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Lake Roosevelt Water Quality and Hydrodynamic Model Calibration with Fish Bioenergetics

Michael Lee McKillip

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By

Mike McKillip,

And

Scott Wells

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PORTLAND STATE UNIVERSITY

Civil and Environmental Engineering Department
Maseeh College of Engineering and Computer Science
P.O. Box 751
Portland, Oregon 97201-0751

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Introduction

An understanding of the effects of hydrodynamics and reservoir operations on the Franklin D. Roosevelt Lake (Lake Roosevelt) aquatic food web allows for better management of the reservoir. A CE-QUAL-W2, v.3.5, hydrodynamic and water quality model (Cole and Wells, 2006[1]) is being applied to the reservoir. The models zooplankton algorithms are expanded and a fish bioenergetics model is incorporated. The Lake Roosevelt model extent is shown in Figure 1. The model includes the lacustrine arms up to full pool on the Sanpoil, Kettle, and Colville Rivers; the Spokane River arm up to Little Falls Dam; and the Columbia River from Grand Coulee Dam to the U.S.-Canadian border.

The previous companion report, "Boundary Conditions and Set-up" (McKillip, Annear, and Wells, 2006), covered

- A limnological overview
- Hydrodynamic boundary condition data and model inputs
- Grand Coulee Dam structures (powerhouse and spillway characteristics)
- Water temperature boundary condition data and model inputs
- Meteorological data and model inputs
- Water quality boundary condition data
- Model bathymetry data and model grid development
- Topographic shading
- Primary and secondary production data
- Kokanee hatchery release data

This report discusses the model calibration and issues related to the calibration. This report discusses the topics of

1) Hydrodynamic calibration: Hydrodynamic calibration focuses on matching the water surface elevation at Grand Coulee Dam.

2) Temperature calibration: Temperature calibration focuses on matching temperature profiles throughout the reservoir and continuous data below Grand Coulee Dam. Many of the calibration issues centered on properly characterizing the localized wind and powerhouse withdrawals.

3) Abiotic water quality calibration: Abiotic water quality calibration focused on matching water quality profile data in the reservoir. The selection of proper rate kinetics and understanding the impact of hydrodynamics on water quality state variables was critical to proper calibration

---

[1] The CE-QUAL-W2 version was upgraded from v.3.2 to v.3.5 since release of the Data Report (McKillip, Annear, and Wells, 2006 (EWR-01-05)). References to the User Manual also changed from Cole and Wells, 2004 (v.3.2) to Cole and Wells, 2006 (v.3.5.)

4) Bioenergetic (algae, zooplankton, kokanee) modeling approach and calibration

5) Sensitivity analyses

The hydrodynamic calibration was performed for three independent years: 2000, 2001, and 2002. Temperature, water quality and bioenergetic calibrations were performed for 2000. Table 1 shows the model calibration periods.

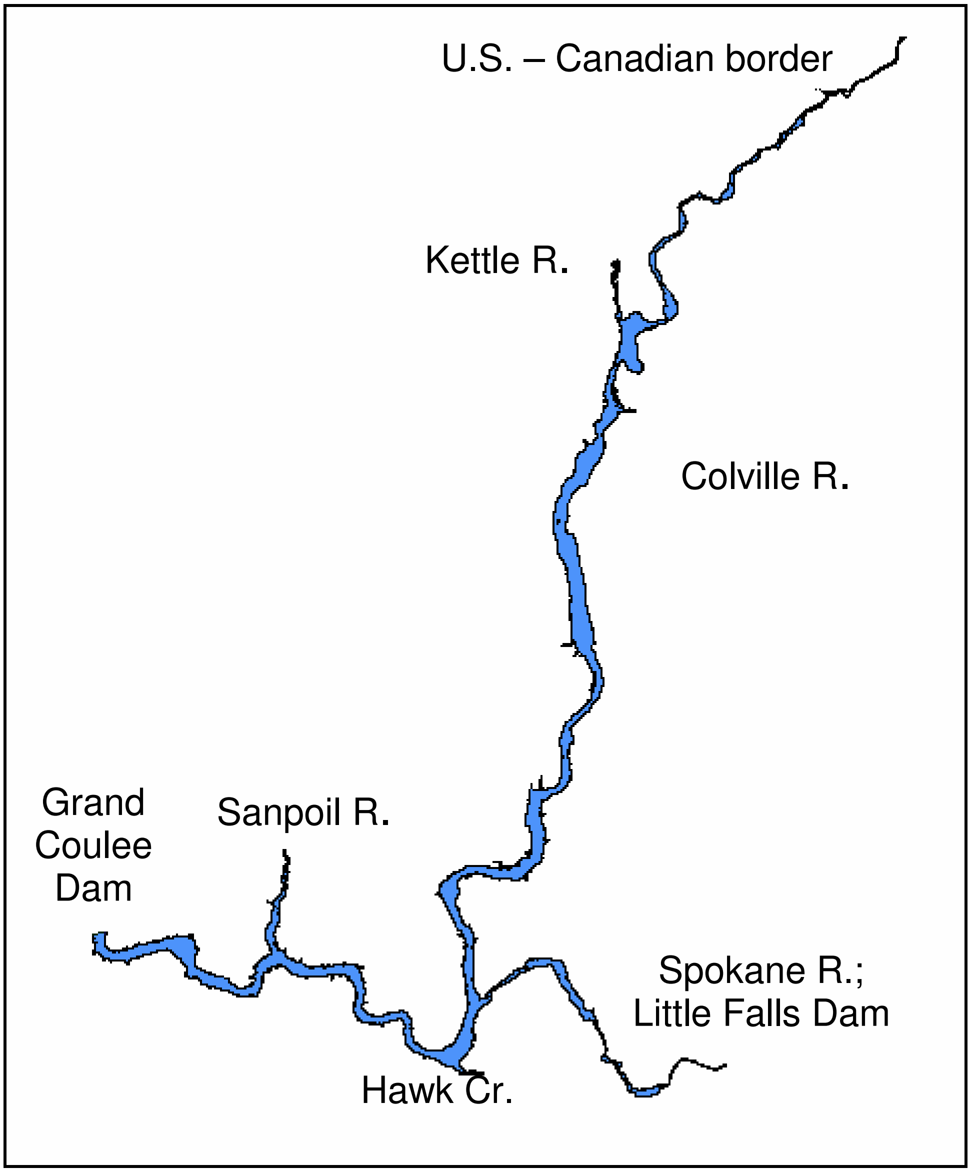

Figure 1. Lake Roosevelt model area.

Table 1. Model calibration periods.

Calibration	Start date	End date
Hydrodynamic	January 1, 2000 January 1, 2001 January 1, 2002	December 31, 2000 December 31, 2001 December 31, 2002
Water temperature	January 1, 2000	December 31, 2000
Water quality	January 1, 2000	December 31, 2000
Bioenergetics	January 1, 2000	December 31, 2000

Monitoring Sites

The water quality monitoring sites are discussed in McKillip, Annear, and Wells (2005). Figure 2 shows the locations of the water quality monitoring stations. Hydrodynamic calibration sites include USACOE FDRW at Grand Coulee Dam and GCGW downstream of the dam. These sites were used for boundary conditions and for model-data comparisons during calibration within Lake Roosevelt.

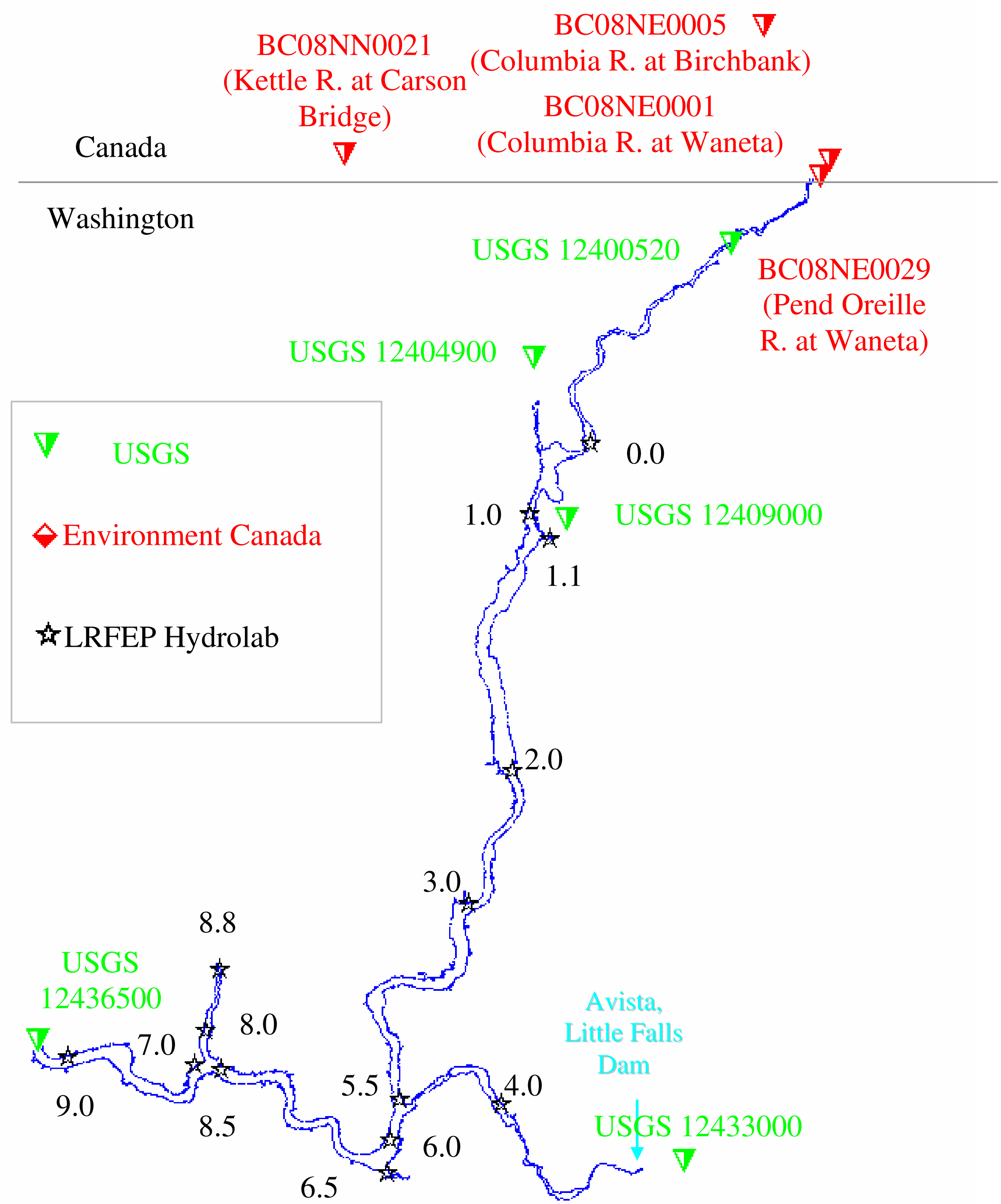

Figure 2. Water quality sampling site locations.

Hydrodynamic Calibration

Hydrodynamic calibration was performed by balancing all of the sources and sinks with a waterbalance flow to match the dam forebay water surface elevation data. Sources include tributary and mainstem inflows, precipitation, and return flows from Banks Lake (cogeneration flows). Sinks include outflows at the dam (powerhouse flows, outlet tubes, and spillway flows) irrigation withdrawals to Banks Lake, and evaporation.

Calibration Stations

The sole hydrodynamic calibration station is at the forebay of Grand Coulee Dam, USACOE gage (GCL). The station reports hourly water surface elevation (stage).

Year 2000

Figure 3 shows the model-data comparison of forebay stage. Table 2 reports the model-data comparison statistics. The magnitude of the waterbalance flows are shown in Figure 4. Figure 5 shows the percent of the waterbalance flows compared to the total flow through the dam. The magnitude of the waterbalance flows is largely within the flow gage measurement error range of 5 to 10%.

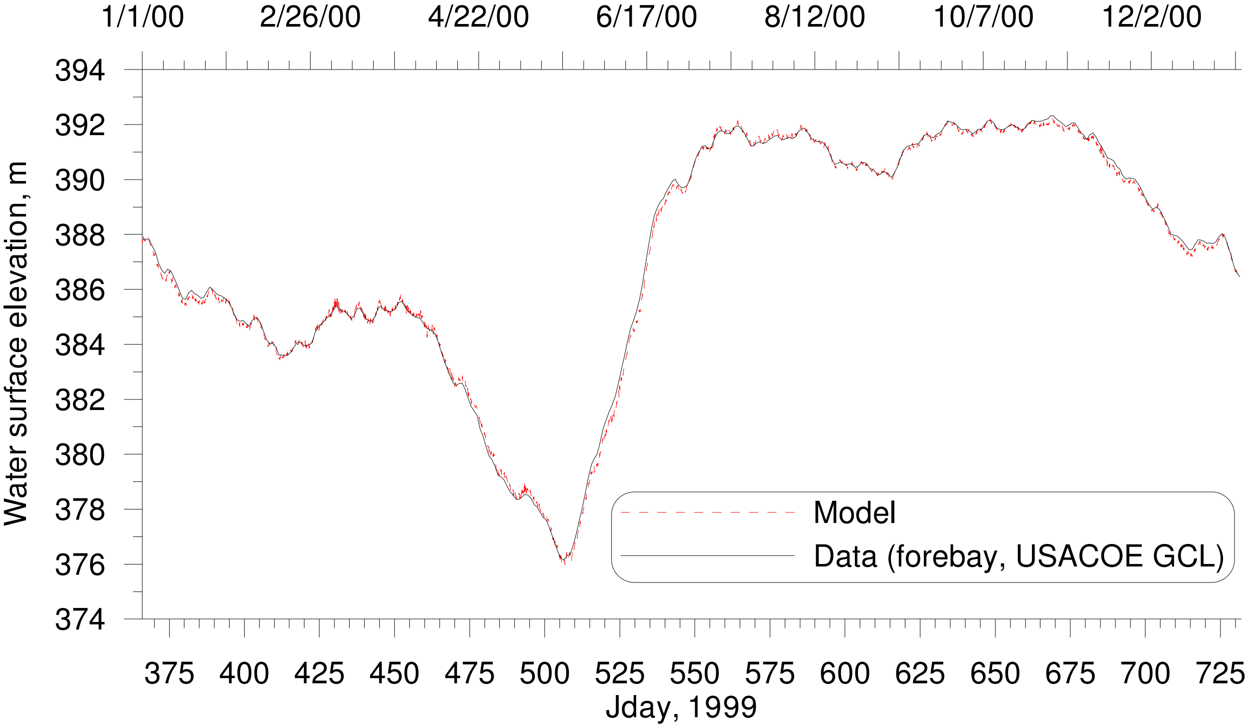

Figure 3. Model-data comparison, Grand Coulee Dam forebay stage, 2000.

Table 2. Grand Coulee Dam forebay stage statistics, 2000.

Statistic (m)	Count	ME*	AME*	RMS*
Daily-average values	366	0.01	0.01	0.01
Hourly-average values	8762	-0.03	0.17	0.17

* ME=mean error, AME=absolute mean error, RMS=root mean square error, see Appendix G.

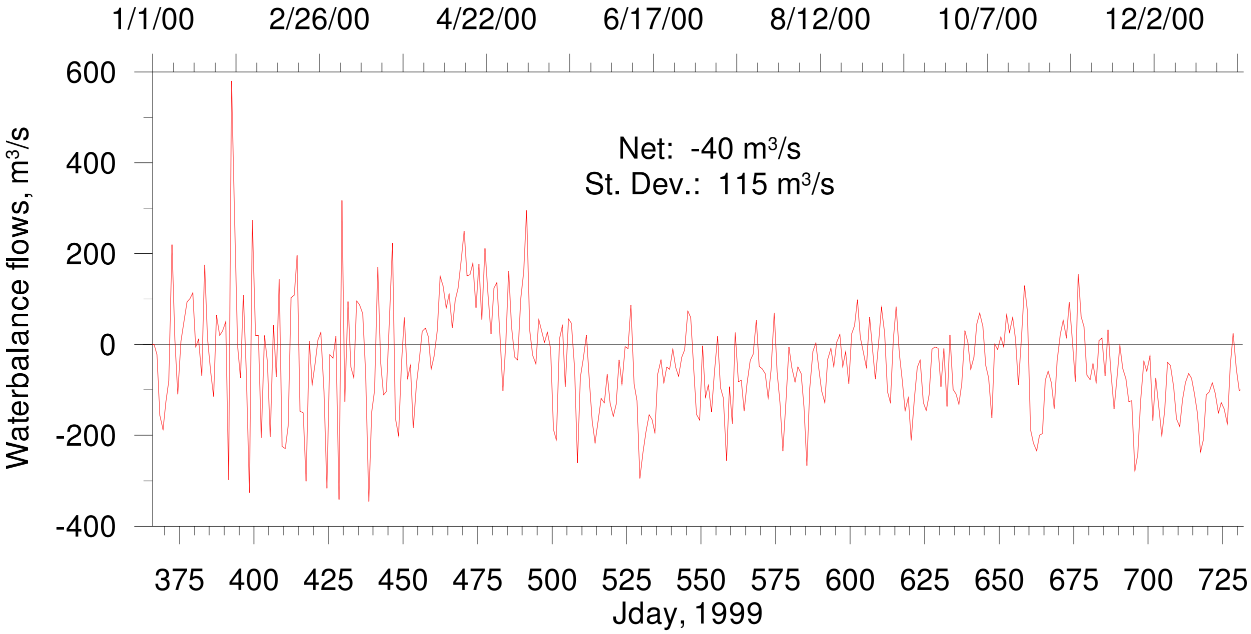

Figure 4. Waterbalance flow magnitudes, 2000.

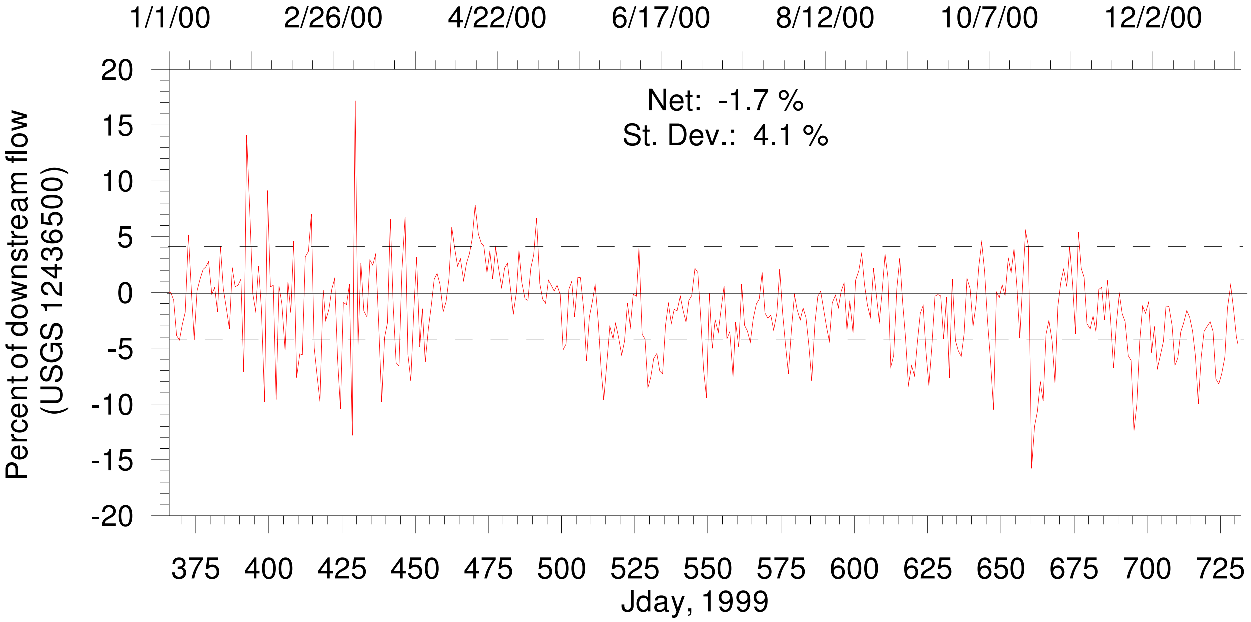

Figure 5. Waterbalance flows as percentage of downstream flows, 2000.

Year 2001

Figure 6 shows the model-data comparison of forebay stage. Table 3 reports the model-data comparison statistics. The waterbalance flows are shown terms of magnitude (Figure 7) and percent of total flow through the dam (Figure 8). Unlike the water balance for 2000, the 2001 water balance shows a bias toward negative flows (water being removed from the river).

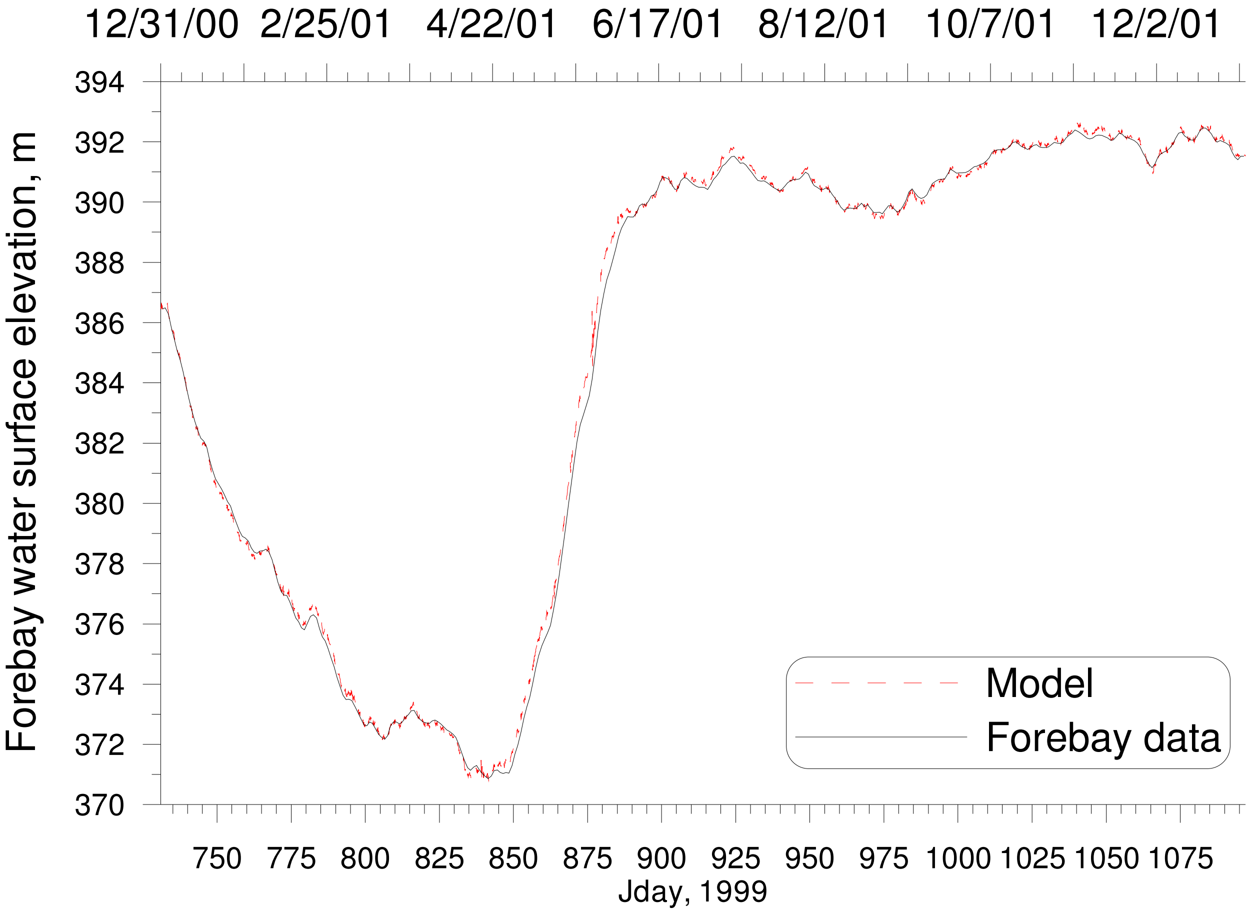

Figure 6. Model-data comparison, Grand Coulee Dam forebay stage, 2001.

Table 3. Grand Coulee Dam forebay stage statistics, 2001.

Statistic (m)	Count	ME*	AME*	RMS*
Daily-average values	366	0.13	0.17	0.27
Hourly-average values	8762	0.01	0.12	0.12

* ME=mean error, AME=absolute mean error, RMS=root mean square error, see Appendix G.

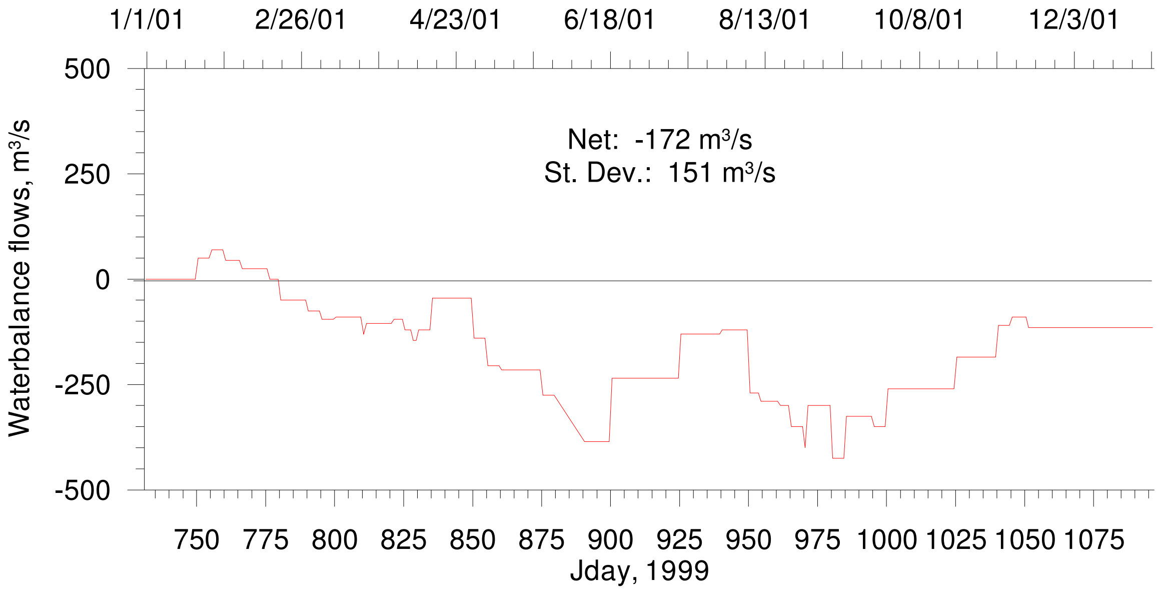

Figure 7. Waterbalance flow magnitudes, 2001.

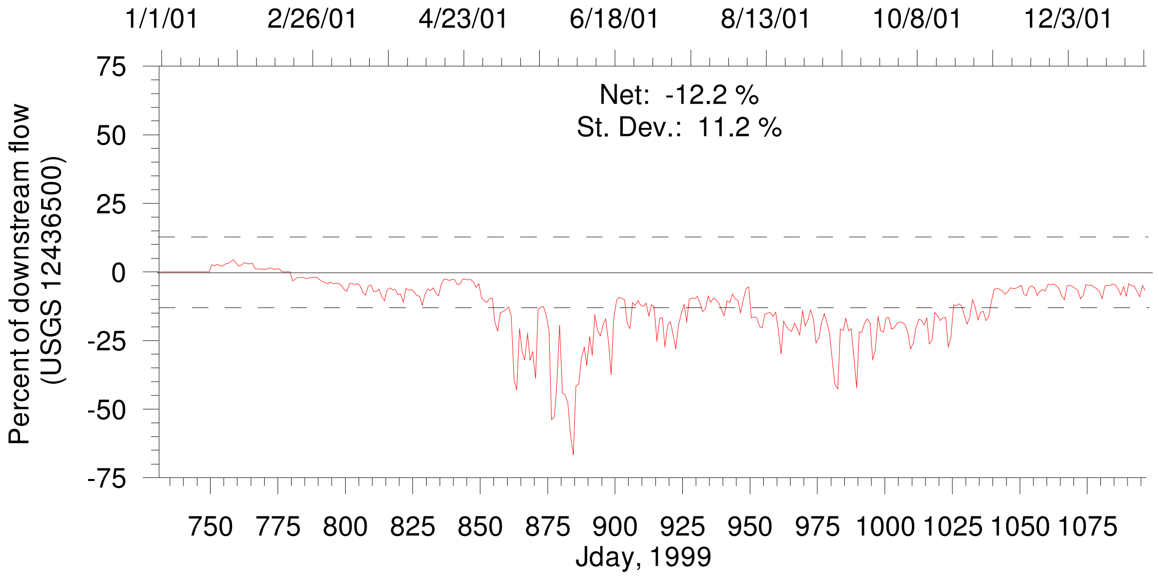

Figure 8. Waterbalance flows as percentage of downstream flows, 2001.

Year 2002

Figure 9 shows the model-data comparison of forebay stage. Table 4 reports the model-data comparison statistics. The waterbalance flows are shown terms of magnitude (Figure 10) and percent of total flow through the dam (Figure 11). Unlike the water balance for 2000, the 2002 water balance shows a bias toward negative flows (water being removed from the river).

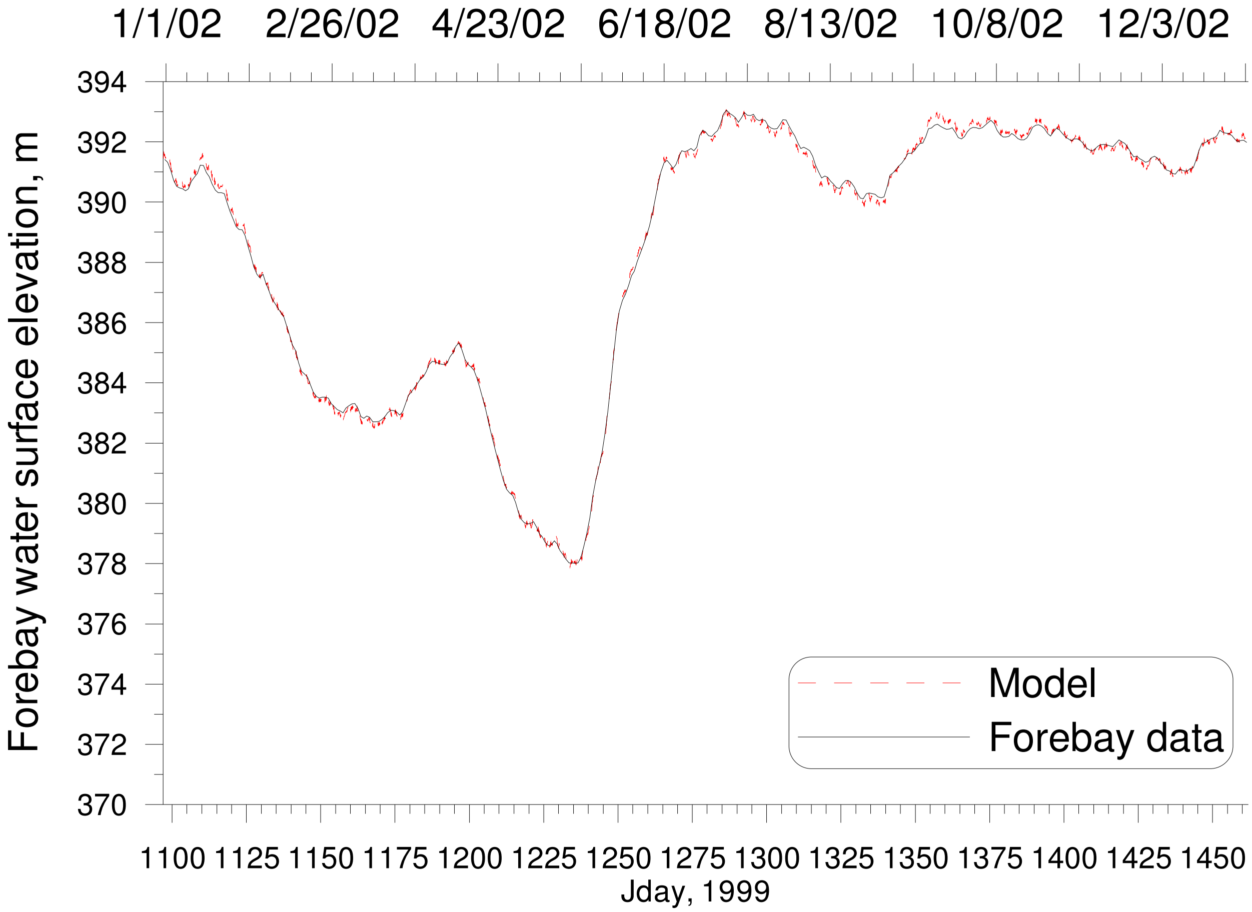

Figure 9. Model-data comparison, Grand Coulee Dam forebay stage, 2002.

Table 4. Grand Coulee Dam forebay stage statistics, 2002.

Statistic (m)	Count	ME*	AME*	RMS*
Daily-average values	366	0.02	0.02	0.02
Hourly-average values	8763	0.01	0.10	0.10

* ME=mean error, AME=absolute mean error, RMS=root mean square error, see Appendix G.

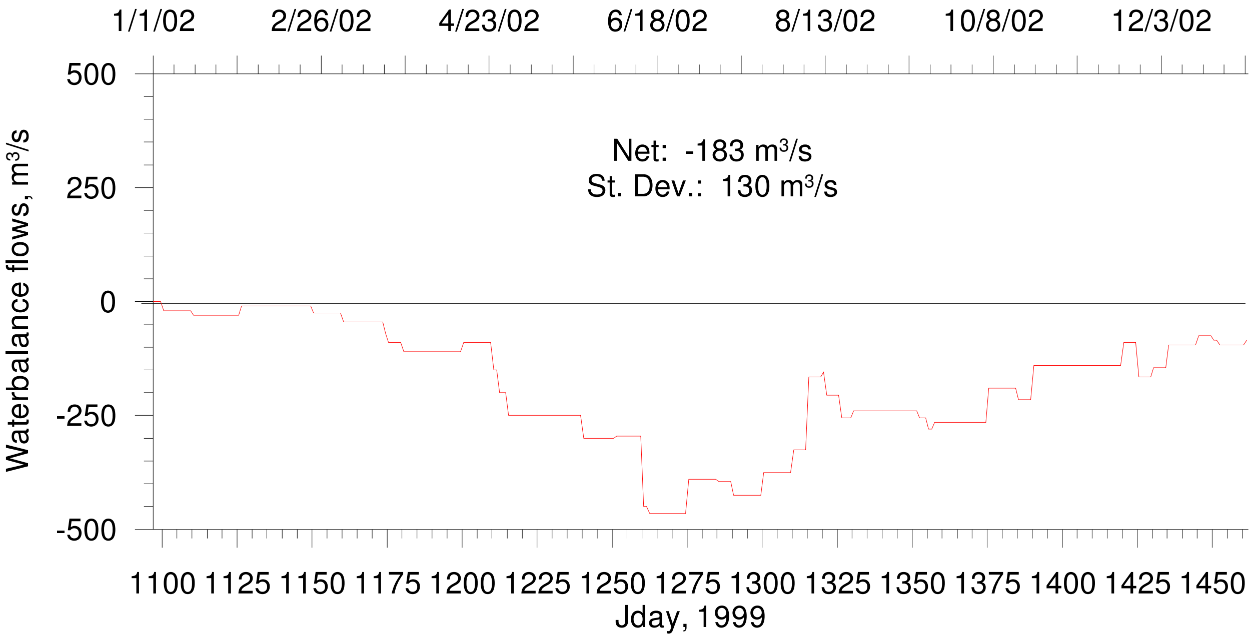

Figure 10. Waterbalance flow magnitudes, 2002.

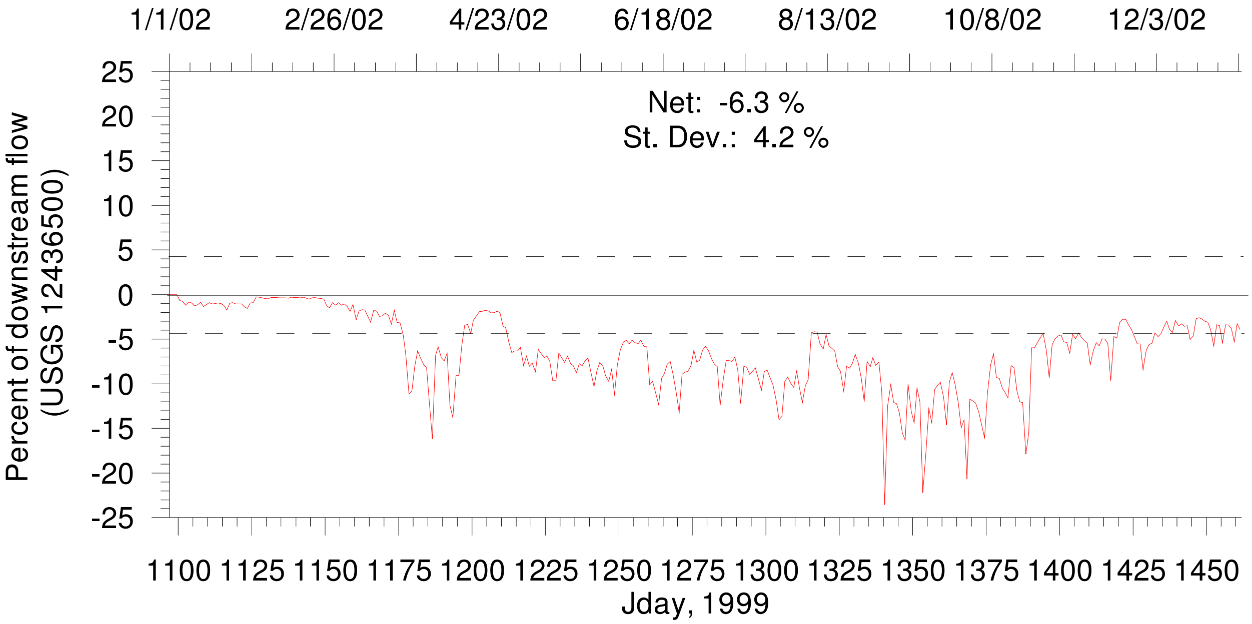

Figure 11. Waterbalance flows as percentage of downstream flows, 2002.

Temperature Calibration

The temperature calibration focused on matching the vertical stratification by adjusting the local wind sheltering coefficient and properly characterizing the powerhouse flows. The selective withdrawal elevation for flow through the third powerhouse had a lower bounds set to allow for more of the warmer surface water characteristic during stratification to be withdrawn. Meteorological inputs were adjusted to allow for the proper level of mean heating in the vertical profile sampling stations and continuous data downstream of Grand Coulee Dam.

Figure 12 shows a comparison of the vertical temperature profile at LRFEP station 9.0 (upstream of Grand Coulee Dam) under the calibrated wind sheltering coefficients [WSC] and with the default values [1.0]. Areas upstream of the dam had decreased WSC values (this in a decrease in wind speed, and hence mixing) which helped to allow greater stratification in the epilimnion.

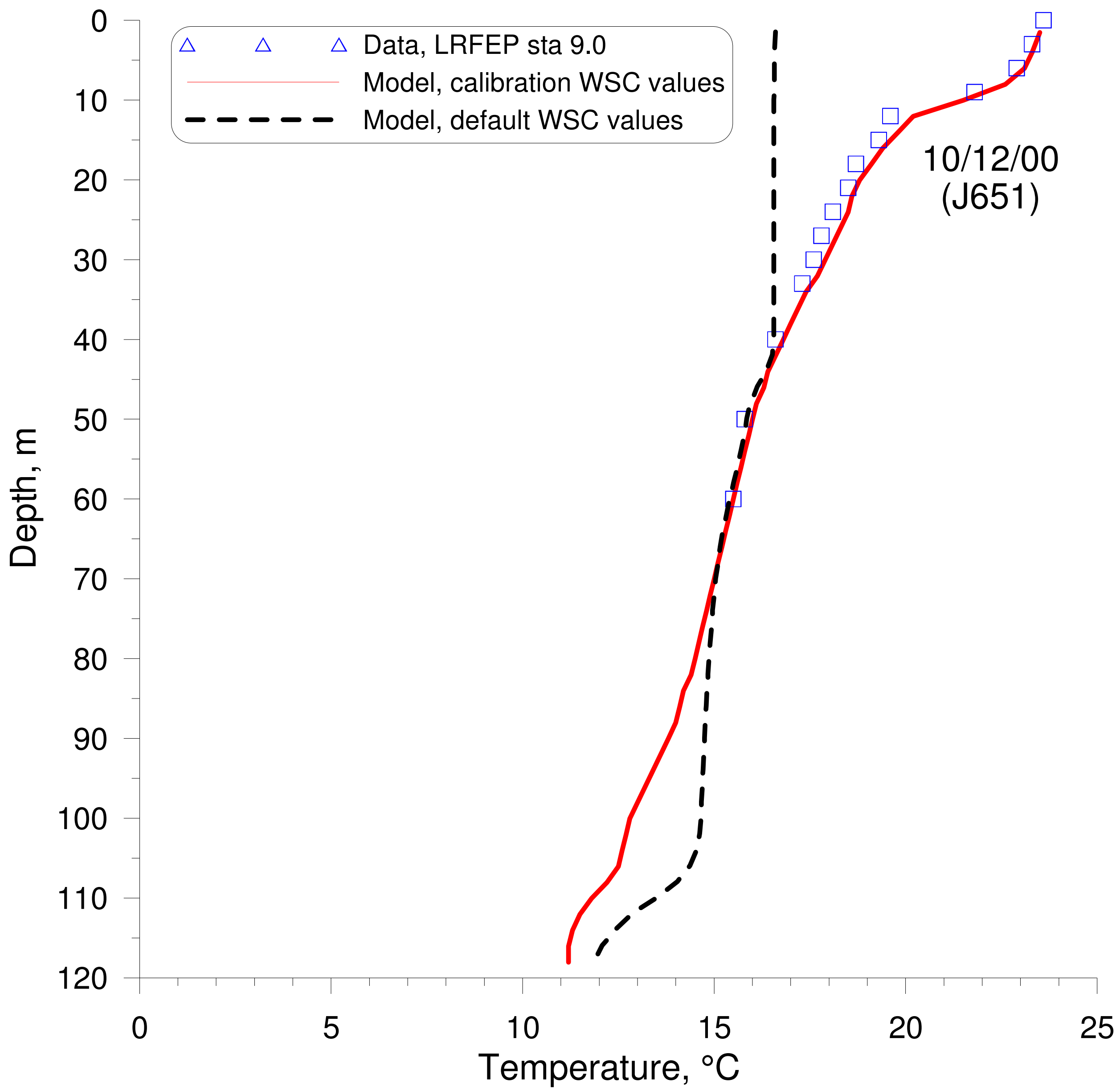

Figure 12. The effects of wind sheltering coefficients on temperature calibration. The default value of WSC of 0.85 was not considered accurate but was used as a basis for comparison to the calibrated value.

Calibration Stations

Two temperature calibration data types were available. Periodic vertical profile data were available at some or all of the 11 LRFEP stations shown in Figure 13. Table 5 lists the gage locations, numbers, and names. Sampling general occurred at a temporal frequency up to monthly at a typical vertical resolution of 3 m over the bulk of the vertical range. Roughly 10 km (6 mi) downstream of Grand Coulee Dam is the USACOE gage (GCGW) which records hourly temperatures. The Columbia River at the gage is riverine, and the temperatures were taken to be representative of the mean temperature.

Two additional temperature data sources were not used for calibration. The USGS gage at Northport (12400520) reported low frequency samples. The values reported were generally much colder than the nearby upstream temperatures reported at the International Boundary (USACOE CIBW) used for the Columbia River temperature boundary condition. The upstream gage, CIBW, agreed well with the most upstream vertical profile station (LRFEP 0.0).

The USBR collects temperatures from a station at the left side of Grand Coulee Dam that floats 60 ft (18.3 m) below the water surface (reported as USACOE: FDRW). These data were likely unrepresentative of the temperatures in the last model segment (which is 1000 m in length) as the instrument was attached to a trash rack near the dam face. Refer to McKillip, Annear, and Wells (2005) for further discussion of the instrument and data quality.

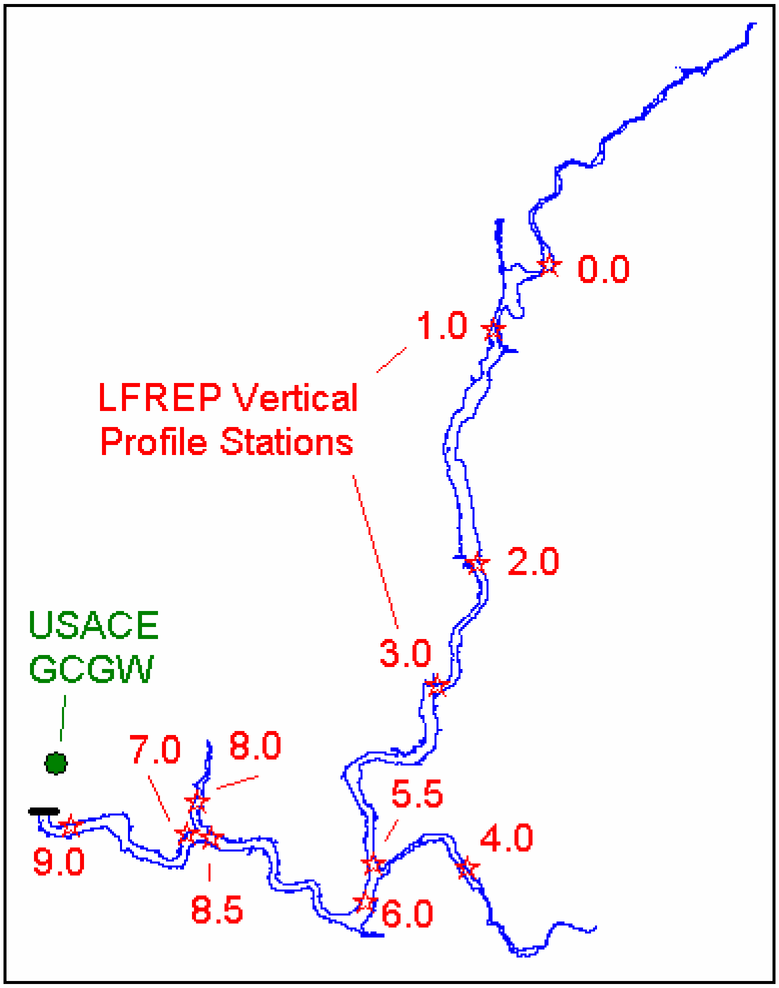

Figure 13. Locations of the temperature calibration sites.

Table 5. LFREP vertical profile stations.

Gage/Station	Location Name	Latitude	Longitude
0.0	Evan's Landing	48.6830	118.0216
1.0	Kettle Falls	48.5992	118.1310
2.0	Gifford	48.2944	118.1540
3.0	Hunters	48.1371	118.2261
4.0	Porcupine Bay	47.9018	118.1651
5.5	Spokane R. Confluence	47.9043	118.3431
6.0	Seven Bays	47.8566	118.3571
7.0	Keller Ferry	47.9398	118.7046
8.0	Sanpoil R.	47.9814	118.6859
8.5	Sanpoil R. Confluence	48.0545	118.6643
9.0	Spring Canyon	47.9462	118.9285

Grand Coulee Dam, Continuous Temperatures

Temperature calibration focused on adjusting the wind magnitude (via the wind sheltering coefficient) temporally and spatially. Because actual wind speed and direction are highly variable around the lake, in order to monitor the wind with sufficient accuracy for calibration, one or a couple of wind monitoring locations may be inadequate to account for the full spatial and temporal variability of the wind field. The temperature data provide a good measure of the level of wind-driven mixing available between stations over the sampling time intervals. Thus, by adjusting the wind magnitude over reaches and time periods where the level of mixing is known (i.e., where temperature data are present), the mean wind speed can be better approximated.

The first target was to approximate the mean downstream temperature data (USACOE GCGW). The second target was to match the vertical temperature profiles (refer to Appendix F), which are a good indicator of the appropriate wind magnitude. In matching the temperatures near Grand Coulee Dam, the vertical profile data at LRFEP station 9.0 were given greater weight than the downstream river temperatures at USACOE GCGW. There is some uncertainty in how representative the downstream data are of the combined dam outflow temperature. This comparison is shown in Figure 14. Statistics are reported in Table 6. The depth of the powerhouse intakes, when compared to the vertical temperature profiles of the data at LRFEP station 9.0 and the model at the last Columbia River segment, suggests that the outflow temperature should be much colder during the summer than the downstream, riverine data. In order to 1) match the downstream, riverine data and 2) obtain the shape of the vertical profile data, the bottom of the selective withdrawal algorithm for the third powerhouse was limited to a minimum elevation of 353 m. This is higher than the centerline intake elevation of 347.5 m. Given the narrow inlet length of the third powerhouse, the surface waters appear to be preferentially withdrawn from the surface. This model characterization is a simplification of the more complicated three-dimensional nature of the flow within the third powerhouse inlet.

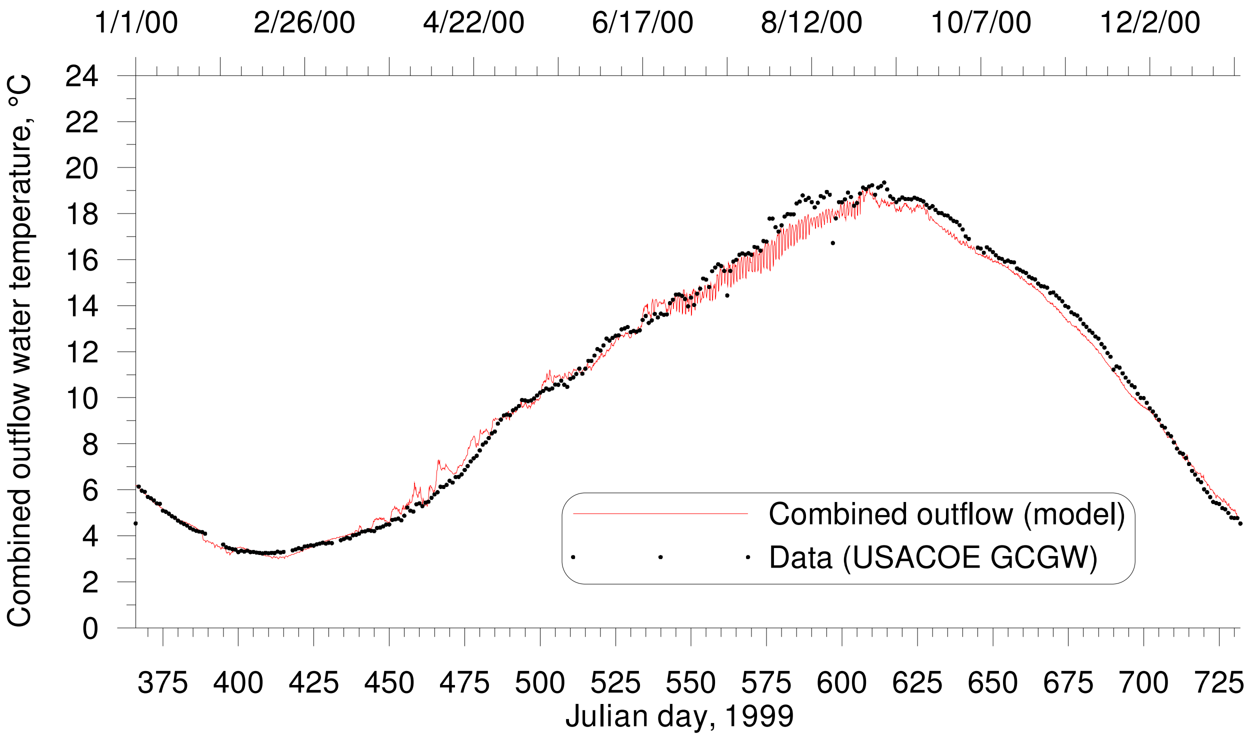

Figure 14. Model-data temperature comparison, below Grand Coulee Dam, 2000.

Table 6. Grand Coulee Dam temperature statistics, 2000.

Statistic (°C)	Count	ME*	AME*	RMS*
Daily-average values	356	-0.12	0.36	0.36
15-min and 60-min average values	24428	-0.24	0.45	0.45

* ME=mean error, AME=absolute mean error, RMS=root mean square error, see Appendix G.

Vertical Profile Stations, Periodic Sampling

The temperature calibration plots and statistics from the LRFEP vertical profile station data are reported in Appendix F. Selected profiles are shown for station 4.0 (Figure 15) and station 9.0 (Figure 16) in this section. Three sampling periods are illustrated for the reservoir conditions near minimum spring pool, near peak thermal stratification, and after fall turnover. Overall temperature model-data profile errors were -0.14°C, 0.49°C, and 0.50°C, for the mean error, absolute mean error, and root-mean-square error, respectively, comparing 114 vertical temperature profiles. Detailed error statistics are shown in Appendix F Table 31.

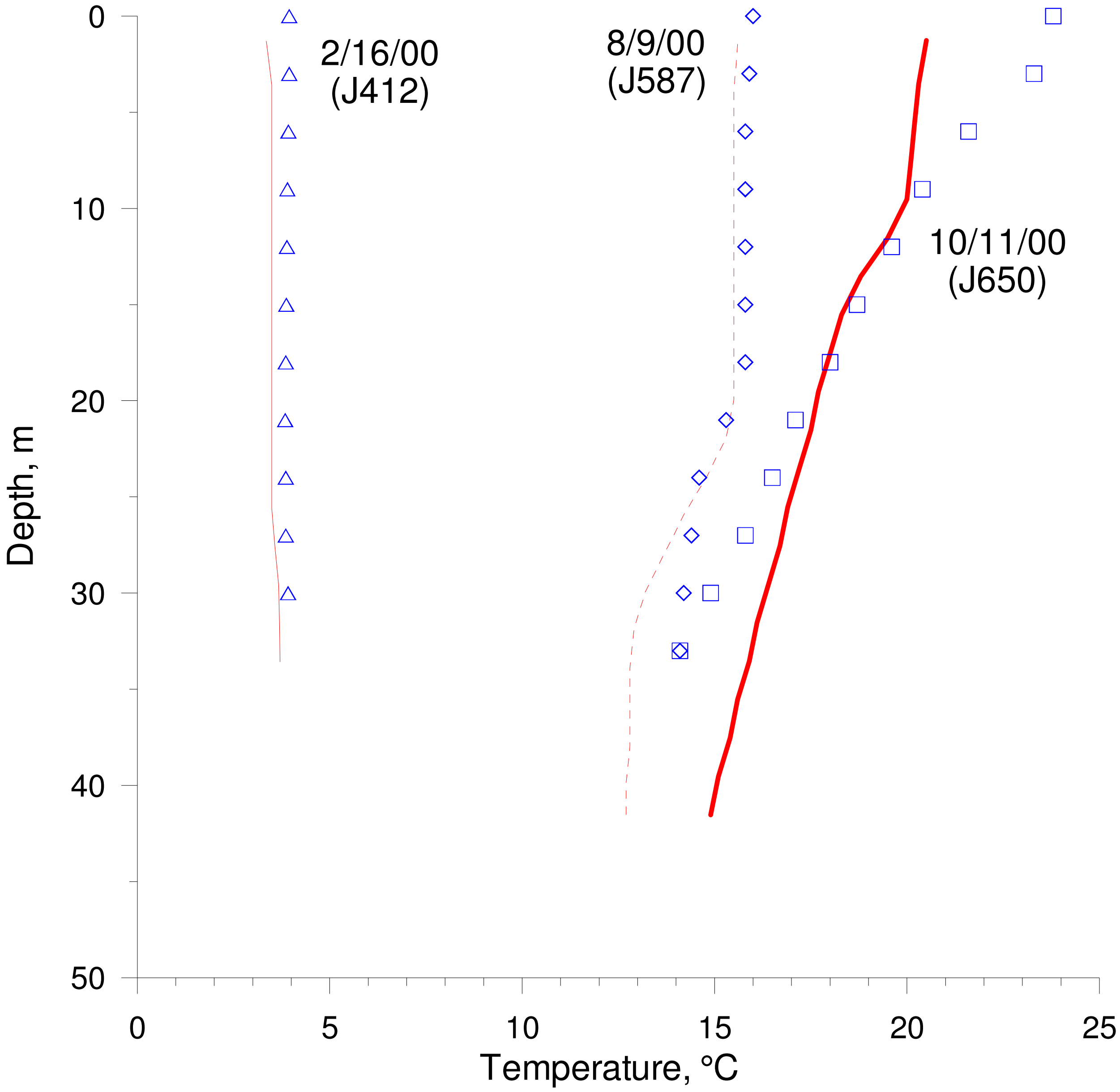

Figure 15. Selected model-data temperature profile comparisons at Porcupine Bay (LRFEP sta 4.0).

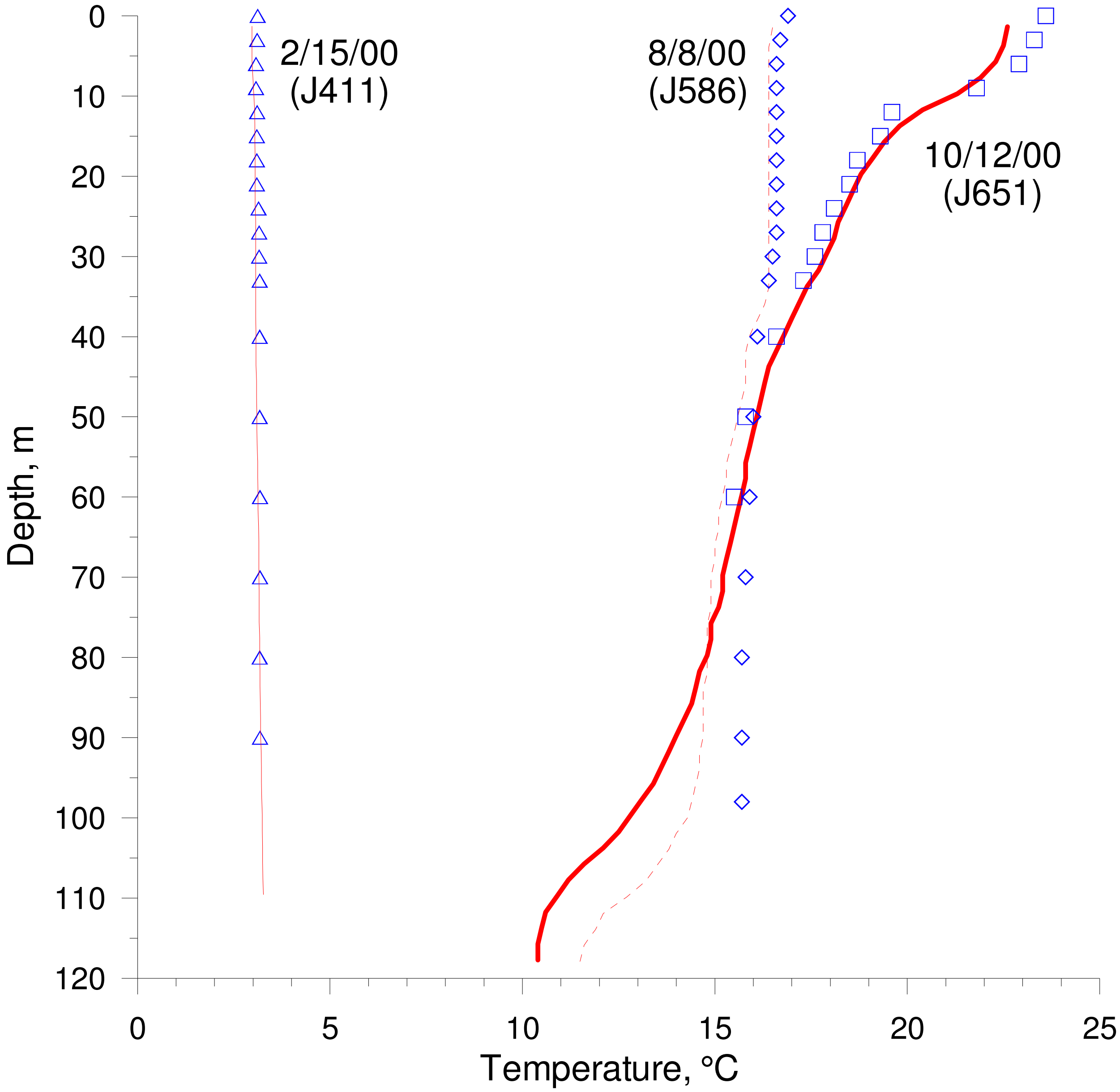

Figure 16. Selected model-data temperature profile comparisons at Spring Canyon (LRFEP sta 9.0).

Abiotic Water Quality Calibration

Calibration Stations

The abiotic water quality calibration stations included the LRFEP stations shown in Figure 13 (in the temperature calibration section) and the USGS gage below Grand Coulee Dam (12436500).

The abiotic water quality calibration plots were grouped into three areas of the report to take advantage of the structure of the data.

- The flow weighted constituent values of the outflow at Grand Coulee Dam are reported in the next section (Grand Coulee Dam Outflow). The time-series results are compared with the vertical data upstream of the dam (LRFEP station 9.0) and the grab sampling in the riverine reach below the dam (USGS 12436500). Data below the dam are not available for all constituents.
- The LRFEP monitoring stations report several constituents associated over specific depths. These constituents are total dissolved solids, dissolved oxygen, and pH. Plots showing the vertical structure are reported in Appendix F.
- Many of the constituents sampled by the LRFEP had a depth loosely associated with the sample. The depths were reported as being in the photic or aphotic zone. The model results were volume-weighted over the upper 10 m to provide a rough estimate of the photic zone constituent value. Plots showing the weighted model results are reported in Appendix E.

Some of the constituents results are illustrated as both continuous outflow concentrations (next section: Grand Coulee Dam, Continuous Temperatures) and as vertical profiles (Appendix F). Model-data comparison statistics are reported based on the structure of the data as shown in Table 7.

Table 7. Organization of the Grand Coulee Dam outflow constituent model-data comparison statistics.

Constituent	**Data**		**Statistics Table**
	structure	source	
Alkalinity	discrete (grab)	STOI Lab sta 9.0	Table 8
Ammonium	discrete (grab)	STOI Lab sta 9.0	Table 8
Dissolved oxygen	profile	LRFEP sta 9.0	Table 31
Nitrate + nitrite	discrete (grab)	STOI Lab sta 9.0	Table 8
pH	profile	LRFEP sta 9.0	Table 31
Orthophosphate	discrete (grab)	STOI Lab sta 9.0	Table 8
Total dissolved solids	profile	LRFEP sta 9.0	Table 31

Constituent Calibration Discussion

Water quality calibration is discussed in several sections:

- Continuous abiotic data near Grand Coulee Dam
- Instantaneous vertical profile of abiotic data at LRFEP stations
- Model-data vertical profile comparisons in Appendix E
- Alternative boundary conditions for DO and pH
- Boundary condition generation in Appendix A

Calibration to temperature, hydrodynamic, abiotic, and biotic data is to a varying degree simultaneous. A discussion of the abiotic calibration is presented in this section in an attempt to present the calibration adjustments in a single section.

In general, the approach to calibration is to calibrate to hydrodynamic data, and then to the temperature data, which often requires adjustment of the hydrodynamic calibration. The most upstream location is calibrated first, for each calibration target, and the earliest targets (in time) are also calibrated first. The downstream stations, and the later time periods, are heavily influenced by the upstream and earlier periods. Thus, a continuous reevaluation of the upstream calibration and boundary conditions is made during calibration.

While considering this general approach, calibration of specific constituents is discussed below.

Alkalinity and pH

Since there is little carbonate chemistry activity in the system, alkalinity behaves like a conservative constituent. The calibration focused on ensuring that all of the carbon chemistry initial conditions were appropriate. The W2 model uses alkalinity, total inorganic carbon (TIC), and bicarbonate (HCO3) to model the carbon system. pH is a derived constituent, meaning its value is determined from other constituents. Overall, pH model-data profile errors were -0.42 0.43, and 0.43, for the mean error, absolute mean error, and root-mean-square error, respectively, comparing 114 vertical pH profiles. Detailed error statistics are shown in Appendix F Table 31.

There is an apparent data conflict between the USGS and LRFEP data. The sub-section Total Inorganic Carbon (pH) of the Alternate Boundary Conditions section examines this conflict.

Ammonium and Nitrate plus Nitrite

Calibration of the nitrogen budget required only small changes from the default conditions. The major change was to reduce the amount of nitrogen in the decaying organic matter [ORGN] to reduce the ammonium concentrations.

Dissolved Oxygen

Dissolved oxygen calibration involved a review of the boundary conditions, inclusion of sediment oxygen demand (SOD), and an investigation of the reaeration equations and algal populations. As might be expected from low algal concentrations, the mainstem Columbia and Spokane River DO concentrations were not sensitive to algal concentration. Similarly, such a large volume system was not sensitive to the reaeration formulation. Inclusion of SOD allowed the model to capture some of the vertical gradients near the bottom of the reservoir. However, the model was not able to fully capture all of the observed vertical gradients—the model predicted less vertical variation. Also, the data exhibit significant shifts in concentrations from month to month and site to site that are not readily explained by known physical processes. For example, the data showed monthly changes of 1 mg/l at a site that would not occur at the next downstream site. Overall, dissolved oxygen model-data profile errors were -0.01 mg/l, 0.14 mg/l, and 0.16 mg/l, for the mean error, absolute mean error, and root-mean-square error, respectively, comparing 114 vertical dissolved oxygen profiles. Detailed error statistics are shown in Appendix F Table 31.

Orthophosphate

Phosphorous calibration was problematic given the large spring spike over the entire system, followed by very low concentrations. The physical cause of this phenomenon is not clear. The phenomenon was characterized as early spring inflows which were then sorbed onto inorganic suspended solids. This approach allowed some of the spring spike to be captured by the model, but the summer and fall concentrations were elevated. Additionally, the organic matter stoichiometry [ORGP] was reduced to lower concentrations. The orthophosphate concentrations were not sensitive to algal stoichiometry or algal concentrations within the range of the system.

Total Dissolved Solids

Total dissolved solids are largely conservative, so calibration focused on ensuring good boundary conditions. The calibration was acceptable for the Columbia River, but the Spokane River showed some problems. While the shape of the vertical gradient was typically captured, there were errors (shifts) in the concentrations. Overall, Total dissolved solids model-data profile errors were -0.18 mg/l, 0.39 mg/l, and 0.44 mg/l, for the mean error, absolute mean error, and root-mean-square error, respectively, comparing 114 vertical TDS profiles. Detailed error statistics are shown in Appendix F Table 31.

Grand Coulee Dam Outflow

The water quality constituents of the modeled outflow from Grand Coulee Dam are compared to data both upstream at LRFEP station 9.0 and downstream at USGS 12436500. The data at these two points do not always agree. The model uses flow weighting from each outlet structure in reporting the model constituent concentrations. The downstream data are from grab samples at a 2riverine reach. The upstream samples are a mix of vertical profile points and grab samples in both the aphotic and euphotic zones. The vertical profile data points are shown to give a sense of the range of the constituent values at the sampling point.

The model-date comparison statistics for the discrete sampling constituents are shown in Table 8. The statistics for the vertical profile sampling constituents are reported in Appendix F (Table 31).

Table 8. Discrete constituent model-data comparison statistics.

Constituent	Orthophosphate	Ammonium	Nitrate plus nitrite	Alkalinity
Unit	mg/L-P	mg/L-N	mg/L-N	mg/L-$CaCO_3$
Count	25	25	25	25
ME	0.00072	-0.0050	-0.017	0.89
AME	0.00097	0.0067	0.036	4.18
RMS	0.00097	0.0067	0.036	4.18

Alkalinity

The alkalinity model-data comparison near Grand Coulee Dam is shown in Figure 17. After ensuring good boundary conditions and hydrodynamic calibration, no further adjustments were made.

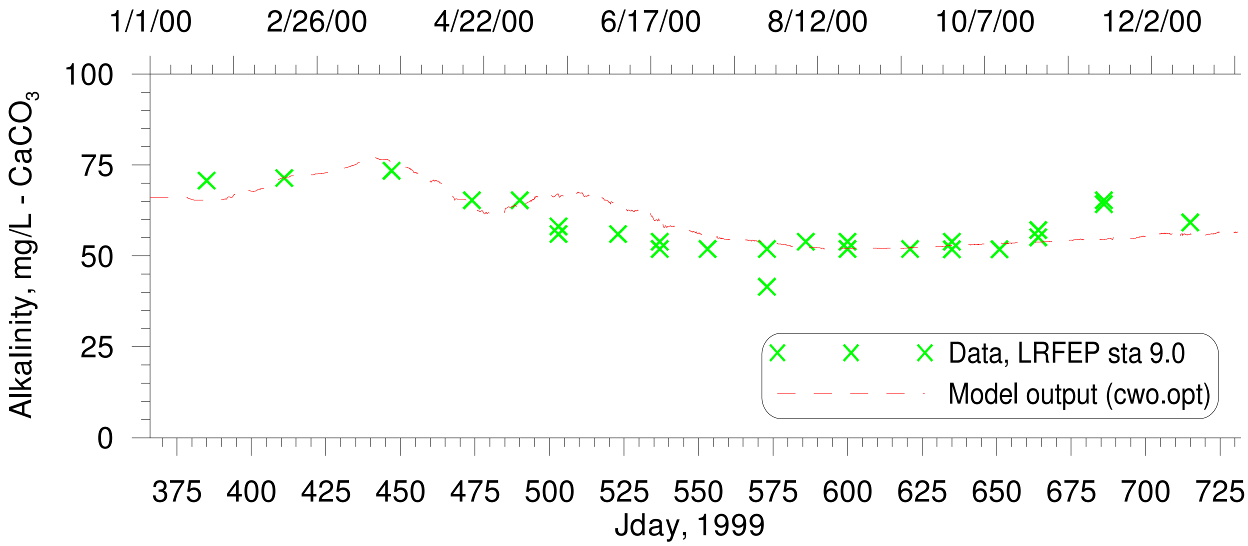

Figure 17. Alkalinity time-series near Grand Coulee Dam.

Ammonium

The ammonium model-data comparison near Grand Coulee Dam is shown in Figure 18. After ensuring good boundary conditions and hydrodynamic calibration, no further adjustments were made. The USGS sampling had a higher detection limit than the LRFEP sampling. The model predicts ammonium concentrations below the USGS sampling detection limit.

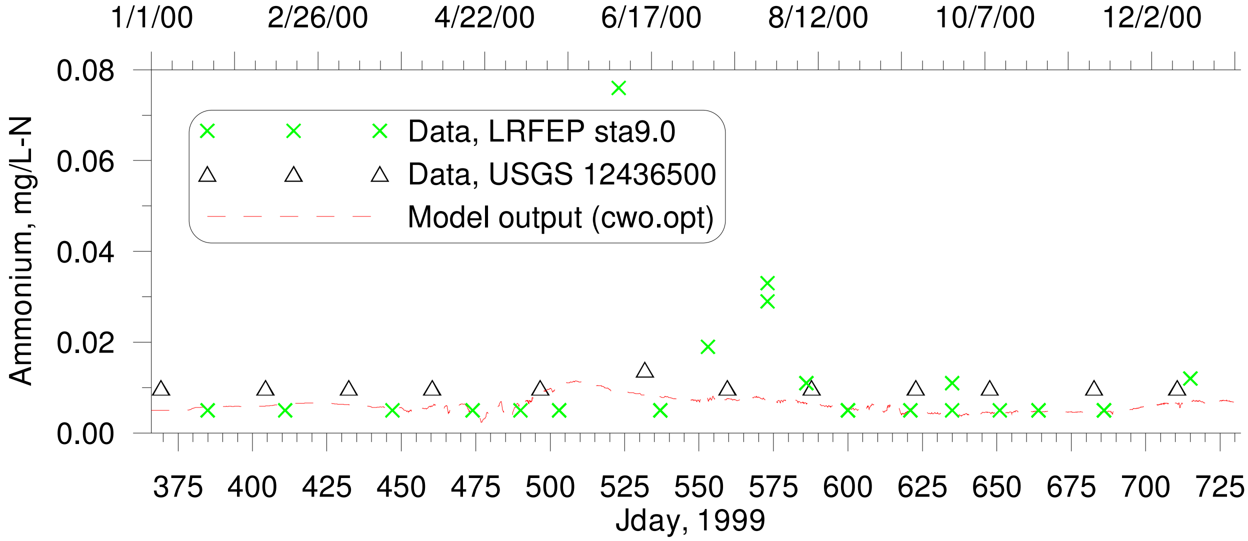

Figure 18. Ammonium time-series near Grand Coulee Dam.

Dissolved Oxygen

The dissolved oxygen model-data comparison near Grand Coulee Dam is shown in Figure 19. After ensuring good boundary conditions and hydrodynamic calibration, no further adjustments were made. The model values are typically near saturation; however, the data are above saturation in the early spring and below saturation in the fall. The source of this discrepancy is unclear. Model results were not sensitive to the algal concentration or the air-water reaeration formulation.

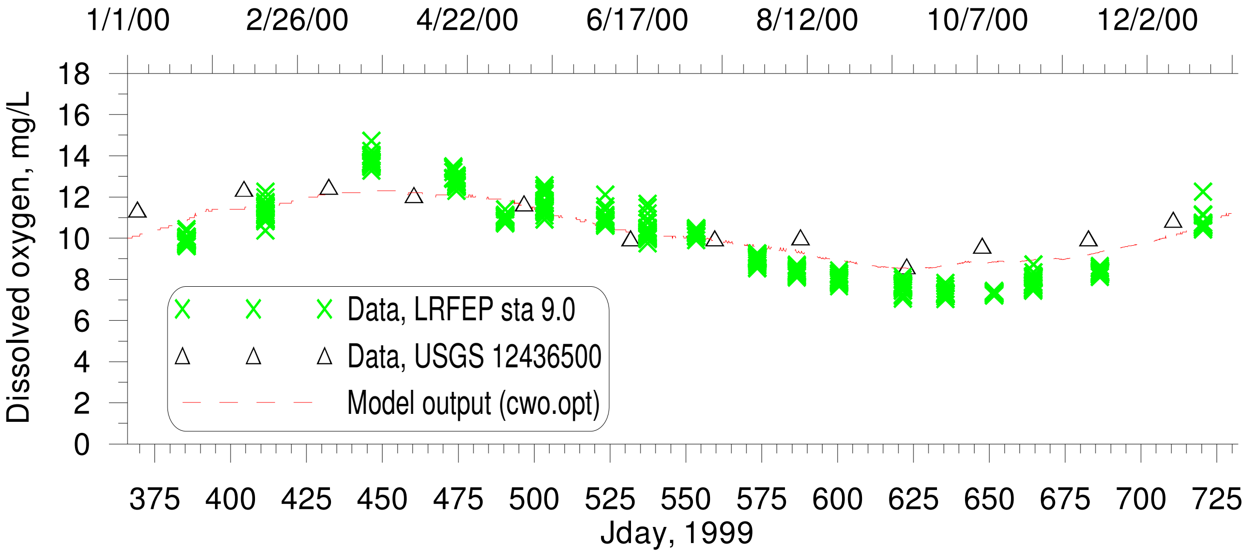

Figure 19. Dissolved oxygen time-series near Grand Coulee Dam.

Nitrate plus nitrite

The nitrate plus nitrite model-data comparison near Grand Coulee Dam is shown in Figure 20. After ensuring good boundary conditions and hydrodynamic calibration, no further adjustments were made.

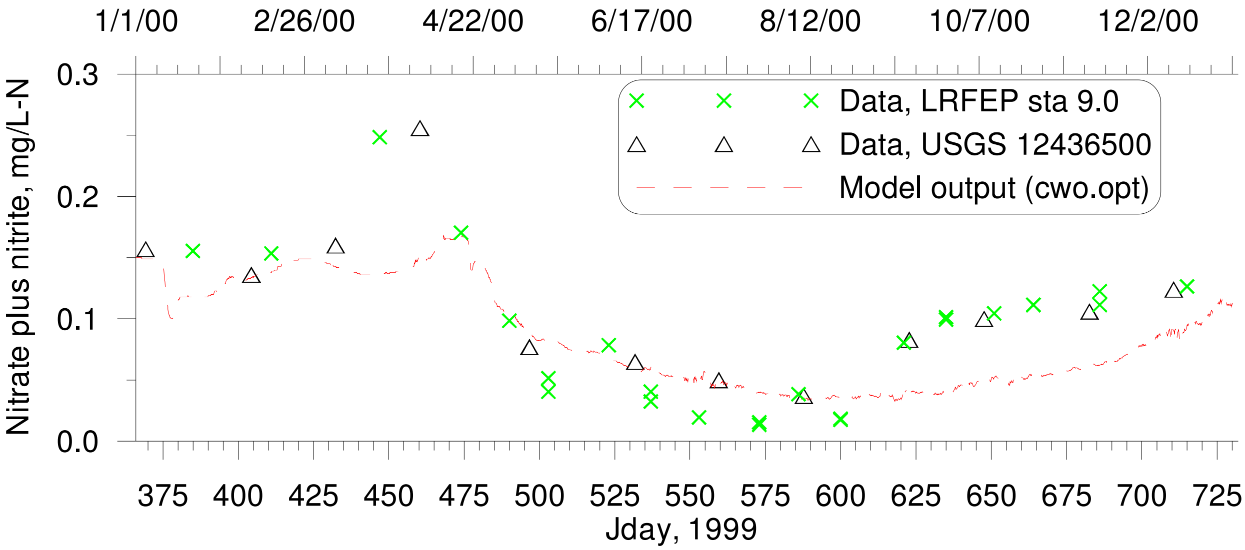

Figure 20. Nitrate time-series near Grand Coulee Dam.

pH

The pH model-data comparison near Grand Coulee Dam is shown in Figure 21. Calibration included ensuring good boundary conditions and good hydrodynamic calibration. While not clearly illustrated in Figure 21, the model does capture the strength of the vertical gradient seen during the summer. Refer to the vertical profile plots in Appendix F. During October and November of 2000, there was a known problem with the sensor probe.

The section Total Inorganic Carbon (pH) in the Alternate Boundary Conditions section of this report discussed the effects of alternate pH boundary conditions.

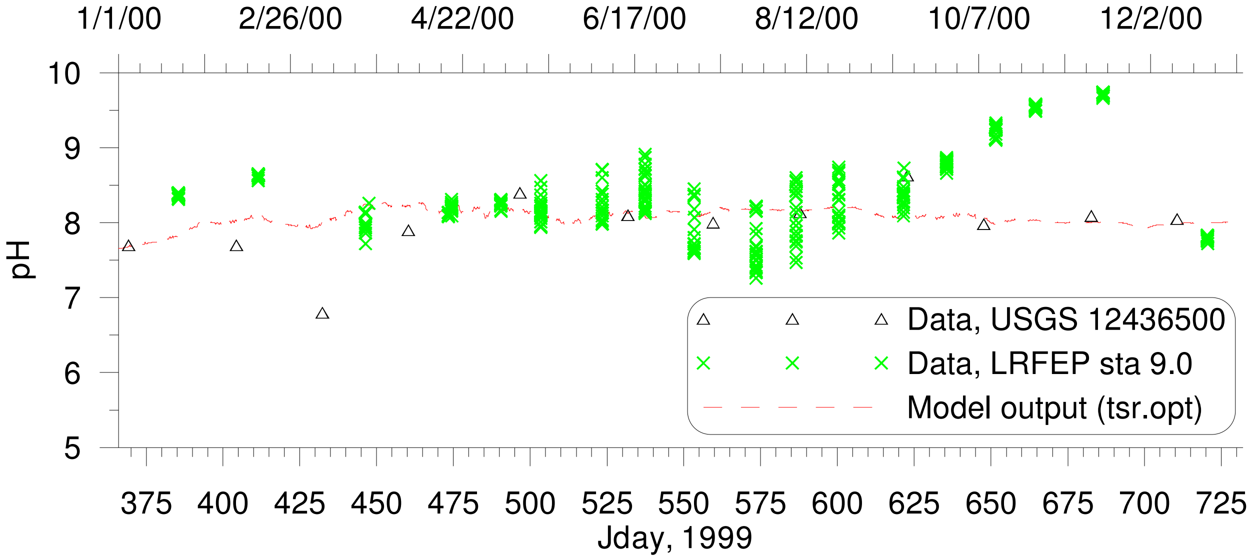

Figure 21. pH time-series near Grand Coulee Dam.

Orthophosphate

The orthophosphate model-data comparison near Grand Coulee Dam is shown in Figure 22. Calibration included ensuring good boundary conditions and good hydrodynamic calibration. The organic mater decay rate was decreased, sorption onto inorganic suspend solids was allowed, and the stoichiometry of organic matter was adjusted to calibrate orthophosphate.

There are several possible sources of the model-data discrepancy. The very low phosphorous concentration makes accurate measurements difficult. The attached algae data are sparse and may not be representative. The relationship between sorbed phosphorous and the stoichiometry of the inflow organic matter is likely neither invariant in time or space. The transition from winter periphyton to spring phytoplankton as the dominant primary production and the heterogeneity in boundary conditions are likely to explain much of the systems behavior.

The USGS sampling had a higher detection limit than the LRFEP sampling. The model predicts orthophosphate concentrations below the USGS sampling detection limit.

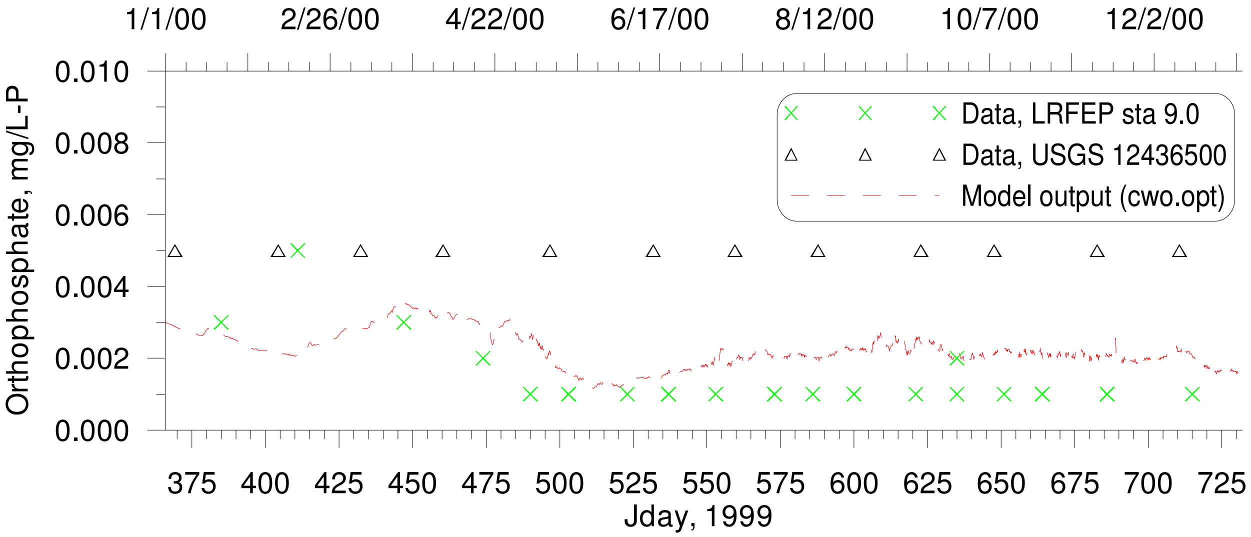

Figure 22. Orthophosphate time-series near Grand Coulee Dam.

Total Dissolved Solids

The total dissolved solids model-data comparison near Grand Coulee Dam is shown in Figure 23. After ensuring good boundary conditions and hydrodynamic calibration, no further adjustments were made.

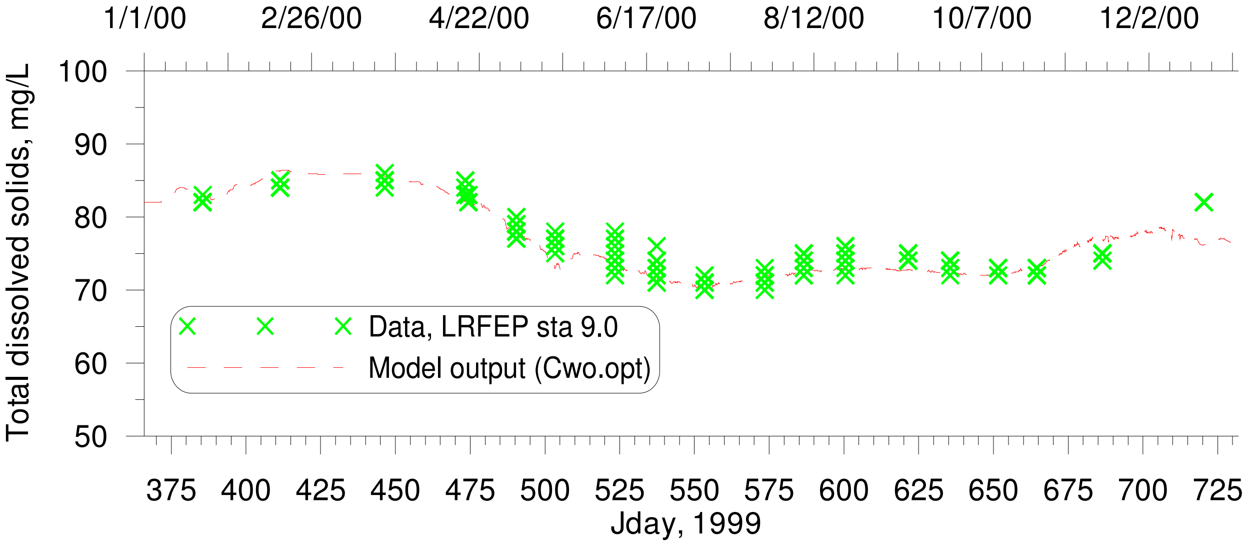

Figure 23. Total dissolved solids time-series near Grand Coulee Dam.

Vertical Profile Stations, Periodic Sampling

Dissolved oxygen, total dissolved solids, and pH calibration plots and statistics from the LRFEP vertical profile station data are reported in Appendix F. Selected profiles are shown for station 4.0 and station 9.0 in this section. Three sampling periods are illustrated for the reservoir conditions near minimum spring pool, near peak thermal stratification, and after fall turnover.

Ensuring hydrodynamic and temperature calibration was the first step in water quality constituent calibration.

Dissolved oxygen (Figure 24 and Figure 25) calibration also included sediment oxygen demand (SOD). Total dissolved solids (Figure 26 and Figure 27) are a conservative constituent, so no additional calibration was made. Calibration for pH (Figure 28 and Figure 29) focused on the selection of boundary conditions.

An investigation of alternative boundary conditions is presented in the subsequent section, Alternate Boundary Conditions.

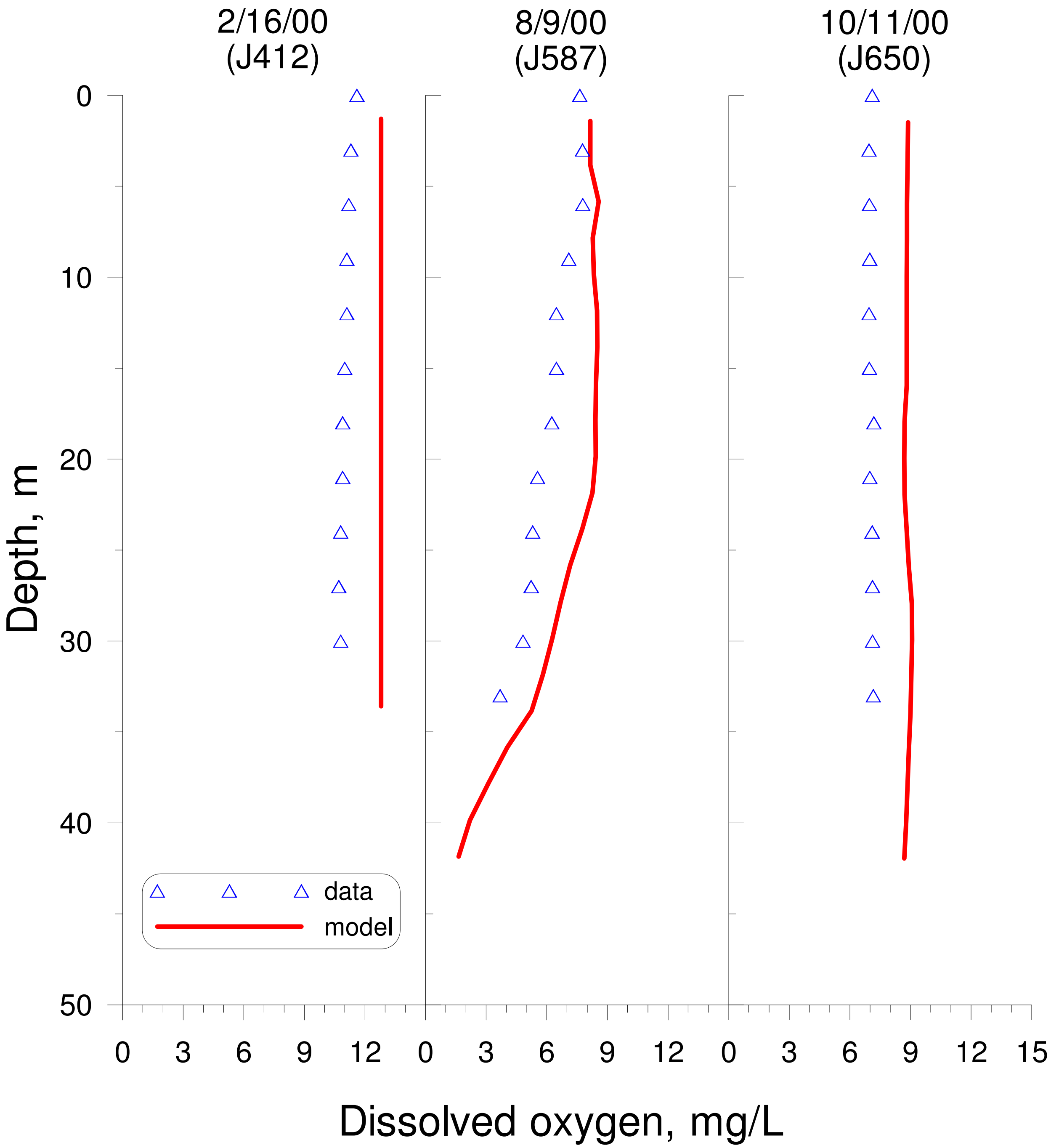

Figure 24. Selected model-data dissolved oxygen vertical profile comparisons at Porcupine Bay (LRFEP stat 4.0).

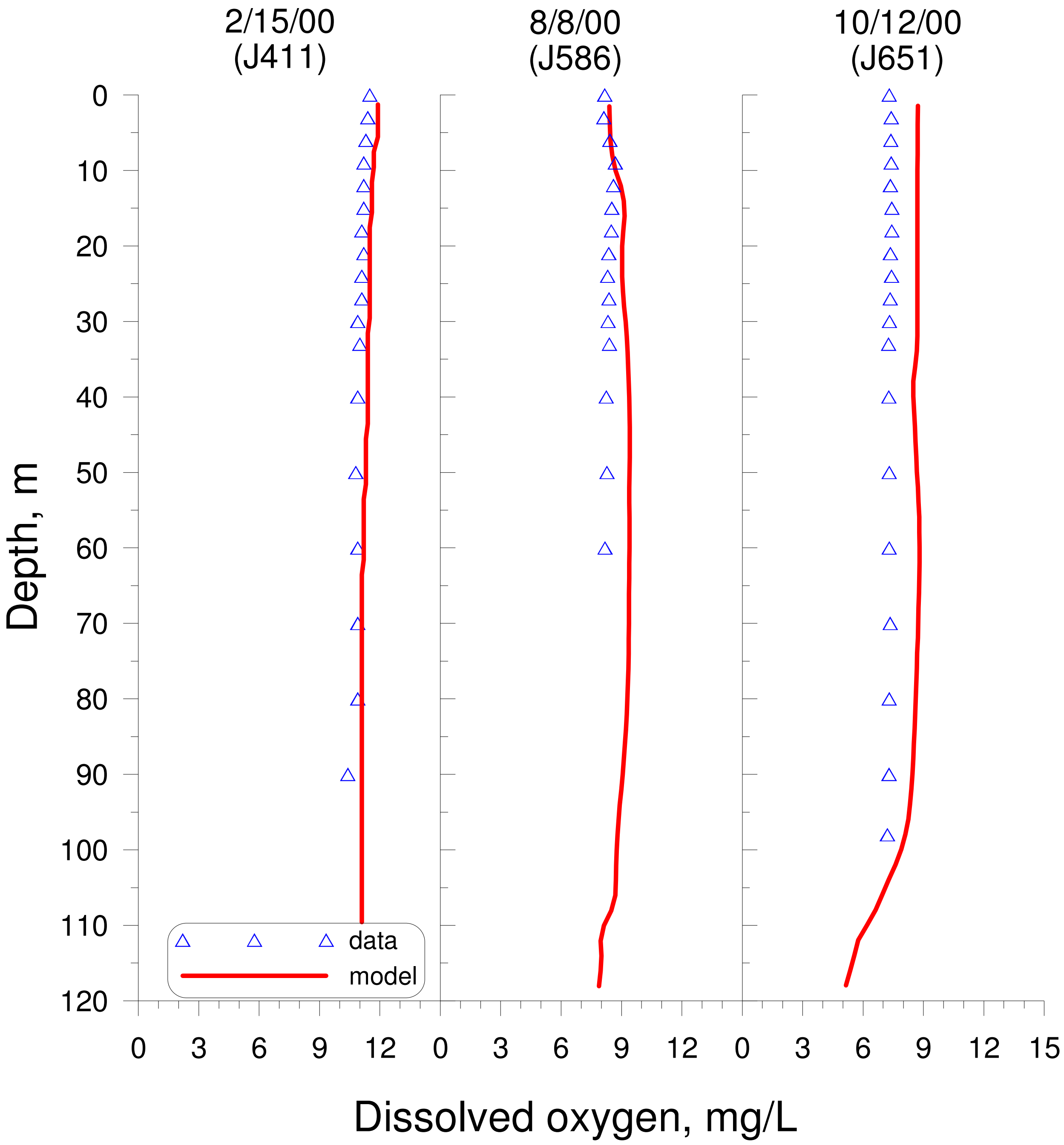

Figure 25. Selected model-data dissolved oxygen vertical profile comparisons at Spring Canyon (LRFEP sta 9.0).

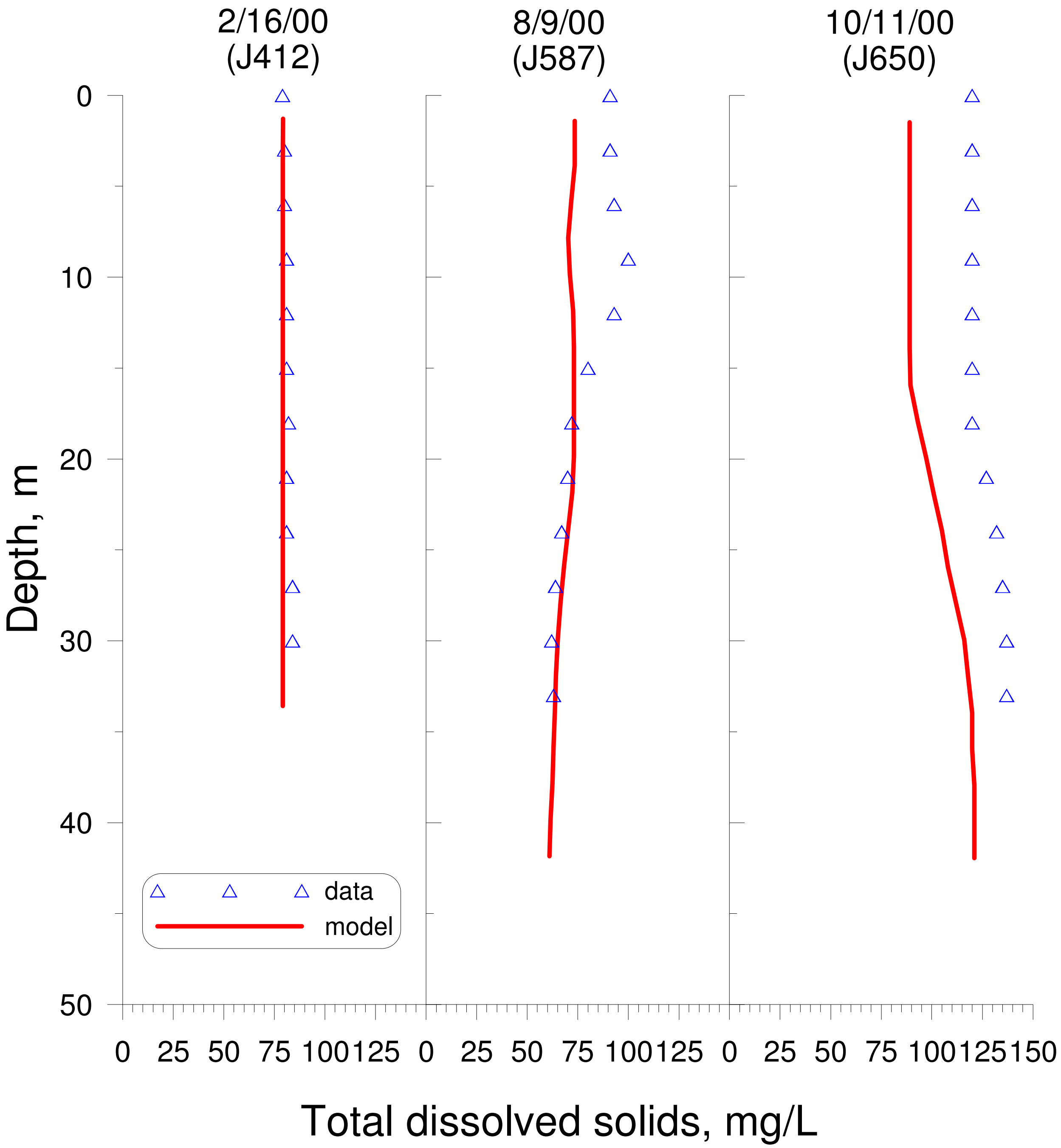

Figure 26. Selected model-data total dissolved solids vertical profile comparisons at Porcupine Bay (LRFEP stat 4.0).

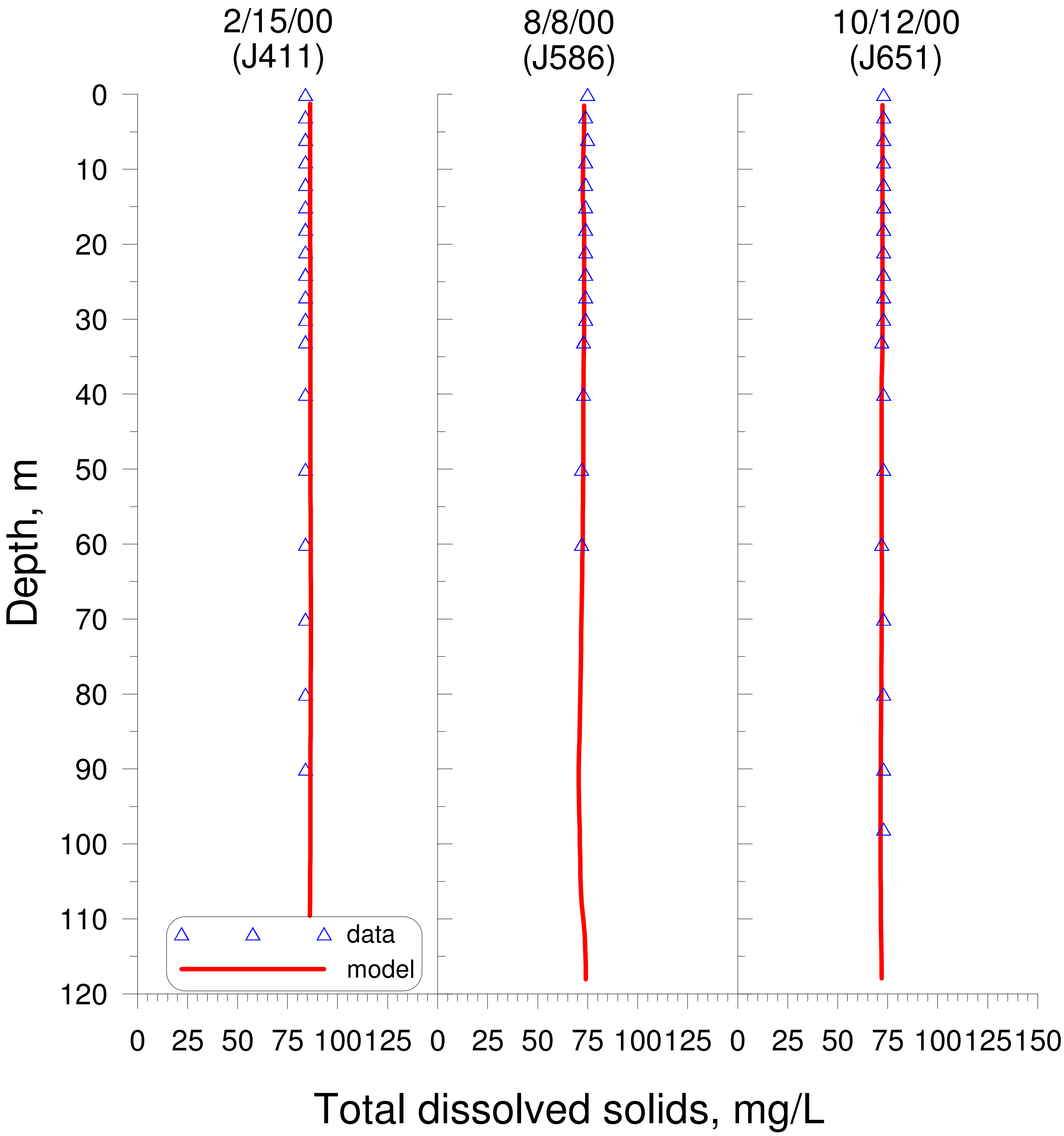

Figure 27. Selected model-data total dissolved solids vertical profile comparisons at Spring Canyon (LRFEP stat 9.0).

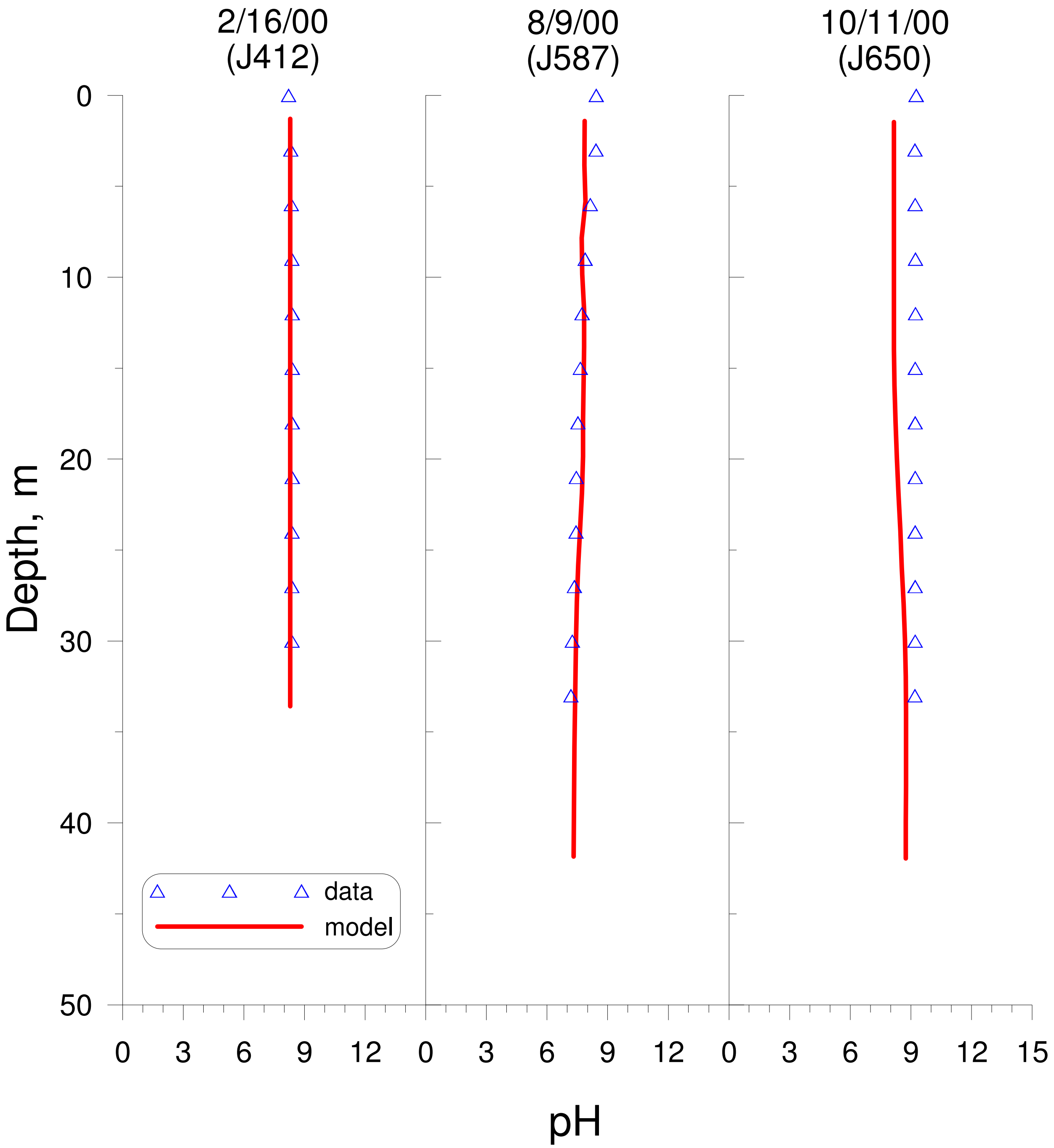

Figure 28. Selected model-data pH vertical profile comparisons at Porcupine Bay (LRFEP stat 4.0).

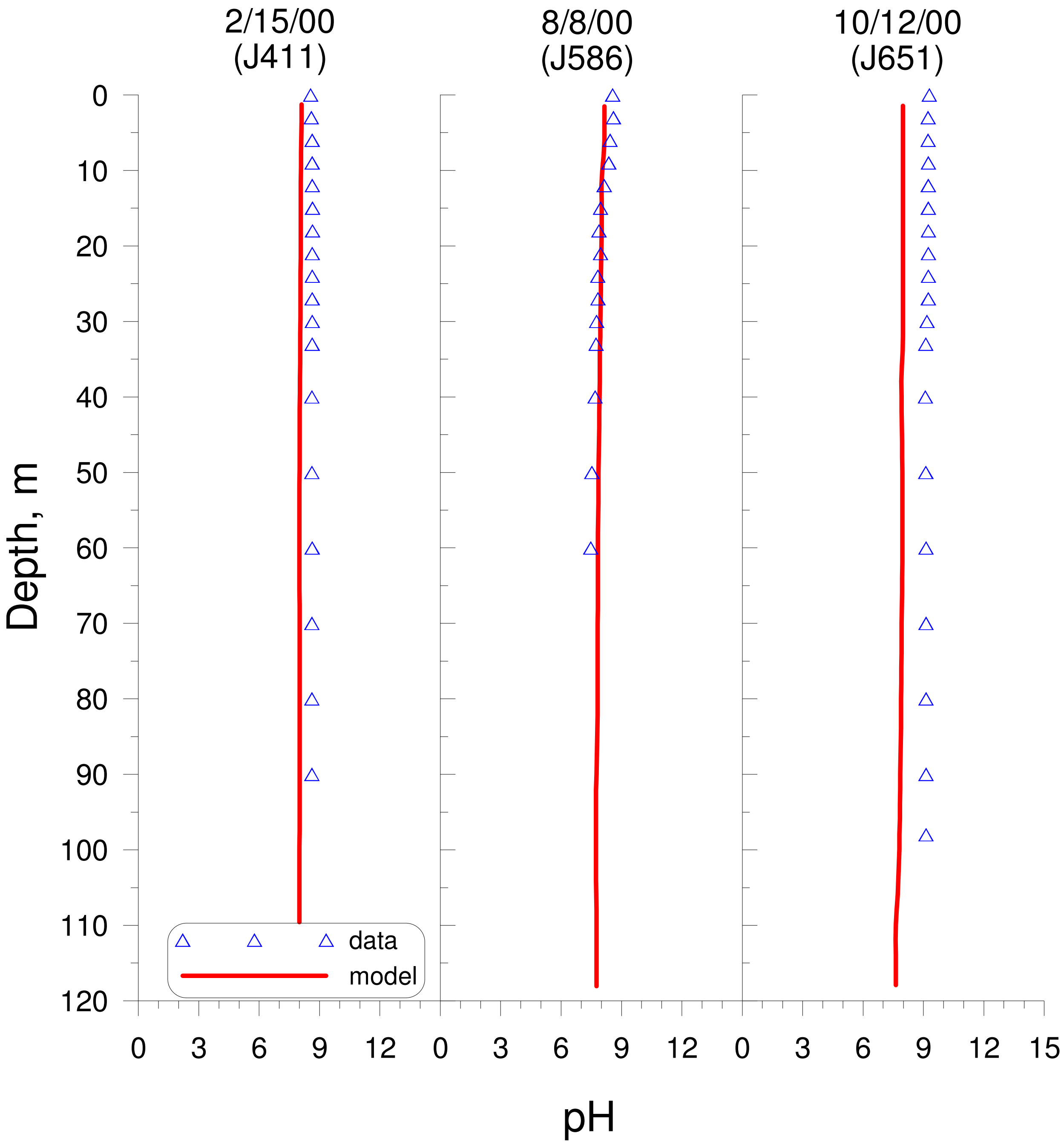

Figure 29. Selected model-data pH vertical profile comparisons at Spring Canyon (LRFEP stat 9.0).

Alternate Boundary Conditions

Two alternative boundary conditions were examined as a tool for examing the use of difference data sources as water quality constituent boundary conditions. These examinations were conducted to show the sensitivity of model results to apparent data conflicts.

Spokane River Dissolved Oxygen

The LRFEP monitoring station 4.0 on the Spokane River is located at approximately just downstream of the riverine to lacustrine system transition point. Thus, the model predictions, especially as they regard to the stratified condition, are sensitive to flow magnitudes and wind driven mixing. Additionally, the monitoring station is located at a bend in the pre-dam river channel which may influence the near-bank system. Attempts to account for these effects did not resolve the apparent data conflict between the choices of Spokane River upstream boundary conditions for dissolved oxygen.

There are hourly-averaged dissolved oxygen data available from Avista Utilities at the Little Falls Dam tailrace. These are the preferred boundary condition data due to their sampling frequency and proximity to the model boundary. There are instantaneous in-stream vertical profile data available from the LRFEP at station 4.0. Ideally, the model should predict the in-stream data using the upstream data as model input. However, the model does not match the data at station 4.0, even when the in-stream data are used as the upstream boundary condition. The model-data comparison under both boundary condition scenarios are illustrated in Figure 30.

The model values at station 4.0 during January and February are largely an echo of the upstream boundary condition. During the early and late summer, when stratification occurs, both data boundary condition scenarios under predict the data. After fall turnover, the model over predicts the data under both scenarios. This suggests that the actual behavior at station 4.0 is significantly influenced by the lacustrine arm of the Spokane River and its interaction with the Columbia River.

The LRFEP conducted a study along the Spokane River arm in 2006 which showed that the Columbia River water rides upstream over trapped Spokane River water during the summer. This results in two to three months of segretation where the hypolimnion sufferes from lack of DO replenishment and potential hypoxia.

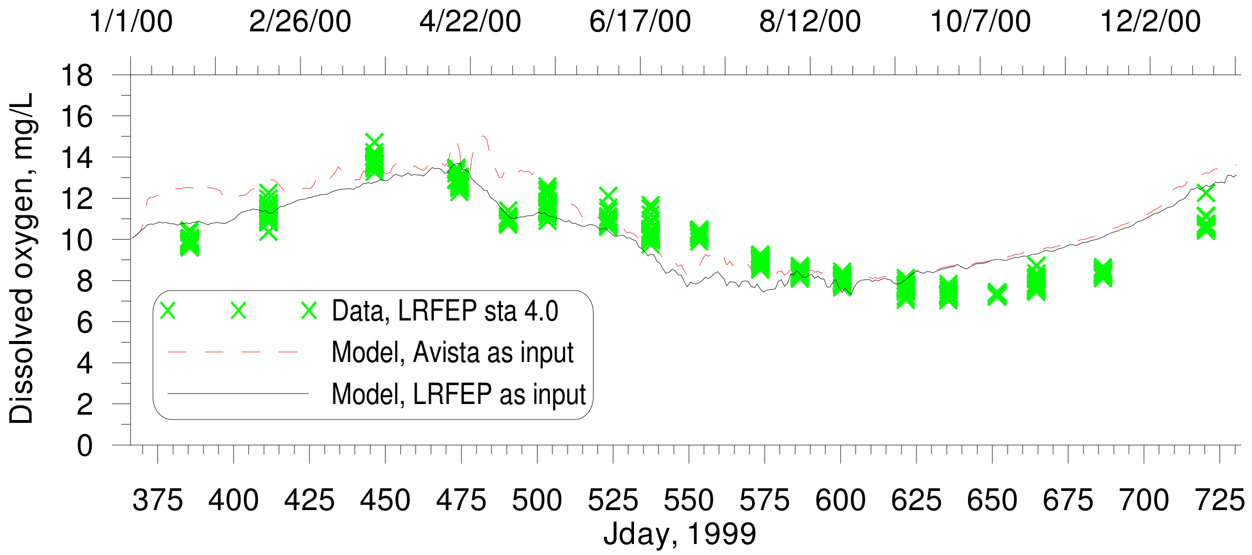

Figure 30. Model-data comparison of dissolved oxygen at LRFEP station 4.0 under different boundary condition scenarios.

Total Inorganic Carbon (pH)

Within the Lake Roosevelt system, there are few sources and sinks of carbon. Plant and phytoplankton concentrations are low and there is little geochemical activity, so pH is largly dictated by boundary conditions and atmospheric interaction. The pH data available from Environment Canada near the confluence of the mainstem Columbia River and the Pend Oreille River form the preferred upstream boundary condition data due to their proximity and roughly bi-weekly sampling frequency. In-stream data are available at LRFEP station 0.0, with a typical travel time of 1 day.

Given the proximity of station 0.0 to the upstream boundary (the U.S.-Canadian border) and the relatively conservative-constituent behavior of pH within the system, it is expected that the model prediction at station 0.0 would echo the upstream carbon boundary condition. Figure 31 illustrates that when the LRFEP data are used as the boundary condition, the model does echo the input. However, the Environment Canada data, when used as the boundary condition, do not show good model-data agreement at station 0.0. This suggests that the LRFEP and Environment Canada data are not in agreement and one or both sources may have some measurement error.

The LRFEP pH data vales are generally between 8 and 9. Much of the system shows pH over 9 in the late fall, over multiple years. The cause of the elevated pH is unclear. When the LRFEP station 0.0 and 4.0 pH data are used as model input for the Columbia and Spokane Rivers, respectively, the mean pH values are conserved downstream at LRFEP station 9.0 upstream of Grand Coulee Dam, but the data at station 9.0 does not match the model predictions. The data show vertical gradients and values much larger than the model predicts. Figure 32 illustrates the model-data comparison.

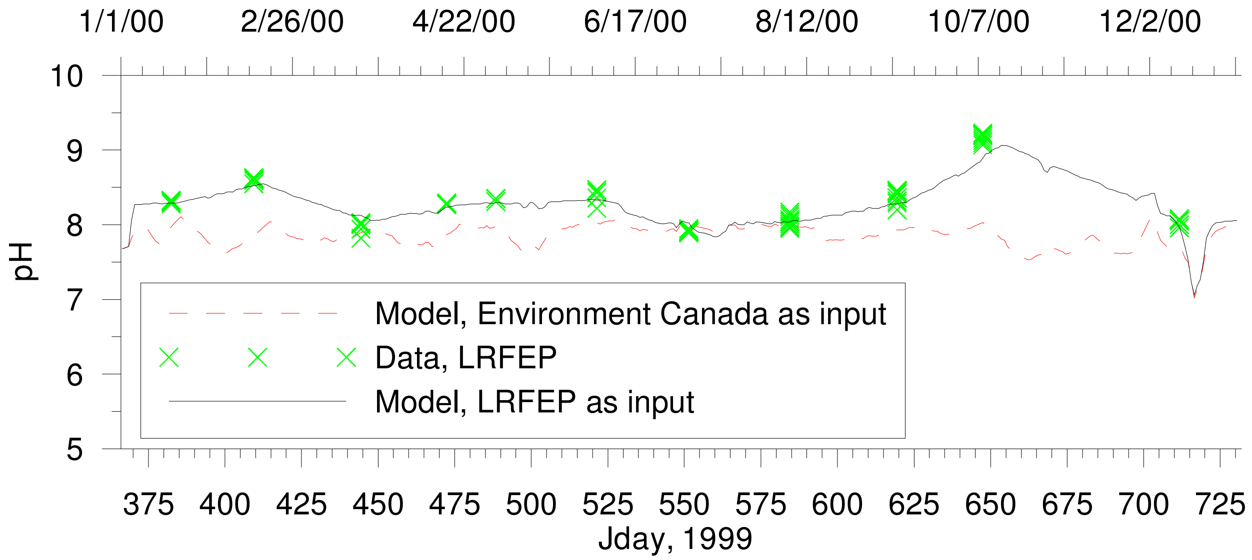

Figure 31. Model-data comparison of pH at LRFEP station 0.0 under different boundary condition scenarios.

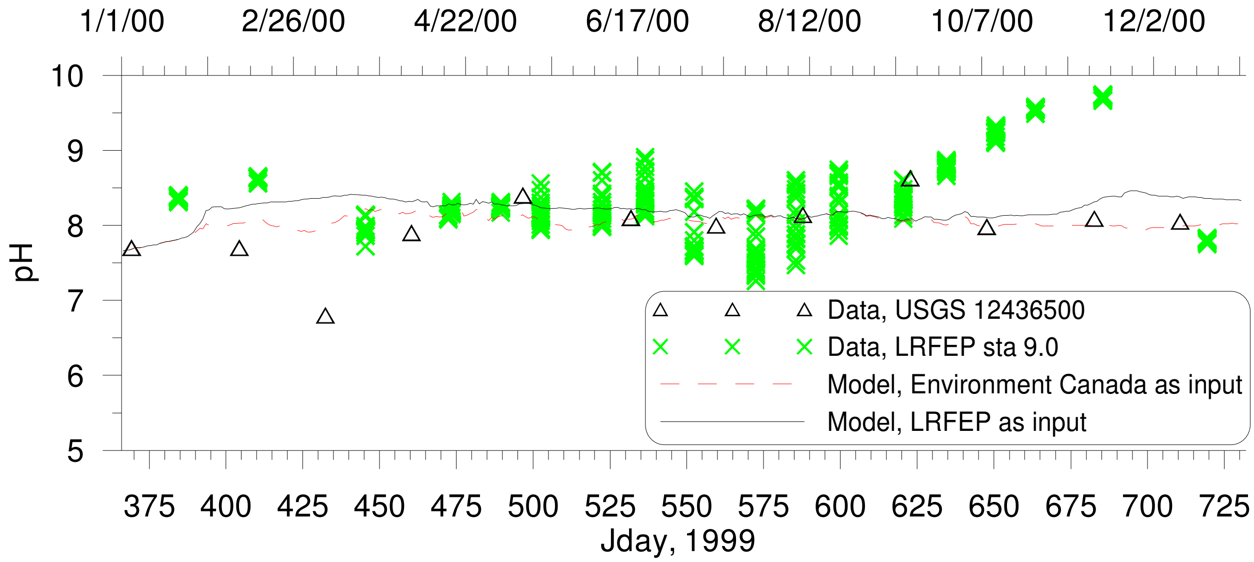

Figure 32. Model-data comparison of pH at LRFEP station 9.0 under different boundary condition scenarios.

Biotic Modeling Approach and Calibration

Approach

The biotic modeling approaches used the conservation of mass as the governing equation. For a more detailed discussion of the algae and zooplankton algorithms, refer to Cole and Wells (2006). Details of the fish bioenergetics model are covered in Appendix C. A conceptual schematic of the interaction among the water quality constituents, algal groups, and zooplankton groups is shown as Figure 33. The fish model uses the zooplankton densities and water temperatures as input, and does not influence the model results.

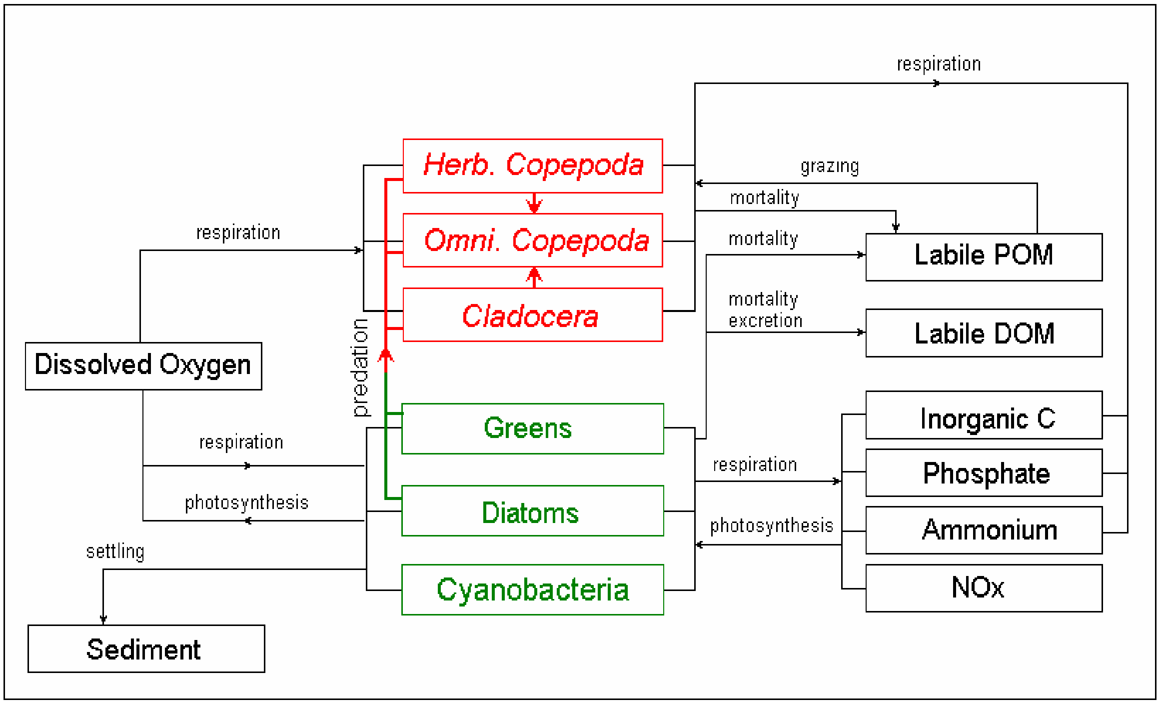

Figure 33. Conceptual diagram of the water quality, algae, and zooplankton interaction.

Algae

Algae biomass was divided into three functional groups based on the taxa data: diatoms, mixed green algae, and cyanobacteria.

The diatom group differs from the mixed green algae in several ways. Diatoms use silica as a nutrient. Since silica was not a limiting nutrient in Lake Roosevelt, silica was not included in the model; however, diatoms are heavier than green algae and rely more on turbulent mixing to remain in the epilimnion due to their larger settling velocity. Diatoms are known to bloom in the spring in Lake Roosevelt, and provide a large portion of the primary production available to zooplankton. *Asterionella formosa* comprised the largest single species within the diatom group

(~50% of the *Bacillariophyceae* biomass) and *Asterionella* was used as the basis for the diatom group kinetics.

The mixed green algae group (or simply the green) was comprised of mostly brown-green algae (*Chryptophyta*) and then green algae (*Chlorophyta*). The green algae are the dominant perennial food supply for zooplankton. Brown-green kinetic values were selected from the literature.

The cyanobacteria group (or blue-green algae), while a small portion of the total algal biomass, was included separately as zooplankton do not appreciable prey up this group. While *Oscillatoria sp*. dominated the group, general cyanobacteria literature values were used for the kinetics. Values for *Oscillatoria* kinetics were scarce and variable in the literature.

Zooplankton

The zooplankton biomass was divided into three functional groups: herbivorous copepoda, omnivorous copepoda, and cladocera.

While all zooplankton biomass decreases during the winter, the copepoda maintain larger numbers than the cladocera in Lake Roosevelt. *Leptodiaptomus ashlandi* and *Diacyclops bicuspidatus thomasi* comprised the main copepoda species. Omnivorous copepoda were assumed to comprise 10% of the total copepoda biomass (personal communication, Mike Mazur). Omnivorous copepoda were assumed to prefer prey equally between the herbivorous copepoda and cladocera.

The cladocera biomass is dominated by *Daphnia sp*. Other cladocera make up roughly 5% of the total cladocera biomass. *Daphnia pulex* dominate the cladocera biomass (~50%). Daphnia differ from copepoda in that they are much larger. Diet studies show that cladocera are the preferred prey item for kokanee in Lake Roosevelt (refer to LRFEP annual reports). While copepoda provide for a perennial food supply for zooplankivorous fish, sampling has shown that Daphnia spp. make up the majority of the kokannee prey biomass, especially over the spring and summer. Winter diets also show a largely Daphnia diet, despite the very low Daphnia concentrations.

Fish Bioenergetics (kokanee)

The bioenergetics growth model is based on Stockwell and Johnson (1999). A more detailed discussion is presented in Appendix C. The model was used to predict fish growth potential, represented as daily change in fish mass. Fish growth was a function of fish mass, prey density, fish and prey energy densities, water temperature, and ambient light. Fish growth potential was determined for each model cell in 30 minute time steps. The results were used in three different *growth prediction* approaches with four fish *growth application* approaches. *Growth prediction* refers to how the daily growth is determined; *growth application* refers to how the daily fish mass is formulated.

Four fish mass time series formulations (or *growth applications*) were allowed, and could be applied to each of the three *growth predictions*.

1) Fish mass could remain constant (steady).
2) Fish mass could grow at a user specified exponential rate. This facilitates comparisons among locations and foraging methods.
3) Fish mass could be set to daily user specified values. This allowed model output to be returned as model input.
4) Daily fish growth could be added to the starting fish mass. Fish mass then becomes model predicted.

General approach

The general approach is to simply determine fish growth potential in each model cell. If fish growth is then applied to the cell, then each cell will then have its own fish mass. Cells located at the bottom of the lake are unlikely to show positive growth, and would be unlikely to represent foraging strategies for the pelagic visual zooplanktivore. A more representative strategy is approximated by the "best growth" approach.

Best growth approach

The "best growth" approach is similar to the general approach. However, instead of simulating growth in each cell, growth in the segment is simulated. At each time step, the cell of most positive growth is determined. The stomach contents are then passed to all of the cells in the segment for the next time step. At the end of the day, growth is determined. The daily *growth application* formulation is applied to all cells. Two assumptions limit this approach. Fish are not allowed to migrate to other segments, and fish growth over a single 30 minute time step does not directly consider the future growth from consumption. Since growth only occurs after digestion, which typically takes a few to several hours, when growth potential becomes negative due to large respiration costs associated with warm water, the approach can result in a non-foraging fish. This is unrepresentative of fish foraging. An improvement to the best growth approach is the "vertical foraging" approach.

Vertical foraging approach

The "vertical foraging" approach makes two improvements to the "best growth" approach. First, in determining the most favorable cell for growth, 20% of the energy from consumption is added to the energy available for growth. This value was based on the general energy balance of Brett and Groves (1979). The determination of growth did not include this amount; it was used only to give weight to the potential growth from consumption over a time step. The second improvement attempted to simulate the vertical foraging forays where kokanee move to the warmer high prey density water to feed and then move to deeper, colder water to digest and benefit from the lower metabolic costs. To simulate these forays, during periods of daylight, if growth potential is found to be negative, then the cell selected at each time step alternates between that of greatest consumption and that of minimum respiration costs. Daylight is user defined as some light threshold in the surface layer. The decision process at each timestep is:

1) Use the cell of best growth if
    a. growth is positive
    b. during nighttime (selects least negative)
2) If daylight (surface lux >1), alternate foraging and "digesting"
    a. Forage at the cell of greatest consumption, C
    b. "Digest" or "rest" at the cell of minimum respiration, R
    c. Alternate foraging and digesting timesteps during daylight.

Calibration

Algae and zooplankton data are available at the LRFEP stations reported in the temperature calibration section (see Figure 13). Data were collected over a variety of depths. Algae were sampled over the euphotic zone. Zooplankton were collected at 17, 33, and 66 m depths. Duplicate samples at the same depth showed large variability.

All data for a given day were arithmetically averaged. Model results, which vary from layer to layer, were averaged over the first 10 meters of depth for comparison to the averaged data.

Algae

Weighted total algae model-data comparisons are shown in Figure 34 through Figure 45.

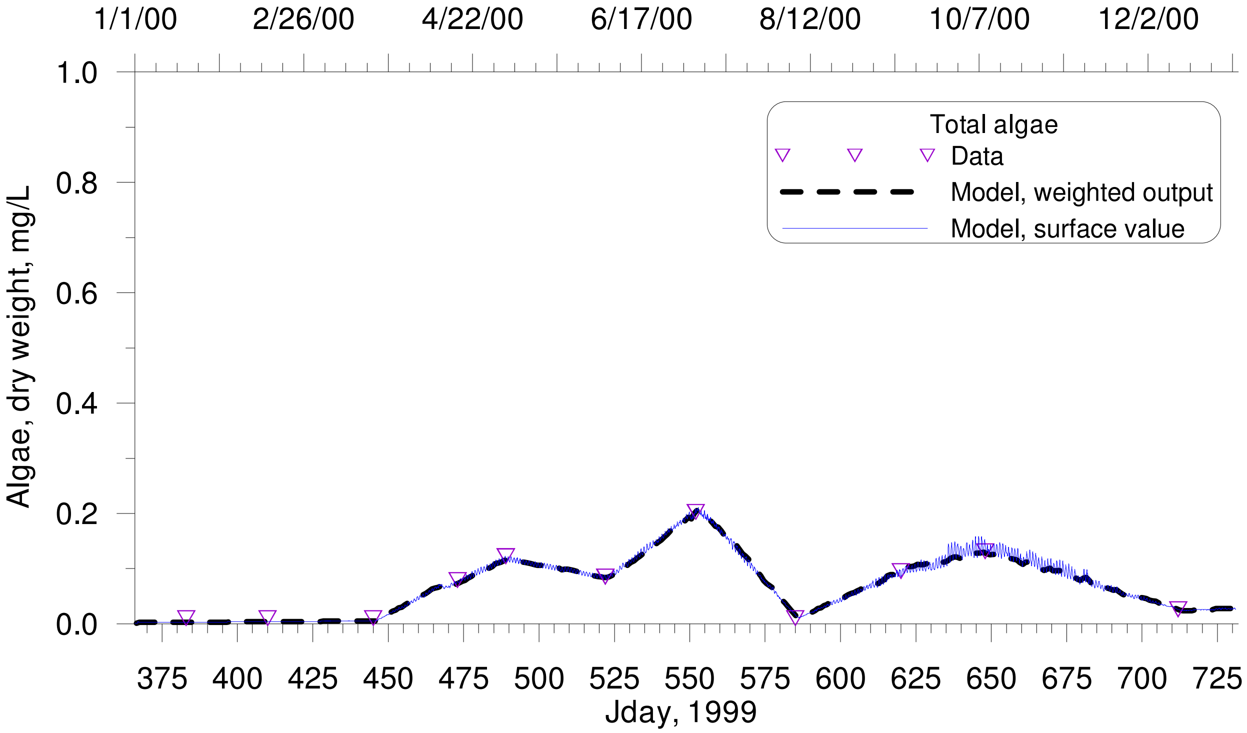

Figure 34. Model-data comparison of weighted total algae, LRFEP station 0.0.

