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Temperature Modeling of Lost Creek Lake Using CE-QUAL-W2

A Report on the Development, Calibration, Verification, and Application of the Model

Tammy L. Threadgill, Daniel F. Turner, Laurie A. Nicholas,
Barry W. Bunch, Dorothy H. Tillman, and David L. Smith

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Under Project 329825, "Temperature Modeling of Lost Creek Lake Using CE-QUAL-W2"

Abstract

The Engineer Research and Development Center (ERDC) Environmental Laboratory (EL) assisted the U.S. Army Corps of Engineers (USACE), Portland District (CENWP) in updating a CE-QUAL-W2 (W2) model of Lost Creek Lake based on a previous version of W2. The model was calibrated using data from calendar year (CY) 2001 validated with data from calendar years 2003 and 2010. One set of W2 parameters were successfully applied to all calendar year types (2001 is a dry year; 2003 is a normal year; and 2010 is a wet year). This model and the corresponding study results provided CENWP with more refined estimates of water temperatures so that more defensible water temperature targets can be discussed with the state of Oregon. This is extremely important because the Rogue and Applegate temperature Total Maximum Daily Loads and Rogue Spring Chinook Conservation Plan require USACE to review the Rogue Basin Project operations to determine whether improvements to downstream temperature can be achieved for the benefit of endangered fish. In addition to modeling the basic calibration for three years, a modified version of W2 was used to create a predictive model to determine the best blending of the intake ports to meet the temperature targets.

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Preface

This study was conducted for the U.S. Army Corps of Engineers (CENWP), Portland, Oregon, under Project Number 329825, “Temperature Modeling of Lost Creek Lake Using CE-QUAL-W2.”

The work was performed by the Water Quality and Contaminant Modeling Branch (WQCMB), Environmental Processes and Engineering Division (EP), U.S. Army Engineer Research and Development Center (ERDC), Environmental Laboratory (EL). At the time of publication, Dr. Dorothy Tillman was Chief, WQCMB; Warren P. Lorentz was Chief, EP. Dr. Al Cofrancesco, CEERD-EZT, was the Senior Science and Technology Manager. The Deputy Director of ERDC-EL was Dr. Jack E. Davis and the Director was Dr. Beth Fleming.

COL Bryan S. Green was Commander of ERDC; Dr. David W. Pittman was the ERDC Executive Director.

Unit Conversion Factors

Multiply	By	To Obtain
acre-feet	1,233.5	cubic meters
cubic feet	0.02831685	cubic meters
degrees Fahrenheit	$(F-32)/1.8$	degrees Celsius
feet	0.3048	meters
gallons (U.S. liquid)	3.785412 E-03	cubic meters
square miles	2.589998 E+06	square meters
Langley per day	0.48	watts per square meter

Acronyms and Units

14WS	14 th Weather Squadron
AM	Applegate Lake Model
BOD	Biochemical Oxygen Demand
CENWP	U.S. Army Corps of Engineers, Portland District
CY	Calendar year (January 1 through December 31)
DO	Dissolved oxygen
ELWS	Water surface elevation
ERDC	Engineer Research and Development Center
ISS	Inorganic suspended solids
LCL	Lost Creek Lake
LCLM	Lost Creek Lake Model
NH ₄	Ammonium
NO ₃	Nitrate
OM	Organic matter
RO	Regulating Outlet
STR ₁	Represents the fixed invert intake with centerline elevation of 1852.5 ft
STR ₂	Represents the fixed invert intake with centerline elevation of 1797.5 ft
STR ₃	Represents the fixed invert intake with centerline elevation of 1737.5 ft
STR ₄	Represents the fixed invert intake with centerline elevation of 1647.5 ft
STR ₅	Represents the turbidity conduit intake with centerline elevation of 1602.5 ft

TDS	Total dissolved solids
TMDL	Total Maximum Daily Loads
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
W2	CE-QUAL-W2 model

1 Introduction

1.1 Objectives

The goal of this project is to develop and calibrate current W2 models for Lost Creek Lake and Applegate Lake so these models can be used to fully evaluate the effects of operational changes on release temperatures at William L. Jess Dam on the Rogue River.

1.2 Background

The Rogue and Applegate temperature Total Maximum Daily Loads (TMDL) and Rogue Spring Chinook Conservation Plan require the USACE to review Rogue Basin Project temperature operations to determine whether improvements to downstream temperature can be achieved for the benefit of fish (ODEQ 2008)(ODFW 2007)(USACE and ODEQ 2009). Oregon Department of Fish and Wildlife (ODFW) will probably also request that the USACE review project temperature operations in connection with the Rogue Fall Chinook Conservation Plan, which was adopted in January 2013 (ODFW 2013).

In the TMDL, the state of Oregon stated that the Corps could evaluate the prescribed temperature targets. This modeling effort refines the estimates of water temperatures at the site of USACE dams in the Rogue Basin and provides more defensible water temperature targets for discussion with the state of Oregon.

Lost Creek Lake is located twenty eight miles northeast of Medford, Oregon on the Rogue River in Jackson, County, Oregon approximately 157.2 miles upstream of its mouth. The William L. Jess Dam was constructed with earth and rock fill and is about 3,600 ft long and about 345 ft high. The primary authorized purposes of the dam are flood damage reduction, fisheries enhancement, irrigation, and municipal and industrial water supply; hydropower, water quality, and recreation are secondary authorized purposes. At maximum pool, Lost Creek Lake is 10 miles long, 3,430 acres, and stores approximately 465,000 acre-ft of water (USACE 1991). Figure 1 is a Google Earth screenshot of the project study area.

Figure 1. Google Earth image of the Lost Creek Reservoir project study area.



1.3 Approach

In order to determine whether the Corps can meet TMDL requirements through operational changes, it was necessary to develop water temperature models of each reservoir. To date, the Corps has in place CE-QUAL-W2 (W2) temperature models for both Lost Creek and Applegate projects. Both projects also have selective withdrawal structures, which allow the projects to release water from fixed elevations in the reservoirs. Both models were run using previous versions of W2 and were calibrated to earlier datasets (90s and prior).

2 Model Selection and Development

W2 is the code selected to develop the Lost Creek Lake Model (LCLM). W2 is a 2D longitudinal-vertical hydrodynamics and water quality model. It is capable of modeling basic eutrophication processes and is best suited for long, narrow waterbodies that do not exhibit substantial lateral variation. W2 has been applied to hundreds of studies on various types of waterbodies (rivers, reservoirs, lakes, and estuaries) all over the world. For a list of the model applications, see the W2 website: <http://www.ce.pdx.edu/w2/>.

2.1 CE-QUAL-W2 description

The numerical modeling code known as W2, version 3.7 (Cole and Wells 2011), was configured for application to Lost Creek Lake. W2 uses a finite difference solution of the laterally averaged equations of fluid motion (Cole and Wells 2013). It allows for application to very complex water systems because it accommodates multiple branches and multiple waterbody types. W2 allows the user to set up variable grid spacing (longitudinally and vertically), time variable boundary conditions, numerous inflows and outflows, and time variable concentrations for each water quality constituent of interest. W2 (V3.7) contains a user-defined port selection algorithm, which allows the user to specify a varying number of elevations for dam structures. Although this feature is not utilized in the calibration, future scenarios may benefit. In addition to water temperature, W2 is capable of modeling water surface elevation, flow, and twenty-eight water quality constituents such as total dissolved solids (TDS), inorganic suspended solids (ISS), ammonium (NH_4), biochemical oxygen demand (BOD), nitrate (NO_3), phytoplankton, dissolved oxygen (DO), and organic matter (OM). This study focuses only on temperature; consequently, the other constituents will not be discussed.

2.2 Project approach

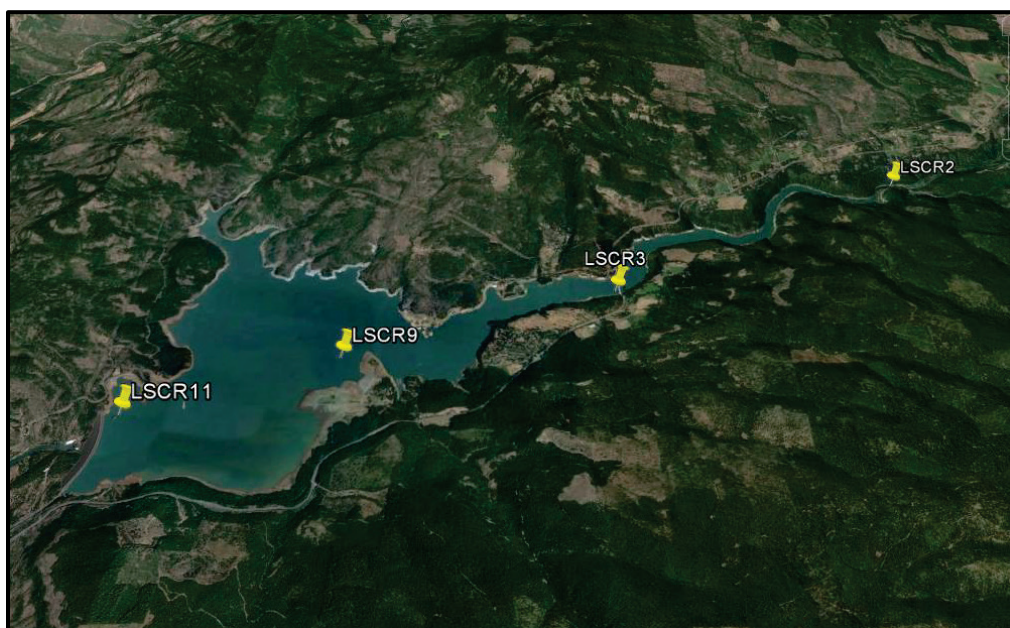
W2 is well-suited for application to Lost Creek Lake for the following reasons:

1. W2 is appropriate for modeling narrow waterbodies with spatially varying depths. Lost Creek Lake is estimated to be 1.5 miles wide at its widest part, but it varies greatly in depths along the length of the reservoir.

2. W2 is capable of modeling hydrodynamics of a reservoir quite well.
3. W2 has been applied to hundreds of systems and is well known, understood, and widely accepted.
4. W2 is capable of providing a wide variety of model output for comparison to observed data.
5. W2 can simulate various responses due to changes in loads and rates.

Three in-lake monitoring stations (LSCR3, LSCR9, and LSCR11) were used for evaluating model performance during calibration. Although temperature data was available from LSCR2, the model grid did not encompass that station (discussed later). Therefore, the LSCR2 data was not used in the calibration process. Temperature data at the dam and downstream from the dam were also used for calibration. The locations of the sites are shown in Figure 2.

Figure 2. In-lake profile monitoring stations.
Site locations provided by Kinsey Friesen (CENWP).



2.3 Calibration strategy

Several factors were used to determine which calendar years (CY) were used to calibrate and validate the model. The largest limiting factor was the availability of observed data. Since more data was available for 2001, CY01 was used to develop a calibrated model. Once an acceptable set of calibration parameters were found, the same set of model parameters were used for CY03 and CY10. Each of the years represents various water year types: 2001 was a dry year, 2003 was an average year, and 2010 was a wet year.

3 Data Analysis and Model Preparation

This section reviews data availability and their use in defining the calibration input files. W2 has several data requirements to meet before simulations can begin:

1. Bathymetry of the waterbody(ies)
2. Flow and temperature characteristics for boundaries, major tributaries, and point sources
3. Dam operations and structure locations
4. Stage data
5. Meteorological conditions: air temperature, dew point temperature, wind speed, wind direction, cloud cover, and short wave solar radiation (if available)

3.1 Model geometry

3.1.1 Bathymetry data

The bathymetry file for the LCLM was originally developed by Mike Schneider (USACE) for the original W2 model of Lost Creek Lake. Due to lack of documentation, it is unknown where he obtained the bathymetry data (sediment range analysis, cross sections, etc.). The current model utilized the original bathymetry file and then refined the grid. Upon completion of this model update, CENWP completed a new survey of the reservoir. Due to time constraints and analysis of the data by CENWP, ERDC decided to not update the model with the new bathymetry.

3.1.2 Model grid development

Lost Creek Lake was split into two branches, with Branch 1 extending from the Rogue River just downstream from Prospect, OR, approximately 7 miles to the dam, and Branch 2 is a side channel that enters the mainstem of the reservoir about 1.5 miles upstream from the dam. The reservoir was modeled with 58 longitudinal segments, varying in length from 200.0 to 350.0 m, and 104 vertical layers of uniform 1 m (3.28 ft) height.

Table 1 provides a description of the branches in the reservoir; the segment numbers do not include the inactive (or “null”) segments that start and end each branch (required in W2). Figure 3 shows an image of

the longitudinal segments used in the model along with the branch configuration, and Figure 4 is a Google Earth image with the model grid overlay.

Table 1. Geometry characteristics.

Description	Branch	Segment Start	Segment End	# Segments	Slope
Mainstem – Prospect to Dam	1	2	47	46	0.000
Branch 2 – Ungauged leg of the lake	2	50	57	8	0.000

Figure 3. Longitudinal segments with branch configuration for the LCLM.

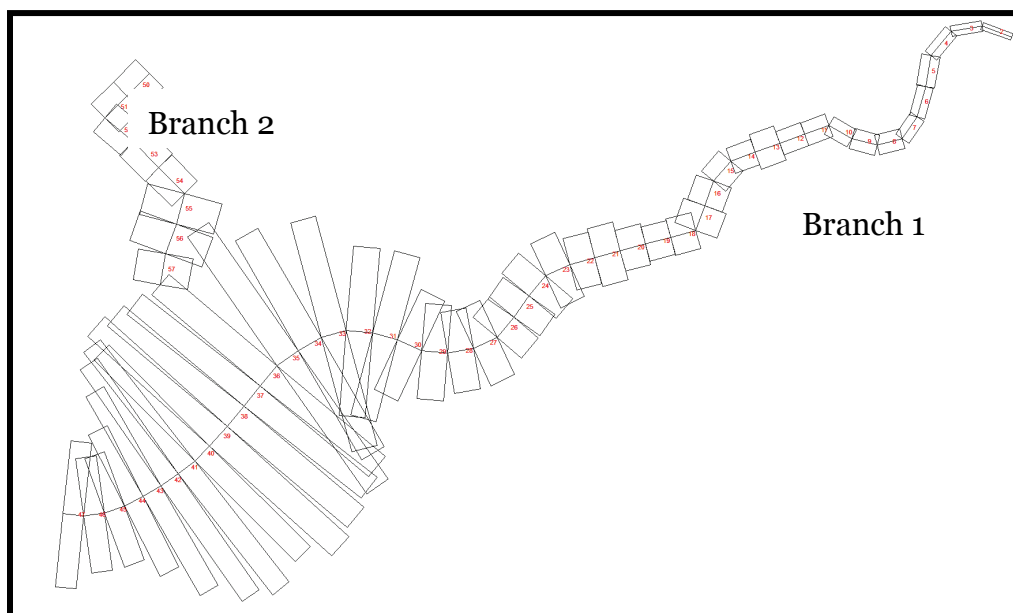
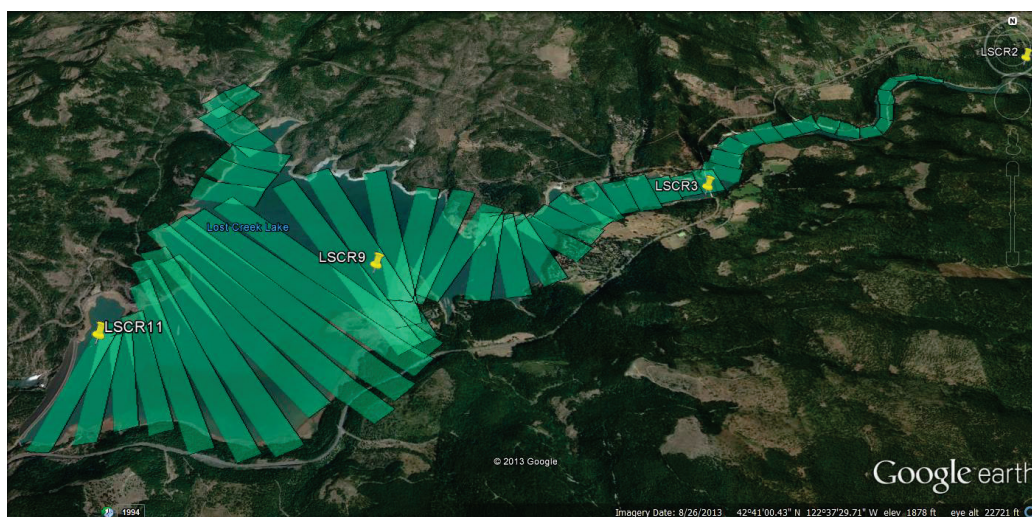


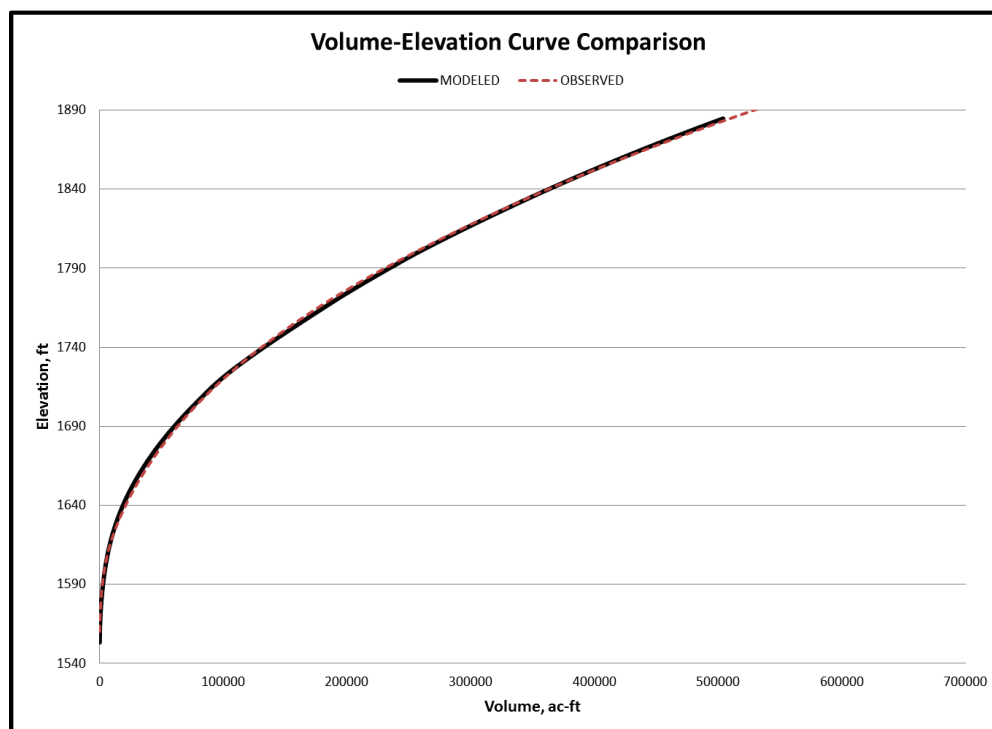
Figure 4. Google Earth image with model grid overlay (produced by W2Tools) for the LCLM.



The bathymetry of the LCLM that has been developed has been verified to replicate the observed storage-elevation curve (obtained from CENWP). Figure 5 shows the storage-elevation curve represented by the model compared to the observed storage-elevation curve (or volume-elevation curve). This provides ERDC with confidence that the bathymetry is good and sufficient for the LCLM. A complete copy of the bathymetry file is in Appendix A. All model input files were delivered to CENWP.

As stated previously, another in-lake profile station was available for CY01; however, due to the fact that the bathymetry did not extend the full length of the true reservoir, this station (LSCR2) was not considered for model evaluation purposes. In order to best represent the full reach of the reservoir and incorporate the bottom elevation changes, the model would need to be set up with two waterbodies: one river and one reservoir. Setting the current model up this way is outside the scope of this project due to the complexity of developing a riverine-reservoir model.

Figure 5. Volume-elevation curve comparison for the LCLM.



3.1.3 Dam features and withdrawal locations

Table 2 presents an abbreviated list of segment numbers in the LCLM bathymetry with a brief description of what site is located at the segment.

For example, the in-lake monitoring site, LSCR11, is represented by segment 47, which is the dam, in the LCLM bathymetry.

Table 2. Model segments of important locations.

Segment	Length (m)	Distance Upstream from Dam(m)	Distance Upstream from Dam (miles)	Identification/Location
1	0.000	0.000	0.000	Boundary (Null Segment)
2	300.000	11150.000	6.928	Beginning of Branch 1
18	250.000	6900.000	4.287	In-lake Station: LSCR3
34	250.000	2900.000	1.802	In-lake Station: LSCR9
36	250.000	2400.000	1.491	Branch 2 Enters Here
47	200.000	0.000	0.000	Dam/In-lake Station: LSCR11
48	0.000	0.000	0.000	Boundary (Null Segment)
49	0.000	0.000	0.000	Boundary (Null Segment)
50	300.000	2550.000	1.584	Beginning of Branch 2
57	300.000	300.000	0.186	End of Branch 2
58	0.000	0.000	0.000	Boundary (Null Segment)

3.2 Flow and elevations

3.2.1 Model inflow boundaries

3.2.1.1 Upstream and downstream boundaries

Mean daily flow for the Rogue River below Prospect, OR (14330000) was available from the United States Geological Survey (USGS) for all years for both calibration and validation of the model. Flow from this site was used as the upstream boundary condition. However, the measured flow did not include flow from the South Fork Rogue River, the confluence of which is between the head of the reservoir and the Rogue River gage. All branches in W2 require input files for flow and temperature. However, since the second branch in this case does not have a major inflow, a dummy file of zero flows was used as input for the model. This branch was modeled to capture the geometry of the reservoir and to maintain the volume-elevation relationship. In essence, this will have no impact on the model. The model will fill solely using the upstream inflow. At the downstream boundary, located at the dam, total outflows were available for all calendar years from the Northwestern Division Corps Water Management System (CWMS) database. The elevation data available at the dam were used solely for model-to-data comparison.

The flow from the monitored station above (Rogue River below Prospect, OR) does not account for all flows into the reservoir. The South Fork Rogue River also accounts for a large amount of flow; however, recent data is limited for this river. There are two stations available on the South Fork Rogue River, but the active station is approximately 10 miles upstream from the confluence with the Rogue River. Due to the inaccuracy associated with flow estimation, a decision was made to account for any water balance issues by using the water balance utility (available with the W2 download).

Table 3 displays the data sources for flow and elevation for various locations: the upstream boundary (PRSO), the downstream boundary (William Jess Dam), and three in-lake locations in the lake. Figure 6- Figure 8 are plots of all flow data used as input for the model at the upstream and downstream boundary for all three calendar years.

Table 3. Data sources for flow and elevation at the model boundaries.

River/Location Name	Mile	Location and ID	Source	Variable	Calendar Year
Rogue River below Prospect	169.4	PRSO; USGS #14330000	USGS	Flow, Mean Daily	2001, 2003, 2010
William L. Jess Dam	157.2	LOS; USGS #14335040	CENWP	Elevation, Mean Daily	2001, 2003, 2010
William L. Jess Dam	157.2	LOS; USGS #14335040	CENWP	Flow, Mean Daily	2001, 2003, 2010

Figure 6. Flow input data for upstream and downstream boundaries for CY01.

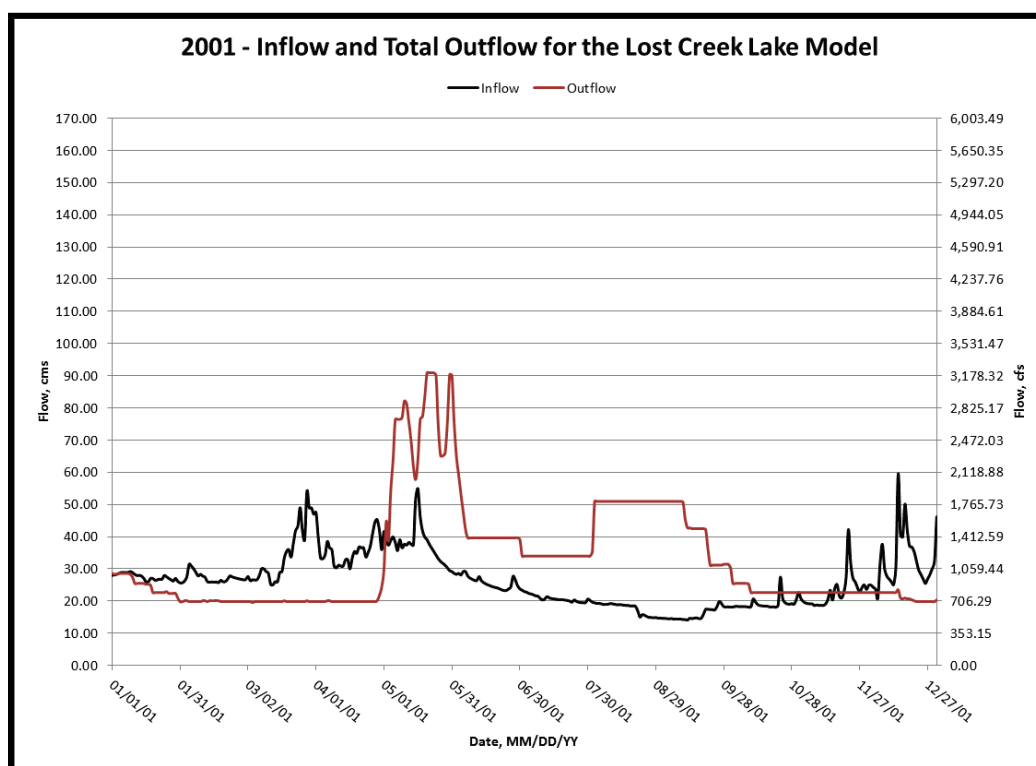


Figure 7. Flow input data for upstream and downstream boundaries for CY03.

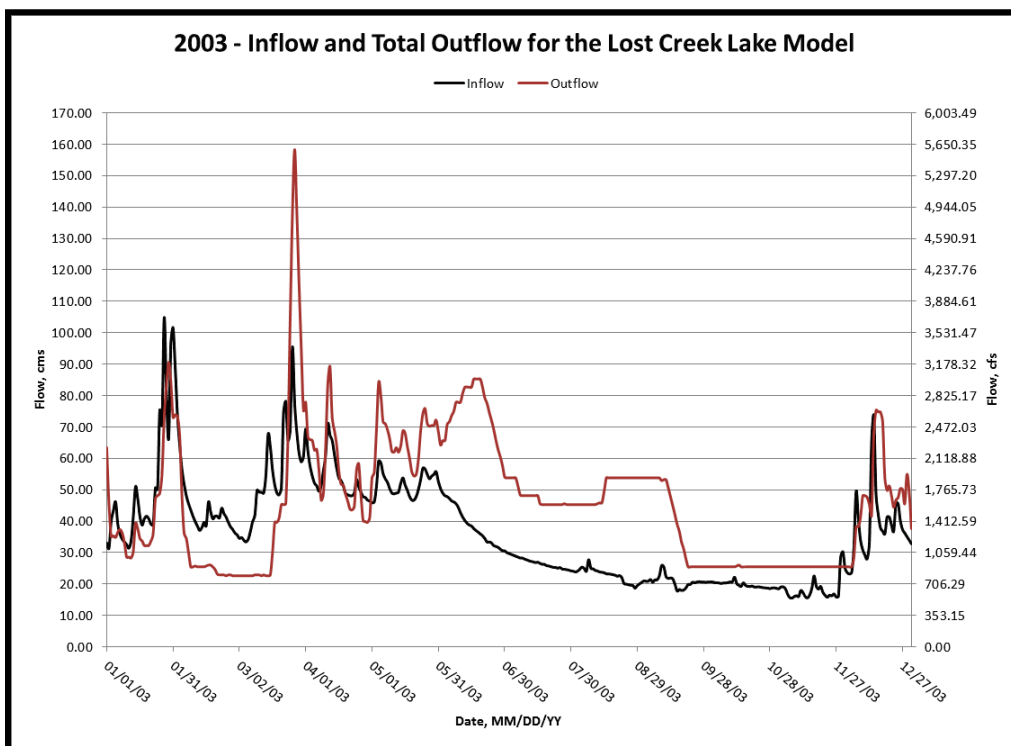
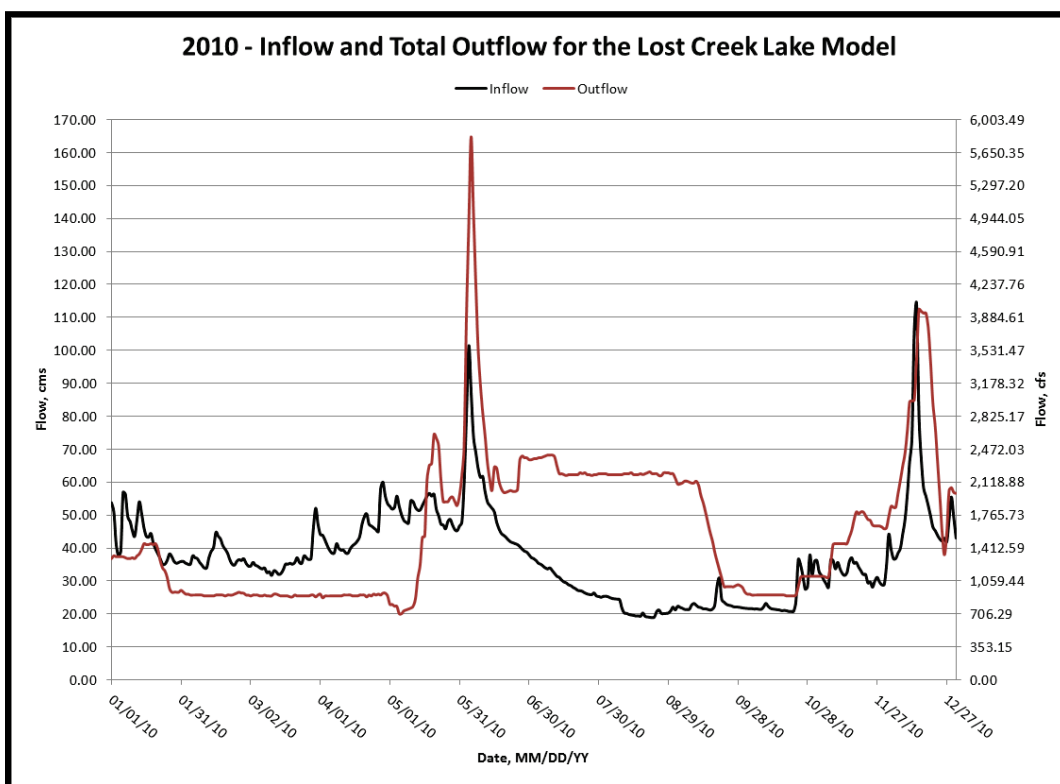


Figure 8. Flow input data for upstream and downstream boundaries for CY10.



3.2.1.2 Tributaries

No gauged streams discharge into Lost Creek Lake. For this reason, no tributaries were defined in the model. However, when ERDC obtained the original model files from CENWP, only one inflow was specified: USGS flow at Prospect, OR (USGS 14330000). There appeared to be a correction applied to that version of the model as well as in subsequent simulations. The assumption is that the correction is accounting for the additional inflow from the South Fork Rogue River (see Figure 9). The model from CENWP was initially calibrated and run for 1990, 1991, and 1999. In more recent years, however, the flow at the closest gauged station (USGS 14334700) to the reservoir is inactive (monitoring ceased in 1992); the next closest active station on the South Fork Rogue River is approximately 10 miles upstream. The flow here (USGS 14332000) underestimates the actual total flows into the lake (see Figure 10); for this reason alone, ERDC decided that instead of making two corrections (adding flows at Prospect and having a distributed tributary) to account for the flow, the model would be better simply by having one correction factor to the flows: the distributed tributary.

Due to the variation observed water surface elevations in early 2003, the model for 2003 had to be run two times in order for the model to best fit the observed water surface elevations. Again, the distributed tributary is used typically when there are ungauged flows entering the system. In this case, the flows are mostly from the South Fork McKenzie River. Figure 11 is the total flow that was added to the system to account for the water balance problems.

Figure 9. USGS Map of all surface-water sites near upstream boundary.



Figure 10. Historical flows (through 1992) for the upstream stations.

