Temperatures in Box Canyon Dam for With and Without Project Conditions

Analysis of Water Temperatures in Box Canyon Dam for With and Without Project Conditions

1.0 Background and Introduction

Box Canyon Reservoir is located on the Pend Oreille River in northeast Washington. The reservoir is about 55.7 miles in length from the tailrace of upstream Albeni Fall Dam to the forebay of Box Canyon Dam. The Public Utility District No. 1 of Pend Oreille County (District) is applying to the Federal Energy Regulatory Commission (FERC) for a re-licensing of the Box Canyon Dam (FERC No. 2042). In order to issue a 401 water quality certificate, the State of Washington must determine if the hydroelectric dam operations will comply with the state water quality standards. The river reach impounded by Box Canyon Dam is included on the state's 303(d) list of impaired waters and temperature is one of the listed impaired parameters.

In support of the District's re-licensing application, Foster Wheeler was contracted by EES Consulting in collaboration with Framatome ANP DE&S (FDE&S) to conduct temperature modeling of Box Canyon Reservoir. The overall objective of this study was to develop the Box Canyon Reservoir temperature model to evaluate the effect of the Box Canyon Hydroelectric project operation on the reservoir temperatures.

2.0 Objectives

The specific objectives of this modeling and analysis effort are as follows:

- Select and setup an appropriate water quality/ temperature model for the Box Canyon Reservoir based on the available bathymetry, river inflow and temperature and meteorological data.
- Calibrate the temperature model using continuous record temperature data for the reservoir (data available for the summer and fall periods in 1997 and 1998).
- Apply the temperature model to simulate the longitudinal temperature distribution in the river for the "without project" condition, using the identical meteorological condition and river flows for the same simulation period conducted in the model calibration.
- Compare the model results between "with project" and "without project" scenarios.
- Compare the results of this modeling effort to a similar modeling study recently completed for the Box Canyon Reservoir by the EPA.

3.0 Model Selection

Box Canyon Reservoir temperature model was developed using the CE-QUAL-W2 temperature and water quality model. CE-QUAL-W2 was originally developed by Edinger and Buchak (1975). The model was subsequently modified by U.S. Army Corps of Engineers Waterway Experiments Station (Cole and Buchak, 1995) and Portland State University (Cole and Wells, 2000). CE-QUAL-W2 is a vertical two-dimensional hydrodynamic and water quality model for reservoirs, lakes, rivers and estuaries. The CE-QUAL-W2 model has been under development for many years and is a public-domain code maintained by the Corps of Engineers, Waterways Experiments Station (WES), located in Vicksburg, Mississippi. The current version, Version 2 (Cole and Buchak 1995), has been superceded by Version 3 developed by WES and Wells (1997). Version 2 of the model has been successfully used in more than 200 river and reservoir applications. Version 3 has undergone rigorous testing and has been successfully applied to many river basin systems. Primary physical processes modeled by CE-QUAL-W2 include surface heat transfer, short-wave and long-wave radiation and penetration, convective mixing, wind and flow induced mixing. The CE-QUAL-W2 (ver. 3.0) model was selected for this study because it has good hydrodynamic and full thermal dynamic modeling capability. It is a public domain model that is in wide use for similar applications, and is very well suited for application to narrow and long reservoirs. The model is also capable of simulating multiple water bodies, such as rivers, reservoirs, and estuaries linked in series. The model solves the lateral averaged momentum and continuity equations to predict the water surface elevation, and longitudinal and vertical velocities. A primary advantage of this model relative to steady-state one-dimensional temperature models is that flow and heat transfer processes are hydrodynamic. The time step can be varied and established at very short periods as opposed to daily average conditions. Vertical and longitudinal variability in the heat transfer processes are accounted for in the model.

Some of the model assumptions and limitations are as follows:

- The model assumes in each model cell that variables are laterally and layer averaged.
- The model uses the hydrostatic assumption and therefore does not account explicitly for vertical momentum effects. Even though the model is able to track density inflows and surface cooling accurately, the vertical momentum equation is not used to compute vertical velocities. A flow balance determines vertical velocities over each cell.
- The current release Version 3 does not account for macrophyte growth.
- The wind sheltering coefficient is a correction on the measured wind velocity but is not based on theory.
- The current release Version 3 does not have a sophisticated solar shading algorithm. Since the Pend Oreille River is relatively large, vegetation and topographical shading were ignored in this modeling effort.

4.0 Model Setup

Modeling requires a representation of the physical world in a manner that can be numerically modeled. Model application steps include:

- Data Collection and analysis (existing data available from license application studies (District 2000) as well as published climate records from nearby government climate stations,
- Develop boundary conditions,
- Discretization of the system into river and reservoir model segments,
- Develop model bathymetry,
- Model calibration/verification, and
- Model application

4.1 Temperature and Meteorological Data

The CE-QUAL-W2 model was setup to simulate the hydrodynamics and temperature distributions for summer and fall of 1997 and 1998 in Box Canyon Reservoir. Water and air temperatures were continuously monitored with thermographs at multiple locations along the reservoir during these periods. Data collection methods are reported in the Box Canyon License Application (Final License Application Appendices E.2-4 and E.2-5: District 2000). All thermograph data were subjected to rigorous quality control/quality assurance procedures. The thermographs were serviced approximately once a month. A calibration temperature measurement using a hand-held mercury thermometer was recorded at each servicing. All thermographs were also subjected to a three-point calibration test using a standardized mercury thermometer prior to deployment and at the end of the study period. The Onset Corporation HOBO thermographs have an accuracy of $\pm$ 0.16°C and a resolution of 0.28°C. With one exception, the thermographs were deployed in the river's thalweg at a depth of 1.0 m off the channel bed. Two thermographs were placed in the river at the confluence with Big Muddy Creek (Ione); one of these was 1.0 m off the bottom and the other was approximately 2.0 m below the water surface when the forebay elevation is at 2,030 ft MSL. Falter et. al. (1991) had documented that minimal to no vertical stratification occurs within the main river of Box Canyon Reservoir.

Meteorological data were not available at sufficient time resolution for the immediate project area. The nearest climate station with hourly data for the 1997-1998 period is Spokane, Washington. Hourly data from the Spokane airport NCDC climate station used in modeling included air temperature, relative humidity, wind speed, solar radiation and cloud cover. Precipitation data were reviewed but not incorporated into this modeling effort.

4.2 Model Geometry and Boundary Definition

Model boundary conditions specify the geographical area to be modeled and define inputs. Model setup involved the development of the model grid and establishment of initial and boundary conditions. The upstream boundary for modeling Box Canyon Reservoir water temperatures was defined as the tailrace of the Albeni Falls Dam (RM 90.1). The downstream boundary was established at the Box Canyon Dam forebay (RM 34.4). The District (District 2000) documented that water temperatures do not change as water passes through the dam structures so modeling of tailrace temperatures was not necessary.

Only one main branch was specified in the model. The sloughs were not modeled nor were islands. Detailed river bathymetry data were collected at river cross sections longitudinally distributed at approximately one-mile intervals for the reservoir as part of habitat mapping studies (Final License Application Appendix E.3.1-5: District 2000). The cross section data were recorded using Acoustic Doppler technology for the submerged portion of the transect and total station surveying for the above water portion of the transect up to an elevation that exceeds the project boundary. GPS was used to delineate the position of the cross section endpoints. Cross section data were subsequently reduced to channel width at 0.5 m vertical increments. Based on a review of reservoir bathymetry data, the reservoir was discretized into 59 segments (Attachment A). Each segment was subsequently discretized into uniform 1-m vertical layers.

The total number of active vertical layers varies by segment; up to 24 layers were modeled to represent the deepest portions of the reservoir. Figure 3.1 shows a schematic of a typical configuration of model layers. The CE-Qual-W2 model processes temperature transfer and hydrodynamics for each cell (defined by segment and layer) within the model grid (Figure 3.2).

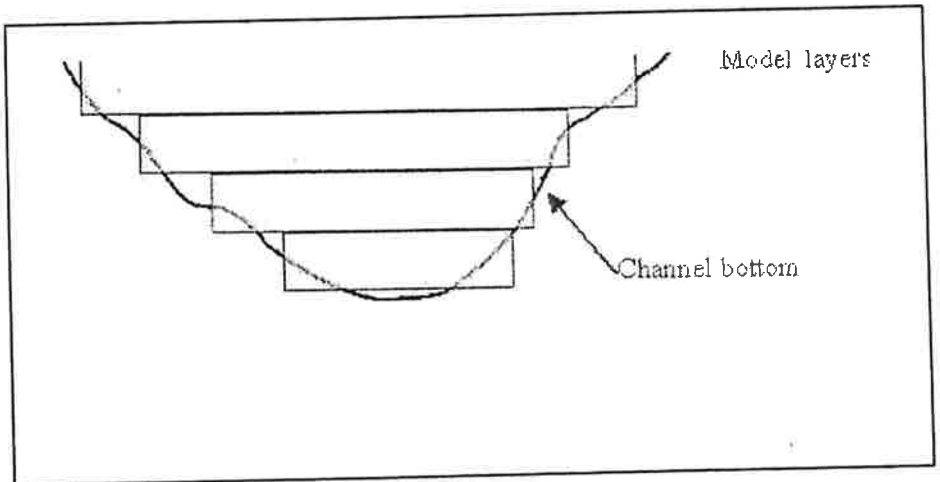

Figure 3.1 Schematic of typical model layers within a channel segment.

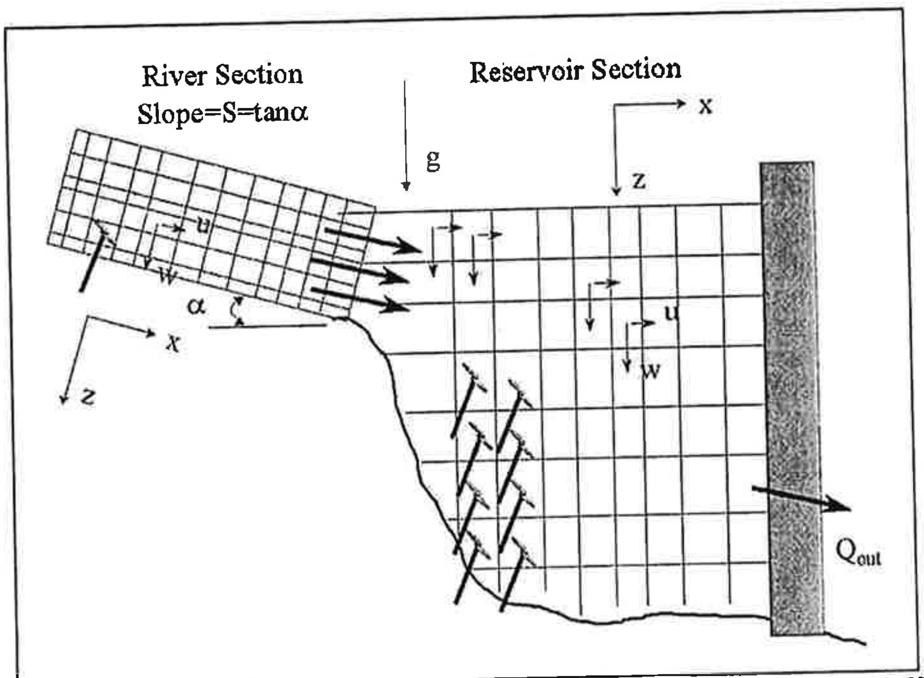

Fig. 3.2 Conceptual schematic of river-reservoir connection in CE-QUAL-W2 Version 3

4.3 Hydrology Data

The upstream boundary inflow data are provided from USGS gaging station located at Newport, WA. The downstream boundary river discharge is based on District operational hourly records at Box Canyon Dam. Inflow accretion between Albeni Falls Dam and Box Canyon Dam is minimal during the summer/fall model period (Exhibit B Final License Application – District 2000). Therefore, tributary and groundwater inflow is not of sufficient quantity to significantly affect the modeled water temperatures. The CEQUAL-W2 water balance sub-model calculated the total accretion (difference between inflow and outflow). The computed accretion was then added to the inflow at the most upstream model segment; i.e., accretion was treated as additional inflow from Albeni Falls.

Hourly water surface elevation data for the model period are reported at the USGS Cusick Gage (RM 70). A HEC-RAS model had been previously applied to the Box Canyon Reservoir to estimate the longitudinal reservoir water surface elevation profile for "with project" and "without project" conditions (District 2000 FLA Exhibit B). The HEC-RAS water elevation data (as a function of total river discharge) were used to establish the initial water surface elevation for each model segment.

5.0 Model Calibration

A water balance analysis was completed as a first step in model calibration. Discharge and water surface elevation data from District and USGS records were used in this calibration. The difference in total discharge between the USGS gage at Newport and total discharge at Box Canyon Dam was treated as gaging data (water surface elevation and discharge The water surface elevation (WSL) at Cusick as predicted by the CE-QUAL-W2 model was compared to actual USGS gage WSL data. Upon completion of hydraulic calibration, the CE-QUAL-W2 model successfully predicted water surface elevations (WSL) as evidenced by the close correspondence between measured and predicted WSL at Cusick for 1997 (Figure 5.1) and 1998 (Figure 5.2).

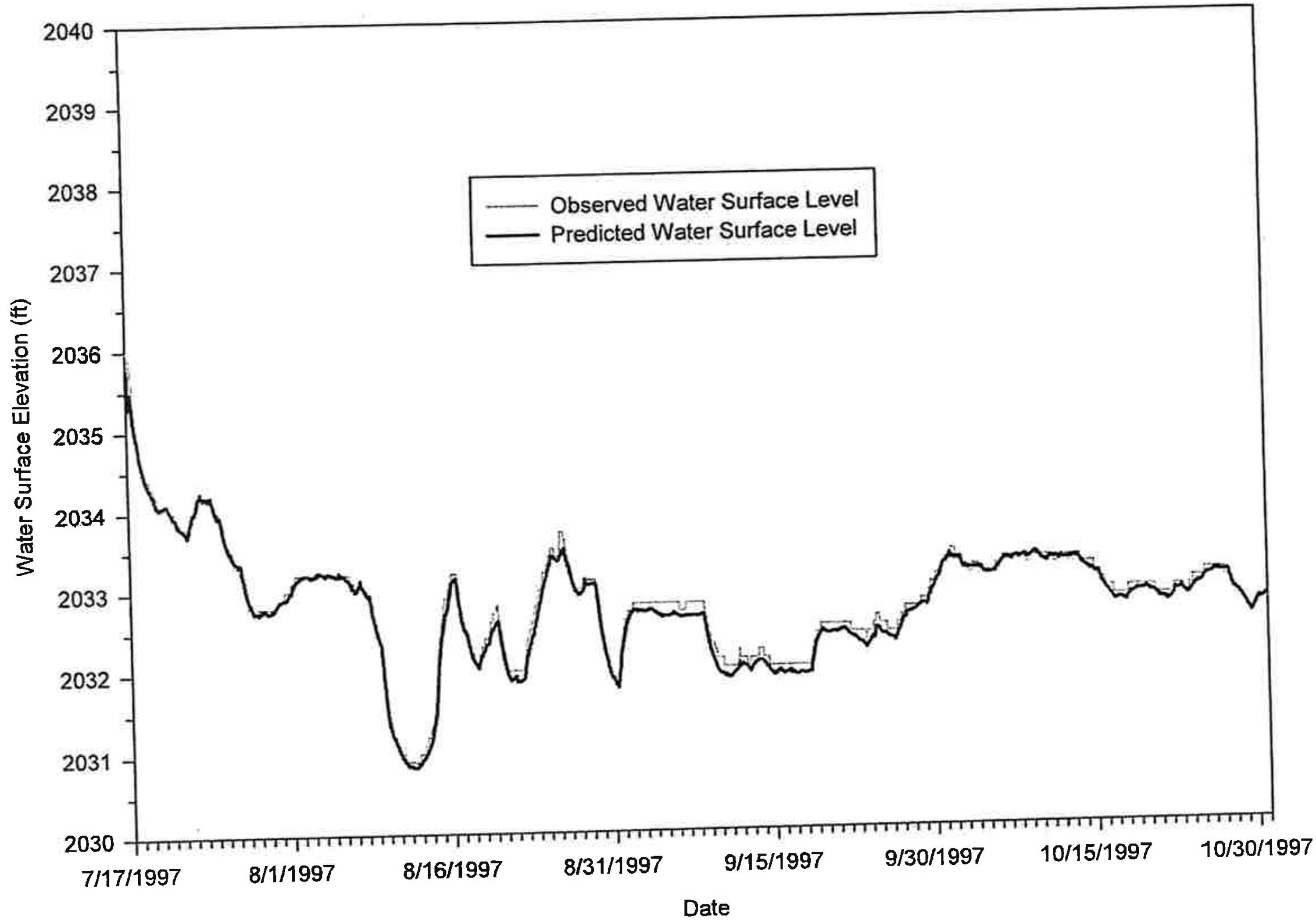

FIGURE 1
COMPARISON OF OBSERVED AND PREDICTED WATER SURFACE LEVELS AT CUSICK -1997

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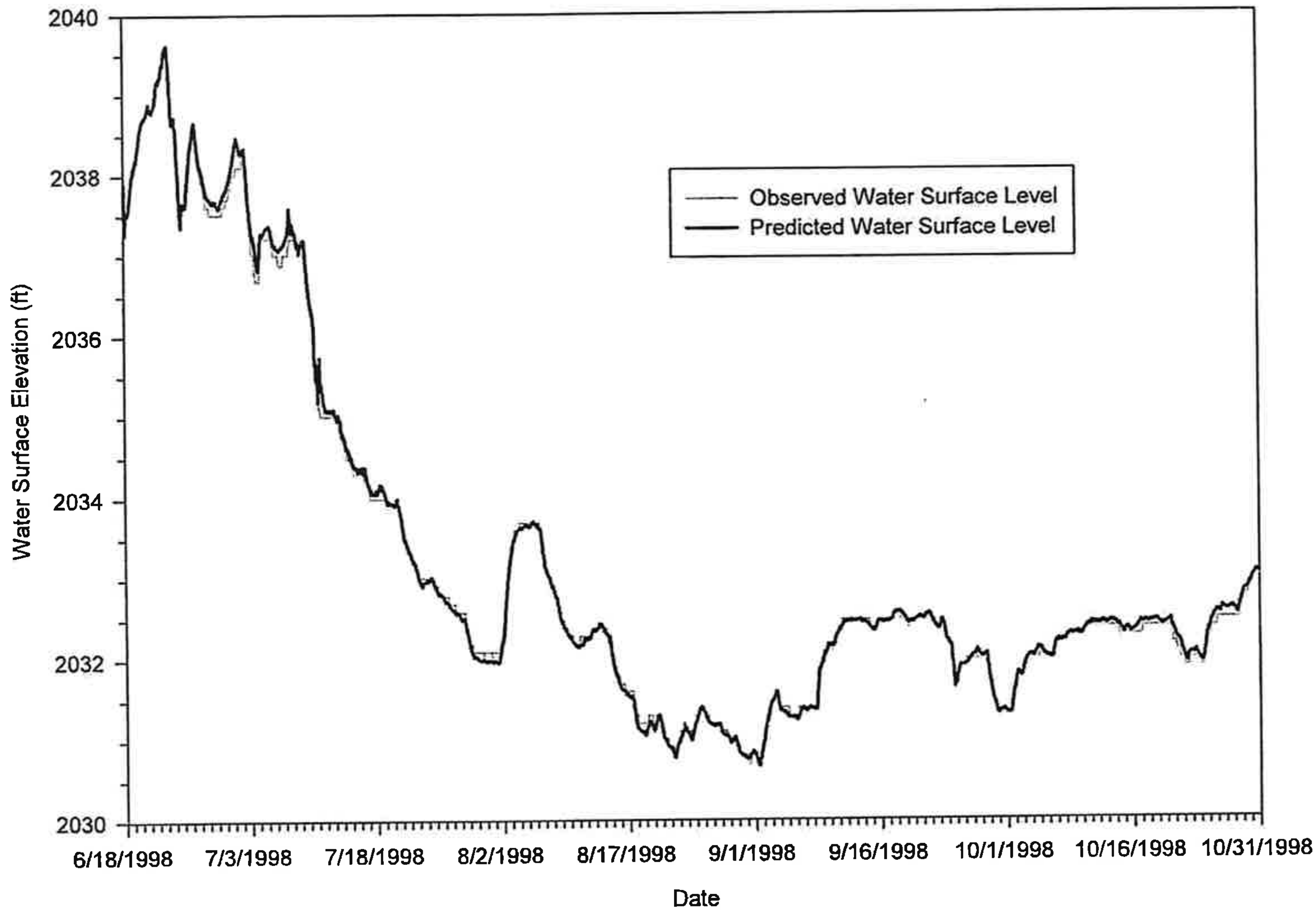

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	FILENAME: BCRCalib98.jnb	CHECKED: T. Khangaonkar	

FIGURE 2
COMPARISON OF OBSERVED AND PREDICTED WATER SURFACE LEVELS AT CUSICK - 1998

The temperature model calibration consisted of adjusting various model parameters and boundary conditions until the model predicted results matched the observed data in the reservoir. Most of the model parameters are global model parameters; i.e. a single value is applied to the entire model reach. Observed temperature profiles (thermograph data) were used to calibrate the temperature model parameters. Two separate wind sheltering coefficients, one for summer and one for fall season, were required in order to achieve satisfactory calibration. The final calibrated model coefficients and factors are provided in Table 5.1. The calibrated coefficients are all within a reasonable range for that parameter.

Table 5.1 Calibrated Model Coefficients for Box Canyon Reservoir

Model Coefficients	Calibrated Value	Typical Value
Heat exchange scheme (SLHTC)	ET	TERM or ET
Wind speed coefficient a (AFW)	9.2	9.2
Wind speed coefficient b (AFW)	0.46	0.46
Wind speed coefficient c (AFW)	2.0	2.0
Transport scheme (SLTRC)	ULTIMATE	QUICKEST or ULTIMATE
Time weighting for advection (THETA)	0.55	0 - 1
Wind sheltering coefficient Day (WSCD) Wind sheltering coefficient (WSC)	1 230 0.6 0.2	0 - 1
Horizontal eddy viscosity (AX)	1	1
Horizontal eddy diffusivity (DX)	1	1
Coef. of bottom heat exchange (CBHE)	$7x10^{-8}$	$7x10^{-8}$
Vertical turbulence closure (AZFORM)	W2N	W2, W2N, etc.
Vertical eddy viscosity scheme (AZC)	IMP	IMP or EXP
Bottom friction formula (TYPE)	CHEZY	CHEZY or MANN
Extinction for pure water (EXH2O)	0.3	0.1 - 3

6.0 Results

6.1 Temperatures for Calibrated Model

Overall, the calibration of the temperature model for Box Canyon Reservoir was completed successfully using the data from 1997 and 1998. Figures 6.1 through 6.9 compare observed and model predicted temperatures at various locations in the reservoir. The locations for thermograph data used in calibration include Pend Oreille River upstream of confluence with Indian Creek (RM 81.2), Skookum Creek RM (74.3), CeeCeeAh Creek (RM 66.6), Mill Creek (RM 58.5), LeClerc Creek (RM 56.5), and Bid Muddy Creek (RM 38.3) in 1997, and at

Skookum Creek, Mill Creek, and Bid Muddy Creek in 1998. Thermograph data from the Box Canyon forebay were also available for 1998. The model reproduces the seasonal changes and daily variations of temperatures in the reservoir very well. The model predicts temperature distributions at different stations in the reservoir with satisfactory accuracy in 1997 and 1998. Statistical analysis of the model calibration shows that the absolute mean errors (AME) for all the stations are bellow 0.5 except at Mill Creek in 1998, which is 0.54. The root mean square errors (RMS) for most of the stations are bellow 0.5 except at LeClerc Creek in 1997 (0.58) and Mill Creek in 1998 (0.66). The AME and RMS of the model calibration results are given in Table 6.1.

Table 6.1 AME and RMS Distributions

Station	AME		RMS	
	1997	1998	1997	1998
Indian Creek	0.16	No Data	0.21	No Data
Skookum Creek	0.28	0.28	0.36	0.34
CeeCeeAh Creek	0.27	No Data	0.35	No Data
Mill Creek	0.32	0.54	0.42	0.66
LeClerc Creek	0.44	No Data	0.58	No Data
Bid Muddy Creek	0.33	0.39	0.40	0.49
Average	**0.33**		**0.42**	

6.2 Comparison of With and Without Project

The calibrated model was applied to simulate the "without project" scenario, i.e., the Box Canyon Dam was removed from the model configuration and the water body was simulated as a run-of-river system with no backwater effect from Box Canyon Dam. Based on the water surface elevation distribution along the river predicted by HEC-RAS model for the "without project" scenario, the river reach was divided into two separate branches with different slopes. The first branch is from segment 2 to segment 32 (RM 90.34 to RM 58.8) with a slope of 0.00005. The second branch starts from segment 33 to segment 58 (RM 58.8 to RM 34.58) with a slope of 0.0001. The initial water surface elevations (WSL at time of model initiation) were interpolated from the HEC-RAS model results.

The CE-QUAL-W2 temperature model for the Box Canyon Reservoir in the "without project" condition was applied using the same hydrological and meteorological forcing and inputs as those used in the model calibration for both 1997 and 1998. It is important to distinguish the "without project" from pre-project since river flow is regulated upstream of Box Canyon Dam.

Model result comparisons indicate that temperatures in the Box Canyon Reservoir are overall slightly cooler for the "with project" condition than the temperatures for the "without project" condition, even though daily variations of warming and cooling are observed. Model results also show that temperature daily variations in the "without project" condition are generally larger than that in the "with project" condition because the water depth is shallower in the "without project" condition. The predicted water temperatures for the calibrated model "with project" are compared to temperatures for the "without project" scenario in Figures 6.10 and 6.11 for the entire model period in 1997 and 1998, respectively, for the Pend Oreille River at Big Muddy Creek confluence near Ione. The results are similar for other locations along the reservoir. Table 6.2 provides a monthly summary of comparative temperature statistics for each of the temperature monitoring locations.

Temperatures in the Box Canyon Reservoir reach of the river exceed the water quality criteria of 20.0°C from mid-July through early September for both the "with project" and "without project" scenarios. In 1997, mean daily temperatures began exceeding 20.0 °C by July 20, 1997 for both the "with" and "without" project scenarios. Daily maximum temperatures remained above 20.0°C through Sept 6 for the "with" project scenario and through September 10 for the "without" project scenario; i.e., standard exceeded for a longer period in the "without" project scenario. In 1998, mean daily temperatures in the reservoir begin to exceed 20 °C by July 9 and maximum daily temperatures remained above 20 °C for both the "with" and "without" scenarios through September 20. Figures 6.12 – 6.20 provide detailed graphs of temperature patterns during the period when the 20°C criteria was exceeded.

Table 6.2 Monthly Temperature Statistics for CE-QUAL-W2 Model for Box Canyon Reservoir
Monthly means of the daily values are report (i.e. Max = monthly mean of daily maximum temperatures). Inst. Max is the highest single hourly record for the month.

Location	With Project					Without Project				
Pend Oreille R at Big Muddy Seg 54 RM 38.3	Month	Min °C	Mean °C	Max °C	Inst Max °C	Month	Min °C	Mean °C	Max °C	Inst Max °C
	July	20.39	20.75	21.17	22.22	July	20.66	21.11	21.67	22.55
	Aug	21.60	21.86	22.16	23.74	Aug	21.71	22.18	22.69	24.11
	Sept	18.10	18.29	18.52	20.88	Sept	18.11	18.48	18.90	21.34
	Oct	12.08	12.23	12.40	16.64	Oct	12.25	12.46	12.81	17.07
	With Project					Without Project				
Pend Oreille R at LeClerc Seg 35 RM 56.5	Month	Min °C	Mean °C	Max °C	Inst Max °C	Month	Min °C	Mean °C	Max °C	Inst Max °C
	July	20.35	20.65	21.15	22.11	July	20.31	21.05	21.84	22.82
	Aug	21.44	21.74	22.08	23.81	Aug	21.45	22.13	22.86	24.32
	Sept	17.95	18.20	18.48	20.89	Sept	17.87	18.44	19.04	21.56
	Oct	12.08	12.25	12.45	16.76	Oct	12.07	12.50	12.88	17.01
	With Project					Without Project				
Pend Oreille R at Mill Seg 33 RM 58.5	Month	Min °C	Mean °C	Max °C	Inst Max °C	Month	Min °C	Mean °C	Max °C	Inst Max °C
	July	20.32	20.70	21.14	22.02	July	20.24	21.04	21.84	22.83
	Aug	21.42	21.72	22.06	23.79	Aug	21.39	22.12	22.88	24.31
	Sept	17.92	18.18	18.48	20.88	Sept	17.78	18.43	19.07	21.58
	Oct	12.08	12.25	12.45	16.77	Oct	12.03	12.50	12.90	17.03
	With Project					Without Project				
Pend Oreille R at CeeCeeAh Seg 28 RM 66.6	Month	Min °C	Mean °C	Max °C	Inst Max °C	Month	Min °C	Mean °C	Max °C	Inst Max °C
	July	20.24	20.68	21.14	21.92	July	20.01	21.00	21.70	22.71
	August	21.38	21.68	22.02	23.72	Aug	21.30	22.07	22.78	24.16
	Sept	17.92	18.16	18.40	20.78	Sept	17.67	18.41	19.03	21.47
	Oct	12.13	12.30	12.50	16.83	Oct	12.07	12.52	12.92	16.93
	With Project					Without Project				
Pend Oreille R at Skookum Seg 19 RM 74.3	Month	Min °C	Mean °C	Max °C	Inst Max °C	Month	Min °C	Mean °C	Max °C	Inst Max °C
	July	20.29	20.67	21.09	21.88	July	20.12	20.83	21.60	22.50
	Aug	21.40	21.69	22.02	23.51	Aug	21.25	21.93	22.60	24.03
	Sept	17.94	18.18	18.44	20.75	Sept	17.76	18.33	18.90	21.28
	Oct	12.27	12.44	12.61	16.64	Oct	12.26	12.57	12.90	16.67
	With Project					Without Project				
Pend Oreille R at Indian Seg 11 RM 81.2	Month	Min °C	Mean °C	Max °C	Inst Max °C	Month	Min °C	Mean °C	Max °C	Inst Max °C
	July	20.17	20.66	21.19	21.97	July	20.12	20.73	21.47	22.37
	Aug	21.32	21.70	22.10	23.55	Aug	21.25	21.83	22.62	23.90
	Sept	17.82	18.18	18.56	20.89	Sept	17.81	18.27	18.95	21.20
	Oct	12.31	12.51	12.72	16.49	Oct	12.29	12.59	13.00	16.63

Table 6.3 compares the horizontal velocities at selected points along the reservoir for the "with" and "without" project scenarios as computed by the CE-QUAL-W2 model. The model computes a horizontal and vertical velocity for each model cell (segment and layer). The velocities for all the layers within a segment were then averaged to compute the mean velocity for that segment.