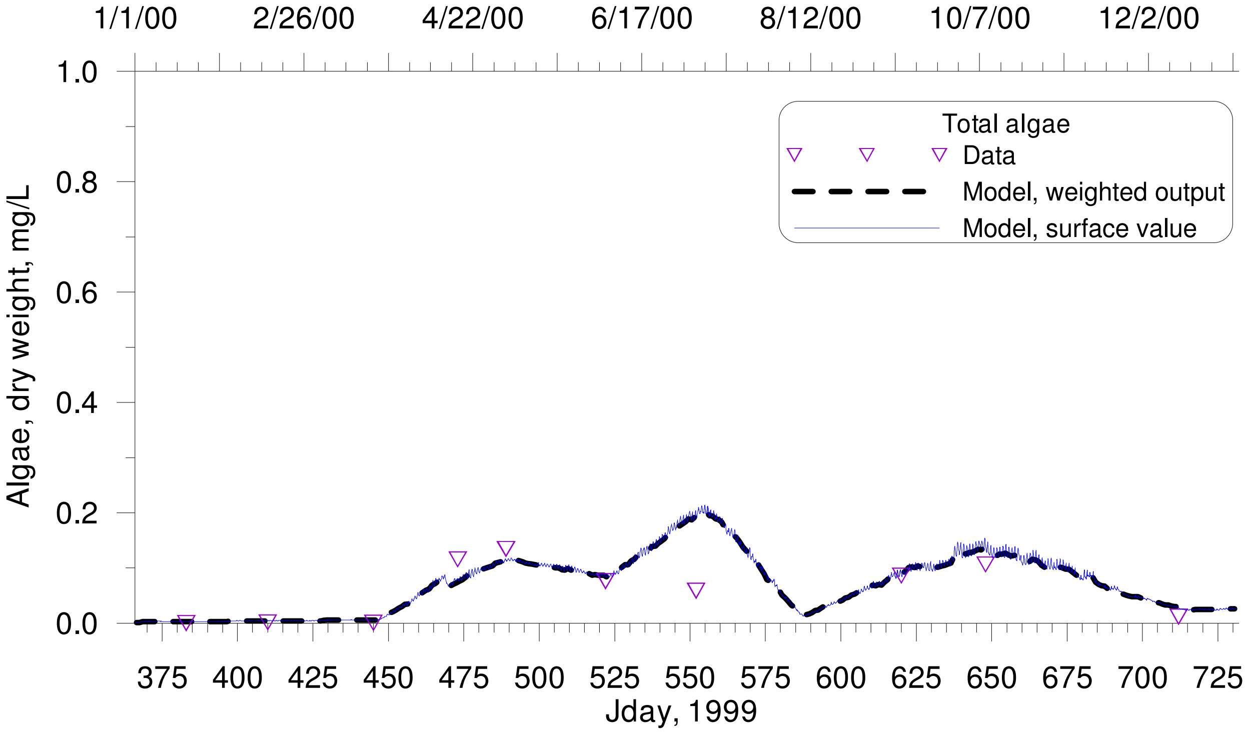

Figure 35. Model-data comparison of weighted total algae, LRFEP station 1.0

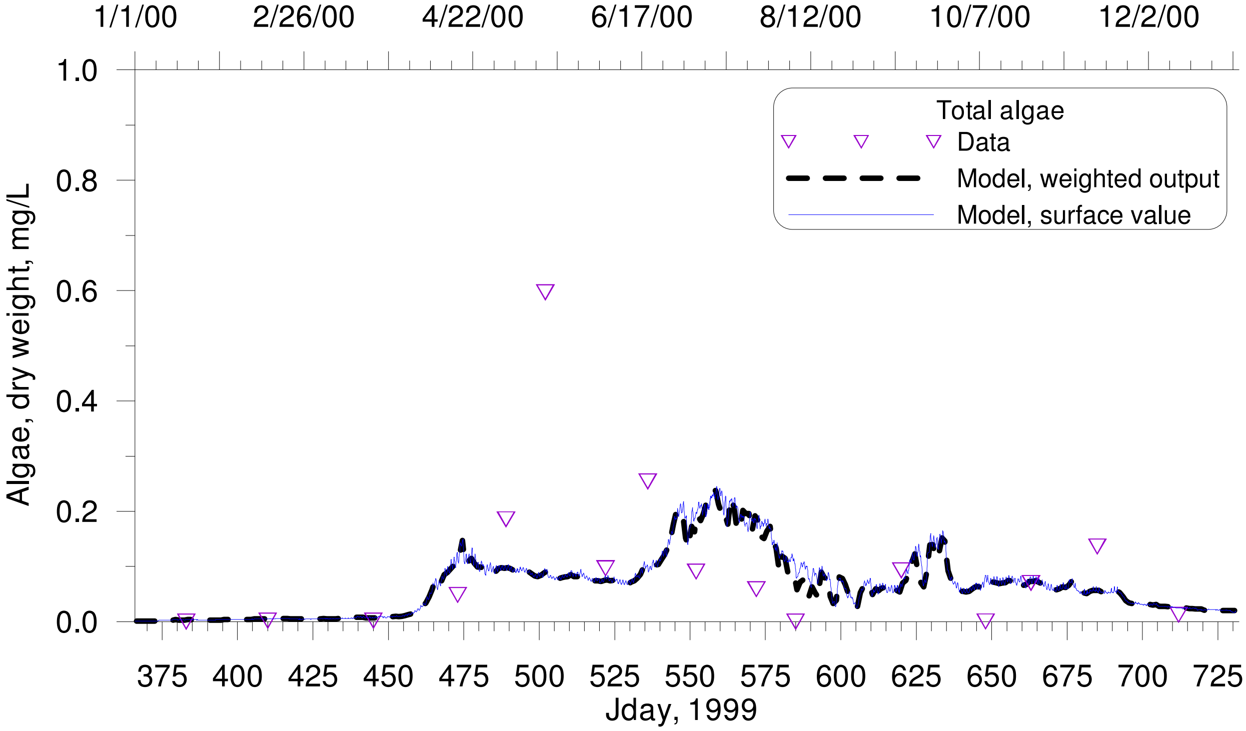

Figure 36. Model-data comparison of weighted total algae, LRFEP station 2.0

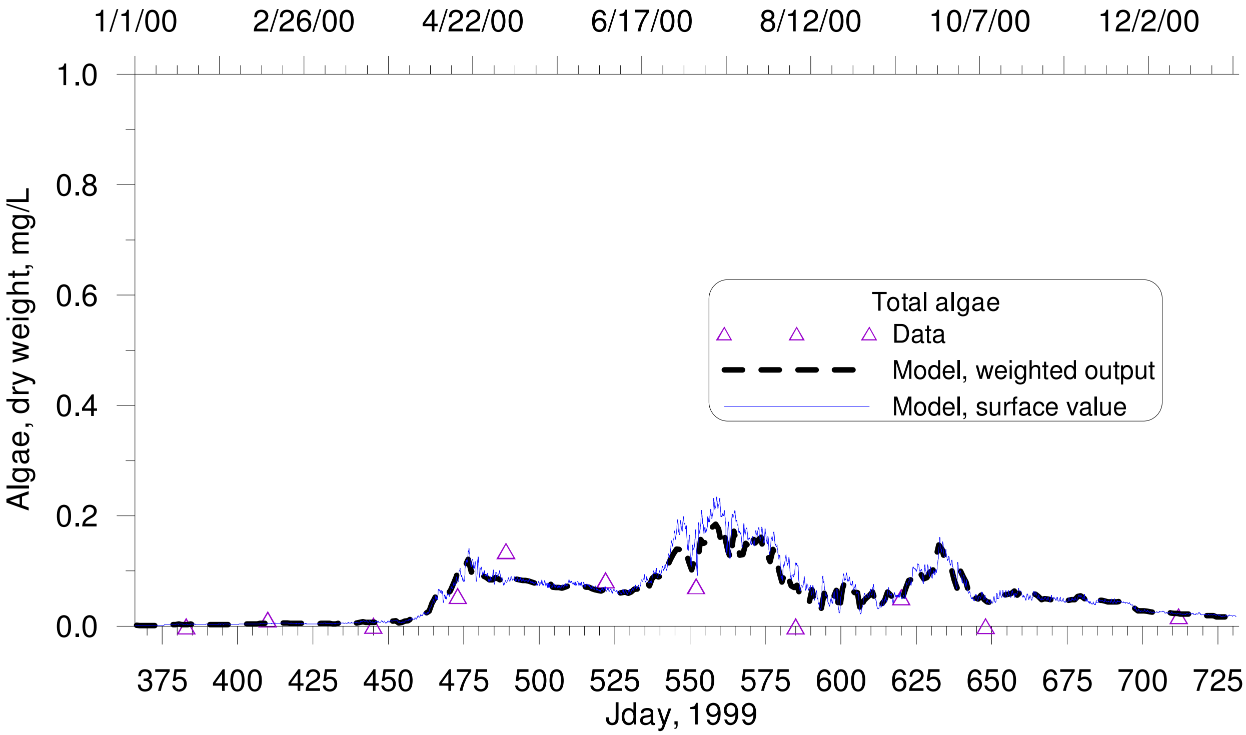

Figure 37. Model-data comparison of weighted total algae, LRFEP station 3.0

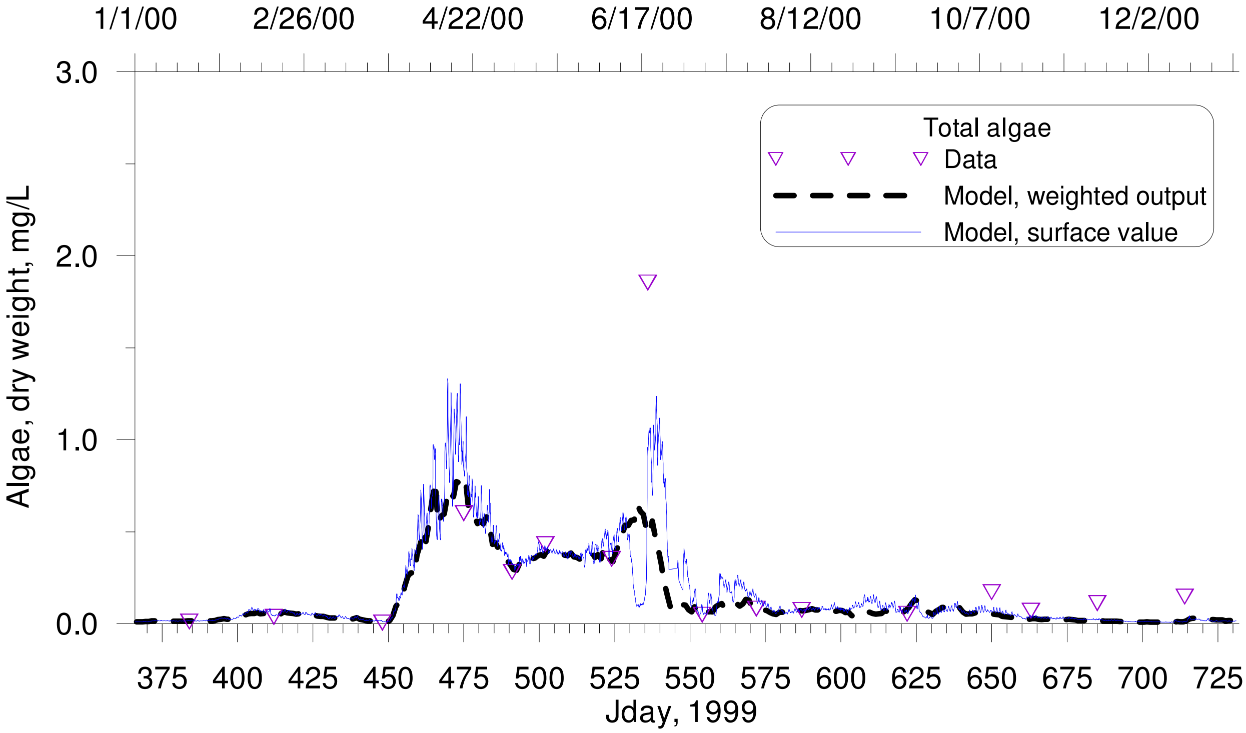

Figure 38. Model-data comparison of weighted total algae, LRFEP station 4.0

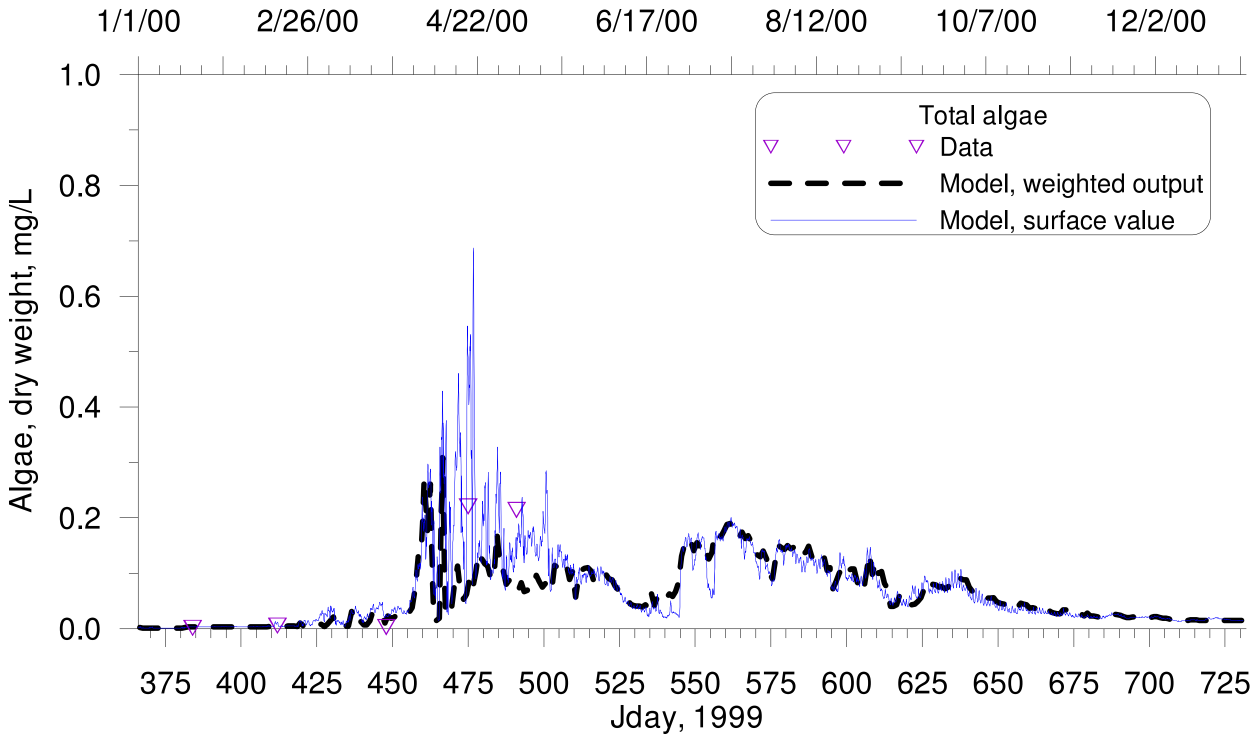

Figure 39. Model-data comparison of weighted total algae, LRFEP station 5.5

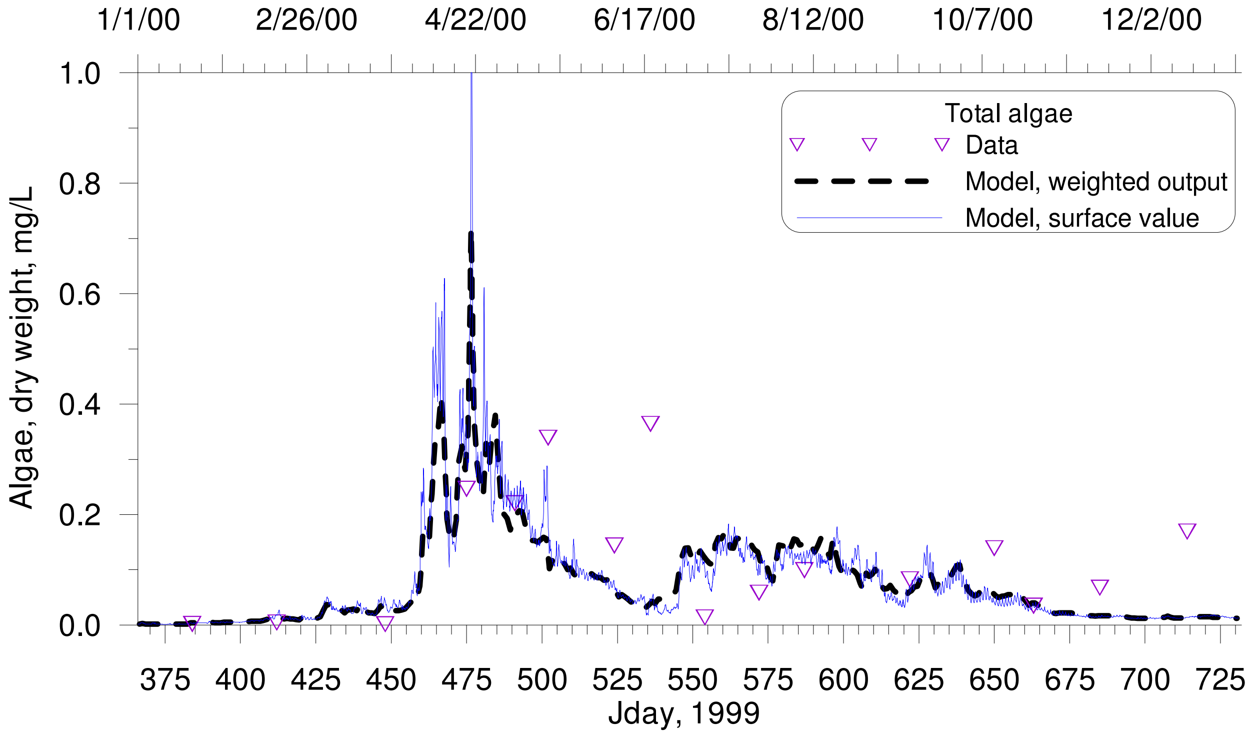

Figure 40. Model-data comparison of weighted total algae, LRFEP station 6.0

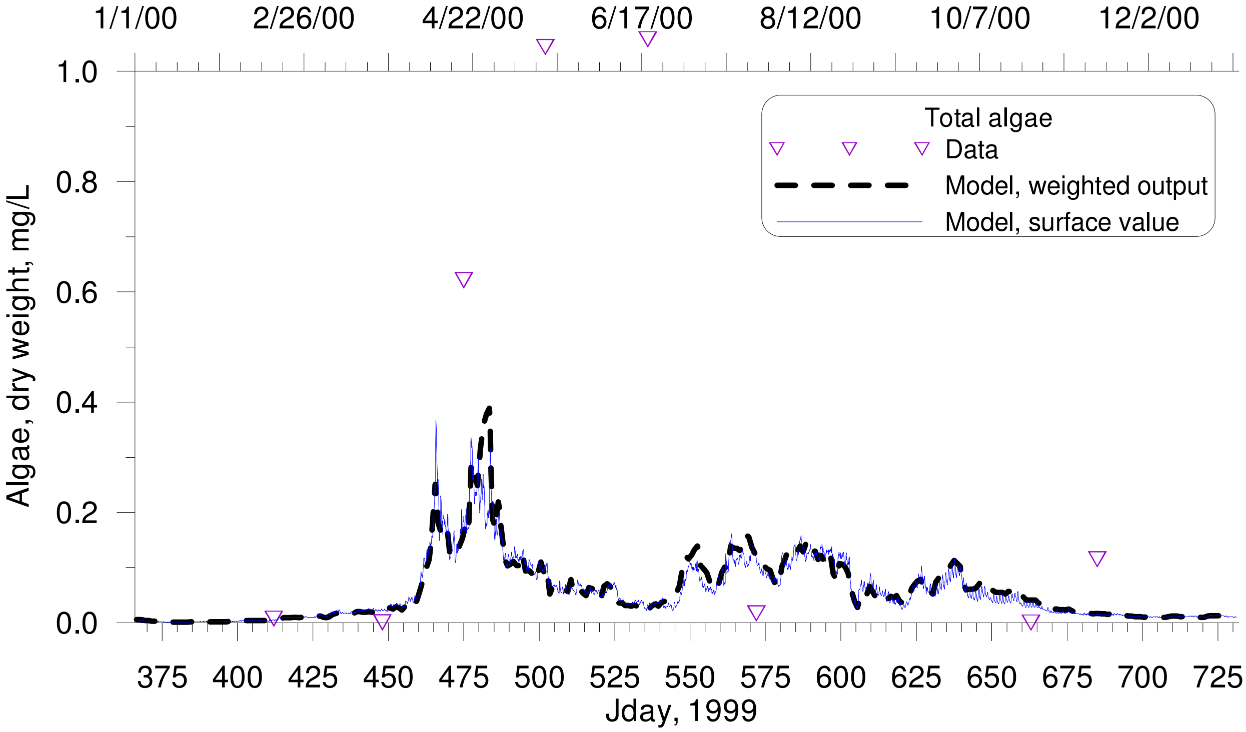

Figure 41. Model-data comparison of weighted total algae, LRFEP station 6.5

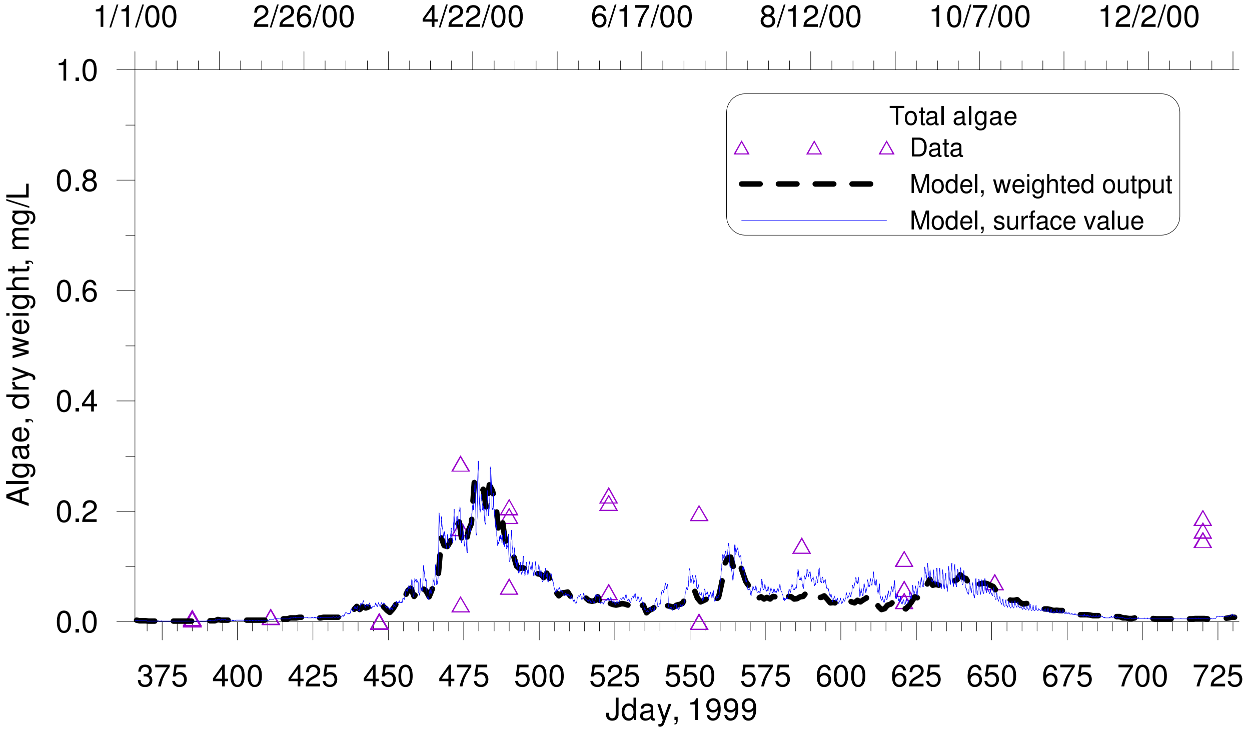

Figure 42. Model-data comparison of weighted total algae, LRFEP station 7.0

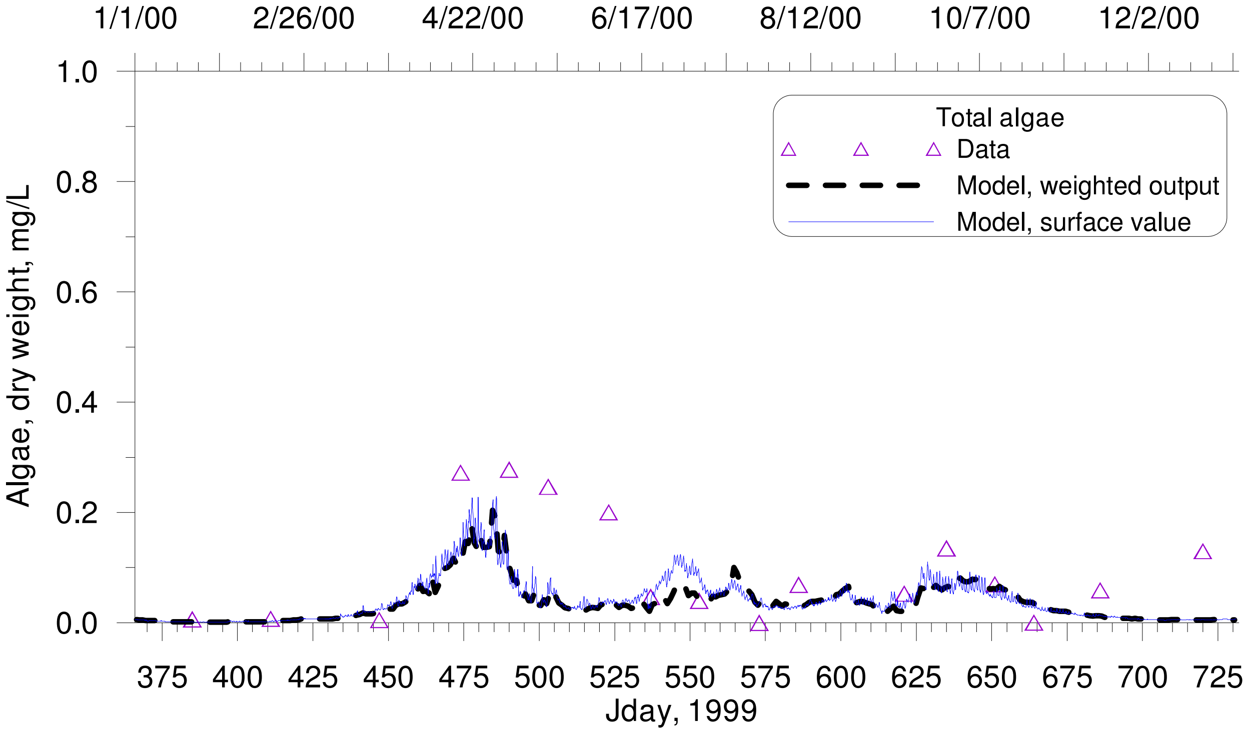

Figure 43. Model-data comparison of weighted total algae, LRFEP station 8.0

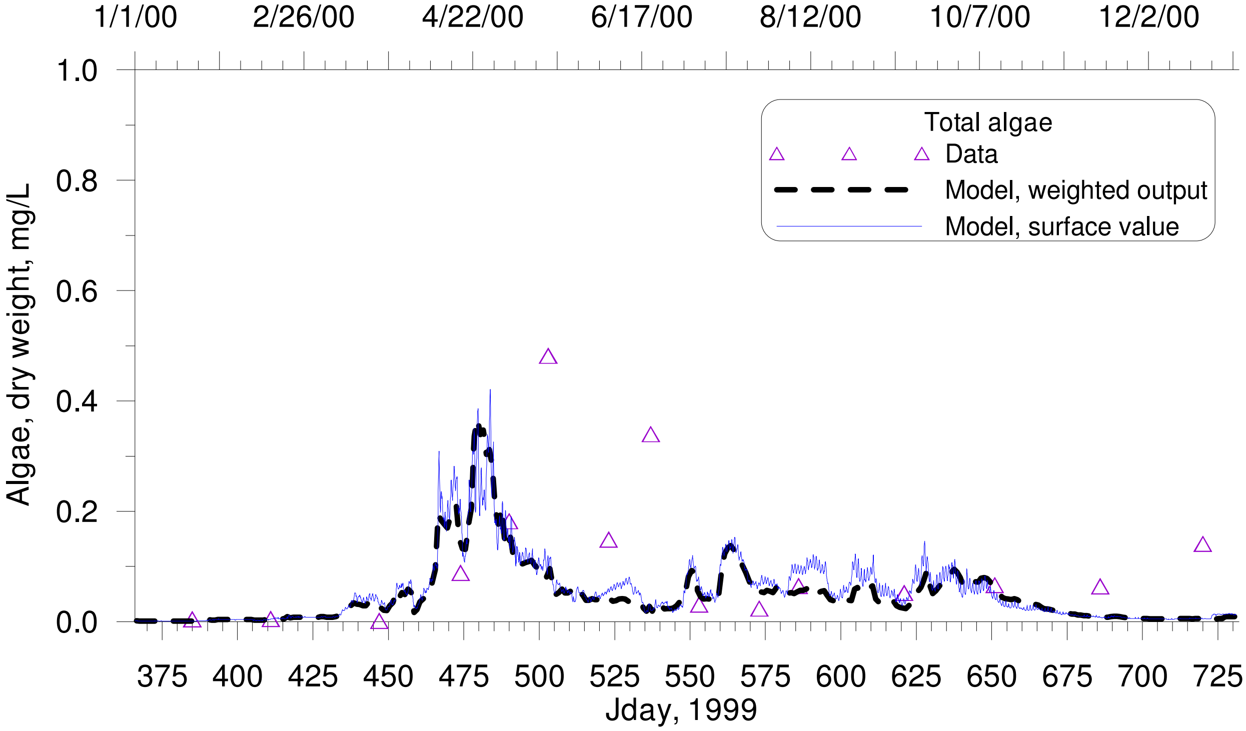

Figure 44. Model-data comparison of weighted total algae, LRFEP station 8.5

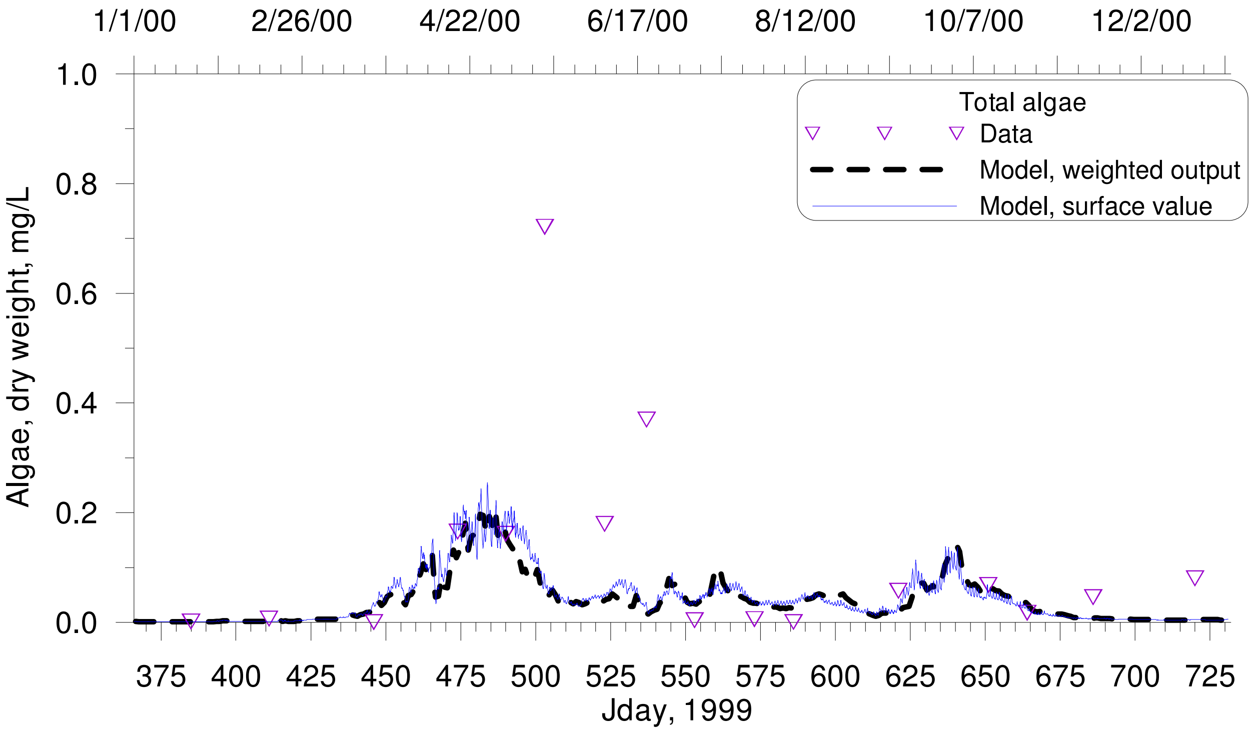

Figure 45. Model-data comparison of weighted total algae, LRFEP station 9.0

Zooplankton

Weighted total zooplankton model-data comparisons are shown in Figure 46 through Figure 57.

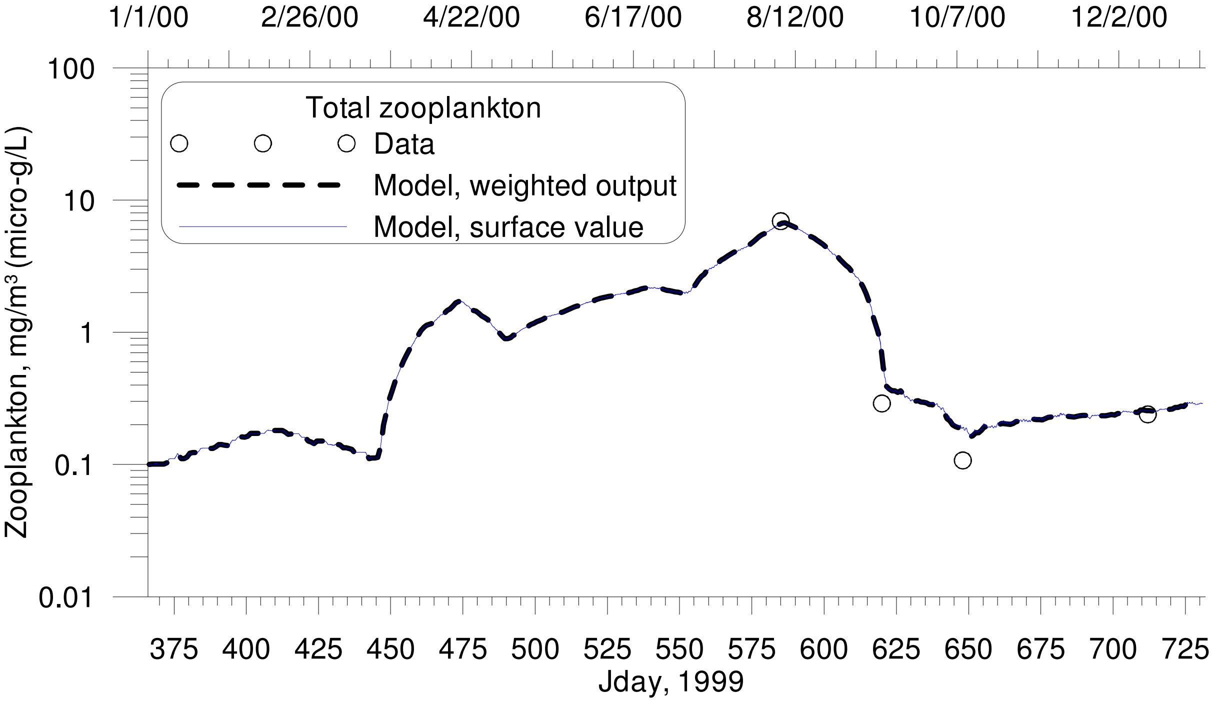

Figure 46. Model-data comparison of weighted total zooplankton, LRFEP station 0.0.

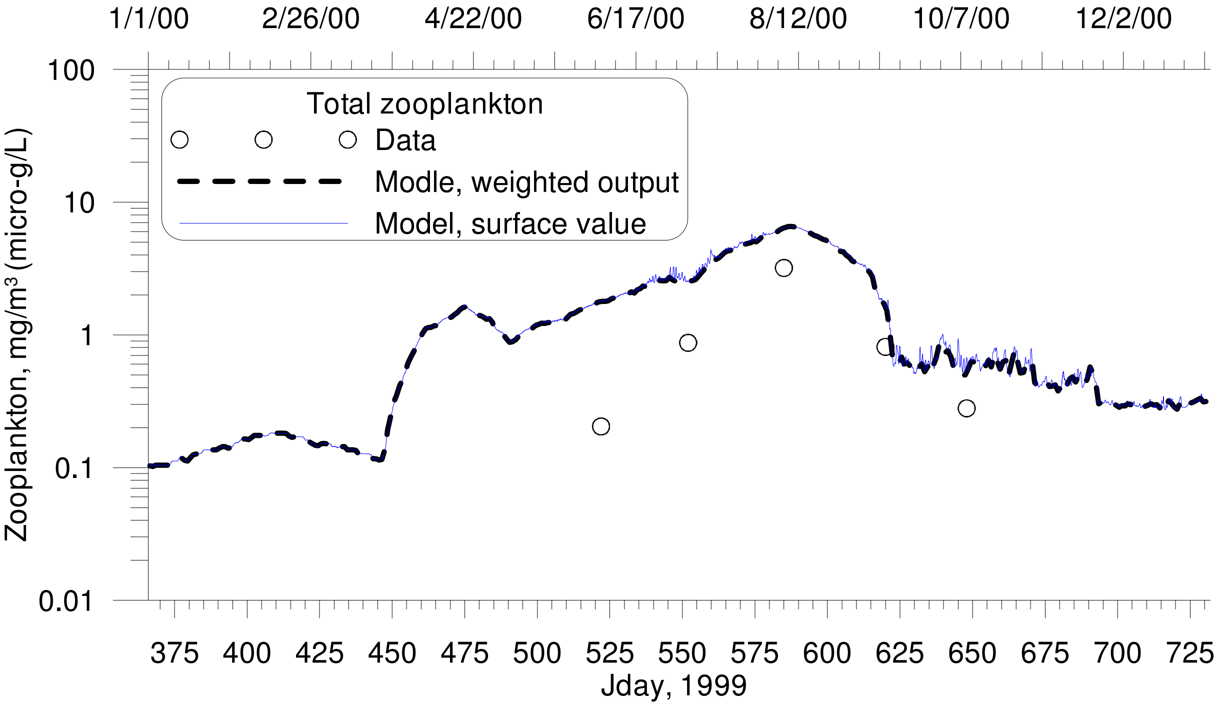

Figure 47. Model-data comparison of weighted total zooplankton, LRFEP station 1.0

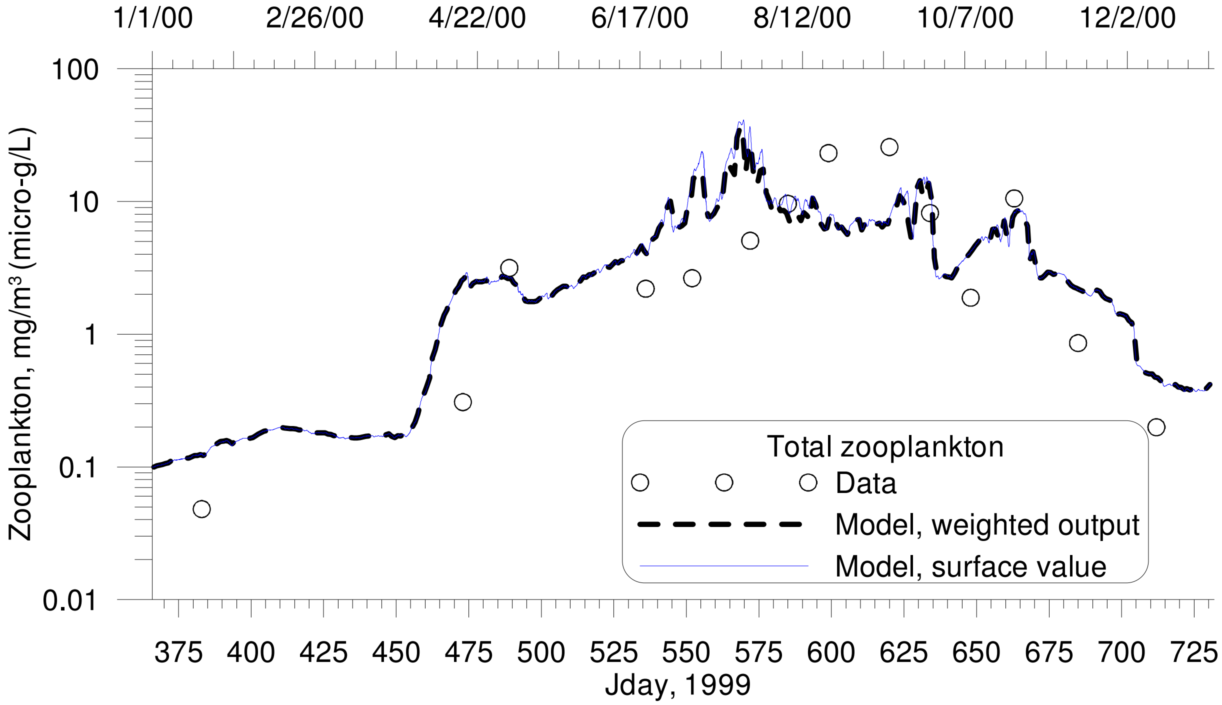

Figure 48. Model-data comparison of weighted total zooplankton, LRFEP station 2.0

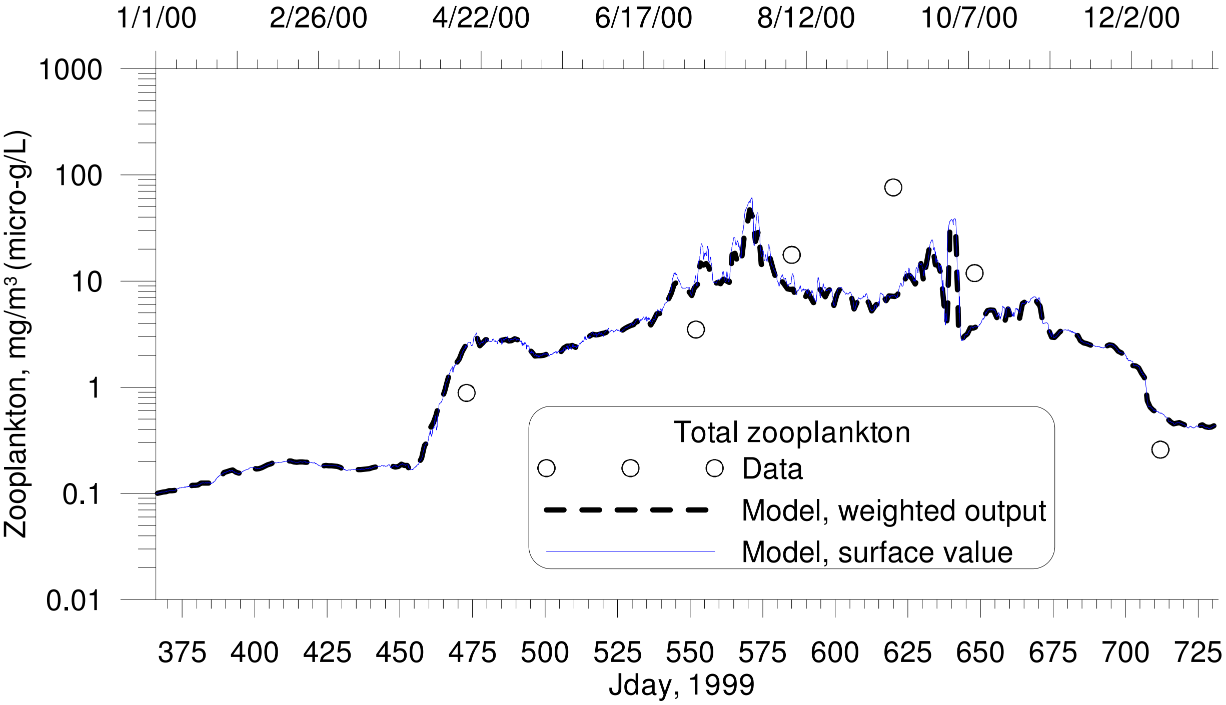

Figure 49. Model-data comparison of weighted total zooplankton, LRFEP station 3.0

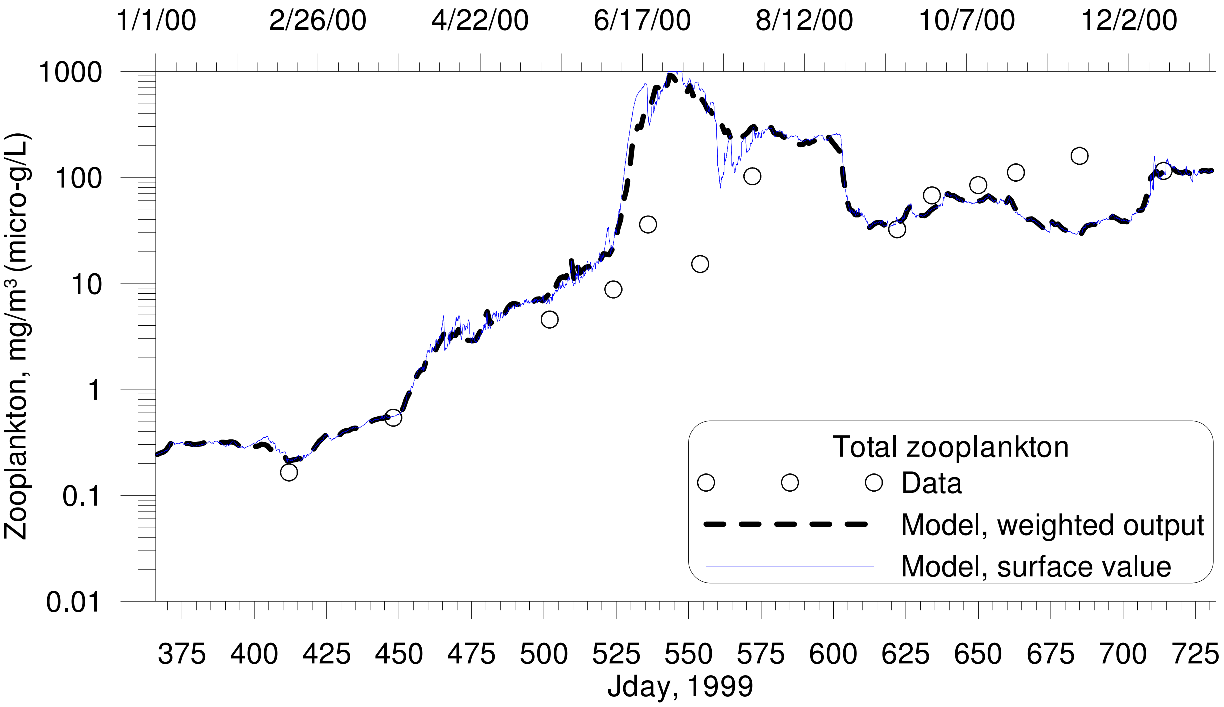

Figure 50. Model-data comparison of weighted total zooplankton, LRFEP station 4.0

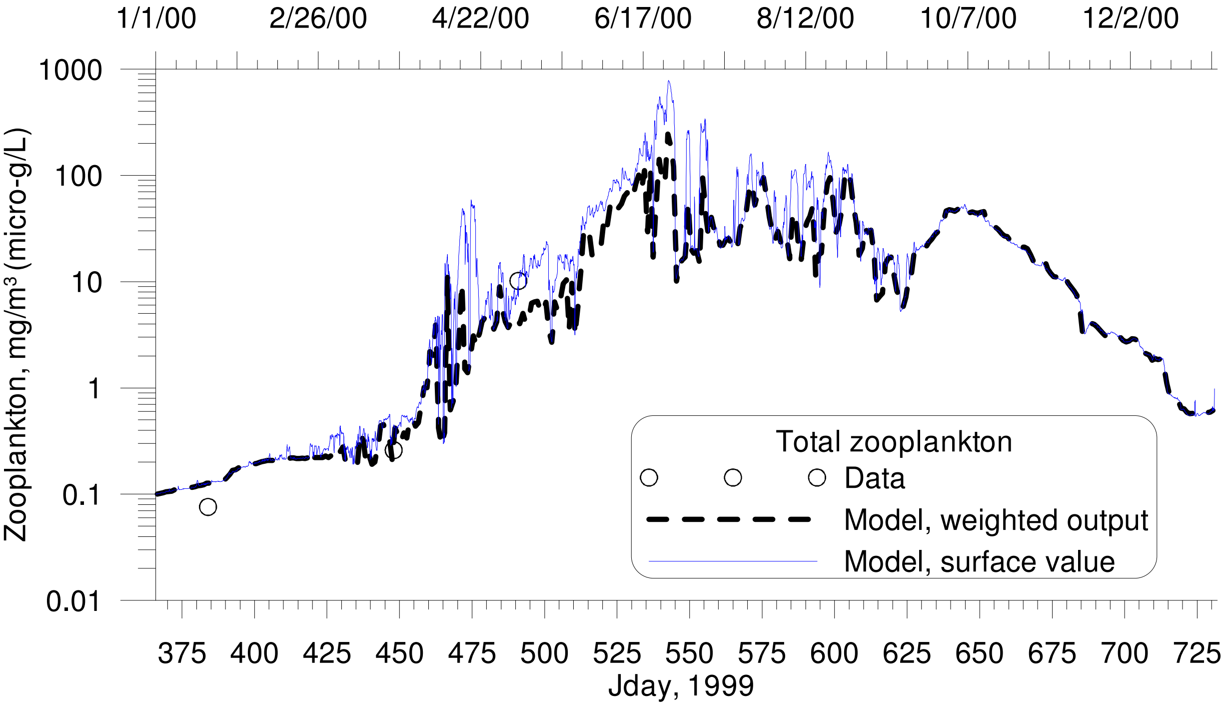

Figure 51. Model-data comparison of weighted total zooplankton, LRFEP station 5.5

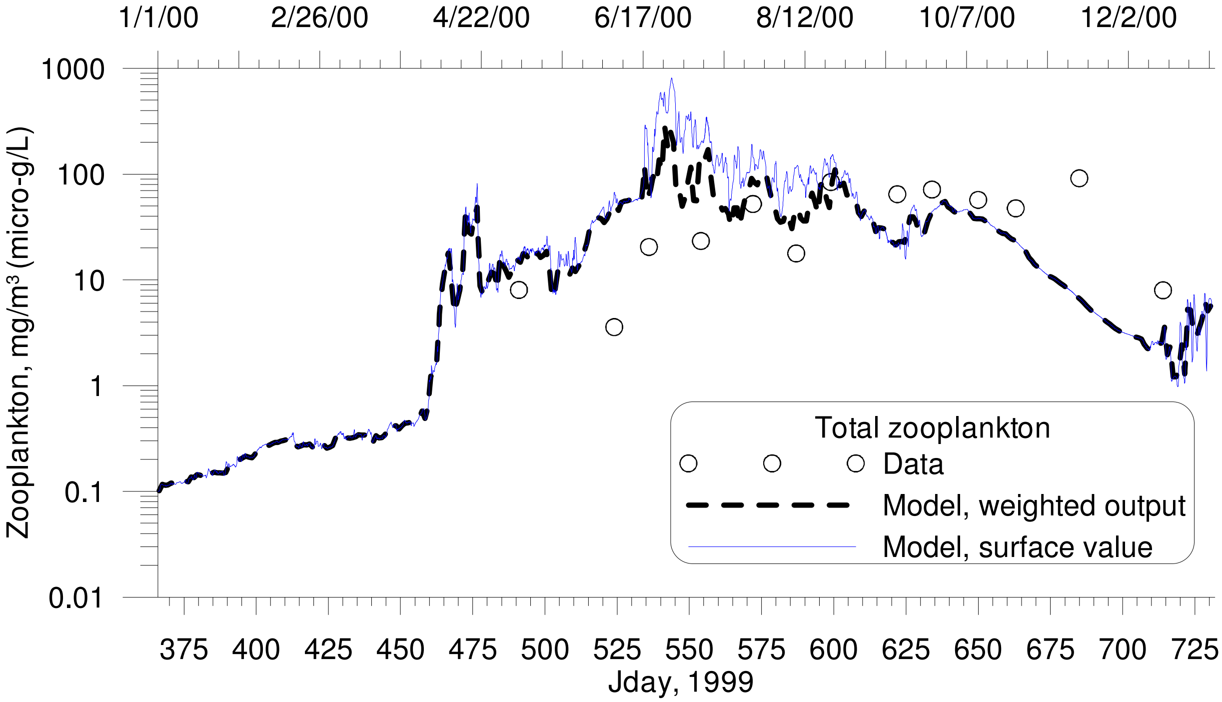

Figure 52. Model-data comparison of weighted total zooplankton, LRFEP station 6.0

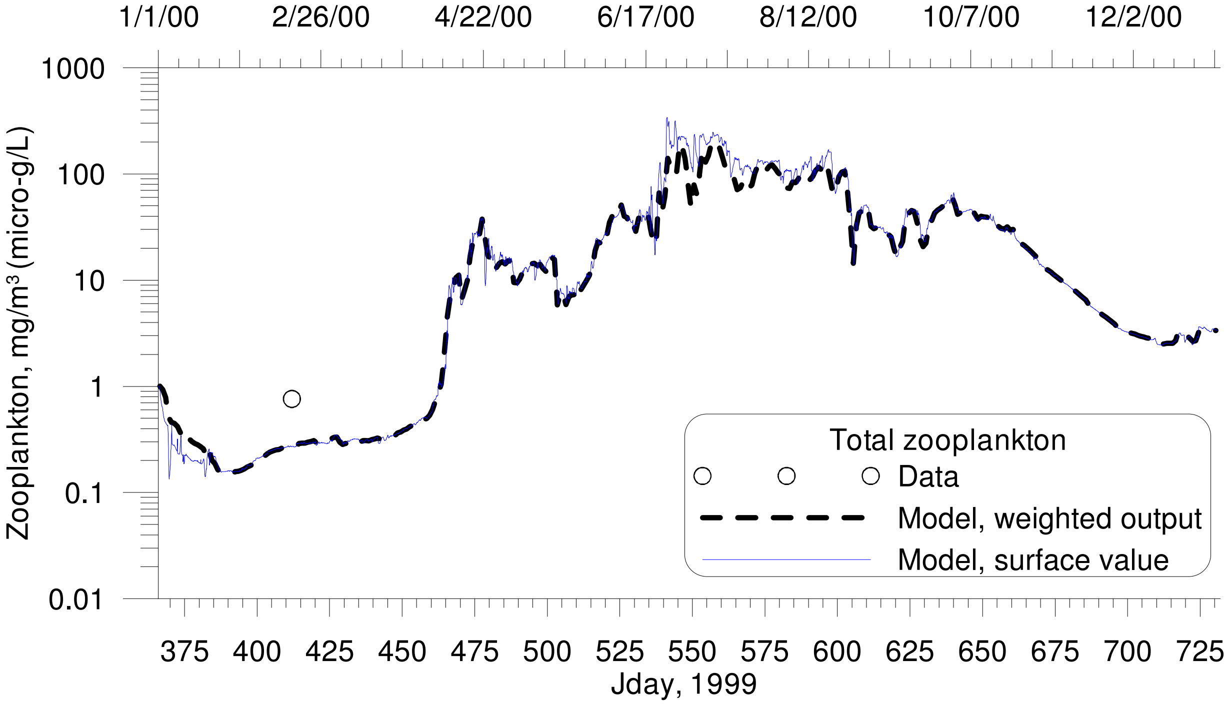

Figure 53. Model-data comparison of weighted total zooplankton, LRFEP station 6.5

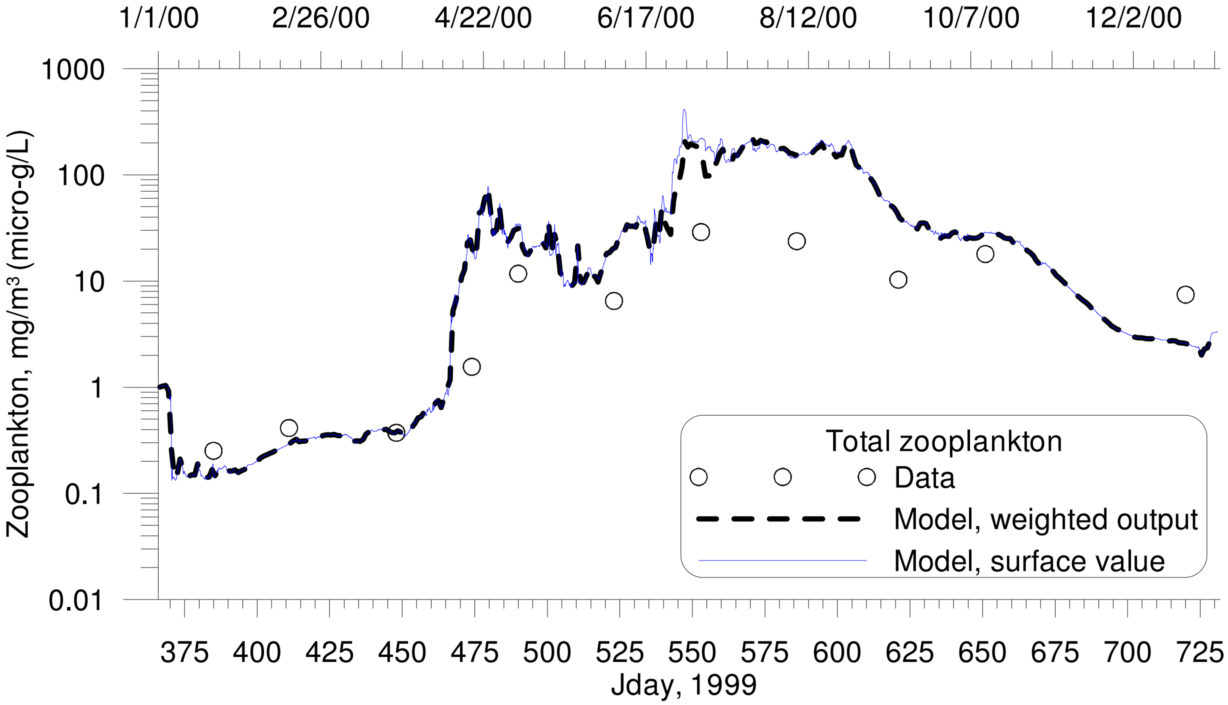

Figure 54. Model-data comparison of weighted total zooplankton, LRFEP station 7.0

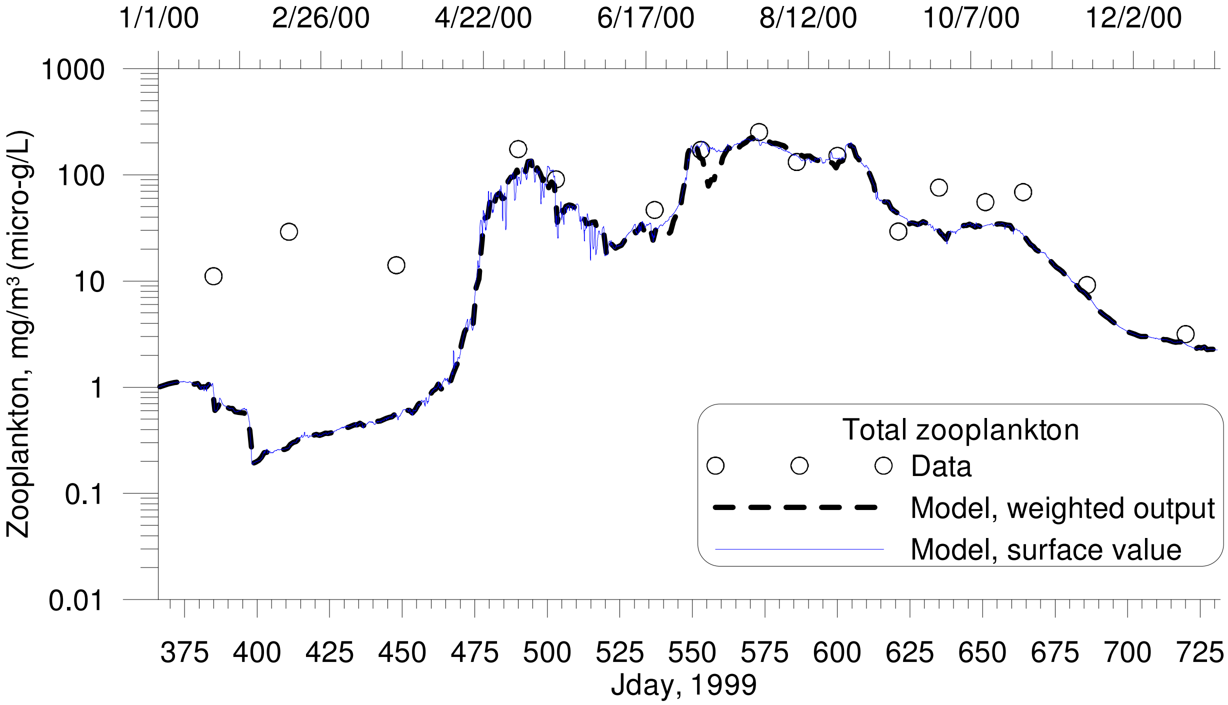

Figure 55. Model-data comparison of weighted total zooplankton, LRFEP station 8.0

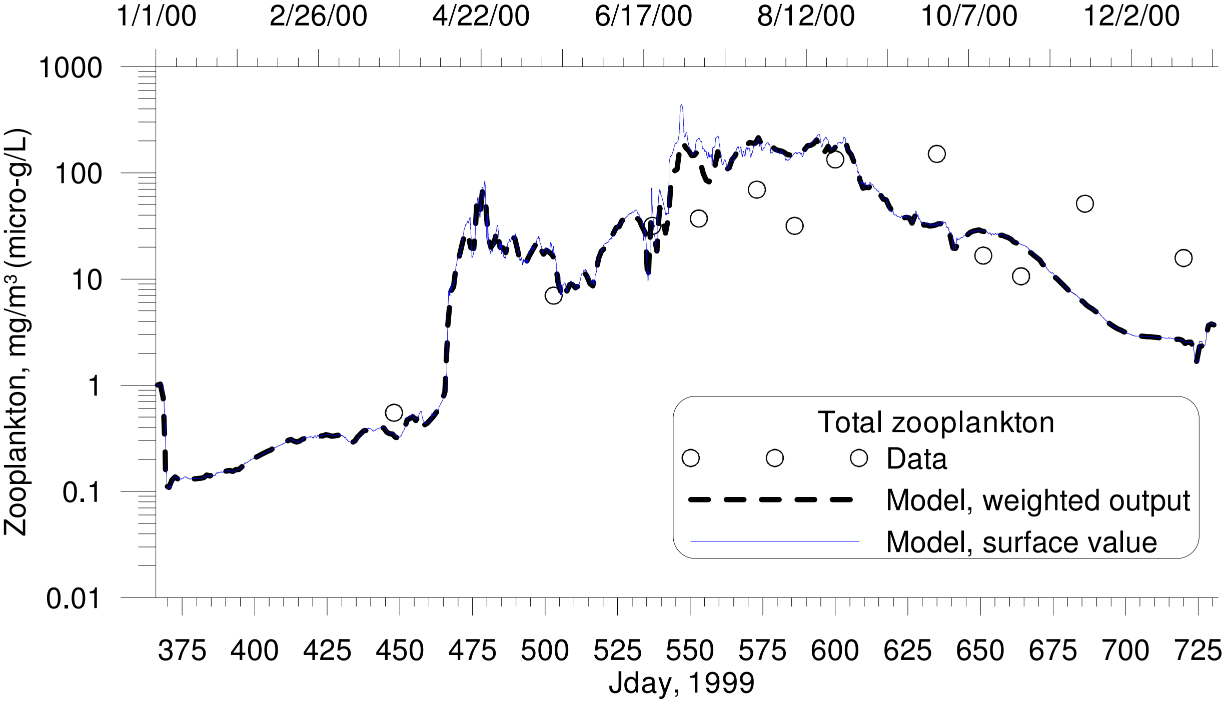

Figure 56. Model-data comparison of weighted total zooplankton, LRFEP station 8.5

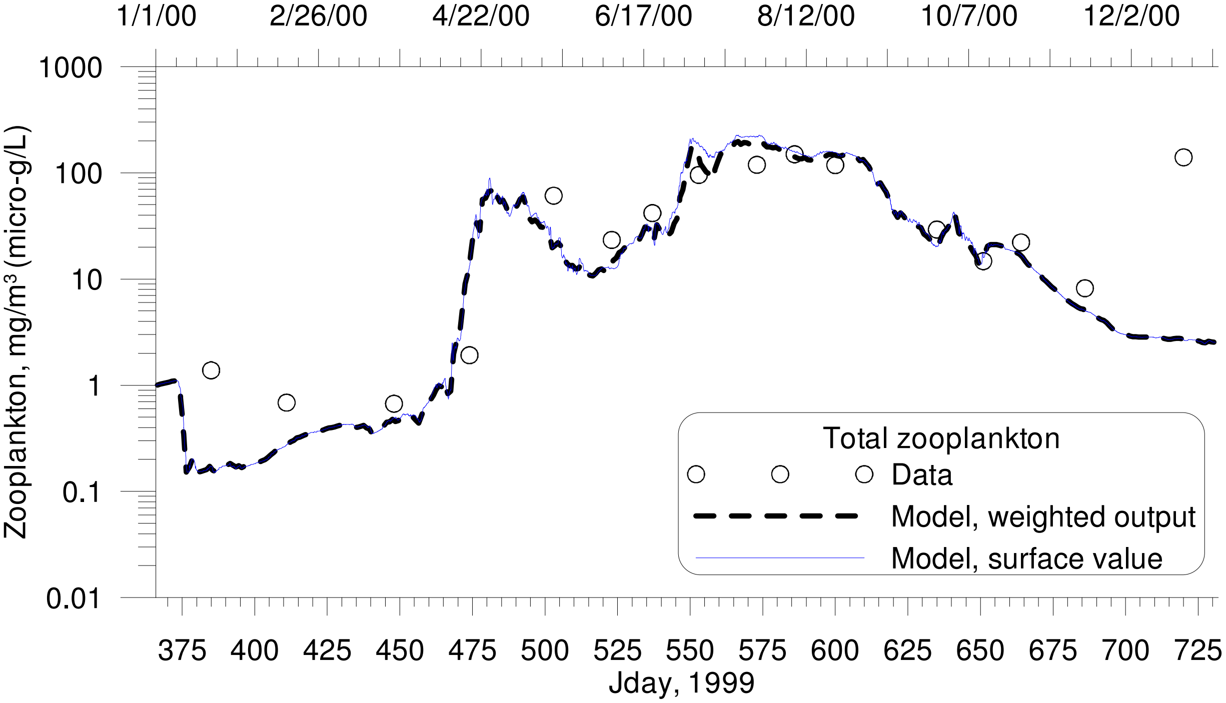

Figure 57. Model-data comparison of weighted total zooplankton, LRFEP station 9.0

Fish Bioenergetics (kokanee)

Results for a variety of cases are reported and show that the model is behaving appropriately, and that some diagnostic conclusions can be drawn.

A prescribed mass case, based on fish growth data, is examined at the Spring Canyon monitoring location (upstream of Grand Coulee Dam). The cell of best growth was selected at each time-step, and stomach content was passed on to the other vertical cells. At the end of the day (taken to be midnight), growth was determined and passed on. A similar case was examined at the Porcupine Bay monitoring location (on the Spokane River arm). The Spokane arm is known to have different fish habitat characteristics, and provides a contrast with the Columbia River site.

A simple vertical foraging strategy was employed to try to capture some realistic foraging behavior; the best growth strategy predicts a period of minimal consumption in the late summer and fall when prey is abundant. The decision process at each time-step is:

3) Use the cell of best growth if
    a. growth is positive
    b. during nighttime (selects least negative)
4) If daylight (surface lux >1), alternate foraging and "digesting"
    a. Forage at the cell of greatest consumption, C
    b. "Digest" or "rest" at the cell of minimum respiration, R
    c. alternate foraging and digesting time-steps during daylight.

These cases show that fish growth can be reasonably modeled. They also predict that there are periods when foraging at some locations in the reservoir are not practical due to the large metabolic costs associated with warm water. Specifically, near the time of fall turnover, the smallest respiration costs at Spring Canyon exceed the best energy gain from consumption. This indicates that fish are unlikely to a) inhabit that part of the reservoir, and/or b) are utilizing a strategy not modeled. Possibilities include finding cold water inflows, or foraging under more successful techniques such as high prey density littoral regions. The comparison between the two sites suggests the possibility of horizontal migration. When the bioenergetics are poor at Spring Canyon in the late fall and winter, they are more favorable at Porcupine Bay.

The shown runs used a handling time of 0.5 sec. Runs with a 0.33 sec handling time do not greatly influence the results: the positive and negative growth periods are the same, but the magnitude is slightly improved.

The results of the fish bioenergetics model show general agreement with literature values. There is a little difference for a 10-g kokanee (see Figure 73 and subsequent comments and figure).

Base Lake Roosevelt Results at Spring Canyon (LRFEP sta 9.0)

Energy content of prey: a constant of 2420 J/g
Growth method: prescribed function based on data.
Feeding: model output prey densities are used.
Foraging: Best cell at each time-step; growth calculated and passed on to all cells in the segment daily.
Comments: During the warm water periods in roughly July through October, the best place to be for a single time-step is at the bottom of the lake. However, only negligible consumption is then possible. This is unlikely the actual fish behavior to these conditions. Compare with the next section.

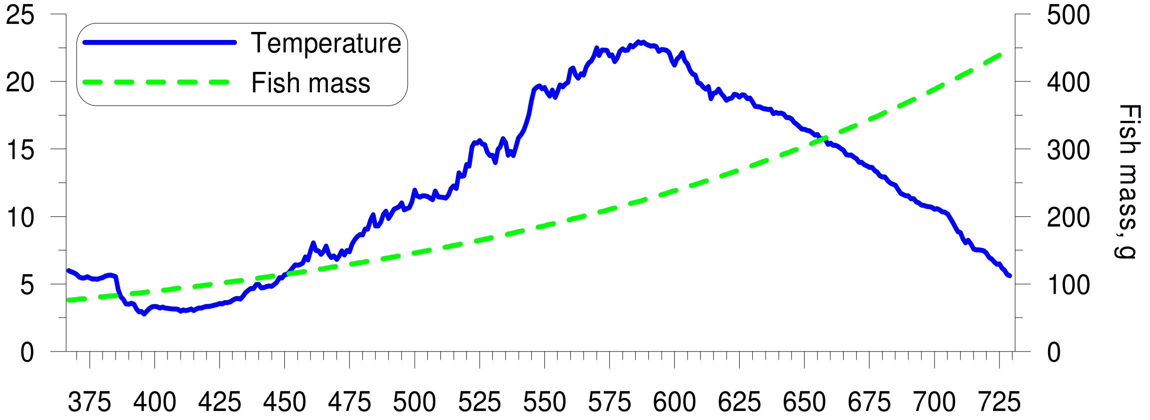

Figure 58. Base case temperature and prescribed fish mass function.

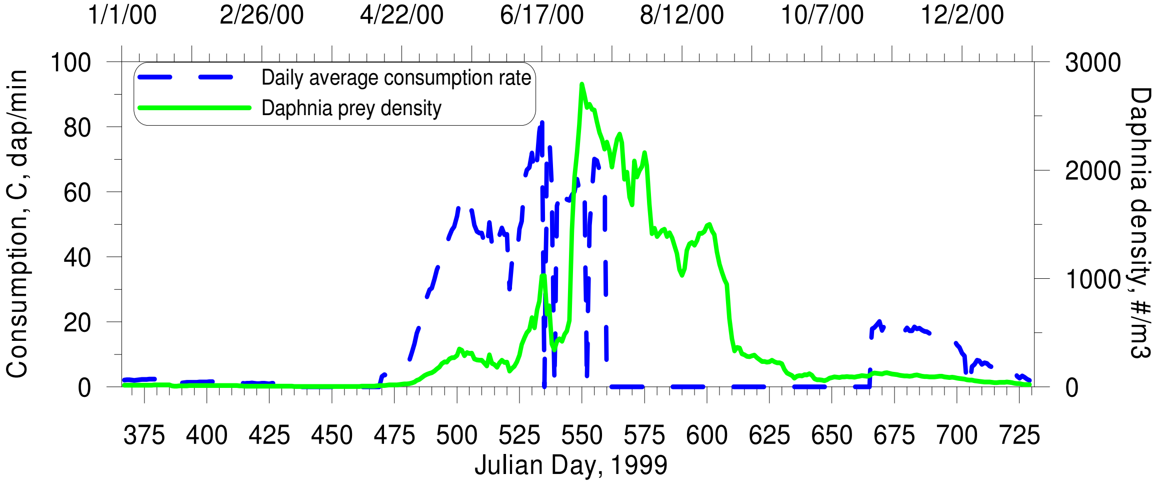

Figure 59. Daily average consumption (includes nighttime) and prey density.

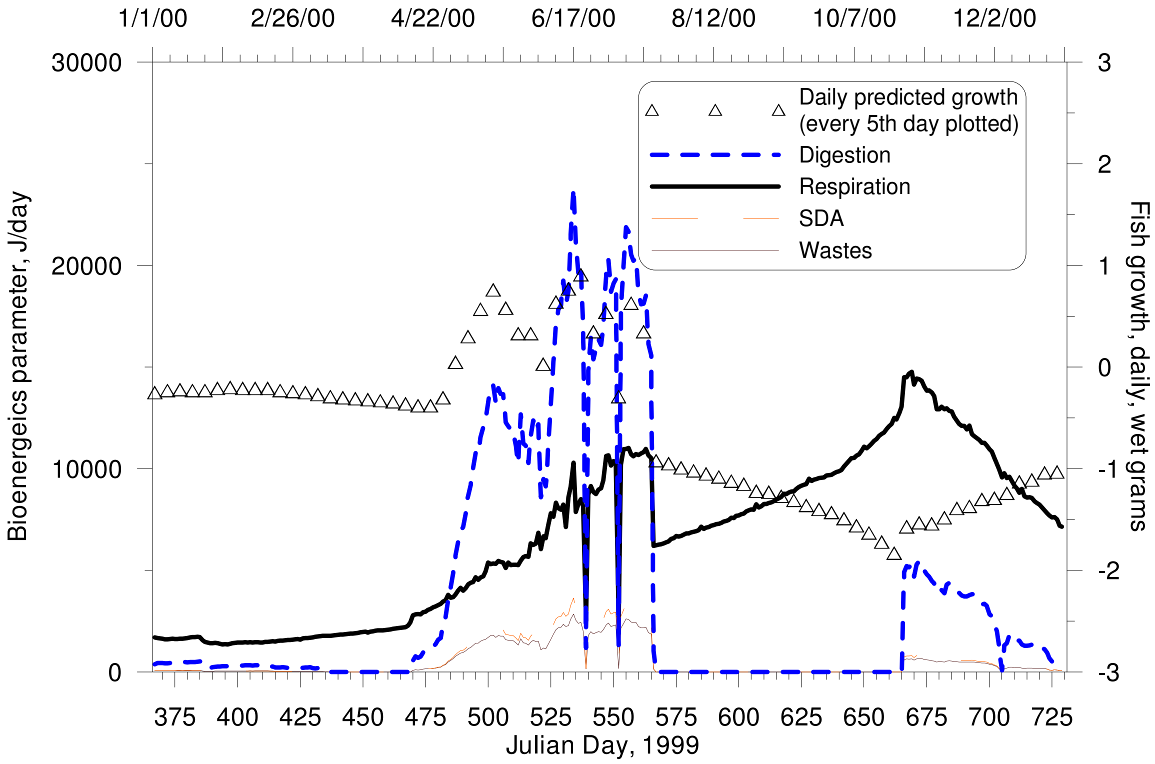

Figure 60. Daily growth and bioenergetic parameters.

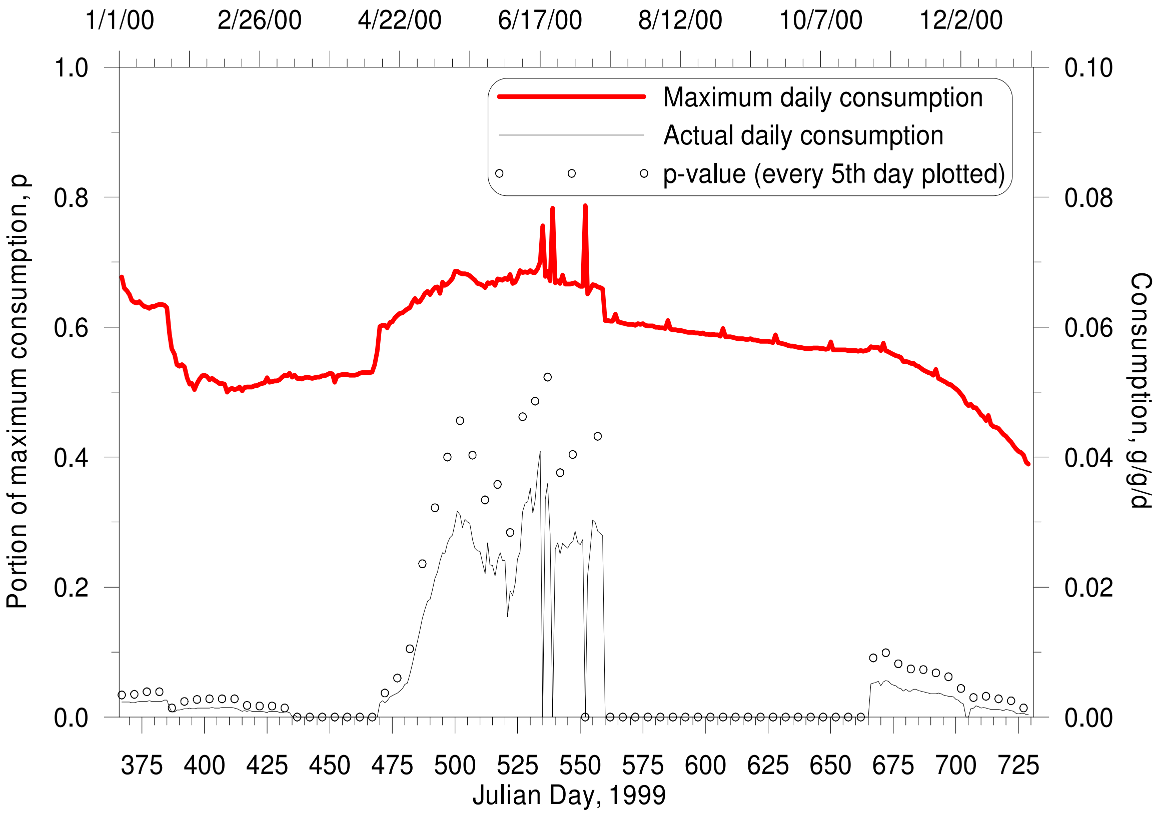

Figure 61. Daily maximum and actual consumption; p-values.

Base Lake Roosevelt Results at Spring Canyon (LRFEP sta 9.0);

Simple foraging algorithm

Energy content of prey: a constant of 2420 J/g
Growth method: prescribed function based on data.
Feeding: model output prey densities are used.
Foraging: "Best growth" with conditional vertical foraging during the day. The decision process at each time-step:

5) Use the cell of best growth if
    a. growth is positive
    b. during nighttime (selects least negative)
6) If daylight (surface lux >1), alternate foraging and "digesting"
    a. Forage at the cell of greatest consumption, C
    b. "Digest" or "rest" at the cell of minimum respiration, R
    c. alternate foraging and digesting time-steps during daylight.

Comments: This is an attempt at simple vertical foraging in an attempt to optimize consumption and respiration. Also, when assessing which cell has the best growth, 20% of the consumption is directly added to the digestion parameter to allow for potential digestion (Brett & Groves, 1979). Without this estimate (only used to estimate the best cell, and not for any parameter calculations), the model will pick the most favorable growth locations using the stomach content at the start of the time-step. Since only a small portion of the prey consumed are digested in the same time-step, the model tends to pick the locations of least respiration cost when the waters become warm which in turn leads to empty stomachs.

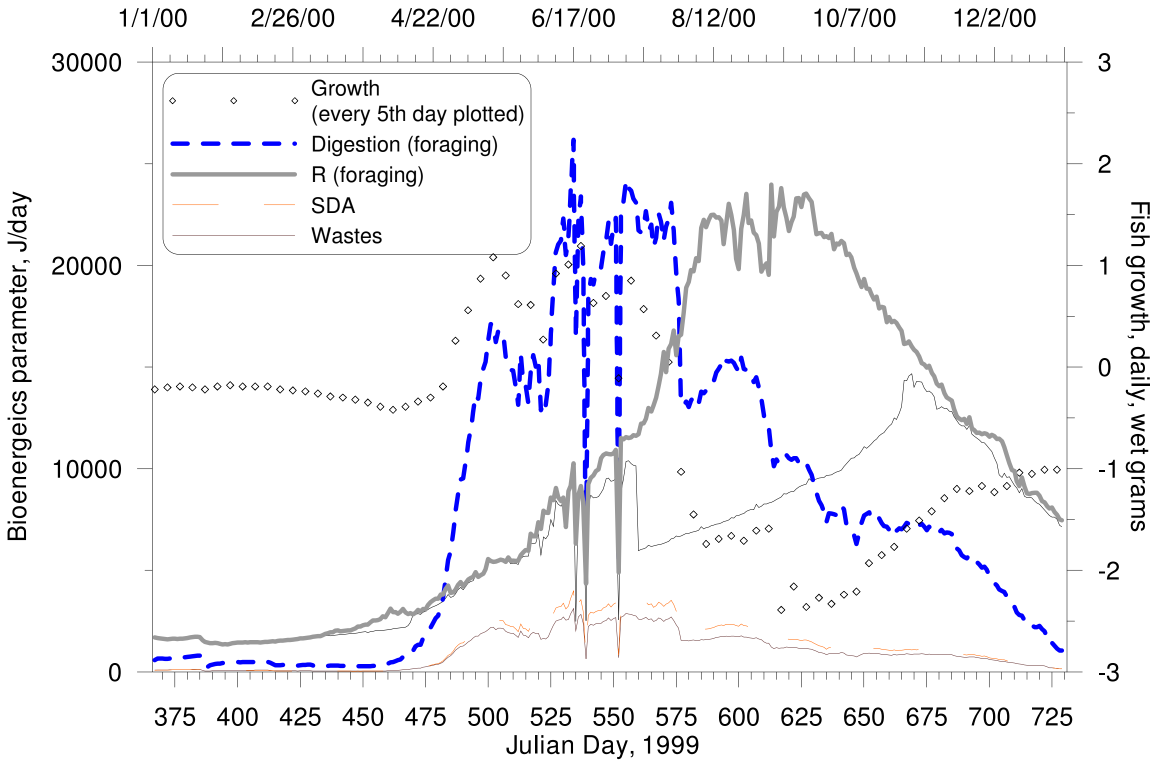

Figure 62. Daily growth and bioenergetic parameters, vertical foraging strategy.

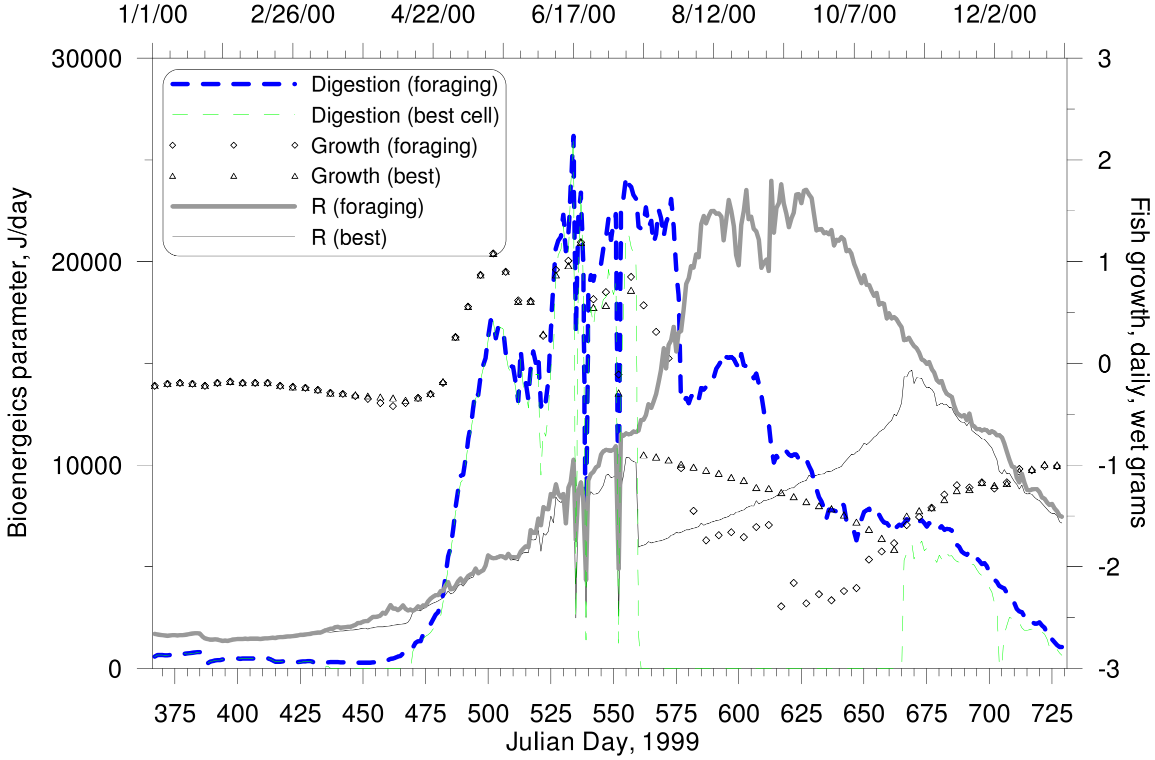

Figure 63. Comparison of fish location optimization strategies: best growth cell and vertical foraging.

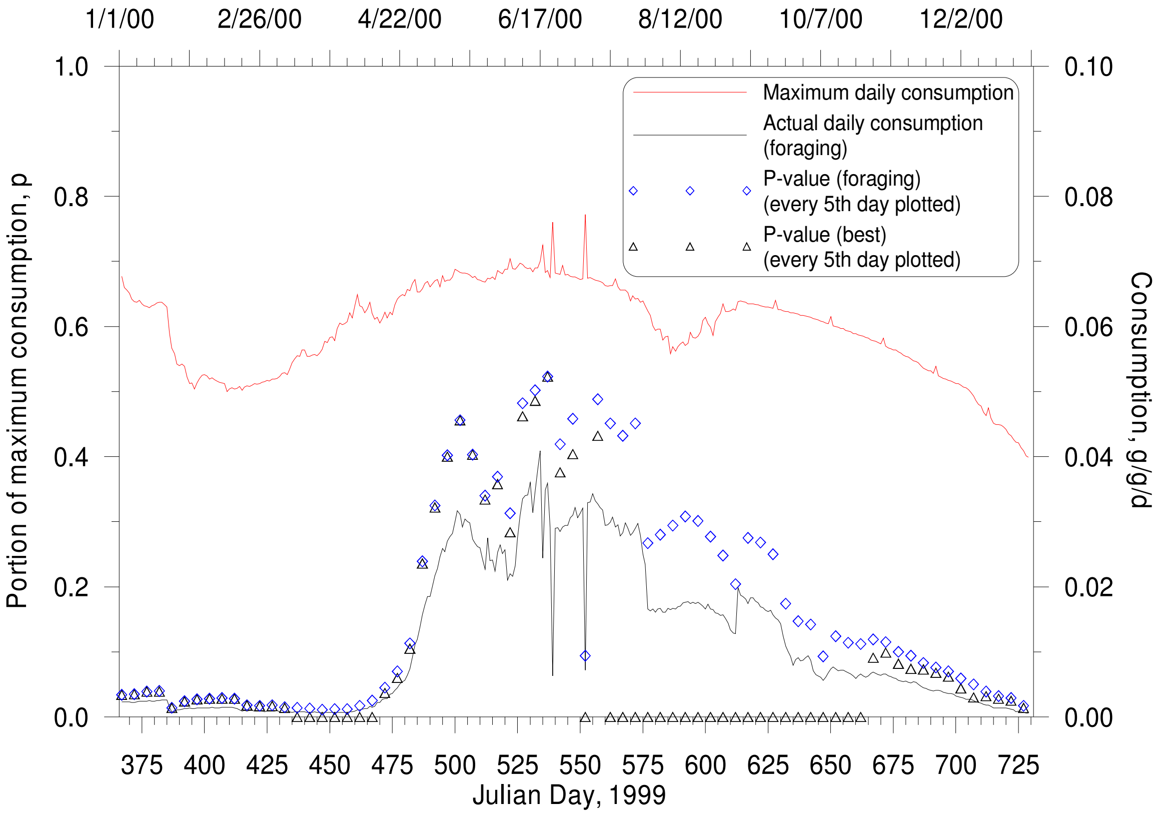

Figure 64. Daily maximum and actual consumption for the foraging model. Comparison of best growth cell and vertical foraging p-values.

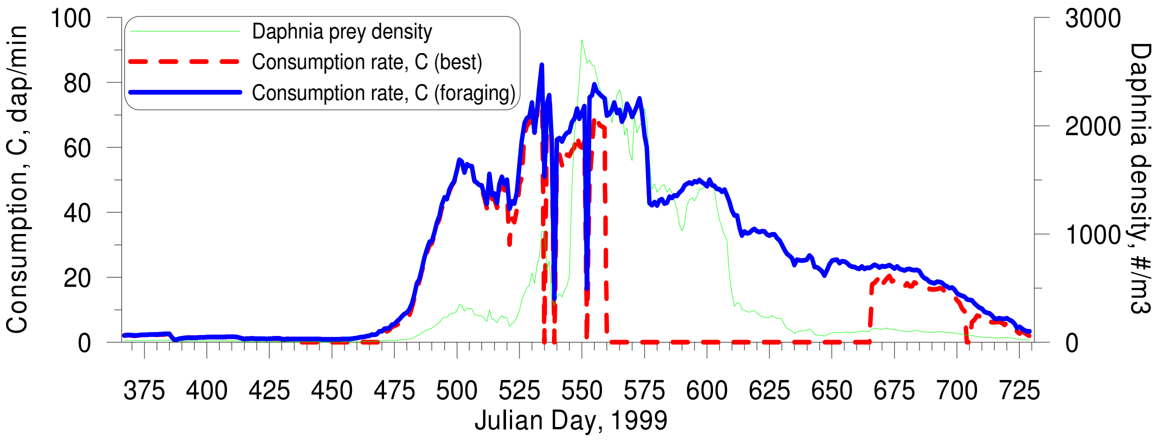

Figure 65. Comparison of daily average consumption rates.

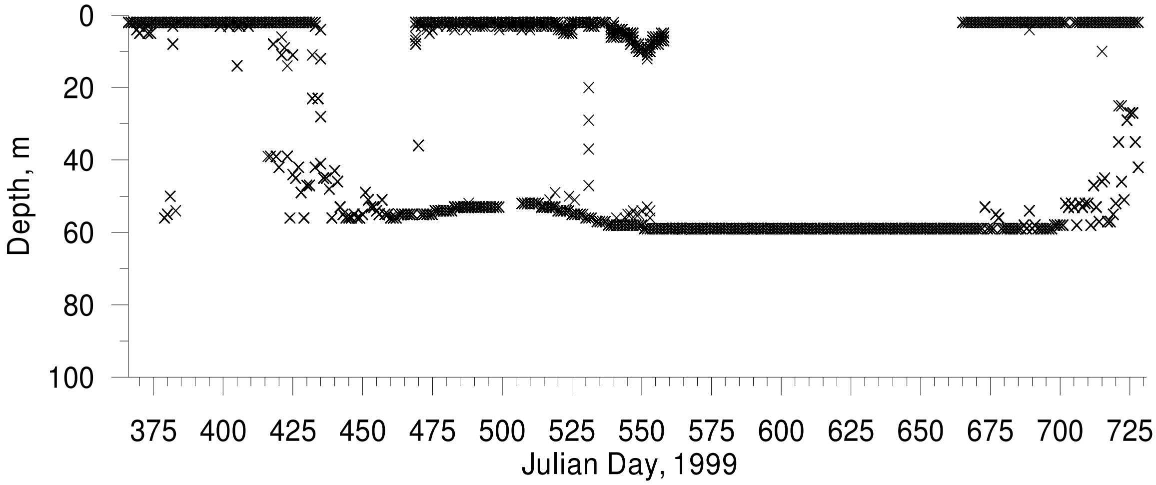

Figure 66. Foraging depths at each time-step, best growth cell method.

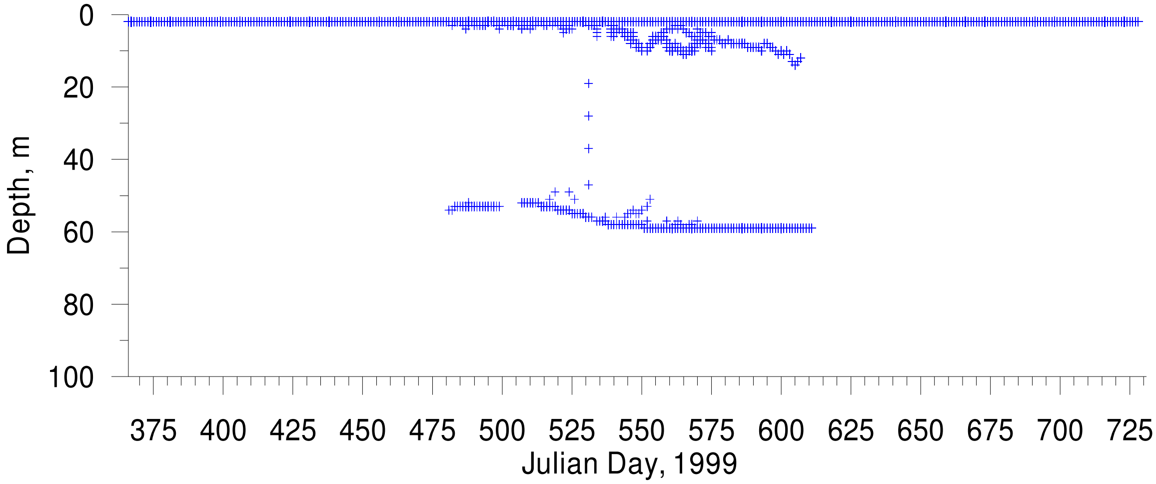

Figure 67. Foraging depths at each time-step, vertical foraging method.

[Figure 66 and Figure 67 were hard to distinguish on the same plot; individual points which look to be the same generally are.]

Comparison of Base Lake Roosevelt Results at Porcupine Bay (Spokane River, LRFEP sta 4.0) with Spring Canyon (Columbia River, LRFEP sta 9.0)

Energy content of prey: a constant of 2420 J/g
Growth method: prescribed function based on data.
Feeding: model output prey densities are used.
Foraging: "Best growth" with conditional vertical foraging during the day. The decision process at each time-step:

7) Use the cell of best growth if
    a. growth is positive
    b. during nighttime (selects least negative)
8) If daylight (surface lux >1), alternate foraging and "digesting"
    a. Forage at the cell of greatest consumption, C
    b. "Digest" or "rest" at the cell of minimum respiration, R
    c. alternate foraging and digesting time-steps during daylight.

Comments: This is the same run as previously reported; a new location is added.

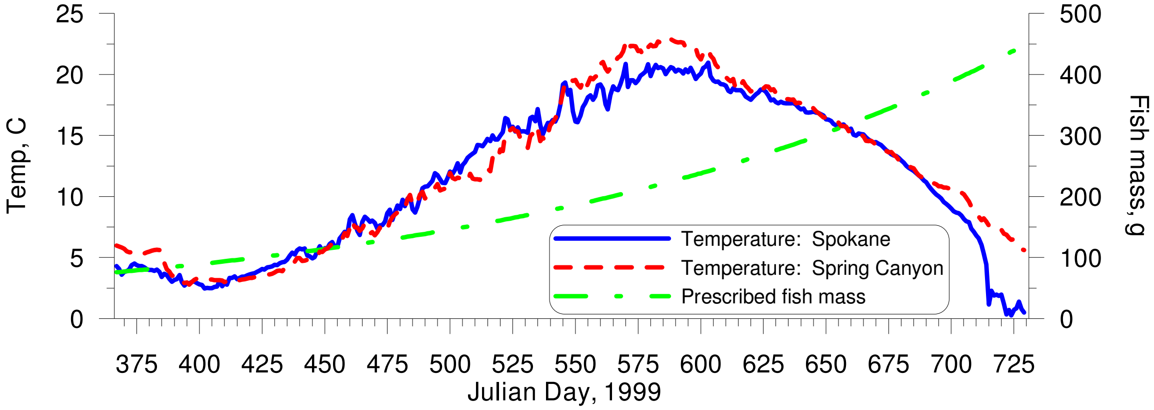

Figure 68. Comparison of water temperatures.

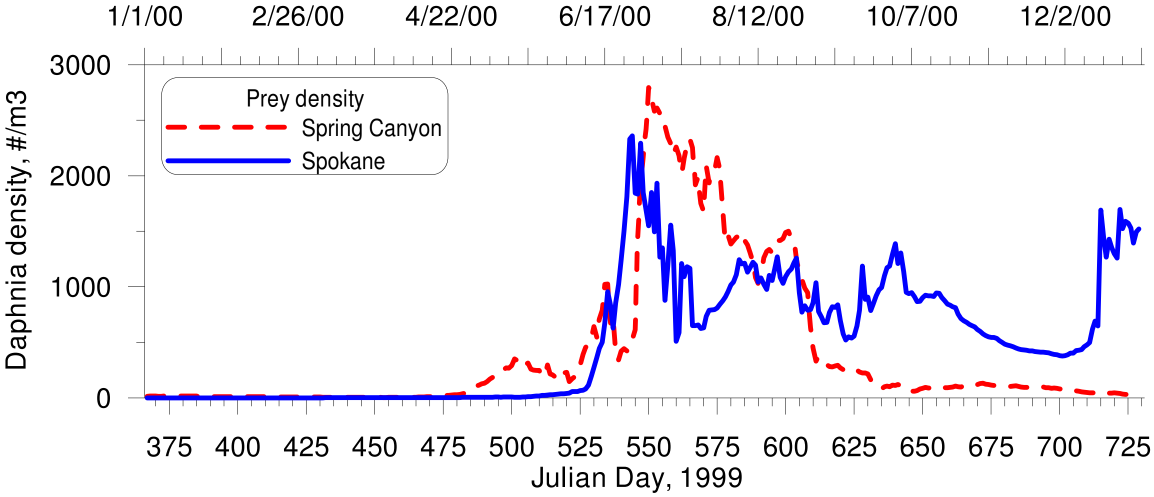

Figure 69. Comparison of prey densities.

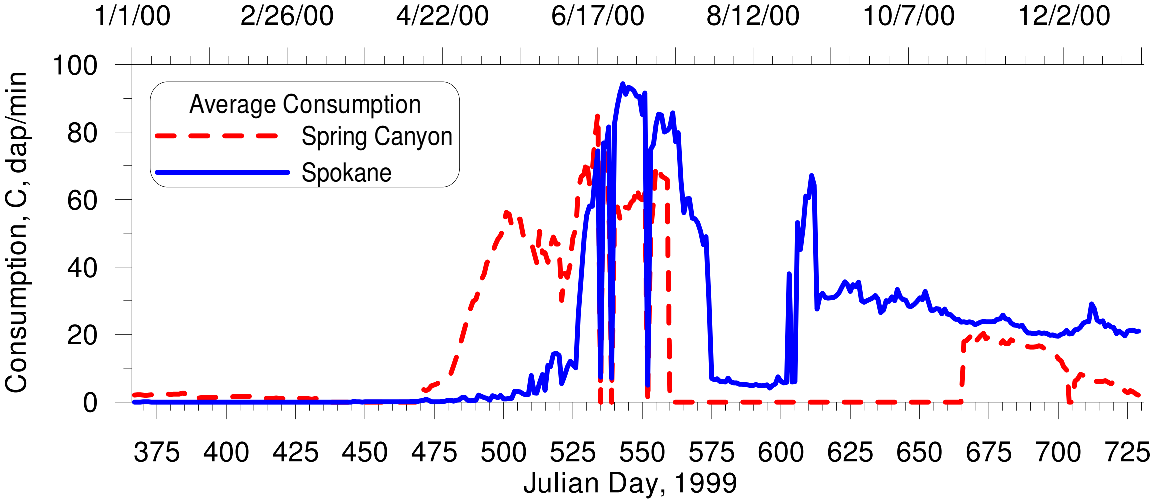

Figure 70. Comparison of consumption rates.

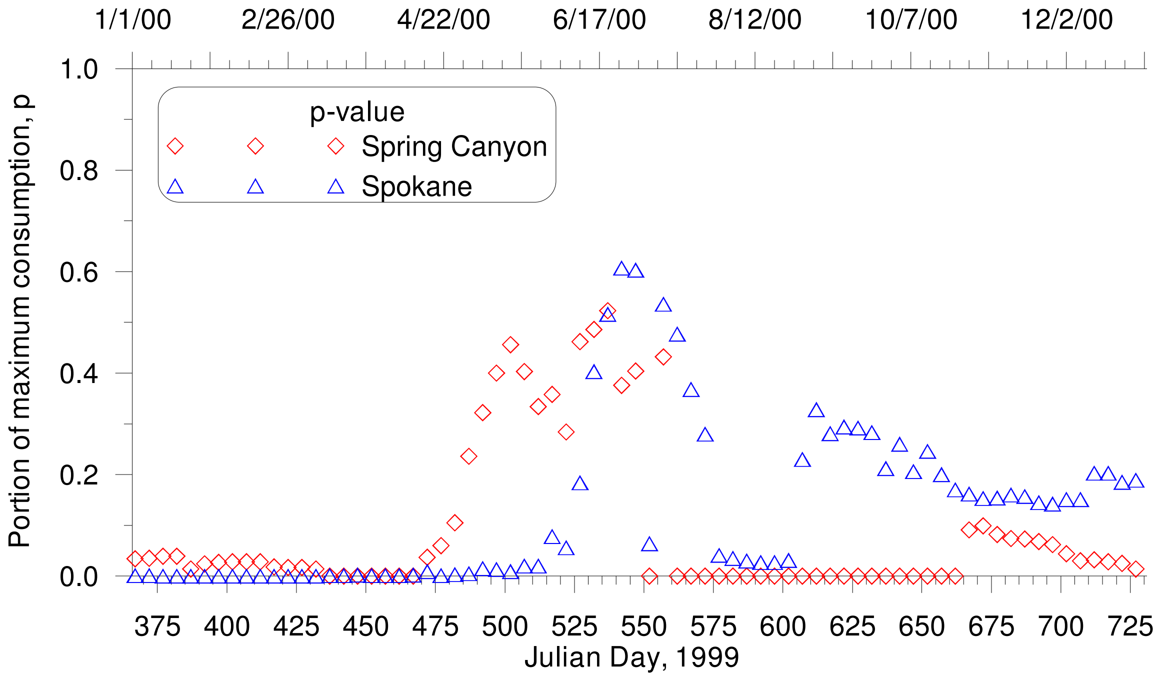

Figure 71. Comparison of p-values.

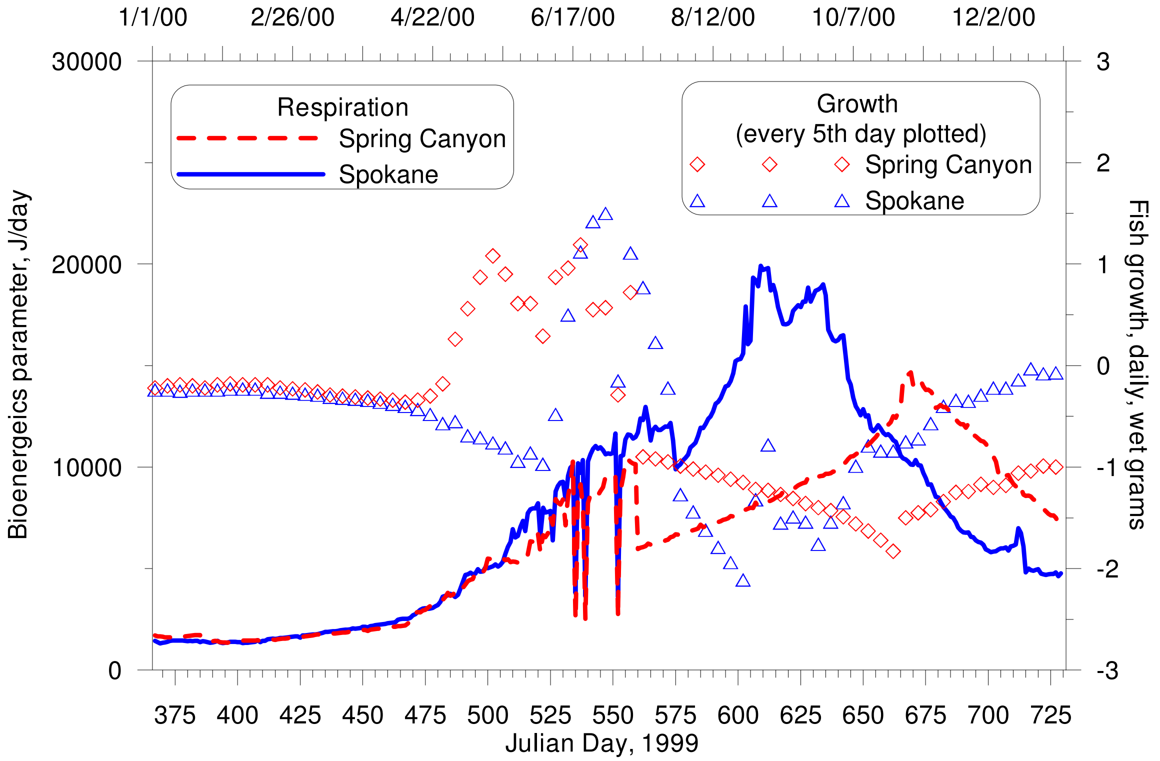

Figure 72. Comparison of respiration and daily growth.

Fixed mass kokanee, diagnostic run at 100% C_{max}.

Energy content of prey: a constant of 2800 J/g
Growth method: no growth: fixed masses of 10 and 100 grams.
Feeding: consumption rate set by Cmax = function (T, mass)
Foraging: Best cell at each time-step.
Comments: Diagnostic run to compare model results to literature results.

C_{max} is formulated using Beauchamp, et al. (1989):

$$C_{\max} = 0.303 \cdot M^{-0.275} \cdot TL(temp) \qquad \text{in g/g/d}$$

$$C_{\max} = 0.303 \cdot M^{-0.275} \cdot TL(temp) \cdot M \cdot E_{daphnia} \qquad \text{in J/d}$$

Foraging rate (C, in daphnia/minute) was determined by dividing C_{max} by 1440; thus feeding occurred continuously and was only a function of temperature (mass was constant).

The allometric function reported by Hewitt & Johnson (1992) is used for the Kokanee energy density.

$$E_{\text{fish}}\left[\text{J}/\text{g}\right] = \begin{cases} 4.1868 \cdot (1.8510 \cdot \text{M} + 1250) & \text{for} \quad \text{M} \le 196 \text{ g} \\ 4.1868 \cdot (1.1254 \cdot \text{M} + 1588) & \text{for} \quad \text{M} > 196 \text{ g} \end{cases}$$

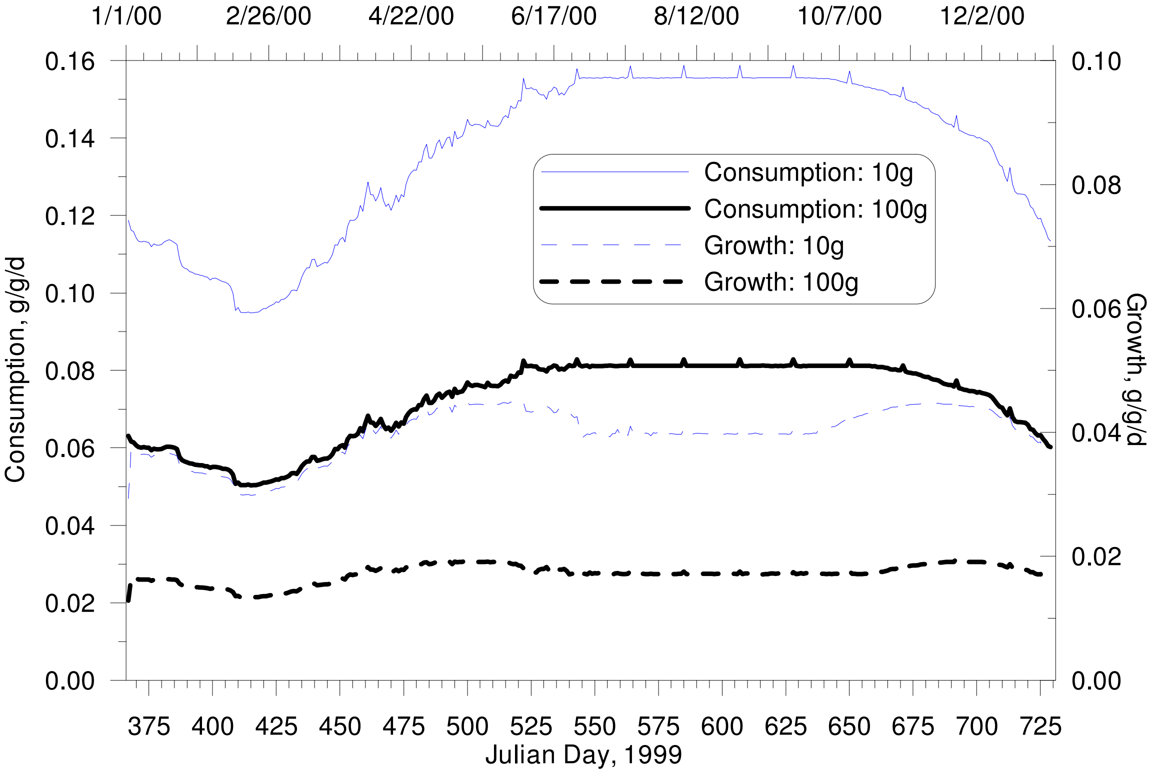

Figure 73. Growth and Consumption rate at C_{max} for a 10 g and 100g kokanee.

Summary

A CE-QUAL-W2, version 3.5, hydrodynamic, temperature, and water quality model was developed and calibrated for the Franklin D. Roosevelt Lake from Grand Coulee Dam to the U.S.- Canadian border. A fish bioenergetics model based on Stockwell and Johnson (1999) was developed. The water quality model output is used by the fish model to estimate fish growth potential within the system.

A summary of the calibration statistics for the year 2000 are presented in Table 9. A discussion of the calibration follows.

Table 9. Calibration statistics summary, 2000.

Parameter/Constituent	Unit	Count	ME*	AME*	RMS*
Grand Coulee Dam Forebay					
Daily-average ELWS**	m	366	0.01	0.01	0.01
Hourly-average ELWS**	m	8762	-0.03	0.17	0.17
LRFEP vertical profile stations					
Total Dissolved Solids	mg/L	1308	-0.18	0.39	0.44
Dissolved Oxygen	mg/L	1308	-0.01	0.14	0.16
pH	-	1308	-0.42	0.43	0.43
Water Temperature	°C	1308	-0.14	0.49	0.50
Below Grand Coulee Dam					
Orthophosphate	mg/L-P	25	0.00072	0.00097	0.00097
Ammonium	mg/L-N	25	-0.005	0.0067	0.0067
Nitrate plus nitrite	mg/L-N	25	-0.017	0.036	0.036
Alkalinity	mg/L-$CaCO_3$	25	0.89	4.18	4.18

* ME=mean error, AME=absolute mean error, RMS=root mean square error, see Appendix G.
** ELWS = Elevation, Water Surface.

Hydrodynamics

The hydrodynamic calibration to the 2000 data is acceptable. The daily-average water surface elevation is within 1 cm, and the hourly-average elevation is within 17 cm with little bias. The water balance flows have a minimal bias and the magnitudes are within the range of river discharge measurement error. While the water surface elevation calibration for 2001 and 2002 appears good, the water balances for both years show a strong bias towards losing water from the river. A further investigation into the cause of this apparent bias is recommended prior to using the model over these time-frames.

Water Temperature

The most comprehensive and representative temperature data are from the LRFEP vertical profiles. The calibrated model shows a slight bias toward underpredicting temperature (by ~0.1 °C), which is acceptable. The RMS error, representing the typical difference in temperature between the model and data, is 0.5 °C, which is considered a good calibration. The calibration of the station data in the Columbia River is good, but there is greater error in the calibration of the Spokane River data.

Alkalinity and pH

While the alkalinity calibration is acceptable, the pH calibration needs further work. There is an apparent data conflict between the USGS/Environment Canada data and the LRFEP data. Additionally, the high pH values seen in the LRFEP data in the fall need to be explained given the low carbonate and algal activity of the system. This conflict is largely the result of a faulty probe.

Ammonium and Nitrate plus Nitrite

The nitrogen balance in the system is largely conservative, so the calibration is straightforward. As with the bulk of the parameters, while the Columbia River calibration is good, the calibration at the Spokane River station shows more disagreement.

Orthosphosphate

While the orthophosphate calibaration is acceptable, it could be improved. A further investigation into the spring spike in phosphorous is warranted. Speculation suggests that attached algae may be a significant player in the spring phosophorous balance prior to the spring phytoplankton bloom. The phosphorous balance is relatively conservative otherwise. Phosphorous concentrations are also very low (near the detection limit), so sampling error may be significant. Within the W2 model, phosphorous calibration included including sorbtion onto sediments and adjusting the organic matter stoichiometry. An organic matter stoichiometry study may provide some insight into the nutrient loadings of the system.

Total Dissolved Solids

The total dissolved solids calibration is acceptable. TDS is largely conservative.

Algae

The algae calibration is acceptable in terms of total algae available for zooplankton consumption. The spring diatom bloom is generally captured. A general problem occurs in matching the dieback in June/July seen over most of the system, which is presumably due to either the hydrodyanmic change in reservoir operation or in the spring zooplankton blooms. The algal populations within Lake Roosevelt experience significant washout and have low nutrient availability. While most stations have a good total algae calibration, the Hawk Creek station underpredicts total algae. W2 is largely a pelagic model, so a further consideration of the littoral primary production may be significant in terms of zooplankton, and hence fish, ecosystems.

Zooplankton

Zooplankton sampling presents many challenges, as does zooplankton modeling. In general, zooplankton concentrations range over 3 to 4 orders of magnitude over a year. The calibration concentration is typically within 1 order of magnitude, and much of the discrepancy occurs during the late winter and early spring. Fortunately, the fish growth potential model is not sensitive to zooplankton prey densities within 1 order of magnitude. Improvements to the zooplankton calibration would incorporate suggestions from biologists as to the important changes in driving factors during the seasonal shifts from winter to spring to summer and an improved understanding of the effects of zooplankton washout and retardation.

Fish Growth Potential

The fish growth potential suggests that growth is limited in the winter by prey availability and in the summer by warm tempertures relative to the available prey. The Spokane River arm demonstrates higher growth potential that the lower Columbia River reaches. This is consistent with anedoctal data and prevailing opinions amongst the fisheries biologists. Further improvements to the fish bioenergetics model would include identification of potential cold water refugia and investigation into the actual fish movement behavior such as diel migration/foraging, spatial distribution in terms of location and depths, and seasonal changes in that distribution. It is important to note that the fish growth potential does not consider entrainment, predation, nor spawning—all of which are not well understood within the Lake Roosevelt system for kokanee salmon.

Recommendations for further study

1. Spokane River arm. As previously recognized by the LRFEP, the Spokane River exhibits complicated hydrodynamics. Changes in Spokane River flow influence the river arm in terms of plunge point and stratification, and the mainstem Columbia River influences much of the lacustrine portion of the Spokane River arm. Given the biological importance of the Spokane River arm to kokanee, three programs would greatly benefit diagnostic understanding of the arm. The first would be to improve the boundary condition data, especially nutrients, flow, and temperature. The second would be to add a second monitoring station between the existing station 4.0, which is about at the riverine/lacustrine transition point, and the confluence with the Columbia River mainstem. An independent model of the Spokane Rive arm may provide insights into the relationships amongst the Columbia River, the boundary conditions, and the arm hydrodynamics. The third program would include a study of fish seasonal distribution within the entire system as well as shifts in diel vertical distributions. A comparison of kokanee behavior within the Spokane River arm with their behavior in the lower third of the Columbia River might suggest important behaviorial factors.
2. Model Improvements.
    a. The model could be calibrated to new data taken recently to extend the calibration period.

    b. The model could be assessed for decreasing the computational time to run a simulation. Currently, it takes a couple days of running the model to do full water quality, fish bioenergetics and hydrodynamics for a full-year for the entire system.

3. Enhancements. The following enhancements could be added to the model to improve its utility as a management tool.
    a. The model could be tied into a chemical equilibrium model for metals to evaluate the effect of metals on fish uptake. Fish growth and metals accumulation could be tracked.
    b. The fish energetics model could be coupled with a smart particle tracking algorithm such as the Numerical Fish Surrogate used by the Corps of Engineers to look at fish movement. The current model evaluated fish either at fixed locations (in a cage) or at a fixed segment but allowing vertical migration. There was no consideration of horizontal movement considering both transport by the fluid and volitional movement of the fish. With this capability, one could release fish, let’s say from a hatchery, and have the model track their movement through the lake and their growth.

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Appendix A: Water quality boundary condition generation

Overview

The following water quality constituents are used as model inputs at the upstream boundary condition for each river.

- Alkalinity
- pH
- Dissolved oxygen
- Total dissolved solids (TDS)
- Inorganic suspended solids (ISS)
- Orthophosphate or soluble reactive phosphorous (ORP or PO4)
- Ammonium (NH3 or NH4)
- Nitrate plus nitrite (NOx)
- Algae
- Organic matter
    - Labile dissolved organic matter (LDOM)
    - Refractory dissolved organic matter (RDOM)
    - Labile particulate organic matter (LPOM)
    - Refractory particulate organic matter (RPOM)
- Total inorganic carbon (TIC)
- Generic constituents
    - Water age
    - Tracer
    - Coliform bacteria

Additional data are used to generate the model inputs:

- Total suspended solids (TSS)
- Conductivity

The water quality data are typically reported biweekly or monthly and each constituent is not always reported at the same time as any other constituent. The W2 model, however, updates all water quality boundary conditions at the same time. To resolve the differences in data reporting dates and times and reporting frequencies, the general approach is to build a daily-frequency time-series data set. Thus, each day of the model simulation will have one updated water quality boundary condition point. For each constituent, the method used to generate the interpolated or estimated values (some boundaries lack data) can differ among the boundaries. Several common methods are linear interpolation, flow weighting, constant value, and using another boundary's values. Each is discussed briefly.

Linear interpolation

The constituent data are converted into a decimal day format to allow for ease of calculation. Linear interpolation is used to generate values at 12:00 pm for each day.

Flow weighting

Several of the constituents at the upstream boundary of the mainstem Columbia River are only available prior to the confluence of the Columbia and Pend Oreille Rivers. To generate the daily time-series boundary condition values, daily-average flow values and daily water quality constituents are determined. Linear interpolation is used to determine the water quality values and to fill in any data gaps in the daily-average flow. The mainstem Columbia River upstream water quality constituent boundary condition the flow weighted average of the branch constituent values.

Constant value

For water quality constituent boundary condition values where the data are sparse or lacking and the model is expected to be insensitive to the values, a constant value may be assumed. The value is selected as being a representative annual average value. An examples is the coliform bacteria concentrations at the Banks Lake return flows which are small (<10% of the mainstem flow) and infrequent (8 days in 2000.)

Another boundary site's values

Some boundaries lack data for many constituents, the Sanpoil River, for example. An initial estimation of the constituent values may be taken from the other boundaries. Linear regressions often do not show a strong correlation between boundaries and constituents. The advantage of using a different boundary's values over a constant value or a estimated value from a poorly correlated relationship is that the seasonal pattern is likely to be preserved in terms of magnitude and variation. Calibration may show the need to further improve the boundary conditions using this approach.

Conductivity

Conductivity is not a model input. The conductivity data are used to generate the total dissolved solids boundary condition (see the section Total dissolved solids.) For each boundary, the data frequency, data source, period of record, and method used to generate daily values is shown in Table 10.

Table 10. Conductivity boundary condition generation summary.

Boundary	**Data frequency**	**Data source**	**Data period**	**Method**
Mainstem Columbia River	*	*	*	Daily flow weighted average value from Columbia R. and Pend Oreille R. values.
Columbia prior to confluence	biweekly	BC08NE0001	JAN99 to DEC04	Linear interpolation between data points
Pend Oreille prior to confluence	biweekly	BC08NE0029	JAN99 to DEC04	Linear interpolation between data points
Kettle River	biweekly	BC08NN0021	JAN99 to SEP04	Linear interpolation between data points
Colville River	--	none	--	Use mainstem Columbia River values
Spokane River	monthly	USGS 12433000	JAN99 to SEP03	Linear interpolation between data points
Sanpoil River	--	none	--	Use mainstem Columbia River values
Banks Lake return flow	monthly	USGS 12436500	OCT01 to SEP04	Average value of entire data set; constant value

Coliform bacteria

Coliform bacteria are included in the model for completeness. For each boundary, the data frequency, data source, period of record, and method used to generate daily values is shown in Table 11.

Table 11. Coliform bacteria boundary condition generation summary.

Boundary	**Data frequency**	**Data source**	**Data period**	**Method**
Mainstem Columbia River	*	*	*	Daily flow weighted average value from Columbia R. and Pend Oreille R. values.
Columbia prior to confluence	biweekly	BC08NE0001	JAN99 to DEC04	Linear interpolation between data points
Pend Oreille prior to confluence	biweekly	BC08NE0029	FEB00 to DEC04	Linear interpolation between data points; repeat first value to prior to start of data set
Kettle River	monthly	USGS 12404900	JAN99 to SEP04	Linear interpolation between data points
Colville River	monthly	USGS 12409000	OCT94 to SEP95; OCT99 to SEP00	Averaged values by month, repeated for all years; linear interpolation between calculated points
Spokane River	--	none	--	Arbitrary value of 1.0; constant value
Sanpoil River	--	none	--	Arbitrary value of 1.0; constant value
Banks Lake return flow	monthly	USGS 12436500	JAN99 to SEP04	Average value of entire data set; constant value

Alkalinity

Alkalinity is an important boundary condition used to model the carbonate chemistry. For each boundary, the data frequency, data source, period of record, and method used to generate daily values is shown in Table 12.

Table 12. Alkalinity boundary condition generation summary.

Boundary	**Data frequency**	**Data source**	**Data period**	**Method**
Mainstem Columbia River	*	*	*	Daily flow weighted average value from Columbia R. and Pend Oreille R. values.
Columbia prior to confluence	biweekly	BC08NE0001	JAN99 to DEC04	Linear interpolation between data points
Pend Oreille prior to confluence	biweekly	BC08NE0029	JAN99 to DEC04	Linear interpolation between data points
Kettle River	--	none	--	Use mainstem Columbia River values
Colville River	--	none	--	Use mainstem Columbia River values
Spokane River	monthly	USGS 12433000	MAY99 to APR00	Average value of entire data set; constant value
Sanpoil River	--	none	--	Use mainstem Columbia River values
Banks Lake return flow	--	none	--	Use mainstem Columbia River values

Dissolved oxygen

Dissolved oxygen is an important water quality constituent to abiotic and biological system. For each boundary, the data frequency, data source, period of record, and method used to generate daily values is shown in Table 13.

Table 13. Dissolved oxygen boundary condition generation summary.

Boundary	**Data frequency**	**Data source**	**Data period**	**Method**
Mainstem Columbia River	monthly	LRFEP sta 0.0	JAN99 to JAN02	Linear interpolation between data points
Kettle River	monthly	USGS 12404900	JAN99 to SEP04	Linear interpolation between data points
Colville River	monthly	USGS 12409000	OCT94 to SEP95; OCT99 to SEP00	Use DSBC; the annual variation at GCL is similar to the limited Colville River data variation
Spokane River	hourly	AvistaCorp. (Little Falls Dam)	APR99 to MAR02	Daily average values
Sanpoil River	monthly	LRFEP sta 8.8	JAN99 to JAN02	Linear interpolation between data points
Banks Lake return flow	monthly	USGS 12436500	JAN99 to SEP04	Linear interpolation between data points

Orthophosphate

Orthophosphate, taken to the equivalent to soluble reactive phosphorous, is an important nutrient. For each boundary, the data frequency, data source, period of record, and method used to generate daily values is shown in Table 14

Table 14. Orthophosphate boundary condition generation summary.

Boundary	Data frequency	Data source	Data period	Method
Mainstem Columbia River	monthly	LRFEP sta 0.0	JAN99 to JAN02	Linear interpolation between data points
Kettle River	monthly	USGS 12404900	JAN99 to SEP04	Linear interpolation between data points
Colville River	--	none	--	Use Kettle River values
Spokane River	monthly	USGS 12433000; LRFEP sta 4.0	JAN99 to APR00; JAN99 to JAN02	Historical monthly average values; adjusted in 2000 to match LRFEP data.
Sanpoil River	--	none	--	Use mainstem Columbia River values
Banks Lake return flow	monthly	USGS 12436500	JAN99 to SEP04	Linear interpolation between data points

Ammonium

Ammonium is an important nutrient. For each boundary, the data frequency, data source, period of record, and method used to generate daily values is shown in Table 15.

Table 15. Ammonium boundary condition generation summary.

Boundary	**Data frequency**	**Data source**	**Data period**	**Method**
Mainstem Columbia River	monthly	LRFEP sta 0.0	JAN99 to JAN02	Linear interpolation between data points
Kettle River	monthly	USGS 12404900	JAN99 to SEP04	Linear interpolation between data points
Colville River	--	none	--	Use Kettle River values
Spokane River	monthly	USGS 12433000	JAN99 to SEP03	Linear interpolation between data points
Sanpoil River	--	none	--	Use mainstem Columbia River values
Banks Lake return flow	monthly	USGS 12436500	JAN99 to SEP04	Linear interpolation between data points

Nitrate plus nitrite

Nitrate plus nitrate, or NOx, is an important nutrient. For each boundary, the data frequency, data source, period of record, and method used to generate daily values is shown in Table 16.

Table 16. Nitrate plus nitrite boundary condition generation summary.

Boundary	**Data frequency**	**Data source**	**Data period**	**Method**
Mainstem Columbia River	monthly	LRFEP sta 0.0	JAN99 to JAN02	Linear interpolation between data points
Kettle River	monthly	USGS 12404900	JAN99 to SEP04	Linear interpolation between data points
Colville River	--	none	--	Use Kettle River values
Spokane River	monthly	USGS 12433000	JAN99 to SEP03	Linear interpolation between data points
Sanpoil River	--	none	--	Use mainstem Columbia River values
Banks Lake return flow	monthly	USGS 12436500	JAN99 to SEP04	Linear interpolation between data points

Chlorophyll-a (algae)

Algae data are available in-stream. Data include biovolume, organism density, speciation, and chlorophyll-a concentrations. The chlorophyll-a data are collected at three relative depths in the water column: lower, middle, and upper.

The values are numerically averaged to provide an single concentration for each sampling date and location. Linear interpolation is used to generate a chlorophyll-a concentration for each simulation day. The values are then converted from chlorophyll-a to algal dry weight using a stoichiometric ratio [ACHLA] of 100.

For each boundary, the data frequency, data source, period of record, and method used to generate daily values is shown in Table 17.

Table 17. Chlorophyll-a (algae) boundary condition generation summary.

Boundary	Data frequency	Data source	Data period	Method
Mainstem Columbia River	monthly	LRFEP sta 0.0	JAN99 to JAN02	Linear interpolation between data points
Kettle River	--	none	--	Use mainstem Columbia River values
Colville River	--	none	--	Not used
Spokane River	monthly	LRFEP sta 4.0	JAN99 to JAN02	Linear interpolation between data points
Sanpoil River	monthly	LRFEP sta 8.0	JAN99 to JAN02	Linear interpolation between data points
Banks Lake return flow	--	none	--	Not used

The algal biomass is partitioned among the 3 algal functional groups (diatoms, mixed greens, and cyanobacteria) using the system wide ratio of the data at all sites. Fractions were generated for days of available data (roughly monthly) and linearly interpolated between to generate daily fractions. Figure 74 shows the interpolated values (lines) and the monthly values (icons). The daily fractions were applied at each boundary condition.

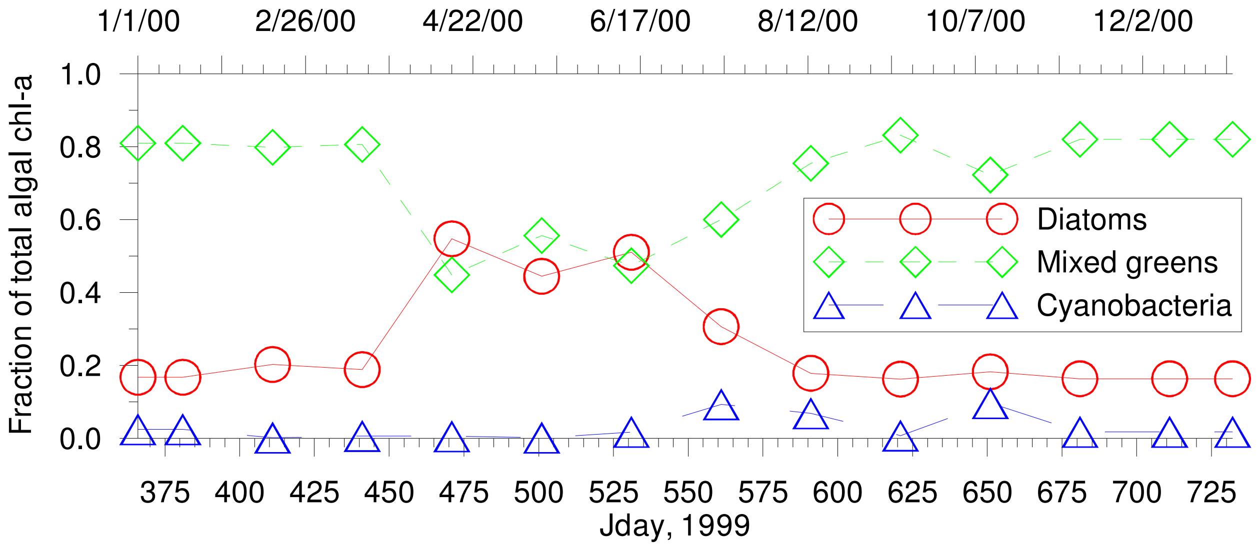

Figure 74. System wide daily fraction of total algal chl-a.

pH

pH is an important boundary condition used to model the carbonate chemistry. For each boundary, the data frequency, data source, period of record, and method used to generate daily values is shown in Table 18. pH is not directly input into the model, but is used to build the total inorganic carbon (TIC) input.

Table 18. pH boundary condition generation summary.

Boundary	**Data frequency**	**Data source**	**Data period**	**Method**
Mainstem Columbia River	monthly	USGS 12400520	JAN99 to SEP03	Linear interpolation between data points
Kettle River	monthly	USGS 12404900	JAN99 to SEP02	Linear interpolation between data points
Colville River	monthly	USGS 12409000	OCT94 to SEP95; OCT99 to SEP00	Not used
Spokane River	monthly	USGS 12433000	JAN99 to SEP03	Linear interpolation between data points
Sanpoil River	--	none	--	Not used
Banks Lake return flow	monthly	USGS 12436500	JAN99 to SEP04	Linear interpolation between data points

Total dissolved solids

Total dissolved solids data are not available at the model boundaries; however, in stream data are collected by the LRFEP. An arithmetic average (as opposed to a volume weighted average) of the TDS and conductivity data at the most upstream station (sta 0.0) yielded the relationship,

$$\text{TDS (mg/L)} = 0.64 \cdot \text{Conductivity } (\mu\text{S/cm})$$

This ratio is consistent with other lacustrine systems and is used to estimate TDS from the conductivity data. Figure 75 is a plot of the linear regression.

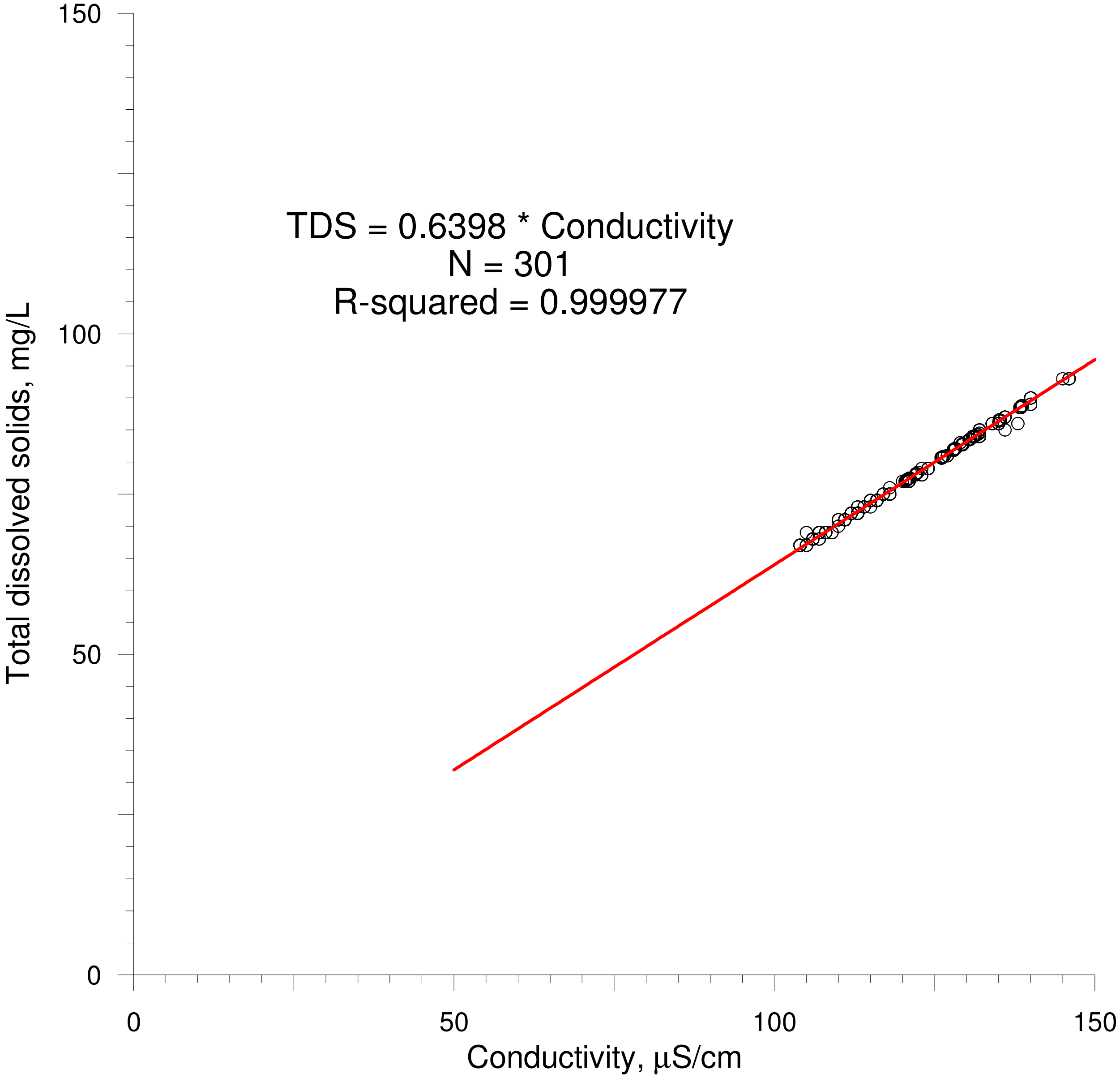

Figure 75. TDS:Conductivity ratio at LRFEP station 0.0, 1999 to 2002.

Total inorganic carbon and total organic matter

Total inorganic carbon

From carbonate chemistry, total inorganic carbon is a function of alkalinity, pH, and temperature.

Dissolved organic carbon

Dissolved organic carbon data are ultimately used to generate the constituents ISS, LDOM, RDOM, LPOM, RPOM. DOC data are only collected at the Environment Canada stations. For each boundary, the data frequency, data source, period of record, and method used to generate daily values is shown in Table 19.

Table 19. Dissolved organic carbon boundary condition generation summary.

Boundary	**Data frequency**	**Data source**	**Data period**	**Method**
Mainstem Columbia River	*	*	*	Daily flow weighted average value from Columbia R. and Pend Oreille R. values.
Columbia prior to confluence	biweekly	BC08NE0001	JAN99 to DEC04	Linear interpolation between data points
Pend Oreille prior to confluence	biweekly	BC08NE0029	JAN99 to DEC04	Linear interpolation between data points
Kettle River	biweekly	BC08NN0021	JAN99 to DEC04	Linear interpolation between data points
Colville River	--	none	--	Use mainstem Columbia River values
Spokane River	--	none	--	Use mainstem Columbia River values
Sanpoil River	--	none	--	Use mainstem Columbia River values
Banks Lake return flow	--	none	--	Use mainstem Columbia River values

Total organic carbon

Total organic carbon is used to calculate TOM. However, only dissolved organic carbon data are available, so a DOC:POC ratio of 8:1 is assumed. TOC is then equal to 1.125*DOC.

Total organic matter

Total organic matter is calculated from TOC using a carbon-biomass ratio, $\delta_C = 0.65$ and the relationship, TOM = TOC/δ_c – algae.

Total suspended solids

Total suspended solids are not directly model input. TSS data are used to calculate the inorganic suspended solids. For each boundary, the data frequency, data source, period of record, and method used to generate daily values is shown in Table 20.

Table 20. Total suspended solids boundary condition generation summary.

Boundary	**Data frequency**	**Data source**	**Data period**	**Method**
Mainstem Columbia River	monthly	USGS 12400520	JAN99 to SEP03	Linear interpolation between data points
Kettle River	monthly	USGS 12404900	JAN99 to SEP04	Linear interpolation between data points
Colville River	--	none	--	Use mainstem Columbia River values
Spokane River	--	none	--	Use mainstem Columbia River values
Sanpoil River	--	none	--	Use mainstem Columbia River values
Banks Lake return flow	monthly	USGS 12436500	JAN99 to SEP04	Linear interpolation between data points

Total inorganic suspended solids (ISS)

Inorganic suspended solids are calculated from the relationship,

$$\text{ISS (mg/L)} = \text{TSS (mg/L)} - \text{POM (mg/L)} - \text{algae(mg/L-dry weight)}$$

A minimum value of 0.1 mg/L was used.

Dissolved organic matter

Dissolved organic matter is calculated from DOC using the relationship, DOM = DOC/ δ_c. The DOM constituent is subdivided into a labile and refractory compartment using $f_{LDOM} = 0.5$ such that,

$$LDOM = f_{LDOM} * DOM$$

and

$$RDOM = (1 - f_{LDOM}) * DOM$$

Particulate organic matter

Particulate organic matter is calculated by,

$$POM = TOM – DOM$$

The POM constituent is subdivided into a labile and refractory compartment using $f_{LPOM} = 0.5$ such that,

$$LPOM = f_{LDOM} * DOM$$

and

$$RPOM = (1 - f_{LDOM}) * DOM$$

Zooplankton

Zooplankton data were collected at 17, 33, and 66 m tow depths. The tows were organized into the functional groups of cladocera and copepoda. The cladocera group was formed by adding the biomass on days with both Daphnia and "other cladocera" data available. The copepoda group was divided into herbivorous and omnivorous sub-groups. The omnivorous group was assumed to be 10% of the copepoda biomass.

For each boundary, the data frequency, data source, period of record, and method used to generate daily values is shown in Table 21.

Table 21. Zooplankton boundary condition generation summary.

Boundary	**Data frequency**	**Data source**	**Data period**	**Method**
Mainstem Columbia River	monthly	LRFEP sta 0.0	JAN99 to JAN02	Linear interpolation between data points
Kettle River	--	none	--	Use mainstem Columbia River values
Colville River	--	none	--	Not used
Spokane River	monthly	LRFEP sta 4.0	JAN99 to JAN02	Linear interpolation between data points
Sanpoil River	monthly	LRFEP sta 8.0	JAN99 to JAN02	Linear interpolation between data points
Banks Lake return flow	--	none	--	Not used

Data and Daily Boundary Condition Model Input Comparison

Mainstem Columbia River

The mainstem Columbia River has 2 stations near the upstream boundary containing dissolved oxygen and nutrient data. The stations showed general agreement. While the USGS gage #12400520 is closer to the boundary, the LRFEP sta 0.0 data were used (echoed) to better match the downstream in-stream data.

For constituents with flow weighting of the Pend Oreille River and Columbia River data, the model inputs should fall between the two values.

The Columbia River water quality boundary condition inputs and the data used to build them (when applicable) are shown in Figure 76 through Figure 89.

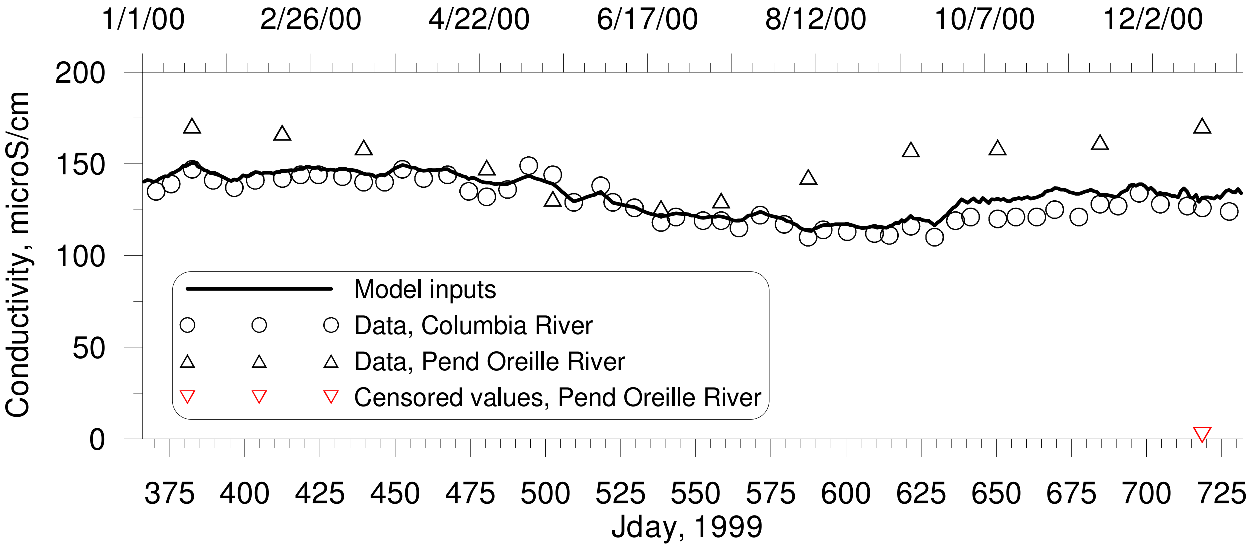

Figure 76. Mainstem Columbia River conductivity boundary condition, 2000.

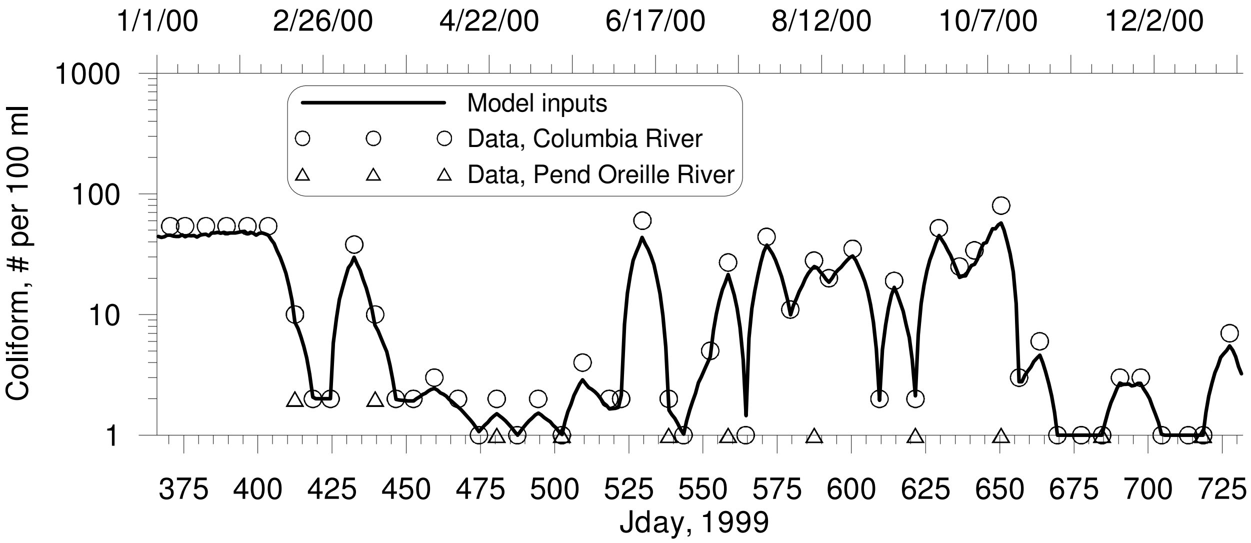

Figure 77. Mainstem Columbia River coliform boundary condition, 2000.

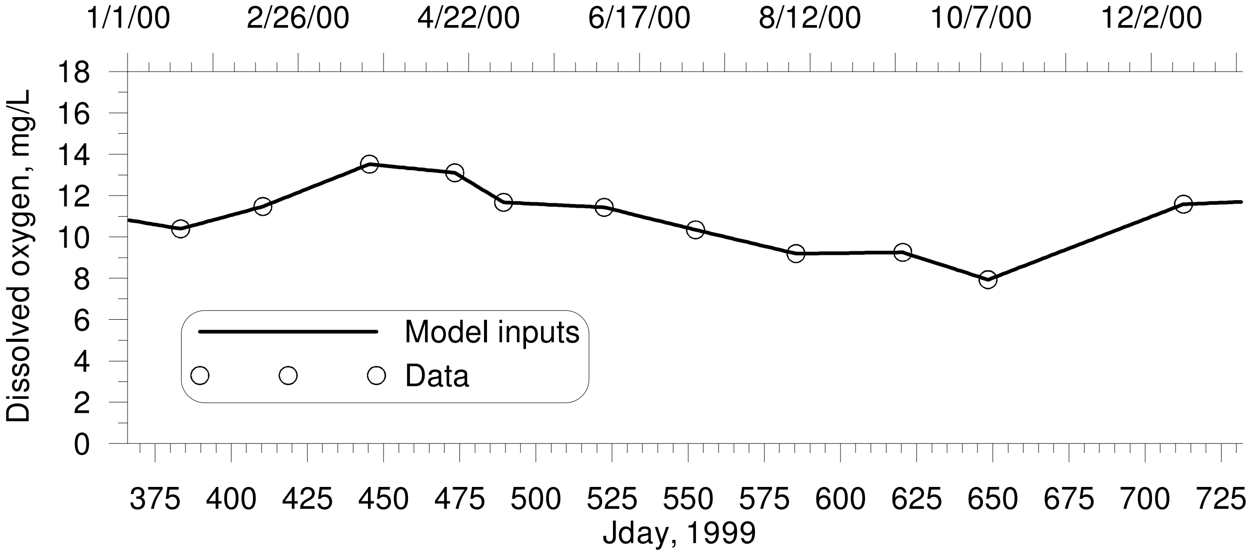

Figure 78. Mainstem Columbia River dissolved oxygen boundary condition, 2000.

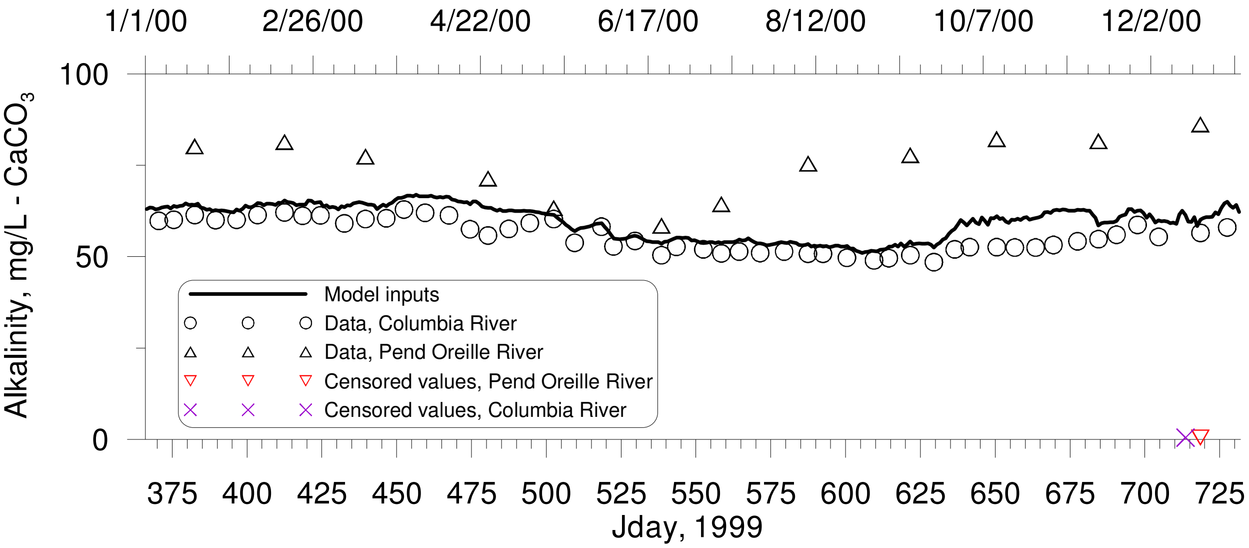

Figure 79. Mainstem Columbia River alkalinity boundary condition, 2000.

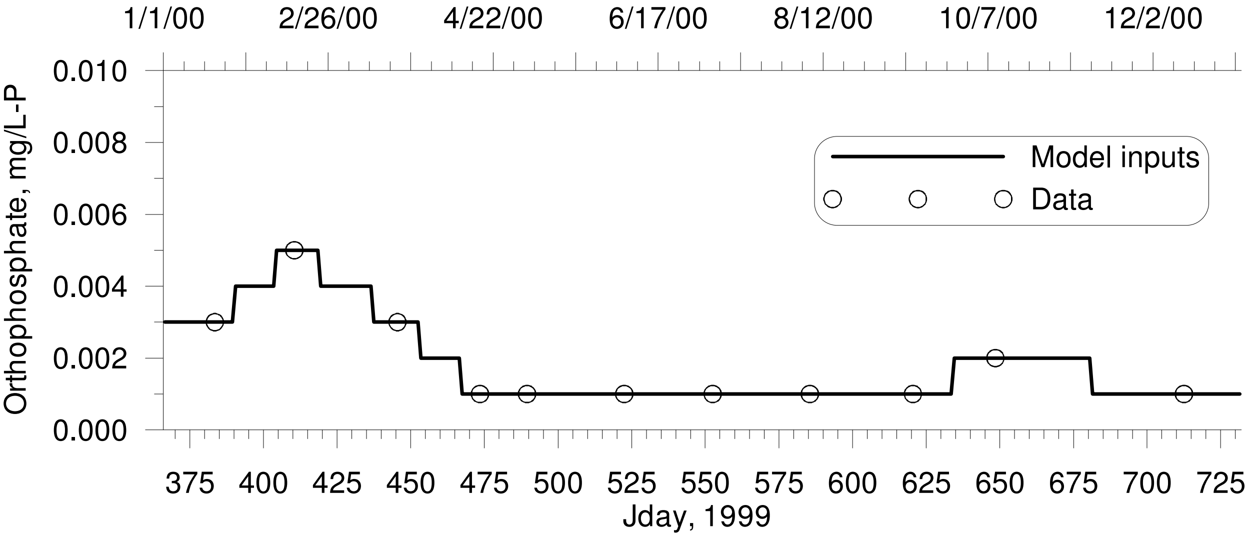

Figure 80. Mainstem Columbia River orthophosphate boundary condition, 2000.

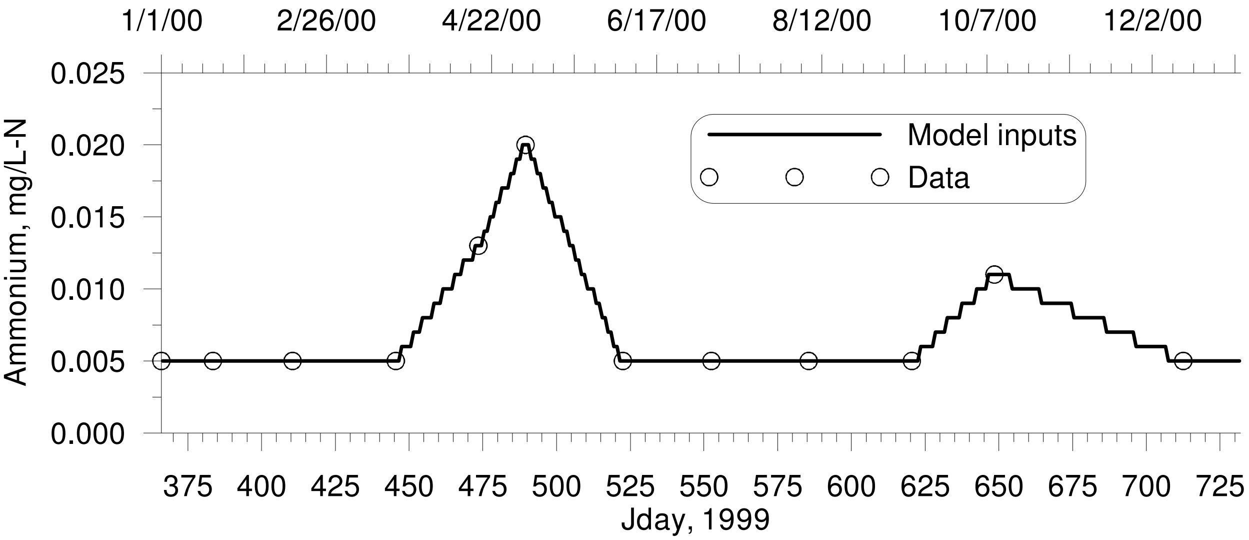

Figure 81. Mainstem Columbia River ammonium boundary condition, 2000.

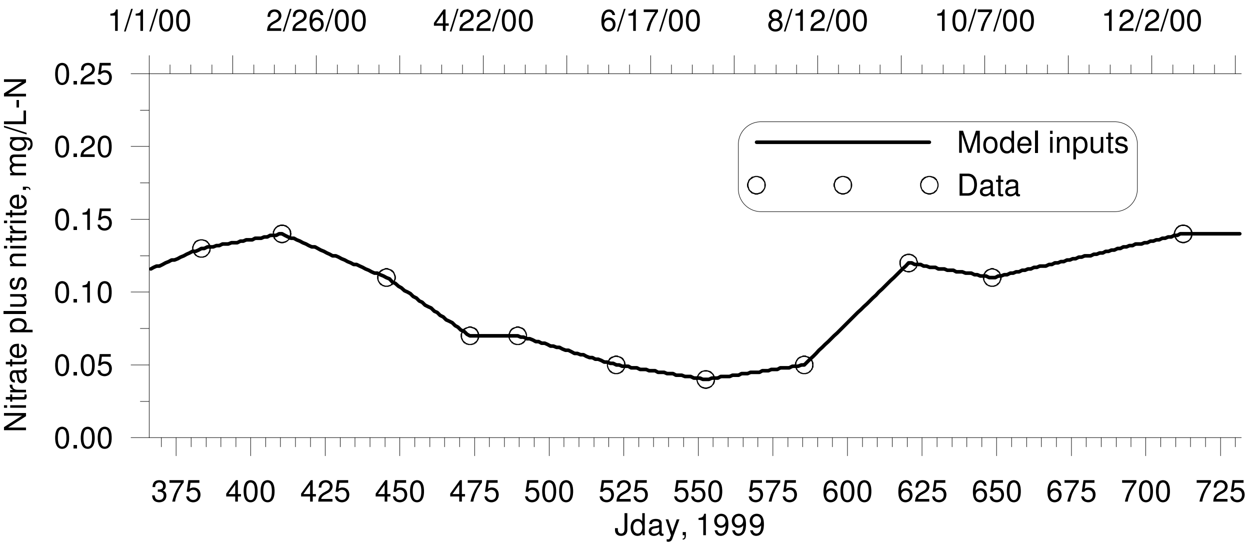

Figure 82. Mainstem Columbia River nitrate plus nitrite boundary condition, 2000.

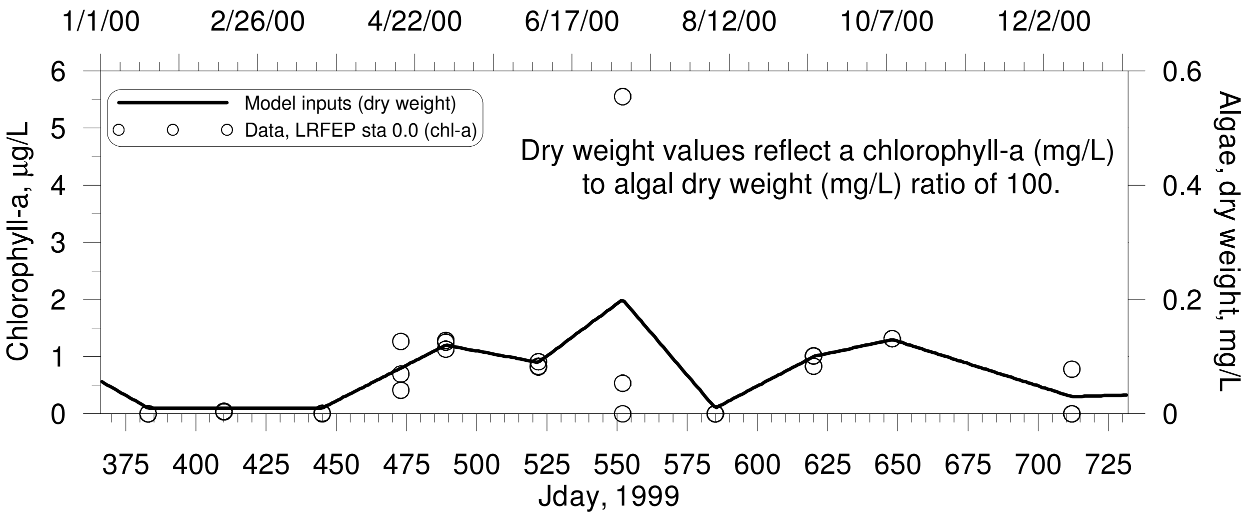

Figure 83. Mainstem Columbia River algal dry weight boundary condition, 2000.