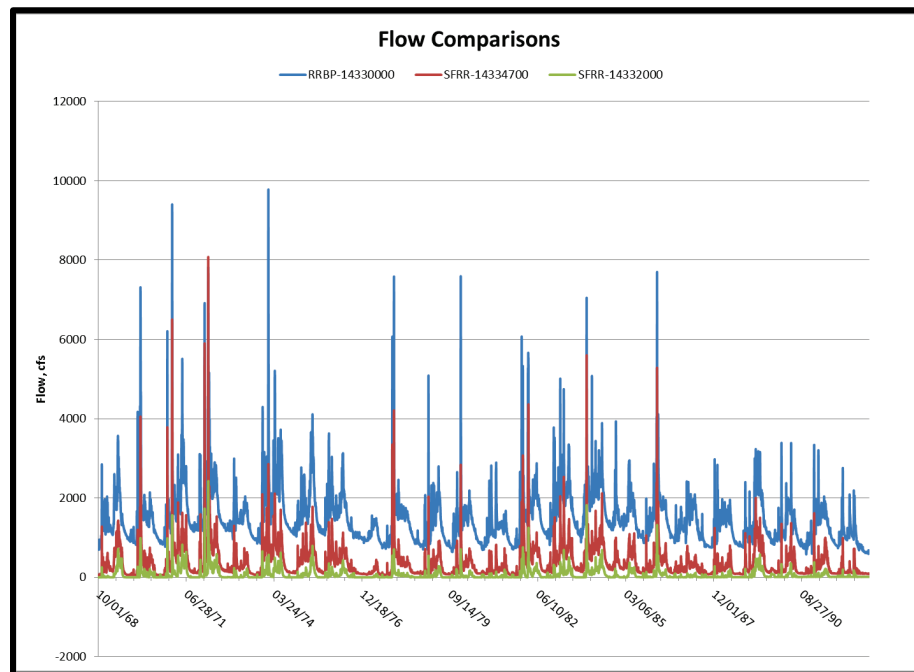
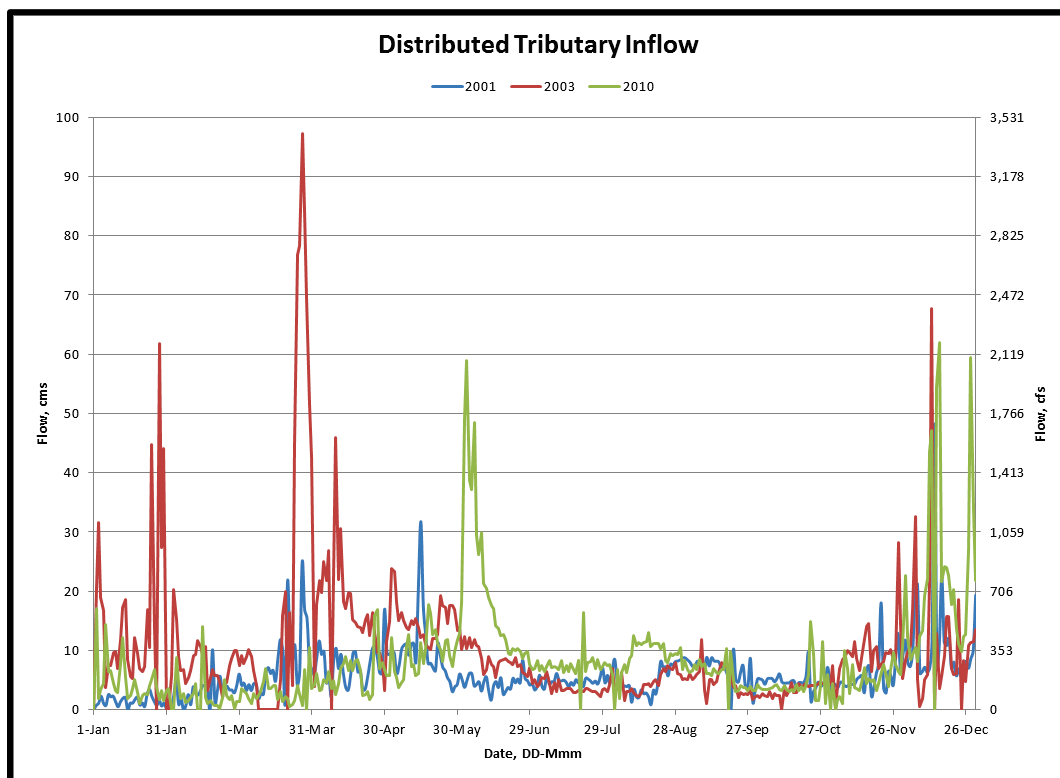


Figure 11. Distributed tributary inflow input data.



3.2.2 Model outflow boundaries

The amount of flow withdrawn through each intake port is not measured; however, gate settings are recorded. Gate settings information was obtained from CENWP as an Excel spreadsheet. These values were then used to develop the necessary file for W2 (QWO file).

Figure 12-Figure 14 is a plot of the outflow specified at each intake structure. ERDC applied conditions to the total outflow based on elevations and operations procedures as detailed in the *Master Water Control Manual* (USACE 1991) to apportion the total outflow to each intake port.

Figure 12. Outflow input data at specified structure for CY01.

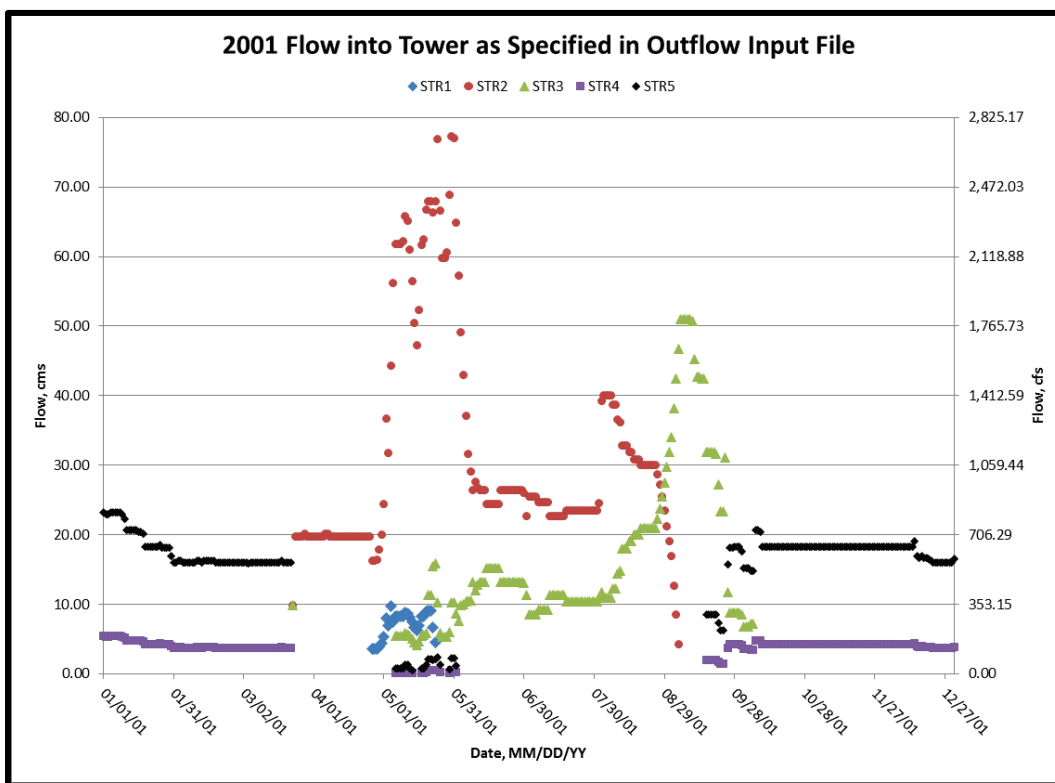


Figure 13. Outflow input data at specified structure for CY03.

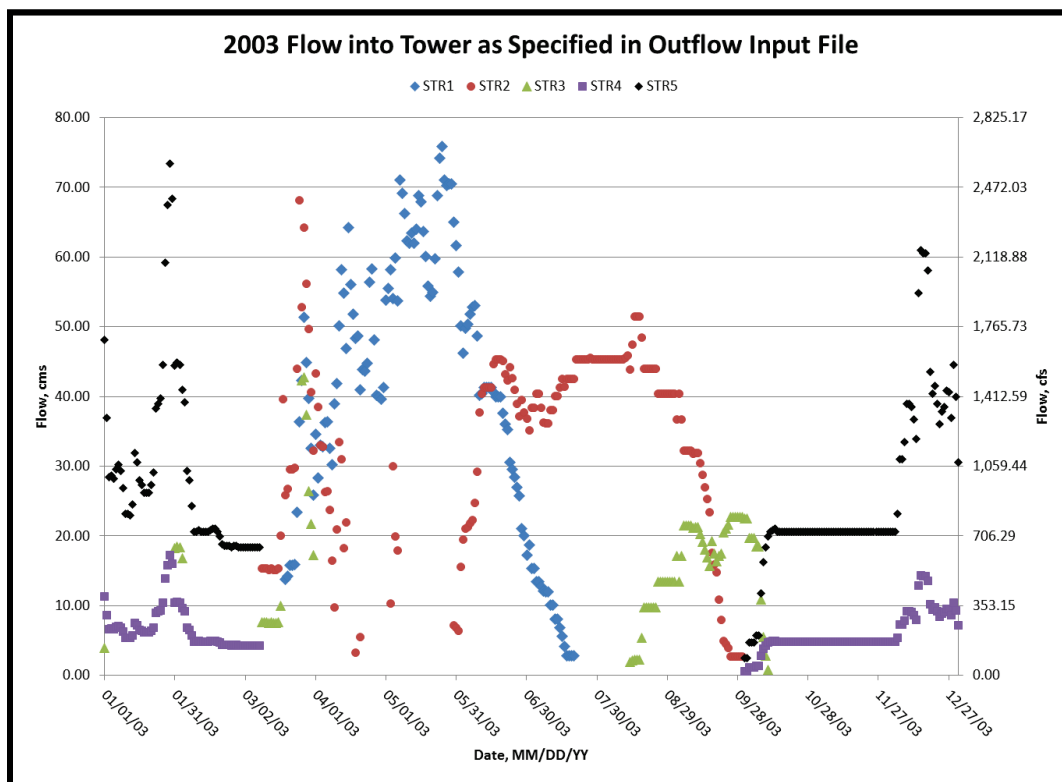
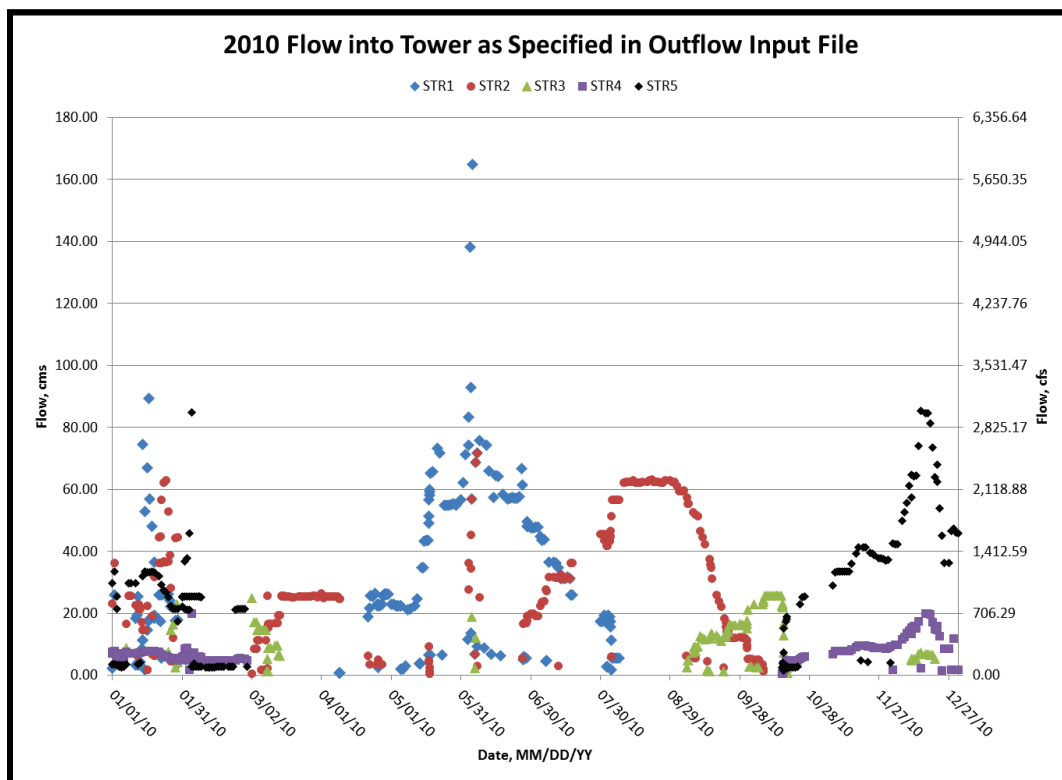


Figure 14. Outflow input data at specified structure for CY10.



3.3 Temperature

3.3.1 Model boundaries

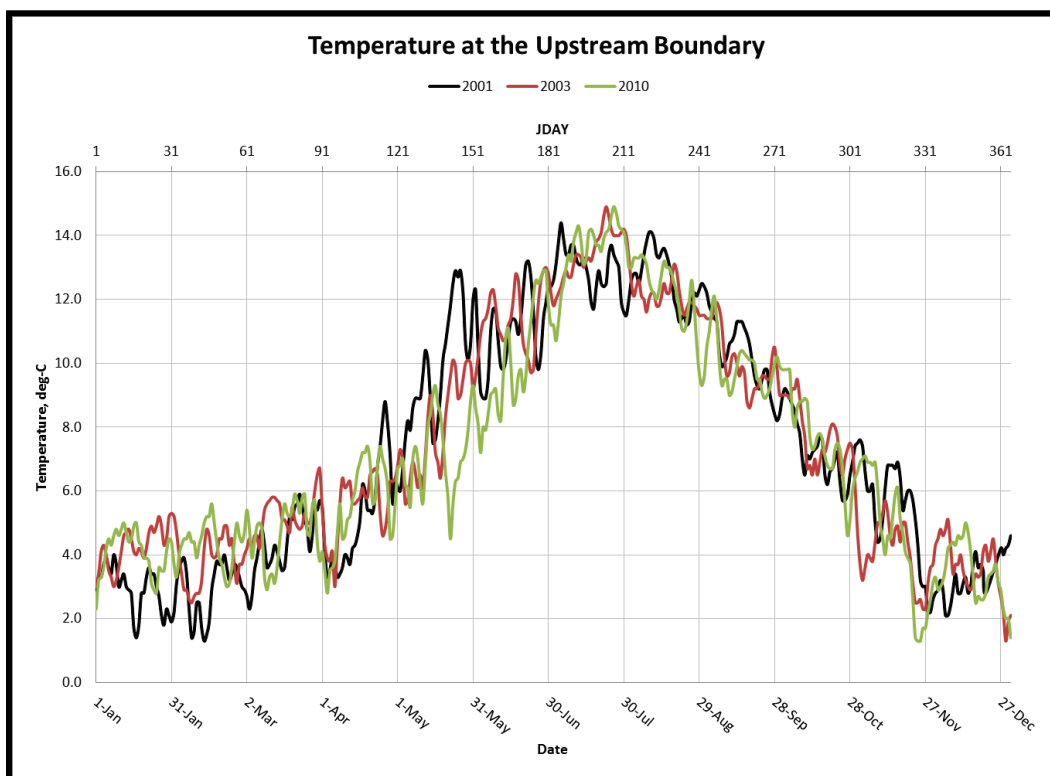
For all calendar years, temperature at the upstream boundary was defined with mean daily temperature from the Rogue River at Prospect (USGS 14330000). Temperature at the upstream boundary was also used as input for the second branch. However, since flows for the second branch are input as zero, the temperature will have no impact on the model.

Temperature data at the dam were used as calibration data for the model. Table 4 presents the locations and sources for temperature data, and Figure 15 provides a time-series plot of temperature at the upstream boundary as defined in the model for all calendar years.

Table 4. Data sources for temperature at the model boundaries.

River/Location Name	Mile	Location and ID	Source	Variable	Calendar Year
Rogue River below Prospect (Upstream Boundary)	169.4	PRSO; USGS #14330000	USGS	Temperature, Mean Daily	2001, 2003, 2010
William L. Jess Dam (Downstream Boundary)	157.2	LOS; USGS #14335040	CENWP	Temperature, Mean Daily	2001, 2003, 2010

Figure 15. Temperature input data for the upstream boundary for 2001, 2003, and 2010.



3.3.2 Tributaries

Since tributaries were not monitored, there are none being modeled. However, because a distributed tributary must be used to improve the water balance, the upstream temperature input file was duplicated and used as input temperature for the distributed tributary. There was no temperature data available at any other gages (South Fork McKenzie) for the time period modeled; for that reason alone, the upstream boundary temperature was used as input for the distributed tributary.

3.4 Meteorological data

Hourly meteorological data were requested from the 14th Weather Squadron (14WS) at Medford, OR (28 miles southwest of Lost Creek Lake). Figure 16-Figure 21 provide a mean daily time-series plots for various meteorological conditions at the upstream boundary as defined in the model for CY01.

Figure 16. Air and dewpoint temperature input data for 2001.

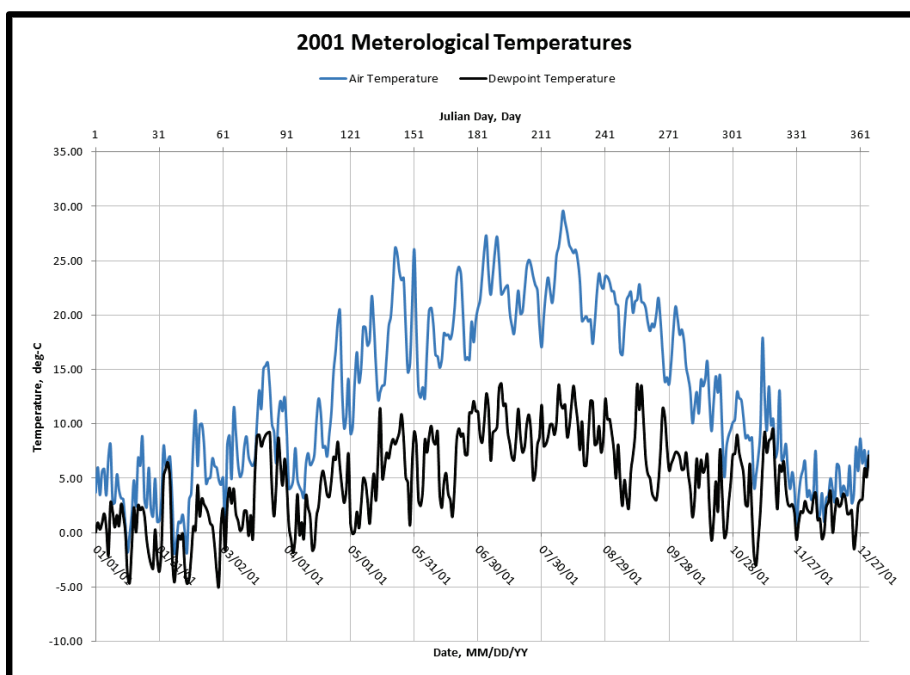


Figure 17. Air and dewpoint temperature input data for 2003.

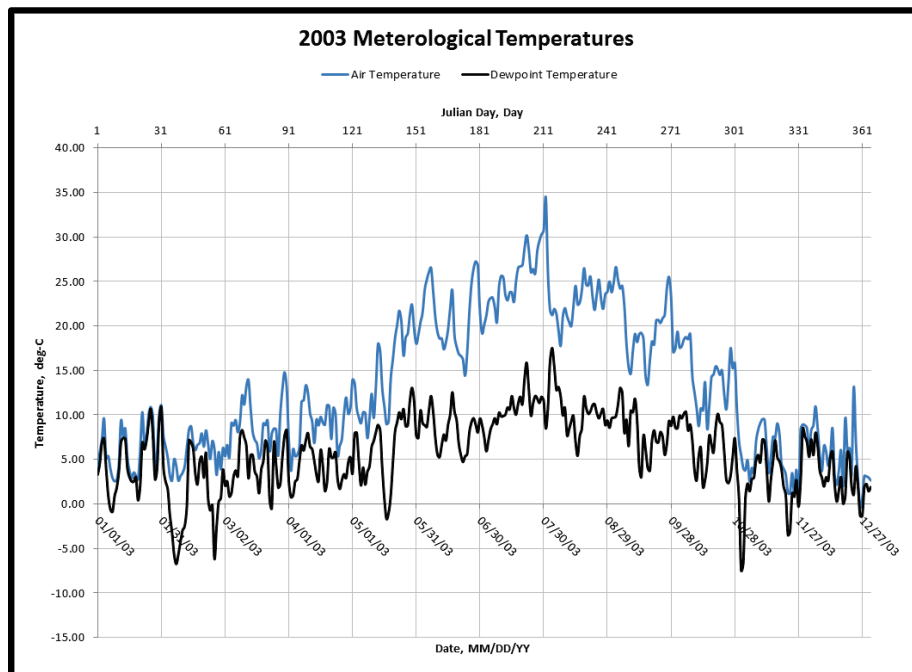


Figure 18. Air and dewpoint temperature input data for 2010.

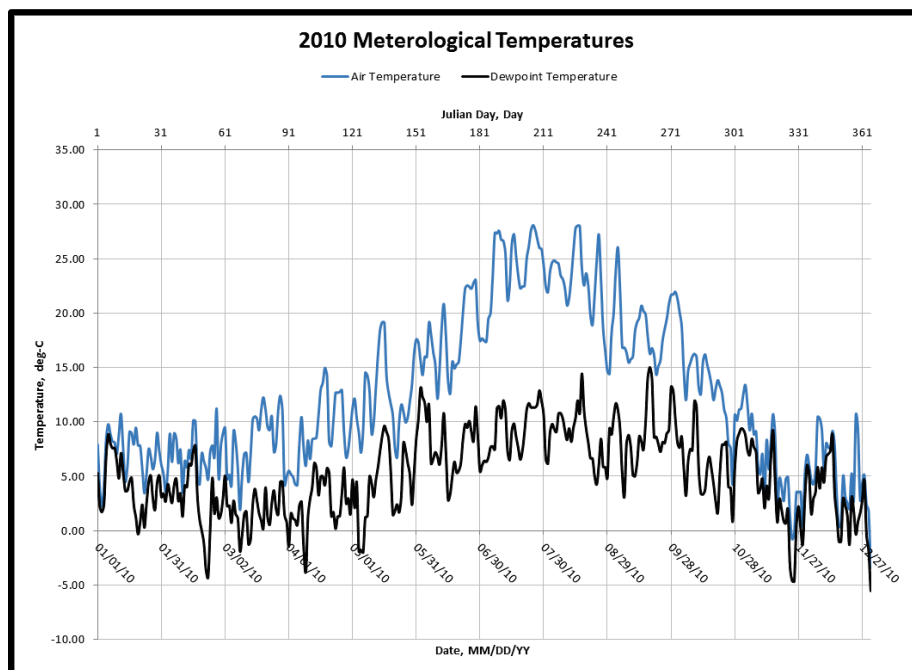


Figure 19. Cloud cover input data for 2001.

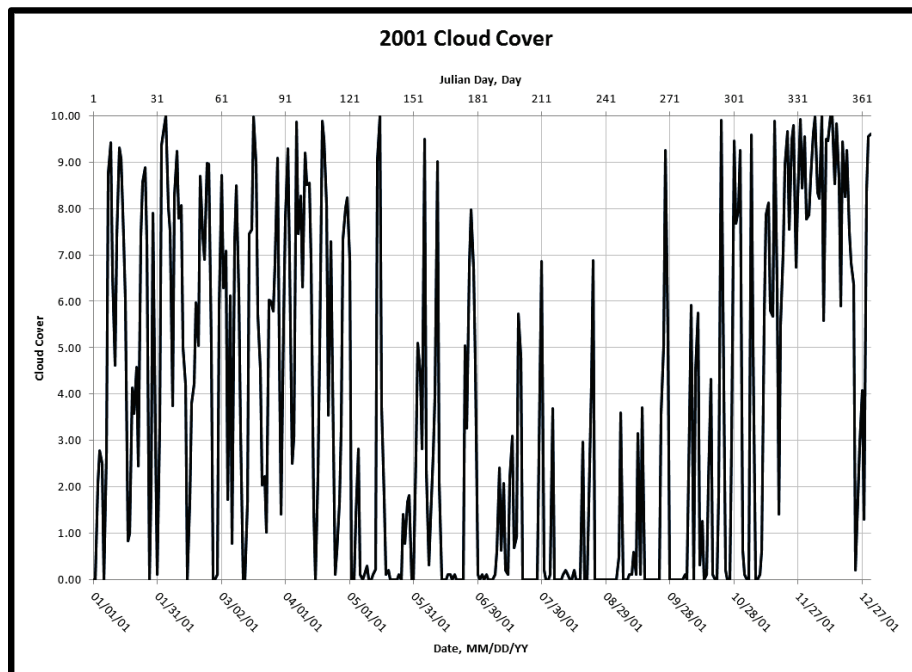


Figure 20. Cloud cover input data for 2003.

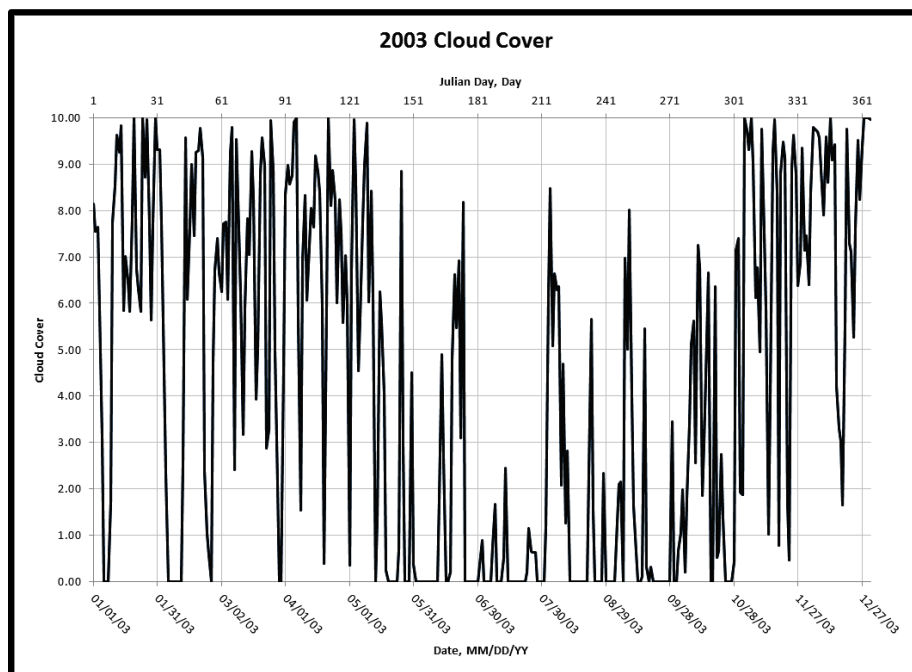
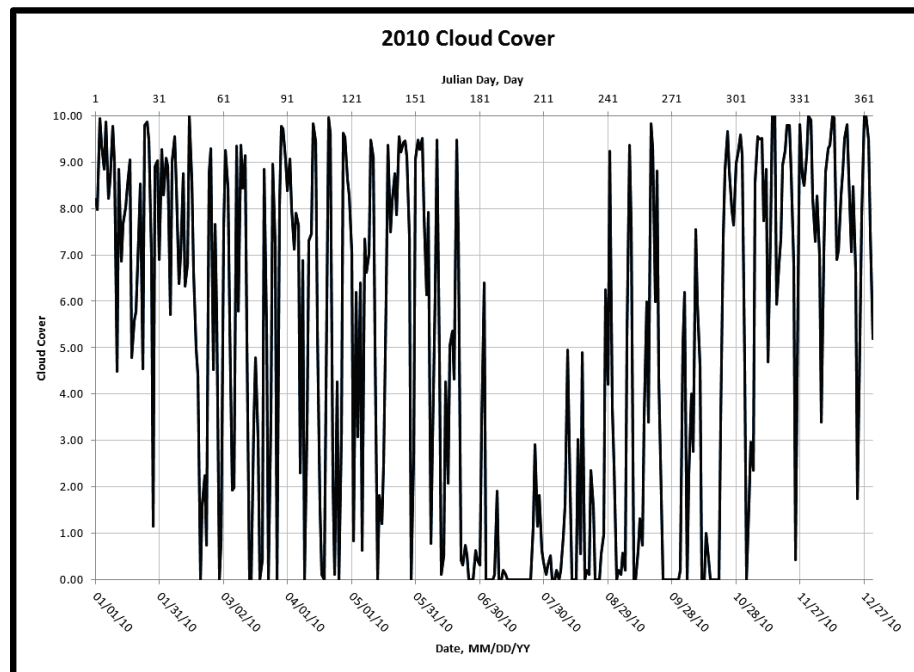


Figure 21. Cloud cover input data for 2010.



3.5 CE-QUAL-W2 control file

The control file for the model calibration (CY01) can be found in Appendix B along with a table detailing any differences for all other model simulations. In order to keep this section concise, only parameters related to temperature are discussed.

3.5.1 Calculations, transport scheme, and heat exchange

Since evaporation is always considered in the surface heat exchange calculations in W2, it is important to turn the evaporation calculation (EVC) on if needed. According to the manual, if calculated inflows are used in setting up a model, then EVC is set to OFF; however, in the case of the LCLM, EVC is set to ON since we are using direct USGS inflows and evaporation is not included in USGS flows.

The transport solution scheme used in the LCLM is the ULTIMATE scheme, which is a higher order solution scheme that reduces numerical diffusion and eliminates the over- and undershoots that the QUICKEST scheme generates near regions of shear concentration gradients (Cole and Wells 2013).

In the W2 control file, the user must specify heat exchange parameters. The first parameter specified is the approach used for computing surface heat exchange (SLHTC). For the LCLM, ERDC chose to use a term-by-term (TERM) heat exchange because it is more theoretically sound according to Cole and Wells (2013) and because it produced better model results than the equilibrium temperature method (ET). Shortwave solar radiation was available, but ERDC chose to let the model calculate it internally because this produced better results (SROC = OFF). Although ERDC was provided with hourly meteorological data, W2 was still allowed to interpolate the input data to correspond to the model time-step by setting the METIC parameter to ON. The wind speed measurement height was set to 10 m in the LCLM as indicated by the 14WS. All other heat exchange parameters were set to the suggested manual values.

3.5.2 Extinction coefficients

The extinction coefficient card contains two important coefficients for temperature calibration. The extinction coefficient for pure water (EXH2O) is set to 0.55 m^{-1} , which is greater than the default value for a temperature-only model (0.45 m^{-1}). However, the value is within the range of values for EXH2O for oligotrophic to eutrophic lakes, $0.2\text{--}1.66 \text{ m}^{-1}$; the higher value accounts for the turbidity of the lake. The BETA parameter determines the fraction of incident solar radiation absorbed at the water surface and is also set to the value of 0.55 in the LCLM model. The W2 manual suggests that typical values for BETA are approximately 0.2–0.7 (Cole and Wells 2013).

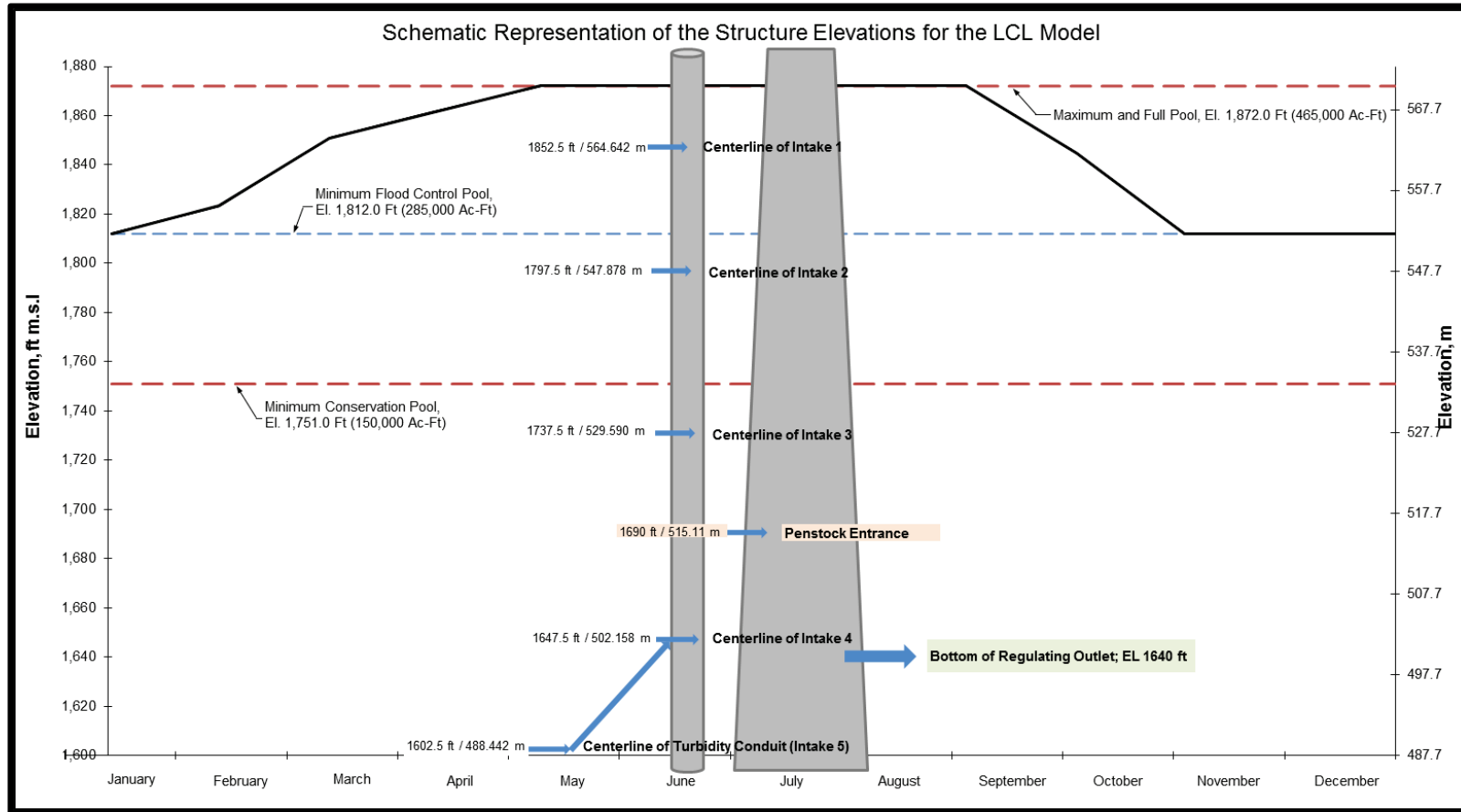
3.5.3 Selective withdrawal

W2 is capable of modeling a temperature control tower with selective withdrawal features. The latest version also has the added capability of dynamic port selection; however, since this was not used for the current model, it will not be discussed here.