Table 6.3 Comparison of velocities as computed by CE-QUAL-W2 Model

Date	Discharge	River Mile	90	73.9	63.7	38.5
		Segment	2	19	28	54
			Average velocity (ft/sec)			
8/13/97	9,247 cfs	With Project	0.8	0.4	0.2	0.4
		Without Project	3.0	2.0	3.9	1.4
		Difference	-2.2	-1.6	-3.7	-1.0
9/7/97	21,443 cfs	With Project	1.4	0.7	0.5	0.8
		Without Project	2.7	2.0	3.0	3.1
		Difference	-1.3	-1.3	-2.4	-2.3
7/19/97	32,520 cfs	With Project	1.8	0.9	0.6	1.2
		Without Project	2.5	1.9	2.2	4.2
		Difference	-0.7	-1.0	-1.6	-2.9

7.0 Conclusion

A dynamic, vertical-2D temperature model was developed for the Box Canyon Reservoir on the Pend Oreille River in northeast Washington using the CE-QUAL-W2 model. The model was calibrated using 1997 and 1998 observed temperature data. Model results showed very good agreement with the observed data. The model successfully reproduced the seasonal and daily variations of temperature in the reservoir. Model simulations showed that the primary factors controlling temperatures in BCR are the upstream boundary condition (inflow temperature from Albeni Falls) and meteorological forcing.

The calibrated model was applied to simulate the "without project" condition to evaluate the effect of the hydroelectric project on the temperature distributions in the reservoir. Model results indicate that project operation results in slight temperature cooling in the reservoir. The only period of note when the "without" project water temperatures were significantly cooler than the "with" project temperatures was August 5-7, 1998. Modeled water temperatures at Ione were, on average, 1°C warmer for the "with" project scenario. During this period, the total river flow at Box Canyon rapidly decreased from approximately 27,700 cfs to about 22,900 cfs. The modeled water surface elevation at Ione without the project dropped about 3.8 ft as opposed to 0.8 ft with the project. Air temperatures were seasonably warm but cooling through this period. It is hypothesized that the smaller water mass without the project was able to respond faster to the short-term cooling climate conditions. The trend in water temperatures; however, reversed itself and the "without" project water temperatures were again slightly warmer than "with" project condition by August 8, 1998. At other times, when cooling air temperatures and dropping flow did not coincide, the "with" project temperatures were cooler; i.e. the trend reversal is dependent upon both contributing factors coinciding with the descending limb of the peak in the heating season.

The CE-QUAL-W2 model provides improved model capabilities over steady state 1-dimensional models. The EPA previously modeled temperatures in the Box Canyon Reservoir using the steady state RBM10 model that predicts mean daily temperatures (unpublished data). The EPA model has a one-day time step whereas the CE-QUAL-W2 time step is variable; for this modeling effort the minimum time step was five minutes. Daily averaging in the RBM10 model reduces the model's responsiveness to flow fluctuations. Travel times can be overestimated when assuming steady state, which can result in a net increase in the heat flux. Both model approaches demonstrate that the project has little to no effect on water temperatures within the Box Canyon Reservoir when model uncertainty is taken into account. The steady state model used by EPA suggested a slight increase in temperatures at certain times whereas the hydrodynamic CE-QUAL-W2 model demonstrates a slight decrease in temperature with project operation. The difference in results is attributable to the necessity to simplify the model environment when relying on a steady state condition.

8.0 References

Cole, T. and S. Wells, 2000: CE-QUAL-W2 Version 3 Workshop Program, Sponsored by US EPA, USACE WES, and Portland State University. August 2000. Portland State University, Portland, Oregon.

Cole, T. and E. Buchak, 1995: CE-QUAL-W2: A Two-dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model, Version . Technical Report EI-95-May 1995. Waterway Experiments Station, Vicksburg, MS.

District. 2000. Final License Application to the FERC Box Canyon Hydroelectric Project (No. 2042). Pend Oreille Public Utility District No. 1 of Pend Oreille County, Washington.

Edinger, J.E. and E. Buchak, 1975: A Hydrodynamic, Two-dimensional Reservoir Model: The Computational Basis. Prepared for U.S. Army Engineer Division, Ohio River, Cincinnati, Ohio

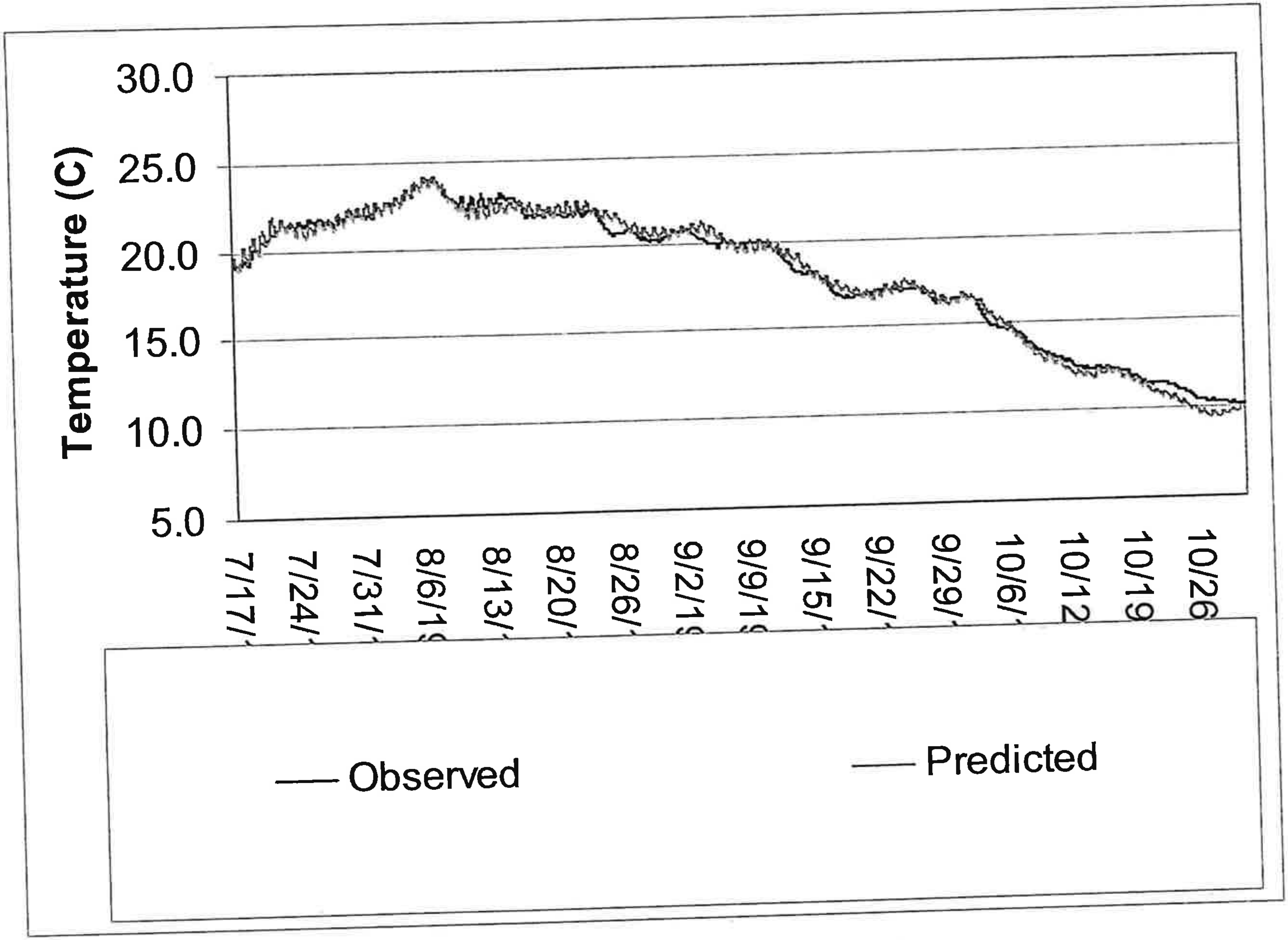


Figure 6.1 Comparison of calibrated-predicted and observed temperatures for Pend Oreille River near Ione at Big Muddy confluence, 1997.

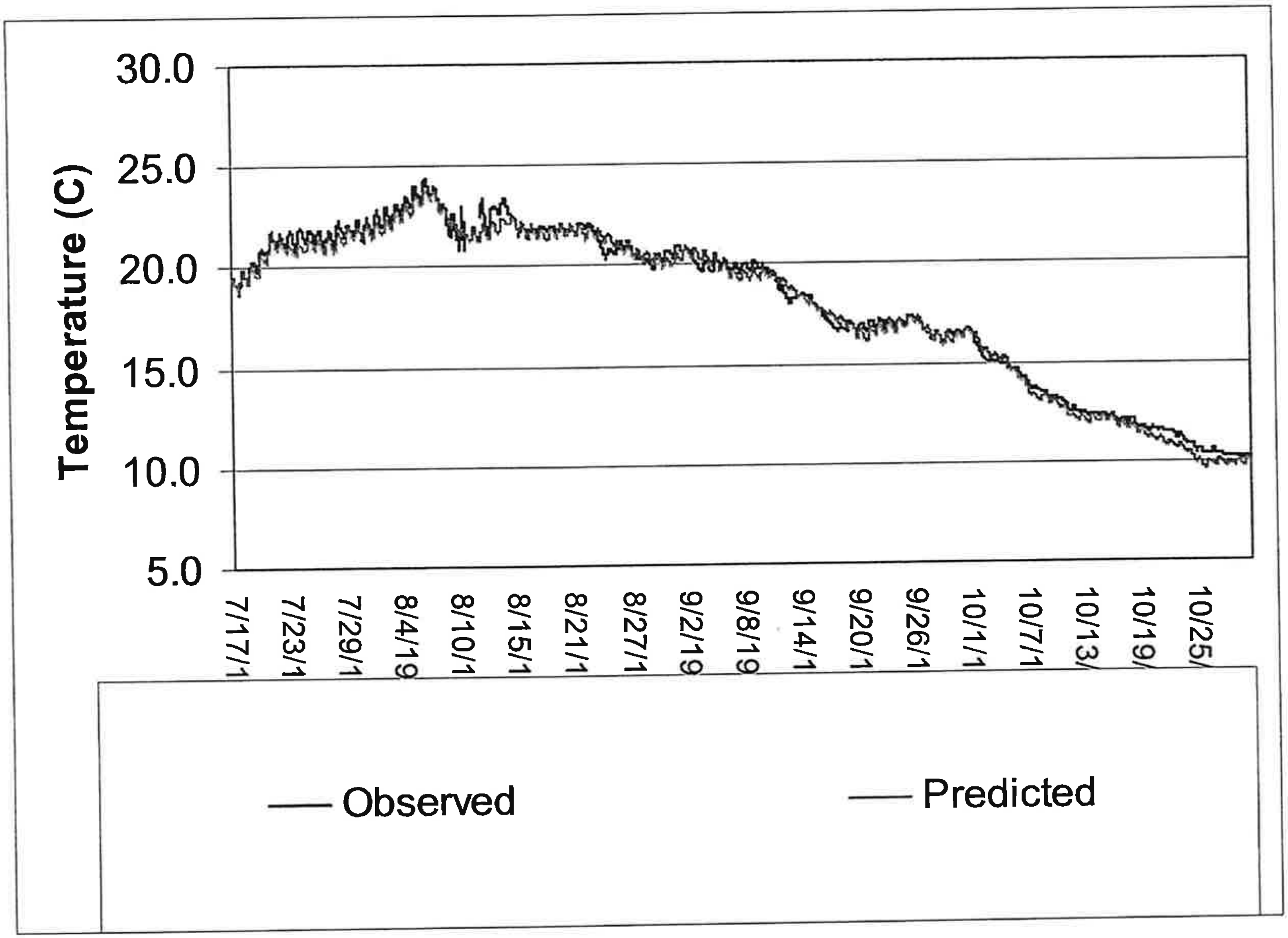


Figure 6.2 Comparison of calibrated-predicted and observed temperatures for Pend Oreille River at LeClerc Cr. 1997.

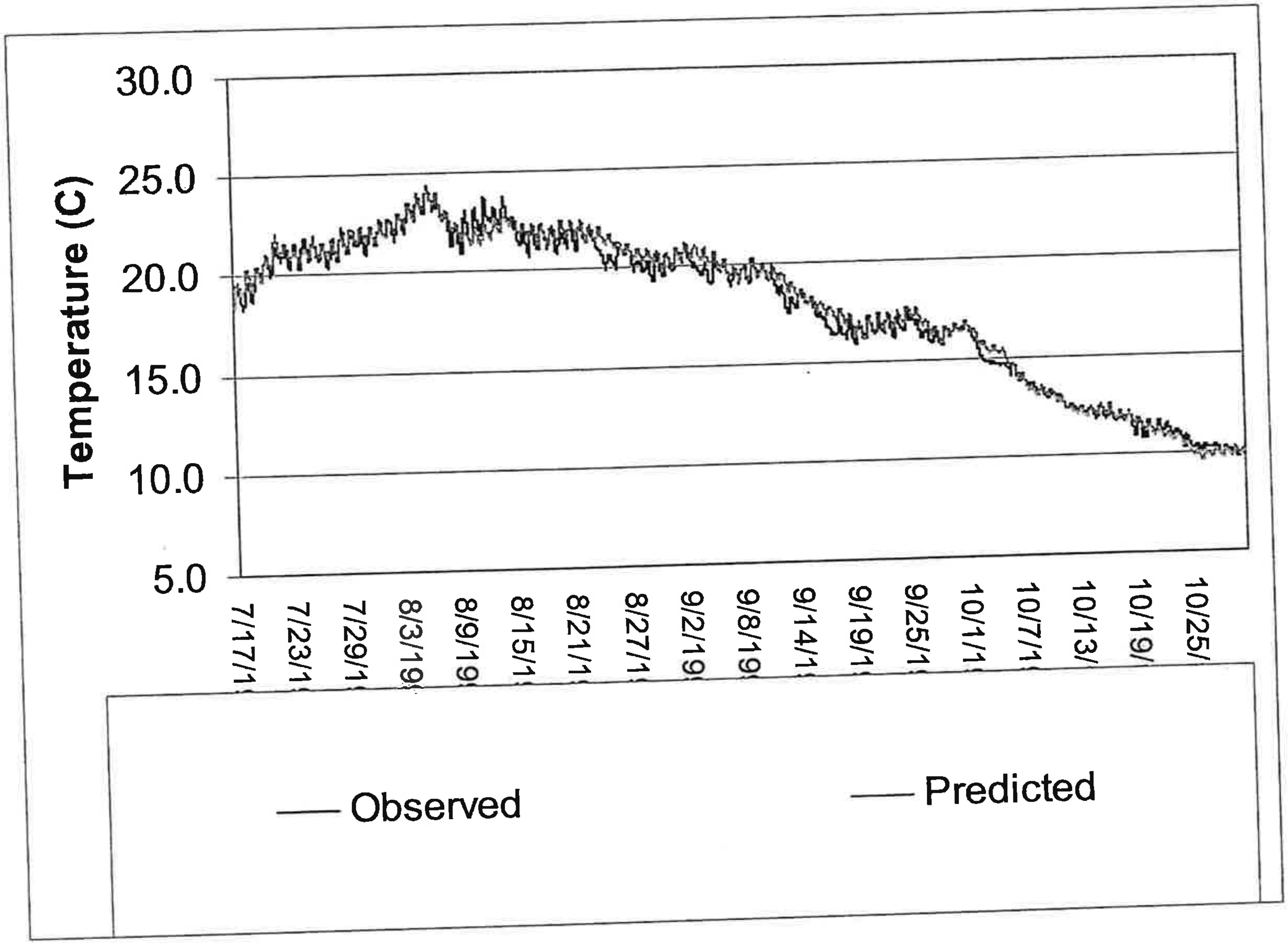


Figure 6.3 Comparison of calibrated-predicted and observed temperatures for Pend Oreille River at Mill Cr. 1997.

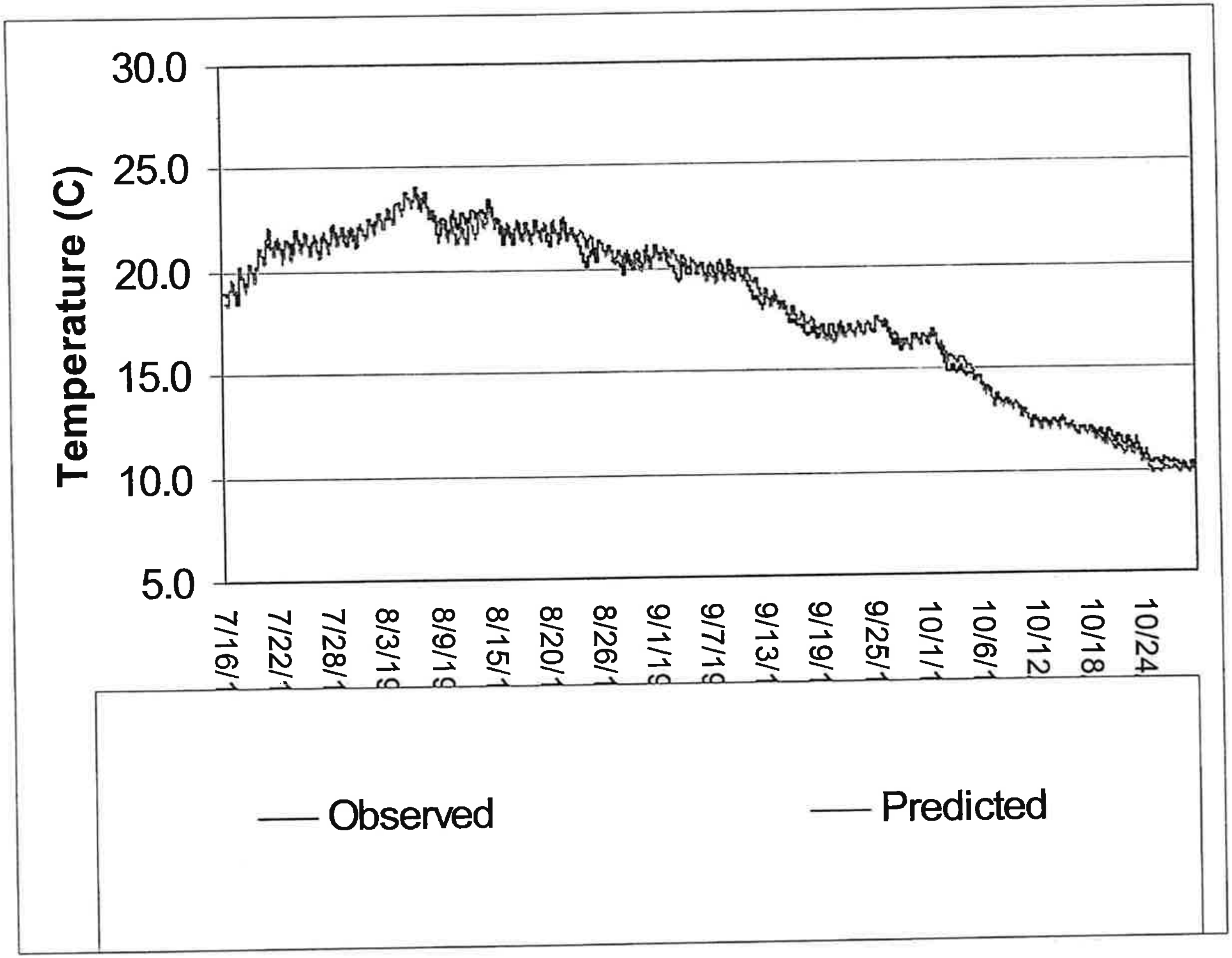


Figure 6.4 Comparison of calibrated-predicted and observed temperatures for Pend Oreille River at CeeCeeAh Cr. 1997.

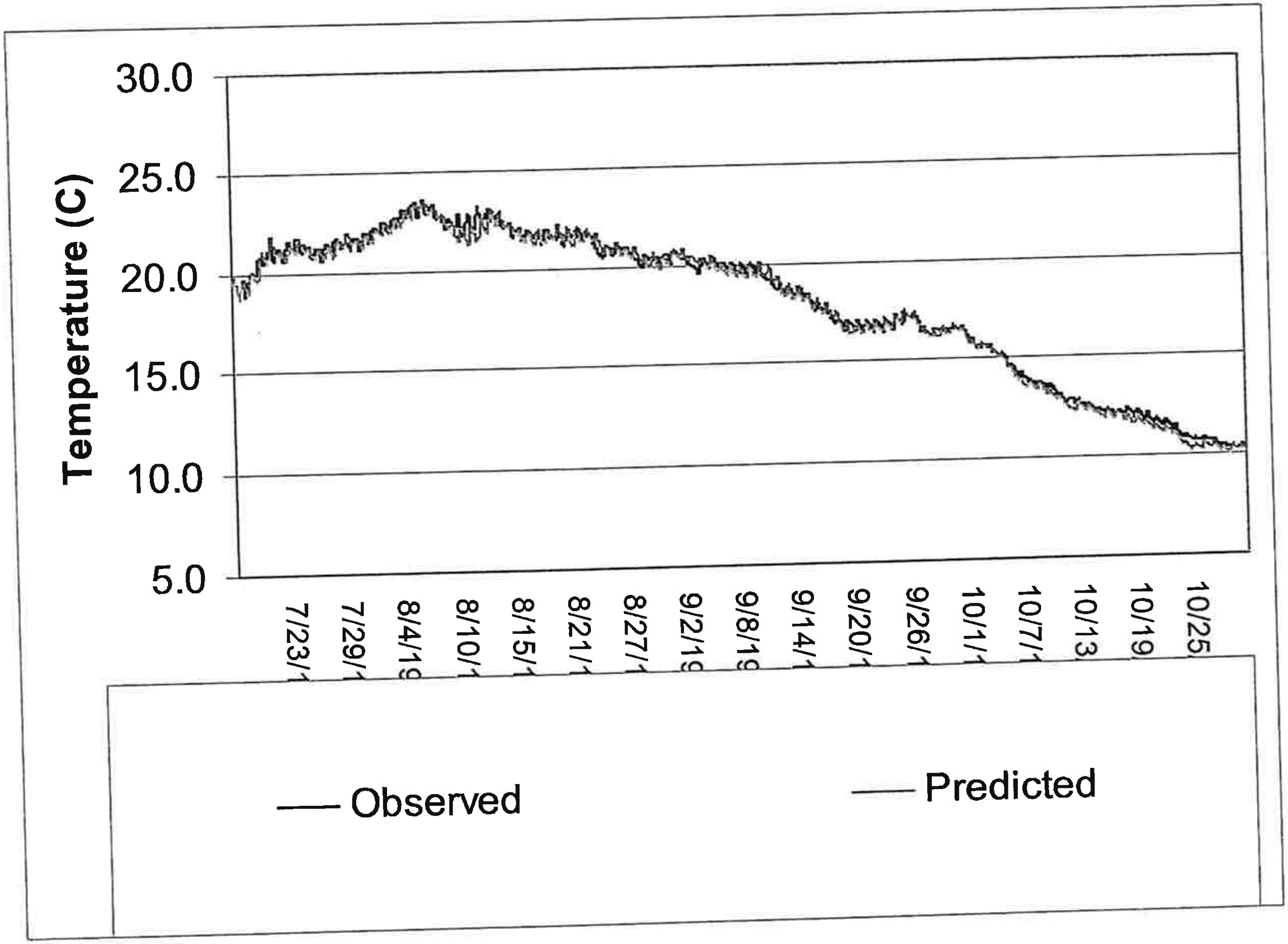


Figure 6.5 Comparison of calibrated-predicted and observed temperatures for Pend Oreille River at Skookum Cr. 1997.

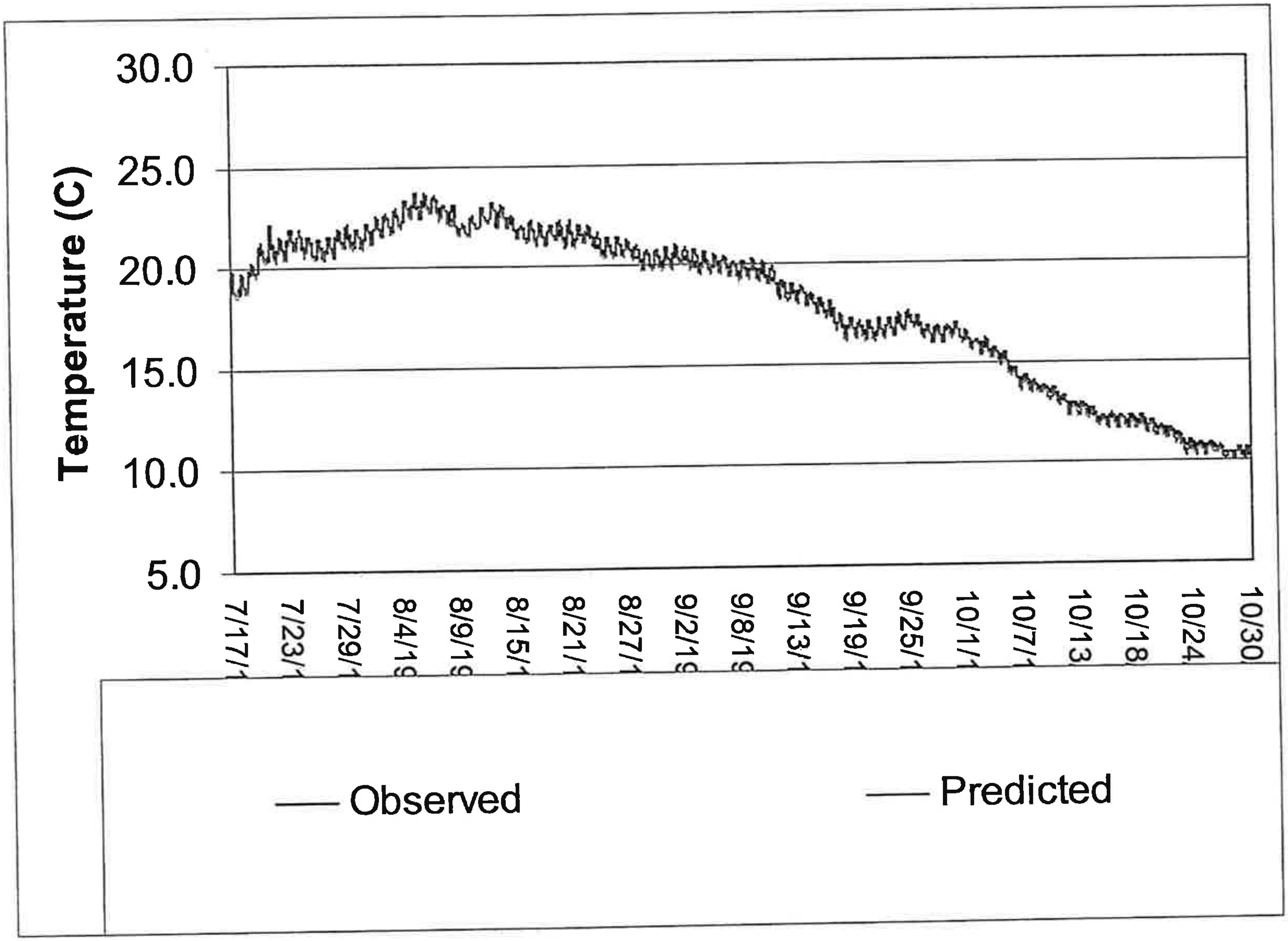


Figure 6.6 Comparison of calibrated-predicted and observed temperatures for Pend Oreille River at Indian Cr. 1997.

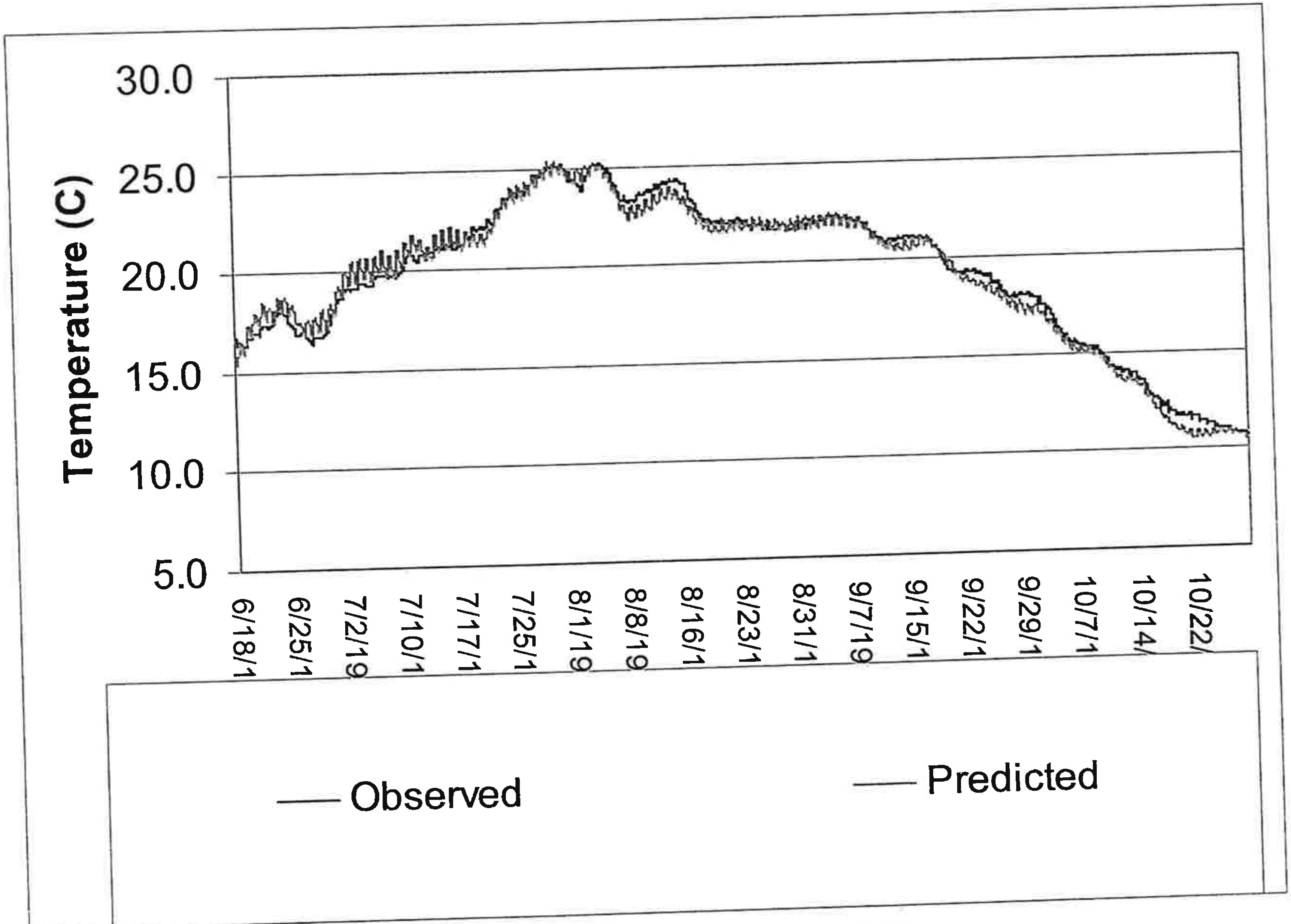


Figure 6.7 Comparison of calibrated-predicted and observed temperatures for Pend Oreille River near Ione at Big Muddy confluence, 1998.