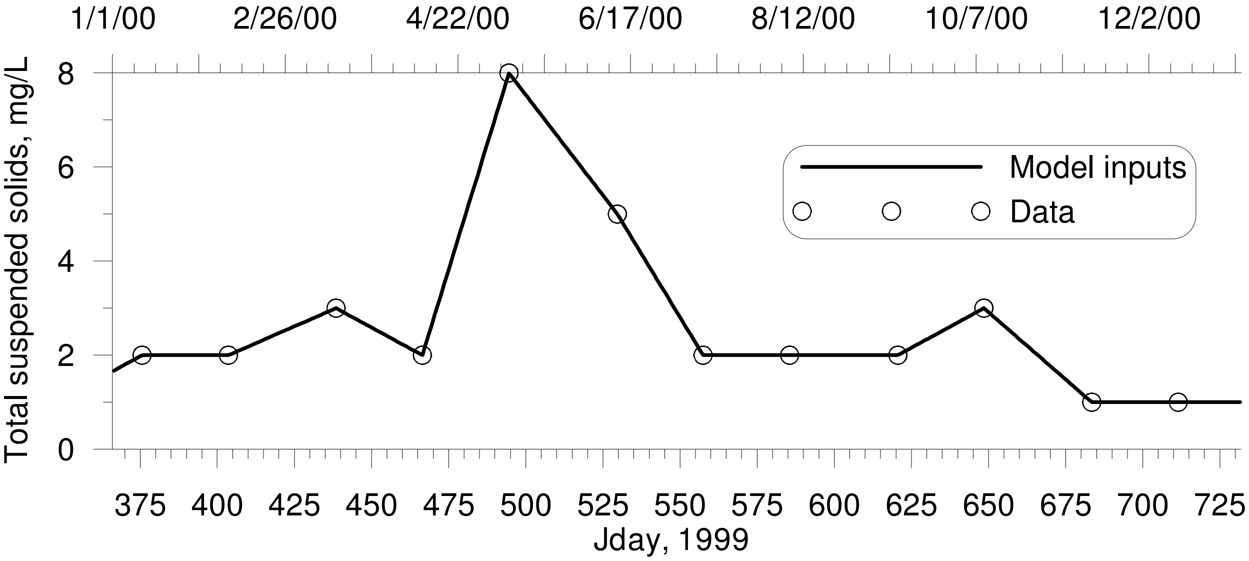

Figure 84. Mainstem Columbia River total suspended solids boundary condition, 2000.

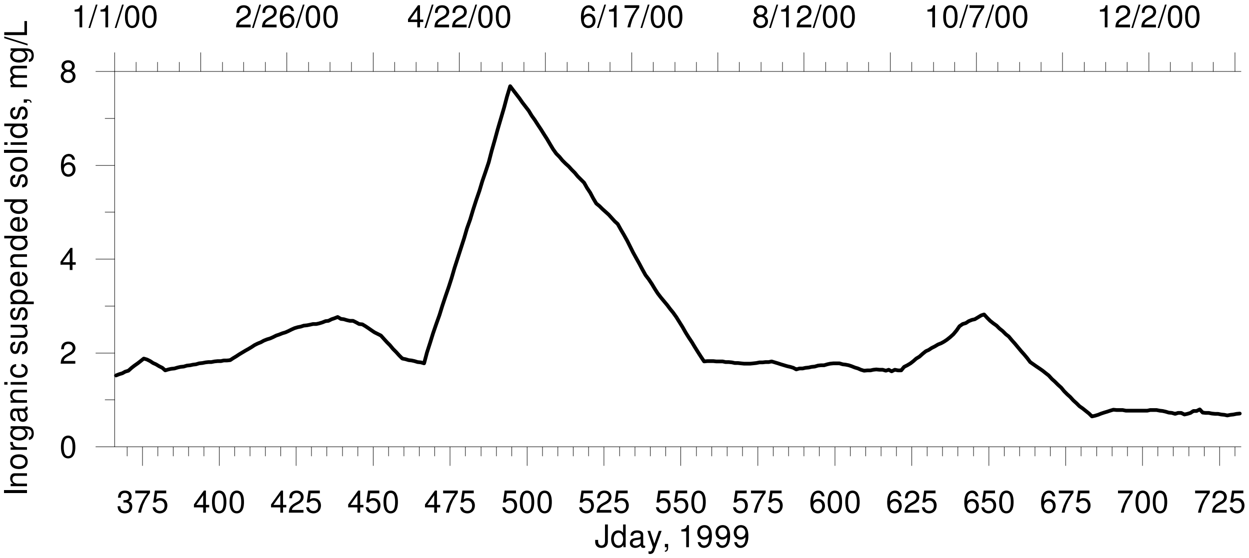

Figure 85. Mainstem Columbia River inorganic suspended solids boundary condition, 2000.

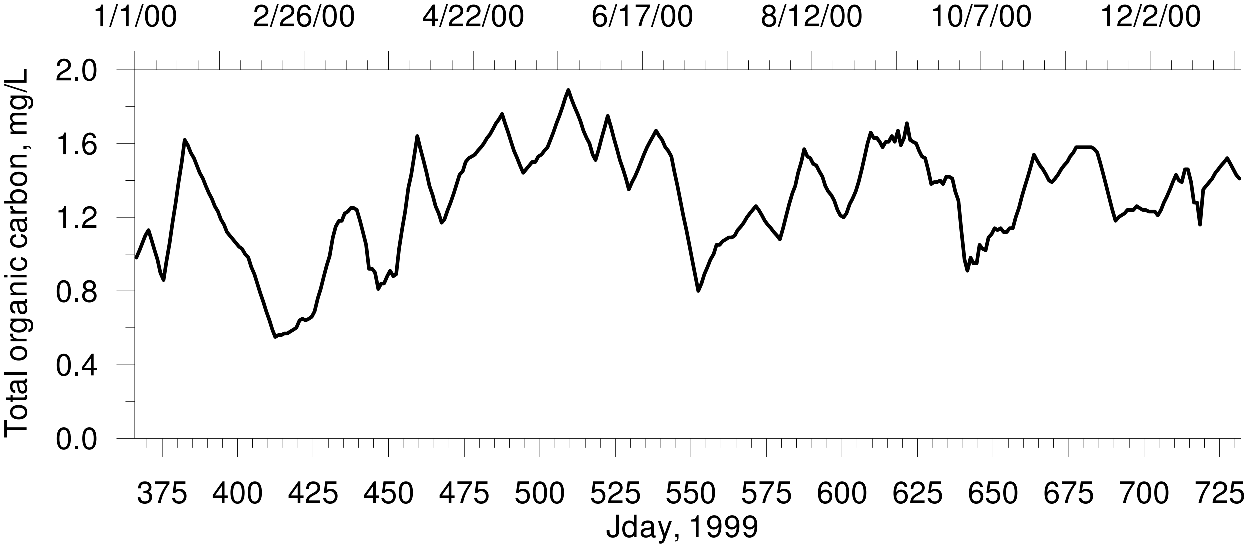

Figure 86. Mainstem Columbia River total organic carbon boundary condition, 2000.

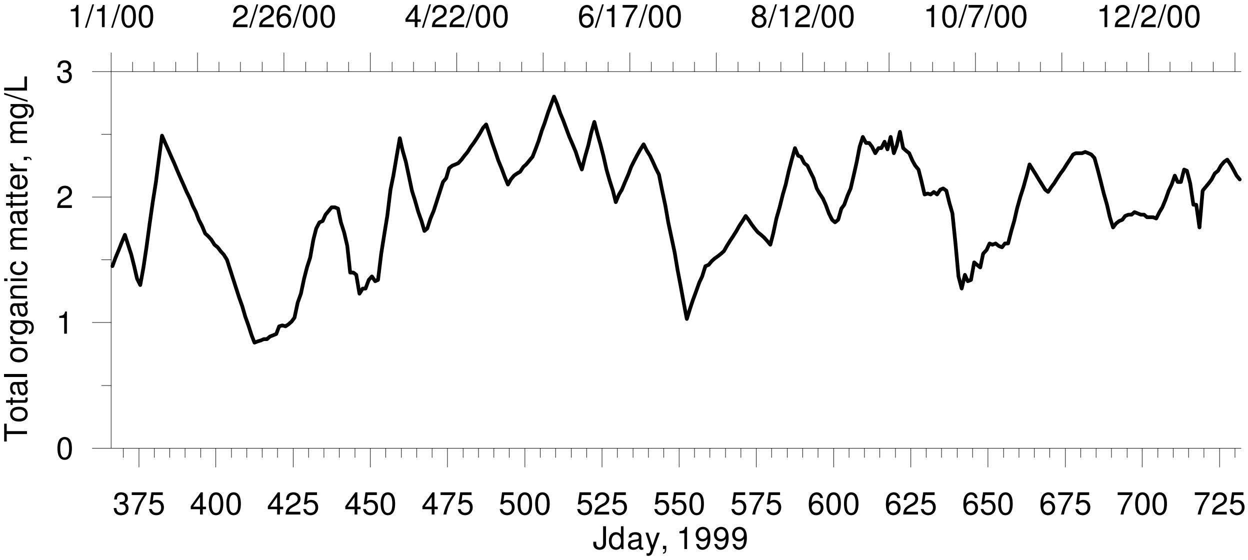

Figure 87. Mainstem Columbia River total organic matter boundary condition, 2000.

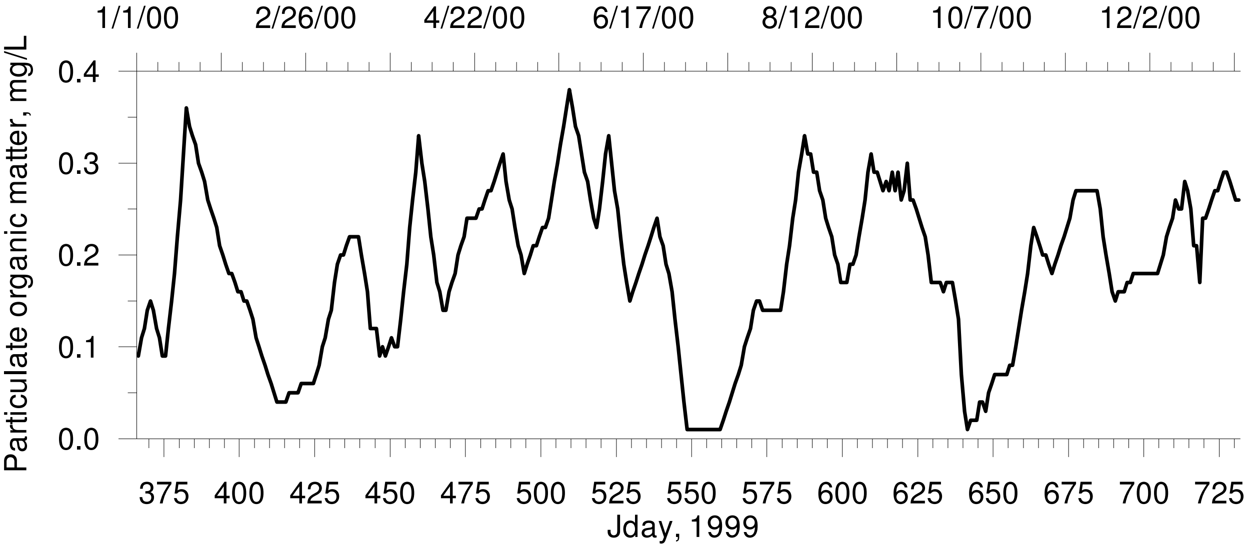

Figure 88. Mainstem Columbia River particulate organic matter boundary condition, 2000.

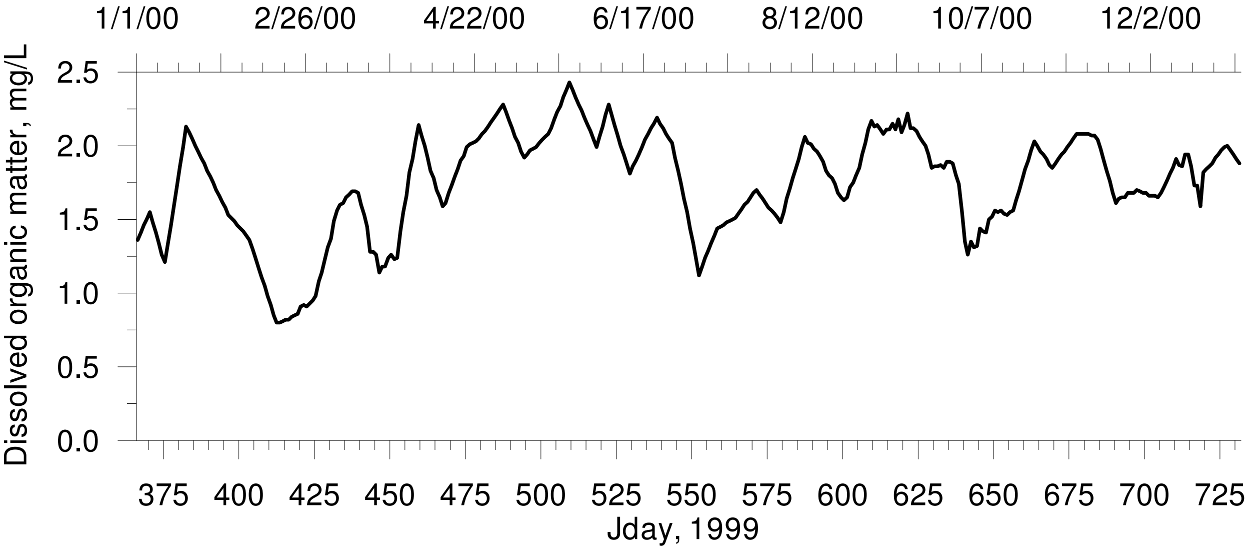

Figure 89. Mainstem Columbia River dissolved organic matter boundary condition, 2000.

Kettle River

The Kettle River water quality boundary condition inputs and the data used to build them (when applicable) are shown in Figure 90 through Figure 95. For constituents that used the Columbia River boundary condition, refer to the Columbia River section.

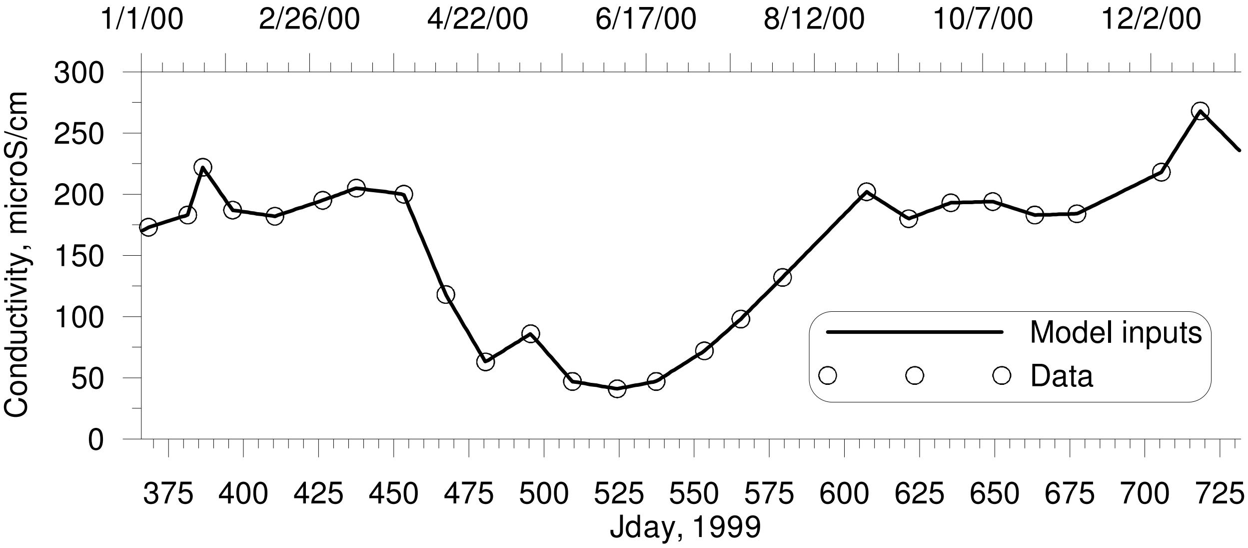

Figure 90. Kettle River conductivity boundary condition, 2000.

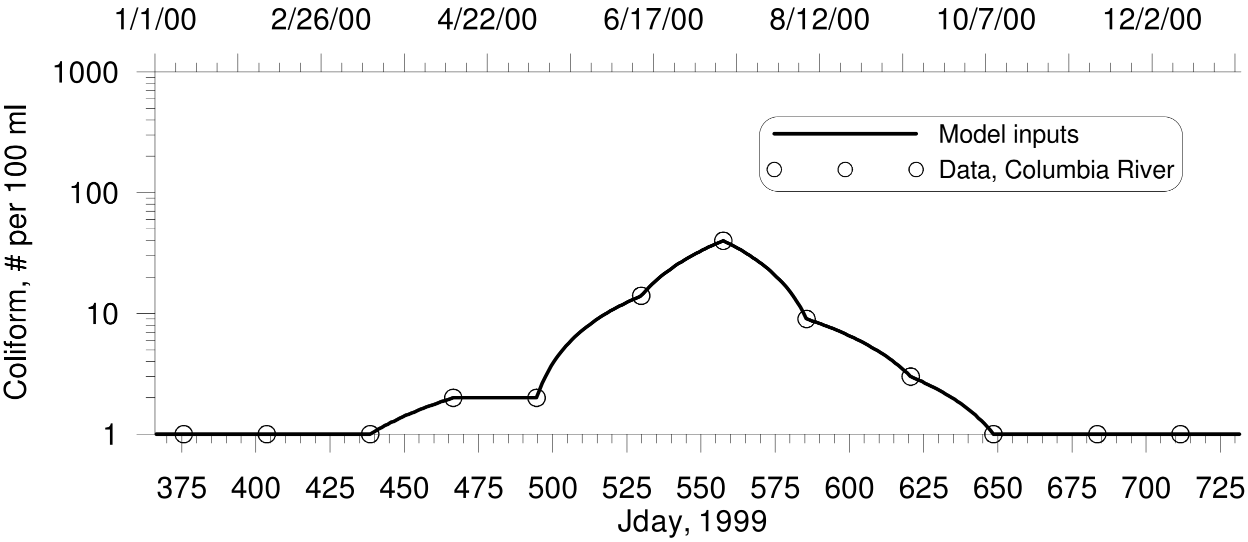

Figure 91. Kettle River coliform boundary condition, 2000.

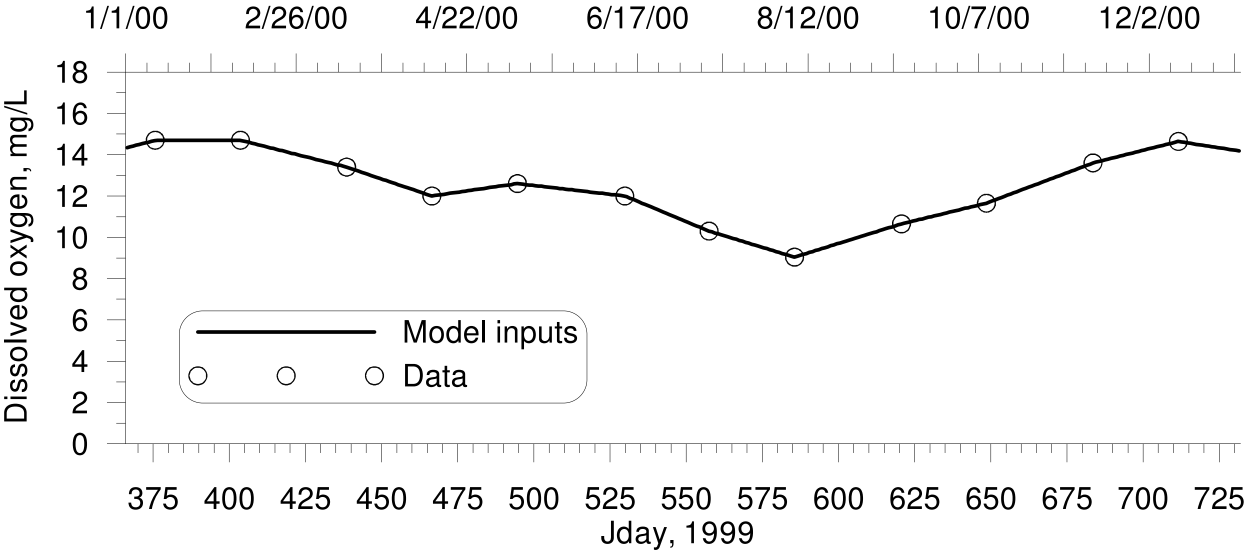

Figure 92. Kettle River dissolved oxygen boundary condition, 2000.

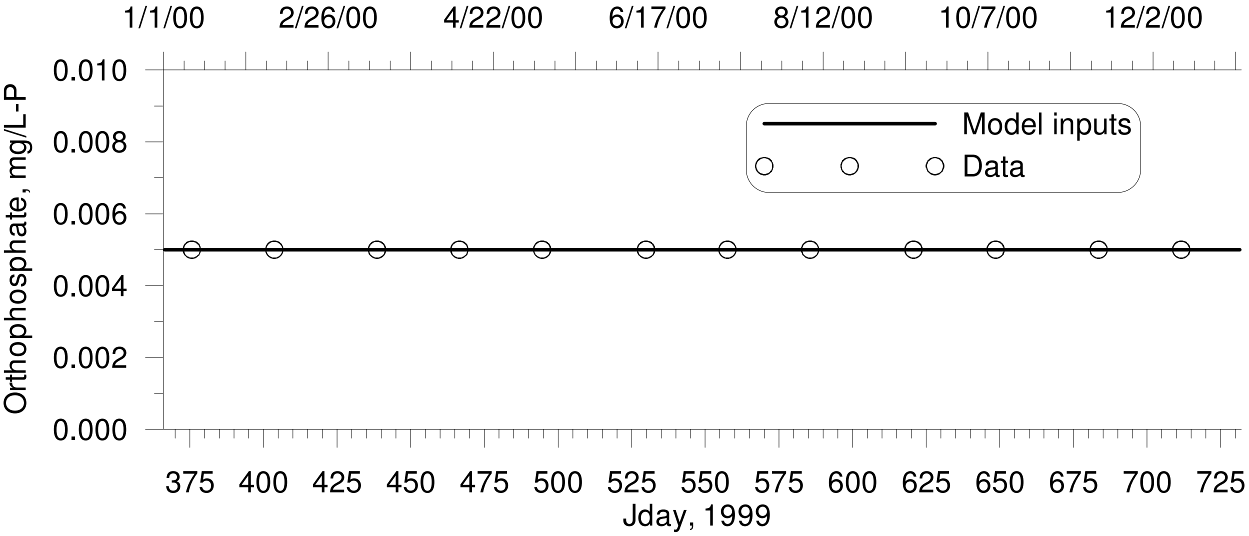

Figure 93. Kettle River orthophosphate boundary condition, 2000.

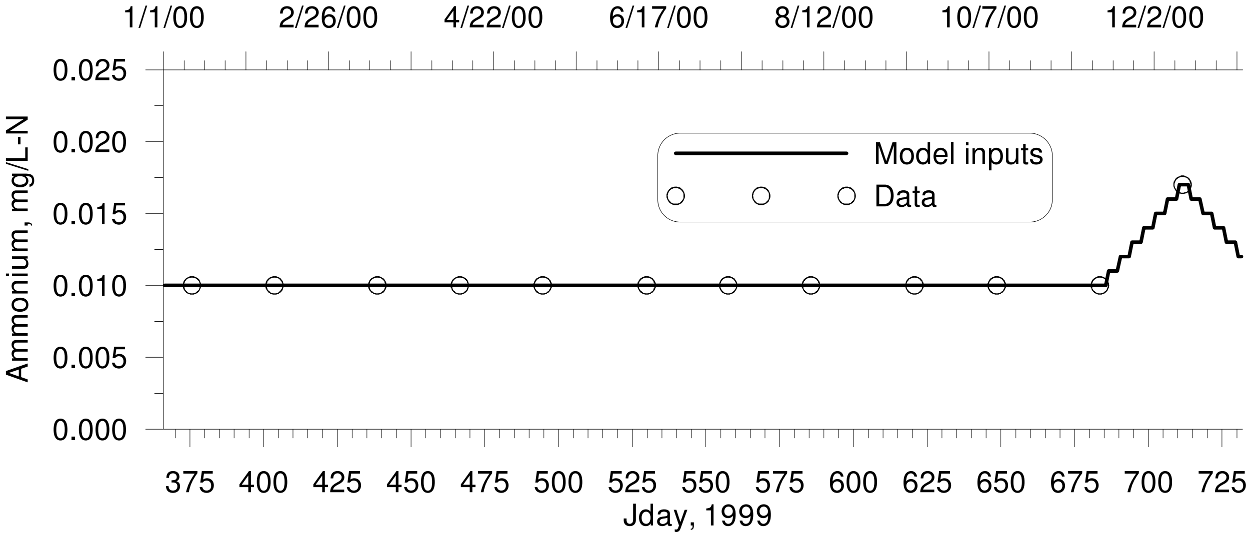

Figure 94. Kettle River ammonium boundary condition, 2000.

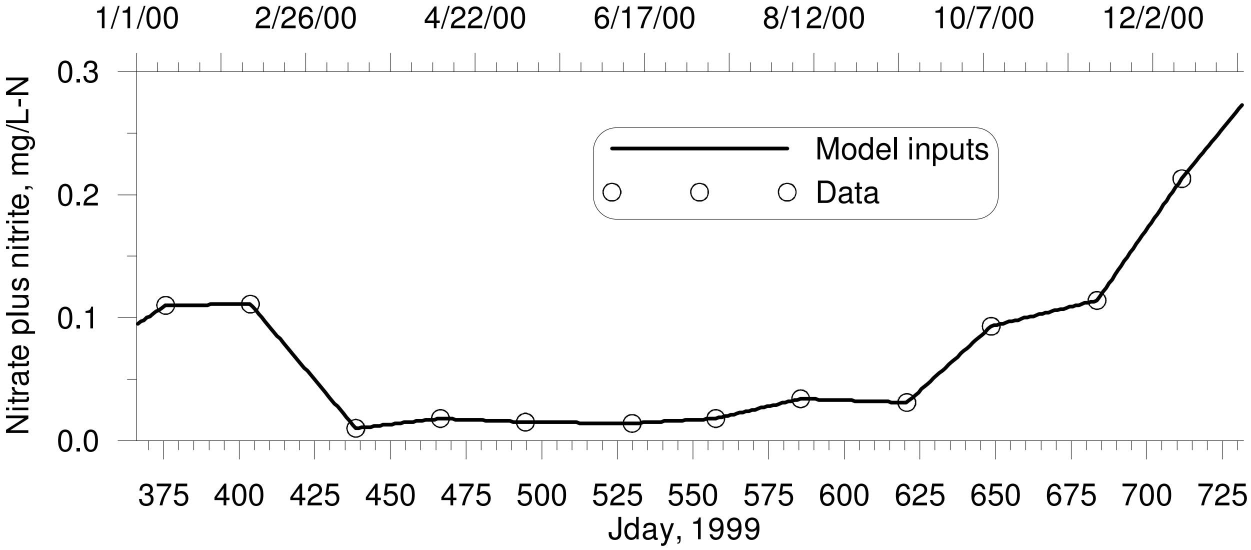

Figure 95. Kettle River nitrate plus nitrite boundary condition, 2000.

Colville River

The Colville River water quality boundary condition inputs and the data used to build them (when applicable) are shown in Figure 96 through Figure 99. For constituents that used the Columbia River boundary condition, refer to the Columbia River section.

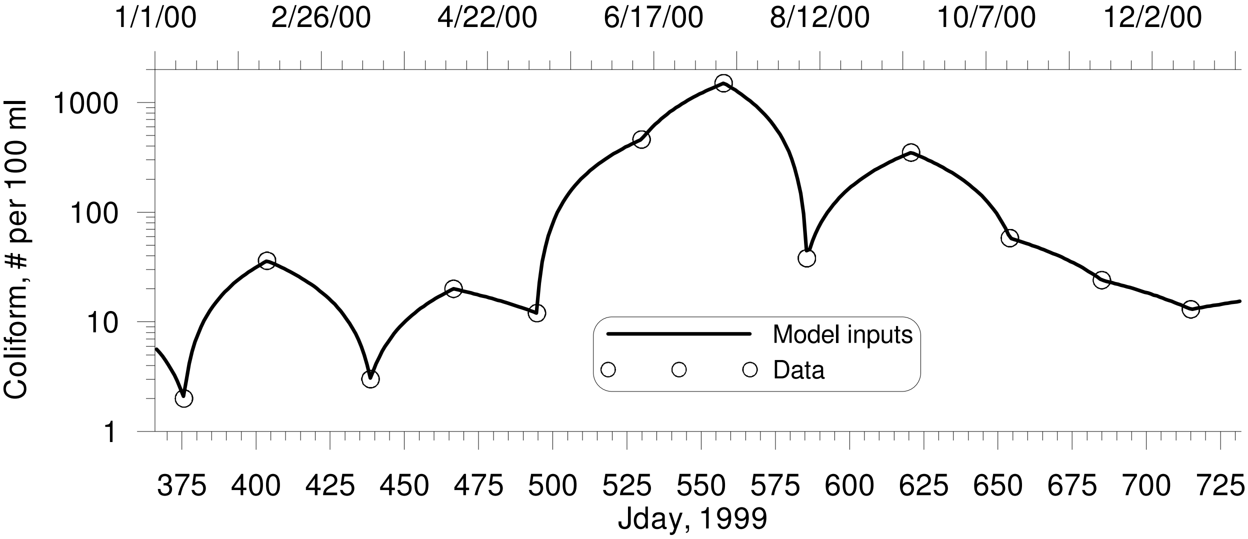

Figure 96. Colville River coliform boundary condition, 2000.

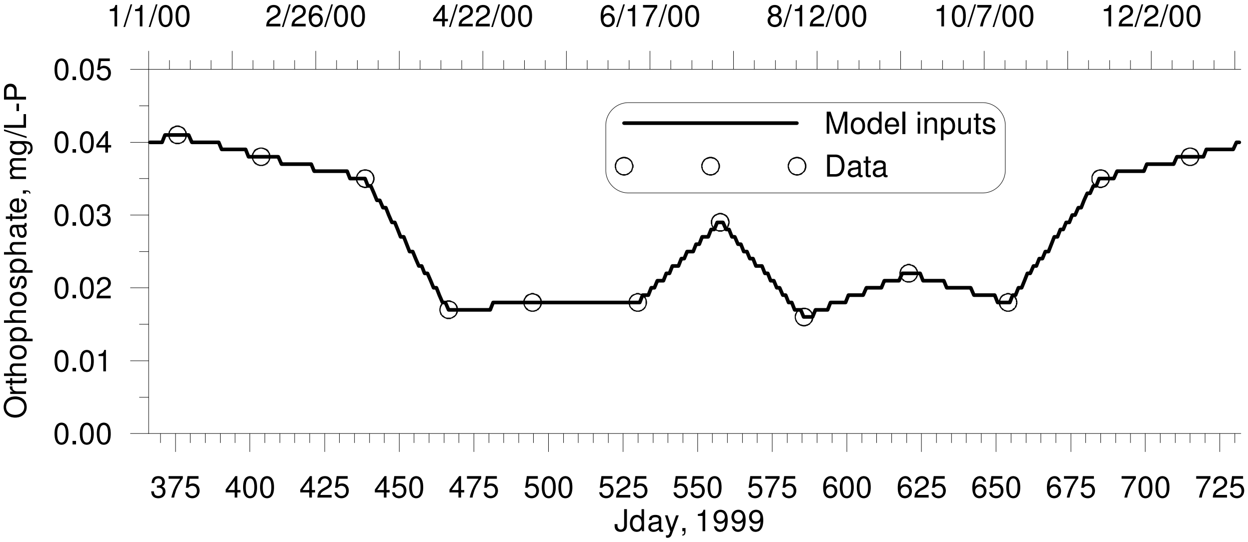

Figure 97. Colville River orthophosphate boundary condition, 2000.

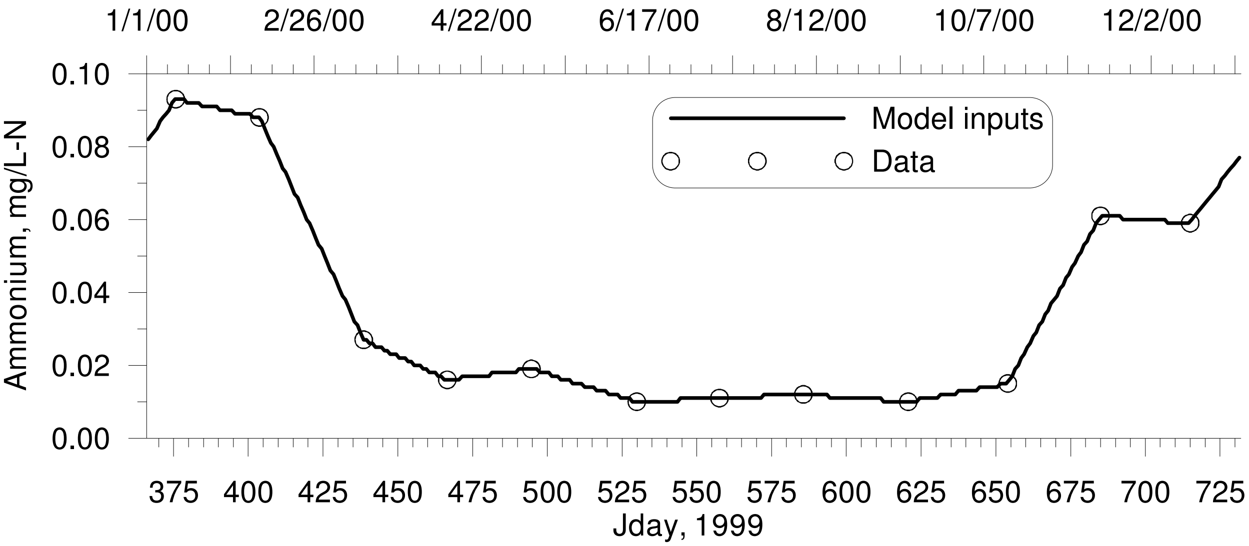

Figure 98. Colville River ammonium boundary condition, 2000.

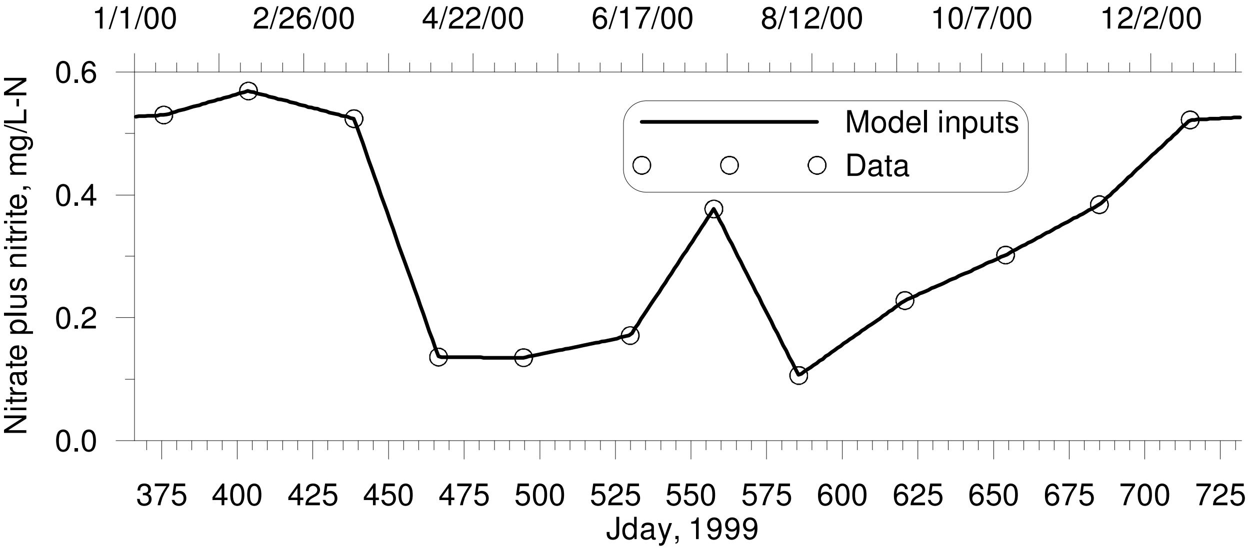

Figure 99. Colville River nitrate plus nitrite boundary condition, 2000.

Spokane River

The Spokane River water quality boundary condition inputs and the data used to build them (when applicable) are shown in Figure 100 through Figure 105. For constituents that used the Columbia River boundary condition, refer to the Columbia River section. The monthly averaged phosphorous inputs were adjusted in 2000 by adding actual data points from the LRFEP station 4.0 on J349, J383, and J411.

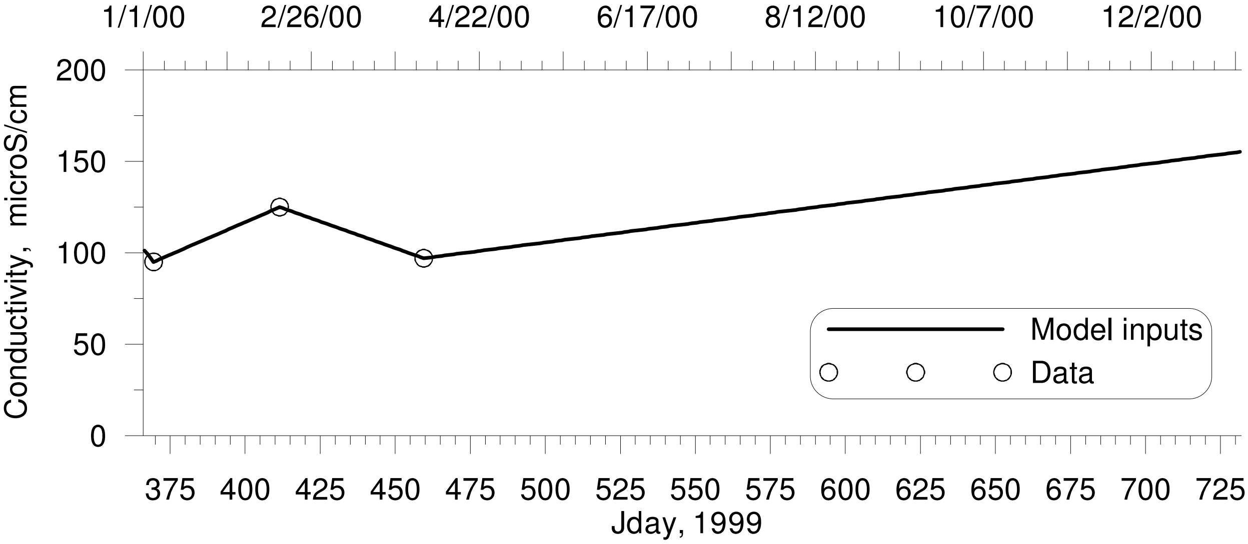

Figure 100. Spokane River conductivity boundary condition, 2000.

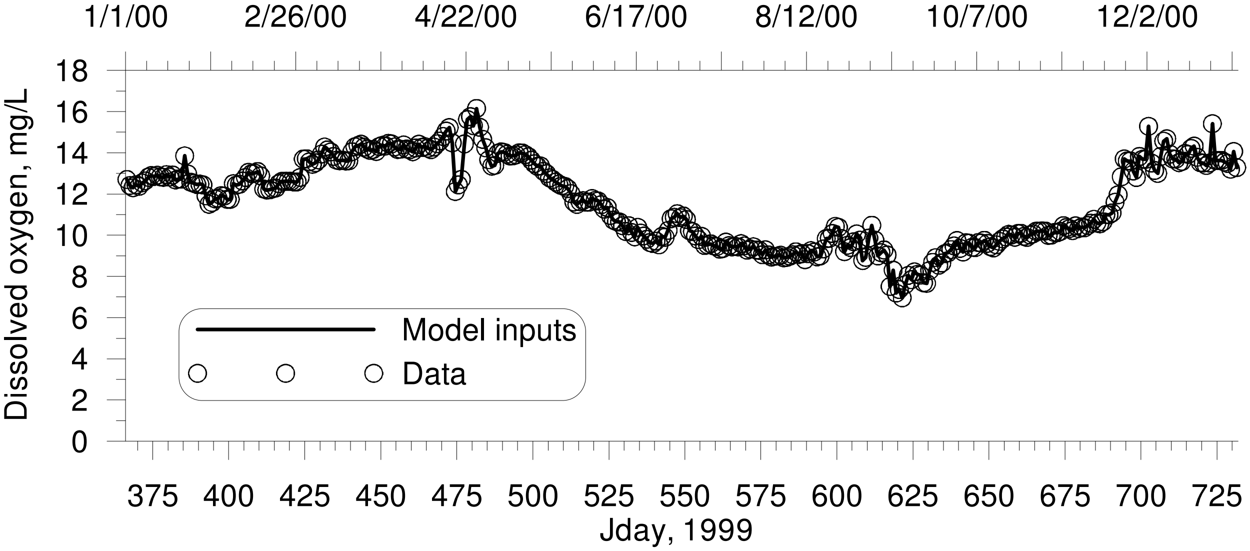

Figure 101. Spokane River dissolved oxygen boundary condition, 2000.

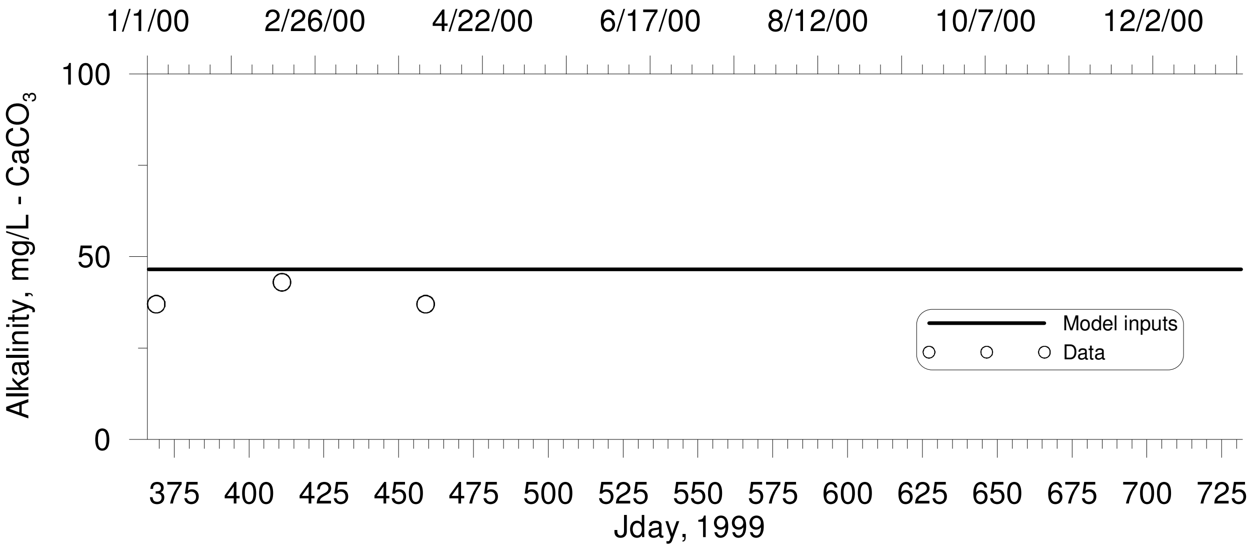

Figure 102. Spokane River alkalinity boundary condition, 2000.

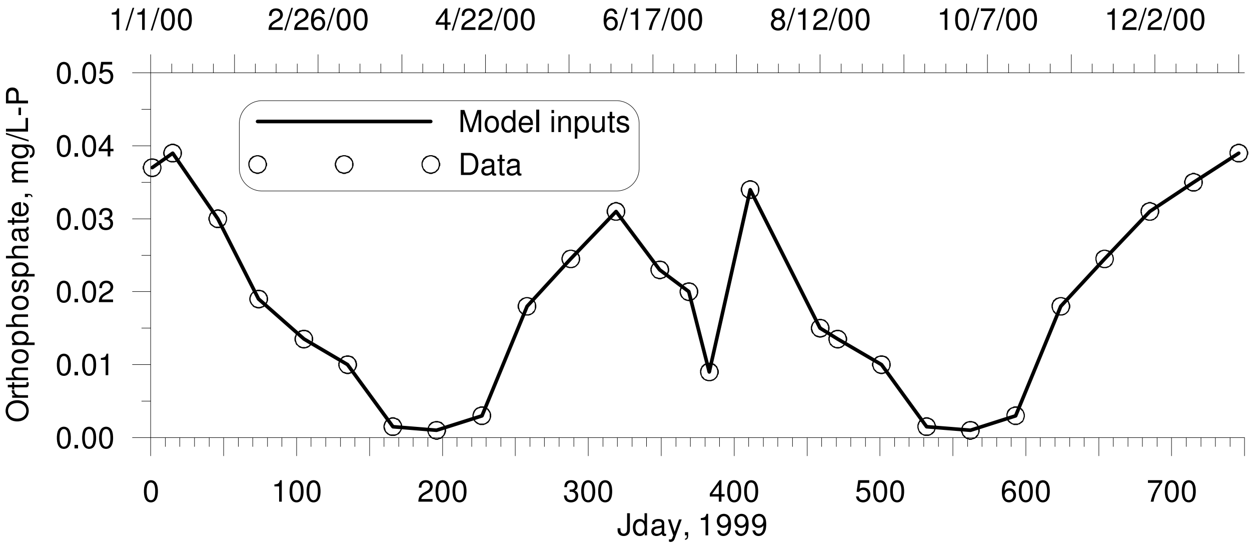

Figure 103. Spokane River orthophosphate boundary condition, 2000.

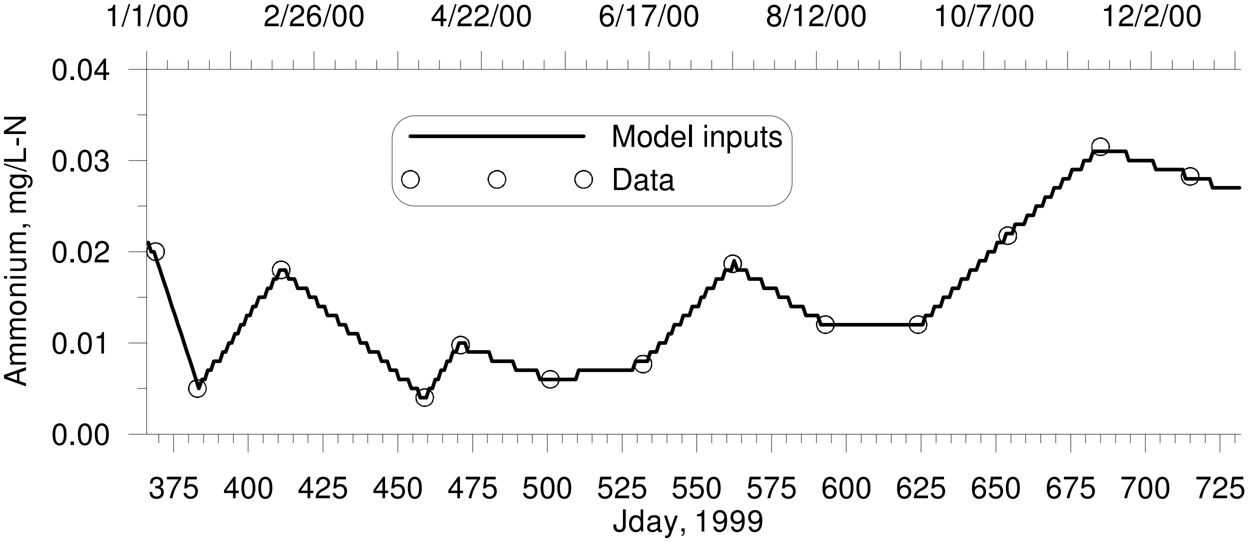

Figure 104. Spokane River ammonium boundary condition, 2000.

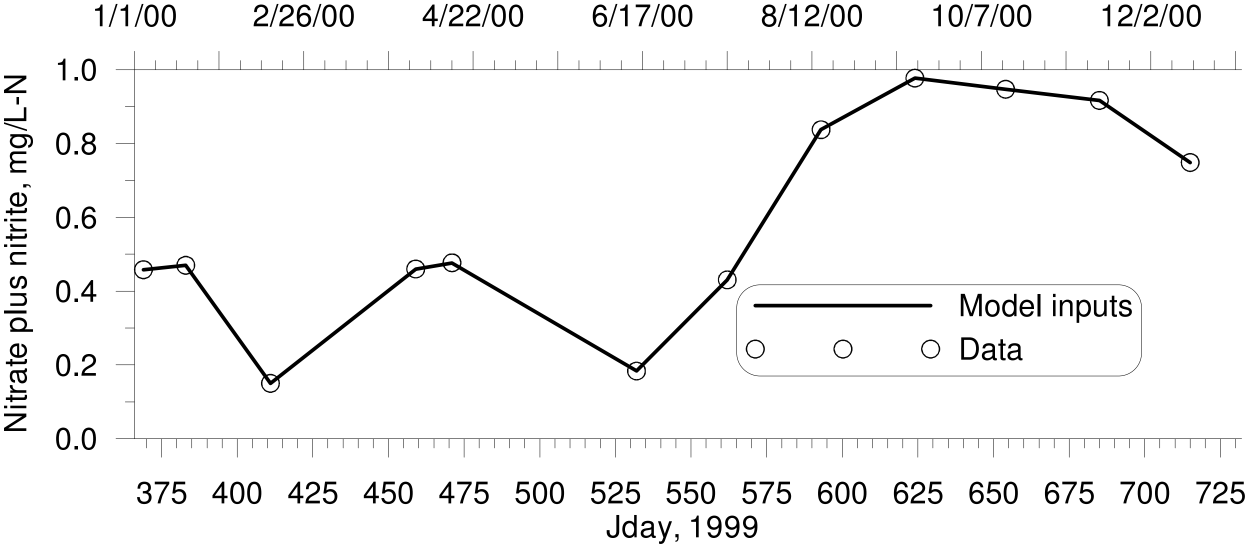

Figure 105. Spokane River nitrate plus nitrite boundary condition, 2000.

Sanpoil River

Dissolved oxygen is the only constituent available for the Sanpoil River. The water quality boundary condition input is shown as Figure 106. For constituents that used the Columbia River boundary condition, refer to the Columbia River section.

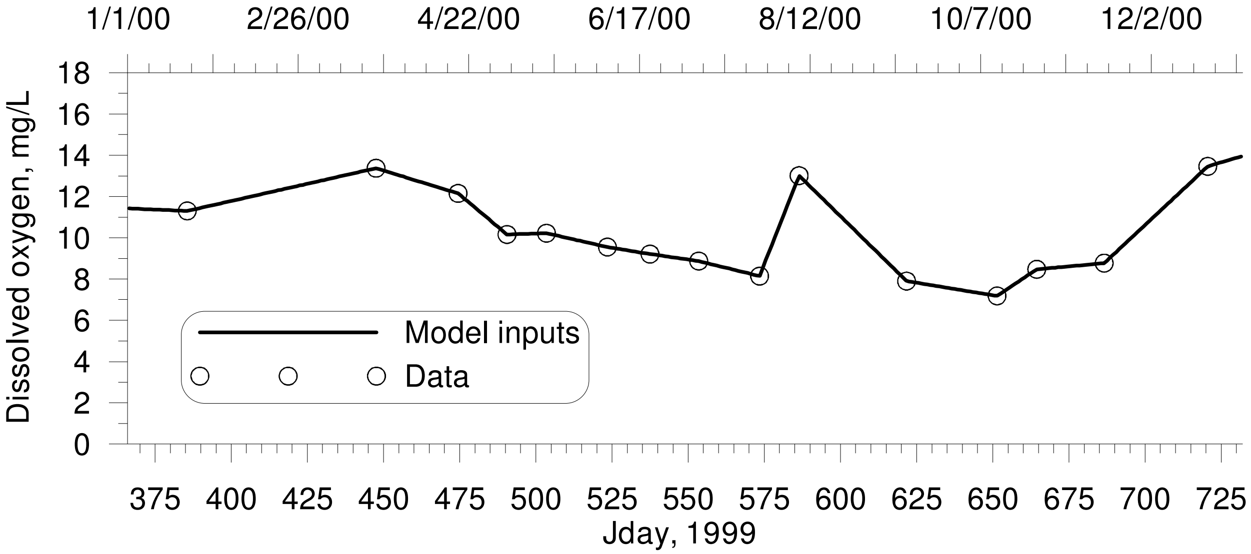

Figure 106. Sanpoil River dissolved oxygen boundary condition, 2000.

Banks Lake Return Flows

The Banks Lake return flow water quality boundary condition inputs and the data used to build them (when applicable) are shown in Figure 107 through Figure 112. For constituents that used the Columbia River boundary condition, refer to the Columbia River section. Note that the water quality constituent values only effect the model results during periods of inflow (marked with blue squares on the date axes). During periods of outflow (withdrawal), the boundary condition values are not used.

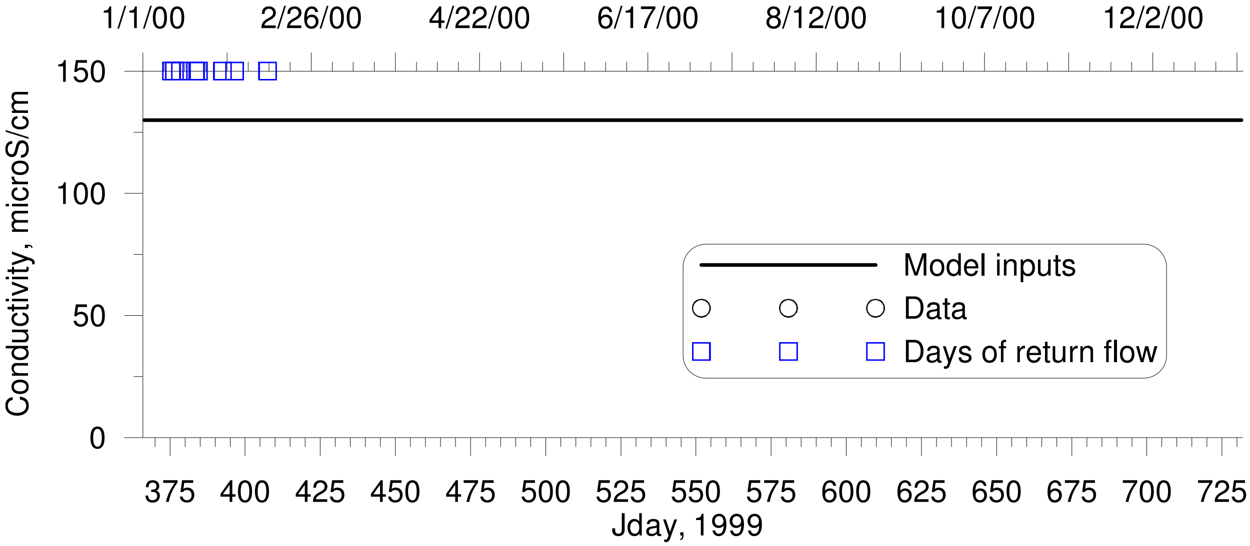

Figure 107. Banks Lake return flow conductivity boundary condition, 2000.

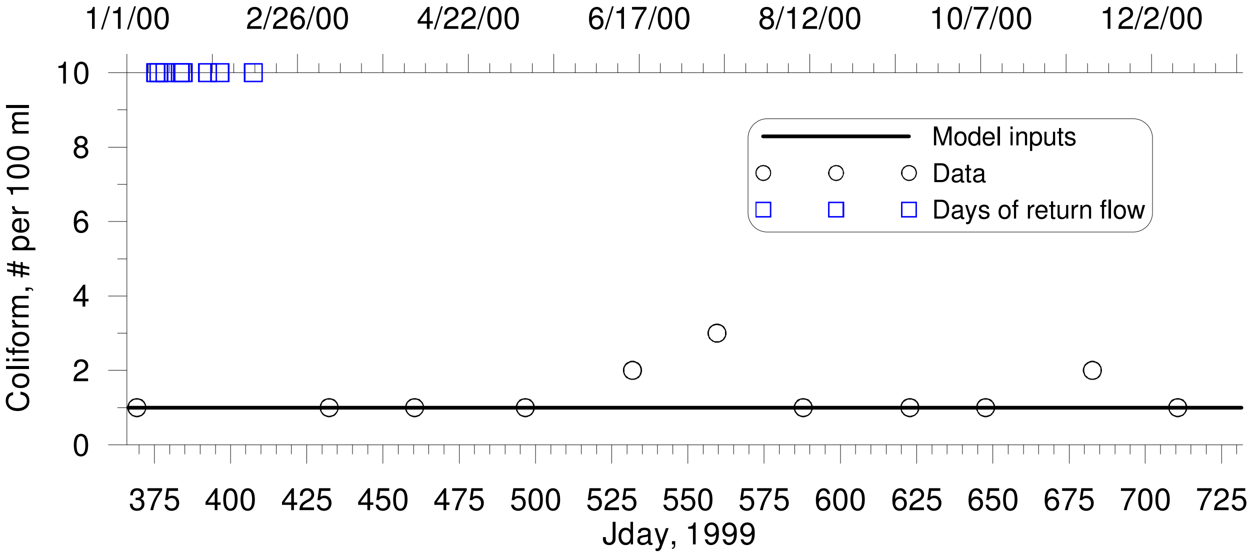

Figure 108. Banks Lake return flow coliform boundary condition, 2000.

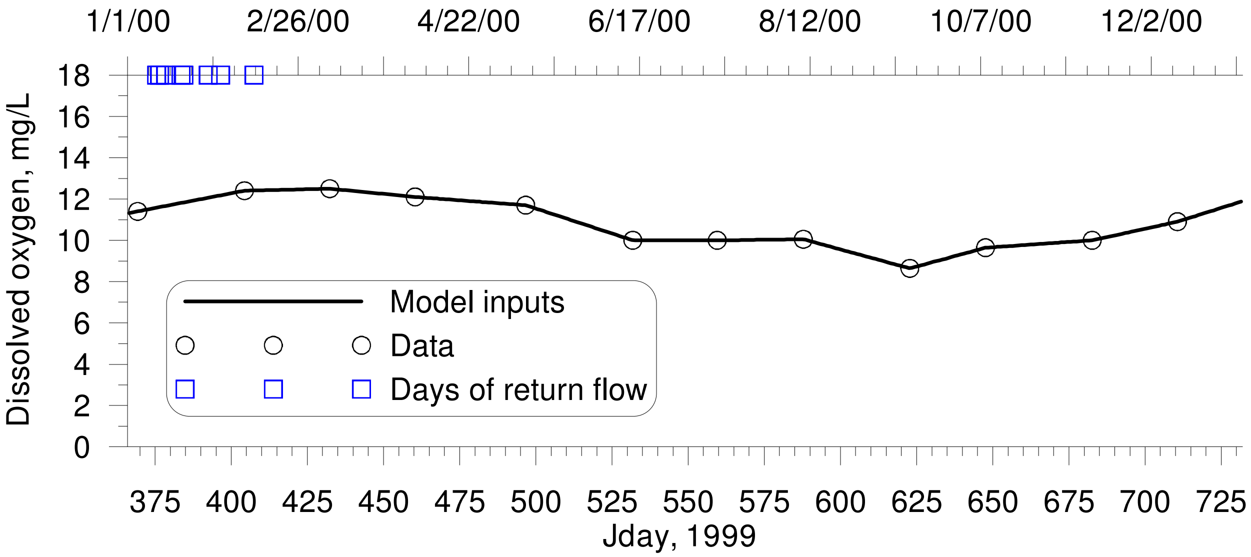

Figure 109. Banks Lake return flow dissolved oxygen boundary condition, 2000.

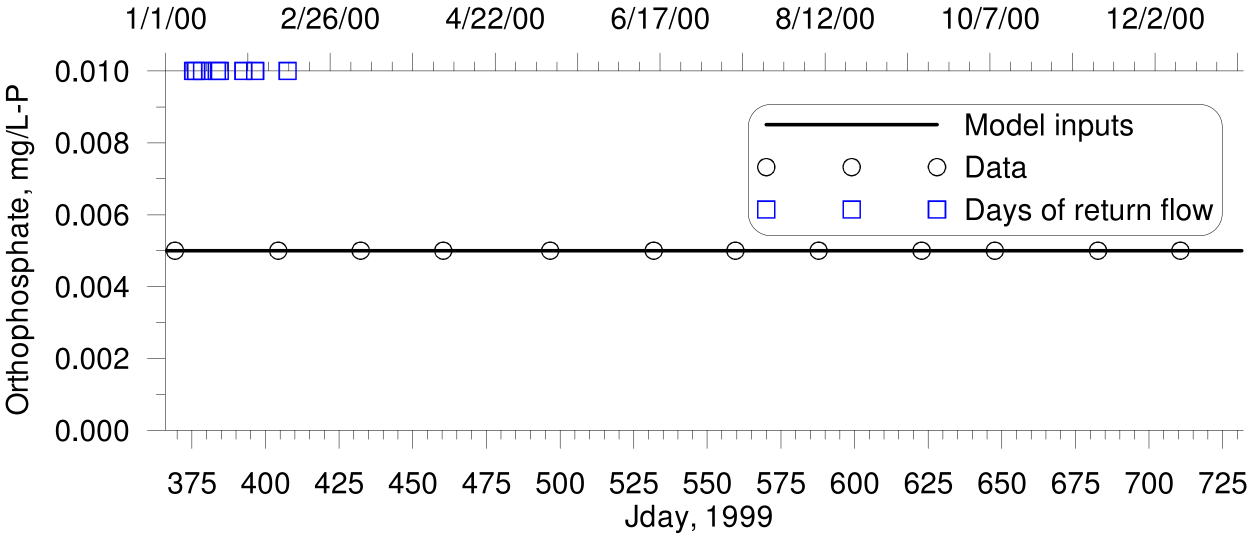

Figure 110. Banks Lake return flow orthophosphate boundary condition, 2000.

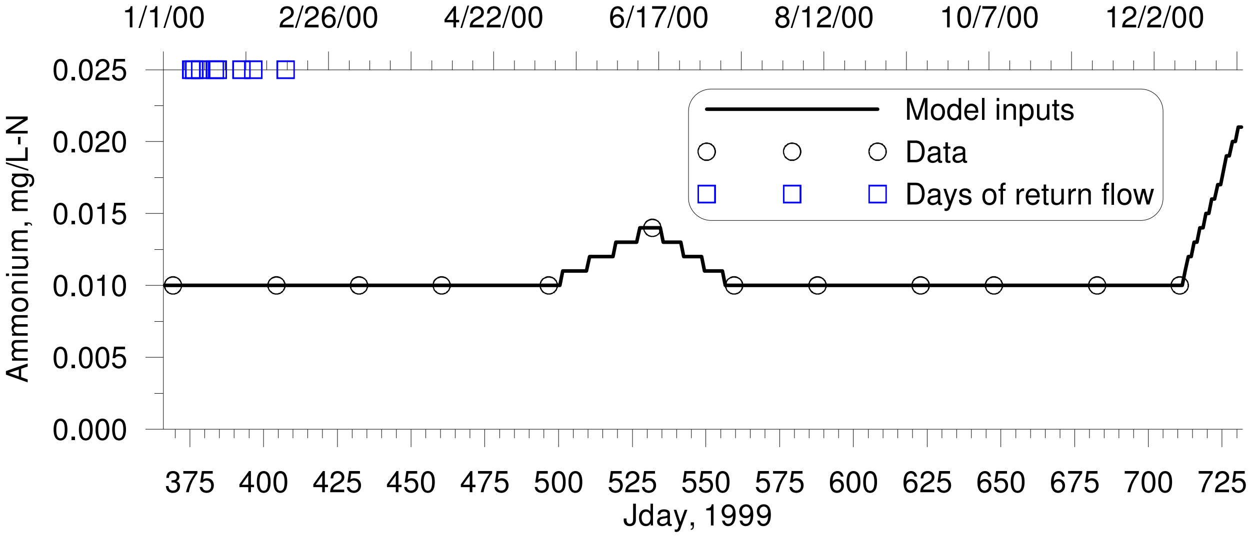

Figure 111. Banks Lake return flow ammonium boundary condition, 2000.

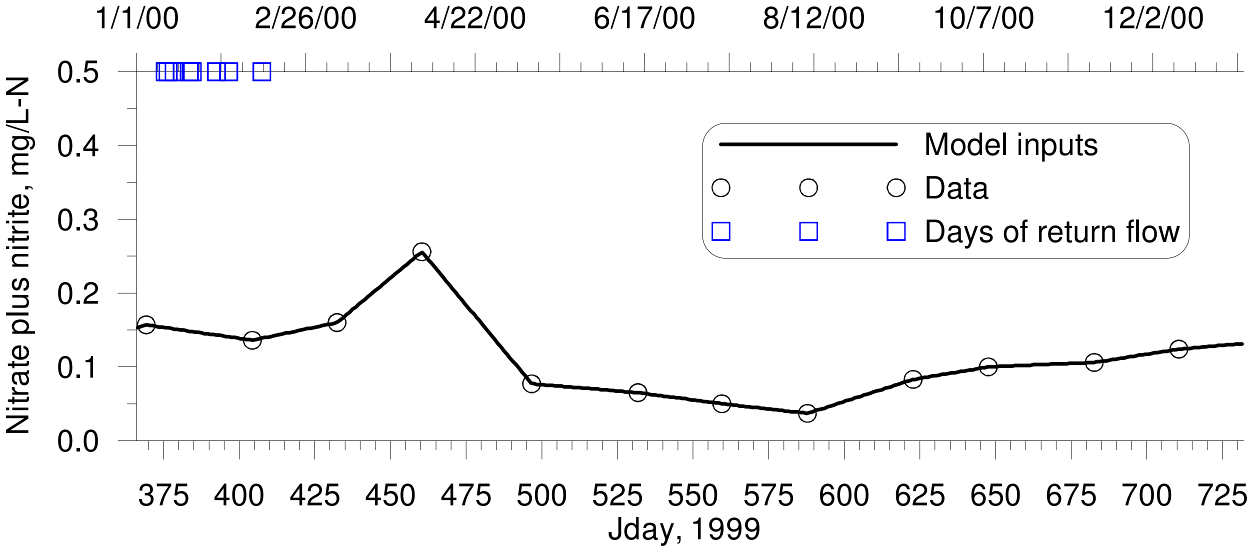

Figure 112. Banks Lake return flow nitrate plus nitrite boundary condition, 2000.

Appendix B: W2 control files

W2_con.npt

A sample W2_con.npt file is shown below. A summary of the water quality parameters is include as Appendix H.

```
  W2 Model Version 3.5

TITLE C ...............................TITLE....................................
        Version 3.5 Lake Roosevelt Model
        Riverine reaches of Columbia and Spokane Rivers broken into several WBs
        for KT thickness control
        Jday 1.0 is Jan 1, 1999

        Run 123

        Tom Cole, WES; Scott Wells, PSU; Rob Annear, PSU; Chris Berger, PSU


GRID         NWB     NBR     IMX     KMX
              25      25     583      76

IN/OUTFL     NTR     NST     NIW     NWD     NGT     NSP     NPI     NPU
               1       4       0       1       0       1       0       0

CONSTITU     NGC     NSS     NAL     NEP    NBOD     NMC     NZP
               3       1       3       1       1       0       3

MISCELL     NDAY
             100

TIME CON  TMSTRT   TMEND    YEAR
         366.000 731.000    1999

DLT CON      NDT  DLTMIN
               8 0.10000

DLT DATE    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD
         366.000 366.050 366.100   455.0   490.0   530.0   550.0   702.0

DLT MAX   DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX
         5.00000  10.000 45.0000   30.00   30.00   15.00   60.00   30.00

DLT FRN     DLTF    DLTF    DLTF    DLTF    DLTF    DLTF    DLTF    DLTF    DLTF
         0.90000 0.90000 0.90000 0.90000 0.90000 0.90000 0.90000 0.90000 0.90000

DLT LIMI    VISC    CELC
WB 1          ON      ON
WB 2          ON      ON
WB 3          ON      ON
WB 4          ON      ON
WB 5          ON      ON
WB 6          ON      ON
WB 7          ON      ON
WB 8          ON      ON
WB 9          ON      ON
WB 10         ON      ON
WB 11         ON      ON
WB 12         ON      ON
WB 13         ON      ON
WB 14         ON      ON
WB 15         ON      ON
WB 16         ON      ON
WB 17         ON      ON
WB 18         ON      ON
WB 19         ON      ON
WB 20         ON      ON
```

```
WB 21         ON      ON
WB 22         ON      ON
WB 23         ON      ON
WB 24         ON      ON
WB 25         ON      ON

BRANCH G      US      DS     UHS     DHS     UQB     DQB   NLMIN   SLOPE
BR1            2      19       0      22       0       0       1 0.00055  Mainstem
BR2           22      31      19      34       0       0       1 0.00000
BR3           34      43      31      46       0       0       1 0.00000
BR4           46      55      43      58       0       0       1 0.00000
BR5           58      67      55      70       0       0       1 0.00000
BR6           70      79      67      82       0       0       1 0.00000
BR7           82      91      79      94       0       0       1 0.00000
BR8           94     103      91     106       0       0       1 0.00000
BR9          106     115     103     118       0       0       1 0.00000
BR10         118     127     115     130       0       0       1 0.00000
BR11         130     139     127     142       0       0       1 0.00000
BR12         142     192     139     195       0       0       1 0.00000  KFLW mainstem
BR13         195     273     192     276       0       0       1 0.00000  SBMW mainstem
BR14         276     317     273       0       0       0       1 0.00000  GCGW mainstem
BR15         320     334       0     144       0       0       1 0.00000  Kettle R
BR16         337     340       0     147       0       0       1 0.00000  Marcus Flats
BR17         343     346       0     154       0       0       1 0.00000  Colville R
BR18         349     360       0     363       0       0       1 0.00067  Spokane R
BR19         363     374     360     377       0       0       1 0.00067
BR20         377     388     374     391       0       0       1 0.00067
BR21         391     402     388     405       0       0       1 0.00067
BR22         405     416     402     419       0       0       1 0.00067
BR23         419     544     416     248       0       0       1 0.00000
BR24         547     554       0     255       0       0       1 0.00000  Hawk Cr
BR25         557     582       0     289       0       0       1 0.00000  Sanpoil R

LOCATION     LAT    LONG    EBOT      BS      BE    JBDN
WB 1     48.9667 117.659 261.000       1       1       1
WB 2     48.9367 117.735 261.000       2       2       2
WB 3     48.9163 117.786 261.000       3       3       3
WB 4     48.8854 117.833 261.000       4       4       4
WB 5     48.8609 117.885 261.000       5       5       5
WB 6     48.8292 117.926 261.000       6       6       6
WB 7     48.8132 117.976 261.000       7       7       7
WB 8     48.7869 118.010 261.000       8       8       8
WB 9     48.7541 118.047 261.000       9       9       9
WB 10    48.7145 118.039 261.000      10      10      10
WB 11    48.6772 118.037 261.000      11      11      11
WB 12    48.5078 118.168 261.000      12      12      12
WB 13    48.0380 118.372 261.000      13      13      13
WB 14    47.9281 118.821 261.000      14      14      14
WB 15    48.7071 118.118 261.000      15      15      15
WB 16    48.6229 118.084 261.000      16      16      16
WB 17    48.5710 118.098 261.000      17      17      17
WB 18    47.8240 117.934 261.000      18      18      18
WB 19    47.8305 117.971 261.000      19      19      19
WB 20    47.8213 118.002 261.000      20      20      20
WB 21    47.8012 118.023 261.000      21      21      21
WB 22    47.7957 118.060 261.000      22      22      22
WB 23    47.9002 118.170 261.000      23      23      23
WB 24    47.8143 118.349 261.000      24      24      24
WB 25    48.0142 118.670 261.000      25      25      25

INIT CND     T2I    ICEI  WTYPEC
WB 1     -2.0000 0.00000   FRESH
WB 2     -2.0000 0.00000   FRESH
WB 3     -2.0000 0.00000   FRESH
WB 4     -2.0000 0.00000   FRESH
WB 5     -2.0000 0.00000   FRESH
WB 6     -2.0000 0.00000   FRESH
WB 7     -2.0000 0.00000   FRESH
WB 8     -2.0000 0.00000   FRESH
WB 9     -2.0000 0.00000   FRESH
WB 10    -2.0000 0.00000   FRESH
WB 11    -2.0000 0.00000   FRESH
WB 12    -2.0000 0.00000   FRESH
WB 13    -2.0000 0.00000   FRESH
WB 14    -2.0000 0.00000   FRESH
WB 15    -2.0000 0.00000   FRESH
WB 16    -2.0000 0.00000   FRESH
WB 17    -2.0000 0.00000   FRESH
WB 18    -2.0000 0.00000   FRESH
WB 19    -2.0000 0.00000   FRESH
WB 20    -2.0000 0.00000   FRESH
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WB 21    -2.0000 0.00000    FRESH
WB 22    -2.0000 0.00000    FRESH
WB 23    -2.0000 0.00000    FRESH
WB 24    -2.0000 0.00000    FRESH
WB 25    -2.0000 0.00000    FRESH

CALCULAT     VBC     EBC     MBC     PQC     EVC     PRC
WB 1          ON      ON      ON     OFF      ON     OFF
WB 2          ON      ON      ON     OFF      ON     OFF
WB 3          ON      ON      ON     OFF      ON     OFF
WB 4          ON      ON      ON     OFF      ON     OFF
WB 5          ON      ON      ON     OFF      ON     OFF
WB 6          ON      ON      ON     OFF      ON     OFF
WB 7          ON      ON      ON     OFF      ON     OFF
WB 8          ON      ON      ON     OFF      ON     OFF
WB 9          ON      ON      ON     OFF      ON     OFF
WB 10         ON      ON      ON     OFF      ON     OFF
WB 11         ON      ON      ON     OFF      ON     OFF
WB 12         ON      ON      ON     OFF      ON     OFF
WB 13         ON      ON      ON     OFF      ON     OFF
WB 14         ON      ON      ON     OFF      ON     OFF
WB 15         ON      ON      ON     OFF      ON     OFF
WB 16         ON      ON      ON     OFF      ON     OFF
WB 17         ON      ON      ON     OFF      ON     OFF
WB 18         ON      ON      ON     OFF      ON     OFF
WB 19         ON      ON      ON     OFF      ON     OFF
WB 20         ON      ON      ON     OFF      ON     OFF
WB 21         ON      ON      ON     OFF      ON     OFF
WB 22         ON      ON      ON     OFF      ON     OFF
WB 23         ON      ON      ON     OFF      ON     OFF
WB 24         ON      ON      ON     OFF      ON     OFF
WB 25         ON      ON      ON     OFF      ON     OFF

DEAD SEA   WINDC    QINC   QOUTC   HEATC
WB 1          ON      ON      ON      ON
WB 2          ON      ON      ON      ON
WB 3          ON      ON      ON      ON
WB 4          ON      ON      ON      ON
WB 5          ON      ON      ON      ON
WB 6          ON      ON      ON      ON
WB 7          ON      ON      ON      ON
WB 8          ON      ON      ON      ON
WB 9          ON      ON      ON      ON
WB 10         ON      ON      ON      ON
WB 11         ON      ON      ON      ON
WB 12         ON      ON      ON      ON
WB 13         ON      ON      ON      ON
WB 14         ON      ON      ON      ON
WB 15         ON      ON      ON      ON
WB 16         ON      ON      ON      ON
WB 17         ON      ON      ON      ON
WB 18         ON      ON      ON      ON
WB 19         ON      ON      ON      ON
WB 20         ON      ON      ON      ON
WB 21         ON      ON      ON      ON
WB 22         ON      ON      ON      ON
WB 23         ON      ON      ON      ON
WB 24         ON      ON      ON      ON
WB 25         ON      ON      ON      ON

INTERPOL   QINIC   DTRIC    HDIC
BR1           ON      ON      ON
BR2           ON      ON      ON
BR3           ON      ON      ON
BR4           ON      ON      ON
BR5           ON      ON      ON
BR6           ON      ON      ON
BR7           ON      ON      ON
BR8           ON      ON      ON
BR9           ON      ON      ON
BR10          ON      ON      ON
BR11          ON      ON      ON
BR12          ON      ON      ON
BR13          ON      ON      ON
BR14          ON      ON      ON
BR15          ON      ON      ON
BR16          ON      ON      ON
BR17          ON      ON      ON
BR18          ON      ON      ON
BR19          ON      ON      ON
BR20          ON      ON      ON
```

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BR21          ON      ON      ON
BR22          ON      ON      ON
BR23          ON      ON      ON
BR24          ON      ON      ON
BR25          ON      ON      ON

HEAT EXCH  SLHTC    SROC  RHEVAP   METIC  FETCHC     AFW     BFW     CFW   WINDH   IWIND
WB 1        TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 2        TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 3        TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 4        TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 5        TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 6        TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 7        TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 8        TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 9        TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 10       TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 11       TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 12       TERM      ON     OFF      ON      ON 9.20000 0.46000 2.00000 2.00000       0
WB 13       TERM      ON     OFF      ON      ON 9.20000 0.46000 2.00000 2.00000       0
WB 14       TERM      ON     OFF      ON      ON 9.20000 0.46000 2.00000 2.00000       0
WB 15       TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 16       TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 17       TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 18       TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 19       TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 20       TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 21       TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 22       TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 23       TERM      ON     OFF      ON      ON 9.20000 0.46000 2.00000 2.00000      -1
WB 24       TERM      ON     OFF      ON     OFF 9.20000 0.46000 2.00000 2.00000       0
WB 25       TERM      ON     OFF      ON      ON 9.20000 0.46000 2.00000 2.00000       0

ICE COVE    ICEC  SLICEC  ALBEDO   HWICE    BICE    GICE  ICEMIN   ICET2
WB 1         OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 2         OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 3         OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 4         OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 5         OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 6         OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 7         OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 8         OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 9         OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 10        OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 11        OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 12        OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 13        OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 14        OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 15        OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 16        OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 17        OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 18        OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 19        OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 20        OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 21        OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 22        OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 23        OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 24        OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000
WB 25        OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000

TRANSPOR   SLTRC   THETA
WB 1    ULTIMATE 0.55000
WB 2    ULTIMATE 0.55000
WB 3    ULTIMATE 0.55000
WB 4    ULTIMATE 0.55000
WB 5    ULTIMATE 0.55000
WB 6    ULTIMATE 0.55000
WB 7    ULTIMATE 0.55000
WB 8    ULTIMATE 0.55000
WB 9    ULTIMATE 0.55000
WB 10   ULTIMATE 0.55000
WB 11   ULTIMATE 0.55000
WB 12   ULTIMATE 0.55000
WB 13   ULTIMATE 0.55000
WB 14   ULTIMATE 0.55000
WB 15   ULTIMATE 0.55000
WB 16   ULTIMATE 0.55000
WB 17   ULTIMATE 0.55000
WB 18   ULTIMATE 0.55000
WB 19   ULTIMATE 0.55000
WB 20   ULTIMATE 0.55000
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WB 21   ULTIMATE 0.55000
WB 22   ULTIMATE 0.55000
WB 23   ULTIMATE 0.55000
WB 24   ULTIMATE 0.55000
WB 25   ULTIMATE 0.55000

HYD COEF       AX       DX     CBHE     TSED       FI    TSEDF   FRICC
WB 1     1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 2     1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 3     1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 4     1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 5     1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 6     1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 7     1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 8     1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 9     1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 10    1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 11    1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 12    1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 13    1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 14    1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 15    1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 16    1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 17    1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 18    1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 19    1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 20    1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 21    1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 22    1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 23    1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 24    1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN
WB 25    1.00000 1.00000 0.30000 11.5000 0.01000 1.00000    MANN

EDDY VISC    AZC   AZSLC   AZMAX  PHISET
WB 1         W2N     IMP 1.00000     0.0
WB 2         W2N     IMP 1.00000     0.0
WB 3         W2N     IMP 1.00000     0.0
WB 4         W2N     IMP 1.00000     0.0
WB 5         W2N     IMP 1.00000     0.0
WB 6         W2N     IMP 1.00000     0.0
WB 7         W2N     IMP 1.00000     0.0
WB 8         W2N     IMP 1.00000     0.0
WB 9         W2N     IMP 1.00000     0.0
WB 10        W2N     IMP 1.00000     0.0
WB 11        W2N     IMP 1.00000     0.0
WB 12         W2     IMP 1.00000     0.0
WB 13         W2     IMP 1.00000     0.0
WB 14         W2     IMP 1.00000     0.0
WB 15         W2     IMP 1.00000     0.0
WB 16         W2     IMP 1.00000     0.0
WB 17         W2     IMP 1.00000     0.0
WB 18        W2N     IMP 0.01000     0.0
WB 19        W2N     IMP 0.01000     0.0
WB 20        W2N     IMP 0.01000     0.0
WB 21        W2N     IMP 0.01000     0.0
WB 22        W2N     IMP 0.01000     0.0
WB 23         W2     IMP 0.01000     0.0
WB 24         W2     IMP 1.00000     0.0
WB 25         W2     IMP 1.00000     0.0

N STRUC     NSTR
BR1            0
BR2            0
BR3            0
BR4            0
BR5            0
BR6            0
BR7            0
BR8            0
BR9            0
BR10           0
BR11           0
BR12           0
BR13           0
BR14           4
BR15           0
BR16           0
BR17           0
BR18           0
BR19           0
BR20           0
```

```
BR21           0
BR22           0
BR23           0
BR24           0
BR25           0

STR INT    STRIC   STRIC   STRIC   STRIC   STRIC   STRIC   STRIC   STRIC   STRIC
BR 1
BR 2
BR 3
BR 4
BR 5
BR 6
BR 7
BR 8
BR 9
BR 10
BR 11
BR 12
BR 13
BR 14         ON      ON      ON      ON
BR 15
BR 16
BR 17
BR 18
BR 19
BR 20
BR 21
BR 22
BR 23
BR 24
BR 25

STR TOP    KTSTR   KTSTR   KTSTR   KTSTR   KTSTR   KTSTR   KTSTR   KTSTR   KTSTR
BR1
BR2
BR3
BR4
BR5
BR6
BR7
BR8
BR9
BR10
BR11
BR12
BR13
BR14           2       2       2       2
BR15
BR16
BR17
BR18
BR19
BR20
BR21
BR22
BR23
BR24
BR25

STR BOT    KBSTR   KBSTR   KBSTR   KBSTR   KBSTR   KBSTR   KBSTR   KBSTR   KBSTR
BR1
BR2
BR3
BR4
BR5
BR6
BR7
BR8
BR9
BR10
BR11
BR12
BR13
BR14          70      36      70      70
BR15
BR16
BR17
BR18
BR19
BR20
```

```
BR21
BR22
BR23
BR24
BR25

STR SINK   SINKC   SINKC   SINKC   SINKC   SINKC   SINKC   SINKC   SINKC   SINKC
BR1
BR2
BR3
BR4
BR5
BR6
BR7
BR8
BR9
BR10
BR11
BR12
BR13
BR14        LINE    LINE    LINE    LINE
BR15
BR16
BR17
BR18
BR19
BR20
BR21
BR22
BR23
BR24
BR25

STR ELEV    ESTR    ESTR    ESTR    ESTR    ESTR    ESTR    ESTR    ESTR    ESTR
BR1
BR2
BR3
BR4
BR5
BR6
BR7
BR8
BR9
BR10
BR11
BR12
BR13
BR14     317.300 364.400 350.500 320.000
BR15
BR16
BR17
BR18
BR19
BR20
BR21
BR22
BR23
BR24
BR25

STR WIDT    WSTR    WSTR    WSTR    WSTR    WSTR    WSTR    WSTR    WSTR    WSTR
BR1
BR2
BR3
BR4
BR5
BR6
BR7
BR8
BR9
BR10
BR11
BR12
BR13
BR14     500.000  60.000 100.000 100.000
BR15
BR16
BR17
BR18
BR19
BR20
```

```
BR21
BR22
BR23
BR24
BR25

PIPES       IUPI    IDPI    EUPI    EDPI     WPI   DLXPI     FPI  FMINPI   WTHLC


PIPE UP    PUPIC   ETUPI   EBUPI   KTUPI   KBUPI


PIPE DOWN  PDPIC   ETDPI   EBDPI   KTDPI   KBDPI


SPILLWAY    IUSP    IDSP     ESP    A1SP    B1SP    A2SP    B2SP   WTHLC
SP 2         317       0 395.200 2000.00 1.50000 900.000 1.50000    DOWN

SPILL UP   PUSPC   ETUSP   EBUSP   KTUSP   KBUSP
SP 2       DISTR 0.00000 0.00000       2      70

SPILL DOWN PDSPC   ETUSP   EBUSP   KTDSP   KBDSP
SP 2       DISTR 0.00000 0.00000       2      70

SPILL GAS GASSPC    EQSP  AGASSP  BGASSP  CGASSP
SP 2         OFF       0 0.00000 0.00000 0.00000

GATES       IUGT    IDGT     EGT    A1GT    B1GT    G1GT    A2GT    B2GT    G2GT   WTHLC


GATE WEIR   GTA1    GTB1    GTA2    GTB2  DYNVAR


GATE UP    PUGTC   ETUGT   EBUGT   KTUGT   KBUGT


GATE DOWN  PDGTC   ETDGT   EBDGT   KTDGT   KBDGT


GATE GAS  GASGTC    EQGT  AGASGT  BGASGT  CGASGT


PUMPS 1     IUPU    IDPU     EPU  STRTPU   ENDPU   EONPU  EOFFPU     QPU   WTHLC


PUMPS 2     PPUC    ETPU    EBPU    KTPU    KBPU


WEIR SEG     IWR     IWR     IWR     IWR     IWR     IWR     IWR     IWR     IWR


WEIR TOP    KTWR    KTWR    KTWR    KTWR    KTWR    KTWR    KTWR    KTWR    KTWR


WEIR BOT    KBWR    KBWR    KBWR    KBWR    KBWR    KBWR    KBWR    KBWR    KBWR


WD INT      WDIC    WDIC    WDIC    WDIC    WDIC    WDIC    WDIC    WDIC    WDIC
              ON

WD SEG       IWD     IWD     IWD     IWD     IWD     IWD     IWD     IWD     IWD
             317

WD ELEV      EWD     EWD     EWD     EWD     EWD     EWD     EWD     EWD     EWD
          363.65

WD TOP      KTWD    KTWD    KTWD    KTWD    KTWD    KTWD    KTWD    KTWD    KTWD
               2

WD BOT      KBWD    KBWD    KBWD    KBWD    KBWD    KBWD    KBWD    KBWD    KBWD
              70

TRIB PLA    PTRC    PTRC    PTRC    PTRC    PTRC    PTRC    PTRC    PTRC    PTRC
         SPECIFY   DISTR SPECIFY

TRIB INT    TRIC    TRIC    TRIC    TRIC    TRIC    TRIC    TRIC    TRIC    TRIC
              ON      ON

TRIB SEG     ITR     ITR     ITR     ITR     ITR     ITR     ITR     ITR     ITR
             316     144     316
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TRIB TOP   ELTRT   ELTRT   ELTRT   ELTRT   ELTRT   ELTRT   ELTRT   ELTRT   ELTRT
         368.000 368.000

TRIB BOT   ELTRB   ELTRB   ELTRB   ELTRB   ELTRB   ELTRB   ELTRB   ELTRB   ELTRB
         359.300 359.300

DST TRIB    DTRC    DTRC    DTRC    DTRC    DTRC    DTRC    DTRC    DTRC    DTRC
BR 1          ON
BR 2          ON
BR 3          ON
BR 4          ON
BR 5          ON
BR 6          ON
BR 7          ON
BR 8          ON
BR 9          ON
BR 10         ON
BR 11         ON
BR 12         ON
BR 13         ON
BR 14         ON
BR 15        OFF
BR 16        OFF
BR 17        OFF
BR 18        OFF
BR 19        OFF
BR 20        OFF
BR 21        OFF
BR 22        OFF
BR 23        OFF
BR 24        OFF
BR 25        OFF

HYD PRIN  HPRWBC  HPRWBC  HPRWBC  HPRWBC  HPRWBC  HPRWBC  HPRWBC  HPRWBC  HPRWBC
NVIOL         ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
U             ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
W             ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
T             ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
RHO          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
AZ           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
SHEAR        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ST           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
SB           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ADMX         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DM           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
HDG          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ADMZ         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
HPG          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
GRAV         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF

SNP PRINT   SNPC    NSNP   NISNP
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WB 1          ON       4      18
WB 2          ON       4      10
WB 3          ON       4      10
WB 4          ON       4      10
WB 5          ON       4      10
WB 6          ON       2       3
WB 7          ON       2       3
WB 8          ON       2       3
WB 9          ON       2       3
WB 10         ON       2       3
WB 11         ON       2       3
WB 12         ON       2      13
WB 13         ON       4      27
WB 14         ON       2      11
WB 15         ON       3      15
WB 16         ON       2       2
WB 17         ON       2       2
WB 18         ON       2       2
WB 19         ON       2       2
WB 20         ON       2       2
WB 21         ON       2       2
WB 22         ON       2       2
WB 23         ON       2      14
WB 24         ON       2       2
WB 25         ON       2       9

SNP DATE    SNPD    SNPD    SNPD    SNPD    SNPD    SNPD    SNPD    SNPD    SNPD
WB 1     1.00000 366.000   590.0   640.0
WB 2     1.00000 366.000   590.0   640.0
WB 3     1.00000 366.000   590.0   640.0
WB 4     1.00000 366.000   590.0   640.0
WB 5     1.00000 366.000   590.0   640.0
WB 6     1.00000 366.000
WB 7     1.00000 366.000
WB 8     1.00000 366.000
WB 9     1.00000 366.000
WB 10    1.00000 366.000
WB 11    1.00000 366.000
WB 12    1.00000 366.000
WB 13    1.00000 366.000  415.00   460.0
WB 14    1.00000 366.000
WB 15    1.00000 366.000  370.00
WB 16    1.00000 366.000
WB 17    1.00000 366.000
WB 18    1.00000 366.000
WB 19    1.00000 366.000
WB 20    1.00000 366.000
WB 21    1.00000 366.000
WB 22    1.00000 366.000
WB 23    1.00000 366.000
WB 24    1.00000 366.000
WB 25    1.00000 366.000

SNP FREQ    SNPF    SNPF    SNPF    SNPF    SNPF    SNPF    SNPF    SNPF    SNPF
WB 1     2.00000 2.50000   0.250    2.00
WB 2     2.00000 2.50000   0.250    2.00
WB 3     2.00000 2.50000   0.250    2.00
WB 4     2.00000 2.50000   0.250    2.00
WB 5     2.00000 2.50000   0.250    2.00
WB 6     2.00000 2.50000
WB 7     2.00000 2.50000
WB 8     2.00000 2.50000
WB 9     2.00000 2.50000
WB 10    2.00000 2.50000
WB 11    2.00000 2.50000
WB 12    2.00000 2.50000
WB 13    2.00000 2.50000   0.500    2.50
WB 14    2.00000 2.50000
WB 15    2.00000 0.10000 2.50000
WB 16    2.00000 2.50000
WB 17    2.00000 2.50000
WB 18    2.00000 2.50000
WB 19    2.00000 2.50000
WB 20    2.00000 2.50000
WB 21    2.00000 2.50000
WB 22    2.00000 2.50000
WB 23    2.00000 2.50000
WB 24    2.00000 2.50000
WB 25    2.00000 2.50000

SNP SEG     ISNP    ISNP    ISNP    ISNP    ISNP    ISNP    ISNP    ISNP    ISNP
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WB 1           2       3       4       5       6       7       8       9      10
              11      12      13      14      15      16      17      18      19
WB 2          22      23      24      25      26      27      28      29      30
              31
WB 3          34      35      36      37      38      39      40      41      42
              43
WB 4          46      47      48      49      50      51      52      53      54
              55
WB 5          58      59      60      61      62      63      64      65      66
              67
WB 6          70      75      79
WB 7          82      85      91
WB 8          94      98     103
WB 9         106     110     115
WB 10        118     122     127
WB 11        130     135     139
WB 12        142     143     144     145     146     147     148     149     150
             160     170     180     192
WB 13        195     210     220     221     222     223     224     225     226
             227     228     229     230     231     232     233     234     235
             236     237     238     239     240     250     260     270     273
WB 14        276     290     300     310     311     312     313     314     315
             316     317
WB 15        320     321     322     323     324     325     326     327     328
             329     330     331     332     333     334
WB 16        337     340
WB 17        343     346
WB 18        349     360
WB 19        363     374
WB 20        377     388
WB 21        391     402
WB 22        405     416
WB 23        419     430     440     450     460     470     480     490     500
             510     520     530     540     544
WB 24        547     554
WB 25        557     560     565     570     575     576     577     580     582

SCR PRINT   SCRC    NSCR
WB 1         OFF       1
WB 2         OFF       1
WB 3         OFF       1
WB 4         OFF       1
WB 5         OFF       1
WB 6         OFF       1
WB 7         OFF       1
WB 8         OFF       1
WB 9         OFF       1
WB 10        OFF       1
WB 11        OFF       1
WB 12        OFF       1
WB 13        OFF       1
WB 14         ON       2
WB 15        OFF       1
WB 16        OFF       1
WB 17        OFF       1
WB 18        OFF       1
WB 19        OFF       1
WB 20        OFF       1
WB 21        OFF       1
WB 22        OFF       1
WB 23        OFF       1
WB 24        OFF       1
WB 25        OFF       1

SCR DATE    SCRD    SCRD    SCRD    SCRD    SCRD    SCRD    SCRD    SCRD    SCRD
WB 1     108.000
WB 2     108.000
WB 3     108.000
WB 4     108.000
WB 5     108.000
WB 6     108.000
WB 7     108.000
WB 8     108.000
WB 9     108.000
WB 10    108.000
WB 11    108.000
WB 12    108.000
WB 13    108.000
WB 14    1.00000 366.000
WB 15    108.000
WB 16    108.000
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WB 17    108.000
WB 18    108.000
WB 19    108.000
WB 20    108.000
WB 21    108.000
WB 22    108.000
WB 23    108.000
WB 24    108.000
WB 25    108.000

SCR FREQ    SCRF    SCRF    SCRF    SCRF    SCRF    SCRF    SCRF    SCRF    SCRF
WB 1     0.00010
WB 2     0.00010
WB 3     0.00010
WB 4     0.00010
WB 5     0.00010
WB 6     0.00010
WB 7     0.00010
WB 8     0.10000
WB 9     0.00010
WB 10    0.00010
WB 11    0.00010
WB 12    0.00010
WB 13    0.00010
WB 14    0.10000 0.10000
WB 15    0.00010
WB 16    0.00010
WB 17    0.00010
WB 18    0.00010
WB 19    0.00010
WB 20    0.00010
WB 21    0.00010
WB 22    0.00010
WB 23    0.00010
WB 24    0.00010
WB 25    0.00010

PRF PLOT    PRFC    NPRF   NIPRF
WB 1         OFF       2       1
WB 2         OFF       2       1
WB 3         OFF       2       1
WB 4         OFF       2       1
WB 5         OFF       2       1
WB 6         OFF       2       1
WB 7         OFF       2       1
WB 8         OFF       2       1
WB 9         OFF       2       1
WB 10        OFF       2       1
WB 11         ON       2       1
WB 12         ON       2       2
WB 13         ON       2       3
WB 14         ON       2       3
WB 15        OFF       2       1
WB 16        OFF       2       1
WB 17        OFF       2       1
WB 18        OFF       2       1
WB 19        OFF       2       1
WB 20        OFF       2       1
WB 21        OFF       2       1
WB 22        OFF       2       1
WB 23         ON       2       1
WB 24         ON       2       1
WB 25         ON       2       2

PRF DATE    PRFD    PRFD    PRFD    PRFD    PRFD    PRFD    PRFD    PRFD    PRFD
WB 1     1.50000 366.500
WB 2     1.50000 366.500
WB 3     1.50000 366.500
WB 4     1.50000 366.500
WB 5     1.50000 366.500
WB 6     1.50000 366.500
WB 7     1.50000 366.500
WB 8     1.50000 366.500
WB 9     1.50000 366.500
WB 10    1.50000 366.500
WB 11    1.50000 366.500
WB 12    1.50000 366.500
WB 13    1.50000 366.500
WB 14    1.50000 366.500
WB 15    1.50000 366.500
WB 16    1.50000 366.500
```

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WB 17    1.50000 366.500
WB 18    1.50000 366.500
WB 19    1.50000 366.500
WB 20    1.50000 366.500
WB 21    1.50000 366.500
WB 22    1.50000 366.500
WB 23    1.50000 366.500
WB 24    1.50000 366.500
WB 25    1.50000 366.500

PRF FREQ    PRFF    PRFF    PRFF    PRFF    PRFF    PRFF    PRFF    PRFF    PRFF
WB 1     1.00000 1.00000
WB 2     1.00000 1.00000
WB 3     1.00000 1.00000
WB 4     1.00000 1.00000
WB 5     1.00000 1.00000
WB 6     1.00000 1.00000
WB 7     1.00000 1.00000
WB 8     1.00000 1.00000
WB 9     1.00000 1.00000
WB 10    1.00000 1.00000
WB 11    1.00000 1.00000
WB 12    1.00000 1.00000
WB 13    1.00000 1.00000
WB 14    1.00000 1.00000
WB 15    1.00000 1.00000
WB 16    1.00000 1.00000
WB 17    1.00000 1.00000
WB 18    1.00000 1.00000
WB 19    1.00000 1.00000
WB 20    1.00000 1.00000
WB 21    1.00000 1.00000
WB 22    1.00000 1.00000
WB 23    1.00000 1.00000
WB 24    1.00000 1.00000
WB 25    1.00000 1.00000

PRF SEG     IPRF    IPRF    IPRF    IPRF    IPRF    IPRF    IPRF    IPRF    IPRF
WB 1           0
WB 2           0
WB 3           0
WB 4           0
WB 5           0
WB 6           0
WB 7           0
WB 8           0
WB 9           0
WB 10          0
WB 11        133
WB 12        151     188
WB 13        211     247     252
WB 14        287     290     313
WB 15          0
WB 16          0
WB 17        344
WB 18          0
WB 19          0
WB 20          0
WB 21          0
WB 22          0
WB 23        475
WB 24        553
WB 25        558     576

SPR PLOT    SPRC    NSPR   NISPR
WB 1         OFF       0       0
WB 2         OFF       0       0
WB 3         OFF       0       0
WB 4         OFF       0       0
WB 5         OFF       0       0
WB 6         OFF       0       0
WB 7         OFF       0       0
WB 8         OFF       0       0
WB 9         OFF       0       0
WB 10        OFF       0       0
WB 11        OFF       0       0
WB 12        OFF       0       0
WB 13        OFF      14       3
WB 14        OFF       0       0
WB 15         ON       1      14
WB 16        OFF       0       0
```

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WB 17        OFF       0       0
WB 18        OFF       0       0
WB 19        OFF       0       0
WB 20        OFF       0       0
WB 21        OFF       0       0
WB 22        OFF       0       0
WB 23        OFF       0       0
WB 24        OFF       0       0
WB 25        OFF       0       0

SPR DATE    SPRD    SPRD    SPRD    SPRD    SPRD    SPRD    SPRD    SPRD    SPRD
WB 1
WB 2
WB 3
WB 4
WB 5
WB 6
WB 7
WB 8
WB 9
WB 10
WB 11
WB 12
WB 13    448.500 475.500 491.500 502.500 524.500 536.500 554.500 572.500 587.500
         599.500 622.500 634.500 650.500 663.500
WB 14
WB 15    368.000
WB 16
WB 17
WB 18
WB 19
WB 20
WB 21
WB 22
WB 23
WB 24
WB 25

SPR FREQ    SPRF    SPRF    SPRF    SPRF    SPRF    SPRF    SPRF    SPRF    SPRF
WB 1
WB 2
WB 3
WB 4
WB 5
WB 6
WB 7
WB 8
WB 9
WB 10
WB 11
WB 12
WB 13    500.000 500.000 500.000 500.000 500.000 500.000 500.000 500.000 500.000
         500.000 500.000 500.000 500.000 500.000
WB 14
WB 15       2.00
WB 16
WB 17
WB 18
WB 19
WB 20
WB 21
WB 22
WB 23
WB 24
WB 25

SPR SEG     ISPR    ISPR    ISPR    ISPR    ISPR    ISPR    ISPR    ISPR    ISPR
WB 1
WB 2
WB 3
WB 4
WB 5
WB 6
WB 7
WB 8
WB 9
WB 10
WB 11
WB 12
WB 13         99     101     103
WB 14
```

```
WB 15        320     321     322     323     324     325     326     327     328
             329     330     331     332     333
WB 16
WB 17
WB 18
WB 19
WB 20
WB 21
WB 22
WB 23
WB 24
WB 25

VPL PLOT    VPLC    NVPL
WB 1         OFF       1
WB 2         OFF       1
WB 3         OFF       1
WB 4         OFF       1
WB 5         OFF       1
WB 6         OFF       1
WB 7         OFF       1
WB 8         OFF       1
WB 9         OFF       1
WB 10        OFF       1
WB 11        OFF       1
WB 12        OFF       1
WB 13        OFF       1
WB 14        OFF       1
WB 15        OFF       1
WB 16        OFF       1
WB 17        OFF       1
WB 18        OFF       1
WB 19        OFF       1
WB 20        OFF       1
WB 21        OFF       1
WB 22        OFF       1
WB 23        OFF       1
WB 24        OFF       1
WB 25        OFF       1

VPL DATE    VPLD    VPLD    VPLD    VPLD    VPLD    VPLD    VPLD    VPLD    VPLD
WB 1     63.5000
WB 2     63.5000
WB 3     63.5000
WB 4     63.5000
WB 5     63.5000
WB 6     63.5000
WB 7     63.5000
WB 8     63.5000
WB 9     63.5000
WB 10    63.5000
WB 11    63.5000
WB 12    63.5000
WB 13    63.5000
WB 14    63.5000
WB 15    63.5000
WB 16    63.5000
WB 17    63.5000
WB 18    63.5000
WB 19    63.5000
WB 20    63.5000
WB 21    63.5000
WB 22    63.5000
WB 23    63.5000
WB 24    63.5000
WB 25    63.5000

VPL FREQ    VPLF    VPLF    VPLF    VPLF    VPLF    VPLF    VPLF    VPLF    VPLF
WB 1     1.00000
WB 2     1.00000
WB 3     1.00000
WB 4     1.00000
WB 5     1.00000
WB 6     1.00000
WB 7     1.00000
WB 8     1.00000
WB 9     1.00000
WB 10    1.00000
WB 11    1.00000
WB 12    1.00000
WB 13    1.00000
```

```
WB 14    1.00000
WB 15    1.00000
WB 16    1.00000
WB 17    1.00000
WB 18    1.00000
WB 19    1.00000
WB 20    1.00000
WB 21    1.00000
WB 22    1.00000
WB 23    1.00000
WB 24    1.00000
WB 25    1.00000

CPL PLOT    CPLC    NCPL
WB 1          ON       2
WB 2          ON       2
WB 3          ON       2
WB 4          ON       2
WB 5          ON       2
WB 6          ON       2
WB 7          ON       2
WB 8          ON       2
WB 9          ON       2
WB 10         ON       2
WB 11         ON       2
WB 12         ON       2
WB 13         ON       2
WB 14         ON       2
WB 15         ON       2
WB 16         ON       2
WB 17         ON       2
WB 18         ON       2
WB 19         ON       2
WB 20         ON       2
WB 21         ON       2
WB 22         ON       2
WB 23         ON       2
WB 24         ON       2
WB 25         ON       2

CPL DATE    CPLD    CPLD    CPLD    CPLD    CPLD    CPLD    CPLD    CPLD    CPLD
WB 1     1.00000 365.000  366.00  600.00
WB 2     1.00000 365.000  366.00  600.00
WB 3     1.00000 365.000  366.00  600.00
WB 4     1.00000 365.000  366.00  600.00
WB 5     1.00000 365.000  366.00  600.00
WB 6     1.00000 365.000  366.00  600.00
WB 7     1.00000 365.000  366.00  600.00
WB 8     1.00000 365.000  366.00  600.00
WB 9     1.00000 365.000  366.00  600.00
WB 10    1.00000 365.000  366.00  600.00
WB 11    1.00000 365.000  366.00  600.00
WB 12    1.00000 365.000  366.00  600.00
WB 13    1.00000 365.000  366.00  600.00
WB 14    1.00000 365.000  366.00  600.00
WB 15    1.00000 365.000  366.00  600.00
WB 16    1.00000 365.000  366.00  600.00
WB 17    1.00000 365.000  366.00  600.00
WB 18    1.00000 365.000  366.00  600.00
WB 19    1.00000 365.000  366.00  600.00
WB 20    1.00000 365.000  366.00  600.00
WB 21    1.00000 365.000  366.00  600.00
WB 22    1.00000 365.000  366.00  600.00
WB 23    1.00000 365.000  366.00  600.00
WB 24    1.00000 365.000  366.00  600.00
WB 25    1.00000 365.000  366.00  600.00

CPL FREQ    CPLF    CPLF    CPLF    CPLF    CPLF    CPLF    CPLF    CPLF    CPLF
WB 1     1.00000 2.00000   0.100    2.00
WB 2     1.00000 2.00000   0.100    2.00
WB 3     1.00000 2.00000   0.100    2.00
WB 4     1.00000 2.00000   0.100    2.00
WB 5     1.00000 2.00000   0.100    2.00
WB 6     1.00000 2.00000   0.100    2.00
WB 7     1.00000 2.00000   0.100    2.00
WB 8     1.00000 2.00000   0.100    2.00
WB 9     1.00000 2.00000   0.100    2.00
WB 10    1.00000 2.00000   0.100    2.00
WB 11    1.00000 2.00000   0.100    2.00
WB 12    1.00000 2.00000   0.100    2.00
WB 13    1.00000 2.00000   0.100    2.00
```

```
WB 14    1.00000 2.00000   0.100    2.00
WB 15    1.00000 2.00000
WB 16    1.00000 2.00000
WB 17    1.00000 2.00000
WB 18    1.00000 2.00000
WB 19    1.00000 2.00000
WB 20    1.00000 2.00000
WB 21    1.00000 2.00000
WB 22    1.00000 2.00000
WB 23    1.00000 2.00000
WB 24    1.00000 2.00000
WB 25    1.00000 2.00000

FLUXES      FLXC    NFLX
WB 1         OFF       0
WB 2         OFF       0
WB 3         OFF       0
WB 4         OFF       0
WB 5         OFF       0
WB 6         OFF       0
WB 7         OFF       0
WB 8         OFF       0
WB 9         OFF       0
WB 10        OFF       0
WB 11        OFF       0
WB 12        OFF       0
WB 13        OFF       0
WB 14        OFF       0
WB 15        OFF       0
WB 16        OFF       0
WB 17        OFF       0
WB 18        OFF       0
WB 19        OFF       0
WB 20        OFF       0
WB 21        OFF       0
WB 22        OFF       0
WB 23        OFF       0
WB 24        OFF       0
WB 25        OFF       0

FLX DATE    FLXD    FLXD    FLXD    FLXD    FLXD    FLXD    FLXD    FLXD    FLXD
WB 1       366.0
WB 2       366.0
WB 3       366.0
WB 4       366.0
WB 5       366.0
WB 6       366.0
WB 7       366.0
WB 8       366.0
WB 9       366.0
WB 10      366.0
WB 11      366.0
WB 12      366.0
WB 13      366.0
WB 14      366.0
WB 15      366.0
WB 16      366.0
WB 17      366.0
WB 18      366.0
WB 19      366.0
WB 20      366.0
WB 21      366.0
WB 22      366.0
WB 23      366.0
WB 24      366.0
WB 25      366.0

FLX FREQ    FLXF    FLXF    FLXF    FLXF    FLXF    FLXF    FLXF    FLXF    FLXF
WB 1         2.0
WB 2         2.0
WB 3         2.0
WB 4         2.0
WB 5         2.0
WB 6         2.0
WB 7         2.0
WB 8         2.0
WB 9         2.0
WB 10        2.0
WB 11        2.0
WB 12        2.0
WB 13        2.0
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WB 14        2.0
WB 15        2.0
WB 16        2.0
WB 17        2.0
WB 18        2.0
WB 19        2.0
WB 20        2.0
WB 21        2.0
WB 22        2.0
WB 23        2.0
WB 24        2.0
WB 25        2.0

TSR PLOT    TSRC    NTSR   NITSR
              ON       2      80

TSR DATE    TSRD    TSRD    TSRD    TSRD    TSRD    TSRD    TSRD    TSRD    TSRD
         1.00000 366.000

TSR FREQ    TSRF    TSRF    TSRF    TSRF    TSRF    TSRF    TSRF    TSRF    TSRF
         0.05000 0.05000

TSR SEG     ITSR    ITSR    ITSR    ITSR    ITSR    ITSR    ITSR    ITSR    ITSR
               2       5      10      15      19      22      31      34      43
              46      55      58      67      70      79      82      91      94
             103     106     115     118     127     130     139     142     150
             160     170     180     192     195     210     220     223     230
             240     250     260     273     276     290     300     317     320
             334     337     340     343     346     349     360     363     374
             377     388     391     402     405     416     419     544     547
             554     557     582     317     475     313     133     151     188
             211     247     252     287     344     553     558     576

TSR LAYE    ETSR    ETSR    ETSR    ETSR    ETSR    ETSR    ETSR    ETSR    ETSR
         0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
         0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
         0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
         0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
         0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
         0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
         0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
         0.00000 0.00000 0.00000 -18.000 0.00000 0.00000 0.00000 0.00000 0.00000
         0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000

WITH OUT    WDOC    NWDO   NIWDO
              ON       1       4

WITH DAT    WDOD    WDOD    WDOD    WDOD    WDOD    WDOD    WDOD    WDOD    WDOD
         366.000 0.00000

WITH FRE    WDOF    WDOF    WDOF    WDOF    WDOF    WDOF    WDOF    WDOF    WDOF
         0.10000 0.10000

WITH SEG    IWDO    IWDO    IWDO    IWDO    IWDO    IWDO    IWDO    IWDO    IWDO
             192     273     317     544

RESTART     RSOC    NRSO    RSIC
              ON       1     OFF

RSO DATE    RSOD    RSOD    RSOD    RSOD    RSOD    RSOD    RSOD    RSOD    RSOD
         450.000 575.000

RSO FREQ    RSOF    RSOF    RSOF    RSOF    RSOF    RSOF    RSOF    RSOF    RSOF
         100.000 500.000

CST COMP     CCC    LIMC     CUF
              ON      ON      12

CST ACTIVE   CAC
TDS           ON
Age           ON
Tracer        ON
Coliform      ON
ISS1          ON
PO4           ON
NH4           ON
NO3           ON
DSI          OFF
PSI          OFF
FE           OFF
LDOM          ON
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RDOM          ON
LPOM          ON
RPOM          ON
BOD1          ON
ALG1          ON
ALG2          ON
ALG3          ON
DO            ON
TIC           ON
ALK           ON
ZOO1          ON
ZOO2          ON
ZOO3          ON
LDOM_P       OFF
RDOM_P       OFF
LPOM_P       OFF
RPOM_P       OFF
LDOM_N       OFF
RDOM_N       OFF
LPOM_N       OFF
RPOM_N       OFF

CST DERI   CDWBC   CDWBC   CDWBC   CDWBC   CDWBC   CDWBC   CDWBC   CDWBC   CDWBC
DOC          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
POC          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
TOC          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DON          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PON          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
TON          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
TKN           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
TN           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DOP          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
POP          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
TOP           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
TP           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
APR          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
CHLA         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ATOT         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
%DO          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
TSS           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
TISS         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
CBOD         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
pH            ON      ON      ON      ON      ON      ON      ON      ON      ON
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              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
CO2          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
HCO3         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
CO3          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF

CST FLUX   CFWBC   CFWBC   CFWBC   CFWBC   CFWBC   CFWBC   CFWBC   CFWBC   CFWBC
TISSIN       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
TISSOUT      OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4AR        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4AG        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4AP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4ER        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4EG        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4EP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4POM       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4DOM       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4OM        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4SED       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4SOD       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4SET       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
NH4NITR      OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
NH4AR         ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
NH4AG         ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
NH4AP         ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
NH4ER         ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
NH4EG         ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
NH4EP         ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
NH4POM        ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
NH4DOM        ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
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              ON      ON      ON      ON      ON      ON      ON
NH4OM         ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
NH4SED        ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
NH4SOD        ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
NO3DEN       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
NO3AG        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
NO3EG        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
NO3SED       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DSIAG        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DSIEG        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DSIPIS       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DSISED       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DSISOD       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DSISET       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PSIAM        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PSINET       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PSIDK        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
FESET        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
FESED        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOMDK       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LRDOM        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RDOMDK       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOMAP       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOMEP       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOMDK       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LRPOM        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RPOMDK       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOMAP       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
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             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOMEP       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOMSET      OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RPOMSET      OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
CBODDK       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DOAP         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DOAR         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DOEP         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DOER         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DOPOM        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DODOM        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DOOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DONITR       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DOCBOD       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DOREAR       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DOSED        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DOSOD        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
TICAG        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
TICEG        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
SEDDK        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
SEDAS        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
SEDLPOM      OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
SEDSET       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
SODDK        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF

CST ICON   C2IWB   C2IWB   C2IWB   C2IWB   C2IWB   C2IWB   C2IWB   C2IWB   C2IWB
TDS        87.00   86.00   85.00   85.00   85.00   85.00   85.00   85.00   85.00
           85.00   85.00   82.00   84.00   82.00   85.00   85.00   85.00   80.00
           80.00   80.00   80.00   80.00   80.00   87.00   86.00
Age      0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
         0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
         0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
Tracer   1000.00 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
         0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
         0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
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Coliform  40.000  30.000  20.000  10.000  5.0000  2.0000  2.0000  2.0000  2.0000
          2.0000  2.0000  2.0000  1.0000  0.5000  2.0000  2.0000  2.0000  2.0000
          2.0000  2.0000  2.0000  2.0000  2.0000  1.0000  0.5000
ISS1      1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000
          1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000
          1.00000 1.00000 1.00000 1.00000 1.00000 1.00000 1.00000
PO4       0.00300 0.00300 0.00300 0.00300 0.00300 0.00300 0.00300 0.00300 0.00300
          0.00300 0.00300 0.00300 0.00300 0.00300 0.00300 0.00300 0.00300 0.00900
          0.00900 0.00900 0.00900 0.00900 0.00900 0.00300 0.00300
NH4       0.00500 0.00500 0.00500 0.00500 0.00500 0.00500 0.00500 0.00500 0.00500
          0.00500 0.00500 0.00500 0.00500 0.00500 0.00500 0.00500 0.00500 0.01500
          0.01500 0.01500 0.01500 0.01500 0.01500 0.00500 0.00500
NO3       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 0.15000 0.10000 0.10000 0.10000 0.40000
          0.40000 0.40000 0.40000 0.40000 0.40000 0.12500 0.15000
DSI       0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
PSI       0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
FE        0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
LDOM      0.65000 0.65000 0.65000 0.65000 0.65000 0.65000 0.65000 0.65000 0.65000
          0.65000 0.65000 0.65000 0.65000 0.65000 0.65000 0.65000 0.65000 0.65000
          0.65000 0.65000 0.65000 0.65000 0.65000 0.65000 0.65000
RDOM      0.65000 0.65000 0.65000 0.65000 0.65000 0.65000 0.65000 0.65000 0.65000
          0.65000 0.65000 0.65000 0.65000 0.65000 0.65000 0.65000 0.65000 0.65000
          0.65000 0.65000 0.65000 0.65000 0.65000 0.65000 0.65000
LPOM      0.05000 0.05000 0.05000 0.05000 0.05000 0.05000 0.05000 0.05000 0.05000
          0.05000 0.05000 0.05000 0.05000 0.05000 0.05000 0.05000 0.05000 0.05000
          0.05000 0.05000 0.05000 0.05000 0.05000 0.05000 0.05000
RPOM      0.05000 0.05000 0.05000 0.05000 0.05000 0.05000 0.05000 0.05000 0.05000
          0.05000 0.05000 0.05000 0.05000 0.05000 0.05000 0.05000 0.05000 0.05000
          0.05000 0.05000 0.05000 0.05000 0.05000 0.05000 0.05000
BOD1      0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
ALG1      0.00020 0.00020 0.00020 0.00020 0.00020 0.00020 0.00020 0.00020 0.00020
          0.00020 0.00020 0.00020 0.00040 0.00040 0.00020 0.00020 0.00020 0.00220
          0.00220 0.00220 0.00220 0.00220 0.00220 0.00140 0.00120
ALG2      0.00080 0.00080 0.00080 0.00080 0.00080 0.00080 0.00080 0.00080 0.00080
          0.00080 0.00080 0.00080 0.00160 0.00160 0.00080 0.00080 0.00080 0.00880
          0.00880 0.00880 0.00880 0.00880 0.00880 0.00560 0.00480
ALG3      0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
DO        10.0000 10.0000 10.0000 10.0000 10.0000 10.0000 10.0000 10.0000 10.0000
          10.0000 10.0000 10.0000 10.0000 10.0000 10.0000 10.0000 10.0000 10.0000
          10.0000 10.0000 10.0000 10.0000 10.0000 10.0000 10.0000
TIC       16.9000 16.9000 16.9000 16.9000 16.9000 16.9000 16.9000 16.9000 16.9000
          16.9000 16.9000 16.9000 16.9000 16.9000 16.9000 16.9000 16.9000 13.5000
          13.5000 13.5000 13.5000 13.5000 13.5000 16.9000 16.9000
ALK       66.0000 66.0000 66.0000 66.0000 66.0000 66.0000 66.0000 66.0000 66.0000
          66.0000 66.0000 66.0000 66.0000 66.0000 66.0000 66.0000 66.0000 55.0000
          55.0000 55.0000 55.0000 55.0000 55.0000 66.0000 66.0000
ZOO1      0.00006 0.00006 0.00006 0.00006 0.00006 0.00006 0.00006 0.00006 0.00006
          0.00006 0.00006 0.00006 0.00006 0.00060 0.00006 0.00020 0.00020 0.00020
          0.00020 0.00020 0.00020 0.00020 0.00020 0.00060 0.00060
ZOO2      0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00010 0.00002 0.00002 0.00002 0.00002
          0.00002 0.00002 0.00002 0.00002 0.00002 0.00010 0.00010
ZOO3      0.00003 0.00003 0.00003 0.00003 0.00003 0.00003 0.00003 0.00003 0.00003
          0.00003 0.00003 0.00003 0.00003 0.00030 0.00002 0.00002 0.00002 0.00002
          0.00002 0.00002 0.00002 0.00002 0.00002 0.00030 0.00030
LDOM_P    0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
RDOM_P    0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
LPOM_P    0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
RPOM_P    0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
LDOM_N    0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
          0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
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RDOM_N   0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
         0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
         0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
LPOM_N   0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
         0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
         0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
RPOM_N   0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
         0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
         0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001

CST PRIN  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC
TDS           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
Age           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
Tracer       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
Coliform      ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
ISS1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
NH4           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
NO3           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
DSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
FE           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOM          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
RDOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOM          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
RPOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
BOD1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ALG1          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
ALG2          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
ALG3          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
DO            ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
TIC           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
ALK           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
ZOO1          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
ZOO2          ON      ON      ON      ON      ON      ON      ON      ON      ON
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              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
ZOO3          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
LDOMP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RDOMP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOMP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RPOMP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOMN        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RDOMN        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOMN        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RPOMN        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF

CIN CON   CINBRC  CINBRC  CINBRC  CINBRC  CINBRC  CINBRC  CINBRC  CINBRC  CINBRC
TDS           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
Age           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
Tracer        ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
Coliform      ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
ISS1          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
PO4           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
NH4           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
NO3           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
DSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
FE           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOM          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
RDOM          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
LPOM          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
RPOM          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
BOD1          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
ALG1          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
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              ON      ON      ON      ON      ON      ON      ON
ALG2          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
ALG3          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
DO            ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
TIC           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
ALK           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON
ZOO1          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF      ON
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ZOO2          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF      ON
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ZOO3          ON     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF      ON
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOMP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RDOMP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOMP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RPOMP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOMN        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RDOMN        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOMN        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RPOMN        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF

CTR CON   CTRTRC  CTRTRC  CTRTRC  CTRTRC  CTRTRC  CTRTRC  CTRTRC  CTRTRC  CTRTRC
TDS           ON      ON
Age           ON      ON
Tracer        ON      ON
Coliform      ON      ON
ISS1          ON      ON
PO4           ON      ON
NH4           ON      ON
NO3           ON      ON
DSI          OFF     OFF
PSI          OFF     OFF
FE           OFF     OFF
LDOM          ON      ON
RDOM          ON      ON
LPOM          ON      ON
RPOM          ON      ON
BOD1          ON      ON
ALG1          ON      ON
ALG2          ON      ON
ALG3          ON      ON
DO            ON      ON
TIC           ON      ON
ALK           ON      ON
ZOO1         OFF     OFF
ZOO2         OFF     OFF
ZOO3         OFF     OFF
LDOM_P       OFF     OFF
RDOM_P       OFF     OFF
LPOM_P       OFF     OFF
RPOM_P       OFF     OFF
LDOM_N       OFF     OFF
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RDOM_N       OFF     OFF
LPOM_N       OFF     OFF
RPOM_N       OFF     OFF

CDT CON   CDTBRC  CDTBRC  CDTBRC  CDTBRC  CDTBRC  CDTBRC  CDTBRC  CDTBRC  CDTBRC
TDS           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
Age           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
Tracer        ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
Coliform      ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ISS1          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
NH4           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
NO3           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
FE           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOM          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RDOM          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOM          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RPOM          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
BOD1          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ALG1          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ALG2          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ALG3          ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DO            ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
TIC           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ALK           ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON      ON      ON      ON     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ZOO1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ZOO2         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ZOO3         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOMP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
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             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RDOMP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOMP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RPOMP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOMN        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RDOMN        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOMN        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RPOMN        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF

CPR CON   CPRBRC  CPRBRC  CPRBRC  CPRBRC  CPRBRC  CPRBRC  CPRBRC  CPRBRC  CPRBRC
TDS          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
Age          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
Tracer       OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
Coliform     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ISS1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
NH4          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
NO3          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
PSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
FE           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RDOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RPOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
BOD1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ALG1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ALG2         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ALG3         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
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             OFF     OFF     OFF     OFF     OFF     OFF     OFF
DO           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
TIC          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ALK          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ZOO1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ZOO2         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
ZOO3         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOMP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RDOMP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOMP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RPOMP        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOMN        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RDOMN        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOMN        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF
RPOMN        OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF

EX COEF    EXH2O    EXSS    EXOM    BETA     EXC    EXIC
WB 1     0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 2     0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 3     0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 4     0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 5     0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 6     0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 7     0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 8     0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 9     0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 10    0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 11    0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 12    0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 13    0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 14    0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 15    0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 16    0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 17    0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 18    0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 19    0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 20    0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 21    0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 22    0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 23    0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 24    0.25000 0.10000 0.10000 0.45000     OFF     OFF
WB 25    0.25000 0.10000 0.10000 0.45000     OFF     OFF

ALG EX       EXA     EXA     EXA     EXA     EXA     EXA     EXA     EXA     EXA
            0.20    0.20    0.20

ZOO EX       EXZ     EXZ     EXZ     EXZ     EXZ     EXZ     EXZ     EXZ     EXZ
             0.2     0.2     0.2

MACRO EX     EXM     EXM     EXM     EXM     EXM     EXM
          0.0100

GENERIC    CGQ10   CG0DK   CG1DK     CGS
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Age         0.00    -1.0     0.0     0.0
Tracer      0.00     0.0     0.0     0.0
Colform     1.04     0.0     0.5     0.0

S SOLIDS     SSS   SEDRC   TAUCR
SS# 1      1.000     OFF 1.0E-05

ALGAL RATE    AG      AR      AE      AM      AS    AHSP    AHSN   AHSSI    ASAT
ALG1     2.50000  0.0400 0.04000 0.08000 0.50000 0.00200 0.01400 0.00000 85.0000   diatoms
ALG2     2.50000  0.0400 0.04000 0.10000 0.05000 0.00300 0.01400 0.00000 36.0000   greens
ALG3     1.00000  0.1000 0.04000 0.08000 0.10000 0.00300 0.01400 0.00000 75.0000   cyanobacteria

ALGAL TEMP   AT1     AT2     AT3     AT4     AK1     AK2     AK3     AK4
ALG1     1.00000 10.0000 20.0000 28.0000 0.20000 0.99000 0.99000 0.10000
ALG2     1.00000 10.0000 20.0000 25.0000 0.20000 0.99000 0.99000 0.10000
ALG3     10.0000 33.0000 35.0000 40.0000 0.05000 0.99000 0.99000 0.10000

ALG STOI    ALGP    ALGN    ALGC   ALGSI   ACHLA   ALPOM   ANEQN    ANPR
ALG1     0.00300 0.03400 0.45000 0.32000   150.0 0.50000       2 0.00100
ALG2     0.00200 0.04000 0.53500 0.00000   150.0 0.50000       2 0.00100
ALG3     0.00800 0.08000 0.47500 0.00000   150.0 0.50000       2 0.00100

EPIPHYTE    EPIC    EPIC    EPIC    EPIC    EPIC    EPIC    EPIC    EPIC    EPIC
EPI1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF

EPI PRIN    EPRC    EPRC    EPRC    EPRC    EPRC    EPRC    EPRC    EPRC    EPRC
EPI1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF

EPI INIT   EPICI   EPICI   EPICI   EPICI   EPICI   EPICI   EPICI   EPICI   EPICI
EPI1     0.00300 0.00300 0.00300 0.00300 0.00300 0.00300 0.00300 0.00300 0.00300
         0.00300 0.00300 0.00300 0.00500 0.01000 0.00300 0.00300 0.00300 0.01000
         0.01000 0.01000 0.01000 0.01000 0.01000 0.00500 0.00500

EPI RATE      EG      ER      EE      EM      EB    EHSP    EHSN   EHSSI
EPI1     2.00000  0.0200 0.04000 0.05000 0.00100 0.00300 0.01400 0.00000

EPI HALF    ESAT     EHS   ENEQN    ENPR
EPI1     85.0000 15.0000       2 0.00100

EPI TEMP     ET1     ET2     ET3     ET4     EK1     EK2     EK3     EK4
EPI1     8.00000 10.0000 20.0000 30.0000 0.10000 0.99000 0.99000 0.10000

EPI STOI      EP      EN      EC     ESI   ECHLA    EPOM
EPI1     0.01000 0.04000 0.50000 0.00000 100.000 0.50000

ZOOP RATE   ZMAX   ZRESP   ZMORT  ZEFFIC   PREFP  ZOOMIN    ZS2P
            2.50   0.100    0.10    0.60    0.10  0.0010    0.30
            2.50   0.100    0.10    0.60    0.10  0.0010    0.50
            2.50   0.100    0.10    0.60    0.10  0.0010    0.30

ZOOP ALGP  PREFA   PREFA   PREFA   PREFA   PREFA   PREFA   PREFA   PREFA   PREFA
Zoo1        0.35    0.55    0.00
Zoo2        0.30    0.40    0.00
Zoo3        0.35    0.55    0.00

ZOOP ZOOP  PREFZ   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ
Zoo1        0.00    0.00    0.00
Zoo2        0.10    0.00    0.10
Zoo3        0.00    0.00    0.00

ZOOP TEMP  ZOOT1   ZOOT2   ZOOT3   ZOOT4   ZOOK1   ZOOK2   ZOOK3   ZOOK4
             1.0    10.0    25.0    36.0     0.3     0.9    0.98   0.200
             1.0    10.0    25.0    36.0     0.3     0.9    0.98   0.200
             1.0    10.0    25.0    36.0     0.3     0.9    0.98   0.200

ZOOP STO      ZP      ZN      ZC
         0.00700 0.08000 0.45000
         0.00700 0.08000 0.45000
         0.00700 0.08000 0.45000

MACROPHYT MACWBC  MACWBC  MACWBC  MACWBC  MACWBC  MACWBC  MACWBC  MACWBC  MACWBC
Mac1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF

MAC PRINT MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC
Mac1         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
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             OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
             OFF     OFF     OFF     OFF     OFF     OFF     OFF

MAC INI  MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI
Mac1     0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
         0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
         0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001

MAC RATE      MG      MR      MM    MSAT    MHSP    MHSN    MHSC    MPOM  LRPMAC
Mac 1       0.30    0.05    0.05    30.0     0.0     0.0     0.0     0.9     0.2

MAC SED     PSED    NSED
MAC 1        0.5     0.5

MAC DIST    MBMP    MMAX
Mac 1       40.0   500.0

MAC DRAG  CDSTEM     DWV    DMSA   ANORM
Mac 1        2.0     7e4    8.00    0.80

MAC TEMP     MT1     MT2     MT3     MT4     MK1     MK2     MK3     MK4
Mac 1        7.0    15.0    24.0    34.0     0.1    0.99    0.99    0.01

MAC STOICH    MP      MN      MC
Mac 1      0.005    0.08    0.45

DOM       LDOMDK  RDOMDK   LRDDK
WB 1     0.01000 0.00100 0.01000
WB 2     0.01000 0.00100 0.01000
WB 3     0.01000 0.00100 0.01000
WB 4     0.01000 0.00100 0.01000
WB 5     0.01000 0.00100 0.01000
WB 6     0.01000 0.00100 0.01000
WB 7     0.01000 0.00100 0.01000
WB 8     0.01000 0.00100 0.01000
WB 9     0.01000 0.00100 0.01000
WB 10    0.01000 0.00100 0.01000
WB 11    0.01000 0.00100 0.01000
WB 12    0.01000 0.00100 0.01000
WB 13    0.01000 0.00100 0.01000
WB 14    0.01000 0.00100 0.01000
WB 15    0.01000 0.00100 0.01000
WB 16    0.01000 0.00100 0.01000
WB 17    0.01000 0.00100 0.01000
WB 18    0.10000 0.00100 0.01000
WB 19    0.10000 0.00100 0.01000
WB 20    0.10000 0.00100 0.01000
WB 21    0.10000 0.00100 0.01000
WB 22    0.10000 0.00100 0.01000
WB 23    0.10000 0.00100 0.01000
WB 24    0.01000 0.00100 0.01000
WB 25    0.01000 0.00100 0.01000

POM       LPOMDK  RPOMDK   LRPDK    POMS
WB 1     0.05000 0.00500 0.01000 0.10000
WB 2     0.05000 0.00500 0.01000 0.10000
WB 3     0.05000 0.00500 0.01000 0.10000
WB 4     0.05000 0.00500 0.01000 0.10000
WB 5     0.05000 0.00500 0.01000 0.10000
WB 6     0.05000 0.00500 0.01000 0.10000
WB 7     0.05000 0.00500 0.01000 0.10000
WB 8     0.05000 0.00500 0.01000 0.10000
WB 9     0.05000 0.00500 0.01000 0.10000
WB 10    0.05000 0.00500 0.01000 0.10000
WB 11    0.05000 0.00500 0.01000 0.10000
WB 12    0.05000 0.00500 0.01000 0.10000
WB 13    0.05000 0.00500 0.01000 0.10000
WB 14    0.05000 0.00500 0.01000 0.10000
WB 15    0.05000 0.00500 0.01000 0.10000
WB 16    0.05000 0.00500 0.01000 0.10000
WB 17    0.05000 0.00500 0.01000 0.10000
WB 18    0.25000 0.00500 0.01000 0.10000
WB 19    0.25000 0.00500 0.01000 0.10000
WB 20    0.25000 0.00500 0.01000 0.10000
WB 21    0.25000 0.00500 0.01000 0.10000
WB 22    0.25000 0.00500 0.01000 0.10000
WB 23    0.25000 0.00500 0.01000 0.10000
WB 24    0.05000 0.00500 0.01000 0.10000
WB 25    0.05000 0.00500 0.01000 0.10000

OM STOIC    ORGP    ORGN    ORGC   ORGSI
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WB 1      0.00500 0.05000 0.45000 0.18000
WB 2      0.00500 0.05000 0.45000 0.18000
WB 3      0.00500 0.05000 0.45000 0.18000
WB 4      0.00500 0.05000 0.45000 0.18000
WB 5      0.00500 0.05000 0.45000 0.18000
WB 6      0.00500 0.05000 0.45000 0.18000
WB 7      0.00500 0.05000 0.45000 0.18000
WB 8      0.00500 0.05000 0.45000 0.18000
WB 9      0.00500 0.05000 0.45000 0.18000
WB 10     0.00500 0.05000 0.45000 0.18000
WB 11     0.00500 0.05000 0.45000 0.18000
WB 12     0.00500 0.05000 0.45000 0.18000
WB 13     0.00500 0.05000 0.45000 0.18000
WB 14     0.00500 0.05000 0.45000 0.18000
WB 15     0.00500 0.05000 0.45000 0.18000
WB 16     0.00500 0.05000 0.45000 0.18000
WB 17     0.00500 0.05000 0.45000 0.18000
WB 18     0.00500 0.05000 0.45000 0.18000
WB 19     0.00500 0.05000 0.45000 0.18000
WB 20     0.00500 0.05000 0.45000 0.18000
WB 21     0.00500 0.05000 0.45000 0.18000
WB 22     0.00500 0.05000 0.45000 0.18000
WB 23     0.00500 0.05000 0.45000 0.18000
WB 24     0.00500 0.05000 0.45000 0.18000
WB 25     0.00500 0.05000 0.45000 0.18000

OM RATE      OMT1    OMT2    OMK1    OMK2
WB 1      4.00000 30.0000 0.10000 0.99000
WB 2      4.00000 30.0000 0.10000 0.99000
WB 3      4.00000 30.0000 0.10000 0.99000
WB 4      4.00000 30.0000 0.10000 0.99000
WB 5      4.00000 30.0000 0.10000 0.99000
WB 6      4.00000 30.0000 0.10000 0.99000
WB 7      4.00000 30.0000 0.10000 0.99000
WB 8      4.00000 30.0000 0.10000 0.99000
WB 9      4.00000 30.0000 0.10000 0.99000
WB 10     4.00000 30.0000 0.10000 0.99000
WB 11     4.00000 30.0000 0.10000 0.99000
WB 12     4.00000 30.0000 0.10000 0.99000
WB 13     4.00000 30.0000 0.10000 0.99000
WB 14     4.00000 30.0000 0.10000 0.99000
WB 15     4.00000 30.0000 0.10000 0.99000
WB 16     4.00000 30.0000 0.10000 0.99000
WB 17     4.00000 30.0000 0.10000 0.99000
WB 18     4.00000 30.0000 0.10000 0.99000
WB 19     4.00000 30.0000 0.10000 0.99000
WB 20     4.00000 30.0000 0.10000 0.99000
WB 21     4.00000 30.0000 0.10000 0.99000
WB 22     4.00000 30.0000 0.10000 0.99000
WB 23     4.00000 30.0000 0.10000 0.99000
WB 24     4.00000 30.0000 0.10000 0.99000
WB 25     4.00000 30.0000 0.10000 0.99000

CBOD         KBOD    TBOD    RBOD   CBODS
BOD 1     0.25080 1.01470 1.85000     0.0

CBOD STOIC   BODP    BODN    BODC
BOD 1     0.00400 0.06000 0.32000

PHOSPHOR     PO4R   PARTP
WB 1      0.00100 0.20000
WB 2      0.00100 0.20000
WB 3      0.00100 0.20000
WB 4      0.00100 0.20000
WB 5      0.00100 0.20000
WB 6      0.00100 0.20000
WB 7      0.00100 0.20000
WB 8      0.00100 0.20000
WB 9      0.00100 0.20000
WB 10     0.00100 0.20000
WB 11     0.00100 0.20000
WB 12     0.00100 0.20000
WB 13     0.00100 0.20000
WB 14     0.00100 0.20000
WB 15     0.00100 0.20000
WB 16     0.00100 0.20000
WB 17     0.00100 0.20000
WB 18     0.00100 0.20000
WB 19     0.00100 0.20000
WB 20     0.00100 0.20000
WB 21     0.00100 0.20000
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WB 22    0.00100 0.20000
WB 23    0.00100 0.20000
WB 24    0.00100 0.20000
WB 25    0.00100 0.20000

AMMONIUM    NH4R   NH4DK
WB 1     0.00100 0.12000
WB 2     0.00100 0.12000
WB 3     0.00100 0.12000
WB 4     0.00100 0.12000
WB 5     0.00100 0.12000
WB 6     0.00100 0.12000
WB 7     0.00100 0.12000
WB 8     0.00100 0.12000
WB 9     0.00100 0.12000
WB 10    0.00100 0.12000
WB 11    0.00100 0.12000
WB 12    0.00100 0.12000
WB 13    0.00100 0.12000
WB 14    0.00100 0.12000
WB 15    0.00100 0.12000
WB 16    0.00100 0.12000
WB 17    0.00100 0.12000
WB 18    0.00100 0.12000
WB 19    0.00100 0.12000
WB 20    0.00100 0.12000
WB 21    0.00100 0.12000
WB 22    0.00100 0.12000
WB 23    0.00100 0.12000
WB 24    0.00100 0.12000
WB 25    0.00100 0.12000

NH4 RATE   NH4T1   NH4T2   NH4K1   NH4K2
WB 1     5.00000 25.0000 0.10000 0.99000
WB 2     5.00000 25.0000 0.10000 0.99000
WB 3     5.00000 25.0000 0.10000 0.99000
WB 4     5.00000 25.0000 0.10000 0.99000
WB 5     5.00000 25.0000 0.10000 0.99000
WB 6     5.00000 25.0000 0.10000 0.99000
WB 7     5.00000 25.0000 0.10000 0.99000
WB 8     5.00000 25.0000 0.10000 0.99000
WB 9     5.00000 25.0000 0.10000 0.99000
WB 10    5.00000 25.0000 0.10000 0.99000
WB 11    5.00000 25.0000 0.10000 0.99000
WB 12    5.00000 25.0000 0.10000 0.99000
WB 13    5.00000 25.0000 0.10000 0.99000
WB 14    5.00000 25.0000 0.10000 0.99000
WB 15    5.00000 25.0000 0.10000 0.99000
WB 16    5.00000 25.0000 0.10000 0.99000
WB 17    5.00000 25.0000 0.10000 0.99000
WB 18    5.00000 25.0000 0.10000 0.99000
WB 19    5.00000 25.0000 0.10000 0.99000
WB 20    5.00000 25.0000 0.10000 0.99000
WB 21    5.00000 25.0000 0.10000 0.99000
WB 22    5.00000 25.0000 0.10000 0.99000
WB 23    5.00000 25.0000 0.10000 0.99000
WB 24    5.00000 25.0000 0.10000 0.99000
WB 25    5.00000 25.0000 0.10000 0.99000

NITRATE    NO3DK    NO3S
WB 1     0.03000 1.00000
WB 2     0.03000 1.00000
WB 3     0.03000 1.00000
WB 4     0.03000 1.00000
WB 5     0.03000 1.00000
WB 6     0.03000 1.00000
WB 7     0.03000 1.00000
WB 8     0.03000 1.00000
WB 9     0.03000 1.00000
WB 10    0.03000 1.00000
WB 11    0.03000 1.00000
WB 12    0.03000 1.00000
WB 13    0.03000 1.00000
WB 14    0.03000 1.00000
WB 15    0.03000 1.00000
WB 16    0.03000 1.00000
WB 17    0.03000 1.00000
WB 18    0.03000 1.00000
WB 19    0.03000 1.00000
WB 20    0.03000 1.00000
WB 21    0.03000 1.00000
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WB 22    0.03000 1.00000
WB 23    0.03000 1.00000
WB 24    0.03000 1.00000
WB 25    0.03000 1.00000

NO3 RATE   NO3T1   NO3T2   NO3K1   NO3K2
WB 1     5.00000 25.0000 0.10000 0.99000
WB 2     5.00000 25.0000 0.10000 0.99000
WB 3     5.00000 25.0000 0.10000 0.99000
WB 4     5.00000 25.0000 0.10000 0.99000
WB 5     5.00000 25.0000 0.10000 0.99000
WB 6     5.00000 25.0000 0.10000 0.99000
WB 7     5.00000 25.0000 0.10000 0.99000
WB 8     5.00000 25.0000 0.10000 0.99000
WB 9     5.00000 25.0000 0.10000 0.99000
WB 10    5.00000 25.0000 0.10000 0.99000
WB 11    5.00000 25.0000 0.10000 0.99000
WB 12    5.00000 25.0000 0.10000 0.99000
WB 13    5.00000 25.0000 0.10000 0.99000
WB 14    5.00000 25.0000 0.10000 0.99000
WB 15    5.00000 25.0000 0.10000 0.99000
WB 16    5.00000 25.0000 0.10000 0.99000
WB 17    5.00000 25.0000 0.10000 0.99000
WB 18    5.00000 25.0000 0.10000 0.99000
WB 19    5.00000 25.0000 0.10000 0.99000
WB 20    5.00000 25.0000 0.10000 0.99000
WB 21    5.00000 25.0000 0.10000 0.99000
WB 22    5.00000 25.0000 0.10000 0.99000
WB 23    5.00000 25.0000 0.10000 0.99000
WB 24    5.00000 25.0000 0.10000 0.99000
WB 25    5.00000 25.0000 0.10000 0.99000

SILICA      DSIR    PSIS   PSIDK  PARTSI
WB 1     0.10000 0.00000 0.30000 0.20000
WB 2     0.10000 0.00000 0.30000 0.20000
WB 3     0.10000 0.00000 0.30000 0.20000
WB 4     0.10000 0.00000 0.30000 0.20000
WB 5     0.10000 0.00000 0.30000 0.20000
WB 6     0.10000 0.00000 0.30000 0.20000
WB 7     0.10000 0.00000 0.30000 0.20000
WB 8     0.10000 0.00000 0.30000 0.20000
WB 9     0.10000 0.00000 0.30000 0.20000
WB 10    0.10000 0.00000 0.30000 0.20000
WB 11    0.10000 0.00000 0.30000 0.20000
WB 12    0.10000 0.00000 0.30000 0.20000
WB 13    0.10000 0.00000 0.30000 0.20000
WB 14    0.10000 0.00000 0.30000 0.20000
WB 15    0.10000 0.00000 0.30000 0.20000
WB 16    0.10000 0.00000 0.30000 0.20000
WB 17    0.10000 0.00000 0.30000 0.20000
WB 18    0.10000 0.00000 0.30000 0.20000
WB 19    0.10000 0.00000 0.30000 0.20000
WB 20    0.10000 0.00000 0.30000 0.20000
WB 21    0.10000 0.00000 0.30000 0.20000
WB 22    0.10000 0.00000 0.30000 0.20000
WB 23    0.10000 0.00000 0.30000 0.20000
WB 24    0.10000 0.00000 0.30000 0.20000
WB 25    0.10000 0.00000 0.30000 0.20000