The Lost Creek Lake Water Temperature Control tower (WTC) has five intake structures into a common wet well: four water temperature control ports and one turbidity conduit. The turbidity conduit is used throughout the year to act as a water temperature control port or to flush the lower levels of the reservoir. The conduit is connected to the middle of the lowest fixed port at elevation 1,640 ft and is often responsible for 81% of the flow entering the tower through that lowest port (USACE 1991). Figure 22 is an

image of where each intake port is identified in the model control file. Two additional intakes are located on the WTC but neither use the tower wet well: a tower bypass intake and fish hatchery warm water supply intake. These two intakes are not explicitly represented in the model because their flow rates are negligible.

Figure 22. Schematic representation of the water temperature control port elevations. (This includes minimum head requirements).



4 Model Calibration – CY01

Final calibration results are presented in this section. In all of the time series plots shown, a black solid line represents model output, a solid red circle or solid or dashed red line represents measured data. Three statistics are also presented in the charts: mean error (ME), absolute mean error (AME), and root mean square error (RMSE). These statistics are calculated as shown in Equations 1-3. The model was output every day as a daily average; when making time series comparisons to the observed data, a tolerance of 0.5 days was used for the model output so that model output and measured data were compared spatially and temporally with minimal averaging. A tolerance of seven days was used for the model output when making profile plot comparisons. In both of the cases, the statistical comparison is a one-to-one comparison. We use the closest date and the closest depth for comparing values. The tolerances used also allowed enough spacing to avoid observed data averaging.

$$ME = \frac{\sum_{1}^n (model - data)}{n} \quad (1)$$

$$AME = \frac{\sum_{1}^n abs(model - data)}{n} \quad (2)$$

$$RMSE = \sqrt{\frac{\sum_{1}^n (model - data)^2}{n}} \quad (3)$$

Cumulative distribution plots are also presented in this section. For these plots, the solid black line represents model output and the dashed red line represents observed data. These plots are used to indicate how the model is behaving overall when compared to the observed values. For example, at high temperatures, the model over-/underpredicts temperature by XX deg-C, where XX represents the AME value. Scatter plots are also presented to give a statistical representation of how the model is behaving.

A general rule of thumb for water quality calibration is that the absolute mean error should be within 10% of the range of monitored data¹, temperature AME should be within 1 deg-C (~1.8 deg-F), and elevations should be within 0.5 m (1.64 ft). Equation 4 is the equation used to calculate the target values for AME. These target values were calculated for each calendar year and will be presented in tabular form in the following sections. Units for these targets are consistent with the minimum and maximum values for each constituent. For example, for flow, the minimum, maximum, the AME, and 10% target are presented in cubic feet per second.

$$\text{Target} = 0.10 * ((\text{maximum observed value}) - (\text{minimum observed value})) \quad (4)$$

4.1 Flow

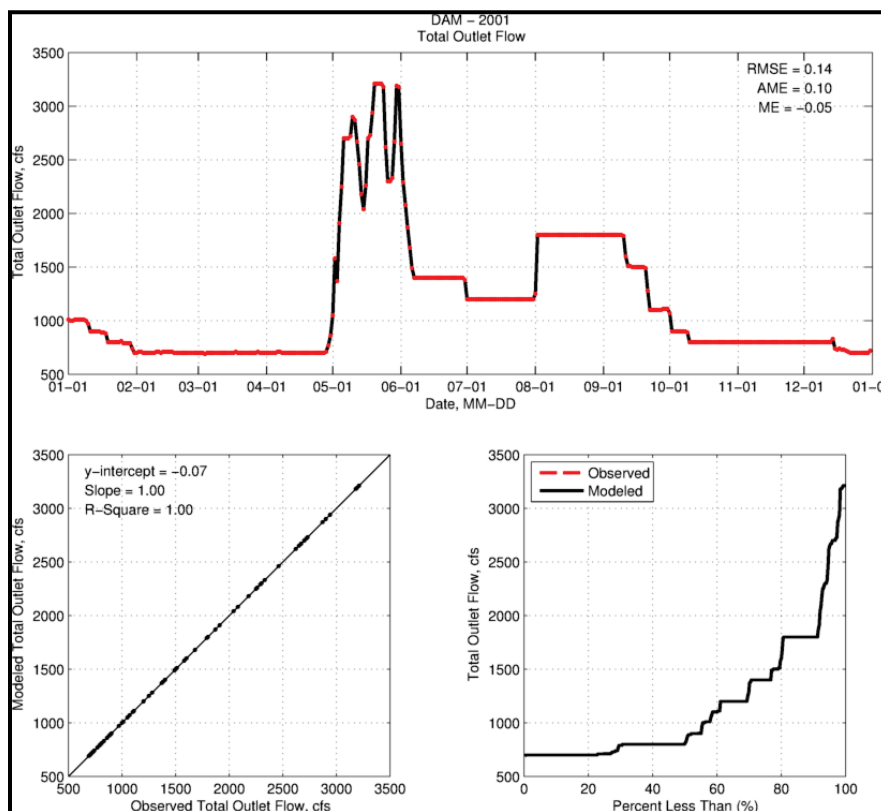
Since the model upstream boundary condition segment often changes based on the reservoir volume, ERDC cannot produce flow plots to verify that the upstream boundary condition for flow is satisfied. Model output along with observed data for CY01 at the dam is shown in Figure 23. Note that this is really just a representation that the data is being read correctly from the input outflow file. The AME for all data pairs for 2001 at the dam is 0.10 cfs, which is well less than 0.5% of the measured range of flows the calendar year. Table 5 presents several basic stats for flow. Based on Figure 23, the slope of the trendline fitted through the data pairs is 1.00 and the R-squared value is 1.00. Overall, the model only underpredicts outflow at the dam by 0.05 cfs.

Table 5. Basic statistics for flow (cfs) for CY01 calibration.

SITE	Observed Minimum	Observed Maximum	AME	ME	Slope	R-Squared
Dam	690.00	3210.00	0.10	-0.05	1.00	1.00

¹ Wells, Scott. 2008. Personal communication with Tammy Threadgill. June 15. CE-QUAL-W2 Workshop, Portland, OR.

Figure 23. Withdrawal flow at the dam for CY01 calibration.



4.2 Temperature

The best hope in correctly predicting the outflow temperature is to correctly predict the in-lake temperature profiles at various locations in the reservoir. If the temperature profiles are not satisfactory, the chance of correctly predicting total outflow temperature is highly unlikely. Profile plots and statistical plots for all in-lake monitoring sites are presented in Figure 24-Figure 29. (Figure 2 shows the location of each of these sites.) A time series plot and statistical plots are presented for the dam in Figure 30. The average AME for each of the in-lake sites are within the acceptable target. Table 6 presents the calculated AME and the temperature target that ERDC attempted to reach for the in-lake sites and for the outflow temperature at the dam. Based on Figure 27-Figure 29, the average slope of the trendlines is 1.12, and the R-squared value is 0.91 for the in-lake sites. Based on the figures below, the model underpredicts the temperature by an average of 0.56 deg-C at the downstream in-lake sites and overpredicts temperature by approximately 0.50 deg-C at the furthest upstream in-lake site (LSCR3). At the dam, the AME is 0.56 deg-C, with a slope of 1.08 and an R-squared value of 0.98 (see Figure 30).

Table 6. Basic statistics for temperature (deg-C) for CY01 calibration.

SITE	Observed Minimum	Observed Maximum	Target AME	AME	ME	Slope	R-Squared
LSCR11 (CY AVG)	5.06	20.61	1.00	0.68	-0.17	1.08	0.96
LSCR9 (CY AVG)	5.03	21.15	1.00	0.90	-0.22	1.13	0.94
LSCR3 (CY AVG)	8.65	16.60	1.00	0.89	0.82	1.04	0.94
Dam (Outflow)	4.50	14.78	1.00	0.52	-0.12	1.13	0.98

Figure 24. Temperature profiles at LSCR11 in CY01 calibration.

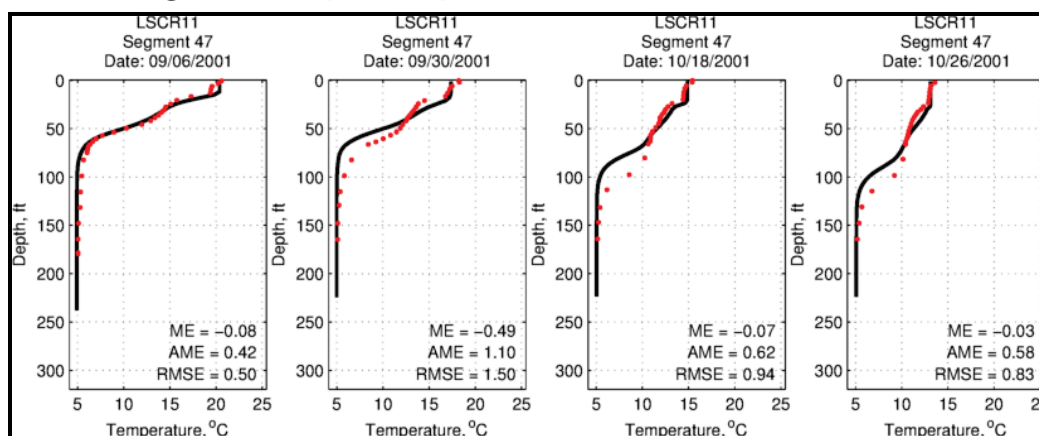


Figure 25. Temperature profiles at LSCR9 in CY01 calibration.

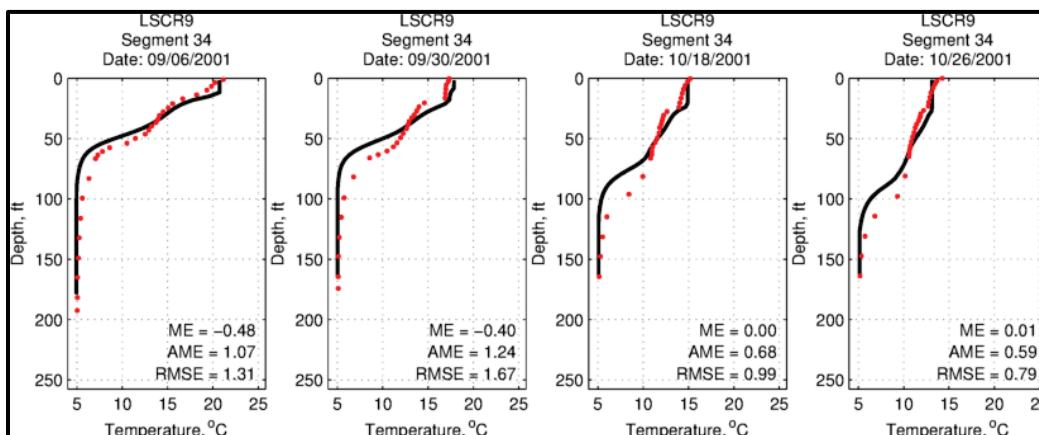


Figure 26. Temperature profiles at LSCR3 in CY01 calibration.

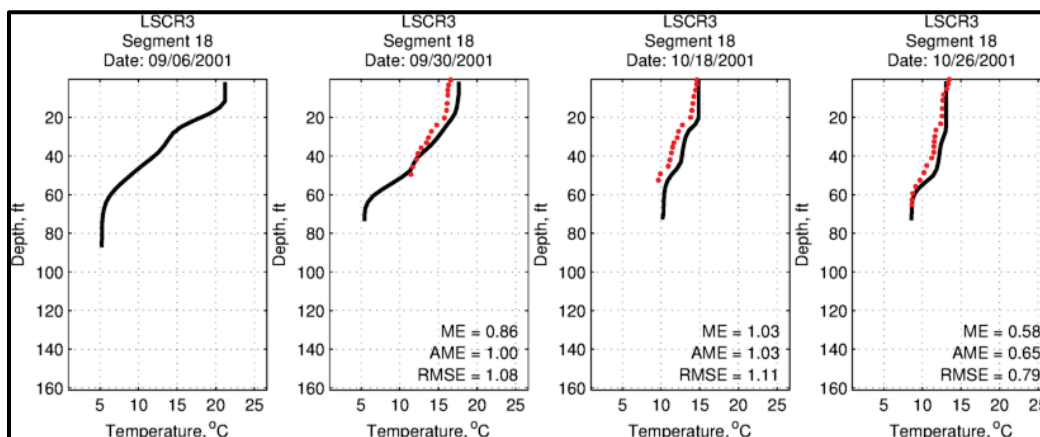


Figure 27. Flow linear and cumulative distribution plots at LSCR11 for CY01 calibration.

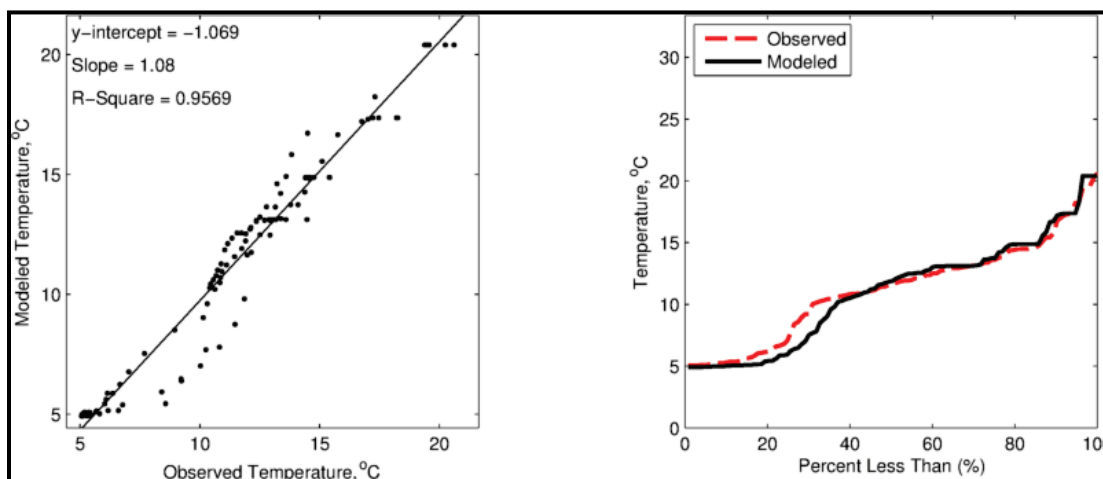


Figure 28. Flow linear and cumulative distribution plots at LSCR9 for CY01 calibration.

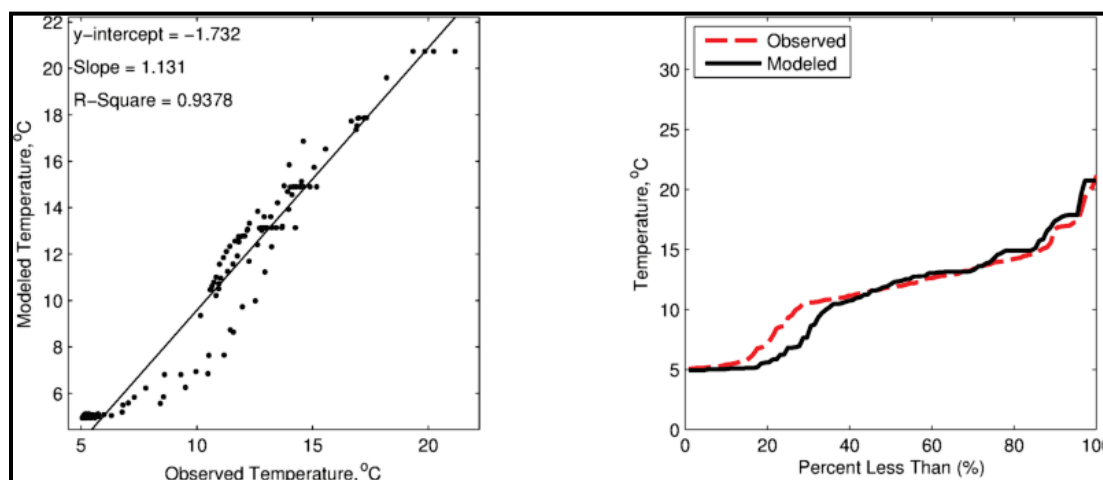


Figure 29. Flow linear and cumulative distribution plots at LSCR3 for CY01 calibration.

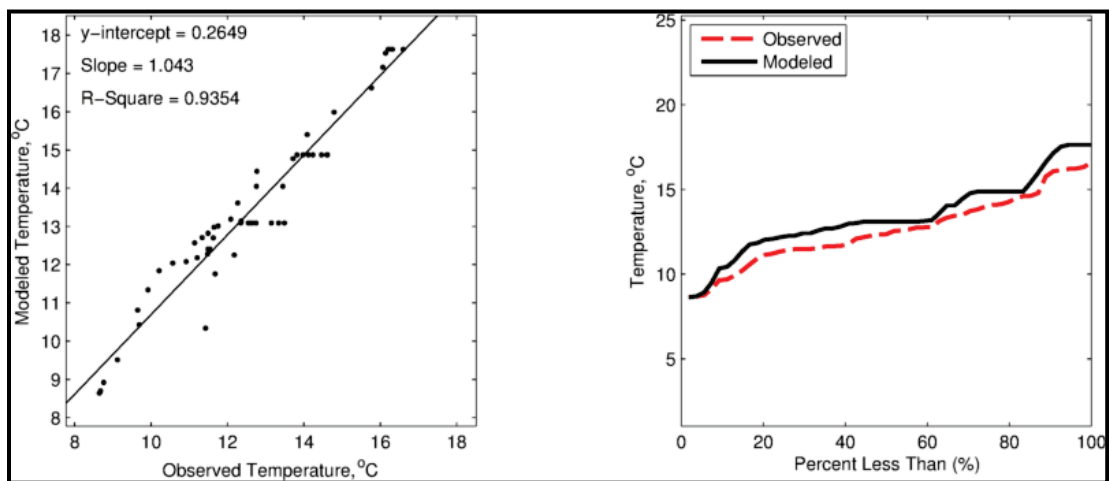
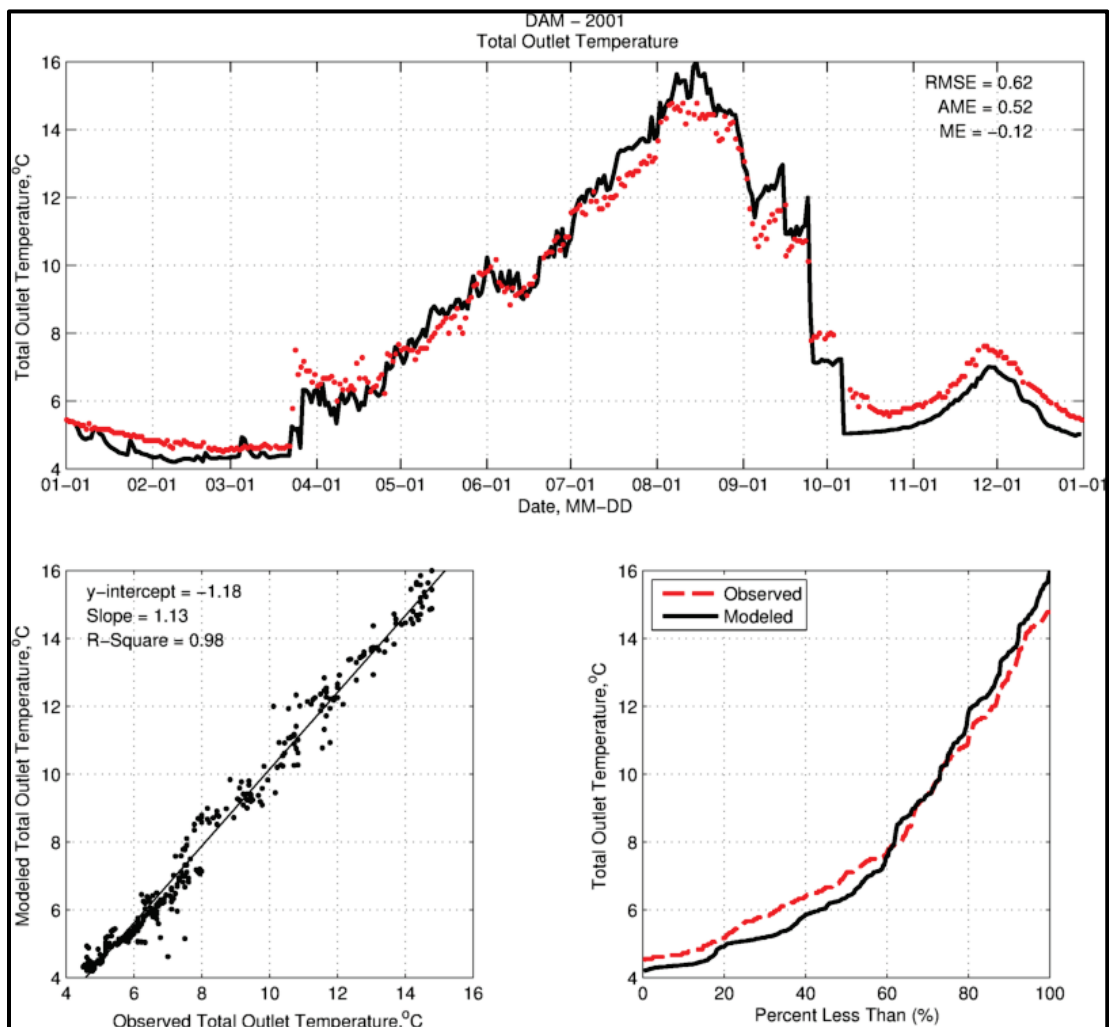


Figure 30. Withdrawal temperature at the dam for CY01 calibration.



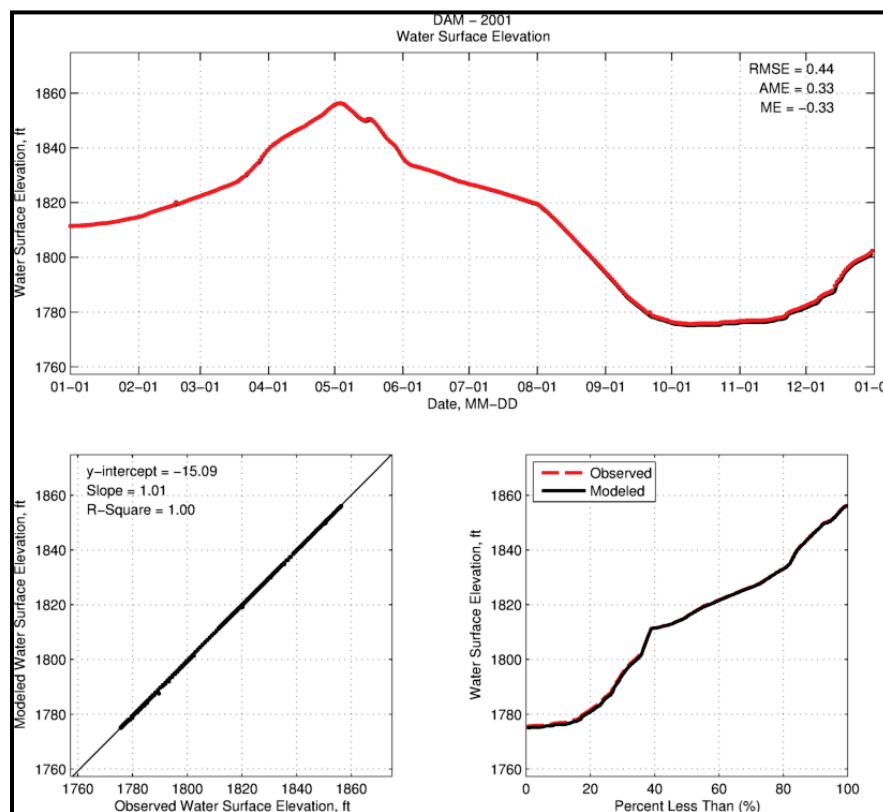
4.3 Water surface elevation

Model output along with observed data for water surface elevations (ELWS) in CY01 at the dam is shown in Figure 31. The AME for all data pairs for 2001 at the dam is 0.33 ft (~0.08 m). Table 7 presents the calculated AME and the 1.64 ft (0.5 m) target that ERDC attempted to reach. The slope of the trendline fitted through the data pairs is 1.01 and the R-squared value is 1.0. Overall, the model only underpredicts ELWS at the dam by 0.33 ft.

Table 7. Basic statistics for water surface elevations (ft) for CY01 calibration.

SITE	Observed Minimum	Observed Maximum	Target AME	AME	ME	Slope	R-Squared
Dam	1775.63	1856.29	1.64	0.33	-0.33	1.01	1.00

Figure 31. Water surface elevations at the dam for CY01 calibration.



5 Calibration Discussion

Model calibration results and all model assumptions are discussed in this section. As stated previously, not only does this report detail graphical comparison, but the authors also present several statistical comparisons: AME, RMSE, and ME. Both the flow results and the temperature results will be discussed below. An inventory of files needed for the calibration runs can be found in Appendix B (Table B2).

5.1 Water surface elevation

As stated previously, due to the water balance instabilities in the model, a distributed tributary was added to the calibration run. This drastically improved the initial results. Figure 32 shows the impact of not using distributed tributary. Notice how the model severely underestimates the water surface elevation for ten months out of the year. By the end of the year, the model has almost 100 ft of elevation worth of unaccounted for water. Once the distributed tributary was added, and before any other parameters were modified, the improvement to the results was astounding (see Figure 33).

Figure 32. Time series and statistical plots of ELWS without the distributed tributary.

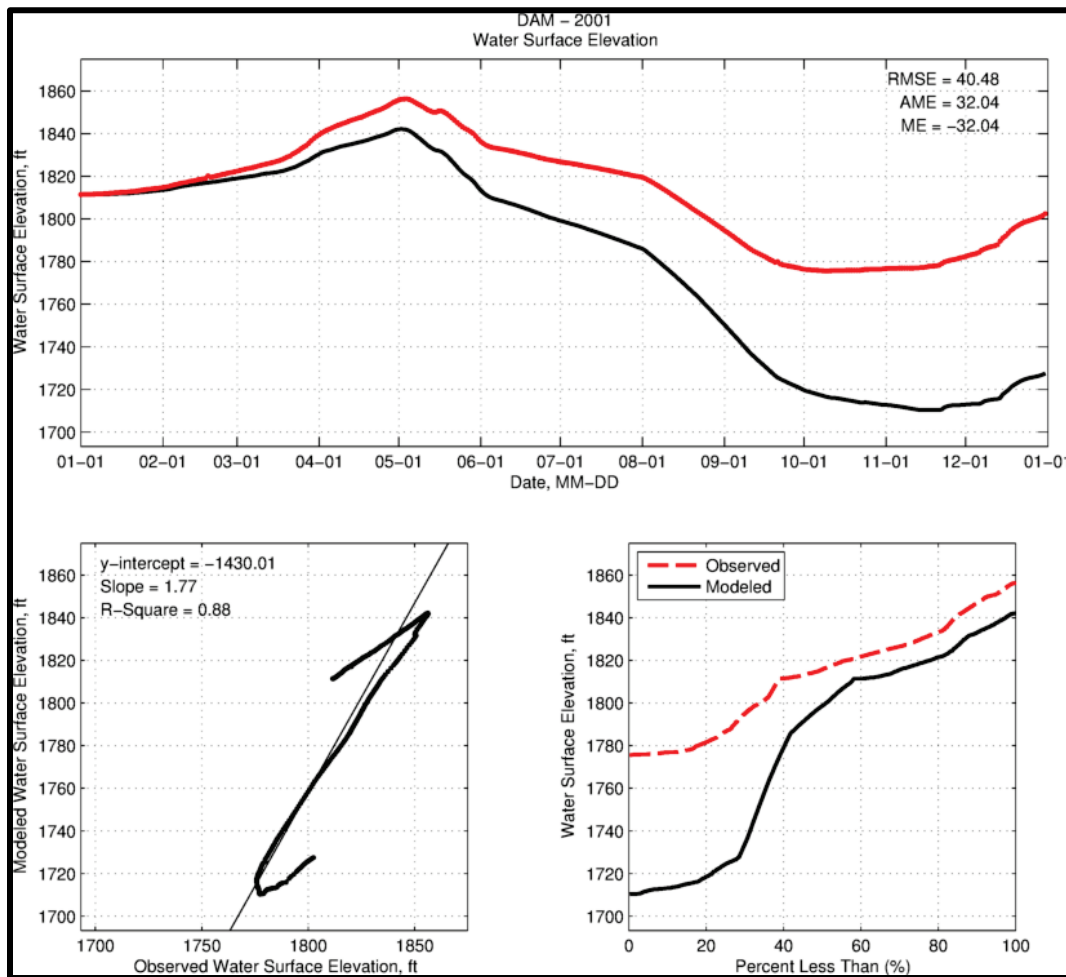
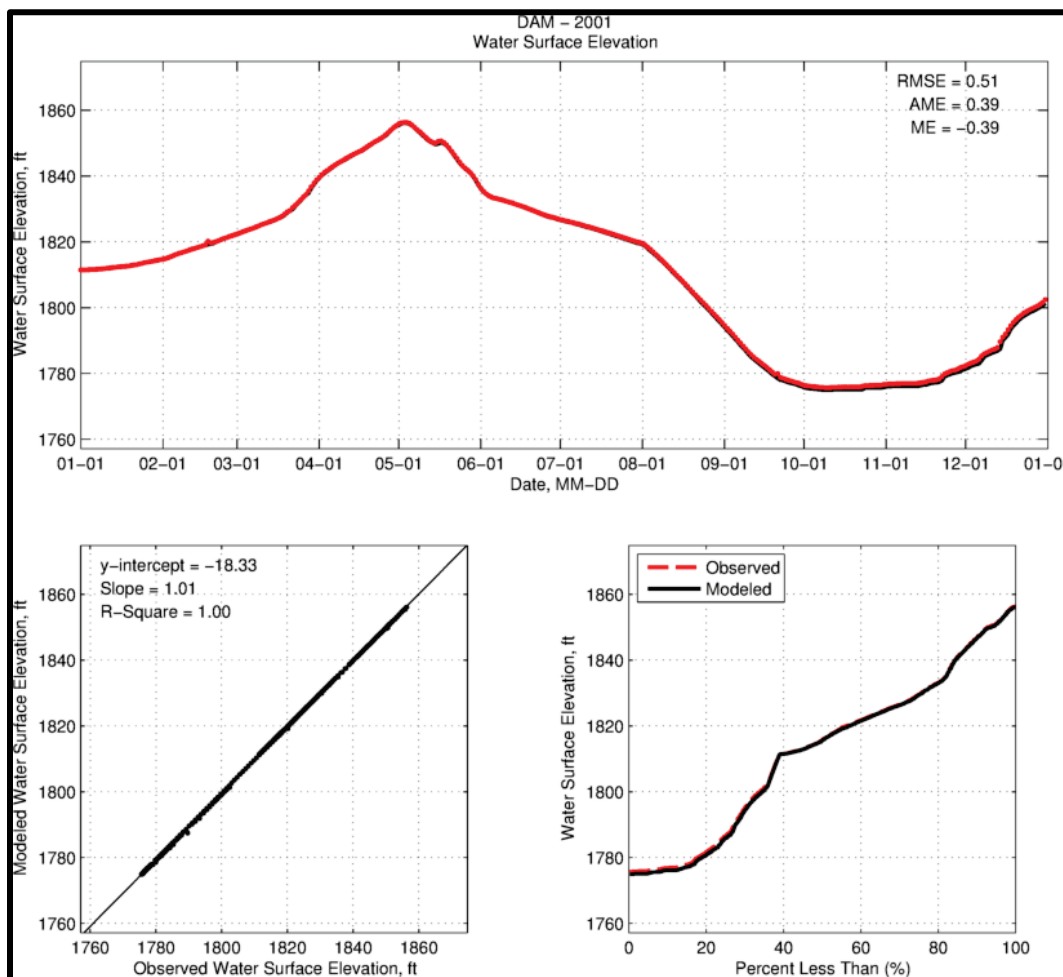


Figure 33. Time series and statistical plots of ELWS with the distributed tributary.