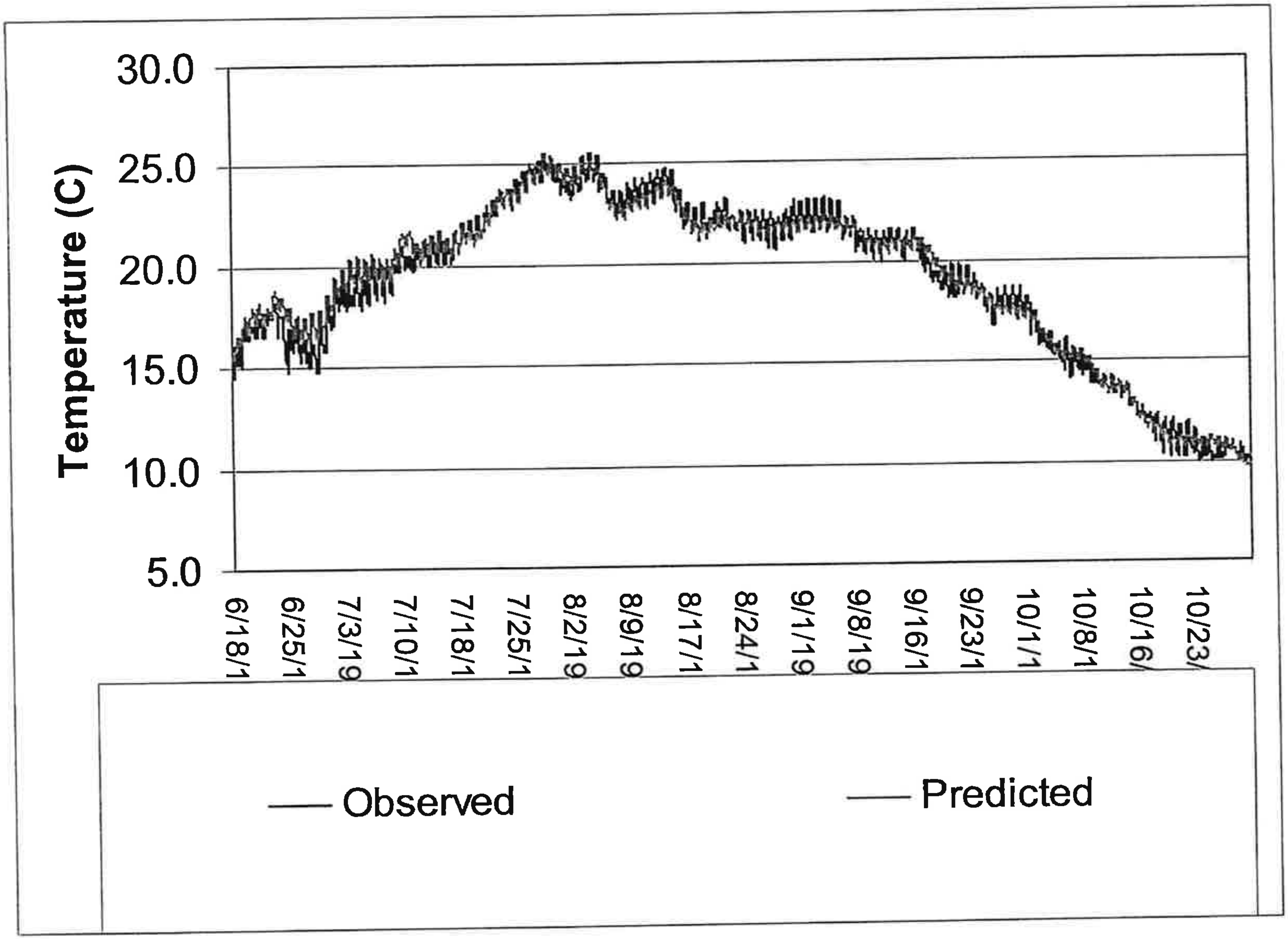


Figure 6.8 Comparison of calibrated-predicted and observed temperatures for Pend Oreille River at Mill Cr. 1998.

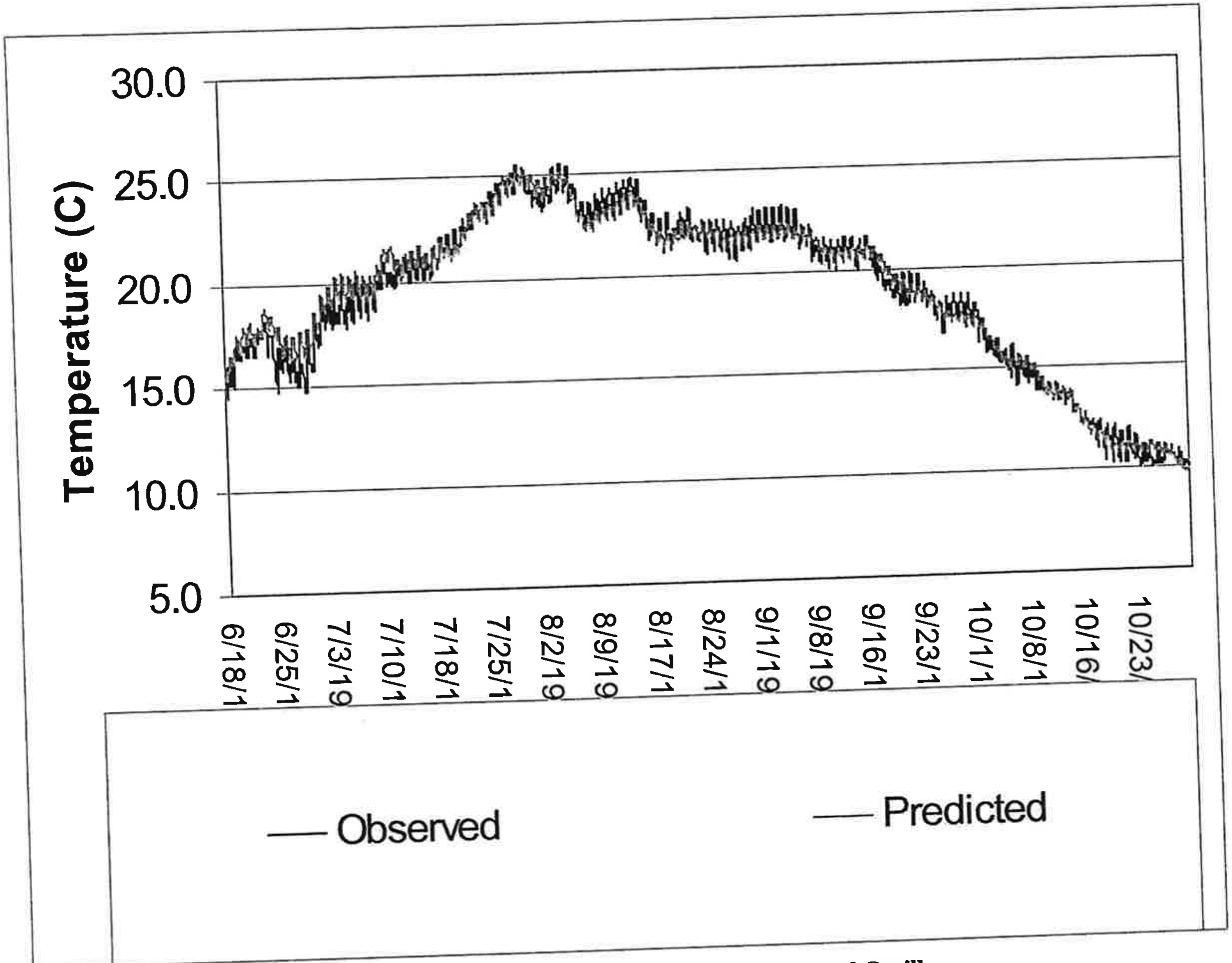


Figure 6.9 Comparison of calibrated-predicted and observed temperatures for Pend Oreille River at Skookum Cr. 1998.

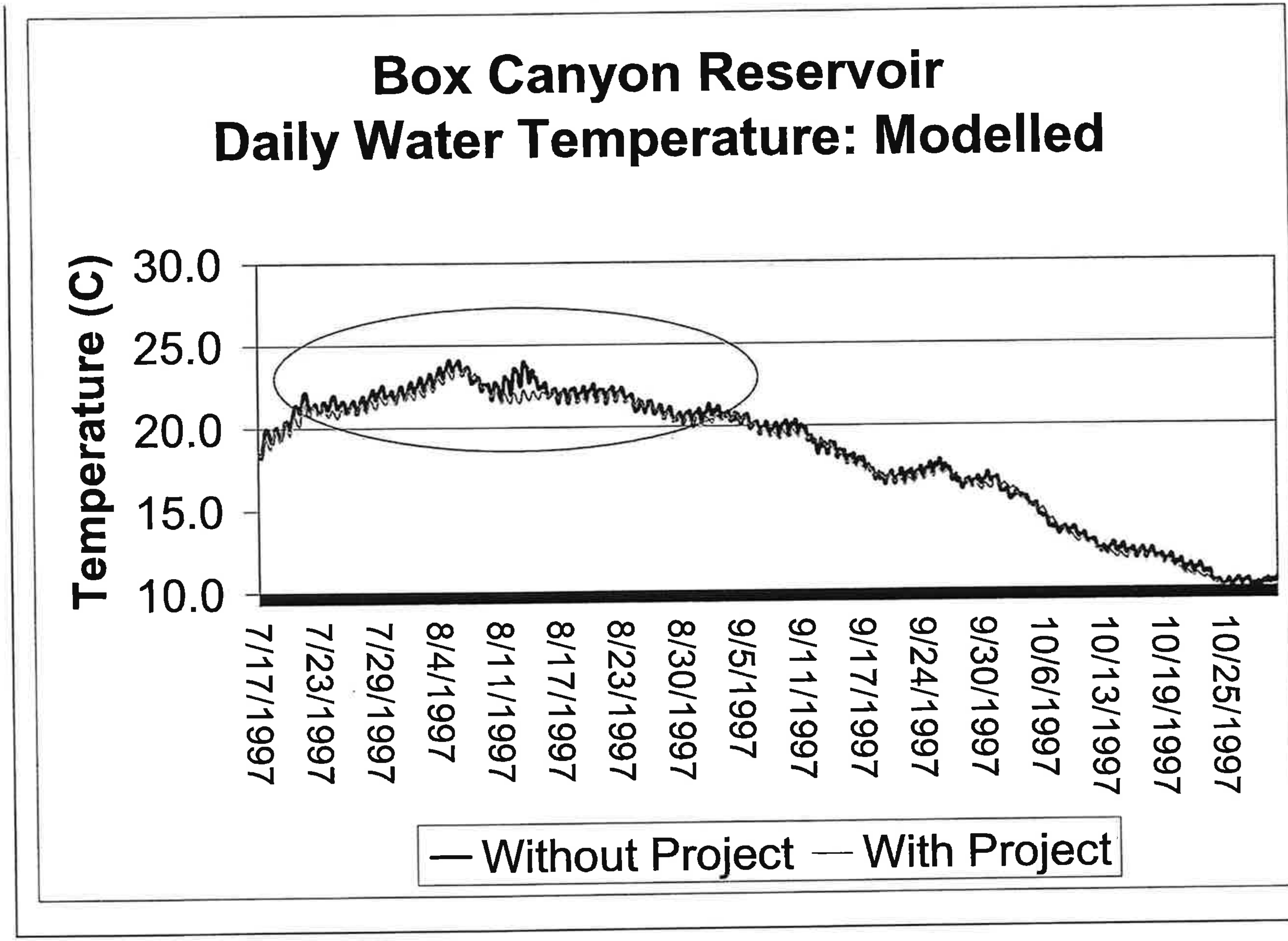


Figure 6.10 Comparison of predicted temperatures for "with" and "without" Box Canyon Dam for Pend Oreille River near Ione at Big Muddy confluence, 1997.

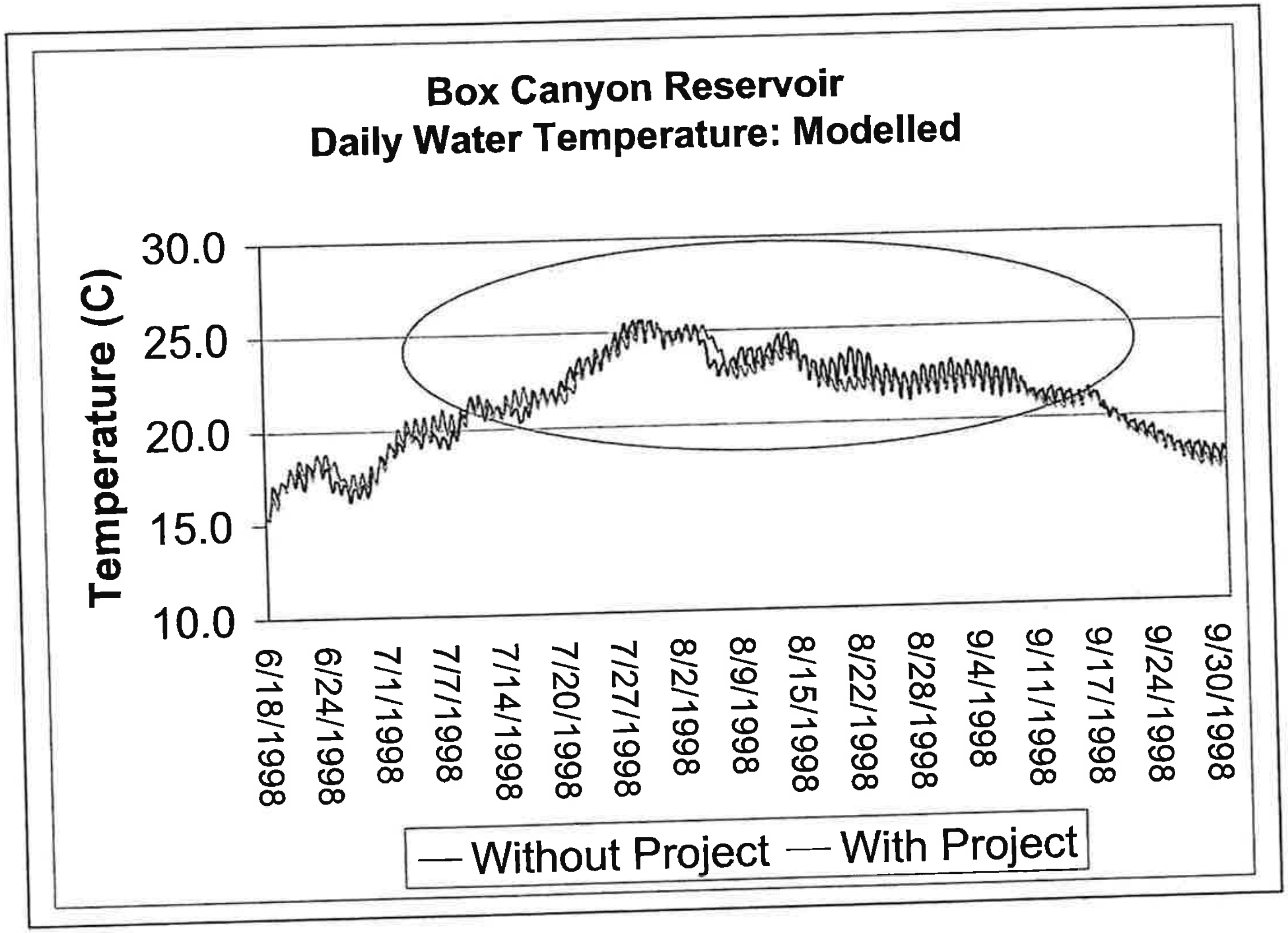


Figure 6.11 Comparison of predicted temperatures for "with" and "without" Box Canyon Dam for Pend Oreille River near Ione at Big Muddy confluence, 1998.

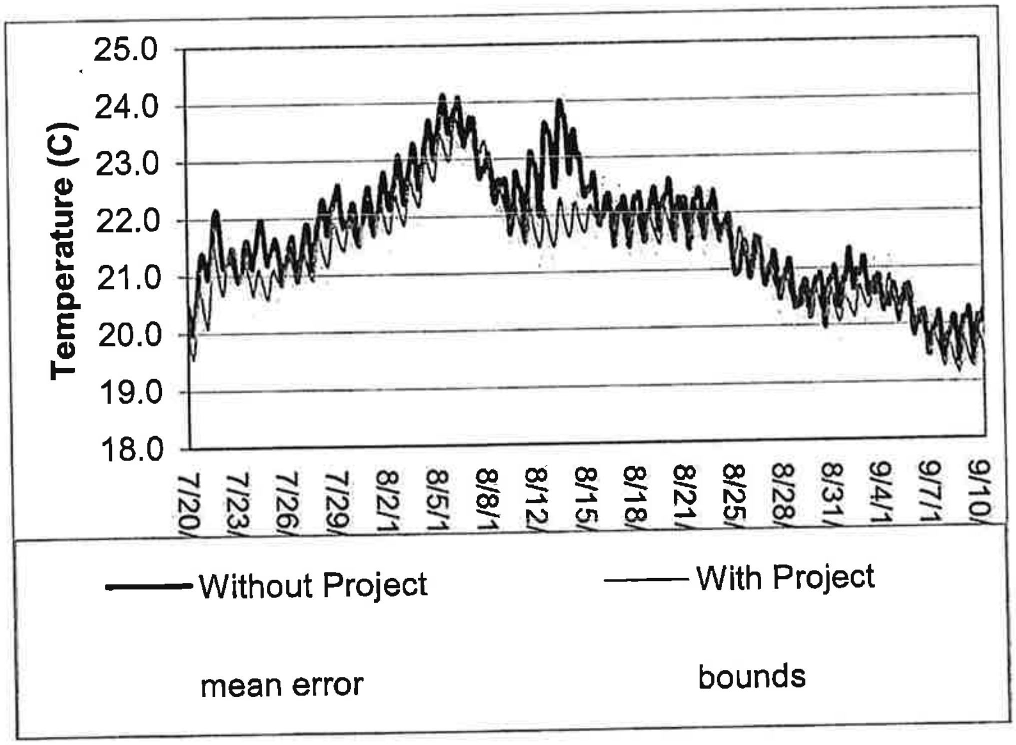


Figure 6.12 Comparison of predicted temperatures for Pend Oreille River at Big Muddy Cr. (RM 38.3) July 20 through September 10, 1997

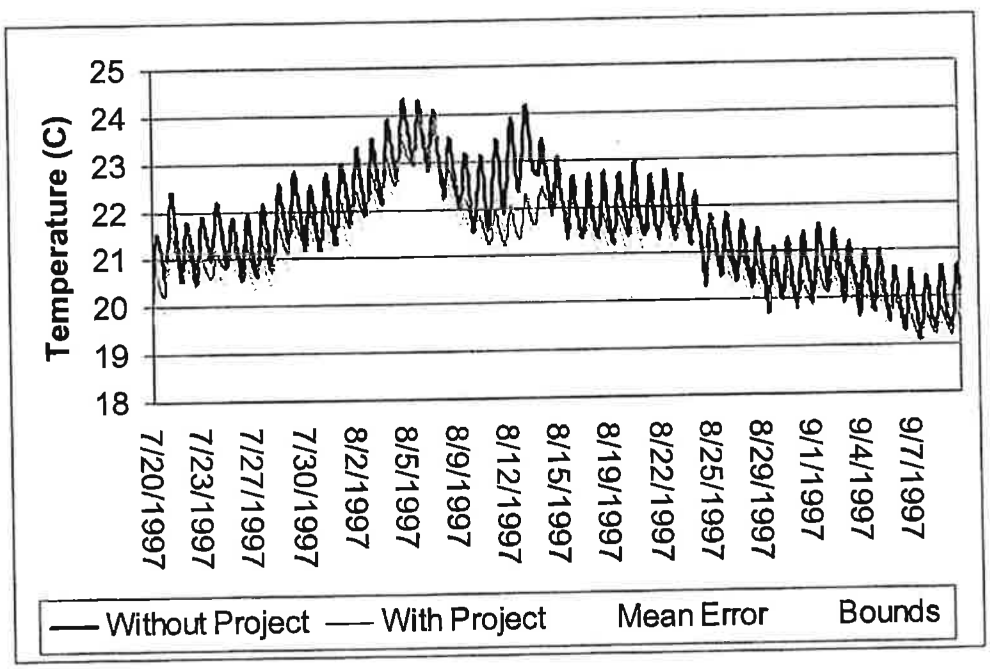


Figure 6.13 Comparison of predicted temperatures for Pend Oreille River at LeClerc Cr. (RM 56.5) July 20 through September 10, 1997

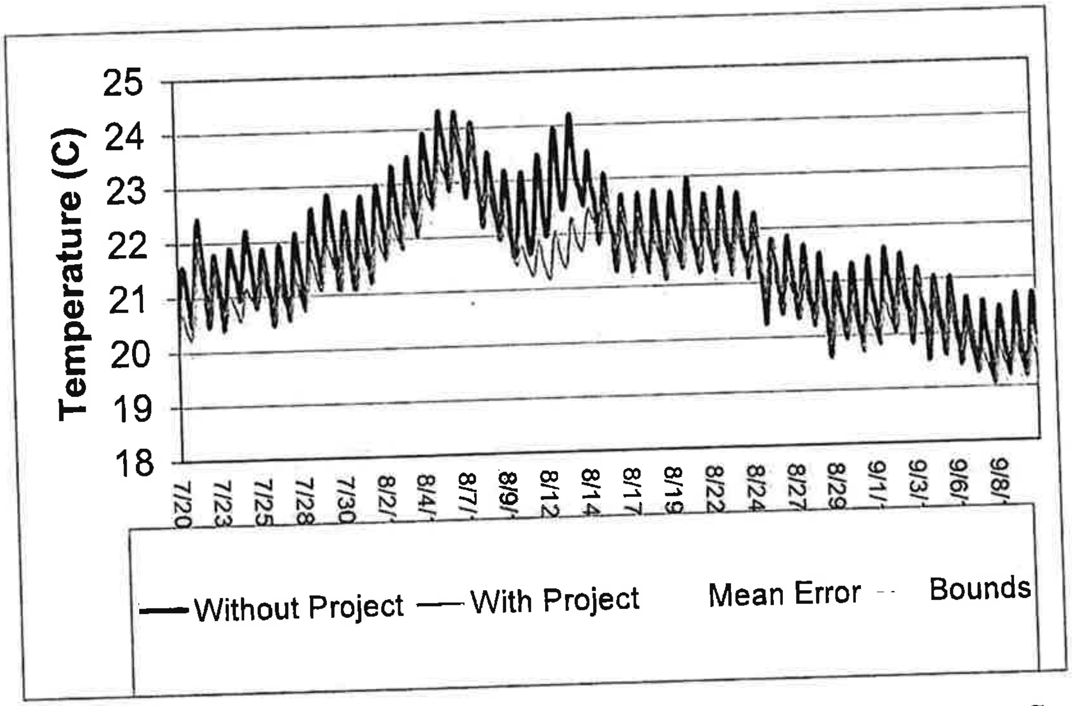


Figure 6.14 Comparison of predicted temperatures for Pend Oreille River at Mill Cr. (RM 58.5) July 20 through September 10, 1997

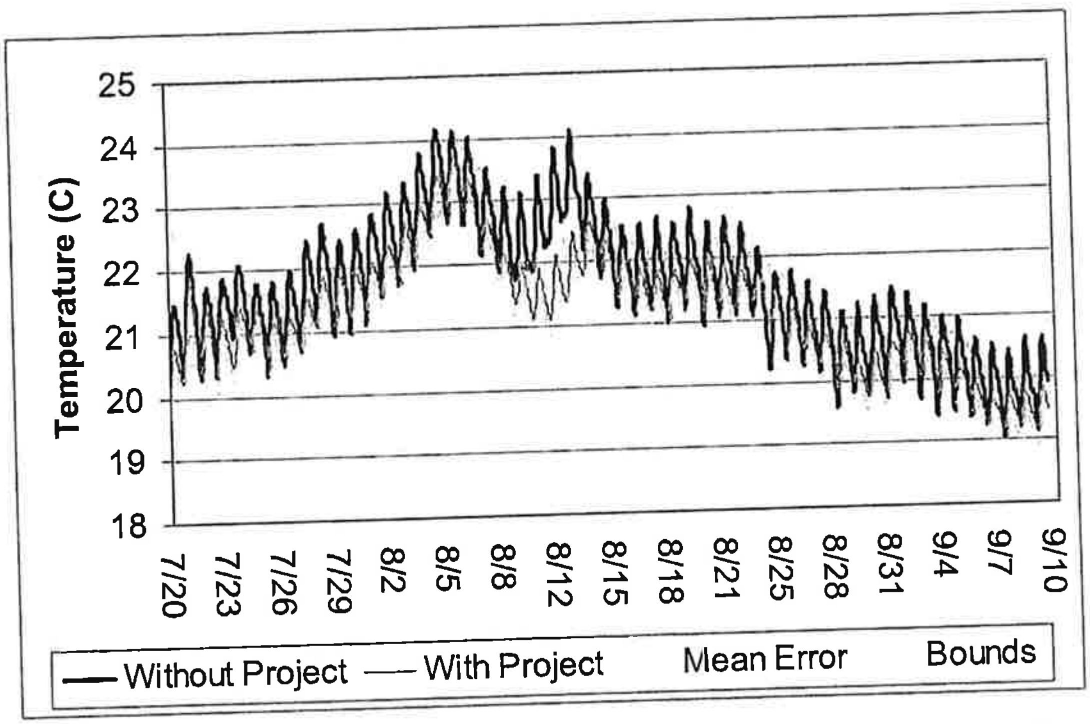


Figure 6.15 Comparison of predicted temperatures for Pend Oreille River at CeeCeeAh Cr. (RM 74.3) July 20 through September 10, 1997

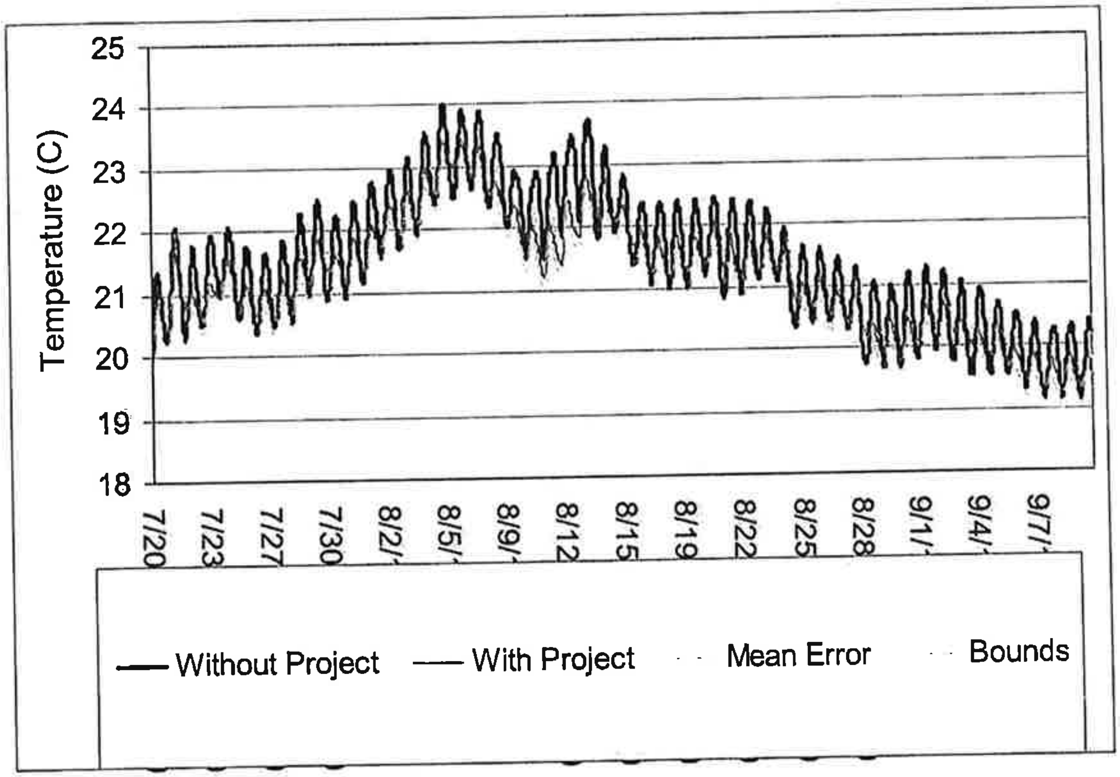


Figure 6.16 Comparison of predicted temperatures for Pend Oreille River at Skookum Cr. (RM 74.3) July 20 through September 10, 1997

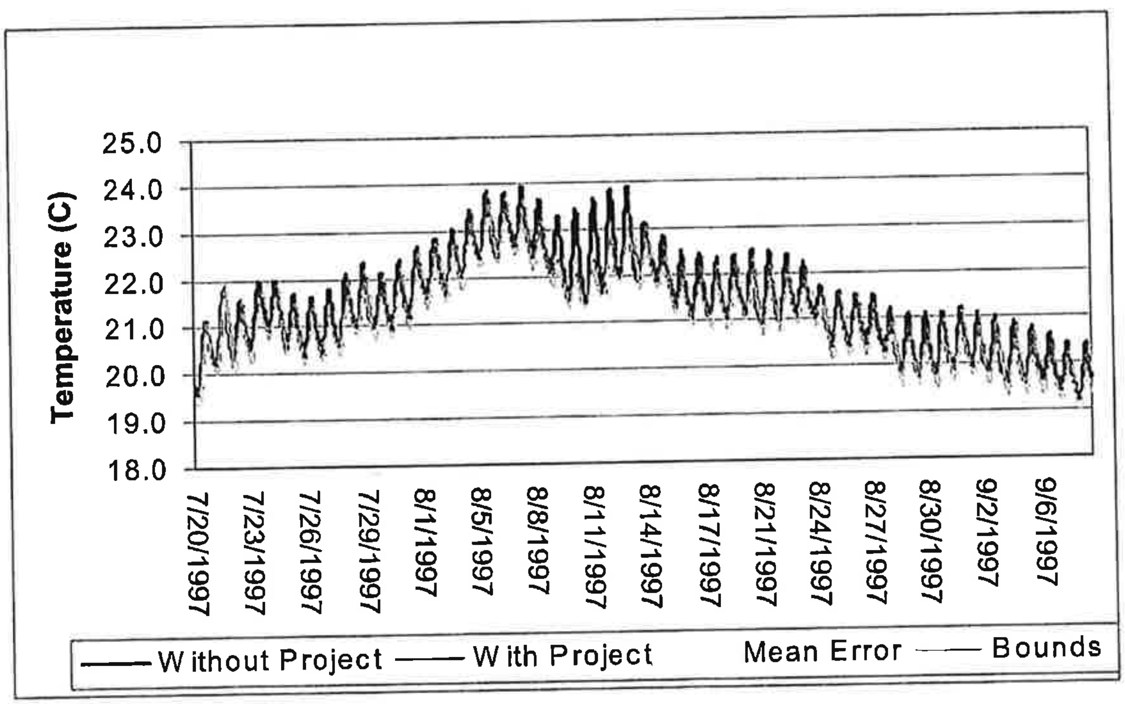


Figure 6.17 Comparison of predicted temperatures for Pend Oreille River at Indian Cr. (RM 81.2) July 20 through September 10, 1997