IRON         FER     FES
WB 1     0.05000 2.00000
WB 2     0.05000 2.00000
WB 3     0.05000 2.00000
WB 4     0.05000 2.00000
WB 5     0.05000 2.00000
WB 6     0.05000 2.00000
WB 7     0.05000 2.00000
WB 8     0.05000 2.00000
WB 9     0.05000 2.00000
WB 10    0.05000 2.00000
WB 11    0.05000 2.00000
WB 12    0.05000 2.00000
WB 13    0.05000 2.00000
WB 14    0.05000 2.00000
WB 15    0.05000 2.00000
WB 16    0.05000 2.00000
WB 17    0.05000 2.00000
WB 18    0.05000 2.00000
WB 19    0.05000 2.00000
WB 20    0.05000 2.00000
WB 21    0.05000 2.00000
```

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WB 22    0.05000 2.00000
WB 23    0.05000 2.00000
WB 24    0.05000 2.00000
WB 25    0.05000 2.00000

SED CO2     CO2R
WB 1     0.10000
WB 2     0.10000
WB 3     0.10000
WB 4     0.10000
WB 5     0.10000
WB 6     0.10000
WB 7     0.10000
WB 8     0.10000
WB 9     0.10000
WB 10    0.10000
WB 11    0.10000
WB 12    0.10000
WB 13    0.10000
WB 14    0.10000
WB 15    0.10000
WB 16    0.10000
WB 17    0.10000
WB 18    0.10000
WB 19    0.10000
WB 20    0.10000
WB 21    0.10000
WB 22    0.10000
WB 23    0.10000
WB 24    0.10000
WB 25    0.10000

STOICH 1   O2NH4    O2OM
WB 1     4.57000 1.40000
WB 2     4.57000 1.40000
WB 3     4.57000 1.40000
WB 4     4.57000 1.40000
WB 5     4.57000 1.40000
WB 6     4.57000 1.40000
WB 7     4.57000 1.40000
WB 8     4.57000 1.40000
WB 9     4.57000 1.40000
WB 10    4.57000 1.40000
WB 11    4.57000 1.40000
WB 12    4.57000 1.40000
WB 13    4.57000 1.40000
WB 14    4.57000 1.40000
WB 15    4.57000 1.40000
WB 16    4.57000 1.40000
WB 17    4.57000 1.40000
WB 18    4.57000 1.40000
WB 19    4.57000 1.40000
WB 20    4.57000 1.40000
WB 21    4.57000 1.40000
WB 22    4.57000 1.40000
WB 23    4.57000 1.40000
WB 24    4.57000 1.40000
WB 25    4.57000 1.40000

STOICH 2    O2AR    O2AG
ALG1     1.10000 1.40000
ALG2     1.10000 1.40000
ALG3     1.10000 1.40000

STOICH 3    O2ER    O2EG
EPI1     1.10000 1.40000

STOICH 4    O2ZR
ZOO1        1.11
ZOO2        1.12
ZOO3        1.13

STOICH 5    O2MR    O2MG
MAC1         1.1     1.4

O2 LIMIT     KDO
         0.10000

SEDIMENT    SEDC  SEDPRC   SEDCI    SEDK    SEDS    FSOD    FSED
WB 1         OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 2         OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
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WB 3         OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 4         OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 5         OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 6         OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 7         OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 8         OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 9         OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 10        OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 11        OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 12        OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 13        OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 14        OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 15        OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 16        OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 17        OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 18        OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 19        OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 20        OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 21        OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 22        OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 23        OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 24        OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000
WB 25        OFF     OFF 0.00000 0.10000 0.10000 1.00000 1.00000

SOD RATE   SODT1   SODT2   SODK1   SODK2
WB 1     4.00000 30.0000 0.10000 0.99000
WB 2     4.00000 30.0000 0.10000 0.99000
WB 3     4.00000 30.0000 0.10000 0.99000
WB 4     4.00000 30.0000 0.10000 0.99000
WB 5     4.00000 30.0000 0.10000 0.99000
WB 6     4.00000 30.0000 0.10000 0.99000
WB 7     4.00000 30.0000 0.10000 0.99000
WB 8     4.00000 30.0000 0.10000 0.99000
WB 9     4.00000 30.0000 0.10000 0.99000
WB 10    4.00000 30.0000 0.10000 0.99000
WB 11    4.00000 30.0000 0.10000 0.99000
WB 12    4.00000 30.0000 0.10000 0.99000
WB 13    4.00000 30.0000 0.10000 0.99000
WB 14    4.00000 30.0000 0.10000 0.99000
WB 15    4.00000 30.0000 0.10000 0.99000
WB 16    4.00000 30.0000 0.10000 0.99000
WB 17    4.00000 30.0000 0.10000 0.99000
WB 18    4.00000 30.0000 0.25000 0.99000
WB 19    4.00000 30.0000 0.25000 0.99000
WB 20    4.00000 30.0000 0.25000 0.99000
WB 21    4.00000 30.0000 0.25000 0.99000
WB 22    4.00000 30.0000 0.25000 0.99000
WB 23    4.00000 30.0000 0.25000 0.99000
WB 24    4.00000 30.0000 0.10000 0.99000
WB 25    4.00000 30.0000 0.10000 0.99000

S DEMAND     SOD     SOD     SOD     SOD     SOD     SOD     SOD     SOD     SOD
            0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10
            0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10
            0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10
            0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10
            0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10
            0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10
            0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10
            0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10
            0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10
            0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
```

```
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   314
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.50
            0.50    0.50    0.50    0.50    0.50    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20
            0.20    0.20    0.20    0.20    0.20    0.20    0.20

REAERATION  TYPE    EQN#   COEF1   COEF2   COEF3   COEF4
WB 1        LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 2        LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 3        LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 4        LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 5        LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 6        LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 7        LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 8        LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 9        LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 10       LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 11       LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 12       LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 13       LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 14       LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 15       LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 16       LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 17       LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 18       LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 19       LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 20       LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 21       LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 22       LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 23       LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 24       LAKE      12 0.00000 0.00000 0.00000 0.00000
WB 25       LAKE      12 0.00000 0.00000 0.00000 0.00000

RSI FILE..................................RSIFN.................................
        rso500.npt

QWD FILE..................................QWDFN.................................
        qwd_irrigationq.npt

QGT FILE..................................QGTFN.................................
        qgt_gcl.npt

WSC FILE..................................WSCFN.................................
        wsc_r123.npt

SHD FILE..................................SHDFN.................................
        shade_topo1.npt

BTH FILE..................................BTHFN.................................
WB 1    bth1_2m_e4.npt
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WB 2    bth2_2m_r56b.npt
WB 3    bth3_2m_e2.npt
WB 4    bth4_2m_r56b.npt
WB 5    bth5_2m_r56b.npt
WB 6    bth6_2m_r56b.npt
WB 7    bth7_2m_r56b.npt
WB 8    bth8_2m_e.npt
WB 9    bth9_2m_e.npt
WB 10   bth10_2m_e.npt
WB 11   bth11_2m_e_mann1.npt
WB 12   bth12_2m_e_mann1.npt
WB 13   bth13_2m_e_mann1.npt
WB 14   bth14_2m_e_mann1.npt
WB 15   bth15_kettle_2m_r53wq.npt
WB 16   bth16_marcus_2m_e.npt
WB 17   bth17_colville_2m_r56b.npt
WB 18   bth18_spokane_2m_e9.npt
WB 19   bth19_spokane_2m_e9.npt
WB 20   bth20_spokane_2m_e9.npt
WB 21   bth21_spokane_2m_e9.npt
WB 22   bth22_spokane_2m_e9.npt
WB 23   bth23_spokane_2m_e.npt
WB 24   bth24_hawk_2m_e.npt
WB 25   bth25_sanpoil_2m_e.npt

MET FILE.................................METFN.................................
WB 1    nmet_kflw_est_wb1.npt
WB 2    nmet_kflw_est_wb2.npt
WB 3    nmet_kflw_est_wb3.npt
WB 4    nmet_kflw_est_wb4.npt
WB 5    nmet_kflw_est_wb5.npt
WB 6    nmet_kflw_est_wb6.npt
WB 7    nmet_kflw_est_wb7.npt
WB 8    nmet_kflw_est_wb8.npt
WB 9    nmet_kflw_est_wb9.npt
WB 10   nmet_kflw_est_wb10.npt
WB 11   nmet_kflw_est_wb11.npt
WB 12   nmet_kflw_est_wb12.npt
WB 13   nmet_sbmw_est_wb13.npt
WB 14   nmet_gcgw_est_wb14.npt
WB 15   nmet_kflw_est_wb15.npt
WB 16   nmet_kflw_est_wb16.npt
WB 17   nmet_kflw_est_wb17.npt
WB 18   nmet_sbmw_est_wb18.npt
WB 19   nmet_sbmw_est_wb19.npt
WB 20   nmet_sbmw_est_wb20.npt
WB 21   nmet_sbmw_est_wb21.npt
WB 22   nmet_sbmw_est_wb22.npt
WB 23   nmet_sbmw_est_wb23.npt
WB 24   nmet_gcgw_est_wb24.npt
WB 25   nmet_gcgw_est_wb25.npt

EXT FILE.................................EXTFN.................................
WB 1    ext_photic_wb1.npt
WB 2    ext_photic_wb2.npt
WB 3    ext_photic_wb3.npt
WB 4    ext_photic_wb4.npt
WB 5    ext_photic_wb5.npt
WB 6    ext_photic_wb6.npt
WB 7    ext_photic_wb7.npt
WB 8    ext_photic_wb8.npt
WB 9    ext_photic_wb9.npt
WB 10   ext_photic_wb10.npt
WB 11   ext_photic_wb11.npt
WB 12   ext_photic_wb12.npt
WB 13   ext_photic_wb13.npt
WB 14   ext_photic_wb14.npt
WB 15   ext_photic_wb15.npt
WB 16   ext_photic_wb16.npt
WB 17   ext_photic_wb17.npt
WB 18   ext_spokane18.npt
WB 19   ext_spokane19.npt
WB 20   ext_spokane20.npt
WB 21   ext_spokane21.npt
WB 22   ext_spokane22.npt
WB 23   ext_spokane23.npt
WB 24   ext_photic_wb24.npt
WB 25   ext_photic_wb25.npt

VPR FILE.................................VPRFN.................................
WB 1    vpr00wb1.npt
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WB 2    vpr00wb2.npt
WB 3    vpr00wb3.npt
WB 4    vpr00wb4.npt
WB 5    vpr00wb5.npt
WB 6    vpr00wb6.npt
WB 7    vpr00wb7.npt
WB 8    vpr00wb8.npt
WB 9    vpr00wb9.npt
WB 10   vpr00wb10.npt
WB 11   vpr00wb11.npt
WB 12   vpr00wb12.npt
WB 13   vpr00wb13.npt
WB 14   vpr00wb14.npt
WB 15   vpr00wb15.npt
WB 16   vpr00wb16.npt
WB 17   vpr00wb17.npt
WB 18   vpr00wb18.npt
WB 19   vpr00wb19.npt
WB 20   vpr00wb20.npt
WB 21   vpr00wb21.npt
WB 22   vpr00wb22.npt
WB 23   vpr00wb23.npt
WB 24   vpr00wb24.npt
WB 25   vpr00wb25.npt

LPR FILE..................................LPRFN.................................
WB 1    lpr_wb01.npt
WB 2    lpr_wb02.npt
WB 3    lpr_wb03.npt
WB 4    lpr_wb04.npt
WB 5    lpr_wb05.npt
WB 6    lpr_wb06.npt
WB 7    lpr_wb07.npt
WB 8    lpr_wb08.npt
WB 9    lpr_wb09.npt
WB 10   lpr_wb10.npt
WB 11   lpr_wb11.npt
WB 12   lpr_wb12.npt
WB 13   lpr_wb13.npt
WB 14   lpr_wb14.npt
WB 15   lpr_wb15.npt
WB 16   lpr_wb16.npt
WB 17   lpr_wb17.npt
WB 18   lpr_wb18.npt
WB 19   lpr_wb19.npt
WB 20   lpr_wb20.npt
WB 21   lpr_wb21.npt
WB 22   lpr_wb22.npt
WB 23   lpr_wb23.npt
WB 24   lpr_wb24.npt
WB 25   lpr_wb25.npt

QIN FILE..................................QINFN.................................
BR1     qin_usbc99_adj1.npt
BR2     qin_br2.npt
BR3     qin_br3.npt
BR4     qin_br4.npt
BR5     qin_br5.npt
BR6     qin_br6.npt
BR7     qin_br7.npt
BR8     qin_br8.npt
BR9     qin_br9.npt
BR10    qin_br10.npt
BR11    qin_br11.npt
BR12    qin_br12.npt
BR13    qin_br13.npt
BR14    qin_br14.npt
BR15    qin_kettle99.npt
BR16    qin_marcus99.npt
BR17    qin_colville_censored.npt
BR18    qin_spokane_avista.npt
BR19    qin_br16.npt
BR20    qin_br17.npt
BR21    qin_br18.npt
BR22    qin_br19.npt
BR23    qin_br20.npt
BR24    qin_hawk99.npt
BR25    qin_sanpoil99.npt

TIN FILE..................................TINFN.................................
BR1     tin_usbc_censored_2000.npt
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BR2     tin_br2.npt
BR3     tin_br3.npt
BR4     tin_br4.npt
BR5     tin_br5.npt
BR6     tin_br6.npt
BR7     tin_br7.npt
BR8     tin_br8.npt
BR9     tin_br9.npt
BR10    tin_br10.npt
BR11    tin_br11.npt
BR12    tin_br12.npt
BR13    tin_br13.npt
BR14    tin_br14.npt
BR15    tin_kettle99.npt
BR16    tin_marcus99.npt
BR17    tin_colville_censored99.npt
BR18    tin_spokane_minT.npt
BR19    tin_br19.npt
BR20    tin_br20.npt
BR21    tin_br21.npt
BR22    tin_br22.npt
BR23    tin_br23.npt
BR24    tin_hawk99.npt
BR25    tin_sanpoil99.npt

CIN FILE..................................CINFN.................................
BR1     cin_columbia_r121.npt
BR2     cin_temp2.npt
BR3     cin_temp3.npt
BR4     cin_temp4.npt
BR5     cin_temp5.npt
BR6     cin_temp6.npt
BR7     cin_temp7.npt
BR8     cin_temp8.npt
BR9     cin_temp9.npt
BR10    cin_temp10.npt
BR11    cin_temp11.npt
BR12    cin_temp12.npt
BR13    cin_temp13.npt
BR14    cin_temp14.npt
BR15    cin_kettle1.npt
BR16    cin_temp16.npt
BR17    cin_colville1.npt
BR18    cin_spokane_r121.npt
BR19    cin_temp19.npt
BR20    cin_temp20.npt
BR21    cin_temp21.npt
BR22    cin_temp22.npt
BR23    cin_temp23.npt
BR24    cin_temp24.npt
BR25    cin_sanpoil1.npt

QOT FILE..................................QOTFN.................................
BR1     qot_br1.npt
BR2     qot_br2.npt
BR3     qot_br3.npt
BR4     qot_br4.npt
BR5     qot_br5.npt
BR6     qot_br6.npt
BR7     qot_br7.npt
BR8     qot_br8.npt
BR9     qot_br9.npt
BR10    qot_br10.npt
BR11    qot_br11.npt
BR12    qot_br12.npt
BR13    qot_br13.npt
BR14    qot_gcl_4structures.npt
BR15    qot_br15.npt
BR16    qot_br16.npt
BR17    qot_br17.npt
BR18    qot_br18.npt
BR19    qot_br19.npt
BR20    qot_br20.npt
BR21    qot_br21.npt
BR22    qot_br22.npt
BR23    qot_br23.npt
BR24    qot_br24.npt
BR25    qot_br25.npt

QTR FILE..................................QTRFN.................................
TR1     qtr_returnq.npt
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TTR FILE..................................TTRFN.................................
TR1     ttr_banks99.npt

CTR FILE..................................CTRFN.................................
TR1     ctr_usbc_banks.npt

QDT FILE..................................QDTFN.................................
BR1     qdt_br1.npt
BR2     qdt_br2.npt
BR3     qdt_br3.npt
BR4     qdt_br4.npt
BR5     qdt_br5.npt
BR6     qdt_br6.npt
BR7     qdt_br7.npt
BR8     qdt_br8.npt
BR9     qdt_br9.npt
BR10    qdt_br10.npt
BR11    qdt_br11.npt
BR12    qdt_br12.npt
BR13    qdt_br13.npt
BR14    qdt_br14.npt
BR15    qdt_br15.npt
BR16    qdt_br16.npt
BR17    qdt_br17.npt
BR18    qdt_br18.npt
BR19    qdt_br19.npt
BR20    qdt_br20.npt
BR21    qdt_br21.npt
BR22    qdt_br22.npt
BR23    qdt_br23.npt
BR24    qdt_br24.npt
BR25    qdt_br25.npt

TDT FILE..................................TDTFN.................................
BR1     tdt_br1.npt
BR2     tdt_br2.npt
BR3     tdt_br3.npt
BR4     tdt_br4.npt
BR5     tdt_br5.npt
BR6     tdt_br6.npt
BR7     tdt_br7.npt
BR8     tdt_br8.npt
BR9     tdt_br9.npt
BR10    tdt_br10.npt
BR11    tdt_br11.npt
BR12    tdt_br12.npt
BR13    tdt_br13.npt
BR14    tdt_br14.npt
BR15    tdt_br15.npt
BR16    tdt_br16.npt
BR17    tdt_br17.npt
BR18    tdt_br18.npt
BR19    tdt_br19.npt
BR20    tdt_br20.npt
BR21    tdt_br21.npt
BR22    tdt_br22.npt
BR23    tdt_br23.npt
BR24    tdt_br24.npt
BR25    tdt_br25.npt

CDT FILE..................................CDTFN.................................
BR1     cdt_usbc1.npt
BR2     cdt_usbc2.npt
BR3     cdt_usbc3.npt
BR4     cdt_usbc4.npt
BR5     cdt_usbc5.npt
BR6     cdt_usbc6.npt
BR7     cdt_usbc7.npt
BR8     cdt_usbc8.npt
BR9     cdt_usbc9.npt
BR10    cdt_usbc10.npt
BR11    cdt_usbc11.npt
BR12    cdt_usbc12.npt
BR13    cdt_usbc13.npt
BR14    cdt_usbc14.npt
BR15    cdt_br15.npt
BR16    cdt_br16.npt
BR17    cdt_br17.npt
BR18    cdt_br18.npt
BR19    cdt_br19.npt
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BR20    cdt_br20.npt
BR21    cdt_br21.npt
BR22    cdt_br22.npt
BR23    cdt_br23.npt
BR24    cdt_br24.npt
BR25    cdt_br25.npt

PRE FILE..................................PREFN................................
BR1     pre_br1.npt - not used
BR2     pre_br2.npt - not used
BR3     pre_br3.npt - not used
BR4     pre_br4.npt - not used
BR5     pre_br5.npt - not used
BR6     pre_br6.npt - not used
BR7     pre_br7.npt - not used
BR8     pre_br8.npt - not used
BR9     pre_br9.npt - not used
BR10    pre_br10.npt - not used
BR11    pre_br11.npt - not used
BR12    pre_br12.npt - not used
BR13    pre_br13.npt - not used
BR14    pre_br14.npt - not used
BR15    pre_br14.npt - not used
BR16    pre_br16.npt - not used
BR17    pre_br17.npt - not used
BR18    pre_br18.npt - not used
BR19    pre_br19.npt - not used
BR20    pre_br20.npt - not used
BR21    pre_br21.npt - not used
BR22    pre_br22.npt - not used
BR23    pre_br23.npt - not used
BR24    pre_br24.npt - not used
BR25    pre_br25.npt - not used

TPR FILE..................................TPRFN................................
BR1     tpr_br1.npt - not used
BR2     tpr_br2.npt - not used
BR3     tpr_br3.npt - not used
BR4     tpr_br4.npt - not used
BR5     tpr_br5.npt - not used
BR6     tpr_br6.npt - not used
BR7     tpr_br7.npt - not used
BR8     tpr_br8.npt - not used
BR9     tpr_br9.npt - not used
BR10    tpr_br10.npt - not used
BR11    tpr_br11.npt - not used
BR12    tpr_br12.npt - not used
BR13    tpr_br13.npt - not used
BR14    tpr_br14.npt - not used
BR15    tpr_br14.npt - not used
BR16    tpr_br16.npt - not used
BR17    tpr_br17.npt - not used
BR18    tpr_br18.npt - not used
BR19    tpr_br19.npt - not used
BR20    tpr_br20.npt - not used
BR21    tpr_br21.npt - not used
BR22    tpr_br22.npt - not used
BR23    tpr_br23.npt - not used
BR24    tpr_br24.npt - not used
BR25    tpr_br25.npt - not used

CPR FILE..................................CPRFN................................
BR1     cpr_br1.npt - not used
BR2     cpr_br2.npt - not used
BR3     cpr_br3.npt - not used
BR4     cpr_br4.npt - not used
BR5     cpr_br5.npt - not used
BR6     cpr_br6.npt - not used
BR7     cpr_br7.npt - not used
BR8     cpr_br8.npt - not used
BR9     cpr_br9.npt - not used
BR10    cpr_br10.npt - not used
BR11    cpr_br11.npt - not used
BR12    cpr_br12.npt - not used
BR13    cpr_br13.npt - not used
BR14    cpr_br14.npt - not used
BR15    cpr_br14.npt - not used
BR16    cpr_br16.npt - not used
BR17    cpr_br17.npt - not used
BR18    cpr_br18.npt - not used
BR19    cpr_br19.npt - not used
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BR20    cpr_br20.npt - not used
BR21    cpr_br21.npt - not used
BR22    cpr_br22.npt - not used
BR23    cpr_br23.npt - not used
BR24    cpr_br24.npt - not used
BR25    cpr_br25.npt - not used

EUH FILE..................................EUHFN.................................
BR1     euh_br1.npt
BR2     euh_br2.npt
BR3     euh_br3.npt
BR4     euh_br4.npt
BR5     euh_br5.npt
BR6     euh_br6.npt
BR7     euh_br7.npt
BR8     euh_br8.npt
BR9     euh_br9.npt
BR10    euh_br10.npt
BR11    euh_br11.npt
BR12    euh_br12.npt
BR13    euh_br13.npt
BR14    euh_br14.npt
BR15    euh_br15.npt
BR16    euh_br16.npt
BR17    euh_br17.npt
BR18    euh_br18.npt
BR19    euh_br19.npt
BR20    euh_br20.npt
BR21    euh_br21.npt
BR22    euh_br22.npt
BR23    euh_br23.npt
BR24    euh_br24.npt
BR25    euh_br25.npt

TUH FILE..................................TUHFN.................................
BR1     tuh_br1.npt
BR2     tuh_br2.npt
BR3     tuh_br3.npt
BR4     tuh_br4.npt
BR5     tuh_br5.npt
BR6     tuh_br6.npt
BR7     tuh_br7.npt
BR8     tuh_br8.npt
BR9     tuh_br9.npt
BR10    tuh_br10.npt
BR11    tuh_br11.npt
BR12    tuh_br12.npt
BR13    tuh_br13.npt
BR14    tuh_br14.npt
BR15    tuh_br15.npt
BR16    tuh_br16.npt
BR17    tuh_br17.npt
BR18    tuh_br18.npt
BR19    tuh_br19.npt
BR20    tuh_br20.npt
BR21    tuh_br21.npt
BR22    tuh_br22.npt
BR23    tuh_br23.npt
BR24    tuh_br24.npt
BR25    tuh_br25.npt

CUH FILE..................................CUHFN.................................
BR1     cuh_br1.npt
BR2     cuh_br2.npt
BR3     cuh_br3.npt
BR4     cuh_br4.npt
BR5     cuh_br5.npt
BR6     cuh_br6.npt
BR7     cuh_br7.npt
BR8     cuh_br8.npt
BR9     cuh_br9.npt
BR10    cuh_br10.npt
BR11    cuh_br11.npt
BR12    cuh_br12.npt
BR13    cuh_br13.npt
BR14    cuh_br14.npt
BR15    cuh_br15.npt
BR16    cuh_br16.npt
BR17    cuh_br17.npt
BR18    cuh_br18.npt
BR19    cuh_br19.npt
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BR20    cuh_br20.npt
BR21    cuh_br21.npt
BR22    cuh_br22.npt
BR23    cuh_br23.npt
BR24    cuh_br24.npt
BR25    cuh_br25.npt

EDH FILE..................................EDHFN................................
BR1     edh_br1.npt
BR2     edh_br2.npt
BR3     edh_br3.npt
BR4     edh_br4.npt
BR5     edh_br5.npt
BR6     edh_br6.npt
BR7     edh_br7.npt
BR8     edh_br8.npt
BR9     edh_br9.npt
BR10    edh_br10.npt
BR11    edh_br11.npt
BR12    edh_br12.npt
BR13    edh_br13.npt
BR14    edh_br14.npt
BR15    edh_br15.npt
BR16    edh_br16.npt
BR17    edh_br17.npt
BR18    edh_br18.npt
BR19    edh_br19.npt
BR20    edh_br20.npt
BR21    edh_br21.npt
BR22    edh_br22.npt
BR23    edh_br23.npt
BR24    edh_br24.npt
BR25    edh_br25.npt

TDH FILE..................................TDHFN................................
BR1     tdh_br1.npt
BR2     tdh_br2.npt
BR3     tdh_br3.npt
BR4     tdh_br4.npt
BR5     tdh_br5.npt
BR6     tdh_br6.npt
BR7     tdh_br7.npt
BR8     tdh_br8.npt
BR9     tdh_br9.npt
BR10    tdh_br10.npt
BR11    tdh_br11.npt
BR12    tdh_br12.npt
BR13    tdh_br13.npt
BR14    tdh_br14.npt
BR15    tdh_br15.npt
BR16    tdh_br16.npt
BR17    tdh_br17.npt
BR18    tdh_br18.npt
BR19    tdh_br19.npt
BR20    tdh_br20.npt
BR21    tdh_br21.npt
BR22    tdh_br22.npt
BR23    tdh_br23.npt
BR24    tdh_br24.npt
BR25    tdh_br25.npt

CDH FILE..................................CDHFN................................
BR1     cdh_br1.npt
BR2     cdh_br2.npt
BR3     cdh_br3.npt
BR4     cdh_br4.npt
BR5     cdh_br5.npt
BR6     cdh_br6.npt
BR7     cdh_br7.npt
BR8     cdh_br8.npt
BR9     cdh_br9.npt
BR10    cdh_br10.npt
BR11    cdh_br11.npt
BR12    cdh_br12.npt
BR13    cdh_br13.npt
BR14    cdh_br14.npt
BR15    cdh_br15.npt
BR16    cdh_br16.npt
BR17    cdh_br17.npt
BR18    cdh_br18.npt
BR19    cdh_br19.npt
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BR20    cdh_br20.npt
BR21    cdh_br21.npt
BR22    cdh_br22.npt
BR23    cdh_br23.npt
BR24    cdh_br24.npt
BR25    cdh_br25.npt

SNP FILE..................................SNPFN.................................
WB 1    snp1.opt
WB 2    snp2.opt
WB 3    snp3.opt
WB 4    snp4.opt
WB 5    snp5.opt
WB 6    snp6.opt
WB 7    snp7.opt
WB 8    snp8.opt
WB 9    snp9.opt
WB 10   snp10.opt
WB 11   snp11.opt
WB 12   snp12.opt
WB 13   snp13.opt
WB 14   snp14.opt
WB 15   snp15.opt
WB 16   snp16.opt
WB 17   snp17.opt
WB 18   snp18.opt
WB 19   snp19.opt
WB 20   snp20.opt
WB 21   snp21.opt
WB 22   snp22.opt
WB 23   snp23.opt
WB 24   snp24.opt
WB 25   snp25.opt

PRF FILE..................................PRFFN.................................
WB 1    prf1.opt
WB 2    prf2.opt
WB 3    prf3.opt
WB 4    prf4.opt
WB 5    prf5.opt
WB 6    prf6.opt
WB 7    prf7.opt
WB 8    prf8.opt
WB 9    prf9.opt
WB 10   prf10.opt
WB 11   prf11.opt
WB 12   prf12.opt
WB 13   prf13.opt
WB 14   prf14.opt
WB 15   prf15.opt
WB 16   prf16.opt
WB 17   prf17.opt
WB 18   prf18.opt
WB 19   prf19.opt
WB 20   prf20.opt
WB 21   prf21.opt
WB 22   prf22.opt
WB 23   prf23.opt
WB 24   prf24.opt
WB 25   prf25.opt

VPL FILE..................................VPLFN.................................
WB 1    vpl1.opt
WB 2    vpl2.opt
WB 3    vpl3.opt
WB 4    vpl4.opt
WB 5    vpl5.opt
WB 6    vpl6.opt
WB 7    vpl7.opt
WB 8    vpl8.opt
WB 9    vpl9.opt
WB 10   vpl10.opt
WB 11   vpl11.opt
WB 12   vpl12.opt
WB 13   vpl13.opt
WB 14   vpl14.opt
WB 15   vpl15.opt
WB 16   vpl16.opt
WB 17   vpl17.opt
WB 18   vpl18.opt
WB 19   vpl19.opt
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WB 20   vpl20.opt
WB 21   vpl21.opt
WB 22   vpl22.opt
WB 23   vpl23.opt
WB 24   vpl24.opt
WB 25   vpl25.opt

CPL FILE..................................CPLFN.................................
WB 1    cpl1.opt
WB 2    cpl2.opt
WB 3    cpl3.opt
WB 4    cpl4.opt
WB 5    cpl5.opt
WB 6    cpl6.opt
WB 7    cpl7.opt
WB 8    cpl8.opt
WB 9    cpl9.opt
WB 10   cpl10.opt
WB 11   cpl11.opt
WB 12   cpl12.opt
WB 13   cpl13.opt
WB 14   cpl14.opt
WB 15   cpl15.opt
WB 16   cpl16.opt
WB 17   cpl17.opt
WB 18   cpl18.opt
WB 19   cpl19.opt
WB 20   cpl20.opt
WB 21   cpl21.opt
WB 22   cpl22.opt
WB 23   cpl23.opt
WB 24   cpl24.opt
WB 25   cpl25.opt

SPR FILE..................................SPRFN.................................
WB 1    spr1.opt
WB 2    spr2.opt
WB 3    spr3.opt
WB 4    spr4.opt
WB 5    spr5.opt
WB 6    spr6.opt
WB 7    spr7.opt
WB 8    spr8.opt
WB 9    spr9.opt
WB 10   spr10.opt
WB 11   spr11.opt
WB 12   spr12.opt
WB 13   spr13.opt
WB 14   spr14.opt
WB 15   spr15.opt
WB 16   spr16.opt
WB 17   spr17.opt
WB 18   spr18.opt
WB 19   spr19.opt
WB 20   spr20.opt
WB 21   spr21.opt
WB 22   spr22.opt
WB 23   spr23.opt
WB 24   spr24.opt
WB 25   spr25.opt

FLX FILE..................................FLXFN.................................
WB 1    flx1.opt
WB 2    flx2.opt
WB 3    flx3.opt
WB 4    flx4.opt
WB 5    flx5.opt
WB 6    flx6.opt
WB 7    flx7.opt
WB 8    flx8.opt
WB 9    flx9.opt
WB 10   flx10.opt
WB 11   flx11.opt
WB 12   flx12.opt
WB 13   flx13.opt
WB 14   flx14.opt
WB 15   flx15.opt
WB 16   flx16.opt
WB 17   flx17.opt
WB 18   flx18.opt
WB 19   flx19.opt
```

```
WB 20   flx20.opt
WB 21   flx21.opt
WB 22   flx22.opt
WB 23   flx23.opt
WB 24   flx24.opt
WB 25   flx25.opt

TSR FILE..................................TSRFN.................................
        tsr.opt

WDO FILE..................................WDOFN.................................
        wdo.opt
```

W2_bio_con.npt

A sample W2_bio_con.npt file is shown below. A further description is provided in Appendix D.

```
Lake Roosevelt Model
Fish Bioenergetics Input File




FISHCOMP   FCALC     FUF  FDIAGC   BESTC   DIELC   CMAXC
              ON      30      ON      ON      ON     OFF

BIO TIME  JSTART    JEND
           366.0   730.0

F KINETI      T1      T2      T3      T4      K1      K2      K3      K4
             3.0    20.0    20.0    24.0    0.58    0.98    0.98    0.50

F STOICH FOXYCAL
         13569.4

F1 IC       MASS  LENGTH STO_CON
            76.0   193.0   0.001

Z LENGTH    LZOO    LZOO    LZOO    LZOO    LZOO    LZOO    LZOO    LZOO
             1.0     1.0     1.3

Z MASS      MZOO    MZOO    MZOO    MZOO    MZOO    MZOO    MZOO    MZOO
          7.7e-3  4.9e-3 8.82e-5

Z STOICH    EZOO    EZOO    EZOO    EZOO    EZOO    EZOO    EZOO    EZOO
          2420.0  2420.0  2420.0

FORAGE    HANDLE   FVELA   FVELB   FVELC THRESHC THRESHV THRESHZ DIELLUX
            0.33   0.099    0.13 0.04505      ON   6.032       3    0.01

FGP PLOT    FGPC
              ON

FGP DATE    FGPD
           367.0

FGP FREQ    FGPF
             1.0

MASSTYPE     GEN    BEST    DIEL
             FXN    USER     SEG

MASS FXN     GIM     BIM     DIM    GALP    BALP    DALP     GTI     BTI     DTI
            76.0    76.0    76.0  0.0049  0.0049  0.0049   366.0   366.0   366.0

DIAG OPT   FISHC BIOPARC   CONSC    DIGC   RESPC   SURFC  DEPTHC
              ON      ON      ON      ON      ON      ON      ON

SINGLEPT SINGLEC  SINGFN SINIBIO     TLC
              ON     143     312     OFF

ZAV FILE..................................ZAVFN.................................
        Zav.npt

FGP FILE..................................FGPFN.................................
WB1     FGP_wb1.opt

FXN FILE..................................FXNFN.................................
GEN     Gen_userfxn.npt
BEST    Best_userfxn.npt
DIEL    Diel_userfxn.npt
```

Appendix C: Fish Bioenergetic Parameter Formulation

While the bioenergetics and foraging model of Stockwell and Johnson (1997) forms the basis of the approach, the formulation of the bioenergetics parameters were resolved into consistent units of joules over each time step. The consumption parameter was left in units of prey per minute, and growth remained in units of mass (g). Table 22 lists the parameters and their units.

Table 22. Bioenergetics parameters summary.

Parameter	Symbol	Units
Consumption	C	#/min (prey)
Digestion	D	J (per timestep)
Excretion	U	J (per timestep)
Egestion	F	J (per timestep)
Respiration	R	J (per timestep)
SDA	S	J (per timestep)
Growth	G	g (per day)

Growth

Growth is computed daily from the sum of the parameters shown in (1) and converted from energy to mass using the fish energy density, E_{fish}.

$$\begin{aligned} G &= \frac{1}{E_{fish}} \sum_{day} (D - U - F - R - S) \\ G &= \frac{[J]}{[J \cdot g^{-1}]} \\ G &= g \text{ (per day)} \end{aligned} \qquad (1)$$

Fish energy density

The allometric function reported by Hewitt & Johnson (1992) is used for the Kokanee energy density (Equation (2)).

$$E_{fish}\left[\frac{J}{g}\right] = \begin{cases} 4.1868 \cdot (1.8510 \cdot M + 1250) & \text{for} \quad M \le 196 \text{ g} \\ 4.1868 \cdot (1.1254 \cdot M + 1588) & \text{for} \quad M > 196 \text{ g} \end{cases} \qquad (2)$$

Digestion

Digestion is formulated as the energy derived from digested prey over the timestep. The energy from consumption is included in the digestion parameter. Consumption does not explicitly appear in the growth equation (Equation (1)). The approach (Equation (3)) is based on Bevelhimer and Adams (1993); physically, the terms represent the initial stomach content to be digested, the prey consumed during the time step, and the undigested stomach contents at the end of the time step. The last term allows for a time-lag between consumption and digestion. The time to digest the bulk of the a full stomach can range from a couple hours if near optimal temperature to roughly half a day if at very cold temperatures. The variables and their units are shown in Table 23.

The digestion parameter is a function of several other functions: the Thornton-Lessem function (see ancillary functions section), the digestion coefficient, the consumption parameter, and the stomach content at the start of the time step.

$$\mathrm{D} = \left(\left(\underbrace{\mathrm{M_o}}_{\textit{initial content}} + \underbrace{(\mathrm{C} \cdot \mathrm{m_z} \cdot \mathrm{t}) \cdot \mathrm{TL}}_{\textit{consumption}} \right) - \left(\underbrace{\mathrm{M_o} e^{-r \cdot t/60} + \frac{\mathrm{C} \cdot \mathrm{m_z} \cdot 60 \cdot \mathrm{TL}}{\mathrm{r}} \left(1 - e^{-r \cdot t/60}\right)}_{\textit{undigested contents}} \right) \right) \cdot E_{prey} \qquad (3)$$

$$\mathrm{D} = \left(\left(\mathrm{g-wet} + \left(\frac{\#}{\mathrm{min}} \cdot \mathrm{g-wet} \cdot \mathrm{min} \right) \right) - \left(\mathrm{g-wet} + \frac{\#}{\mathrm{min}} \cdot \mathrm{g-wet} \cdot \mathrm{min} \right) \right) \left(\frac{\mathrm{J}}{\mathrm{g-wet}} \right)$$

$$\mathrm{D} = [\mathrm{J}] \text{ (per timestep)}$$

Table 23. Digestion parameter variables and units.

Variable	Units	Definition
M_o	g-wet	Initial stomach content
C	#/min (e.g., Daphnia)	Consumption
m_z	g-wet	mass of a single prey zooplankton
t	(30) minutes	Timestep
TL	dimensionless	Thornton-Lessem function
r	dimensionless	digestion coefficient
E_{prey}	J/g-wet	Prey energy content (density)
60	minutes	unit conversion factor

Digestion coefficient (function)

A kokanee digestion coefficient, r, is reported by Stockwell & Johnson (1999) and Bevelhimer and Adams (1993) and reproduced in Table 24. The Stockwell & Johnson formulation is used to avoid non-positive values which may occur at low temperatures. Additionally, the temperature input to the bioenergetics algorithms is constrained to a minimum value of 0.01 °C.

Table 24. Digestion coefficient formulations

Equation	Source	#
$r = 0.014 \cdot T - 0.0154$	Bevelhimer and Adams (1993)	(4)
$r = 0.014 \cdot T + 0.1135$	Stockwell & Johnson (1999)	(5)

Stomach content and capacity

Stomach content is updated after each time step. The remaining stomach content is composed of the undigested initial stomach content and the consumed prey undigested over the time step, as shown in Equation (6).

$$M_0^{new} = \underbrace{M_o e^{-r \cdot t/60}}_{undigested\ initialcontent} + \underbrace{\frac{C \cdot m_z \cdot 60 \cdot TL}{r}\left(1 - e^{-r \cdot t/60}\right)}_{undigested\ consumption} \qquad (6)$$

Stomach capacity is formulated based on Brett (1971). If, at the start of any time step, the stomach content exceeds the stomach capacity, then consumption is zero for that time step.

$$\text{Capacity}[g] = \begin{cases} M \cdot (14.1 - 4.95 \cdot \log(M))/100 & \text{for} \quad M \le 253.5\ g \\ 0.022 \cdot M & \text{for} \quad M > 253.5\ g \end{cases} \qquad (7)$$

Consumption, Search Volume, and Reaction Distance

Consumption is based on the Stockwell & Johnson (1997) model (Equation (8)), and is a function of other functions: search volume (rate), and the Thornton-Lessem function (see ancillary functions section).

$$\mathrm{C} = \frac{E \cdot z}{1 + E \cdot z \cdot h} \cdot TL \cdot 60 \qquad (\ 8\ )$$

$$\mathrm{C} = \frac{\mathrm{m}^3\!/\mathrm{s} \cdot \frac{\#}{\mathrm{m}^3}}{\mathrm{m}^3\!/\mathrm{s} \cdot \frac{\#}{\mathrm{m}^3} \cdot \frac{\mathrm{s}}{\#}} \cdot \frac{60\mathrm{s}}{\mathrm{min}}$$

$$\mathrm{C} = \left[\frac{\#}{\mathrm{min}}\right] \text{ (“prey” per timestep)}$$

The search volume (rate) is the simple cylinder suggested by Eggers (1977) (Equation (9)). The reaction distance is taken to be a sphere described by Link and Edsall (1996) (Equation (10)). The consumption, search volume, and reaction distance parameter variables and units are shown in Table 25

$$\mathrm{E}\left[\frac{\mathrm{m}^3}{\mathrm{s}}\right] = \pi \cdot R_d^2 \cdot v \qquad (\ 9\ )$$

$$\mathrm{R}_{\mathrm{d}}\ [\mathrm{m}] = 0.01 \cdot 4.9424 \cdot \mathrm{lux}^{0.086} \qquad (\ 10\ )$$

Table 25. Consumption parameter variables and units.

Variable	Units	Definition
R_d	m	Predator reaction distance
lux	lux	Ambient light intensity
E	m^3 / s	Search rate
v	m / s	fish swimming speed
z	# / m^3	prey density
h	# / s	handling time
TL	dimensionless	Thorton-Lessem function
60	s / min	unit conversion factor

Egestion & Excretion

Egestion (fecal wastes) and excretion (urinary wastes) are formulated using the approach of Hewett & Johnson (1987). Parameter variables and units are shown for egestion in Table 26 and for excretion in Table 27.

$$F = 0.455 \cdot T^{-0.222} \cdot D \qquad (11)$$

$$F = \left(\frac{1}{°C}\right) °C \cdot J = J$$

$$F = [J] \text{ (per timestep)}$$

Table 26. Egestion parameter variables and units.

Variable	Units	Definition
T	deg. C	Temperature
D	J (per timestep)	Digestion parameter

$$U = 0.0233 \cdot T^{0.58} \cdot (D - F) \qquad (12)$$

$$U = \left(\frac{1}{°C}\right) °C \cdot J = J$$

$$U = [J] \text{ (per timestep)}$$

Table 27. Excretion parameter variables and units.

Variable	Units	Definition
T	deg. C	Temperature
D	J (per timestep)	Digestion parameter
F	J (per timestep)	Egestion parameter

Specific Dynamic Action (SDA)

Specific dynamic action (the physiological cost of digesting a meal) is formulated using the approach of Brett & Groves (1979). The coefficient (0.172) in Equation (13) for kokanee is taken from Beauchamp, et al. (1989). The variables and units of SDA are shown in Table 28.

$$\mathrm{SDA} = 0.172 \cdot (\mathrm{D} - \mathrm{F}) \qquad (13)$$

$$\mathrm{SDA} = [\mathrm{J}] \text{ (per timestep)}$$

Table 28. Specific dynamic action parameter variables and units.

Variable	**Units**	**Definition**
D	J (per timestep)	Digestion parameter
F	J (per timestep)	Egestion parameter

Respiration

The respiration parameter (Equation (14)) is formulated based on the approach of Beauchamp, et al. (1989) as are the activity, ACT, and cruising speed (velocity) functions, Equations (15) and (16), respectively. The respiration, activity, and cruising speed variables and units are shown in Table 29. The value for the oxycaloric conversion factor is that used by Stockwell & Johnson (1997) of 3241 cal/ g-O_2 (13569.4 J/ g-O_2).

The respiration formulation has included fish mass, and was converted from cal to J. The activity formulation was converted from velocity inputs in cm/s to units of m/s. The cruising speed was converted from units of cm/s to units of m/s.

$$R = 0.00143 \cdot M^{-0.209} \cdot e^{0.086 \cdot T} \cdot ACT \cdot OXYCAL \cdot \frac{t}{t_{day}} \cdot M \qquad (14)$$

$$R = \frac{g - O_2}{(\sim g - fish) \cdot (\sim g - fish)^{-0.209}} (\sim g - fish)^{-0.209} \frac{J}{g - O_2} \cdot \frac{min}{min} \cdot g - fish$$

$$R = \left[\frac{J}{g\text{ - fish}} \cdot g\text{ - fish} \right] = [J] \text{ (per timestep)}$$

$$ACT = \exp(0.0234 \cdot v \cdot 100) \qquad (15)$$

$$v = 0.01 \cdot 9.9 \cdot \exp(0.0405 \cdot T) \cdot M^{0.13} \qquad (16)$$

Table 29. Respiration parameter variables and units.

Variable	Units	Definition
M	g-wet	Fish mass
T	deg. C	Temperature
ACT	dimensionless	Activity
OXYCAL	J / g-O_2	Oxycaloric conversion factor
t	(30) minutes	Timestep
t_{day}	(1440) minutes	Duration of a day

Ancillary function values

The bioenergetics parameters are a function of other, ancillary functions. Table 30 reports the values of those functions for a 76 and 125 g kokanee at 4 and 20 °C to give a sense of the range and sensitivity of the ancillary functions.

Table 30. Representative ancillary function values for 76 and 125 g kokanee at 4 and 20 °C.

Temperature:	4 °C		20 °C	
Fish mass:	76 g	125 g	76 g	125 g
Ancillary function				
E_{fish}, fish energy density (J/g)	5822.5	6202.2	5822.5	6202.2
TL function	0.58	0.58	0.98	0.98
r, digestion coefficient	0.17	0.17	0.39	0.39
Stomach capacity (g)	3.64	4.65	3.64	4.65
v, velocity (m/s)	0.204	0.218	0.391	0.417
ACT	1.61	1.66	2.50	2.65
at 50,000 lux (summer, noon, near the surface)				
R_d, reaction distance (m)	0.125	0.125	0.125	0.125
E, search volume (m^3/s)	10.00 x10^{-3}	10.70 x10^{-3}	19.19 x10^{-3}	20.47 x10^{-3}
at 10 lux (crepuscular or at depth)				
R_d, reaction distance (m)	0.06	0.06	0.06	0.06
E, search volume (m^3/s)	2.31 x10^{-3}	2.46 x10^{-3}	4.42 x10^{-3}	4.72 x10^{-3}

The formulation of the Thornton-Lessem function is identical to that of Beachamp, et al. (1989), which was later used by Stockwell & Johnson (1997). A plot of the function is shown as Figure 113.

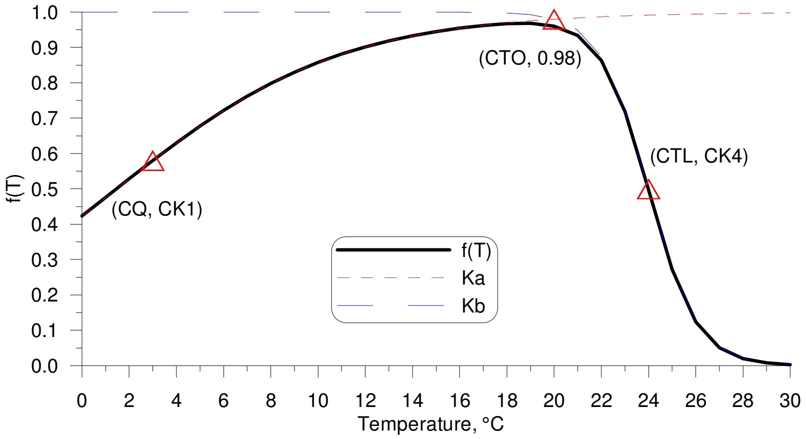


Figure 113. Plot of the Thornton-Lessem function.

Appendix D: Bioenergetics control file explanation

A separate control file, "W2_bio_con.npt," was generated for the fish bioenergetics algorithm. A sample file is shown in Appendix B. This section describes the control file inputs to the fish bioenergetics routine. Some features are placeholders for future development and integration with the CE-QUAL-W2 code.

The input "type" can be of several formats: The ON/OFF format is used to turn on logical controls. The INTEGER format cannot contain decimals, and the REAL format must contain one decimal. The REAL format can also use scientific notation, but there must be a decimal in the value (e.g., 3.1e-5). The ON/OFF, INTEGER, and REAL formats are right justified, meaning that the rightmost character must be located at the right edge of the column. Each column has 8 spaces, and the first column is not read by the code, but can contain notes to the user. The CHARACTER format is used for words in the *fish mass* type cards and filenames in the *filenames* cards. The fish mass type card is also right justified and case-sensitive. The filenames are left justified, and are not case sensitive. Refer to the examples below.

The first 8 lines of the card are ignored. They can be used to make notes for the user.

Fish Computation

The FCALC value turns the routine on. FCALC and FUF are placeholders for integration within W2. FDIAGC allows for the output of diagnostic values. FDIAGC must be ON for BESTC and DIELC outputs. BESTC turns on the calculation and output of the 'best growth' algorithm. DIELC turns on the calculation and output of the 'vertical foraging' routine. CMAXC sets the model consumption to 100% of the practical maximum consumption, as outlined by Beauchamp, et al., 1989. This is a useful feature for comparing results to literature values and for evaluating maximum consumption scenarios.

Input	Type	Description
FCALC	ON/OFF	Turns on fish calculations
FUF	INTEGER	Model timestep, in minutes
FDIAGC	ON/OFF	Turns on diagnostic calculations and output
BESTC	ON/OFF	Turns on "best growth" cell calculations and output.
DIELC	ON/OFF	Turns on "vertical foraging" calculations and output.
CMAXC	ON/OFF	Sets model consumption (prey/min) to 100% of the internally defined maximum practical consumption

Example:

```
FISHCOMP   FCALC     FUF  FDIAGC   BESTC   DIELC   CMAXC
              ON      30      ON      ON      ON      ON
```

Bioenergetic time control

This card specifies the starting and ending dates for the fish model.

Input	Type	Description
JSTART	REAL	Sets the starting julian date
JEND	REAL	Sets the ending julian date

Example:

```
BIO TIME  JSTART    JEND
           366.0   730.0
```

Fish temperature kinetics

This card specifies the four pairs of temperature and function values in the Thornton-Lessem function.

Input	Type	Description
T1	REAL	Thornton-Lessem T1 or CQ temperature
T2	REAL	Thornton-Lessem T2 or CTO temperature
T3	REAL	Thornton-Lessem T3 or CTM temperature
T4	REAL	Thornton-Lessem T4 or CTL temperature
K1	REAL	Thornton-Lessem K1 or CK1 kinetic term
K2	REAL	Thornton-Lessem K2 or CK2 kinetic term
K3	REAL	Thornton-Lessem K3 or CK3 kinetic term
K4	REAL	Thornton-Lessem K4 or CK4 kinetic term

Example:

```
F KINETI      T1      T2      T3      T4      K1      K2      K3      K4
             3.0    20.0    20.0    24.0    0.58    0.98    0.98    0.50
```

Fish oxycaloric stoichiometric constant

This card specifies the oxycaloric stoichiometric constant, OXYCAL in the literature.

Input	Type	Description
FOXYCAL	REAL	Fish oxycaloric stoichiometric constant

Example:

```
F STOICH FOXYCAL
         13569.4
```

Fish physical properties initial conditions

This card specifies the initial physical fish properties for all cells. Fish length is currently not used for any calculations and is a placeholder for future use.

Input	Type	Description
MASS	REAL	Initial fish mass, in grams, at the starting date
LENGTH	REAL	Initial fish length, in mm, at the starting date
STO_CON	REAL	Initial fish stomach content, in grams, at the starting date

Example:

```
F1 IC       MASS  LENGTH STO_CON
            10.0   193.0   0.001
```

Zooplankton property cards

This card specifies the zooplankton population physical properties. These properties are steady and uniform. Each zooplankton group can have different properties. The LZOO values is not used for any calculation and is a placeholder for future development.

Input	Type	Description
LZOO	REAL	Average length of the zooplankton group population, in mm.
MZOO	REAL	Average mass of the zooplankton group population, in g/m^3.
EZOO	REAL	Average energy content of the zooplankton group population, in J/g.

Example:

```
Z LENGTH    LZOO    LZOO    LZOO    LZOO    LZOO    LZOO    LZOO    LZOO
             1.0     1.0     1.3

Z MASS      MZOO    MZOO    MZOO    MZOO    MZOO    MZOO    MZOO    MZOO
          7.7e-3  4.9e-3 5.73e-5

Z STOICH    EZOO    EZOO    EZOO    EZOO    EZOO    EZOO    EZOO    EZOO
          2420.0  2420.0  2420.0
```

Foraging constants

This card specifies user-defined foraging constants. HANDLE is the average prey handling time. Values for kokanee near 1.0 second per prey item are common in the literature; a minimum of 0.33 s/prey (Stockwell and Johnson, 1999) is recommended for kokanee. The Allometric fish velocity function can be defined by the user using FVELA, FVELB, and FVELC in the form of the velocity (m/s) shown below (fish mass, M, in grams; water temperature, T, in Celsius.)

$$\mathrm{v} = A \cdot \exp(C \cdot \mathrm{T}) \cdot \mathrm{M}^{\mathrm{B}} \qquad (17)$$

At a minimum prey density threshold, selective (one prey group) feeding may be prescribed by THRESHC. The zooplankton group number, THRESHZ, and the critical density, THRESHV, are user defined.

When using the 'vertical foraging' strategy, activated by DIELC, the user may define daylight conditions using the DIELLUX value, in lux. This is the irradiance value in the surface layer of the model. As the sun rises and sets quickly, the model is not sensitive to small (one order of magnitude) changes in the value of DIELLUX.

Input	Type	Description
HANDLE	REAL	Average prey handling time, in seconds
FVELA	REAL	Allometric fish velocity parameter, A
FVELB	REAL	Allometric fish velocity parameter, B
FVELC	REAL	Allometric fish velocity parameter, C
THRESHC	ON/OFF	Turns on preying upon a single zooplankton group at a threshold prey density
THRESHV	REAL	Critical prey density for threshold feeding
THRESHZ	INTEGER	The zooplankton group number for threshold feeding
DIELLUX	REAL	User defined light intensity for daylight conditions, in lux

Example:

```
FORAGE    HANDLE   FVELA   FVELB   FVELC THRESHC THRESHV THRESHZ DIELLUX
            0.50   0.099    0.13 0.04505      ON   6.032       3    0.01
```

Fish growth potential animation cards

This card allows for the fish growth potential output in a format ready for use by the TECPLOT software for the generation of graphic animations. Only one date, FGPD, is supported.

Input	Type	Description
FGPC	ON/OFF	Turns on the fish growth potential output file.
FGPD	REAL	Specifies the starting Julian date of the fish growth potential output file
FGPF	REAL	Specifies the frequency of output to the fish growth potential output file, in days

Example:

```
FGP PLOT    FGPC
              ON

FGP DATE    FGPD
           367.0

FGP FREQ    FGPF
             1.0
```

Fish mass type

This card specifies the method used to change the fish mass with time. The general algorithm uses CELL, FIXED, FXN, USER. The 'best' and 'vertical foraging' algorithms use SEG, FIXED, FXN, and USER.

FIXED allows the fish mass to remain constant at the initial value. FXN prescribes fish growth as an exponential function (see *fish mass function parameters*). This is useful for reproducing growth from field data. USER allows a user defined mass time-series, which need not be a "nice" mathematical function. CELL allows the daily predicted fish growth potential for each model cell to be applied to that cell. Similarly, SEG allows the predicted growth to be applied to *all* cells in the model segment.

Input	Type	Description
GEN	CHARACTER	Determines the method used to describe the fish mass time-series for the general function
BEST	CHARACTER	Determines the method used to describe the fish mass time-series for the best growth function
DIEL	CHARACTER	Determines the method used to describe the fish mass time-series for the vertical foraging function

Example:

```
MASSTYPE     GEN    BEST    DIEL
           FIXED     SEG     FXN
```

Fish mass function parameters

This card specifies the parameters of the prescribed exponential fish mass time-series function. The form of the equation is shown below. M and IM are in grams; TI is in days.

$$\mathrm{M} = IM \cdot \exp\left(ALP\left(JDAY - TI\right)\right) \tag{18}$$

Input	Type	Description
GIM	REAL	General function (by cell) initial mass
BIM	REAL	"Best growth" (by segment) initial mass
DIM	REAL	"Vertical foraging" (by segment) initial mass
GALP	REAL	General function alpha parameter
BALP	REAL	"Best growth" function alpha parameter
DALP	REAL	"Vertical foraging" function alpha parameter
GTI	REAL	General function initial time parameter
BTI	REAL	"Best growth" function initial time parameter
DTI	REAL	"Vertical foraging" function initial time parameter

Example:

```
MASS FXN     GIM     BIM     DIM    GALP    BALP    DALP     GTI     BTI     DTI
            76.0    76.0    76.0  0.0049  0.0049  0.0049   366.0   366.0   366.0
```

Diagnostic output controls

This card activates the diagnostic output. FISHC must be ON for any of the other outputs. These features are best used with the single location feature as output from all active segments will be reported in a single file. Output is reported daily at midnight.

Input	Type	Description
FISHC	ON/OFF	Turns on all diagnostic output
BIOPARC	ON/OFF	Turns on the bioenergetics parameter output
CONSC	ON/OFF	Turns on the consumption diagnostic output
DIGC	ON/OFF	Turns on the digestion diagnostic output
RESPC	ON/OFF	Turns on the respiration diagnostic output
SURFC	ON/OFF	Turns on selected output for the surface cell
DEPTHC	ON/OFF	Turns on the reporting of the foraging layers for the best growth and vertical foraging routines.

Example:

```
DIAG OPT   FISHC BIOPARC   CONSC    DIGC   RESPC   SURFC  DEPTHC
              ON      ON      ON      ON      ON      ON      ON
```

Single location controls

This card allows for computation of the bioenergetics routine at a single segment. This allows for faster computations. The TLC feature allows reporting of the calculated Thorton-Lessem function values. TLC should be set to OFF unless needed. To limit file size, the values are reported at midnight for the surface layer. Output is also only available if SINGLEC is ON.

Input	Type	Description
SINGLEC	ON/OFF	Turns on fish calculations at a single location
SINGFN	INTEGER	Specifies the input file number for single location calculations
SINIBIO	INTEGER	Specifies the CE-QUAL-W2 model segment number for single location calculations
TLC	ON/OFF	Turns on the Thornton-Lessem function value output file.

Example:

```
SINGLEPT SINGLEC   SINGFN SINIBIO     TLC
              ON      143     312     OFF
```

User defined input and output filenames

This card allows the user to specify some of the output filenames. ZAV is the zooplankton biological availability fraction (0 to 1) filename. The TECPLOT format fish growth potential file and the user defined fish mass time-series files can also be named. The filenames, including the file extension, cannot exceed 72 characters.

Input	Type	Description
ZAV FILE	CHARACTER	The zooplankton availability input filename
FGP FILE	CHARACTER	The fish growth output filename
GEN FXN FILE	CHARACTER	The general (by cell) user defined fish mass input file
BEST FXN FILE	CHARACTER	The “best growth” (by segment) user defined fish mass input file
DIEL FXN FILE	CHARACTER	The “vertical foraging” (by segment) user defined fish mass input file

Example:

```
ZAV FILE..................................ZAVFN.................................
        Zav.npt

FGP FILE..................................FGPFN.................................
WB1     FGP_wb1.opt


FXN FILE..................................FXNFN.................................
GEN     Gen_userfxn.npt
BEST    Best_userfxn.npt
DIEL    Diel_userfxn.npt
```

Appendix E: Plots of weighted model results and model-data comparisons

Weighted algae and zooplankton are shown in the Biotic Modeling Approach and Calibration section.

Water quality constituent calibration is discussed in the section, Constituent Calibration Discussion. The discrepancy in model-data comparisons of pH are discussed in the section Alternate Boundary Conditions.

The sampling locations were shown in Figure 2 in the
Monitoring Sites section.

The water quality data are often collected at varied depths. When a notable vertical gradient is exhibited in the data or the model results, the exact depth can be important. To better compare the model and data given the potential uncertainty in vertical location in the water column, model results are averaged over the upper 5 model layers (approximately 10 m). Values at the surface layer (from the *tsr.opt* output files) are also shown to give a sense of the vertical gradient exhibited by the model.

Model-data comparison plots of orthophosphate, ammonium, nitrate plus nitrite (NOx), dissolved oxygen, alkalinity, pH, and total dissolved solids are shown where data are available.

Station 0.0

The water quality constituent concentrations at station 0.0 predicted by the model are largely an echo of the upstream boundary conditions. With the exception of pH, the boundary conditions are generated from the data at station 0.0. The travel time from the U.S.-Canadian border to station 0.0 ranges from roughly 0.5 days during spring drawdown to 2 days during the fall. As such, there is little time to influence the constituent concentrations.

The stair stepping of the model concentrations seen in the orthophosphate (Figure 114) and ammonium (Figure 115) is a result of the model input file having concentrations in 3 decimal places (0.001 increments).

The model exhibits a vertically well-mixed water column at station 0.0.

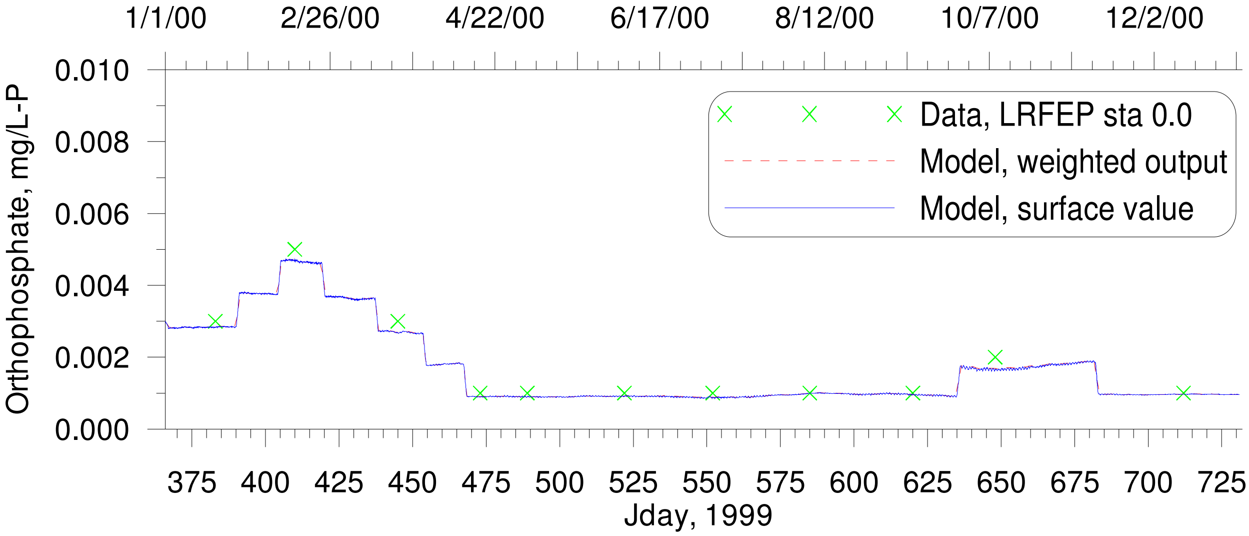


Figure 114. Model-data comparison of orthophosphate at LRFEP station 0.0.

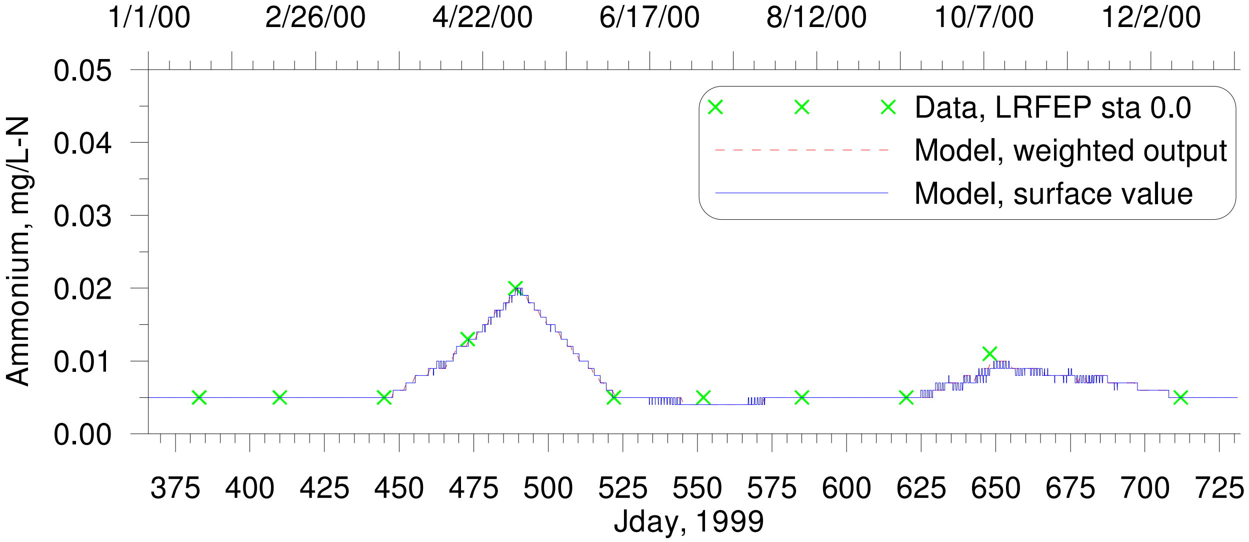


Figure 115. Model-data comparison of ammonium at LRFEP station 0.0.

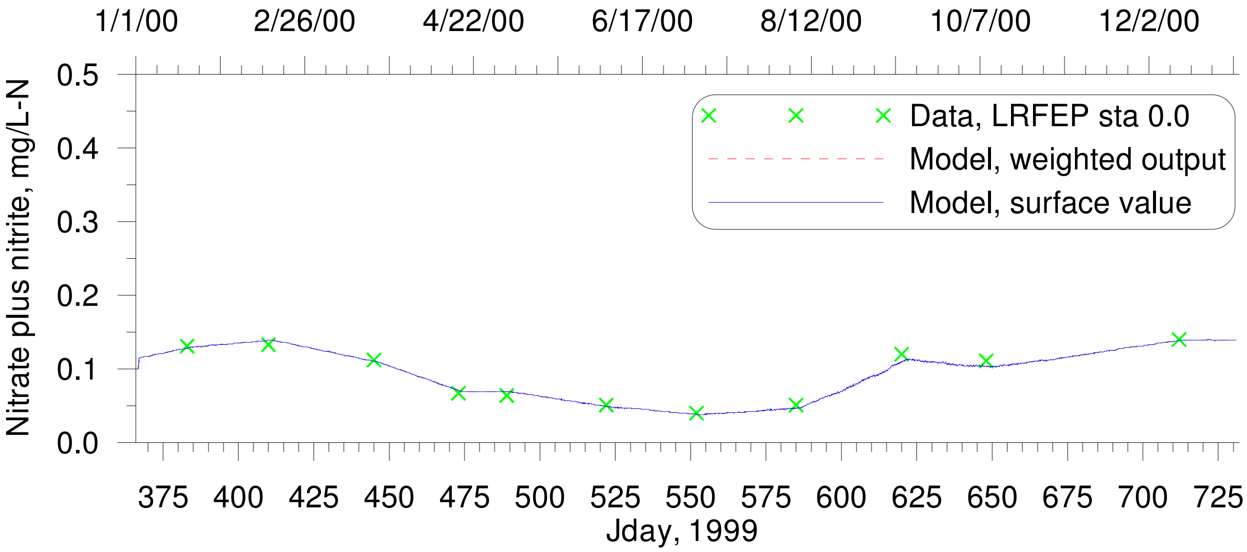


Figure 116. Model-data comparison of nitrate plus nitrite at LRFEP station 0.0.

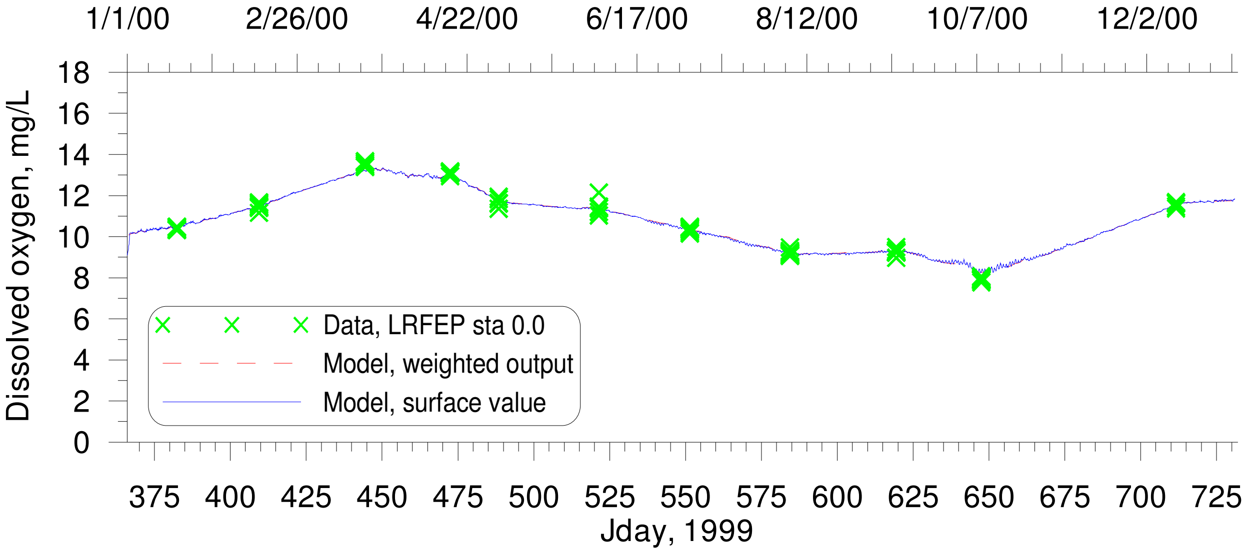


Figure 117. Model-data comparison of dissolved oxygen at LRFEP station 0.0.

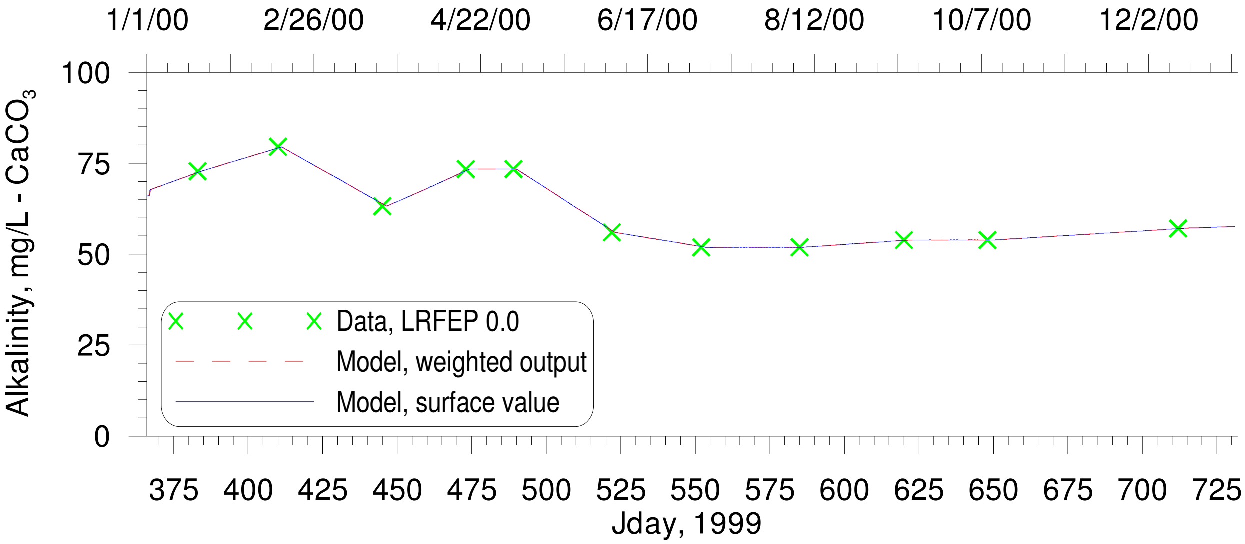


Figure 118. Model-data comparison of alkalinity at LRFEP station 0.0.

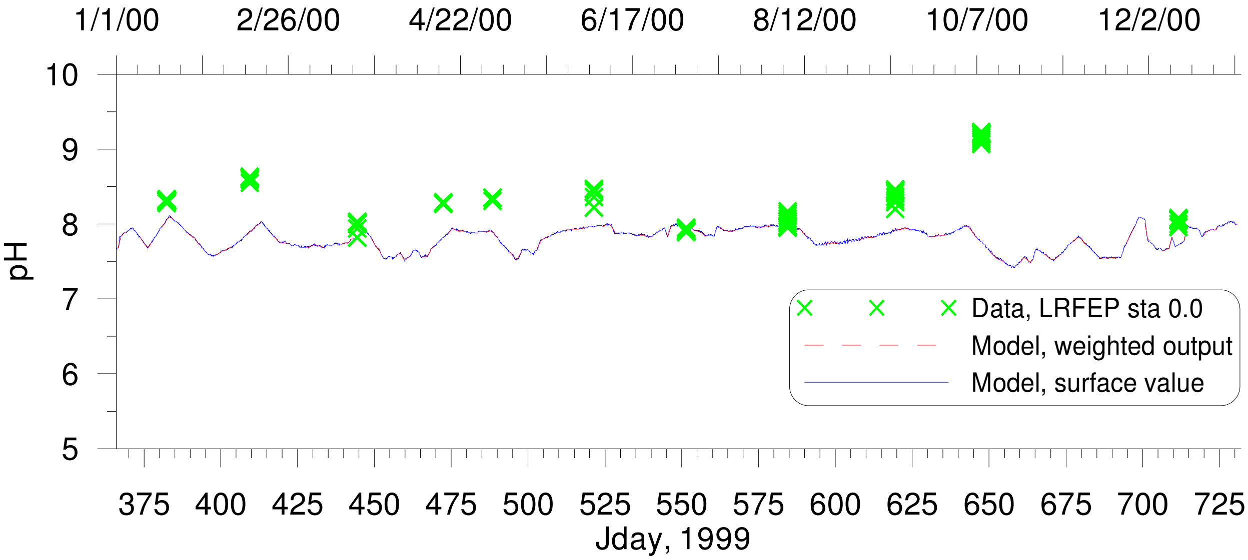


Figure 119. Model-data comparison of pH at LRFEP station 0.0.

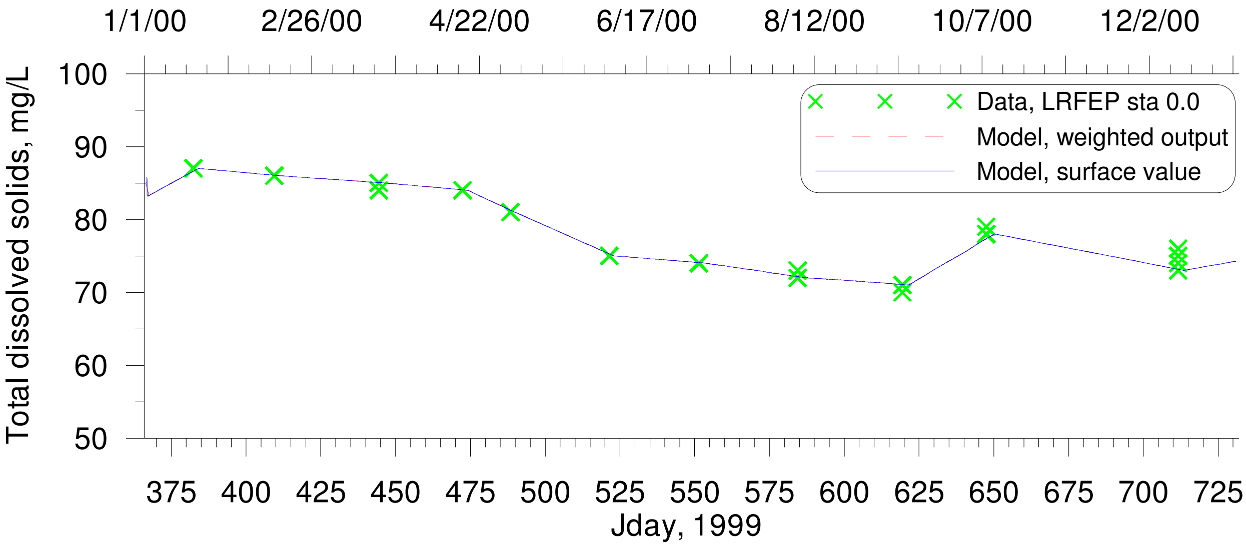


Figure 120. Model-data comparison of total dissolved solids at LRFEP station 0.0.

Station 1.0

The travel time to station 1.0 ranges roughly from 0.6 to 4 days from the U.S.-Canadian border, which is only slightly larger than the travel time to the nearby station 0.0. The water quality constituent concentrations are still largely an echo of the upstream boundary conditions. The model exhibits a vertically well-mixed water column.

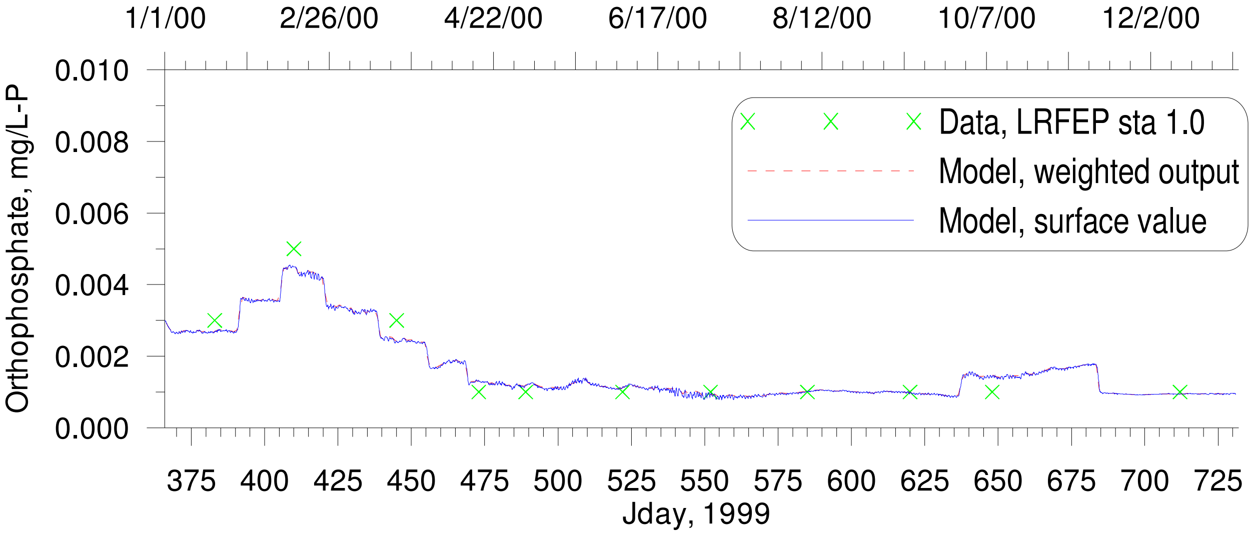


Figure 121. Model-data comparison of orthophosphate at LRFEP station 1.0.

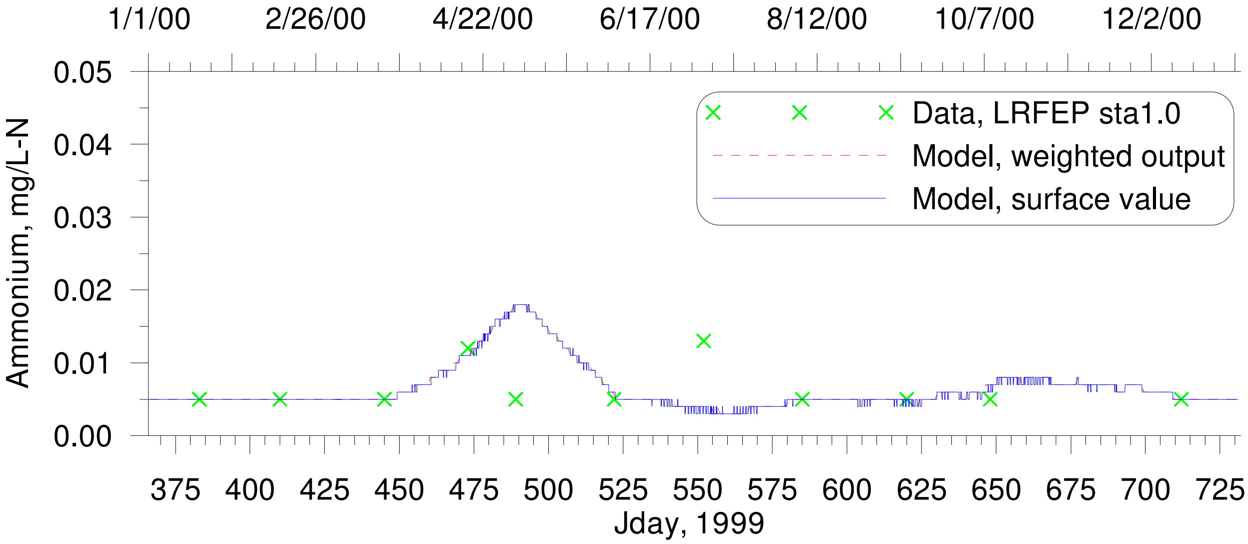


Figure 122. Model-data comparison of ammonium at LRFEP station 1.0.

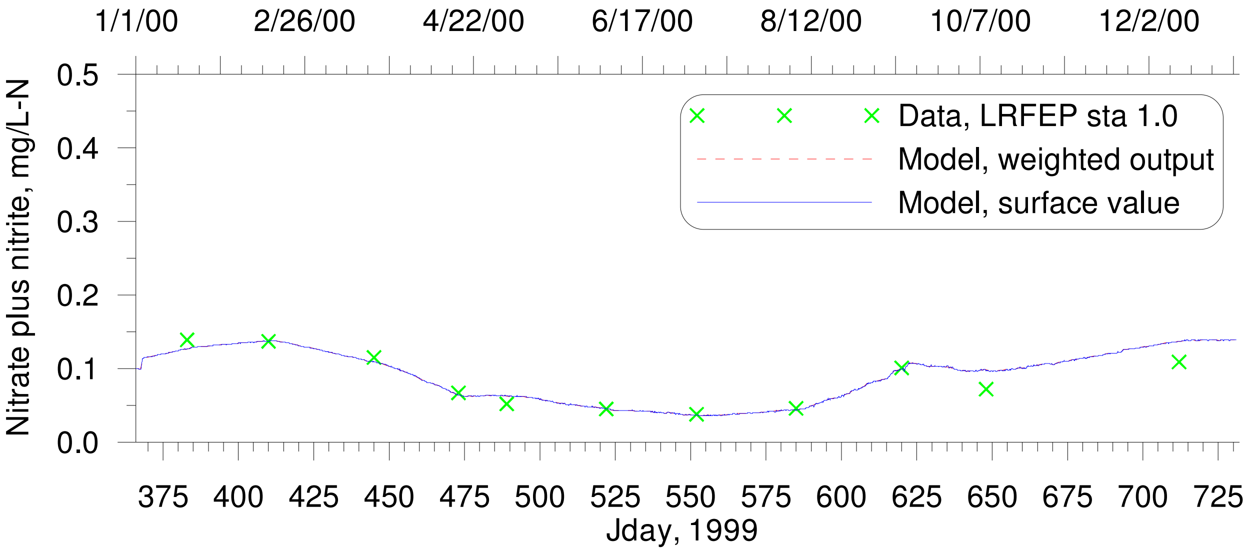


Figure 123. Model-data comparison of nitrate plus nitrite at LRFEP station 1.0.

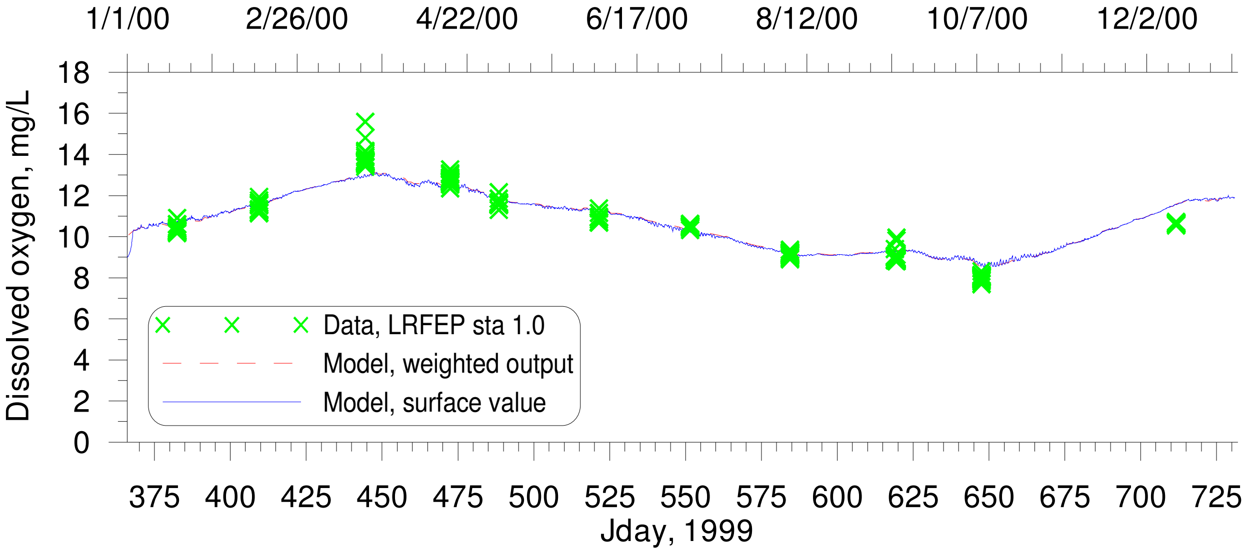


Figure 124. Model-data comparison of dissolved oxygen at LRFEP station 1.0.

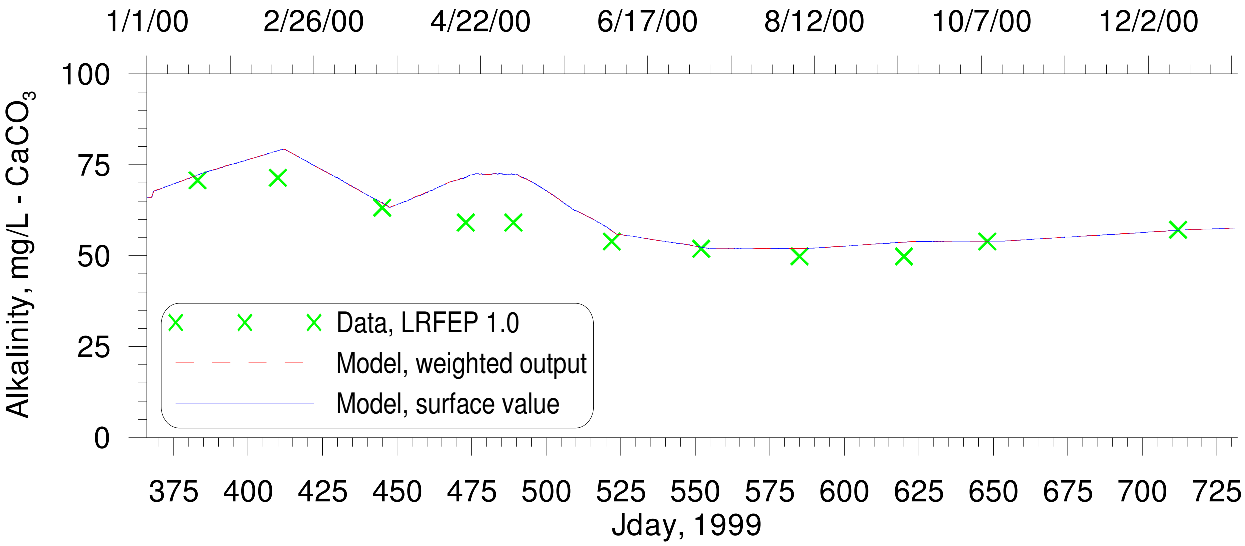


Figure 125. Model-data comparison of alkalinity at LRFEP station 1.0.

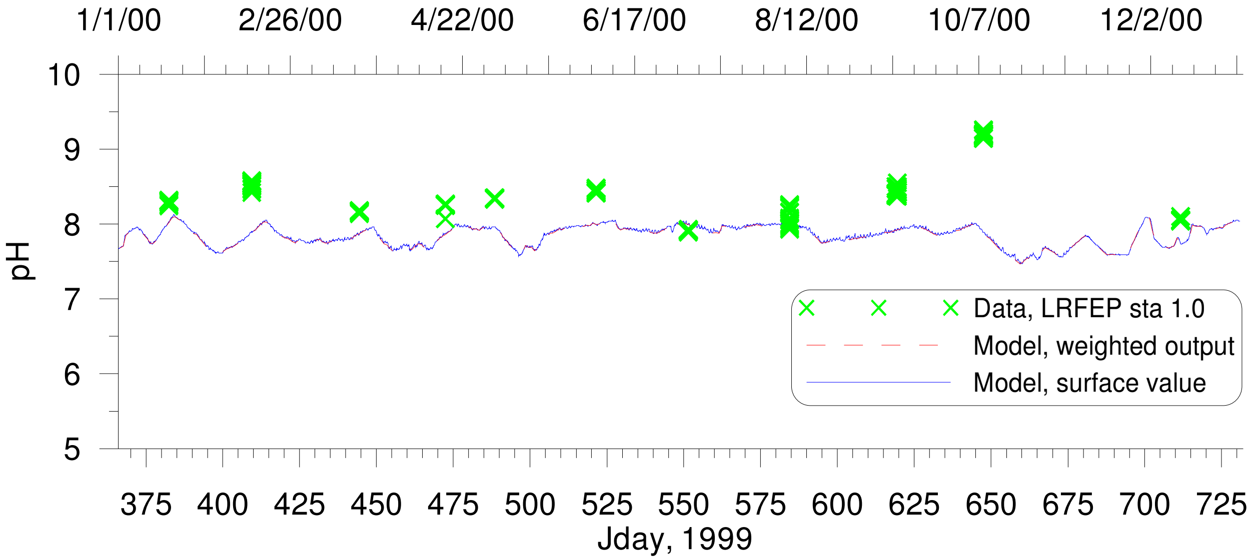


Figure 126. Model-data comparison of pH at LRFEP station 1.0.

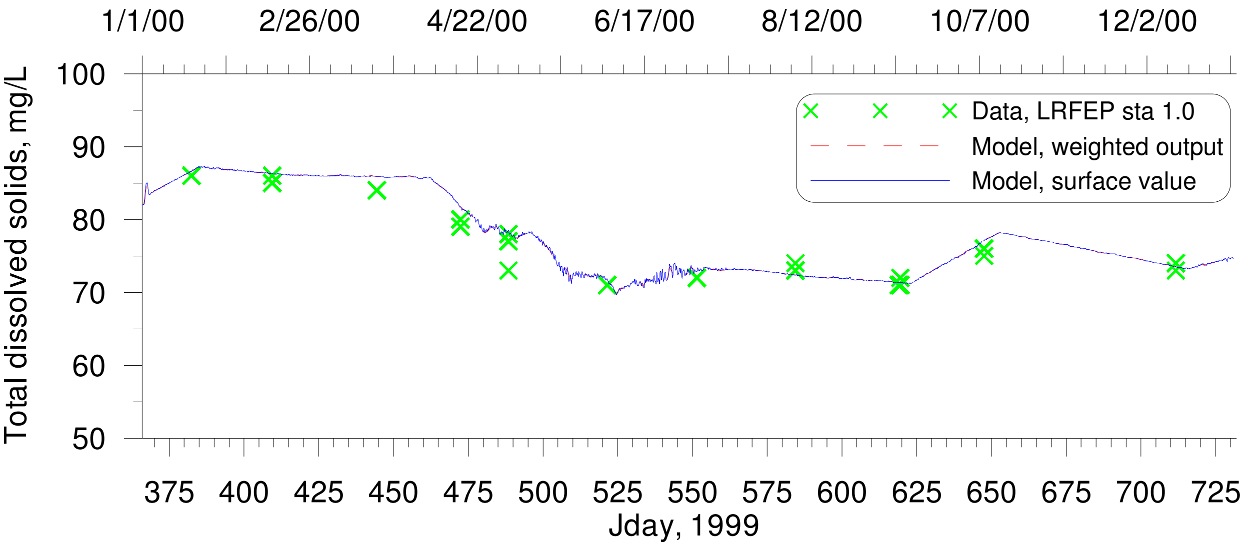


Figure 127. Model-data comparison of total dissolved solids at LRFEP station 1.0.

Station 2.0

The travel time to station 2.0 ranges roughly from 5 to 20 days from the U.S.-Canadian border. The model exhibits some small and isolated vertical gradients; the data show larger vertical gradients, however, especially for the dissolved oxygen (Figure 131) and total dissolved solids (TDS) (Figure 134) constituents. The TDS data at station 2.0 have much higher values than the upstream and downstream stations during spring drawdown. This could be the result of the nearby upstream tributary streams.

The stair stepping seen in the ammonium concentrations (Figure 129) is a result of the model output having 3 decimal places.

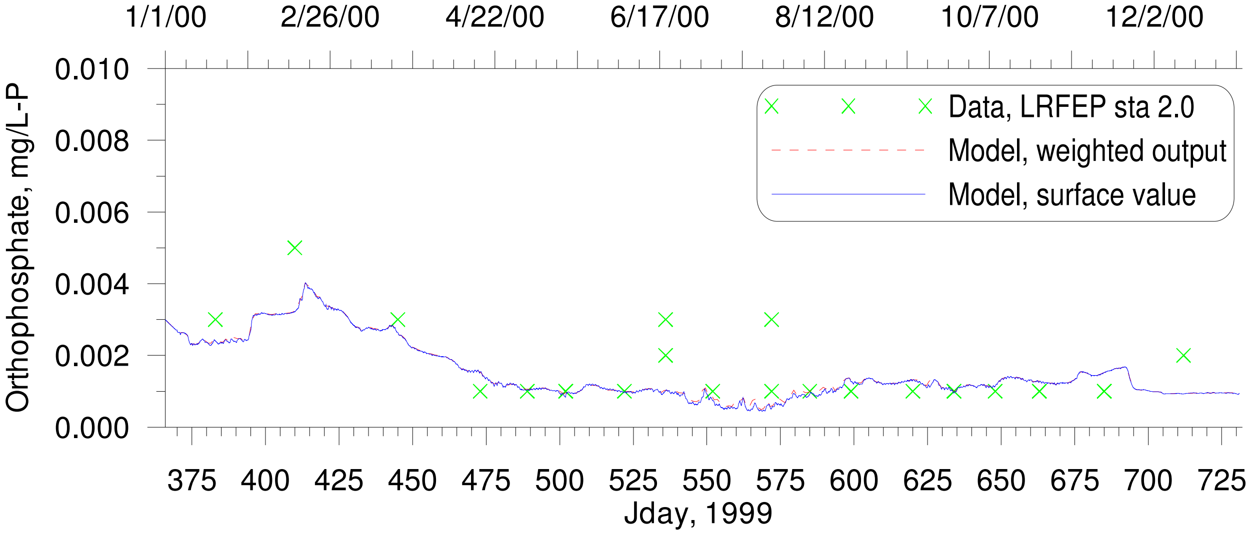


Figure 128. Model-data comparison of orthophosphate at LRFEP station 2.0.

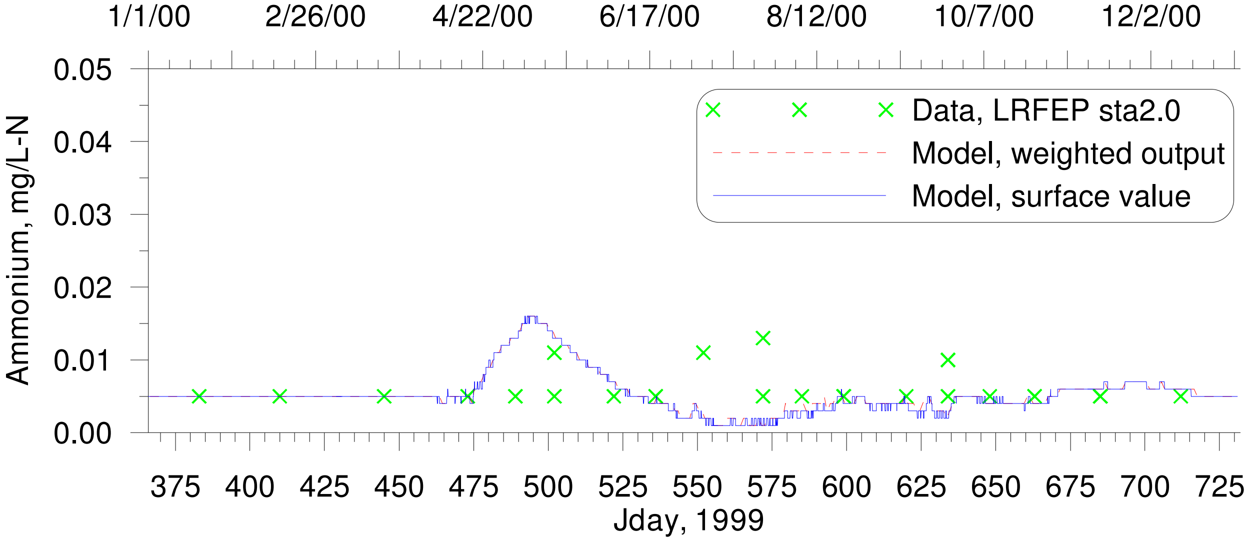


Figure 129. Model-data comparison of ammonium at LRFEP station 2.0.

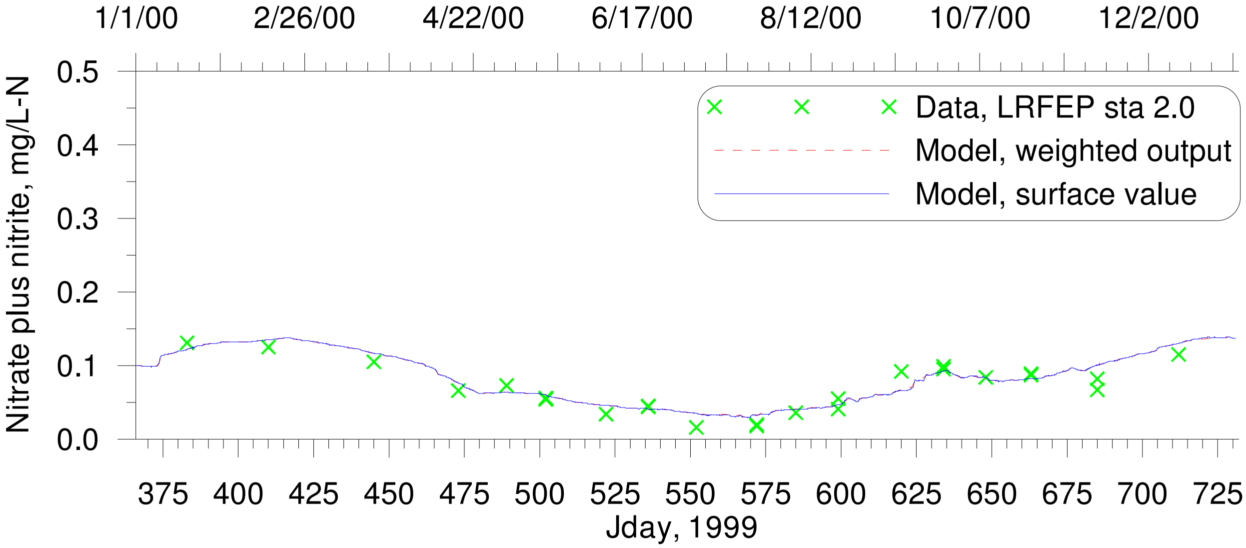


Figure 130. Model-data comparison of nitrate plus nitrite at LRFEP station 2.0.

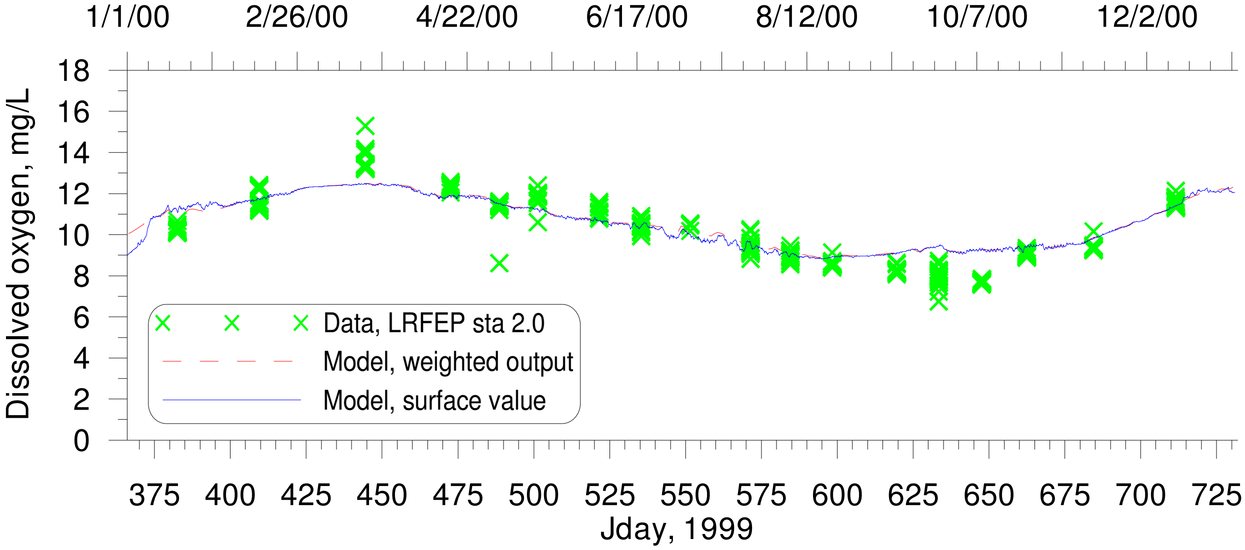


Figure 131. Model-data comparison of dissolved oxygen at LRFEP station 2.0.

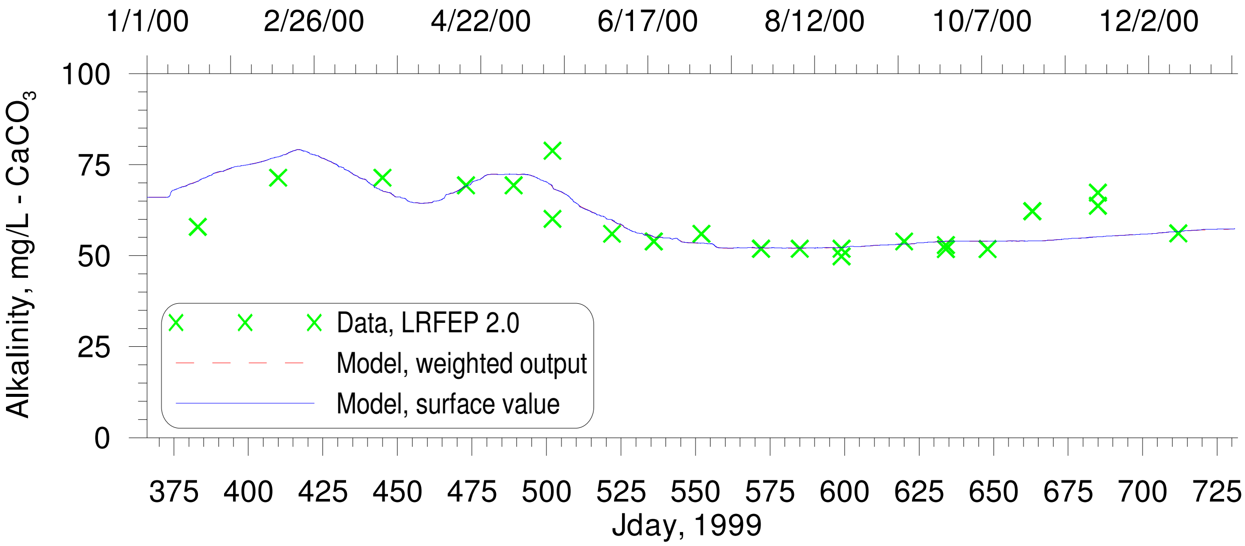


Figure 132. Model-data comparison of alkalinity at LRFEP station 2.0.

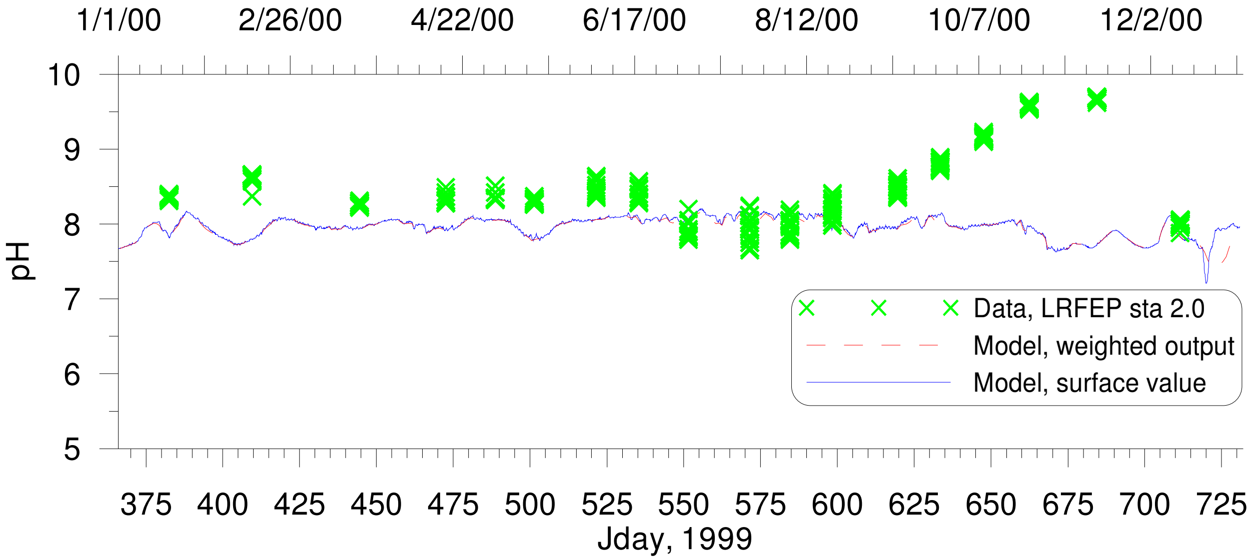


Figure 133. Model-data comparison of pH at LRFEP station 2.0.

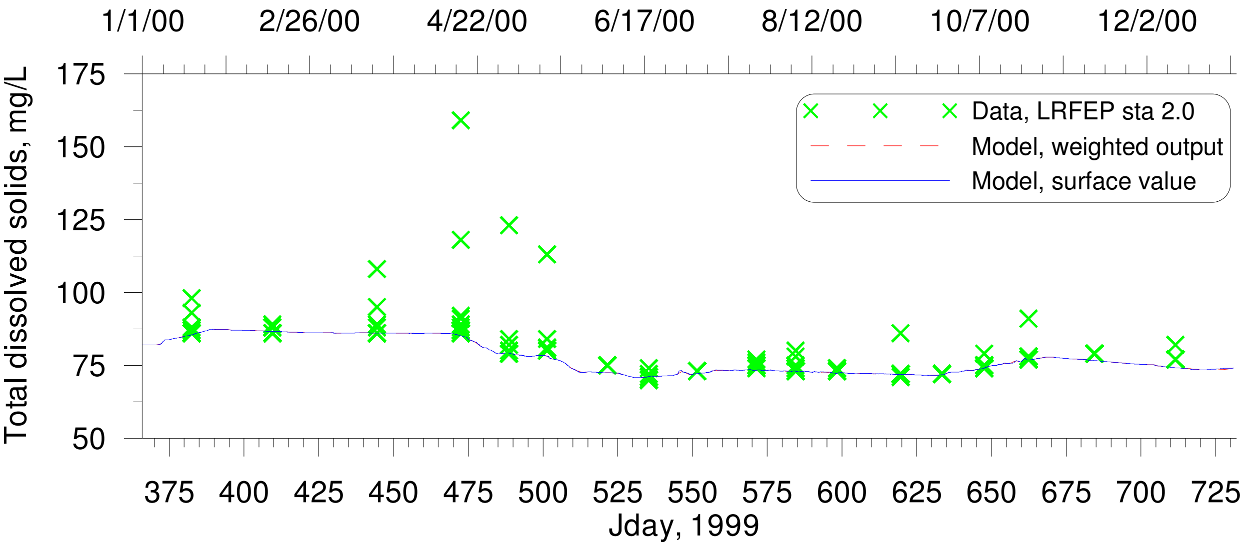


Figure 134. Model-data comparison of total dissolved solids at LRFEP station 2.0.

Station 3.0

The travel time to station 3.0 ranges roughly from 6 to 22 days from the U.S.-Canadian border. The model exhibits some small and isolated vertical gradients; the data show larger vertical gradients, however.

The stair stepping seen in the ammonium concentrations (Figure 136) is a result of the model output having 3 decimal places.

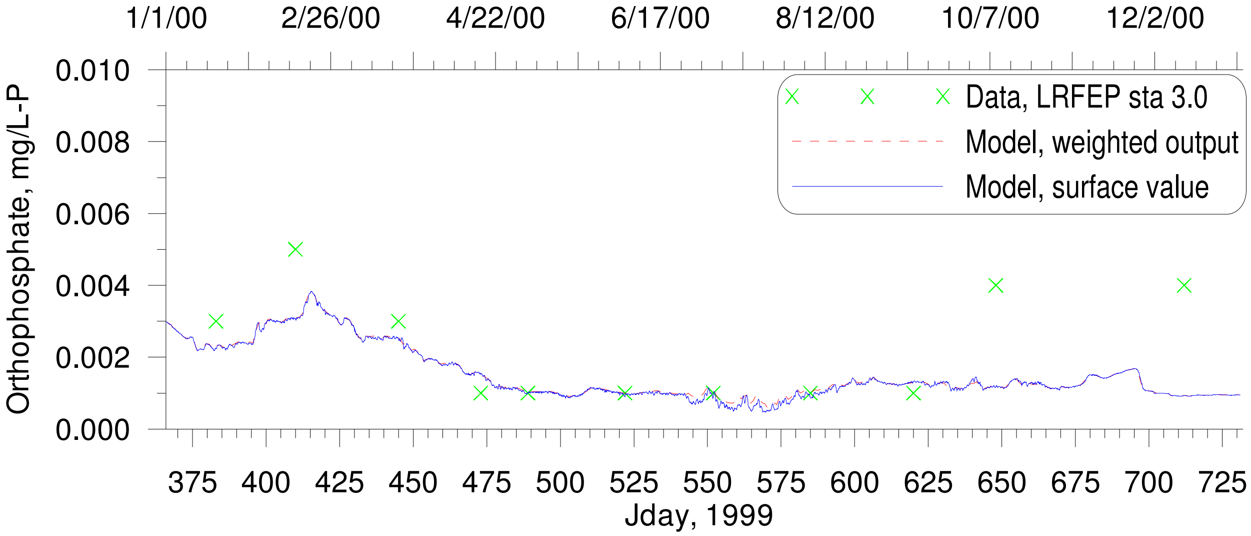


Figure 135. Model-data comparison of orthophosphate at LRFEP station 3.0.

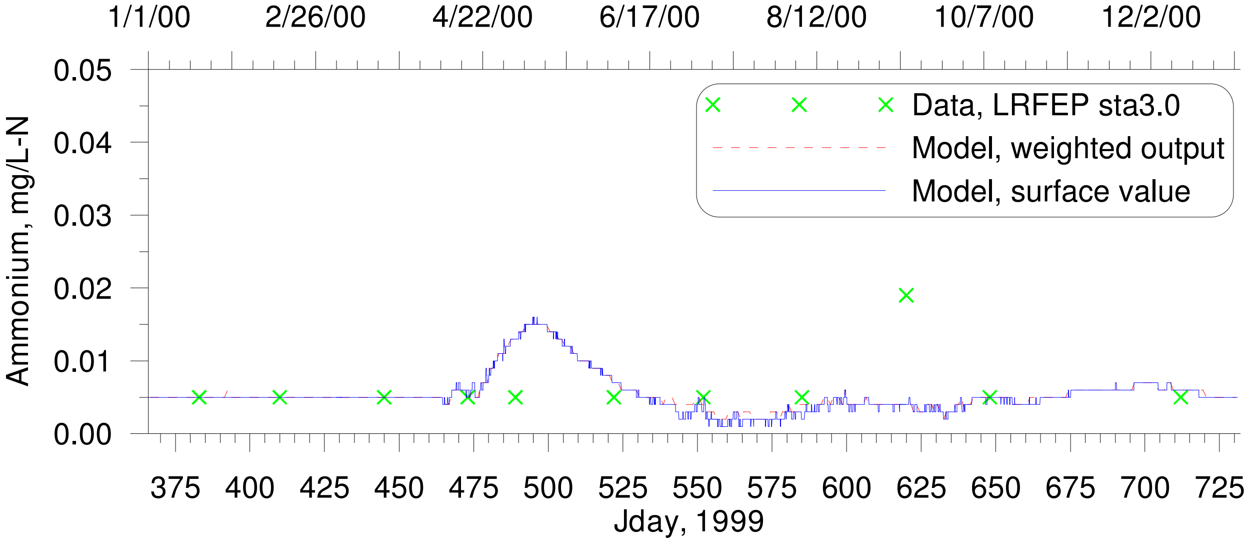


Figure 136. Model-data comparison of ammonium at LRFEP station 3.0.

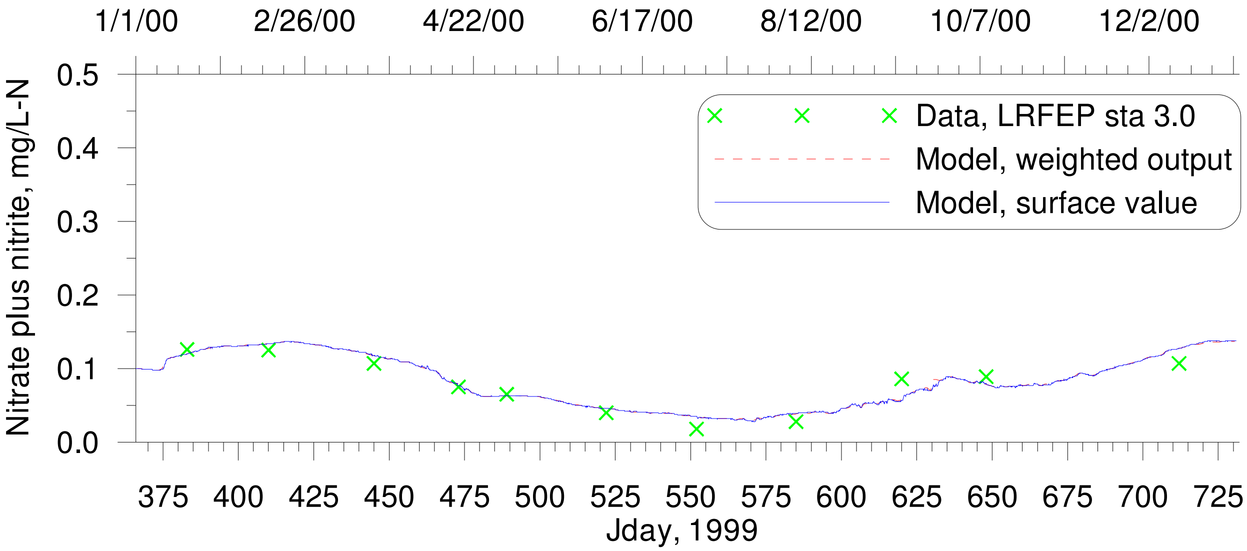


Figure 137. Model-data comparison of nitrate plus nitrite at LRFEP station 3.0.

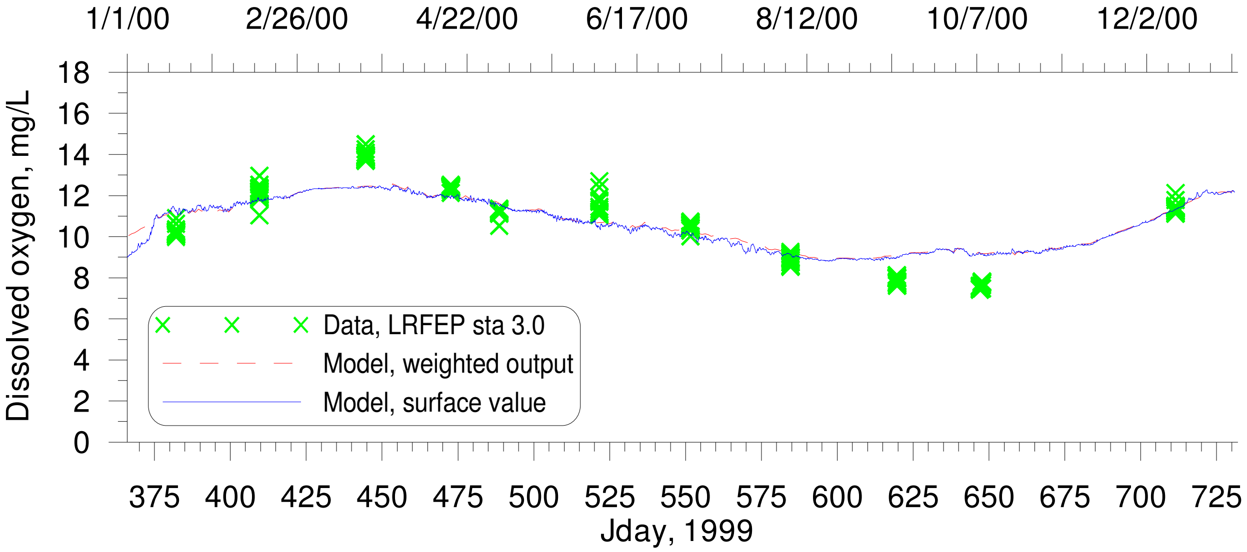


Figure 138. Model-data comparison of dissolved oxygen at LRFEP station 3.0.

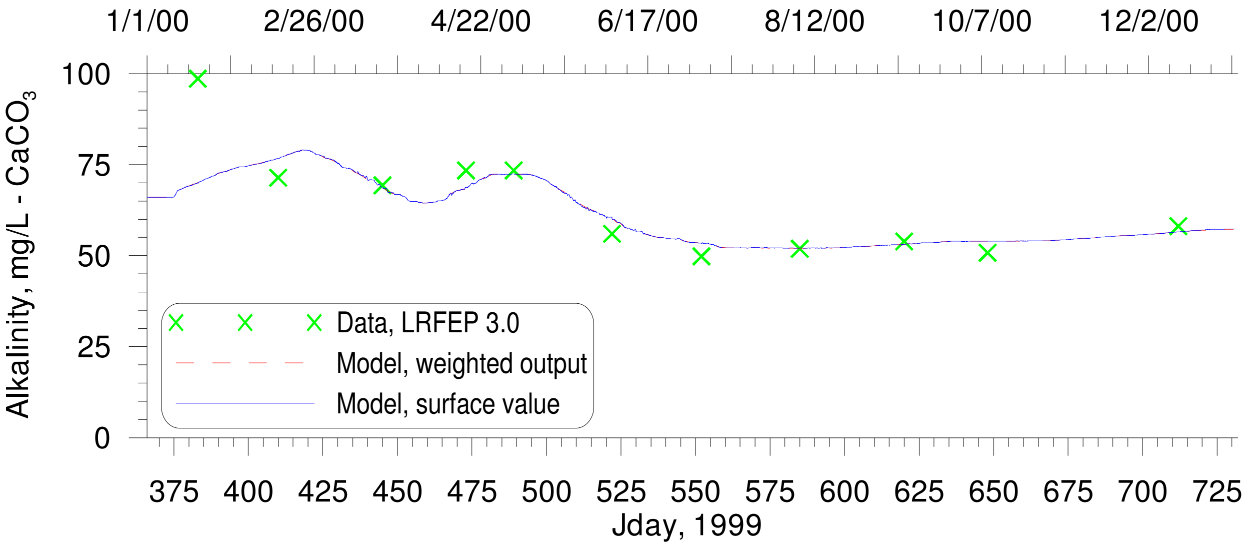


Figure 139. Model-data comparison of alkalinity at LRFEP station 3.0.

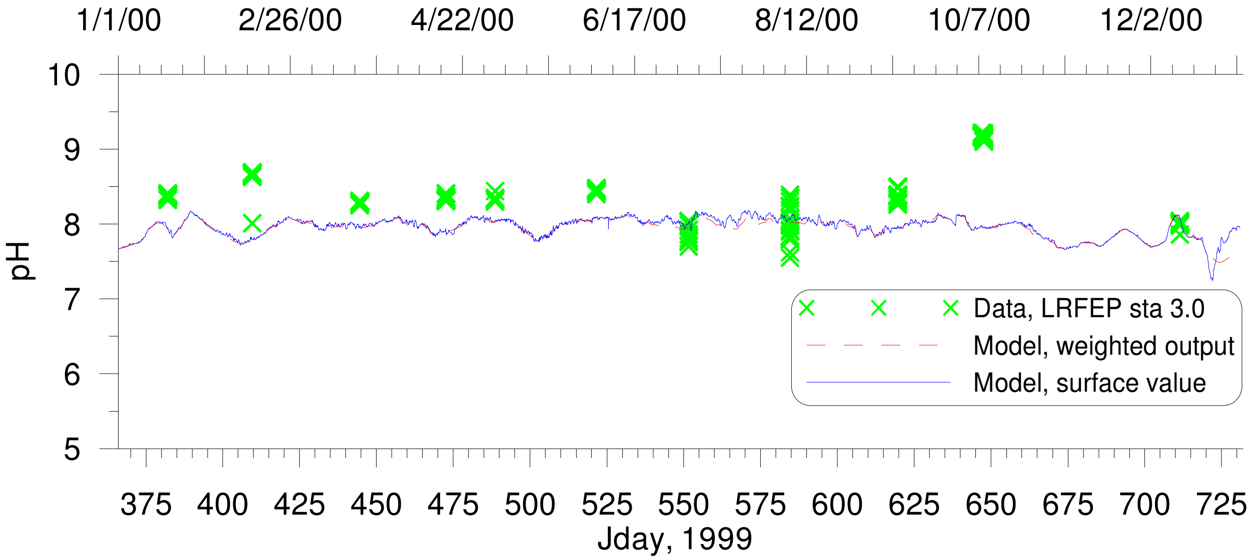


Figure 140. Model-data comparison of pH at LRFEP station 3.0.

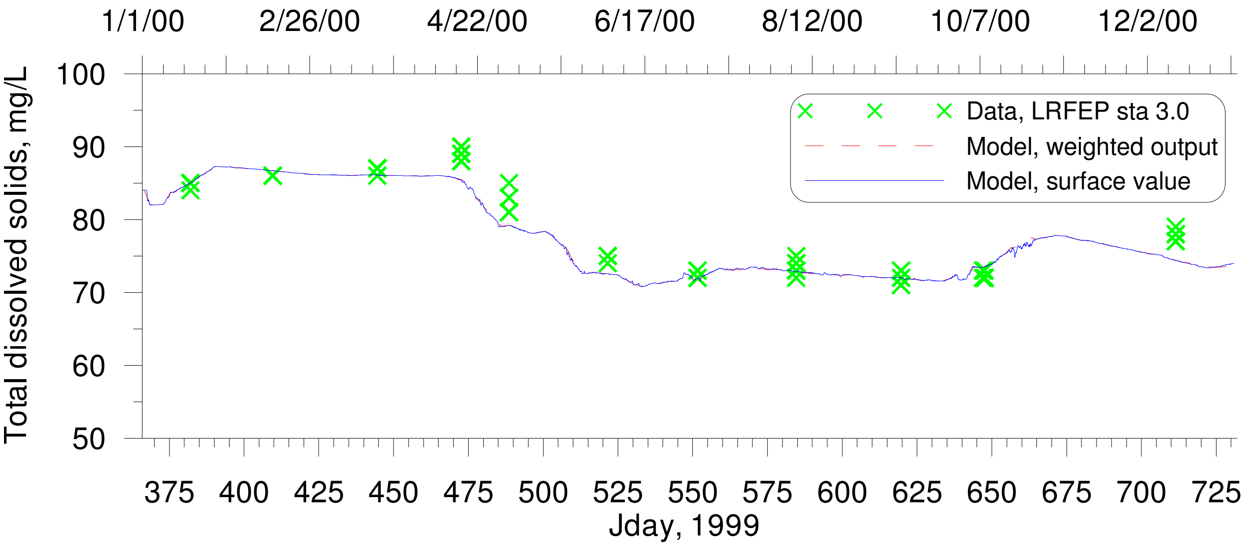


Figure 141. Model-data comparison of total dissolved solids at LRFEP station 3.0.

Station 4.0

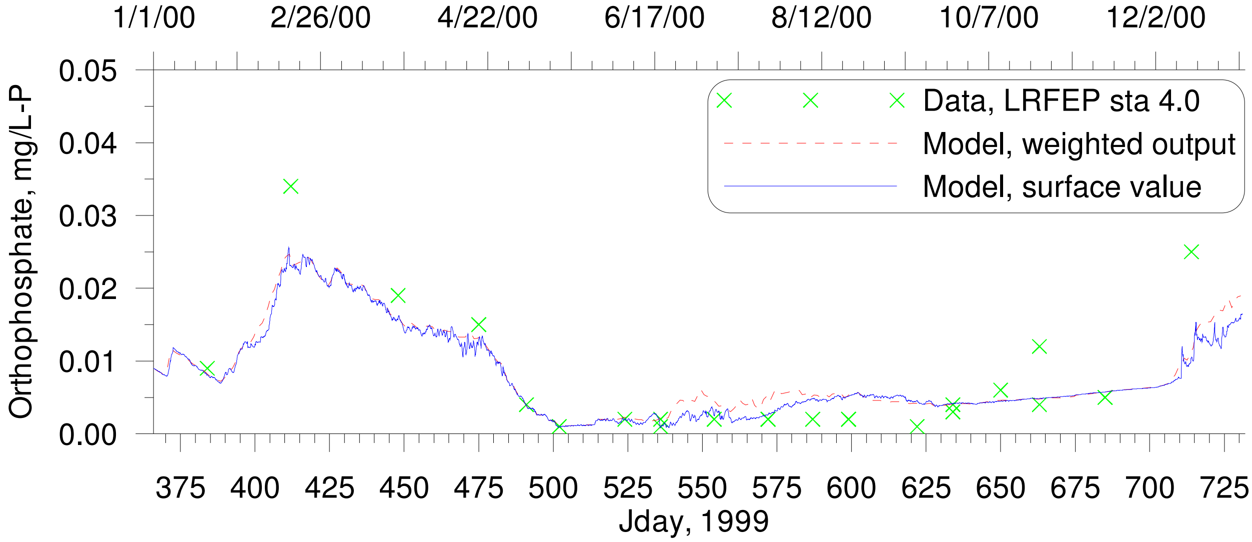


Figure 142. Model-data comparison of orthophosphate at LRFEP station 4.0.

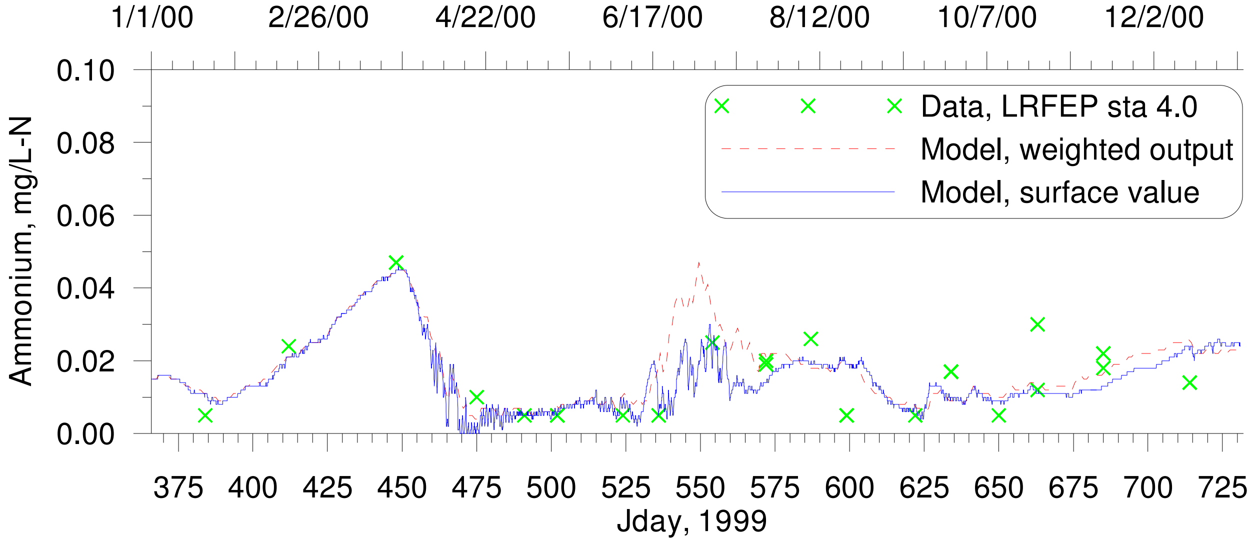


Figure 143. Model-data comparison of ammonium at LRFEP station 4.0.

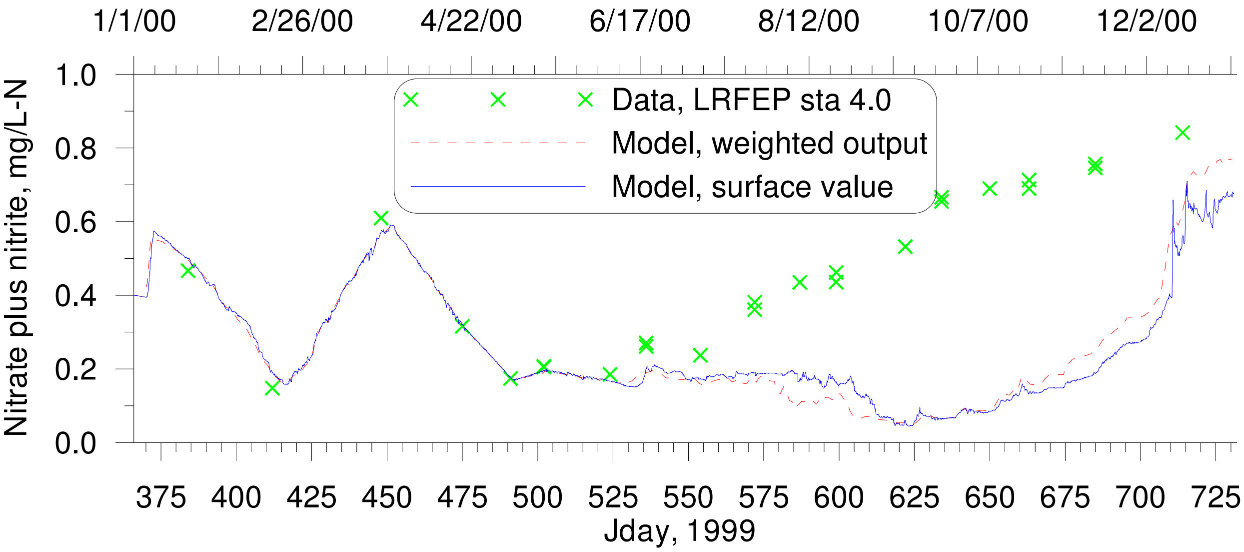


Figure 144. Model-data comparison of nitrate plus nitrite at LRFEP station 4.0.

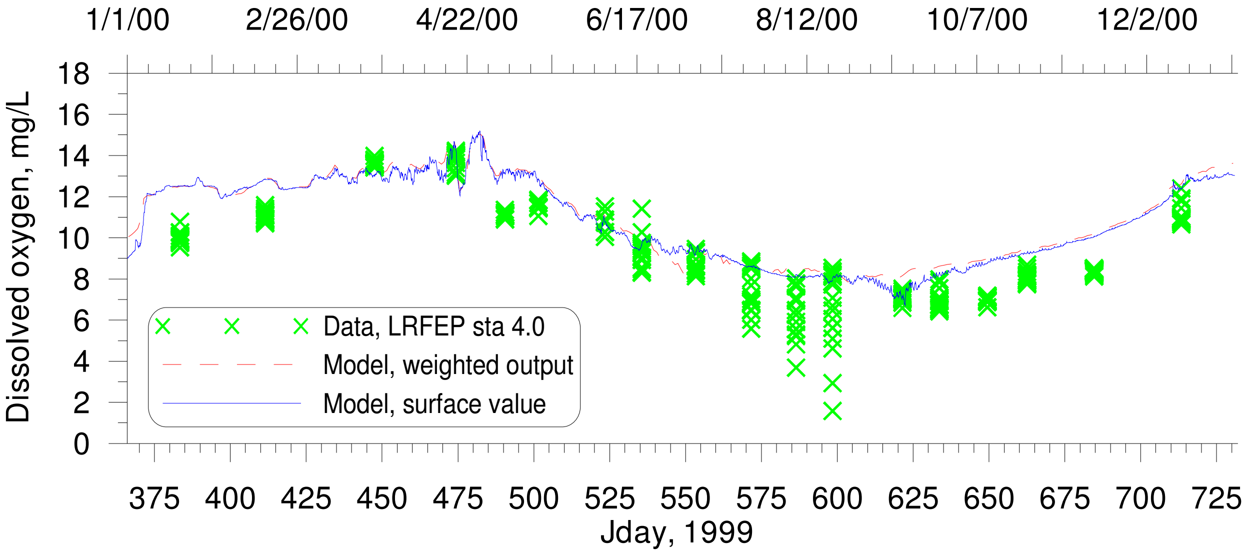


Figure 145. Model-data comparison of dissolved oxygen at LRFEP station 4.0.

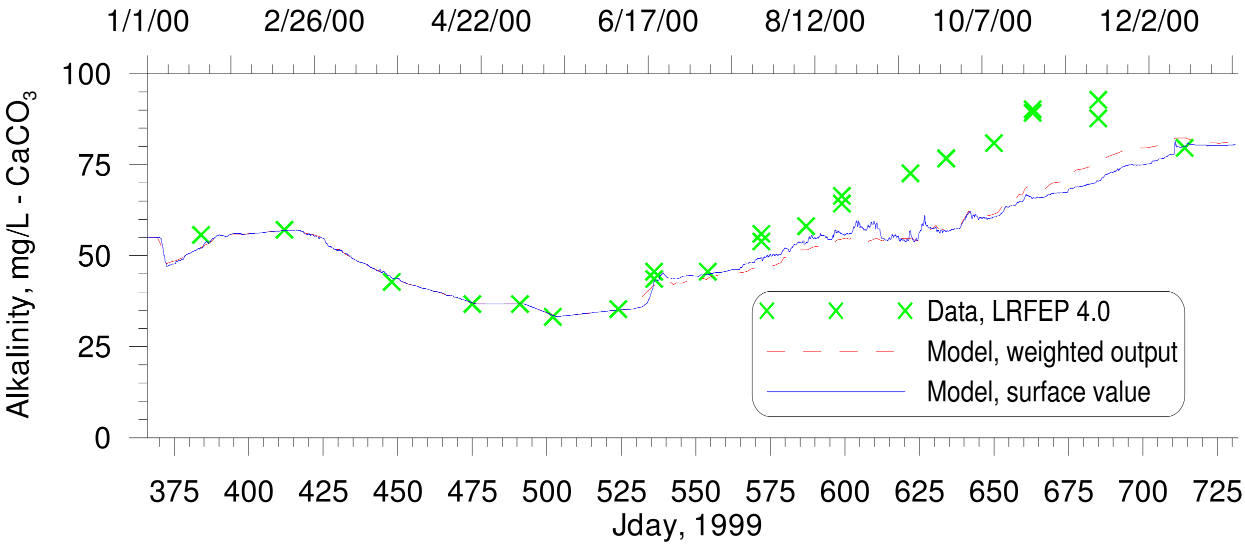


Figure 146. Model-data comparison of alkalinity at LRFEP station 4.0.

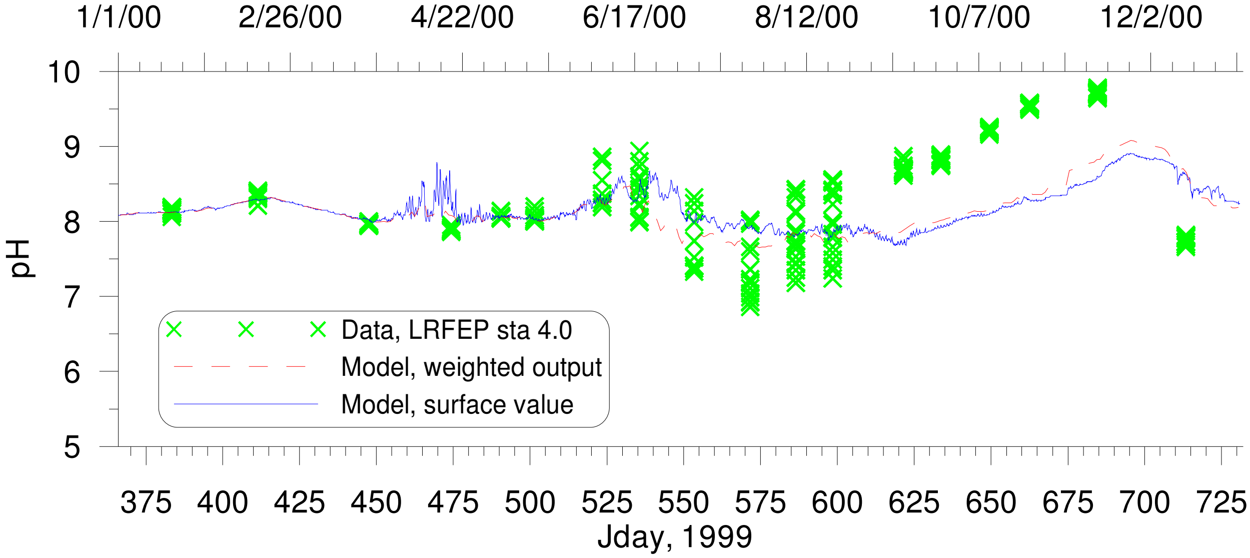


Figure 147. Model-data comparison of pH at LRFEP station 4.0.

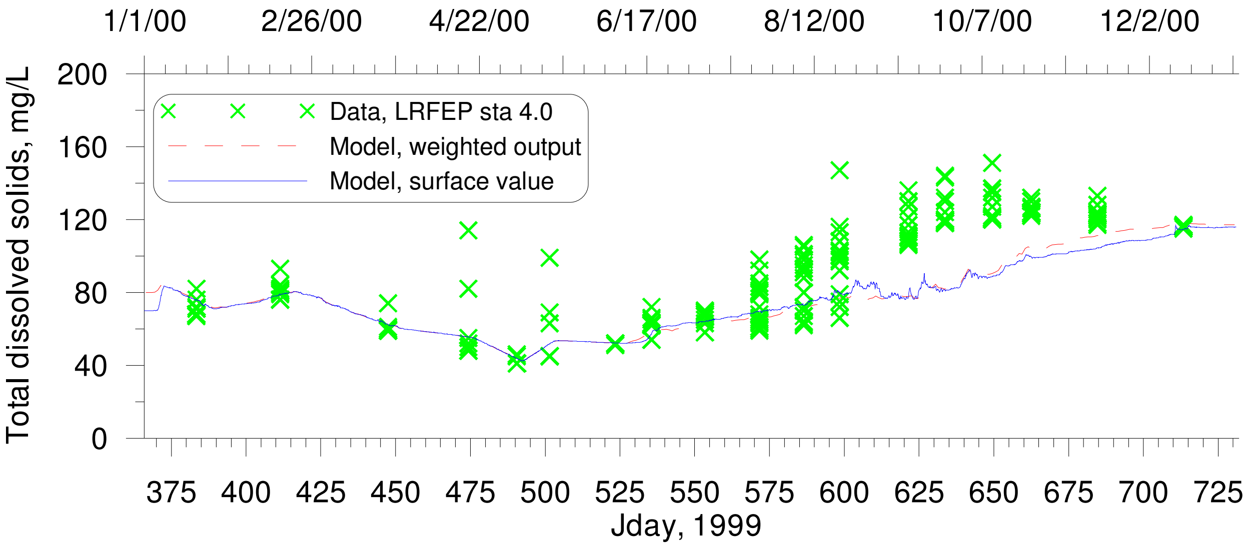


Figure 148 Model-data comparison of total dissolved solids at LRFEP station 4.0.

Station 5.5

The travel time to station 5.5 ranges roughly from 9 to 56 days from the U.S.-Canadian border. The model exhibits some vertical gradients at times for most of the constituents

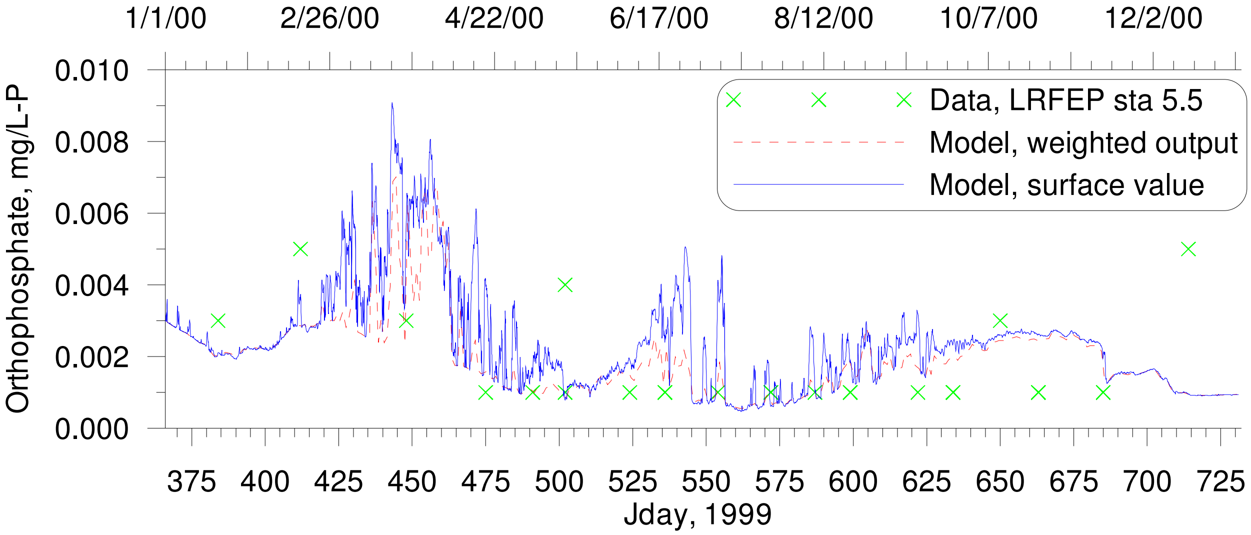


Figure 149. Model-data comparison of orthophosphate at LRFEP station 5.5.

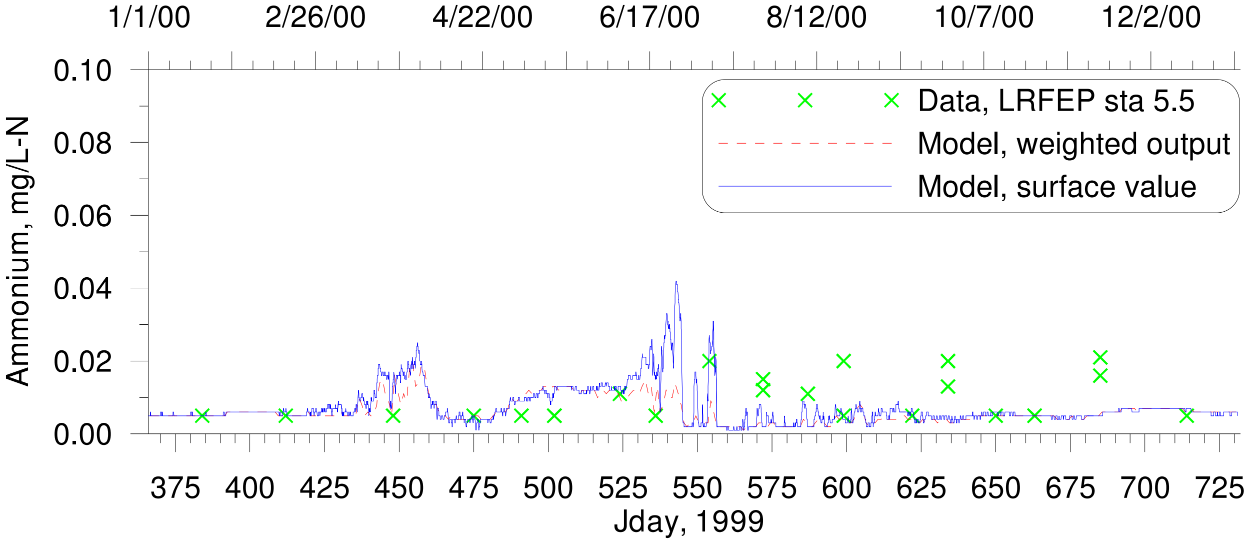


Figure 150. Model-data comparison of ammonium at LRFEP station 5.5.

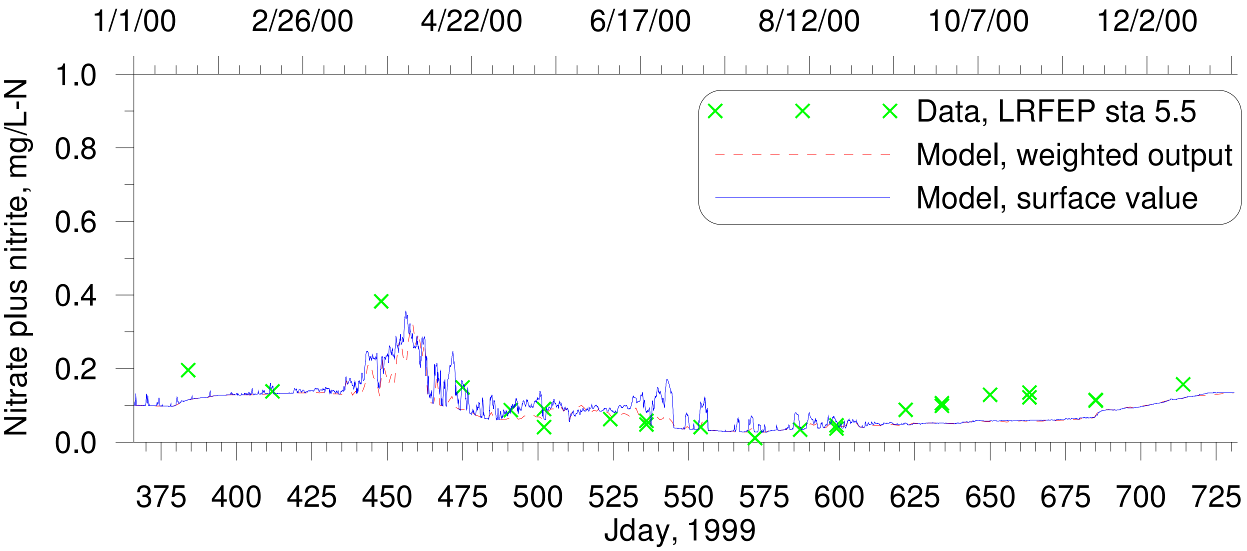


Figure 151. Model-data comparison of nitrate plus nitrite at LRFEP station 5.5.