5.2 Temperature

Initially, before the water balance issues were corrected, the model was drastically miscalculating the temperature. However, once the distributed tributary was added, the model was still overpredicting the temperature (CY01-Run02). Upon observing the in-lake profile plots, the surface temperature was too warm. ERDC performed three more simulations with the following changes:

1. Set SROC = OFF in the control file. Due to the fact that the meteorological station is not located at the dam, ERDC has found in previous studies that the model performs better when the W2 is allowed to calculate SRO (short wave solar radiation) internally. Making this change had the most significant effect on the surface temperature. (CY01-Run03 – not plotted below)

2. Changed EXH20 from 0.45 to 0.55 in order to increase the amount of heat retained at the surface instead of letting the heat descend into the water column. After setting SROC = OFF above, although the surface water cooled down significantly, the water was still too warm from 10-50 feet below the surface. Next, the team changed BETA from 0.45 to 0.55. BETA is similar to EXH20 in that it also helps to retain more heat surface. These changes (independent of each other) had a very small positive impact on model temperature predictions. (CY01-Run05 shows these modifications together even though they were run in consecutive runs.)
3. During calibration, the team realized that the outflow for day 267 (September 24th) was incorrect. The values for this day were replaced with the values from the previous day (note the spike in CY01-Run05). Sediment temperature was corrected to average air temperature for the year. Originally, it was 11.5 deg-C. Although this was a very close approximation, the value was corrected to 11.984. (CY01-Run09)
4. The final attempt to improve the in-lake profile temperature predictions was to modify the wind-sheltering coefficient during fall and winter periods when there are no leaves on the trees. This made a significant improvement to model predictions. (CY01-Run13)

Temperature comparisons at the in-lake stations and the dam between each of the runs discussed above are seen in Figure 34-Figure 37. In all of the plots below, the red dots are observed data. The time series comparison is more indicative of the gains in temperature improvement with the above modifications than are the profile comparisons.

Figure 34. Profile comparison at LSCR3.

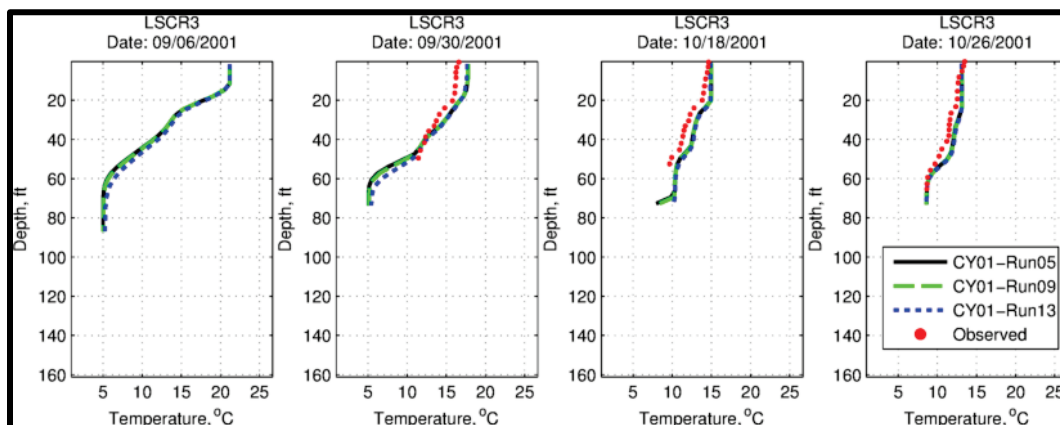


Figure 35. Profile comparison at LSCR9.

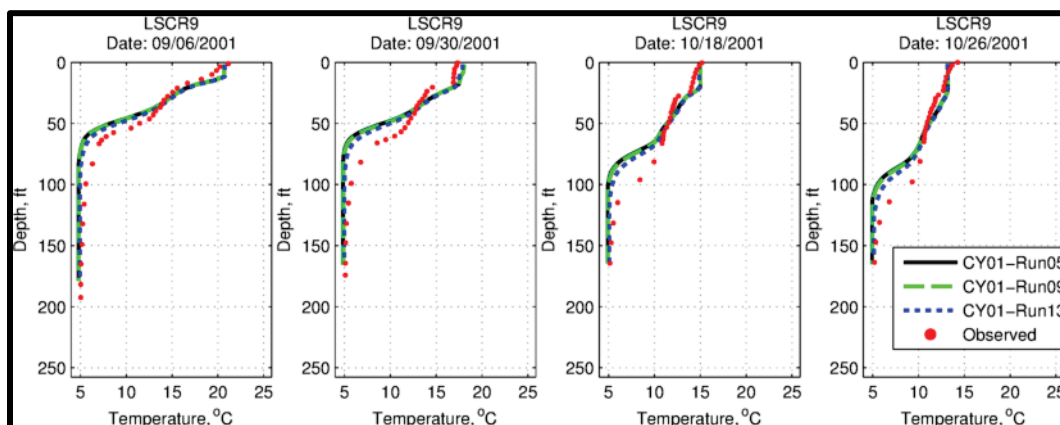


Figure 36. Profile comparison at LSCR11.

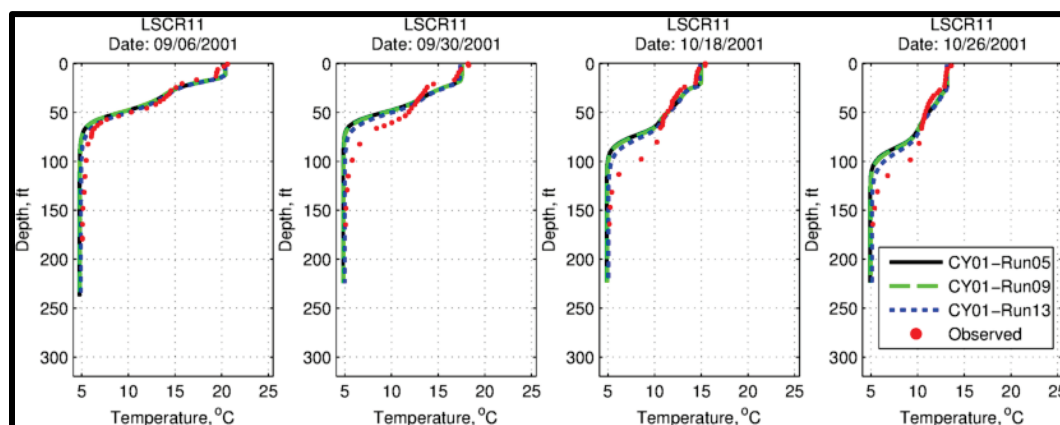
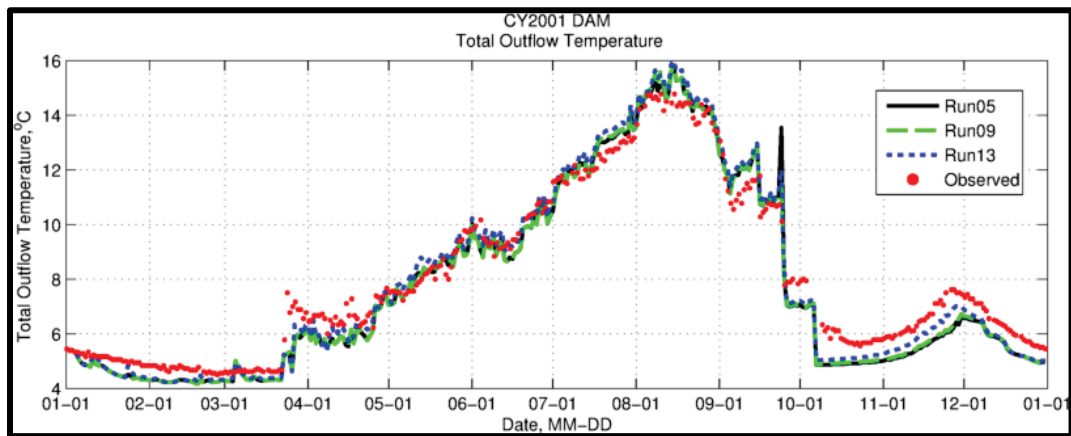


Figure 37. Time series comparison at the dam for CY01.



6 Model Verification – CY03 and CY10

Model verification results are presented in this section. CY03 and 2010 were used because they had the same types of monitored data and similar available in-lake profile data. All of the plots and statistics presented in this section were developed in an identical manner to those in the previous section. Just as for the calibration runs, an inventory of data files can be found in Appendix B (Table B2).

6.1 Flow

Model output along with observed data for CY03 and 2010 at the dam is shown in Figure 38 and Figure 39. Again, this is really just a representation that the data is read correctly from the input outflow file. The AME for all data pairs for 2005 at the dam is 0.08 cfs, which is well less than 0.5% of the measured range of flows for the calendar year. Table 8 presents the 1% AME target that ERDC attempted to reach. The slope of the trendline fitted through the data pairs is 1.00, and the R-squared value is 1.0. Overall, the model only underpredicts outflow at the dam by less than 0.01 cfs.

Table 8. 1% Target for flow (cfs) for CY03 verification.

SITE	Observed Minimum	Observed Maximum	Target AME	AME	ME	Slope	R-Squared
Dam - 2003	800.00	5590.00	47.90	0.19	-0.03	1.00	1.00
Dam - 2010	710.00	5820.00	51.10	0.90	0.68	1.00	1.00

Figure 38. Withdrawal flow at the dam for CY03 verification.

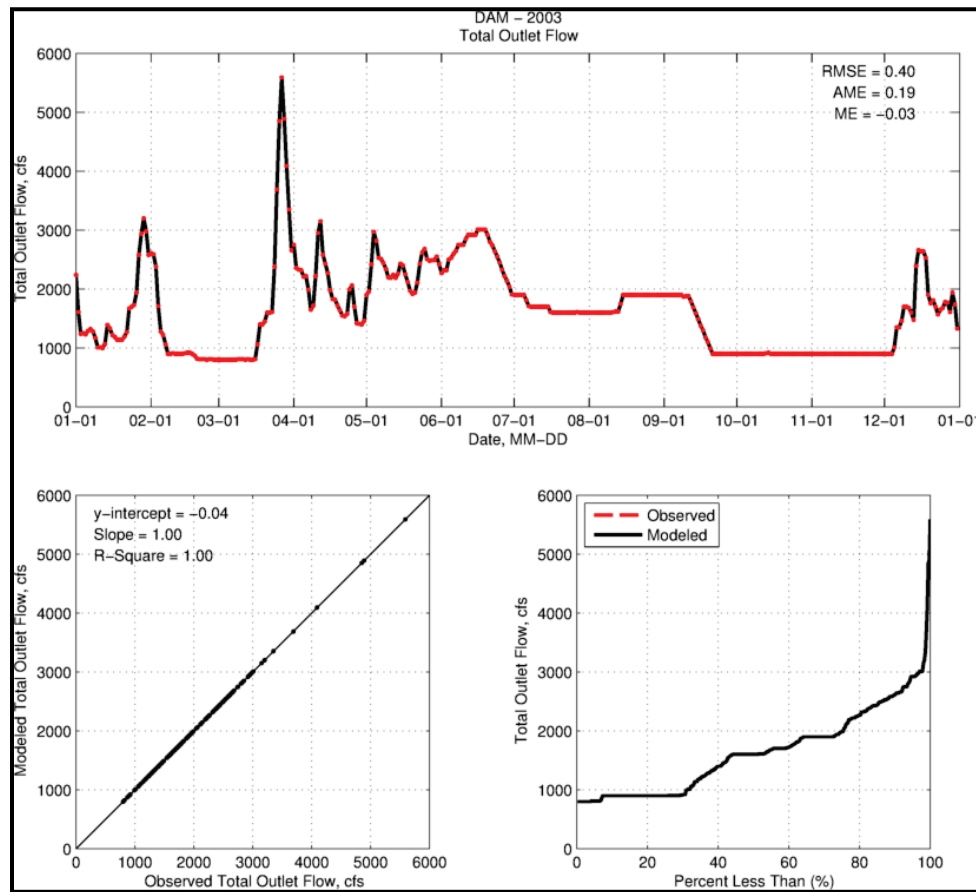
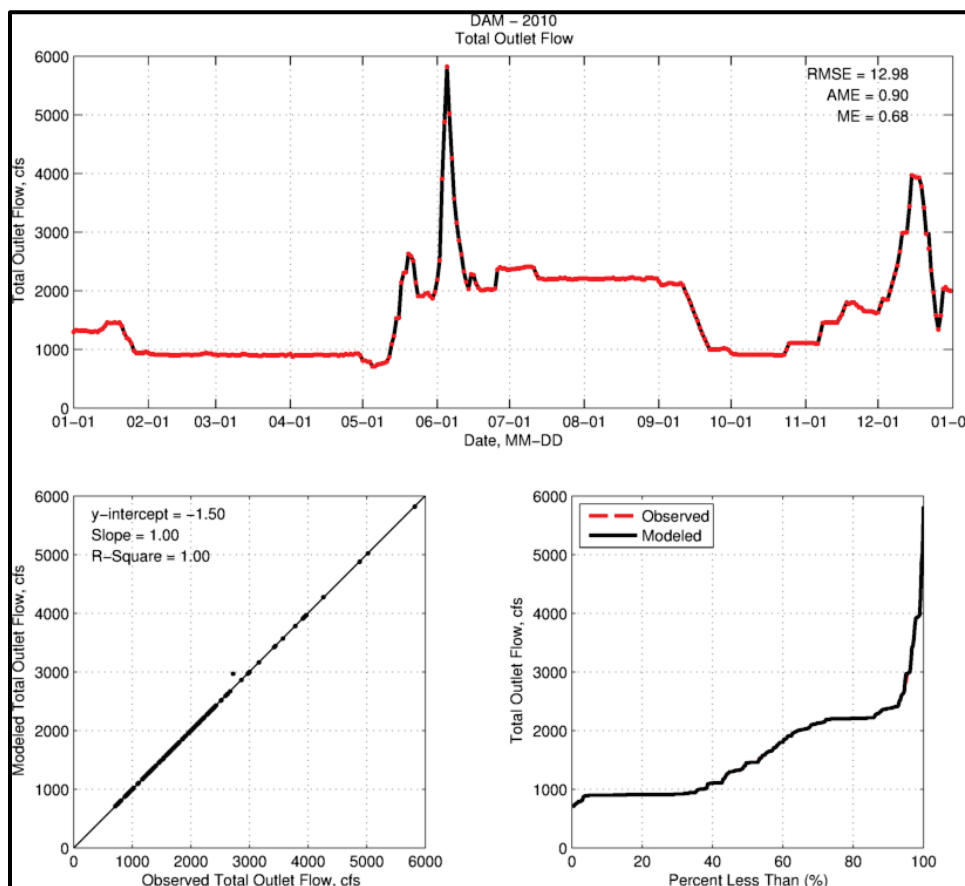


Figure 39. Withdrawal flow at the dam for CY10 verification.



6.2 Temperature

The data available for the verification years was a little different than in CY01. For CY03, only one sample data at one station was available (August 23 at LSCR11). For CY10, no true in-lake stations were monitored. In order to provide feedback on in-lake temperatures, ERDC chose to use temperatures from selected dates available from the temperature string located at the dam (in place since 2006). It is important to note that the temperature string data was only available through May. The 15th day of Jan-May was chosen as representative for each month in CY10. The segments used for data comparison can be found in Table 2.

Profile plots and statistical plots for all in-lake monitoring sites are presented in Figure 40-Figure 43. Time series plots and statistical plots are presented for the dam in Figure 44 (CY03) and Figure 45 (CY10). Table 9 presents the calculated AME and the temperature target that ERDC attempted to reach for the in-lake sites and for the outflow temperature at the dam. The average AME for each of the in-lake sites are

within the acceptable target of 1 deg-C. Based on Figure 41 and Figure 43, the average slope of the trendlines is 0.75 and the R-squared value is 0.90 for the in-lake profile site LSCR11 (dam temperature string) for both years. Overall, the model only underpredicts temperature at this site by approximately 0.51 deg-C in CY03 and 0.39 deg-C in CY10. At the dam (temperature string), the AME is 0.47 deg-C and 0.63 deg-C for CY03 and CY10, respectively (see Figure 44 and Figure 45). The model underpredicts temperature by an average of approximately 0.15 deg-C at the dam.

Table 9. Temperature stats (deg-C) for verification years.

SITE	Observed Minimum	Observed Maximum	Target AME	AME	ME	SLOPE	R-squared
LSCR11 (CY03 – one day only)	5.25	23.93	1.00	0.33	-0.25	0.98	0.99
Dam Temp. String (CY10 AVG)	4.51	14.72	1.00	0.53	-0.20	0.51	0.80
Dam (CY03)	4.72	13.50	1.00	0.48	0.06	1.12	0.97
Dam (CY10)	4.89	13.89	1.00	0.64	0.09	1.18	0.96

Figure 40. Temperature profile at LSCR11 in CY03 verification.

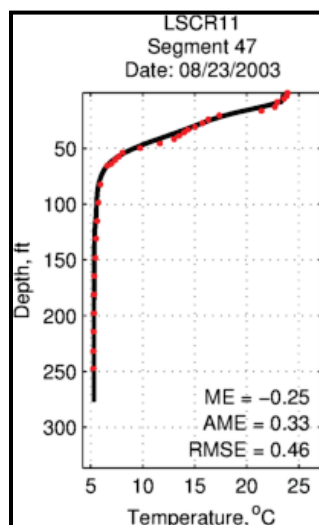


Figure 41. Flow linear and cumulative distribution plots at LSCR11 for CY03 verification.

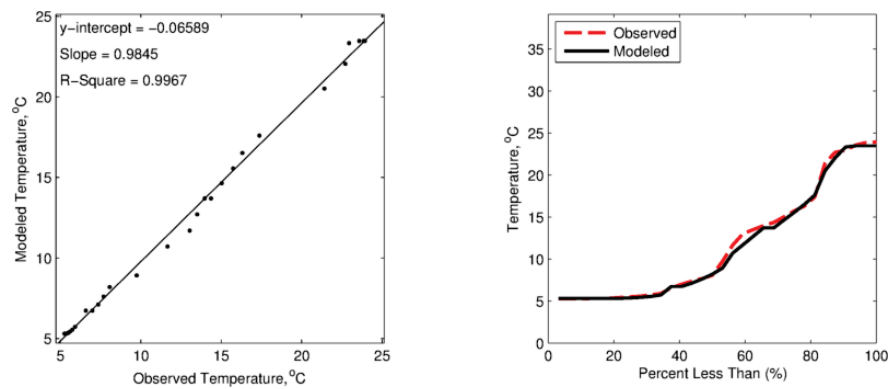


Figure 42. Temperature profiles at the dam temperature string in CY10 verification.

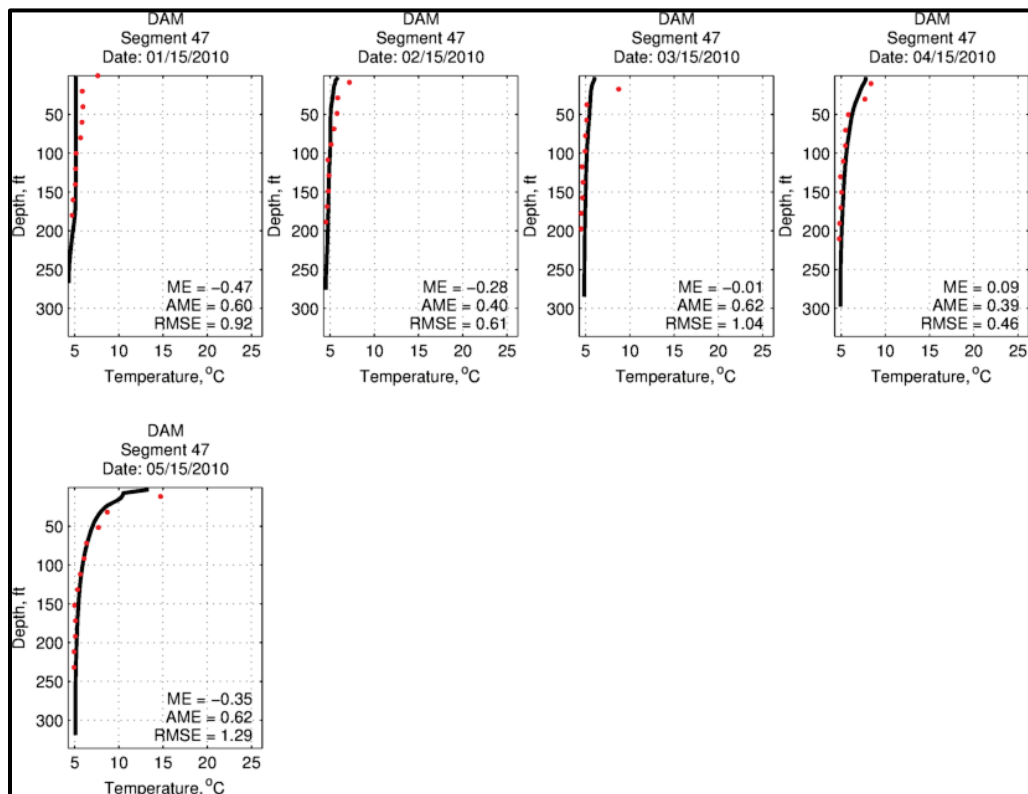


Figure 43. Flow linear and cumulative distribution plots at the dam temperature string for CY10 verification.

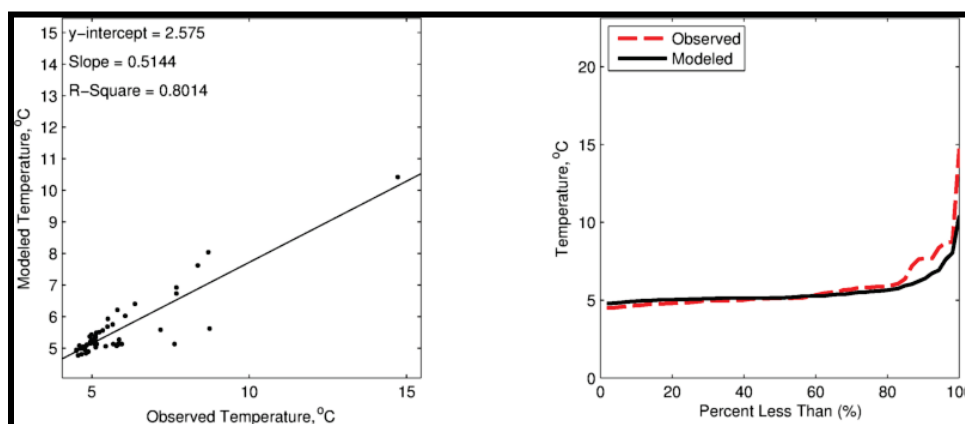


Figure 44. Withdrawal temperature at the dam for CY03 verification.

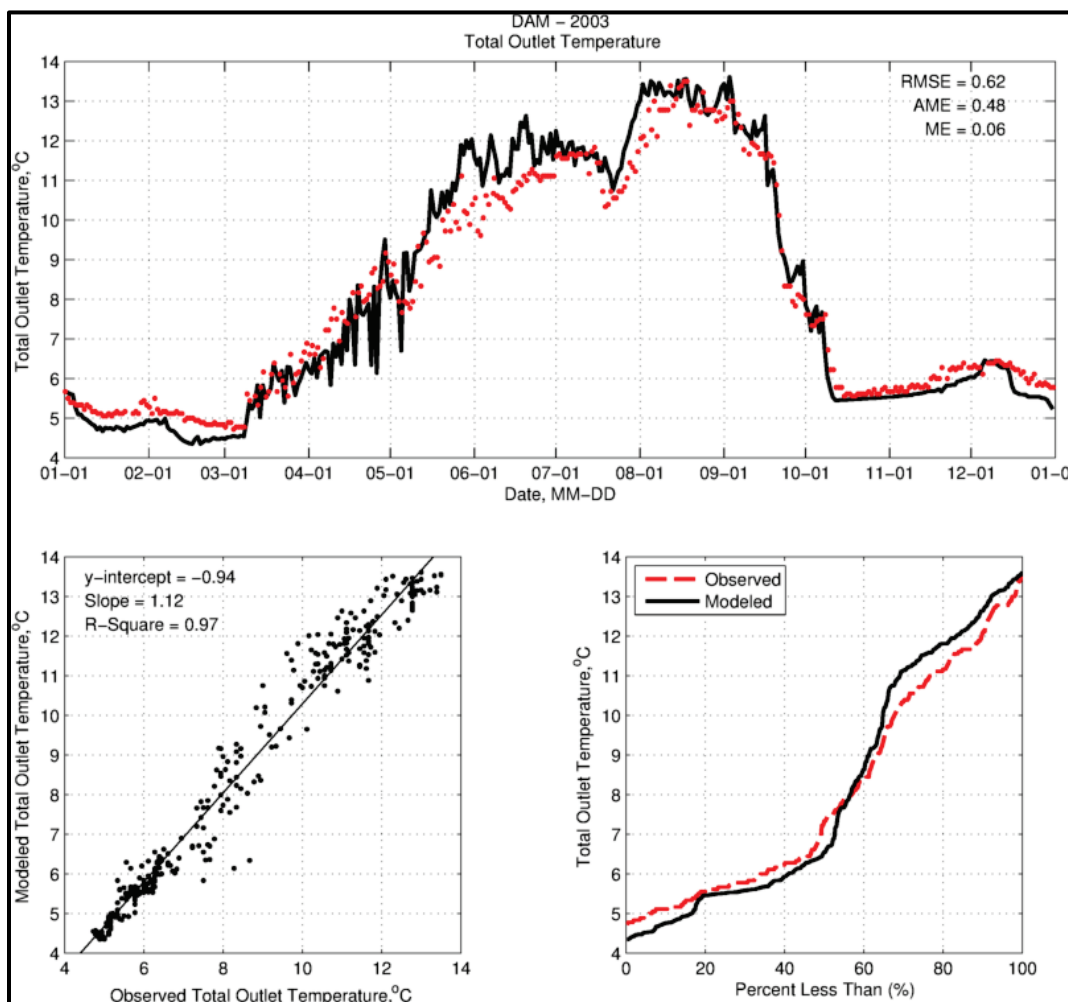
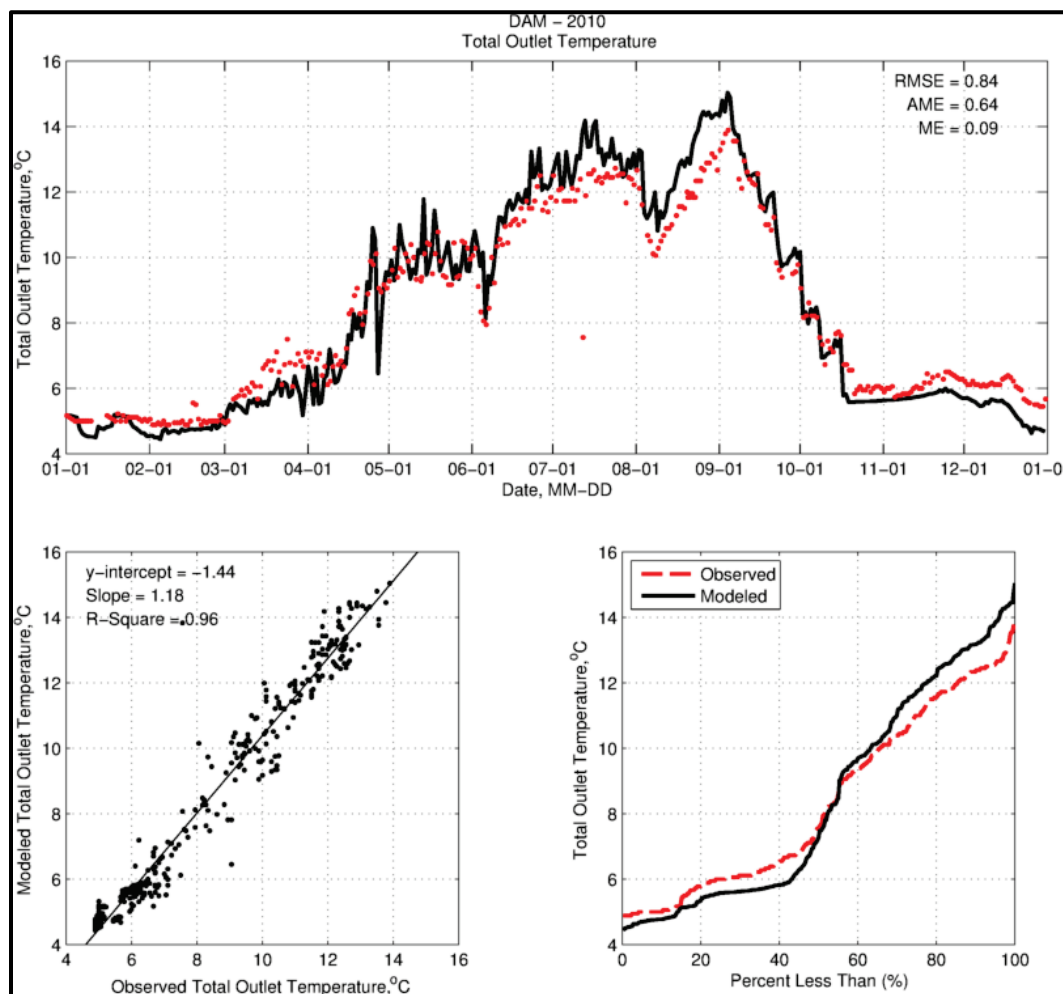


Figure 45. Withdrawal temperature at the dam for CY10 verification.



6.3 Water surface elevation

Model output along with observed data for ELWS CY03 at the dam is shown in Figure 46 and in Figure 47 for CY10. Table 10 presents several stats and lists the target AME for each verification year.

Table 10. Basic statistics water surface elevations (ft) for CY03 verification.

SITE	Observed Minimum	Observed Maximum	Target AME	AME	ME	Slope	R-Squared
Dam (CY03)	1808.78	1872.01	1.64	0.61	-0.48	0.99	1.00
Dam (CY10)	1807.43	1872.60	1.64	0.43	-0.43	1.01	1.00

Figure 46. Water surface elevations at the dam for CY03 verification.

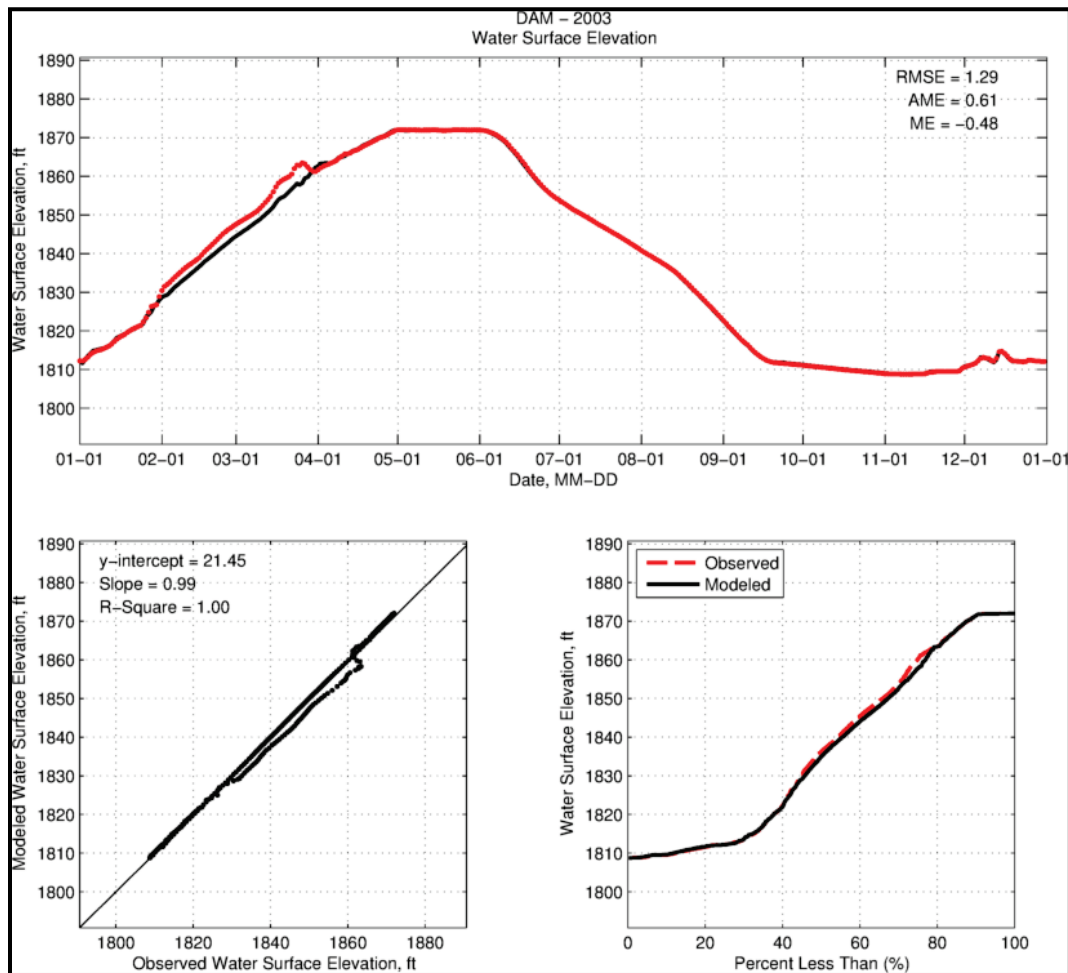
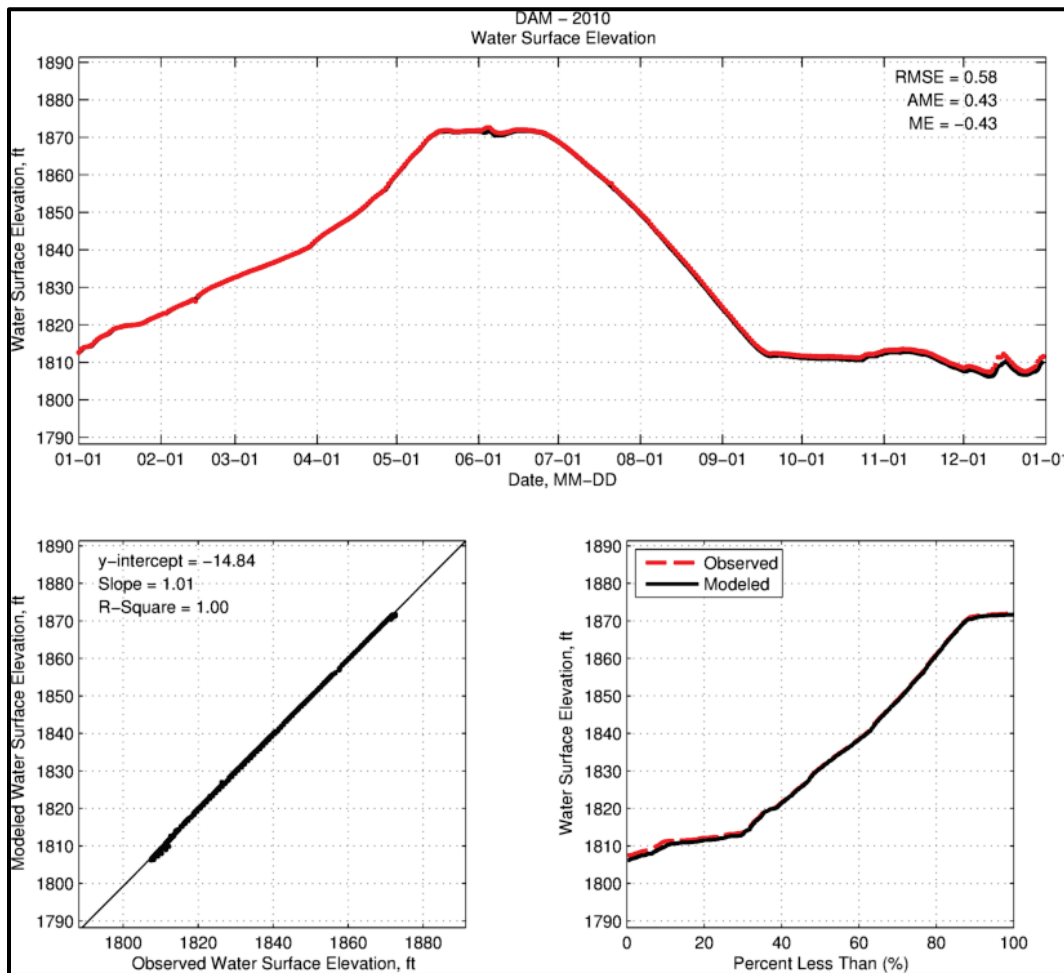


Figure 47. Water surface elevations at the dam for CY10 verification.