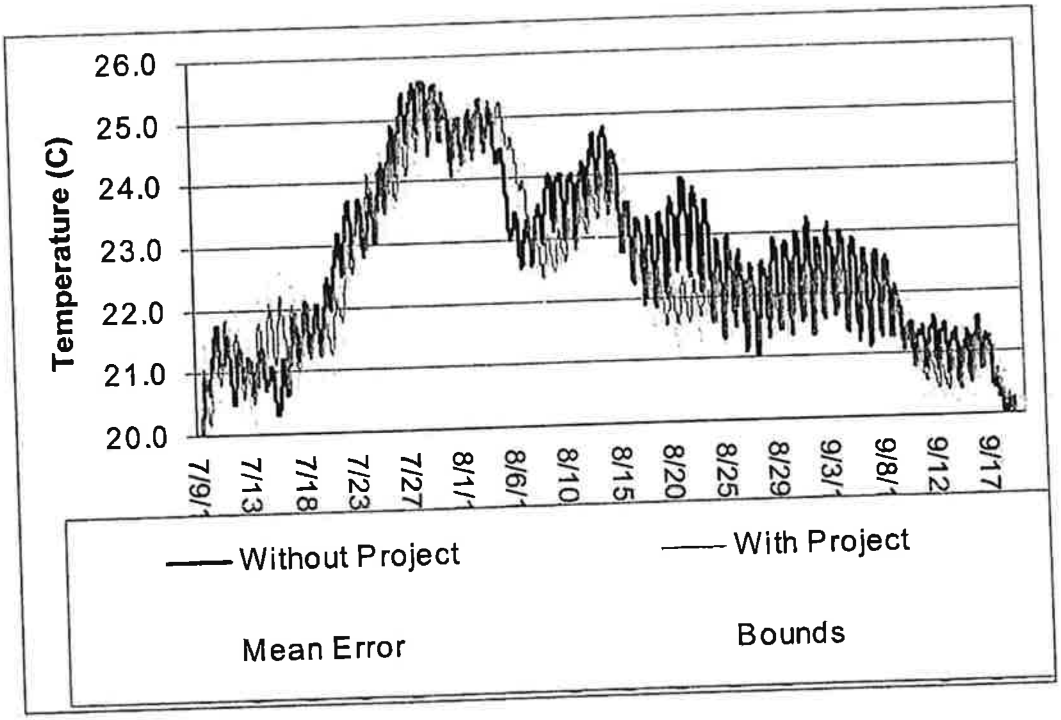


Figure 6.18 Comparison of predicted temperatures for Pend Oreille River at Big Muddy Cr (RM 38.3) July 20 through September 20, 1998

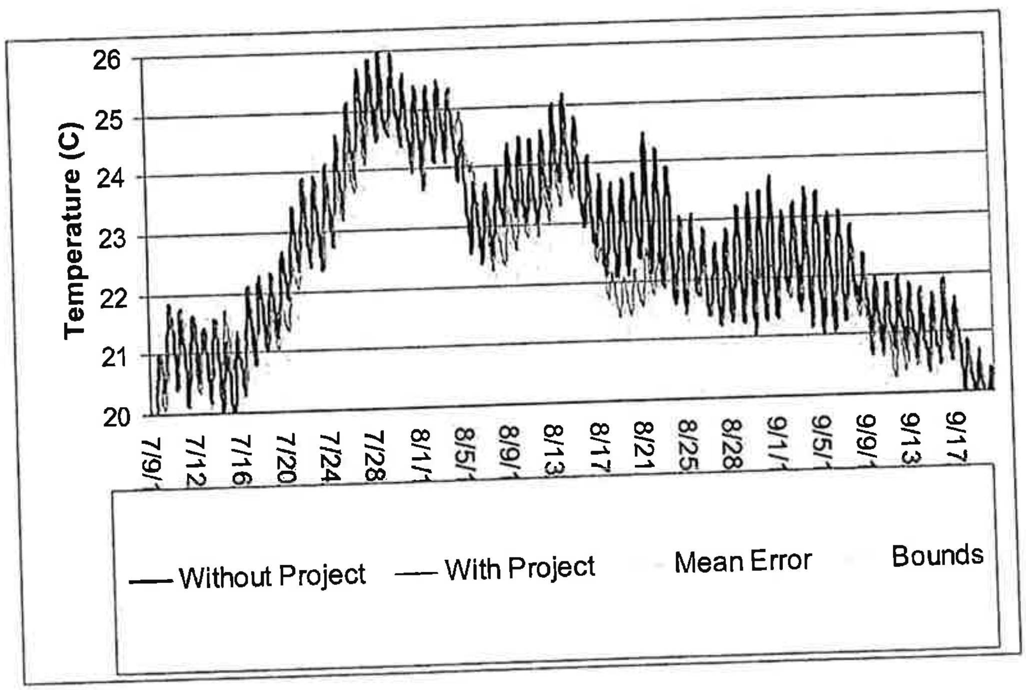


Figure 6.19 Comparison of predicted temperatures for Pend Oreille River at Mill Cr. (RM 58.5) July 20 through September 20, 1998

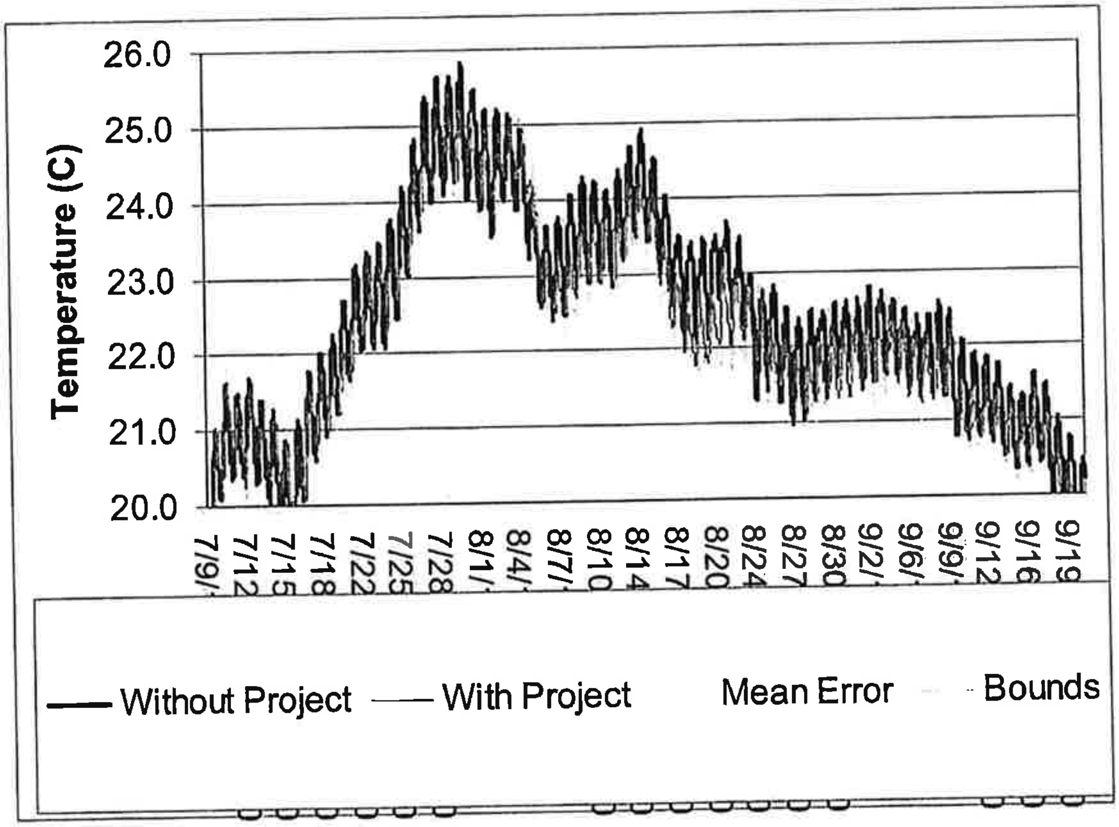
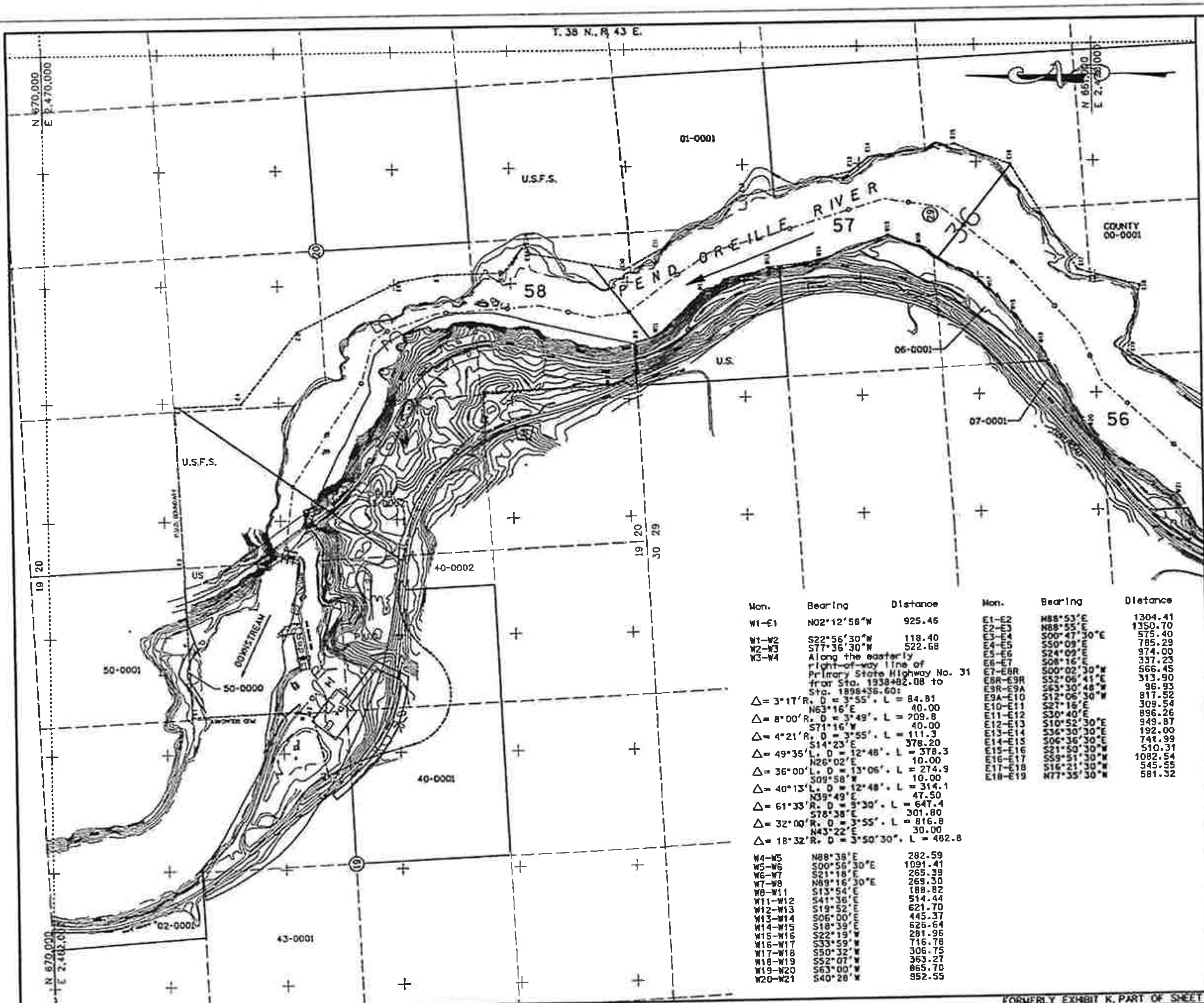


Figure 6.20 Comparison of predicted temperatures for Pend Oreille River at Skookum Cr. (RM 74.3) July 20 through September 20, 1998

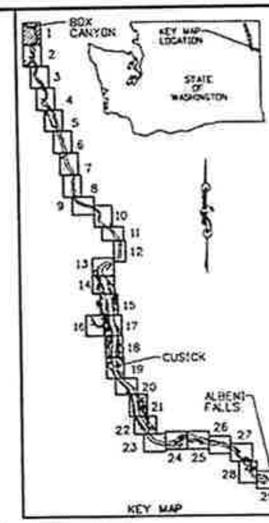
ATTACHMENT A
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES
FOR
BOX CANYON RESERVOIR



Mon.	Bearing	Distance
W1–E1	N02°12'58"W	925.46
W1–W2	S22°56'30"W	118.40
W2–W3	S77°36'30"W	522.68
W3–W4	Along the easterly right-of-way line of Primary State Highway No. 31 from Sta. 1938+82.08 to Sta. 1898+36.60:	
	Δ= 3°17'R, D = 3°55', L = 84.81	
	N63°16'E	40.00
	Δ= 8°00'R, D = 3°49', L = 209.8	
	S71°16'W	40.00
	Δ= 4°21'R, D = 3°55', L = 111.3	
	S14°23'E	378.20
	Δ= 49°35'L, D = 12°48', L = 378.3	
	N26°02'E	10.00
	Δ= 36°00'L, D = 13°06', L = 274.9	
	S09°58'W	10.00
	Δ= 40°13'L, D = 12°48', L = 314.1	
	N39°49'E	47.50
	Δ= 61°33'R, D = 9°30', L = 647.4	
	S78°38'E	301.80
	Δ= 32°00'R, D = 3°55', L = 816.8	
	N43°22'E	30.00
	Δ= 18°32'R, D = 3°50'30", L = 482.8	
W4–W5	N88°38'E	282.59
W5–W6	S00°56'30"E	1091.41
W6–W7	S21°18'E	265.39
W7–W8	N89°16'30"E	269.30
W8–W11	S13°54'E	188.82
W11–W12	S41°36'E	514.44
W12–W13	S19°52'E	621.70
W13–W14	S06°00'E	445.37
W14–W15	S18°39'E	626.64
W15–W16	S22°19'W	281.96
W16–W17	S33°59'W	716.78
W17–W18	S50°32'W	306.75
W18–W19	S52°07'W	363.27
W19–W20	S63°00'W	865.70
W20–W21	S40°28'W	952.55

Mon.	Bearing	Distance
E1–E2	N88°53'E	1304.41
E2–E3	N88°55'E	1350.70
E3–E4	S00°47'30"E	575.40
E4–E5	S50°09'E	785.29
E5–E6	S24°09'E	974.00
E6–E7	S08°16'E	337.23
E7–E8R	S00°02'30"W	566.45
E8R–E9R	S52°06'41"E	313.90
E9R–E9A	S63°30'48"W	96.93
E9A–E10	S12°06'30"W	817.52
E10–E11	S27°16'E	309.54
E11–E12	S30°40'E	896.26
E12–E13	S10°52'30"E	949.87
E13–E14	S36°30'30"E	192.00
E14–E15	S06°36'30"E	741.99
E15–E16	S21°50'30"W	510.31
E16–E17	S59°51'30"W	1082.54
E17–E18	S16°21'30"W	545.55
E18–E19	N77°35'30"W	581.32

FORMERLY EXHIBIT K, PART OF SHEET 1



LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

400 0 400 800 1200
SCALE: 1" = 400'

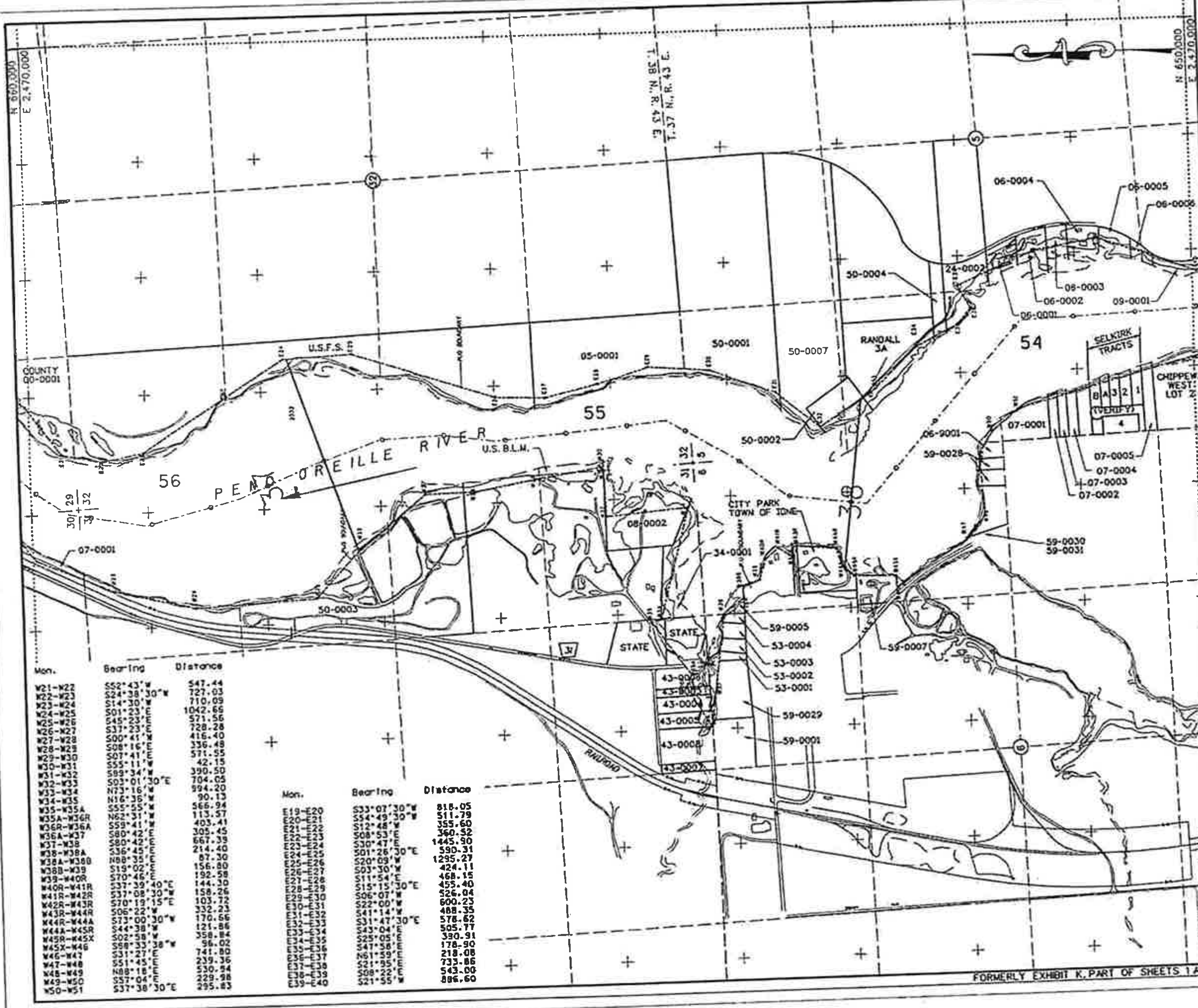
EXHIBIT G — SHEET 1

CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

BOX CANYON POWER PROJECT

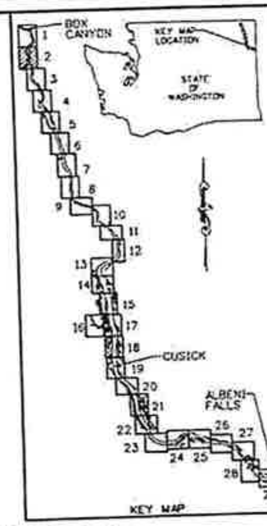
PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY — NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 — NOVEMBER 2002



Mon.	Bearing	Distance
W21-W22	S52°43'W	547.44
W22-W23	S24°38'30"W	727.03
W23-W24	S14°30'W	710.09
W24-W25	S01°23'E	1042.65
W25-W26	S45°23'E	571.56
W26-W27	S37°23'E	728.28
W27-W28	S00°41'W	416.40
W28-W29	S08°16'E	336.48
W29-W30	S07°41'E	571.55
W30-W31	S55°11'W	42.15
W31-W32	S89°34'W	390.50
W32-W33	S03°01'30"E	704.05
W33-W34	N73°16'W	994.20
W34-W35	N16°36'W	90.13
W35-W35A	S55°55'W	566.94
W35A-W36R	N62°31'W	113.57
W36R-W36A	S59°41'W	403.41
W36A-W37	S80°42'E	305.45
W37-W38	S80°42'E	667.39
W38-W38A	S36°45'E	214.40
W38A-W38B	N88°35'E	87.30
W38B-W39	S19°02'E	156.80
W39-W40R	S70°46'E	192.58
W40R-W41R	S37°39'40"E	144.30
W41R-W42R	S37°08'30"W	158.26
W42R-W43R	S70°19'15"E	103.72
W43R-W44R	S06°22'W	332.23
W44R-W44A	S73°00'30"W	170.66
W44A-W45R	S44°38'W	121.86
W45R-W45X	S02°58'W	358.84
W45X-W46	S58°33'38"W	96.02
W46-W47	S31°27'E	741.80
W47-W48	S51°45'E	239.36
W48-W49	N88°18'E	530.54
W49-W50	S37°04'E	229.98
W50-W51	S37°38'30"E	295.83

Mon.	Bearing	Distance
E19-E20	S33°07'30"W	818.05
E20-E21	S54°49'30"W	511.79
E21-E22	S12°48'W	355.60
E22-E23	S08°53'E	360.52
E23-E24	S30°47'E	1445.90
E24-E25	S01°26'30"E	590.31
E25-E26	S20°09'W	1295.27
E26-E27	S03°30'W	424.11
E27-E28	S11°54'E	468.15
E28-E29	S15°15'30"E	455.40
E29-E30	S06°07'W	526.04
E30-E31	S22°00'W	600.23
E31-E32	S41°14'W	488.35
E32-E33	S31°47'30"E	578.62
E33-E34	S43°04'E	505.77
E34-E35	S25°05'E	390.91
E35-E36	S47°58'E	178.90
E36-E37	N61°59'E	218.08
E37-E38	S21°55'E	733.86
E38-E39	S08°22'E	543.00
E39-E40	S21°55'W	886.60



LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

400 0 400 800 1200
SCALE: 1" = 400'

EXHIBIT G — SHEET 2

CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

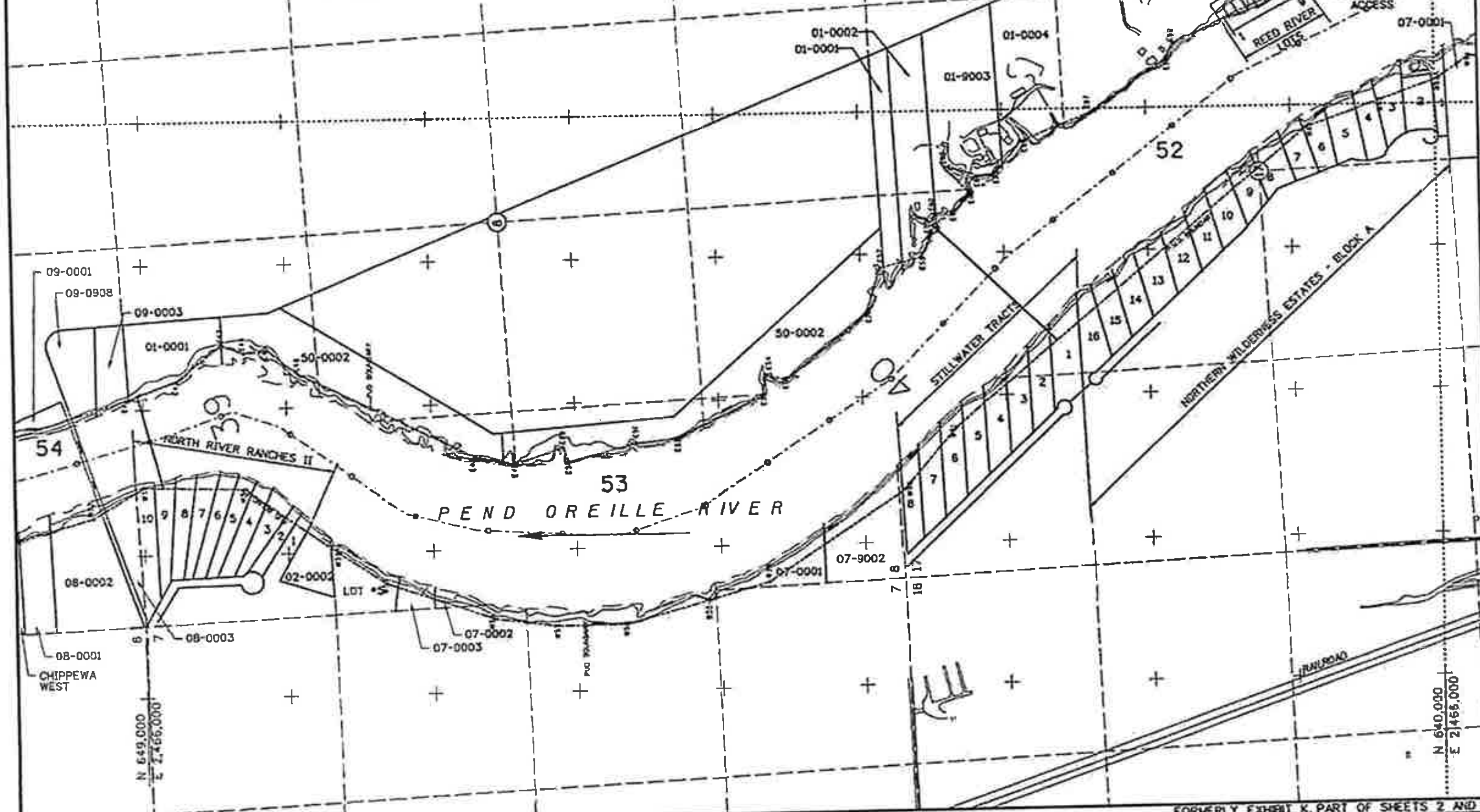
BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY — NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 — NOVEMBER 2002

Mon.	Bearing	Distance
W51-W52	S13°40'E	2231.92
W52-W53	S27°23'E	416.70
W53-W54	S01°16'W	699.13
W54-W54A	S36°37'20"W	781.66
W54A-W55	S34°46'30"W	400.42
W55-W56	S21°08'W	785.89
W56-W57	S08°36'W	444.72
W57-W58	S01°22'W	478.07
W58-W58-2	S14°08'30"E	596.05
W58-2 - W59	S15°06'E	431.67
W59-W60	S31°34'E	1143.13
W60-W61	S47°34'30"E	549.68
W61-W62	S38°22'E	3208.48
W62-W63	S18°23'E	352.32
W63-W63A	S18°23'E	440.25
W63A-W64	S34°08'30"E	267.10

Mon.	Bearing	Distance
E40-E41	S14°51'E	883.33
E41-E42	S18°17'E	377.20
E42-E43	S40°00'E	412.00
E43-E44	S23°34'W	167.37
E44-E45	S04°51'E	167.60
E45-E46	S40°00'W	262.64
E46-E47	S27°25'W	1360.55
E47-E48	S11°19'W	287.14
E48-E49	S18°35'E	347.17
E49-E50	S69°55'W	103.19
E50-E51	S12°35'E	487.30
E51-E52	S05°21'E	291.40
E52-E53	S23°46'E	643.60
E53-E54	S76°36'E	155.55
E54-E55	S16°49'W	148.00
E55-E56	S37°09'E	722.80
E56-E57	S71°47'30"E	332.05
E57-E58	S12°06'E	300.60
E58-E59	S64°45'E	185.55
E59-E60	S79°25'E	134.20
E60-E61	S02°35'E	123.20
E61-E62	S39°42'E	177.74
E62-E63	N50°00'E	269.00
E63-E64	S16°18'W	258.58
E64-E65	S10°00'E	96.90
E65-E66	S48°24'E	286.70
E66-E67	S20°34'E	519.90
E67-E68	S33°39'E	643.90
E68-E69	S63°24'E	117.75
E69-E70	S23°16'E	1041.90
E70-E71	S37°49'E	627.32
E71-E72A	S20°44'30"E	714.02



LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

400 0 400 800 1200
SCALE: 1" - 400'

EXHIBIT G SHEET 3

CE-QUAL-W2 MODEL SEGMENT BOUNDARIES
BOX CANYON POWER PROJECT
PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY NEWPORT, WASHINGTON
FERC PROJECT NO. 2042 NOVEMBER 2002

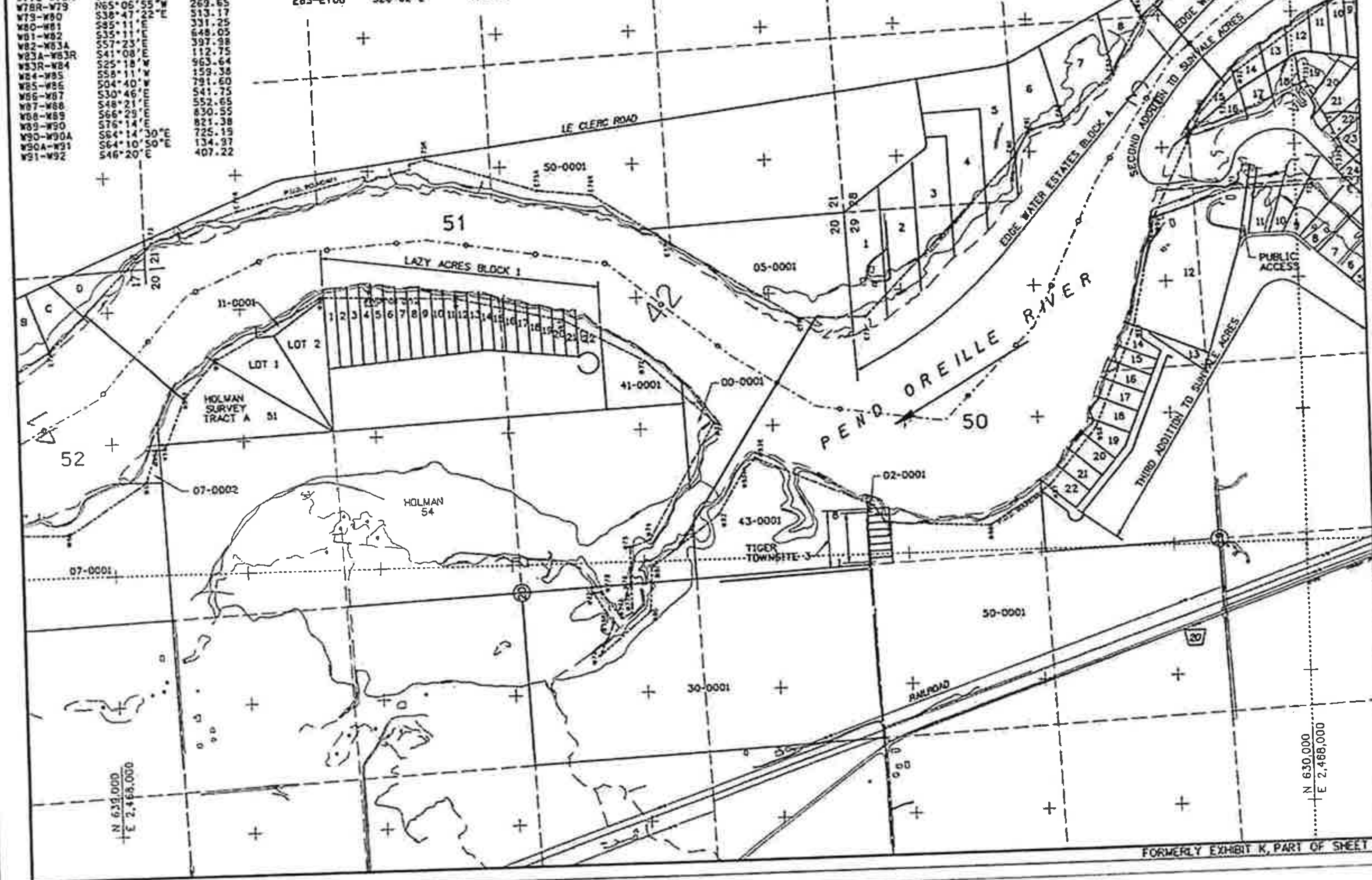
T. 37 N., R. 43 E.