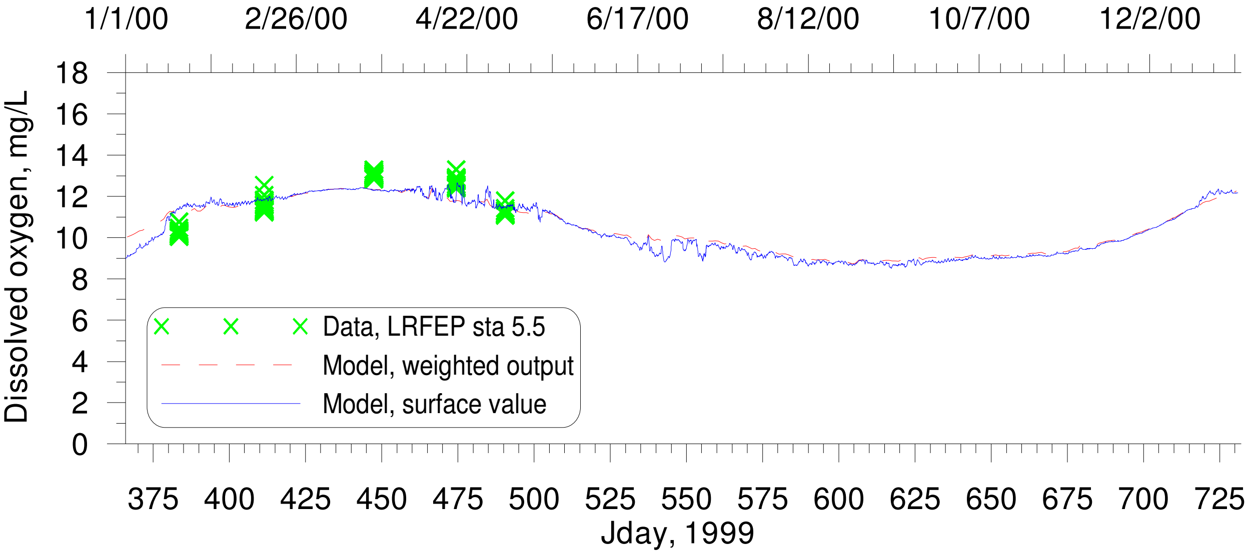


Figure 152. Model-data comparison of dissolved oxygen at LRFEP station 5.5.

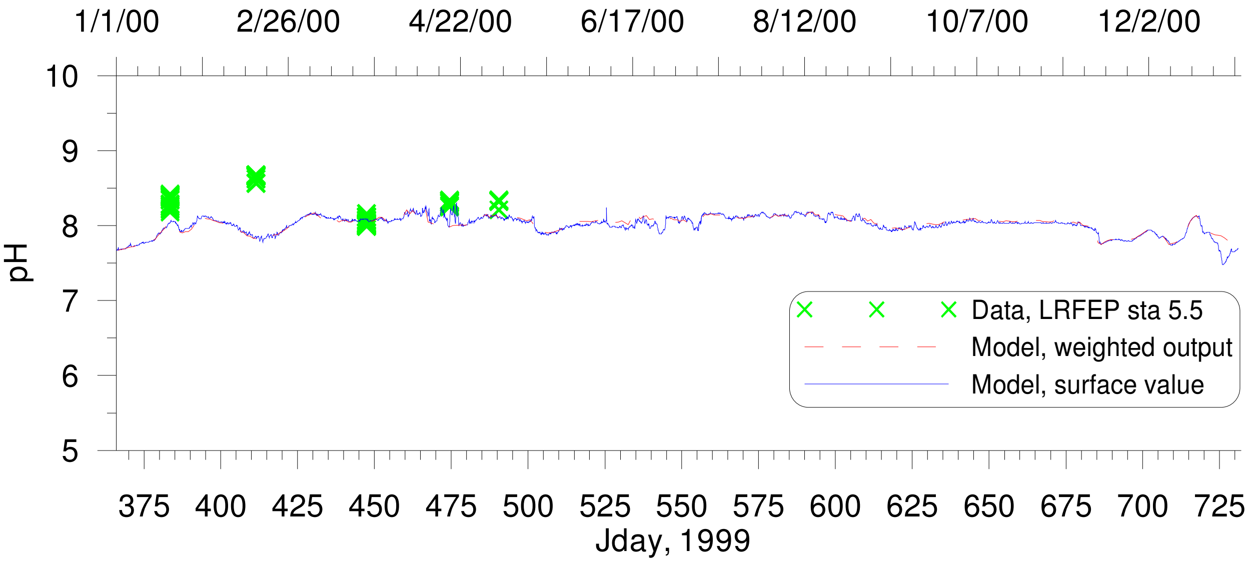


Figure 153. Model-data comparison of pH at LRFEP station 5.5.

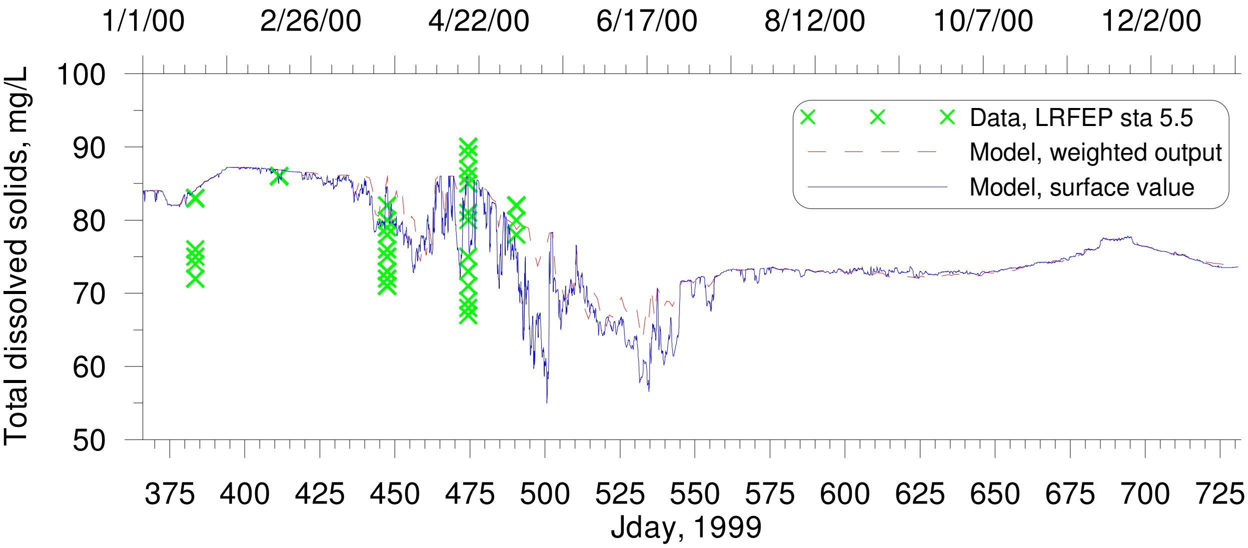


Figure 154. Model-data comparison of total dissolved solids at LRFEP station 5.5.

Station 6.0

Station 6.0 is located downstream of the confluence of the Spokane and Columbia Rivers. The noise seen in the orthophosphate (Figure 155), ammonium (Figure 156), and nitrate plus nitrite (Figure 157) is a result of algal activity.

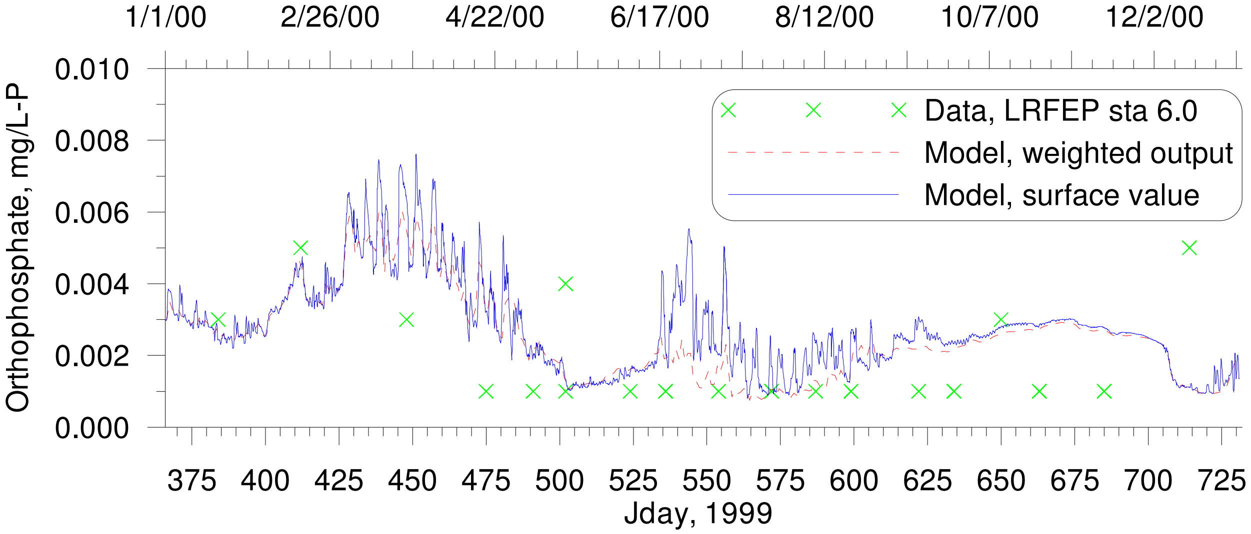


Figure 155. Model-data comparison of orthophosphate at LRFEP station 6.0.

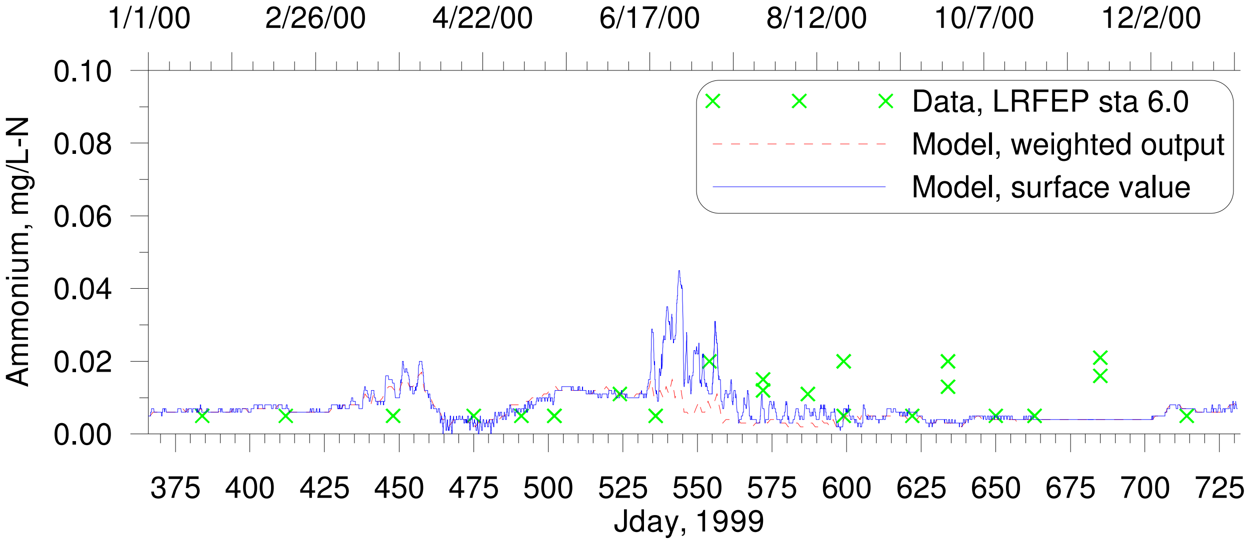


Figure 156. Model-data comparison of ammonium at LRFEP station 6.0.

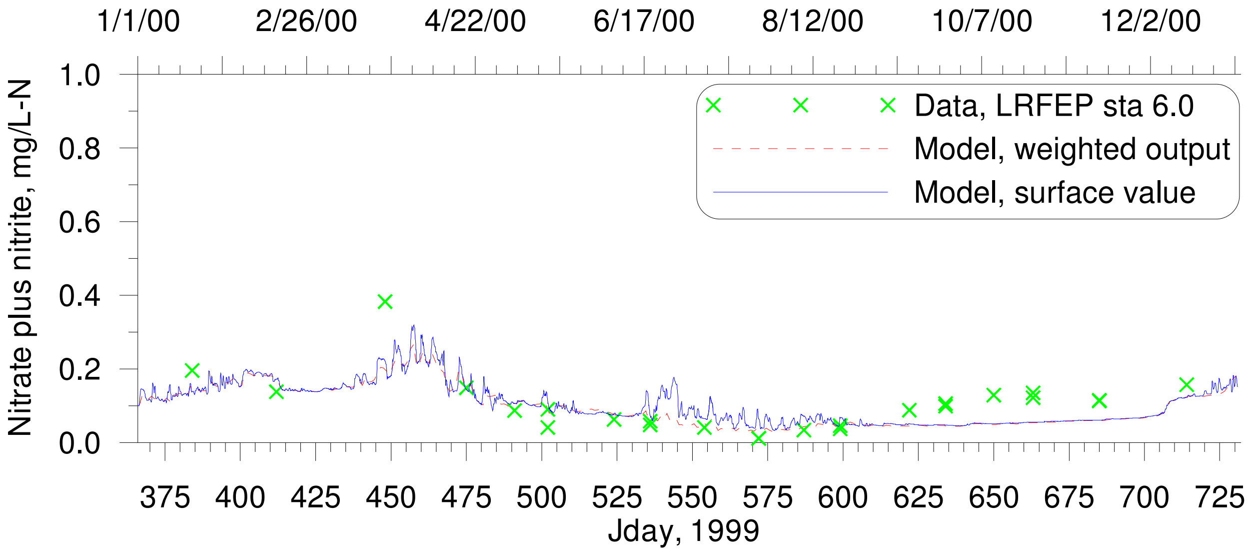


Figure 157. Model-data comparison of nitrate plus nitrite at LRFEP station 6.0.

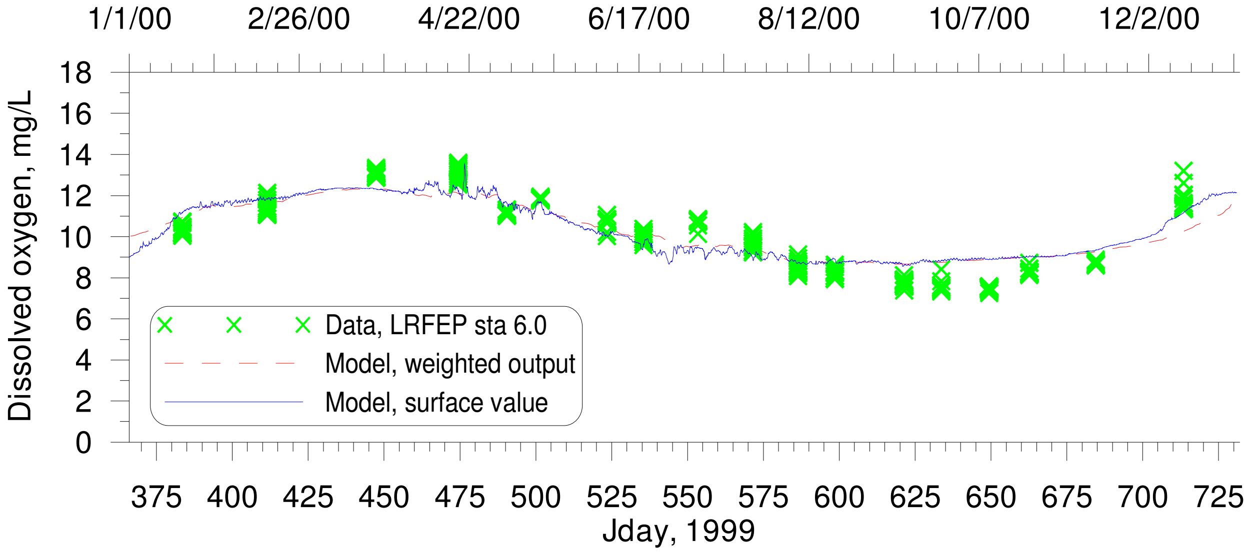


Figure 158. Model-data comparison of dissolved oxygen at LRFEP station 6.0.

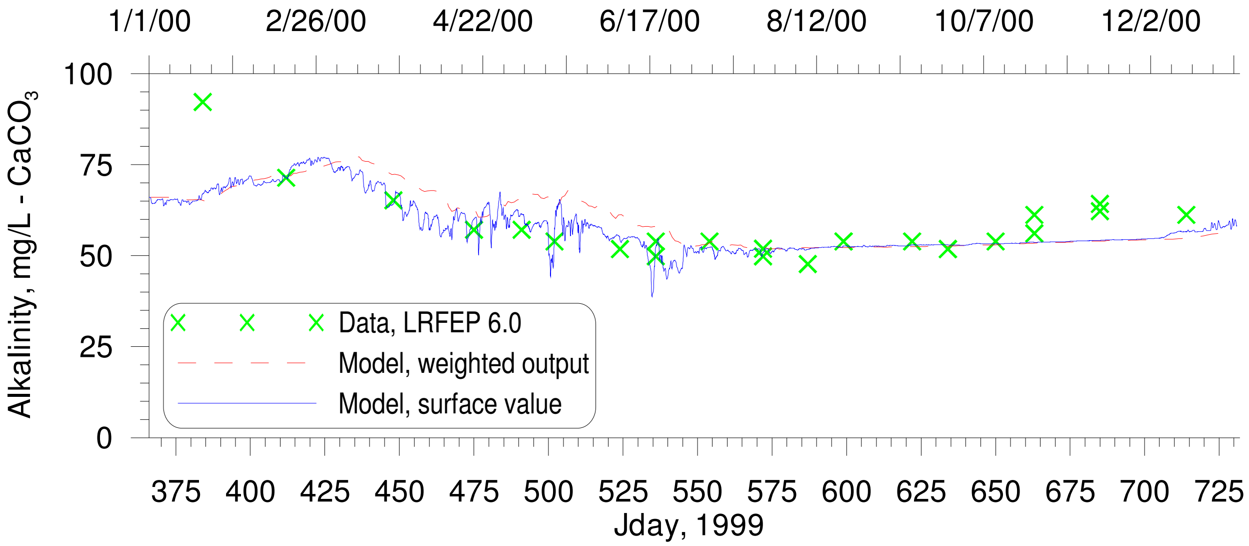


Figure 159. Model-data comparison of alkalinity at LRFEP station 6.0.

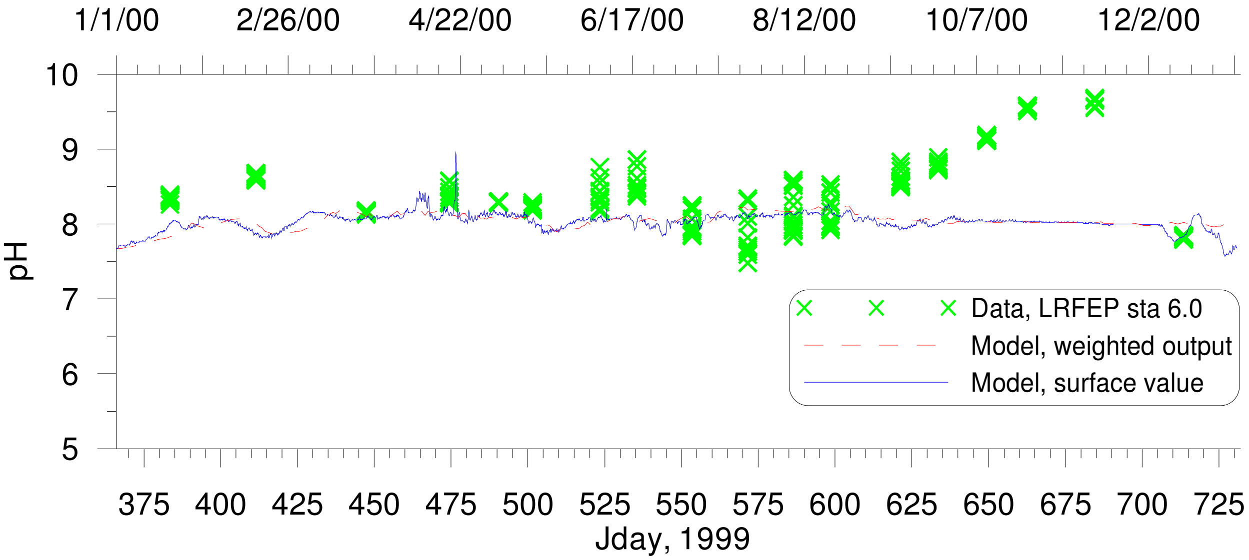


Figure 160. Model-data comparison of pH at LRFEP station 6.0.

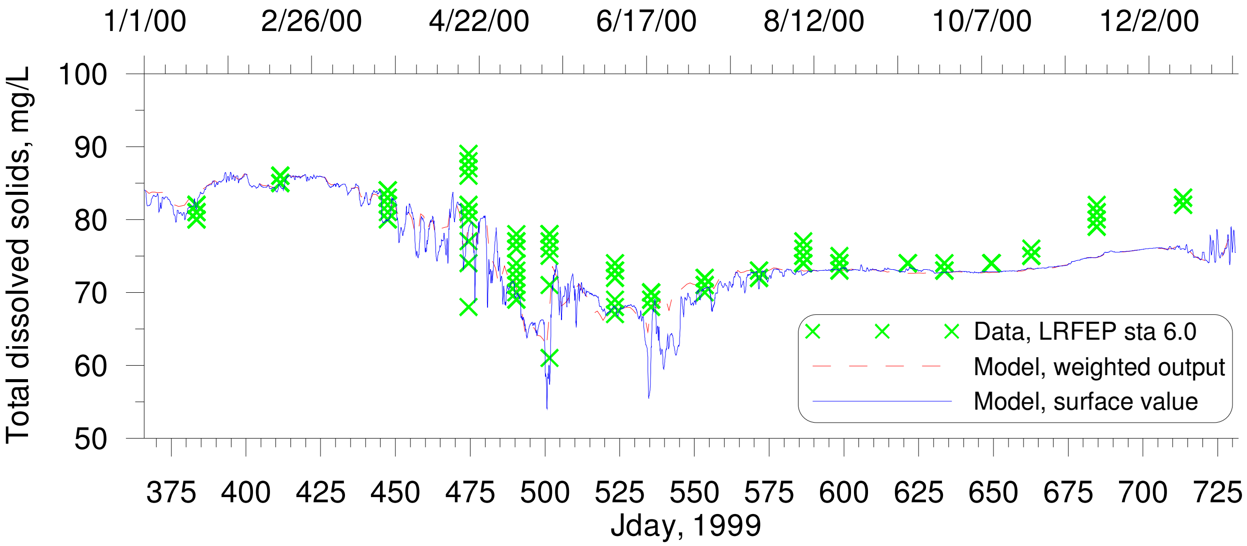


Figure 161. Model-data comparison of total dissolved solids at LRFEP station 6.0.

Station 6.5

Only dissolved oxygen (Figure 162), pH (Figure 163), and total dissolved solids (Figure 164) data are available at station 6.5. The model exhibits less vertical gradient than the data. The model also predicts that the constituent concentrations at station 6.5 are more influenced by the Columbia River mainstem than the data suggest. There are two likely explanations. One, the sampling location is more sheltered than the model's laterally averaged results would suggest. Two, the model does not include any inflow from Hawk Creek since no data were available, but the inflow of nutrients may be biologically significant. Refer also to the algae calibration section.

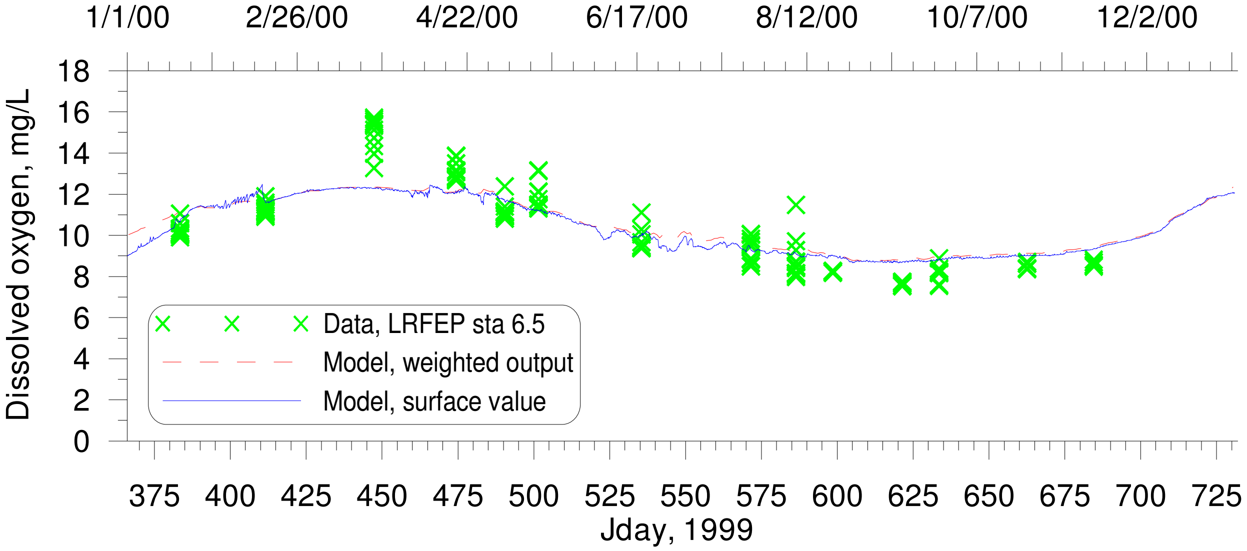


Figure 162. Model-data comparison of dissolved oxygen at LRFEP station 6.5.

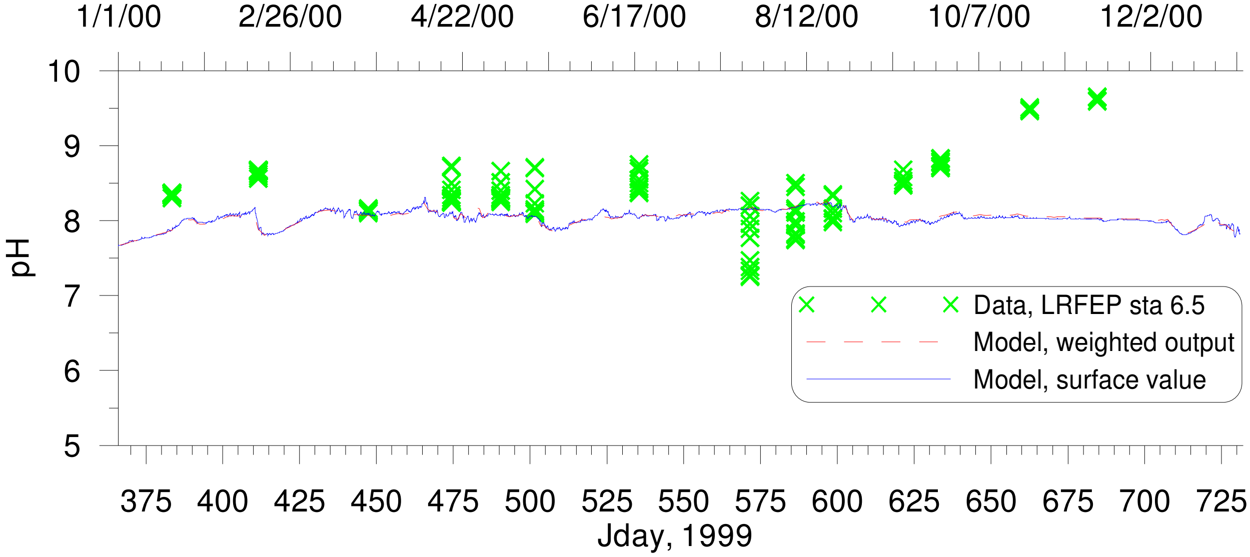


Figure 163. Model-data comparison of pH at LRFEP station 6.5.

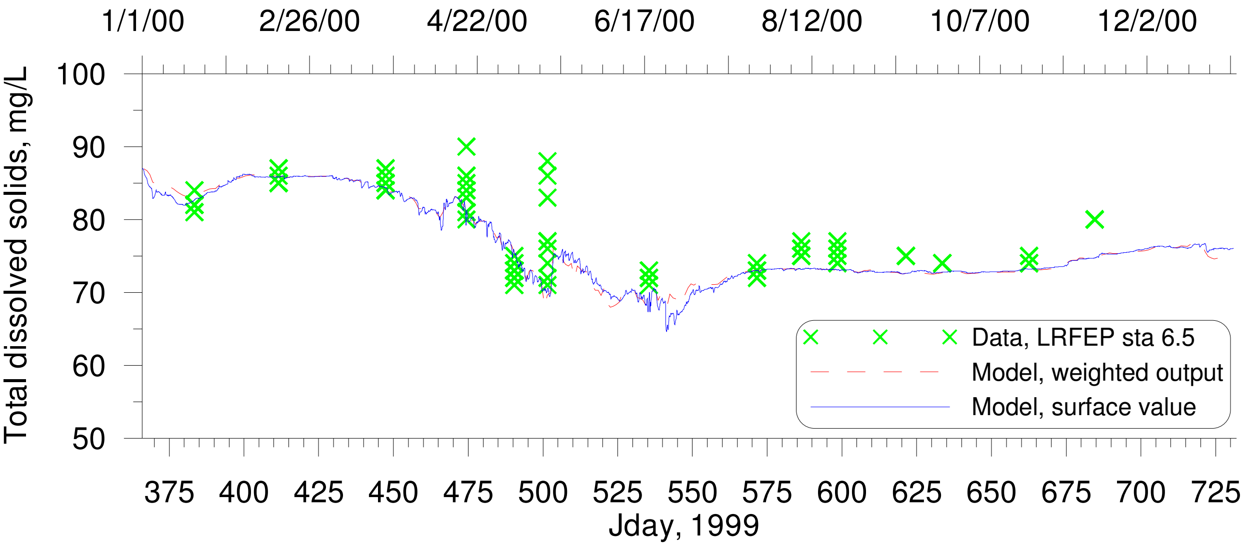


Figure 164. Model-data comparison of total dissolved solids at LRFEP station 6.5.

Station 7.0

The model exhibits some weak vertical gradients at station 7.0 during and after thermal stratification.

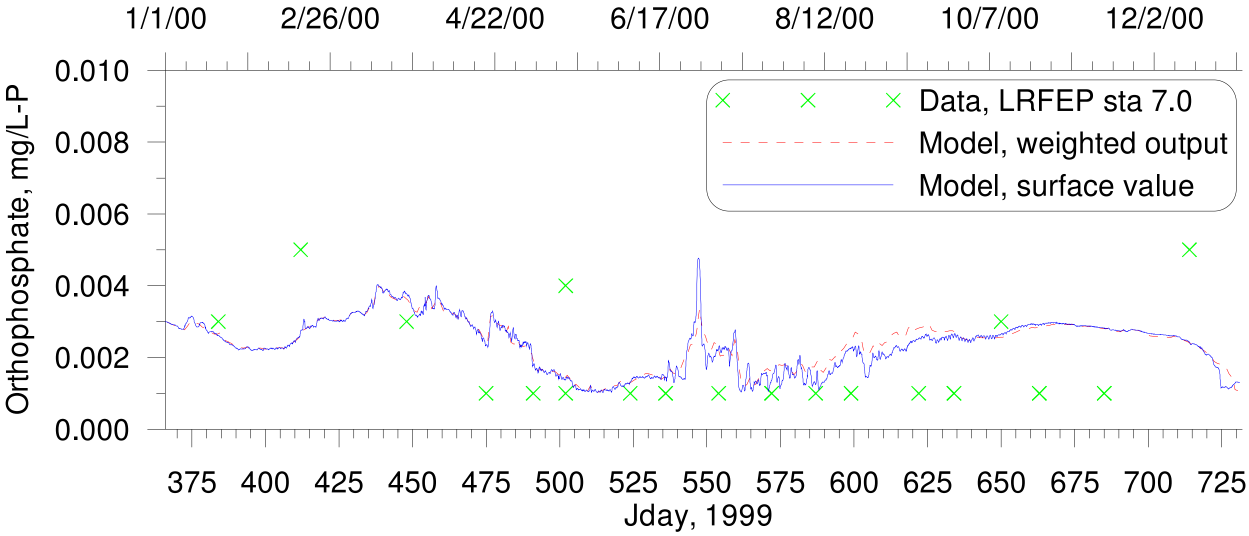


Figure 165. Model-data comparison of orthophosphate at LRFEP station 7.0.

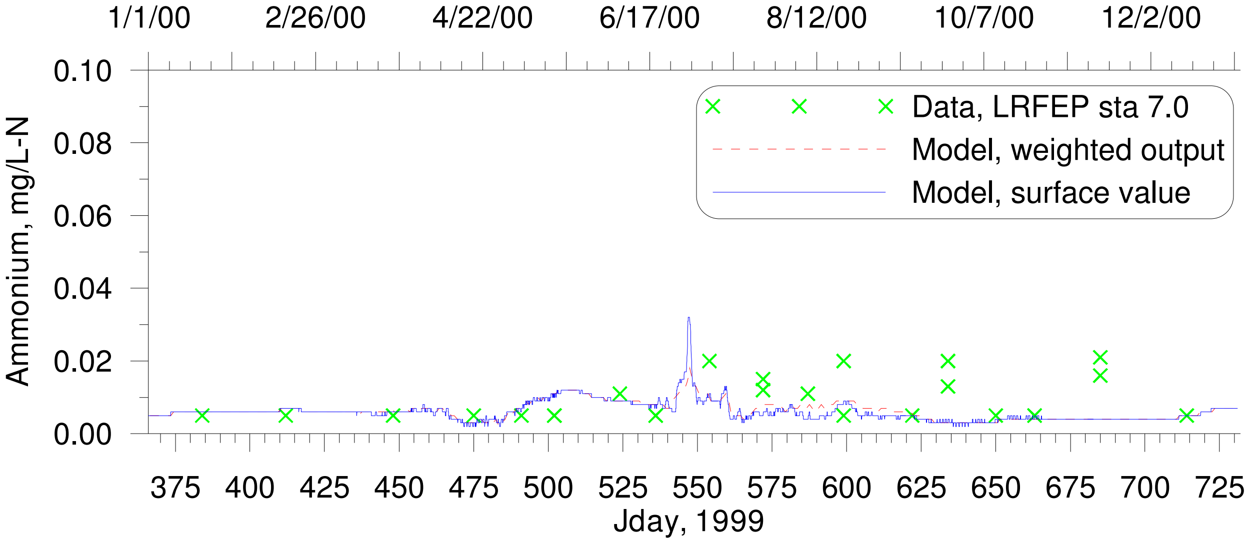


Figure 166. Model-data comparison of ammonium at LRFEP station 7.0.

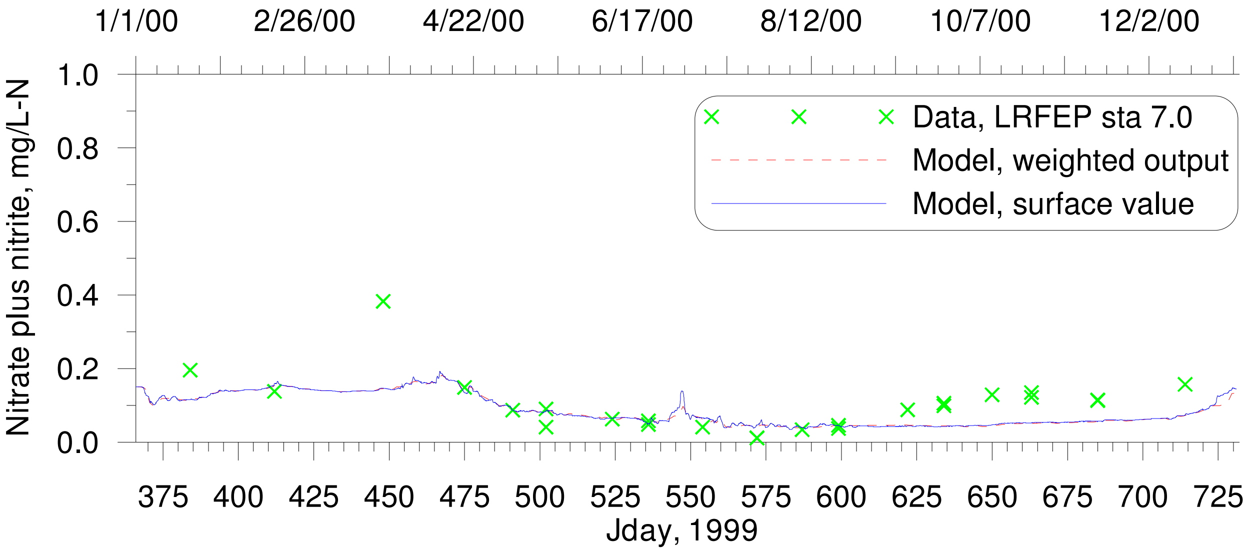


Figure 167. Model-data comparison of nitrate plus nitrite at LRFEP station 7.0.

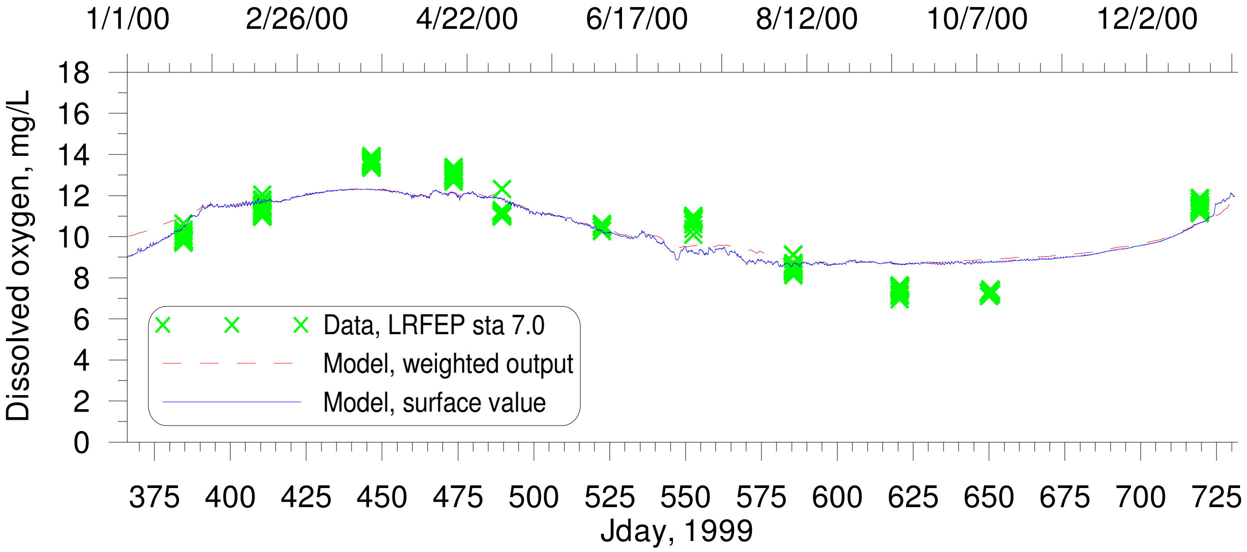


Figure 168. Model-data comparison of dissolved oxygen at LRFEP station 7.0.

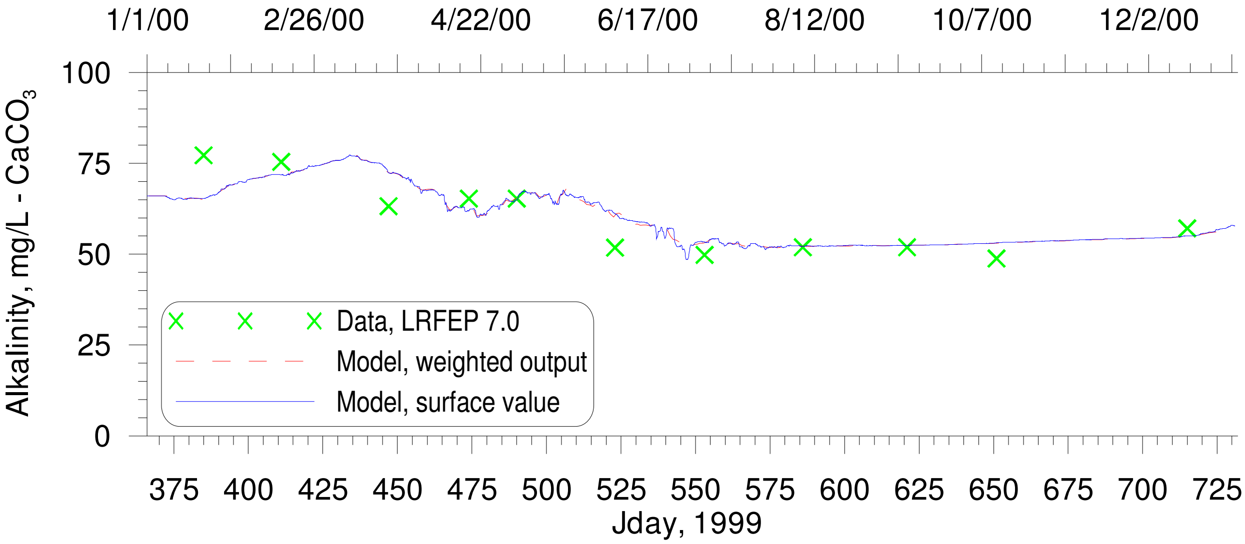


Figure 169. Model-data comparison of alkalinity at LRFEP station 7.0.

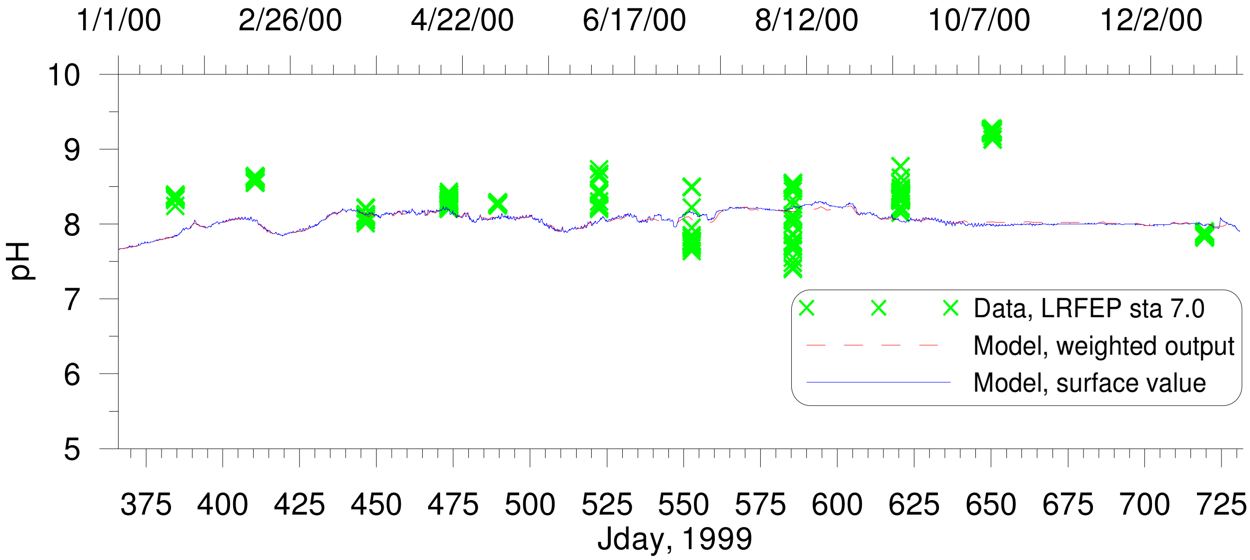


Figure 170. Model-data comparison of pH at LRFEP station 7.0.

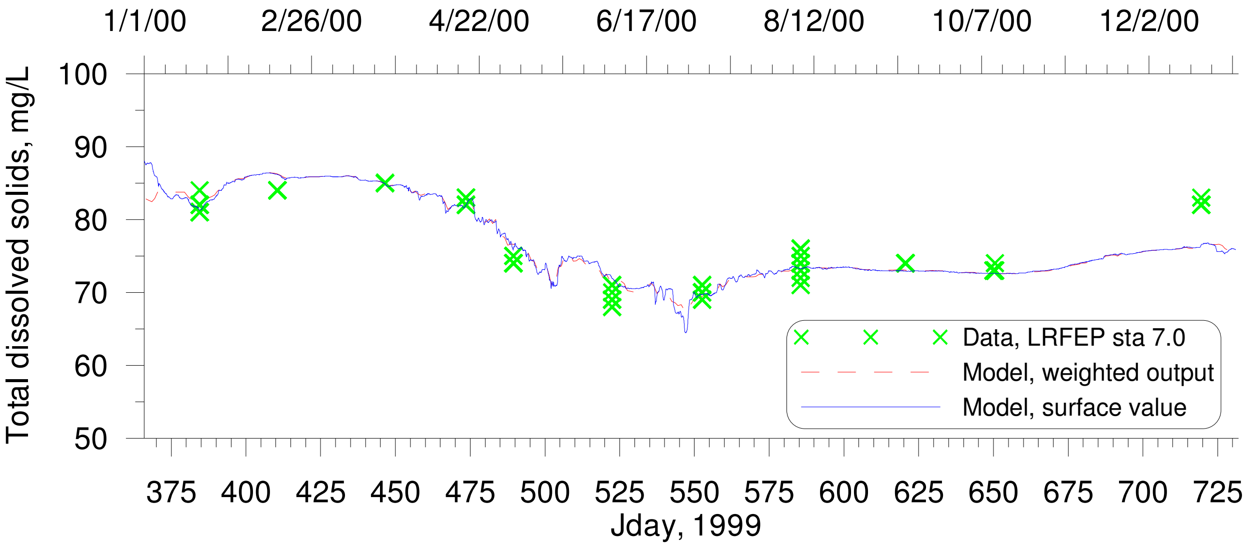


Figure 171. Model-data comparison of total dissolved solids at LRFEP station 7.0.

Station 8.0

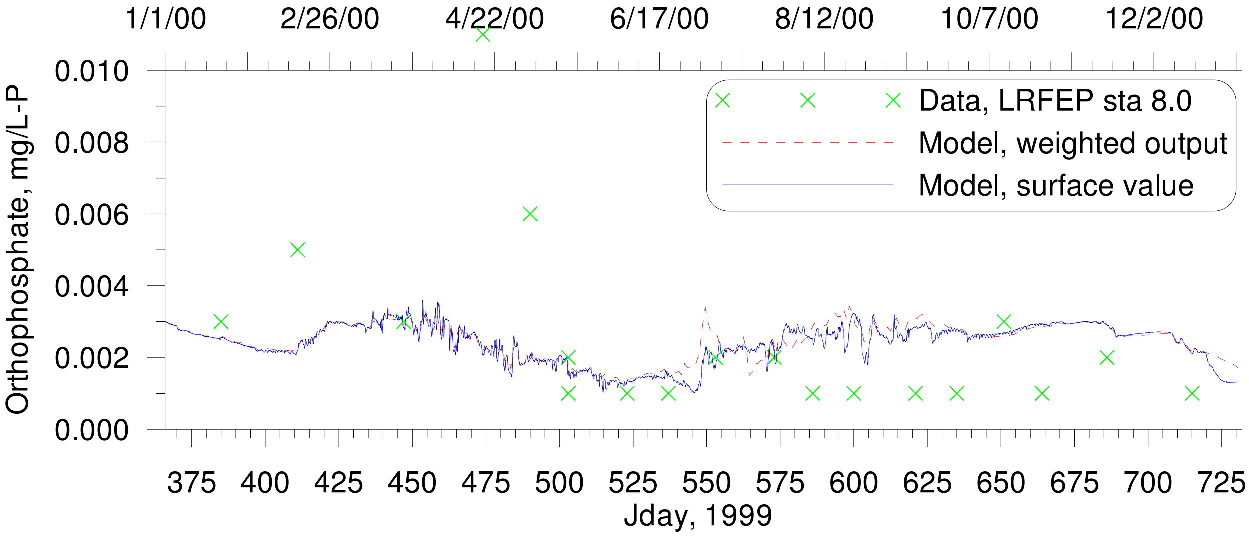


Figure 172. Model-data comparison of orthophosphate at LRFEP station 8.0.

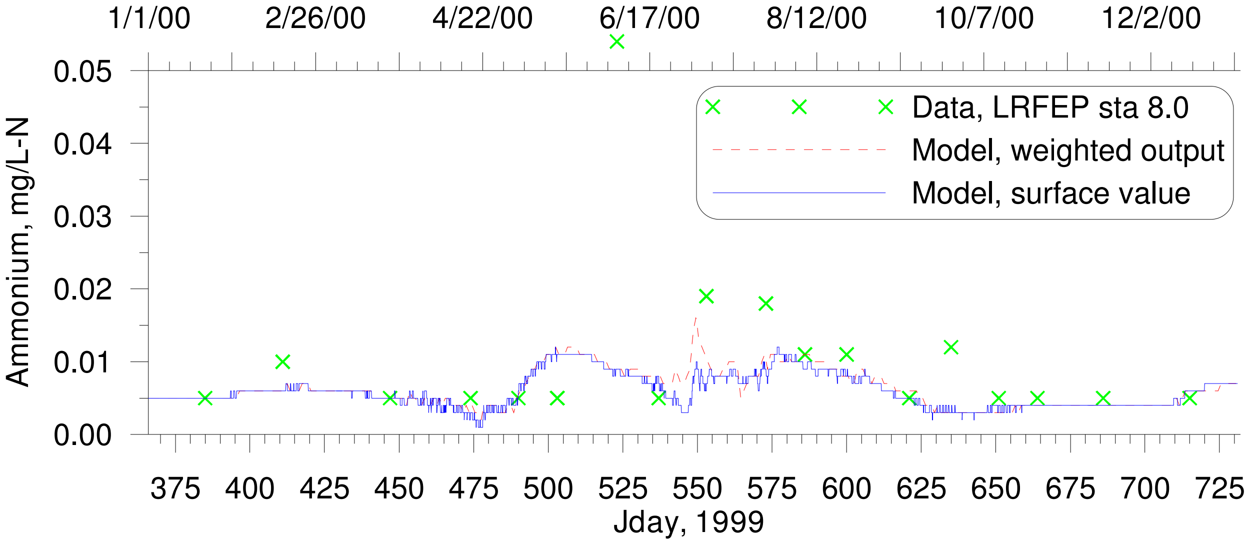


Figure 173. Model-data comparison of ammonium at LRFEP station 8.0.

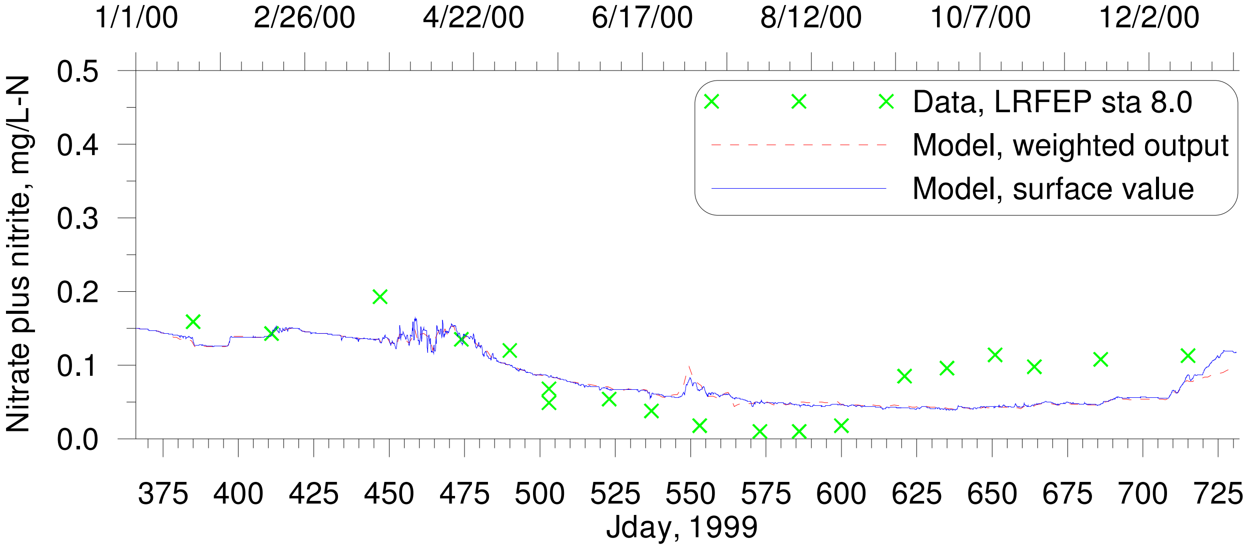


Figure 174. Model-data comparison of nitrate plus nitrite at LRFEP station 8.0.

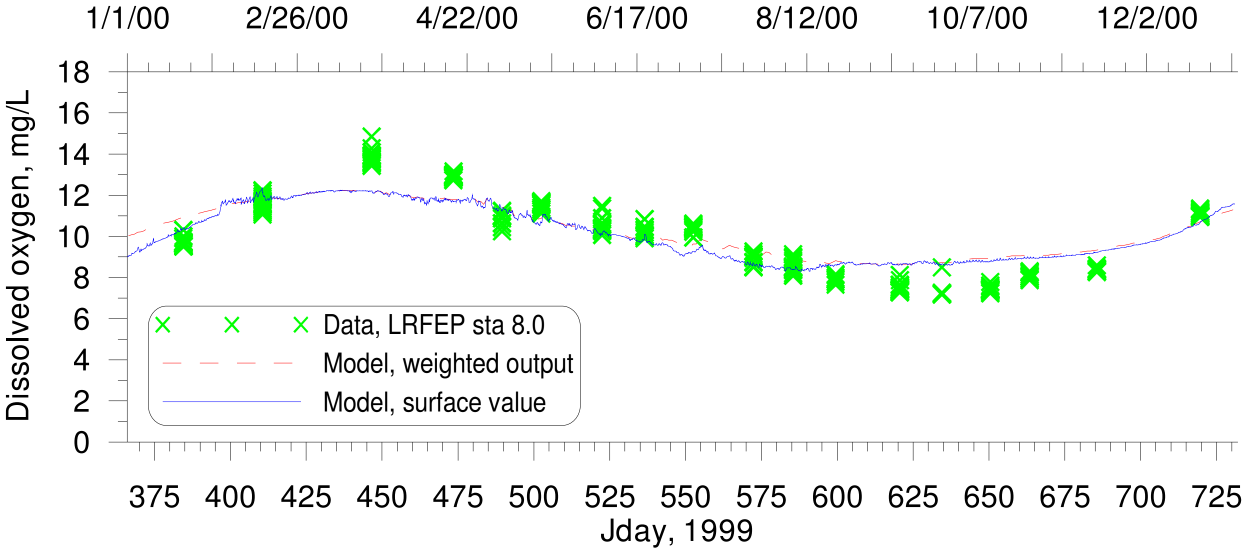


Figure 175. Model-data comparison of dissolved oxygen at LRFEP station 8.0.

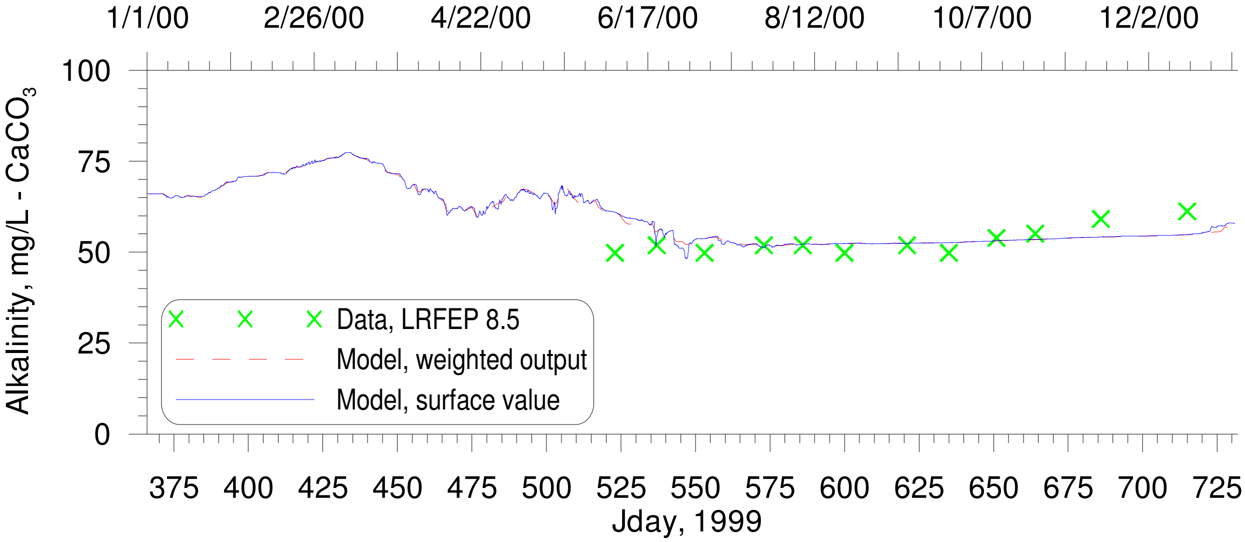


Figure 176. Model-data comparison of alkalinity at LRFEP station 8.0.

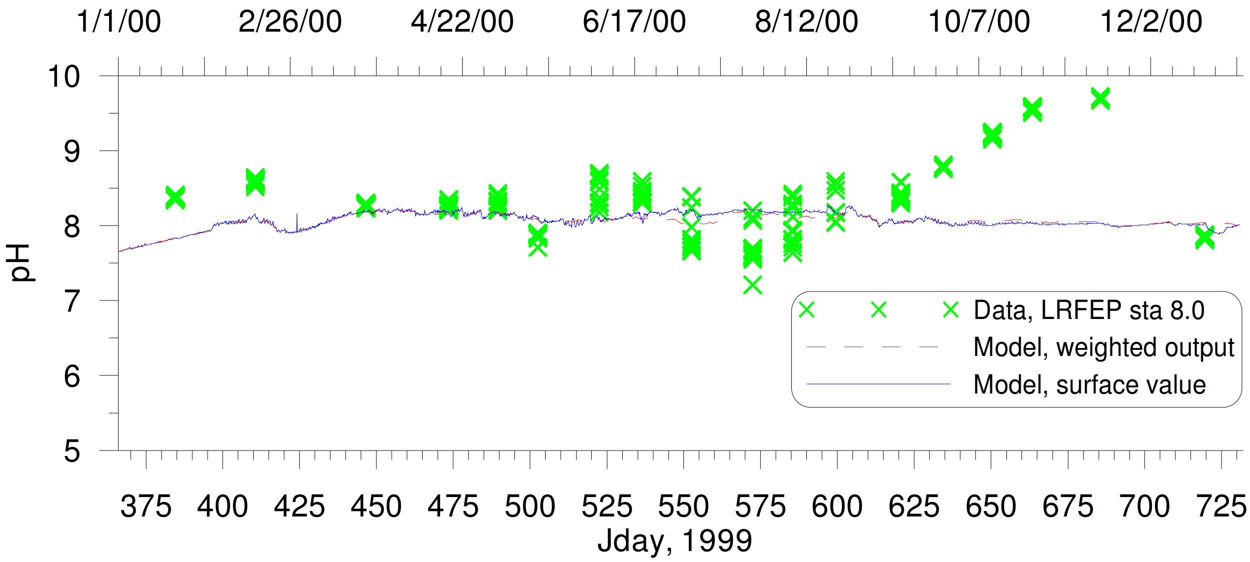


Figure 177. Model-data comparison of pH at LRFEP station 8.0.

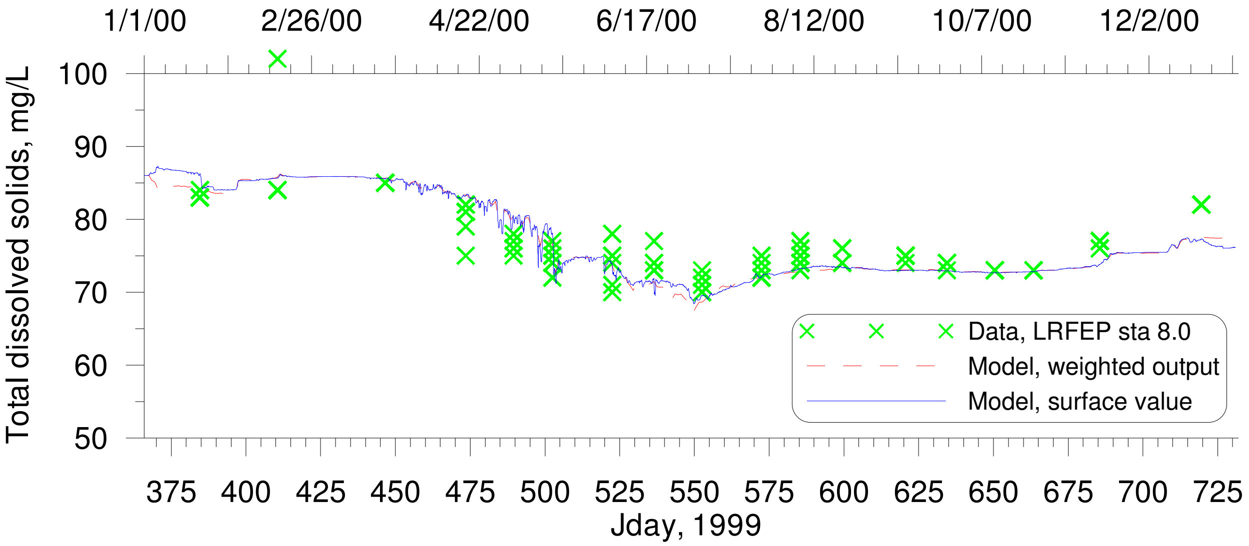


Figure 178. Model-data comparison of total dissolved solids at LRFEP station 8.0.

Station 8.5

The model exhibits some weak vertical gradients at station 8.5 during and after thermal stratification. The model does not exhibit the strong total dissolved solids gradient seen in the data (Figure 185).

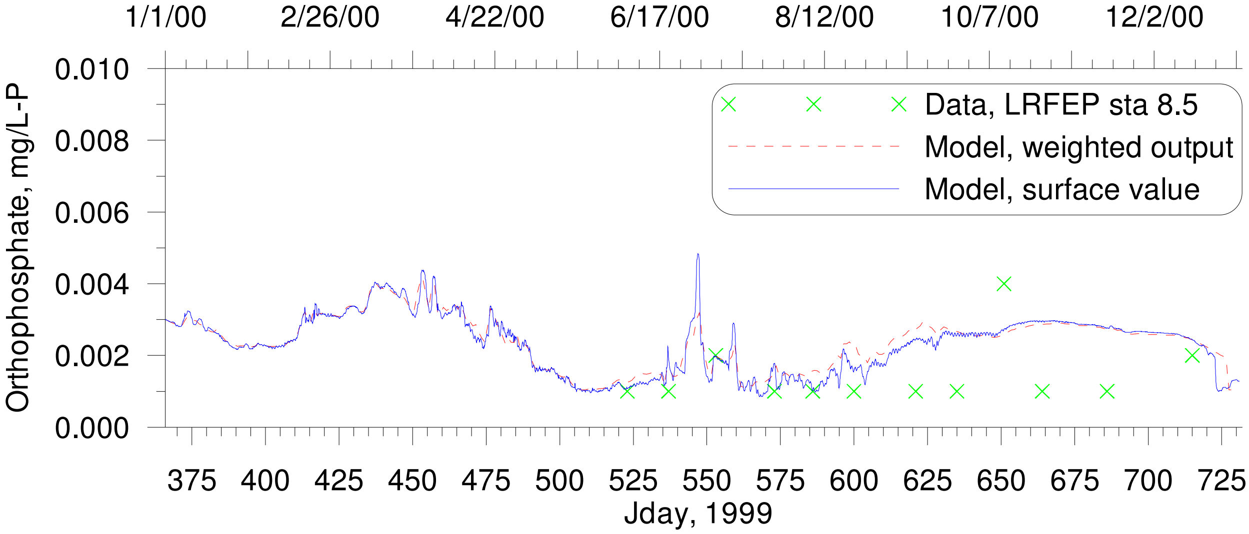


Figure 179. Model-data comparison of orthophosphate at LRFEP station 8.5.

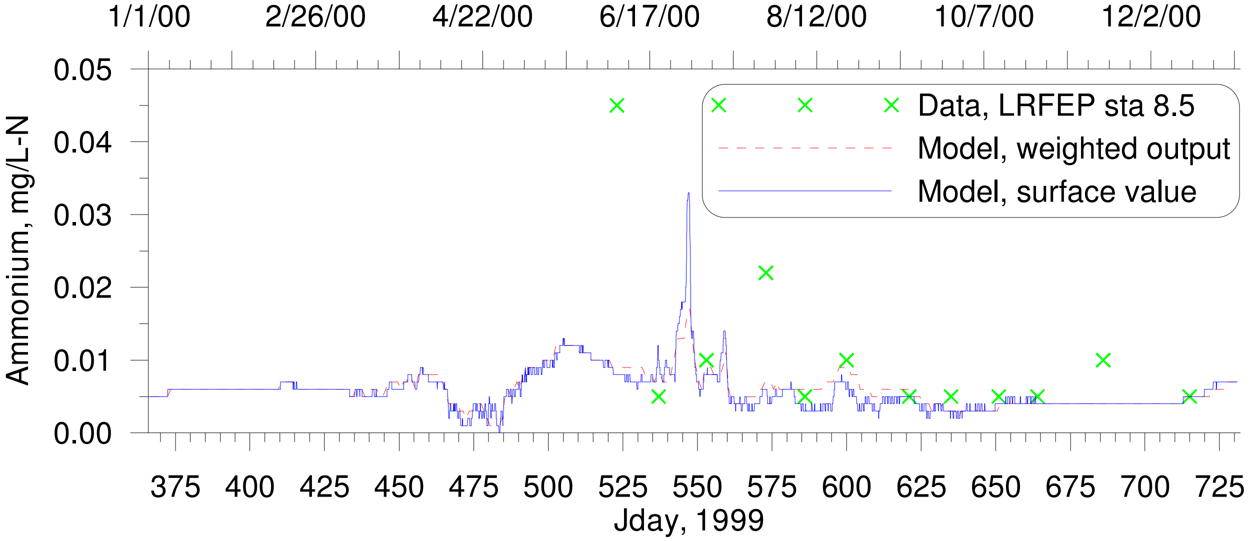


Figure 180. Model-data comparison of ammonium at LRFEP station 8.5.

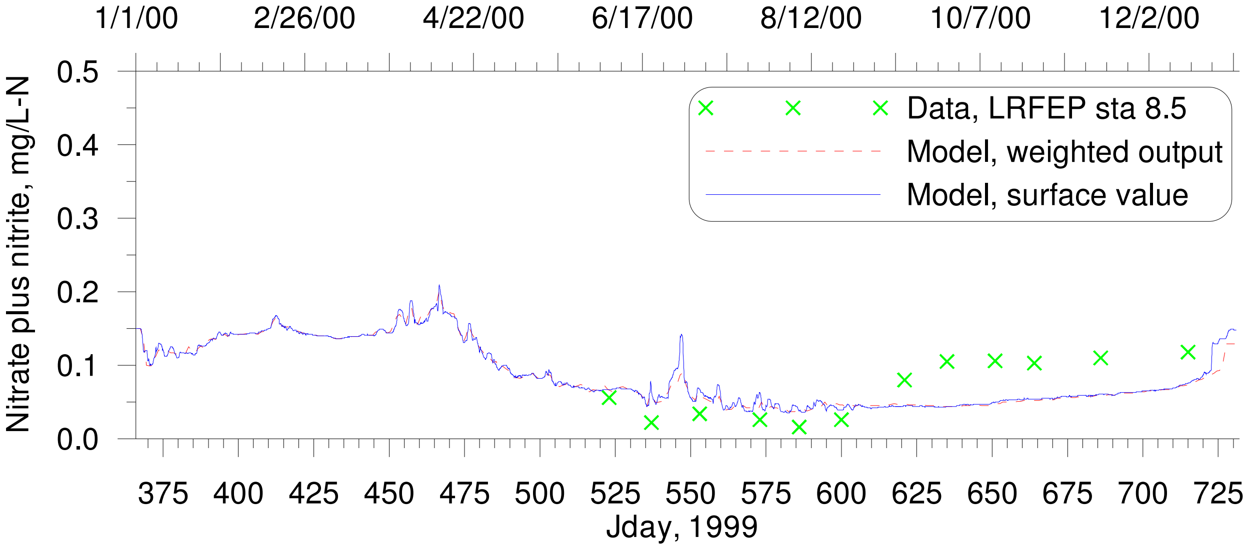


Figure 181. Model-data comparison of nitrate plus nitrite at LRFEP station 8.5.

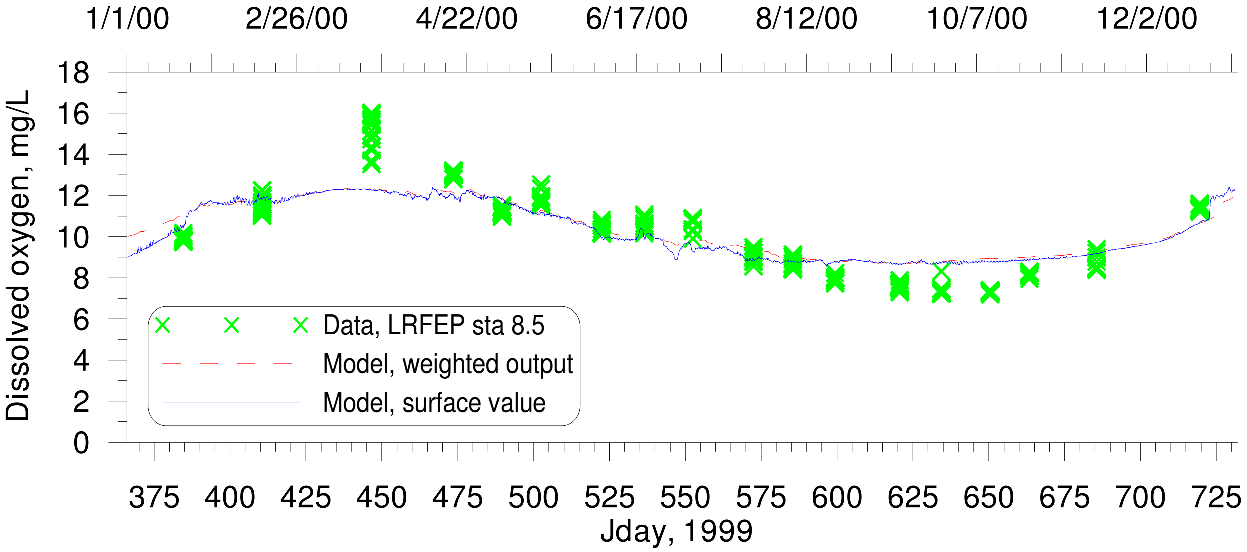


Figure 182. Model-data comparison of dissolved oxygen at LRFEP station 8.5.

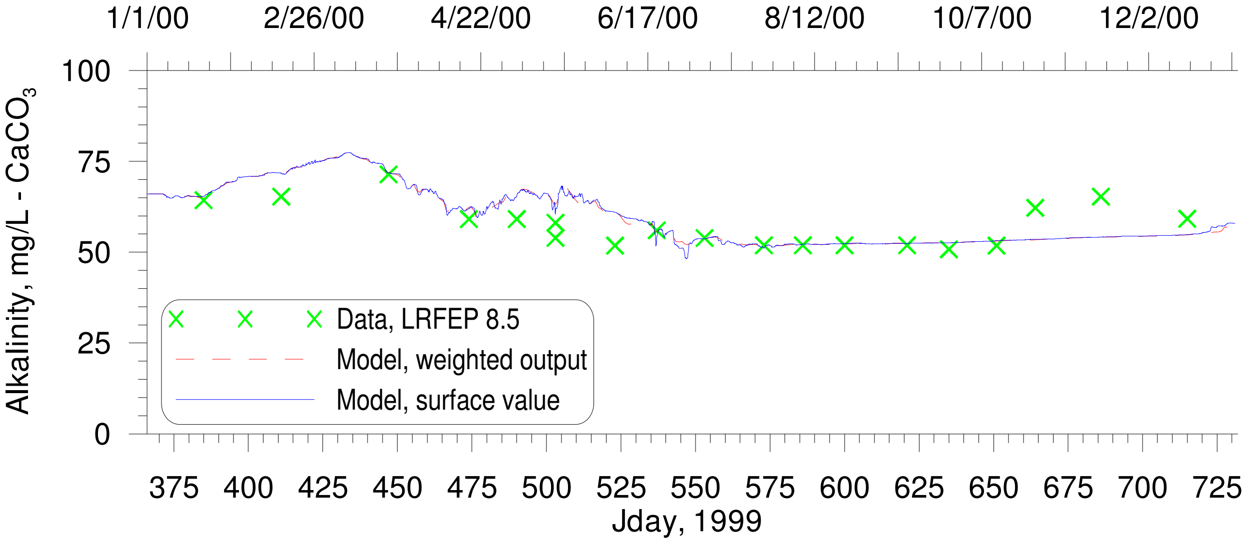


Figure 183. Model-data comparison of alkalinity at LRFEP station 8.5.

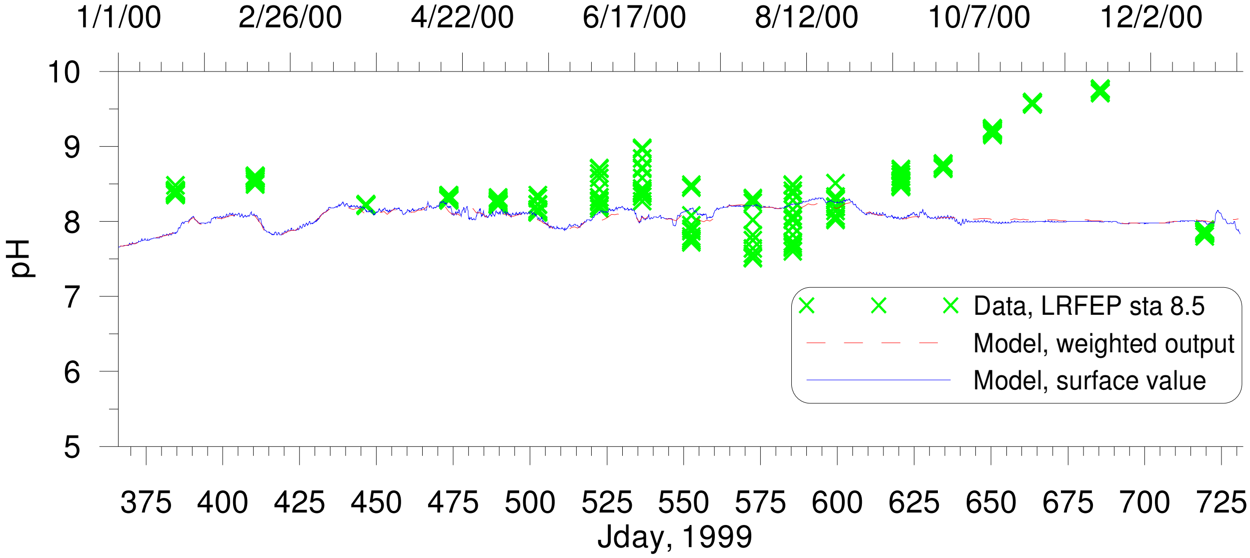


Figure 184. Model-data comparison of pH at LRFEP station 8.5.

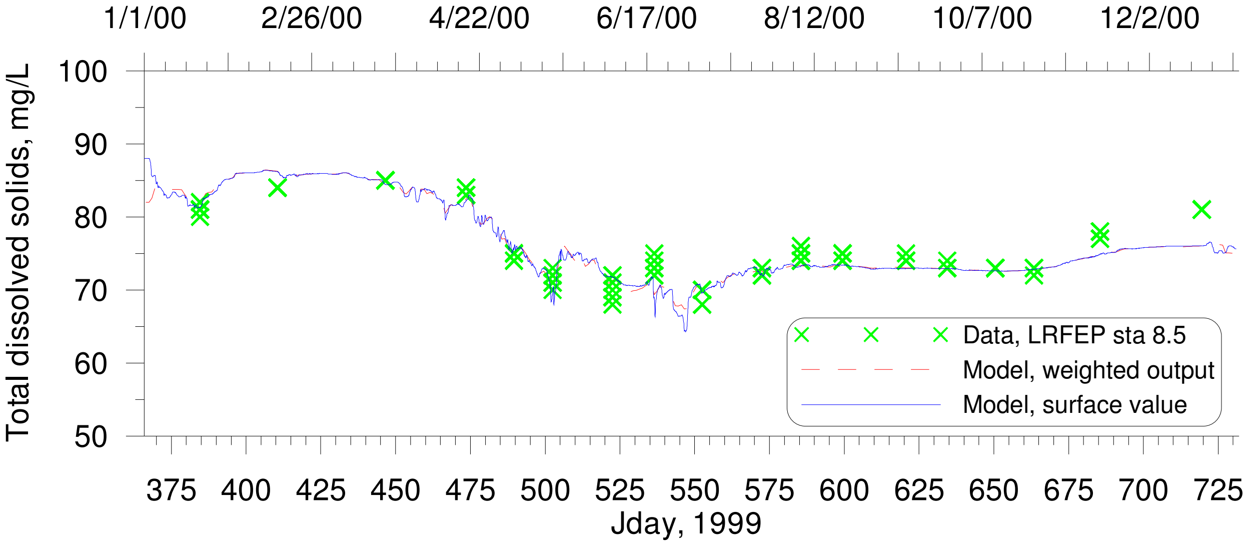


Figure 185. Model-data comparison of total dissolved solids at LRFEP station 8.5.

Station 9.0

The model exhibits a weak vertical gradient during and after thermal stratification. The dissolved oxygen (Figure 189) and total dissolved solids (Figure 192) data exhibit a stronger gradient.

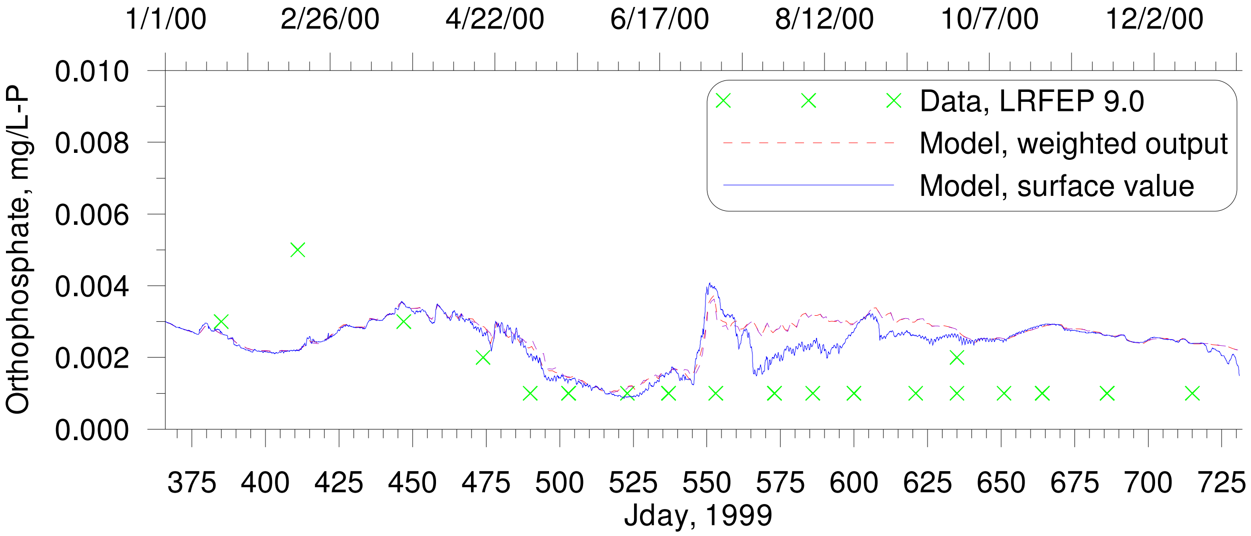


Figure 186. Model-data comparison of orthophosphate at LRFEP station 9.0.

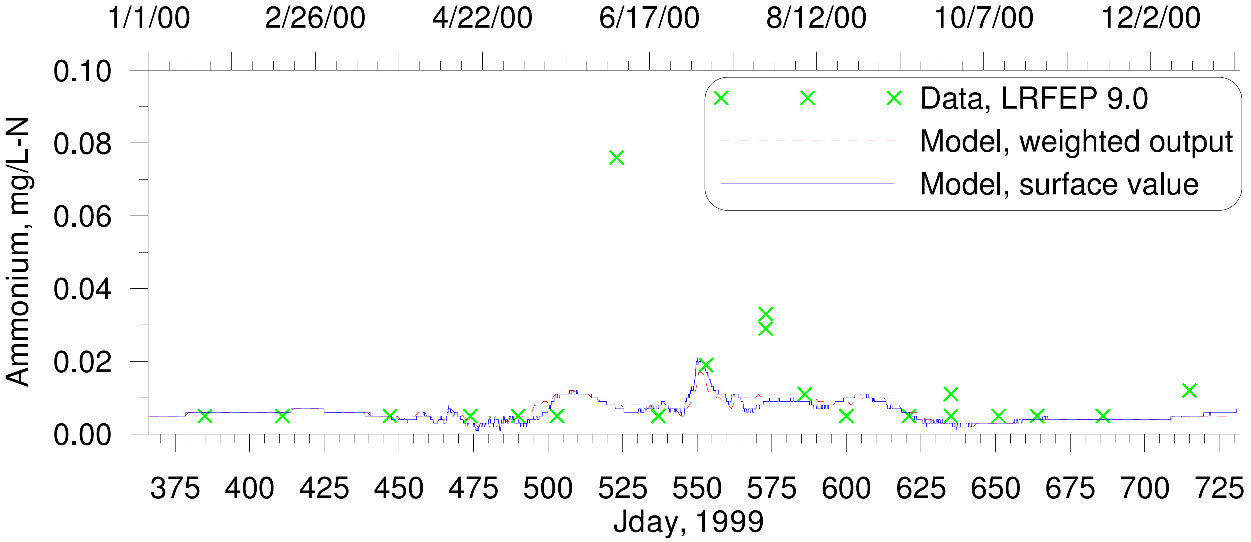


Figure 187. Model-data comparison of ammonium at LRFEP station 9.0.

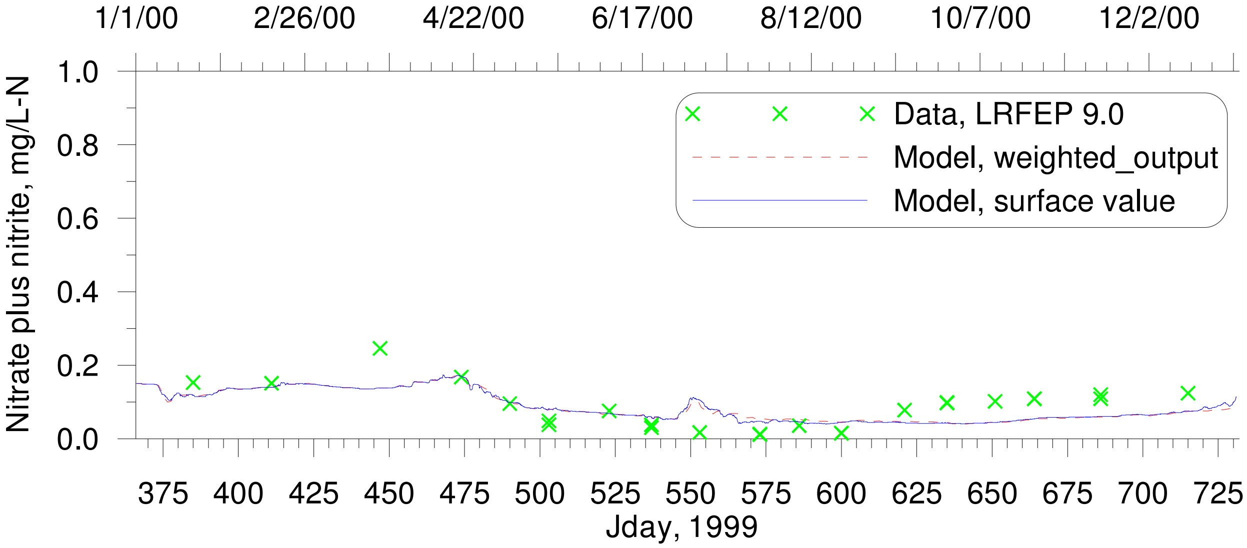


Figure 188.   Model-data comparison of nitrate plus nitrite at LRFEP station 9.0.

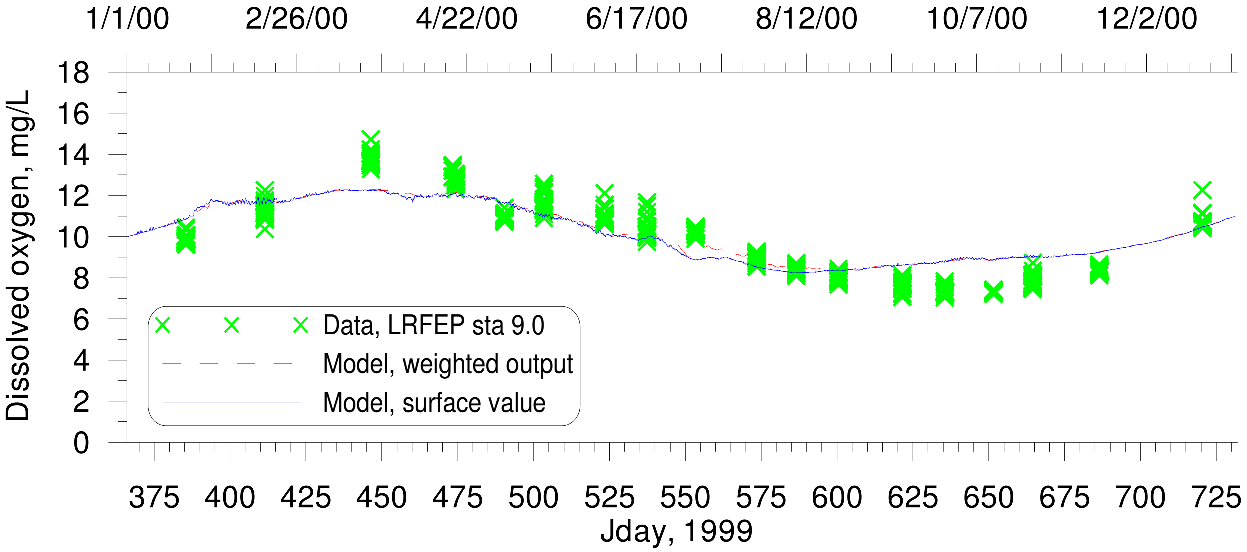


Figure 189. Model-data comparison of dissolved oxygen at LRFEP station 9.0.

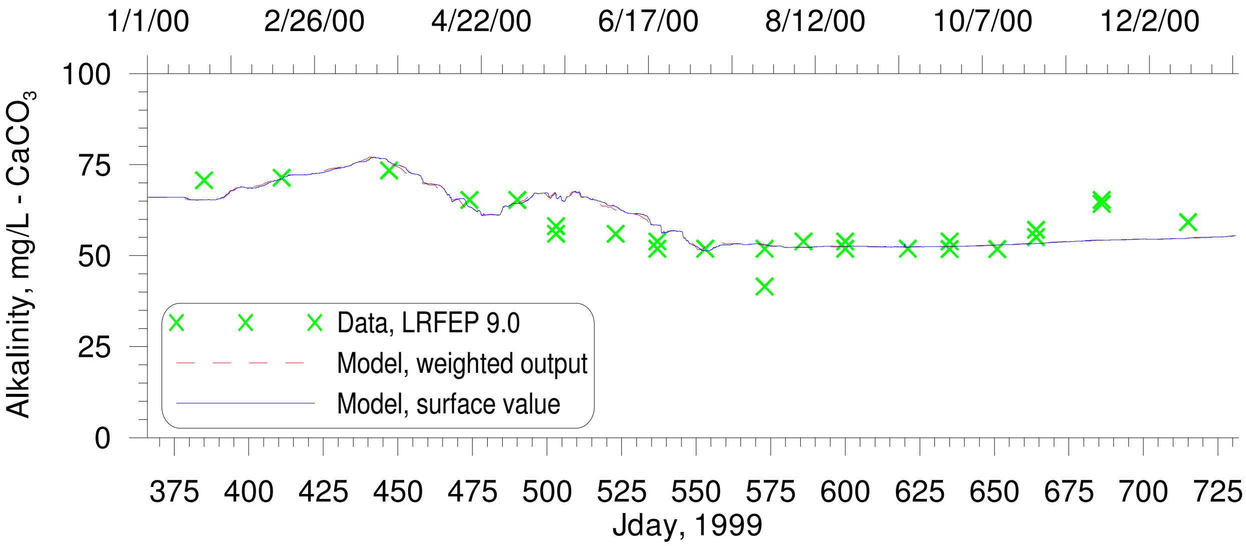


Figure 190. Model-data comparison of alkalinity at LRFEP station 9.0.

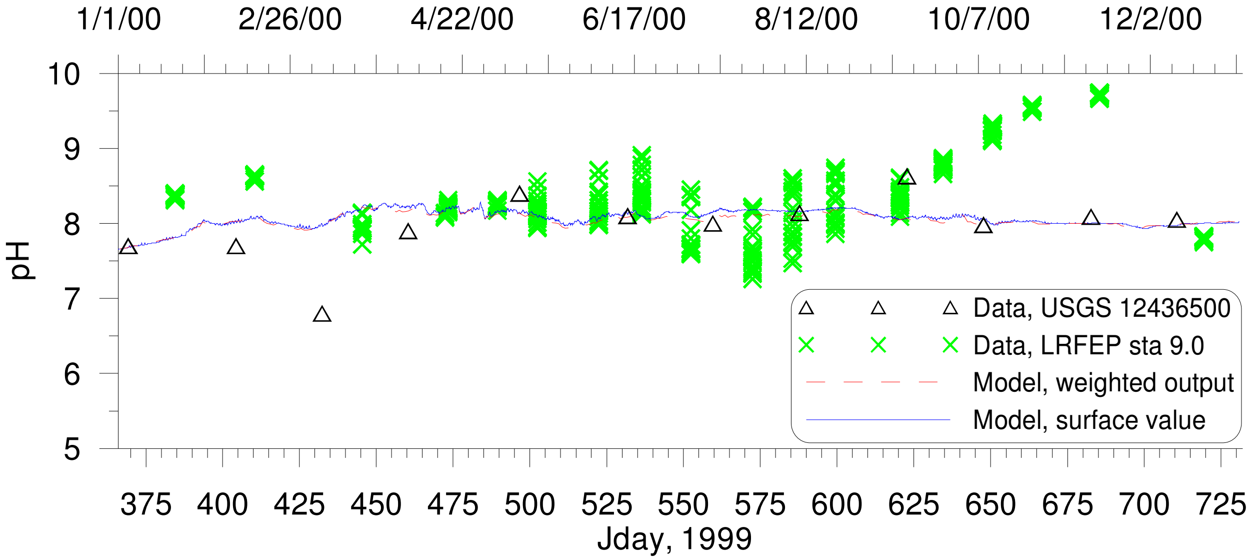


Figure 191. Model-data comparison of pH at LRFEP station 9.0.

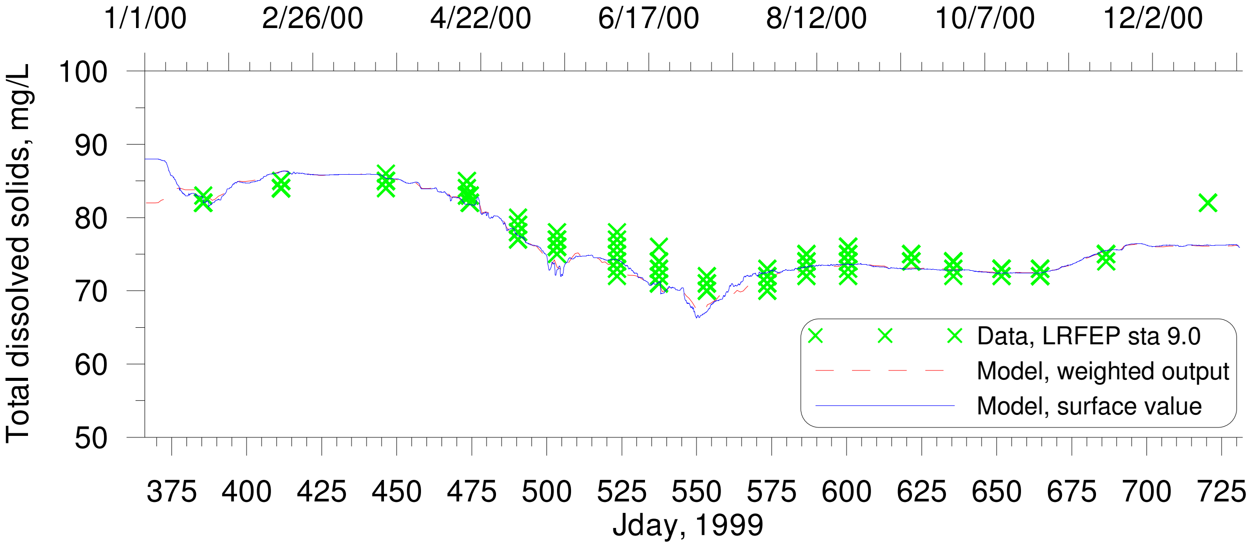


Figure 192. Model-data comparison of total dissolved solids at LRFEP station 9.0.

Appendix F: Vertical profile model-data comparison plots.

Vertical data exist for water temperature, dissolved oxygen, total dissolved solids, and pH. Model-data comparison statistics are reported in Table 31.

Table 31. Vertical profile calibration statistics, 2000.

Station	**Location**	**#days, (# points)**	**Statistic**	**TDS** mg/L	**DO** mg/L	**pH** -	**Temp** ℃
0.0	Columbia R.	11 (80)	ME	-0.18	-0.01	-0.42	-0.14
			AME	0.39	0.14	0.43	0.49
			RMS	0.44	0.16	0.43	0.50
1.0	Columbia R.	11 (111)	ME	0.72	0.18	-0.41	-0.15
			AME	0.97	0.38	0.42	0.40
			RMS	1.03	0.40	0.42	0.41
2.0	Columbia R.	18 (194)	ME	-0.91	0.29	-0.55	-0.11
			AME	1.17	0.56	0.59	0.56
			RMS	1.21	0.59	0.59	0.60
3.0	Columbia R.	11 (121)	ME	-0.95	0.12	-0.42	-0.26
			AME	1.52	0.65	0.45	0.58
			RMS	1.56	0.69	0.45	0.61
5.5	Columbia R.	5 (55)	ME	-1.47	0.35	-0.46	0.28
			AME	2.14	0.71	0.51	0.49
			RMS	2.29	0.75	0.52	0.51
7.0	Columbia R.	11 (163)	ME	-0.08	0.21	-0.30	0.15
			AME	1.53	0.87	0.37	0.37
			RMS	1.62	0.90	0.38	0.42
9.0	Columbia R.	18 (284)	ME	-0.70	0.39	-0.40	0.25
			AME	1.37	0.79	0.50	0.46
			RMS	1.48	0.85	0.51	0.55
4.0	Spokane R.	18 (179)	ME	-6.68	1.18	-0.21	-0.49
			AME	10.90	1.44	0.38	0.86
			RMS	11.80	1.51	0.40	0.94
8.0	Sanpoil R.	11 (121)	ME	-0.42	0.16	-0.27	0.35
			AME	1.93	0.83	0.35	0.51
			RMS	2.09	0.87	0.36	0.55
System	**Average**	114 (1308)	ME	-0.18	-0.01	-0.42	-0.14
			AME	0.39	0.14	0.43	0.49
			RMS	0.44	0.16	0.43	0.50

Total dissolved solids

For days when data were recorded, vertical profile plots of total dissolved solids are shown in Figure 193 through Figure 239.

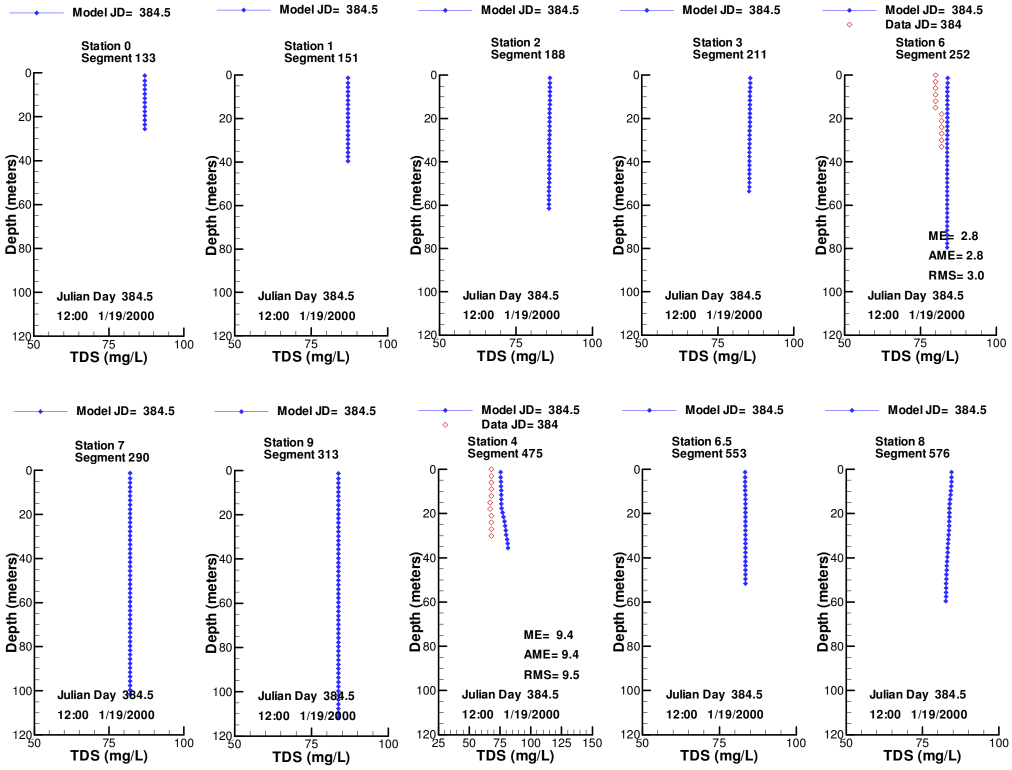


Figure 193. Vertical total dissolved solids model-data comparison, J384.

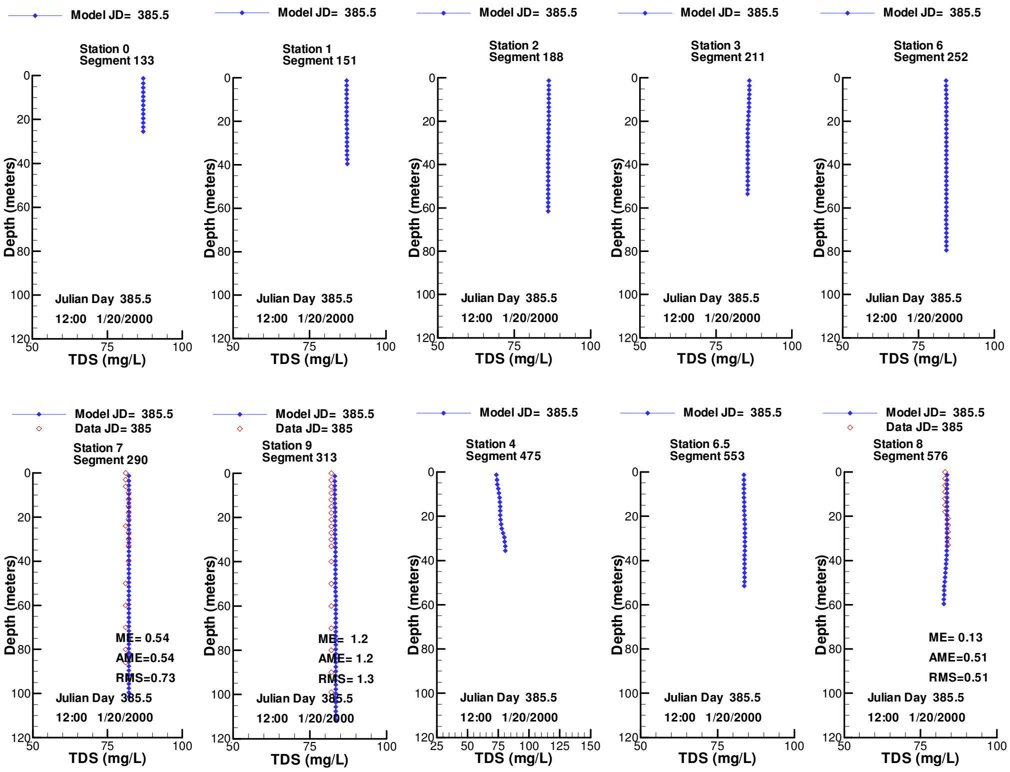


Figure 194. Vertical total dissolved solids model-data comparison, J385.

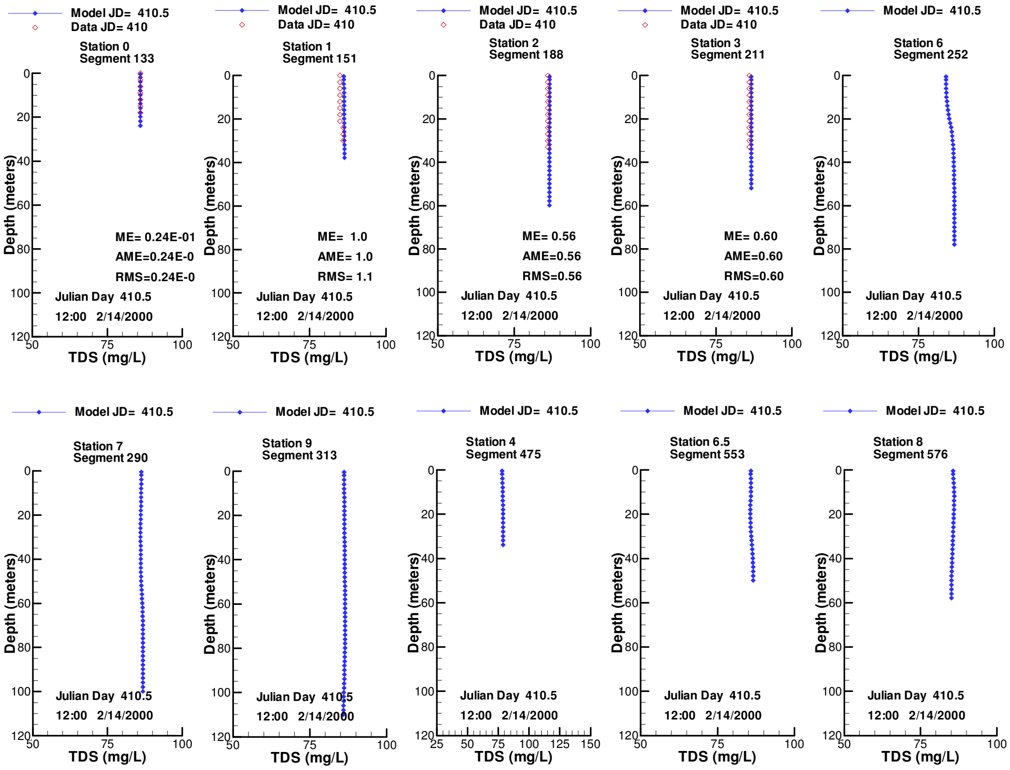


Figure 195. Vertical total dissolved solids model-data comparison, J410.

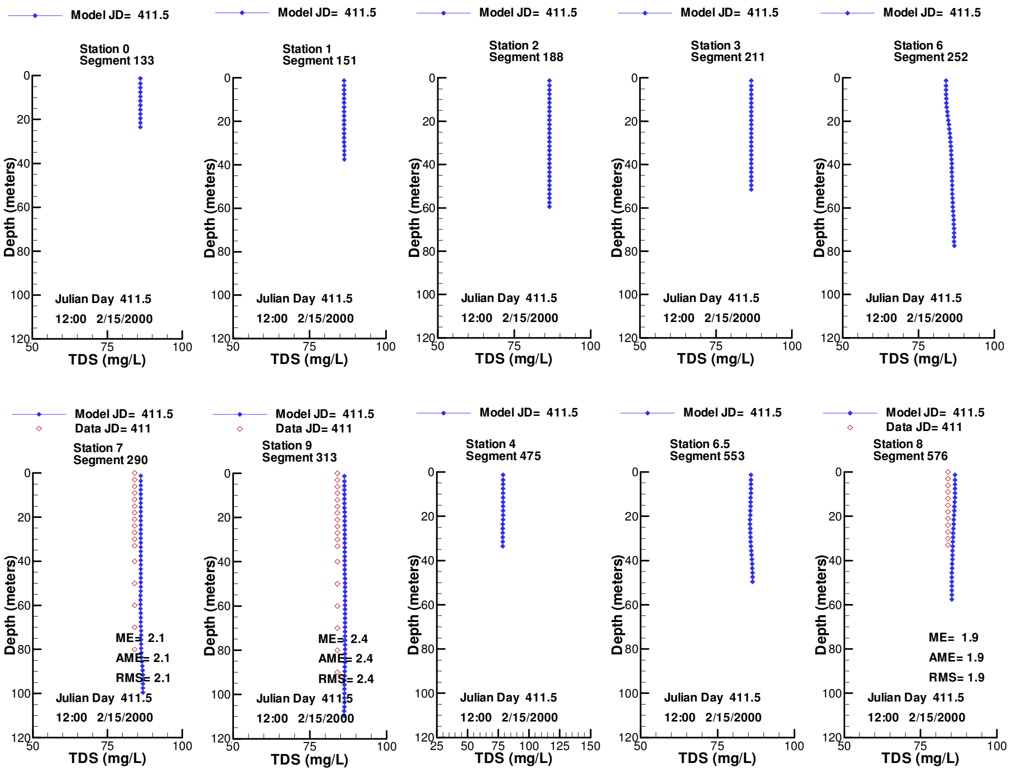


Figure 196. Vertical total dissolved solids model-data comparison, J411.

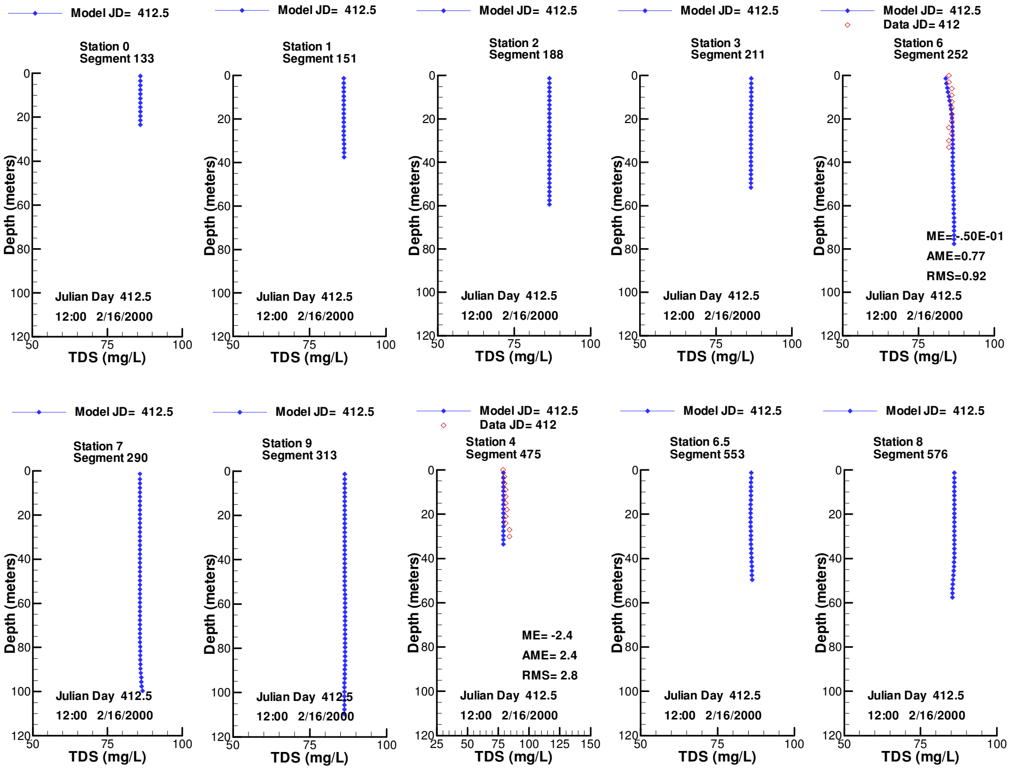


Figure 197. Vertical total dissolved solids model-data comparison, J412.

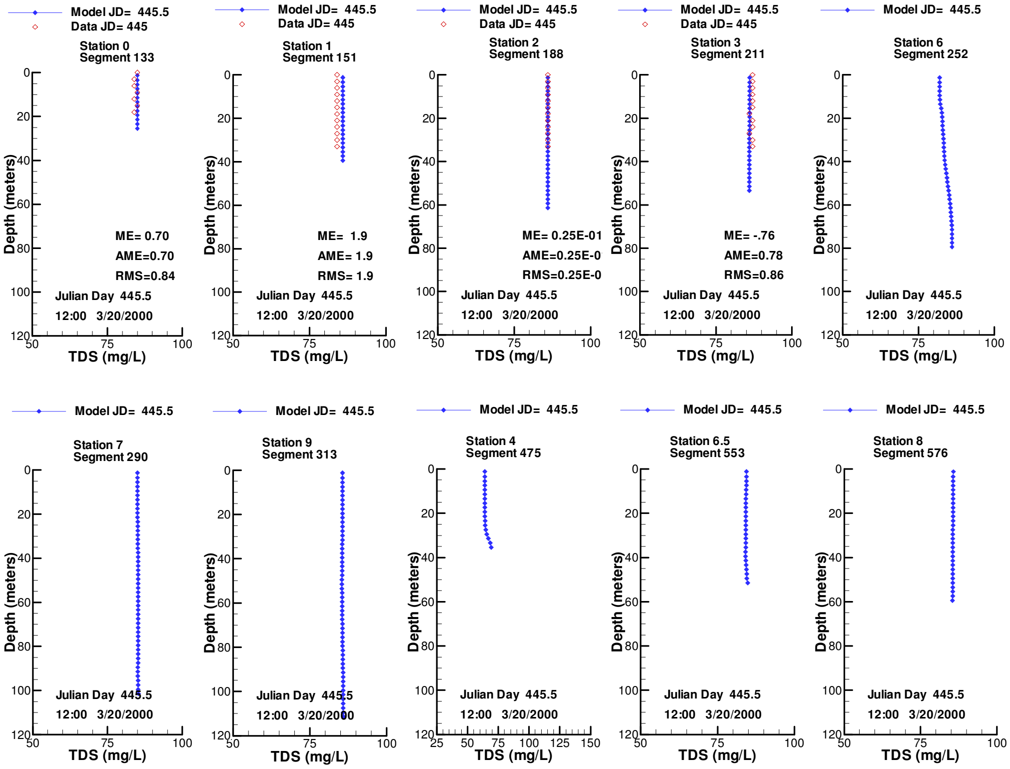


Figure 198. Vertical total dissolved solids model-data comparison, J445.

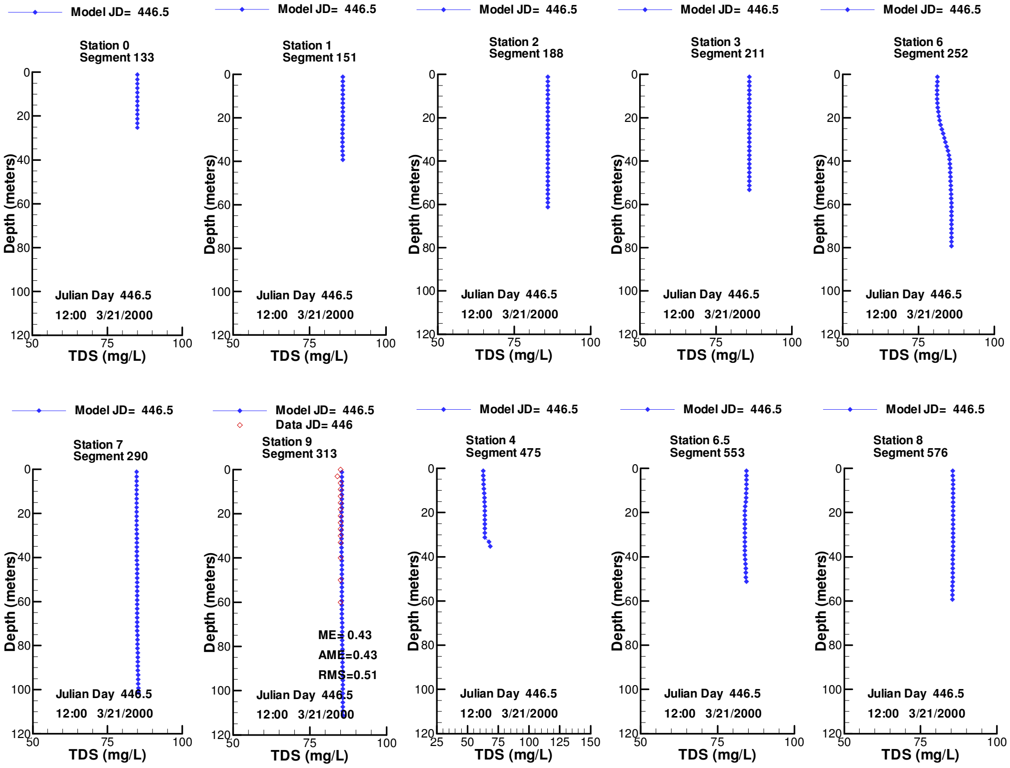


Figure 199. Vertical total dissolved solids model-data comparison, J446.

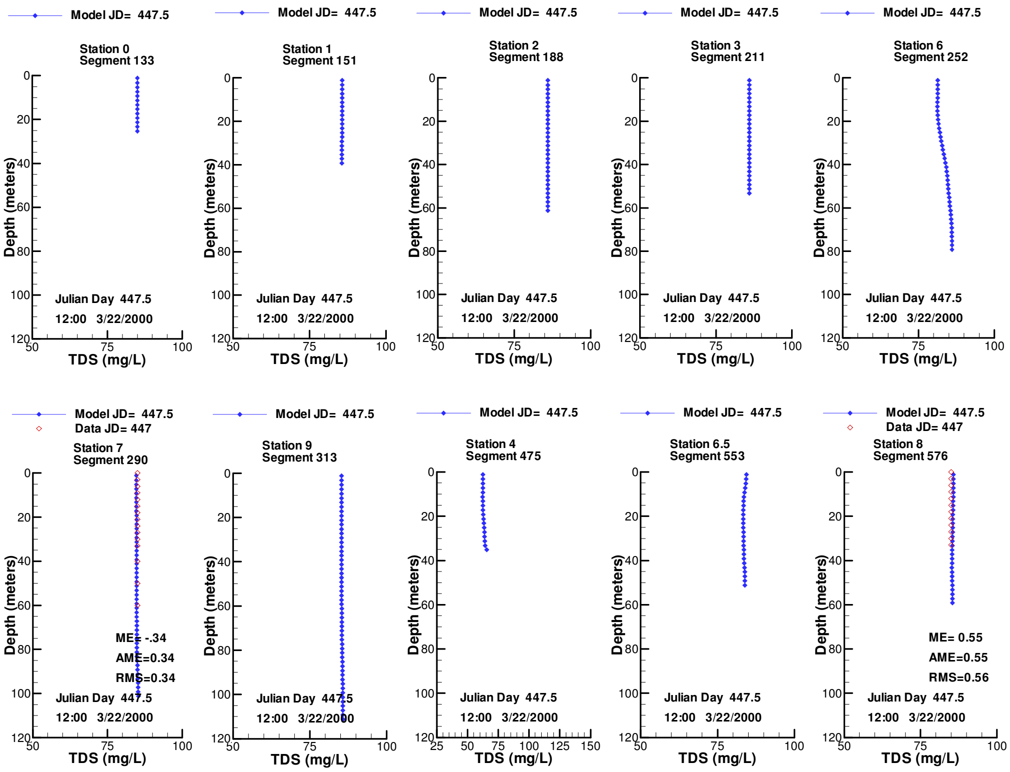


Figure 200. Vertical total dissolved solids model-data comparison, J447.

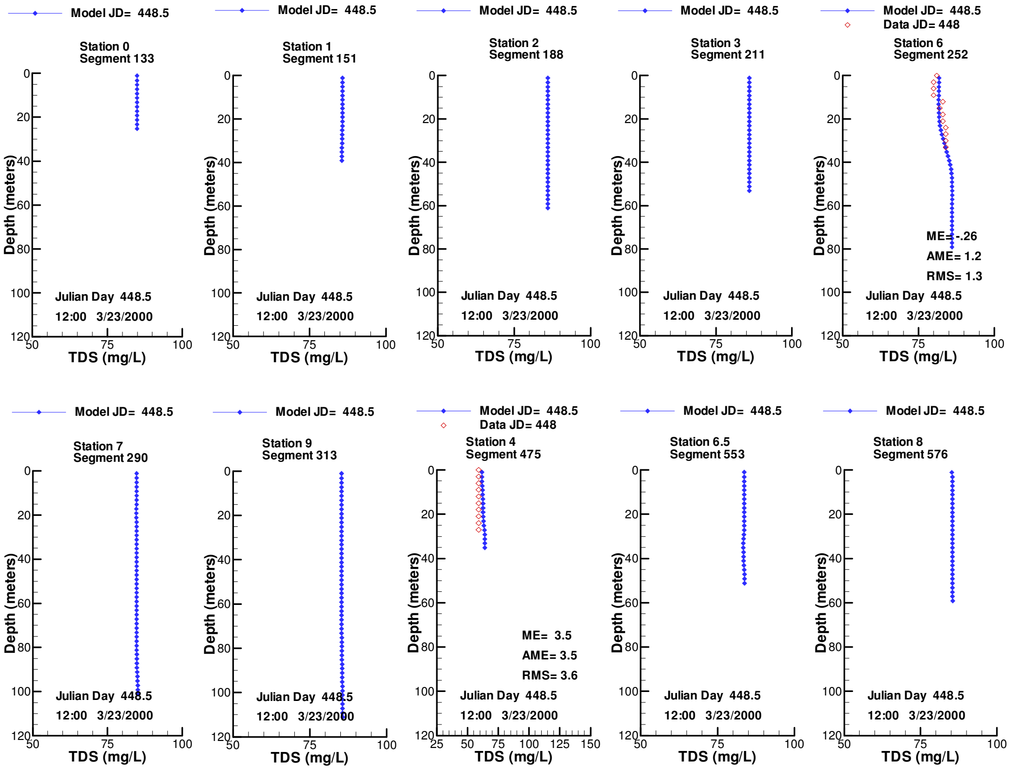


Figure 201. Vertical total dissolved solids model-data comparison, J448.

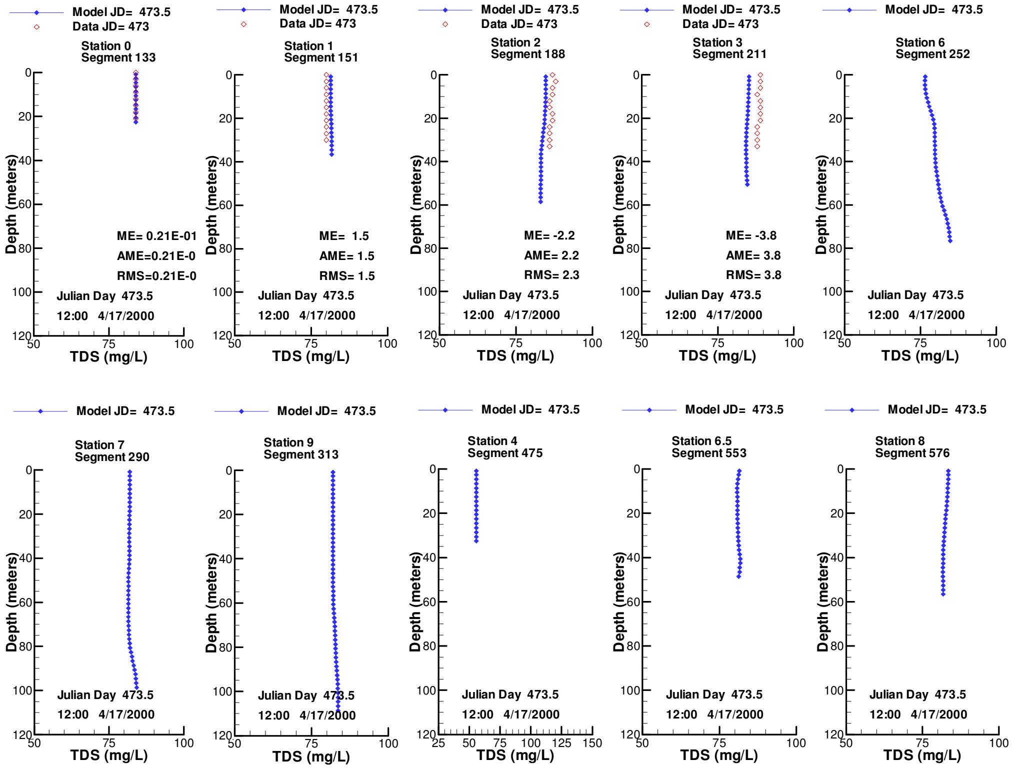


Figure 202. Vertical total dissolved solids model-data comparison, J473.

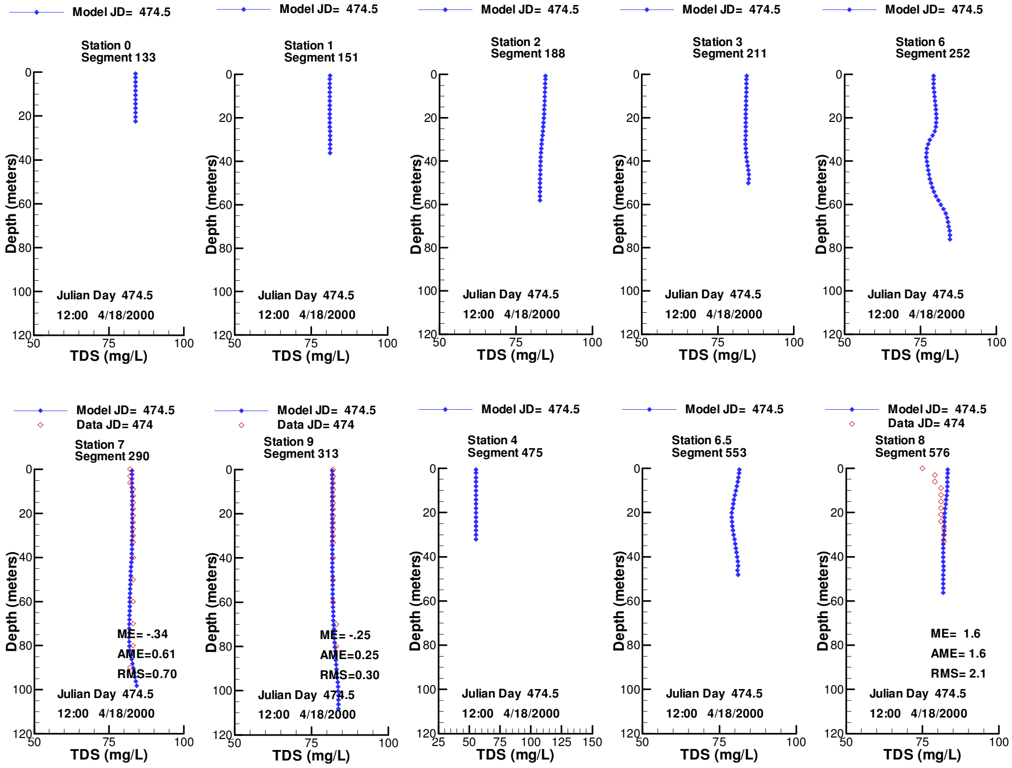


Figure 203. Vertical total dissolved solids model-data comparison, J474.

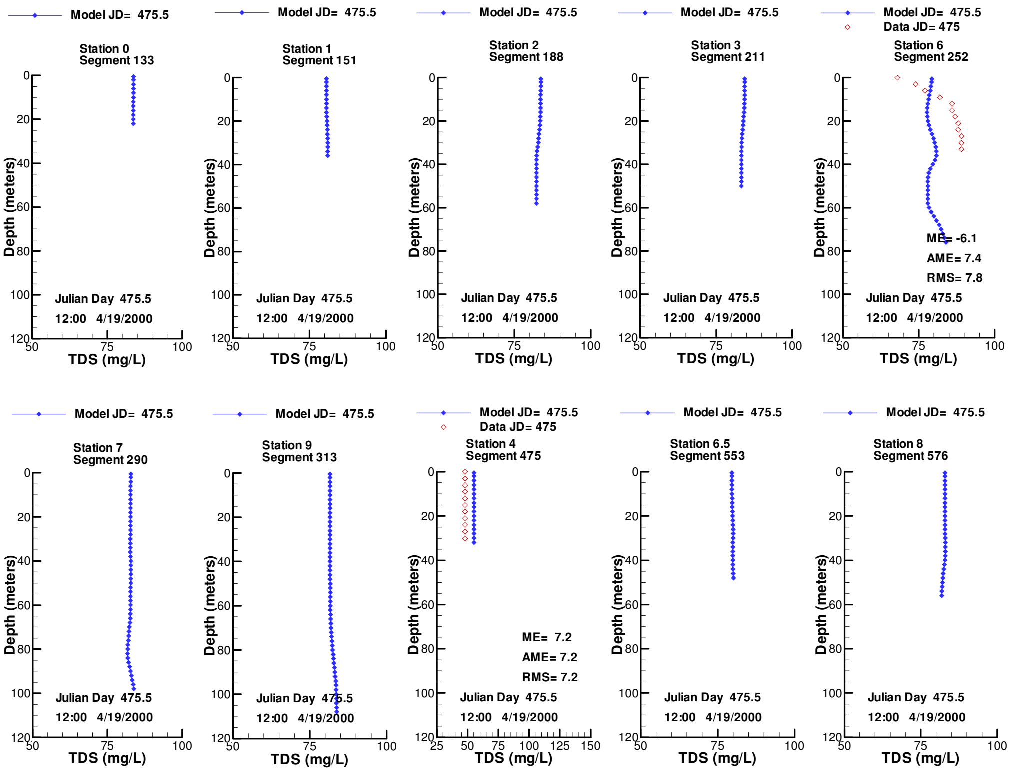


Figure 204. Vertical total dissolved solids model-data comparison, J475.

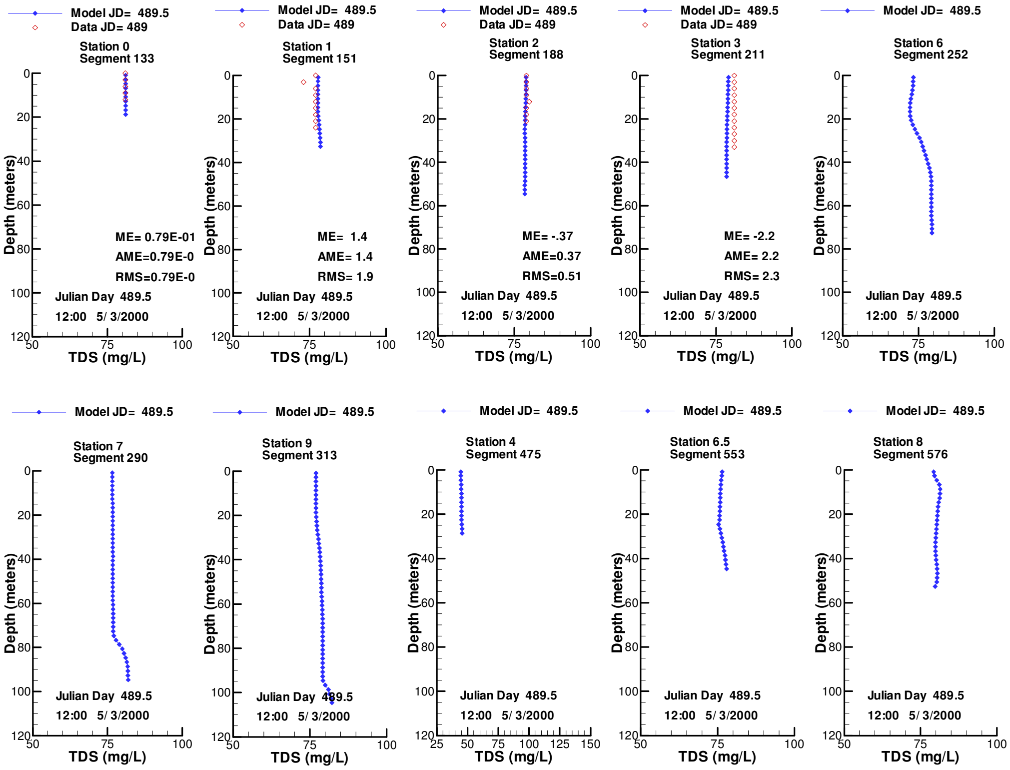


Figure 205. Vertical total dissolved solids model-data comparison, J489.

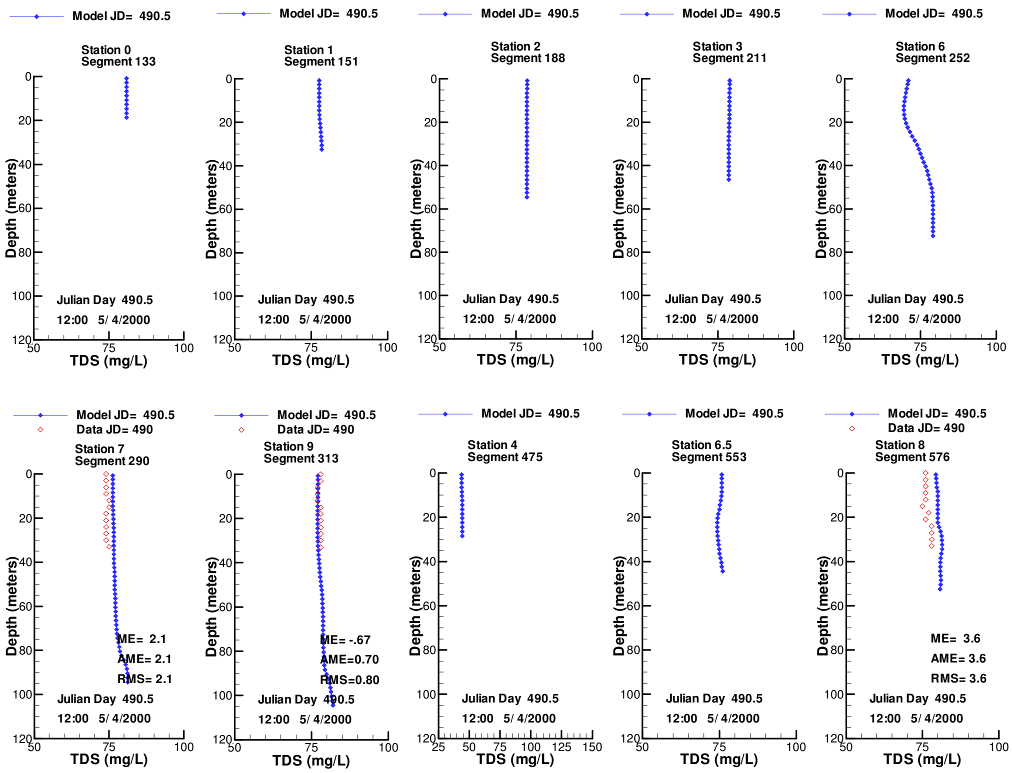


Figure 206. Vertical total dissolved solids model-data comparison, J490.

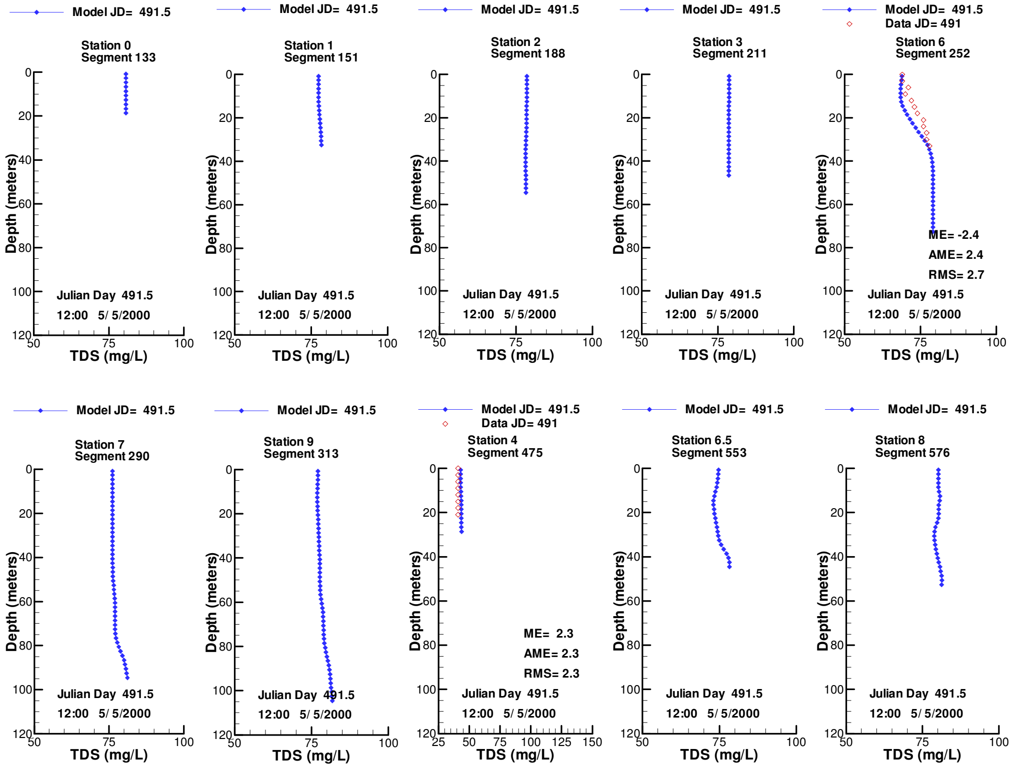


Figure 207. Vertical total dissolved solids model-data comparison, J491.

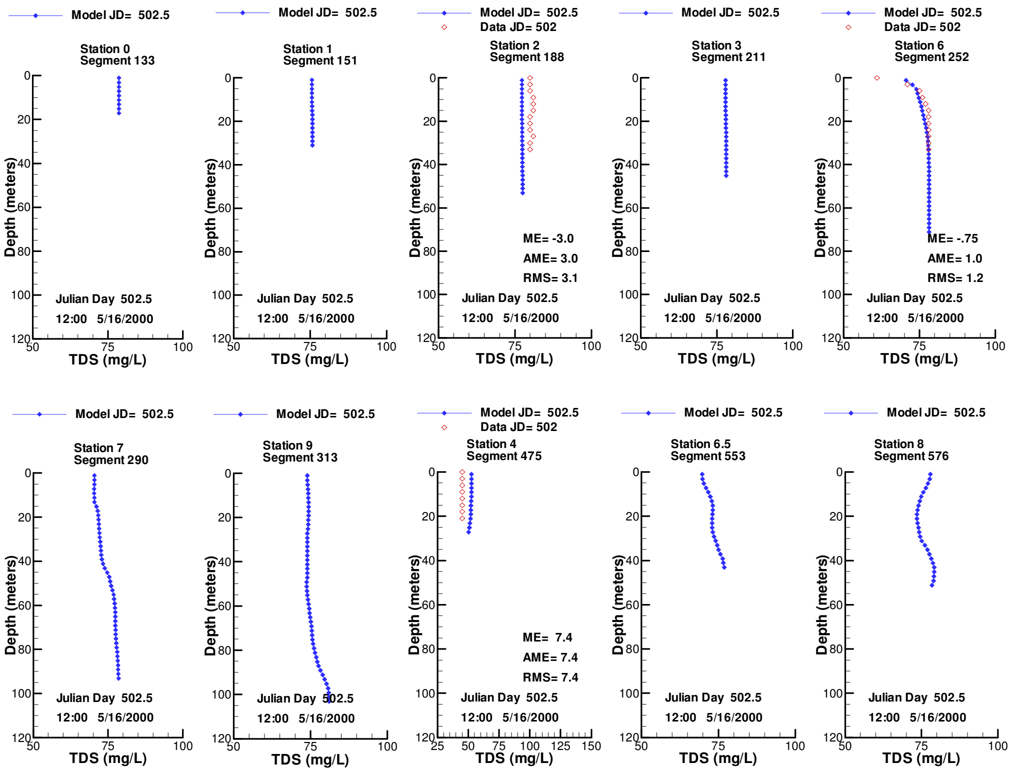


Figure 208. Vertical total dissolved solids model-data comparison, J502.

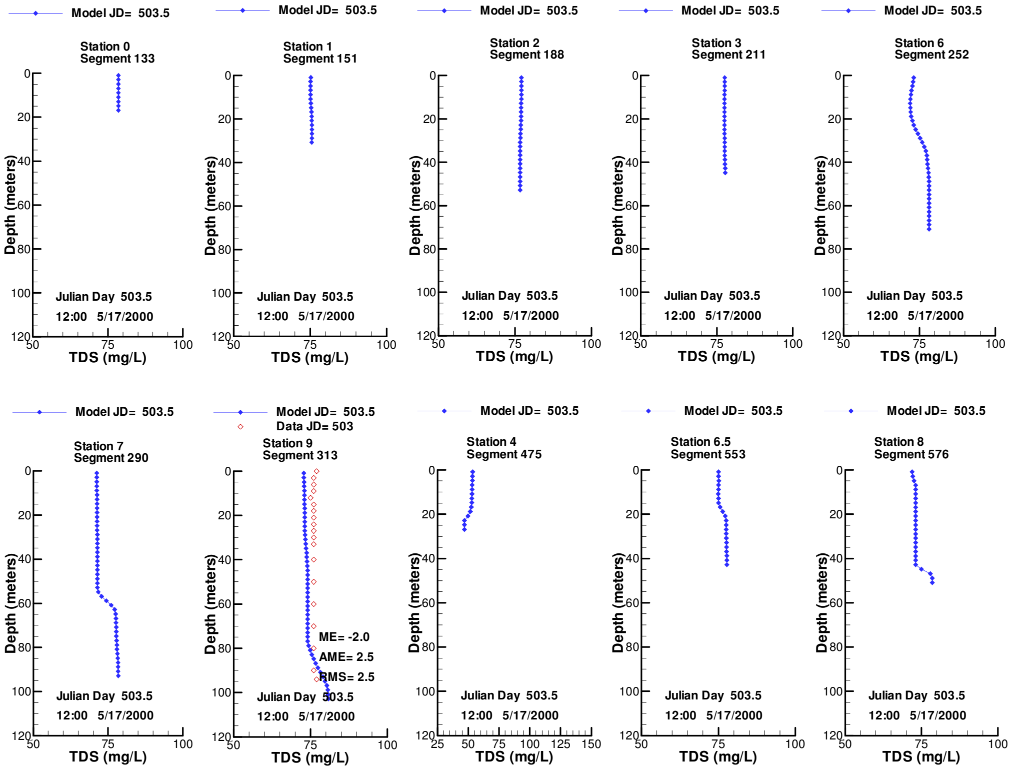


Figure 209. Vertical total dissolved solids model-data comparison, J503.

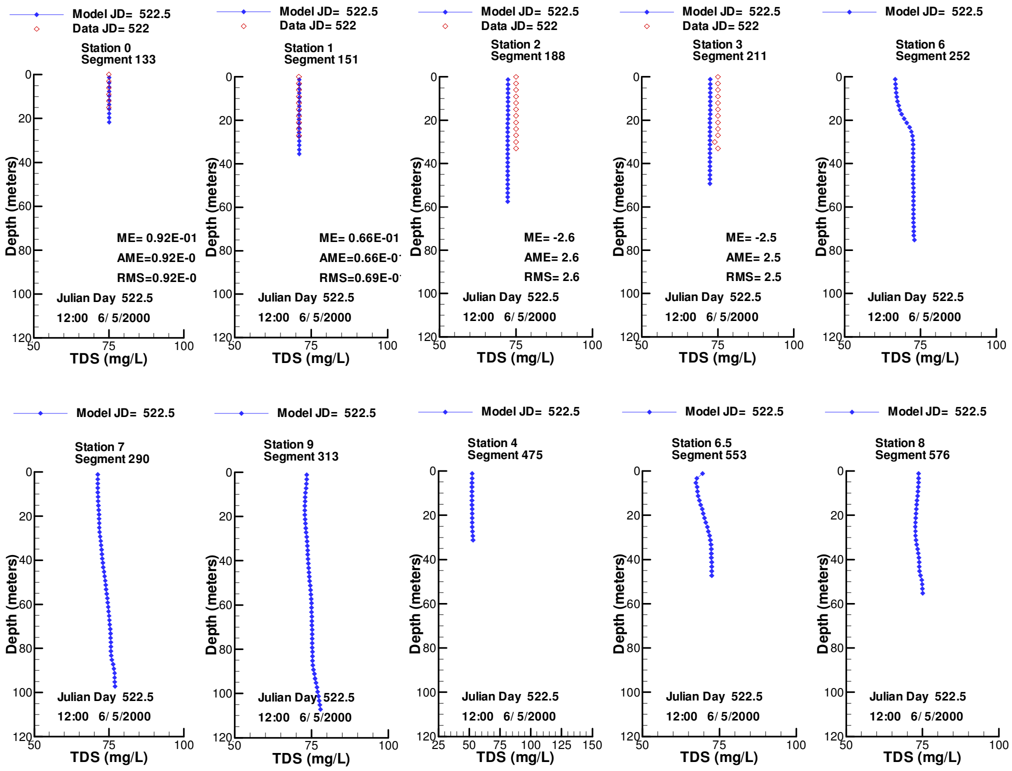


Figure 210. Vertical total dissolved solids model-data comparison, J522.

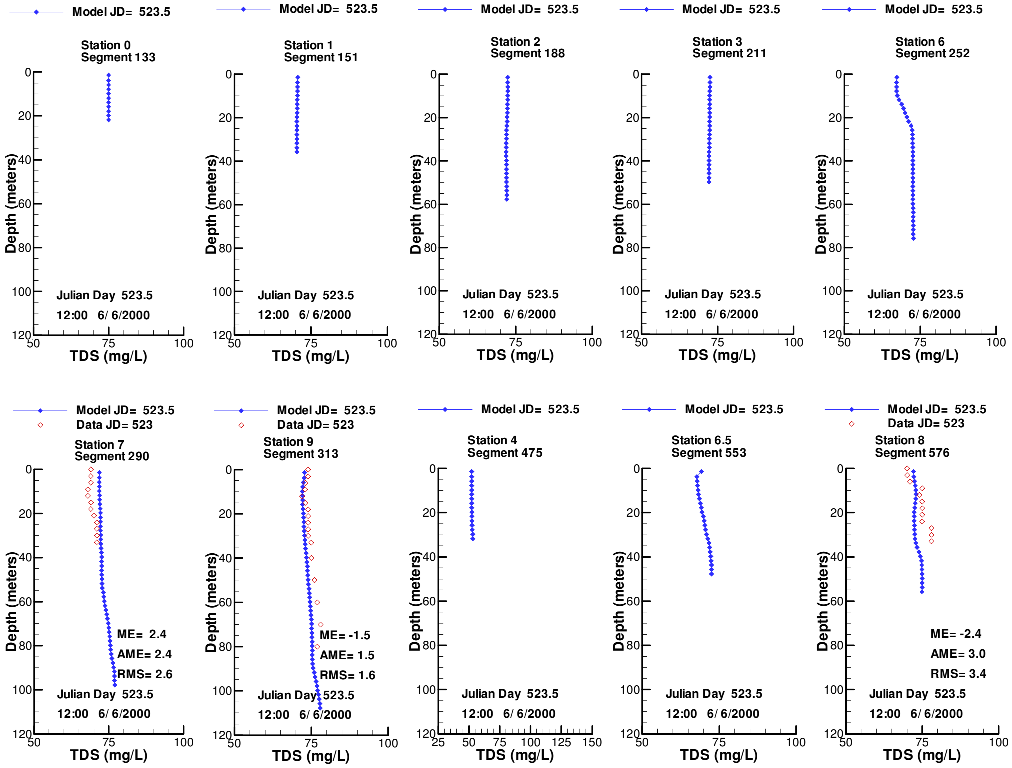


Figure 211. Vertical total dissolved solids model-data comparison, J523.