7 Verification Discussion

This section serves to discuss the results and the impacts that changes have made on the model runs. Due to the similarity in available input data for each of the verification years compared to the calibration year, no changes were made to the control file. Just as for CY01, a distributed tributary was needed for both calendar years. The water balance utility used to calculate the distributed tributary flow had to be run two times for CY03 due to a sudden increase in the water surface elevations between February and April (see Figure 46). A distributed tributary is utilized in W2 when there is an inconsistent trend with the water balance and when the user can account for missing or too much flow (i.e., ungauged flows). It can be used to add or remove water from the system. In the case of the LCLM, a distributed tributary was used to add water to the system.

To develop a distributed tributary input file, initial model output and observed elevations must be input into the Water Balance Utility developed by Portland State University for use with W2. In the case of the LCLM for CY03, the utility had to be run two times on consecutive runs in order to obtain an acceptable water balance. Additionally, in the event the Water Balance Utility calculated negative flows, these flows were adjusted so that only positive flows were introduced in the model. More information on developing a distributed tributary file can be found in the “Release Notes” that accompany the full W2 download along with the Users’ Manual.

8 Predictive Port Selection Model Application

In order to provide CENWP with the best model to use for operation modifications, the calibrated model was used as a base run to set up a fully predictive model. The model will guide dam operations based on desired temperature targets. The temperature target presented is the bi-weekly target developed by Oregon Department of Fish and Wildlife for 2014 operations. The current version of W2 (v3.71 – 07/15/14) has an algorithm in it to do just this; however, it is limited to only blending temperatures with only two ports at a time. Oftentimes, even the calibration, as previously reported, has three to four ports operating at a time. Upon recommendation from CENWP, ERDC-EL reached out to Stewart Rounds (USGS) to see whether he would be willing to share his version of a less restrictive blending algorithm that is fully integrated with a previous version of W2 (v3.7 from 2012). Mr. Rounds provided ERDC-EL with his code and executables; the results from the USGS version of W2 will be presented in this section. Briefly, the PSU version of W2 results will be discussed as well. An inventory of all files used for each model simulation can be found in Appendix B (Table B3).

8.1 PSU – W2 predictive port selection

PSU's current version of W2 has not fully integrated the algorithm developed by Mr. Rounds at USGS. According to personal correspondence with Dr. Scott Wells (2014), however, it is definitely on the list of model improvements for a future release. W2 is limited to blending temperatures between only two ports. In order to optimize the temperature release, the user must run the model multiple times with minor adjustments (date and temperature adjustments in the w2_selective.npt file). Below are the steps required to run the PSU-Predictive model:

1. Begin with base calibration run for desired year.
2. Place all outflows in topmost port.
3. Run the model with the automatic selection of outlet port control (DYNSTR1 CONTROL) turned ON. This will result in a qwo file that contains information regarding elevation of the withdrawal to get the closest desired temperature.

4. Based on the results from (3) above, create a new QOT input file. Ex: If in the QWO file from (3), flow was specified at the 4th intake port for days 300-365, then in the new QOT file for days 300-365, move the original flow into the column for intake 4.
5. Now turn OFF the DYNSTR1 CONTROL card turned on in (3). Turn ON the SPLIT1 CNTR card. Based on the results from (3), take a best guess on when blending should occur between which ports and update the SPLIT2 cards. Use the desired temperature targets in the TTARGET column.
6. Rerun and plot results. Based on results, modify the SPLIT2 cards as needed and rerun. Repeat this step as necessary.

As one can see, this method is quite cumbersome for the end user. At any point, the user wants to blend between more than 2 ports, more steps have to be repeated. It is a long and tedious task.

Model simulations were run for all years using the PSU version of the code; the results will be presented with the USGS results in the next section.

8.2 USGS – W2 predictive port selection

Detailed information on the development and modifications to the original W2 code can be found in “Improved Algorithms in the CE–QUAL–W2 Water-Quality Model for Blending Dam Releases to Meet Downstream Water-Temperature Targets” (Rounds and Buccola 2015) . Specifics relating to setup of the Lost Creek Lake Predictive Model (LCLPM) will be discussed here. The USGS code uses an iterative process to determine the optimal flows that will produce the desired target temperatures. Of course, this means that the run time will also increase. In the case of the LCLPM, using this code tripled the run time (from about 3-5 minutes to 10-12 minutes).

There were no changes to the main control file from the calibration model (aside from output filename changes). All changes that were made were made in the w2_selective.npt file, which is required when the SELECTC card in the control file is turned ON. Although the structure of the w2_selective.npt file is very similar to the PSU version, there are several new options. The new cards are:

1. TSSSHARE: when blending occurs between two ports, having this option ON allows the flows to be best distributed based on desired temperature instead of an even 50-50 split between multiple outlets. (NOTE: For the LCLPM, this was set to ON.)
2. DEPTH: when a non-zero value is input, this allows the model to treat the outlet as a floating outlet. (NOTE: For the LCLPM, DEPTH was set to 0 since Lost Creek Dam consists of fixed ports.)
3. MINFRAC: this specifies the minimum flow rate (when a negative value is entered) or fraction (when a value 0-1 is entered) for a port when that port is active. (NOTE: For the LCLPM, according to the WCM ((USACE 1990), 19% of the flow from the lowest intake is associated with flows at that level. The rest of the flow is assumed to come from the turbidity conduit.)
4. PRIORITY: this specifies the priority for port operations. (NOTE: During various times of the year, CENWP operates to use more surface water sometimes and at other times, the cold lower waters are used. So for the fall and winter months, the priority was shifted to the bottom two ports. Outside of that the priority was to use the topmost port.)
5. MINHEAD: This is the minimum depth in meters for the outlet to be used. (NOTE: Technically, this should be set to 5 m, but since the centerline in the calibration run accounts for the intake roof and minimum head, the ERCD-EL chose not to modify the ESTR card in the W2_control.npt file. With that said, the LCLPM MINHEAD conditions are all set to 0.)
6. MAXHEAD: This is the maximum depth in meters for the outlet to be used. (NOTE: LCLPM MAXHEAD values are set to 0, as well.)
7. MAXFLOW: This is the maximum flow capacity of the port. A zero value indicates no maximum flow criterion. (NOTE: LCLPM values are all set to 0.)

As mentioned above, the minimum head values are accounted for in the specification of the ESTR in the main control file. Since this file was not modified, a MINHEAD was not specified. In the LCLPM w2_selective.npt file, the user will find that three split times were identified. The reason these dates were identified is due to operational constraints with seasonal withdrawal depths. Specifying it this way allowed ERDC-EL to set the PRIORITY based on which ports were desired.

The only other caveat that should be mentioned here is that, although only 19% of the flow from the lowest intake is taken at the level, there was no

easy way to have the model ONLY use 19% of the flow from here. As the model is set up now with TSSSHARE ON and with Intake 4 and the turbidity conduit having the same priority, when flows are taken from either of those ports, a MINIMUM of 19% of the flow will be taken from the total flow. The remaining flow will be split between the two to optimize temperature targets; this results in the fact that more than 19% of the flow is actually taken at the elevation of Intake 4 instead of a hard 19-81% split between the intake and the turbidity conduit.

The user should note that in all of the following plots, the red lines represent a temperature target range. The ODFW targets are used for determining the target values; however, what is represented on the following plots is a target range, which is the ODFW temperature target ± 1 deg-C, which is a standard measuring error for temperature.

Figure 48 is the w2_selective file used for all of the LCLPM model runs. Figure 49-Figure 59 are plots from CY01 (dry year) that compare the results from the calibration, the results from the PSU-W2 blending algorithm, and the results from the USGS-W2 blending algorithm. Figure 60-Figure 70 represent the same plots for CY03 (normal year), and Figure 71-Figure 81 represent CY10 (wet year). As one can see, the outflow temperatures are fairly consistent between the two blending algorithms; however, the flows and the releases are drastically different at times. Figure 82 shows the average percentage of model-predicted temperatures that fall within the desired target range. As one can see, the USGS algorithm produces better results more often than the calibration run and more often than the multi-step PSU version. To save the user multiple runs for the predictive mode model, ERDC-EL suggests that the USGS algorithm be used.

Figure 48. W2_Selective.NPT file used for the LCLPM.

```

W2_SELECTIVE.NPT

Selective input control file - LCL-CV01 USGS PortRun13
Temperature outlet control - frequency of output for temperature
OUT FREQ TFRQTMP
1.000
Structure outlet control based on time and temperature and branch
DYNSTR1 CONTROL NUM FREQ
OFF 1 0.50

DYNSTR2 ST/WD JB JS/NW YEARLY TSTR TEND TEMP NELEV ELEV1 ELEV2 ELEV3 ELEV4 ELEV5
1 ST 1 1 ON 1.0 46.0 3.3 5 564.642 547.878 529.590 502.158 488.442

MONITOR LOC ISEG ELEV DYNCEL
1 0 -1.0 OFF

AUTO ELEVCONTROL
1 ON

SPLIT1 CNTR NUM TSFREQ TSCONV
ON 3 0.250 0.005

SPLIT2 ST/WD JB YEARLY TSTR TEND TTARGET DYNSEL ELCONT NOUIS TSSHARE
1 ST 1 ON 1.0 60.0 3.0 ON OFF 5 ON
2 ST 1 ON 60.1 274.0 3.0 ON OFF 5 ON
3 ST 1 ON 274.1 366.0 3.0 ON OFF 5 ON

SPLITOUT JS1/NW1 JS2/NW2 JS3/NW3 JS4/NW4 JS5/NW5 JS6/NW6 JS7/NW7 JS8/NW8 JS9/NW9 JS10/NW10
1 1 2 3 4 5
2 1 2 3 4 5
3 1 2 3 4 5

DEPTH DEPTH1 DEPTH2 DEPTH3 DEPTH4 DEPTH5 DEPTH6 DEPTH7 DEPTH8 DEPTH9 DEPTH10
1 0 0 0 0 0 0 0 0 0
2 0 0 0 0 0 0 0 0 0
3 0 0 0 0 0 0 0 0 0

MINFRAC MINFRAC1 MINFRAC2 MINFRAC3 MINFRAC4 MINFRAC5 MINFRAC6 MINFRAC7 MINFRAC8 MINFRAC9 MINFRAC10
1 0 0 0 0 0.19 0.00
2 0 0 0 0 0.19 0.00
3 0 0 0 0 0.19 0.00

PRIORITY PRIOR1 PRIOR2 PRIOR3 PRIOR4 PRIOR5 PRIOR6 PRIOR7 PRIOR8 PRIOR9 PRIOR10
1 4 3 2 1 1
2 1 2 3 4 4
3 4 3 2 1 1

MINHEAD MINHD1 MINHD2 MINHD3 MINHD4 MINHD5 MINHD6 MINHD7 MINHD8 MINHD9 MINHD10
1 0 0 0 0 0 0 0 0 0
2 0 0 0 0 0 0 0 0 0
3 0 0 0 0 0 0 0 0 0

MAXHEAD MAXHD1 MAXHD2 MAXHD3 MAXHD4 MAXHD5 MAXHD6 MAXHD7 MAXHD8 MAXHD9 MAXHD10
1 0 0 0 0 0 0 0 0 0
2 0 0 0 0 0 0 0 0 0
3 0 0 0 0 0 0 0 0 0

MAXFLOW MAXFLO1 MAXFLO2 MAXFLO3 MAXFLO4 MAXFLO5 MAXFLO6 MAXFLO7 MAXFLO8 MAXFLO9 MAXFLO10
1 0 0 0 0 0 0 0 0 0
2 0 0 0 0 0 0 0 0 0
3 0 0 0 0 0 0 0 0 0

THRESH1 TEMPN
12

THRESH2 TEMPCRIT
1 4.50
2 5.30
3 5.30
4 6.75
5 8.65
6 12.00
7 14.25
8 14.00
9 12.30
10 8.95
11 6.45
12 5.00

```

(**NOTE: ELEV6-10 are cut off for better image clarity. These values are blank since there are only 5 ports.)

Figure 49. CY01 - LCLPM temperature comparison with target temperatures.

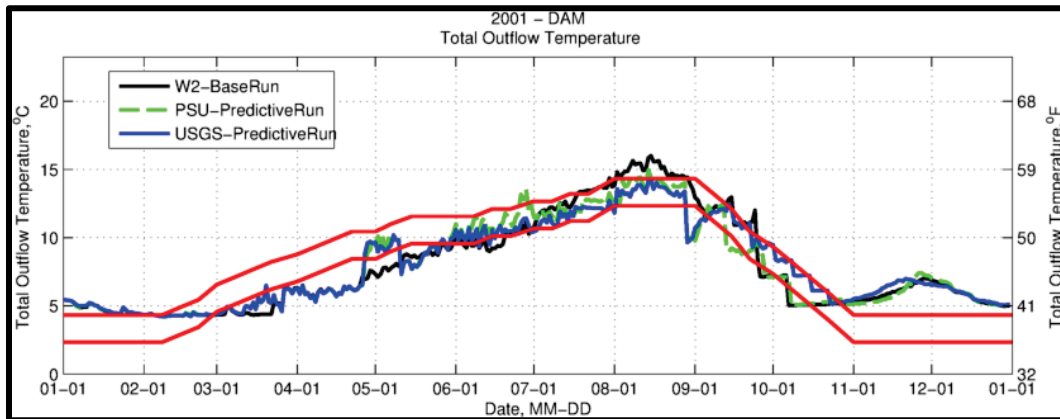


Figure 50. CY01 - Intake 1 - temperature into tower.

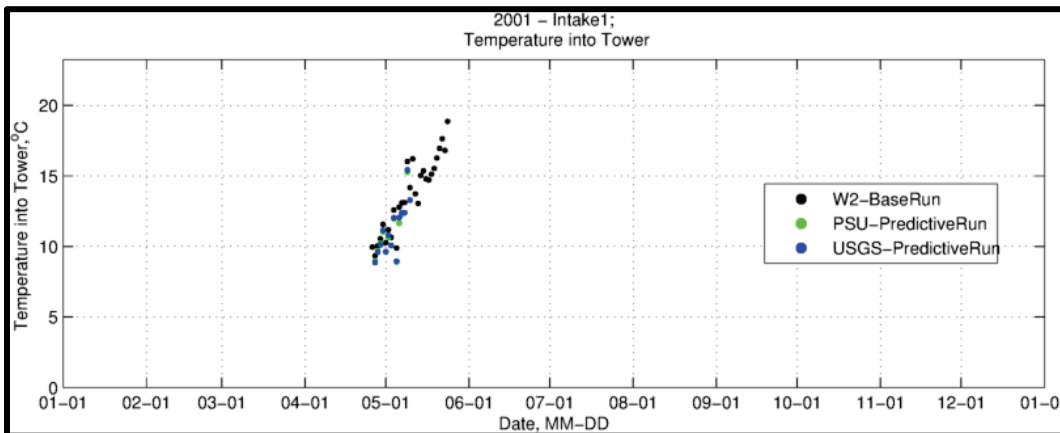


Figure 51. CY01 - Intake 2 - temperature into tower.

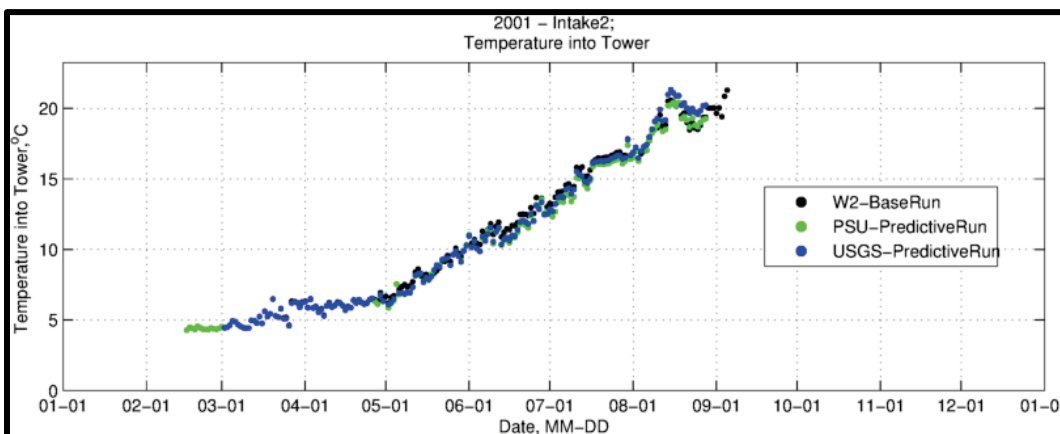


Figure 52. CY01 - Intake 3 - temperature into tower.

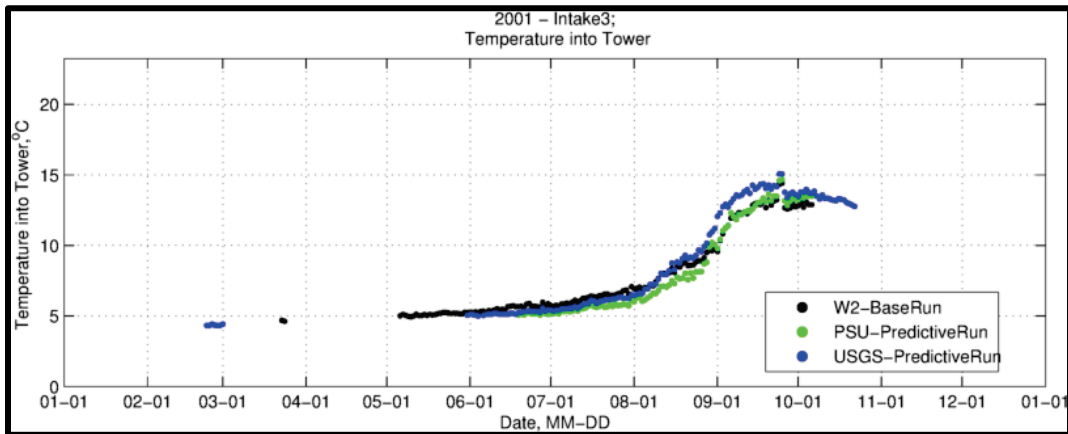


Figure 53. CY01 - Intake 4 - temperature into tower.

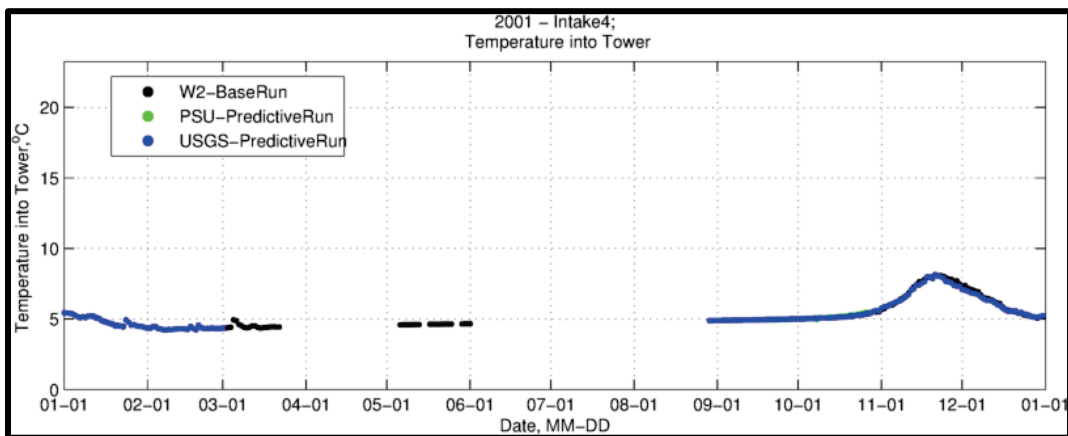


Figure 54. CY01 - Turbidity conduit - temperature into tower.

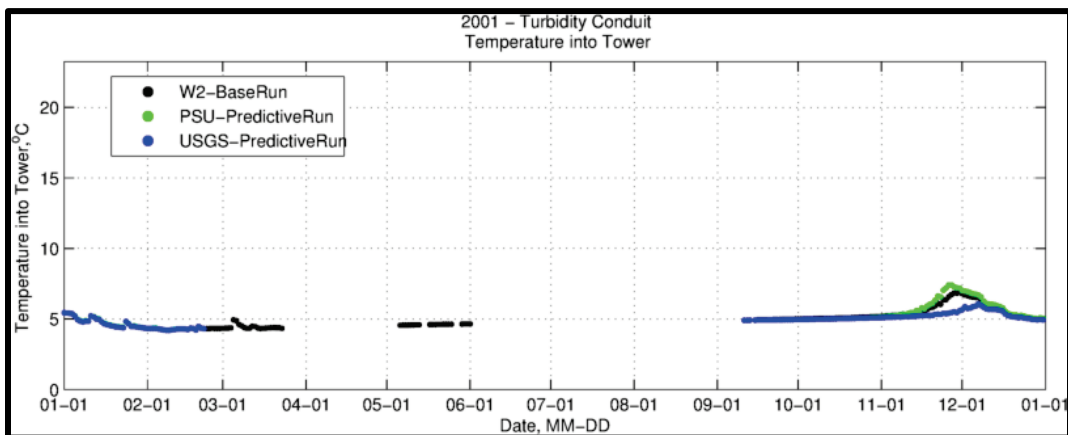


Figure 55. CY01 - Intake 1 - flow into tower.

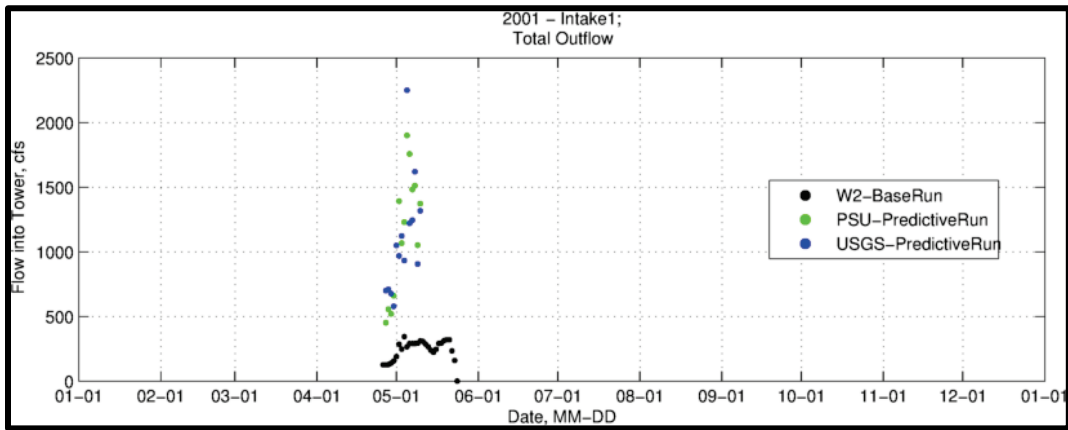


Figure 56. CY01 - Intake 2 - flow into tower.

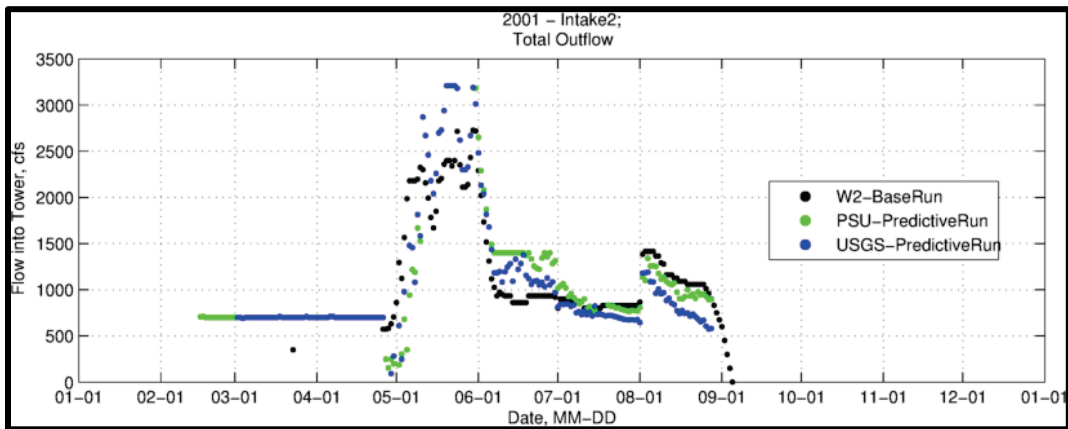


Figure 57. CY01 - Intake 3 - flow into tower.

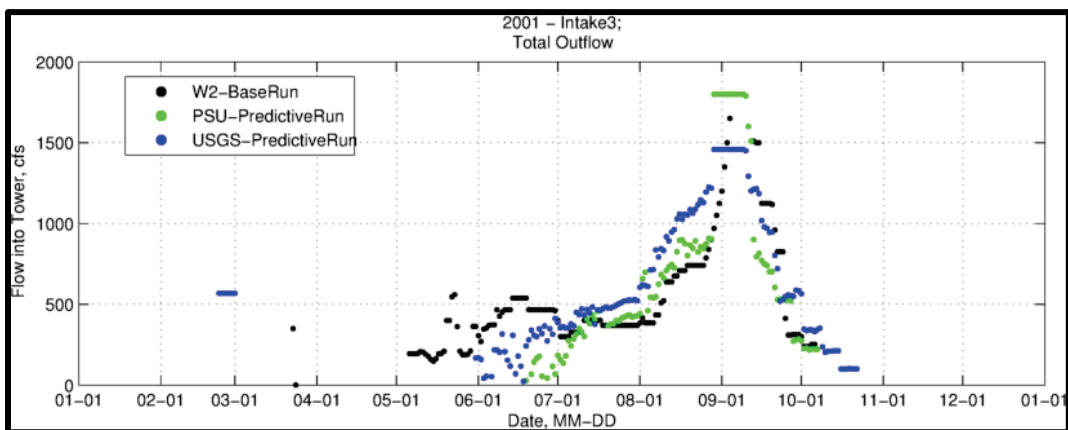


Figure 58. CY01 - Intake 4 - flow into tower.

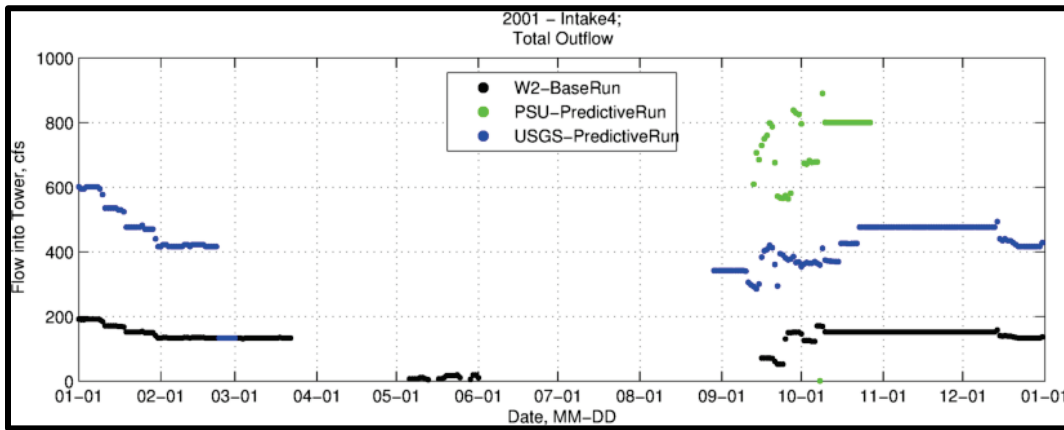


Figure 59. CY01 - Turbidity conduit - flow into tower.

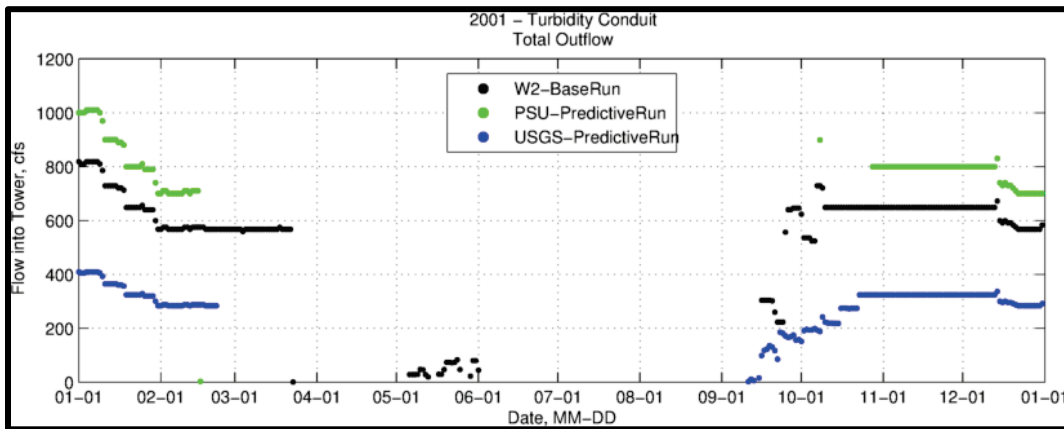


Figure 60. CY03 - LCLPM temperature comparison with target temperatures.

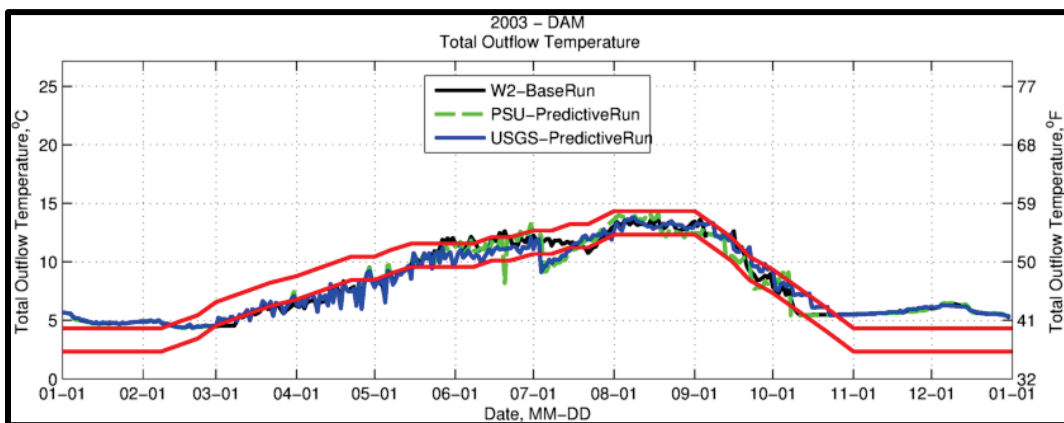


Figure 61. CY03 - Intake 1 - temperature into tower.