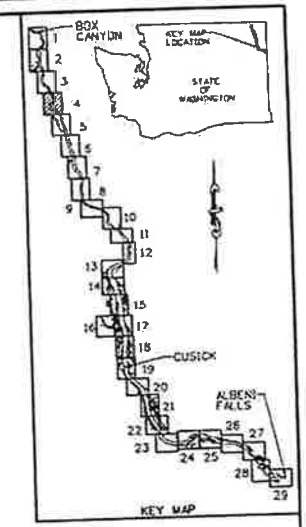
Mon.	Bearing	Distance
W64-W65	S03°04'W	417.10
W65-W66	S31°17'E	708.35
W66-W66A	S69°42'47"E	261.67
W66A-W66B	N01°14'W	69.84
W66B-W67R	S66°24'56"E	406.18
W67R-W68	S48°12'46"E	368.35
W68-W69	S27°53'E	936.20
W69-W70	S03°33'W	1018.36
W70-W71	S14°26'W	835.30
W71-W72	S30°01'W	604.78
W72-W73	S44°48'W	701.56
W73-W74	N58°12'W	1012.80
W74-W75	N17°15'W	163.93
W75-W76	N88°51'W	268.68
W76-W77R	N88°51'W	228.34
W77R-W77A	N27°02'W	89.98
W77A-W77B	N56°08'E	251.98
W77B-W77C	N01°19'43"W	65.23
W77C-W78R	S60°26'14"W	278.75
W78R-W79	N65°06'55"W	269.65
W79-W80	S38°47'22"E	513.17
W80-W81	S85°11'E	331.25
W81-W82	S35°11'E	648.05
W82-W83A	S57°23'E	397.98
W83A-W83R	S41°08'E	112.75
W83R-W84	S25°18'W	963.64
W84-W85	S58°11'W	159.38
W85-W86	S04°40'W	791.60
W86-W87	S30°46'E	541.75
W87-W88	S48°21'E	552.65
W88-W89	S66°29'E	830.55
W89-W90	S76°14'E	821.38
W90-W90A	S64°14'30"E	725.19
W90A-W91	S64°10'50"E	134.97
W91-W92	S46°20'E	407.22

Mon.	Bearing	Distance
E72A-E72R	S29°54'E	306.10
E72R-E73	S43°16'E	1133.77
E73-E74R	S17°04'E	696.54
E74R-R/W	S12°01'E	992.62
R/W-R/W	S77°59'W	40.00
R/W-R/W	S12°01'E	350.00
R/W-R/W	N77°59'E	40.00
R/W-E75R	S12°01'E	129.66
E75R-E75A	S18°21'30"W	970.02
E75A-E76R	S07°38'W	413.67
E76R-E77	S33°42'W	693.46
E77-E78	S33°28'W	1113.10
E78-E79	S02°10'W	514.80
E79-E80	S43°43'E	1651.20
E80-E81	S58°37'E	213.60
E81-E82	S12°38'E	263.70
E82-E83	S40°09'E	525.20
E83-E84	S60°09'E	484.80
E84-E85	S42°21'E	786.70
E85-E100	S28°02'E	416.50

Mon	Bearing	Distance
W90-T1	S18°15'56"E	636.43
T1-T2	S01°38'32"E	591.68
T2-T3	S43°44'28"W	807.27

Mon	Bearing	Distance
W90A-T328	S17°24'51"E	270.76
T328-T327	S23°18'00"E	649.84
T327-T326R	S62°14'35"W	577.30
T326R-T325R	S44°13'26"W	926.39





LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

SCALE: 1" - 400'

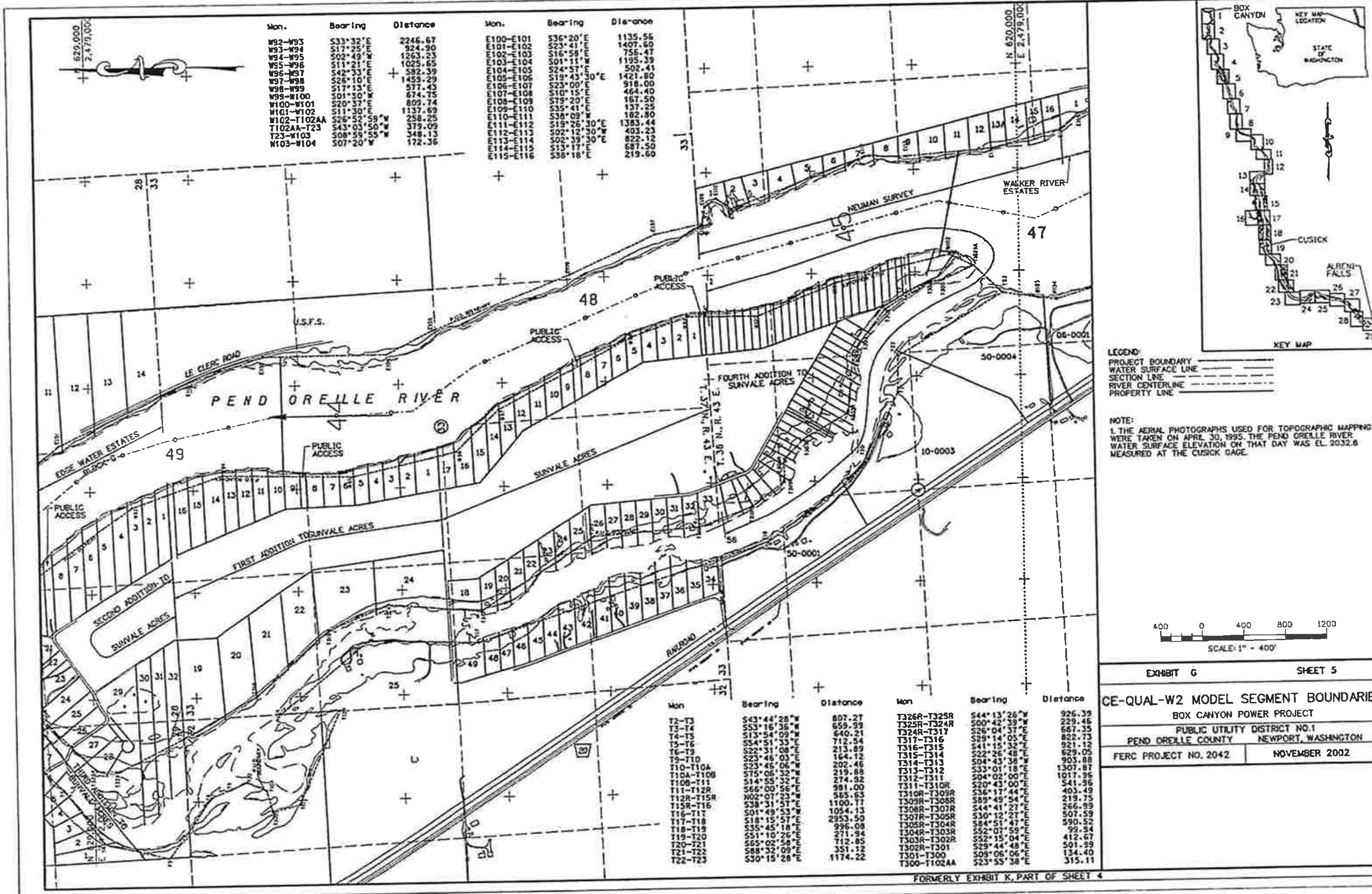
EXHIBIT G — SHEET 4

CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY — NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 — NOVEMBER 2002



Mon.	Bearing	Distance
W92-W93	S33°32'E	2246.67
W93-W94	S17°25'E	924.90
W94-W95	S02°49'W	1263.23
W95-W96	S11°21'E	1025.65
W96-W97	S42°33'E	582.39
W97-W98	S26°10'E	1459.29
W98-W99	S17°13'E	577.43
W99-W100	S01°50'W	674.75
W100-W101	S20°37'E	809.74
W101-W102	S11°30'E	1137.69
W102-T102AA	S26°52'59"W	258.25
T102AA-T23	S43°03'50"W	379.09
T23-W103	S08°59'55"W	348.13
W103-W104	S07°20'W	172.36

Mon.	Bearing	Distance
E100-E101	S36°20'E	1135.56
E101-E102	S23°41'E	1407.60
E102-E103	S16°58'E	756.47
E103-E104	S01°11'W	1195.39
E104-E105	S24°57'E	502.41
E105-E106	S19°43'30"E	1421.80
E106-E107	S23°00'E	918.00
E107-E108	S10°15'E	464.40
E108-E109	S79°20'E	167.50
E109-E110	S35°41'E	137.25
E110-E111	S38°09'W	182.80
E111-E112	S19°26'30"E	1383.44
E112-E113	S02°12'30"W	403.23
E113-E114	S02°39'30"E	822.12
E114-E115	S13°17'E	687.50
E115-E116	S38°18'E	219.60

Mon	Bearing	Distance
T2-T3	S43°44'28"W	807.27
T3-T4	S53°16'36"W	659.99
T4-T5	S13°54'09"W	640.21
T5-T6	S54°51'33"E	712.54
T6-T9	S22°31'08"E	213.89
T9-T10	S23°46'03"E	164.12
T10-T10A	S23°46'06"W	202.46
T10A-T10B	S75°06'32"W	219.88
T10B-T11	S14°55'32"E	274.92
T11-T12R	S66°00'56"E	981.00
T12R-T15R	N02°07'23"W	565.63
T15R-T16	S38°31'57"E	1100.77
T16-T17	S01°49'53"W	1054.13
T17-T18	S18°15'57"E	2953.50
T18-T19	S35°45'18"E	996.08
T19-T20	S51°10'26"E	271.94
T20-T21	S65°02'58"E	712.85
T21-T22	S88°32'09"E	351.12
T22-T23	S30°15'28"E	1174.22

Mon	Bearing	Distance
T326R-T325R	S44°13'26"W	926.39
T325R-T324R	S00°42'39"W	229.46
T324R-T317	S26°04'37"E	687.35
T317-T316	S29°14'05"E	822.73
T316-T315	S41°15'32"E	921.12
T315-T314	S22°26'48"E	629.05
T314-T313	S04°43'38"W	903.88
T313-T312	S33°01'18"E	1307.87
T312-T311	S04°02'00"E	1017.96
T311-T310R	S20°43'00"E	541.96
T310R-T309R	S36°17'44"E	403.49
T309R-T308R	S89°49'54"E	219.75
T308R-T307R	S44°41'27"E	266.99
T307R-T305R	S30°12'27"E	507.59
T305R-T304R	S84°51'47"E	590.52
T304R-T303R	S52°07'59"E	99.34
T303R-T302R	S52°15'04"E	412.67
T302R-T301	S29°44'48"E	501.99
T301-T300	S09°06'06"E	134.40
T300-T102AA	S23°55'38"E	315.11

LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

EXHIBIT G — SHEET 5

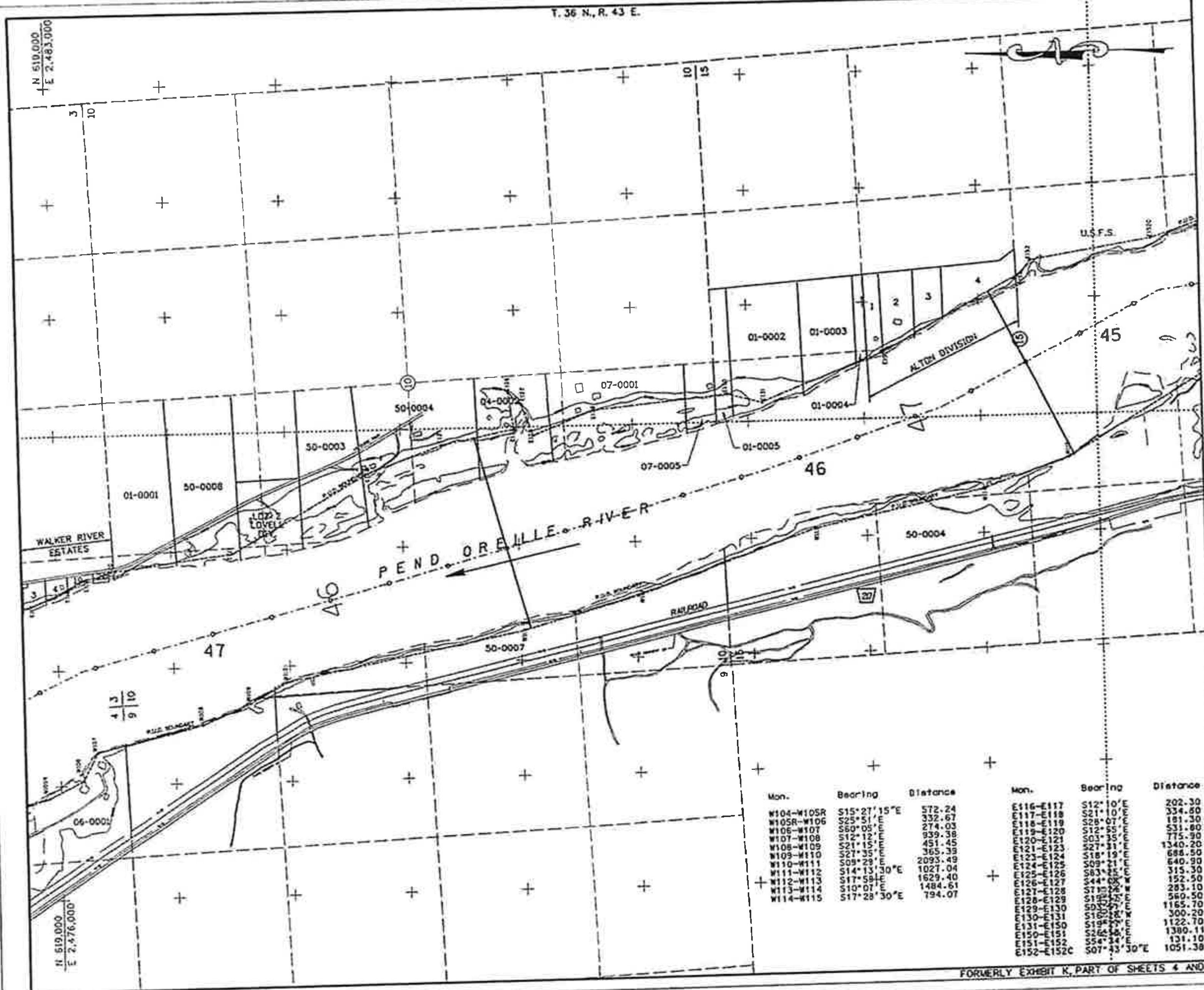
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY — NEWPORT, WASHINGTON

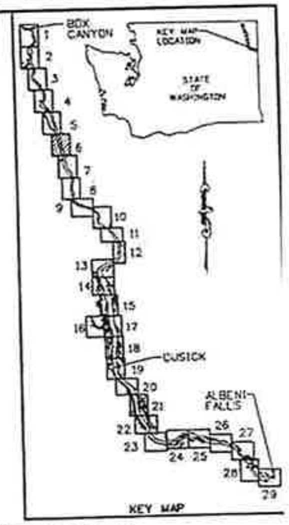
FERC PROJECT NO. 2042 — NOVEMBER 2002

FORMERLY EXHIBIT K, PART OF SHEET 4



Mon.	Bearing	Distance
W104-W105R	S15°27'15"E	572.24
W105R-W106	S25°51'E	332.67
W106-W107	S60°05'E	274.03
W107-W108	S12°12'E	939.38
W108-W109	S21°15'E	451.45
W109-W110	S27°35'E	365.39
W110-W111	S09°29'E	2093.49
W111-W112	S14°13'30"E	1027.04
W112-W113	S17°59'E	1629.40
W113-W114	S10°07'E	1484.61
W114-W115	S17°28'30"E	794.07

Mon.	Bearing	Distance
E116-E117	S12°10'E	202.30
E117-E118	S21°10'E	334.60
E118-E119	S28°07'E	181.30
E119-E120	S12°55'E	531.80
E120-E121	S03°35'E	775.90
E121-E123	S27°31'E	1340.20
E123-E124	S18°19'E	688.50
E124-E125	S09°21'E	640.90
E125-E126	S83°25'E	315.30
E126-E127	[illegible]	152.50
E127-E128	[illegible]	283.10
E128-E129	[illegible]	560.50
E129-E130	[illegible]	1165.70
E130-E131	[illegible]	300.20
E131-E150	[illegible]	1122.70
E150-E151	[illegible]	1380.11
E151-E152	S54°34'E	131.10
E152-E152C	S07°43'30"E	1051.38



LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

SCALE: 1" - 400'

EXHIBIT G — SHEET 6

CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

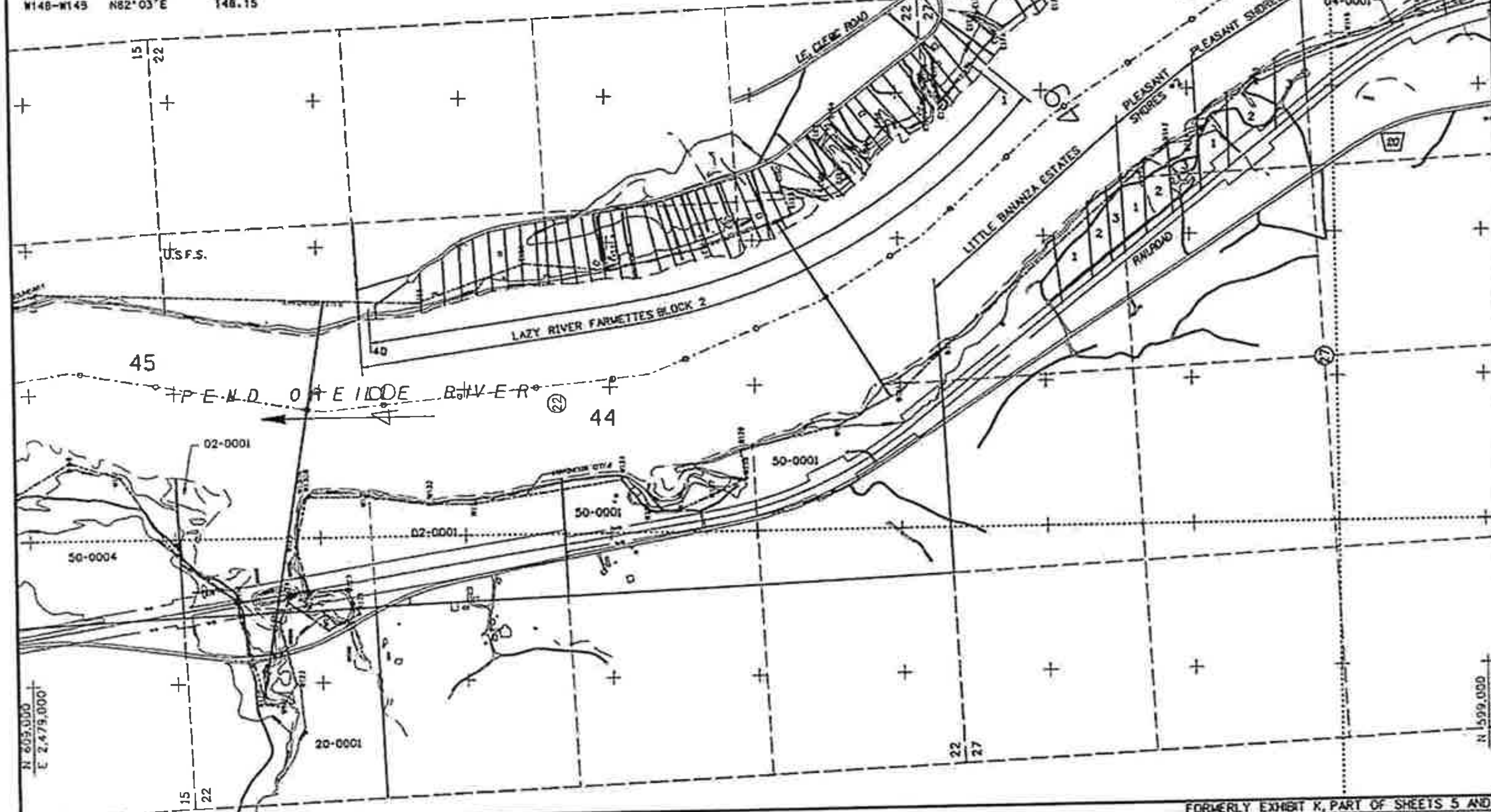
BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY — NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 — NOVEMBER 2002

Mon.	Bearing	Distance
W115-W116	S29°05'E	1769.71
W116-W117	S18°46'W	366.65
W117-W118	S36°15'W	652.92
W118-W119	S35°21'W	516.26
W119-W120	S76°21'W	741.53
W120-W121	S13°15'W	119.27
W121-W122	S56°11'E	184.32
W122-W123	N77°30'E	446.60
W123-W124	S64°30'E	147.44
W124-W125	S37°23'E	334.08
W125-W126	S24°36'E	244.32
W126-W127	N65°18'E	190.26
W127-W128	N01°12'W	262.63
W128-W129	N76°45'E	318.14
W129-W130A	S76°34'E	333.95
W130A-W130B	S30°36'30"E	27.27
W130B-W131	S02°01'W	394.20
W131-W132	S09°25'W	433.64
W132-W133	S01°29'W	320.88
W133-W134	S06°49'E	1018.47
W134-W135	S51°17'W	290.14
W135-W136	S01°16'E	208.49
W136-W137	S22°16'E	293.08
W137-W138	S23°28'E	212.70
W138-W139	N81°12'E	195.64
W139-W140	S12°10'E	695.75
W140-W141	S26°00'E	488.76
W141-W142	S42°12'E	462.82
W142-W143	S40°18'E	2052.65
W143-W144	S02°23'E	138.83
W144-W145	S41°54'E	631.85
W145-W146	S21°31'E	716.90
W146-W147	S12°37'E	510.59
W147-W148	S20°32'E	323.90
W148-W149	N82°03'E	148.15

Mon.	Bearing	Distance
E152C-E153	S16°58'E	606.78
E153-E155	S03°34'W	2628.63
E155-E156	S18°02'E	785.70
E156-E157	S06°32'W	590.00
E157-E158	S11°14'E	653.70
E158-E159	S18°10'E	660.80
E159-E160	N70°35'E	201.60
E160-E161	S06°54'W	280.90
E161-E162	S23°18'E	199.70
E162-E163	N51°31'E	311.70
E163-E164	S52°20'E	159.94
E164-E165	S42°59'W	295.34
E165-E166	S49°15'E	215.20
E166-E167	S17°03'E	305.67
E167-E168	S88°19'E	201.00
E168-E169	S23°45'E	48.80
E169-E170	S71°15'W	158.60
E170-E171	S47°44'E	582.40
E171-E172	N41°32'E	181.90
E172-E173	S61°55'E	59.80
E173-E174	S31°03'W	206.50
E174-E174A	S33°17'E	424.00
E174A-E174B	S22°21'E	407.80
E174B-E174C	N56°14'E	112.90
E174C-E174D	S14°17'E	533.00
E174D-E174E	S23°04'E	993.80
E174E-E175	S06°23'E	263.90
E175-E176	S19°22'E	1096.72



LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.5 MEASURED AT THE CUSICK GAGE.

400 0 400 800 1200
SCALE: 1" = 400'

EXHIBIT G — SHEET 7

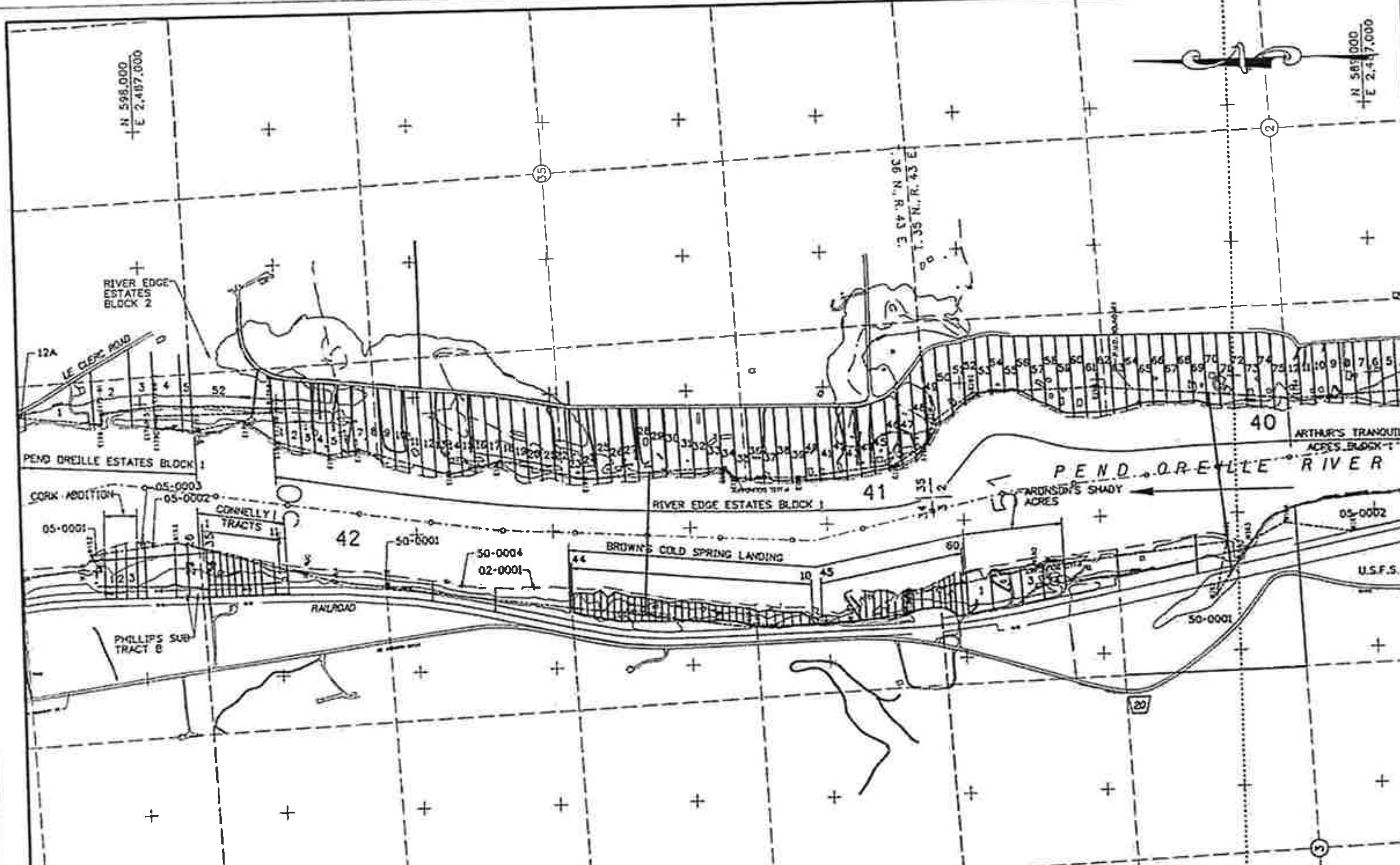
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

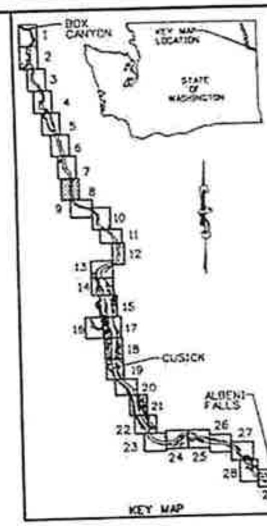
BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY — NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 — NOVEMBER 2002

FORMERLY EXHIBIT K, PART OF SHEETS 5 AND 6





LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

Mon.	Bearing	Distance
W149-W150	S04°12'E	656.12
W150-W151	S07°42'W	139.06
W151-W152	N60°10'E	141.20
W152-W153	S04°53'E	646.33
W153-W154	S16°22'W	1157.98
W154-W155	S10°25'W	419.96
W155-W156	S09°02'W	2661.49
W156-W157	S00°29'W	749.85
W157-W158	S05°49'E	398.78
W158-W159	S88°21'E	128.95
W159-W160	S09°13'E	983.72
W160-W161	S04°26'E	1394.90
W161-W162	N76°06'W	392.29
W162-W163	S53°33'E	468.57
W163-W164	S26°00'E	273.02
W164-W165	S10°39'W	490.72

Mon.	Bearing	Distance
E176-E176B	S07°14'W	604.42
E176B-E176B1	S82°46'E	70.00
E176B1-E176B2	S05°52'E	419.40
E176B2-E176B3	S03°51'W	826.20
E176B3-E176B4	N86°09'W	33.30
E176B4-E176B5	N01°09'E	831.30
E176B5-E176C	N82°46'W	92.42
E176C-E177	S07°14'W	321.04
E177-E179	S10°56'E	333.86
E179-E180	S35°10'W	296.49
E180-E181	S16°32'W	389.42
E181-E182	S07°32'E	217.00
E182-E183	S18°25'W	683.73
E183-E184	S12°04'E	381.66
E184-E185	S14°39'W	653.10
E185-E186	S01°55'E	1014.57
E186-E187	S49°33'W	95.90
E187-E188	S03°20'W	477.90
E188-E189	S04°37'E	717.30
E189-E190	S31°55'E	254.61
E190-E191	S66°19'E	187.15
E191-E192	S33°01'E	345.26
E192-E193	S00°29'W	898.30
E193-E194	S06°06'30"W	1465.40

400 0 400 800 1200
SCALE: 1" = 400'