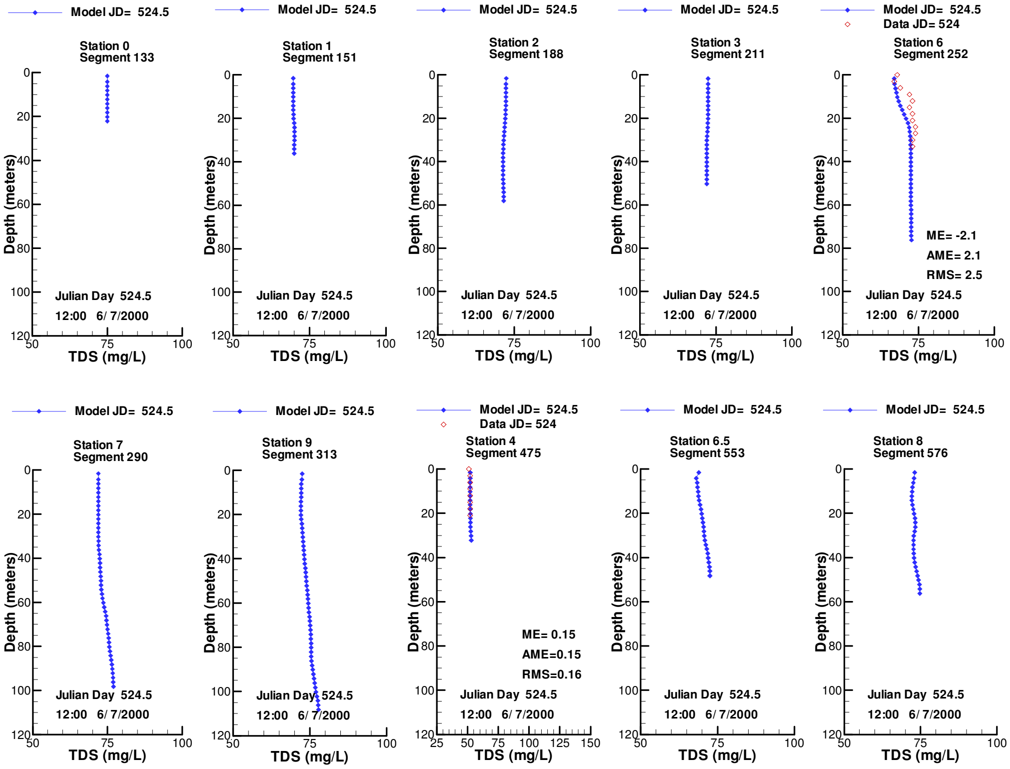


Figure 212. Vertical total dissolved solids model-data comparison, J524.

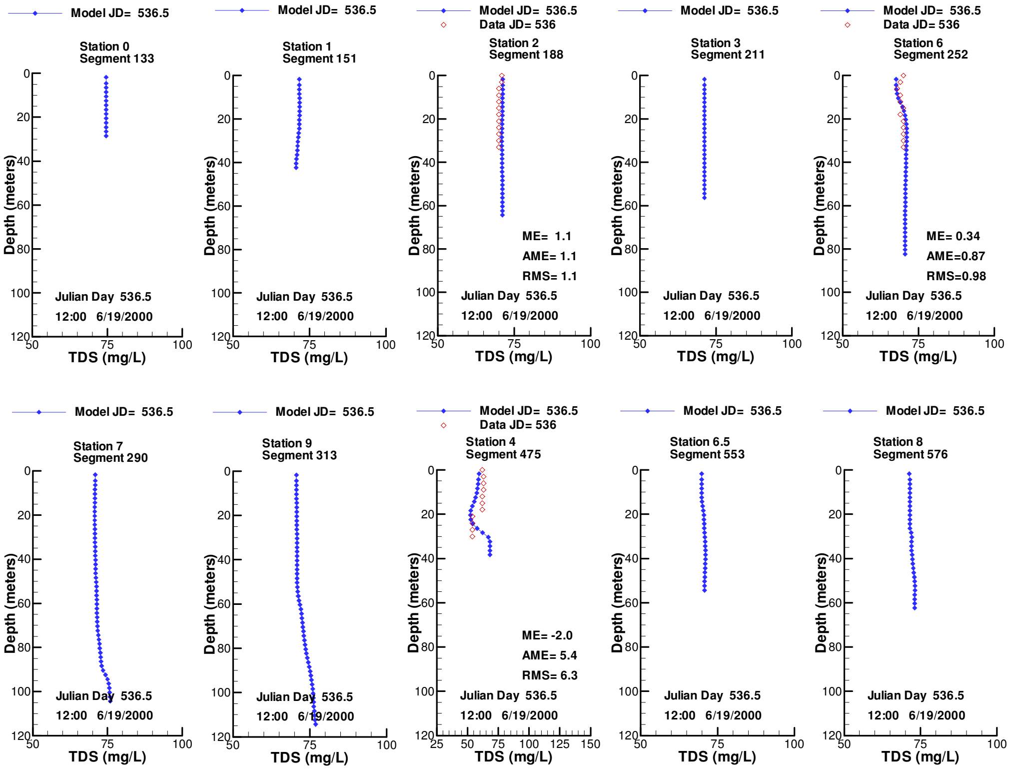


Figure 213. Vertical total dissolved solids model-data comparison, J536.

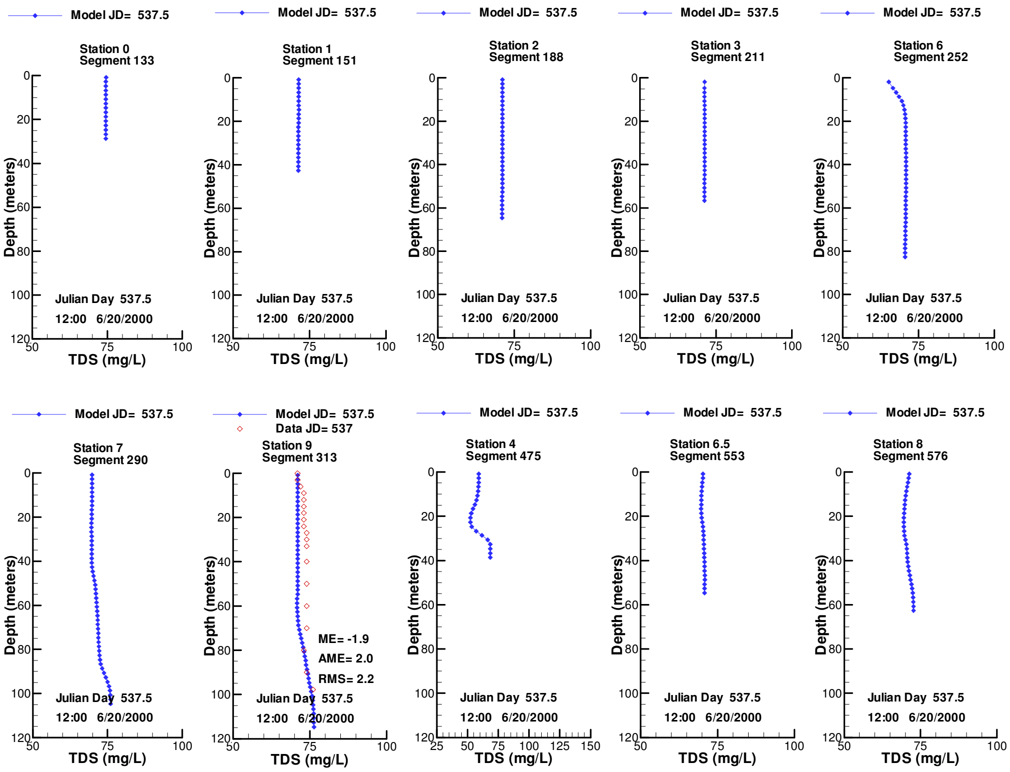


Figure 214. Vertical total dissolved solids model-data comparison, J537.

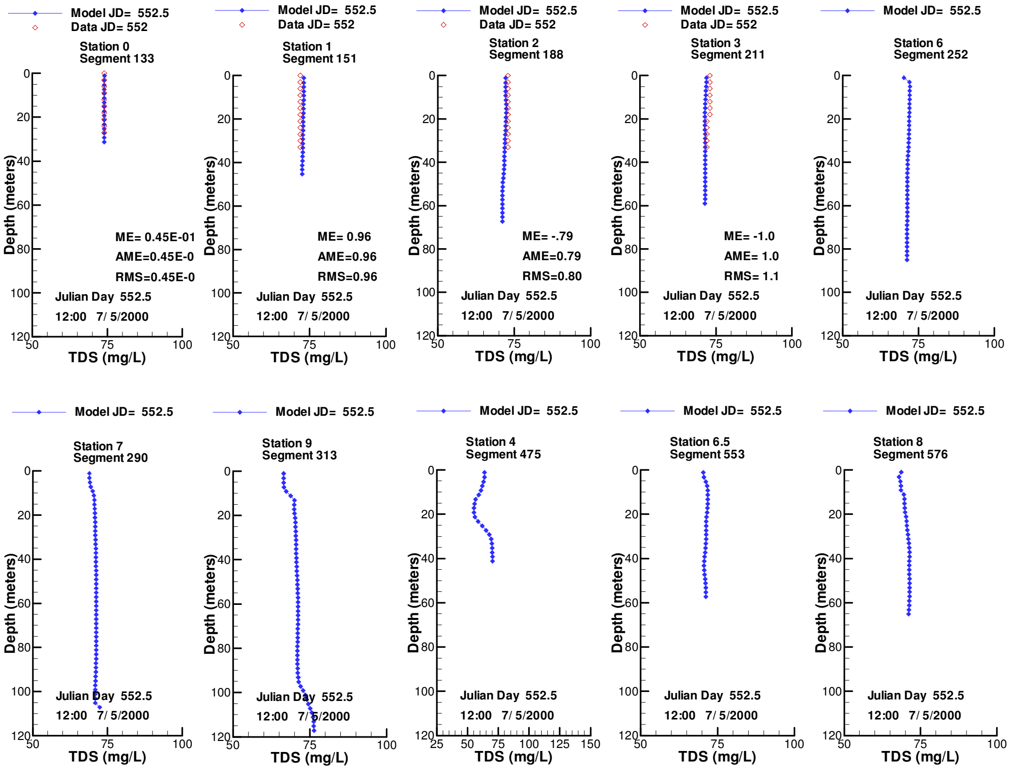


Figure 215. Vertical total dissolved solids model-data comparison, J552.

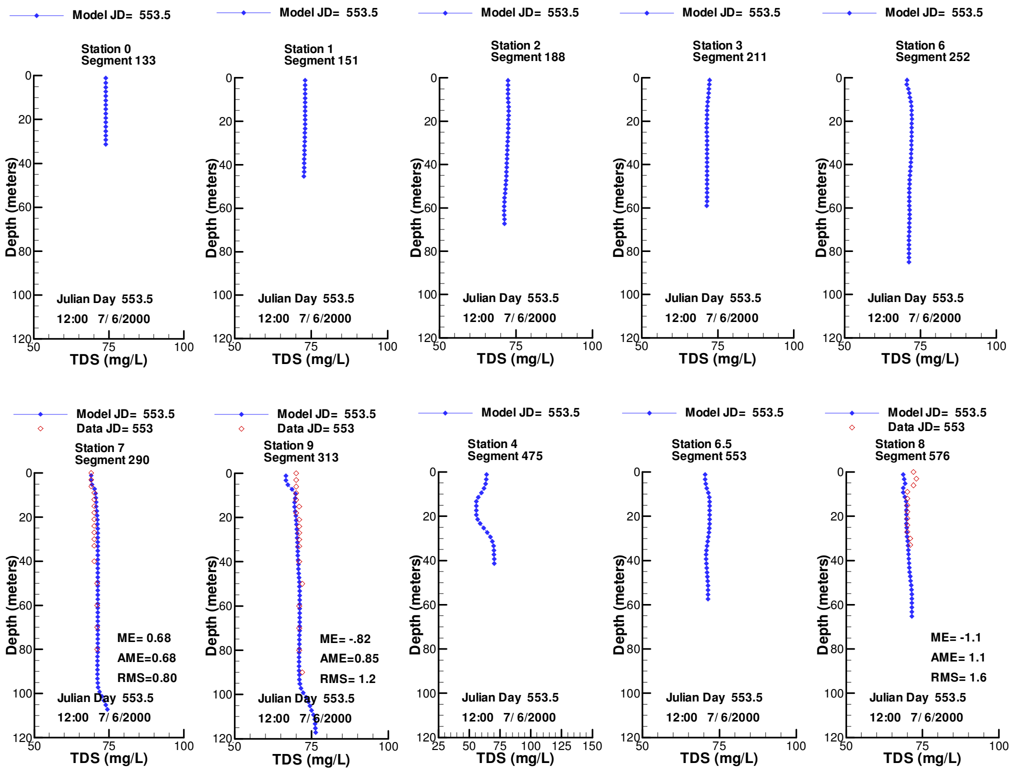


Figure 216. Vertical total dissolved solids model-data comparison, J553.

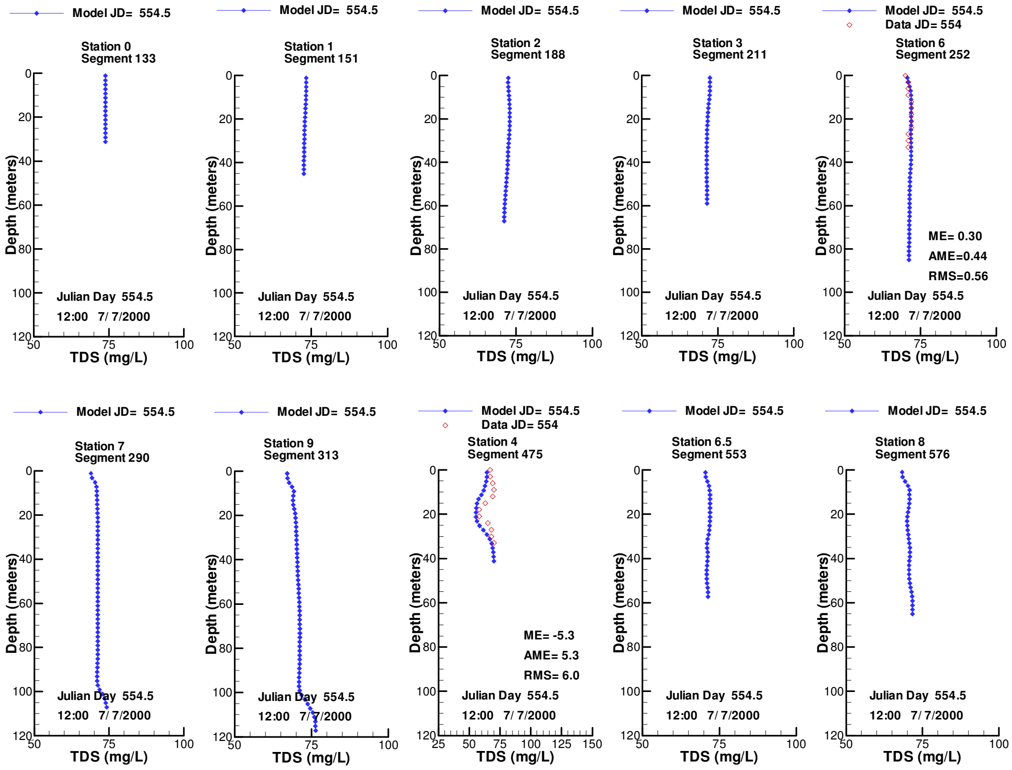


Figure 217. Vertical total dissolved solids model-data comparison, J554.

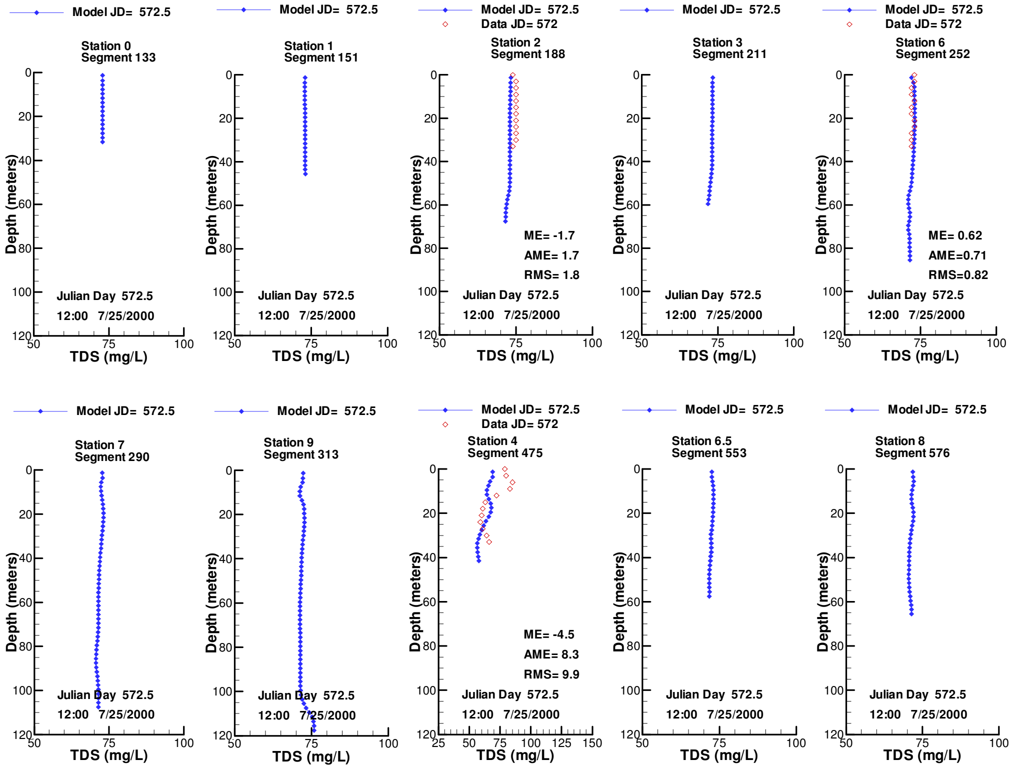


Figure 218. Vertical total dissolved solids model-data comparison, J572.

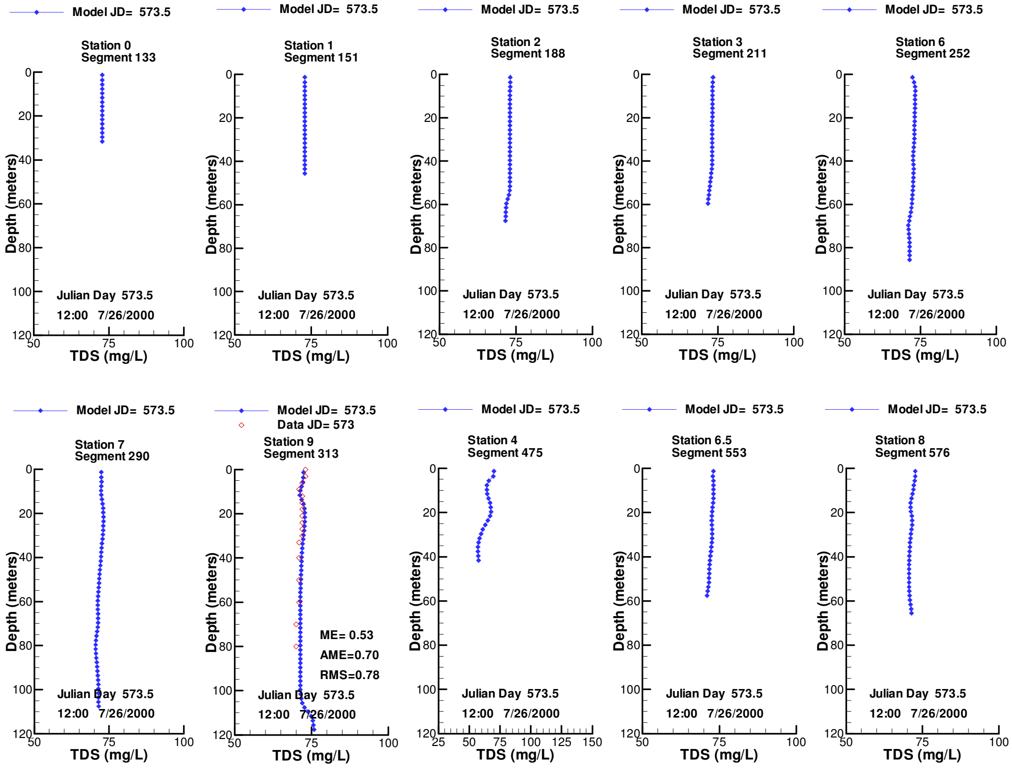


Figure 219. Vertical total dissolved solids model-data comparison, J573.

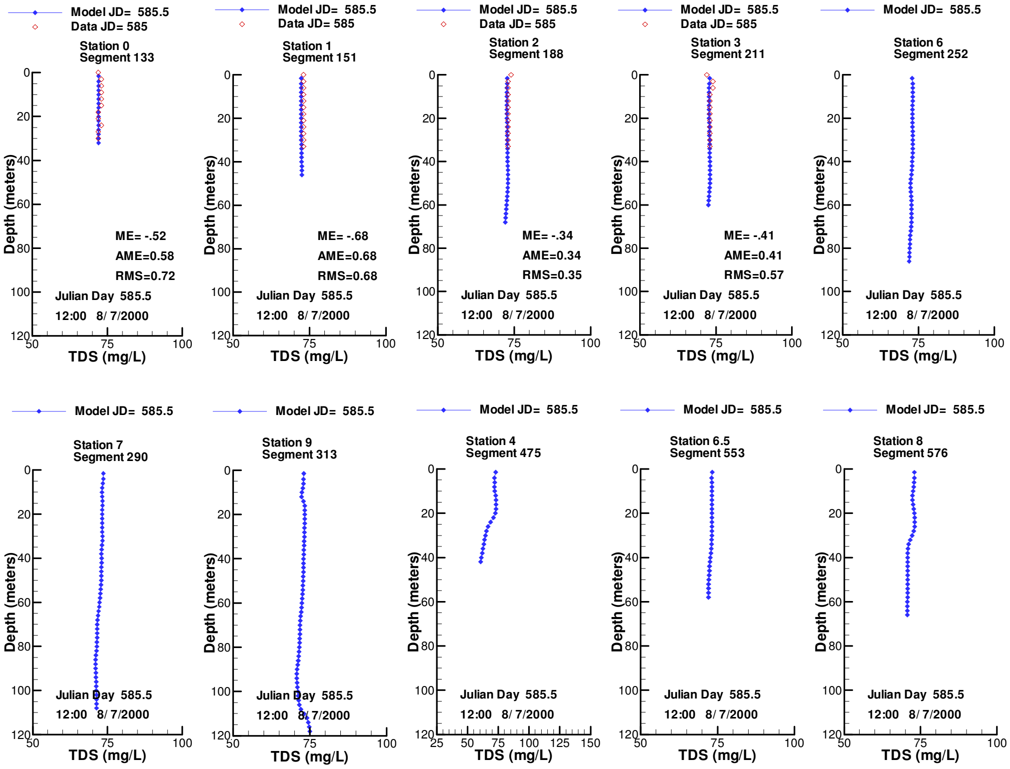


Figure 220. Vertical total dissolved solids model-data comparison, J585.

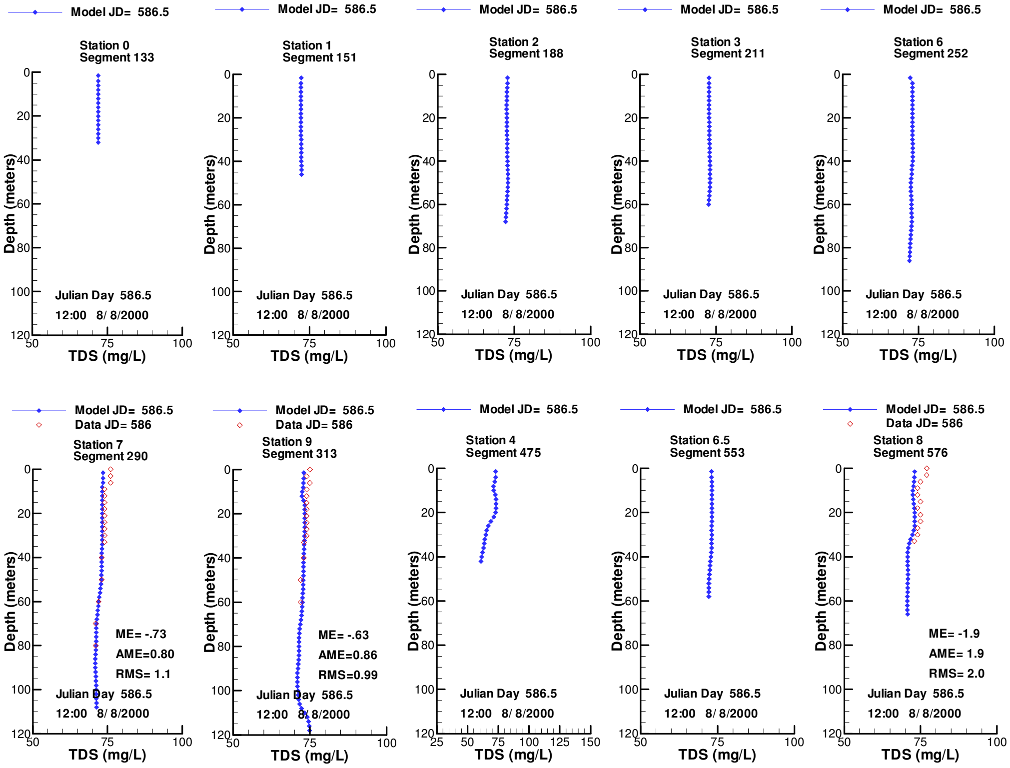


Figure 221. Vertical total dissolved solids model-data comparison, J586.

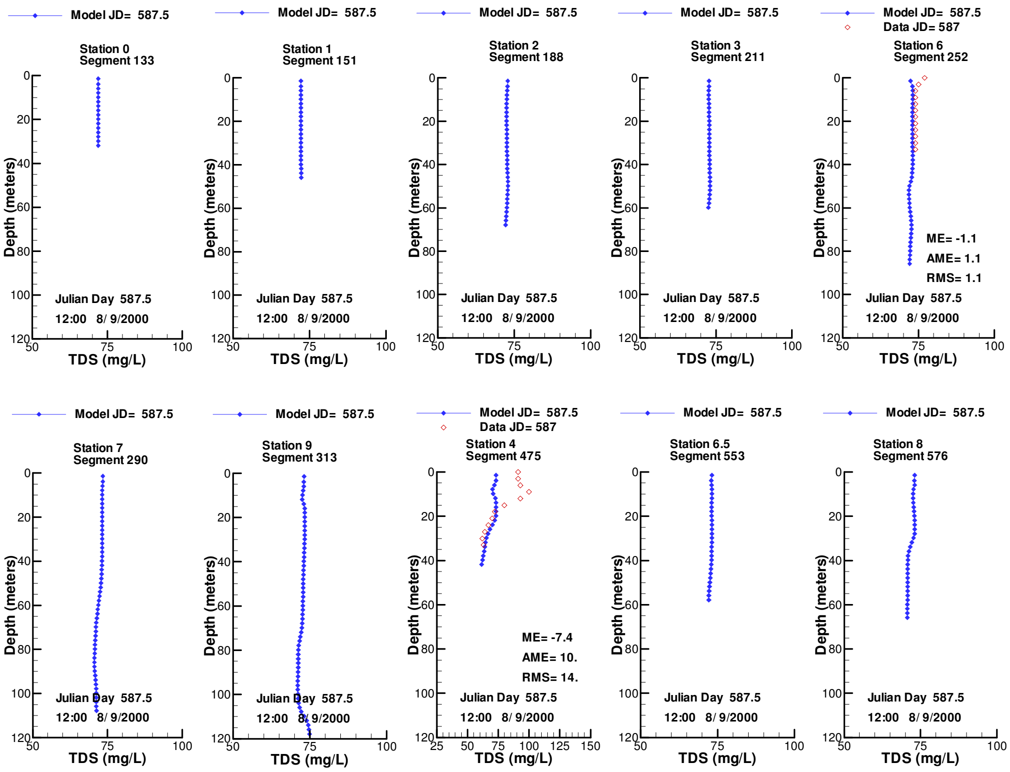


Figure 222. Vertical total dissolved solids model-data comparison, J587.

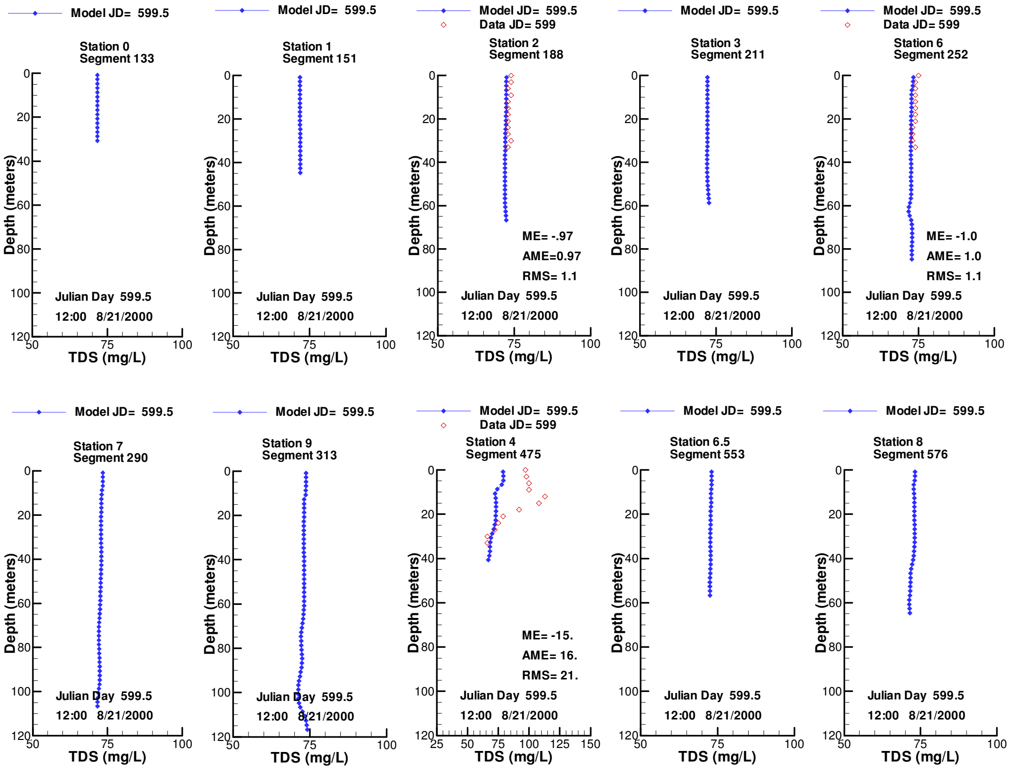


Figure 223. Vertical total dissolved solids model-data comparison, J599.

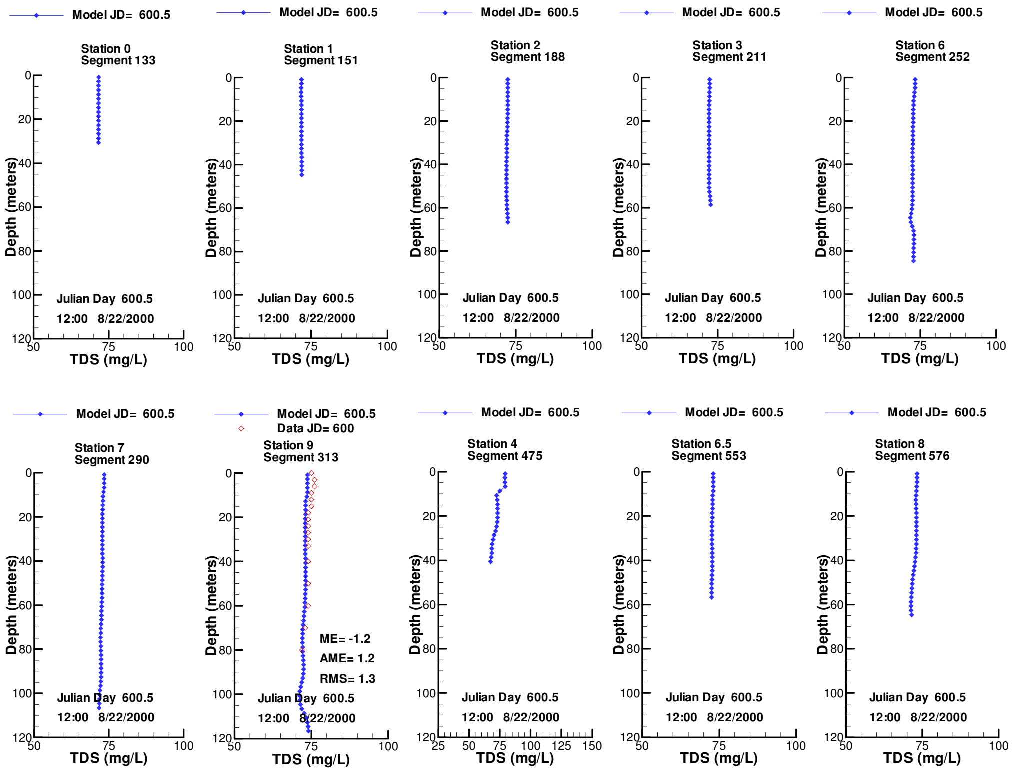


Figure 224. Vertical total dissolved solids model-data comparison, J600.

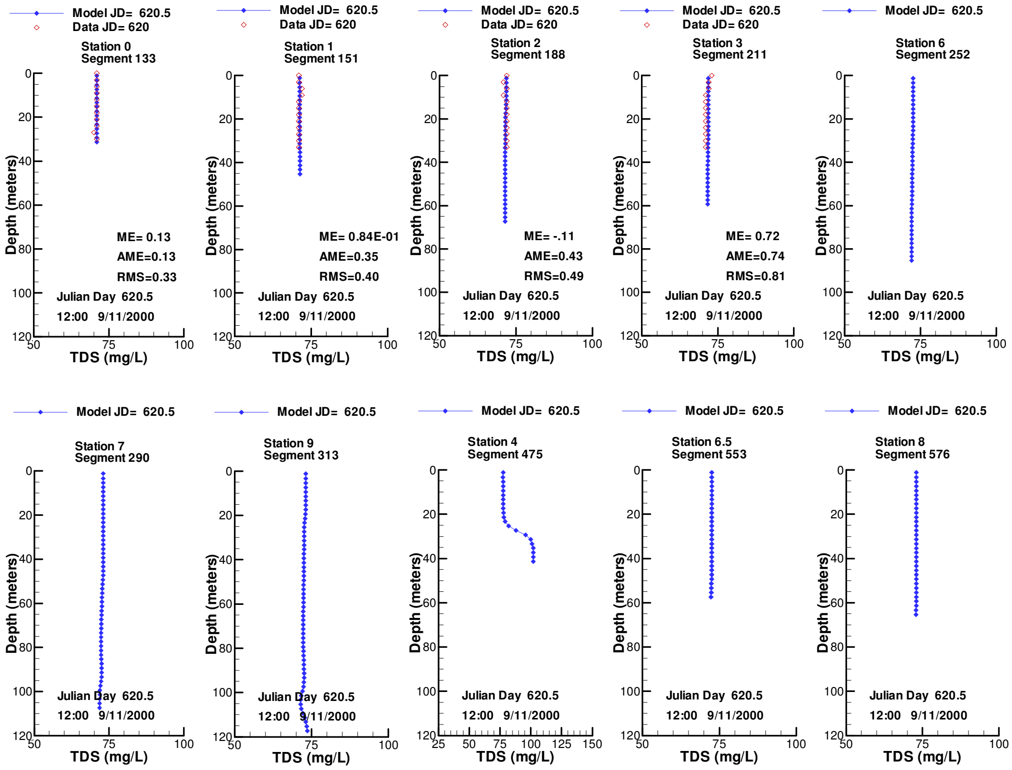


Figure 225. Vertical total dissolved solids model-data comparison, J620.

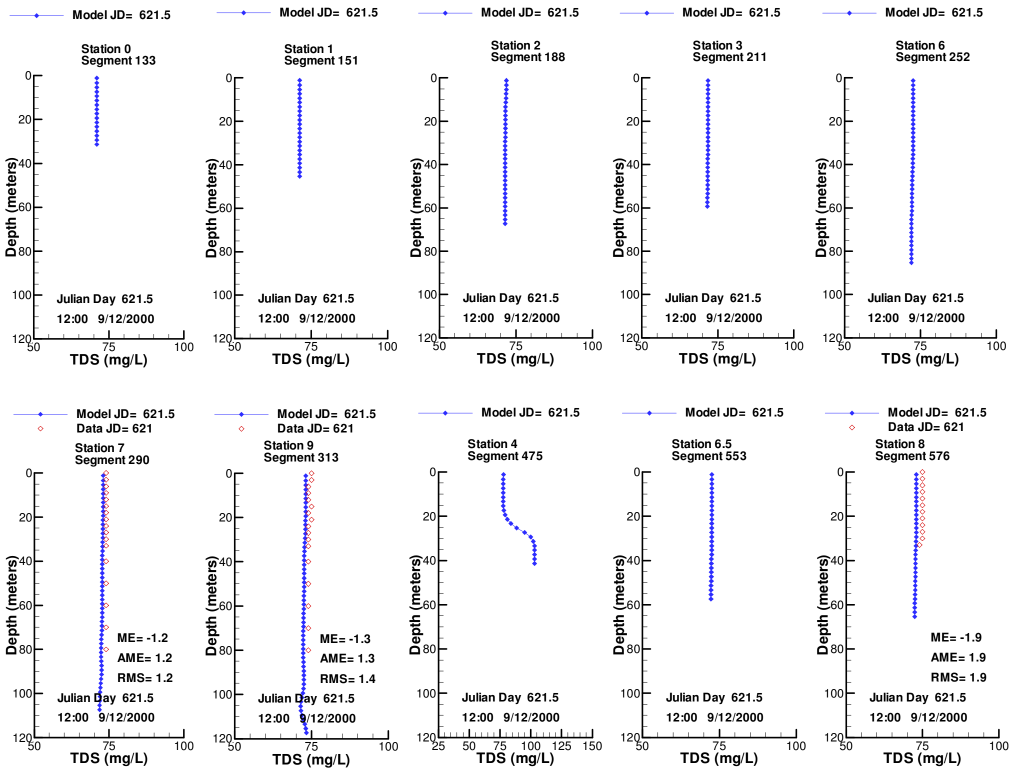


Figure 226. Vertical total dissolved solids model-data comparison, J621.

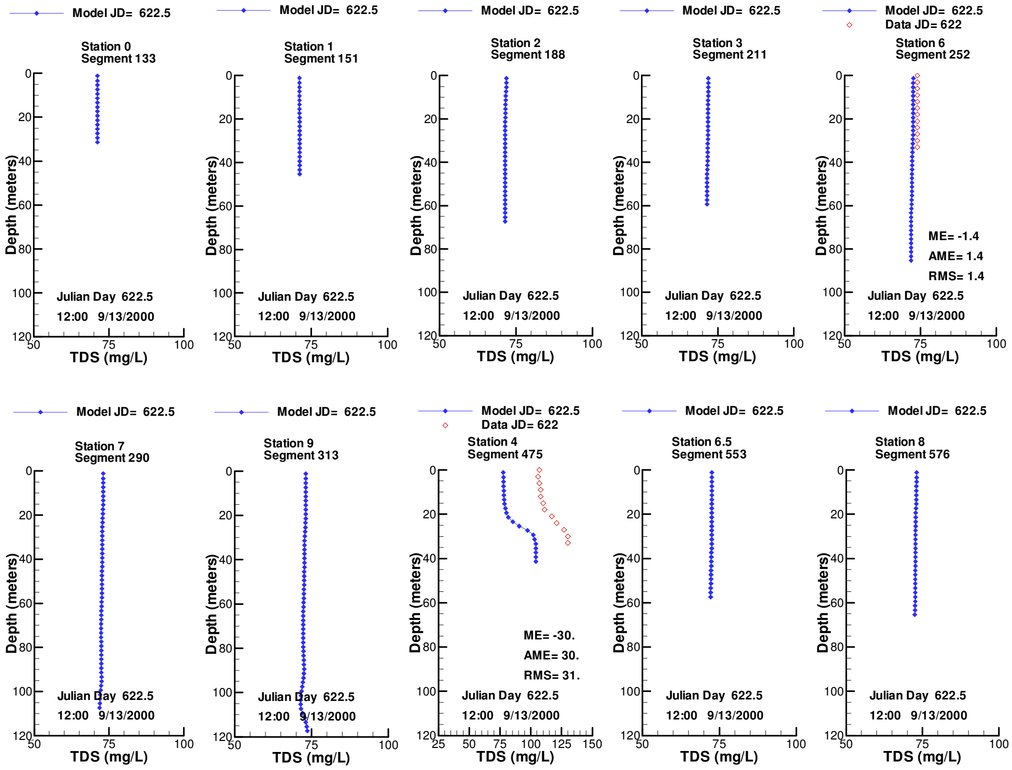


Figure 227. Vertical total dissolved solids model-data comparison, J622.

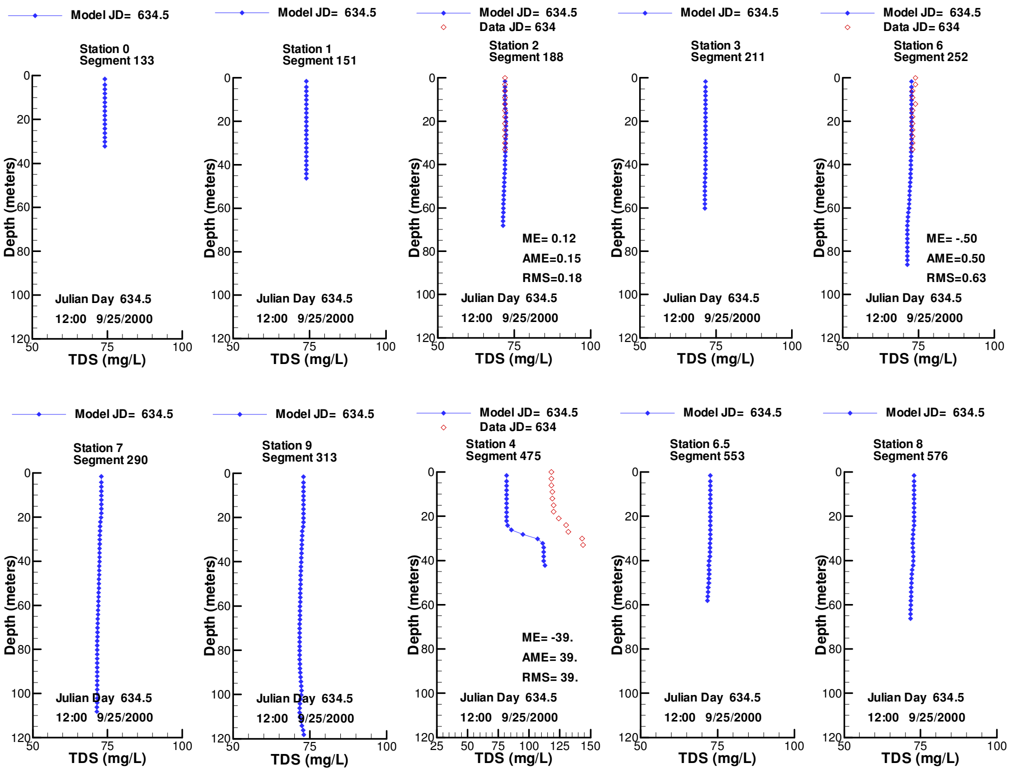


Figure 228. Vertical total dissolved solids model-data comparison, J634.

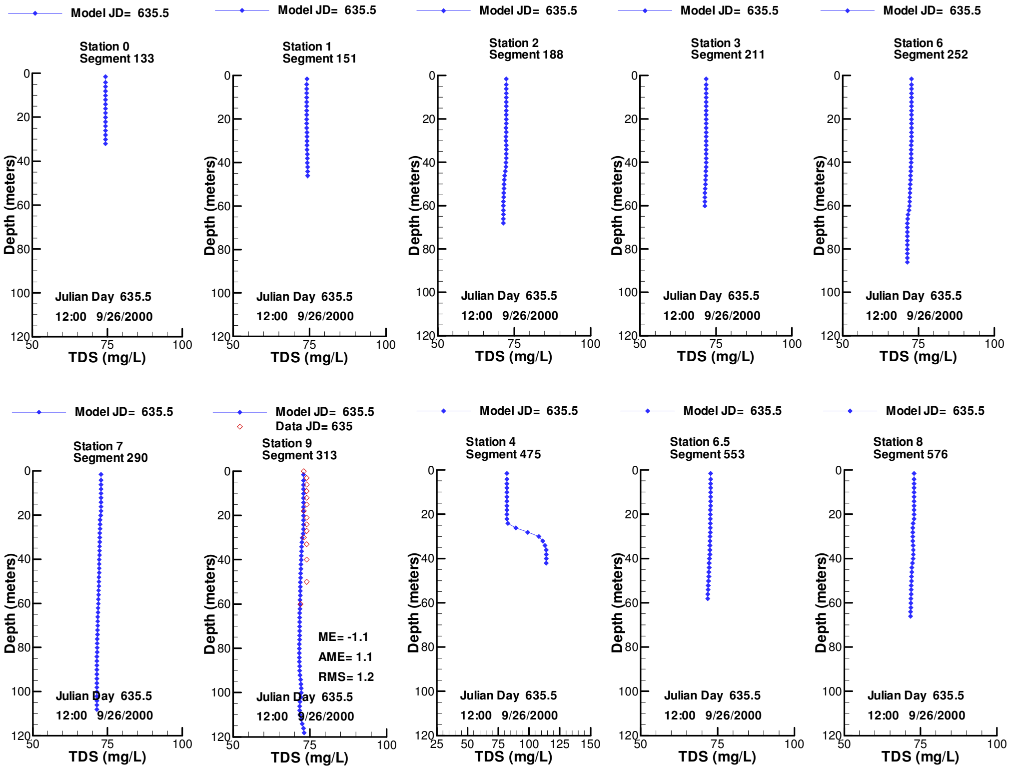


Figure 229. Vertical total dissolved solids model-data comparison, J635.

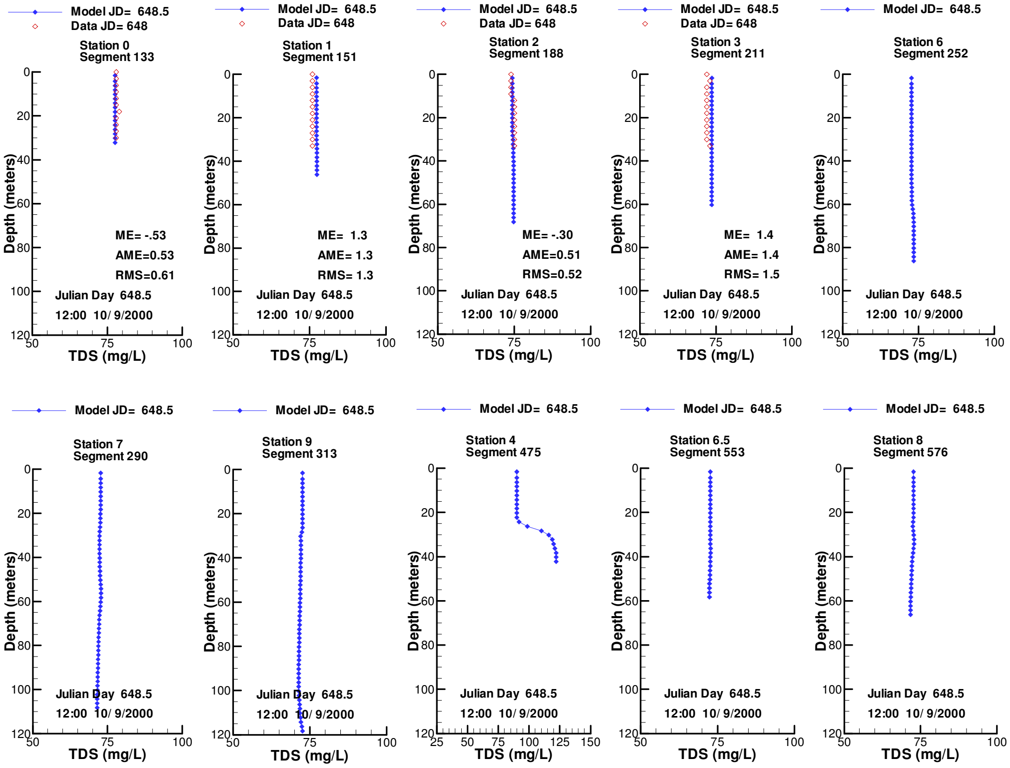


Figure 230. Vertical total dissolved solids model-data comparison, J648.

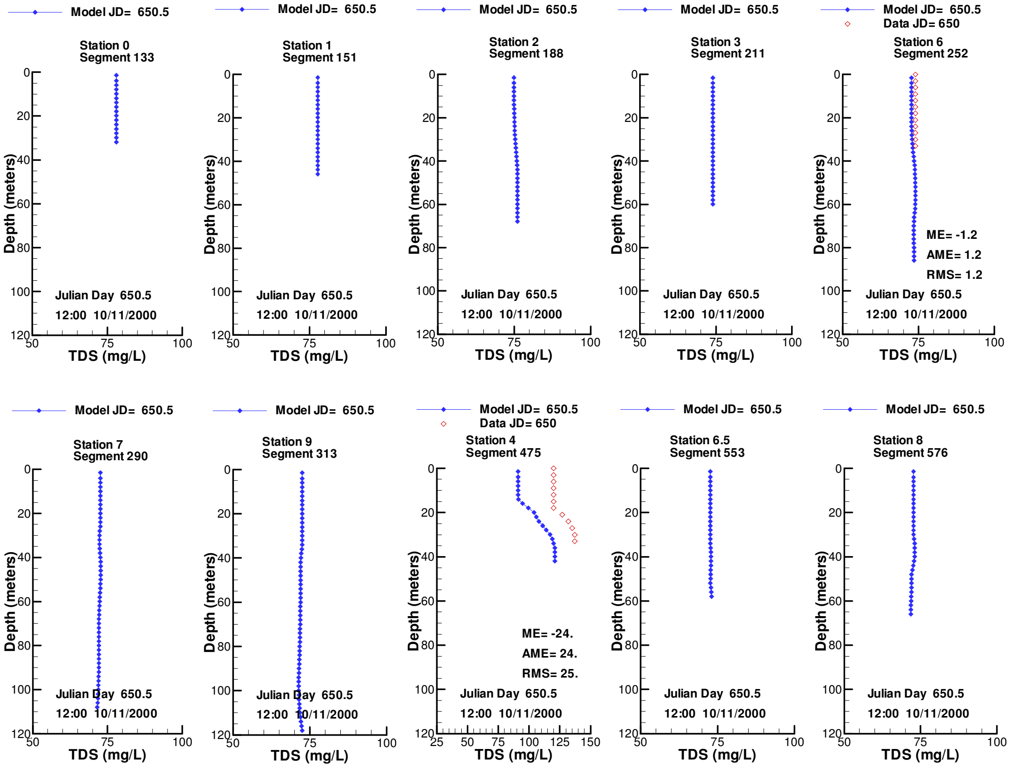


Figure 231. Vertical total dissolved solids model-data comparison, J650.

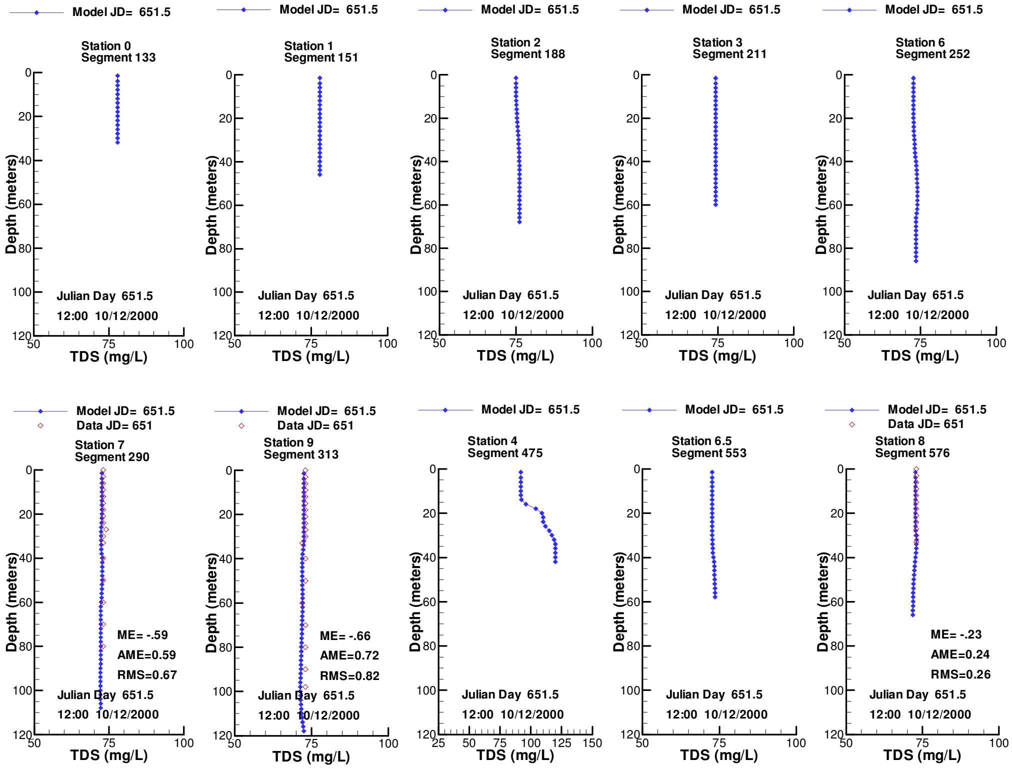


Figure 232. Vertical total dissolved solids model-data comparison, J651.

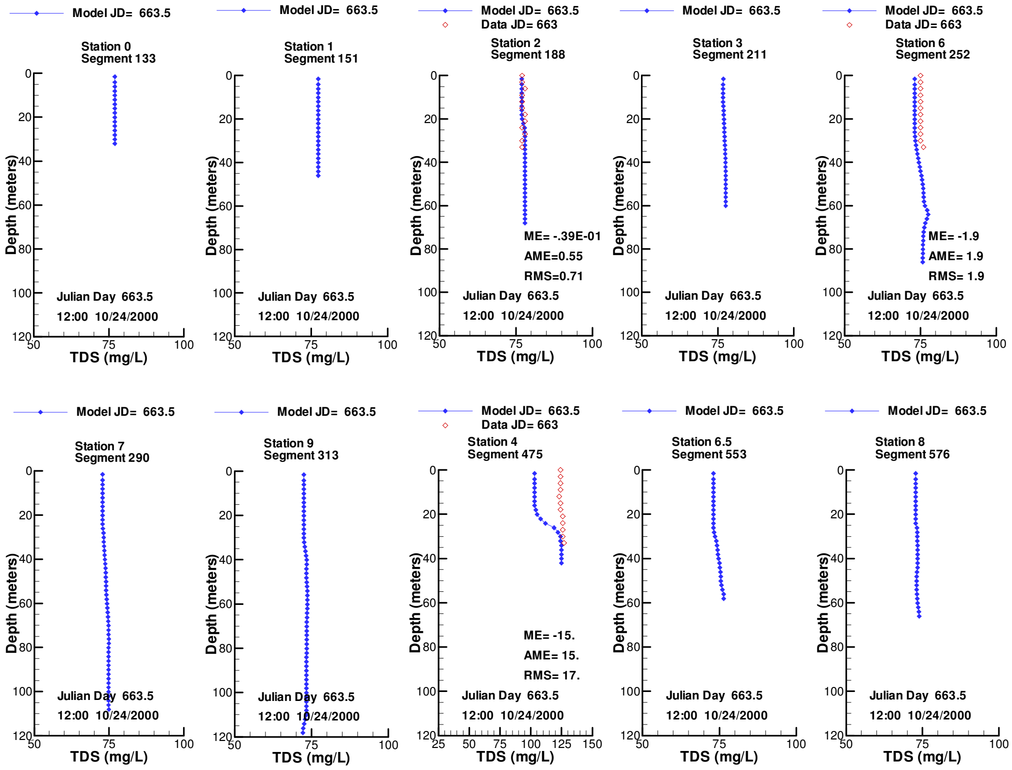


Figure 233. Vertical total dissolved solids model-data comparison, J663.

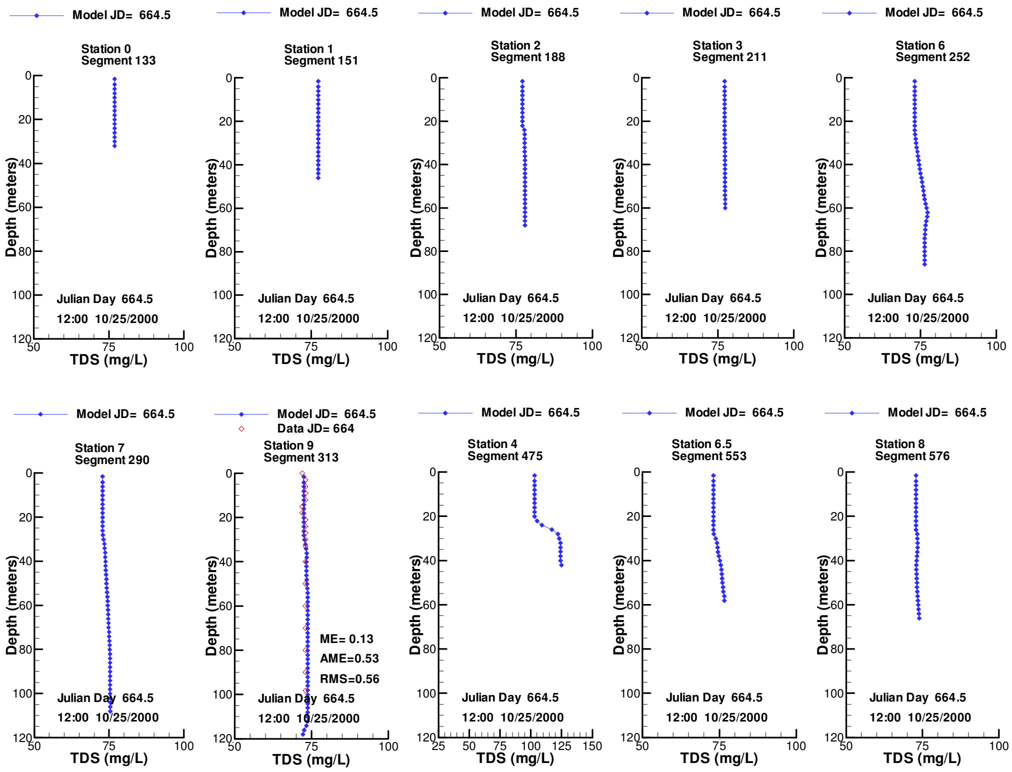


Figure 234. Vertical total dissolved solids model-data comparison, J664.

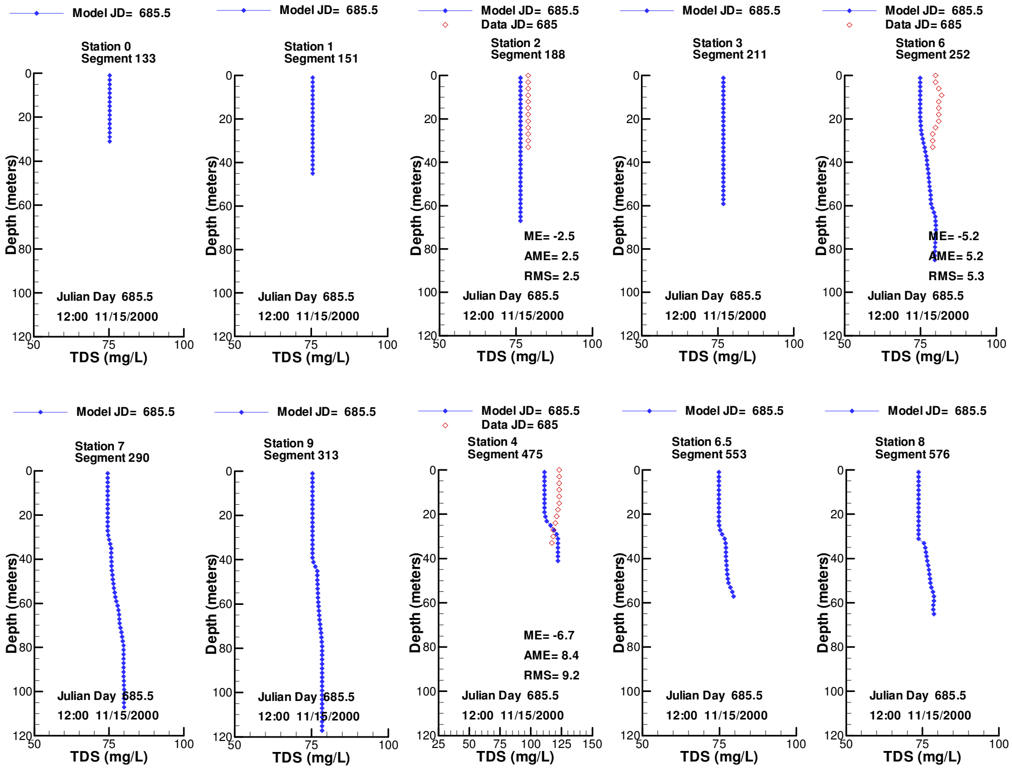


Figure 235. Vertical total dissolved solids model-data comparison, J685.

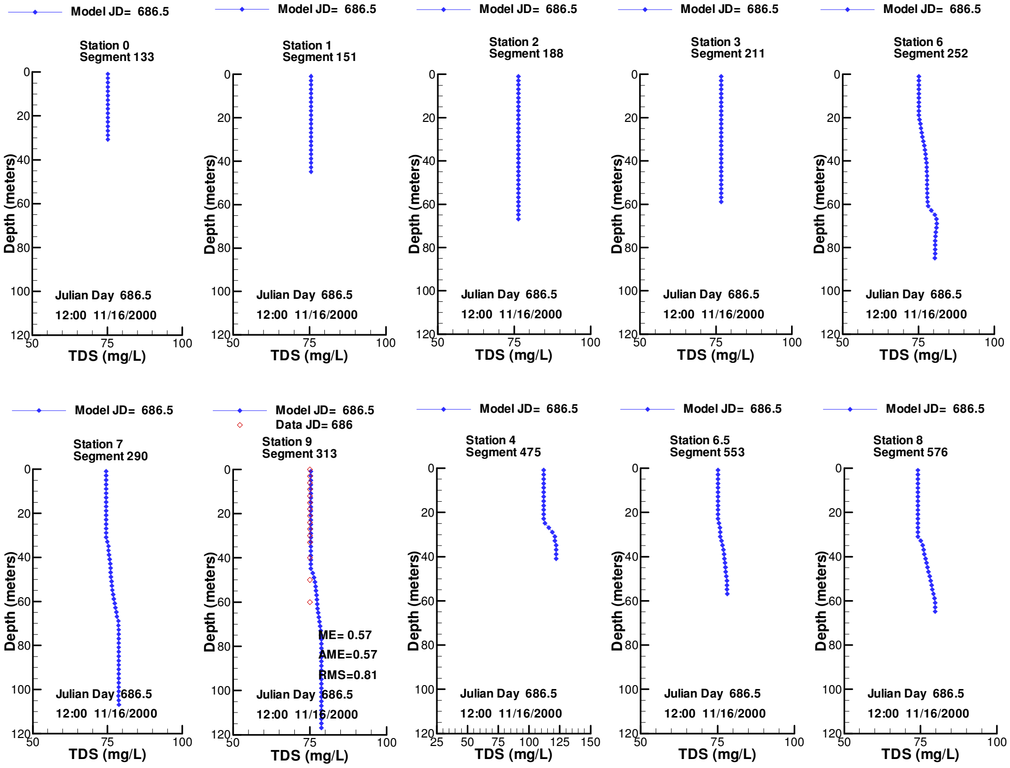


Figure 236. Vertical total dissolved solids model-data comparison, J686.

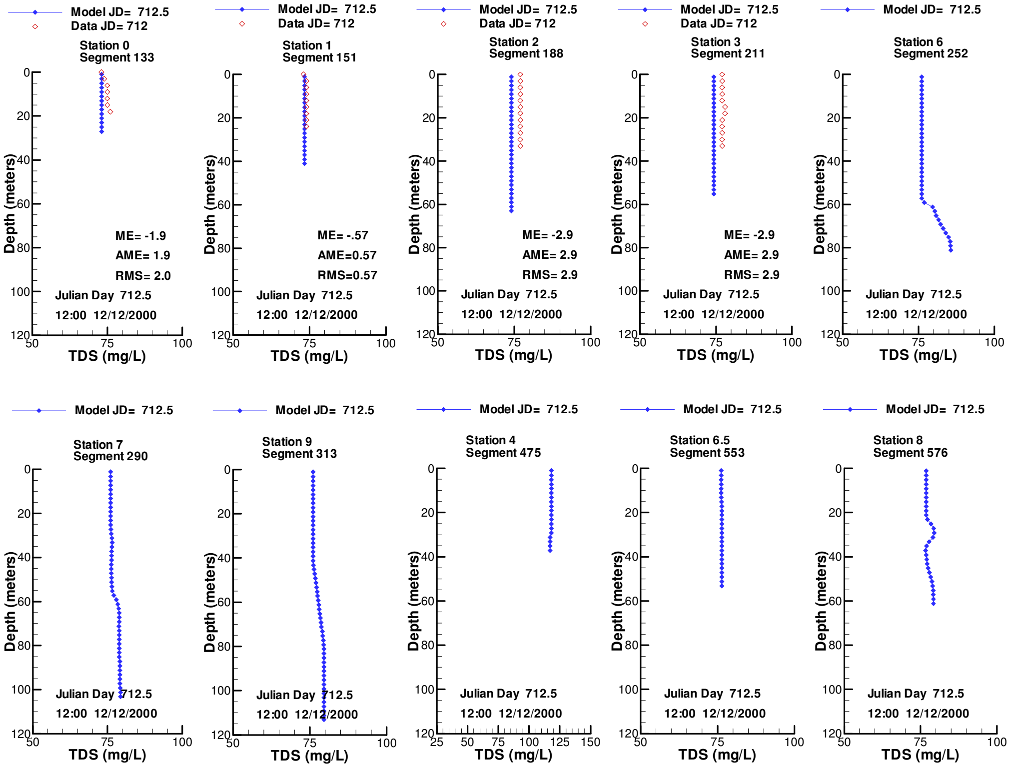


Figure 237. Vertical total dissolved solids model-data comparison, J712.

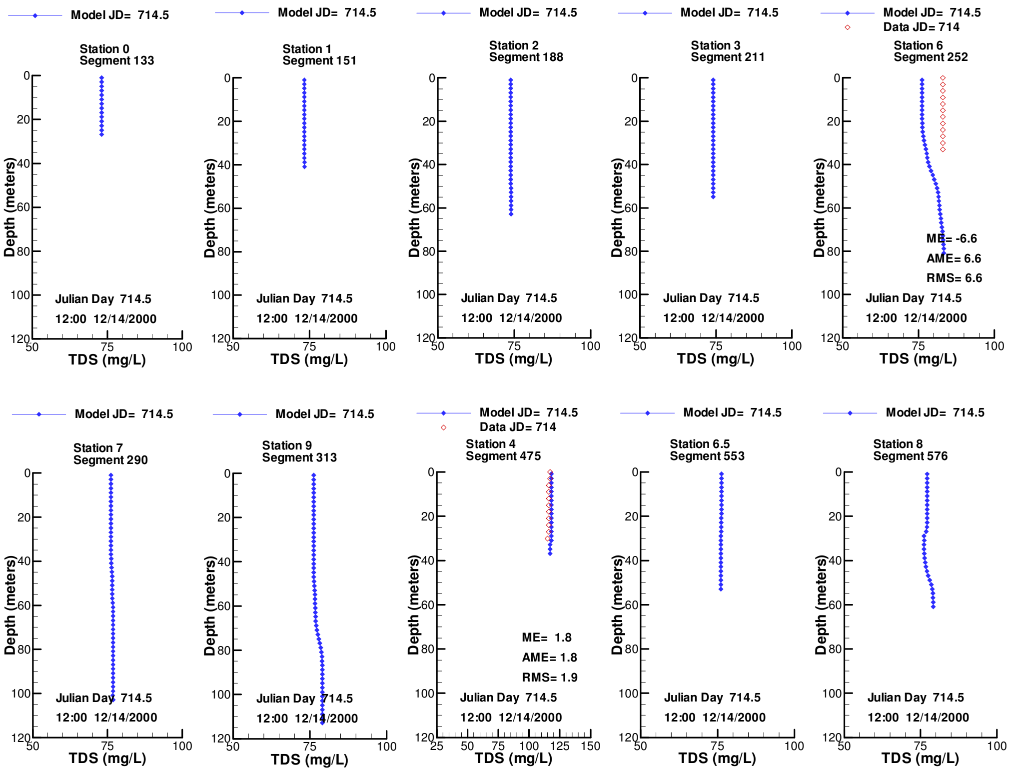


Figure 238. Vertical total dissolved solids model-data comparison, J714.

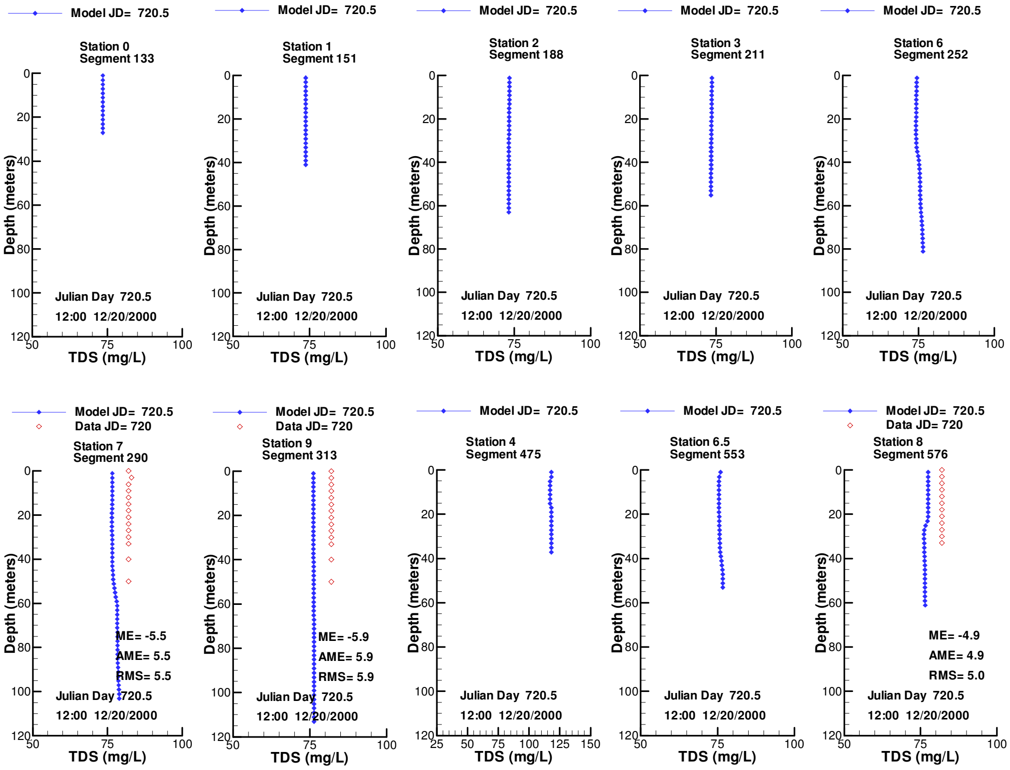


Figure 239. Vertical total dissolved solids model-data comparison, J720.

Dissolved oxygen

For days when data were recorded, vertical profile plots of dissolved oxygen are shown in Figure 240 through Figure 286.

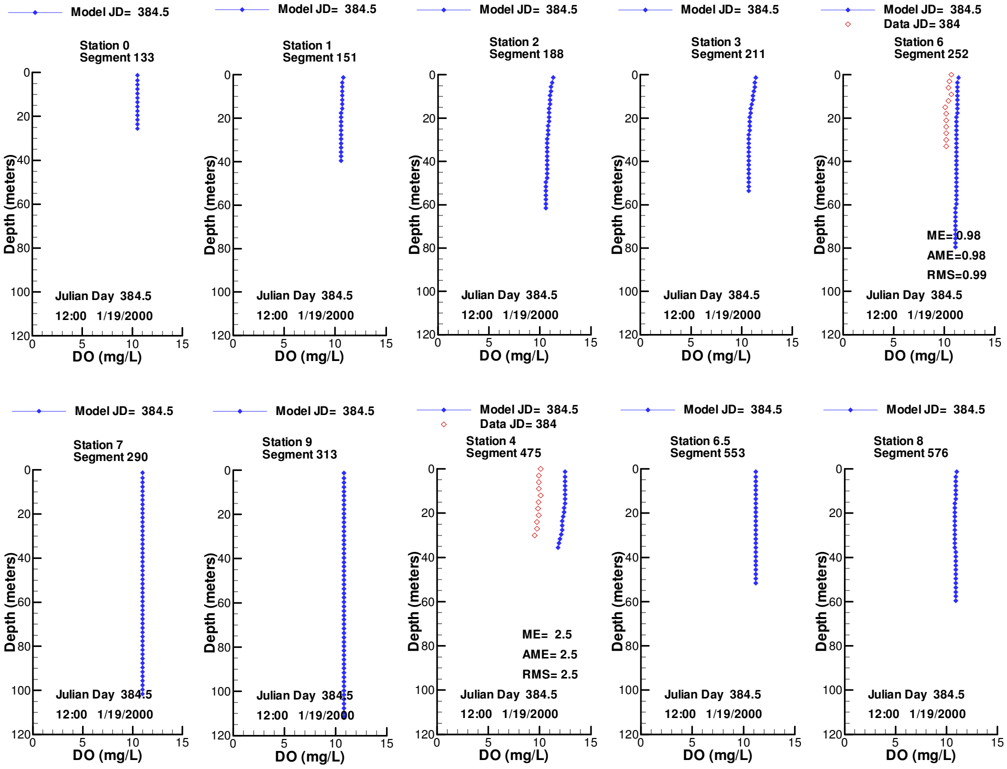


Figure 240. Vertical dissolved oxygen profile model-data comparison, J384.

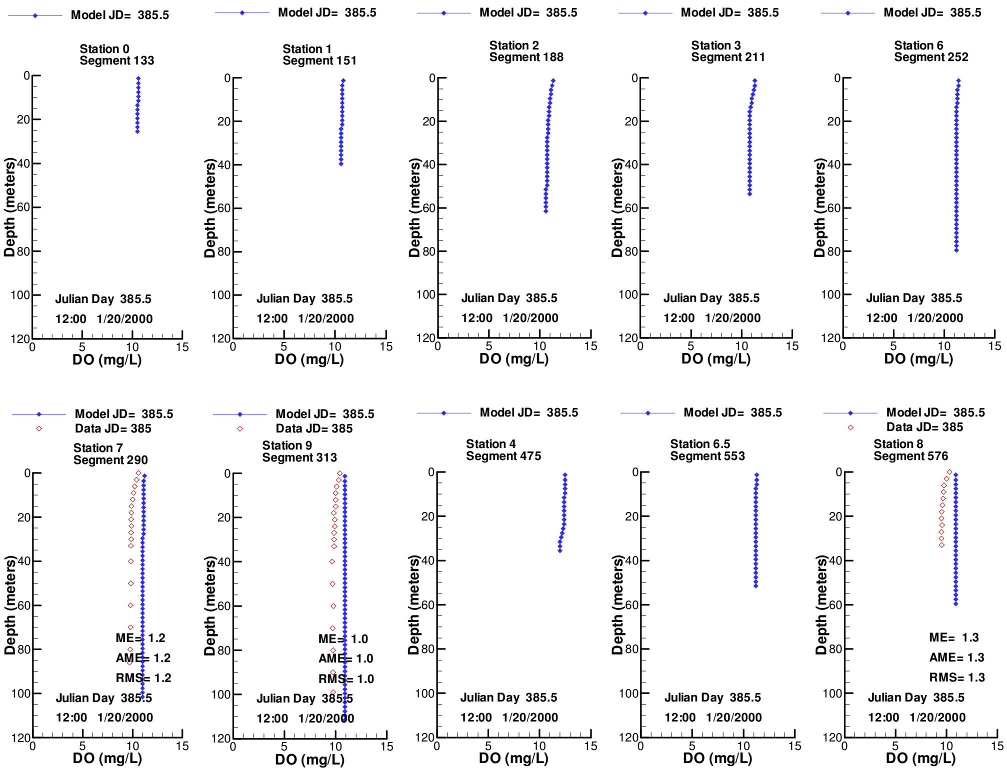


Figure 241. Vertical dissolved oxygen profile model-data comparison, J385.

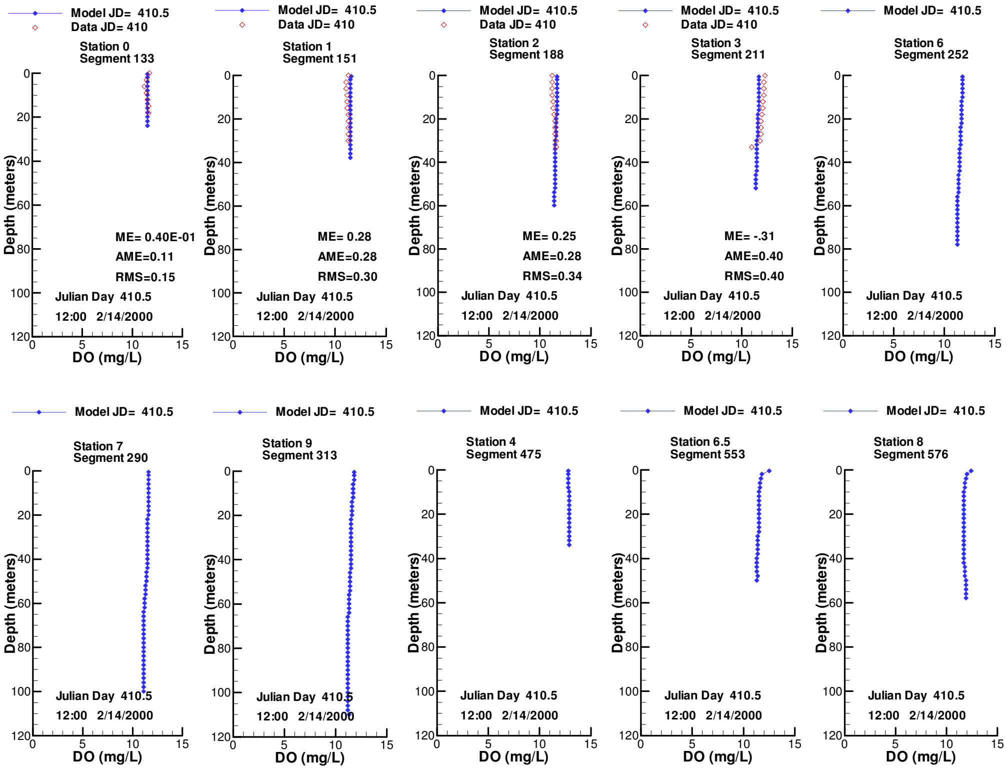


Figure 242. Vertical dissolved oxygen profile model-data comparison, J410.

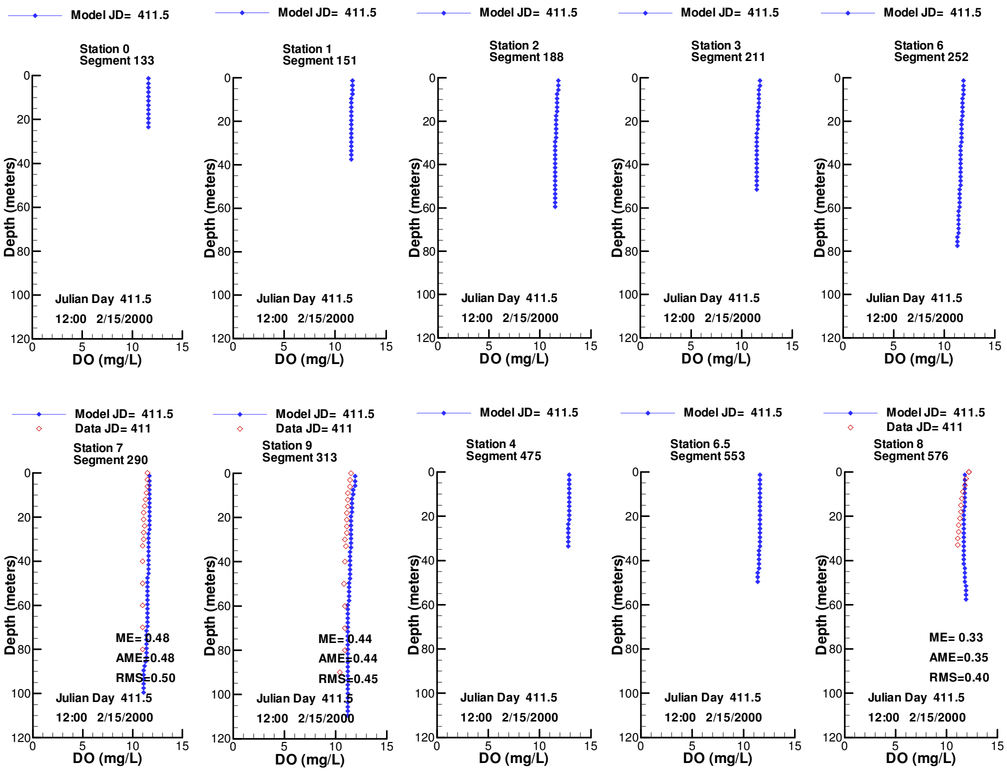


Figure 243. Vertical dissolved oxygen profile model-data comparison, J411.

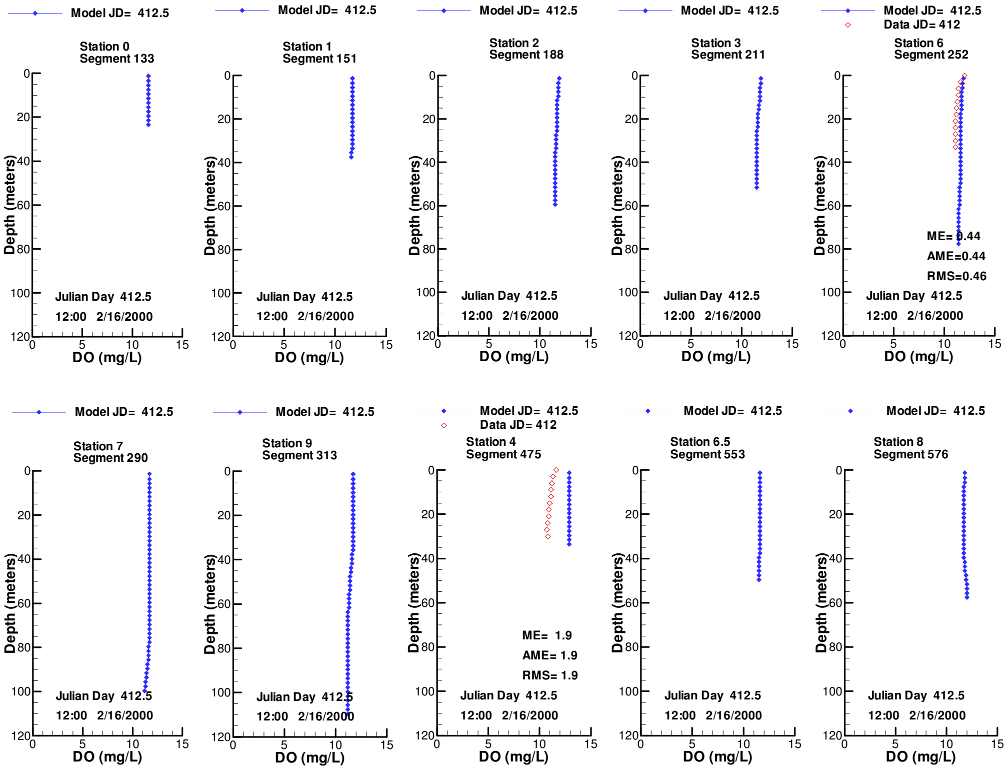


Figure 244. Vertical dissolved oxygen profile model-data comparison, J412.

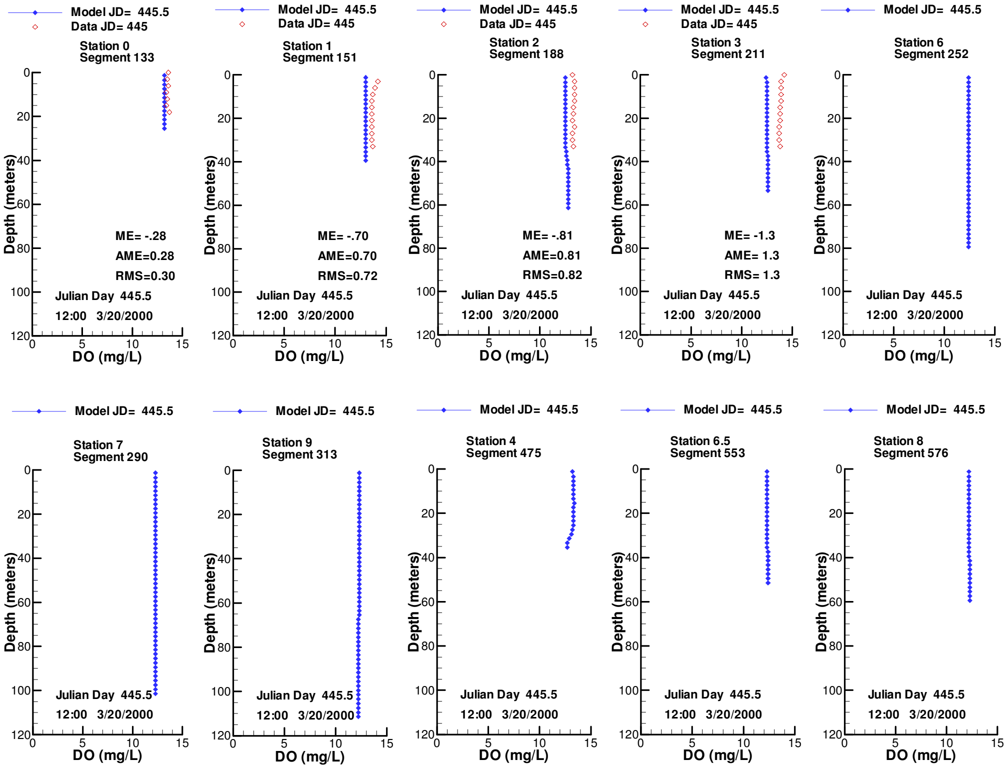


Figure 245. Vertical dissolved oxygen profile model-data comparison, J445.

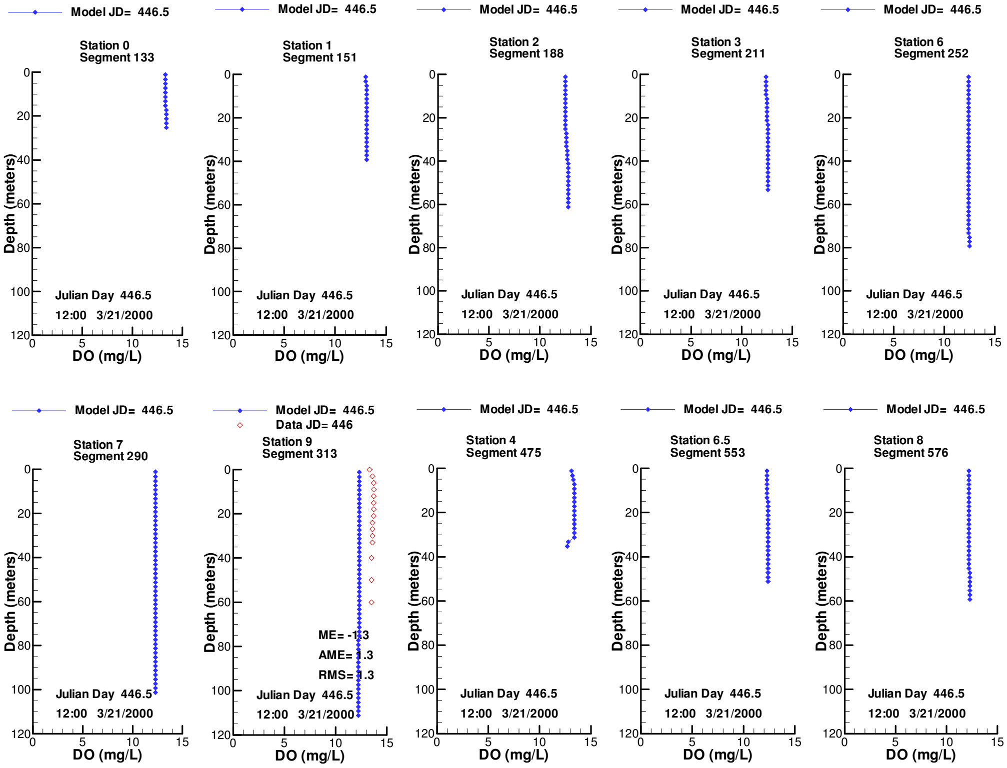


Figure 246. Vertical dissolved oxygen profile model-data comparison, J446.

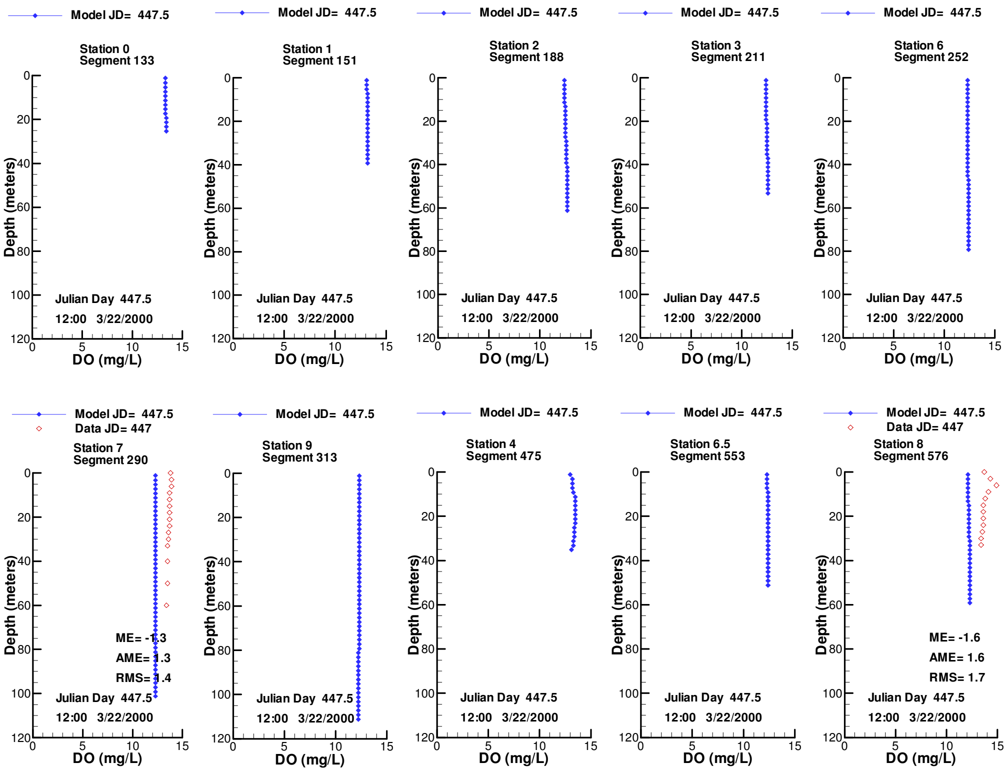


Figure 247. Vertical dissolved oxygen profile model-data comparison, J447.

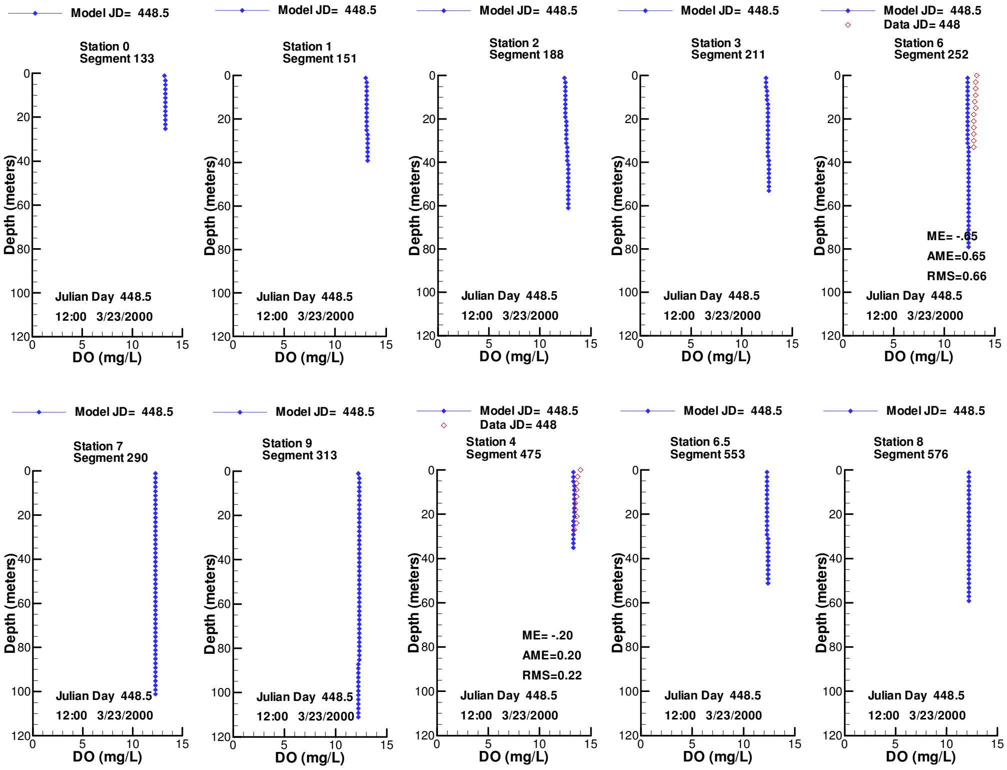


Figure 248. Vertical dissolved oxygen profile model-data comparison, J448.

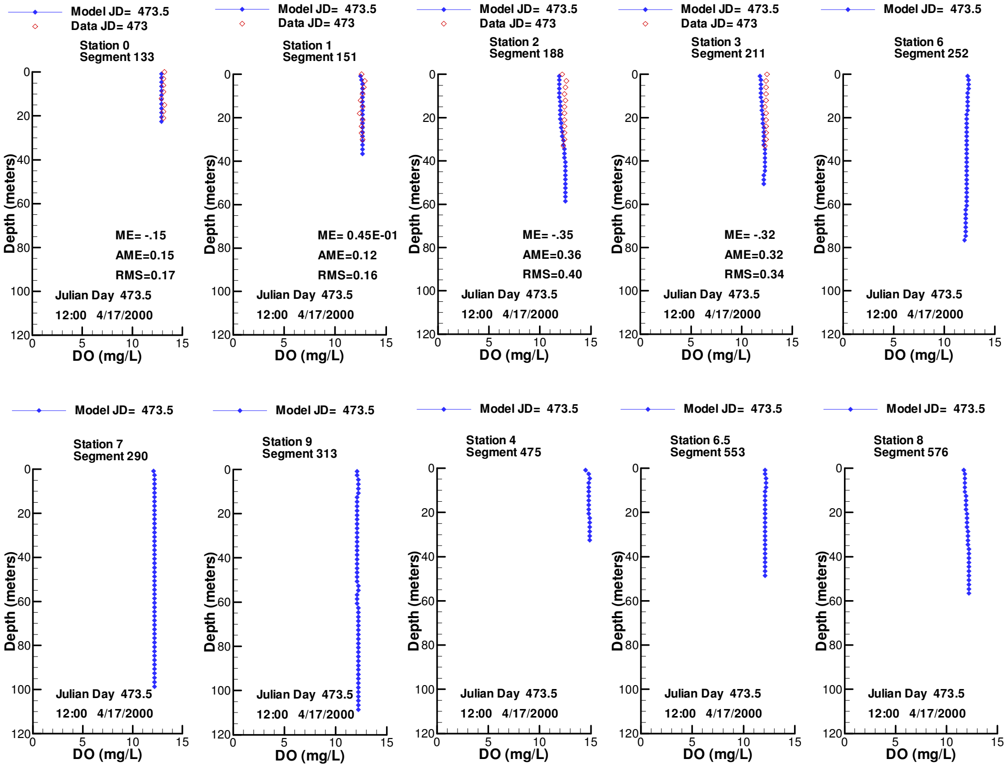


Figure 249. Vertical dissolved oxygen profile model-data comparison, J473.

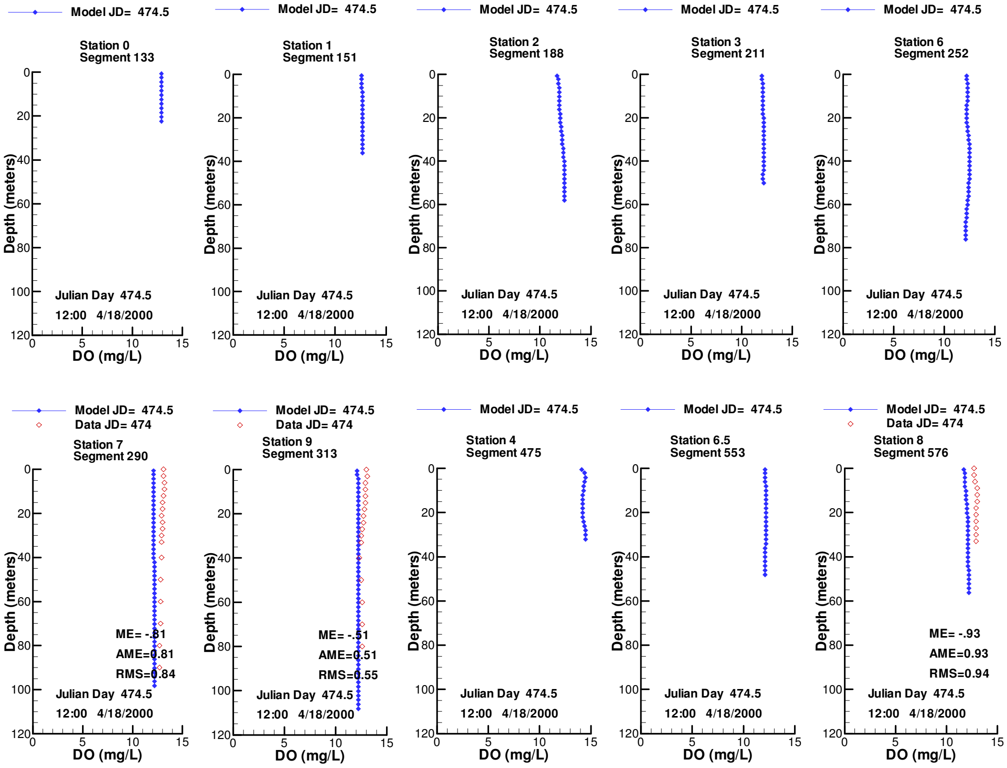


Figure 250. Vertical dissolved oxygen profile model-data comparison, J474.

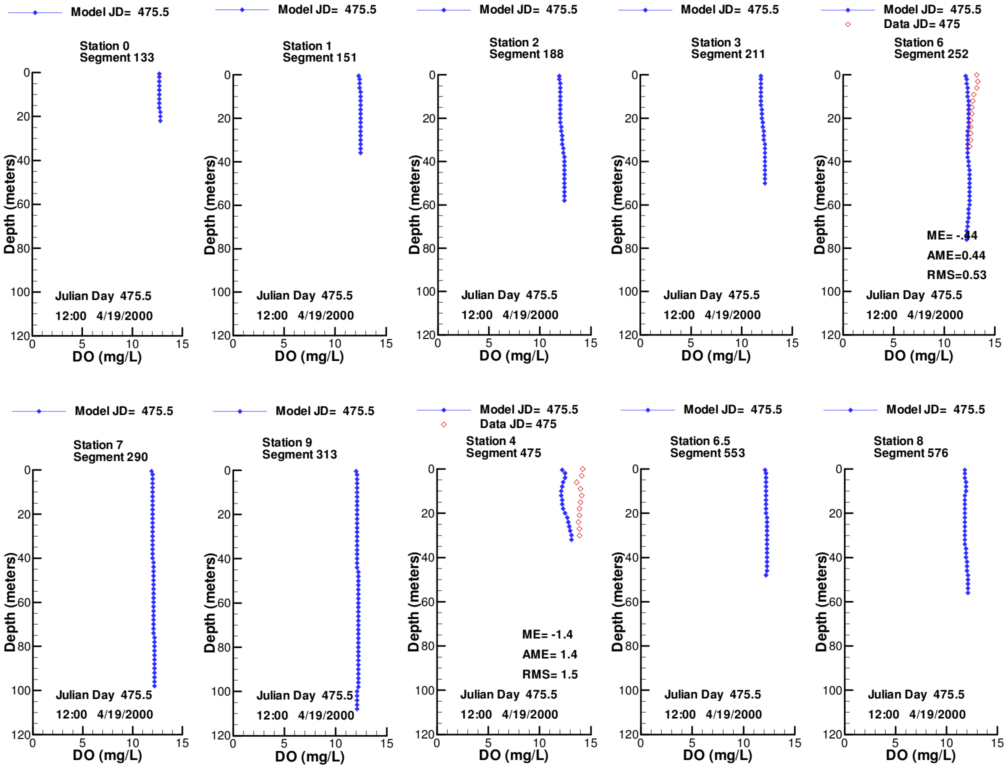


Figure 251. Vertical dissolved oxygen profile model-data comparison, J475.

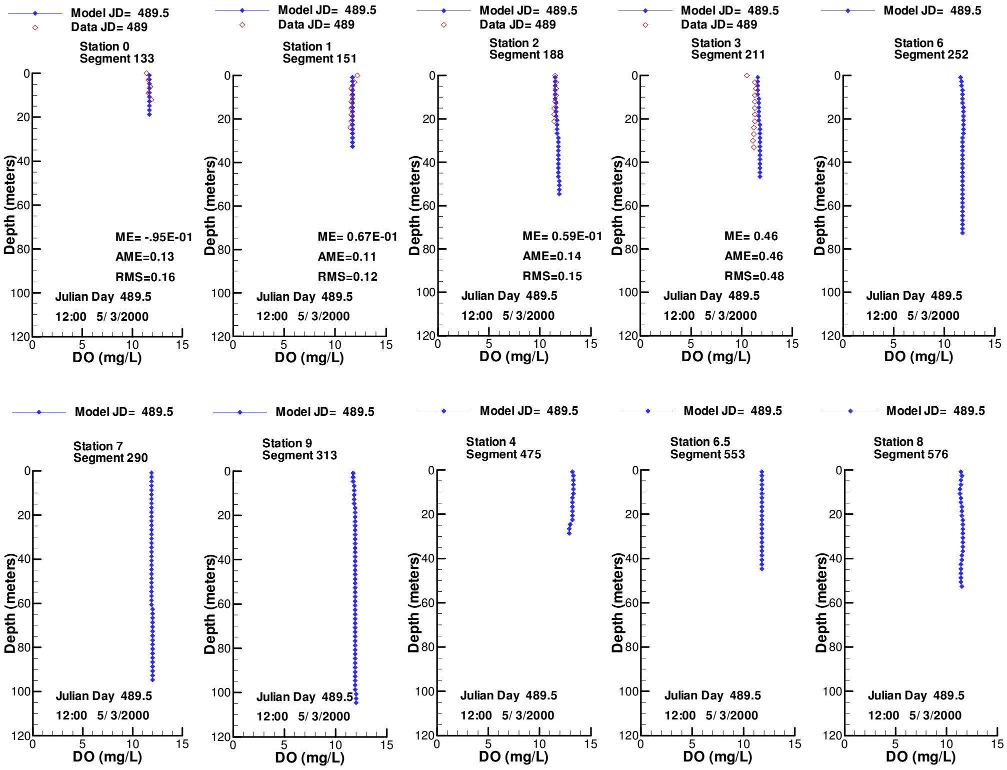


Figure 252. Vertical dissolved oxygen profile model-data comparison, J489.

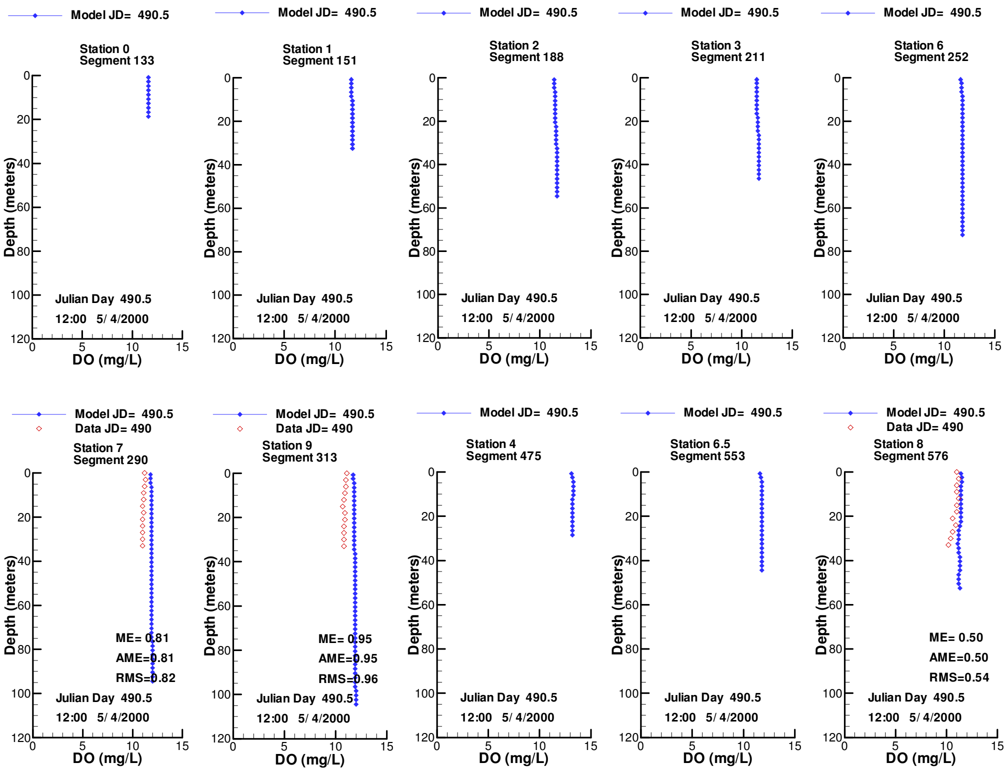


Figure 253. Vertical dissolved oxygen profile model-data comparison, J490.

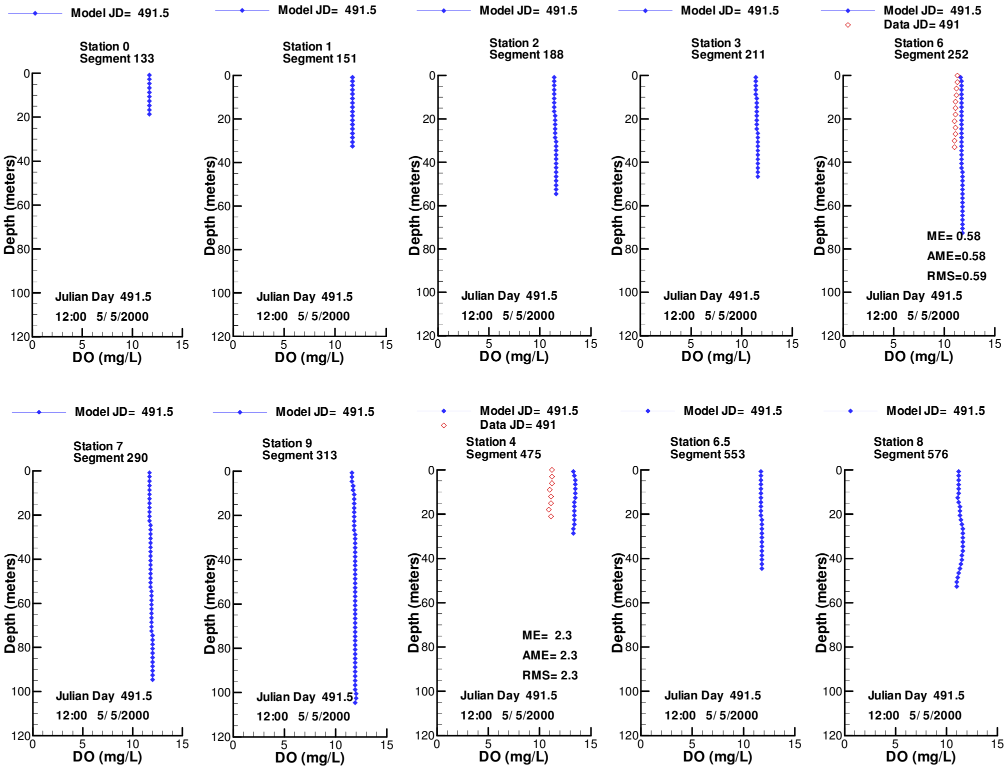


Figure 254. Vertical dissolved oxygen profile model-data comparison, J491.

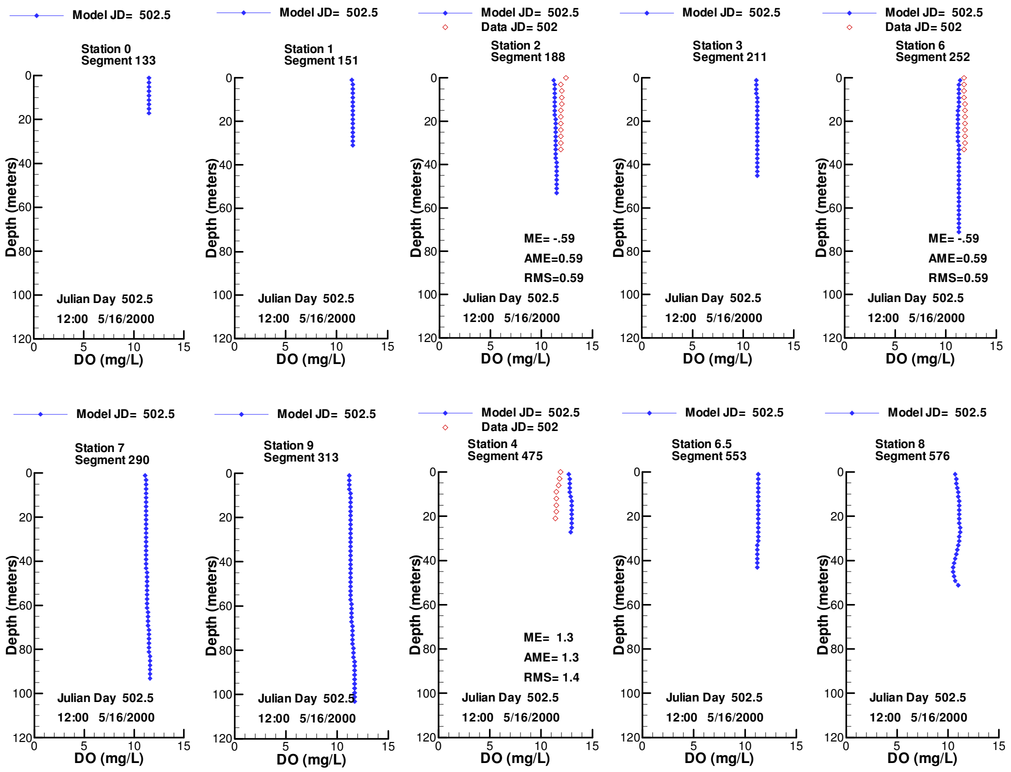


Figure 255. Vertical dissolved oxygen profile model-data comparison, J502.

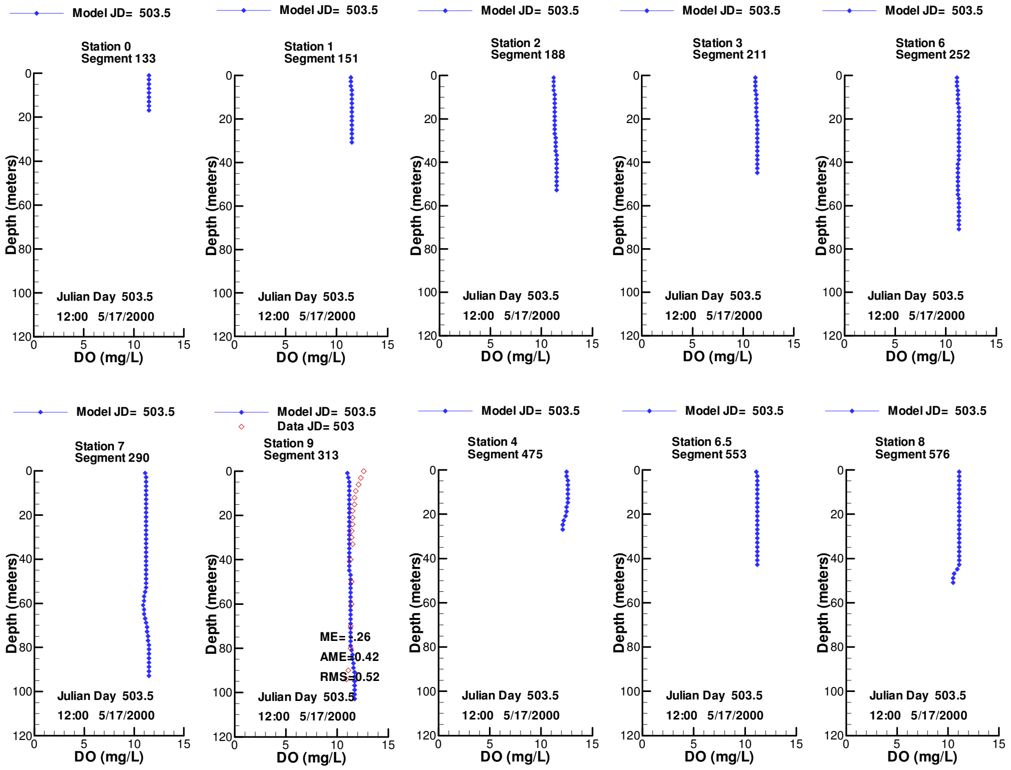


Figure 256. Vertical dissolved oxygen profile model-data comparison, J503.

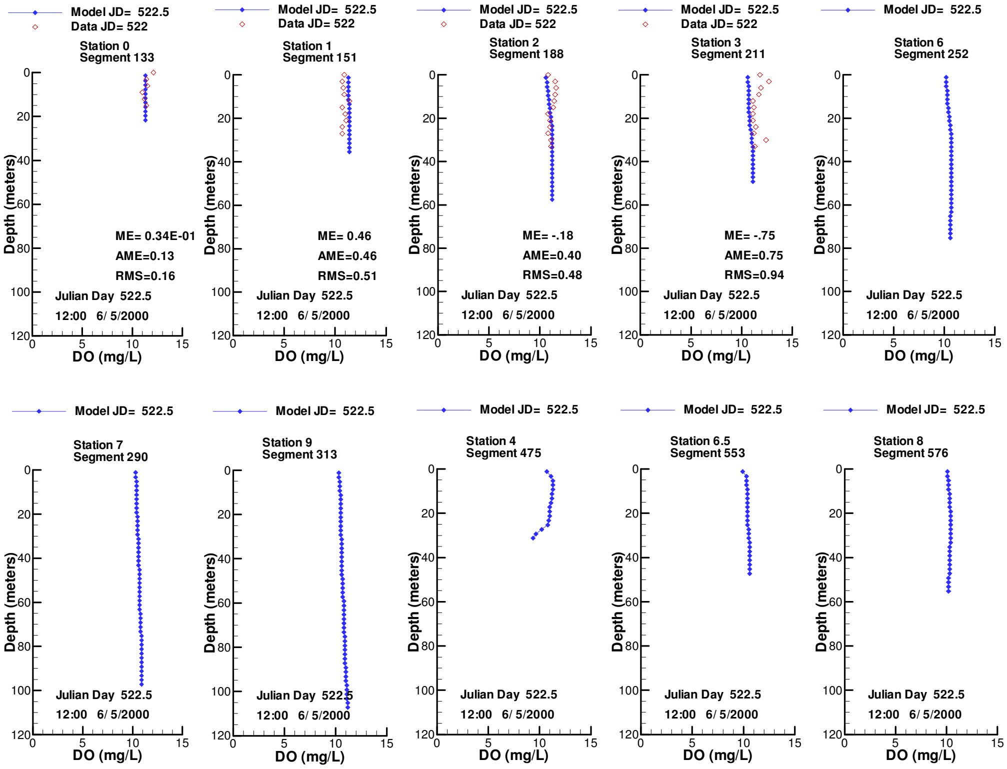


Figure 257. Vertical dissolved oxygen profile model-data comparison, J522.

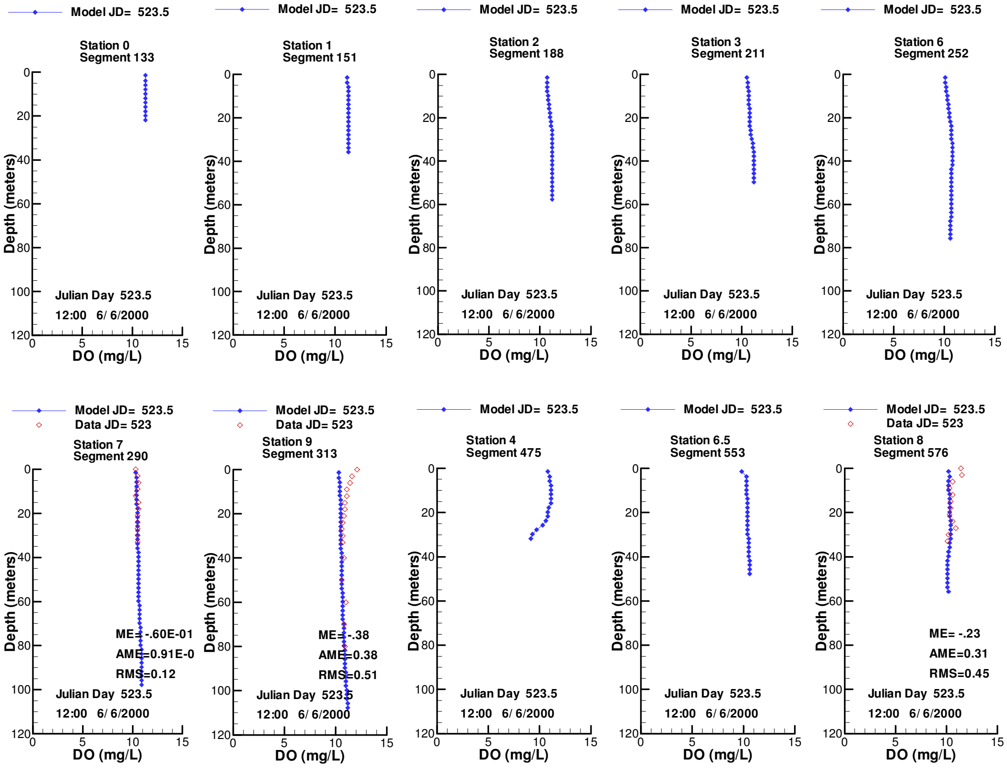


Figure 258. Vertical dissolved oxygen profile model-data comparison, J523.

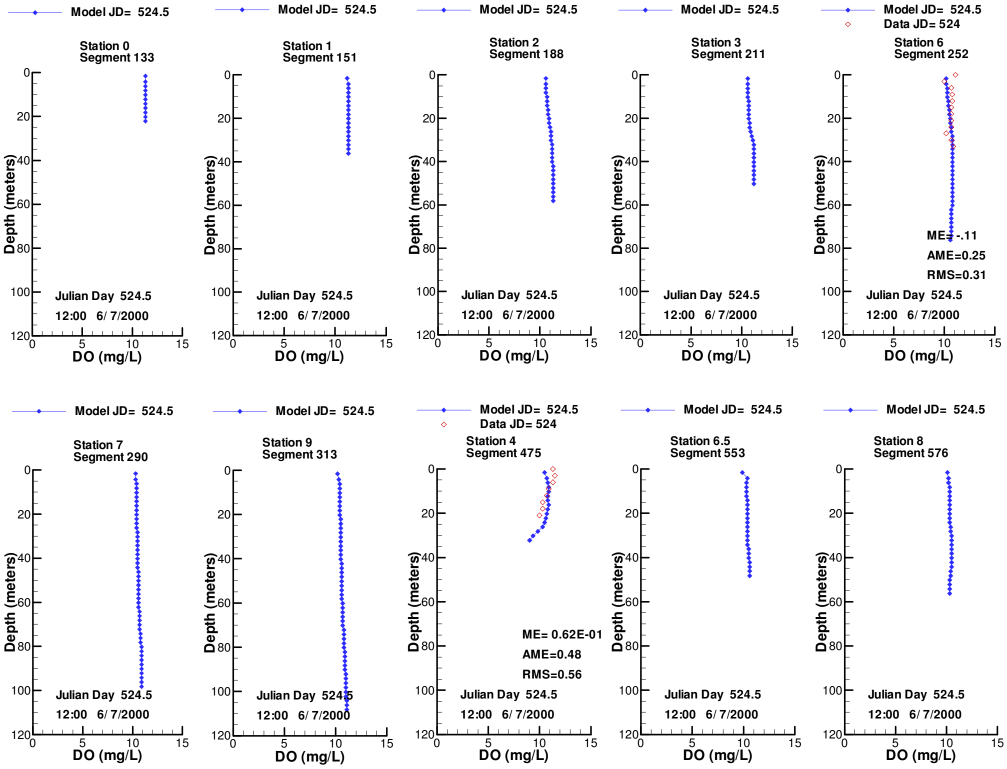


Figure 259. Vertical dissolved oxygen profile model-data comparison, J524.

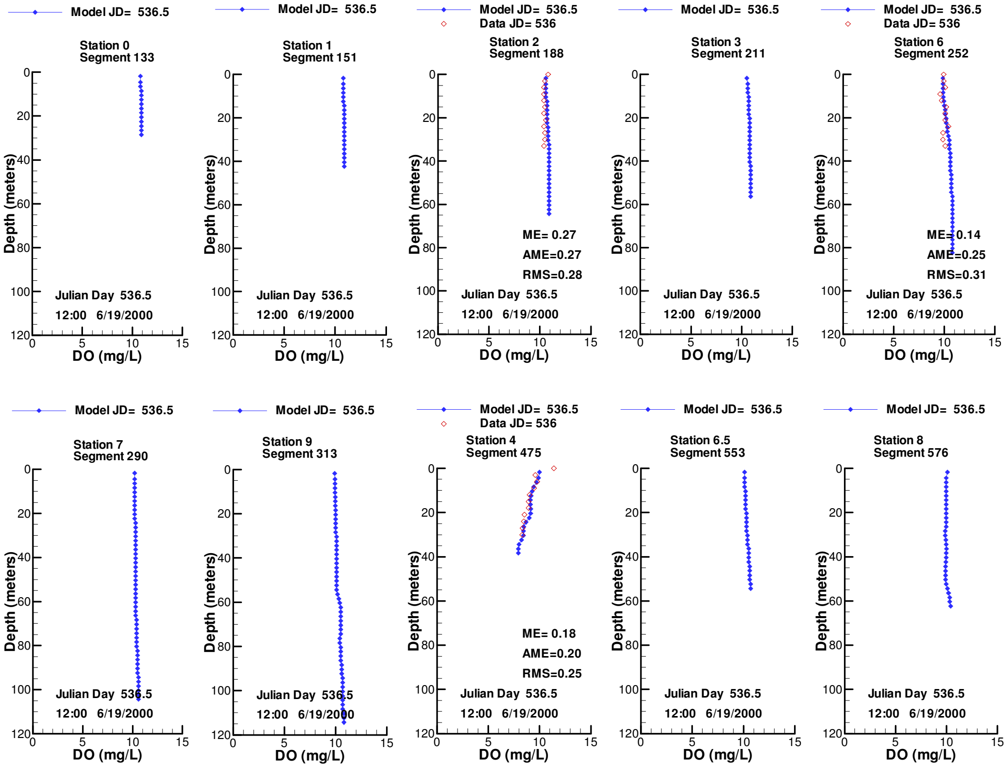


Figure 260. Vertical dissolved oxygen profile model-data comparison, J536.

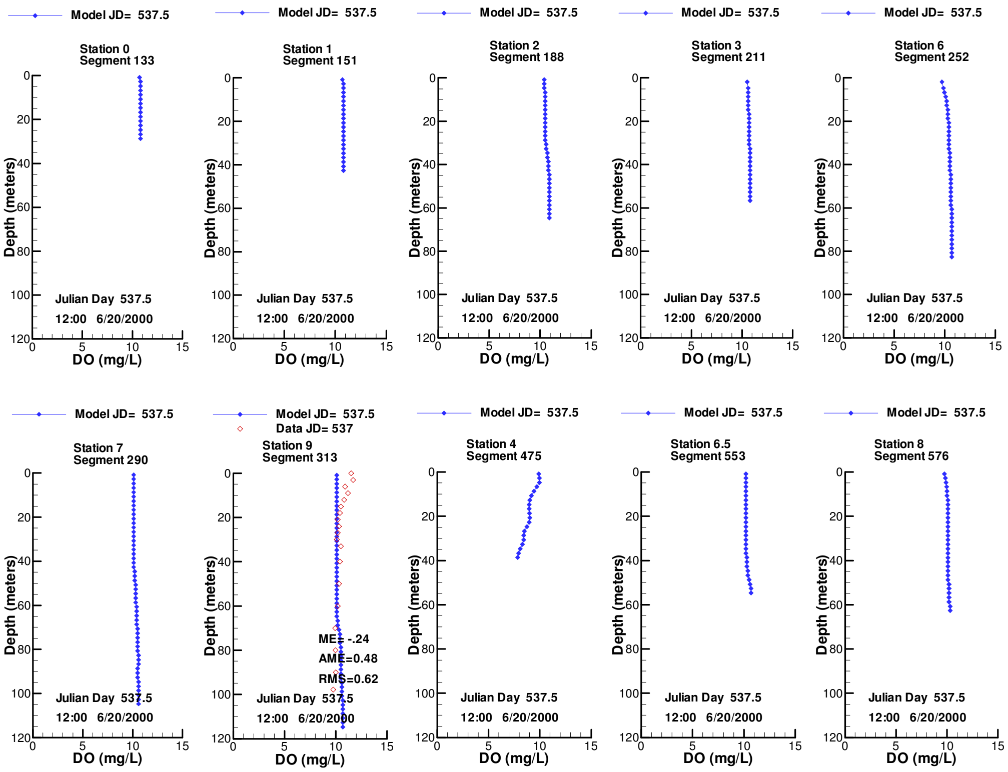


Figure 261. Vertical dissolved oxygen profile model-data comparison, J537.

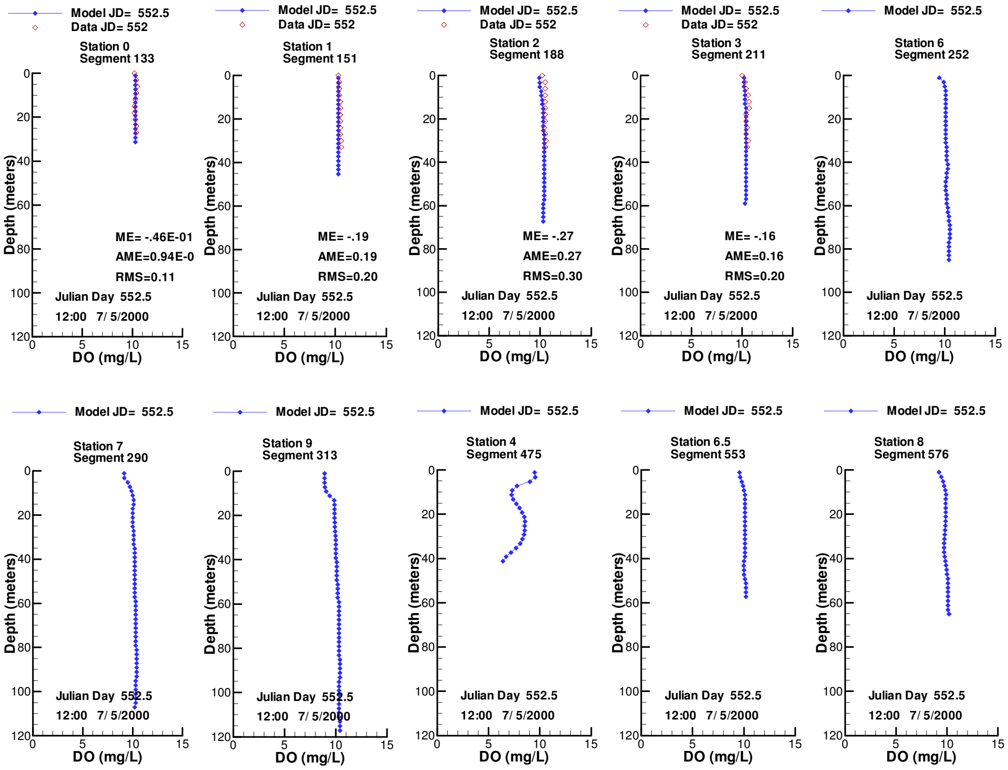


Figure 262. Vertical dissolved oxygen profile model-data comparison, J552.

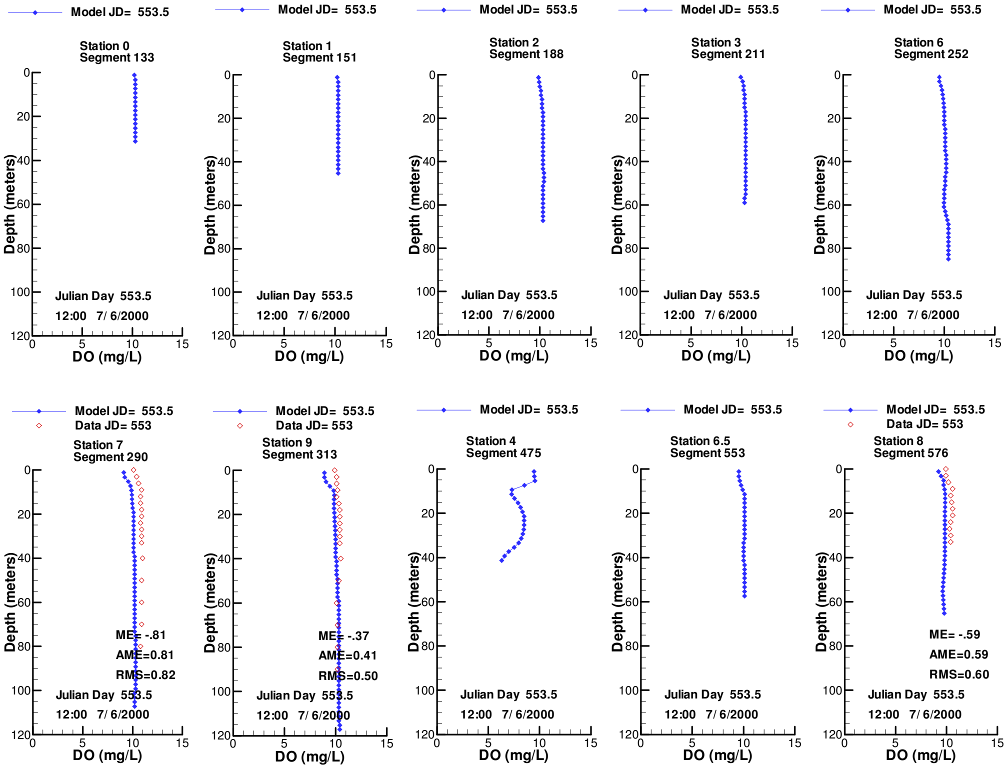


Figure 263. Vertical dissolved oxygen profile model-data comparison, J553.

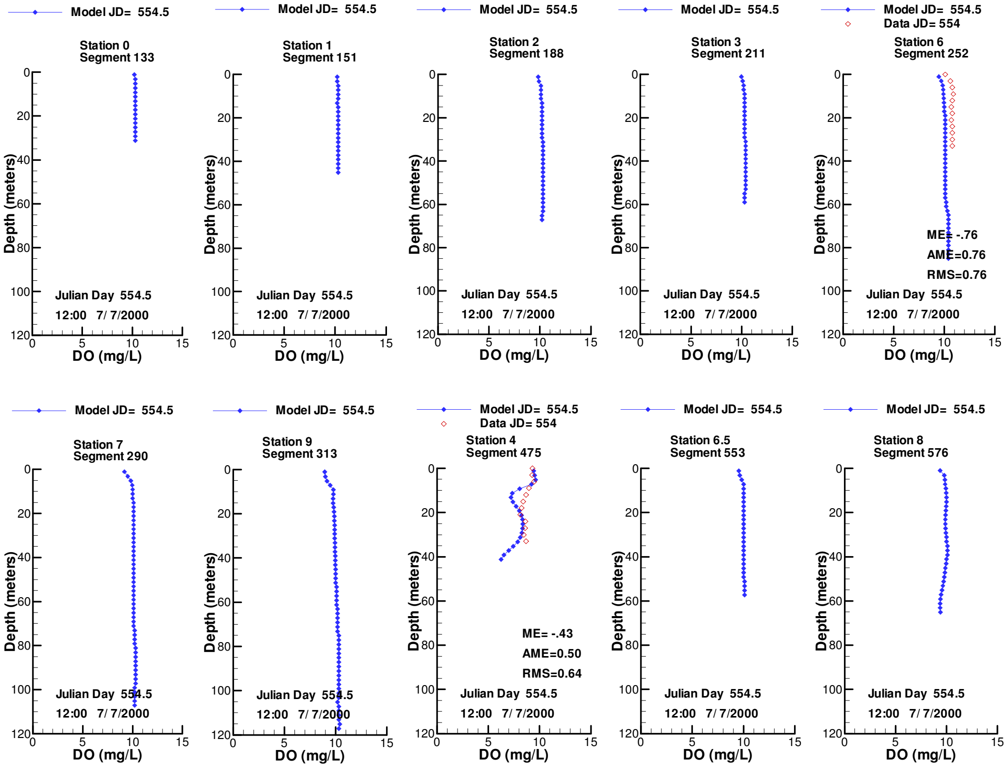


Figure 264. Vertical dissolved oxygen profile model-data comparison, J554.

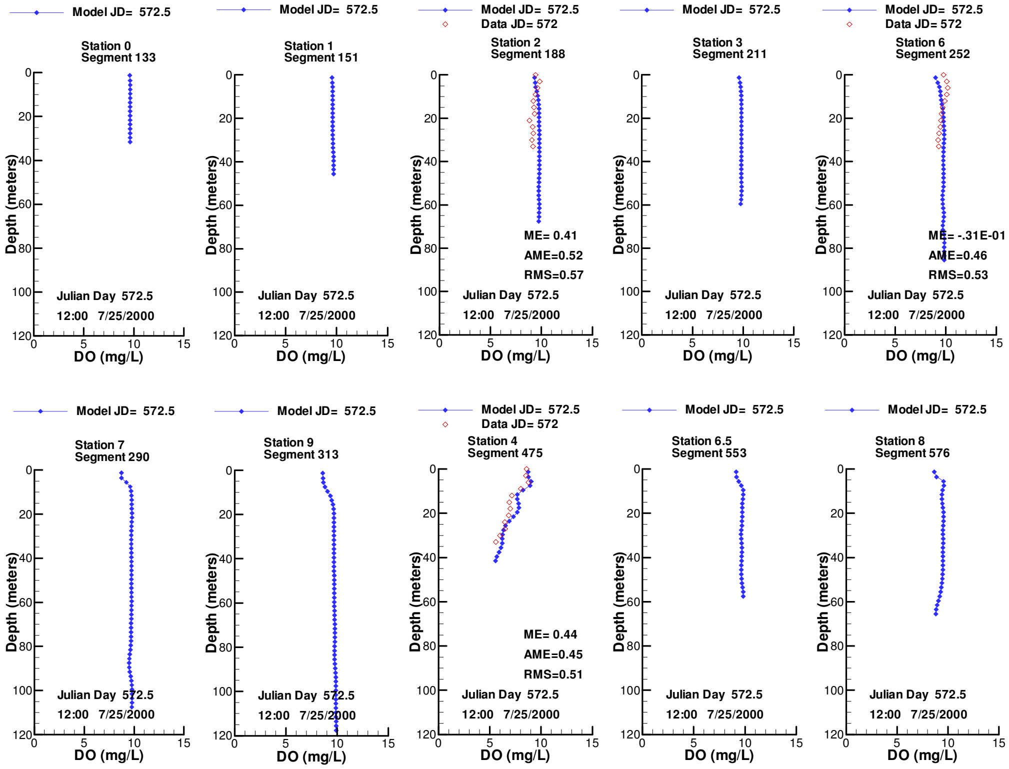


Figure 265. Vertical dissolved oxygen profile model-data comparison, J572.

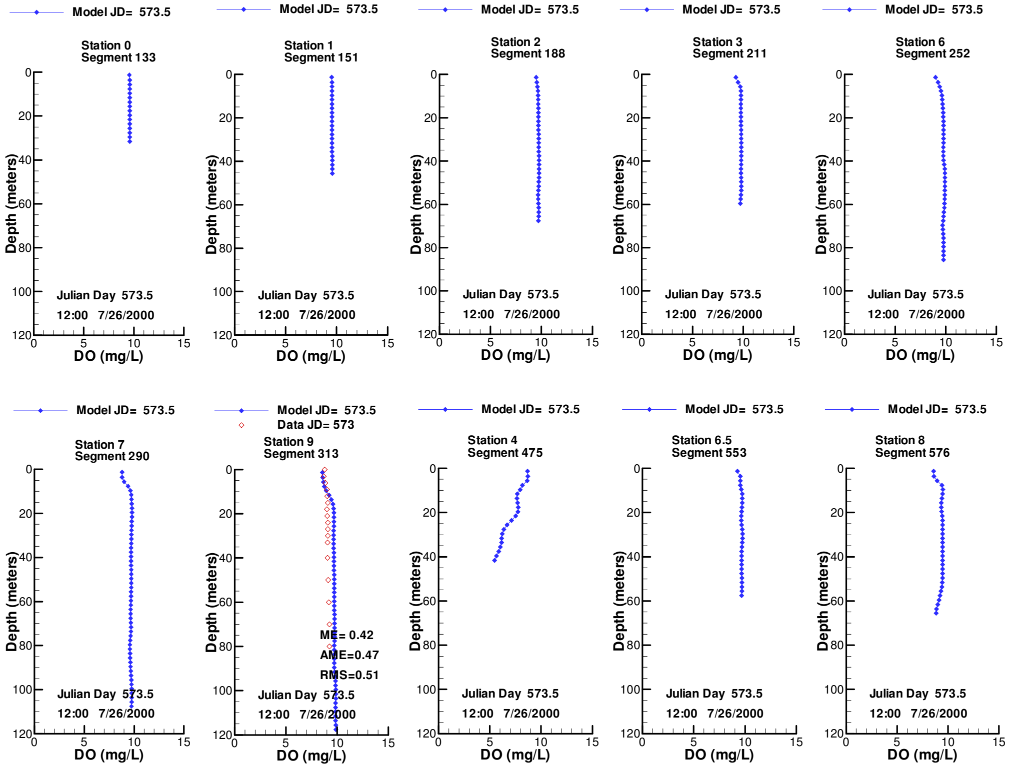


Figure 266. Vertical dissolved oxygen profile model-data comparison, J573.

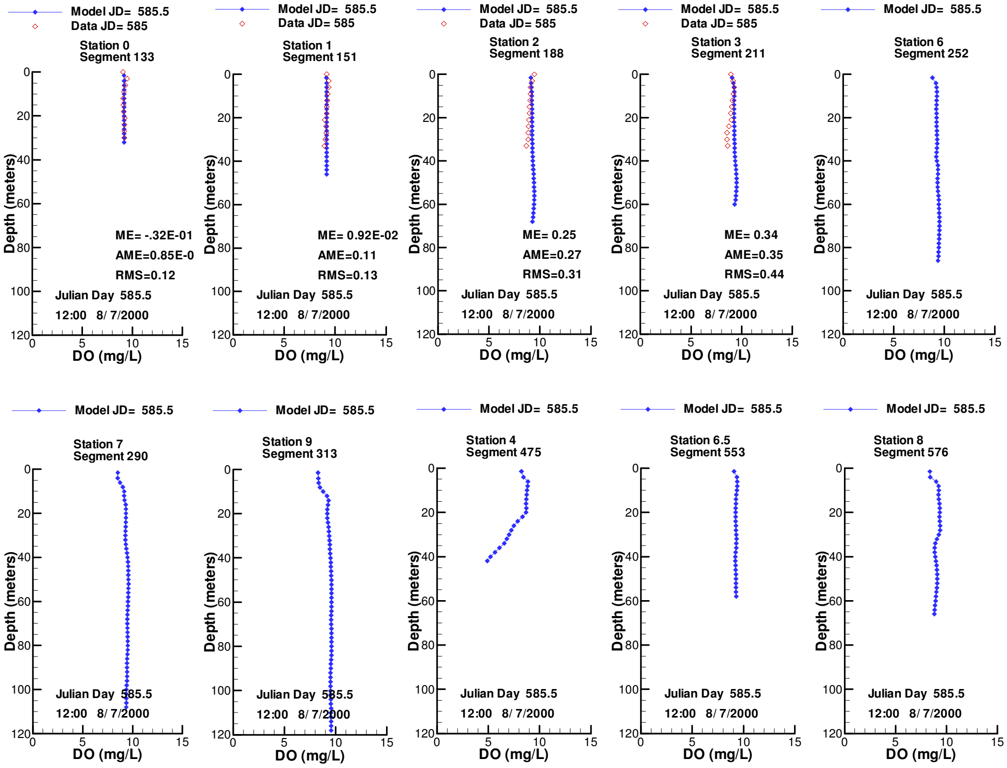


Figure 267. Vertical dissolved oxygen profile model-data comparison, J585.

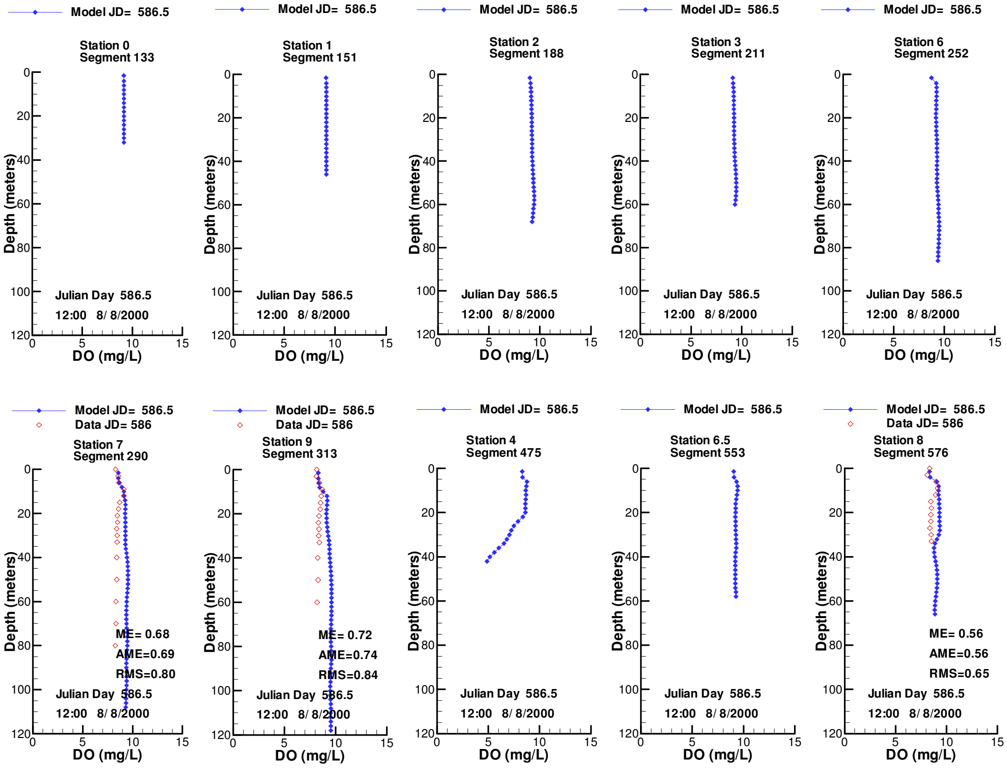


Figure 268. Vertical dissolved oxygen profile model-data comparison, J586.