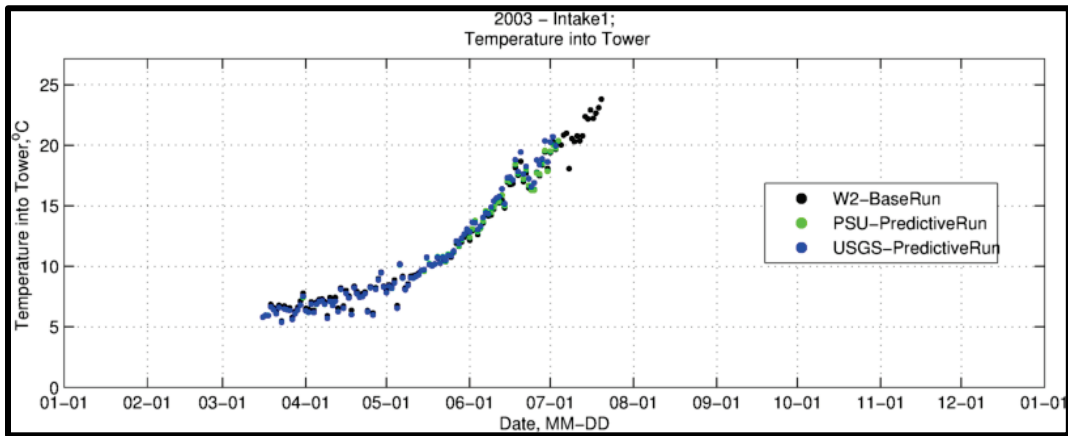


Figure 62. CY03 - Intake 2 - temperature into tower.

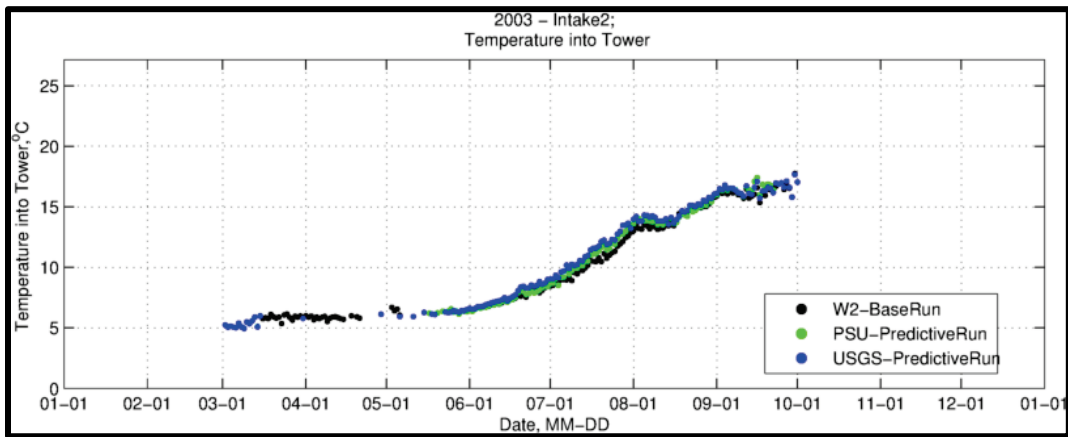


Figure 63. CY03 - Intake 3 - temperature into tower.

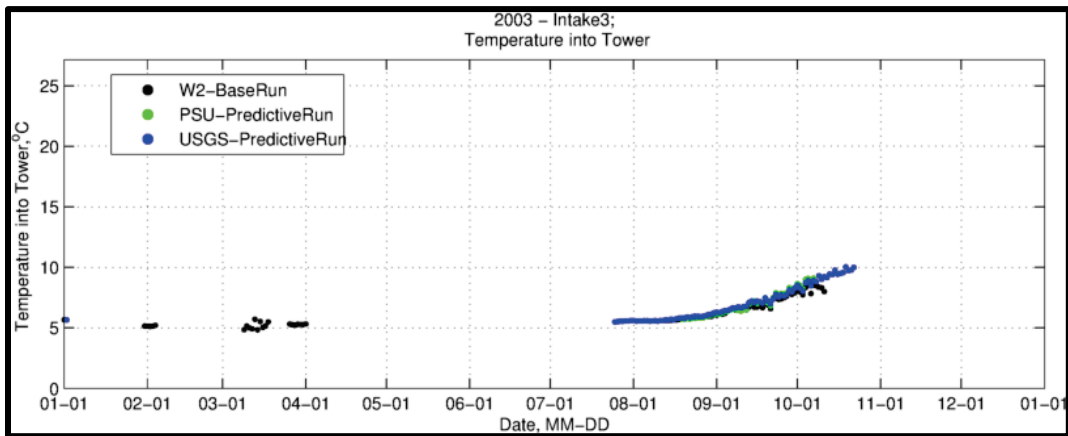


Figure 64. CY03 - Intake 4 - temperature into tower.

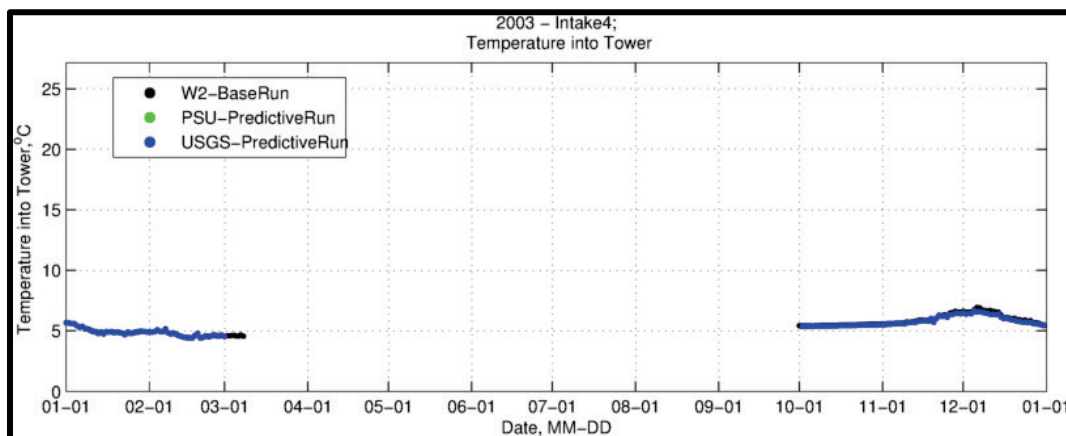


Figure 65. CY03 - Turbidity conduit - temperature into tower.

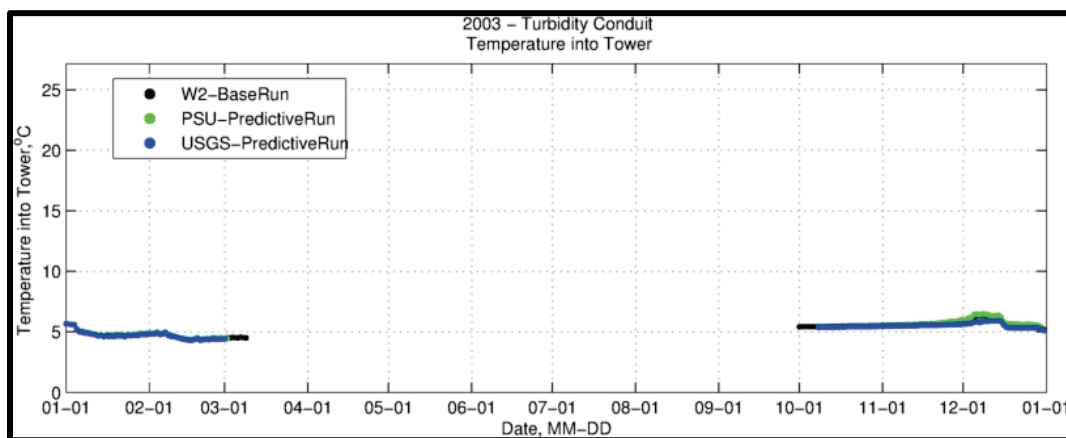


Figure 66. CY03 - Intake 1 - flow into tower.

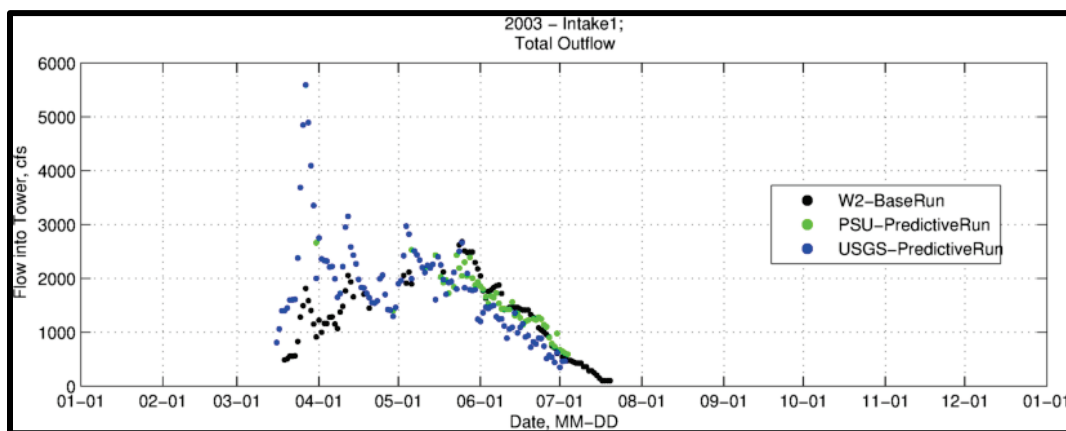


Figure 67. CY03 - Intake 2 - flow into tower.

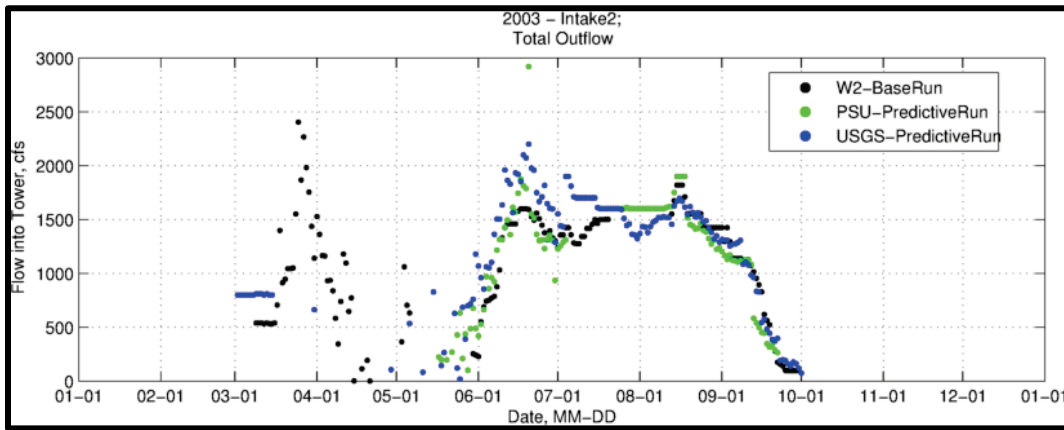


Figure 68. CY03 - Intake 3 - flow into tower.

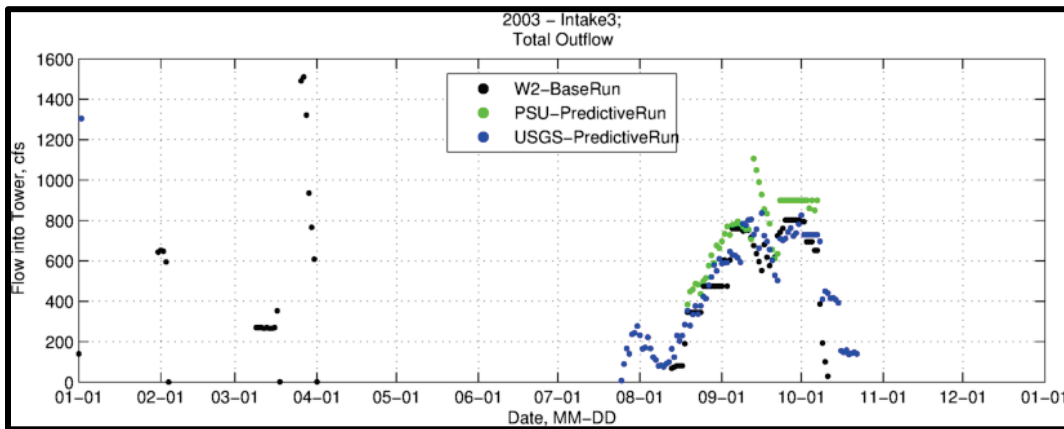


Figure 69. CY03 - Intake 4 - flow into tower.

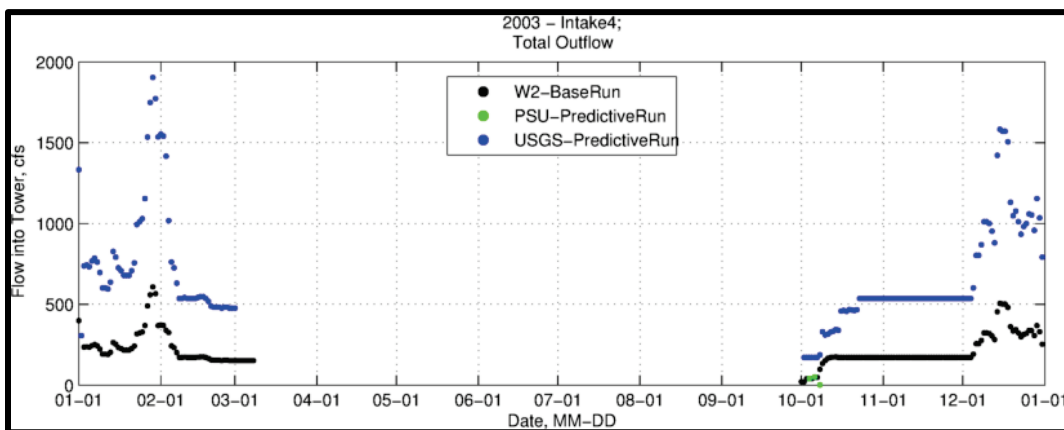


Figure 70. CY03 - Turbidity conduit - flow into tower.

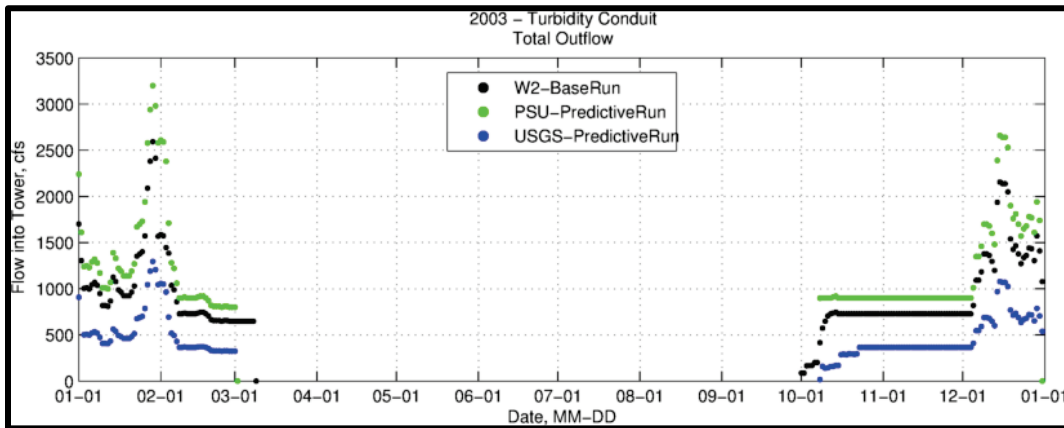


Figure 71. CY10 - LCLPM temperature comparison with target temperatures.

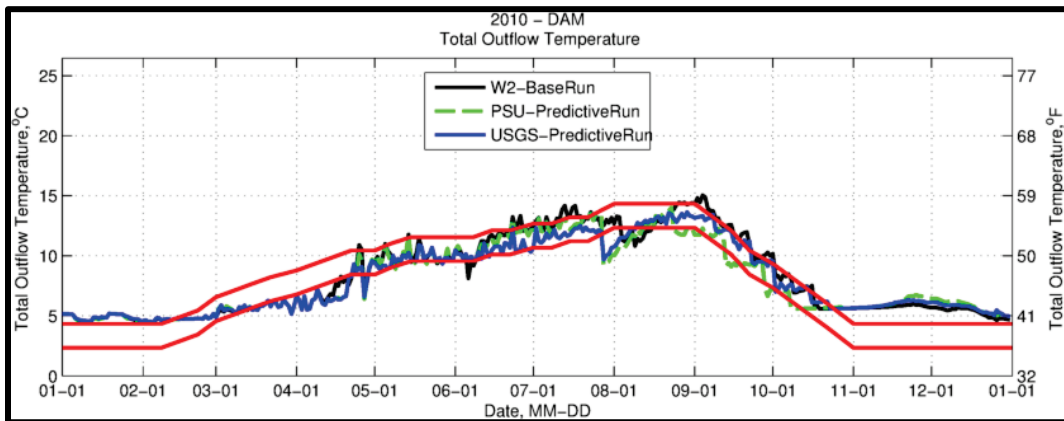


Figure 72. CY10 - Intake 1 - temperature into tower.

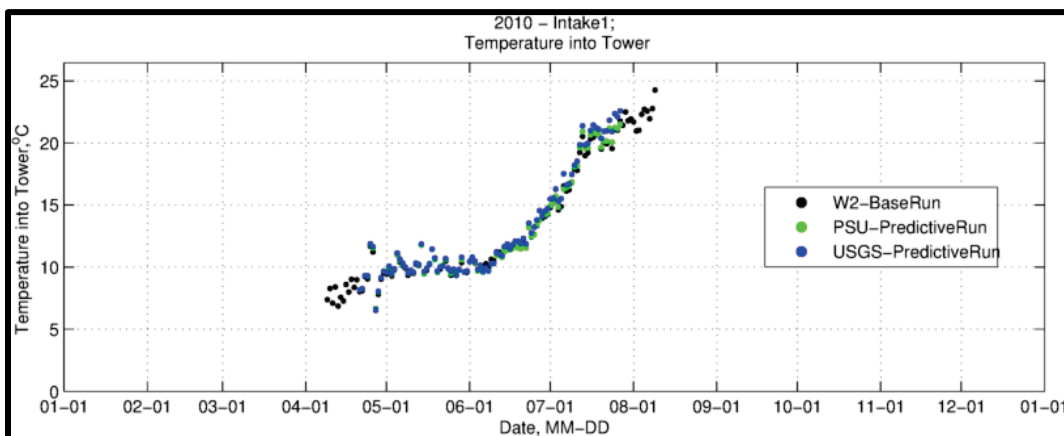


Figure 73. CY10 - Intake 2 - temperature into tower.

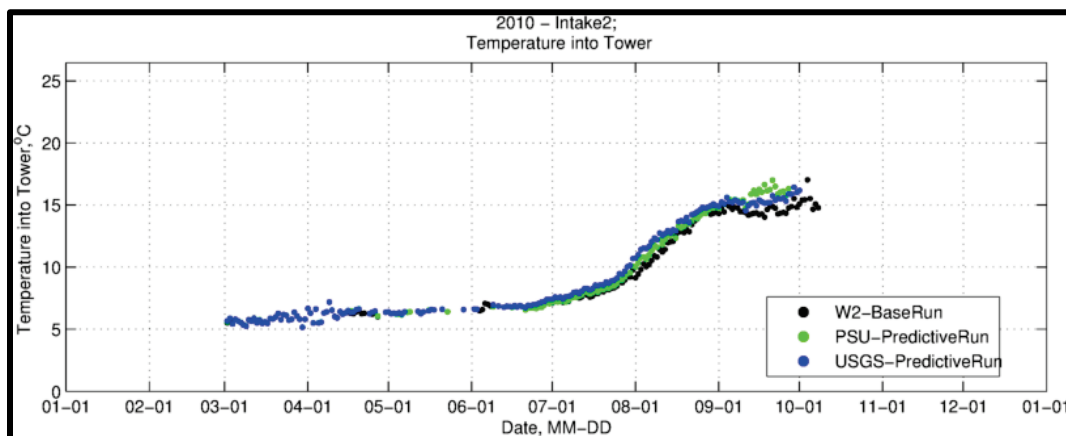


Figure 74. CY10 - Intake 3 - temperature into tower.

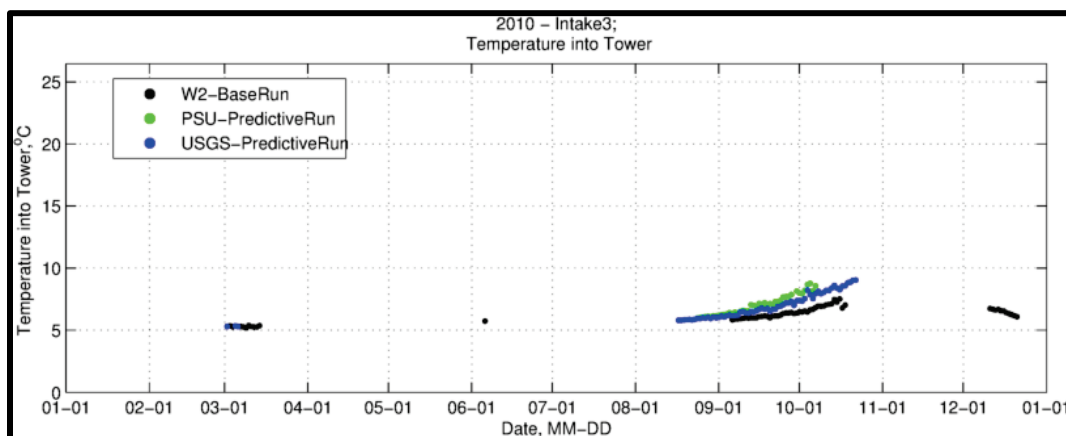


Figure 75. CY10 - Intake 4 - temperature into tower.

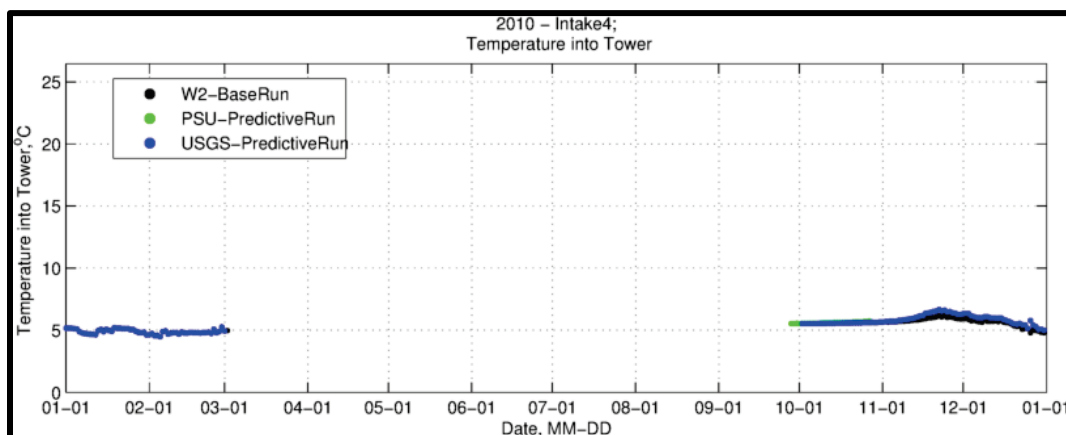


Figure 76. CY10 - Turbidity conduit - temperature into tower.

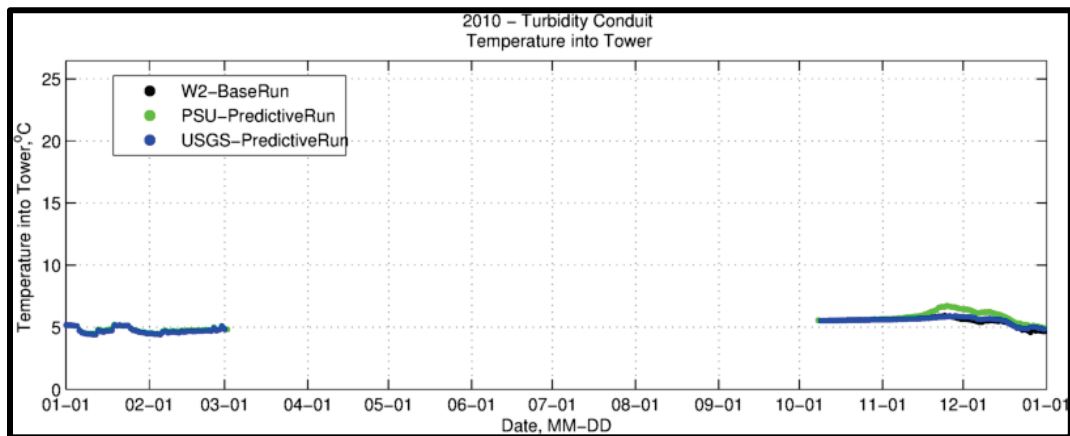


Figure 77. CY10 - Intake 1 - flow into tower.

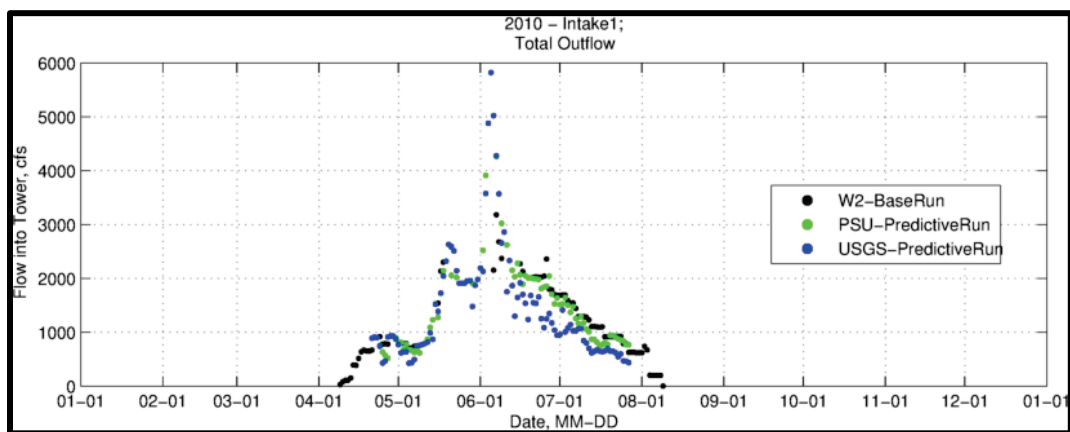


Figure 78. CY10 - Intake 2 - flow into tower.

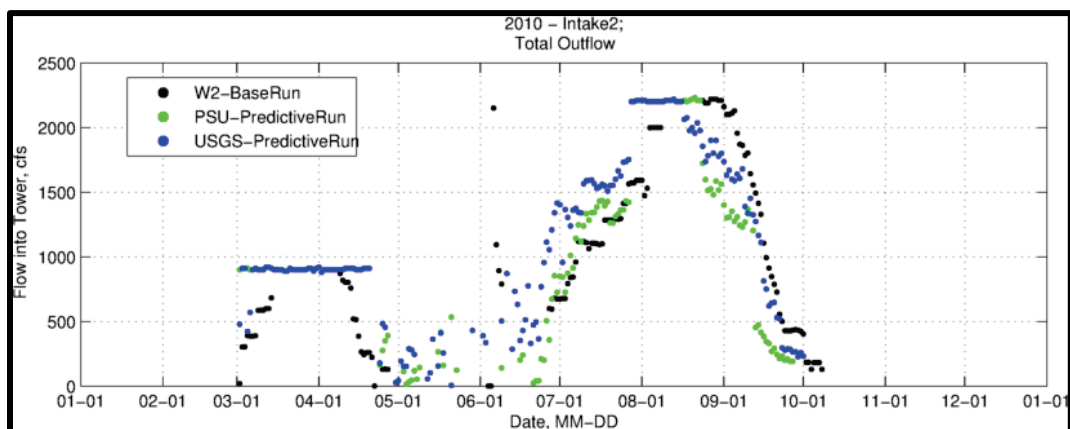


Figure 79. CY10 - Intake 3 - flow into tower.

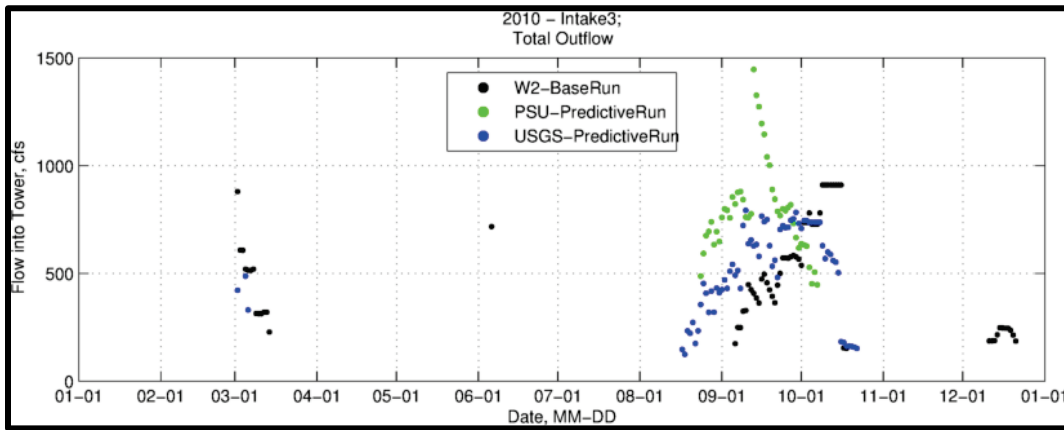


Figure 80. CY10 - Intake 4 - flow into tower.

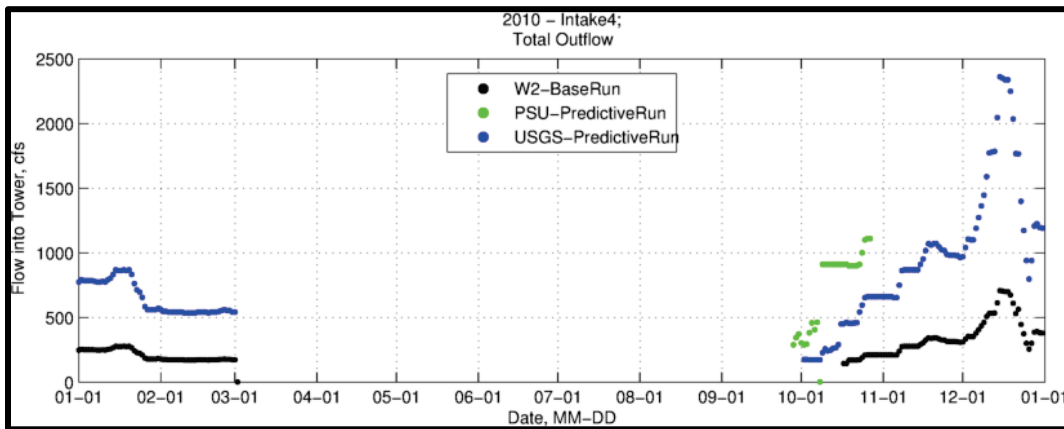


Figure 81. CY10 - Turbidity conduit - flow into tower.

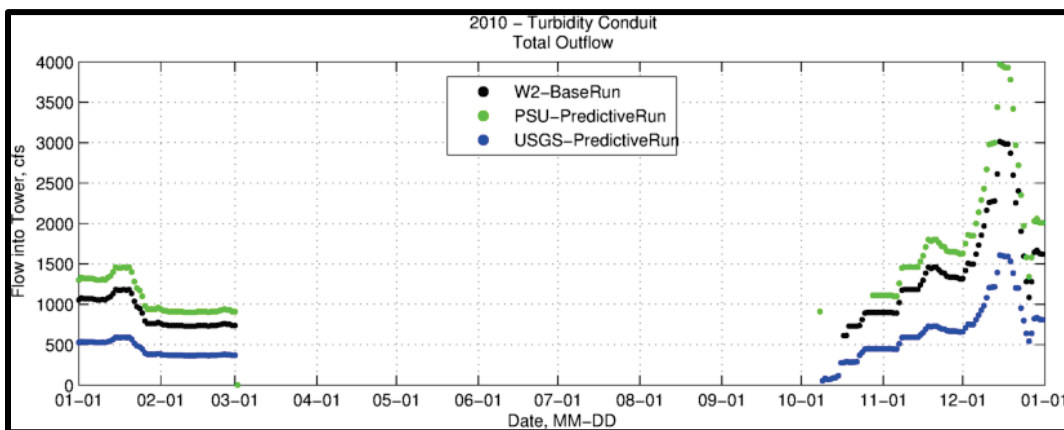


Figure 82. Average % of model temperature within the target range.



9 Summary and Conclusions

The USACE-ERDC-EL assisted CENWP in updating a W2 model of Lost Creek Lake based on inputs from an existing model of the reservoir. The model was calibrated using data from calendar year (CY) 2001 (dry), 2003 (normal), and 2010 (wet). Across all calendar years, the model captured the quantitative and qualitative trends for temperature and flow.

Quantitatively, the model predicted temperatures within 1.0 deg-C for most of the calibration sites (in-lake sites and at the dam), which is far better than many other temperature studies (Arhonditsis and Brett 2004). Qualitatively, trends were consistent with measured data. Model performance statistics were paired temporally and spatially closely with the measured data.

In addition to a fully updated calibrated model, ERDC-EL also developed an application of the model using modified W2 code from the USGS that allows for a better functioning blending algorithm between multiple ports. Using this algorithm has multiple advantages over the current version of W2:

1. One run produces the results needed to obtain the target temperature. With a few minutes spent in updating the w2_selective file, the user can generate the results with far fewer runs.
2. Multiple outlets can be blended to reach desired temperature. The current version of W2 (PSU) limits the user to at most two ports being blended.