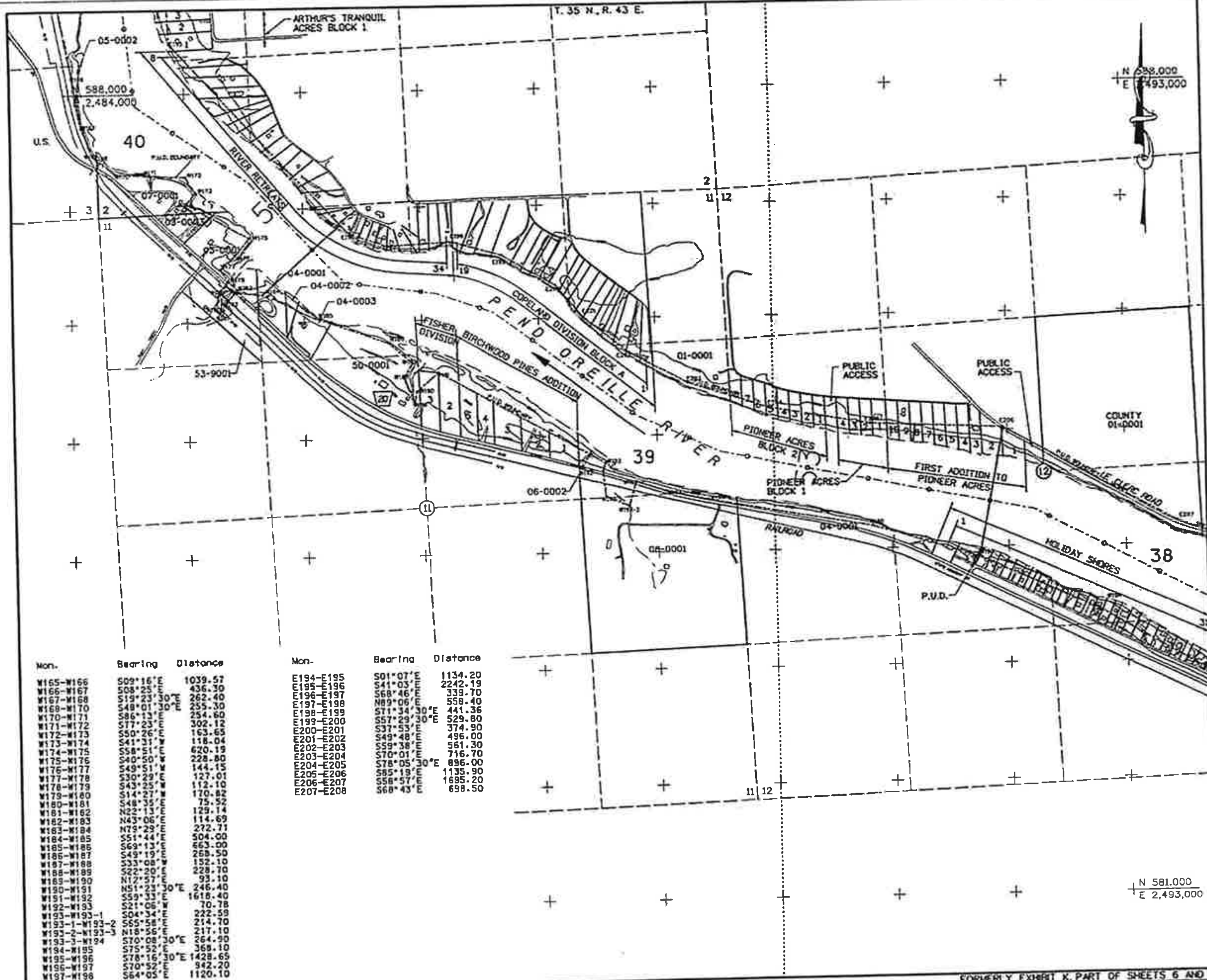
EXHIBIT G SHEET 8

CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY NEWPORT, WASHINGTON
FERC PROJECT NO. 2042 NOVEMBER 2002

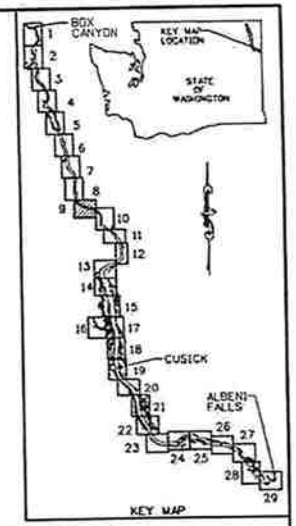
FORMERLY EXHIBIT K, PART OF SHEET 8



Mon.	Bearing	Distance
W165-W166	S09°16'E	1039.57
W166-W167	S08°25'E	436.30
W167-W168	S19°23'30"E	262.40
W168-W170	S48°01'30"E	255.30
W170-W171	S86°13'E	254.60
W171-W172	S77°23'E	302.12
W172-W173	S50°26'E	163.65
W173-W174	S41°31'W	118.04
W174-W175	S58°51'E	620.19
W175-W176	S40°50'W	228.80
W176-W177	S49°51'W	144.15
W177-W178	S30°29'E	127.01
W178-W179	S43°25'W	112.10
W179-W180	S14°27'W	170.82
W180-W181	S48°35'E	75.52
W181-W182	N22°13'E	129.14
W182-W183	N43°06'E	114.69
W183-W184	N79°29'E	272.71
W184-W185	S51°44'E	504.00
W185-W186	S69°13'E	663.00
W186-W187	S49°19'E	268.50
W187-W188	S33°08'W	152.10
W188-W189	S22°20'E	228.70
W189-W190	N12°57'E	93.10
W190-W191	N51°23'30"E	246.40
W191-W192	S59°33'E	1618.40
W192-W193	S21°06'W	70.78
W193-W193-1	S04°34'E	222.59
W193-1-W193-2	S55°58'E	214.70
W193-2-W193-3	N18°56'E	217.10
W193-3-W194	S70°08'30"E	264.90
W194-W195	S75°52'E	368.10
W195-W196	S78°16'30"E	1428.65
W196-W197	S70°52'E	942.20
W197-W198	S64°05'E	1120.10

Mon.	Bearing	Distance
E194-E195	S01°07'E	1134.20
E195-E196	S41°03'E	2242.19
E196-E197	S68°46'E	339.70
E197-E198	N89°06'E	558.40
E198-E199	S71°34'30"E	441.36
E199-E200	S57°29'30"E	529.80
E200-E201	S37°53'E	374.90
E201-E202	S49°48'E	496.00
E202-E203	S59°38'E	561.30
E203-E204	S70°01'E	716.70
E204-E205	S78°05'30"E	896.00
E205-E206	S85°19'E	1135.90
E206-E207	S58°57'E	1695.20
E207-E208	S68°43'E	698.50

FORMERLY EXHIBIT K, PART OF SHEETS 6 AND 7



LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

400 0 400 800 1200
SCALE: 1" = 400'

EXHIBIT G SHEET 9

CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

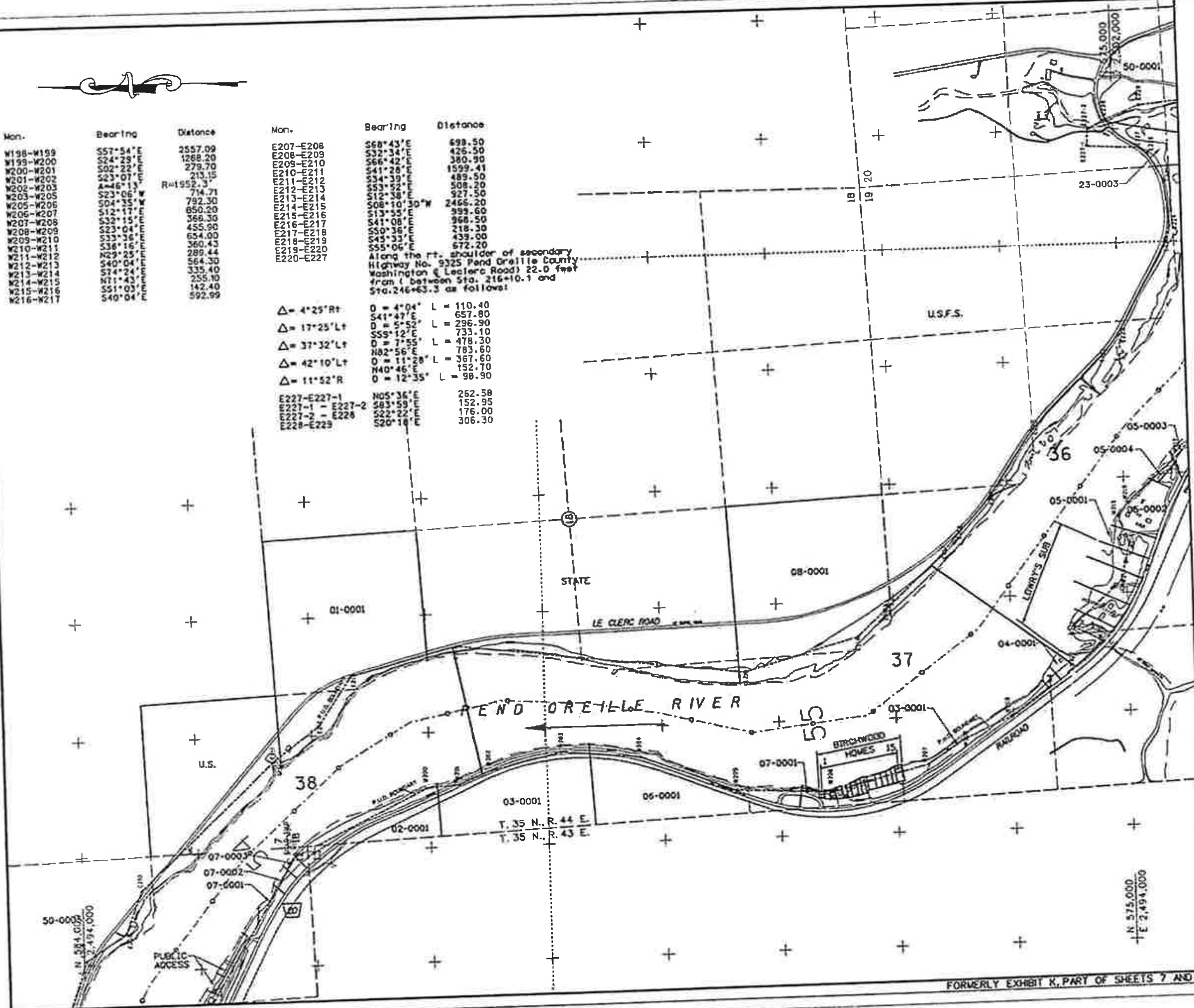
BOX CANYON POWER PROJECT

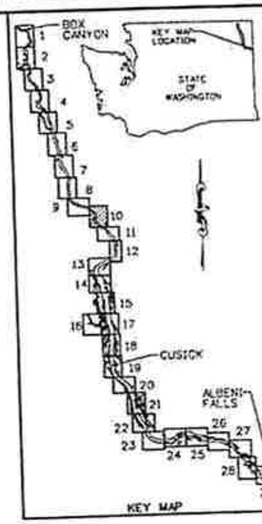
PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 NOVEMBER 2002

Mon.	Bearing	Distance
W198-W199	S57°54'E	2557.09
W199-W200	S24°29'E	1268.20
W200-W201	S02°22'E	279.70
W201-W202	S23°07'E	213.15
W202-W203	A=46°13'	R=1952.3'
W203-W205	S23°06'W	714.71
W205-W206	S04°35'W	792.30
W206-W207	S12°17'E	850.20
W207-W208	S32°15'E	366.30
W208-W209	S23°04'E	455.90
W209-W210	S33°36'E	654.00
W210-W211	S38°16'E	360.43
W211-W212	N29°25'E	289.44
W212-W213	S40°04'E	564.30
W213-W214	S74°24'E	335.40
W214-W215	N71°43'E	255.10
W215-W216	S51°03'E	142.40
W216-W217	S40°04'E	592.99

Mon.	Bearing	Distance
E207-E208	S68°43'E	698.50
E208-E209	S32°34'E	426.50
E209-E210	S66°42'E	380.90
E210-E211	S41°28'E	1599.41
E211-E212	S34°39'E	489.50
E212-E213	S53°52'E	508.20
E213-E214	S12°38'E	927.50
E214-E215	S08°10'30"W	2466.20
E215-E216	S13°55'E	999.60
E216-E217	S41°08'E	968.50
E217-E218	S50°36'E	218.30
E218-E219	S45°33'E	439.00
E219-E220	S55°06'E	672.20
E220-E227	Along the rt. shoulder of secondary Highway No. 9325 Pend Oreille County Washington (Leclerc Road) 22.0 feet from (between Sta. 216+10.1 and Sta.246+63.3 as follows:	
Δ= 4°25'Rt	D = 4°04'	L = 110.40
	S41°47'E	657.80
Δ= 17°25'Lt	D = 5°52'	L = 296.90
	S55°12'E	733.10
Δ= 37°32'Lt	D = 7°55'	L = 478.30
	N82°56'E	783.60
Δ= 42°10'Lt	D = 11°28'	L = 367.60
	N40°46'E	152.70
Δ= 11°52'R	D = 12°35'	L = 98.90
E227-E227-1	N05°36'E	262.58
E227-1 - E227-2	S83°59'E	152.95
E227-2 - E228	S22°22'E	176.00
E228-E229	S20°18'E	306.30





LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL 2032.6 MEASURED AT THE CUSICK GAGE.

400 0 400 800 1200
SCALE: 1" - 400'

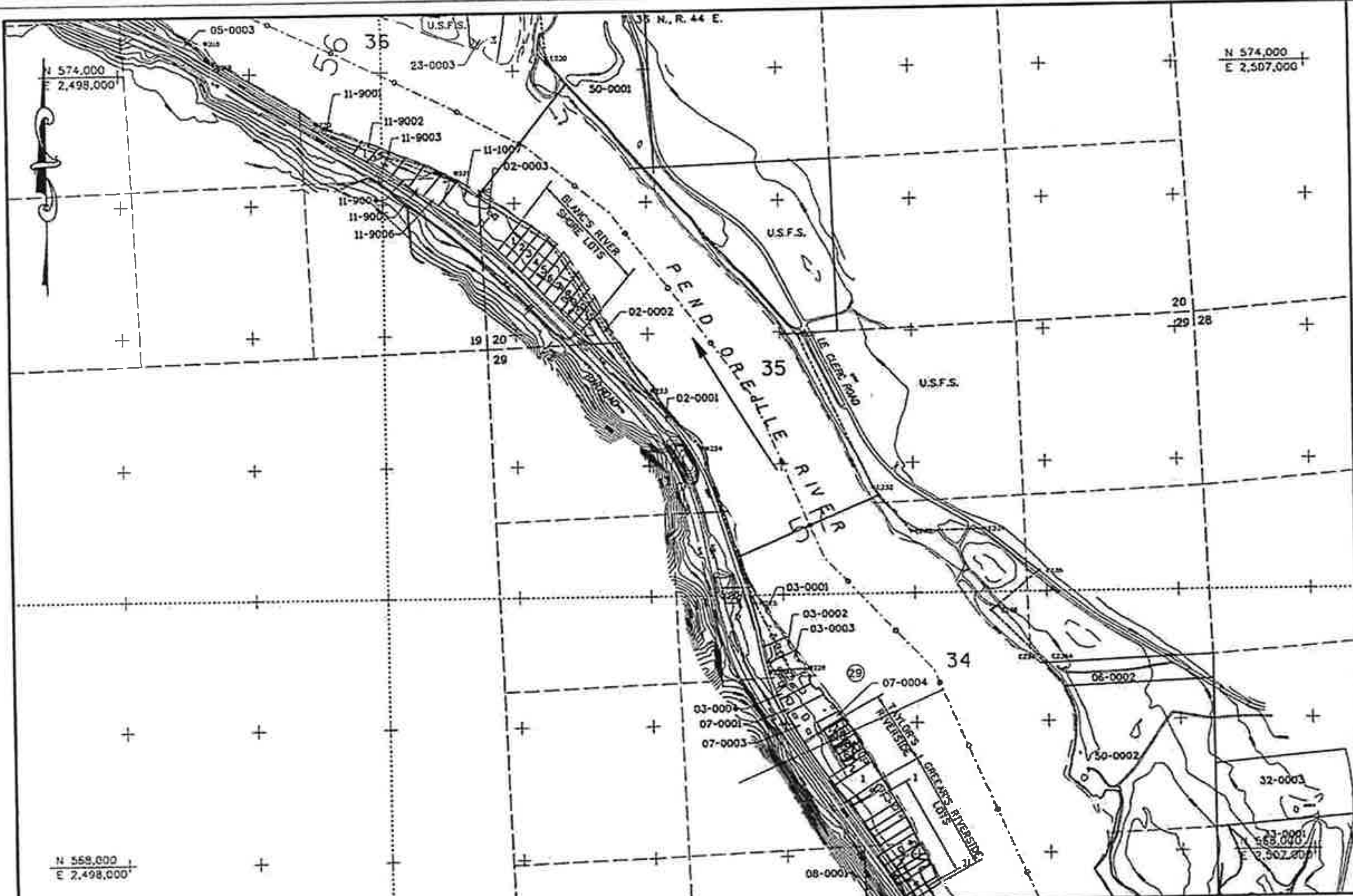
EXHIBIT G — SHEET 10

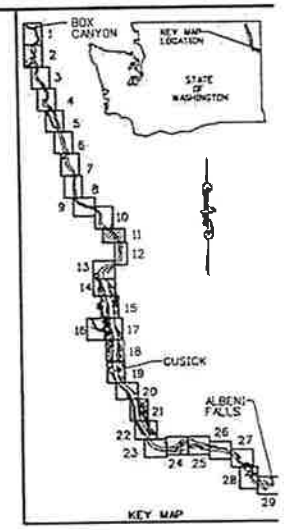
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY — NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 — NOVEMBER 2002





LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

2. UNLESS SURVEY METES AND BOUNDS ARE SHOWN, BACKWATER CURVES FROM DRAWINGS I-1 THRU I-3 FROM THE ORIGINAL LICENSE APPLICATION, WHICH HAVE NOW BEEN REDRAWN WITHOUT CHANGES ON EXHIBIT B, FIG. B2.4-1, HAVE BEEN UTILIZED TO ESTABLISH THE MAXIMUM WATER SURFACE ELEVATION AT THE PROJECT BOUNDARY ALONG THE SHORELINE AS SHOWN ON THESE MAPS USING EL. 2041.0 AT THE CUSICK GAGE AS REFERENCE ELEVATION FOR MAXIMUM WATER SURFACE CONDITIONS.

400 0 400 800 1200
SCALE: 1" = 400'

Mon.	Bearing	Distance
W217-W218	S50°56'E	536.40
W218-W219	S40°16'E	266.60
W219-W220	S56°44'E	818.30
W220-W221	S67°38'E	1108.54
W221-W222	S55°07'30"E	897.70
W222-W223	S30°39'E	1327.80
W223-W224	S41°07'30"E	601.20
W224-W225	S16°29'E	1260.30
W225-W225A	S26°09'45"E	639.72
W225A-W226	N87°40'27"E	126.07

W226 TO ALBENI FALLS - BOUNDARY FOLLOWS CONTOUR LINE - SEE NOTE 2

Mon.	Bearing	Distance
E229-E230	S02°58'E	705.70
E230-E231	S39°38'E	2809.50
E231-E232	S23°36'30"E	1287.86
E232-E233	S37°59'E	441.70
E233-E234	S89°01'30"E	555.10
E234-E235	S48°45'E	521.80
E235-E236	S52°07'W	478.20
E236-E236A	S44°30'30"E	382.49
E236A-E237	S87°40'27"W	11.79

E237 TO ALBENI FALLS - BOUNDARY FOLLOWS CONTOUR LINE - SEE NOTE 2

EXHIBIT G-11 SHEET 11

CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

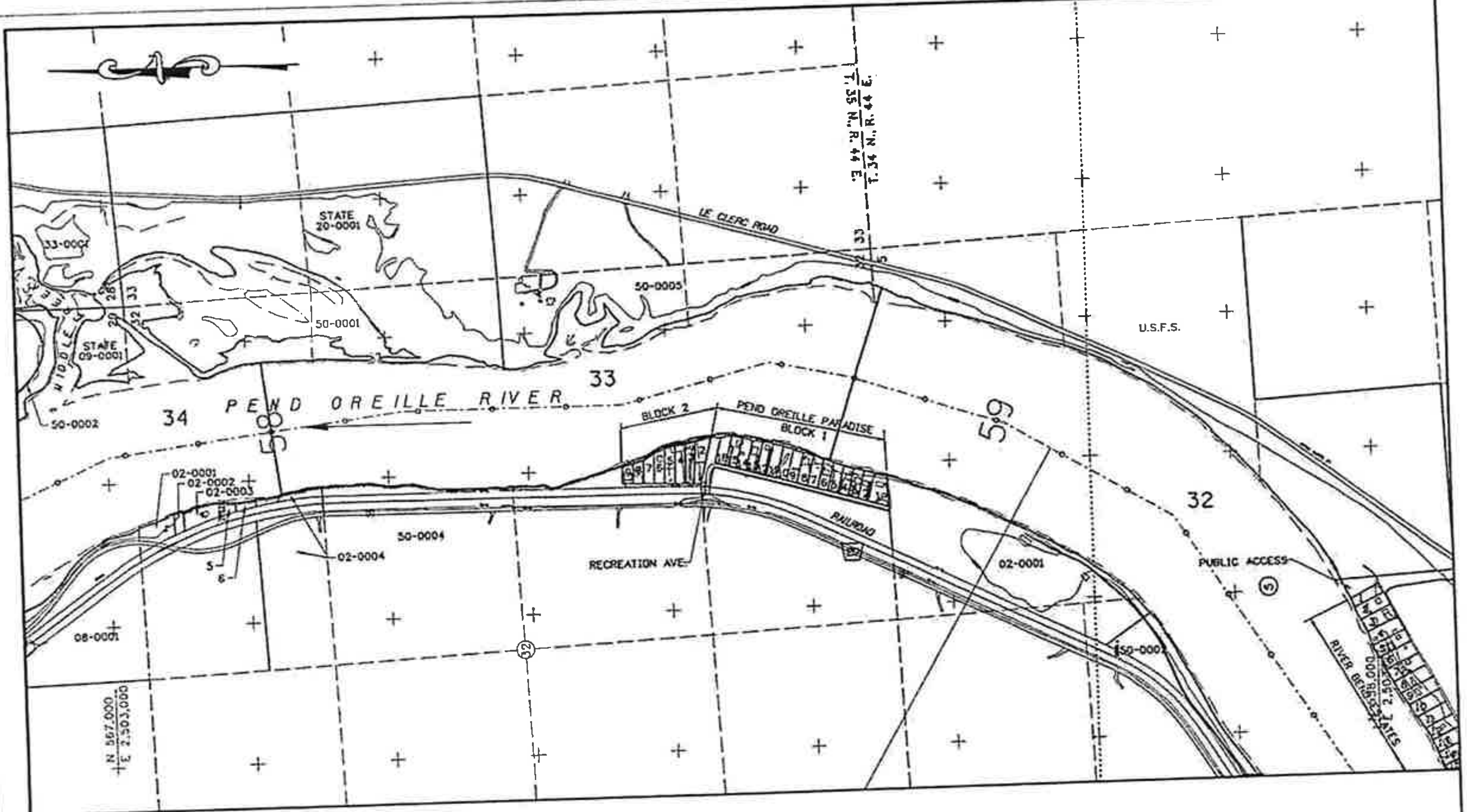
BOX CANYON POWER PROJECT

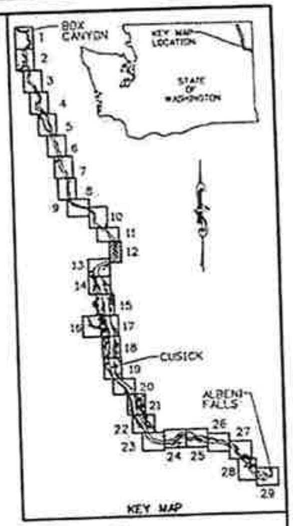
PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 NOVEMBER 2002

FORMERLY EXHIBIT K, PART OF SHEETS 8 AND 9

FERC DRAWING NO. 2042-





LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

2. BACKWATER CURVES FROM DRAWINGS I-1 THRU I-3 FROM THE ORIGINAL LICENSE APPLICATION, WHICH HAVE NOW BEEN REDRAWN WITHOUT CHANGES ON EXHIBIT B, FIG. B2.4-1, HAVE BEEN UTILIZED TO ESTABLISH THE MAXIMUM WATER SURFACE ELEVATION AT THE PROJECT BOUNDARY ALONG THE SHORELINE AS SHOWN ON THESE MAPS USING EL. 2041.0 AT THE CUSICK GAGE AS REFERENCE ELEVATION FOR MAXIMUM WATER SURFACE CONDITIONS.

400 0 400 800 1200
SCALE: 1" = 400'

EXHIBIT G-12 SHEET 12

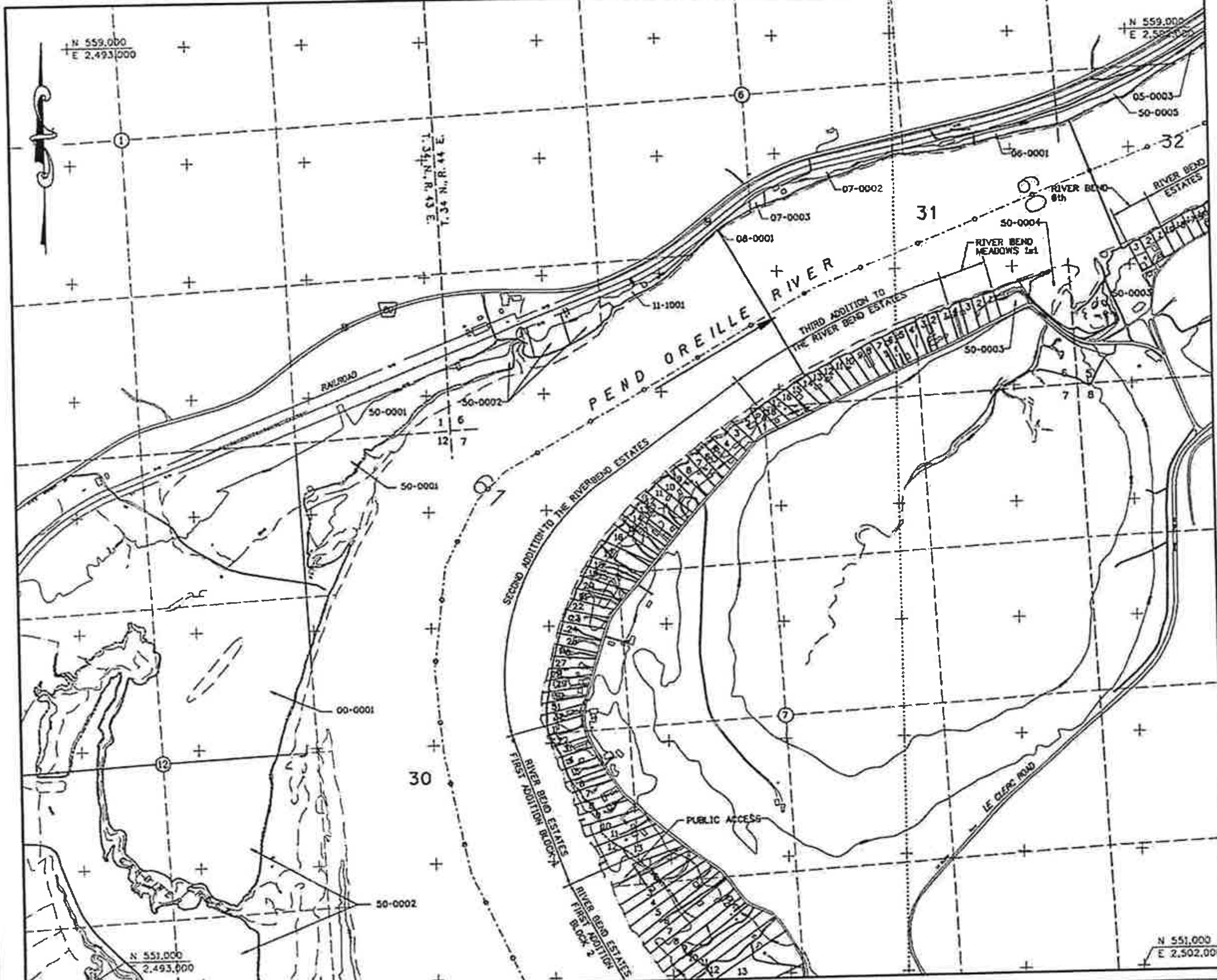
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

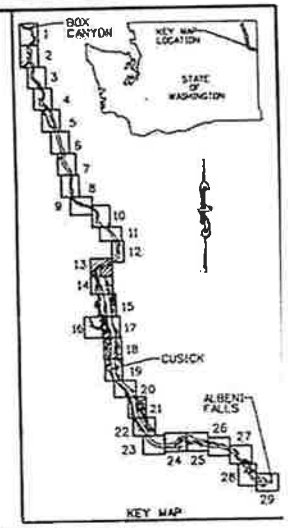
BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 NOVEMBER 2002

FERC DRAWING NO. 2042-





LEGEND:

PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:

1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

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400 0 400 800 1200

SCALE: 1" = 400'

EXHIBIT G-13 SHEET 13

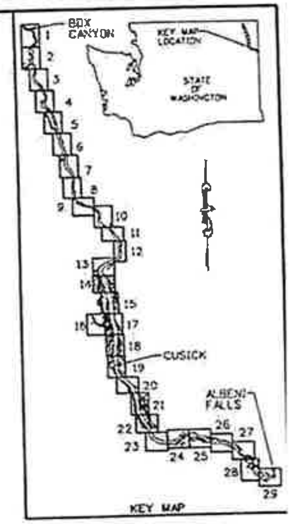
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 NOVEMBER 2002

FERC DRAWING NO. 2042-



LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

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400 0 400 800 1200
SCALE: 1" = 400'

EXHIBIT G-14 SHEET 14

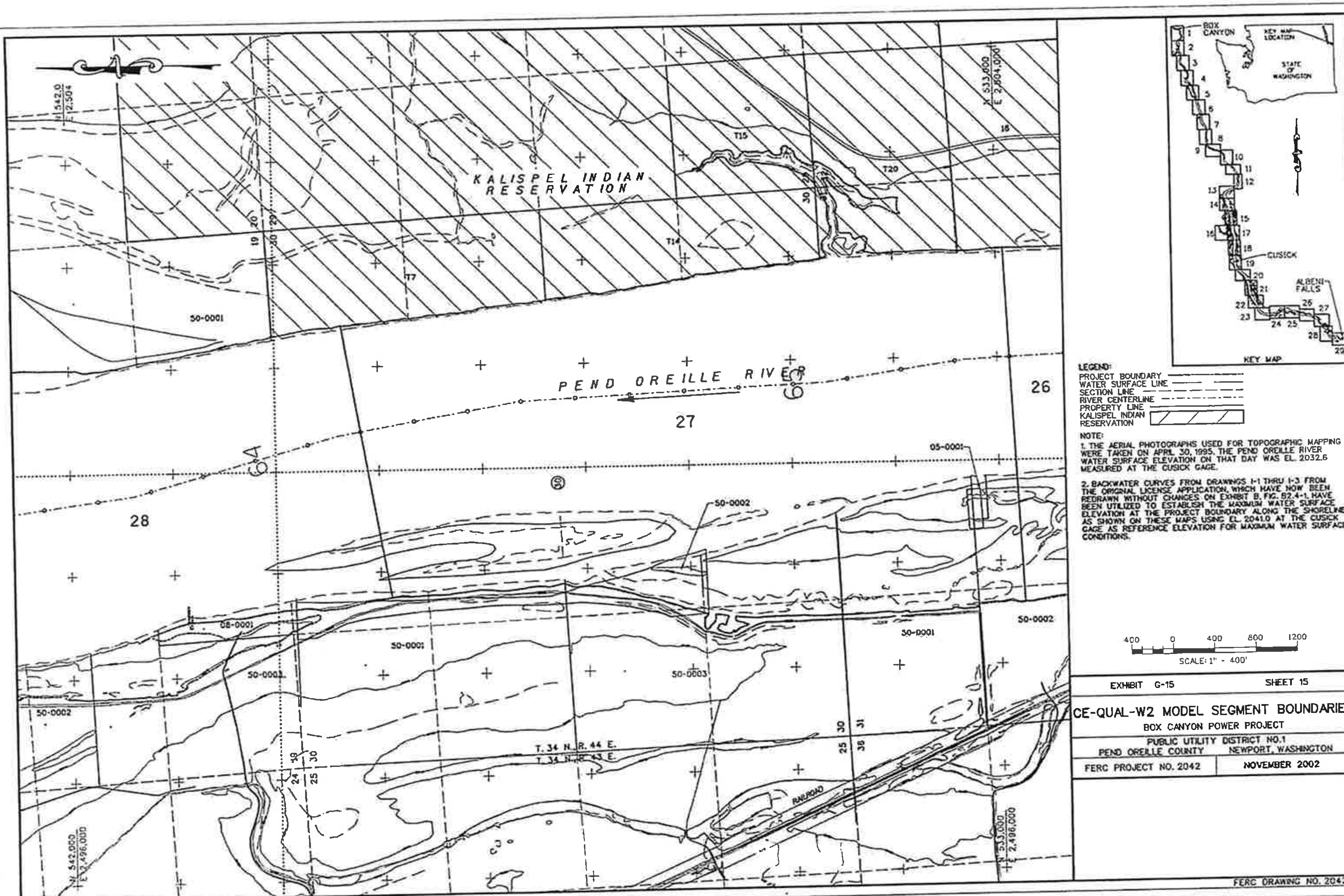
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 NOVEMBER 2002