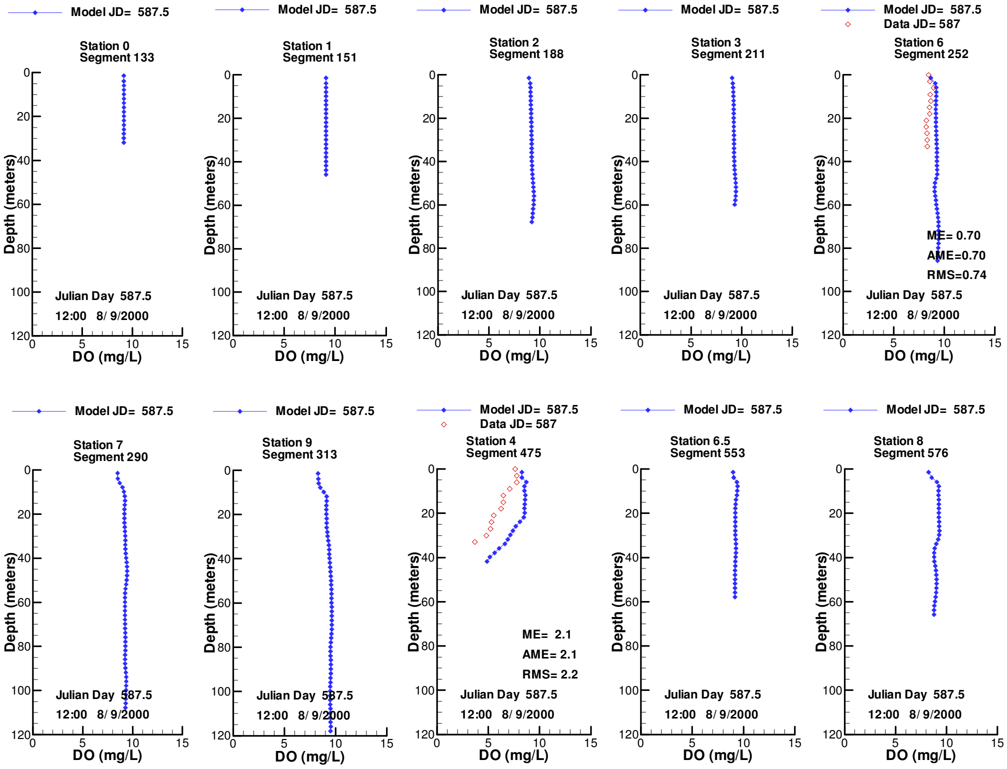


Figure 269. Vertical dissolved oxygen profile model-data comparison, J587.

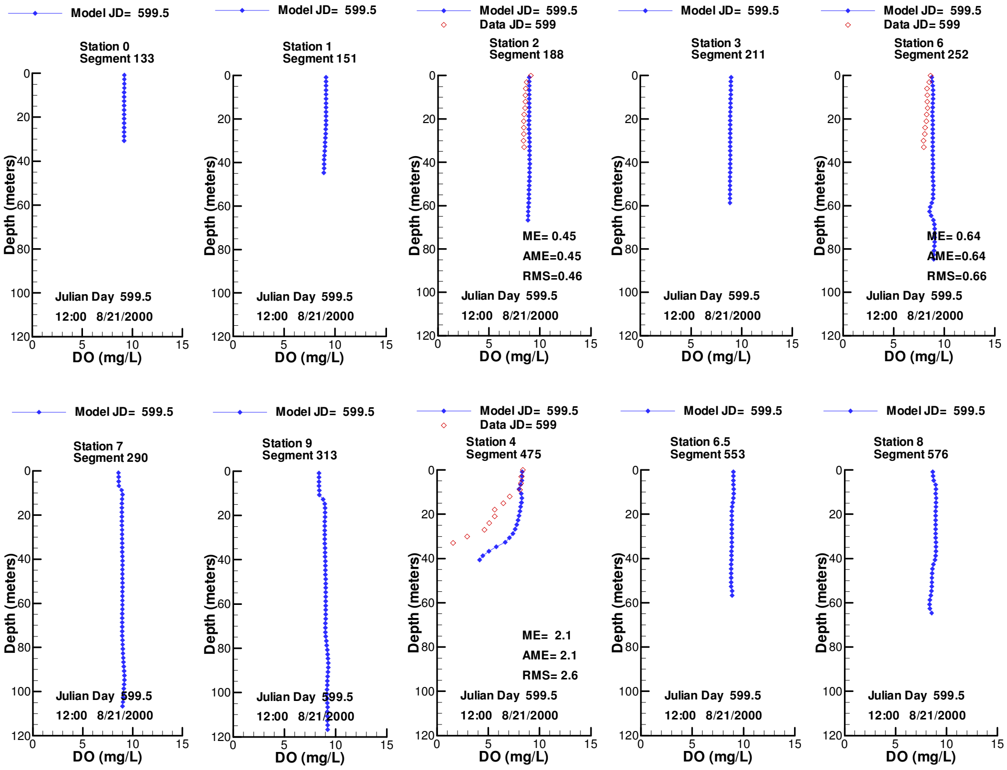


Figure 270. Vertical dissolved oxygen profile model-data comparison, J599.

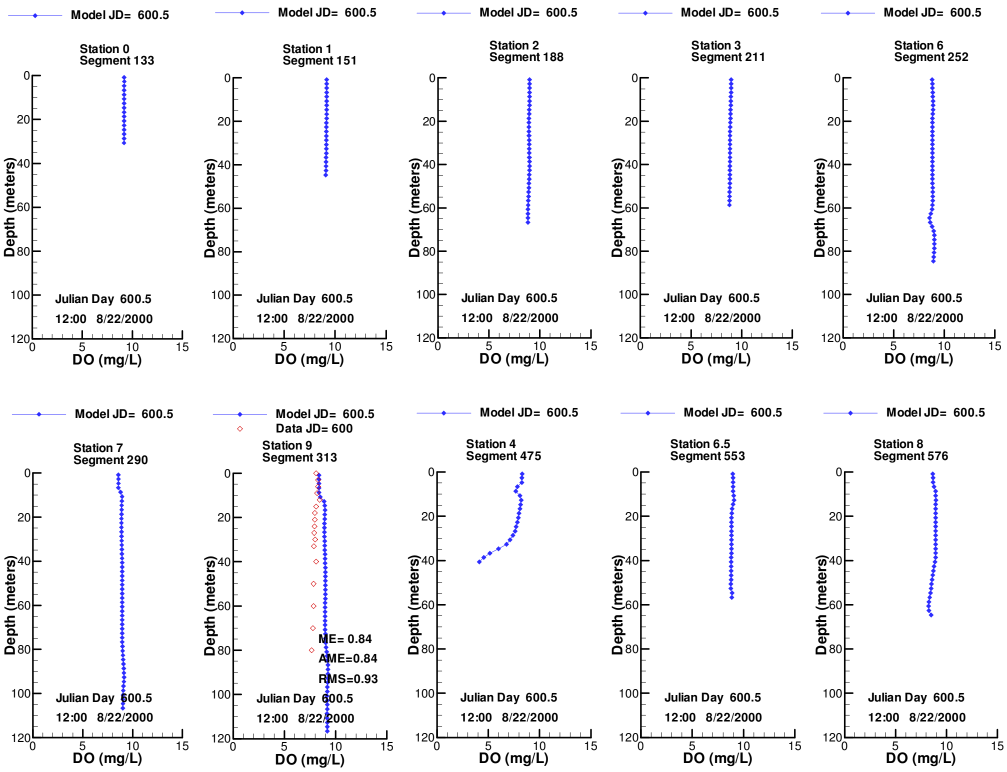


Figure 271. Vertical dissolved oxygen profile model-data comparison, J600.

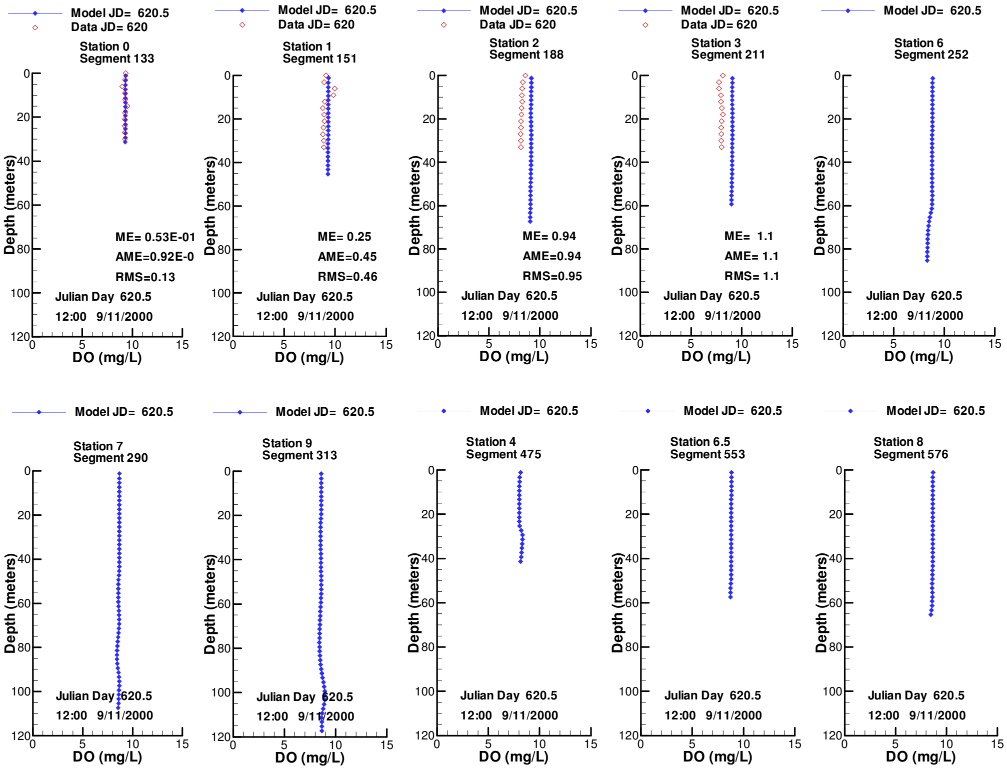


Figure 272. Vertical dissolved oxygen profile model-data comparison, J620.

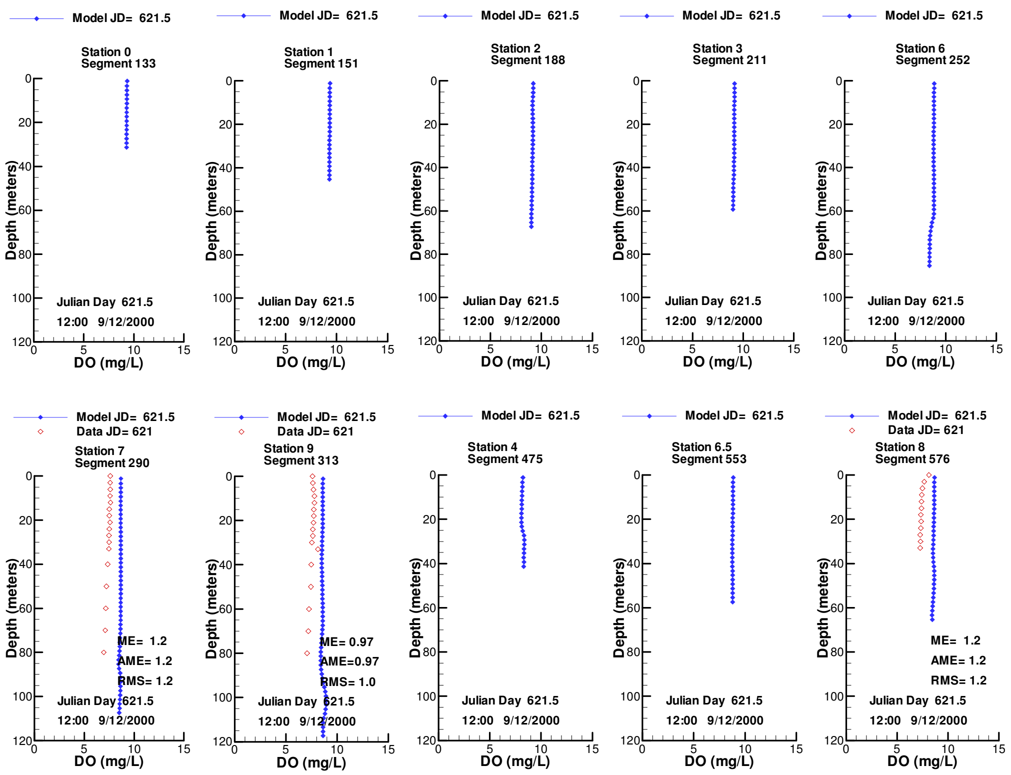


Figure 273. Vertical dissolved oxygen profile model-data comparison, J621.

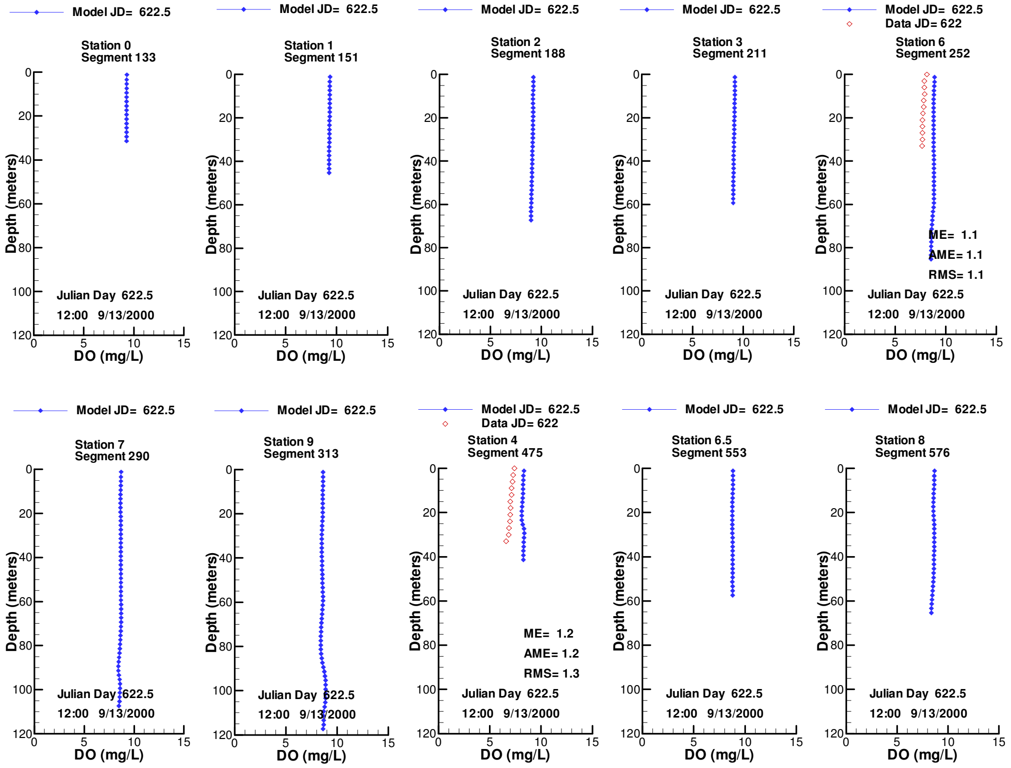


Figure 274. Vertical dissolved oxygen profile model-data comparison, J622.

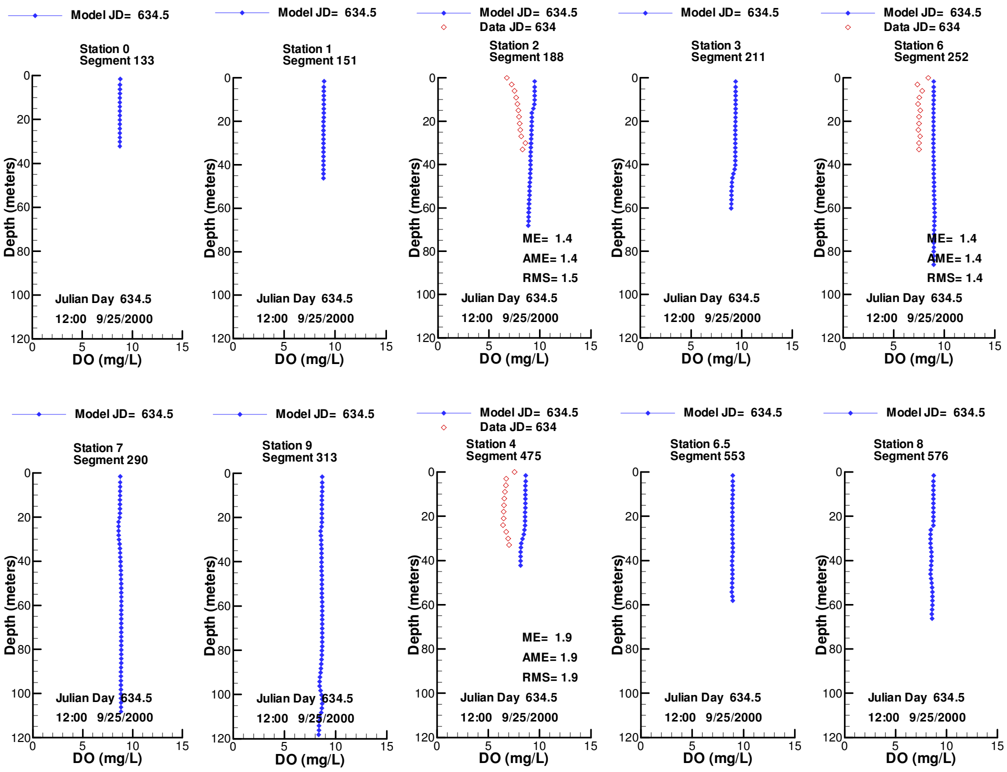


Figure 275. Vertical dissolved oxygen profile model-data comparison, J634.

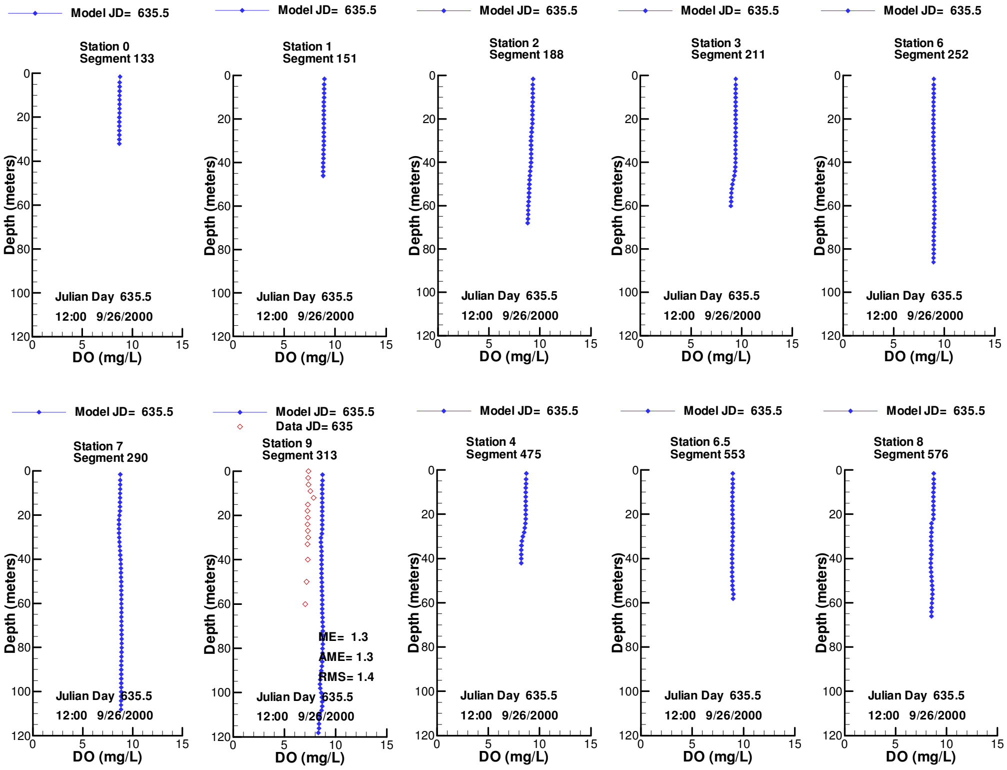


Figure 276. Vertical dissolved oxygen profile model-data comparison, J635.

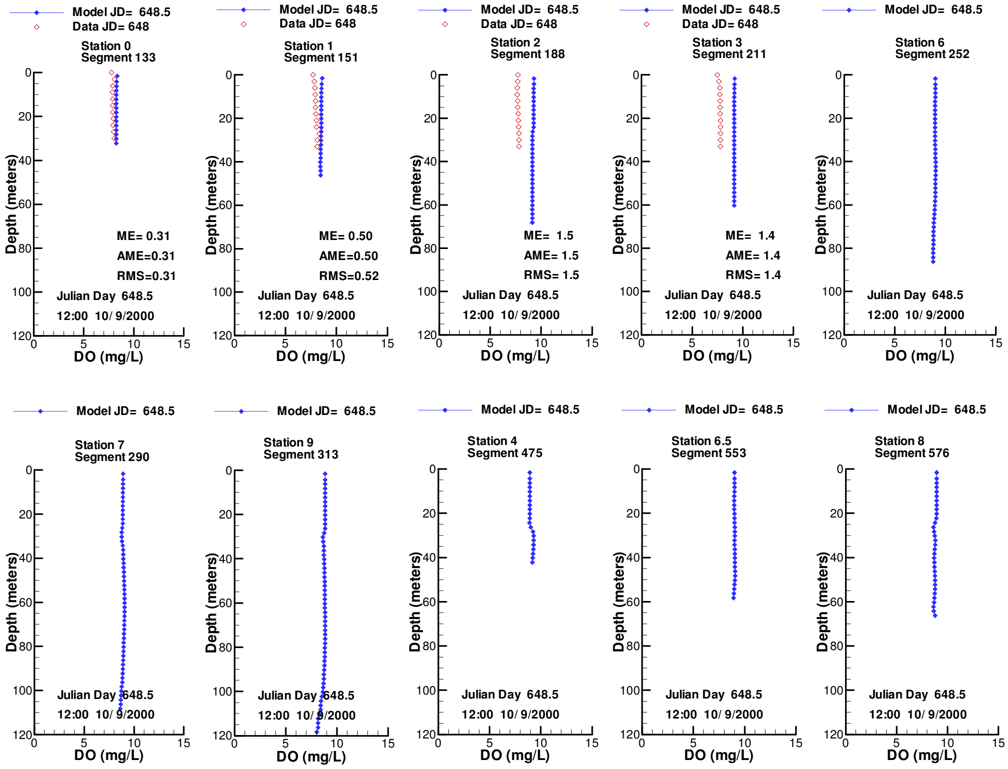


Figure 277. Vertical dissolved oxygen profile model-data comparison, J648.

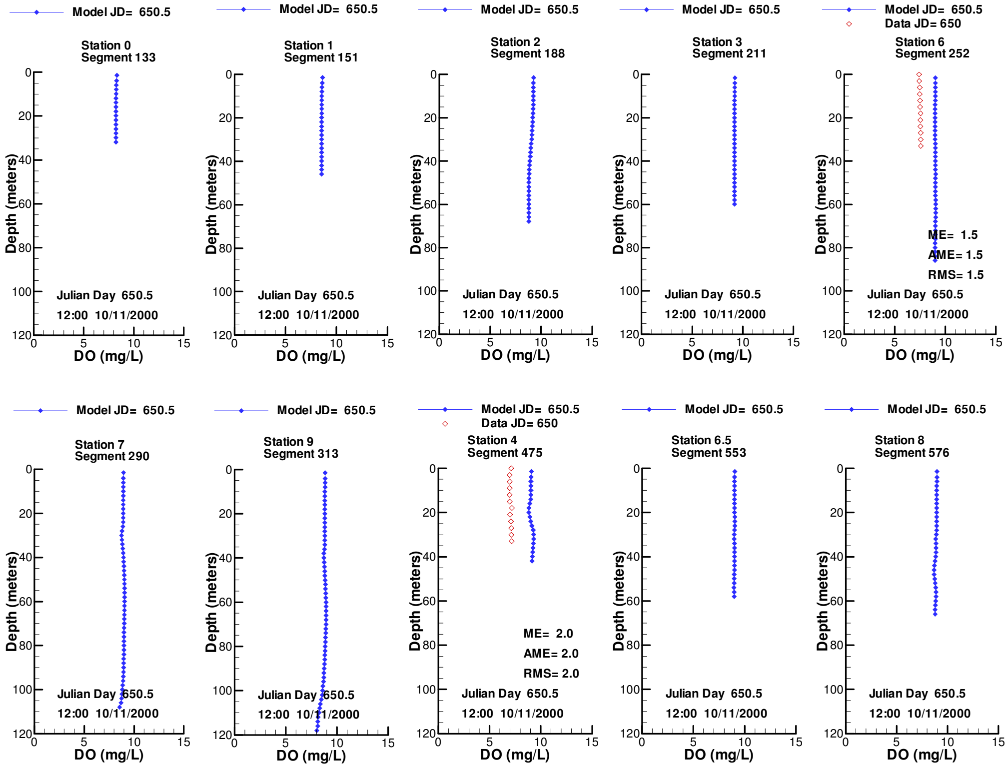


Figure 278. Vertical dissolved oxygen profile model-data comparison, J650.

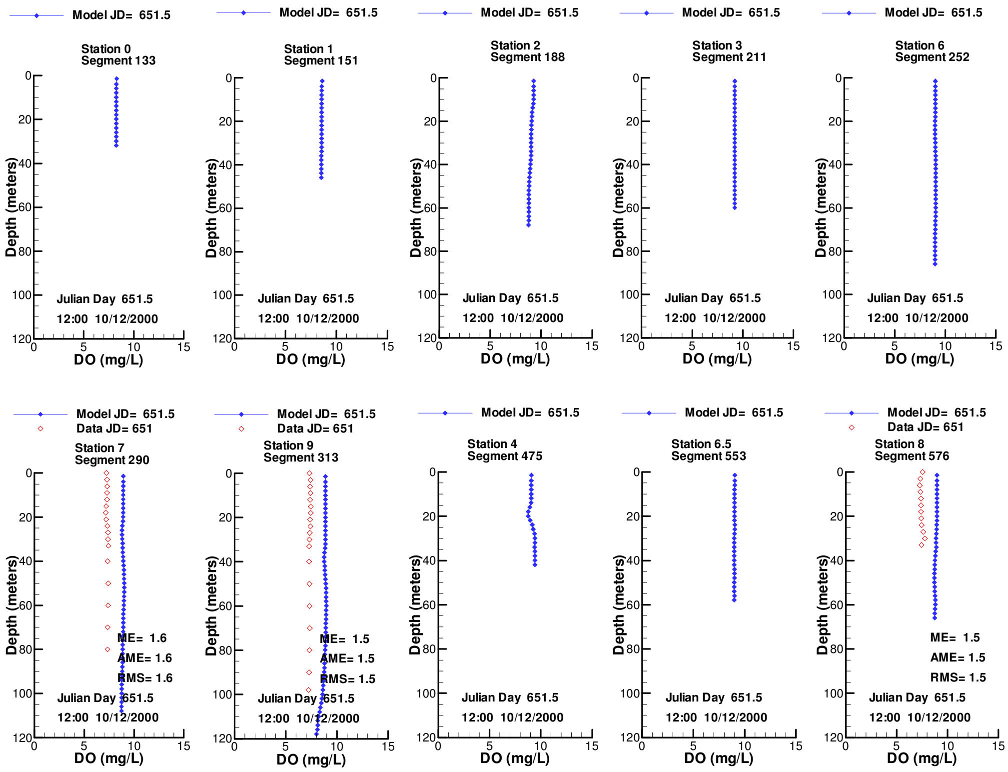


Figure 279. Vertical dissolved oxygen profile model-data comparison, J651.

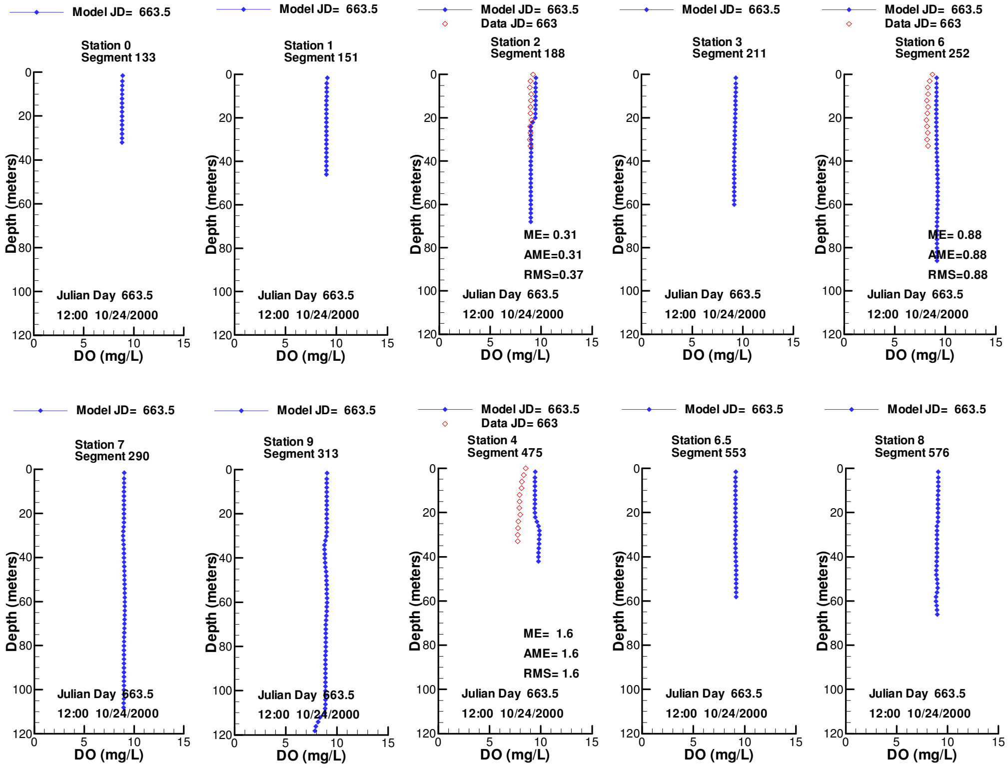


Figure 280. Vertical dissolved oxygen profile model-data comparison, J663.

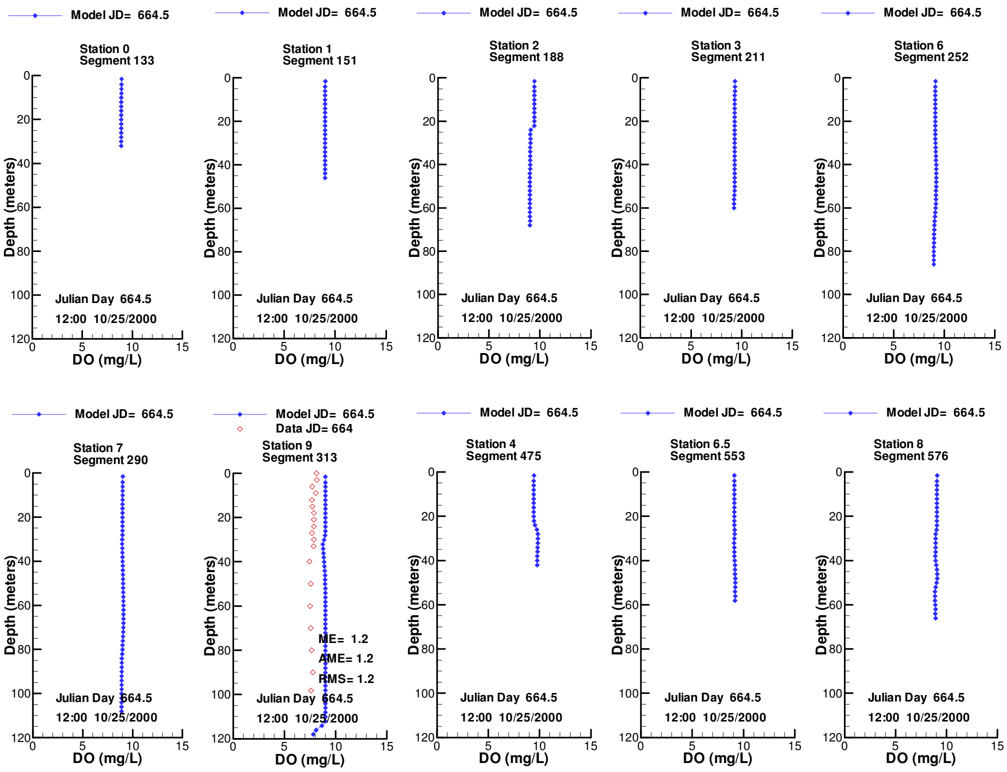


Figure 281. Vertical dissolved oxygen profile model-data comparison, J664.

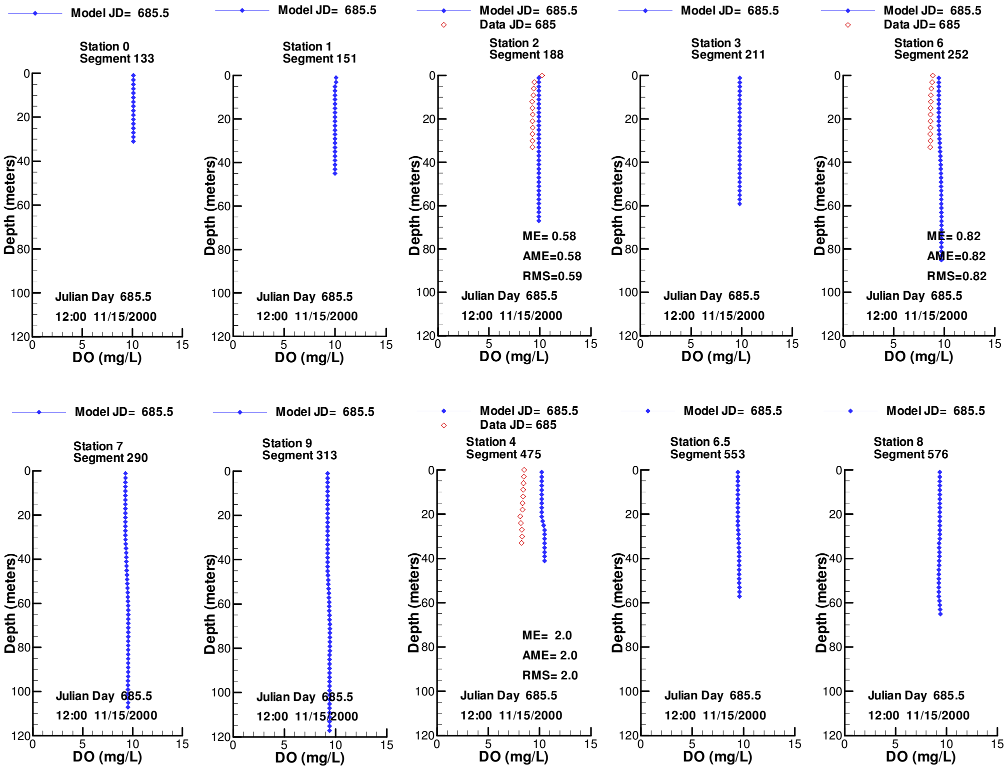


Figure 282. Vertical dissolved oxygen profile model-data comparison, J685.

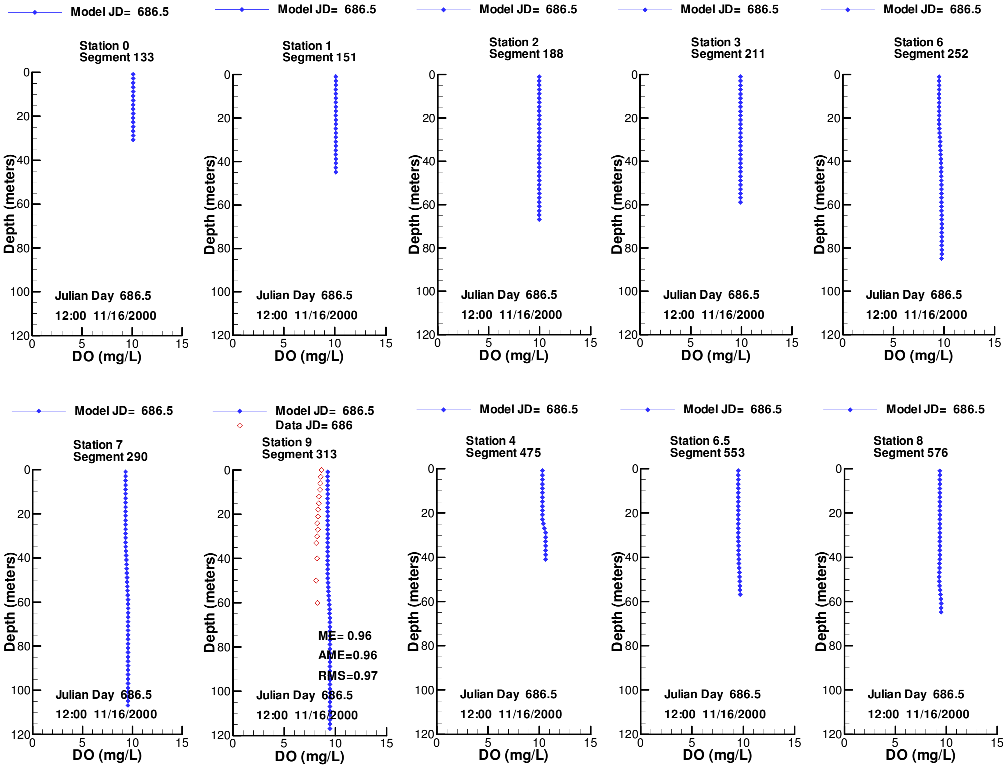


Figure 283. Vertical dissolved oxygen profile model-data comparison, J686.

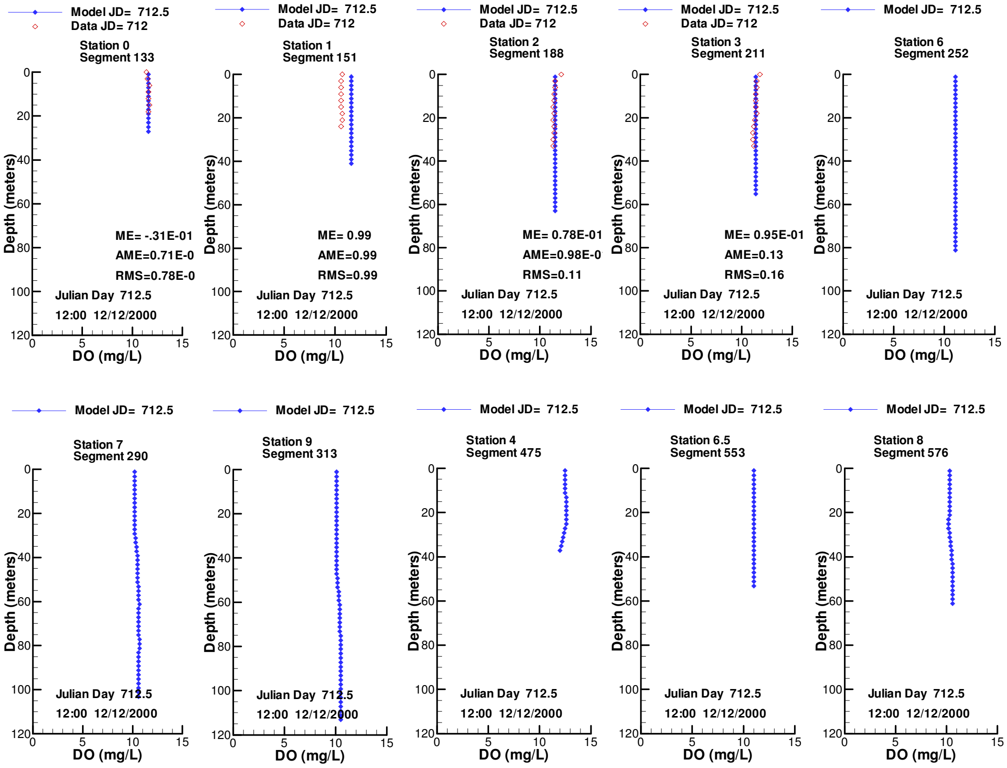


Figure 284. Vertical dissolved oxygen profile model-data comparison, J712.

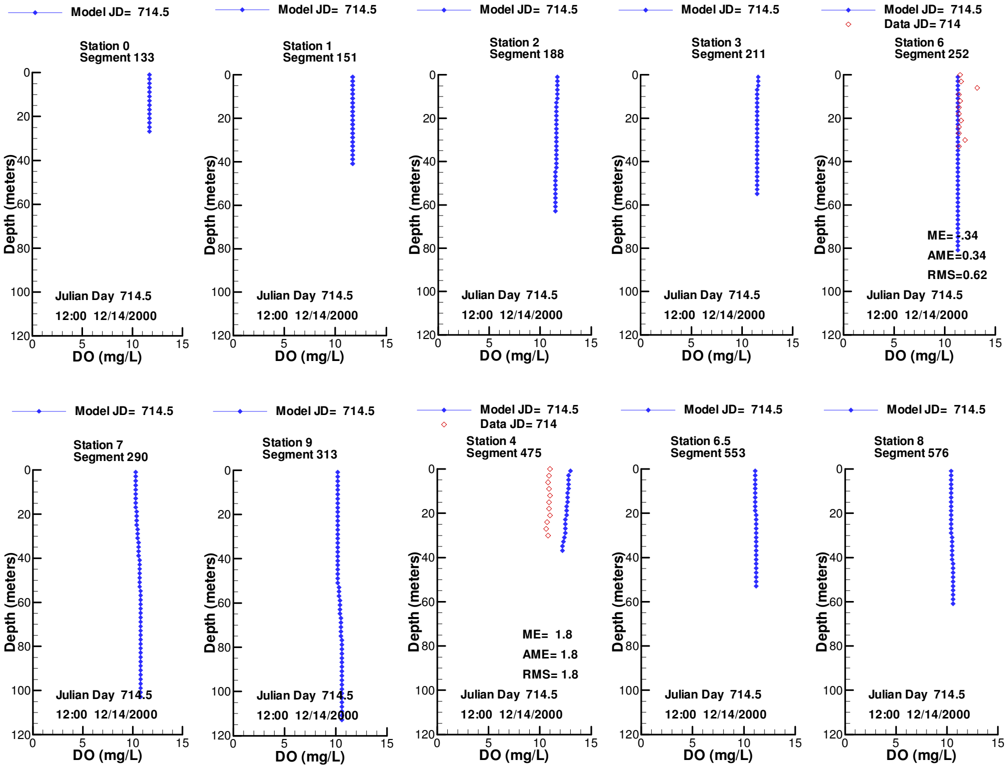


Figure 285. Vertical dissolved oxygen profile model-data comparison, J714.

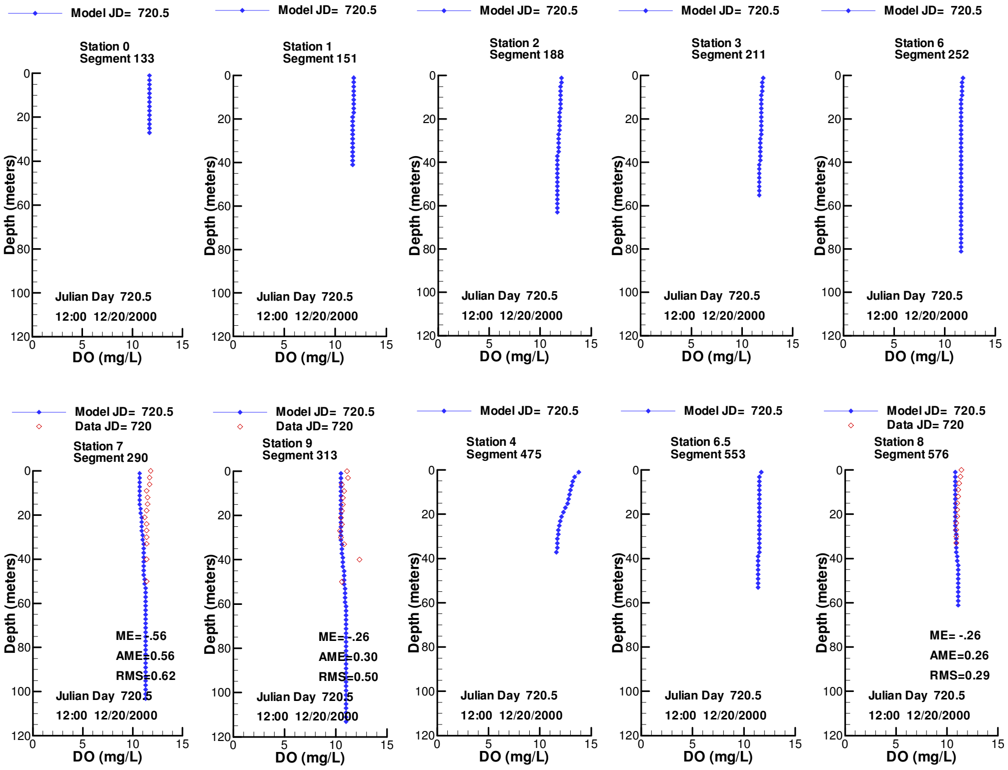


Figure 286. Vertical dissolved oxygen profile model-data comparison, J720.

Temperature

For days when data were recorded, vertical profile plots of water temperature are shown in Figure 287 through Figure 333.

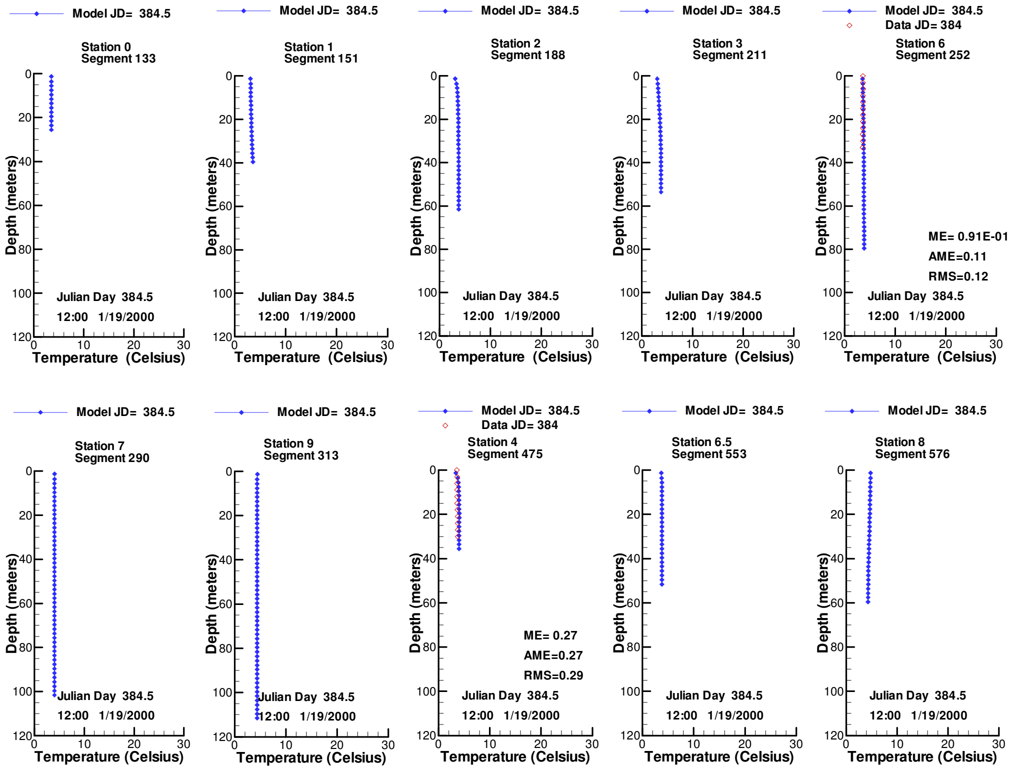


Figure 287. Vertical temperature profile model-data comparison, J384.

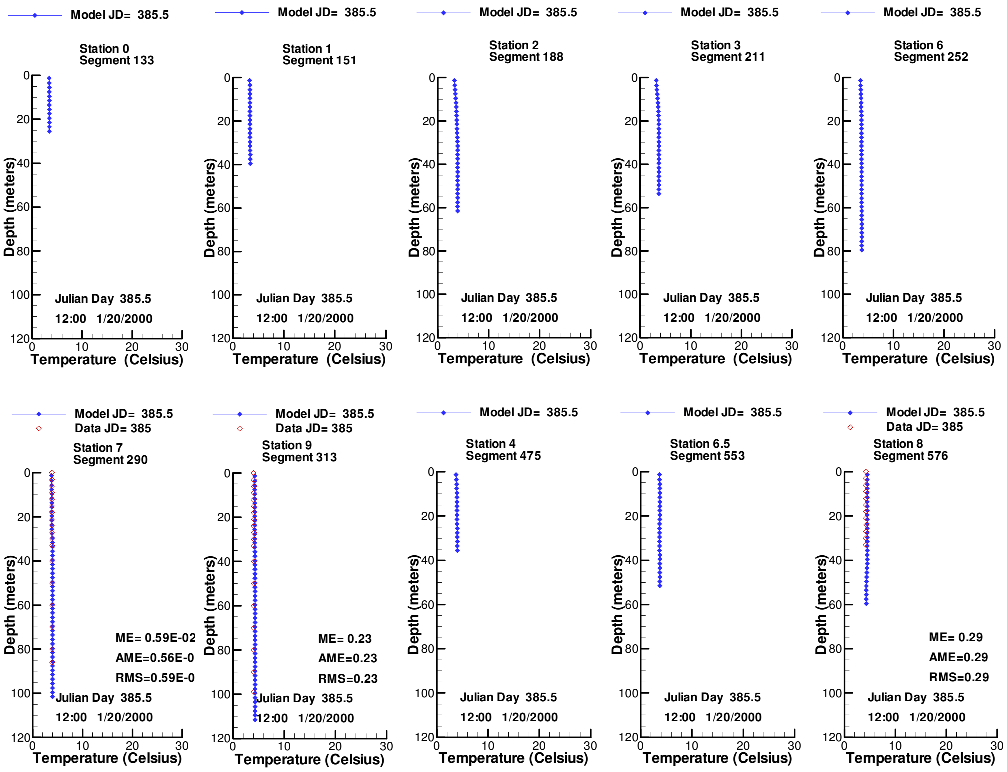


Figure 288. Vertical temperature profile model-data comparison, J385.

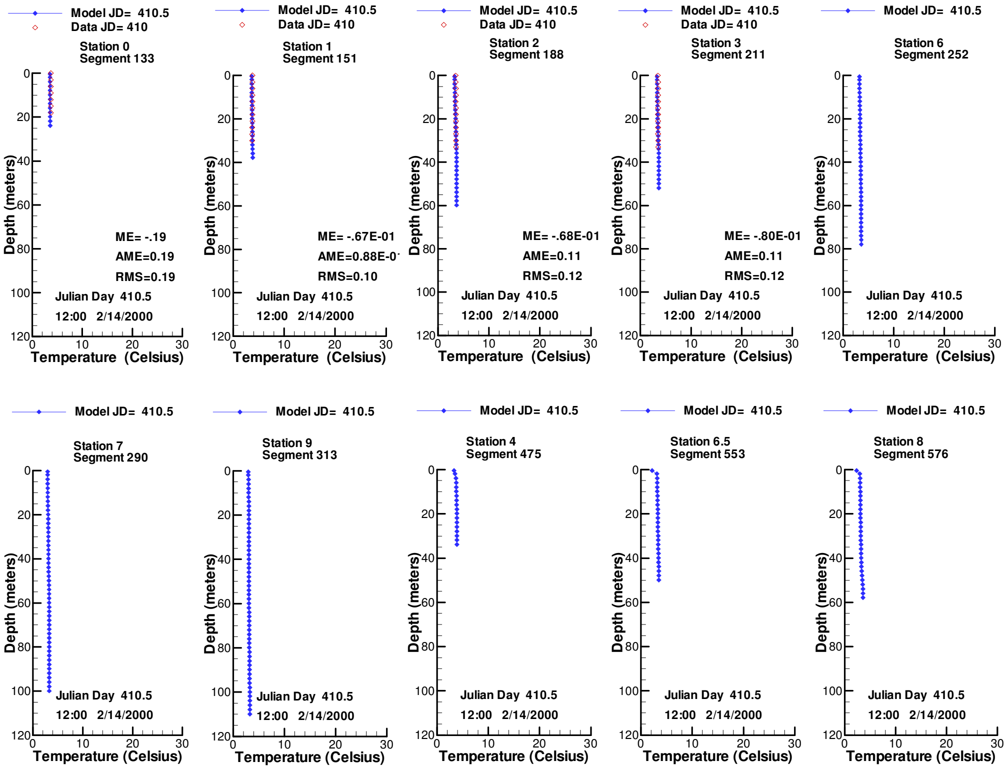


Figure 289. Vertical temperature profile model-data comparison, J410.

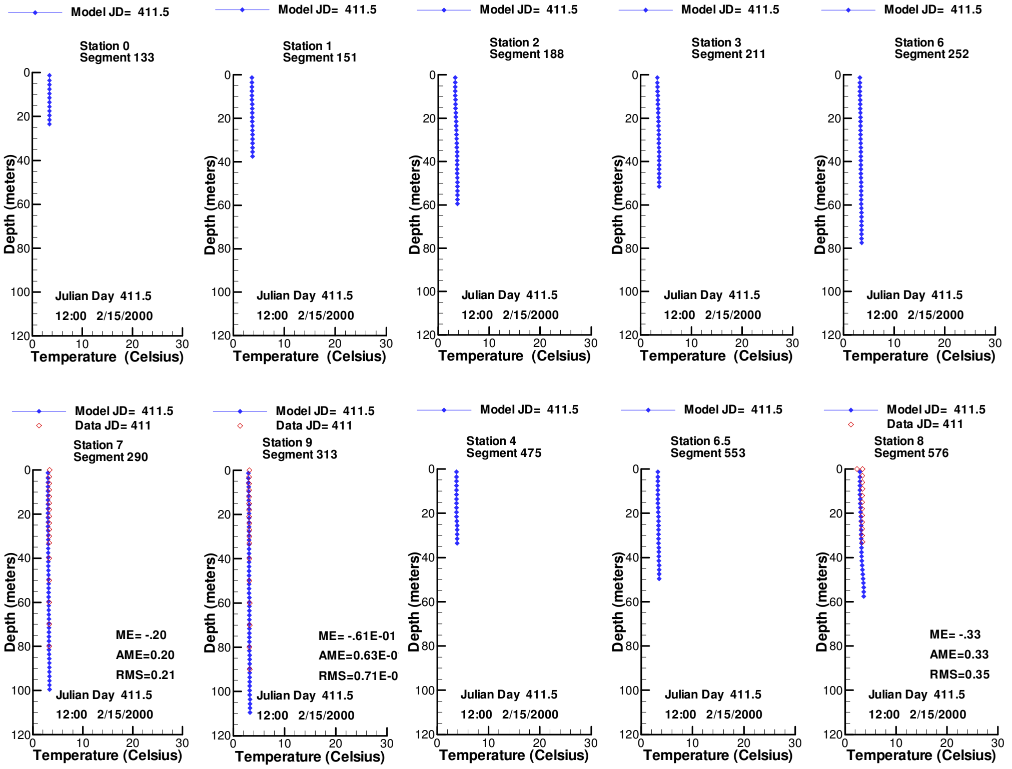


Figure 290. Vertical temperature profile model-data comparison, J411.

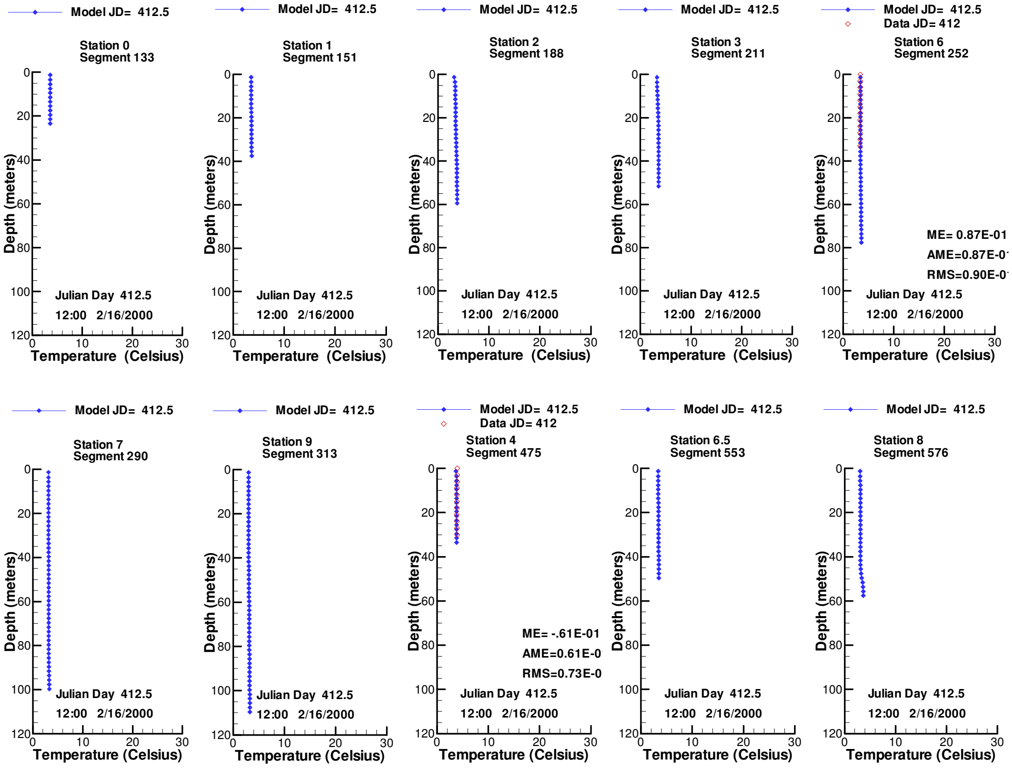
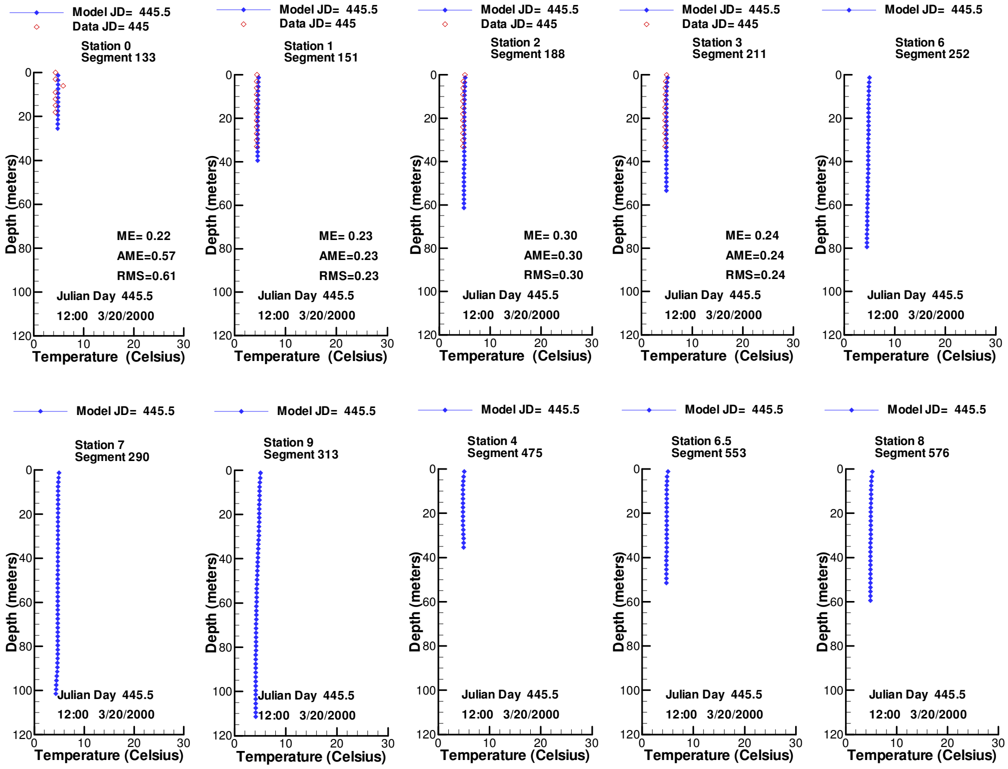


Figure 291. Vertical temperature profile model-data comparison, J412.



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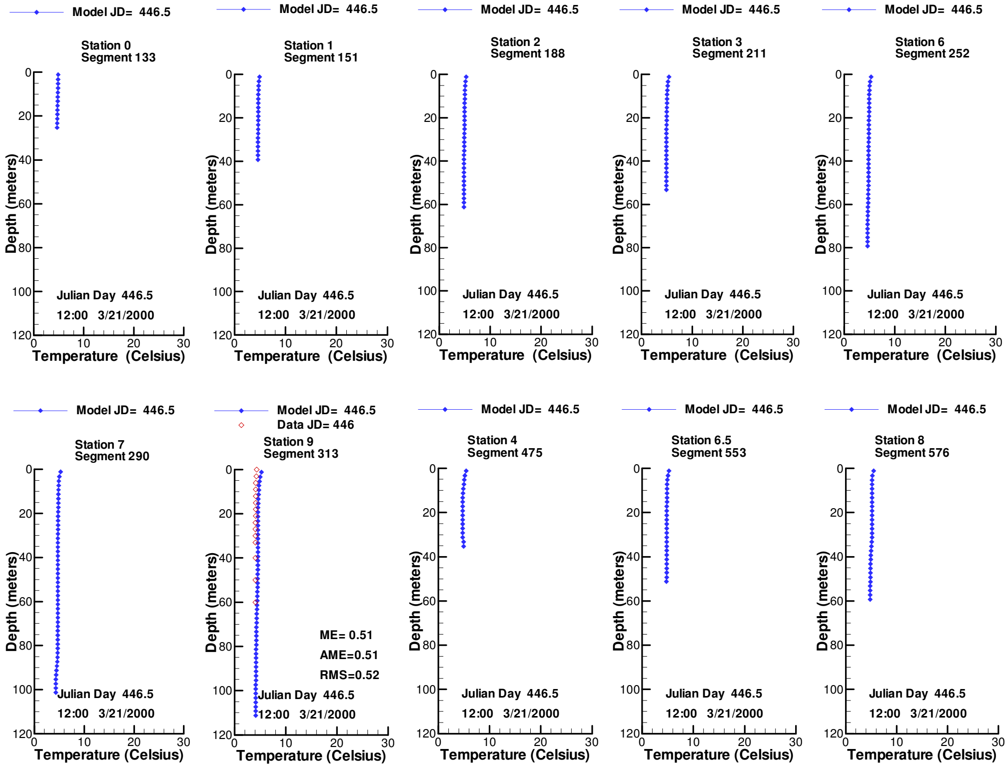


Figure 293. Vertical temperature profile model-data comparison, J446.

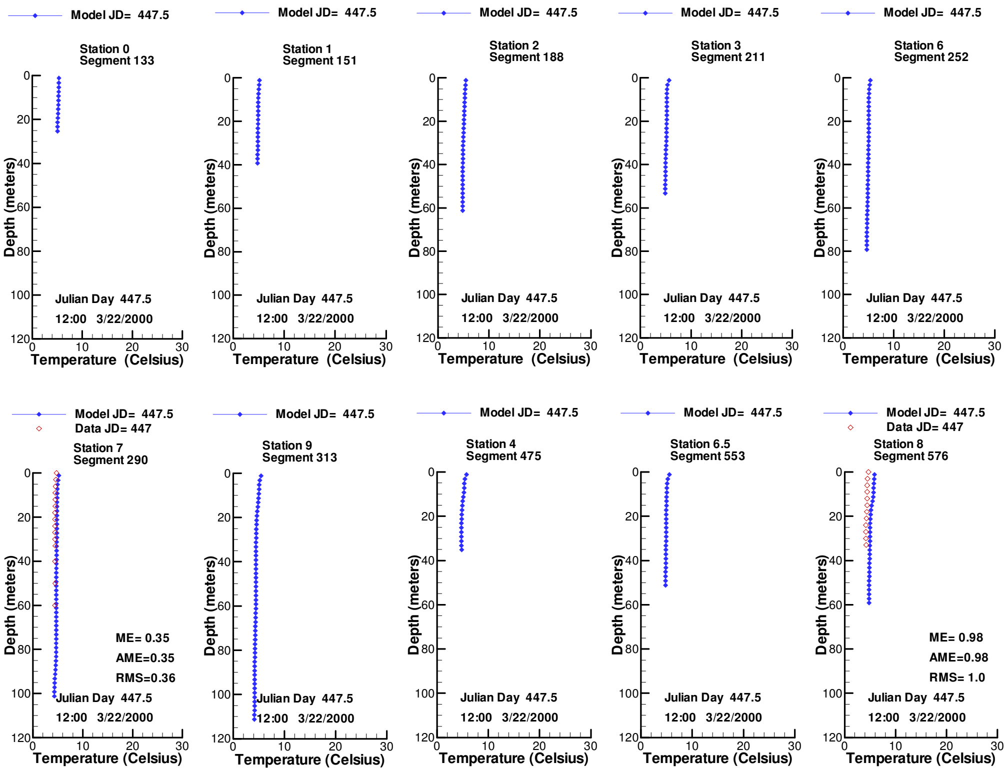


Figure 294. Vertical temperature profile model-data comparison, J447.

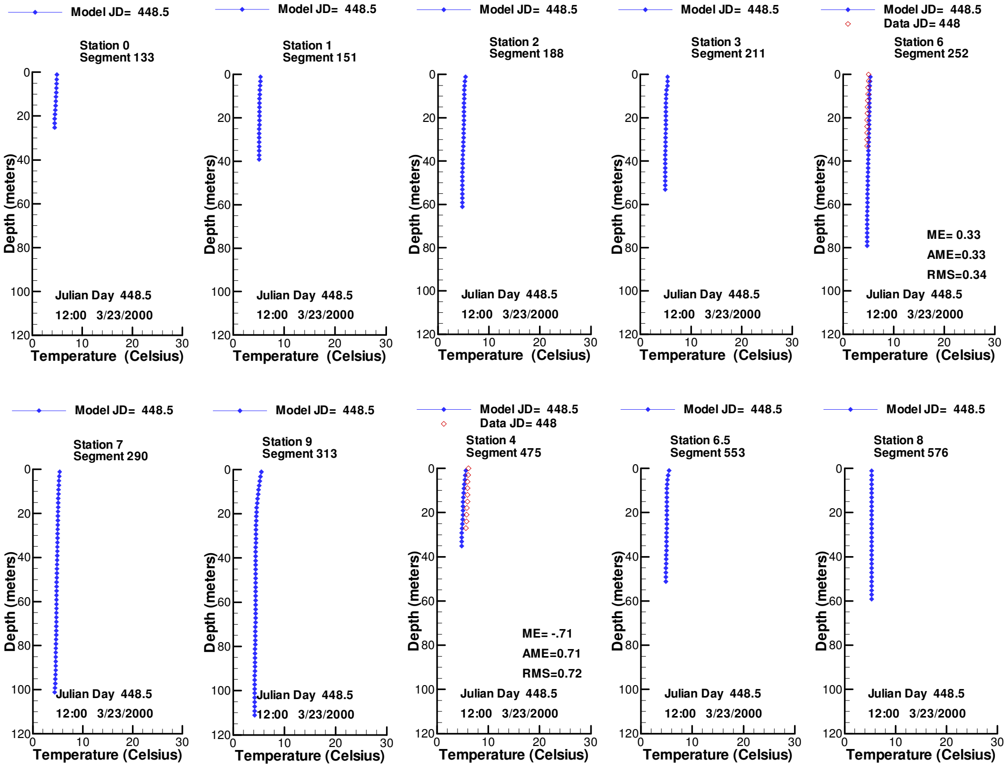


Figure 295. Vertical temperature profile model-data comparison, J448.

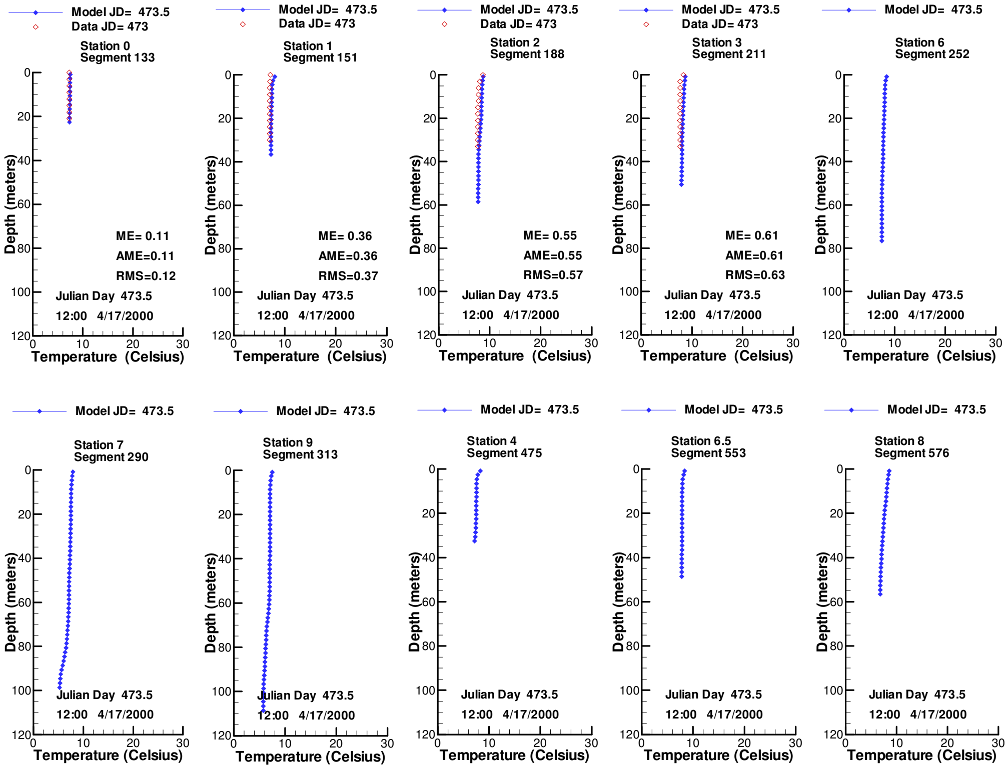


Figure 296. Vertical temperature profile model-data comparison, J473.

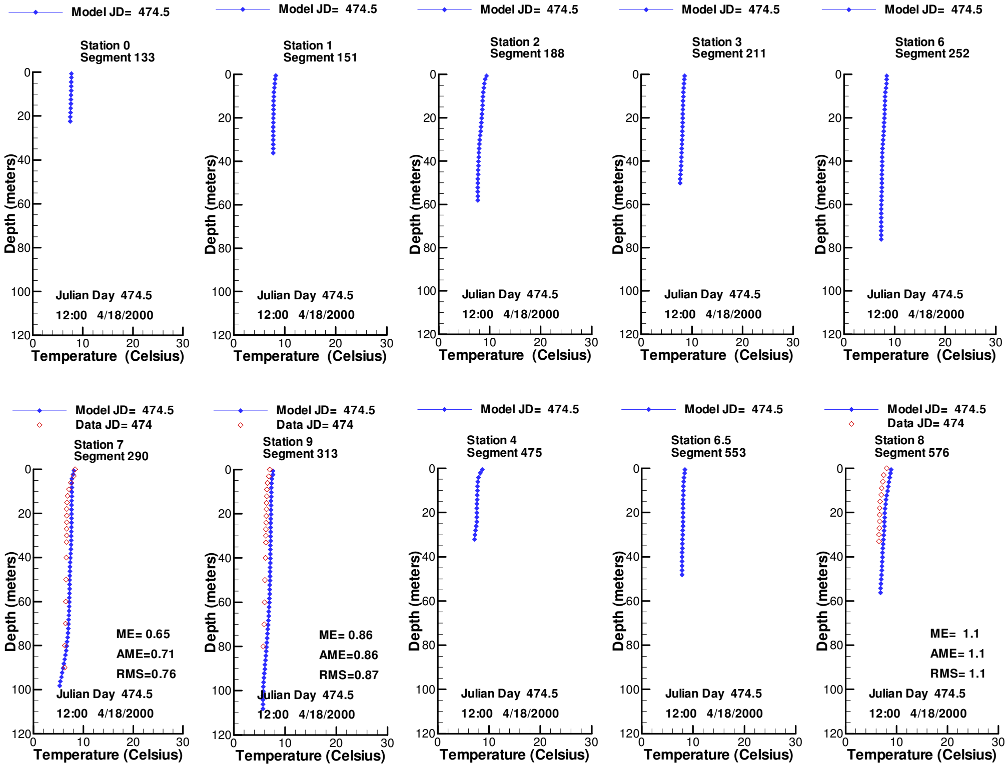


Figure 297. Vertical temperature profile model-data comparison, J474.

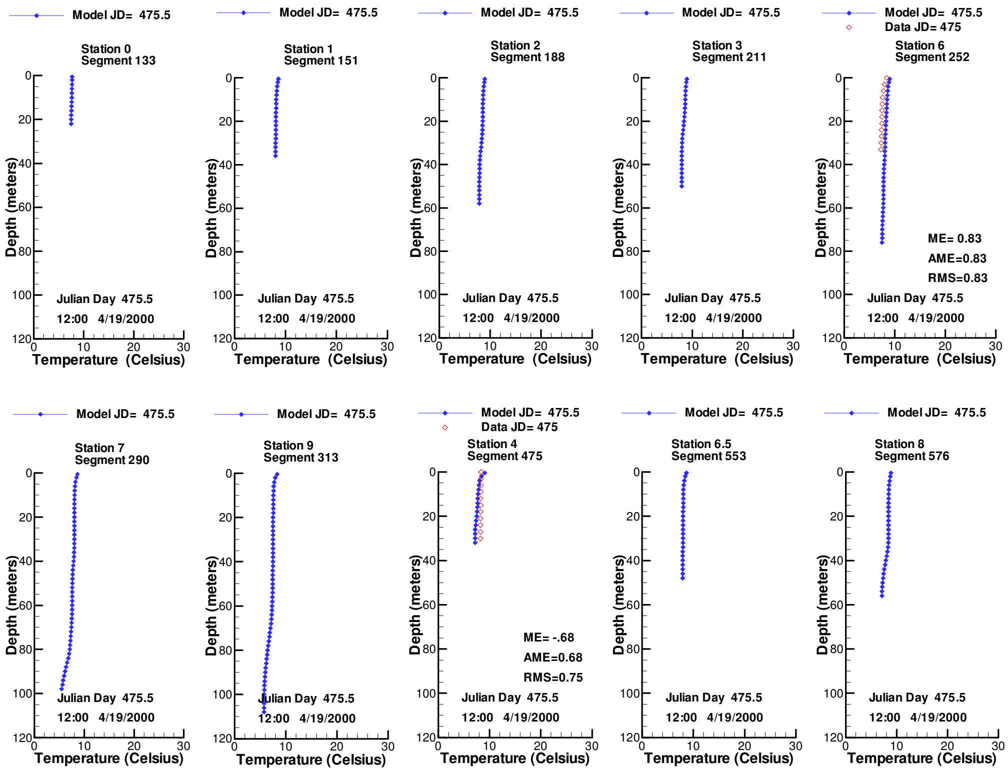


Figure 298. Vertical temperature profile model-data comparison, J475.

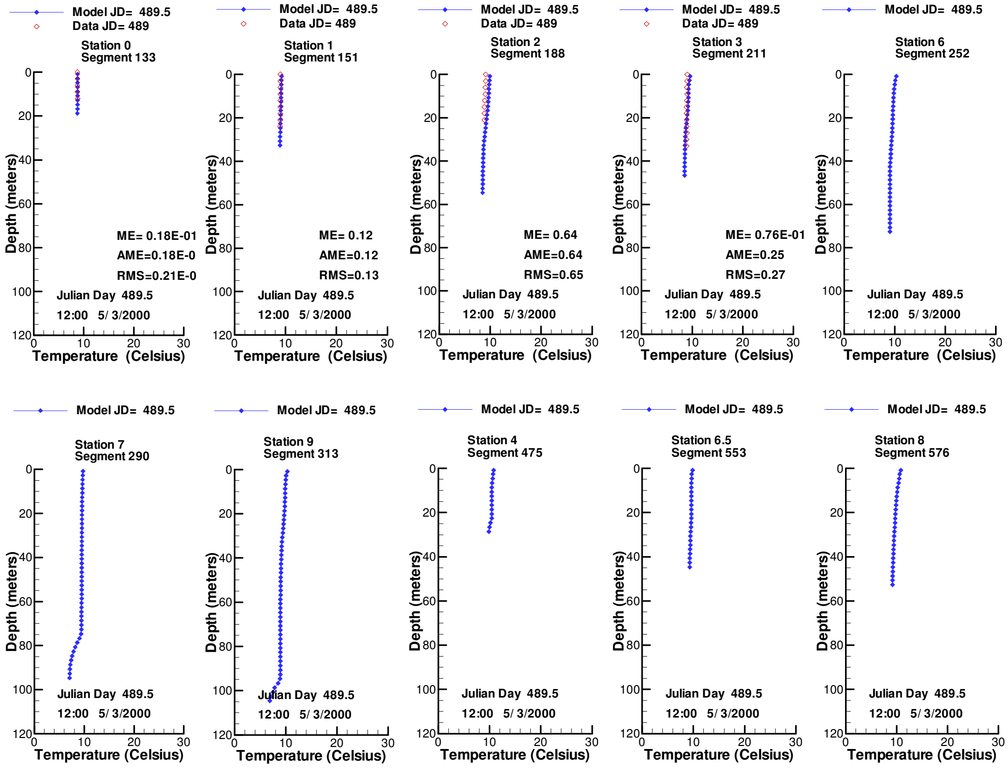
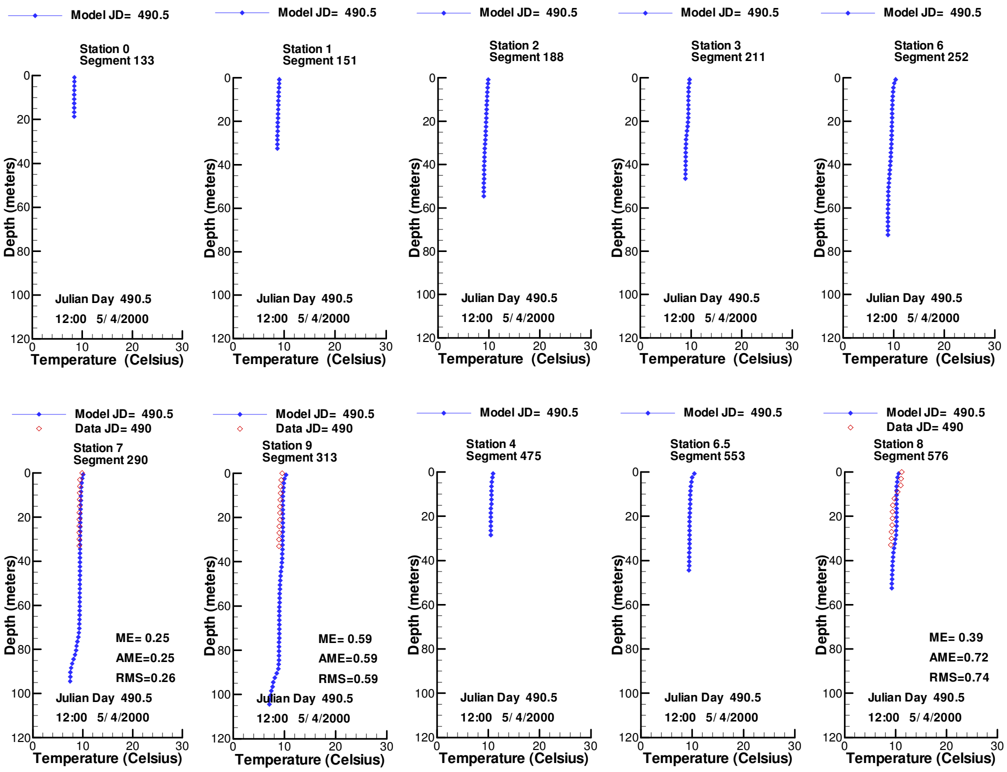


Figure 299. Vertical temperature profile model-data comparison, J489.



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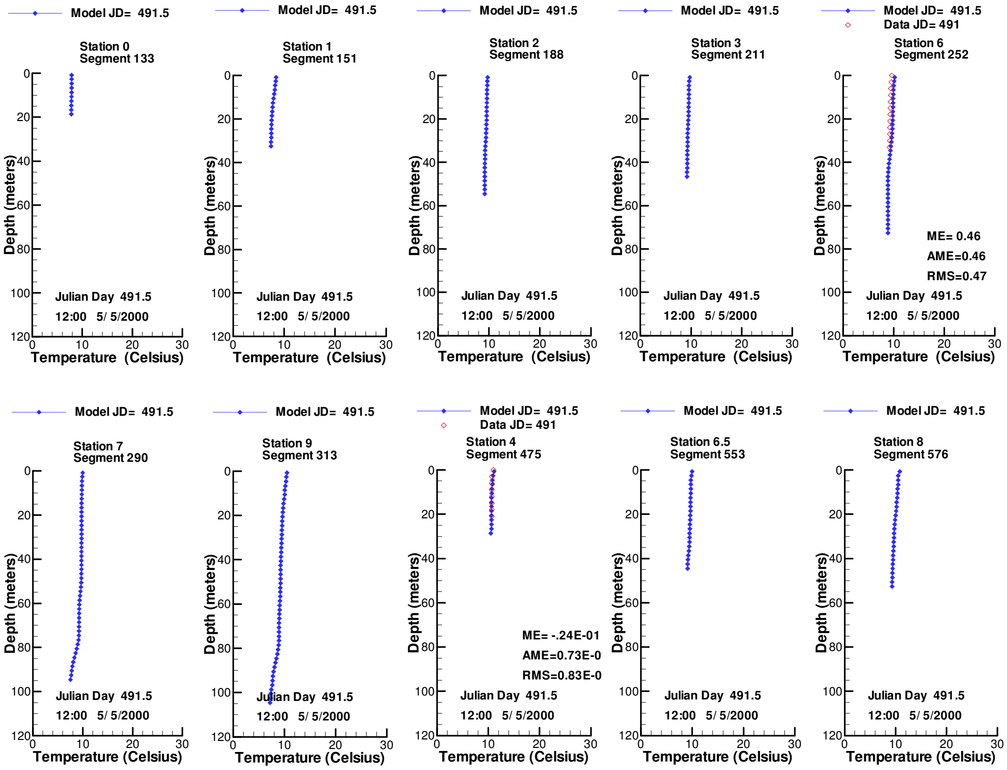

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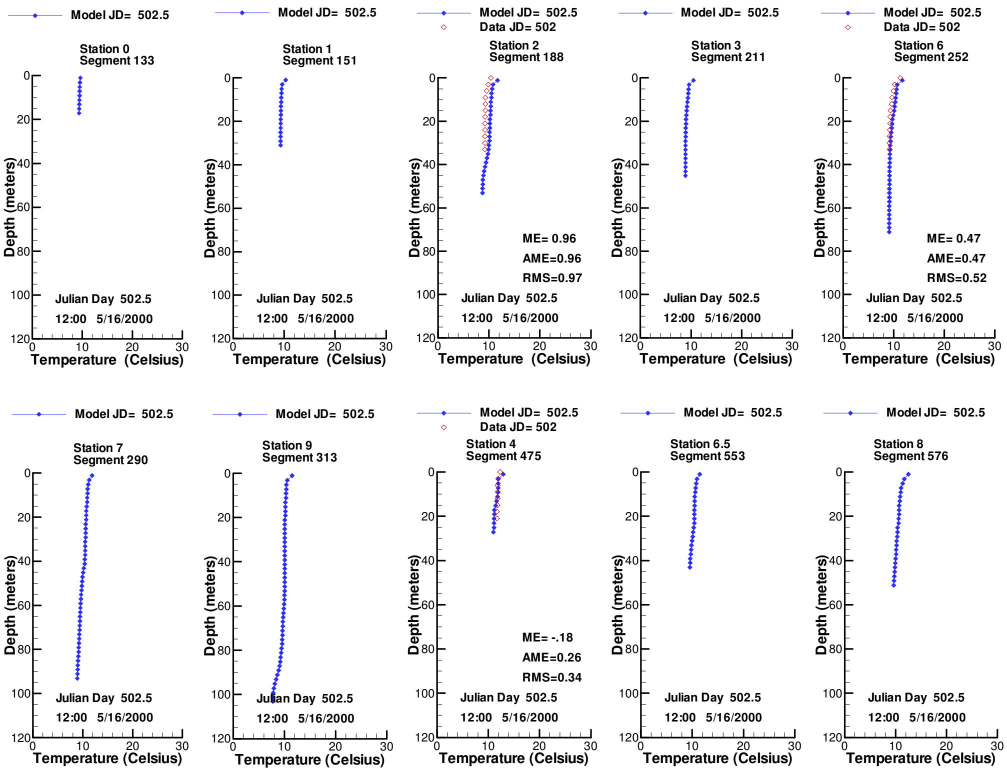


Figure 302. Vertical temperature profile model-data comparison, J502.

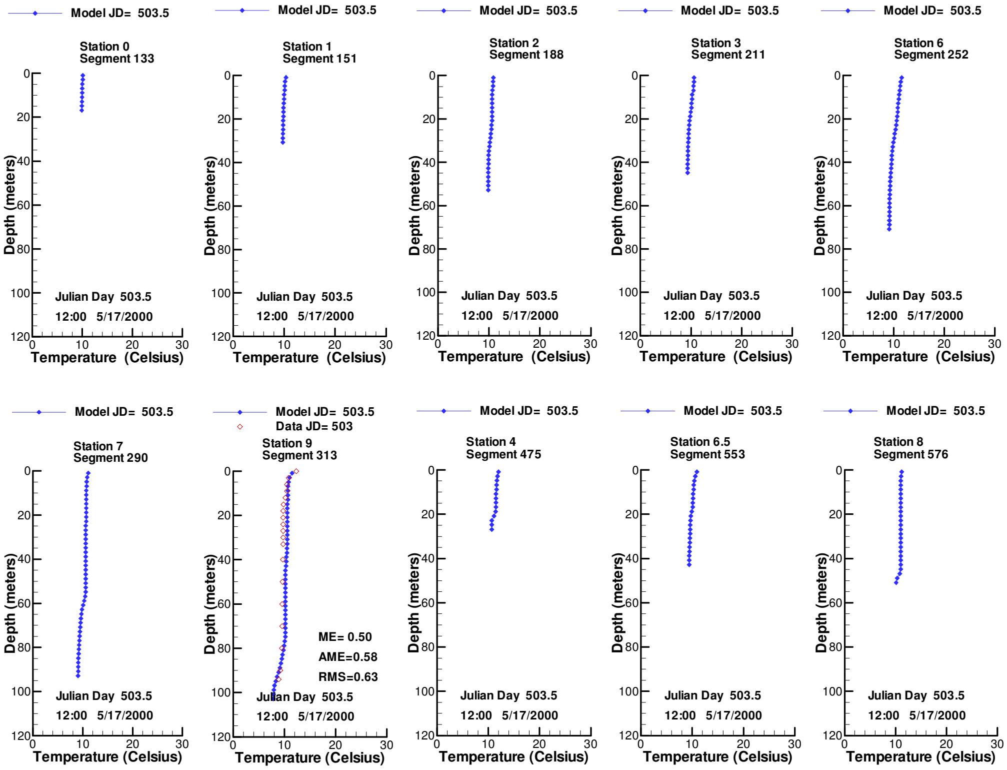


Figure 303. Vertical temperature profile model-data comparison, J503.

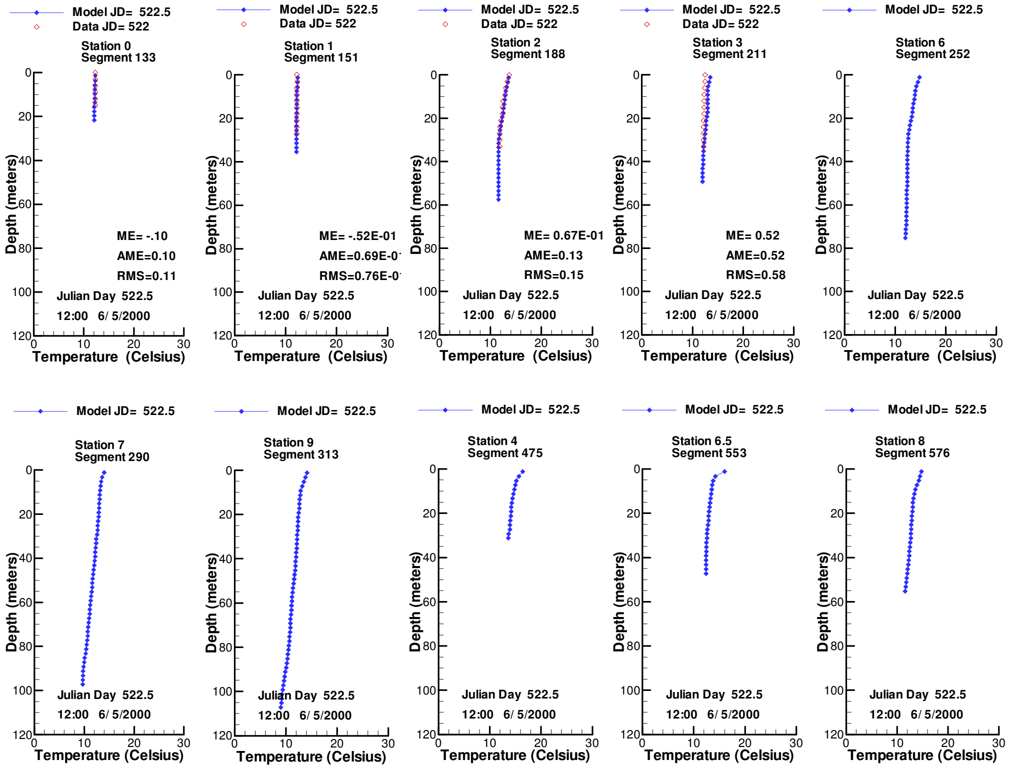


Figure 304. Vertical temperature profile model-data comparison, J522.

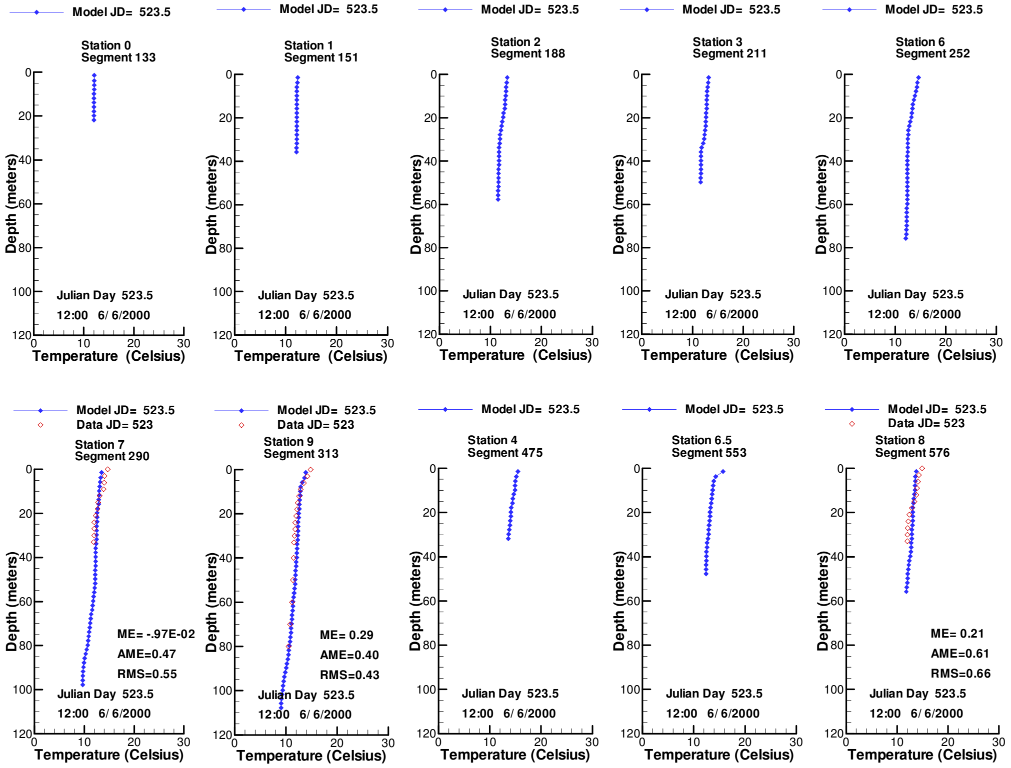
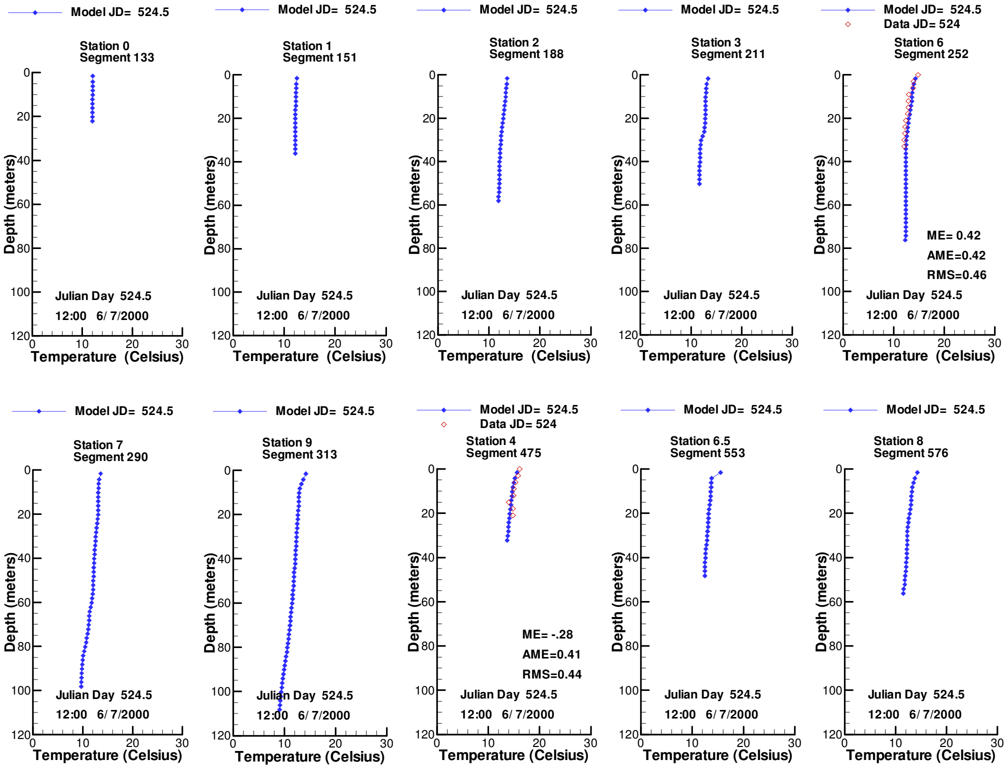


Figure 305. Vertical temperature profile model-data comparison, J523.



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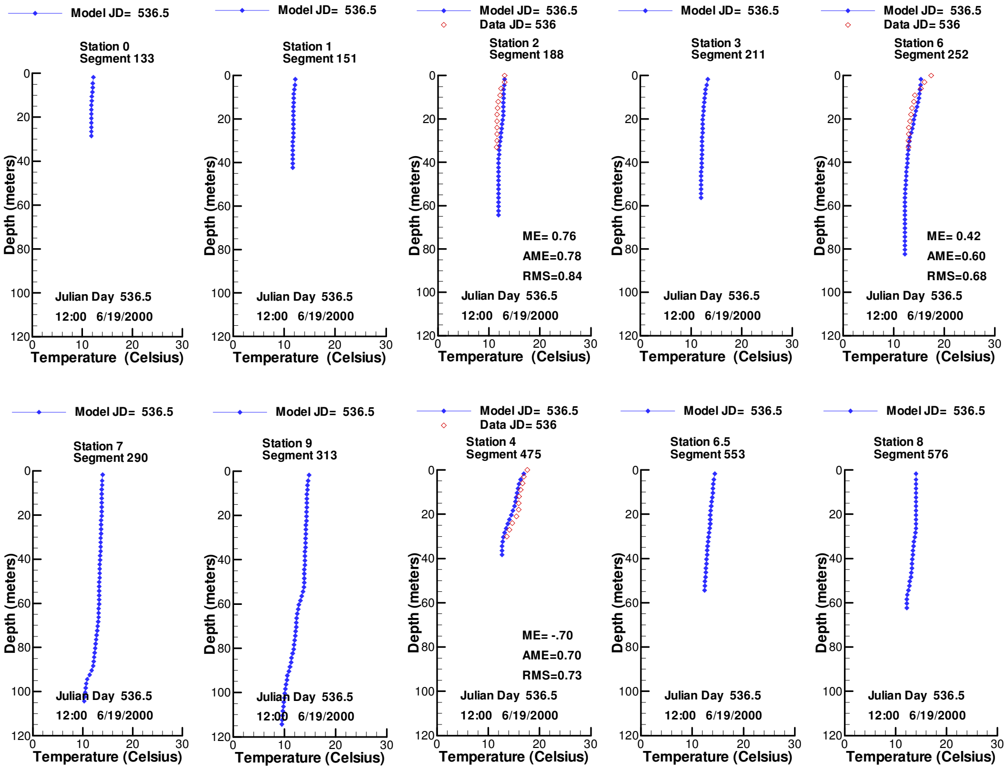

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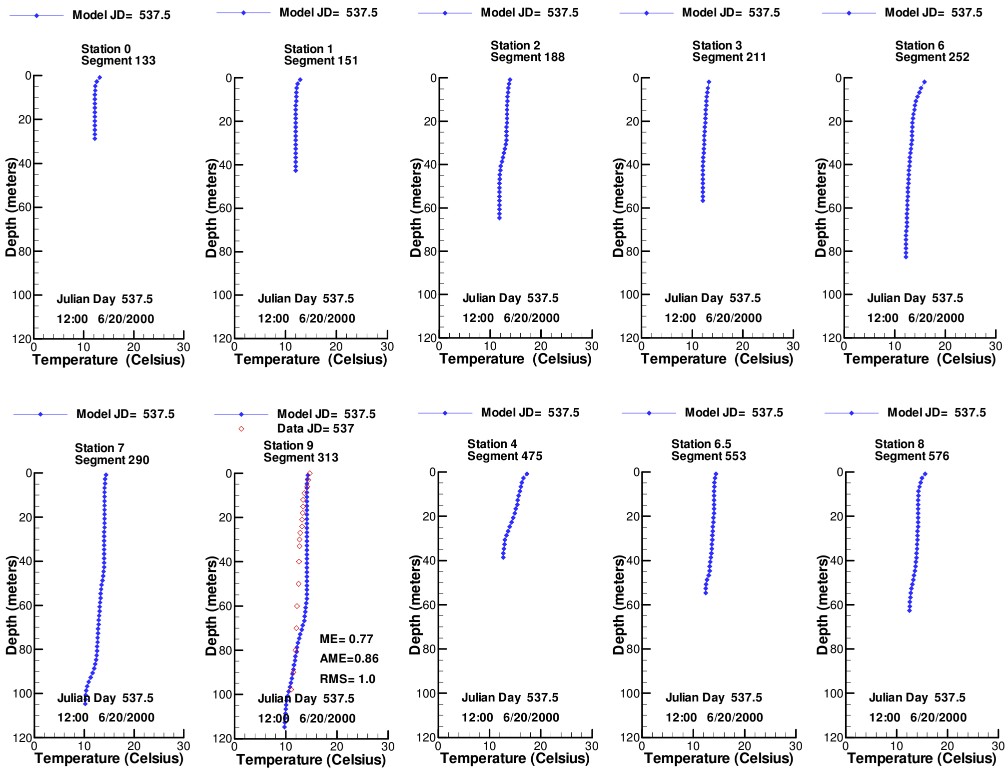

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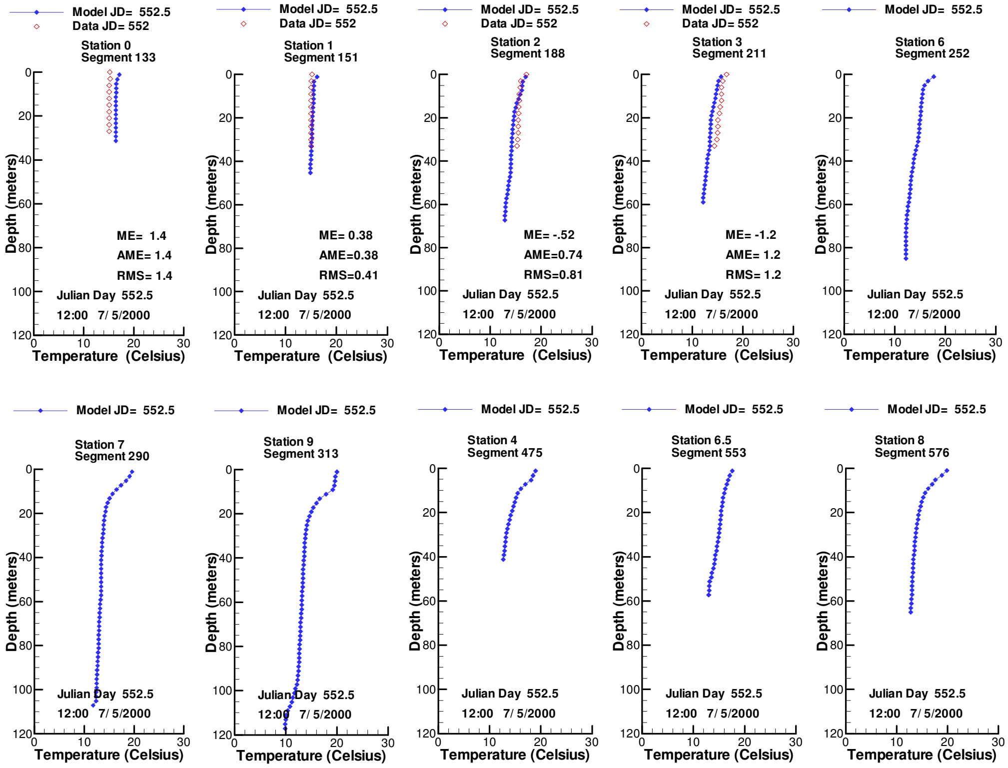
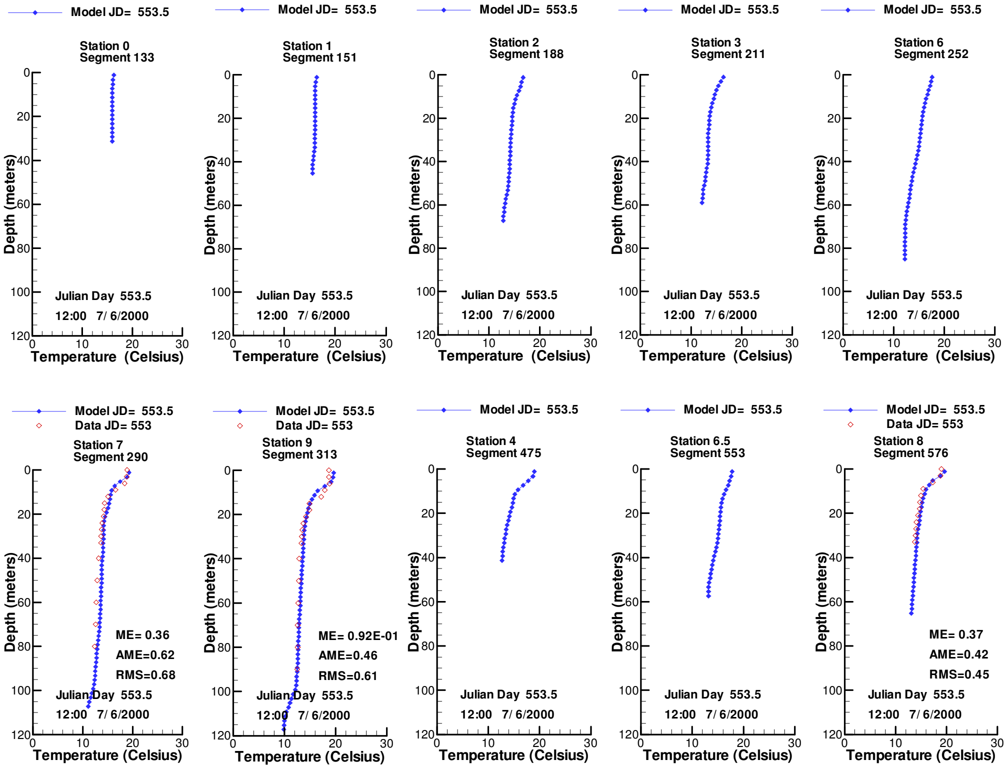


Figure 309. Vertical temperature profile model-data comparison, J552.



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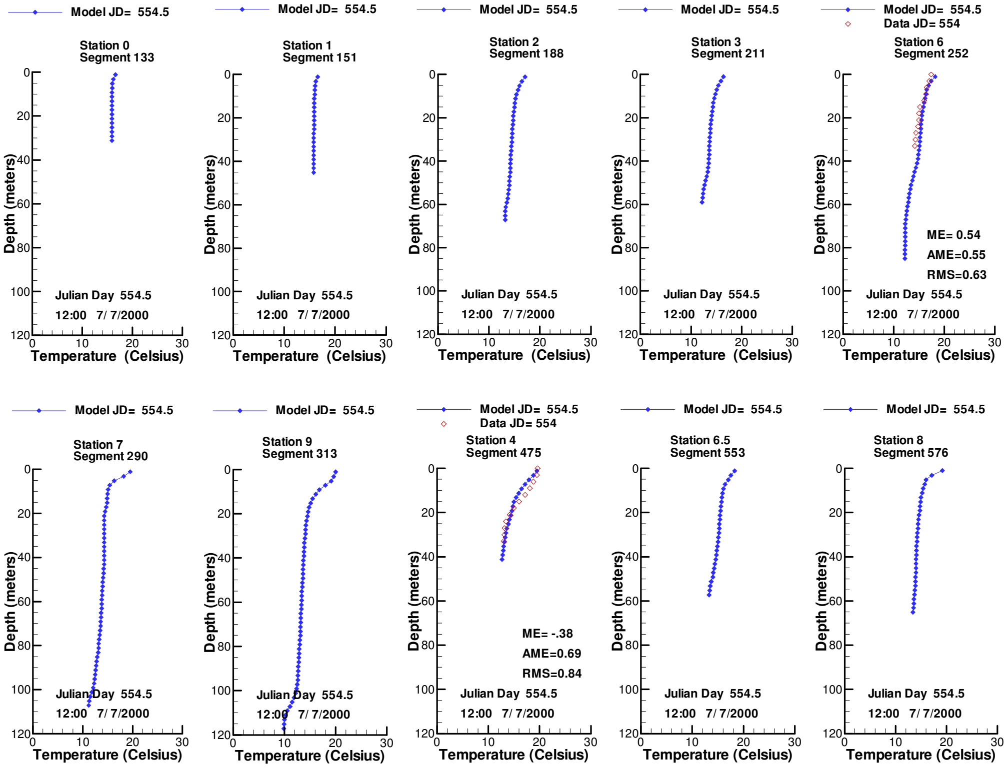

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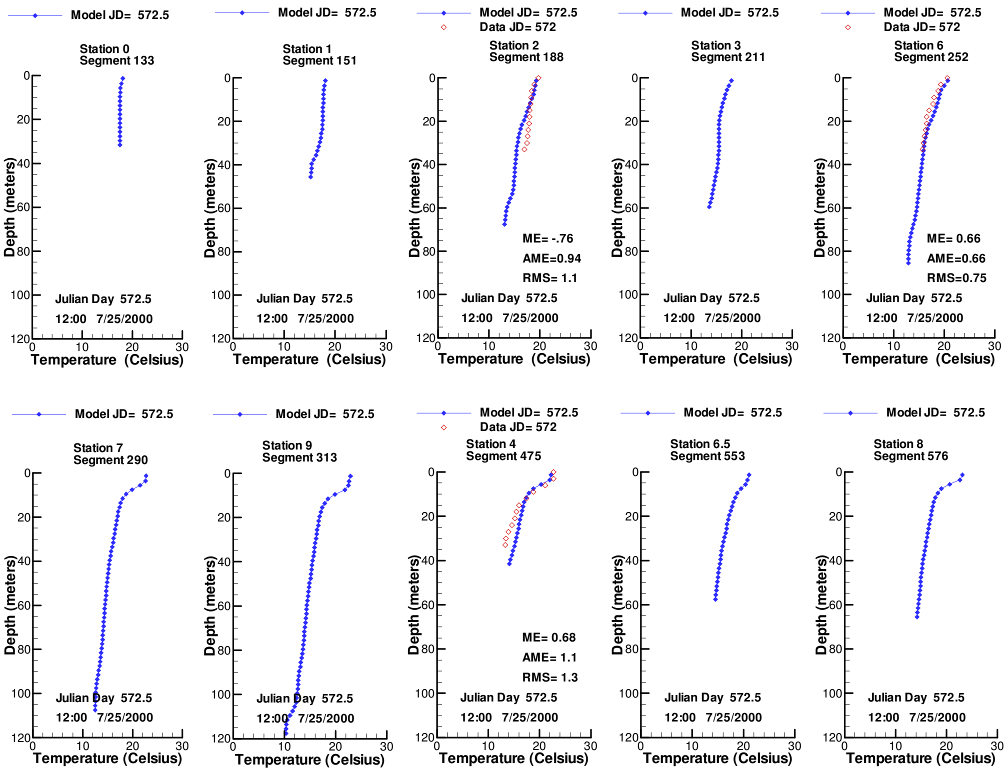

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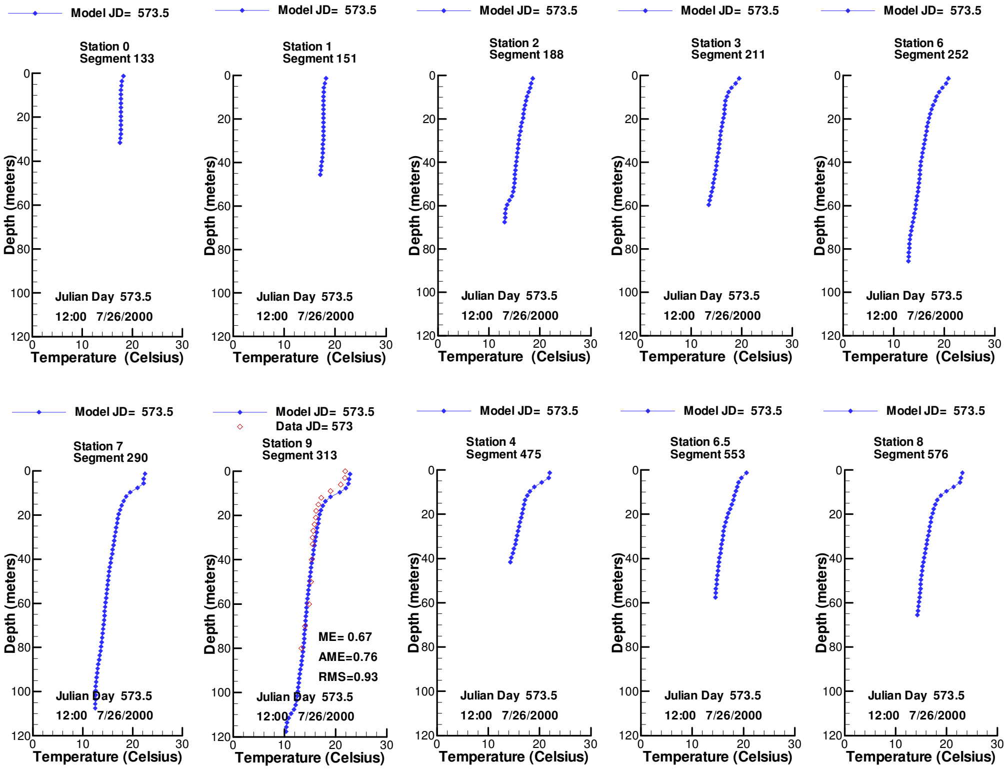

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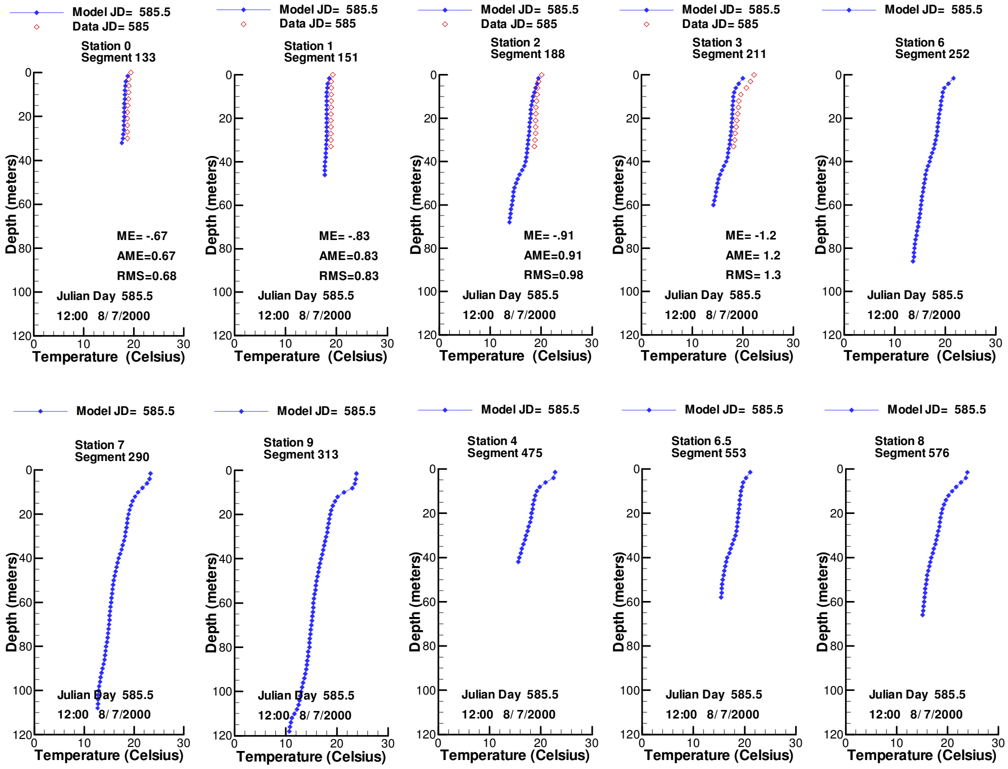
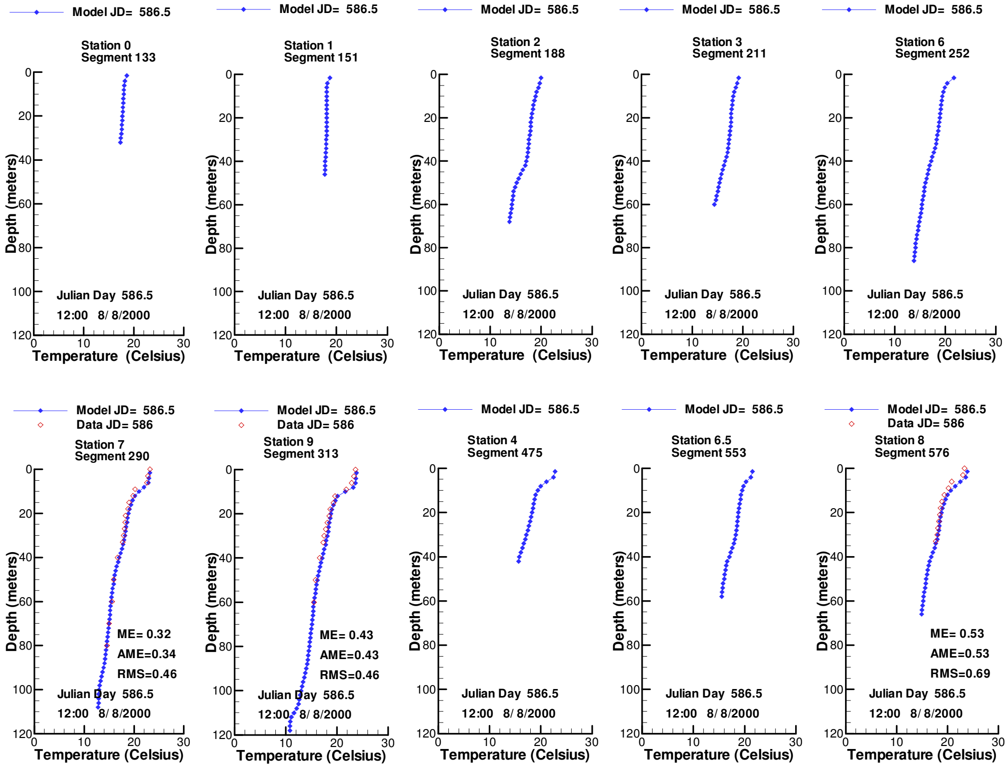


Figure 314. Vertical temperature profile model-data comparison, J585.



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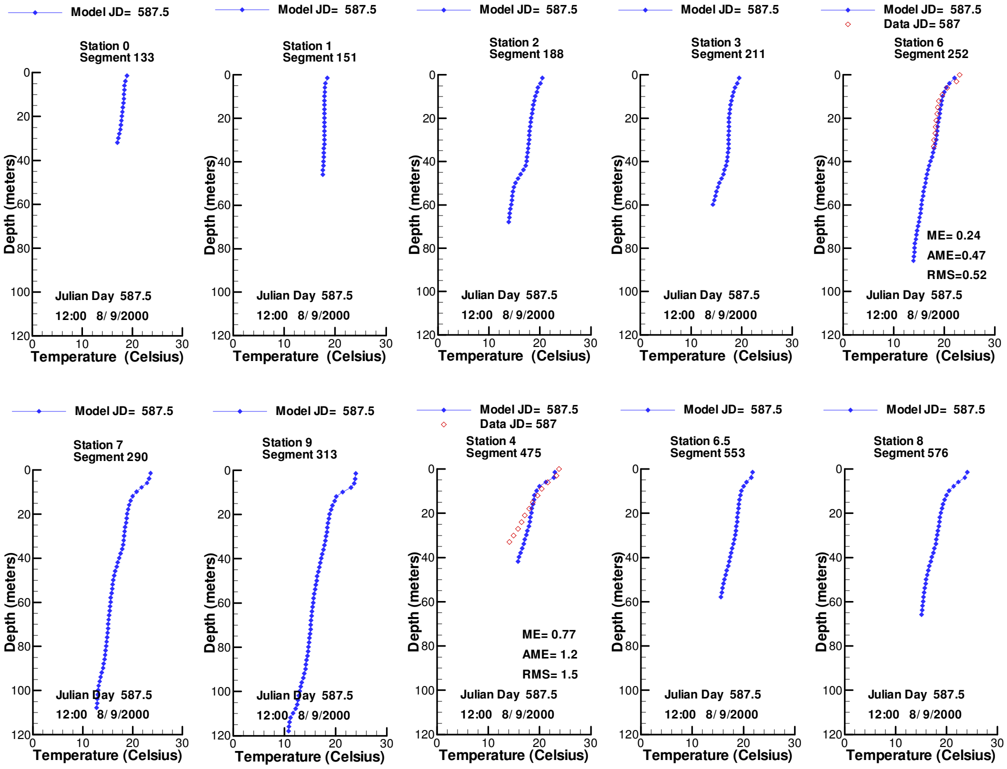

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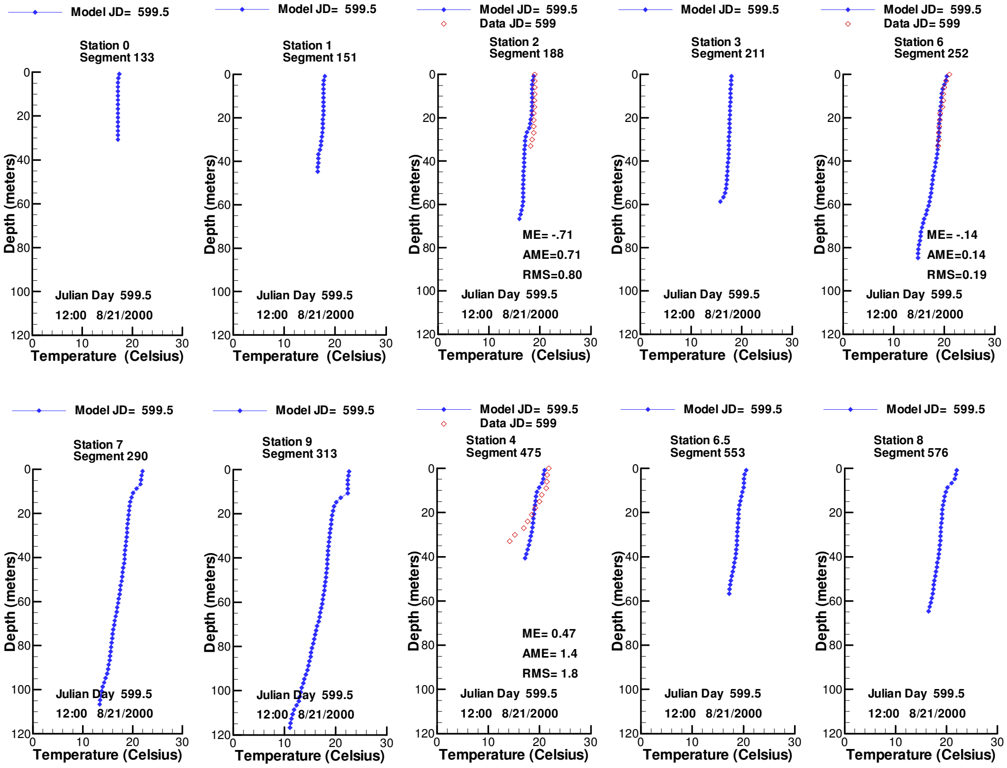

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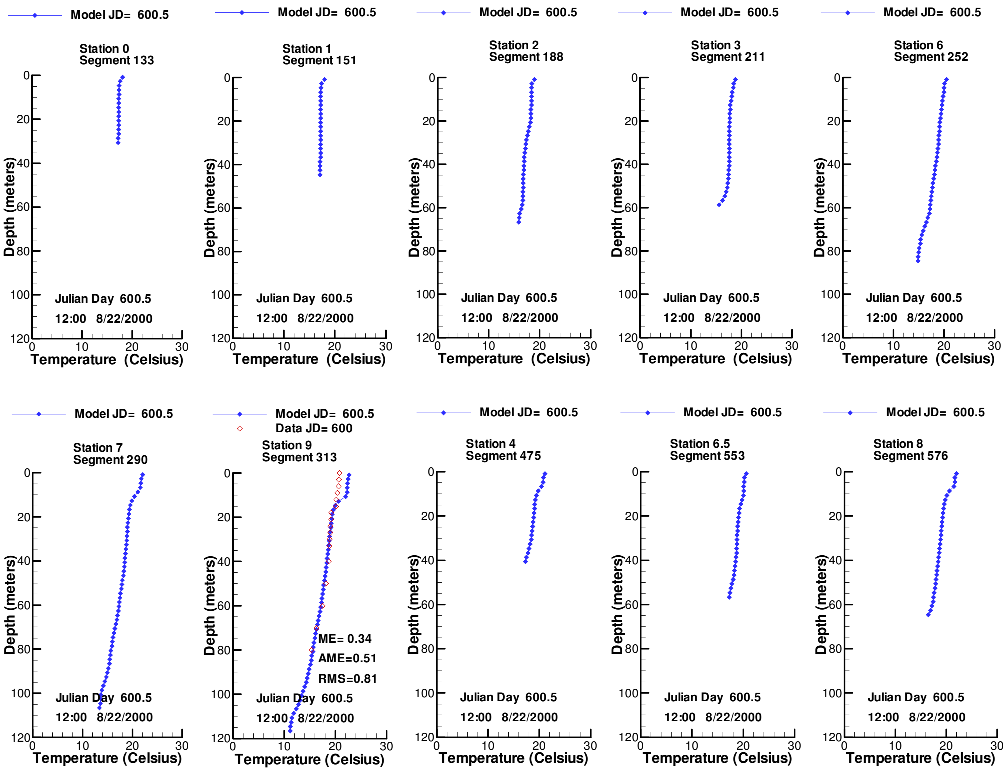

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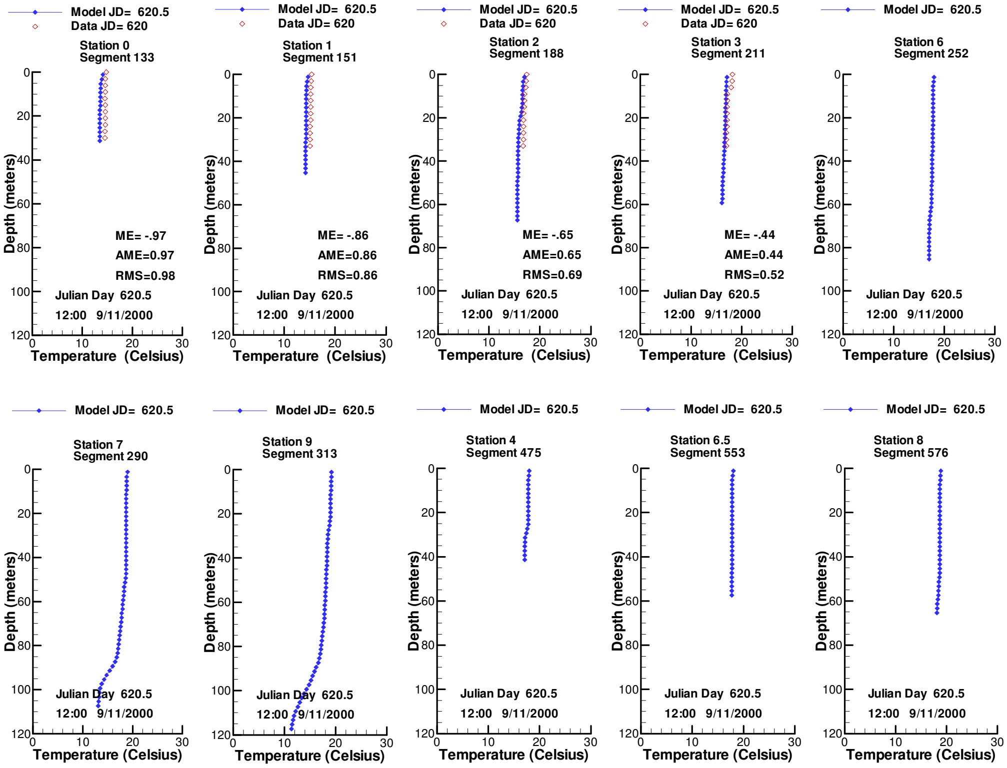

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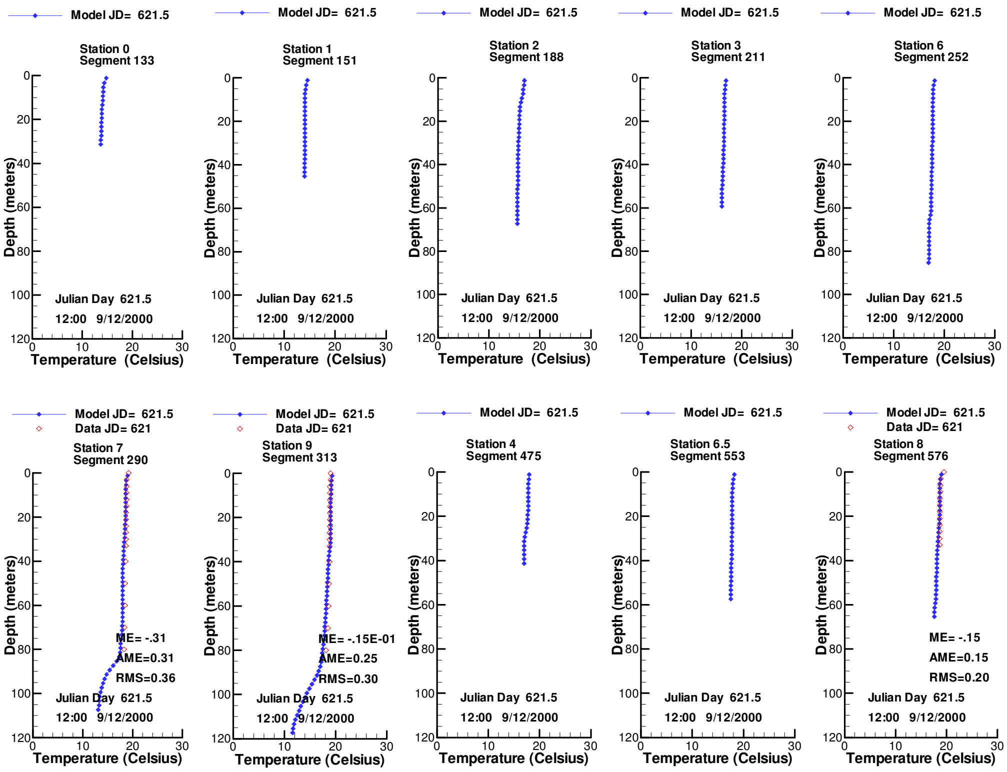
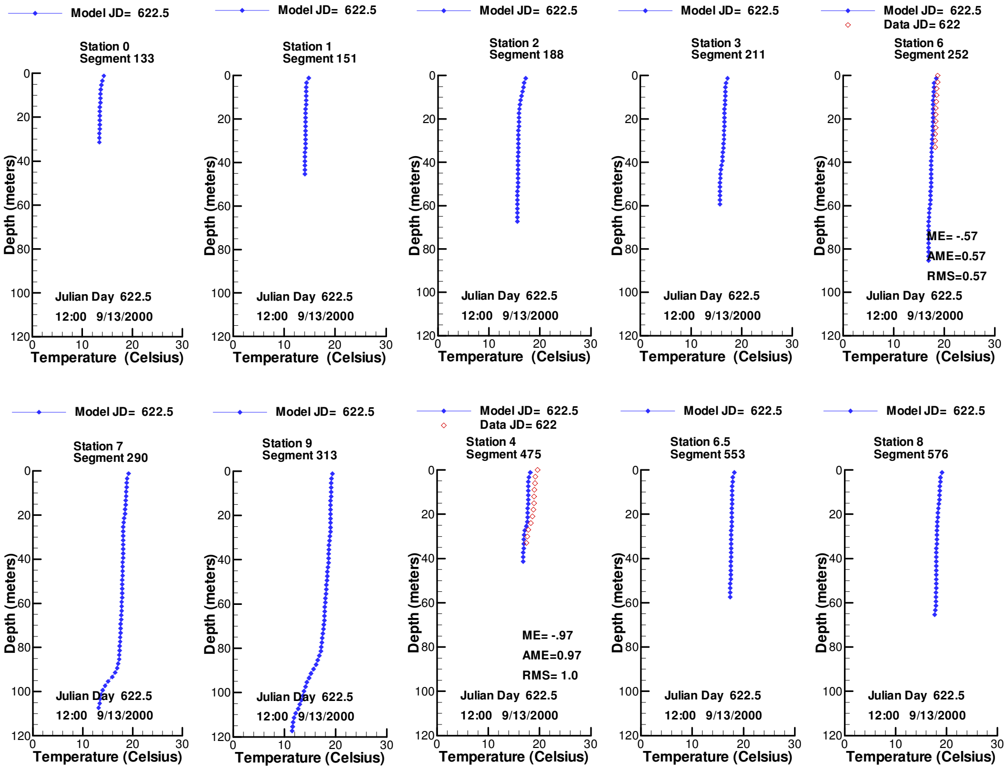


Figure 320. Vertical temperature profile model-data comparison, J621.



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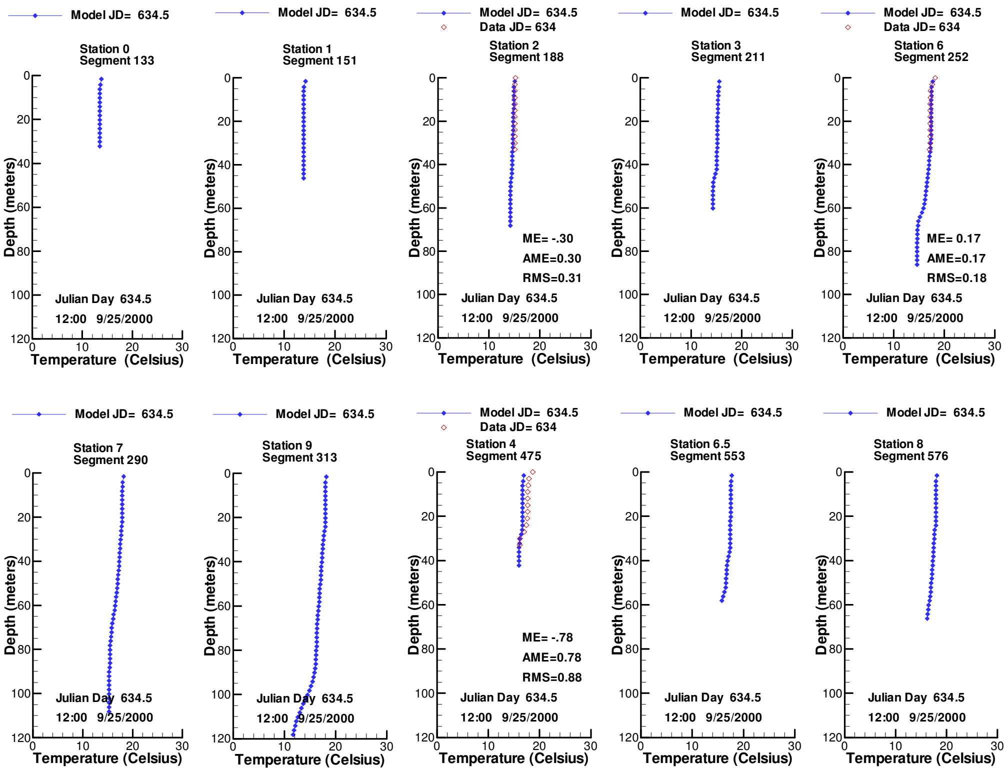

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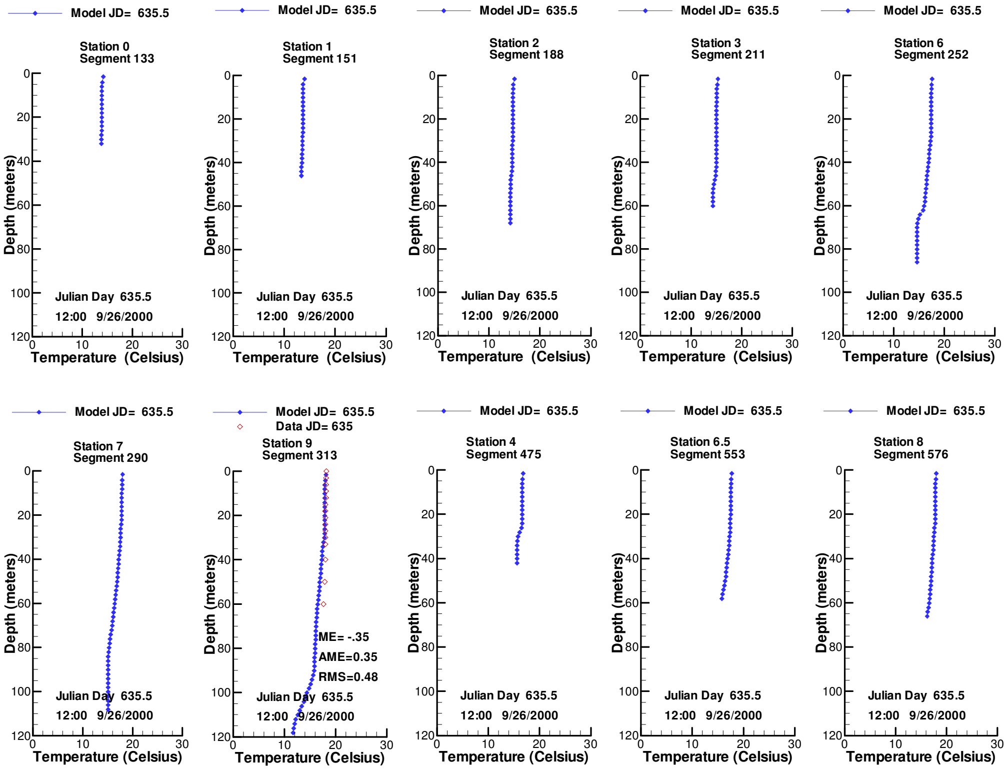

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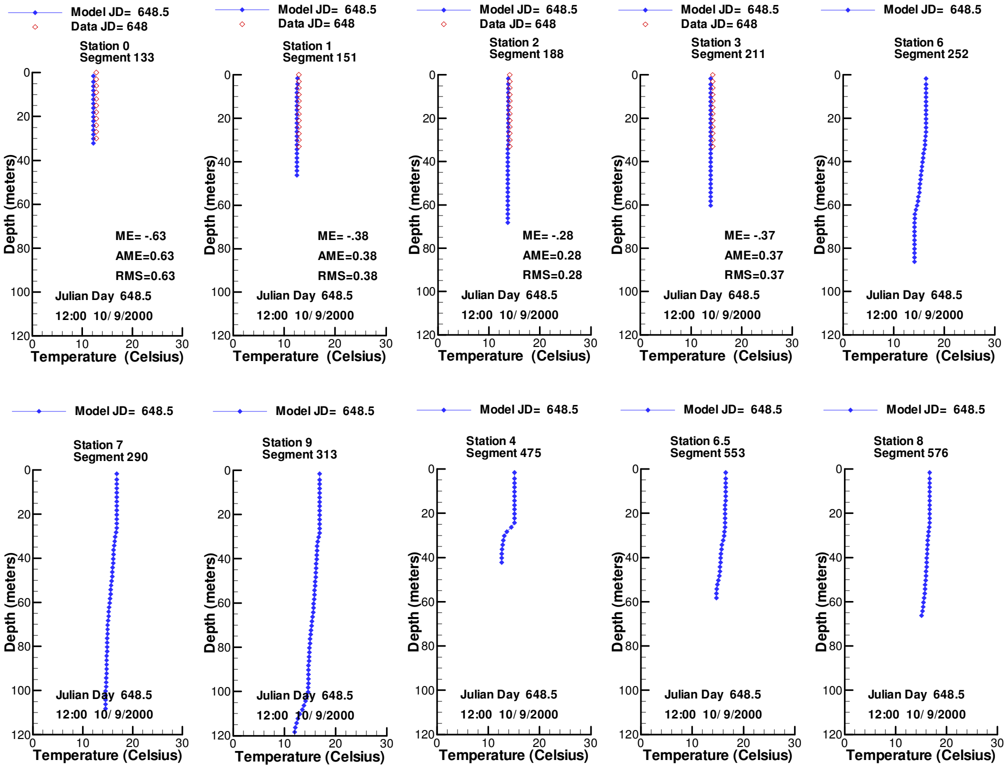

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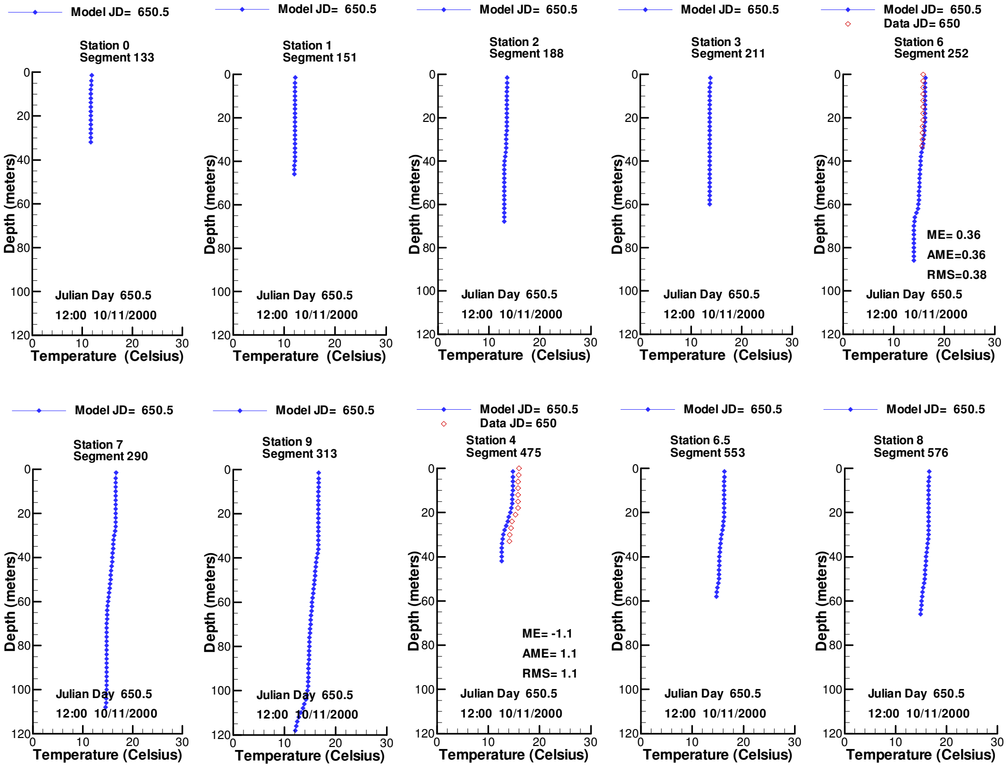

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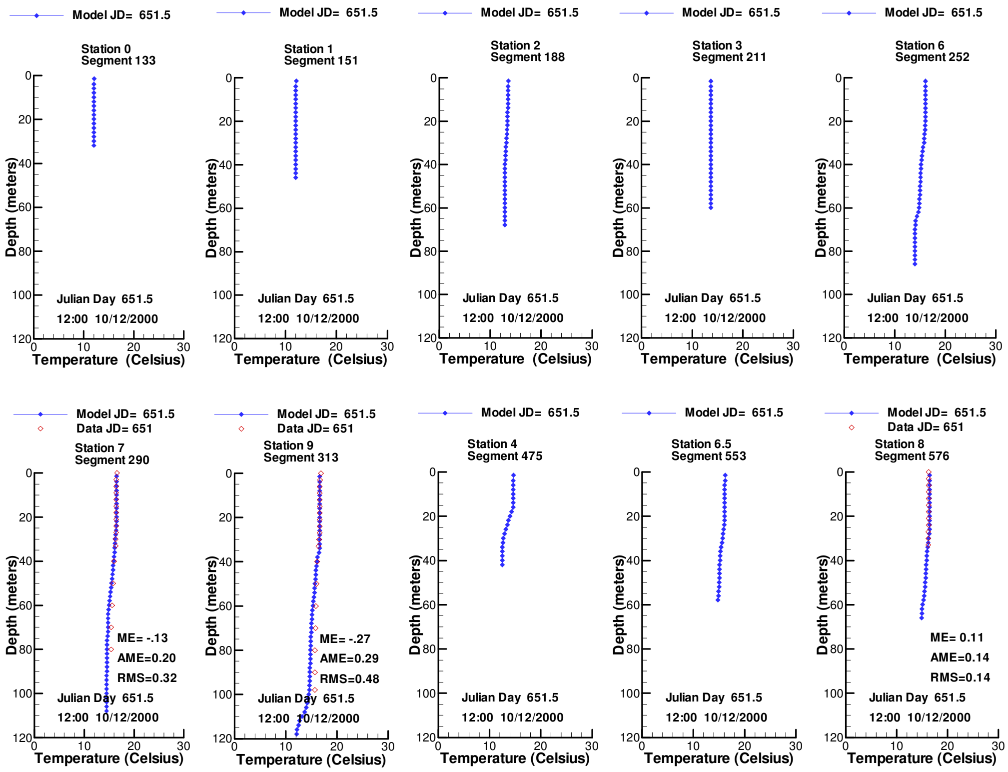

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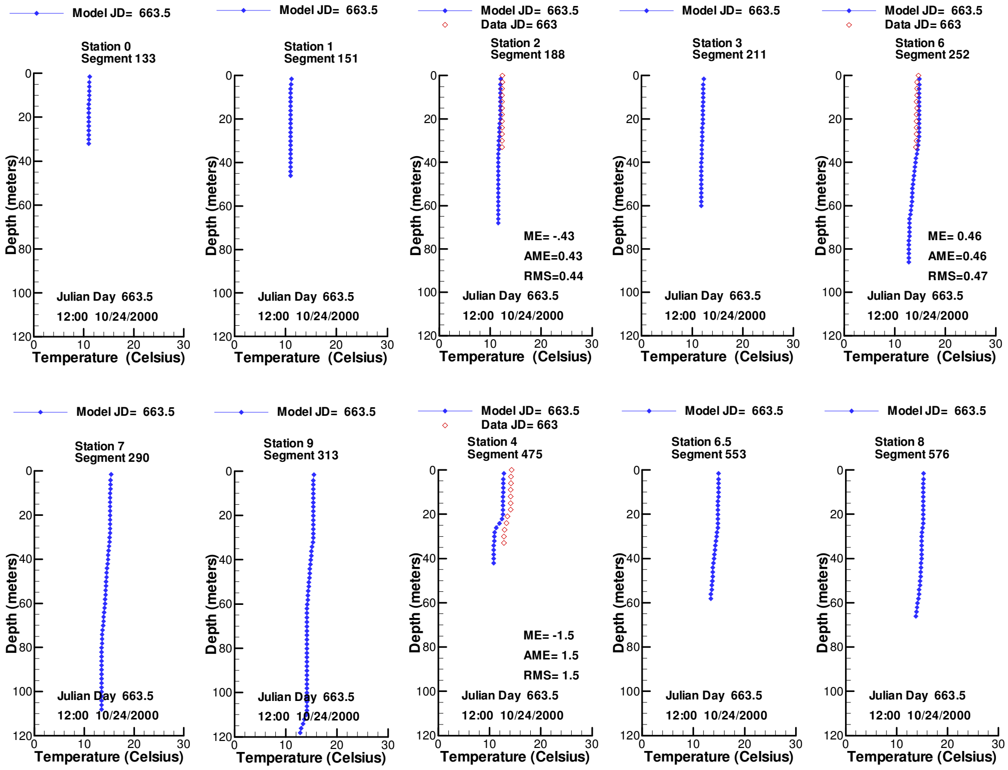

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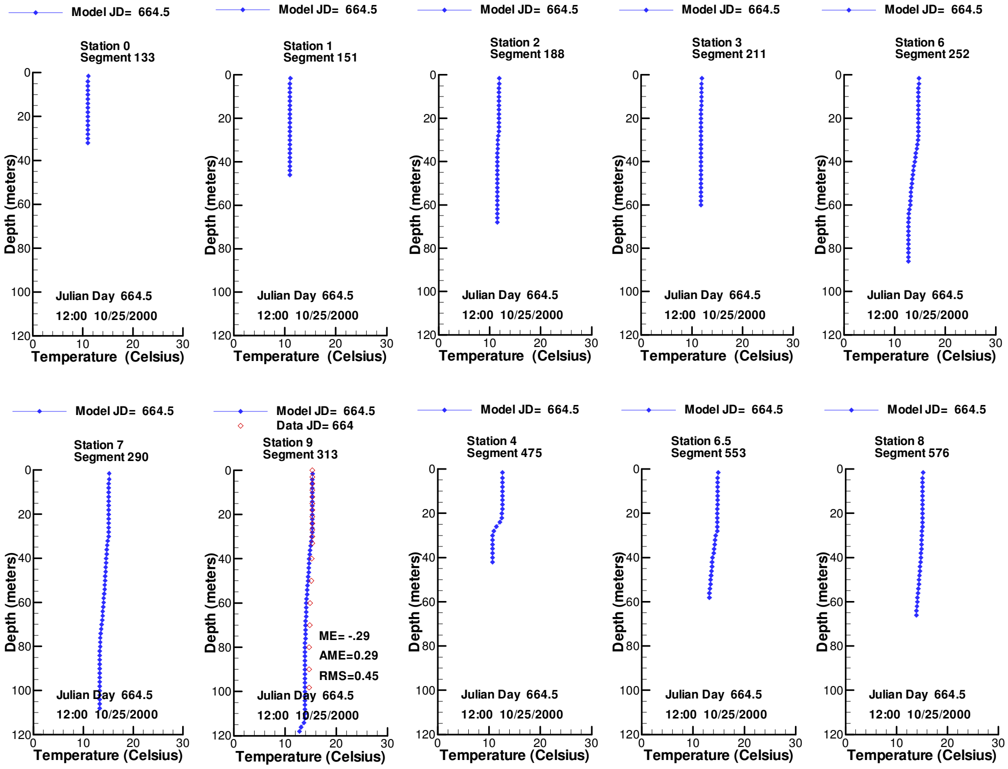

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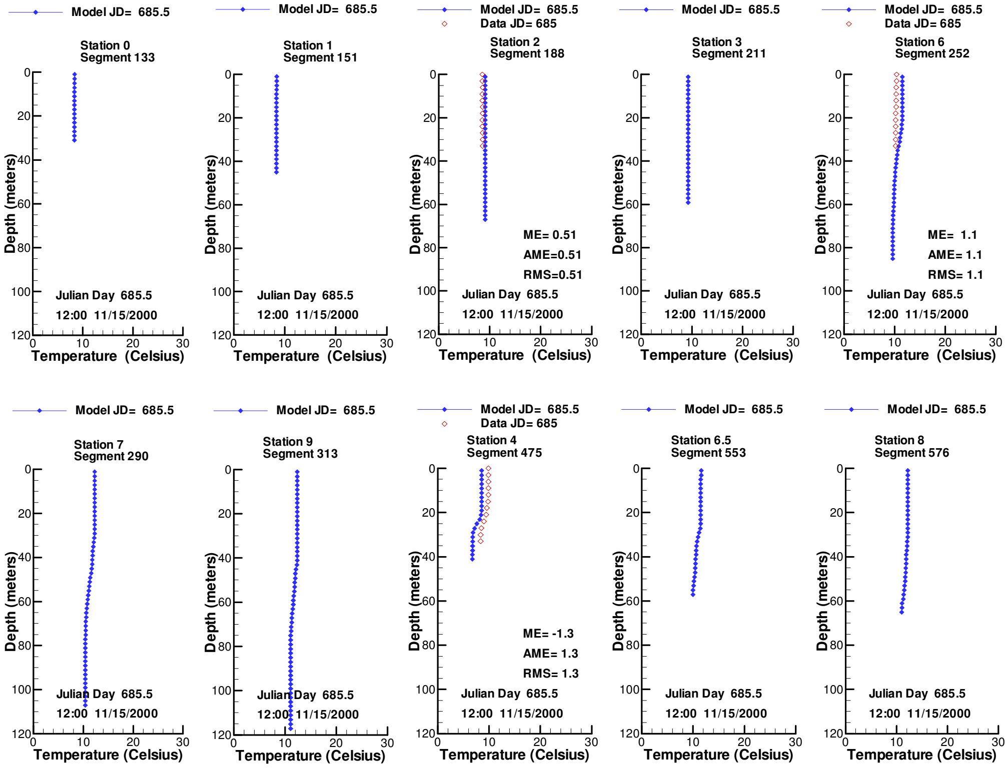

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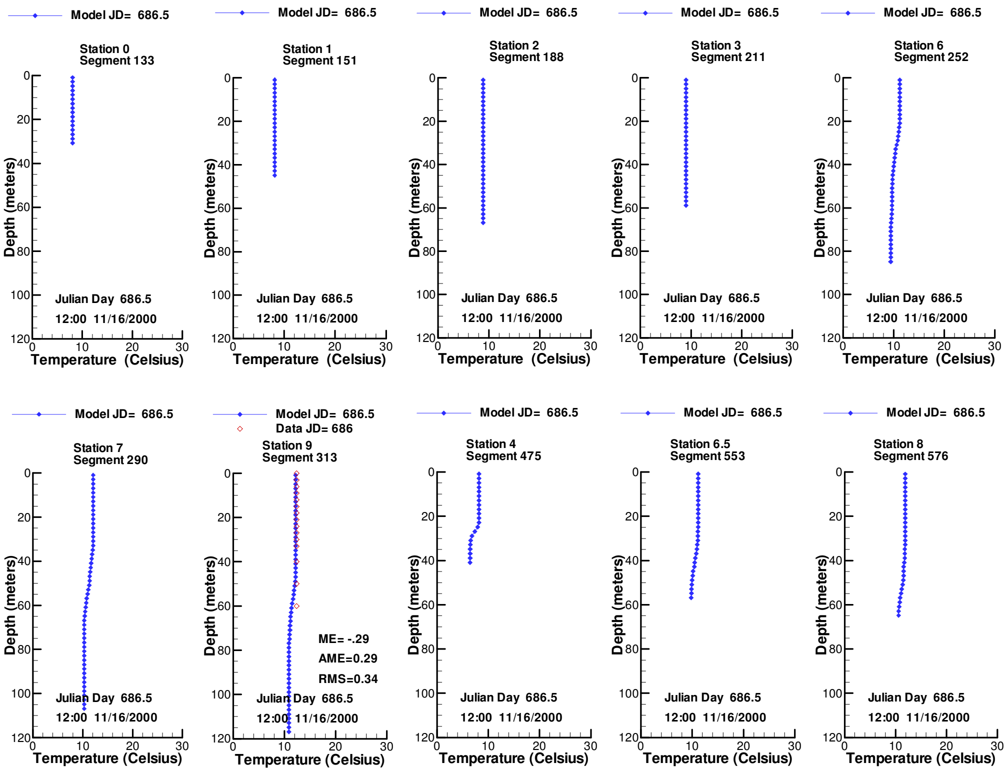

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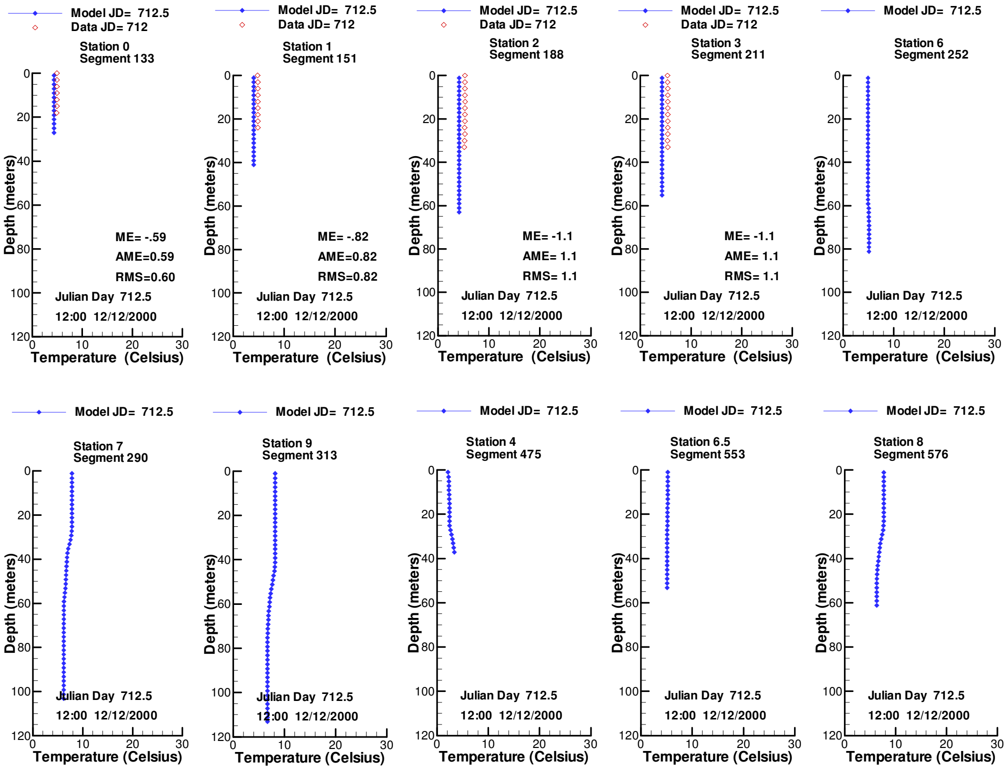


Figure 331. Vertical temperature profile model-data comparison, J712.