The major downfall of the USGS code is that the base W2 code is not the latest version of the code. The base for the USGS code was the first release of W2v3.7. According to personal correspondence with Dr. Scott Wells (PSU) and Mr. Stewart Rounds, the PSU version of W2 will be updated in a future release to include all of the USGS updates. A secondary downfall of this code is that due to its iterative nature, the run time is also increased (almost tripled in the case of LCLPM).

This model and the corresponding results from the study provide CENWP with a fully capable model in determining how operational changes will impact downstream water temperature. This is extremely important

because the Rogue and Applegate temperature Total Maximum Daily Loads (TMDL), Rogue Spring Chinook Conservation Plan, and possibly the Rogue Fall Chinook Conservation Plan require the Corps to review the operations to determine whether improvements to downstream temperature for the benefit of endangered fish can be achieved.

Additional work to consider would be the impacts of these temperatures on fish with respect to egg emergence data. This model, coupled with an in-depth fish analysis, would provide CENWP with invaluable information regarding dam operations and the impacts to fish.

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Appendix A: Bathymetry File

This section contains an image of the bathymetry file used for the LCLM. The only difference between calendar years was the initial water surface elevation used in creating the bathymetry file. W2 V3.7 now has the capability to use a csv file developed in Excel. The images below (Figure A1-Figure A8) are pages from the Excel file used to develop the csv file; to read them correctly, it is important to know that page two contains the widths for the remaining depths of the reservoir for the first thirteen segments; page four gives the same information for segments 14-28, and so on. Table A1 is the initial water surface (ELWS) used in the development of the bathymetry files for each of the model simulations.

Table A1. Initial ELWS used in bathymetry files for all simulations.

Calendar Year	ELWS (m)	ELWS (ft)
Calibration-2001	552.13	1811.46
Verification-2003	552.37	1812.22
Verification-2010	552.49	1812.64

5 foot Creek Lake Railway - Updated from 18th to new version - December 17, 2017: updated angles and weights to better fit Google Earth data													
Line	1	2	3	4	5	6	7	8	9	10	11	12	13
DLX	0.00	300.00	300.00	300.00	300.00	300.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00
BLWS	552.265	552.265	552.265	552.265	552.265	552.265	552.265	552.265	552.265	552.265	552.265	552.265	552.265
PctG	0.002	0.002	1.296	0.588	0.175	0.262	0.611	0.338	2.096	1.322	1.222	1.222	1.222
ELEV	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
LAYER	BRI												
1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.000	0.000	0.000	371.820	139.700	178.900	149.100	151.700	144.300	150.000	150.000	230.000	235.000	235.000
1.000	0.000	48.800	89.600	131.100	165.800	139.900	145.000	140.000	188.300	171.500	233.000	233.000	233.000
1.000	0.000	32.800	75.500	125.100	154.100	131.800	142.000	170.700	181.800	171.500	210.000	214.000	307.000
1.000	0.000	23.000	69.200	113.000	144.000	127.000	138.000	163.000	177.200	167.000	194.000	200.000	296.000
1.000	0.000	9.800	27.500	45.500	70.900	51.700	61.700	73.000	84.000	73.000	84.000	100.000	100.000
1.000	0.000	19.000	52.000	100.000	133.700	118.400	127.000	154.500	167.500	159.000	183.000	197.200	278.000
1.000	0.000	0.000	46.800	102.400	174.500	113.700	123.000	149.300	161.700	164.000	177.900	191.400	271.000
1.000	0.000	0.000	40.800	96.500	157.700	109.000	116.800	140.000	157.900	150.200	172.900	187.000	234.000
1.000	0.000	0.000	90.000	35.400	90.700	112.400	104.600	114.700	139.800	152.300	168.000	184.000	257.000
1.000	0.000	0.000	29.400	54.000	109.400	120.000	117.900	134.000	148.800	141.900	169.700	178.300	250.000
1.000	0.000	0.000	24.000	24.500	79.700	96.500	96.100	107.000	129.000	144.600	138.000	163.000	174.000
1.000	0.000	0.000	72.000	27.500	27.500	91.700	103.700	120.000	140.000	140.000	155.000	166.000	200.000
1.000	0.000	0.000	22.000	65.500	82.000	87.400	102.000	121.700	137.000	130.700	152.000	165.000	231.000
1.000	0.000	0.000	0.000	45.000	78.500	84.800	98.000	120.000	136.000	130.000	151.000	165.000	229.000
1.000	0.000	0.000	0.000	34.000	54.000	72.600	81.200	99.000	117.000	133.000	127.800	149.000	163.000
1.000	0.000	0.000	36.000	0.000	36.000	66.000	76.700	91.700	107.000	124.000	124.000	145.000	162.000
1.000	0.000	0.000	0.000	24.100	62.000	73.200	89.100	119.000	126.000	120.000	142.000	156.000	217.000
1.000	0.000	0.000	0.000	18.000	55.000	67.800	85.000	105.000	122.600	117.200	138.000	151.000	233.000
1.000	0.000	0.000	0.000	0.000	48.800	63.100	81.						

[illegible]

Figure A3. Page 3 from bathymetry development Excel file.

try (WQ-Tools) - September 24, 2013, mace corrections for volume elevation curve November 15, 2013																											
14	15	16	17	18	19	20	21	22	23	24	25	26	27	28													
250.000	250.000	250.000	250.000	250.000	250.000	250.000	250.000	250.000	250.000	250.000	250.000	250.000	250.000	250.000													
552.345	552.345	552.345	552.345	552.345	552.345	552.345	552.345	552.345	552.345	552.345	552.345	552.345	552.345	552.345													
1.122	0.696	0.349	0.349	1.309	1.309	1.309	1.309	1.309	1.309	1.309	1.309	1.309	1.309	1.309													
0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025													
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000													
256.120	259.100	333.900	419.800	355.200	331.200	400.600	569.500	508.400	674.500	674.500	744.875	815.250	1025.200	1150.600													
242.700	251.800	336.100	410.000	334.100	317.700	381.700	561.600	495.200	666.300	666.300	738.007	809.714	1021.429	1140.600													
234.000	270.400	322.800	393.400	335.700	308.300	367.300	551.500	484.800	646.200	646.200	732.414	804.629	1017.857	1130.600													
219.000	269.800	313.700	384.100	311.900	287.100	349.700	541.400	477.100	632.400	632.400	715.671	788.543	1014.286	1110.000													
225.500	257.100	305.200	375.400	305.300	285.500	352.400	532.400	469.600	643.200	643.200	717.529	781.857	1010.714	1110.000													
271.700	270.800	298.400	367.400	298.400	270.100	347.400	524.400	463.700	633.600	633.600	709.511	784.411	1007.143	1100.000													
217.000	245.400	292.400	360.700	229.900	284.700	342.100	517.200	455.400	623.800	623.800	701.468	779.146	1003.571	1093.333													
212.800	248.200	284.600	354.400	282.600	279.600	336.400	509.900	448.500	613.600	613.600	693.225	772.850	1000.200	1086.467													
208.700	235.100	281.100	348.400	283.700	274.700	331.800	502.900	441.600	603.300	603.300	680.850	758.400	990.200	1050.000													
205.000	230.200	275.700	342.500	279.000	270.000	326.800	496.000	434.800	593.100	593.100	666.925	745.950	990.200	1033.233													
202.100	225.400	270.800	337.000	274.600	265.800	322.200	494.400	429.100	581.600	581.600	655.900	739.600	940.200	1024.667													
198.100	220.900	266.200	331.100	273.600	261.700	321.400	484.900	421.900	569.600	569.600	642.025	715.450	920.200	1000.000													
197.600	219.100	265.200	329.000	271.600	261.200	319.400	480.400	421.800	554.800	554.800	628.275	701.750	900.200	982.002													
196.400	217.400	263.600	326.100	269.400	259.000	317.300	477.600	419.600	546.900	546.900	619.567	691.567	894.005	964.005													
192.400	213.100	259.300	321.600	264.000	257.400	314.700	477.500	415.900	542.900	542.900	615.583	687.583	891.000	961.000													
192.100	212.300	257.900	317.100	261.900	252.200	308.400	477.400	407.600	542.000	542.000	615.583	687.583	891.000	961.000													
189.100	206.700	233.700	310.800	261.300	251.300	305.900	472.450	407.200	539.900	539.900	615.583	687.583	891.000	961.000													
186.100	205.200	231.500	304.400	257.700	247.800	300.500	467.500	401.000	536.300	536.300	615.583	687.583	891.000	961.000													
183.100	201.700	224.600	296.100	254.100	244.400	295.300	462.600	396.100	530.400	530.400	615.583	687.583	891.000	961.000													
180.200	198.200	221.600	291.700	250.400	241.100	290.300	457.500	390.000	524.500	524.500	615.583	687.583	891.000	961.000													
177.300	194.800	217.700	285.600	246.100	237.000	285.000	452.800	389.900	519.100	519.100	615.583	687.583	891.000	961.000													
174.400	191.500	214.000	279.600	243.900	234.500	281.600	448.400	387.900	514.400	514.400	615.583	687.583	891.000	961.000													
171.500	188.200	210.200	273.600	241.600	231.600	278.600	444.000	385.900	509.400	509.400	615.583	687.583	891.000	961.000													
169.100	185.100	206.400	268.200	239.600	228.900	274.700	439.500	383.700	503.900	503.900	615.583	687.583	891.000	961.000													
166.400	181.800	202.400	262.000	237.000	226.600	272.400	434.600	381.500	500.000	500.000	615.583	687.583	891.000	961.000													
163.700	178.500	200.000	257.900	234.200	224.500	270.200	429.500	379.300	496.000	496.000	615.583	687.583	891.000	961.000													
162.400	177.000	216.300	255.800	235.500	222.800	278.700	436.200	358.200	490.000	490.000	615.583	687.583	891.000	961.000													
160.800	174.400	212.700	252.800	233.900	221.400	277.500	430.000	356.800	486.000	486.000	615.583	687.583	891.000	961.000													
159.600	173.000	211.500	251.600	232.700	220.200	276.300	428.800	355.600	484.000	484.000	615.583	687.583	891.000	961.000													
158.500	171.700	209.800	249.600	231.600	219.000	275.100	427.600	354.400	482.000	482.000	615.583	687.583	891.000	961.000													
157.350	170.350	208.650	247.200	230.525	217.900	273.900	426.450	353.250	480.000	480.000	615.583	687.583	891.000	961.000													
156.120	169.000	207.400	245.400	229.400	216.800	272.700	425.300	352.100	478.000	478.000	615.583	687.583	891.000	961.000													
154.900	167.800	206.200	243.600	228.200	215.600	271.500	424.150	350.950	476.000	476.000	615.583	687.583	891.000	961.000													
153.700	166.600	205.000	241.800	227.000	214.400	270.300	423.000	349.800	474.000	474.000	615.583	687.583	891.000	961.000													
152.500	165.400	203.800	240.000	225.800	213.200	269.100	421.850	348.650	472.000	472.000	615.583	687.583	891.000	961.000													

Figure A5. Page 5 from bathymetry development Excel file.

29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
250.000	150.000	250.000	150.000	250.000	150.000	250.000	150.000	250.000	150.000	250.000	150.000	250.000	150.000	250.000
552.365	552.365	552.365	552.365	552.365	552.365	552.365	552.365	552.365	552.365	552.365	552.365	552.365	552.365	552.365
.458	.007	1.833	1.458	1.309	1.047	0.960	0.936	0.969	0.733	0.696	0.960	0.260	1.047	
0.015	0.025	0.025	0.015	0.025	0.025	0.015	0.025	0.015	0.025	0.025	0.015	0.025	0.025	
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1219.700	1418.800	1617.900	1617.900	2260.300	2750.100	2780.600	3134.200	3158.100	3402.000	3545.900	2518.500	2390.900	2684.800	2185.000
1195.760	1395.050	1593.300	1593.300	2247.300	2731.800	2772.600	3103.800	3247.333	3390.867	3534.400	2512.100	2086.400	2651.900	2165.000
1177.820	1386.500	1570.700	1570.700	2212.400	2714.500	2761.600	3098.400	3241.767	3345.133	3524.300	2501.800	2498.800	2614.700	2166.000
1147.800	1331.600	1551.100	1551.100	2175.300	2684.500	2751.600	3056.400	3189.700	3361.000	3521.300	2488.400	2765.200	2579.900	2155.200
1123.940	1311.500	1529.800	1529.800	2132.300	2671.900	2739.500	3031.200	3193.233	3355.267	3517.300	2473.300	2784.500	2556.100	2138.400
1100.000	1295.000	1510.700	1510.700	2092.200	2648.100	2726.000	3008.600	3169.400	3308.200	3477.000	2457.200	2687.700	2494.200	2121.500
1090.000	1279.900	1491.900	1491.900	2048.600	2595.100	2711.300	3025.000	3163.733	3342.467	3441.200	2440.900	2642.000	2453.800	2102.600
1080.000	1275.975	1471.900	1471.900	2009.800	2562.800	2695.700	3016.100	3155.667	3329.213	3434.800	2424.700	2595.300	2413.200	2080.900
1070.000	1273.350	1452.200	1452.200	1979.300	2540.600	2679.500	3006.100	3146.100	3186.100	3416.100	2408.700	2550.400	2373.100	2062.300
1060.000	1270.925	1432.500	1432.500	1948.900	2495.700	2663.100	2996.000	3136.333	3176.667	3417.000	2393.100	2507.200	2353.500	2040.600
1050.000	1268.600	1412.700	1412.700	1918.300	2438.000	2644.900	2984.300	3127.033	3167.867	3408.500	2377.700	2465.700	2333.700	2017.800
1040.000	1266.275	1407.900	1407.900	1897.100	2386.800	2624.000	2977.400	3115.700	3150.000	3401.300	2362.500	2436.400	2315.000	1994.100
1030.000	1263.950	1397.900	1397.900	1875.600	2326.000	2575.500	2969.500	3111.667	3133.833	3396.000	2315.300	2421.300	2287.100	1974.300
1020.000	1261.625	1381.300	1381.300	1859.300	2283.700	2468.800	2962.400	3105.767	3119.133	3382.500	2300.700	2408.900	2265.000	1958.200
1010.000	1259.300	1364.000	1364.000	1842.700	2255.700	2440.300	2955.100	3100.200	3102.500	3369.400	2286.200	2398.700	2245.800	1938.700
1000.000	1256.975	1347.600	1347.600	1826.000	2228.000	2416.000	2944.700	3093.767	3091.333	3356.900	2271.800	2385.200	2226.100	1919.700
990.000	1254.650	1331.000	1331.000	1809.300	2200.300	2391.700	2934.000	3084.000	3084.000	3344.000	2257.400	2371.700	2206.300	1905.700
980.000	1252.325	1314.500	1314.500	1792.600	2172.600	2368.000	2924.300	3074.333	3074.333	3334.000	2242.400	2356.200	2187.000	1887.000
970.000	1250.000	1298.000	1298.000	1776.000	2145.000	2344.000	2914.600	3064.667	3064.667	3324.000	2227.400	2341.200	2167.000	1868.300
960.000	1247.675	1281.500	1281.500	1759.300	2117.300	2320.000	2904.900	3055.000	3055.000	3314.000	2212.400	2326.000	2147.000	1849.600
950.000	1245.350	1265.000	1265.000	1742.600	2089.600	2296.000	2895.200	3045.333	3045.333	3304.000	2202.400	2310.800	2127.000	1830.900
940.000	1243.025	1248.500	1248.500	1726.000	2061.900	2271.000	2885.500	3035.667	3035.667	3294.000	2192.400	2295.600	2107.000	1812.200
930.000	1240.700	1232.000	1232.000	1709.300	2034.200	2246.000	2875.800	3026.000	3026.000	3284.000	2182.400	2280.400	2087.000	1793.500
920.000	1238.375	1215.500	1215.500	1692.600	2006.500	2221.000	2866.100	3016.333	3016.333	3274.000	2172.400	2265.200	2067.000	1774.800
910.000	1236.050	1199.000	1199.000	1676.000	1978.800	2196.000	2856.400	3006.667	3006.667	3264.000	2162.400	2250.000	2047.000	1756.100
900.000	1233.725	1182.500	1182.500	1659.300	1951.100	2171.000	2846.700	2997.000	2997.000	3254.000	2152.400	2234.800	2027.000	1737.400
890.000	1231.400	1166.000	1166.000	1642.600	1923.400	2146.000	2837.000	2987.333	2987.333	3244.000	2142.400	2219.600	2007.000	1718.700
880.000	1229.075	1149.500	1149.500	1626.000	1895.700	2121.000	2827.300	2977.667	2977.667	3234.000	2132.400	2204.400	1987.000	1700.000
870.000	1226.750	1133.000	1133.000	1609.300	1868.000	2096.000	2817.600	2968.000	2968.000	3224.000	2122.400	2189.200	1967.000	1681.300
860.000	1224.425	1116.500	1116.500	1592.600	1840.300	2071.000	2807.900	2958.333	2958.333	3214.000	2112.400	2174.000	1947.000	1662.600
850.000	1222.100	1099.000	1099.000	1576.000	1812.600	2046.000	2798.200	2948.667	2948.667	3204.000	2102.400	2158.800	1927.000	1643.900
840.000	1219.775	1082.500	1082.500	1559.300	1784.900	2021.000	2788.500	2939.000	2939.000	3194.000	2092.400	2143.600	1907.000	1625.200
830.000	1217.450	1066.000	1066.000	1542.600	1757.200	1996.000	2778.800	2929.333	2929.333	3184.000	2082.400	2128.400	1887.000	1606.500
820.000	1215.125	1049.500	1049.500	1526.000	1729.500	1971.000	2769.100	2919.667	2919.667	3174.000	2072.400	2113.200	1867.000	1587.800
810.000	1212.800	1033.000	1033.000	1509.300	1701.800	1946.000	2759.400	2910.000	2910.000	3164.000	2062.400	2098.000	1847.000	1569.100
800.000	1210.475	1016.500	1016.500	1492.600	1674.100	1921.000	2749.700	2900.333	2900.333	3154.000	2052.400	2082.800	1827.000	1550.400
790.000	1208.150	999.000	999.000	1476.000	1646.400	1896.000	2740.000	2890.667	2890.667	3144.000	2042.400	2067.600	1807.000	1531.700
780.000	1205.825	982.500	982.500	1459.300	1618.700	1871.000	2730.300	2881.000	2881.000	3134.000	2032.400	2052.400	1787.000	1513.000
770.000	1203.500	966.000	966.000	1442.600	1591.000	1846.000	2720.600	2871.333	2871.333	3124.000	2022.400	2037.200	1767.000	1494.300
760.000	1201.175	949.500	949.500	1426.000	1563.300	1821.000	2710.900	2861.667	2861.667	3114.000	2012.400	2022.000	1747.000	1475.600
750.000	1198.850	933.000	933.000	1409.300	1535.600	1796.000	2701.200	2852.000	2852.000	3104.000	2002.400	2006.800	1727.000	1456.900
740.000	1196.525	916.500	916.500	1392.600	1507.900	1771.000	2691.500	2842.333	2842.333	3094.000	1992.400	1991.600	1707.000	1438.200
730.000	1194.200	899.000	899.000	1376.000	1480.200	1746.000	2681.800	2832.667	2832.667	3084.000	1982.400	1976.400	1687.000	1419.500
720.000	1191.875	882.500	882.500	1359.300	1452.500	1721.000	2672.100	2823.000	2823.000	3074.000	1972.400	1961.200	1667.000	1400.800
710.000	1189.550	866.000	866.000	1342.600	1424.800	1696.000	2662.400	2813.333	2813.333	3064.000	1962.400	1946.000	1647.000	1382.100
700.000	1187.225	849.500	849.500	1326.000	1397.100	1671.000	2652.700	2803.667	2803.667	3054.000	1952.400	1930.800	1627.000	1363.400
690.000	1184.900	833.000	833.000	1309.300	1369.400	1646.000	2643.000	2794.000	2794.000	3044.000	1942.400	1915.600	1607.000	1344.700
680.000	1182.575	816.500	816.500	1292.600	1341.700	1621.000	2633.300	2784.333	2784.333	3034.000	1932.400	1899.400	1587.000	1326.000
670.000	1180.250	799.000	799.000	1276.000	1314.000	1596.000	2623.600	2774.667	2774.667	3024.000	1922.400	1883.200	1567.000	1307.300
660.000	1177.925	782.500	782.500	1259.300	1286.300	1571.000	2613.900	2765.000	2765.000	3014.000	1912.400	1867.000	1547.000	1288.600
650.000	1175.600	766.000	766.000	1242.600	1258.600	1546.000	2604.200	2755.333	2755.333	3004.000	1902.400	1850.800	1527.000	1269.900
640.000	1173.275	749.500	749.500	1226.000	1230.900	1521.000	2594.500	2745.667	2745.667	2994.000	1892.400	1834.600	1507.000	1251.200
630.000	1170.950	733.000	733.000	1209.300	1203.200	1496.000	2584.800	2736.000	2736.000	2984.000	1882.400	1818.400	1487.000	1232.500
620.000	1168.625	716.500	716.500	1192.600	1175.500	1471.000	2575.100	2726.333	2726.333	2974.000	1872.400	1802.200	1467.000	1213.800
610.000	1166.300	699.000	699.000	1176.000	1147.800	1446.000	2565.400	2716.667	2716.667	2964.000	1862.400	1786.000	1447.000	1195.100
600.000	1163.975	682.500	682.500	1159.300	1120.100	1421.000	2555.700	2707.000	2707.000	2954.000	1852.400	1769.800	1427.000	1176.400
590.000	1161.650	666.000	666.000	1142.600	1092.400	1396.000	2546.000	2697.333	2697.333	2944.000	1842.400	1753.600	1407.000	1157.700
580.000	1159.325	649.500	649.500											

Figure A 7. Page 7 from bathymetry development Excel file.

44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
200.000	200.000	200.000	200.000	0.000	0.000	300.000	300.000	350.000	350.000	350.000	300.000	300.000	0.000	0.000
552.365	552.365	552.365	552.365	552.365	552.365	552.365	552.365	552.365	552.365	552.365	552.365	552.365	552.365	552.365
1.100	1.127	1.431	1.476	0.000	0.000	0.785	0.785	0.783	0.411	5.498	0.262	0.349	0.175	0.000
0.015	0.025	0.025	0.025	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.025	0.015	0.015	0.025
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1512.900	1100.000	1250.000	1400.000	0.000	0.000	370.900	376.900	345.600	400.000	345.600	734.200	734.200	734.200	0.000
1504.700	990.000	1370.000	1350.000	0.000	0.000	335.500	335.500	334.900	375.000	334.900	711.400	711.400	711.400	0.000
1496.600	936.300	1118.150	1300.000	0.000	0.000	300.900	300.900	324.000	300.000	324.000	691.900	691.900	691.900	0.000
1492.900	930.600	1102.800	1275.000	0.000	0.000	275.800	275.800	312.800	300.000	312.800	674.600	674.600	674.600	0.000
1486.900	924.000	1087.000	1250.000	0.000	0.000	260.900	260.900	301.600	275.000	301.600	656.300	656.300	656.300	0.000
1457.100	917.200	1071.100	1225.000	0.000	0.000	247.400	247.400	291.000	247.400	291.000	639.000	639.000	639.000	0.000
1451.400	898.800	1049.400	1200.000	0.000	0.000	234.900	234.900	280.900	234.900	280.900	622.600	622.600	622.600	0.000
1445.500	892.200	1017.767	1133.933	0.000	0.000	222.900	222.900	271.100	222.900	271.100	609.200	609.200	609.200	0.000
1438.900	885.300	975.983	1066.667	0.000	0.000	211.100	211.100	261.500	211.100	261.500	589.900	589.900	589.900	0.000
1431.200	878.600	959.900	1000.000	0.000	0.000	189.300	189.300	252.200	299.300	252.200	573.500	573.500	573.500	0.000
1425.900	872.400	918.533	998.667	0.000	0.000	186.800	186.800	242.200	296.800	242.200	557.100	557.100	557.200	0.000
1420.800	867.000	900.167	933.333	0.000	0.000	172.800	172.800	234.500	272.800	234.500	540.900	540.900	540.900	0.000
1415.700	862.400	881.200	900.000	0.000	0.000	157.500	157.500	226.200	257.500	226.200	525.100	525.100	525.100	0.000
1411.000	856.800	874.400	890.000	0.000	0.000	131.600	131.600	210.900	231.600	210.900	518.200	518.200	518.200	0.000
1407.000	856.000	868.000	880.000	0.000	0.000	116.000	116.000	214.000	216.000	214.000	508.600	508.600	508.600	0.000
1404.600	853.900	861.950	870.000	0.000	0.000	108.400	108.400	205.800	208.900	205.800	495.000	495.000	495.000	0.000
1404.100	851.900	855.950	860.000	0.000	0.000	100.700	100.700	197.800	200.700	197.800	481.600	481.600	481.600	0.000
1401.100	849.900	849.950	850.000	0.000	0.000	93.000	93.000	189.900	193.000	189.900	468.300	468.300	468.300	0.000
1397.600	847.500	847.517	848.333	0.000	0.000	86.700	86.700	182.300	185.100	182.300	455.100	455.100	455.100	0.000
1393.100	844.700	845.683	846.667	0.000	0.000	80.900	80.900	175.000	175.000	175.000	441.500	441.500	441.500	0.000
1388.600	841.900	843.450	845.000	0.000	0.000	75.200	75.200	167.800	175.200	167.800	429.300	429.300	429.300	0.000
1384.900	839.400	841.367	843.333	0.000	0.000	69.400	69.400	160.800	169.400	160.800	417.000	417.000	417.000	0.000
1381.200	837.100	839.183	841.667	0.000	0.000	63.800	63.800	153.800	163.800	153.800	404.600	404.600	404.600	0.000
1377.200	834.500	837.250	840.000	0.000	0.000	57.500	57.500	146.300	157.500	146.300	391.800	391.800	391.800	0.000
1371.400	831.200	833.782	836.384	0.000	0.000	50.400	50.400	138.200	150.400	138.200	378.400	378.400	378.400	0.000
1364.600	826.700	829.714	832.717	0.000	0.000	42.500	42.500	129.300	142.500	129.300	364.600	364.600	371.600	0.000
1359.100	814.200	821.646	829.917	0.000	0.000	35.000	35.000	116.200	135.000	116.200	349.400	349.400	378.800	0.000
1331.400	813.600	819.527	825.455	0.000	0.000	25.000	25.000	115.000	25.000	125.000	345.000	345.000	369.000	0.000
1330.500	813.575	817.697	821.818	0.000	0.000	18.000	18.000	114.000	18.000	124.000	340.000	340.000	368.000	0.000
1328.700	813.550	815.866	818.182	0.000	0.000	18.000	18.000	113.000	18.000	123.000	338.000	338.000	367.000	0.000
1328.850	813.525	814.035	814.544	0.000	0.000	0.000	0.000	100.400	0.000	100.400	334.400	334.400	365.000	0.000
1326.000	813.300	812.205	810.509	0.000	0.000	0.000	0.000	87.600	0.000	87.600	318.300	318.300	361.000	0.000
1321.700	812.600	809.996	807.273	0.000	0.000	0.000	0.000	76.200	0.000	76.200	302.400	302.400	352.600	0.000
1296.200	820.700	807.169	803.636	0.000	0.000	0.000	0.000	66.600	0.000	66.600	287.600	287.600	343.700	0.000
1295.100	784.400	787.200	800.000	0.000	0.000	0.000	0.000	57.700	0.000	57.700	272.900	272.900	334.100	0.000
1284.100	792.600	795.467	798.333	0.000	0.000	0.000	0.000	48.900	0.000	48.900	257.400	257.400	313.500	0.000
1283.363	792.250	794.498	796.667	0.000	0.000	0.000	0.000	47.763	0.000	47.763	255.063	255.063	312.138	0.000
1282.333	791.900	793.450	795.000	0.000	0.000	0.000	0.000	46.625	0.000	46.625	252.725	252.725	310.775	0.000
1281.648	791.550	792.442	793.333	0.000	0.000	0.000	0.000	45.480	0.000	45.480	250.380	250.380	310.413	0.000
1280.650	791.200	791.433	791.667	0.000	0.000	0.000	0.000	44.350	0.000	44.350	248.050	248.050	310.050	0.000
1280.033	790.850	790.425	790.000	0.000	0.000	0.000	0.000	43.213	0.000	43.213	245.713	245.713	310.688	0.000
1279.175	790.500	789.417	788.933	0.000	0.000	0.000	0.000	42.075	0.000	42.075	243.375	243.375	310.325	0.000
1276.338	790.150	788.408	786.667	0.000	0.000	0.000	0.000	40.938	0.000	40.938	241.038	241.038	310.963	0.000
1277.500	789.800	787.400	785.000	0.000	0.000	0.000	0.000	39.800	0.000	39.800	238.700	238.700	312.600	0.000
1272.500	785.900	784.617	783.333	0.000	0.000	0.000	0.000	29.700	0.000	29.700	220.000	220.000	321.800	0.000
1260.600	781.900	781.783	781.667	0.000	0.000	0.000	0.000	24.400	0.000	24.400	201.400	201.400	296.700	0.000
1255.000	777.300	778.950	780.000	0.000	0.000	0.000	0.000	20.200	0.000	20.200	182.500	182.500	287.400	0.000
1226.000	776.100	770.050	764.000	0.000	0.000	0.000	0.000	20.000	0.000	20.000	187.300	180.750	282.045	0.000
1216.600	775.250	761.600	748.000	0.000	0.000	0.000	0.000	0.000	0.000	154.700	179.000	276.890	0.000	0.000
1135.950	750.025	741.023	732.000	0.000	0.000	0.000	0.000	0.000	0.000	116.025	177.250	271.335	0.000	0.000
1047.000	724.850	720.425	716.000	0.000	0.000	0.000	0.000	0.000	0.000	88.660	175.500	265.960	0.000	0.000
961.050	699.675	699.838	700.000	0.000	0.000	0.000	0.000	0.000	0.000	86.875	173.750	260.624	0.000	0.000
877.100	674.500	682.746	696.992	0.000	0.000	0.000	0.000	0.000	0.000	85.096	170.180	255.269	0.000	0.000
877.100	674.500	684.242	699.985	0.000	0.000	0.000	0.000	0.000	0.000	83.305	166.615	249.914	0.000	0.000
877.100	674.500	682.738	696.977	0.000	0.000	0.000	0.000	0.000	0.000	81.510	163.039	244.559	0.000	0.000
877.100	674.500	681.235	687.949	0.000	0.000	0.000	0.000	0.000	0.000	79.735	159.469	239.204	0.000	0.000
877.100	674.500	679.791	684.962	0.000	0.000	0.000	0.000	0.000	0.000	77.950	155.899	234.849	0.000	0.000
826.100	672.800	677.377	681.994	0.000	0.000	0.000	0.000	0.000	0.000	76.165	152.323	230.494	0.000	0.000
777.000	670.700	674.823	676.946	0.000	0.000	0.000	0.000	0.000	0.000	74.380	148.759	223.139	0.000	0.000
777.000	670.700	673.319	675.948	0.000	0.000	0.000	0.000	0.000	0.000	72.595	145.189	217.784	0.000	0.000
723.700	668.300	670.615	672.931	0.000	0.000	0.000	0.000	0.000	0.000	70.810	141.619	212.429	0.000	0.000
714.900	663.700	667.812	669.923	0.000	0.000	0.000	0.000	0.000	0.000	69.024	138.049	207.073	0.000	0.000
714.900	663.700	666.308	666.915	0.000	0.000	0.000	0.000	0.000	0.000	67.239	134.479	201.718	0.000	0.000
712.300	663.200	663.554	663.908	0.000	0.000	0.000	0.000	0.000	0.000	40.000	109.182	196.363	0.000	0.000
709.600	660.900	660.900	660.900	0.000	0.000	0.000	0.000	0.000	0.000	10.000	85.904	191.000	0.000	0.000
709.600														

Appendix B: W2 Control File with Detailed Modifications

This appendix serves to present the control file (w2_con.npt) used for the calibration of the model (see Figure B1-Figure B11) along with a table of changes for every model run simulated (see Table B1). All other model simulations will be compared to the Calibration w2_selective.npt file. Discussions of all modifications are made in the main report text.

Figure B1. Page 1 from CY01 w2_con.npt file.