FERC DRAWING NO. 2042-



LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE
KALISPEL INDIAN RESERVATION

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

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400 0 400 800 1200
SCALE: 1" - 400'

EXHIBIT G-15 SHEET 15

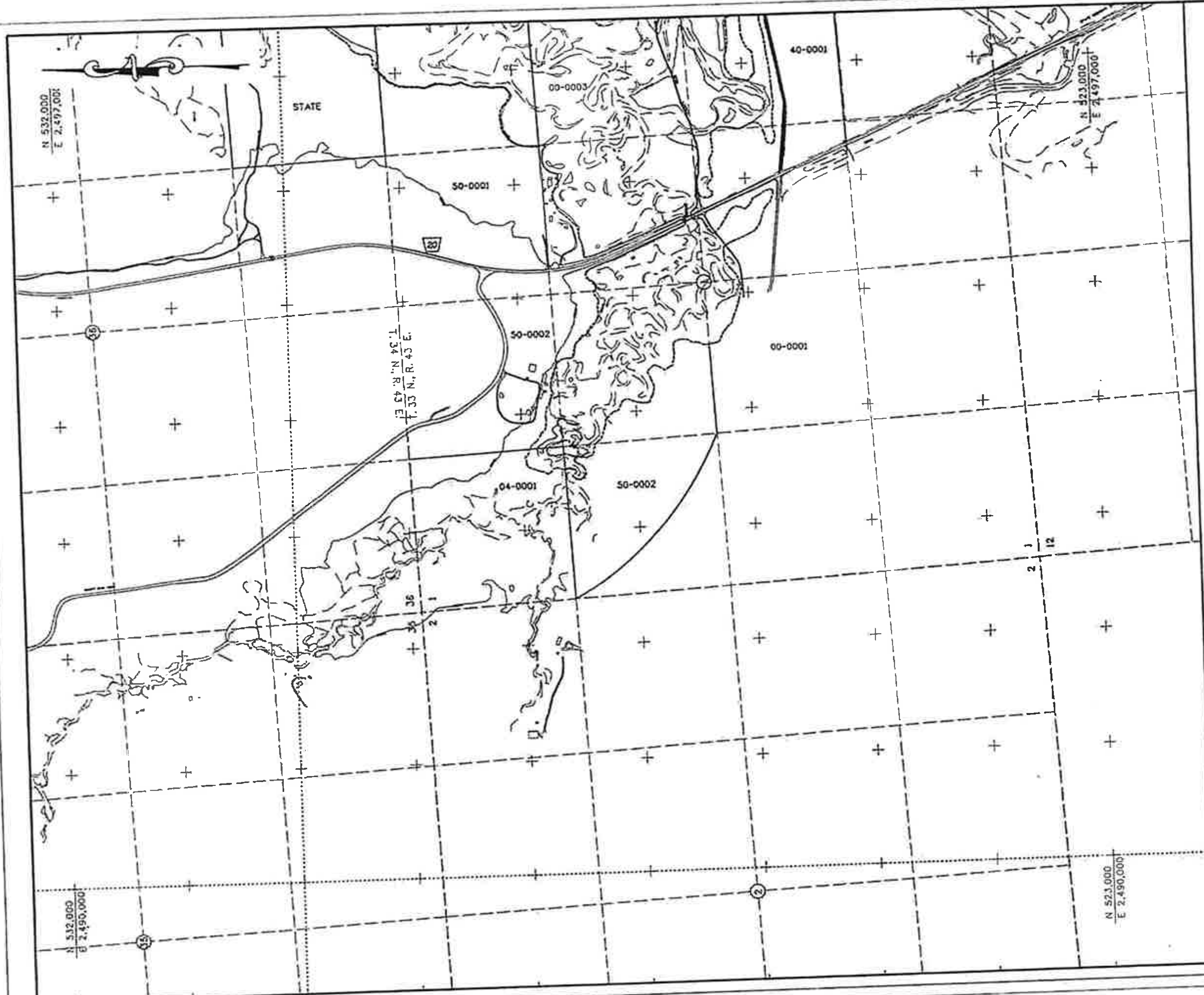
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

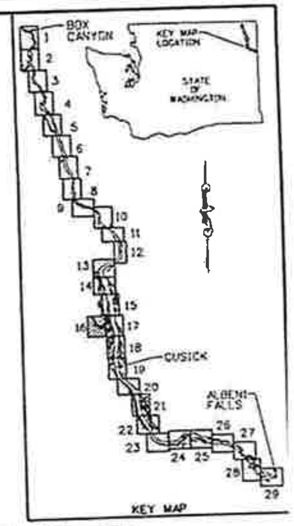
BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 NOVEMBER 2002

FERC DRAWING NO. 2042-





LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

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400 0 400 800 1200
SCALE: 1" = 400'

EXHIBIT G-16 SHEET 16

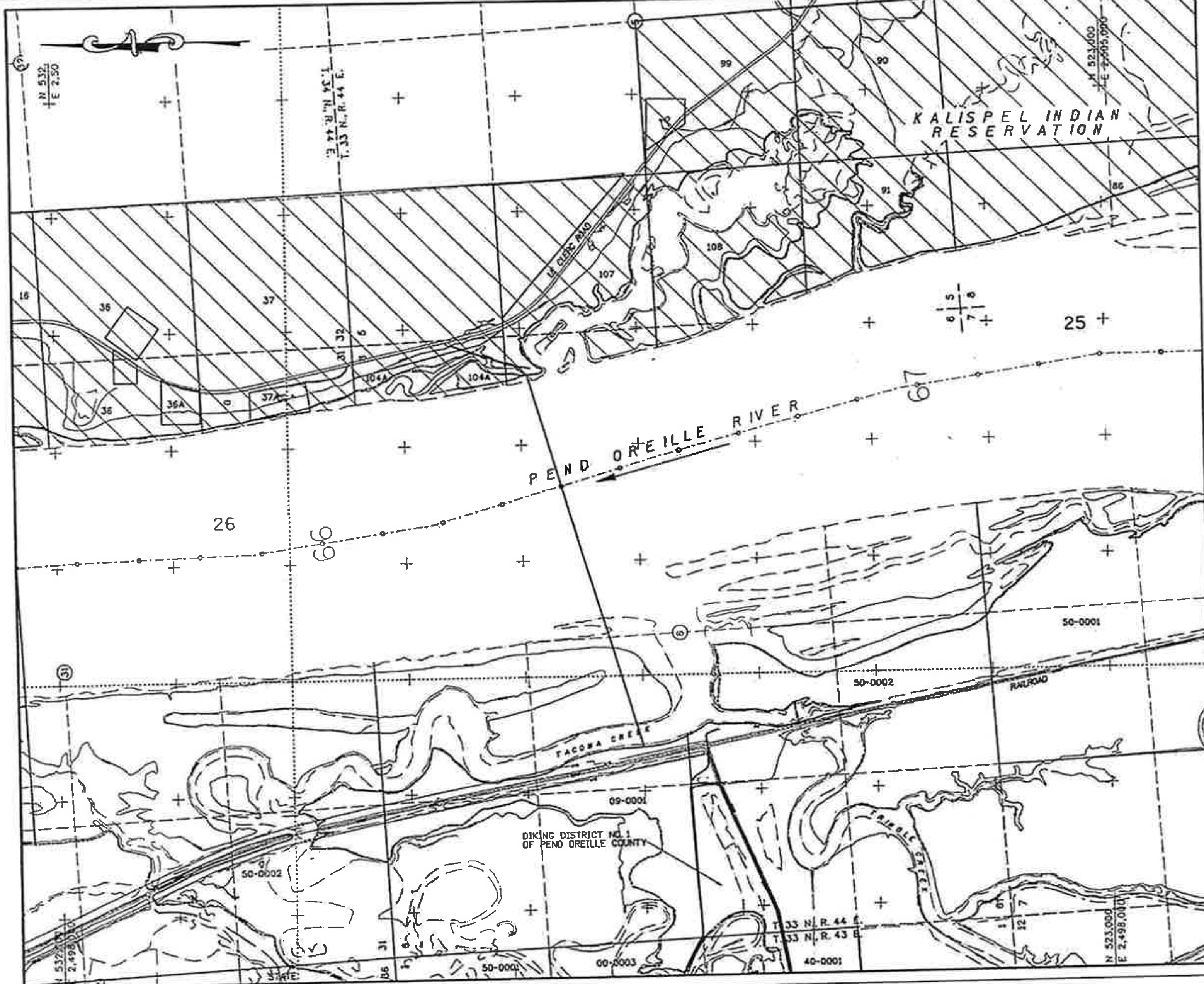
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

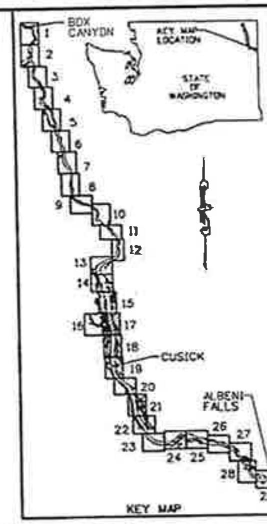
BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 NOVEMBER 2002

FERC DRAWING NO. 2042-





LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE
KALISPEL INDIAN RESERVATION

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

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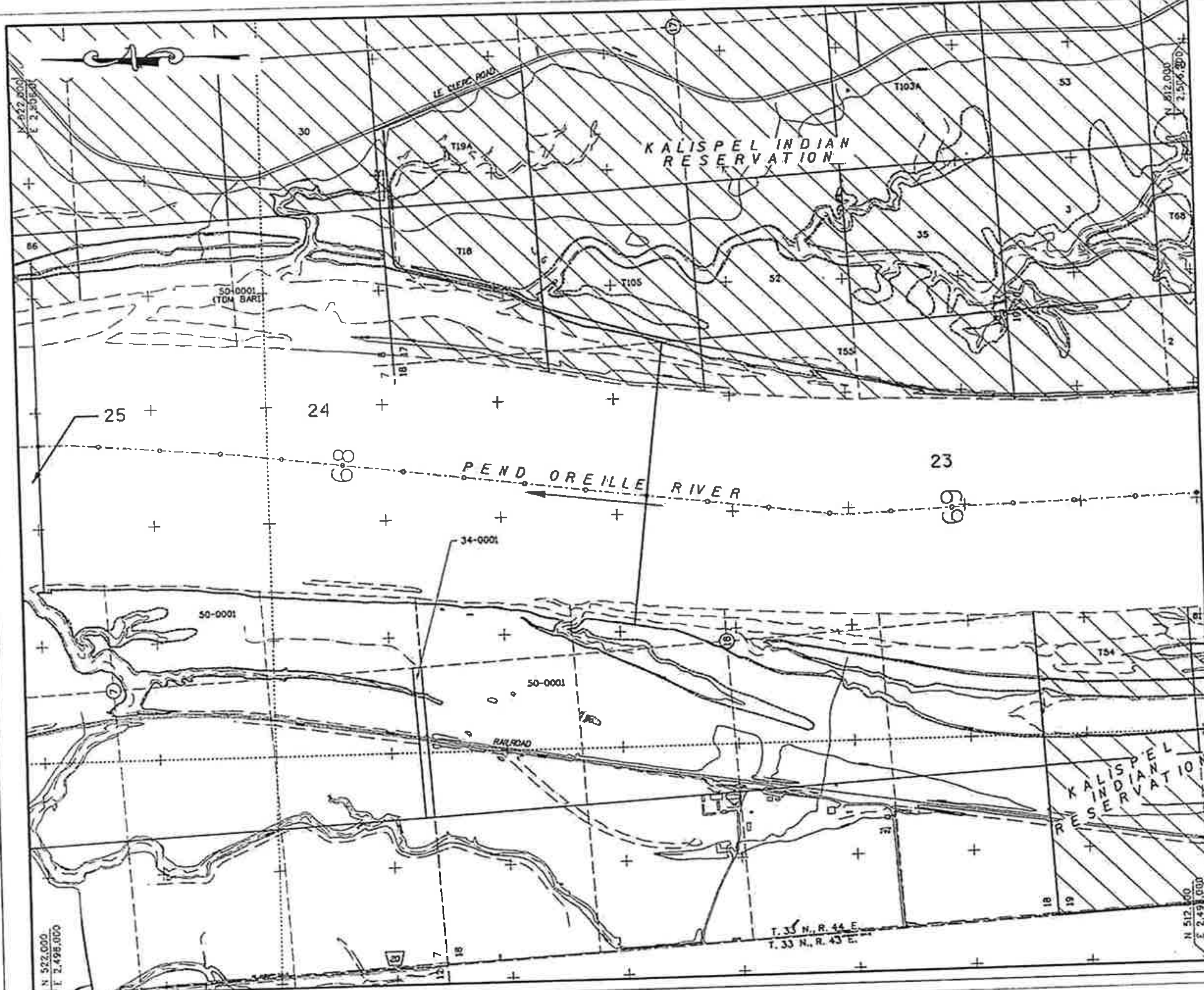
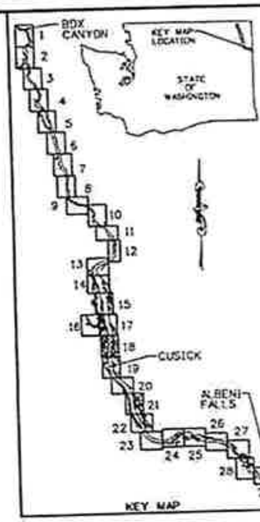
400 0 400 800 1200
SCALE: 1" - 400'

EXHIBIT G-17	SHEET 17
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES BOX CANYON POWER PROJECT	
PUBLIC UTILITY DISTRICT NO.1 PEND OREILLE COUNTY NEWPORT, WASHINGTON	
FERC PROJECT NO. 2042	NOVEMBER 2002

FERC DRAWING NO. 2042-





LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE
KALISPEL INDIAN RESERVATION

NOTE:

1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

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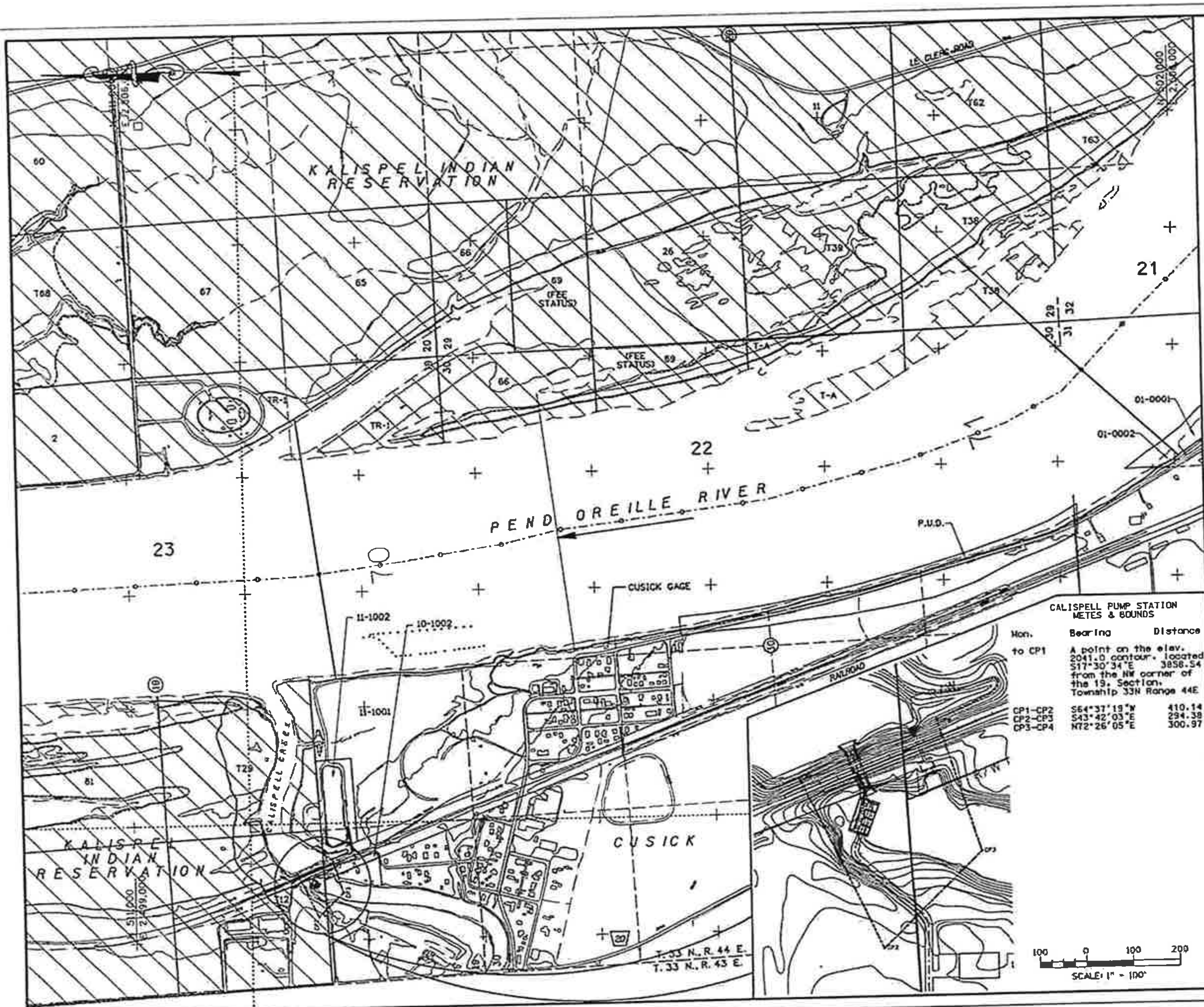
400 0 400 800 1200
SCALE: 1" = 400'

EXHIBIT G-18 SHEET 18

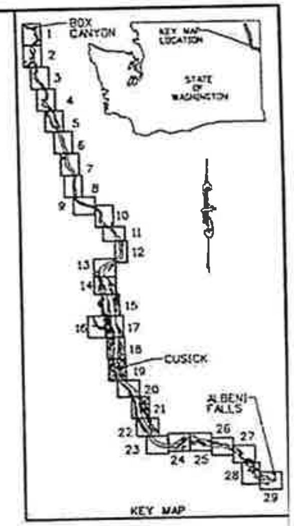
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES
BOX CANYON POWER PROJECT
PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY NEWPORT, WASHINGTON
FERC PROJECT NO. 2042 NOVEMBER 2002

FERC DRAWING NO. 2042-



CALISPELL PUMP STATION METES & BOUNDS

Mon.	Bearing	Distance
to CP1	A point on the elev. 2041.0 contour, located S17°30'34"E from the NW corner of the 19, Section, Township 33N Range 44E	3858.54
CP1-CP2	S64°37'19"W	410.14
CP2-CP3	S43°42'03"E	294.38
CP3-CP4	N72°26'05"E	300.97



LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE
KALISPEL INDIAN RESERVATION

NOTE:

1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

2. BACKWATER CURVES FROM DRAWINGS 1-1 THRU 1-3 FROM THE ORIGINAL LICENSE APPLICATION, WHICH HAVE NOW BEEN REDRAWN WITHOUT CHANGES ON EXHIBIT B, FIG. B2.4-1, HAVE BEEN UTILIZED TO ESTABLISH THE MAXIMUM WATER SURFACE ELEVATION AT THE PROJECT BOUNDARY ALONG THE SHORELINE AS SHOWN ON THESE MAPS USING EL. 2041.0 AT THE CUSICK GAGE AS REFERENCE ELEVATION FOR MAXIMUM WATER SURFACE CONDITIONS.

400 0 400 800 1200
SCALE: 1" = 400'

EXHIBIT G-19 | SHEET 19

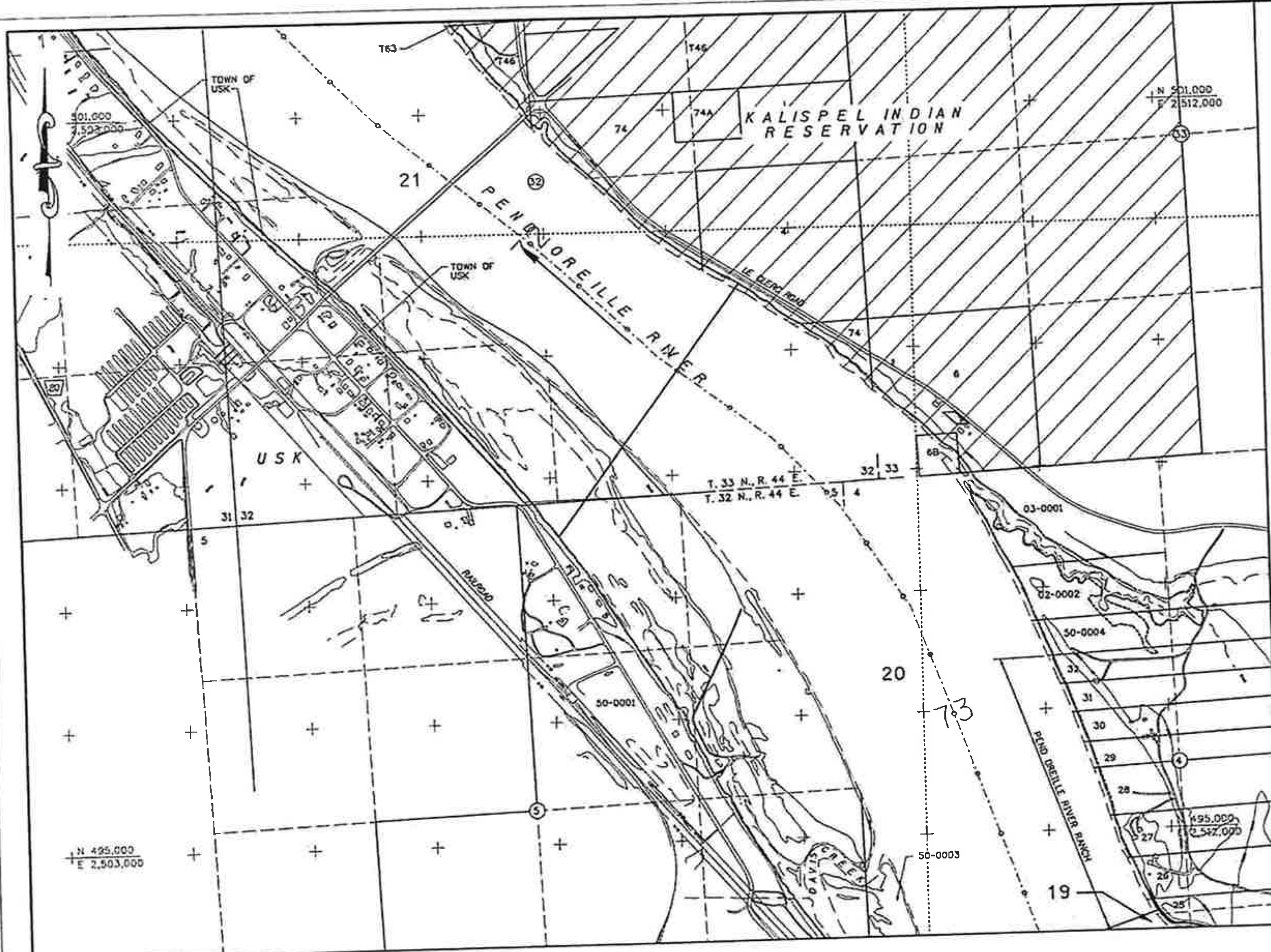
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

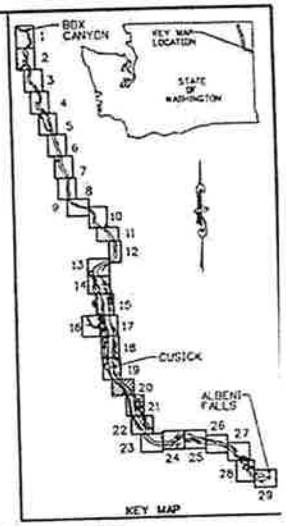
BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY | NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 | NOVEMBER 2002

FERC DRAWING NO. 2042-3





LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE
KALISPEL INDIAN RESERVATION

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

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400 0 400 800 1200
SCALE: 1" = 400'

EXHIBIT G-20 SHEET 20

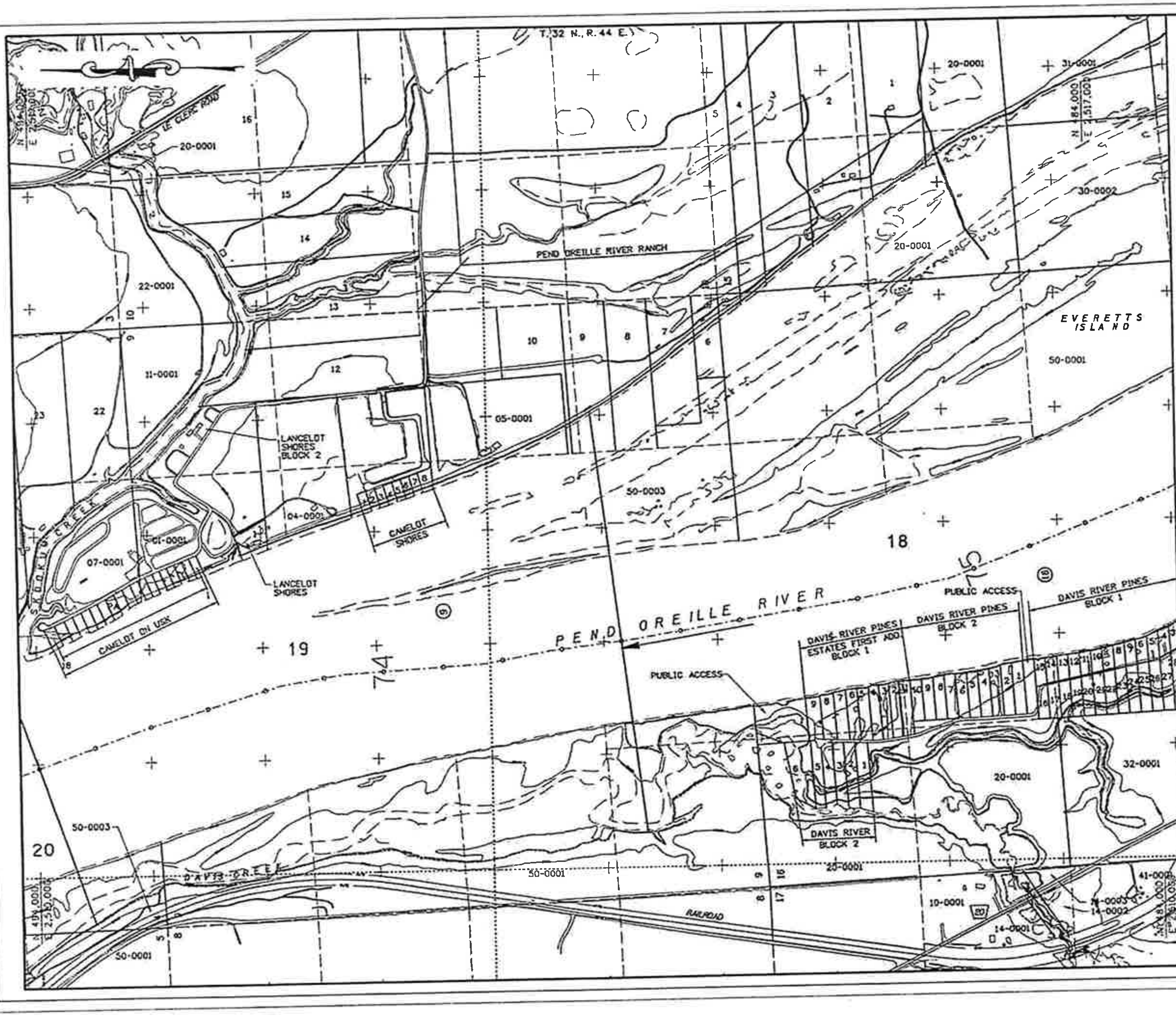
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

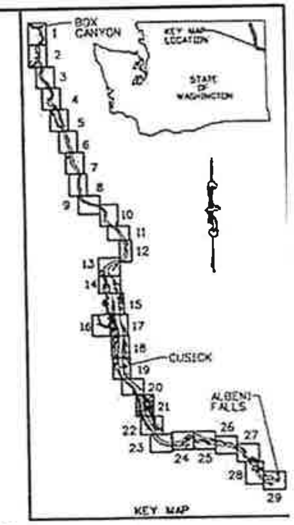
BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 NOVEMBER 2002

FERC DRAWING NO. 2042-





LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:

1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

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400 0 400 800 1200
SCALE: 1" = 400'

EXHIBIT G-21 SHEET 21

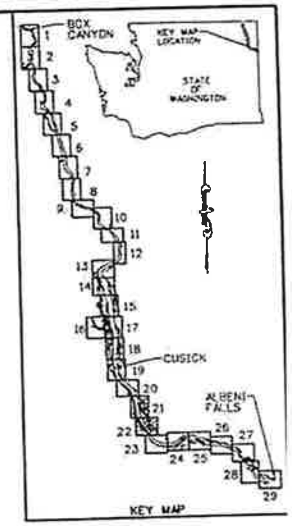
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 NOVEMBER 2002