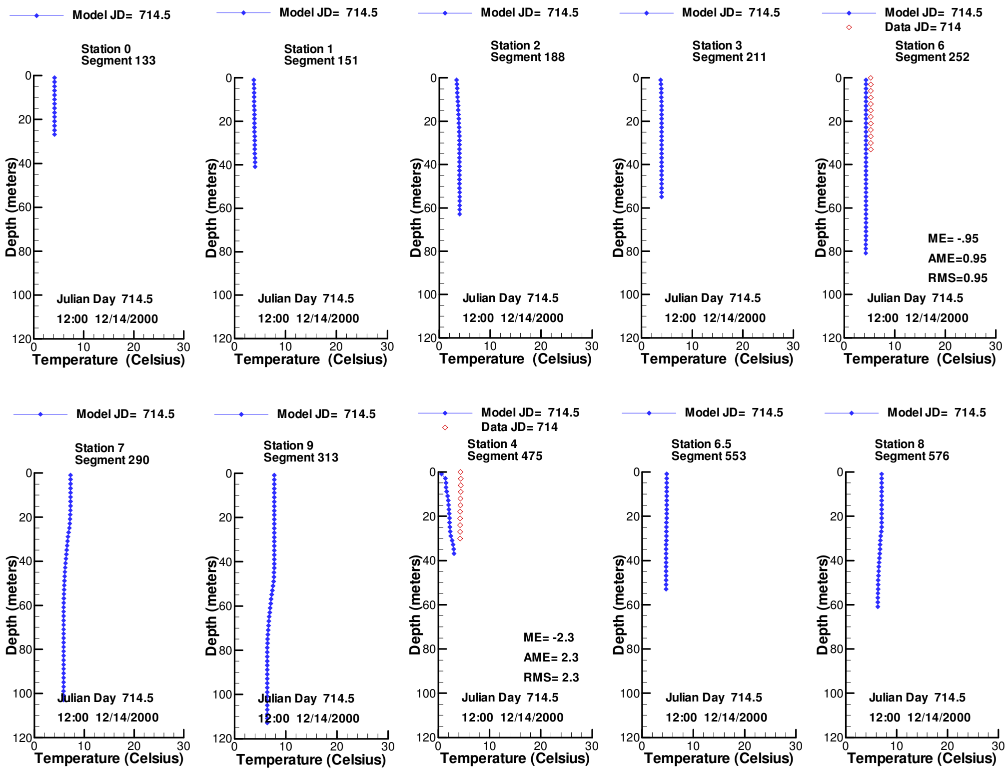


Figure 332. Vertical temperature profile model-data comparison, J714.

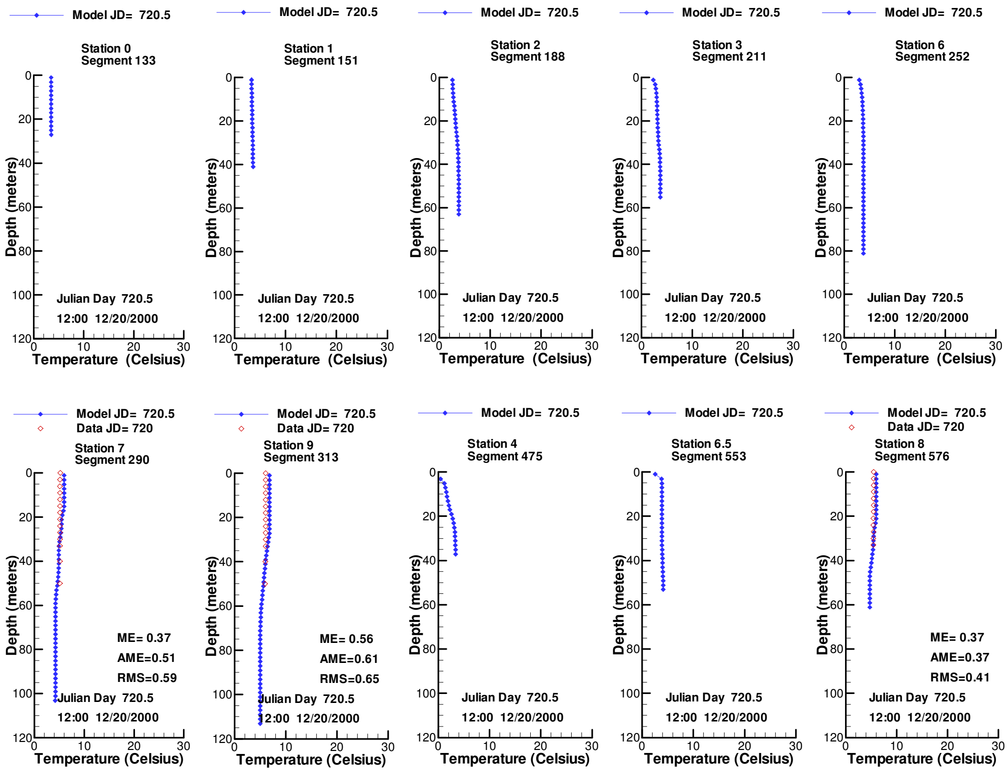


Figure 333. Vertical temperature profile model-data comparison, J720.

pH

For days when data were recorded, vertical profile plots of pH are shown in Figure 334 through Figure 380. The model-data comparison for pH is poor due to a disagreement between the boundary condition and in-stream data. Refer to the section Alternate Boundary Conditions section for a discussion.

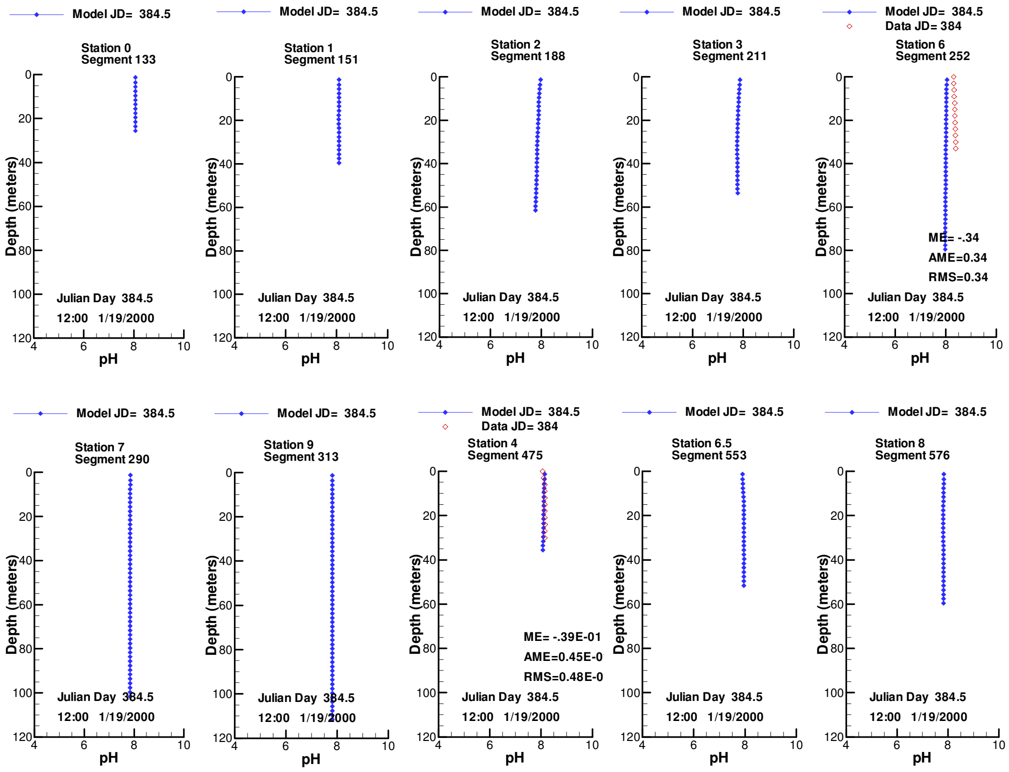


Figure 334. Vertical pH model-data comparison, J384.

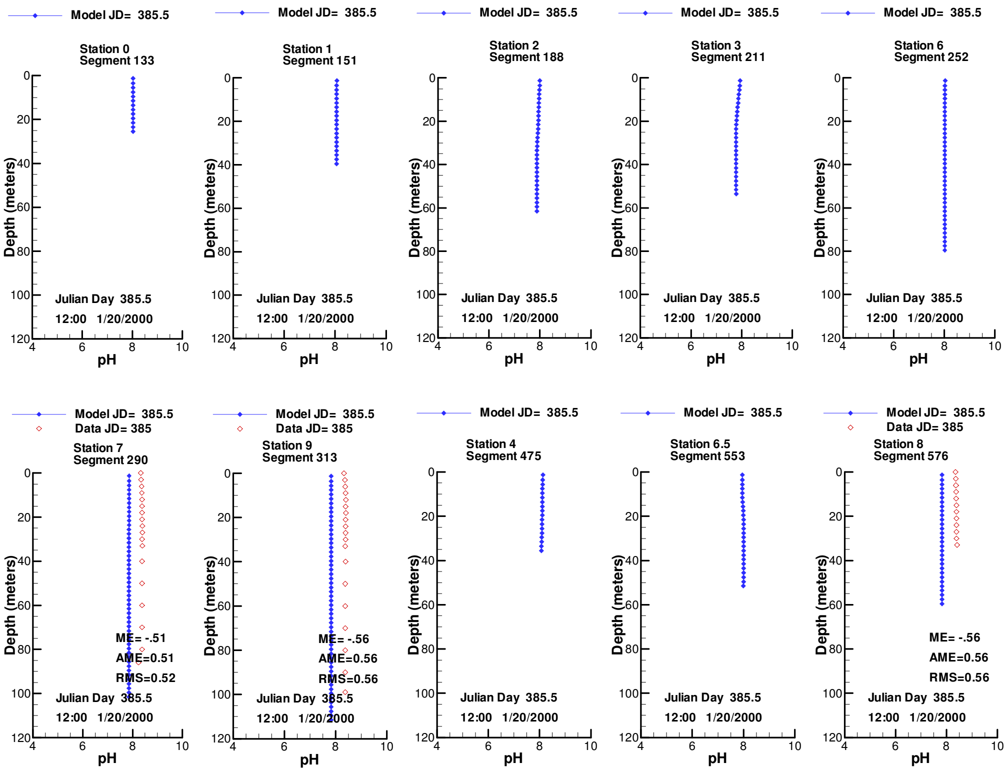


Figure 335. Vertical pH model-data comparison, J385.

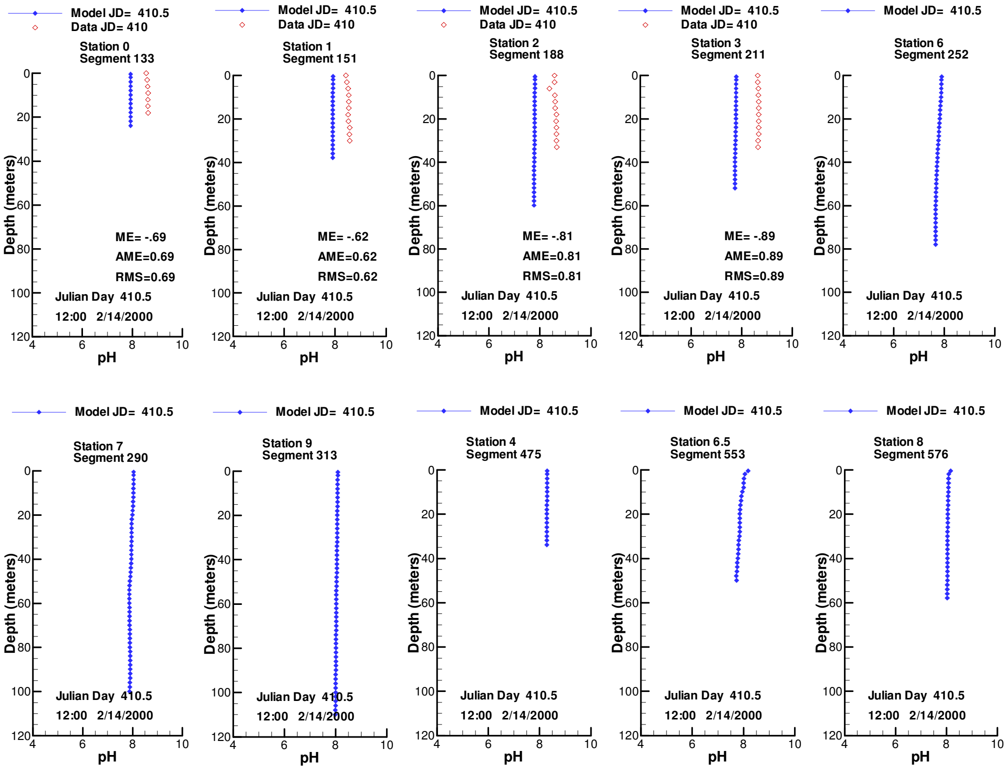


Figure 336. Vertical pH model-data comparison, J410.

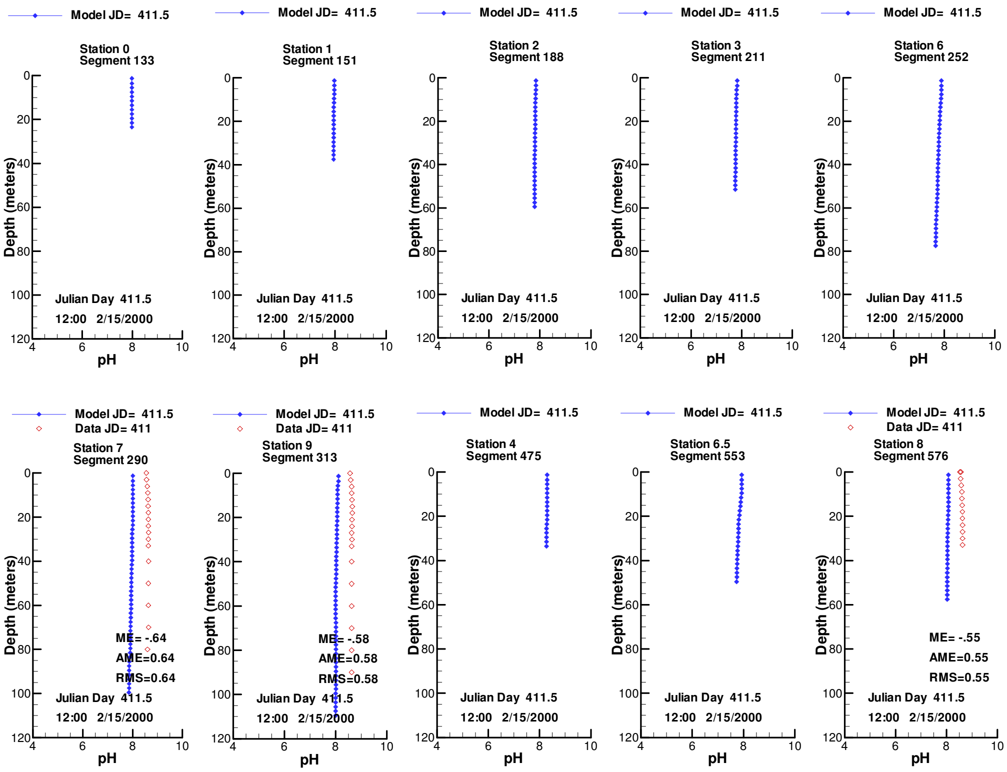
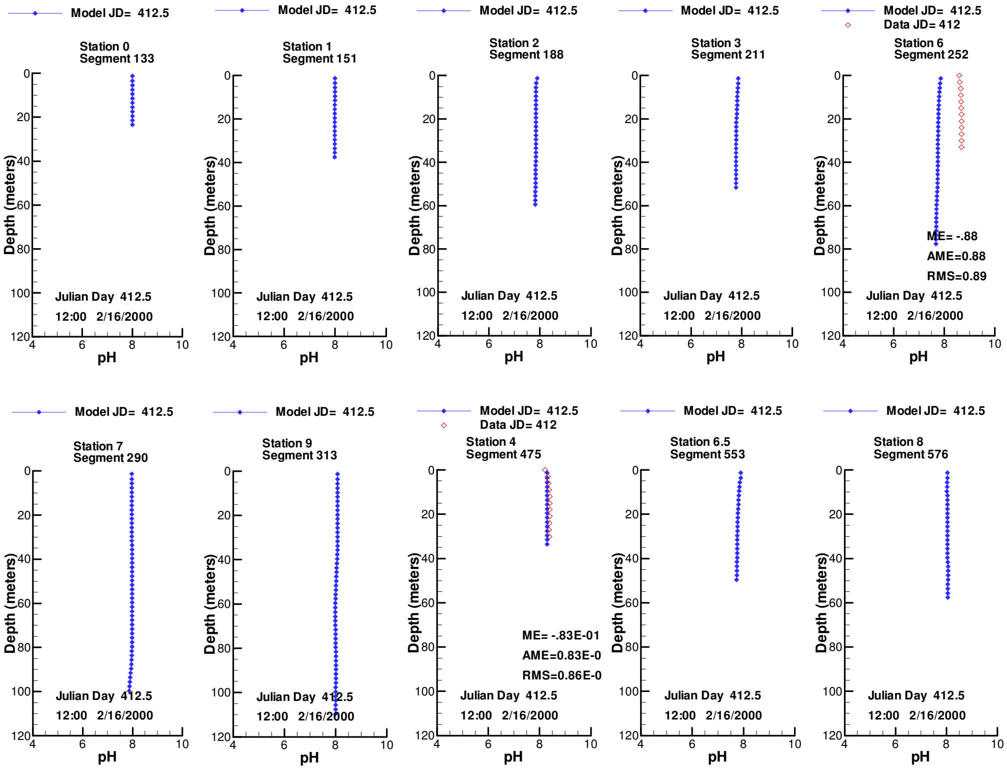


Figure 337. Vertical pH model-data comparison, J411.



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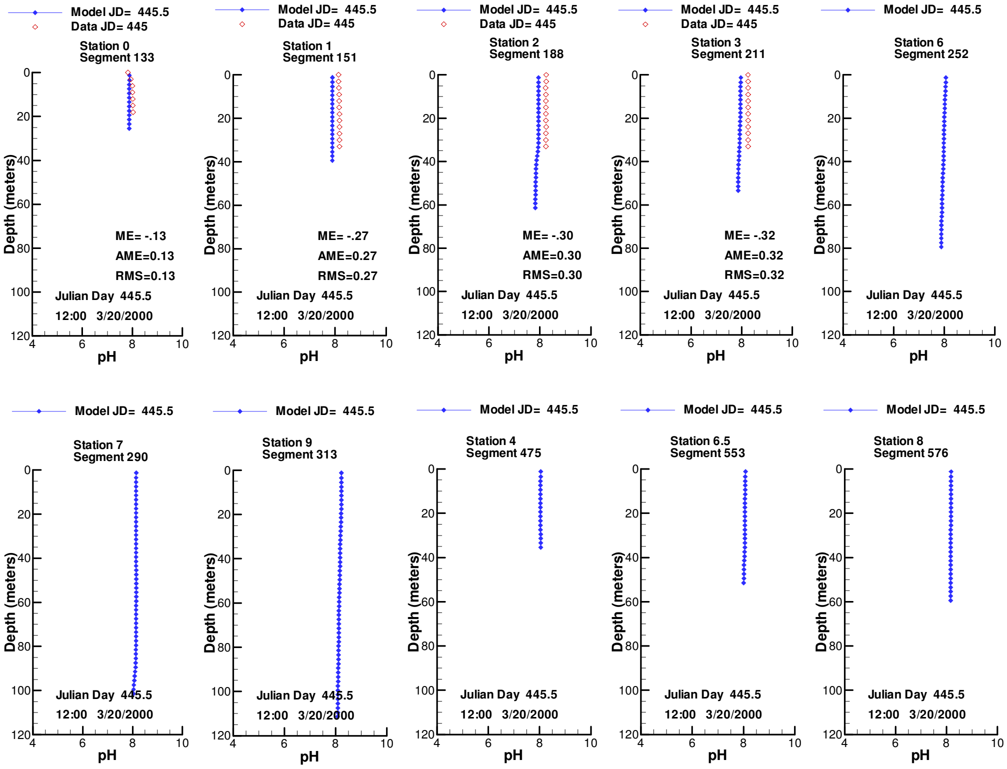


Figure 339. Vertical pH model-data comparison, J445.

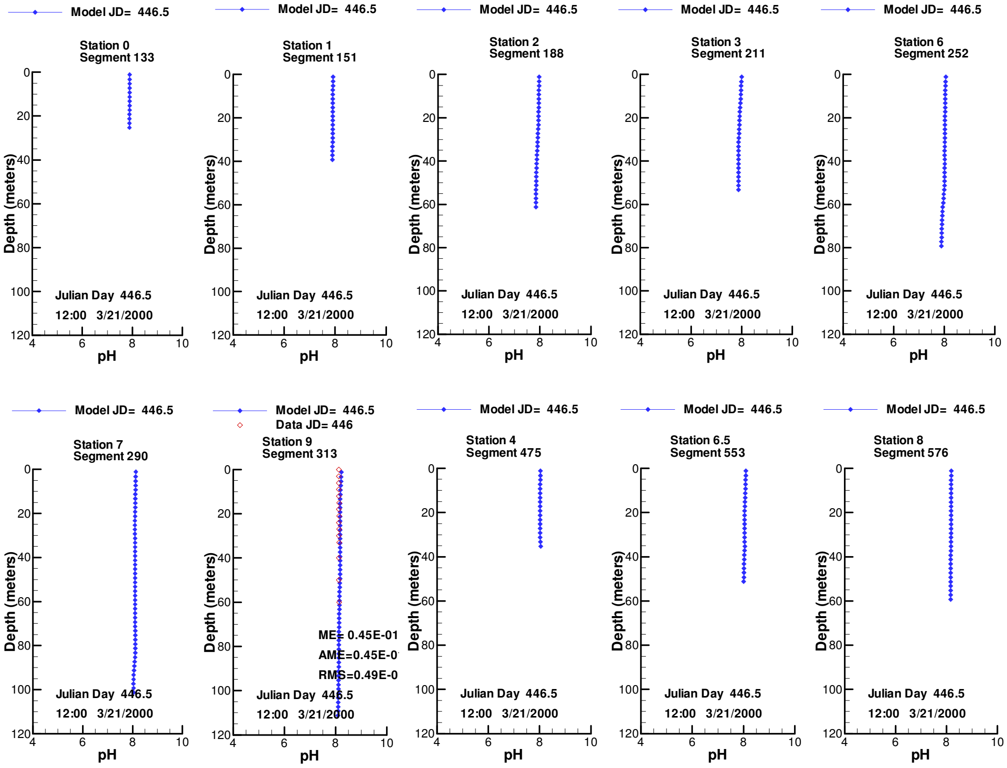


Figure 340. Vertical pH model-data comparison, J446.

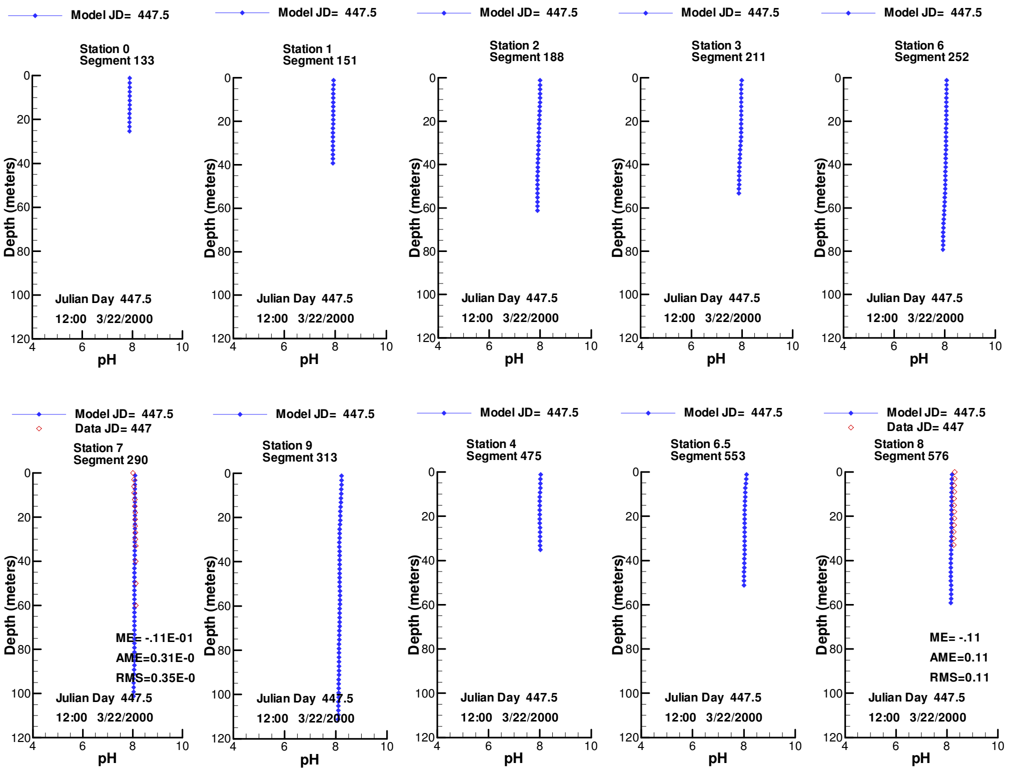
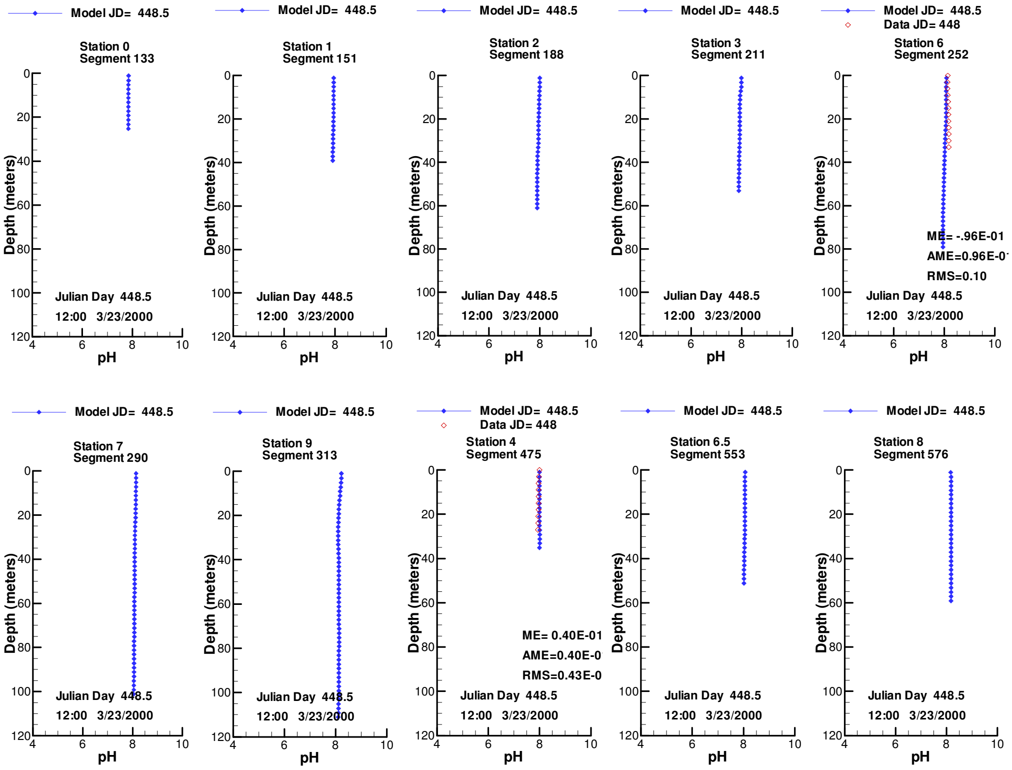


Figure 341. Vertical pH model-data comparison, J447.



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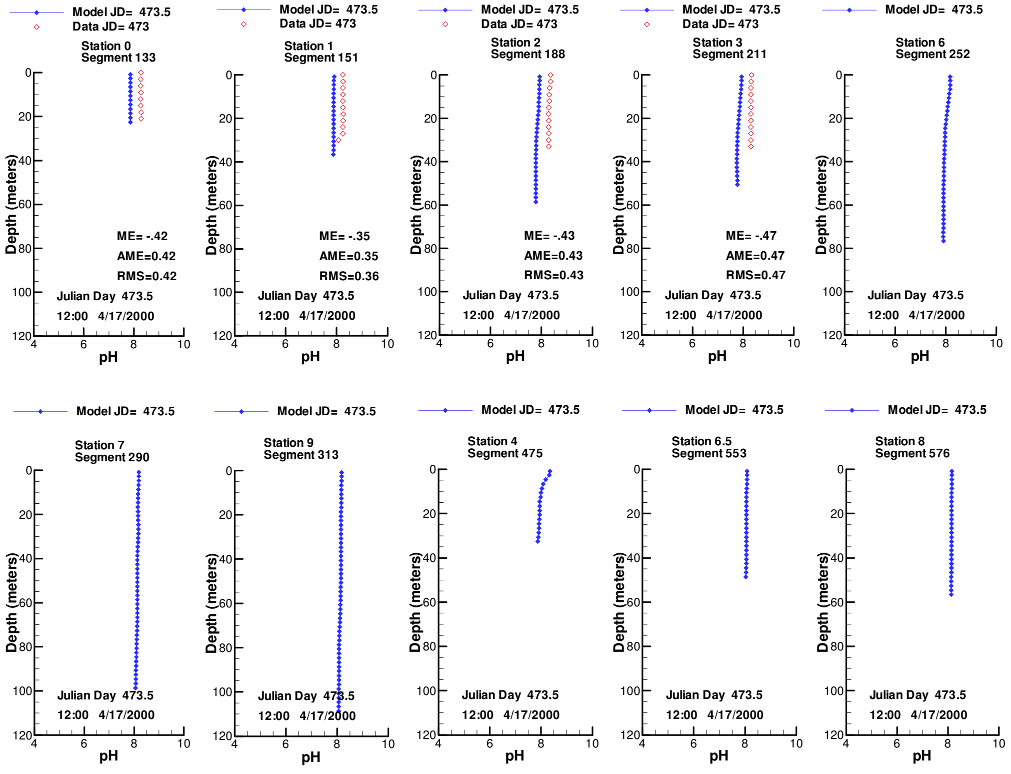


Figure 343. Vertical pH model-data comparison, J473.

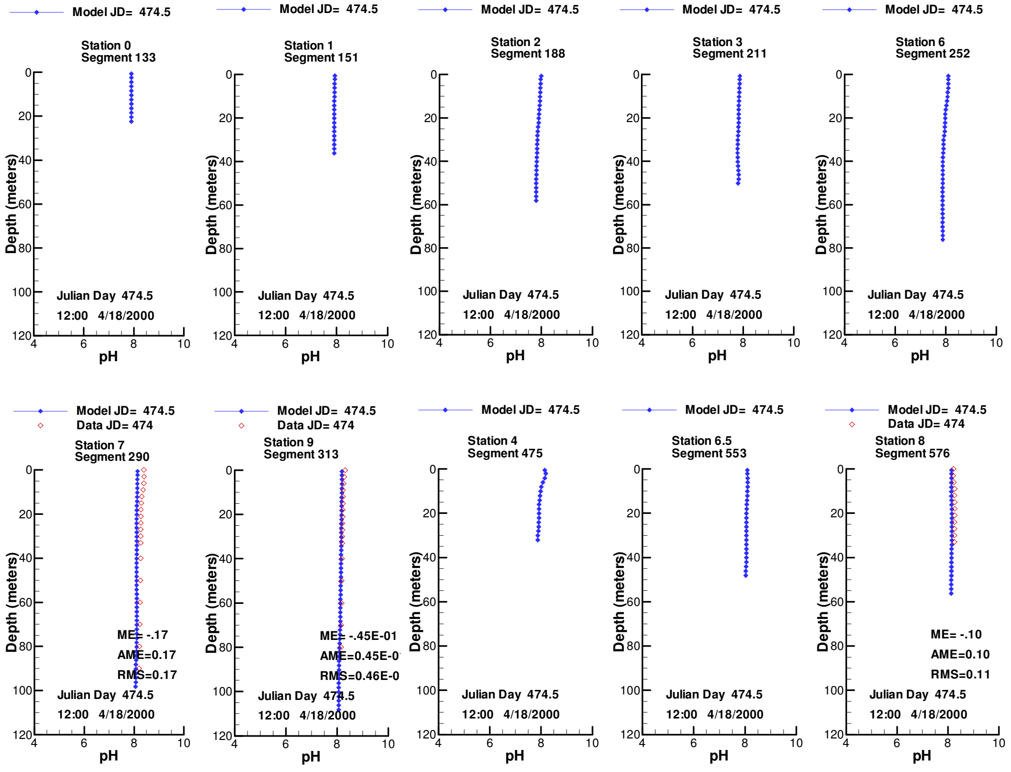


Figure 344. Vertical pH model-data comparison, J474.

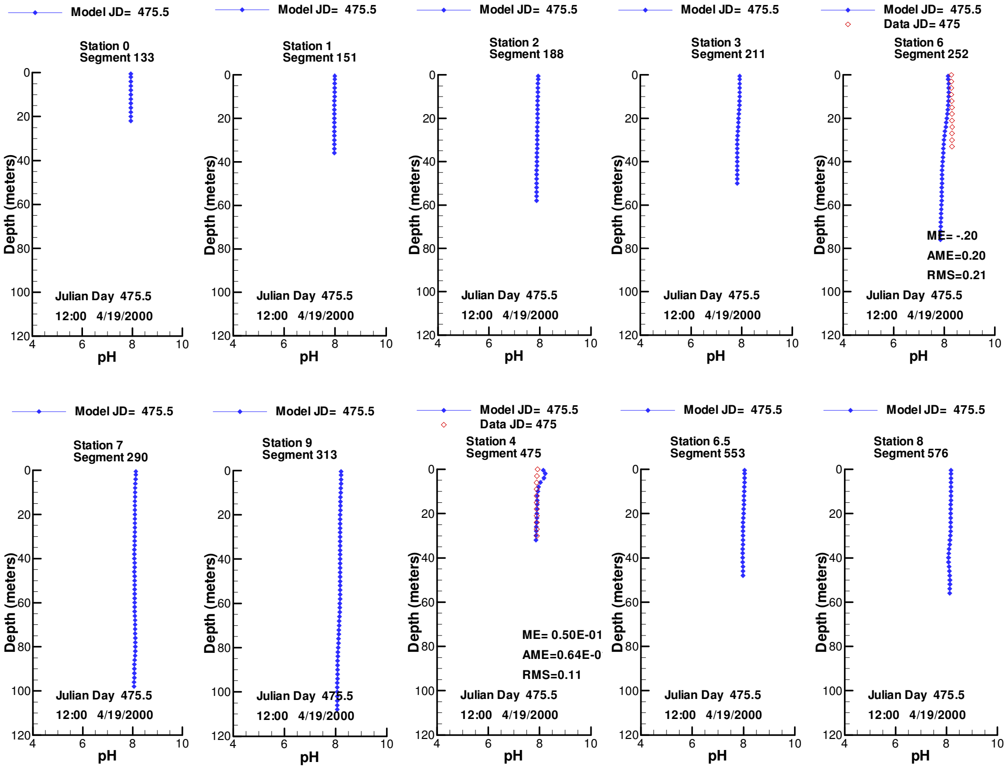
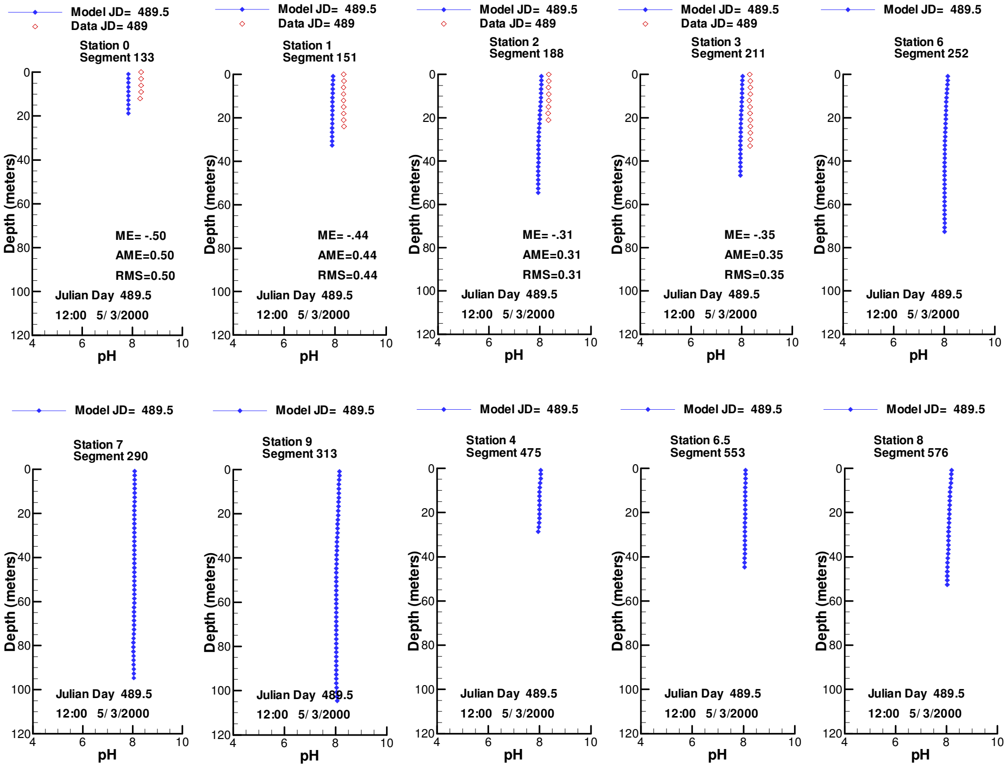


Figure 345. Vertical pH model-data comparison, J475.



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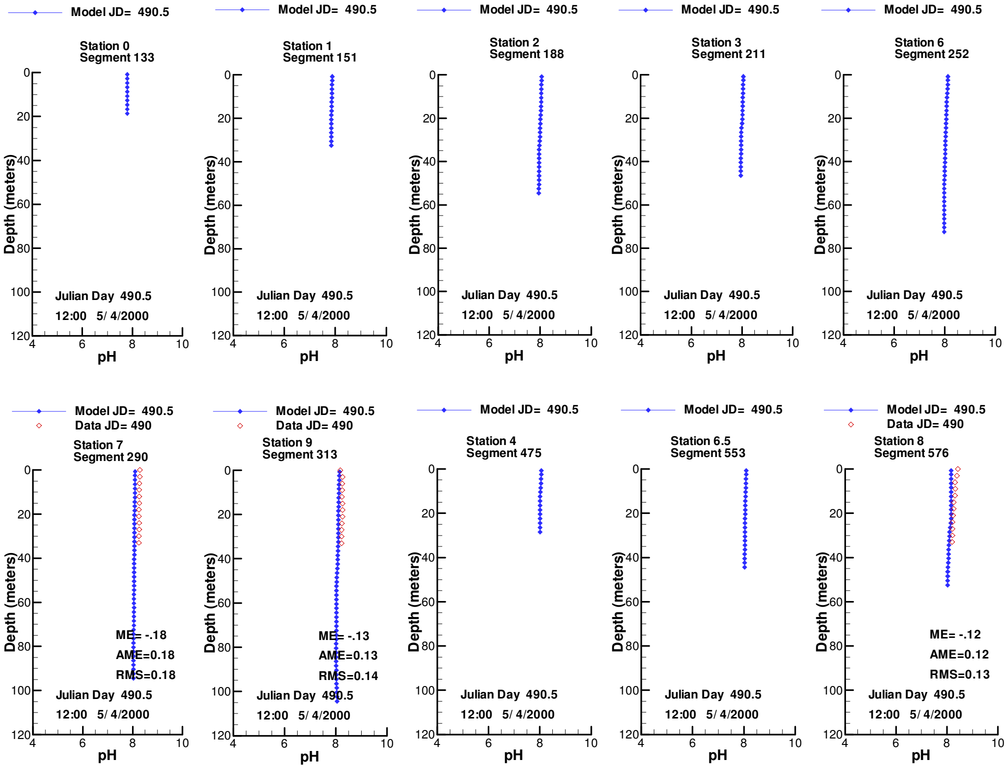
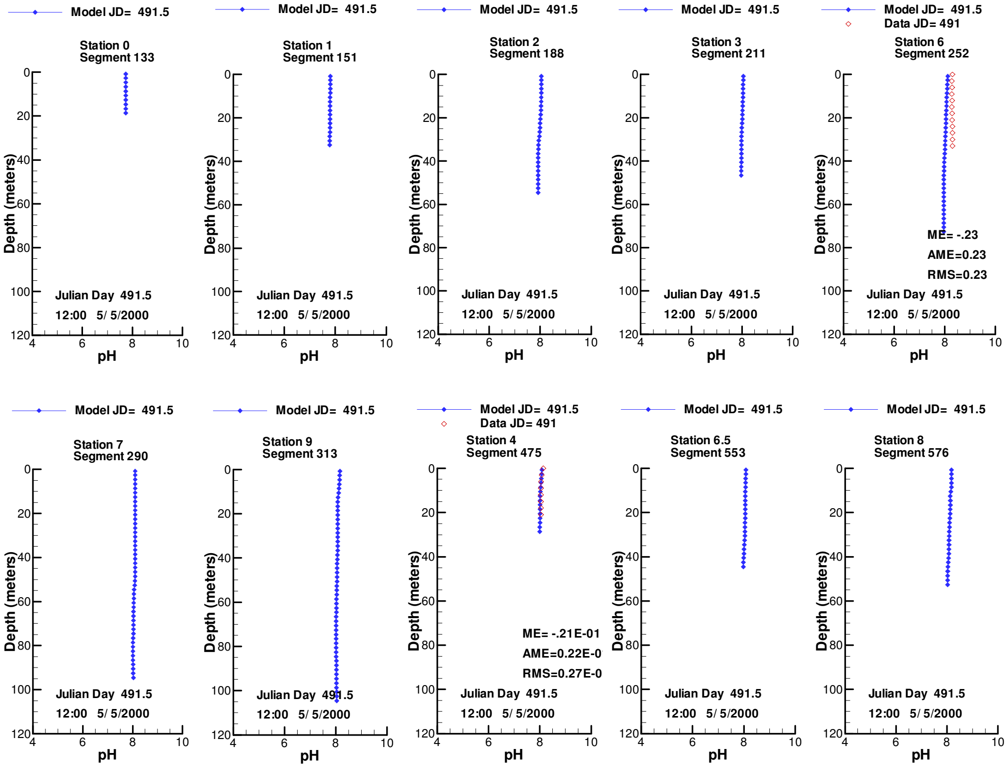


Figure 347. Vertical pH model-data comparison, J490.



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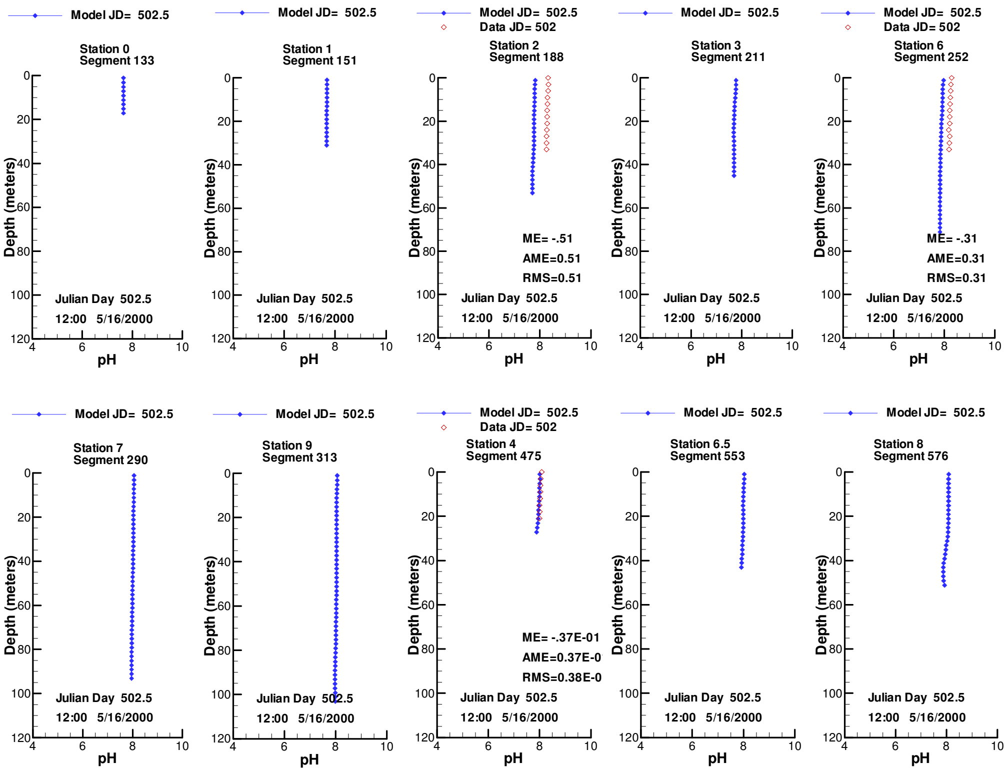
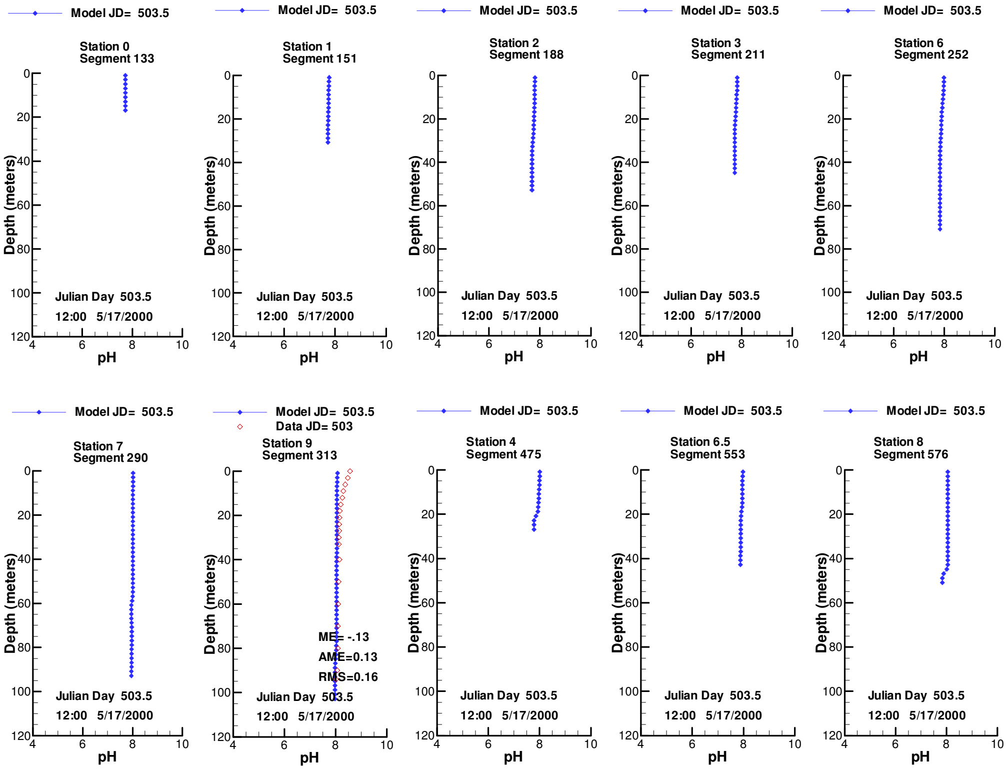


Figure 349. Vertical pH model-data comparison, J502.



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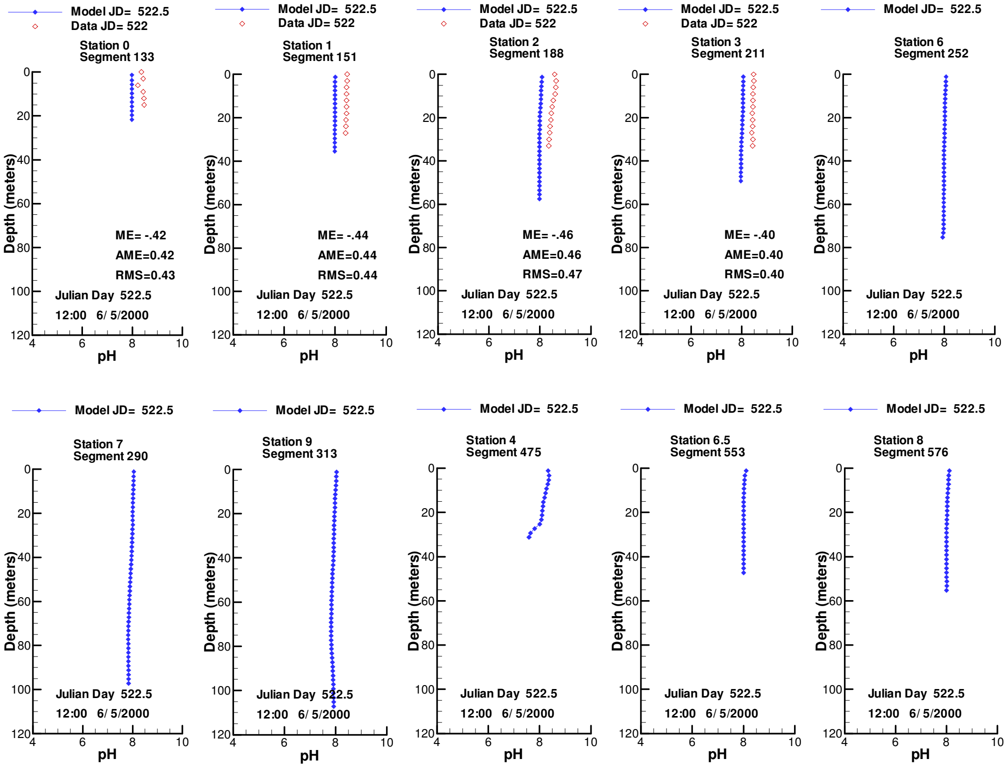

Figure 351. Vertical pH model-data comparison, J522.

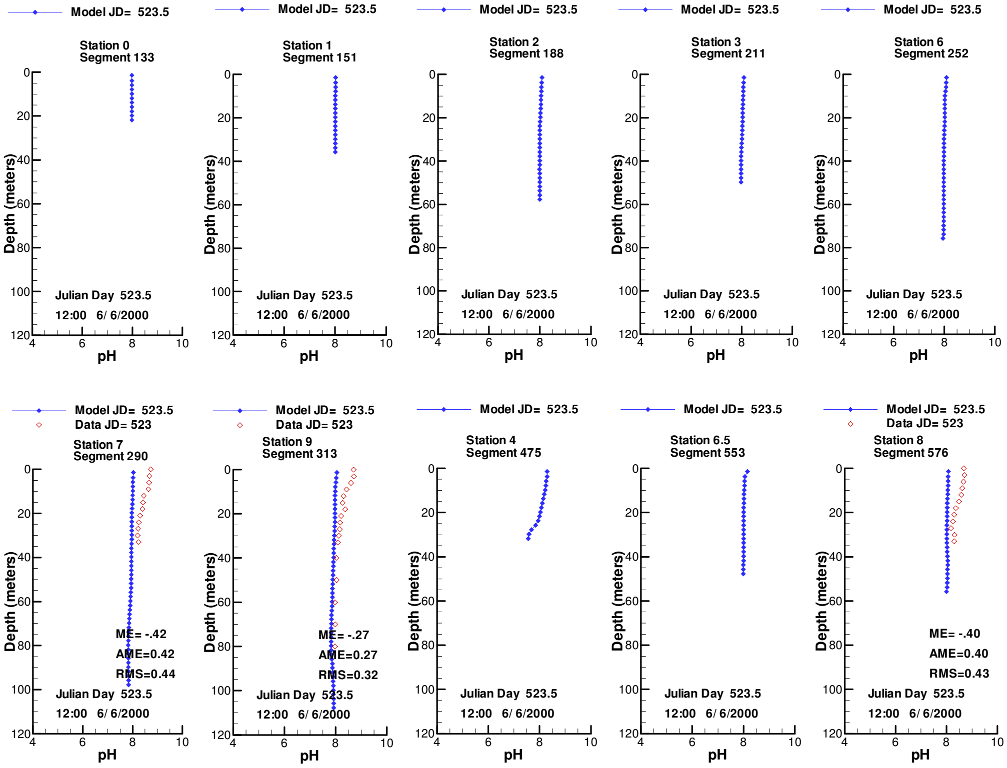

Figure 352. Vertical pH model-data comparison, J523.

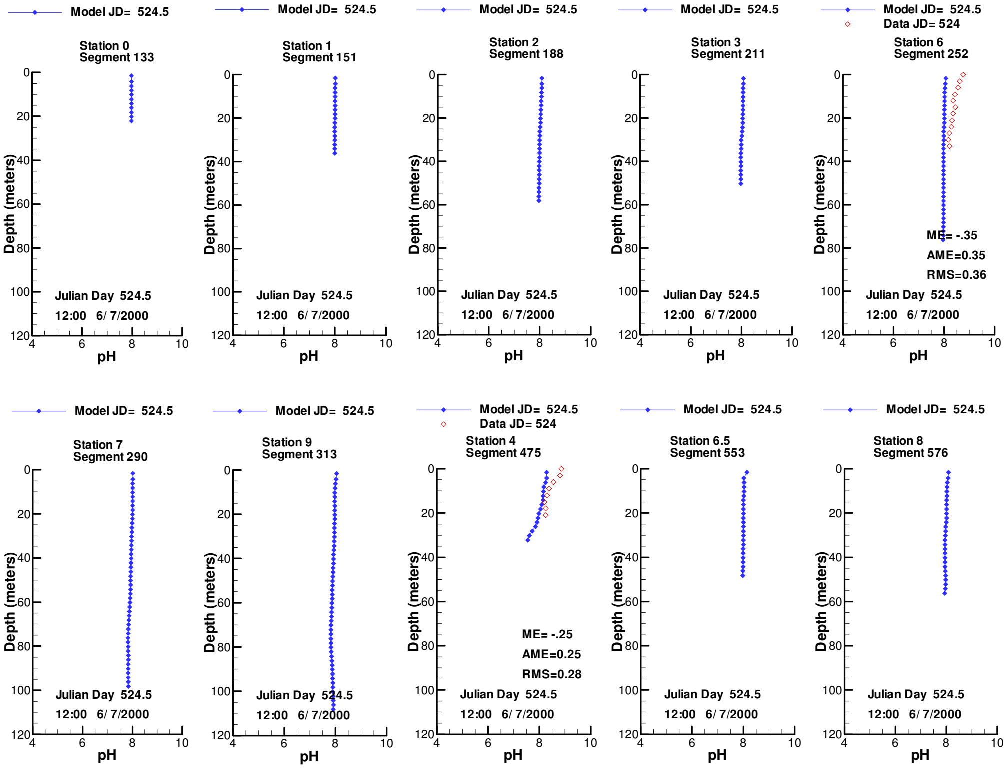

Figure 353. Vertical pH model-data comparison, J524.

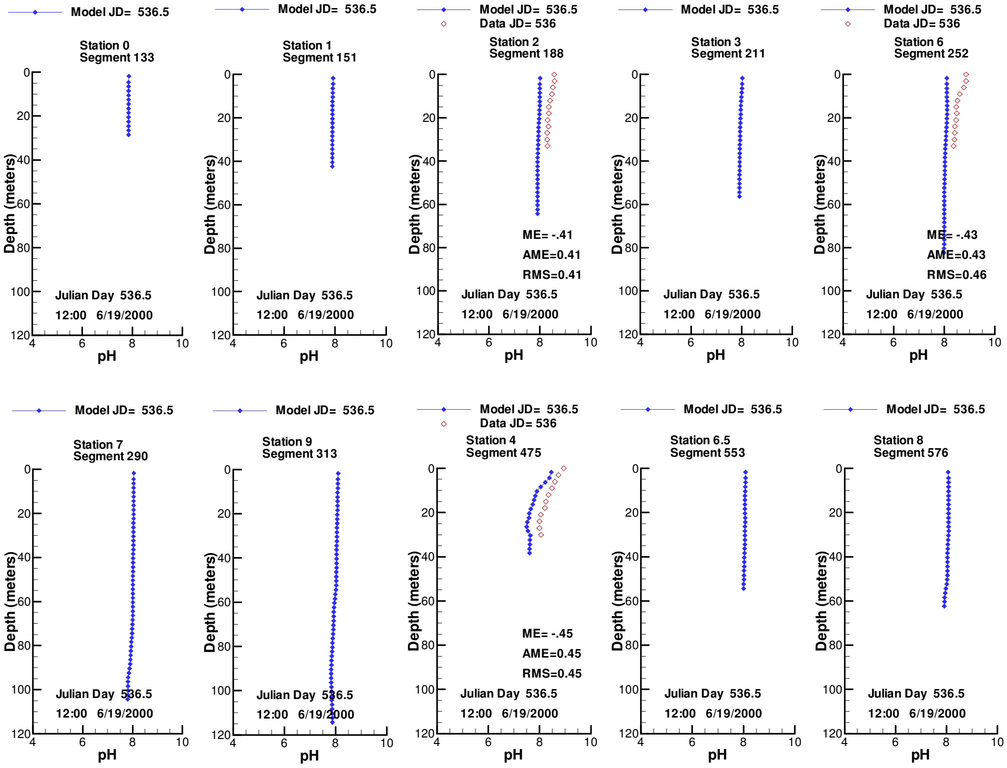

Figure 354. Vertical pH model-data comparison, J536.

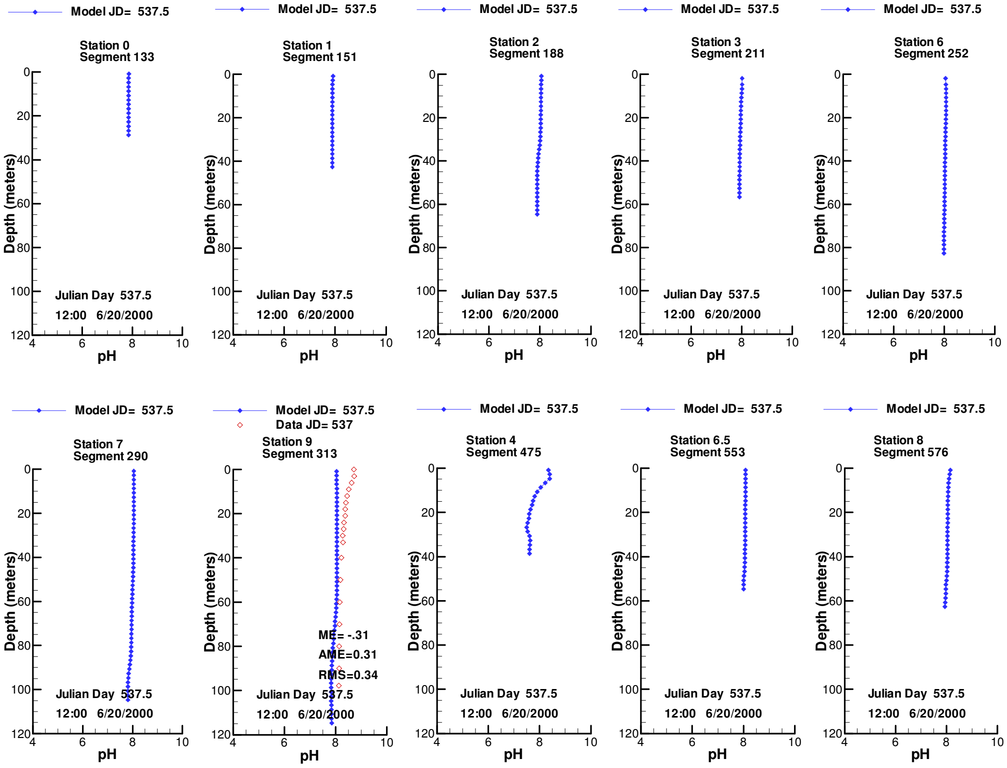

Figure 355. Vertical pH model-data comparison, J537.

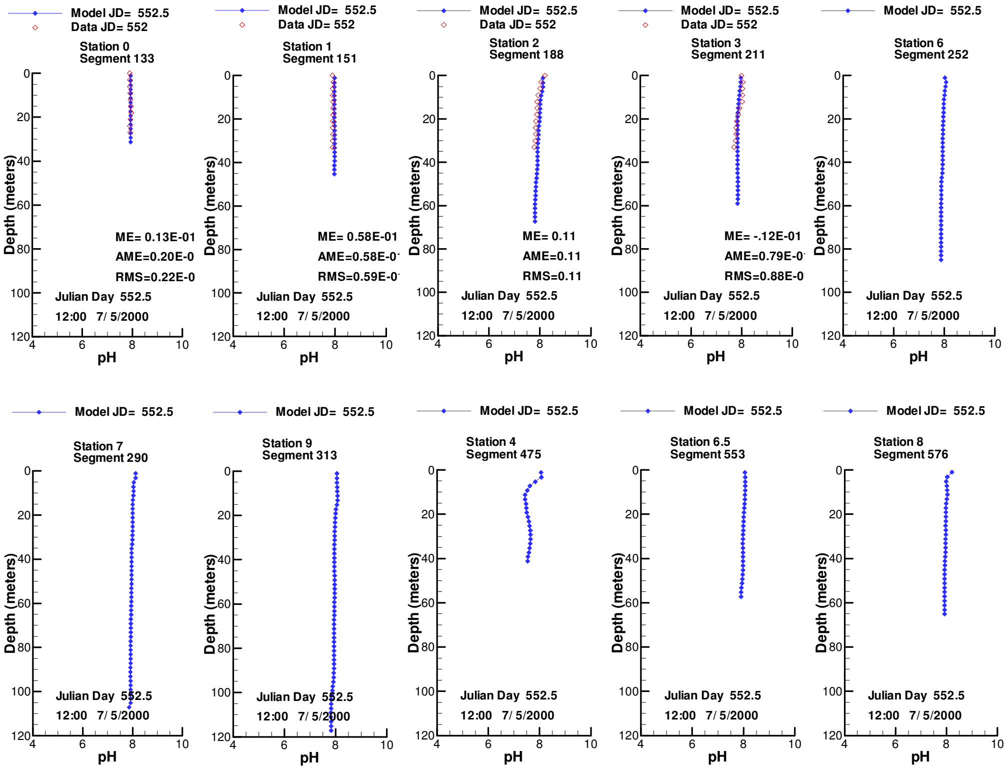

Figure 356. Vertical pH model-data comparison, J552.

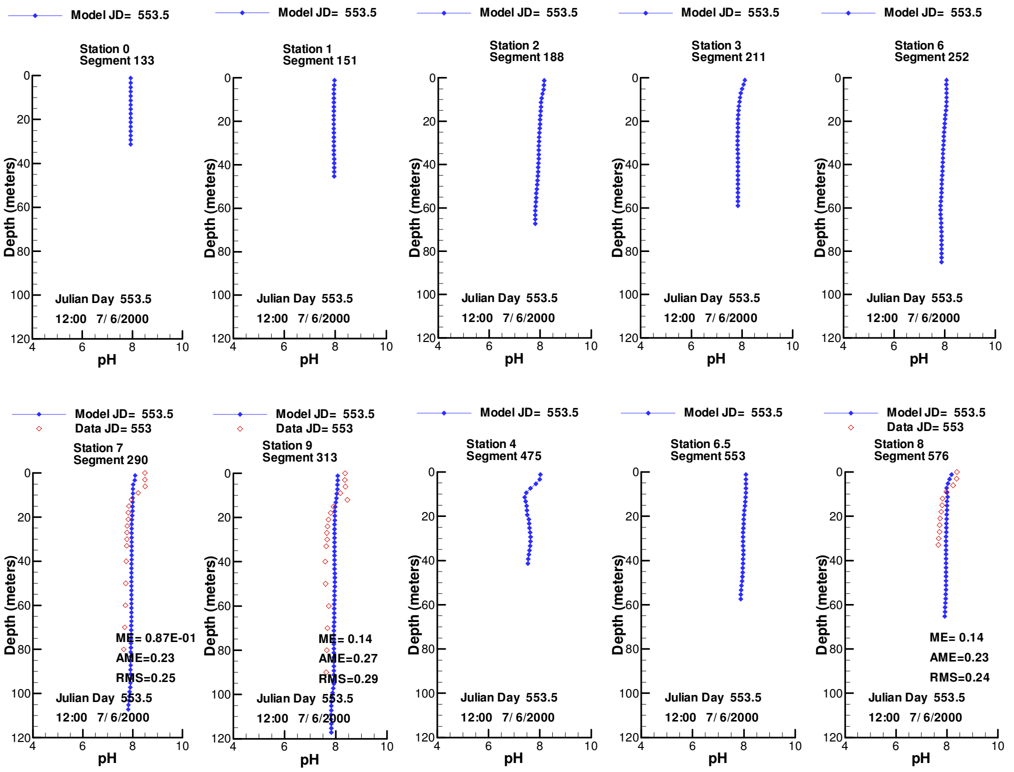

Figure 357. Vertical pH model-data comparison, J553.

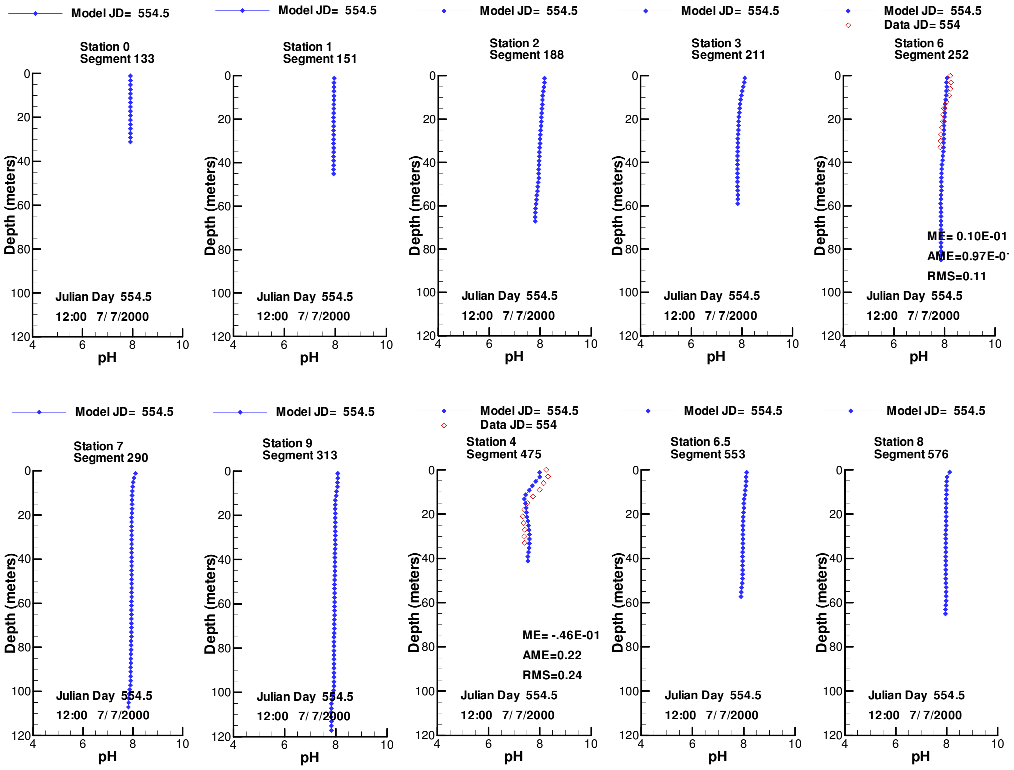

Figure 358. Vertical pH model-data comparison, J554.

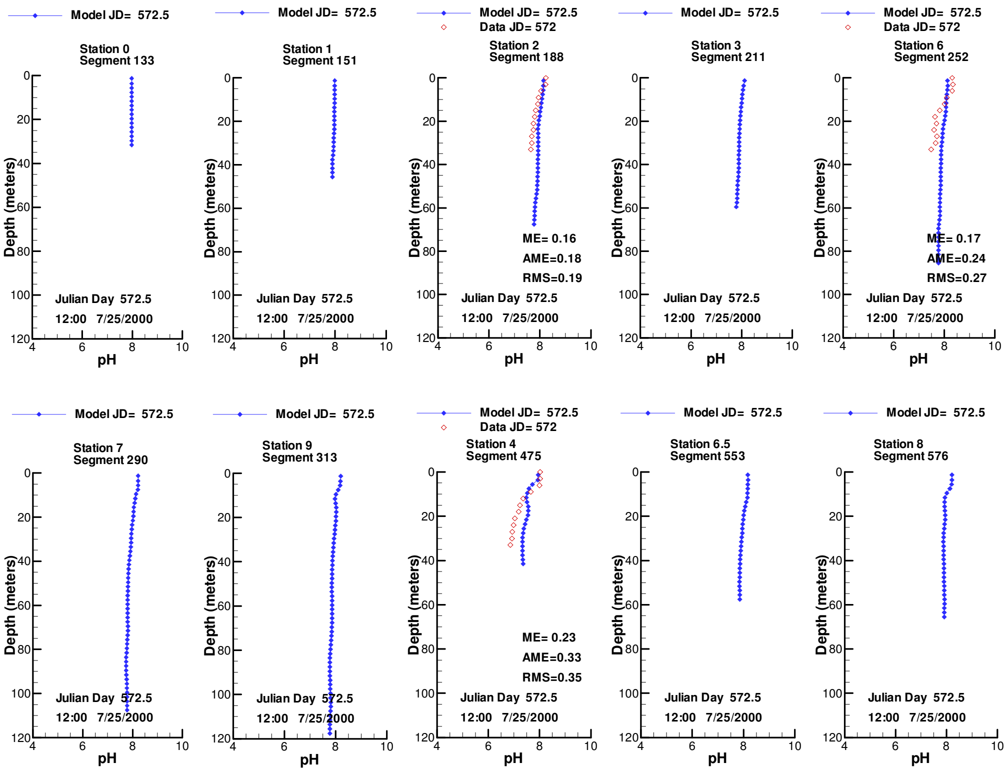

Figure 359. Vertical pH model-data comparison, J572.

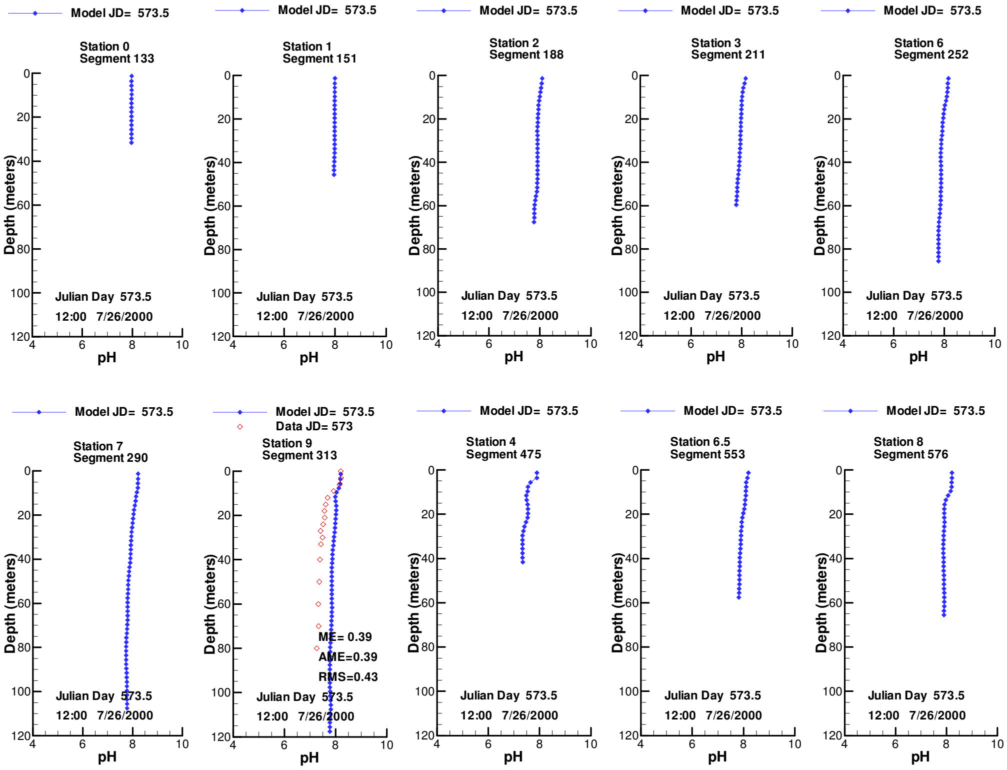

Figure 360. Vertical pH model-data comparison, J573.

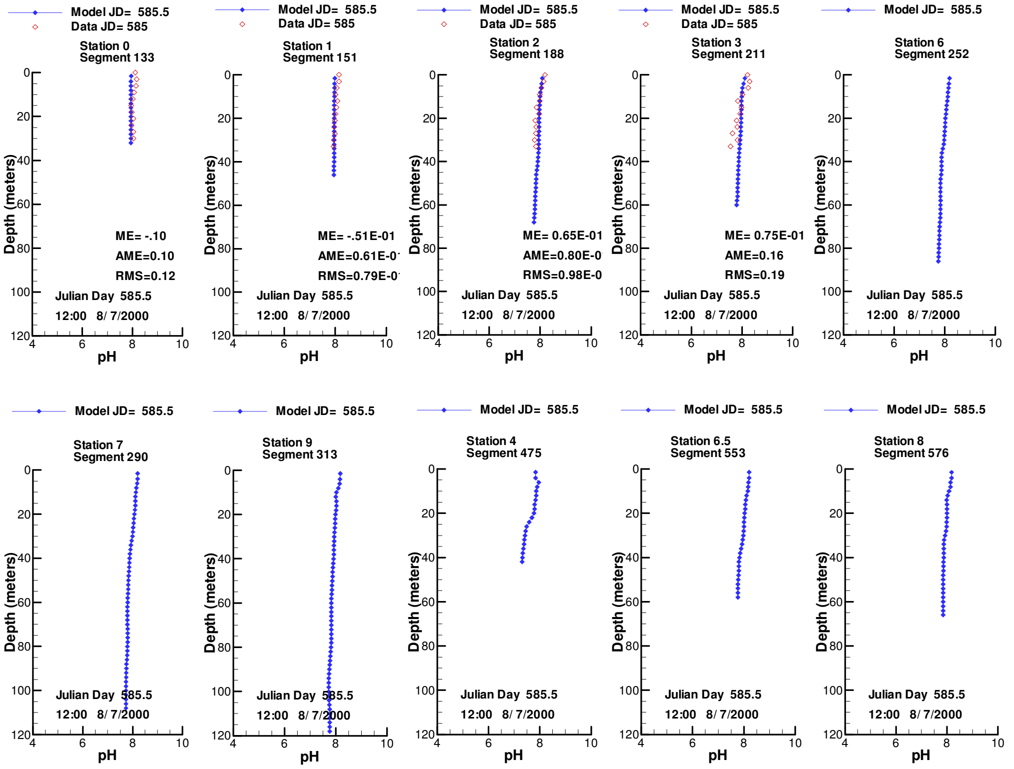

Figure 361. Vertical pH model-data comparison, J585.

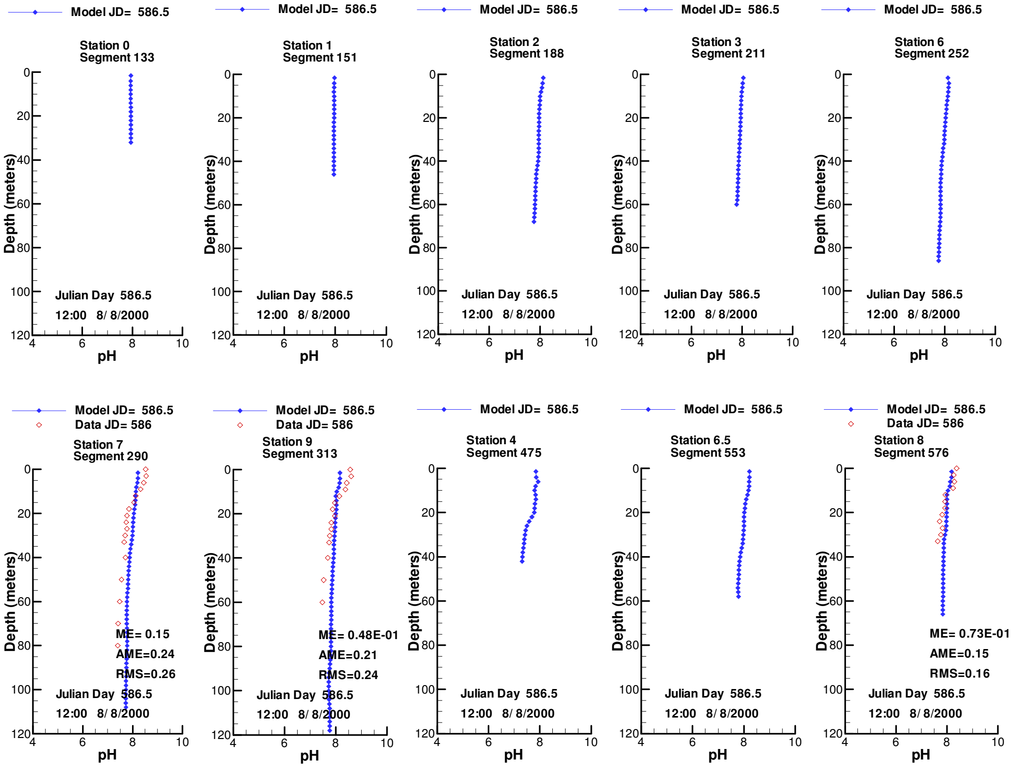

Figure 362. Vertical pH model-data comparison, J586.

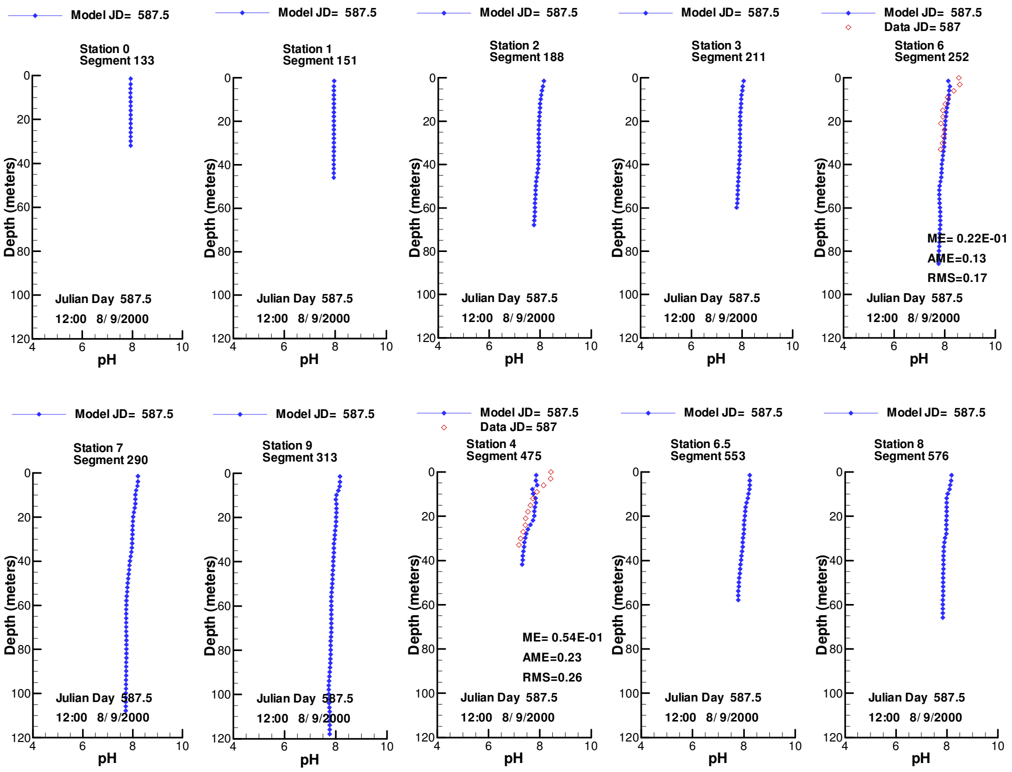

Figure 363. Vertical pH model-data comparison, J587.

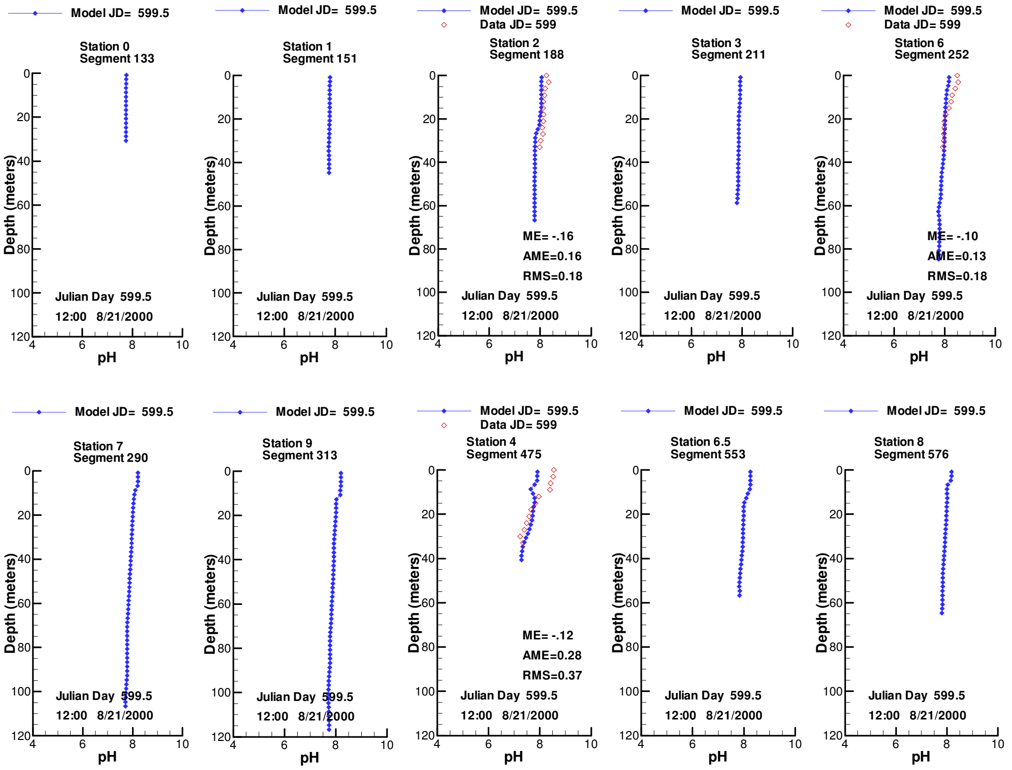

Figure 364. Vertical pH model-data comparison, J599.

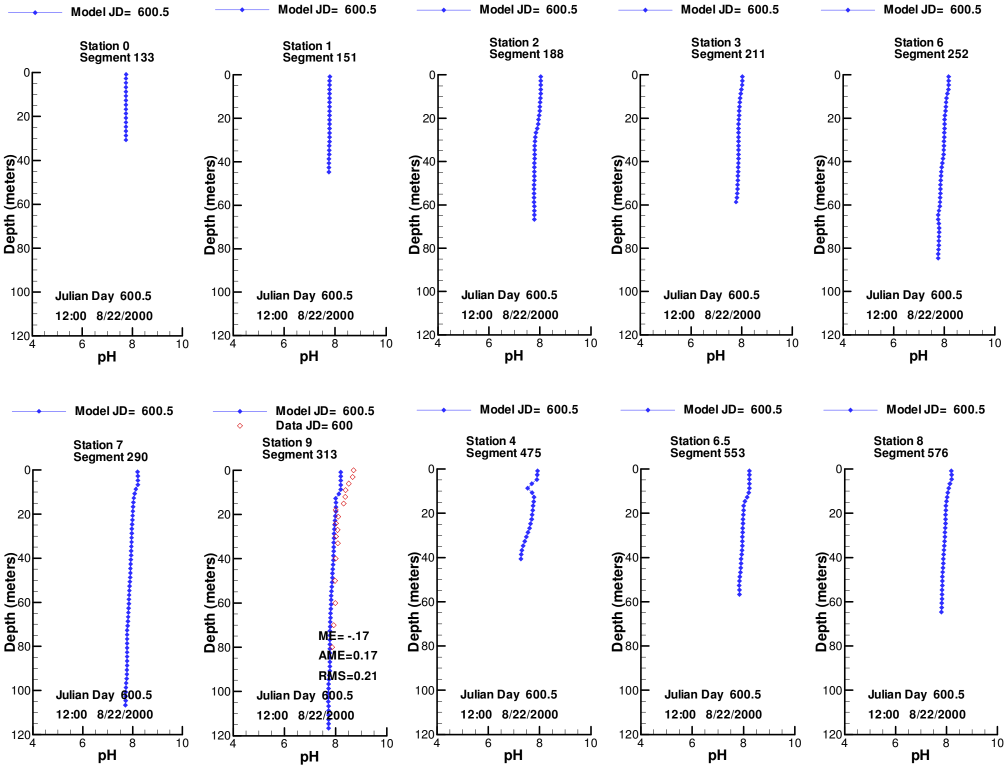

Figure 365. Vertical pH model-data comparison, J600.

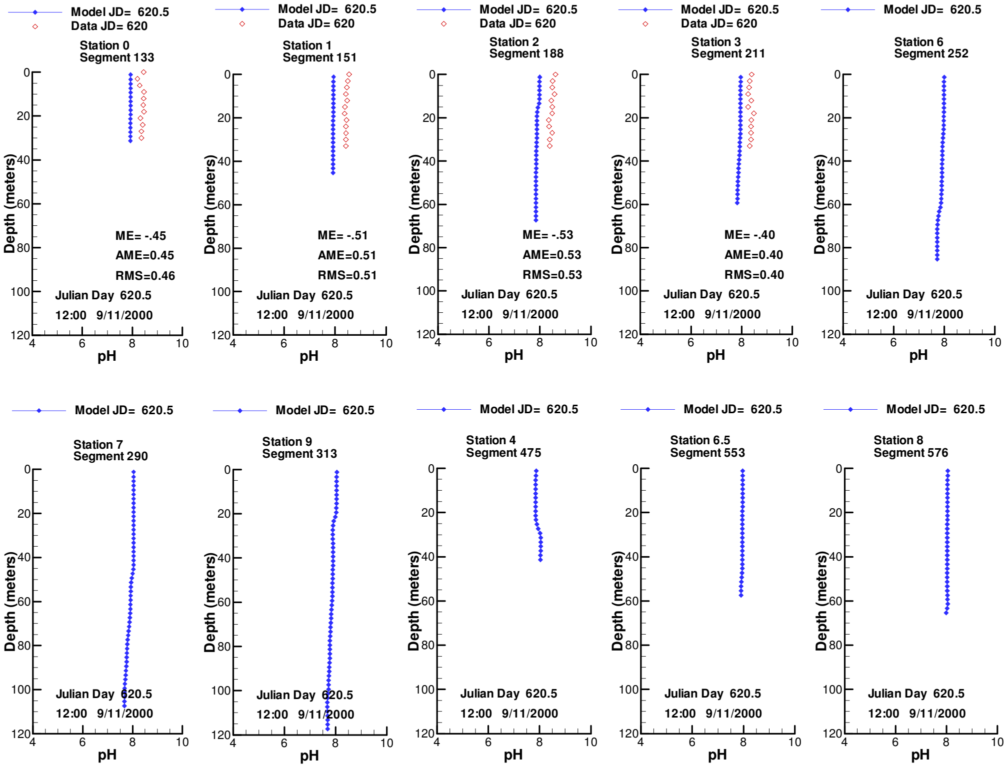

Figure 366. Vertical pH model-data comparison, J620.

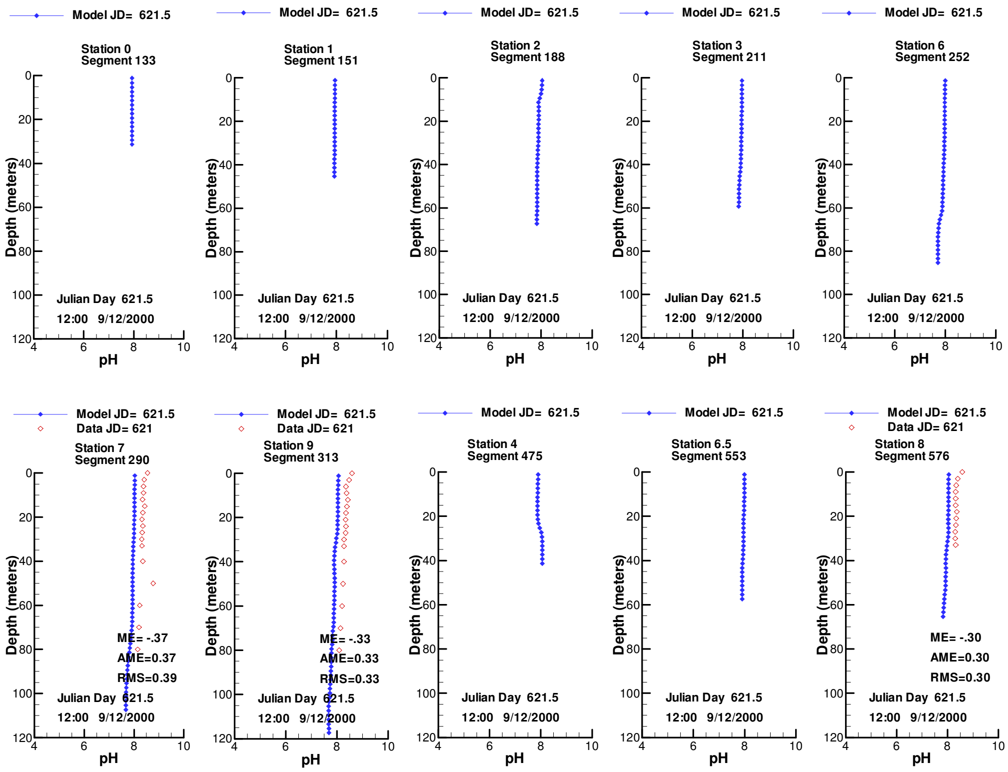

Figure 367. Vertical pH model-data comparison, J621.

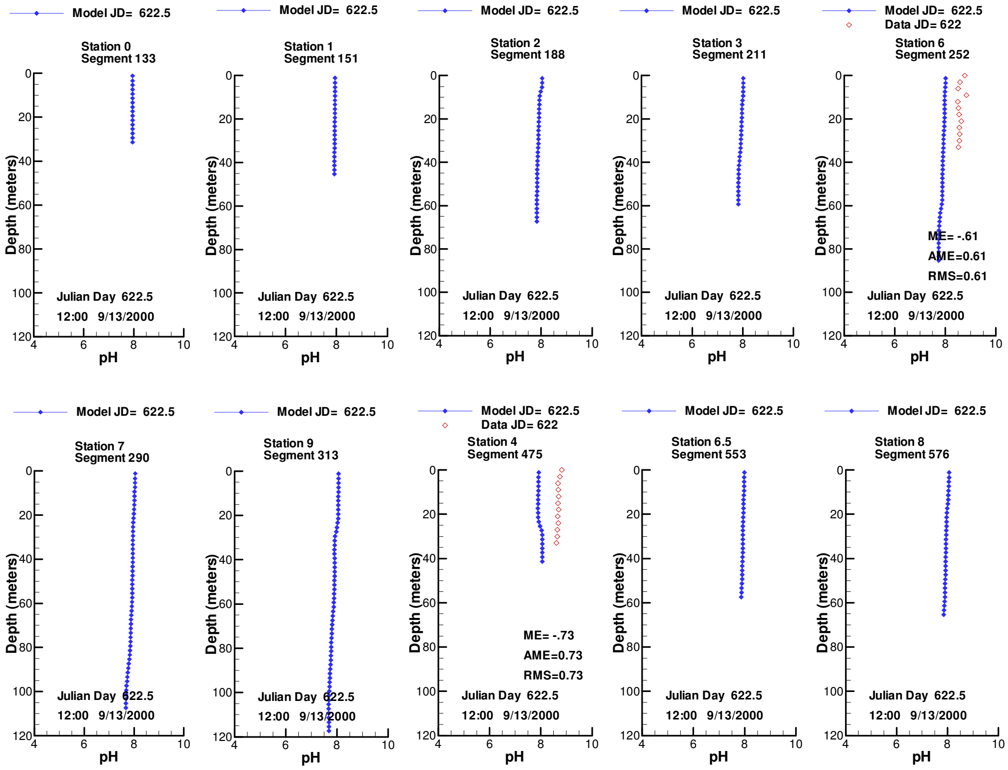

Figure 368. Vertical pH model-data comparison, J622.

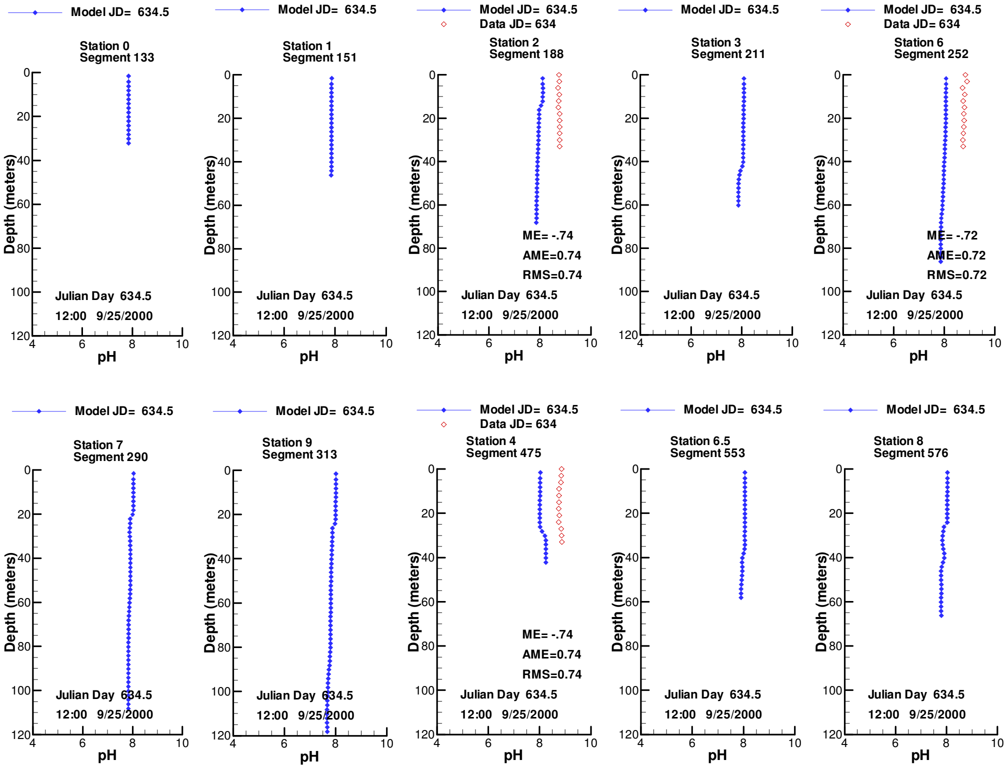

Figure 369. Vertical pH model-data comparison, J634.

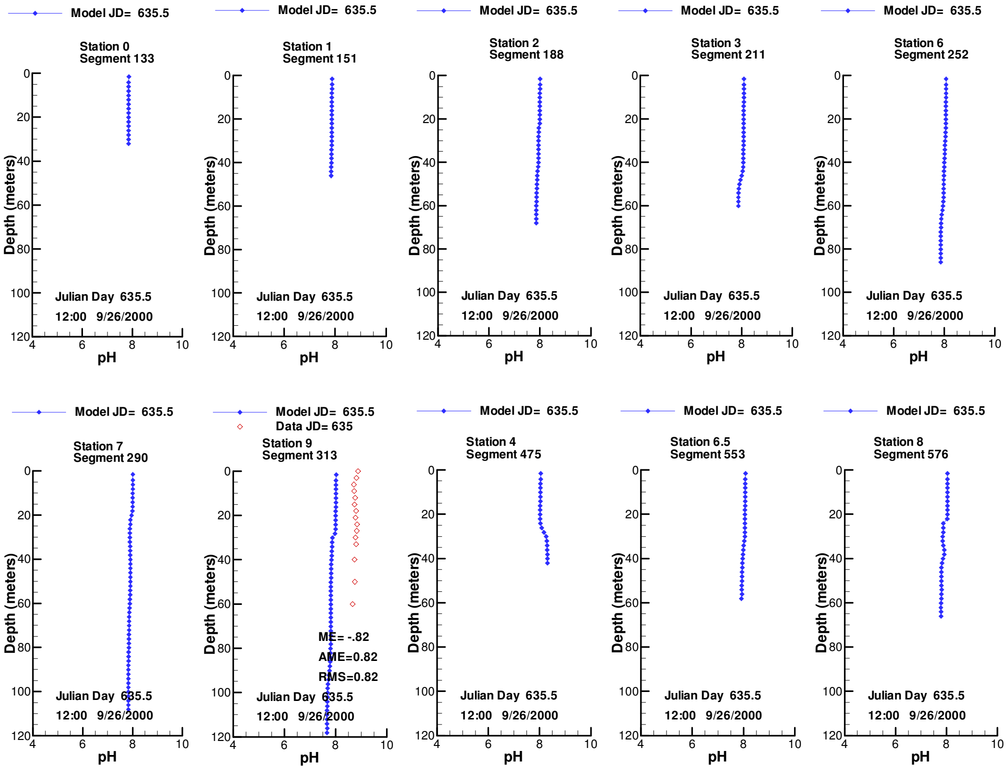

Figure 370. Vertical pH model-data comparison, J635.

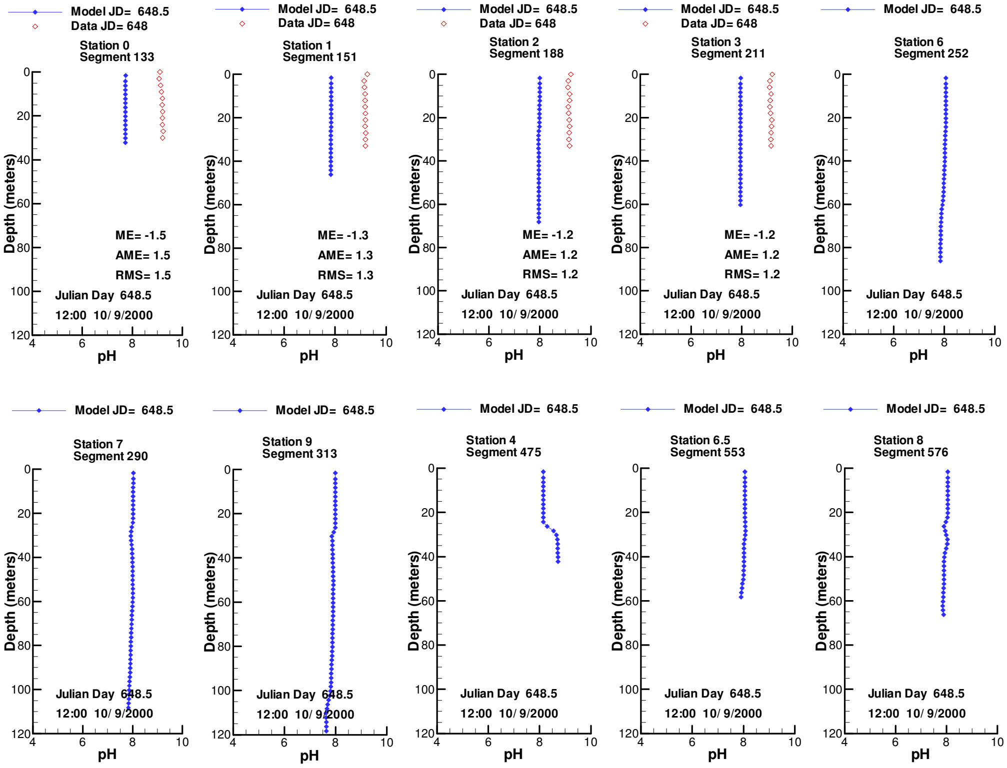

Figure 371. Vertical pH model-data comparison, J648.

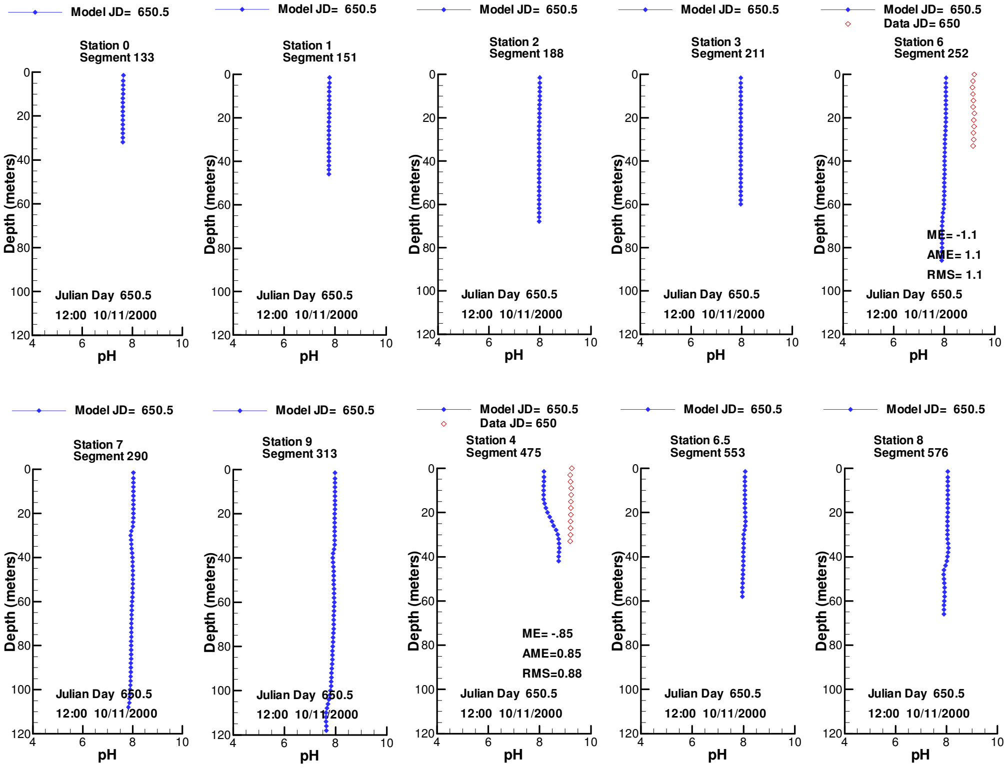

Figure 372. Vertical pH model-data comparison, J650.

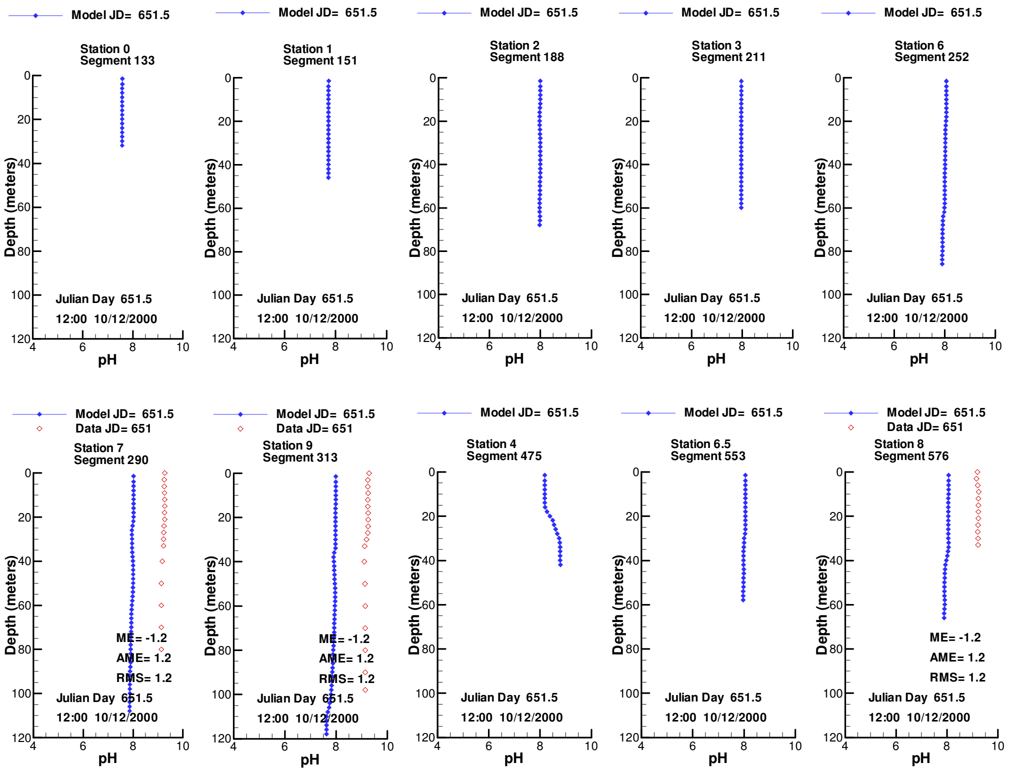

Figure 373. Vertical pH model-data comparison, J651.

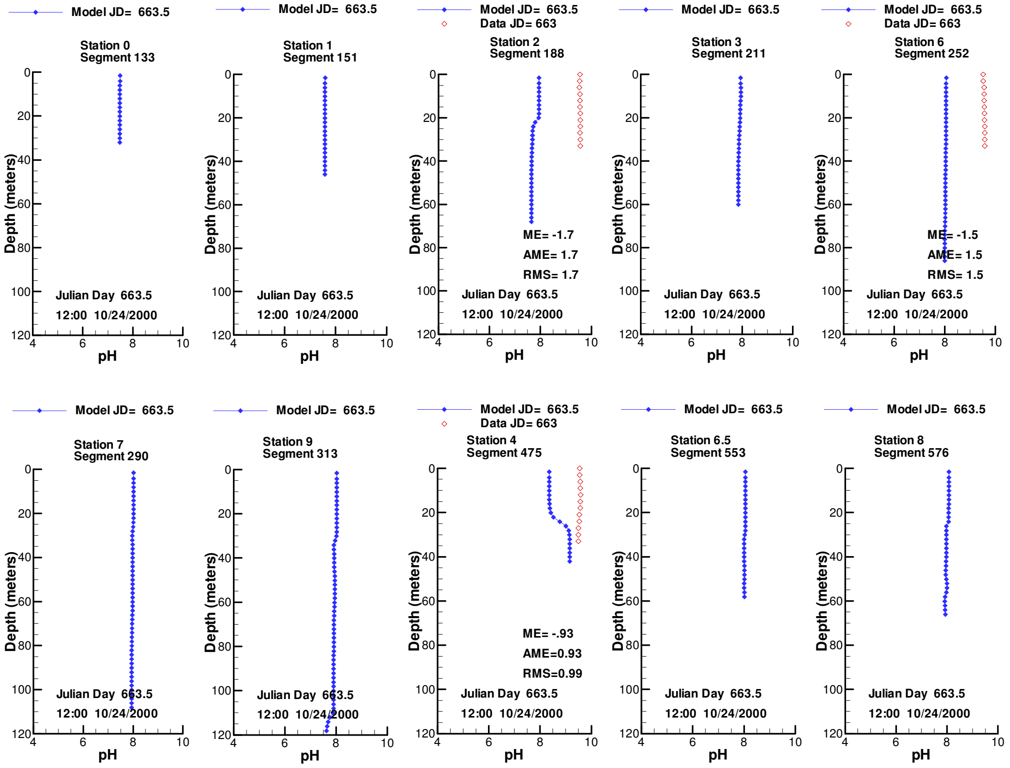

Figure 374. Vertical pH model-data comparison, J663.

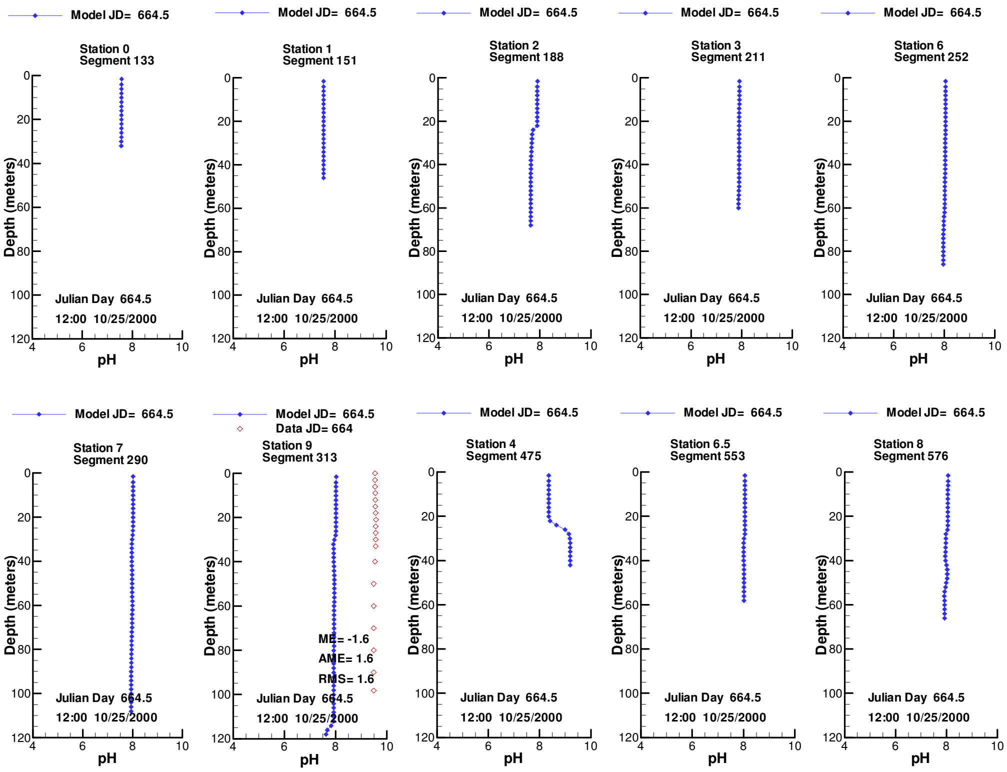

Figure 375. Vertical pH model-data comparison, J664.

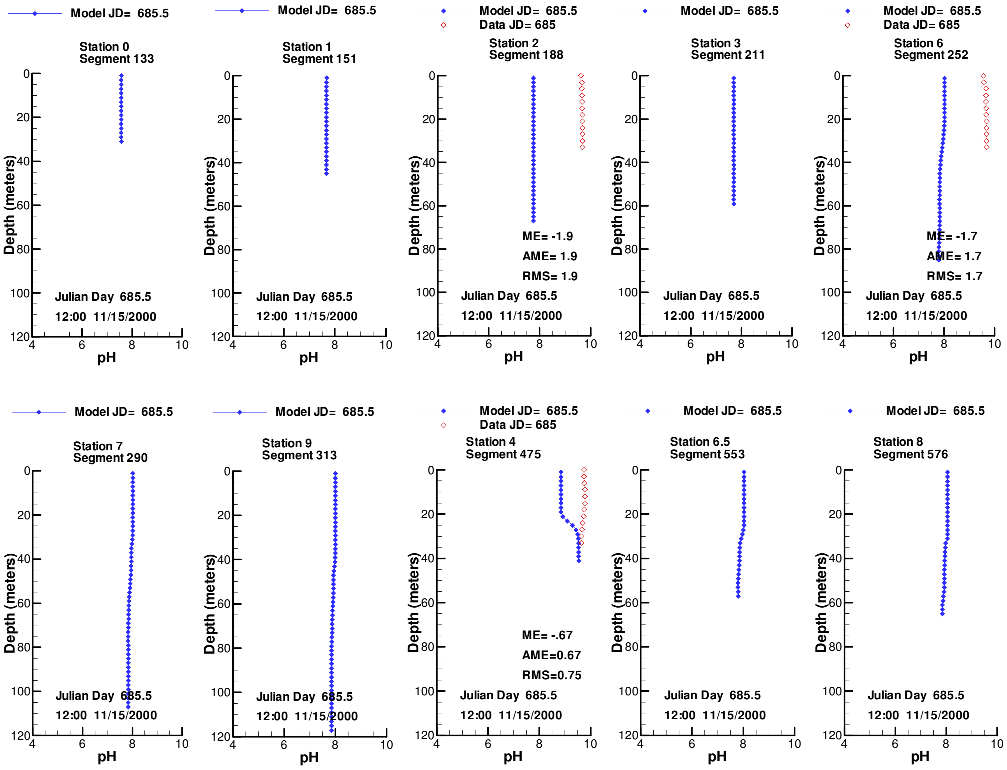

Figure 376. Vertical pH model-data comparison, J685.

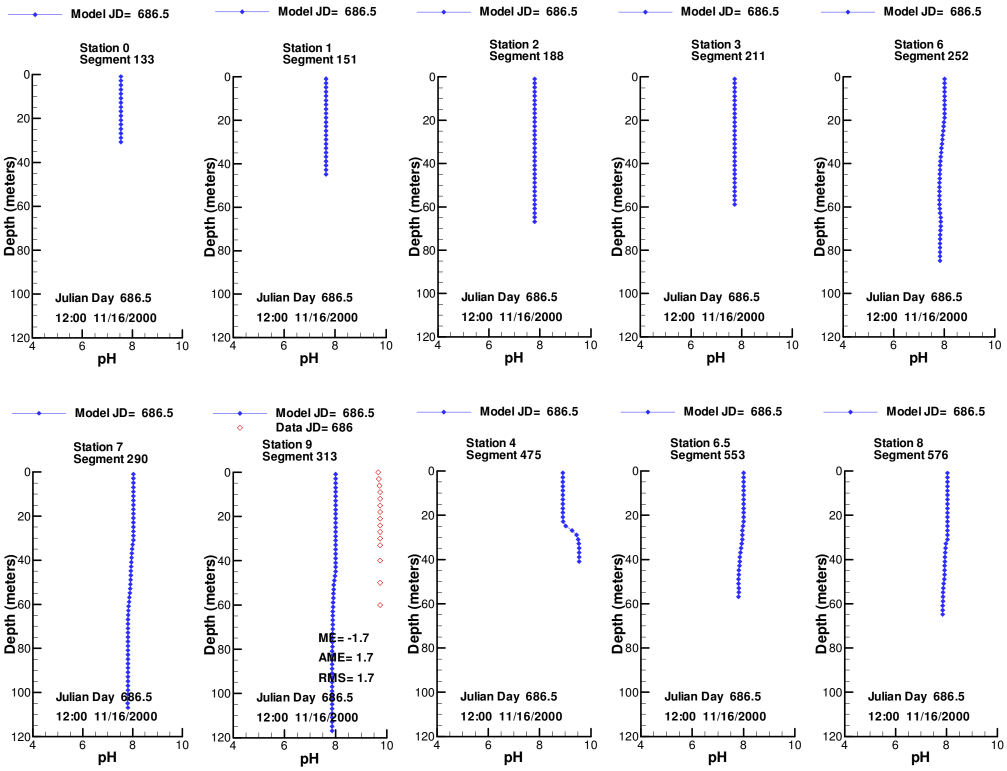

Figure 377. Vertical pH model-data comparison, J686.

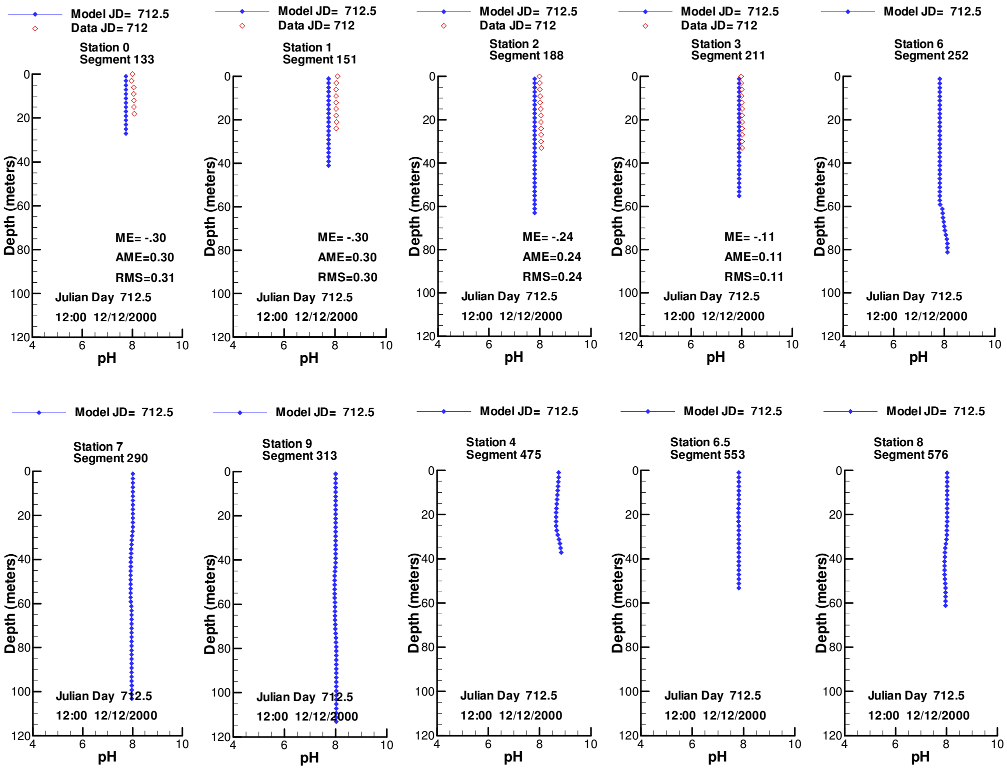

Figure 378. Vertical pH model-data comparison, J712.

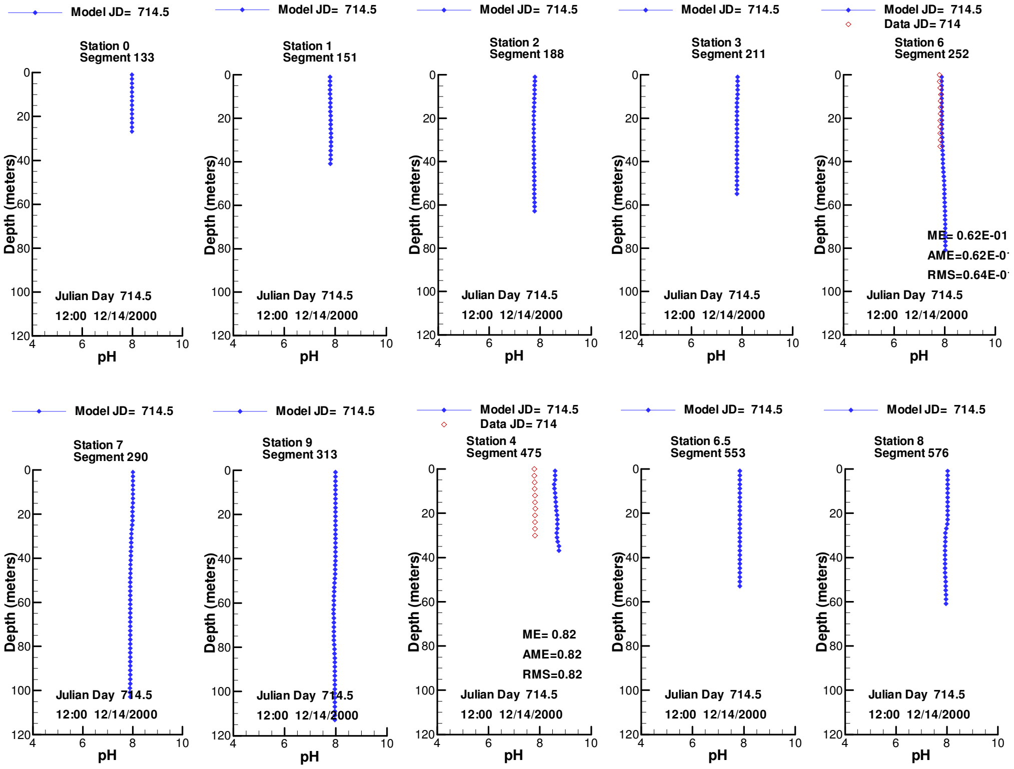

Figure 379. Vertical pH model-data comparison, J714.

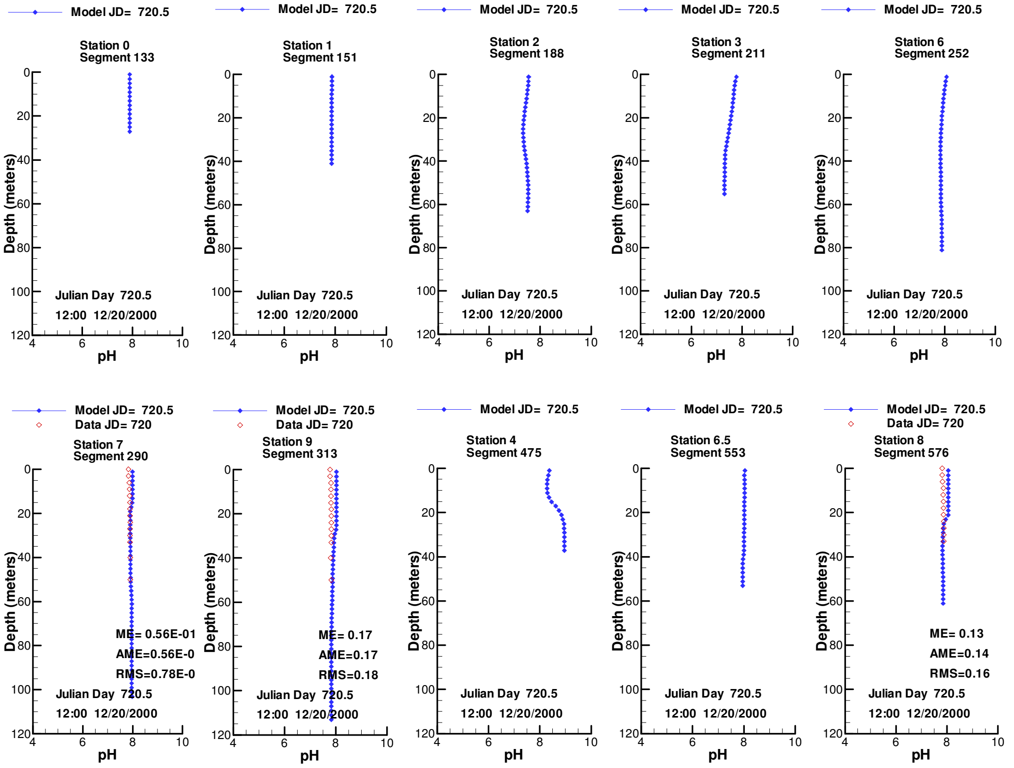

Figure 380. Vertical pH model-data comparison, J720.

Appendix G: Statistics Calculations

Model-data error statistics were computed using formulas for the mean error, absolute mean error, and root mean square error. The mean error (ME) was calculated as

$$ME = \frac{\sum_{1}^{n} (\text{model} - \text{data})}{n} \tag{19}$$

The absolute mean error was calculated as

$$AME = \frac{\sum_{1}^{n} abs(\text{model} - \text{data})}{n} \tag{20}$$

The root mean square error was calculated as

$$RMS = \sqrt{\frac{\sum_{1}^{n} (\text{model} - \text{data})^2}{n}} \tag{21}$$

where n is the number of observations, model is the model predicted state variable and data is the field data variable.

Appendix H: W2 Model Water Quality Parameters

Table 32 summarizes the model water quality parameters used. When applicable, typical literature values are included. For variables with multiple entries, such as EXA1, the last number always refers to the constituent group. Thus EXA1 is the extinction due to organic algal type 1. Similarly, PREFA23 is the feeding preference of zooplankton group 3 on algal group 2.

For clarity,

- Algal group 1 represents mixed diatoms, dominated by *asterionella formosa*.
- Algal group 2 represents mixed green algae.
- Algal group 3 represents mixed cyanobacteria.
- Zooplankton group 1 represents herbivorous copepoda
- Zooplankton group 2 represents omnivorous copepoda
- Zooplankton group 3 represents cladocera, dominated by *Daphnia*

Table 32. W2 Model Water Quality Parameters Summary

Variable	Description	Units	Typical values*	Calibration Values
Hydrodynamics and Longitudinal Transport				
AX	Longitudinal eddy viscosity (for momentum dispersion)	m^2/sec	1	1
DX	Longitudinal eddy diffusivity (for dispersion of heat and constituents)	m^2/sec	1	1
Temperature				
CBHE	Coefficient of bottom heat exchange	Wm^2/sec	0.30	0.30
TSED	Sediment (ground) temperature	^{o}C	12.8	11.5
WSC	Wind sheltering coefficient		1.0	0.4-2.0
BETA	Fraction of incident solar radiation absorbed at the water surface		0.45	0.45
Water Quality				
EXH20	Extinction for water	/m	0.25	0.25
EXSS	Extinction due to inorganic suspended solids	m^3/m/g	0.01	0.1
EXOM	Extinction due to organic	m^3/m/g	0.17	0.1

Variable	Description	Units	Typical values*	Calibration Values
	suspended solids			
EXA1 EXA2 EXA3	Extinction due to organic algal type ‘n’	$m^3/m/g$	0.1	0.2 0.2 0.2
SSS	Suspended solids settling rate	m/day	2	1.0
AG1 AG2 AG3	Algal growth rate for algal type ‘n’	/day	1.1	2.5 2.5 1.0
AM1 AM2 AM3	Algal mortality rate for algal type ‘n’	/day	0.01	0.08 0.10 0.08
AE1 AE2 AE3	Algal excretion rate for algal type ‘n’	/day	0.01	0.04 0.04 0.04
AR1 AR2 AR3	Algal dark respiration rate for algal type ‘n’	/day	0.02	0.04 0.04 0.10
AS1 AS2 AS3	Algal settling rate for algal type ‘n’	/day	0.14	0.50 0.05 0.10
ASAT1 ASAT2 ASAT3	Saturation intensity at maximum photosynthetic rate for algal type ‘n’	W/m^2	150	85 36 75
APOM1 APOM2 APOM3	Fraction of algal biomass lost by mortality to detritus for algal type ‘n’		0.8	0.50 0.50 0.50
AT11 AT12 AT13	Lower temperature for algal growth for algal type ‘n’	^oC	10	1.0 1.0 10.0
AT21 AT22 AT23	Lower temperature for maximum algal growth for algal type ‘n’	^oC	30	10.0 10.0 33.0
AT31 AT32 AT33	Upper temperature for maximum algal growth for algal type ‘n’	^oC	35	20.0 20.0 35.0
AT41 AT42 AT43	Upper temperature for algal growth for algal type ‘n’	^oC	40	28.0 25.0 40.0
AK11 AK12	Fraction of algal growth rate at ALGT1 for algal		0.1	0.20 0.20

Variable	Description	Units	Typical values*	Calibration Values
AK13	type ‘n’			0.05
AK21 AK22 AK23	Fraction of maximum algal growth rate at ALGT2 for algal type ‘n’		0.99	0.99 0.99 0.99
AK31 AK32 AK33	Fraction of maximum algal growth rate at ALGT3 for algal type ‘n’		0.99	0.99 0.99 0.99
AK41 AK42 AK43	Fraction of algal growth rate at ALGT4 for algal type ‘n’		0.1	0.1 0.1 0.1
ALGP-A1 ALGP-A2 ALGP-A3	Stoichiometric equivalent between organic matter and phosphorus for algal type ‘n’		0.011	0.003 0.002 0.008
ALGN-A1 ALGN-A2 ALGN-A3	Stoichiometric equivalent between organic matter and nitrogen for algal type ‘n’		0.08	0.034 0.040 0.080
ALGC-A1 ALGC-A2 ALGC-A3	Stoichiometric equivalent between organic matter and carbon for algal type ‘n’		0.45	0.450 0.535 0.475
LDOMDK	Labile DOM decay rate	/day	0.12	Spokane: 0.1 Others: 0.01
LRDDK	Labile to refractory DOM decay rate	/day	0.001	0.01
RDOMDK	Maximum refractory decay rate	/day	0.001	0.001
LPOMDK	Labile Detritus decay rate	/day	0.06	Spokane: 0.25 Others: 0.05
LRPDK	Labile to refractory POM decay rate	/day	0.01	0.01
POMS	Detritus settling rate	m/day	0.35	0.1
RPOMDK	Refractory Detritus decay rate	/day		0.005
OMT1	Lower temperature for organic matter decay	^{o}C	4	4
OMT2	Lower temperature for maximum organic matter decay	^{o}C	20	30
OMK1	Fraction of organic matter decay rate at OMT1		0.1	0.1
OMK2	Fraction of organic matter		0.99	0.99

Variable	Description	Units	Typical values*	Calibration Values
	decay rate at OMT2			
SEDK	Sediment decay rate	/day	0.06	0.1
PARTP	Phosphorous partitioning coefficient for suspended solids		1.2	0.2
AHSP1 AHSP2 AHSP3	Algal half-saturation constant for phosphorous – algae 1	g/m	0.009	0.002 0.003 0.003
NH4DK	Ammonia decay rate (nitrification rate)	/day	0.12	0.12
AHSN	Algal half-saturation constant for ammonia	g/m^3	0.014	0.014
NH4T1	Lower temperature for ammonia decay	^oC	5	5
NH4T2	Lower temperature for maximum ammonia decay	^oC	20	25
NH4K1	Fraction of nitrification rate at NH4T1		0.1	0.1
NH4K2	Fraction of nitrification rate at NH4T2		0.99	0.99
NO3DK	Nitrate decay rate (denitrification rate)	/day	0.102	0.03
NO3S	Denitrification rate from sediments	m/day	1.0	1.0
NO3T1	Lower temperature for nitrate decay	^oC	5	5
NO3T2	Lower temperature for maximum nitrate decay	^oC	20	25
NO3K1	Fraction of denitrification rate at NO3T1		0.1	0.1
NO3K2	Fraction of denitrification rate at NO3T2		0.99	0.99
O2NH4	Oxygen stoichiometric equivalent for ammonia decay		4.57	4.57
O2OM	Oxygen stoichiometric equivalent for organic matter decay		1.4	1.4
O2AR	Oxygen stoichiometric equivalent for dark respiration		1.4	1.1
O2AG	Oxygen stoichiometric		1.4	1.4

Variable	Description	Units	Typical values*	Calibration Values
	equivalent for algal growth			
ORGP	Stoichiometric equivalent between organic matter and phosphorus		0.011	0.05
ORGN	Stoichiometric equivalent between organic matter and nitrogen		0.08	0.05
ORGC	Stoichiometric equivalent between organic matter and carbon		0.45	0.45
O2LIM	Dissolved oxygen concentration at which anaerobic processes begin	g/m^3	0.1	0.1
EXZ1 EXZ2 EXZ3	Extinction due to organic zooplankton type ‘n’	$m^3/m/g$	0.1	0.2 0.2 0.2
ZMAX1 ZMAX2 ZMAX3	Maximum zooplankton growth rate for zooplankton type ‘n’	/day	1.5	2.5 2.5 2.5
ZRESP1 ZRESP2 ZRESP3	Maximum zooplankton respiration rate for zooplankton type ‘n’	/day	0.1	0.1 0.1 0.1
ZMORT1 ZMORT2 ZMORT3	Maximum zooplankton mortality rate for zooplankton type ‘n’	/day	0.01	0.1 0.1 0.1
ZEFFIC1 ZEFFIC2 ZEFFIC3	Zooplankton assimilation efficiency or the proportion of food assimilated to food consumed for zooplankton type ‘n’		0.5	0.6 0.6 0.6
PREFP1 PREFP2 PREFP3	Preference factor of zooplankton for detritus or LPOM for zooplankton type ‘n’		0.5	0.1 0.1 0.1
ZOOMIN1 ZOOMIN2 ZOOMIN3	Threshold food concentration at which zooplankton feeding begins for zooplankton type ‘n’	g/m^3	0.01	0.001 0.001 0.001
ZS2P1 ZS2P2 ZS2P3	Zooplankton half-saturation constant for food (inclues LPOM, algae, and zooplankton) ingestion for	g/m^3	0.3	0.3 0.5 0.3

Variable	Description	Units	Typical values*	Calibration Values
	zooplankton type ‘n’			
PREFA11 PREFA12 PREFA13	Preference factor of zooplankton type ‘n’ for algae type 1			0.35 0.30 0.35
PREFA21 PREFA22 PREFA23	Preference factor of zooplankton type ‘n’ for algae type 2			0.55 0.40 0.55
PREFA31 PREFA32 PREFA33	Preference factor of zooplankton type ‘n’ for algae type 3			0.00 0.00 0.00
PREFZ11 PREFZ12 PREFZ13	Preference factor of zooplankton type ‘n’ for zooplankton 1			0.00 0.10 0.00
PREFZ21 PREFZ22 PREFZ23	Preference factor of zooplankton type ‘n’ for zooplankton 2			0.00 0.00 0.00
PREFZ31 PREFZ32 PREFZ33	Preference factor of zooplankton type ‘n’ for zooplankton 3			0.00 0.10 0.00
ZT11 ZT12 ZT13	Lower temperature for algal growth for zooplankton type ‘n’	^{o}C	5.0	1.0 1.0 1.0
ZT21 ZT22 ZT23	Lower temperature for maximum zooplankton growth for zooplankton type ‘n’	^{o}C	25.0	10.0 10.0 10.0
ZT31 ZT32 ZT33	Upper temperature for maximum zooplankton growth for zooplankton type ‘n’	^{o}C	35.0	25.0 25.0 25.0
ZT41 ZT42 ZT43	Upper temperature for zooplankton growth for zooplankton type ‘n’	^{o}C	40.0	36.0 36.0 36.0
ZK11 ZK12 ZK13	Fraction of zooplankton growth rate at ZT1 for zooplankton type ‘n’		0.1	0.30 0.30 0.30
ZK21 ZK22 ZK23	Fraction of maximum zooplankton growth rate at ZT2 for zooplankton type ‘n’		0.99	0.90 0.90 0.90
ZK31 ZK32	Fraction of maximum zooplankton growth rate at		0.99	0.98 0.98

Variable	Description	Units	Typical values*	Calibration Values
ZK33	ZT3 for zooplankton type ‘n’			0.98
ZK41 ZK42 ZK43	Fraction of zooplankton growth rate at ZT4 for zooplankton type ‘n’		0.1	0.20 0.20 0.20
ZP1 ZP2 ZP3	Stoichiometric equivalent between organic matter and phosphorus for zooplankton type ‘n’		0.005	0.007 0.007 0.007
ZN1 ZN2 ZN3	Stoichiometric equivalent between organic matter and nitrogen for zooplankton type ‘n’		0.08	0.080 0.080 0.080
ZC1 ZC2 ZC3	Stoichiometric equivalent between organic matter and carbon for zooplankton type ‘n’		0.45	0.045 0.045 0.045
* Cole and Wells (2006)				