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W2 Model Version 3.7
TITLE C .....TITLE.....
Version 3.7 Lost Creek Reservoir 2001
Model Run from 01/01/2001 to 12/30/2001 (Jday: 1 to 365)

CY01-RUN13 - CY01-RUN12
- Adjust timing on WSC increase in WSC file.
- Based on Run12 Results.
-

Tammy Threadgill - USACE ERDC EL
.....
GRID      NWE      NER      IMX      KMX      NPROC      CLOSEC
          1        2        58      104        1        OFF

IN/OUTFL   NTR      NST      NIW      NWD      NGT      NSP      NPI      NPU
          0        5        0        0        0        0        0        0

CONSTITU   NGC      NSS      NAL      NEP      NBOD      NMC      NZP
          0        0        0        0        0        0        0

MISCELL    NDAY SELECTC HABTATC ENVIRPC AERATEC INITUWL
          100      OFF      OFF      OFF      OFF      OFF      OFF

TIME CON   TMSTRT  TMEND      YEAR
          1.0000  365.000  2001

DLT CON     NDT  DLTMIN DLTINTR
          1    0.10000  OFF

DLT DATE    DLTG      DLTG      DLTG      DLTG      DLTG      DLTG      DLTG      DLTG
          1.00000

DLT MAX     DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX
          3600.00

DLT FRN      DLTG      DLTG      DLTG      DLTG      DLTG      DLTG      DLTG      DLTG
          0.90

DLT LIM1     VISC      CELC
WE 1         ON        ON

BRANCH G     US      DS      UHS      DHS      UQE      DQE      NLMIN      SLOPE      SLOPEC
BR1          2      47      0        0        0        0        1  0.00000  0.00000
BR2          50     57      0      36      0        0        1  0.00000  0.00000

LOCATION      LAT      LONG      EBOT      ES      BE      JBDN
WE 1        42.6900  122.658  472.440  1        2        1

INIT CND     T2I      ICHI      WTYPEC      GRIDC
WE 1        5.444    0.000    FRESH      RECT

CALCULAT     VBC      EBC      MBC      PQC      EVC      PRC
WE 1         OFF      OFF      OFF      ON      ON      OFF

DEAD SEA     WINDC      QINC      QOUTC      HEATC
WE 1         ON      ON      ON      ON

INTERPOL     QINIC      DTRIC      HDIC
BR1          OFF      OFF      OFF
BR2          OFF      OFF      OFF

HEAT EXCH    SLHTC      SROC      RHEVAP      METIC      FETCHC      AFW      BFW      CFW      WINDH
WE 1         TERM      OFF      OFF      ON      OFF      9.20000  0.46000  2.00000  10.0000

ICE COVE     ICEC      SLICEC      ALBEDO      HWICE      BICE      GICE      ICEMIN      ICET2
WE 1         OFF      DETAIL  0.25000  10.0000  0.60000  0.07000  0.05000  3.00000

TRANSPOR     SLTRC      THETA
WE 1         ULTIMATE  0.55

HYD COEF     AX      DX      CBHE      TSED      FI      TSEDF      FRICC      Z0
WE 1         1.00000  1.00000  0.30000  11.984  0.01000  1.00000  MANN  0.00100

EDDY VISC     AZC      AZSLC      AZMAX      FBC      E      ARODI      STRCKLR      BOUNDFR      TKECAL
WE 1         W2      IMP      1.0

N STRUC      NSTR
ER1          5
ER2          0

STR INT      STRIC      STRIC      STRIC      STRIC      STRIC      STRIC      STRIC      STRIC      STRIC
ER 1         ON      ON      ON      ON      ON      ON      ON      ON      ON
ER 2

STR TOP      KTSTR      KTSTR      KTSTR      KTSTR      KTSTR      KTSTR      KTSTR      KTSTR      KTSTR
ER1          2        2        2        2        2        2        2        2        2
ER2

STR BOT      KBSTR      KBSTR      KBSTR      KBSTR      KBSTR      KBSTR      KBSTR      KBSTR      KBSTR
ER 1         100     100     100     100     100     100     100     100     100

```

Figure B2. Page 2 from CY01 w2_con.npt file.

[illegible]

Figure B3. Page 3 from CY01 w2_con.npt file.

DST TRIB	DTRC	DTRC	DTRC	DTRC	DTRC	DTRC	DTRC	DTRC	DTRC
BR 1	ON								
BR 2	OFF								
HVD PRIN	HPRWBC	HPRWBC	HPRWBC	HPRWBC	HPRWBC	HPRWBC	HPRWBC	HPRWBC	HPRWBC
NVIOL	OFF								
U	ON								
W	ON								
T	ON								
RHO	OFF								
AZ	OFF								
SHEAR	OFF								
ST	OFF								
SE	OFF								
ADMX	OFF								
DM	OFF								
HDG	OFF								
ADMZ	OFF								
HFG	OFF								
GRAV	OFF								
SNP PRINT	SNPC	NSNP	NISNP						
WE 1	ON	1	4						
SNP DATE	SNPD	SNPD	SNPD	SNPD	SNPD	SNPD	SNPD	SNPD	SNPD
WE 1	1.00000								
SNP FREQ	SNPF	SNPF	SNPF	SNPF	SNPF	SNPF	SNPF	SNPF	SNPF
WE 1	1.00000								
SNP SEG	ISNP	ISNP	ISNP	ISNP	ISNP	ISNP	ISNP	ISNP	ISNP
WE 1	2	18	34	47					
SCR PRINT	SCRC	NSCR							
WE 1	ON	1							
SCR DATE	SCRD	SCRD	SCRD	SCRD	SCRD	SCRD	SCRD	SCRD	SCRD
WE 1	1.00000								
SCR FREQ	SCRF	SCRF	SCRF	SCRF	SCRF	SCRF	SCRF	SCRF	SCRF
WE 1	0.10000								
PRF PLOT	PRFC	NPRF	NIPRF						
WE 1	OFF								
PRF DATE	PRFD	PRFD	PRFD	PRFD	PRFD	PRFD	PRFD	PRFD	PRFD
PRF FREQ	PRFF	PRFF	PRFF	PRFF	PRFF	PRFF	PRFF	PRFF	PRFF
PRF SEG	IPRF	IPRF	IPRF	IPRF	IPRF	IPRF	IPRF	IPRF	IPRF
SPR PLOT	SPRC	NSPR	NISPR						
WE 1	ON	1	46						
SPR DATE	SPRD	SPRD	SPRD	SPRD	SPRD	SPRD	SPRD	SPRD	SPRD
WE 1	1.00								
SPR FREQ	SPRF	SPRF	SPRF	SPRF	SPRF	SPRF	SPRF	SPRF	SPRF
WE 1	1.00								
SPR SEG	ISPR	ISPR	ISPR	ISPR	ISPR	ISPR	ISPR	ISPR	ISPR
WE 1	2	3	4	5	6	7	8	9	10
	11	12	13	14	15	16	17	18	19
	20	21	22	23	24	25	26	27	28
	29	30	31	32	33	34	35	36	37
	38	39	40	41	42	43	44	45	46
	47								
VPL PLOT	VPLC	NVPL							
WE 1	ON	1							
VPL DATE	VPLD	VPLD	VPLD	VPLD	VPLD	VPLD	VPLD	VPLD	VPLD
WE 1	1.0								
VPL FREQ	VPLF	VPLF	VPLF	VPLF	VPLF	VPLF	VPLF	VPLF	VPLF
WE 1	500.0								
CPL PLOT	CPLC	NCPL	TECPLOT						
WE 1	OFF	2	ON						
CPL DATE	CPLD	CPLD	CPLD	CPLD	CPLD	CPLD	CPLD	CPLD	CPLD
CPL FREQ	CPLF	CPLF	CPLF	CPLF	CPLF	CPLF	CPLF	CPLF	CPLF
FLUXES	FLXC	NFLX							
WE 1	OFF	0							

Figure B4. Page 4 from CY01 w2_con.npt file.

FLX DATE WE 1	FLXD	FLXD	FLXD	FLXD	FLXD	FLXD	FLXD	FLXD	FLXD
FLX FREQ WE 1	FLXF	FLXF	FLXF	FLXF	FLXF	FLXF	FLXF	FLXF	FLXF
TSR PLOT	TSRC ON	NTSR 1	NITSR 4						
TSR DATE	TSRD 1.00	TSRD	TSRD	TSRD	TSRD	TSRD	TSRD	TSRD	TSRD
TSR FREQ	TSRF 1.0	TSRF	TSRF	TSRF	TSRF	TSRF	TSRF	TSRF	TSRF
TSR SEG WE 1	ITSR 2	ITSR 18	ITSR 34	ITSR 47	ITSR	ITSR	ITSR	ITSR	ITSR
TSR LAYE	ETSR 0.00	ETSR 0.00	ETSR 0.00	ETSR 0.00	ETSR 0.00	ETSR 0.00	ETSR 0.00	ETSR 0.00	ETSR 0.00
WITH OUT	WDOC ON	NWDO 1	NIWDO 1						
WITH DAT	WDOD 1.00	WDOD	WDOD	WDOD	WDOD	WDOD	WDOD	WDOD	WDOD
WITH FRE	WDOF 1.00	WDOF	WDOF	WDOF	WDOF	WDOF	WDOF	WDOF	WDOF
WITH SEG	IWDO 47	IWDO	IWDO	IWDO	IWDO	IWDO	IWDO	IWDO	IWDO
RESTART	RSOC OFF	NRSO 0	RSIC OFF						
RSO DATE	RSOD	RSOD	RSOD	RSOD	RSOD	RSOD	RSOD	RSOD	RSOD
RSO FREQ	RSOF	RSOF	RSOF	RSOF	RSOF	RSOF	RSOF	RSOF	RSOF
CST COMP	CCC OFF	LIMC OFF	CUF 10						
CST ACTIVE	CAC OFF								
TDS	OFF								
PO4	OFF								
NH4	OFF								
NO3	OFF								
DSI	OFF								
PSI	OFF								
FE	OFF								
LDOM	OFF								
RDOM	OFF								
LFOM	OFF								
RFOM	OFF								
DO	OFF								
TIC	OFF								
ALK	OFF								
LDOM-P	OFF								
RDOM-P	OFF								
LFOM-P	OFF								
RFOM-P	OFF								
LDOM-N	OFF								
RDOM-N	OFF								
LFOM-N	OFF								
RFOM-N	OFF								
CST DERI	CDWBC	CDWBC	CDWBC	CDWBC	CDWBC	CDWBC	CDWBC	CDWBC	CDWBC
DOC	OFF								
POC	OFF								
TOC	OFF								
DON	OFF								
PCN	OFF								
TON	OFF								
TKN	OFF								
TN	OFF								
DOP	OFF								
POP	OFF								
TOP	OFF								
TP	OFF								
APR	OFF								
CHLA	OFF								
ATOT	OFF								
%DO	OFF								
TSS	OFF								
TISS	OFF								
CBOD	OFF								
pH	OFF								
CO2	OFF								
HCO3	OFF								

Figure B5. Page 5 from CY01 w2_con.npt file.

CC3	OFF								
CST FLUX	CFWBC	CFWBC	CFWBC	CFWBC	CFWBC	CFWBC	CFWBC	CFWBC	CFWBC
TISSIN	OFF								
TISSOUT	OFF								
PO4AR	OFF								
PO4AG	OFF								
PO4AP	OFF								
PO4ER	OFF								
PO4EG	OFF								
PO4EP	OFF								
PO4POM	OFF								
PO4DOM	OFF								
PO4OM	OFF								
PO4SED	OFF								
PO4SOD	OFF								
PO4SET	OFF								
NH4NITR	OFF								
NH4AR	OFF								
NH4AG	OFF								
NH4AP	OFF								
NH4ER	OFF								
NH4EG	OFF								
NH4EP	OFF								
NH4POM	OFF								
NH4DOM	OFF								
NH4OM	OFF								
NH4SED	OFF								
NH4SOD	OFF								
NO3DEN	OFF								
NO3AG	OFF								
NO3EG	OFF								
NO3SED	OFF								
DSIAG	OFF								
DSIEG	OFF								
DSIPIS	OFF								
DSISED	OFF								
DSISOD	OFF								
DSISET	OFF								
PSIAM	OFF								
PSINET	OFF								
PSIDK	OFF								
FESET	OFF								
FESED	OFF								
LDOMDK	OFF								
LRDOM	OFF								
RDOMDK	OFF								
LDOMAP	OFF								
LDOMEP	OFF								
LFOMDK	OFF								
LRPOM	OFF								
RFOMDK	OFF								
LFOMAP	OFF								
LFOMEP	OFF								
LFOMSET	OFF								
RFOMSET	OFF								
CBODDK	OFF								
DOAP	OFF								
DOAR	OFF								
DOEP	OFF								
DOER	OFF								
DOPOM	OFF								
DODOM	OFF								
DCOM	OFF								
DONITR	OFF								
DOCBOD	OFF								
DOREAR	OFF								
DOSOD	OFF								
TICAG	OFF								
TICEG	OFF								
SEDDK	OFF								
SEDAS	OFF								
SEDLFOM	OFF								
SEDSET	OFF								
SODDK	OFF								
CST ICON	C2IWB	C2IWB	C2IWB	C2IWB	C2IWB	C2IWB	C2IWB	C2IWB	C2IWB
TDS	0.00000								
PO4	0.00200								
NH4	0.00500								
NO3	0.04000								
DSI	0.00000								
PSI	0.00000								
FE	0.00000								
LDOM	0.10000								
RDOM	0.10000								
LFOM	0.10000								
RFOM	0.10000								
DO	12.0000								
TIC	5.00000								
ALK	19.8000								
LDOM-P	0.00050								

Figure B7. Page 7 from CY01 w2_con.npt file.

TIC	OFF	OFF							
ALK	OFF	OFF							
LDOM-P	OFF	OFF							
RDOM-P	OFF	OFF							
LPOM-P	OFF	OFF							
RFOM-P	OFF	OFF							
LDOM-N	OFF	OFF							
RDOM-N	OFF	OFF							
LPOM-N	OFF	OFF							
RFOM-N	OFF	OFF							
CPR CON	CPRBRC	CPRBRC	CPRBRC	CPRBRC	CPRBRC	CPRBRC	CPRBRC	CPRBRC	CPRBRC
TDS	OFF	OFF							
PO4	OFF	OFF							
NH4	OFF	OFF							
NO3	OFF	OFF							
DSI	OFF	OFF							
PSI	OFF	OFF							
FE	OFF	OFF							
LDOM	OFF	OFF							
RDOM	OFF	OFF							
LPOM	OFF	OFF							
RFOM	OFF	OFF							
DO	OFF	OFF							
TIC	OFF	OFF							
ALK	OFF	OFF							
LDOM-P	OFF	OFF							
RDOM-P	OFF	OFF							
LPOM-P	OFF	OFF							
RFOM-P	OFF	OFF							
LDOM-N	OFF	OFF							
RDOM-N	OFF	OFF							
LPOM-N	OFF	OFF							
RFOM-N	OFF	OFF							
EX COEF	EXH2O	EXSS	EXOM	BETA	EXC	EXIC			
WE 1	0.550	0.1000	0.10000	0.55	OFF	OFF			
ALG EX	EXA	EXA	EXA	EXA	EXA	EXA			
ZOO EX	EXZ	EXZ	EXZ	EXZ	EXZ	EXZ			
MACRO EX	EXM	EXM	EXM	EXM	EXM	EXM			
GENERIC	CGQ10	CGQDK	CG1DK	CGS					
S SOLIDS	SSS	SEDR	TAUCR						
ALGAL RATE	AG	AR	AE	AM	AS	AHSP	AHSN	AHSSI	ASAT
ALGAL TEMP	AT1	AT2	AT3	AT4	AK1	AK2	AK3	AK4	
ALG STOI	ALGP	ALGN	ALGC	ALGSI	ACHLA	ALPOM	ANEQN	ANPR	
EPIPHYTE	EPIC	EPIC	EPIC	EPIC	EPIC	EPIC	EPIC	EPIC	EPIC
EPI1	OFF								
EPI PRIN	EPRC	EPRC	EPRC	EPRC	EPRC	EPRC	EPRC	EPRC	EPRC
EPI1	OFF								
EPI INIT	EPICI	EPICI	EPICI	EPICI	EPICI	EPICI	EPICI	EPICI	EPICI
EPI RATE	EG	ER	EE	EM	EE	EHSP	EHSN	EHSSI	
EPI HALF	ESAT	EHS	ENEQN	ENPR					
EPI TEMP	ET1	ET2	ET3	ET4	EK1	EK2	EK3	EK4	
EPI STOI	EP	EN	EC	ESI	ECHLA	EPOM			
ZOOP RATE	ZG	ZR	ZM	ZEFF	PREFP	ZOOMIN	ZS2P		
ZOOP ALGP	PREFA	PREFA	PREFA	PREFA	PREFA	PREFA	PREFA	PREFA	PREFA
ZOOP ZOOP	PREFZ	PREFZ	PREFZ	PREFZ	PREFZ	PREFZ	PREFZ	PREFZ	PREFZ
ZOOP TEMP	ZT1	ZT2	ZT3	ZT4	ZK1	ZK2	ZK3	ZK4	

Figure B8. Page 8 from CY01 w2_con.npt file.

ZOOP	STOI	ZP	ZN	ZC					
MACROPHYT	MACWBC	MACWBC	MACWBC	MACWBC	MACWBC	MACWBC	MACWBC	MACWBC	MACWBC
Mac1	OFF								
MAC PRINT	MPRWBC	MPRWBC	MPRWBC	MPRWBC	MPRWBC	MPRWBC	MPRWBC	MPRWBC	MPRWBC
Mac1	OFF								
MAC INI	MACWBCI	MACWBCI	MACWBCI	MACWBCI	MACWBCI	MACWBCI	MACWBCI	MACWBCI	MACWBCI
MAC RATE	MG	MR	MM	MSAT	MHSP	MHSN	MHSC	MPOM	LRPMAC
MAC SED	PSED	NSED							
MAC DIST	MEMP	MMAX							
MAC DRAG	CDDRAG	DMV	DWSA	ANORM					
MAC TEMP	MT1	MT2	MT3	MT4	MK1	MK2	MK3	MK4	
MAC STOICH	MP	MN	MC						
DOM	LDOMDK	RDOMDK	LRDDK						
POM	LPOMDK	RPOMDK	LRPDK	POMS					
OM STOIC	ORGF	ORGN	ORGC	ORGSI					
OM RATE	OMT1	OMT2	OMK1	OMK2					
CBOD	KBOD	TBOD	RBOD	CBODS					
CBOD STOIC	BODP	BODN	BODC	BODC					
PHOSPHOR	P04R	PARTP							
AMMONIUM	NH4R	NH4DK							
NH4 RATE	NH4T1	NH4T2	NH4K1	NH4K2					
NITRATE	NO3DK	NO3S	FNO3SED						
NO3 RATE	NO3T1	NO3T2	NO3K1	NO3K2					
SILICA	DSIR	PSIS	PSIDK	PARTSI					
IRON	FER	FES							
SED CO2	CO2R								
STOICH 1	O2NH4	O2OM							
STOICH 2	O2AR	O2AG							
STOICH 3	O2ER	O2EG							
STOICH 4	O2ZR								
STOICH 5	O2MR	O2MG							
O2 LIMIT	O2LIM								
SEDIMENT	SEDC	SEDCPC	SEDCI	SEDC	SEDS	FSOD	FSED	SEDE	DYNSEDC

Figure B9. Page 9 from CY01 w2_con.npt file.

```

WE 1      OFF      OFF 0.00000 0.10000      0.1 1.00000 1.00000      0.0      OFF

SOD RATE  SODT1  SODT2  SODK1  SODK2
WE 1      4.00000 32.0000 0.10000 0.99000

S DEMAND   SOD     SOD     SOD     SOD     SOD     SOD     SOD     SOD     SOD
           0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000
           0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000
           0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000
           0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000
           0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000
           0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000
           0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000
           0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000

REABRATON  TYPE  EQN#  COEF1  COEF2  COEF3  COEF4
WE 1      LAKE      6  0.00000 0.00000 0.00000 0.00000

RSI FILE.....RSIFN.....
rsi.npt

QWD FILE.....QWDFN.....
qwd.npt

QGT FILE.....QGTFN.....
qgt.npt

WSC FILE.....WSCFN.....
LCL-WSC-012314-ADJ.NPT

SHD FILE.....SHDFN.....
LCL-SHD.NPT

BTH FILE.....BTHFN.....
WE 1      LCL-BATH-2001-FINAL.NPT

MET FILE.....METFN.....
WE 1      LCL-MET-2001.NPT

EXT FILE.....EXTFN.....
WE 1      ext_wb1.npt

VPR FILE.....VPRFN.....
WE 1      vpr_wb1.npt

LPR FILE.....LPRFN.....
WE 1      lpr_wb1.npt

QIN FILE.....QINFN.....
BR1      LCL-QIN-2001.NPT
BR2      LCL-BR2-QIN.NPT

TIN FILE.....TINFN.....
BR1      LCL-TIN-2001.NPT
BR2      LCL-BR2-TIN.NPT

CIN FILE.....CINFN.....
BR1      Cin_br1.npt - not used
BR2      Cin_br2.npt - not used

QOT FILE.....QOTFN.....
BR1      LCL-QOUT-2001-SSTR-012214.NPT
BR2      qot_br2.npt - not used

QTR FILE.....QTRFN.....
TR1      qtr_tr1.npt - not used

TTR FILE.....TTRFN.....
TR1      ttr_tr1.npt - not used

CTR FILE.....CTRFN.....
TR1      ctr_tr1.npt - not used

QDT FILE.....QDTFN.....
BR1      LCL-QDT-2001.NPT
BR2      qdt_br2.npt - not used

TDT FILE.....TDTFN.....
BR1      LCL-TDT-2001.NPT
BR2      tdt_br2.npt - not used

CDT FILE.....CDTFN.....
BR1      cdt_br1.npt - not used
BR2      cdt_br2.npt - not used

PRE FILE.....PREFN.....
BR1      pre_br1.npt - not used
BR2      pre_br2.npt - not used

TPR FILE.....TPRFN.....
BR1      tpr_br1.npt - not used
BR2      tpr_br2.npt - not used

CFR FILE.....CFRFN.....

```

Figure B10. Page10 from CY01 w2_con.npt file.

```

BR1      cpr br1.npt - not used
BR2      cpr_br2.npt - not used

EUH FILE.....EUHFN.....
BR1      euh br1.npt - not used
BR2      euh_br2.npt - not used

TUH FILE.....TUHFN.....
BR1      tuh br1.npt - not used
BR2      tuh_br2.npt - not used

CUH FILE.....CUHFN.....
BR1      cuh br1.npt - not used
BR2      cuh_br2.npt - not used

EDH FILE.....EDHFN.....
BR1      edh br1.npt - not used
BR2      edh_br2.npt - not used

TDH FILE.....TDHFN.....
BR1      tdh br1.npt - not used
BR2      tdh_br2.npt - not used

CDH FILE.....CDHFN.....
BR1      cdh br1.npt - not used
BR2      cdh_br2.npt - not used

SNP FILE.....SNPFN.....
WE 1      LCL-CY01-Run13-snp.opt

PRF FILE.....PRFFN.....
WE 1      LCL-CY01-Run13-prf.opt

VPL FILE.....VPLFN.....
WE 1      LCL-CY01-Run13-vpl.w2l

CPL FILE.....CPLFN.....
WE 1      LCL-CY01-Run13-cpl.opt

SPR FILE.....SPRFN.....
WE 1      LCL-CY01-Run13-spr.opt

FLX FILE.....FLXFN.....
WE 1      LCL-CY01-Run13-kfl.opt

TSR FILE.....TSRFN.....
          LCL-CY01-Run13-tsrf.opt

WDO FILE.....WDOFN.....
          LCL-CY01-Run13-wdo.opt

```

Table B1. Changes to calibration w2_con.npt file for other runs.

RUN	YEAR	TEMPI	TSED
Calibration-2001	2001	5.444	11.984
Verification-2003	2003	5.667	12.513
Verification-2010	2010	5.167	11.743

Table B2. Inventory of files needed to run the LCLM.

Run Name	CY01_Run13		CY03-Run03		CY10-Run02	
File Type	Calibration – 2001	Date Stamp	Verification – 2003	Date Stamp	Verification – 2010	Date Stamp
W2_CON.NPT	–	1/23/14 3:15 pm	–	2/11/14 11:35 am	–	2/11/14 11:35 am
WSC File	LCL-WSC-012314-ADJ.NPT	1/23/14 3:40 pm	LCL-WSC-012314-ADJ.NPT	1/23/14 3:40 pm	LCL-WSC-012314-ADJ.NPT	1/23/14 3:40 pm
SHD File	LCL-SHD.NPT	10/17/13 1:49 pm	LCL-SHD.NPT	10/17/13 1:49 pm	LCL-SHD.NPT	10/17/13 1:49 pm
BTH File	LCL-BATH-2001-FINAL.NPT	11/15/13 2:22 pm	LCL-BATH-2003-FINAL.NPT	11/15/13 2:24 pm	LCL-BATH-2010-FINAL.NPT	11/15/13 4:15 pm
MET File	LCL-MET-2001.NPT	1/27/14 10:54 am	LCL-MET-2003.NPT	1/27/14 10:56 am	LCL-MET-2010.NPT	1/27/14 10:48 am
QIN File	LCL-QIN-2001.NPT	1/22/13 10:52 am	LCL-QIN-2003.NPT	12/17/12 4:07 pm	LCL-QIN-2010.NPT	1/22/13 10:14 am
	LCL-BR2-QIN.NPT	12/17/12 4:18 pm	LCL-BR2-QIN.NPT	12/17/12 4:18 pm	LCL-BR2-QIN.NPT	12/17/12 4:18 pm
TIN File	LCL-TIN-2001.NPT	1/22/13 11:04 am	LCL-TIN-2003.NPT	12/17/12 4:23 pm	LCL-TIN-2010.NPT	1/22/13 11:03 am
	LCL-BR2-TIN.NPT	12/17/12 4:19 pm	LCL-BR2-TIN.NPT	12/17/12 4:19 pm	LCL-BR2-TIN.NPT	12/17/12 4:19 pm
QOT File	LCL-QOUT-2001-5STR-012214.NPT	1/22/14 1:03 pm	LCL-QOUT-2003-5STR.NPT	10/22/13 2:48 pm	LCL-QOUT-2010-5STR.NPT	1/7/14 2:59 pm
QDT File	LCL-QDT-2001.NPT	1/27/14 11:25 am	LCL-QDT-2003-2.NPT	2/11/14 12:21 pm	LCL-QDT-2010.NPT	2/11/14 12:23 pm
TDT File	LCL-TDT-2001.NPT	1/22/13 11:04 am	LCL-TDT-2003.NPT	1/22/13 11:04 am	LCL-TDT-2010.NPT	1/22/13 11:03 am

Table B3. Inventory of files needed to run the LCLPM (predictive model).

Run Name	CY01-USGS-PortRun13		CY03-USGS-PortRun01		CY10-USGS-PortRun01	
File Type	Calibration – 2001	Date Stamp	Verification – 2003	Date Stamp	Verification – 2010	Date Stamp
W2_CON.NPT	–	2/3/15 2:26 pm	–	2/4/15 8:36 am	–	2/4/2015 8:37 am
WSC File	LCL-WSC-012314-ADJ.NPT	1/23/14 3:40 pm	LCL-WSC-012314-ADJ.NPT	1/23/14 3:40 pm	LCL-WSC-012314-ADJ.NPT	1/23/14 3:40 pm
SHD File	LCL-SHD.NPT	10/17/13 1:49 pm	LCL-SHD.NPT	10/17/13 1:49 pm	LCL-SHD.NPT	10/17/13 1:49 pm
BTH File	LCL-BATH-2001-FINAL.NPT	11/15/13 2:22 pm	LCL-BATH-2003-FINAL.NPT	11/15/13 2:24 pm	LCL-BATH-2010-FINAL.NPT	11/15/13 4:15 pm
MET File	LCL-MET-2001.NPT	1/27/14 10:54 am	LCL-MET-2003.NPT	1/27/14 10:56 am	LCL-MET-2010.NPT	1/27/14 10:48 am
QIN File	LCL-QIN-2001.NPT	1/22/13 10:52 am	LCL-QIN-2003.NPT	12/17/12 4:07 pm	LCL-QIN-2010.NPT	1/22/13 10:14 am
	LCL-BR2-QIN.NPT	12/17/12 4:18 pm	LCL-BR2-QIN.NPT	12/17/12 4:18 pm	LCL-BR2-QIN.NPT	12/17/12 4:18 pm
TIN File	LCL-TIN-2001.NPT	1/22/13 11:04 am	LCL-TIN-2003.NPT	12/17/12 4:23 pm	LCL-TIN-2010.NPT	1/22/13 11:03 am
	LCL-BR2-TIN.NPT	12/17/12 4:19 pm	LCL-BR2-TIN.NPT	12/17/12 4:19 pm	LCL-BR2-TIN.NPT	12/17/12 4:19 pm
QOT File	LCL-QOUT-2001.NPT	5/23/14 9:10 am	LCL-QOUT-2003.NPT	10/27/14 3:14 pm	LCL-QOUT-2010.NPT	10/31/14 2:15 pm
QDT File	LCL-QDT-2001.NPT	1/27/14 11:25 am	LCL-QDT-2003-2.NPT	2/11/14 12:21 pm	LCL-QDT-2010.NPT	2/11/14 12:23 pm
TDT File	LCL-TDT-2001.NPT	1/22/13 11:04 am	LCL-TDT-2003.NPT	1/22/13 11:04 am	LCL-TDT-2010.NPT	1/22/13 11:03 am
W2_SELECTIVE.NPT	–	2/3/15 2:25 pm	–	2/3/15 2:25 pm	–	2/3/15 2:25 pm

**Note: The same w2_selective.npt file is used for all 3 cases!

Appendix C: LCLM and LCLPM Files

This appendix serves to provide a description of each file needed to run the model. The files are grouped by year. As an aside, ERDC typically has the following file organization system (see Table C1).

Table C1. Typical File Organization

CY01		Main folder for year identification for the particular model. Most models will be designed to run with multiple years.
	Results	Upon running the model, the results are moved out of the executables folder and into their own folder; typically, these folders are named something like CYXX_RunXX. NOTE: Always copy the control file (and any needed selective withdrawal files) used for the run into the results folder so that you can duplicate the run in the future if necessary.
	Executables	This is where all of the necessary files needed to run the model are located: W2 executables, Inflows, Outflows, Temperature/Concentration files, Met files, Bathymetry, etc.

Table C2. Files needed to run LCL model for each year.

File Description	CY01	CY03	CY10
Graph File	graph.npt	graph.npt	graph.npt
Control File	w2_con.npt	w2_con.npt	w2_con.npt
Bathymetry File	LCL-BATH-2001-FINAL.NPT	LCL-BATH-2003-FINAL.NPT	LCL-BATH-2010-FINAL.NPT
Meteorology File	LCL-MET-2001.NPT	LCL-MET-2003.NPT	LCL-MET-2010.NPT
Wind Sheltering Coefficient File	LCL-WSC-012314-ADJ.NPT	LCL-WSC-012314-ADJ.NPT	LCL-WSC-012314-ADJ.NPT
Shade File	LCL-SHD.NPT	LCL-SHD.NPT	LCL-SHD.NPT
Upstream Inflow File	LCL-QIN-2001.NPT	LCL-QIN-2003.NPT	LCL-QIN-2010.NPT
Upstream Temperature File	LCL-TIN-2001.NPT	LCL-TIN-2003.NPT	LCL-TIN-2010.NPT
Branch 2 Inflow File (zero)	LCL-BR2-QIN.NPT	LCL-BR2-QIN.NPT	LCL-BR2-QIN.NPT
Branch 2 Temperature File (placeholder)	LCL-BR2-TIN.NPT	LCL-BR2-TIN.NPT	LCL-BR2-TIN.NPT
Dam Outflow File	LCL-QOUT-2001-5STR.NPT	LCL-QOUT-2003-5STR.NPT	LCL-QOUT-2010-5STR.NPT
Distributed Tributary Inflow File	LCL-QDT-2001.NPT	LCL-QDT-2003-2.NPT	LCL-QDT-2010.NPT
Distributed Tributary Temperature File (duplicated upstream temps)	LCL-TDT-2001.NPT	LCL-TDT-2003.NPT	LCL-TDT-2010.NPT

Table C3. Files needed to run LCLPM model for each year.

File Description	CY01	CY03	CY10
Graph File	graph.npt	graph.npt	graph.npt
Control File	w2_con.npt	w2_con.npt	w2_con.npt
Selective Withdrawal Control File	w2_selective.npt	w2_selective.npt	w2_selective.npt
Target Temperature File	dynsplit_selectiveX.npt	dynsplit_selectiveX.npt	dynsplit_selectiveX.npt
Dam Outflow File	LCL-QOUT-2001.NPT	LCL-QOUT-2003.NPT	LCL-QOUT-2010.NPT
Distributed Tributary Inflow File	LCL-QDT-2001.NPT	LCL-QDT-2003-2.NPT	LCL-QDT-2010.NPT
Distributed Tributary Temperature File (duplicated upstream temps)	LCL-TDT-2001.NPT	LCL-TDT-2003.NPT	LCL-TDT-2010.NPT

**NOTE: All other files are the same as found in Table C2

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14. ABSTRACT The U.S. Army Corps of Engineers Engineer Research and Development Center (USACE-ERDC) Environmental Lab (EL) assisted USACE, Portland District (CENWP) in updating a CE-QUAL-W2 (W2) model of Lost Creek Lake based on a previous version of W2. The model was calibrated using data from calendar year (CY) 2001 validated with data from calendar years 2003 and 2010. One set of W2 parameters were successfully applied to all calendar year types (2001 is a dry year; 2003 is a normal year; and 2010 is a wet year). This model and the corresponding results from the study provided CENWP with more refined estimates of water temperatures so that more defensible water temperature targets can be discussed with the state of Oregon. This is extremely important because the Rogue and Applegate temperature Total Maximum Daily Loads and Rogue Spring Chinook Conservation Plan require the Corps to review the Rogue Basin Project operations to determine whether improvements can be achieved to downstream temperature for the benefit of endangered fish. In addition to modeling the basic calibration for three years, a modified version of W2 was used to create a predictive model to determine the best blending of the intake ports to meet the temperature targets.					
15. SUBJECT TERMS CE-QUAL-W2, eutrophication, Lost Creek Lake, longitudinal-vertical hydrodynamics model, water quality model, W2, Reservoirs, Water temperature, Fishes--Effect of temperature on					
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