FERC DRAWING NO. 2042-



LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

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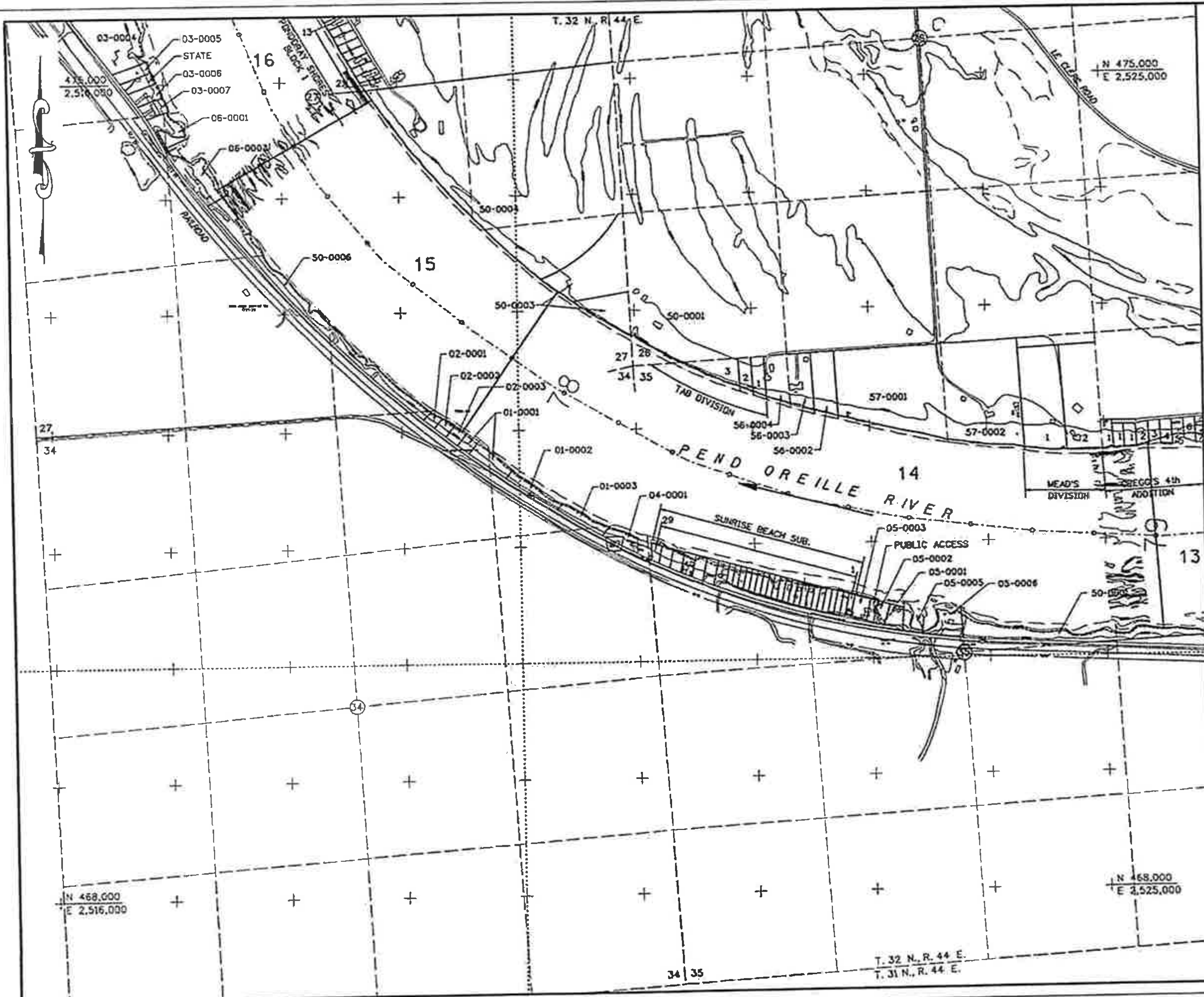
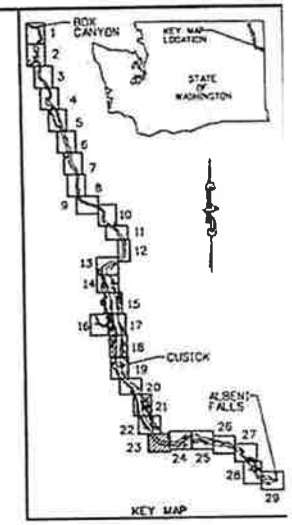
400 0 400 800 1200
SCALE: 1" - 400'

EXHIBIT G-22	SHEET 22
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES	
BOX CANYON POWER PROJECT	
PUBLIC UTILITY DISTRICT NO.1	
PEND OREILLE COUNTY	NEWPORT, WASHINGTON
FERC PROJECT NO. 2042	NOVEMBER 2002

FERC DRAWING NO. 2042-





LEGEND:
- PROJECT BOUNDARY
- WATER SURFACE LINE
- SECTION LINE
- RIVER CENTERLINE
- PROPERTY LINE

NOTE:

1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

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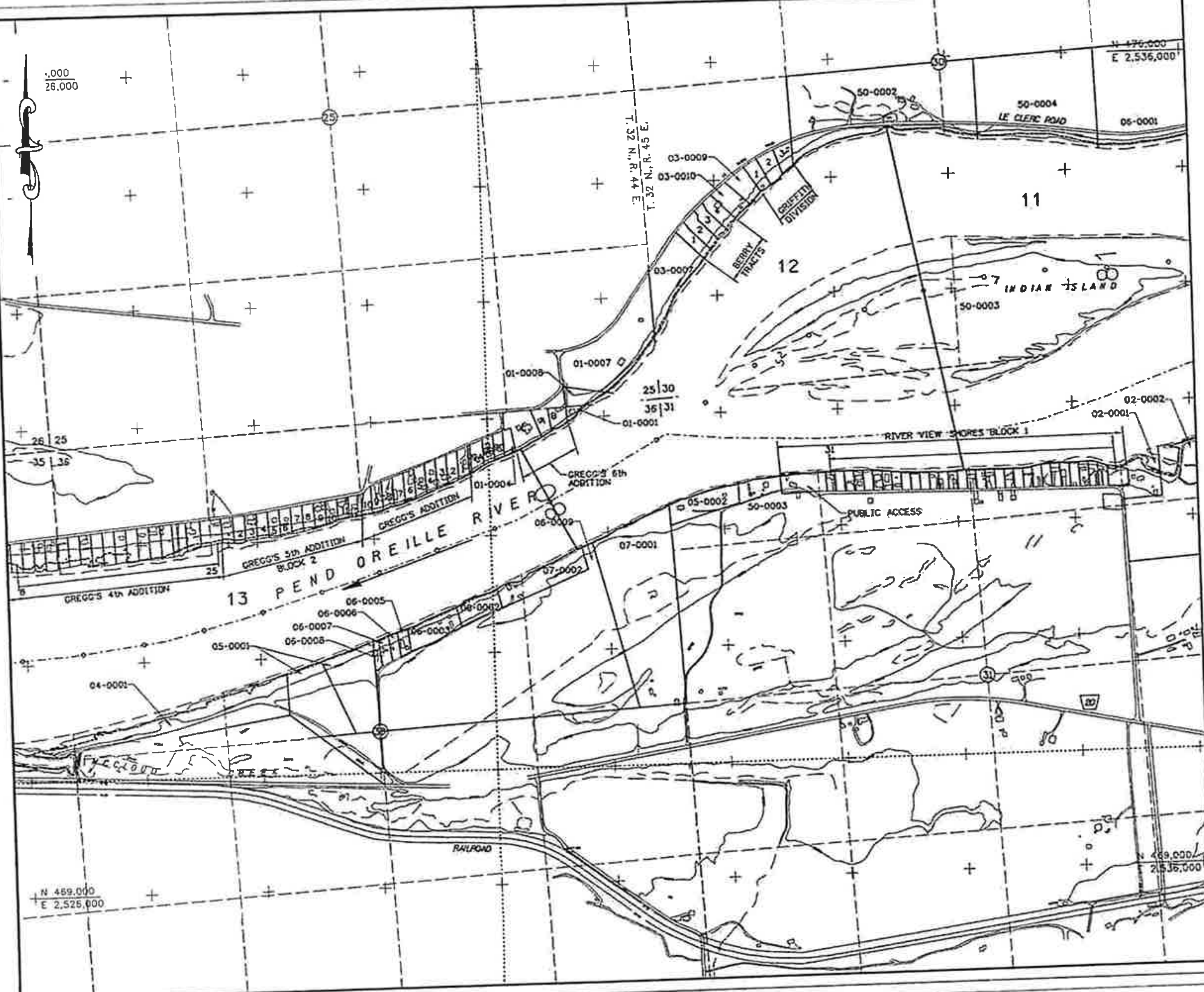
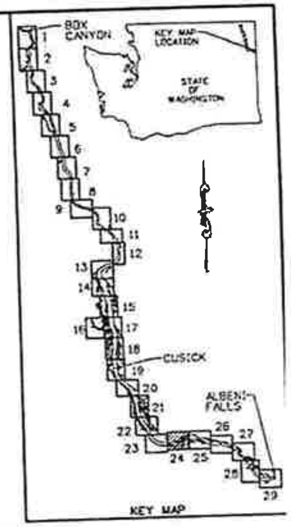
400 0 400 800 1200

SCALE: 1" = 400'

EXHIBIT G-23	SHEET 23
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES BOX CANYON POWER PROJECT	
PUBLIC UTILITY DISTRICT NO.1 PEND OREILLE COUNTY	NEWPORT, WASHINGTON
FERC PROJECT NO. 2042	NOVEMBER 2002

FERC DRAWING NO. 2042-





LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

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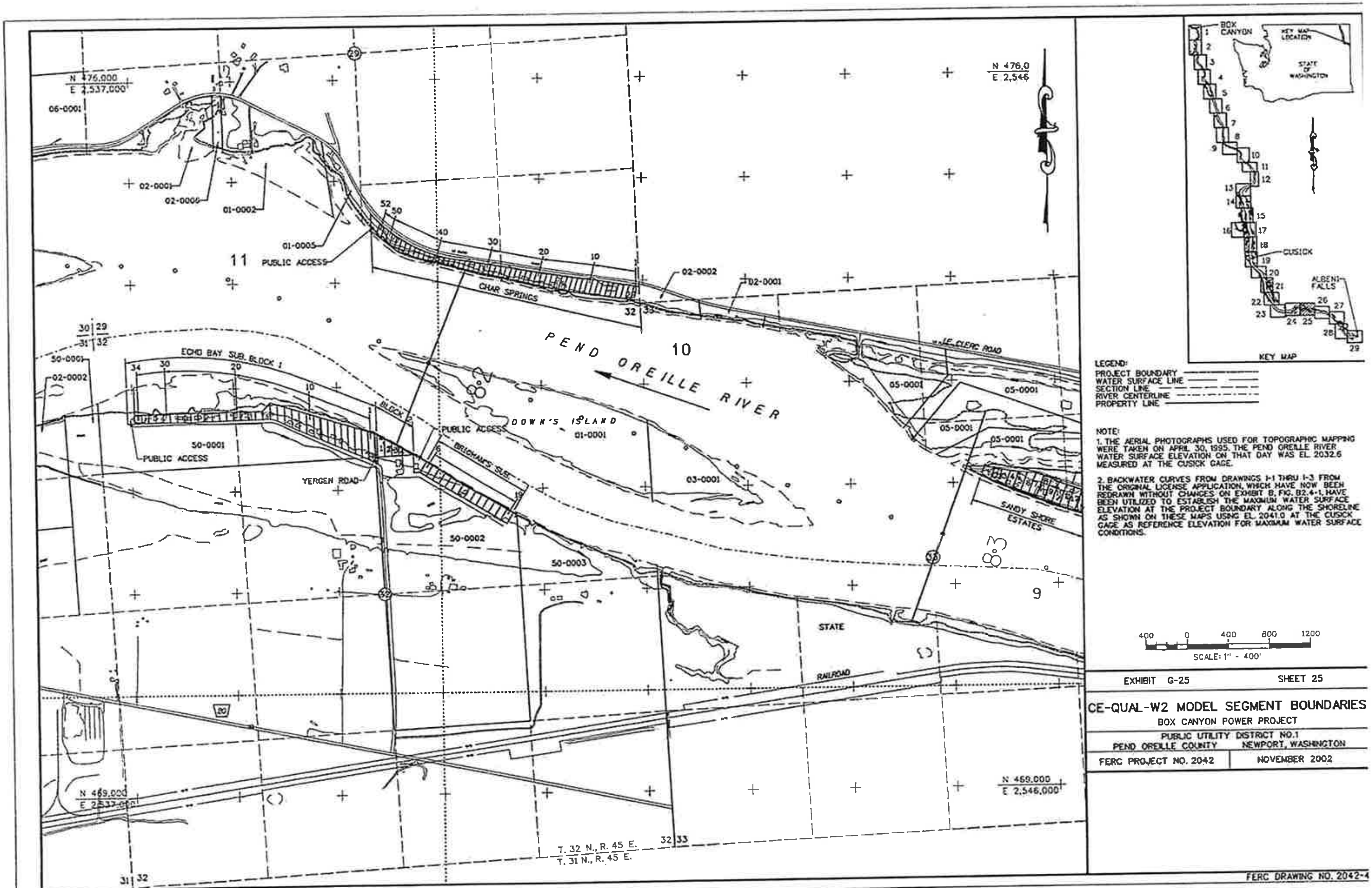
400 0 400 800 1200

SCALE: 1" = 400'

EXHIBIT G-24	SHEET 24
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES BOX CANYON POWER PROJECT	
PUBLIC UTILITY DISTRICT NO.1 PEND OREILLE COUNTY NEWPORT, WASHINGTON	
FERC PROJECT NO. 2042	NOVEMBER 2002

FERC DRAWING NO. 2042-


PEND OREILLE RIVER
10
11
9
DOWN'S ISLAND
CHAR SPRINGS
ECHO BAY SUB. BLOCK 1
BRIGHAM'S SUB.
SANDY SHORE ESTATES
PUBLIC ACCESS
YERGEN ROAD
LE CLERC ROAD
STATE
RAILROAD
N 476,000
E 2,537,000
N 476,0
E 2,546
N 469,000
E 2,537,000
N 469,000
E 2,546,000
T. 32 N., R. 45 E.
T. 31 N., R. 45 E.
06-0001
02-0001
02-0006
01-0002
01-0005
02-0002
01-0001
03-0001
05-0001
50-0001
50-0002
50-0003
KEY MAP
BOX CANYON
CUSICK
ALBENI FALLS
KEY MAP LOCATION
STATE OF WASHINGTON
LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE
NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.
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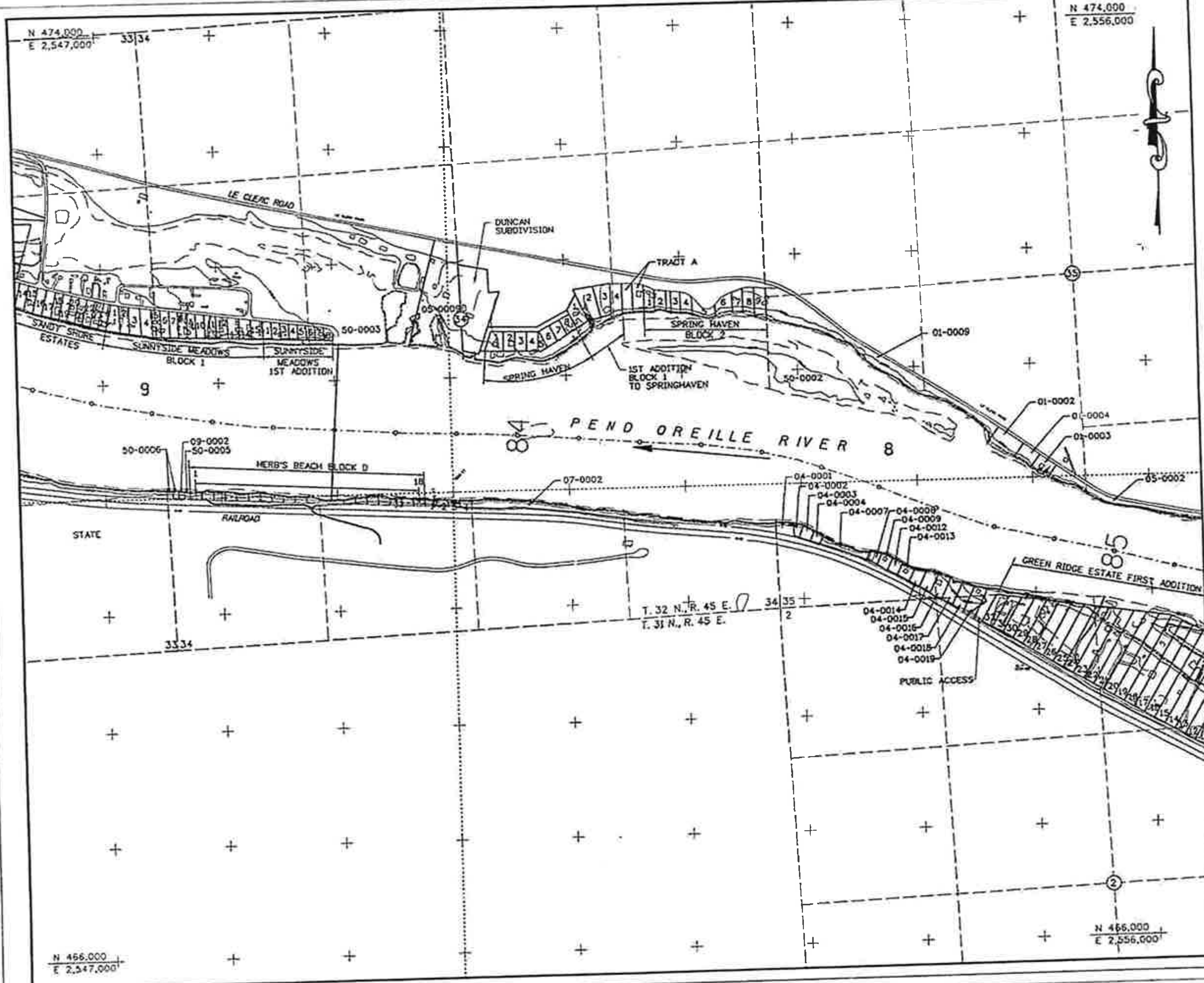
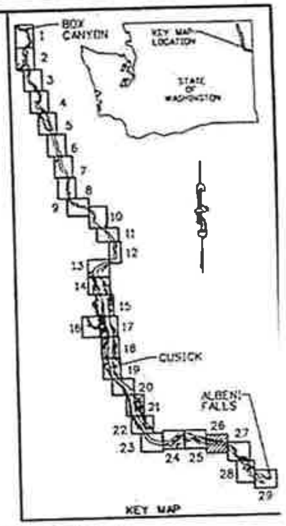
400 0 400 800 1200
SCALE: 1" - 400'
EXHIBIT G-25
SHEET 25
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES
BOX CANYON POWER PROJECT
PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY
NEWPORT, WASHINGTON
FERC PROJECT NO. 2042
NOVEMBER 2002
FERC DRAWING NO. 2042-4





LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:

1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

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400 0 400 800 1200

SCALE: 1" = 400'

EXHIBIT G-26	SHEET 26

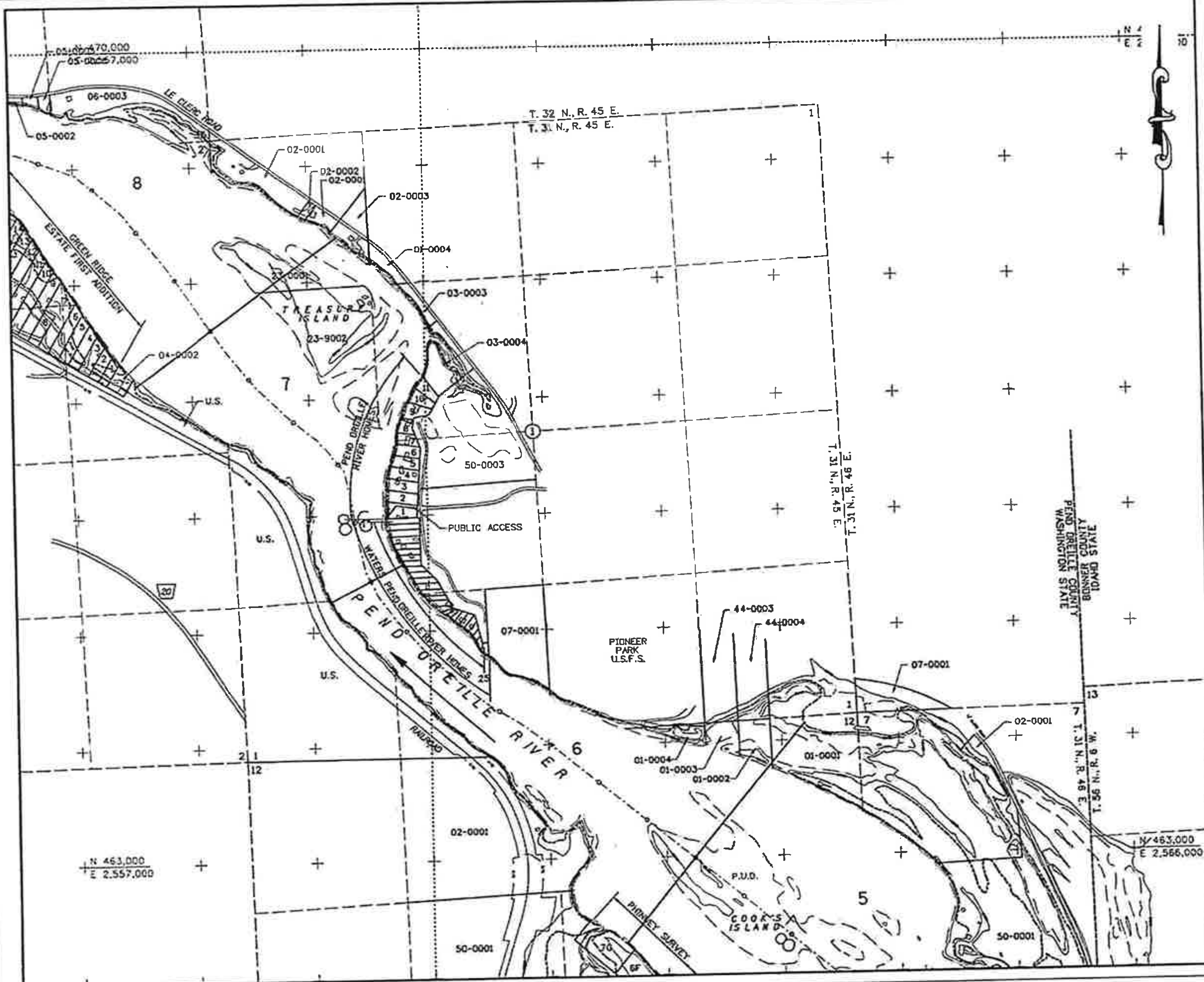
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

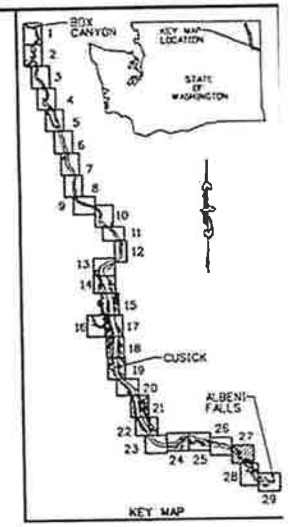
BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1

PEND OREILLE COUNTY	NEWPORT, WASHINGTON
FERC PROJECT NO. 2042	NOVEMBER 2002

FERC DRAWING NO. 2042-





LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE
STATE LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL 2032.6 MEASURED AT THE CUSICK GAGE.

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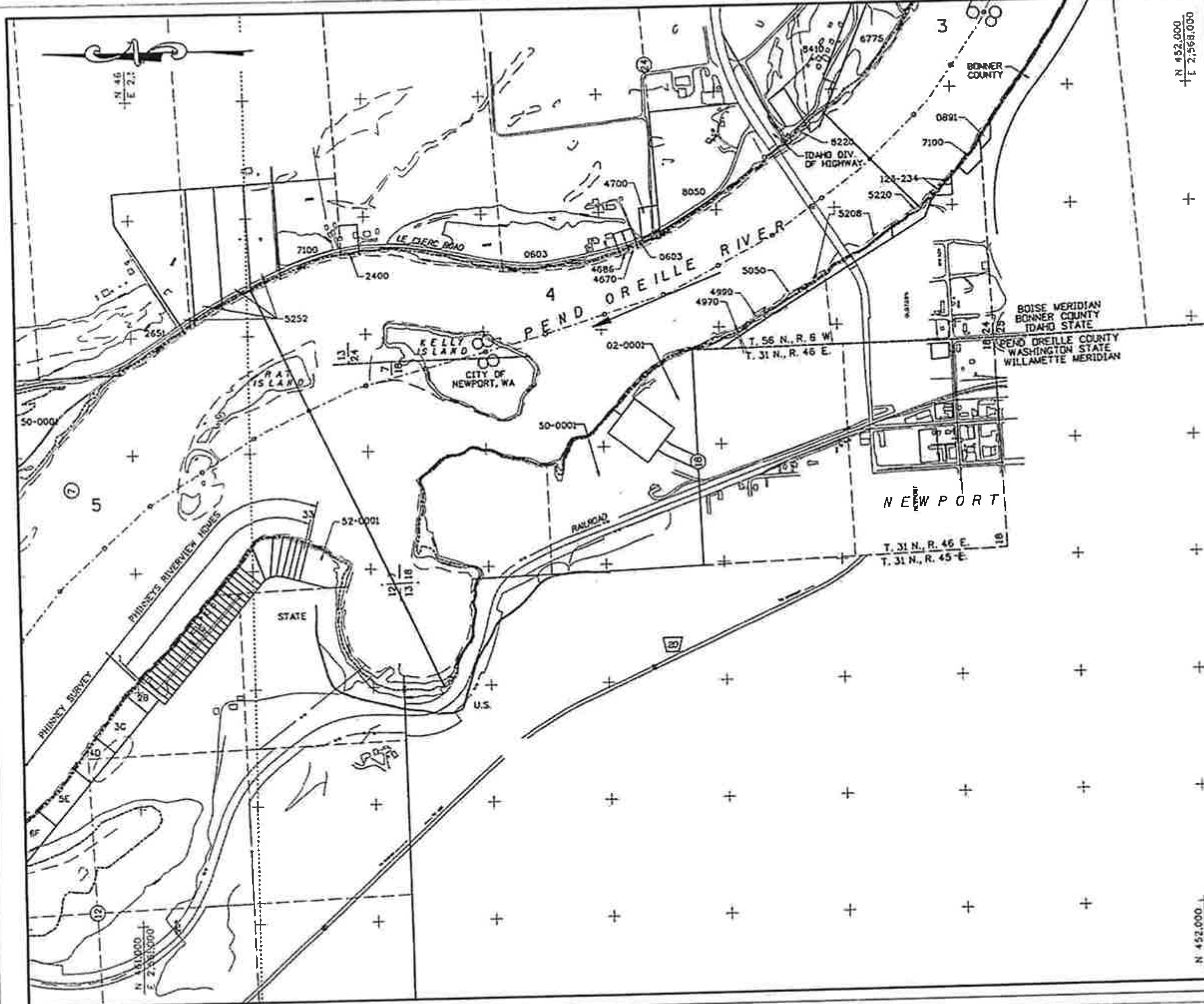
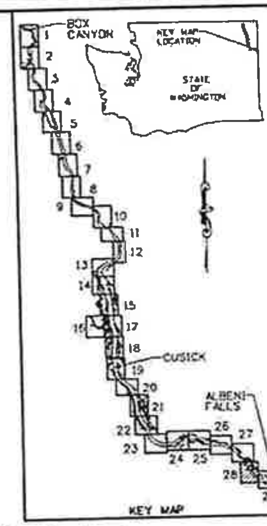
400 0 400 800 1200
SCALE: 1" - 400'

EXHIBIT G-27	SHEET 27
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES BOX CANYON POWER PROJECT	
PUBLIC UTILITY DISTRICT NO.1 PEND OREILLE COUNTY NEWPORT, WASHINGTON	
FERC PROJECT NO. 2042	NOVEMBER 2002

FERC DRAWING NO. 2042-





LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE
STATE LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

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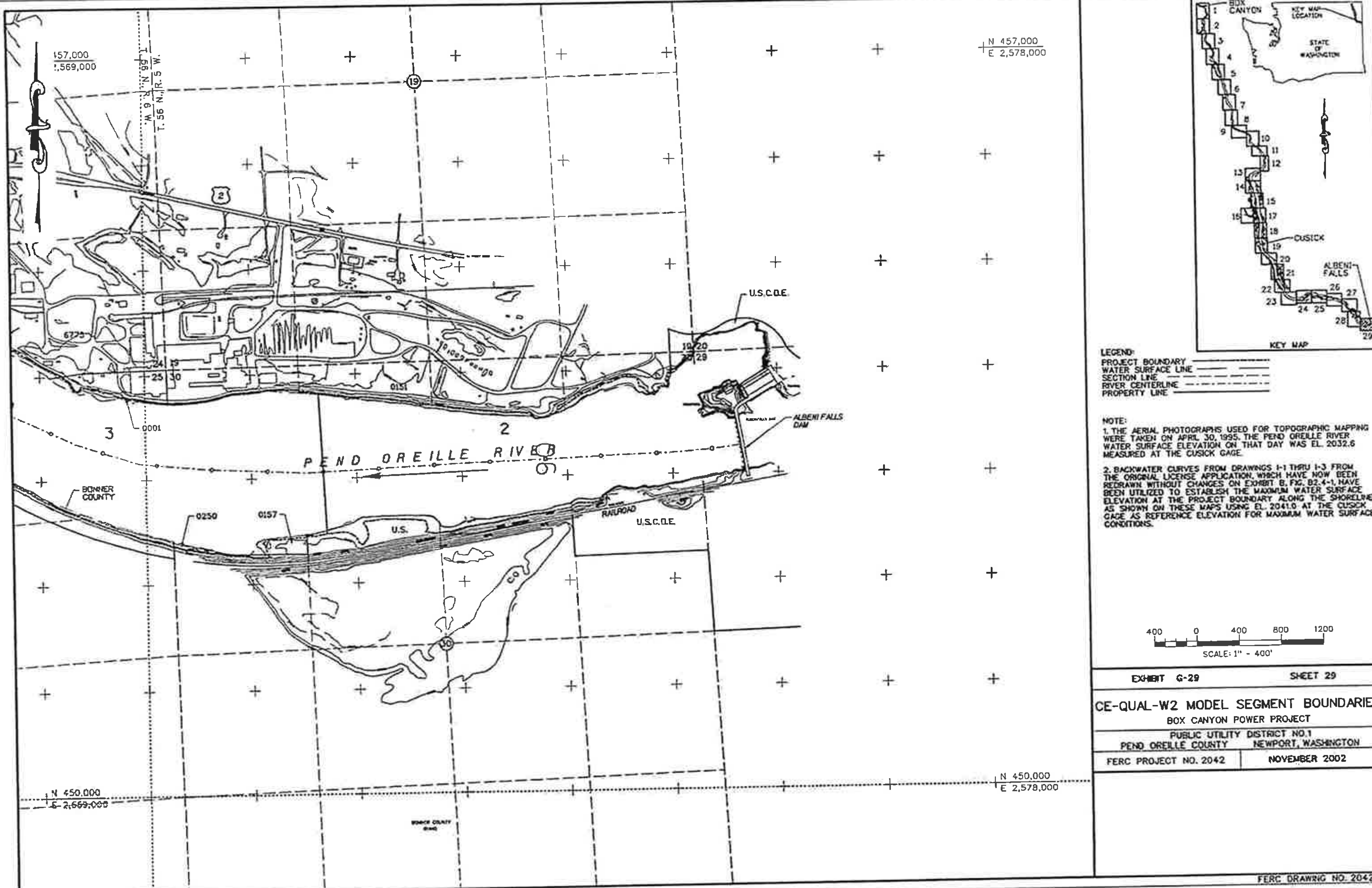
400 0 400 800 1200
SCALE: 1" = 400'

EXHIBIT G-28	SHEET 28
CE-QUAL-W2 MODEL SEGMENT BOUNDARIES BOX CANYON POWER PROJECT	
PUBLIC UTILITY DISTRICT NO.1 PEND OREILLE COUNTY	NEWPORT, WASHINGTON
FERC PROJECT NO. 2042	NOVEMBER 2002

FERC DRAWING NO. 2042-4



LEGEND:
PROJECT BOUNDARY
WATER SURFACE LINE
SECTION LINE
RIVER CENTERLINE
PROPERTY LINE

NOTE:
1. THE AERIAL PHOTOGRAPHS USED FOR TOPOGRAPHIC MAPPING WERE TAKEN ON APRIL 30, 1995. THE PEND OREILLE RIVER WATER SURFACE ELEVATION ON THAT DAY WAS EL. 2032.6 MEASURED AT THE CUSICK GAGE.

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400 0 400 800 1200
SCALE: 1" - 400'

EXHIBIT G-29 SHEET 29

CE-QUAL-W2 MODEL SEGMENT BOUNDARIES

BOX CANYON POWER PROJECT

PUBLIC UTILITY DISTRICT NO.1
PEND OREILLE COUNTY NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 NOVEMBER 2002

FERC DRAWING NO. 2042-4